From:	Srock, John
To:	Nathan Wiser/R8/USEPA/US@EPA
Cc:	Blauch, Matthew; Dorfman, Grant; Jeanne Briskin/DC/USEPA/US@EPA; Christopher Impellitteri/CI/USEPA/US@EPA
Subject:	RE: Proposal: EPA and Superior data sharing
Date:	03/29/2012 12:51 PM

Nathan:

Thanks for your message and for keeping us updated on the progress of EPA's study. As we have discussed, Superior Well Services is encouraged that EPA is seeking hard data on which to base the agency's findings. We are hopeful that factual information will replace the rumor and innuendo that seems to form the basis for much public discussion of hydraulic fracturing.

With regard to the proposal that was attached to your March 19 email, Superior is willing to participate with other hydraulic fracturing service companies and producers in a joint program to help EPA acquire the additional data you are seeking. However, please understand that Superior cannot take the lead in this initiative and submit requests to others on behalf of EPA. We think that EPA needs to reach out directly to other fracturing service providers and to the producers themselves to create the collaborative working group described in your proposal. It is important that other service companies are included in the working group so that the producers do not perceive that their confidential information is better protected by using a service provider who is not part of the working group. Also, it is important that several large producers be included in the working group because the flowback water belongs to the producer and it will be necessary to secure their willing participation in the working group in order for you to be able to collect samples of flowback water from multiple sources.

If EPA can arrange for a majority of the hydraulic fracturing service providers (perhaps the companies that responded to EPA's information request in the fall of 2010), Superior will participate with the others in the proposed working group. We are also willing to work with any of our clients whom you persuade to participate in this initiative. Superior would like to assist EPA in obtaining the hard data and factual information that will support the findings in your forthcoming report, but we need to look to EPA to take the initiative in putting together a working group involving a majority of industry participants to provide this information

Thank you, John

-Regards

John Srock HSE Director Health, Safety, and Environmental

SUPERIOR WELL SERVICES INC.

A Nabors Industries Company W: 724.403.9066 | C: 724.541.7822 | F: 866.691.8298 | <u>www.swsi.com</u> | <u>www.nabors.com</u> | From: Nathan Wiser [mailto:Wiser.Nathan@epamail.epa.gov]
Sent: Wednesday, March 14, 2012 1:29 PM
To: Srock, John
Cc: Blauch, Matthew; Dorfman, Grant; Jeanne Briskin; Christopher Impellitteri
Subject: Proposal: EPA and Superior data sharing

Hi John,

Attached please find a proposal from EPA outlining the ideas that we discussed Monday March 5, 2012, for collecting physical fluid samples at well stimulation locations and for sharing data. If you would like to schedule a call with EPA as follow up, please let me know and we can arrange for that. It is my understanding that you will transmit this proposal to your clients to gauge their interest. Please let me know if there anything else we can do you think would be useful.

Also, we look forward to receiving the existing data you have collected, stored as data in a spreadsheet or database. To date, we have not yet received it.

Thank you.

(See attached file: EPA_Superior_Data_Share_Proposal_March_2012.docx)

--Nathan Wiser Environmental Scientist U.S. EPA, Office of Research and Development Office of Science Policy (303) 312-6211 office (303) 312-6953 fax wiser.nathan@epa.gov

mailing address: U.S. EPA Region 8 (Mail Code 8ENF-UFO) 1595 Wynkoop Street Denver, Colorado 80202

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EPA HF Study – Haynesville Prospective Site F2F Meeting 9/19/2011

Agenda:

- Introductions
- Review Status of Actions
 - Verify with Director that EPA analytical methods can be released to outside party (Bob, 9/19/2011 IN PROGRESS)
 - Design plan for geophysical work to be included in the QAPP (Bob, 9/19/2011 IN PROGRESS)
 - E&E to develop additional design plans for monitoring well location and installation to provide further options for discussion (Gene, 9/19/2011 IN PROGRESS) E&E has provided to EPA.
 - Develop a draft communication plan (Chris, 9/19/2011 **IN PROGRESS**)
 - EPA to develop FTP site for all study data and materials and will provide CHK with access. (Bob, 9/19/2011 IN PROGRESS)
 - E&E to provide EPA with names and contact information for all parties requiring access to FTP site. (Gene, 9/19/2011 **IN PROGRESS**)
- Tentative Schedule
- Monitoring Wells
 - o Layout
 - o **Design**
 - Geophysical Techniques
 - Down-hole video
 - 3-arm caliper
 - Natural gamma
 - Electromagnetic induction
 - Single point resistance
 - Self potential
 - Long and short normal resistivity
 - Acoustic and optical televiewer with borehole deviation
 - Fluid conductivity-- logged under ambient and pumped conditions
 - Fluid temperature -- logged under ambient and pumped conditions
 - Heat-pulse flow meter or EM flow meter -- logged under ambient and pumped conditions
 - CNL-FDC (compensated neutron log formation density)
 - o Construction
 - o Security
- Domestic Wells Sampling
 - o Agreements
 - Procedures
- Soil samples
 - o Locations
 - o Procedures
- Sampling and Analytical Methods
- Communication Plan

Documents Provided:

- Tentative Schedule (pg 3)
- CHK Comments on Draft QAPP (pg 4)
- Proposed Surface Location Plat (pg 80)
- Proposed Surface Location Aerial (pg 81)
- Proposed Soil Sample Locations (pg 82)
- Typical Well Completions (E&E) (pg 83)
- Security Seal Example (pg 85)
- De Soto Parish 1/2 mile Buffer Parcel Map (pg 86)
- CHK List of Analytical Parameters (pg 87)
- CHK Sample Collection List (EPA Table 8) (pg 92)
- Representative Chemical Disclosures (5 mile radius from site) (pg 93)
 - BSOA 14-14-15 H-1 (pg 93)
 - o BURFORD 21-14-15 H-1 (pg 98)
 - FORCAP 4-13-15 H-2 (pg 103)
 - o KEATCHIE 15-14-15 H-1 (pg 108)
 - MARTINEZ 3-13-15 H-1 (pg 112)
- CHK Draft Data Quality Evaluation and Validation Effort (pg 117)
- CHK Draft Flowback and Baseline Sampling Procedures (pg 128)
- CHK Draft Communication Plan (pg 135)

ID	0	Task Name	Duration	Start	Finish	June 11 6/5 8/7
1		QAPP	30 days	Mon 8/22/11	Fri 9/30/11	P
2		Monitoring Well Construction Bids	5 days	Mon 9/26/11	Fri 9/30/11	
3		Monitoring Well Land Owner Agreements	10 days	Mon 10/3/11	Fri 10/14/11	
4		Monitoring Well Construction	45 days	Mon 10/17/11	Fri 12/16/11	
5		Domestic Baseline Sampling Land Owner Agreements and Outreach	10 days	Mon 9/26/11	Fri 10/7/11	
6		Domestic Baseline Sampling	15 days	Mon 10/10/11	Fri 10/28/11	
7		Baseline Monitoring Well Sampling	20 days	Mon 12/19/11	Fri 1/13/12	
8		Pad Construction	20 days	Wed 2/1/12	Wed 2/29/12	
9		Post-Pad Construction Sampling	15 days	Wed 2/29/12	Wed 3/21/12	
10		Drilling	45 days	Wed 3/21/12	Tue 5/22/12	
11		Post-Drilling Sampling	10 days	Wed 5/23/12	Tue 6/5/12	
12		Completions	15 days	Wed 9/5/12	Tue 9/25/12	
13		Post-Completions Sampling	10 days	Wed 9/26/12	Tue 10/9/12	
14		Production Equipment Installation	15 days	Wed 10/24/12	Tue 11/13/12	
15		Post-Production Sampling	260 days	Wed 11/14/12	Tue 11/12/13	

Project: Project1 Date: Mon 9/19/11	Task Split	Progress Milestone	♦	Summary Project Summary		External Tasks External Milestone 🗇	Deadline	û
					Page 1			



1.0 Project Management

1.1 Project/Task Organization

The organizational structure for the Hydraulic Fracturing Prospective Case Study located in the Haynesville Shale, in Desoto Parish Louisiana is shown in Figure 1. The responsibilities of the principal personnel associated with this case study are listed below.

Dr. Robert Puls, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Robert S. Kerr Environmental Research Center (RSKERC), Ada, OK. Dr. Puls is the overall technical lead on the Hydraulic Fracturing Study. He is the principal investigator of this project and is responsible for preparing and maintaining the <u>Quality Assurance Project Plan (QAPP)</u> and ensuring completion of all aspects of this QAPP, including overall responsibility for QA. He will lead the collection, analysis, and interpretation of groundwater and surface water samples.

Mr. Steve Vandegrift, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, RSKERC, Ada, OK. Mr. Vandegrift is responsible for quality assurance review/approval of the QAPP, conducting audits, and QA review/approval of the final report. His HAZWOPER certification is current.

Dr Randall Ross, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, <u>RSKERC</u>, Ada, OK. Dr. Ross will assist in the analysis of hydrologic conditions at the Haynesville site and will assist in the development of the site hydrologic conditions. His HAZWOPER certification is current.

Mr. Steve Acree, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, <u>RSKERC</u>, Ada, OK. Mr. Acree will assist in the analysis of hydrologic conditions at the Haynesville site and will assist in the development of the site hydrologic conditions. His HAZWOPER certification is current.

Mr. Russell Neill, Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, <u>RSKERC</u>, Ada, OK. Mr. Neill is responsible for assisting in ground water sampling. His HAZWOPER certification is current.

Dr. Sujith Kumar, Shaw Environmental, Ada, OK. Dr. Kumar is responsible for overseeing the analytical work performed under <u>Ground Water and Ecosystems Restoration Division's</u> (<u>GWERD</u>) on site analytical contract (VOC's, dissolved gases, and metals).

Ms. Shauna Bennett, Shaw Environmental, Ada, OK. Dr. Ms. Bennett is the QC Coordinator for Shaw Environmental and will coordinate QC for Shaw Environmental portion of this study.

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Ms. Cynthia Caporale, USEPA Region 3 Analytical Laboratory, Laboratory Branch Chief/Technical Director. Ms. Caporale will act as a liason between the Region 3 Lab and RSKERC.

Mr. Christopher Hill, Chesapeake Energy, Oklahoma City, OK. Mr. Hill will be the single point of contact for Chesapeake Energy throughout the Haynesville prospective study.

Dr. Puls is responsible for initiating contact with appropriate project participants as he deems necessary. Other project participants will keep Dr. Puls informed whenever significant developments or changes occur. Lines of communication among project participants may be conducted via in person conversations, electronic mail, phone conversations, conference calls, and periodic meetings.

1.2 Problem Definition/Background

The prospective case study in the Haynesville Shale (see Figure 2) will investigate the construction of a new well pad, new production well, hydraulic fracturing of said well, management and disposal of wastewater and production of gas from said well for about 1 year following hydraulic fracturing to determine if there is a negative impact to drinking water. The investigation will initially involve sampling ground water, surface water and soil and sediment sampling in the vicinity of the well pad to determine baseline characteristics. This study will be conducted in conjunction with the Louisiana Department of Environmental Quality (LDEQ). Chesapeake Energy, U.S. Environmental Protection Agency, Region 6 (EPA R6); and U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory (NRMRL), Ground Water and Ecosystems Restoration Division (GWERD). GWERD will be the lead organization for this case study.

The proposed pad location is in Desoto Parish in north western LA and has an estimated population of 26,656 individuals (2010). The area surrounding the proposed site is currently experiencing extensive natural gas exploration using horizontal drilling technology and hydraulic fracturing is being employed to stimulate production in these wells.

The objectives of this case study are listed below.

Primary Objective: Evaluate groundwater, surface water and soil characteristics before, during and after key phases of a shale gas well development; pad construction, well drilling, well completion, and production to identify if there is a significant change in media characteristics.

Secondary Objective 1: Determine the <u>appropriate</u> baseline <u>characteristics of</u> <u>groundwater, surface</u> water, and soil.

Section No. 2 Revision No. 0 September 18, 2011 Page 2 of 70

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Comment [c1]: 1 year following initial production was stated during a conference call

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Comment [c2]: All potential sources of contamination should be identified before the project proceeds A EDR/Phase I data review should be used to identify any potential sources such as USTs, landfills, spills along the railroad easement, salt storage yards, septic tanks, sewer lines, stormwater lines, etc within a 3-mile radius of the site

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Comment [C3]: http://quickfacts census gov/qfd/s tates/22/22031 html

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Comment [C4]: CHK has not had the opportunity to see the Final Study Plan or data quality objectives, therefore, we found it difficult to comment on the case study objective which should be the same as the Final Study Plan However, we did provide comments based on the QAPP's current content

Comment [c5]: "Drinking water" did not adequately describe scope of media under investigation

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Comment [c6]: We are initiating the study prepad construction, not just pre-drilling

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Comment [C7]: Given the current schedule, there does not appear enough time to capture seasonal variations in sample characteristic

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Secondary Objective 2: Determine <u>characteristics of groundwater</u>, <u>surface water</u>, <u>and</u> <u>soil throughout the key phases of the gas well development</u>; <u>post-pad construction to</u> <u>approximately one year after initial gas production</u>.

Secondary Objective 3: Determine the chemistry, volumes and rate of produced water, specifically flowback, over a period of months from the production well following hydraulic fracturing.

Secondary Objective 4: Compare data gathered for secondary objectives 1 and 2 to determine if significant changes were observed in the media baseline characteristics, and if this change could be attributed to the gas well development.

Secondary Objective 5: <u>Review wastewaters</u> site management and disposal <u>practices</u> <u>during</u> drilling and hydraulic fracturing, <u>and qualitatively identify risks to drinking water</u> <u>sources</u>.

1.3 Project/Task Description

In order to accomplish the primary objective of the study, the established monitoring well network, along with any pertinent domestic wells and municipal supply wells will be sampled for the following components found in Table 1. In addition, select hydraulic fracturing fluid components (such as potassium (K), barium (Ba), alcohols, naphthalene, and boron), potentially mobilized naturally occurring substances (such as arsenic (As), selenium (Se), strontium (Sr), and other trace metals) will also be tested along with changes in background water quality (pH, major anions and cations). In addition, during future samplings soil and stream samples will be taken and the critical analytes for these sample types are the same as listed previously.

In order to address secondary objective 1, groundwater sampling, surface water sampling and soil and sampling will be necessary. The target parameters listed in the primary objective will be needed to address this objective.

Secondary objective 2 will entail re-sampling of groundwater, surface water, and soils for the same suite of parameters to see if there was any adverse impact.

Secondary objective 3 will require the sampling of the waters/fluids returned to the surface following hydraulic fracturing and release of downhole pressures during fracturing. Very few studies have been done to evaluate the chemistry of those fluids, the exact volumes returned to the surface over time and the rate at which these fluids return from the formation. These fluids will include the chemicals injected (see Table 2), degradation products of those chemicals, and native constituents in the targeted fractured formation (e.g. brines, radium, radon, metals etc.)

Section No. 2 Revision No. 0 September 18, 2011 Page 3 of 70 **Deleted:** if water quality of drinking water resources has been impacted from pad and well construction

Comment [c8]: The methods of accurately measuring produced water volumes and rates has not seen discussed in the current version of this locument
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Comment [c9]: Radium and radon are listed in secondary objective 3 analytes but are not listed in the primary objective It is recommended they are included in both for comparative purposes

Comment [c10]: As experience has shown, multiple samplings of surface water and groundwater is needed to define the variability of parameter constituents, which will vary depending on climatic conditions, sampling methodology, sample collection depth, and laboratory variability in sample results Suggest at least 3 baseline samplings be conducted at a minimum to define the water-quality variability

Comment [c11]: All analytes and methods should be consistent for baseline and non-baseline sampling

Comment [c12]: The number of sampling events between key phases of the gas well development should be indentified

Comment [c13]: All analytes to be investigated in produced fluids should be investigated during baseline sampling For example, radon is not included in baseline analytes Additional analytes that may be considered useful are gross alpha, gross beta, Ra 226/228

Secondary objective 4 will determine if these same drinking water resources have been impacted following well completion or hydraulic fracturing activities. The target parameters listed above in paragraph 1 will be needed to address this objective.

Secondary objective 5 will allow for the evaluation of best management practices by industry regarding on-site management and ultimate disposal of wastewaters from hydraulic fracturing operations.

The data collected from this case study will be incorporated into the larger Hydraulic Fracturing report to Congress. It is also anticipated that this data will be utilized in EPA reports, conference proceedings and journal articles. In addition, the data collected in this case study may be used by policy and decision makers in EPA and state regulatory agencies.

A proposed schedule for field activities is provided in Table 3.

1.4 Project Quality Objectives and Criteria

As part of this case study, detailed site history has been collected and is continuing to be collected. This data has been collected from Chesapeake and other sources of public information. The site history will be used to determine the background conditions at the site as well as the potential for other activities in the area to be a potential source of the impact to the local aquifer. Natural sources of contaminants or other human activities could potentially create sample bias and effect the conclusions of the study.

The installed monitoring well network and domestic water well surrounding the proposed pad and conducting groundwater sampling, soil sampling and surface water sampling should yield a representative data set that will be analyzed to determine if significant changes were observed in the media baseline characteristics, and if these changes could be attributed to the gas well development. To date EPA has received limited information on the hydrologic conditions near the proposed well pad During the initial and subsequent sampling events water level measurements will be taken in order to address the hydrologic setting, flow direction and velocity

Other project quality objectives, such as precision, accuracy, sensitivity, and etc. will be discussed primarily in sections 2, 3, and 4.

1.5 Special Training/Certification

A current HAZWOPER certification is required for on-site work. HAZWOPER training and yearly refresher training is provided to GWERD personnel at an appropriate training facility chosen by GWERD SHEMP (Safety, Health, and Environmental Management Program) manager. The HAZWOPER certificate and wallet card is provided to each person completing

Section No. 2 Revision No. 0 September 18, 2011 Page 4 of 70 Comment [c14]: The evaluation of industry practices requires, in our opinion, industry experience. It is recommended EPA considers including a team member from the EPA with this type of experience

Comment [c15]: Chesapeake would appreciate the opportunity to be included in the production and review of these reports We request that we discuss our role up front

Comment [c16]: Any potential sources of contamination should be identified before the project proceeds A EDR/Phase I data review should be used to identify any potential sources such as USTs, landfills, spills along the rairoad easement, salt storage yards, septic tanks, sewer lines, stormwater lines, etc within a 3-mile radius of the site

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Comment [C17]: Data collection may not be conducted long enough to represent seasonal variations

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Comment [c18]: There has been no discussion of geophysical work, and associated QA requirements, that is plan as part of the study

Comment [c19]: Consider using water-quality trolls such as Specific Conductivity and water level recording trolls to use in-situ in select wells in an area to provide pre-drill baseline data—continuous water-level and water quality data—this is a cheap way of collecting data. Same on streams in area Need good baseline data that defines variability in sampling, which can be significant, especially for some metals such as iron and manganese

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the training. All EPA contractor personnel will also be required to have HAZWOPER training and up-to-date training certificates. In addition to HAZWOPER training, Chesapeake is requiring that all field personnel undergo hydrogen sulfide training. This training will be provided by Chesapeake.

The laboratories performing critical analyses in support of this case study must demonstrate their competency in the fields of analyses to be conducted, prior to performing such analyses. Competency may be demonstrated through documentation of certification/accreditation or some other means as determined to be acceptable by project participants. The EPA GP laboratory and the Shaw laboratories, the on-site contractor laboratory at **RSKERC**, will be used to analyze select critical analytes listed in Table 1. These laboratories have demonstrated competency through the implementation of ORD PPM 13.4, *Minimum QA/QC Practices for ORD Laboratories Conducting Research* which includes external independent assessments. These laboratories are also routinely subjected to internal laboratory assessments and performance evaluation (PE) samples.

The USEPA Region VIII Laboratory will be used to analyze those critical analytes listed in Table 1. This laboratory has been subjected to the National Environmental Laboratory Accreditation Program (NELAP) accreditation process through the state of Texas and is expected to soon be granted approval

The Region III Laboratory will be used to analyze glycols, which is not identified as critical at this time. However, it is accredited under the NELAP through the state of New Jersey as the Accrediting Body. The particular method being used by Region III for these analyses are not accredited, but the laboratory follows all the requirements for an accredited method. However, initial data reported from the glycol analysis will be flagged as "screening" data from a method that is currently being developed. Once the data is validated, it will no longer be flagged as "screening" data.

1.6 Documents and Records

Data reports will be provided electronically as Excel spreadsheets. Shaw's raw data is kept onsite at the GWERD and will be provided on CD/DVD to Dr. Puls. Raw data for sub-contracted laboratories shall be included with the data reports. Calibration and QC data and results shall be included. Field notebooks will be kept as well as customized data entry forms if needed.

Records and documents expected to be produced include: field data, chain-of-custody (COC), QA audit reports for field and laboratory activities, data reports, raw data, calibration data, QC data, interim reports, and a final report.

All field and laboratory documentation shall provide enough detail to allow for reconstruction of events. Documentation practices shall adhere to ORD PPM 13.2, "Paper Laboratory Records."

Section No. 2 Revision No. 0 September 18, 2011 Page 5 of 70 Deleted:

Comment [c20]: The laboratory should also be a certified or accredited lab in Louisiana for drinking water-quality testing, since the objective is drinking water quality

Comment [c21]: CHK would recommend that the lab receives accreditation prior to participating in the study In addition, since the project is located in LA, the lab should be accredited and meet this state's requirements Only acceptable EPA test methods should be used

Comment [C22]: EPA Region III Laboratory needs to provide a detailed comparison of the result of their method and a more accepted method to provide documentation that the analytical method is adequate CHK requests a copy of all nonpromulgated EPA method

Comment [c23]: CHK is operating under the assumption that EPA will make all data associate with the Haynesville site available on an FTP website in a timely manner

Since this is a QA Category 1 project, all project records require permanent retention per Agency Records Schedule 501, *Applied and Directed Scientific Research*. They shall be stored in Dr. Puls's office in the GWERD until they are transferred to GWERD's Records Storage Room. At an as yet to be determined time in the future the records will be transferred to a National Archive facility.

2.0 Data Generation and Acquisition

2.1 Sampling Process Design (Experimental Design)

First sampling events in 2011 will include soils, surface water and ground water samples only. Flowback and produced water will be sampled after hydraulically fracturing the well in 2012. The QAPP will be revised as appropriate following these events and prior to succeeding sampling events.

2.1.1 Background Geologic and Hydrological Information

Geology

Surface exposures consist of Pleistocene and Holocene sediment. Sandy, gravelly and muddy alluvium from rivers and coastal marsh deposits make up the Holocene while terraces of glacial sand, gravel and mud deposits from the North make up the Pleistocene. Underlying the Pleistocene units are the units of the Eocene and Paleocene. Two formations from these periods that are of note are Claiborne group and the underlying Wilcox group. These groups are composed primarily of sandstones and are an important aquifer in Louisiana and Texas. This aquifer will be discussed in greater detail below. Underlying the Wilcox formation is the Midway formation which is a confining layer composed of clays. Underlying this are Upper Cretaceous formations which contain marl, chalk, limestone and shale and some groups which are known for hydrocarbon production in the area. These units, in order from top down are the Navarro, Taylor, Austin, Eagle Ford, Tuscaloosa and the top of the Washita. The Lower Cretaceous is composed of the limestone, chalk, marl, shales and sandstones of the Washita-Fredericksburg and Trinity Groups. Underlying the Lower Cretaceous is the Upper Jurassic which contains the Cotton Valley Group's shallow marine shales. The Haynesville Formation lies below the Cotton Valley group and is a hydrocarbon producing black shale and the equivalent of the Lower Bossier Formation in Texas. Underlying the Haynesville is the calcareous shelf/reef/lagoon formations of the Smackover limestone which is underlain by the Norphlet mudstone. The Louann Salt and Werner red shale and sandstone formations are located underneath the Norphlet mudstone. The underlying Upper Triassic contains the thick red beds of the Eagle Mills Group which are above the undifferentiated rock of the Paleozoic (LAGS 2008 and AKGS).

Desoto Parish

Section No. 2 Revision No. 0 September 18, 2011 Page 6 of 70 **Comment [c24]:** In order to ensure direct comparison, parameters analyzed in post activities and flowback should be the same as baseline

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Desoto Parish is located in the northwestern region of Louisiana in a geologically significant area called the Sabine Uplift. The Sabine Uplift area was created as a result of the combination of the rifting events which created the Gulf of Mexico and shearing forces resulting from tectonics in North America. These same forces are the cause of multiple salt domes that occur in the county. While the stratigraphic sequence is the same in the county as the rest of the state, the Jurassic age formations of the Haynesville and Bossier shales are of note as both are well-known as hydrocarbon producers. The Bossier Shale is dark, calcareous, fossiliferous marine shale in sequence with sandstone that is determined to be the source rock for the gas accumulation in upper formations. The Haynesville Shale is a carbonaceous, ultra-low permeability/high porosity black shale below the Bossier Shale with the thin Gilmer Lime separating the two formations (LAGS 2008 and AKGS).

Hydrology

The Carrizo-Wilcox is an Eocene and Paleocene age aquifer and is comprised of hydraulically connected, well sorted, fine to medium grained, cross bedded sands and silts from the Wilcox Group and the Carrizo Formation of the Claiborne Group (Ashworth and Hopkins, 1995). The origins of the sands which compose the Carrizo-Wilcox are both fluvial and fluvial-deltaic in origin. The Carrizo-Wilcox aquifer extends across Texas from the Rio Grande in the southwest to Red River the northeast including Desoto Parish in Louisiana. The aquifer is bounded at its base by the confining clays of the Midway group and is overlain by the confining clays and silty clays of Cane River formation. The aquifer has a down-dip trend to the south which is the primary factor in ground water flow direction. Brackish water found in the aquifer is most likely the result of dissolution of salt domes found in the area and most likely also plays a role in the direction of groundwater flow because density differences. Water also moves between overlying alluvial and terrace aquifers, the Sparta aquifer, and the Carrizo-Wilcox aquifer, according to hydraulic head differences and in some places artesian pressures within the aquifer were originally sufficient to drive water above ground. Water level fluctuations are mostly seasonal, and the hydraulic conductivity varies between 2 and 40ft./day. Primary recharge of the Carrizo-Wilcox aquifer occurs from direct infiltration of rainfall in upland outcrop-subcrop areas. Maximum depths of occurrence of freshwater in the Carrizo-Wilcox range from 200ft. above sea level to 1,100ft. below sea level. Based on well completion records from the Bankston 28-14-15H well in Desoto Parish, the base of the Carrizo-Wilcox aquifer appears to be greater than 1,000 feet deep near the study location. The range of thickness of the fresh water interval in the aquifer is 50 to 850ft. Depths of drinking water wells in the immediate vicinity of the site range from 70ft. to 566ft. below ground surface. Analysis of the quality of the water from the Carrizo-Wilcox aquifer shows it to be soft and of good quality with an average pH of 8.31, total dissolved solids (TDS) of 0.48 g/L, a salinity of 0.36 ppt and chloride content of 66.4 mg/L. Further information about the water quality from the Carrizo-Wilcox can be found in Table 4 (LDEQ 2009).

Section No. 2 Revision No. 0 September 18, 2011 Page 7 of 70 Comment [c25]: Addition resources are available regarding the groundwater and surface water quality This information should be complied and tabulated Examples include USGS NWIS and NURE sites

2.1.2 Ground-Water Monitoring

Groundwater sampling and analysis will provide data that can be used to identify changes in water quality and investigate if these changes have potentially been caused by the introduction of drilling fluids, hydraulic fracturing fluids, and formation fluids and gases to underground sources of drinking water. This sampling will aid in the understanding of the potential chemicals constituents that could contaminate shallow ground water as well as the potential future impacts to shallow groundwater that may occur as the result of the transport of contaminants to the site. The groundwater sampling component of this project is intended to provide a survey of water quality in the area of investigation throughout the key phases of the gas well development; prepad construction to approximately one year after initial gas production. Location, distribution, and number of sampling sites can affect the quality and applicability of the resulting data (USGS, 2010). Therefore, the following criteria may be used to determine groundwater water sampling locations: study objectives and sampling methods; all available historical information; physical characteristics of the area, such as size and shape, land use, geology, point and nonpoint sources of contamination, hydraulic conditions, climate, water depth; chemical characteristics of the area; and the types of equipment that will be needed for sampling (USGS, 2010). GWERD, EPA R6, LADEQ, and Chesapeake will survey the existing data and potentially speak to landowners near the proposed pad to determine if ground water wells in the area could be sampled for the study. The domestic well(s), will be sampled via homeowner taps. It is believed that most domestic wells are screened in the surficial aquifer between 100 and 500 ft below ground surface. Similarly, the water supply wells will be sampled similar to the domestic wells. It is anticipated that the monitoring wells will be necessary and sampled quarterly by EPA over a period of 1.5 years. The minimum number of sampling events to determine if an impact to the aquifer happened is estimated to be three sampling events.

It is estimated that up to 18 monitoring wells will be installed to monitor groundwater quality near the study location. Monitoring wells will be clustered, with a shallow, intermediate and deep monitoring well to monitor the full thickness of the aquifer (see Table 5). Where appropriate and based on well screen depths, a domestic supply well may be substituted for one of the monitoring wells. Proposed monitoring well locations will include:

- A well cluster upgradient of the drilling location;
- Two shallow monitoring wells immediately down gradient of the well pad;
- Two complete well clusters on either side of the lateral approximately ½ to ¾ of a mile south of the drilling location; and
- Three complete well clusters approximately ¼ of a mile south of the end of the lateral. These clusters will be oriented east to west with approximately ½ mile spacing between clusters.

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Comment [c26]: The list of analytes should be the chemical constituents that could potentially contaminate ground water The data will aid in determining <u>IF</u> there has been a contamination

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Comment [c27]: If there is a treatment system in place, sampling needs to take place before the treatment system Not all systems have a tap provided prior to the treatment system. How will sampling be conducted in that event?

Comment [c28]: Experience has shown that depending on the use of a domestic water well by the landowner before sampling, the baseline results can vary widely Heavy use before baseline sampling event affects the sampling results different than samples collected from a well with no prior domestic use before baseline sampling Information on the landowner pump setting is also very important, along with accurate records on well construction, Much of these data will not be available unless a downhole survey is done in each water well Multiple sampling are required under differing pumping conditions to define the variability in analytical results during baseline sampling

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The study area and proposed locations of monitoring wells as well as existing water supply and gas wells is illustrated in Figure 3

2.1.3 Surface Water Sampling

Surface water sampling and analysis will provide data that can be used to identify changes in water quality and investigate if these changes have potentially been caused by the introduction of drilling fluids, hydraulic fracturing fluids, and formation fluids and gases to surface water sources of drinking water. This sampling will aid in the understanding of the potential chemicals constituents that could contaminate surface water that may occur as the result of the transport of contaminants to the site.

There are several ways in which surface water quality could be impacted as the result of hydraulic fracturing. One possible mechanism is the direct contamination caused by the spillage of drilling, hydraulic fracturing, or formation fluids into the surface water body. In addition, runoff and or subsurface transport of drilling, hydraulic fracturing, or formation fluid through the soil could cause impacts to surface water.

Each surface water location has a unique set of conditions that needs to be identified and considered in the sample selection process. Therefore, it is important that sample locations accurately represent the intended conditions (such as time of year and flow rate or stage) of the aqueous system being studied with respect to study objectives. In most bodies of flowing or still water, a single sampling site or point is not adequate to describe the physical properties and the distribution and abundance of chemical constituents. Location, distribution, and number of sampling sites can affect the quality and applicability of the resulting data (USGS, 2010). Therefore, the following criteria may be used to determine surface water sampling locations: study objectives and sampling methods; all available historical information; physical characteristics of the area, such as size and shape, land use, tributary and runoff characteristics, geology, point and nonpoint sources of contamination, hydraulic conditions, climate, water depth, and fluvial-sediment transport characteristics; chemical characteristics of the area; and the types of equipment that will be needed for sampling (USGS, 2010).

Surface water bodies are of two basic types: flowing water bodies (intermittent and perennial flow) and still water bodies (e.g., lakes and ponds). Flowing-water sites can refer to streams (fast or slow, intermittent, ephemeral, or perennial), canals, ditches, and flumes of all sizes and shapes, or to any other surface feature in which water moves unidirectionally (USGS, 2010). Still-water sites refer to all sizes and shapes of lakes, reservoirs, ponds, swamps, marshes, riverine backwaters, or any other body of surface water where water generally does not move unidirectionally (USGS, 2010).

For flowing water the optimal sampling locations is in straight reaches having uniform flow and stable bottom contours; far enough above and below confluences of streamflow or point sources

Section No. 2 Revision No. 0 September 18, 2011 Page 9 of 70 Comment [c29]: The monitoring well network has significantly changed since the QAPP was provide to CHK Therefore, comments will not be provided on this content However, before it is agreed upon the locations of the monitoring wells, the local geology and flow direction must be understood and defined Geophysical techniques should be used to understand the local hydrogeology In addition, potential sources of contamination should be well understood prior to sitting monitoring wells CHK is against having monitoring wells on the pad location

Comment [C30]: Consider using continuous recording sondes for basic water quality parameters for baseline characterization, and during monitoring With periodic sampling for more comprehensive analytical list per seasonal or local flow conditions high flow vs low flow, consider if base flow occurs in stream and its affect on local gw quality

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Comment [c31]: It is understood from this statement that only drinking water sources will be investigated

Comment [c32]: The list of analytes should be the chemical constituents that could potentially contaminate ground water. The data will aid in determining **IF** there has been a contamination

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Comment [C33]: It appears the study has not been limited to hydraulic fracturing Deleted:)

Comment [c34]: CHK agrees with this paragraph, however, it is not well understood how the study will incorporate these criteria Sampling locations should be prescribed in the QAPP

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of contamination to avoid sampling a cross section where flows are poorly mixed or not unidirectional; and in reaches upstream from bridges or other structures, to avoid contamination from the structure or from a road surface (USGS, 2010). Similarly, for still water sampling sites the optimal locations should avoid areas near structures such as harbors, boat ramps, piers, fuel docks, and moored houseboats (to avoid point sources of contamination), unless these structures are part of the study (USGS, 2010).

Baseline water quality will be assessed in order to establish a benchmark for water quality changes that have occurred as the result of drilling and hydraulic fracturing process. The baseline water quality will be collected based on historical data, if available, or upstream of the potentially impacted area.

2.1.4 Flowback/ Produced Water Sampling

Flowback and produced water sampling will be part of the Haynesville Shale prospective study. Flowback/ produced water sampling will identify the specific chemical constituents associated with flowback/ produced water_; understand the potential chemicals constituents that could contaminate surface water, groundwater and soil; and provide information to understand how flowback produced water affects water treatment and disposal.

In general, several frac tanks are connected in-line and filled simultaneously with the flow back water. This is completed to avoid back pressure when shutting one frac tank and opening another tank for additional capacity. This filling process will provide a composite sample of the flow back water over time. To minimize volatilization, a representative composite sample of the flow back water samples will be collected from the top of a frac tank or flow back impoundment (Hayes 2009).

The <u>produced</u> water <u>will be flowed back</u> into frac tanks for storage until the water is disposed of properly. When frac tanks are used the sample will be collected by pumping the sample from the frac tank using a peristaltic pump.

A baseline fracturing fluid sample will be collected prior to going down hole. The baseline fracturing fluid will be collected from either the sampling lines built into the blenders or as a grab sample from the blending containers. In either case a representative sample of the fluid will be collected.

Fracturing is completed over several days depending on the geological formation. Because the flow back water is under pressure, initially the flowback water is recovered at a faster rate in the beginning of fracturing and significantly declines as fracturing continues and the well is released to production. The initial concentrations at the start of fracturing (high yields of flow back water) should yield lower concentrations of naturally occurring chemicals. It is assumed that the concentration of the fracturing chemicals remain constant throughout the flow back regardless of the rate of return. However, the increase concentration of naturally occurring chemicals is due to

Section No. 2 Revision No. 0 September 18, 2011 Page 10 of 70 Deleted:)

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Comment [c35]: Baseline downstream information should be collected as well Deleted: , if any

Comment [c36]: Based on CHK's experience, these sampling locations will not results in representative samples for produced formation water Frac tanks are not certified clean or empty when brought to location Sampling needs to occur prior to placement in tanks If sampling must be done from tanks then each tank on site will need to be sampled for all COCs prior to filling with any flowback water The flowback water will stratify chemically due to density, so should use sampling methods that will collect a representative sample over its full depth, if collecting from a tank Better to collect before the tankage, if possible Recommend special manifold/valves to be installed/operated by service company personnel who will collect sample in clean buckets

Comment [C37]: Recommend collecting sample directly from valve on line instead of at the tank Needs special personal to accomplish, but closer any sample is to the source, the more representative it will be at source

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Comment [c38]: CHK does not use surface impoundments to store produced water onsite

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Comment [C39]: Recommend sampling prior to sand addition and conducting time series samples

Comment [c40]: Assumption may not be necessarily true

a longer residence time in the applicable formation and the potential release of naturally occurring chemicals caused by geochemical process and physical changes brought about by the fracturing process. Therefore, to obtain representative samples of the flow back water, samples will be collected on 5 separate days. The data obtained beyond day 15 should represent the chemical characteristics of the produced water.

2.1.5 Soil Sampling

Soil sampling will be part of the monitoring utilized in the prospective case study. Soil sampling and analysis will provide data that can be used to identify changes in soil characteristics and investigate if these changes have potentially been caused by the transport and release of contaminants during the <u>development</u> process. Not only can soils potentially act as a sink for the contaminants in the environment but, soils could also serve as a source of contaminants to surface water and shallow groundwater through their gradual release back into surface water and shallow groundwater. Therefore, it is important to investigate <u>if there is an</u> accumulation of contaminants in soil as the result of hydraulic fracturing understand the potential chemicals constituents that could contaminate drinking water; and provide information to understand the <u>risk (frequency and magnitude) to</u> drinking water impacts resulting from hydraulic fracturing

Baseline soil samples will be assessed in order to establish a benchmark for impacts to soil that have occurred as the result of drilling and hydraulic fracturing processes. The baseline soil samples will be collected in and around where the pad will be constructed. NRMRL-Ada and ??? will survey the area and speak to stakeholders in Keatchie to determine the location of sampling points. It is anticipated that the soils will be sampled prior to pad and well construction and again (at the same locations) following the hydraulic fracturing of the well. The latitude and longitude of the sampling locations will be recorded so that the locations can be consistently sampled throughout the study.

In the area in and surrounding the proposed drilling pad, composite surface soil samples will be collected using a predetermined sampling grid. Figure 4 shows the proposed sampling locations. Each composite sample will be representative of approximately a 200 square foot area as shown in Figure 4. Additionally, soil samples will be collected using geoprobe sampling techniques, from the soil water interface at two locations within the pad boundaries, two locations immediately topographically down gradient of the drill pad, and one sample upgradient of the pad. Proposed geoprobe sampling locations are also shown in Figure 4.

2.2 Sampling Methods

2.2.1 Installation of Monitoring Wells

Section No. 2 Revision No. 0 September 18, 2011 Page 11 of 70 **Comment [c41]:** Based on CHK's experience in the Haynesville this is not long enough for the produced water to reach a stable concentration Need to sample out to at least 45 days following stimulation and perhaps out as far as 90 days Need to sample until TDS and chloride stabilize in two successive samplings

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Comment [c42]: This study does not appear to be limited to hydraulic fracturing

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Comment [C43]: It is recommend other potential sources of contamination are identified and tested

Comment [C44]: A sub-meter GPS should be used for all sample locations

Comment [c45]: Suggest we do an EM-38 survey of the well pad area first (the pad and a 100 foot buffer surrounding the pad footprint), then use those results in conjunction with the soil types to collect representative baseline samples with depth and soil type/horizon The baseline EM survey can be repeated adjacent to the pad once completed The EM-38 is an extremely sensitive tool to changes in the conductivity of soils caused by fluid releases containing salts or brines

Comment [c46]: Do the EM-38 first, then can grid based upon those results

Comment [c47]: No sample depth noted or depth criteria listed Must consider soil types in area, and collect samples relative to soil types and horizons, this is very important to understand and must be considered to get accurate and representative data

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Comment [c48]: Should consider groundwater flow before selecting locations The local geology and hydrogeology should be reviewed and de[...[3]

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The monitoring well design and construction ... [4]

The monitoring wells will be constructed using 2 in PVC casing and slotted PVC screens. The screen intervals in the monitoring wells will be based on information generated as part of site background data. The annular space between the borehole wall and the well screen will backfilled with 10-20 silica sand, usually to two feet above and below the screened interval. The remaining annular space above the sand pack will be sealed with a 3 to 5 foot bentonite pellet seal followed by a bentonite cement grout to within 5 feet below ground surface. The wells are then completed at the surface by concreting a lockable stick-up protective monitoring well cover. The designated measuring point and elevation datum at each monitoring well is defined as the ground surface immediately adjacent to the surficial concrete pad to the north and the top of the inner PVC well casing on the north side. These points will be surveyed in the horizontal and vertical positions of the monitoring wells.

The installed wells will be developed by the driller and/or the EPA contractor (E & E)...

2.2.2 Ground-Water Monitoring

2.2.2.1 Monitoring Wells

EPA Region 3 low flow sampling procedures will be used to sample the wells as described below:

- Water level measurements will be taken prior to and during the pumping of the wells. The water level measurements will follow the RSKSOP-326 standard operating procedure. Water levels will be recorded in the field notebook prior to sampling.
- 2) A new piece of tubing will be connected to the sampling port of the well and the dedicated pump will be powered on. It is expected that the pump will yield a maximum initial flow rate of approximately 1 L min⁻¹). This flow will pass through a flow cell equipped with an YSI 5600 multiparameter probe (or equivalent probes). The rate of pumping will be determined by measuring the water volume collected after approximately 15 seconds into a 4 L graduated cylinder; the desirable pumping rate through the flow cell should be less than 1 L/min. The pumping rate will ideally maintain minimal drawdown. Water levels will be taken following sampling to confirm the drawdown caused by pumping.
- 3) The YSI probe (or equivalent probes and electrodes) will be used to track the stabilization of pH, oxidation-reduction potential (ORP), specific conductance (SC), dissolved oxygen (DO), and temperature. In general, the guidelines in Table 6 will be used to determine when parameters have stabilized. These criteria are initial guidelines; professional judgment in the field will be used to determine on a well-by-well basis when stabilization occurs.

Section No. 2 Revision No. 0 September 18, 2011 Page 12 of 70 Comment [c50]: Recommend 3 feet

Comment [c51]: Recommend 6% by weight, use pure-gold bentonite, neutral pH

Comment [c52]: The required accuracy of survey should be defined as horizontal 1 foot, vertical to 0 01 or 0 1 foot

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Comment [c53]: The contractors experience needs to be vetted for drilling deep wells, along with the contractors experience CHK should be involved in this process

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Comment [c54]: Methane should be baseline sampled in monitoring wells If methane is present, isotopic analysis should be preformed

Comment [c55]: Consider installing trolls in select wells to monitor water levels long term and in getting a baseline

Comment [c56]: Low flow techniques require monitoring of water levels during pumping

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Comment [c57]: The type of pump should be specified

Comment [c58]: Measurement must be taken during the actual sampling, not just afterwards A warning, in a stratified environment, low flow purging will not result in representative samples

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Comment [c59]: The frequency of recording should be specified

- Once stabilization occurs, the final values for pH, ORP, specific conductance, dissolved oxygen, and temperature will be recorded.
- After the values for pH, ORP, SC, DO, and temperature have been recorded, the flow cell will be disconnected. A series of unfiltered samples will be collected as follows:
 - a. Duplicate 40 mL VOA vials (amber glass) will be collected, without headspace, for VOC analysis using RSKSOP-299v1. Tribasic Sodium Phosphate (TSP) will be added to the VOA vial prior to shipping to the field for sampling as a preservative. (Acid will not be used as a preservative due to a concern of acid hydrolysis of some analytes.) The samples will be stored and shipped on ice to Shaw, NRMRL-Ada's on-site contractor for GC-MS analysis.
 - b. Duplicate 60 mL serum bottles will be collected, without headspace, for dissolved gas analysis (e.g., hydrogen, carbon dioxide, ethane, methane, butane, propane). The bottles will contain trisodium phosphate as a preservative and will be filled with no head space and sealed with a crimp cap. The samples will be stored and shipped on ice to Shaw, NRMRL-Ada's on-site contractor for analysis.
 - c. Duplicate 1 L amber glass bottles will be collected for semi-volatile organic compounds. These samples will be stored and shipped on ice to EPA Region VIII Laboratory for analysis.
 - d. Duplicate 1L amber glass bottles will be collected for diesel range organic (DRO) analysis. These samples will be preserved with HCl, pH <2, and shipped on ice to EPA Region VIII Laboratory for analysis.</p>
 - e. Duplicate 40 mL amber VOA vials will be collected without headspace for gasoline range organic analysis (GRO). These samples will be preserved with HCl, pH <2, and shipped on ice to EPA Region VIII Laboratory for analysis.</p>
 - f. Duplicate 40 mL amber VOA vials will be collected for glycol analysis. These samples will be stored and shipped on ice to EPA Region III Laboratory for analysis.
 - g. Duplicate 40 mL glass VOA vials will be collected for low molecular weight acids using RSKSOP-112v6. Tribasic Sodium Phosphate (TSP) will be added to the VOA vial prior to shipping to the field for sampling as a preservative. The samples will be stored and shipped on ice to Shaw, NRMRL-Ada's on-site contractor for GC-MS analysis.
 - h. A 1-liter plastic beaker will be filled for selected analyses to be conducted in the field. Field measurements will consist of turbidity, alkalinity, ferrous iron, and dissolved sulfide (Table 7). Turbidity (Standard Method 180.1) will be measured using a

Section No. 2 Revision No. 0 September 18, 2011 Page 13 of 70 Comment [c60]: It is recommended to record turbidity also because it is a must to be able to understand metals data later on Collect dissolved samples if turbidity is over 5 to 10 NTU Deleted:

Comment [c61]: Method is equivalent to SW846 method 8260B While TSP is an acceptable preservative, it should not be used if brominated compounds are of critical interest due to possible degradation in the analytical process Suggest either both HCL and TSP vials be collected (for brominated compounds) or no preservation and a 7

day holding time

HACH 2100Q portable turbidimeter (or equivalent instrument). Alkalinity will be measured by titrating ground water with 1.6N H₂SO₄ to the bromcresol green-methyl red endpoint using a HACH titrator (HACH method 8203, equivalent to Standard Method 2320B for alkalinity). Ferrous iron will be measured using the 1,10phenanthroline colorimetric method (HACH DR/2010 spectrometer, HACH method 8146, equivalent to Standard Method 3500-Fe B for wastewater). Dissolved sulfide will be measured using the methylene blue colorimetric method (HACH DR/2010 spectrometer; HACH method 8131, equivalent to Standard Method 4500-S²⁻ D for wastewater).

- 6) After the unfiltered samples have been collected a high-capacity cartridge ground-water filter (0.45µm, Pall Corporation, or equivalent manufacturer) will be placed on the end of the pump tubing and filtered samples will be collected into pre-labeled sample bottles. First, approximately 100 mL of ground water will be filtered and sent to waste and next the following series of samples will be collected:
 - a. 125 mL plastic bottle for metals analysis by ICP-OES for Al, Ag, As, B, Be, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Sr, Ti, Tl, V, Zn, Si, and S; this sample will also be used for ICP-MS analysis for Cd, Cr, As, Cu, Pb, Ni, Se, Hg, and Tl. This sample will be filtered and preserved by adding 5 drops of concentrated HNO₃ (pH test strips will be used to confirm that the sample pH is <2). Test strips for pH will be used on every sample to insure that a proper preservation pH is attained. This is especially important in case high alkalinity samples are encountered during the ground-water sampling. The samples will be stored and shipped on ice to Shaw, NRMRL-Ada's on-site contractor for analysis.</p>
 - b. One 60 mL clear plastic bottle for CE (capillary electrophoresis) sulfate, chloride, bromide and fluoride. This sample will be filtered, no preservative added. The samples will be stored and shipped on ice to the RSKERC general parameters lab.
 - c. One 60 mL clear plastic bottle for nitrate + nitrite and ammonium. This sample will be filtered, 2 drops of sulfuric acid added as preservative (pH test strips will be used to confirm that the sample pH is <2; see note above regarding use of pH test strips). The samples will be stored and shipped on ice to the RSKERC general parameters lab.</p>
 - d. Duplicate 40 mL glass VOA vial in duplicate for analysis of dissolved inorganic carbon (DIC). This sample will be filtered, no preservative added. The samples will be stored and shipped on ice to the RSKERC general parameters lab.

Comment [c62]: Field tests for alkalinity and dissolved sulfide particularly may be suitable for baseline samples but not for flow back samples High salt and dissolved solids content and matrix color interferences will make these Hach colorimetric method unsuitable with the more complex matrices Suggest consistent with all matrices using fixed based lab methods for these analyses

Comment [c63]: What about the other field parameters, going to use the flow cell values, or collect the actual water from the actual time of sampling for these parameters?

Comment [c64]: Measure turbidity of filtered sample in field and record in log book to insure and document did not have sediment breakthrough in filters

Comment [c65]: There are more analytes listed here than appear in the Methods tables

Comment [c66]: Add carbonate and bicarbonate and turbidity, and TSS to insure no sediment was in sample analysed for dissolved cations and metals

Comment [c67]: Are the pH test strip contaminant free, need to see documentation on this

Comment [C68]: Suggest we also test for organic nitrogen or TKN, useful in evaluating septic impacts

Comment [c69]: It is not understood why and how this parameter will be used in the EPA study

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e. Duplicate 40 mL glass VOA vial in duplicate for analysis of dissolved organic carbon (DOC). This sample will be filtered, phosphoric acid added to pH<2. A duplicate set of 40 mL VOA vials will be collected without preservation in case acid preservation interferes with the analysis or primary instrument is unavailable. VOA vials will indicate if preservative was added. The samples will be stored and shipped on ice to the RSKERC general parameters lab.</p>

See Tables 8 and 9 for numbers of sample bottles needed for each sample type and field QC samples for ground and surface water sampling.

2.2.2.2 Domestic wells, water supply wells, and municipal supply wells

Domestic wells will be sampled directly from the tap or where possible, by accessing the well directly using pumps lowered down the well casing. If a pump is used, the well will be purging with the down-hole pump lowered to the water intake location within the well casing. Whenever possible, drawdown of the water table will be tracked by taking water level measurements every 10 to 15 minutes during well purging. The water level measurements will follow the RSKSOP-326 standard operating procedure. Water levels will be recorded in a field notebook during purging prior to sampling.

1. At each sampling site, GPS coordinates will be collected with a handheld device. Photos will be taken and stamped with the date. Pertinent information about well will be recorded where possible (e.g., depth, well diameter, configuration, etc.). The ground-water level will next be measured using a Solinst water level indicator (or equivalent) and recorded. In cases where a remote pump can be used, the pump will be hooked up with new polyethylene tubing. Tubing will be changed in between each well and the pump will be rinsed with distilled water. The pump (Proactive Hurricane or equivalent) will be lowered down the well casing to a level selected in the field and powered on. In most cases, well construction details will not be available. The goal in domestic well sampling is generally to purge sufficient water to access native aquifer water prior to sampling. Professional judgment will be used in the field and consider variables such as water volume pumped, water level drawdown, and stabilization of geochemical parameters. In all cases, the water volume pumped will be tracked by recording time and purge rate. It is expected that the pump will yield an initial flow rate of approximately 1-2 L/min. This flow will pass through a flow cell equipped with a YSI 5600 multiparameter probe (or equivalent probes). The rate of pumping will be determined by measuring the water volume collected after approximately 15 seconds into a 4 L graduated cylinder; the desirable pumping rate through the flow cell should be less than 2 L/min. The pumping rate will ideally maintain minimal drawdown. Draw down will be monitored by measuring the water level (where possible) approximately every 10 to 15 minutes.

Section No. 2 Revision No. 0 September 18, 2011 Page 15 of 70 Comment [c70]: It is not understood why and how this parameter will be used in the EPA study

Comment [c71]: Need to define how the intake location will be determined, purging times and volumes, and be aware of any in-home water softeners or other treatment units or filters. It is preferable to collect from before the pressure tank, if possible Use of the well by the landowner in the preceeding 24 hour period must be identified, and experience has shown that use by homeowner can dramatically affect the results, especially heavy use in a low yielding well Must document this prior to sampling

Comment [c72]: Also take field indicator parameter reading to insure stabilization of parameters before sampling

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Comment [c73]: Sub-meter unit

Comment [c74]: The homeowner should be interviewed and questions about historical water quality issues Often they are knowledgeable about iron or Mn staining of sinks, scale buildup, odors, salty tasting water, turbidity issues, yield issues This very important, as landowners often knows of water quality problems with their own water wells and this can be documented during baseline interviews Also interview landowner about their well construction, depth, when drilled, driller, etc

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Comment [c75]: Purging too much can result in excessive turbidity and higher than normal metals concentrations in the samples The purge volume needs to be recorded as does the homeowner's recent use history, e g did a load of laundry in the last hour, etc

- 2. The YSI probe (or equivalent probes and electrodes) will be used to track the stabilization of pH, oxidation-reduction potential (ORP), specific conductance (SC), dissolved oxygen (DO), and temperature. In general, the following guidelines in Table 6 will be used to determine when parameters have stabilized. These criteria are initial guidelines; professional judgment in the field will be used to determine on a well-by-well basis when stabilization occurs.
- 3. Once stabilization occurs, the final values for pH, ORP, specific conductance, dissolved oxygen, and temperature will be recorded. For these well types it will be assumed that once stabilization occurs that the samples collected will be water from the formation and not water entrained in the well bore.
- After the values for pH, ORP, SC, DO, and temperature have been recorded, the flow cell will be disconnected. A series of unfiltered samples and filtered samples will be collected as in section 2.2.1.1 number 5.

See Tables 8 and 9 for numbers of sample bottles needed for each sample type and field QC samples for ground and surface water sampling.

2.2.3 Surface Water Sampling

Methods will be provided if there is a surface water body present that can serve as a source of drinking water.

2.2.4 Flowback/Produced water Sampling

2.2.4.1 Collection of Flowback/ Produced Water- Peristaltic Pump

A weighted sample tubing will be placed in the frac tank near the bottom, but high enough from the bottom of the tank as to not collect sediment that may have accumulated in the bottom of the tank. Alternatively, in a surface impoundment the sample tubing will be suspended in the water column but far enough from the bottom again as not to collect any sediment that may have accumulated on the bottom of the surface impoundment. The exact depth at which the sample will be collected will depend on the volume of fluid in the tank or surface impoundment at the time of sampling and cannot be determined at this time. The tubing will be connected to the peristaltic pump to collect the flowback or produced water sample. The sample tubing will be replaced after each sampling and multiple sample tubing will be used in the advent of multiple frac tanks or surface impoundments.

The following methodology will be used for the flowback/ produced water sampling.

1) The peristaltic pump will be powered on. The rate of pumping will be determined by measuring the water volume collected after approximately 15 seconds into a 4 L

Section No. 2 Revision No. 0 September 18, 2011 Page 16 of 70 Comment [c76]: The frequency of recording should be specified

Comment [c78]: It is CHK understand that only

drinking water sources will be investigated

Comment [C77]: Measure turbidity of filtered sample in field and record in log book to insure and document did not have sediment breakthrough in

filters

Comment [c79]: CHK has developed and will provide SOPs for collection of produced formation water See provided SOPs for recommended method for sampling produced water

graduated cylinder; the desirable pumping rate through the flow cell should be less than 2 L/min. If the flow rate is greater than 2 L/min the flow rate will be adjusted so that the flow is less than 2 L/min. The sample tubing will then be connected to the flow cell and the flow will be allowed to pass into a flow cell equipped with a pH, ORP, SC, DO, and temperature probes.

- 2) The probes installed in the flow cell will be used to track the stabilization of pH, oxidation-reduction potential (ORP), specific conductance (SC), dissolved oxygen (DO), and temperature. In general, the following guidelines will be used to determine when parameters have stabilized: pH changes <0.02 standard units per minute, ORP changes <2 mV per minute, and specific conductance changes <1% per minute. These criteria are initial guidelines; professional judgment in the field will be used to determine on a well-by-well basis when stabilization occurs.</p>
- Once stabilization occurs, the final values for pH, ORP, specific conductance, dissolved oxygen, and temperature will be recorded.
- After the values for pH, ORP, SC, DO, and temperature have been recorded, the flow cell will be disconnected. A series of unfiltered samples will be collected as follows:
 - a. Triplicate 1 L samples (amber glass) and duplicate 20 mL vials (amber glass) will be collected for the ??? lab. No preservative will be added to these samples for trace organic analyses. The samples will be stored and shipped on ice to the ??? facility for GC-MS analysis.
 - b. Duplicate 60 mL serum bottles will be collected for dissolved gas analysis (e.g., hydrogen, carbon dioxide, ethane, methane, butane, propane). The bottles will contain trisodium phosphate as a preservative and will be filled with no head space and sealed with a crimp cap.
 - c. A 1 L plastic bottle containing a caplet of benzalkonium chloride will be filled and sealed and shipped to Isotech for δ^{13} C of C1-C5 dissolved gases and δ^{2} H of methane.
 - d. A 1-liter plastic beaker will be filled for selected analyses to be conducted in the field. Field measurements will consist of alkalinity, ferrous iron, and dissolved sulfide. Alkalinity will be measured by titrating ground water with 1.6N H₂SO₄ to the bromcresol green-methyl red endpoint using a HACH titrator (HACH method 8203, equivalent to Standard Method 2320B for alkalinity). Ferrous iron will be measured using the 1,10-phenanthroline colorimetric method (HACH DR/2010 spectrometer, HACH method 8146, equivalent to Standard Method 3500-Fe B for wastewater). Dissolved sulfide will be measured using the

Section No. 2 Revision No. 0 September 18, 2011 Page 17 of 70 Comment [c80]: With the exception of temperature, the field parameters pH, ORP, SC, and DO are problematic The high temperature and high salinity of the fluids make getting a stable accurate reading almost impossible Further, the field data is of little utility in interpretation of the data Need turbidity measurement

Comment [c81]: Will be very difficult to achieve, suggest 0 05 or 0 1

Comment [c82]: Suggest 5%

Deleted:

Comment [c83]: turbidity

Comment [c84]: see previous comments regarding bottles and preservation

Comment [c85]: Consider using isobags

Comment [c86]: Should be included in baseline if methane is present

Comment [c87]: HACH methods need to be verified as sufficiently robust against the high levels of chloride and TDS expected in the samples

methylene blue colorimetric method (HACH DR/2010 spectrometer; HACH method 8131, equivalent to Standard Method 4500-S²⁻ D for wastewater).

- f. A summary of QA/QC requirements from SOPs and ground-water sampling details are provided in Tables 9 and 10.
- 5) After the unfiltered samples have been collected filtered samples will be collected. A high-capacity cartridge ground-water filter will be attached to the sample tubing and the sample will be collected into pre-labeled sample bottles. The following series of samples will be collected:
 - a. 125 mL plastic bottle for metals analysis by ICP-OES for Al, Ag, As, B, Be, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Sr, Ti, Tl, V, Zn, Si, and S; this sample will also be used for ICP-MS analysis for Cd, Cr, As, Cu, Pb, Ni, Se, Hg, and Tl, This sample will be filtered and preserved by adding 5 drops of concentrated HNO₃ (pH test strips will be used to confirm that the sample pH is <2). Test strips for pH will be used on every sample to insure that a proper preservation pH is attained. This is especially important in case high alkalinity samples are encountered during the ground-water sampling.</p>
 - b. 30 mL amber plastic bottle for LC-ICP-MS analysis of arsenic speciation. The method of preservation for this sample will depend on the result of the dissolved sulfide measurement (step 4d above). If the dissolved sulfide concentration is <0.1 mg/L, then the sample will be preserved with 2 drops of concentrated hydrochloric acid (pH test strips will be used to confirm that the sample pH is <2; see note above regarding use of pH test strips). If the dissolved sulfide concentration is >0.1 mg/L, then no acid will be added. The sample will be stored and transported on ice.
 - c. 30 mL clear plastic bottle for CE (capillary electrophoresis) sulfate, chloride, and fluoride. This sample will be filtered, no preservative added.
 - d. 30 mL clear plastic bottle for FIA (flow injection analysis) for nitrate + nitrite and ammonium. This sample will be filtered, 2 drops of sulfuric acid added as preservative (pH test strips will be used to confirm that the sample pH is <2; see note above regarding use of pH test strips).</p>
 - e. 30 mL clear plastic bottle for FIA for bromide. Add details.
 - f. 45 mL glass VOA vial in duplicate for analysis of dissolved inorganic carbon (DIC) and dissolved organic carbon (DOC). This sample will be filtered, no preservative added.

Section No. 2 Revision No. 0 September 18, 2011 Page 18 of 70 **Comment [c88]:** See earlier comments on unfiltered sampling Filtered or dissolved analyses should be conducted

Comment [C89]: More analytes listed here than in the methods table Add carbonate and bicarbonate

Comment [C90]: Will be extremely difficult and may not be possible to filter the initial flowback samples due to matrix complexities Deleted:

Comment [c91]: Test strips contaminant free

Comment [C92]: Not sure that the analytical methods is sufficient to handle the high levels of salts expected in the sample Provide rational and intended use of data

Comment [c93]: Capillary electrophesis and flow injection analyses for anions and ammonia may not be robust enough for the high dissolved solids and salt (C1) of flow back or produced waters For consistency would recommend Ion Chromatography as a more robust determination for the complex matrices

- g. 60 mL plastic bottle for analysis of δ¹³C of dissolved inorganic carbon. This sample will be filtered, no preservative added. Samples will be shipped on ice to Isotech Laboratories for isotopic analyses.
- h. 20 mL glass VOA vial for analysis of δ^{18} O and δ^{2} H of water using IRMS. This sample will be filtered, no preservative added.

Unless noted otherwise above, ground-water samples will be submitted to Shaw, NRMRL-Ada's on-site contractor, and the EPA General Parameters (GP) Laboratory, for fixed-laboratory analysis. Specific samples will be delivered to the ??? analytical facility or to Isotech Laboratories for isotopic analyses of dissolved inorganic carbon and dissolved gases.

2.2.4.2 Collection of Flowback/ Produced Water- Bailed Samples

Bailed sample will be collected using a new PVC bailer from the top of the frac tank. The bailer will be lowered into the frac tanks and allowed to sink below the surface of the fluid. Once the bailer is filled it will be brought to the surface and the collected sample will be poured into a large plastic beaker. A portion of this initial sample will be poured into a vessel that will accommodate the pH, ORP, SC, DO, and temperature probes. The probes will be allowed to equilibrate with the collected sample. In general, the following guidelines will be used to determine when parameters have stabilized: pH changes <0.02 standard units per minute, ORP changes <2 mV per minute, and specific conductance changes <1% per minute. These criteria are initial guidelines; professional judgment in the field will be used to determine on a well-by-well basis when stabilization occurs.

- Once stabilization occurs, the final values for pH, ORP, specific conductance, dissolved oxygen, and temperature will be recorded.
- 2) After the values for pH, ORP, SC, DO, and temperature have been recorded, remaining sample will have other field measurements taken. Field measurements will consist of alkalinity, ferrous iron, and dissolved sulfide. Alkalinity will be measured by titrating ground water with 1.6N H₂SO₄ to the bromcresol green-methyl red endpoint using a HACH titrator (HACH method 8203, equivalent to Standard Method 2320B for alkalinity). Ferrous iron will be measured using the 1,10-phenanthroline colorimetric method (HACH DR/2010 spectrometer, HACH method 8146, equivalent to Standard Method 3500-Fe B for wastewater). Dissolved sulfide will be measured using the methylene blue colorimetric method (HACH DR/2010 spectrometer; HACH method 8131, equivalent to Standard Method 4500-S^{2–} D for wastewater).
- An additional 6 L of sample will then be bailed and poured into a large container. This will be split into the following samples:

Section No. 2 Revision No. 0 September 18, 2011 Page 19 of 70 Comment [c94]: Discussion regarding QA/QC samples, duplicates, field blanks, trip blanks, etc should be included

Comment [C95]: Unacceptable collection method See CHK provided SOPs and comments from previous section

Deleted:

- a. Triplicate 1 L samples (amber glass) and duplicate 20 mL vials (amber glass) will be collected for the ??? lab. No preservative will be added to these samples for trace organic analyses. The samples will be stored and shipped on ice to the ??? facility for GC-MS analysis.
- b. Duplicate 60 mL serum bottles will be collected for dissolved gas analysis (e.g., hydrogen, carbon dioxide, ethane, methane, butane, propane). The bottles will contain trisodium phosphate as a preservative and will be filled with no head space and sealed with a crimp cap.
- c. A 1 L plastic bottle containing a caplet of benzalkonium chloride will be filled and sealed and shipped to Isotech for δ^{13} C of C1-C5 dissolved gases and δ^{2} H of methane.
- 4) After the unfiltered samples have been collected a 4 L capacity vessel will be filled up with flowback/produced water. A peristaltic pump will be used pump water from the vessel through teflon-lined polyethylene tubing and through high-capacity ground-water filters into pre-labeled sample bottles. First, approximately 100 mL of ground water will be filtered and sent to waste and next the following series of samples will be collected:
 - a. 125 mL plastic bottle for metals analysis by ICP-OES for Al, Ag, As, B, Be, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Sr, Ti, Tl, V, Zn, Si, and S; this sample will also be used for ICP-MS analysis for Cd, Cr, As, Cu, Pb, Ni, Se, Hg, and Tl. This sample will be filtered and preserved by adding 5 drops of concentrated HNO₃ (pH test strips will be used to confirm that the sample pH is <2). Test strips for pH will be used on every sample to insure that a proper preservation pH is attained. This is especially important in case high alkalinity samples are encountered.
 - b. 30 mL amber plastic bottle for LC-ICP-MS analysis of arsenic speciation. The method of preservation for this sample will depend on the result of the dissolved sulfide measurement (step 2 above). If the dissolved sulfide concentration is <0.1 mg/L, then the sample will be preserved with 2 drops of concentrated hydrochloric acid (pH test strips will be used to confirm that the sample pH is <2; see note above regarding use of pH test strips). If the dissolved sulfide concentration is >0.1 mg/L, then no acid will be added. The sample will be stored and transported on ice.
 - c. 30 mL clear plastic bottle for CE (capillary electrophoresis) sulfate, chloride, and fluoride. This sample will be filtered, no preservative added.

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- d. 30 mL clear plastic bottle for FIA (flow injection analysis) for nitrate + nitrite and ammonium. This sample will be filtered, 2 drops of sulfuric acid added as preservative (pH test strips will be used to confirm that the sample pH is <2; see note above regarding use of pH test strips).</p>
- e. 30 mL clear plastic bottle for FIA for bromide. Add details.
- f. 45 mL glass VOA vial in duplicate for analysis of dissolved inorganic carbon (DIC) and dissolved organic carbon (DOC). This sample will be filtered, no preservative added.
- g. 60 mL plastic bottle for analysis of δ¹³C of dissolved inorganic carbon. This sample will be filtered, no preservative added. Samples will be shipped on ice to Isotech Laboratories for isotopic analyses.
- h. 20 mL glass VOA vial for analysis of δ^{18} O and δ^{2} H of water using IRMS. This sample will be filtered, no preservative added.

Unless noted otherwise above, flowback/ produced samples will be submitted to Shaw, NRMRL-Ada's on-site contractor, and the EPA General Parameters (GP) Laboratory, for fixed-laboratory analysis. Specific samples will be delivered to the ??? analytical facility or to Isotech Laboratories for isotopic analyses of dissolved inorganic carbon and dissolved gases.

2.2.4.3 Collection of Flowback/ Produced Water- Grab Samples

Although it is unlikely grab samples collected from surface impoundment may be necessary. In this case a large volume bottle with lid secured will be lowered below the surface of the fluid and sufficiently above the bottom of the surface impoundment to prevent the sediment collected at the bottom from entering into the bottle. Once the bottle is positioned the lid will be removed to allow the fluid to enter into the sample bottle. When the bottle is filled the lid will be replaced and the samples will be analyzed as indicated in 2.2.4.2. This may require multiple sampling to get the necessary volume for all the split samples.

2.2.5 Soil Sampling

Soil sampling will be accomplished using either geoprobe sampling method (RSKSOP-221) or the use of hand held samplers. The use of hand held samplers will in general only be used in areas where the geoprobe equipment cannot be set up, e.g. heavily wooded areas. The depth to which samples can be collected using a hand held sampler will be limited to the length of the sampling barrel.

2.2.5.1 Soil sampling with Geoprobe Macro-Core Soil Sampler

Section No. 2 Revision No. 0 September 18, 2011 Page 21 of 70 Comment [c96]: See CHK SOPs Should only have one method

Comment [C97]: Descriptions are provided for a variety of sampling methods, in reality the geoprobe or hand auguring methods or direct push methods will be used, why give all possibilities, not needed here, just address the main methods that will be used Deleted:

The macro-core® (MC) soil sampler is a steel tubular sleeve that is used to collect core samples of unconsolidated material in four different lengths: 60-, 48-, 36-, or 24-inch lengths, each 2.2 inches in diameter. The unconsolidated material may include soils, sediment, and waste materials. When using the MC soil sampler, there are two sampling options, open tube and closed piston. Samples are recovered inside a removable liner that is inserted inside the MC soil sampler. Liners are 58-, 46-, 34-, or 22-inches in length and fit inside the respective size sampler. The liners are available in stainless steel, Teflon®, PVC, and PETG. MC spacer rings are used to attach the liners to the cutting shoe. Core catchers are sometimes used to improve sample recovery in some formations.

In this method, an assembled MC soil sampler is advanced into the subsurface one sampling interval and retracted using a Geoprobe machine. The collected soil sample is removed from the sampler inside a liner. After decon, the MC sampler is reassembled with a new clean liner. The clean sampler is placed in the same hole and is advanced to the next sampling interval.

In stable soil, an open tube MC sampler can be used. Coring starts at the ground with a sampler that is open at the leading end. The sampler is advanced into the ground then retrieved to obtain the first core sample. An open tube sampler is placed in the same hole to collect the next core.

In unstable soil, the closed piston rod point assembly is used. The point fits in the cutting shoe and is held into place by a piston rod and stop pin. The MC closed piston system prevents collapsed soil from entering the sampler as it is advanced to the bottom of an existing hole.

The MC closed piston sampler is not designed to be driven through undisturbed soil. A probe hole must be opened above the sampling interval either by continuous sampling or MC pre-probe to depth.

Once a hole is open to depth, an assembled MC closed piston sampler is advanced through the slough material to the next sampling interval. Release rods are lowered inside the push rods and threaded into the stop pin. When unthreaded, the stop pin assembly and release rods are removed from the push rods. With the piston released, the sampler is advanced to fill the sampler with soil. The piston is later recovered with the soil sample.

Loose soils may fall out of the sampler as it is retrieved. The MC core catcher is used to alleviate this problem. The core catcher should be used in saturated sands and other noncohesive materials. It should not be used with tight soils as it might inhibit sample recovery. The core catcher can be used with all Geoprobe liners.

Soil sampling using the Geoprobe sampling will follow the current SOP outlined in RSKSOP-221 as described below for either open tube sampler or closed piston sampler methods.

2.2.5.1.1 Open Tube Sampling Method.

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- 1. Locate and set the Geoprobe rig in the sampling location.
- 2. Push the base of an MC spacer ring onto threaded end of cutting shoe (if an MC core catcher is to be used, first place the open end of core catcher over the threaded end of cutting shoe).
- 3. Thread the cutting shoe onto open end of MC sample tube.
- 4. Tighten shoe with MC combo wrench.
- 5. Insert a liner into open end of sample tube.
- 6. Thread an MC drive head into top of sample tube and tighten with MC combo wrench. Sampler assembly is complete (Figure 5.
- 7. Thread a drive cap onto drive head and position sampler under Geoprobe hammer.
- 8. The sampler should be centered inside the probe foot and parallel with probe derrick.
- 9. Apply weight and hammer to advance the sampler until the drive head reaches the ground surface (Figure 5.
- 10. Raise the hammer and remove the drive cap and thread a pull cap onto the drive head.
- 11. Lower the hammer and hook hammer latch over the pull cap and remove the sampler.
- 12. The soil sample is removed from the sampler by removing the cutting shoe with a MC combo wrench and pulling out the liner.
- 13. The sample is retained in the liner by placing vinyl caps over the ends of the liner and label the top and bottom of the core as well as the depth increment that was sampled.
- 14. Place the core on ice in a cooler.
- 15. To sample consecutive cores, advance a clean MC open tube sampler down the same hole to the top of the next sampling interval.
- 16. Drive the sampler the length of the sampler to collect the next soil core. Change to a MC piston rod sampler if side slough is encountered.
- 17. Once all the depths have been collected ship the soil cores to the lab as outlined later.

2.2.5.1.2 Closed Piston Sampling Method.

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- 1. Locate and set the Geoprobe rig in the sampling location.
- 2. Put an o-ring in the groove on the piston rod point.
- 3. Push the point completely into the cutting shoe (Figure 6.
- 4. Place a core catcher or spacer ring onto threaded end of cutting shoe (Figure 6.
- 5. Thread the cutting shoe into the sample tube.
- 6. Put a liner inside sample tube and then thread drive head into sample tube.
- 7. Make sure cutting shoe and drive head are completely tightened.
- 8. Insert piston rod/stop-pin assembly through the drive head until the threads on the stop pin contact inside threads of drive head.
- 9. Thread stop-pin into drive head (left hand thread) until tight (Figure 6.
- 10. Attach drive cap to drive head and advance the sampler adding probe rods until the desired sampling interval is reached.
- 11. Once the desired depth is reached, raise the hammer and remove the drive cap.
- 12. Insert extension rods down inside the probe rods. Use extension rod couplers or quick links to connect the extension rods together until the leading rod touches the stop-pin.
- 13. Thread extension rod handle onto rod string and turn handle to thread extension rods into stop-pin. This is a left handed thread so that extension rods will not be unthreaded.
- 14. Continue turning handle until stop-pin is unthreaded from drive head.
- 15. Lift and remove extension rods and piston rod/ stop-pin assembly (Figure 6).
- 16. Thread the drive cap onto push rod and advance tool string the length of sampler.
- 17. Remove drive cap and thread pull cap onto top push rod.
- 18. Use hammer latch to pull rods until the sampler is brought to ground surface.

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- 19. The sample is removed from the sample tube in the same manner as the open tube sampler by placing vinyl caps over the ends of the liner and label the top and bottom of the core as well as the depth increment that was sampled.
- 20. The piston rod tip is now retrieved from the end of the liner.
- 21. Place the core on ice in a cooler.
- 22. To sample consecutive cores, repeat steps 2-21 in the same hole.
- 23. Once all the depths have been collected ship the soil cores to the lab as outlined later.
- 2.2.5.2 Soil Sampling Using a Hand held Sampler.

Soil cores can be collected using a hand held soil sampler. The procedure is outlined below.

- 1. Locate the sampling location.
- 2. Insert the sample liner in to the sample tube and screw on the end cap.
- 3. Screw the sampler rod and cross handle onto the sampler end cap.
- 4. Push the sampler into the soil to the desired depth. A sledge hammer or weighted drive sleeve and pounding cap may be necessary to drive the sampler to the desired depth.
- 5. Remove the sampler from the soil.
- 6. Remove the sampler rod and cross handle from the end cap.
- 7. Remove the end cap from the sampler.
- 8. Gently remove the liner from the sampler placing an end caps on the liner and marking the top and bottom of the liner in the correct orientation.
- 9. Label the core.
- 10. Place the core on ice in a cooler.
- 11. Once all samples are collected in the cooler, ship the cooler to the lab.
- 12. Decon the sampler.
- 13. Once samples arrive at the lab, place the samples in the freezer.

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14. Cut the core in the liner at the appropriate depth increments.

15. Sub-sample the increments and place in appropriate containers for analysis.

2.2.5.3 Soil Core Sub-Sampling

The individual sub samples for each depth increment will need to be split for the appropriate sample analysis.

- 1. Remove the sample from the liner and place in a clean container.
- 2. Homogenize the sample.
- 3. Split the homogenized sample into appropriate containers.
 - a. Metals
 - b. General parameters (pH, Eh, electrical conductivity, BOD, total organic carbon, total inorganic carbon)
 - c. Chemical Analysis (CEC, amporphous Al, Fe, Mn, acid volatile sulfur)
 - d. VOC and semi-VOC
 - e. Organic chemical analysis (for example THP, DRO, GRO, PAH, etc.)
 - f. Isotopic analysis
 - g. Particle size analysis
 - h. Mineralogical Analysis
- Samples destined for analysis where volatilization or loss of moisture could affect the results should not be dried prior to analysis. These should be placed in the freezer until analysis.
- 5. When appropriate air dry the samples. Store samples until analysis.

2.3 Sample Handling and Custody

Section No. 2 Revision No. 0 September 18, 2011 Page 26 of 70 Comment [c98]: Needs to be conducted using the saturated paste method Comment [c99]: The purpose of soil BOD, TOC TIC is not understood Comment [c100]: ?

Comment [c101]: In bullet f, please define isotopic analyses intended, section h define mineralogical analyses intended Comment [c102]: This needs to be defined Comment [c103]: This needs to be defined Comment [c104]: Add moisture content

Comment [c105]: No mention of QA/QC samples, e g duplicates, trip blanks, field blanks, etc

2.3.1 Sampling Labeling

Each well, surface water body and soil sample location will be uniquely labeled. Samples collected from each of these locations will also include the unique label, well # or name of sample location, the date, the initials of the sampler, and designation of the sample type, e.g., "metals" and preservation technique (when applicable). This information will be recorded onto labeling tape, using water-insoluble ink, affixed to each sample bottle.

2.3.2 Sample Packing and Shipping

All samples will placed together in a sealed Ziploc plastic bag. The bags will be placed on ice in coolers. Glass bottles will be packed with bubble wrap to prevent breakage. The coolers will be sent via <u>FedEx</u>, overnight, to the appropriate lab with chain of custody forms (see Figure 7) and custody seal.

R.S. Kerr Environmental Research Center 919 Kerr Research Drive Ada, OK 74820 1-580-436-8920 ATTN: Andrew Greenwood (for samples analyzed by both Shaw and EPA General Parameters Laboratory)

EPA Region 8 Lab 16194 West 45th Drive Golden, CO 80403 1-303-312-7775 ATTN: Mark Murphy Sample receipt and log-in at the Region 8 laboratory shall be conducted as described in their SOP, *Sample Receipt and Control Procedure*, #GENLP-808 Rev. 1.0 and the Region 8 Quality Manual, # QSP-001 Rev. 1.0

EPA Region 3 Lab 701 Maples Road Ft. Meade, MD 20755 1-410-305-2835 ATTN: Jennie Gundersen Sample receipt and log-in at the Region 3 laboratory shall be conducted as described in their SOP, *Sample Scheduling, Receipt, Log-In, Chain of Custody, and Disposal Procedures*, R3-QA061.

2.4 Analytical Methods

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Comment [c106]: Wet ice packaging recommended

Comment [c107]: The analytical methods chosen for use are not the methods which are more commonly used by commercial analytical laboratories Potentially this could affect the quality of the data generated by the study, potentially provide for significant differences between EPA findings and spilt samples analyzed by a commercial laboratory. If the RSKERC methods are equivalent to SW methods, then this should be clearly documented

Ground-water samples will be collected and analyzed using RSKERC standard operating procedures (RSKSOPs) at RSKERC and EPA Methods at the Region VIII laboratory (Table 8).

Region III's **LC-MS-MS** method for glycols is under development with the intent to eventually have a validated, documented method. Aqueous samples are injected directly on the HPLC after tuning MS/MS with authentic standards (2-butoxyethanol, di-, tri-, and tetraethylene glycols) and development of the HPLC gradient. HPLC column is Waters (Milford MA) Atlantis dC18 3um, 2.1 x 150mm column (p/n 186001299). HPLC gradient is with H₂O and CH₃CN with 0.1% formic acid. The 3 glycols are run on a separate gradient than the 2-butoxyethanol. All details of instrument conditions will be included in case file. EPA SW-846 Method 8000B and C are used for basic chromatographic procedures. A suitable surrogate has not been identified. Since there is no extraction or concentration step in sample preparation, extraction efficiency calculations using a surrogate are not applicable. If a suitable surrogate is found, it will be used to evaluate matrix effects. Custom standard mix from Ultra Scientific, (Kingstown RI) is used for the instrument calibration (IC). The working, linear range varies for each compound but is about 10-100 µg L⁻¹ and may change with further development. Initial Calibration (IC) is performed before each day's sample set, calibration verification is done at the beginning, after every 10 sample injections, and at the end of a sample set. The correlation coefficient (r^2) of the calibration curve must be >0.99. An instrument blank is also run after every 10 sample injections. The performance criteria are provided in Table 10. The system is tuned with individual authentic standards (at 1mg L⁻¹ concentration) of each compound according to the manufacturer's directions using the Waters Empower "Intellistart" tune/method development program in the MRM (multiple reaction monitoring) ESI+ (electrospray positive) mode. Tune data is included in the case file. Target masses, transition data and voltages determined in each tune for each compound are compiled into one instrument method. Only one MS tune file (which determines gas flow rates and source temperatures) may be used during a sample set. For these samples, the tetraethylene glycol tune is used as it provides adequate response for all targets. Due to differences in optimal chromatographic separation, the three glycols are analyzed in one run and 2-butoxyethanol is analyzed separately. Exact mass calibration of the instrument is done annually with the preventive maintenance procedure. Mass calibration was successfully performed according to manufacturer's specifications with NaCsI on 6/17/2010 by a certified Waters Corp Service technician. Custom mix supplied by Accustandard (New Haven, CT) is used as a second source verification (SSV). The SSV is run after IC. Matrix spikes and matrix spike duplicates are also performed.

Analysis at RSKERC includes inductively coupled plasma – optical emission spectroscopy (ICP-OES; for cations), inductively coupled plasma – mass spectroscopy (ICP-MS; for trace metals), capillary electrophoresis (CE, for anions), carbon analysis using combustion and infrared detection, gas chromatography (GC, for dissolved gas analysis) and gas chromatography-mass spectroscopy (GC-MS) for VOCs. Analysis by the EPA Region VIII laboratory includes GC for GRO, DRO, and GC-MS for semivolatiles with appropriate sample preparation and introduction techniques. These analytical methods are presented in Table 8.

Section No. 2 Revision No. 0 September 18, 2011 Page 28 of 70 Comment [c108]: LC-MS-MS for glycols is a suitable method currently under evaluation but not widely accepted or validated May be suitable for baseline analyses but potential interferences from high solids and salt content in flowback water and produced water may be an issue with this method

The RSKSOPs and their associated target analyte list are presented in Table 11. For these analyses, the only surrogates used are for the VOC analysis. Surrogate compounds used are p-bromofluorobenzene and 1,2-dichlorobenzene-d4, spiked at 100 ug/L.

For the semivolatiles the target analyte list is presented in Table 12. Surrogates used include phenol-d6, 2-fluorophenol, 2,4,6-tribromophenol, nitrobenzene-d5, 2-fluorobiphenyl, and p-terphenyl-d14. The concentrations used for the surrogates shall be spiked at 5 μ g mL⁻¹. For samples containing components not associated with the calibration standards, non-target peaks will be reported as tentatively identified compounds (TICs) based on a library search. Only after visual comparison of sample spectra with the nearest library search results will tentative identifications be made. Guidelines for making tentative identification are:

- A peak must have an area at least 10% as large as the area of the nearest internal standard.
- Major ions in the reference spectrum (ions > 10% of the most abundant ion) should be
 present in the sample spectrum.
- The relative intensities of the major ions should agree within ± 20%. (Example: For an ion with an abundance of 50 % in the reference spectrum, the corresponding sample ion abundance must be between 30 and 70 %.)
- Molecular ions present in the reference spectrum should be present in the sample spectrum.
- Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination or presence of co-eluting compounds. Ions present in the reference spectrum but not in the sample spectrum should be reviewed for possible subtraction from the sample spectrum because of background contamination or coeluting peaks. Data system library reduction programs can sometimes create these discrepancies.

Commercial standards for DRO calibration is locally procured DF #2 (source: Texaco station). Surrogates used in DRO include o-terphenyl at spiking concentrations of 10 μ g L⁻¹.

Commercial standards for GRO calibration are BTEX, MTBE, naphthalene, and gasoline range hydrocarbons (purchased as certified solutions) and unleaded gasoline from Supelco (product number 47516-U). Surrogates used in GRO include 4- bromofluorobenzene at spiking concentrations of 50 μ g L⁻¹.

2.5 Quality Control

2.5.1 Quality Metrics for Aqueous Analysis

For analyses done at RSKERC, QA/QC practices (e.g., blanks, calibration checks, duplicates, second source standards, matrix spikes, and surrogates) are described in various in-house Section No. 2 Revision No. 0 September 18, 2011 Page 29 of 70 Comment [c109]: Not recommend: The analysis of TICs is only at best "estimated" data and CHK would not recommend any study to be performed or replicated on the basis of "estimated data" This will only be suspect data at best and not valid data by a chemist review This would apply to any GC/MS (i e VOC or SVOC analyses) method performed Deleted:

Comment [c110]: Is this the certified standard for Fuel Oil #2? Deleted:

Standard Operating Procedures (RSKSOPs) and summarized in Table 13. Matrix spikes sample spiking levels are determined at the discretion of the individual analysts (based on sample concentrations) and are included with the sample results. Corrective actions are outlined in the appropriate SOPs and when corrective actions occur in laboratory analysis it will be documented and the PI will be notified as to the nature of the corrective action and the steps taken to correct the problem. The PI will review this information and judge if the corrective action was appropriate.

For analyses done by the Region VIII laboratory, QA/QC requirements are:

(1) Samples shall be processed and analyzed within the following holding times (from date sampled):

Semivolatiles: 7 days until extraction, 30 days after extraction

DRO: 14 days until extraction*, 40 days after extraction

GRO: 14 days*

*With acid preservation

(2) Data verification shall be performed by the Region VIII laboratory to ensure data meets their SOP requirements.

(3) Complete data package shall be provided electronically on disk, including copies of chain-of-custody forms, copy of method or Standard Operating Procedure used, calibration data, raw data (including notebook pages), QC data, data qualifiers, quantitation (reporting) and detection limits, deviations from method, and interpretation of impact on data from deviations from QC or method requirements. (All documentation needed to be able to re-construct analysis.)

(4) Detection limits (DL) and quantitation (reporting) limits (RL) for the semivolatiles are as provided in Table 12. The DL and RL for DRO and GRO are both at 20 μ g/L.

(5) The laboratory shall be subject to an on-site QA audit and analysis of Performance Evaluation samples. If the laboratory is currently analyzing Performance Evaluation (aka Proficiency Testing) samples, a request will be made for this data. If they are not actively involved in analyzing these samples, then they shall be provided by RSKERC.

(6) See Table 14 for QC types and performance criteria.

Corrective Actions: If any samples are affected by failure of a QC sample to meet its performance criteria, the problem shall be corrected and samples will be re-analyzed. If re-

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analysis is not possible (such as lack of sample volume), the PI shall be notified. The data will be qualified with a determination as to impact on the sample data. Failures and resulting corrective actions shall be reported.

For analyses done by the Region III laboratory, QA/QC requirements are:

- (1) Samples shall be analyzed within the holding time of 14 days.
- (2) Data verification shall be performed by the Region III laboratory to ensure data meets the method requirements.
- (3) Complete data package shall be provided electronically on disk, including copies of chain-of-custody forms, copy of method or Standard Operating Procedure used, calibration data, raw data (including notebook pages), QC data, data qualifiers, quantitation (reporting) and detection limits, deviations from method, and interpretation of impact on data from deviations from QC or method requirements. (All documentation needed to be able to re-construct analysis.)
- (4) Detection and reporting limits are still be determined, but most will be between 10 and 50 ppb.
- (5) The laboratory shall be subject to an on-site QA audit if the glycol data becomes "critical" at a later data after method validation.
- (6) See Table 15 for QC types and performance criteria.
- (7) Until the method is validated, the data will be considered "screening" data.

Corrective Actions: If any samples are affected by failure of a QC sample to meet its performance criteria, the problem shall be corrected and samples will be re-analyzed. If re-analysis is not possible (such as lack of sample volume), the PI shall be notified. The data will be qualified with a determination as to impact on the sample data. Failures and resulting corrective actions shall be reported.

2.5.2 Measured and Calculated Solute Concentration Data Evaluation

The computer program AqQA (RockWare Inc., version 1.1.1) will be used as a check on the quality of solute concentration data. Two methods will be used. First, the specific conductance values measured in the field will be compared to a calculated value that is based on anion- and cation-specific resistivity constants and the measured concentrations of anions and cations in specific ground-water samples. The agreement between the measured and calculated values should be within 15%. The second method will be to calculate the charge balance for each solution. This is done by summing and comparing the net positive and negative charge from the Section No. 2 Revision No. 0 September 18, 2011 Page 31 of 70
measured concentrations of anions and cations. The agreement should be within 10%. Poor agreement would suggest that some major solute(s) is not accounted for in the analytical measurements. At the discretion of the PI, discrepancies in this manner will be either flagged or the identity of other sample components and/or reason(s) for poor agreement will be investigated.

2.5.3 Detection Limits

Detection limits for the various analytes are listed in the RSKERC Standard Operating Procedures for these methods and are not repeated here. Updated detection limits are provided in the data reports. Detection limits for the analytes, including those to be done by the contract lab are given in Table 11. They are adequate for project objectives.

2.5.4 QA/QC Calculations

% Recovery or Accuracy

$$\%$$
REC= $\frac{m}{n} \times 100$

Where m = measurement result n = True Value (a certified or known value) of standard or reference

Precision

Precision is described by Relative Percent Difference (RPD) as previously defined. The Relative Percent Difference (RPD) is calculated based on the following:

$$RPD = \frac{2(a-b)}{a+b} \times 100$$

where a = sample measurement and b = duplicate sample measurement and a > b.

Matrix Spike Recovery

Matrix spikes sample spiking levels are determined at the discretion of the individual analysts (based on sample concentrations) and are included with the sample results.

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%Recovery= spiked sample concentration-native sample concentration spiked sample concentration ×100

2.6 Instrument/Equipment Testing, Inspection, and Maintenance

RSKERC laboratory instrumentation used for analysis of project analytes are in routine use and are tested for acceptable performance prior to analyzing actual samples through the analysis of standards and QC samples. Field instruments are tested prior to use in the field by calibrating or checking calibration with standards. Routine inspection and maintenance of these instruments is documented in instrument logbooks. RSKSOPs provide details on instrument testing and corrective actions.

2.7 Instrument/Equipment Calibration and Frequency

RSKERC calibration and calibration frequency are described in RSKSOPs (RSKERC Standard Operating Procedures). For the sub-contracted laboratory, these requirements are identified in the EPA Methods and the SOW (Statement of Work) included with the purchase requisition (PR) as well as in Table 10 Standards used for GRO and DRO calibration will be acquired from a commercial source. The SOW will be reviewed by the QAM for QA requirements prior to issuing the PR.

Field instruments are calibrated or checked for calibration daily prior to use, mid-day, and at the end of the day after the last sample measurement. Calibration standards shall be traceable to NIST, if available and all dated calibration standards are not beyond their expiration date and will not expire during the field trip. Prior to the sampling event each test meter will be check that it is in good working order. Calibration data will be recorded in a bound waterproof notebook and personnel making entries will adhere to the GWERD Notebook policy. Calibration of instruments will be performed daily prior to initiation of sample collection and will be performed according to manufacturer's instructions and will be recorded in the field notebook. In addition calibration checks will be performed using known standards or buffers before use, mid-day and at the end of the day. With the exception of pH all checks must be exceed $\pm 10\%$ of known concentrations and in the case of pH must be within ± 0.2 pH units. These calibration checks will be recorded in the field notebook. If a calibration check fails, this will be recorded in the field notebook and the possible causes of the failure will be investigated. Upon investigation corrective action will be taken and the instrument will be recalibrated. Samples taken between the last good calibration check and the failed calibration check will be flagged to indicate there was a problem. Duplicate field measurements are not applicable to measurements in flow through cell (RSKSOP-211).

Hach spectrophotometers and turbidity meters will inspected prior to going to the field and there function verified. Calibration of these instruments are internal and calibration will be checked in the lab prior to going to the field. Standards for redox sensitive species such as sulfide and Section No. 2 Revision No. 0 September 18, 2011 Page 33 of 70

ferrous iron are difficult to use in the field because once exposed to atmospheric oxygen there concentrations can change. Similarly calibration standards for alkalinity are sensitive to atmospheric carbon dioxide. Duplicates will be performed once a day or on every tenth sample. Duplicates acceptance criteria are \pm 15 % RPD. The values obtained for each duplicate sample will be recorded in the field notebook and RPD will be calculated (section 2.5.4) and recorded in the field notebook. If the duplicate samples fail and additional duplicate sample will be taken and reanalyzed. If the additional duplicate samples fail to meet the QC criteria, then the instruments will be checked and corrective action taken. The corrective actions will be recorded in the field notebook. Samples collected between the last valid duplicate sample and the failed duplicate sample will be flagged.

2.8 Inspection/Acceptance of Supplies and Consumables

RSKSOPs provide requirements for the supplies and consumables needed for each method. The analyst is responsible for verifying that they meet the RSKSOP requirements. The supplies or consumables not addressed by the RSKSOPs that are critical to this project are listed in Table 13. It should be noted that the vendors listed in Table 13 are suggest vendor and equivalent parts may be available from other vendors or substitute for based on purchasing rules. Dr. Puls is responsible for ensuring these are available and to ensure they are those as listed previously. If subcontractors are responsible for sampling, they will be responsible for providing the PI with information on their sample containers to ensure they meet project requirements.

2.9 Non-direct Measurements

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2.10 Data Management

The PI is responsible for maintaining data files, including their security and integrity. All files (both electronic and hard copy) will be labeled such that it is evident that they are for the hydraulic fracturing project in Desoto Parish, LA.

Data will be submitted to Dr. Puls as either hard copies (field notes), or electronically (laboratory data) in Excel spreadsheets on CD or DVD or via email. Data in hard copy form will be manually entered into Excel spreadsheets on Dr. Puls's computer or designated GWERD staff computer and will be given to Dr. Puls. Either, Dr. Puls or a technician or student will conduct this task. Data will be spot-checked by Dr. Puls to ensure accuracy. If errors are detected during the spot-check, the entries will be corrected. Detection of an error will prompt a more extensive inspection of the data, which could lead to a 100% check of the data set being entered at that time if multiple errors are found.

Data in electronic form shall be electronically transferred to the spreadsheets. Data will be spotchecked by Dr. Puls to ensure accuracy of the transfer. If errors are detected during the spot-

Section No. 2 Revision No. 0 September 18, 2011 Page 34 of 70 Deleted:),

Comment [c111]: Electronic Data delivery should be used Field notes should be digitized Deleted: into

check, the entries will be corrected. Detection of an error will prompt a more extensive inspection of the data, which could lead to a 100% check of the data set being entered at that time if multiple errors are found.

2.10.1 Data Analysis, Interpretation, and Management

Data validation will consist of initial and final review of data. Initial review will include continuous oversight during field collection of data by the principal investigator to avoid common transcription errors associated with recording of data. Final review will include evaluation of all collected data for suitability in data interpretation. It will include but is not limited to the following activities: (1) assessment of data completeness, (2) review of log books and forms used for data logging, and (3) review of calibration and standard checks.

2.10.2 Data Recording

Data collected during the ground-water investigation will be recorded into field notebooks and entered into EXCEL spreadsheets. Water quality data will also be entered into AqQA a program for evaluating ground water quality and for evaluating data validity. Graphs will be produced using EXCEL or Origin to show key data trends.

2.10.3 Data Storage

As this is a Category I project, all data and records associated with this project will be kept permanently and will not be destroyed. All data generated in this investigation will be stored electronically in Microsoft EXCEL and backed up in RSKERC's local area network 'M' drive. All paper-based records will be kept in the PI's offices. If the project records are archived, Dr. Puls will coordinate with GWERD management and GWERD's records liaison and contract support the compiling of all data and records.

2.10.4 Analysis of Data

All data collected associated with groundwater and surface water sampling will be summarized in EXCEL spreadsheets. Data in spreadsheets will be spot-checked against original data reports by selecting random data points for comparison to verify accuracy of data transfer. When possible, data sets will be graphically displayed using EXCEL to reveal important trends. Comment [c112]: Need an outlier data resolution program that is agreeable to both parties There will be outliers in the data, or unrealistic results, that likely will be traced to sampling or lab error Needs to be provided in report

Is the data going to be shared with the landowners A discussion, clarification, and description on this issue is needed

Comment [c113]: Should also be part of final review and final acceptance of data

Comment [c114]: The handling of produced fluids and samples of hydraulic stimulation fluid are not mentioned in this section

Comment [c115]: If comparisons are made to standards, appropriate standards should be used, e g drinking water standards are not appropriate for surface water resources which are not directly consumed as human drinking water The comparison should focus more on comparison to background levels EPA does need to identify what actions if any will be taken to notify residents if baseline sampling has parameters which are higher than drinking water standards

A discussion on recommendations to a landowner if say nitrate is exceeded (due to septic impacts This needs to be spelled out in the document, and would recommend the landowner be notified as soon as the baseline result is available that a MCL or SMCL is exceeded, or an organic compound found in their well at high levels)

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3.0 Assessment and Oversight

3.1 Assessments and Response Actions

Technical Systems Audits (TSAs),Audits of Data Quality (ADQs), and Performance Evaluations will be conducted early in the project to allow for identification and correction of any issues that may affect data quality. TSAs will be conducted on both field and laboratory activities. Detailed checklists, based on the procedures and requirements specified in this QAPP, related SOPs, and SOWs, will be prepared and used during these TSAs. These audits will be conducted with contract support from Neptune and Co., with oversight by Steve Vandegrift, QAM, for those that are done outside of RSKERC. Those at RSKERC will be done by the QAM. See Section 4.2 for additional discussion on ADQs.

Laboratory TSAs will focus on the critical target analytes at sub-contract laboratories. A laboratory TSA will be conducted at RSKERC for critical target analytes.

ADQs will be conducted on a representative sample of data for the critical target analytes. These will also be performed by the Neptune and Co., with oversight by Steve Vandegrift, QAM.

Performance Evaluations will be conducted on critical target analytes for those that are available commercially. The QAM shall acquire and submit the PE samples. These shall be coordinated with the PI for the contract laboratory.

See Section 3.2 for how and to whom assessment results are reported.

Assessors do not have stop work authority; however, they can advise the PI if a stop work order is needed in situations where data quality may be significantly impacted, or for safety reasons. The PI makes the final determination as to whether or not to issue a stop work order.

For assessments that identify deficiencies requiring corrective action, the audited party must provide a written response to each finding and observation to the QA Manager, which shall include a plan for corrective action and a schedule. The PI is responsible for ensuring that audit findings are resolved. The QA Manager will review the written response to determine their appropriateness and provide, if necessary. If the audited party is other than the PI, then the PI shall also review and concur the corrective actions. The QA Manager will track implementation and completion of corrective actions. After all corrective actions have been implemented and confirmed to be completed, the QA Manager shall send documentation to the PI and their supervisor that the audit is closed. Audit reports and responses shall be maintained by the PI in the project file and the QA Manager in the QA files, including QLOG.

3.1.1 Assessments

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TSAs will be conducted on both field and laboratory activities. Detailed checklists, based on the procedures and requirements specified in this QAPP, SOPs, EPA Methods, and SOW will be prepared and used during these TSAs. One field TSA will be done. It is anticipated this will take place in the summer of 2011. The laboratory audit will take place when samples are anticipated to be in the laboratory's possession and being processed.

Laboratory TSAs will focus on the critical target analytes (Table 14) and will be conducted onsite at RSKERC (involves both EPA and contractor-operated labs) and at an off-site contract laboratory which will analyze for semi-volatile organic, DRO and GRO analyses. It is anticipated this will take place in the summer of 2011. At this time, EPA Region III Laboratory and EPA Region VIII Laboratory are be the off-site laboratories.

ADQs will be conducted on a representative sample of data for the critical target analytes. . These will begin with the first data packages to ensure there are no issues with the data and to allow for appropriate corrective actions on subsequent data sets if needed.

Performance Evaluations will be conducted on critical target analytes for those that are available commercially. These are anticipated to be done in the summer of 2011.

3.1.2 Assessment Results

At the conclusion of a TSA, a debriefing shall be held between the auditor and the PI or audited party to discuss the assessment results. Assessment results will be documented in reports to the PI, the PIs first-line manager, and the GWERD Division Director. If any serious problems are identified that require immediate action, the QAM will verbally convey these problems at the time of the audit to the PI.

The PI is responsible for responding to the reports as well ensuring that corrective actions are implemented, if needed, in a timely manner to ensure that quality impacts to project results are minimal.

3.2 Reports to Management

All final audit reports shall be sent to the GWERD Division Director, and copied to Dr. Puls. Audit reports will be prepared by the QA Manager or the QA support contractor, which will be reviewed and approved prior to release. Specific actions will be identified in the reports.

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4.0 Data Validation and Usability

4.1 Data Review, Verification, and Validation

Criteria that will be used to accept, reject, or qualify data will include specifications presented in this QAPP, including the methods used and the measurement performance criteria presented in Tables 8, 9 and 10. In addition, sample preservation and holding times will be evaluated against requirements Table 7.

Data will not be released outside of RSKERC until all study data have been reviewed, verified and validated as described below. The PI is responsible for deciding when project data can be shared with interested stakeholders in conjunction with the GWERDs Director's approval.

4.2 Verification and Validation Methods

Data verification will evaluate data at the data set level for completeness, correctness, and conformance with the method. Data verification will be done by those generating the data. This will begin with the analysts in the laboratory and the personnel in the field conducting field measurements, monitoring the results in real-time or near real-time. At RSKERC, Shaw's, verification includes team leaders, the QC coordinator, and the program manager. For the EPA GP Lab at RSKERC, data verification includes peer analysts in the GP lab and the team leader. Shaw's and the EPA GP Lab's process goes beyond the verification level, as they also evaluate the data at the analyte and sample level by evaluating the results of the QC checks against the RSKSOP performance criteria.

For the Region VIII laboratory, QA/QC requirements include data verification prior to reporting and detailed description can be found in the QSP-001-10 QA Manual (Burkhardt and Datschelet, 2010). Results are reported to the client electronically, unless requested otherwise. Electronic test results reported to the client include the following: Data release memo from the analysts, LQAO, Laboratory Director (or their Designees) authorizing release of the data from the Laboratory, and a case narrative prepared by the analysts summarizing the samples received, test methods, QC notes with identification of noncompliance issues and their impact on data quality, and an explanation of any data qualifiers applied to the data.

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The Region III laboratory data verification and validation procedure is described in detail in their Laboratory Quality Manual (Metzger et al., 2011). Briefly, the procedure is as follows. The actual numeric results of all quality control procedures performed must be included in the case file. The data report and narrative must describe any limitations of the data based on a comprehensive review of all quality control data produced. A written procedure or reference must be available for the method being performed and referenced in the narrative. If the method to be performed is unique, the procedures must be fully documented and a copy included in the case file. Verify that the calibration and instrument performance was checked by analyzing a second source standard (SCV). (The concentration of the second source standard must be in the range of the calibration.) Results must be within the method, procedure, client or in-house limits. At least one blank (BLK), duplicate analysis, and spiked sample must be carried through the entire method or procedure. Peer reviewers complete the On-Demand Data Checklist. The data report must document the accuracy and precision of the reported data by applying qualifier codes, if applicable, and include a summary of the quality control in the case file.

For field measurements, Dr. Puls will verify the field data collected.

The laboratories shall contact the PI upon detection of any data quality issues which significantly affect sample data. They shall also report any issues identified in the data report, corrective actions, and their determination of impact on data quality.

Data validation is an analyte- and sample-specific process that evaluates the data against the project specifications as presented in the QAPP. Data validation will be performed by a party independent of the data collection activity. Neptune and Company, a QA support contractor, will conduct data validation on a representative sample of the critical analytes with oversight by the QAM. Data packages for the critical analytes that have been accepted by Doug Beak as ready to use or report shall be provided to Steve Vandegrift, QAM, who will coordinate the data validation with Neptune. Neptune shall evaluate data against the QAPP specifications. Neptune will use NRMRL SOP #LSAS-QA-02-0, "Performing Audits of Data Quality" as a guide for conducting the data validation. The outputs from this process will include the validated data and the data validation report. The report will include a summary of any identified deficiencies, a summary statement regarding the adequacy of the data for its intended use, and a discussion on each individual deficiency and any effect on data quality and recommended corrective action.

As part of the data validation process, the synthesis of data and conclusions drawn from the data will be reviewed by the RSKERC Case Study Team (minimally will include case study PIs, Technical Research Lead for case studies, and GWERD Director) prior to release of this information or data to entities outside of RSKERC. Once reviewed by the RSKERC Case Study Team in coordination with the GWERD Director, the GWERD Director will approve its release.

Section No. 4 Revision No. 0 , 2011 Page 39 of 70 Comment [c116]: A common problem is data review of field readings in a timely manner Experience has shown that field reading often contain outliers due to instrument calibration issues, mis-reading by technicians, or transcription errors Review of the field results is very important and needs to be conducted immediately after sample collection by both EPA and CHK, jointly Validation of field screening parameters should not be left to one person

4.3 Reconciliation with User Requirements

The PI, Dr. Puls, shall analyze the data, as presented below. Dr. Puls shall also review the results from the data verification and validation process. Dr. Puls shall make a determination as to whether or not the data quality has met project requirements and thereby the user requirements. If there are data quality issues that impact their use, the impact will be evaluated by the PI. If corrective actions are available that would correct the issue, Dr. Puls will make the determination to implement such actions. For example, the PI may have the option to re-sample or re-analyze the affected samples. If not, then the PI will document the impact in the final report such that it is transparent to the data users how the conclusions from the project are affected.

The types of statistical analyses that will be performed include summary statistics (mean, median, standard deviation, minimum, maximum, etc.) if applicable. In addition, the data will be plotted graphically over time and trends in the data will be analyzed, for example increasing or decreasing concentrations of a particular analyte.

Data will be presented in both graphical and tabular form. Tabular forms of the data will include Excel spreadsheets for raw data and tables containing the processed data. Graphical representations of the data will not only include time series plots as previously described, but also Durov and Piper Diagrams for major anions and cations. In addition, concentrations of data could be plotted on surface maps of the Killdeer site showing well locations and concentrations of analytes and contours may be developed to show "analyte plumes", if present.

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5.0 References

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RSKSOP-152v3. Ground-Water Sampling. 5 p.

RSKSOP-175v5. Sample Preparation and Calculations for Dissolved Gas Analysis in Water Samples Using a GC Headspace Equilibration Technique. 33 p.

RSKSOP-194v4. Gas Analysis by Micro Gas Chromatograph (Agilent Micro 3000). 13 p.

RSKSOP-211v3. Field Analytical QA/QC. 4 p. Section No. 5 Revision No. 0 September 18, 2011 Page 41 of 70

RSKSOP-212v6. Standard Operating Procedure for Quantitative Analysis of Low Molecular Weight Acids in Aqueous Samples by HPLC. 22 p.

RSKSOP-213v4. Standard Operating Procedure for Operation of Perkin Elmer Optima 3300 DV ICP-OES. 22 p.

RSKSOP-216v2. Sample Receipt and Log-In Procedures for the On-Site Analytical Contractor. 5 p.

RSKSOP-257v3. Operation of Thermo Elemental PQ Excell ICP-MS. 16 p.

RSKSOP-275v1. Collection of Water Samples from Monitoring Wells. 10 p.

RSKSOP-276v3. Determination of Major Anions in Aqueous Samples Using Capillary Ion Electrophoresis with Indirect UV Detection and Empower 2 Software. 11 p.

RSKSOP-299v1. Determination of Volatile Organic Compounds (Fuel Oxygenates, Aromatic and Chlorinated Hydrocarbons) in Water Using Automated Headspace Gas Chromatography/Mass Spectrometry (Agilent 6890/5973 Quadrupole GC/MS System). 25 p.

RSKSOP-326v0. Manual Measurement of Groundwater Levels for Hydrogeologic Characterization. 4 p.

RSKSOP-330v0. Determination of Various Fractions of Carbon in Aqueous Samples Using the Shimadzu TOC-VCPH Analyzer. 15 p.

Tetra Tech. 2003. Literature review and report surface sediment sampling technologies. Report for U.S. Environmental Protection Agency, National Exposure Research Laboratory. GSA Contract No. GS-10F-0076K.

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6.0 Tables

Table 1. Critical analytes

Analyte	Analysis Method	Laboratory Performing the Analysis
Gasoline Range Organics (GRO)	ORGM-506 r1.0, EPA Method 8015D	EPA Region VIII Laboratory
Diesel Range Organics (DRO)	ORGM-508 r1.0, EPA Method 8015D	EPA Region VIII Laboratory
Volatile Organic Compounds (VOC)*	RSKSOP-299v1	Shaw Environmental
Semivolatile Organic Compounds (SVOC)	ORGM-515 r1.1, EPA Method 8270D	EPA Region VIII Laboratory
Dissolved Gases**	RSKSOP-194v4 &-175v5	Shaw Environmental
Metals (e.g. As, Se, Sr, Ba, B)	RSKSOP-213v4 &-257v2	Shaw Environmental
Major Cations (Ca, Mg, Na, K)	RSKSOP-213v4	Shaw Environmental
Major Anions (Cl, NO3, SO42)	RSKSOP-276v3	RSKERC general parameters lab

*alcohols (isopropyl alcohol and t-butyl alcohol), naphthalene (using RSKSOP-299v1) **methane, ethane, propane, butane

methane, emane, propane, outane

Only those SVOC compounds in Table 12 that have DL, RL, and Control Limits listed may be used as critical analytes. Others only as screening data.

Both VOC and SVOC have many target analytes and initially all are considered as critical (with exception for SVOC noted above). A tiered approach will be used to further refine the identification of specific compounds as critical. Data from the first sampling events will be evaluated by the PI to determine if there are specific compounds that are identified in these samples which would warrant their specific identification as critical to narrow the list. These will be identified in a subsequent QAPP revision.

GRO analysis provides data for not only TPH as gasoline, but several other compounds. Only TPH as gasoline will be considered critical from this analysis.

Section No. 6 Revision No. 0 September 18, 2011 Page 43 of 70 **Comment [C117]:** Radon and radium are mentioned in the discussion but no methods are identified for use

Comment [c118]: H2 and CO2 not listed as critical items

Deleted: .

Comment [c119]: In general, EPA should be using methods that are commonly in use with the third party analytical laboratories Use of nonreadily available method will call into question the comparability of the data

Comment [c120]: SW8260B is the more commonly used method

Comment [c121]: Why is SW6010 or 6020 is not being used for metals

Comment [c122]: Add bromide to list, add CO3 and HCO3 to list, add MBAS to list, add Mn and Fe to list, lots missing from this list

Comment [c123]: See above comments about potential interference issues with this method on flow back or produced waters

Deleted:

Comment [c124]: The more common alcohols in a hydraulic stimulation fluid are ethanol and methanol

Table 2. Known constituents of the Hydraulic Fracturing Fluid Component use for the production well.

Active Ingredients	CAS Number	Chemical Formula	Use
		2 2	
		A 21	
		-	

Comment [C125]: The exact constituents used in the prospective study site's hydraulic fracturing fluid can not be provided at this time because technology is continuously improving and CHK uses the best available products at the time of completions However, MSDS disclosure sheets have been provided for 5 wells within a 5 mi radius of the study site for reference purposes

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Table 3. Tentative schedule of field activities for the Hydraulic Fracturing Prospective Case Study <u>Haynesville</u> Shale, <u>De Soto Parish, Lousiana</u>.

Media	Nov 2011	March	June	August	Nov	April	
		2012	2012	2012	2012	2013	
Groundwater	XXX	XXX	XXX	XXX	XXX	XXX	
Surface Water ¹	XXX	-	XXX	XXX		XXX	
Flowback				XXX			
Sediment			XXX		XXX	XXX	
Soil	2	XXX			XXX	XXX	

Deleted: Chesapeake input¶

- Comment [c126]: Finalize Land owner agreements 10/3/11 Complete monitoring well construction 11/15/11 Spud date 3/21/12 Begin pad construction 3-4 weeks prior to the spud date
- Well completion is typically 6 mo after spud date Production typically begins 2 mo after well
- EPA intends to sample for approximately 12 after production begins

Deleted: Marcellus

Deleted: Washington County, PA

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	PARAMETER	FY 1995 AVERAGE	FY 1998 AVERAGE	FY 2001 AVERAGE	FY 2004 AVERAGE	FY 2007 AVERAGE
	Temperature (^o C)	21.44	21.30	21 98	21.39	21.83
	pH (SU)	7.53	7.65	7.87	7.75	8.31
ELD	Specific Conductance (mmhos/cm)	0.676	0.732	0.808	0.80	0.740
π	Salinity (ppt)	0.35	0.36	0.40	0.39	0.36
	TDS (g/L)	223	2	14	0.520	0.480
	Alkalinity (mg/L)	267.2	251.5	249.4	273.5	283.4
	Chloride (mg/L)	59.2	71.6	69.7	66.5	66.4
	Color (PCU)	25.8	13.8	24.1	14.8	82
	Specific Conductance (umhos/cm)	726.4	772.4	748.1	799.5	739
7	Sulfate (mg/L)	30.1	30.5	28.7	26.6	13.1
OR	TDS (mg/L)	434.7	435.7	449.6	481.2	429.7
RAT	TSS (mg/L)	<4	4.9	<4	<4	<4
ő	Turbidity (NTU)	2.6	5.2	23	1.6	19
P	Ammonia, as N (mg/L)	0.42	0.64	0.64	0.81	0.63
	Hardness (mg/L)	52.4	42.2	31.3	41.0	33.5
	Nitrite - Nitrate, as N (mg/L)	0.08	0.07	0.07	0.07	0.10
	TKN (mg/L)	0.78	0.96	0.82	0.97	0.77
	Total Phosphorus (mg/L)	0.29	0.24	0.26	0.33	0.26

Table 4. Water Quality of the Carizzo-Wilcox Aquifer. Data from LDEQ 2009

Table 5. The physical characteristics of the monitoring wells near the proposed well pad.

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Monitoring Well	Screen Interval (ft)	Screen Length (ft)	Total Depth (ft)
MW-1	TBD	TBD	TBD
MW-2	TBD	TBD	TBD
MW-3	TBD	TBD	TBD
MW-4	TBD	TBD	TBD
MW-5	TBD	TBD	TBD
MW-6	TBD	TBD	TBD
MW-7	TBD	TBD	TBD
MW-8	TBD	TBD	TBD

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Table 6. Field parameter stabilization criteria and calibration standards.

Comment [c127]: Turbidity and temperature should be added Deleted: .

Parameter	Stabilization Criteria	Calibration Standards
pH	≤0.02 pH units min ⁻¹	pH 4, 7, and 10 buffers
Oxidation Reduction Potential (ORP)	$\leq 2 \text{mV min}^{-1}$	Zobells Solution
Specific Conductance (SC)	$\leq 1\% \text{ min}^{-1}$	1413 µS Conductivity Standard

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Table 7. Groundwater Field Analytical Methods

Parameter	Method	Equipment
Alkalinity	EPA Standard Method 2320B; HACH method 8203	HACH Model AL-DT Digital Titrator (or equivalent device)
Ferrous Fe	EPA Standard Method 3500-Fe B; HACH Method 8146	HACH DR890 Portable Colorimeter (or equivalent device)
Dissolved Sulfide	EPA Standard Method 4500-S ²⁻ D; HACH Method 8131	HACH DR890 Portable Colorimeter (or equivalent device)
Turbidity	EPA Standard Method 180.1	HACH 2100Q Portable Turbidity meter

Comment [c128]: The text indicates YSI meter, which is not identified in this table Calibration requirements should be provided Deleted: .

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Comment [c129]: Recommend to use promulgated methods and not SOPs if possible to be

Table 8. Ground and Surface Water	Sample Collection.
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able to replicate data if needed and use standardized methodology of proven methods I am not familiar Analysis Method Sample Bottles/# of with some of these unique methods Preservation/ Holding Sample Type (EPA Method) bottles* Storage Time(s) Comment [c130]: Add CO3, HCO3, MBAS, others-methanol, ethanol, etc , list appear to be incomplete RSKSOP-194v4 No Headspace 14 days &-175v5 60 mL serum bottles/2 TSP[†], pH>10; **Dissolved** gases refrigerate <6 C^{††} (No EPA Method) RSKSOP-213v4 6 months &-257v2 Metals 125 mL plastic bottle/1 HNO₃, pH<2 (Hg 28 (EPA Methods days) 200.7 and 6020) RSKSOP-276v3 SO4, C1, F, Br (EPA Method 60 mL plastic/1 Refrigerate < 6 C 28 days 6500) RSKSOP-276v3 H₂SO₄ pH<2; NO3 + NO2, NH4 (EPA Method 60 mL plastic/1 28 days Comment [c131]: Add TKN and ammonia refrigerate ≤6 €-6500) RSKSOP-330v0 40 mL clear glass VOA refrigerate <6 C DIC 14 days vial/2 RSKSOP-330v0 40 mL clear glass VOA 2- H3PO4, pH<2. DOC (EPA Method 28 days vial/4 2- refrigerate ≤6 C 9060A) No Headspace RSKSOP-299v1 40 mL amber glass Volatile organic (EPA Method TSP[†], pH>10; 14 days compounds (VOC) VOA vial/2 5021A+8260C) refrigerate <6 C RSKSOP-112v6 TSP[†], pH>10; Low Molecular 40 mL glass VOA vial/2 30 days (No EPA Weight Acids refrigerate 6 C Comment [c132]: It appears these are not Method) discussed in the text The intent of conducting this 1L Amber glass bottle/2 7 days until analysis is not understood and for every 10 extraction. No current EPA SW846 methods are widely used for samples of ground water ORGM-515 r1.1, 30 days the LC methods for glycols and low molecular Semi-volatile need 2 more bottles for weight acids Analyses by these methods can be provided but more widely accepted and validated (EPA Method Refrigerate <6 C after one selected sample, or organic compounds 8270D) extraction methodology (Ion Chromatography or Gas if <10 samples collected, Chromatography) should be considered collect 2 more bottles for one select sample 1L Amber glass bottle/2 7 days until and for every 10 extraction. samples of ground water ORGM-508 r1.0, 40 days need 2 more bottles for HC1, pH<2; DRO (EPA Method after refrigerate <6 C one selected sample, or 8015D) extraction if <10 samples collected, collect 2 more bottles for one select sample ORGM-506 r1.0, No Headspace 40 mL amber glass GRO (EPA Method HC1, pH<2; 14 days VOA vial/2 8015D) refrigerate <6 C

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1	Glycols	Region III method** (No EPA Method)	40 mL amber glass VOA vial/2	Refrigerate ≤6 C	14 days	Deleted: Gycols
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[†] trisodium phosphate ^{††}above freezing point of water

*Spare bottles made available for laboratory QC samples and for replacement of compromised

samples (broken bottle, QC failures, etc.).

**under development

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Table 9. Field QC Samples for Water Samples

Comment [c133]: Did not see discussion in report

QC Sample	Purpose	Method	Frequency	Acceptance Criteria/Corrective Action
Trip Blanks (VOAs and Dissolved Gases)	Assess contamination during transportation.	Fill bottles with reagent water and preserve, take to field and returned without opening.	One in each ice chest with VOA and dissolved gas samples.	<mdl; if="">MDL, PI will determine if significant relative to sample data.</mdl;>
Equipment Blanks	Assess contamination from field equipment, sampling procedures, sample container, preservative, and shipping.	Apply only to filtered samples: Reagent water is filtered and collected into bottles and preserved same as filtered samples.	One per day of sampling	<mdl; if="">MDL, PI will determine if significant relative to sample data.</mdl;>
Field Duplicates	Represent precision of field sampling, analysis, and site heterogeneity.	One or more samples collected immediately after original sample.	One in every 10 samples, or if <10 samples collected for a water type (ground or surface), collect a duplicate for one sample	Report duplicate data; PI will determine if significant relative to sample data.
Temperature Blanks	Measure temperature of samples in the cooler.	Water sample that is transported in cooler to lab.	One per cooler.	<u><</u> 4ºC
Field Blanks (not used for VOCs or dissolved gas samples)	Assess contamination introduced from sample container with applicable preservative.	In the field, reagent water is collected into sample containers with preservatives.	One taken with each equipment blank	<rl; if="">RL, PI will determine if significant relative to sample data.</rl;>

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Table 10. Region III Laboratory QA/QC Requirements for Glycols.

QC Туре	Performance Criteria	Frequency	
Method Blanks	<rl< td=""><td>One per every 20 samples</td><td></td></rl<>	One per every 20 samples	
Solvent Blanks	<rl< td=""><td>One per every 10 samples</td><td></td></rl<>	One per every 10 samples	
Initial and Continuing Calibration Checks	80-120% of expected value	At beginning of sample set, every tenth sample, and end of sample set	
Second Source Standards	80-120% of expected value	Each time calibration performed	
Laboratory Control Samples (LCS)	80-120% of expected value	One per analytical batch or every 20 samples, whichever is greater	
Matrix Spikes (MS)	70-130% of expected value	One per sample set or every 20 samples, whichever is more frequent	RL =
MS/MSD	RPD ≤ 25	One per sample set or every 20 samples, whichever is more frequent	rting Limit
			Corr

ective Actions: If any samples are affected by failure of a QC sample to meet its performance criteria, the problem shall be corrected and samples will be re-analyzed. If re-analysis is not possible (such as lack of sample volume), the data will be qualified with a determination as to impact on the sample data.

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Table 11. RSKERC Detection limits for various analytes

Deleted: .

Analyte	Method	MDL (µg L ⁻¹)	QL or LOQ (µg L ⁻¹)
VOCs			
		101210	
Vinyl chloride	RSKSOP-299v1	0.18	0.50
Ethanol	RSKSOP-299v1	18.0	100
1,1-Dichloroethene	RSKSOP-299v1	0.12	0.50
Acetone	RSKSOP-299v1	3.45	10.0
Isopropyl alcohol	RSKSOP-299v1	2.37	10.0
Carbon disulfide	RSKSOP-299v1	0.21	0.50
Methylene chloride	RSKSOP-299v1	0.21	1.00
t-Butyl alcohol	RSKSOP-299v1	2.41	10.0
Methyl t-butyl ether	RSKSOP-299v1	0.09	1.00
t-1,2-Dichloroethene	RSKSOP-299v1	0.10	0.50
1,1-Dichloroethane	RSKSOP-299v1	0.13	0.50
Diisopropyl ether	RSKSOP-299v1	0.11	1.00
Ethyl t-butyl ether	RSKSOP-299v1	0.08	1.00
c-1,2-Dichloroethene	RSKSOP-299v1	0.14	0.50
Chloroform	RSKSOP-299v1	0.13	0.50
1,1,1-Trichloroethane	RSKSOP-299v1	0.13	0.50
Carbon tetrachloride	RSKSOP-299v1	0.12	0.50
Benzene	RSKSOP-299v1	0.06	0.50
1,2-Dichloroethane	RSKSOP-299v1	0.21	0.50
t-Amyl methyl ether	RSKSOP-299v1	0.09	1.00
Trichloroethene	RSKSOP-299v1	0.09	0.50
Toluene	RSKSOP-299v1	0.08	0.50
1,1,2-Trichloroethane	RSKSOP-299v1	0.21	0.50
Tetrachloroethene	RSKSOP-299v1	0.13	0.50
Chlorobenzene	RSKSOP-299v1	0.08	0.50
Ethyl benzene	RSKSOP-299v1	0.06	0.50
m/p-Xylene	RSKSOP-299v1	0.09	1.00
o-Xvlene	RSKSOP-299v1	0.08	0.50
Isopropyl benzene	RSKSOP-299v1	0.05	0.50
1.3.5-Trimethylbenzene	RSKSOP-299v1	0.05	0.50
1,2,4-Trimethylbenzene	RSKSOP-299v1	0.05	0.50
1.3-Dichlorobenzene	RSKSOP-299v1	0.16	0.50
1.4-Dichlorobenzene	RSKSOP-299v1	0.17	0.50
1.2.3-Trimethylbenzene	RSKSOP-299v1	0.07	0.50
1.2-Dichlorobenzene	RSKSOP-299v1	0.10	0.50
Naphthalene	RSKSOP-299v1	0.31	1.00
		0101	1.00
Metals ICP-MS		MDL ($\mu g L^{-1}$)	QL or LOQ (µg L ⁻¹)
		10 /	
As	RSKSOP-257v2	0.050	0.167
Be	RSKSOP-257v2	0.005	0.015
Analyte	Method	$MDL (\mu g L^{-1})$	QL or LOQ (µg L ⁻¹)

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Cd	RSKSOP-257v2	0.020	0.067
Cr	RSKSOP-257v2	0.037	0.124
Cu	RSKSOP-257v2	0.287	0.957
Fe	RSKSOP-257v2	0.105	0.350
Hg	RSKSOP-257v2	0.019	0.064
Mn	RSKSOP-257v2	0.037	0.124
Мо	RSKSOP-257v2	0.008	0.027
Ni	RSKSOP-257v2	0.048	0.160
Pb	RSKSOP-257v2	0.043	0.143
Sb	RSKSOP-257v2	0.014	0.047
Se	RSKSOP-257v2	0.159	0.530
Sr	RSKSOP-257v2	0.012	0.040
Tl	RSKSOP-257v2	0.04	0.013
V	RSKSOP-257v2	0.003	0.010
Zn	RSKSOP-257v2	0.072	0.240
U	RSKSOP-257v2	0.002	0.007
Ce	RSKSOP-257v2	0.006	0.020
Metals ICP-OES		$MDL (mg L^{-1})$	QL or LOQ (mg L ⁻¹)
Na	RSKSOP-213v4	0.046	0.154
K	RSKSOP-213v4	0.029	0.097
Ca	RSKSOP-213v4	0.026	0.087
Mg	RSKSOP-213v4	0.013	0.044
Fe	RSKSOP-213v4	0.013	0.044
Mn	RSKSOP-213v4	0.001	0.004
Со	RSKSOP-213v4	0.001	0.004
Мо	RSKSOP-213v4	0.001	0.004
Al	RSKSOP-213v4	0.024	0.080
As	RSKSOP-213v4	0.007	0.024
Se	RSKSOP-213v4	0.007	0.024
Cd	RSKSOP-213v4	0.001	0.004
Be	RSKSOP-213v4	0.001	0.004
Cu	RSKSOP-213v4	0.002	0.007
Sb	RSKSOP-213v4	0.008	0.027
Cr	RSKSOP-213v4	0.001	0.004
Ni	RSKSOP-213v4	0.001	0.004
Zn	RSKSOP-213v4	0.005	0.017
Ag	RSKSOP-213v4	0.003	0.010
Tl	RSKSOP-213v4	0.009	0.030
Pb	RSKSOP-213v4	0.003	0.010
Sr	RSKSOP-213v4	0.001	0.004
Analyte	Method	$MDL (mg L^{-1})$	QL or LOQ (mg L ⁻¹)
V	RSKSOP-213v4	0.002	0.007

Comment [c134]: U and Ce are included in the table but not referenced in the body of the document What is the purpose of these two analytes? Also, U is included by both ICP and ICP-MS

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ва	KSKSOP-215V4	0.001	0.004
B	RSKSOP-213v4	0.005	0.017
Ti	RSKSOP-213v4	0.001	0.004
Si	RSKSOP-213v4	0.019	0.064
Р	RSKSOP-213v4	0.011	0.037
S	RSKSOP-213v4	0.026	0.087
U	RSKSOP-213v4	0.009	0.030
Dissolved Gases*		MDL ($ug L^{-1}$)	$OL \text{ or } LOO (\text{ug } L^{-1})$
Dissorred dases		MDD (kg D)	QL of Log (kg L)
Methane	RSKSOP-194v4 &	1.000	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
Fieulane	RSKSOP-175v5	0.08	1.5
Ethylong	RSKSOP-194v4 &		5
Ethylene	RSKSOP-175tr5	0.56	4.11
Ethana	PSKSOP 104:48		
Luiane	RSKSOP-175v5	0.20	2.91
Acotriono	PSKSOP 104v4 &	1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 -	1 Portanza A
Acetylene	RSKSOP-175v5	2	18.7
Carbon Diarrida	PSVSOD 104-48		
Carbon Dioxide	RSKSOP-1940400	20.4	262
Durana	PSVSOD 104-48-		
Propane	RSKSOP 175v5	0.24	4.1
Putana	RSKSOP 104 v4&		-
Butane	DSKSOP-194046	0.22	5.22
TT]	RSKSOP-175V5		
Hydrogen	RSK50P-194V4&	0.01	0.33
	K3K30F-175V5		-
DIC /DOC		MDI (mg I ⁻¹)	$OI \approx I OO (m \pi I^{-1})$
DIC/DOC		WIDL (Hig L)	QL & LOQ (Hg L)
Dag	BCKCOD 220-0	0.067	0.50
DOC	RSKSOP-330V0	0.067	0.50
DIC	KSKSOP-330V0	0.017	0.30
Anions		MDL (mg L ⁻)	QL or LOQ (mg L [*])
Br	RSKSOP-276v3	0.248	1.00
Cl-	RSKSOP-276v3	0.118	1.00
SO4 ²⁻	RSKSOP-276v3	0.226	1.00
NO ₂ -	RSKSOP-276v3	0.042	0.20
NO ₃ -	RSKSOP-276v3	0.032	0.20
F-	RSKSOP-276v3	0.052	0.20
Ammonia			
NH4 ⁺	FIA 10-107-06-1-A	0.012	0.05
Low Molecular Weight		Lenge of the	
Acids	Method	MDL (mg L [*])	$QL (mg L^{-})$
Lactate	RSKSOP-112v6	0 020	0 100
Ductato	101001-11210	0.020	0.100

DOLLOD ALL

Comment [c135]: For dissolved gases, acetylene is listed but not referenced in the body of the document

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F -

Isobutyrate	RSKSOP-112v6	0.018	0.100
Acetate	RSKSOP-112v6	0.011	0.100
Propionate	RSKSOP-112v6	0.022	0.100
Formate	RSKSOP-112v6	0.015	0.100
Butyrate	RSKSOP-112v6	0.025	0.100

*Aqueous concentrations are dependent on headspace volume, aqueous volume, temperature, pressure, etc. These limits were calculated based on a 60 mL bottle, 6 mL headspace, 25 degrees C, headspace pressure of 1 atm, and using the "created" headspace calculations.

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Table 12. Region VIII Detection and Reporting limits and LCS and MS control limits for semivolatile organic compounds (SVOC) using Method 8270.

Comment [c136]: For SVOC analyses, method 8270D – define the analytes d-Limonene through Tri(2-butoxyethyl)phosphate? Are these calibrated analytes or TIC's?

$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Applita	Detection Limit		Control	Control Limits			
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Analyte	Detection Limit	S					
1-Chloronaphthalene 1		DL (μg L ⁻¹)	RL (µg L ⁻¹)	Mean	Standard Deviation	Control Limit	Control Limit	
12-Dibromo-3-chloropropane 0.218 0.500 67.3 11.4 33 10 1.2-Dintrobenzene 0.218 0.500 67.3 11.4 33 10 1.2-Dintrobenzene 0.208 0.500 71.7 11.6 37 11 1.2-Tirchlorobenzene 0.208 0.500 71.7 11.6 37 10 1.2-A-Tirchlorobenzene 0.226 0.500 64.8 10.9 32 9 1.3-Dintrobenzene 0.225 0.500 64.8 10.9 32 9 1.4-Dichlorobenzene 0.225 0.500 64.8 10.9 32 9 1.4-Dintrobenzene 0.167 0.500 71.3 11.4 37 10 2-Chloronphthalene 0.167 0.500 71.3 11.4 37 10 2-Fluorobiphenyl (Surrogate) 0.190 0.500 75.0 9.5 46 10 2-Methylaphthalene 0.190 0.500 75.8 12.4 39 11	1-Chloronaphthalene							
1.2-Dichlorobenzene 0.218 0.500 67.3 11.4 33 10 1.2-Dichlorobenzene 0.218 0.500 71.7 11.6 37 11 1.2-Dichlorobenzene 0.208 0.500 71.7 11.6 37 11 1.2.4-57-Etachlorobenzene 0.208 0.500 64.8 10.9 32 9 1.3-Dichlorobenzene 0.225 0.500 64.8 10.9 32 9 1.4-Dichlorobenzene 0.225 0.500 64.8 10.9 32 9 1.4-Dichlorobenzene 0.225 0.500 64.8 10.9 32 9 1.4-Dichlorobenzene 0.167 0.500 - - - - 2-Chloronaphthalene 0.167 0.500 71.3 11.4 37 10 2-Fluorobiphenyl (Surrogate) - 63.7 14.8 19 10 2-Methylnaphthalene 0.190 0.500 73.3 11.7 38 10 2	1.2-Dibromo-3-chloropropane	-			a			
1,2-Dinitrobenzene 0.240 0.500 0.75 1.17 0.550 1.17 0.550 1.17 1.55 1.17 1,2-Dinitrobenzene 0.208 0.500 71.7 11.6 37 11 1,2,4,5-Tetrachlorobenzene 0.208 0.500 71.7 11.6 37 11 1,3-Dichlorobenzene 0.226 0.500 64.8 10.9 32 9 1,4-Dichlorobenzene 0.225 0.500 64.8 10.9 32 9 1,4-Dichlorobenzene 0.225 0.500 64.8 10.9 32 9 1,4-Dichlorobenzene 0.167 0.500 71.3 11.4 37 10 2-Chlorophenol 0.243 0.500 71.3 11.4 37 10 2-Fluorophenol (Surrogate) 63.7 14.8 19 10 2-Methylaphthalene 0.190 0.500 73.3 11.7 38 10 2-Mitrophenol 0.118 0.500 75.8 12.4	1.2-Dichlorobenzene	0.218	0.500	67.3	11.4	33	102	
1,2-Diphenylhydrazine 84.8 9.4 57 11 1,2-A-Trichlorobenzene 0.208 0.500 71.7 11.6 37 10 1,2-A-Trichlorobenzene 0.226 0.500 64.8 10.9 32 9 1,3-Dichlorobenzene 0.226 0.500 64.8 10.9 32 9 1,4-Dichlorobenzene 0.225 0.500 64.8 10.9 32 9 1,4-Dichlorobenzene 0.225 0.500 64.8 10.9 32 9 1,4-Dinitrobenzene 0.225 0.500 64.8 10.9 32 9 1,4-Dinitrobenzene 0.167 0.500 71.3 11.4 37 10 2-Chlorophenol 0.243 0.500 71.3 11.4 37 10 2-Fluorophenol (Surrogate) 63.7 14.8 19 10 2-Methylaphthalene 0.190 0.500 75.0 9.5 46 10 2-Methylaphenol 0.217 0.500	1.2-Dinitrobenzene	0.210	0.500	01.5	11.1	55	102	
1,2,4-Trichlorobenzene 0.208 0.500 71.7 11.6 37 11 1,2,4-Trichlorobenzene 0.208 0.500 71.7 11.6 37 10 1,3-Dichlorobenzene 0.226 0.500 64.8 10.9 32 9 1,4-Dichlorobenzene 0.225 0.500 64.8 10.9 32 9 2-Chlorophenol 0.243 0.500 71.3 11.4 37 10 2-Fluorobhenol (Surrogate) 0.190 0.500 75.0 9.5 46 10 2-Methylaphthalene 0.190 0.500 73.3 11.7 38 10 2-Methylaphenol 0.217 0.500 75.8 12.4 39 11	1.2-Dinhenvlhydrazine	1		84.8	94	57	113	
1,2,4,5-Tetrachlorobenzene 0.500 111 1100 111 1,2,4,5-Tetrachlorobenzene 0.226 0.500 64.8 10.9 32 9 1,3-Dichlorobenzene 0.225 0.500 64.8 10.9 32 9 1,4-Dichlorobenzene 0.225 0.500 64.8 10.9 32 9 1,4-Dichlorobenzene 0.225 0.500 71.3 11.4 37 10 2-Chloronaphthalene 0.167 0.500 71.3 11.4 37 10 2-Chlorophenol (Surrogate) 79.9 10.6 48 11 2-Fluorobiphenyl (Surrogate) 63.7 14.8 19 10 2-Methylaphthalene 0.190 0.500 75.0 9.5 46 10 2-Nitroanline 0.118 0.500 75.8 12.4 39 11 2.4-Dichlorophenol 0.185 0.500 75.8 12.4 39 11 2,4-Dinitrophenol 0.185 0.500 75.8	1.2.4-Trichlorobenzene	0.208	0.500	717	11.6	37	107	
1.3Dichlorobenzene 0.226 0.500 64.8 10.9 32 9 1.3-Dichlorobenzene 0.225 0.500 64.8 10.9 32 9 1.4-Dichlorobenzene 0.225 0.500 64.8 10.9 32 9 1.4-Dinitrobenzene 0.225 0.500 64.8 10.9 32 9 1.4-Dinitrobenzene 0.167 0.500	1.2.4.5-Tetrachlorobenzene	0.200	0.500	11.1	11.0	51	107	
1,3-Dinitrobenzene 0.300 0.300 0.300 0.30 0.300 <th0.300< th=""> 0.300 0.300</th0.300<>	1.3-Dichlorobenzene	0.226	0 500	64.8	10.9	32	98	
1.4-Dichlorobenzene 0.225 0.500 64.8 10.9 32 9 1.4-Dichlorobenzene 0.225 0.500 64.8 10.9 32 9 2-Chloronaphthalene 0.167 0.500 2-Chlorophenol 0.243 0.500 71.3 11.4 37 10 2-Fluorobiphenyl (Surrogate) 79.9 10.6 48 11 2-Fluorophenol (Surrogate) 63.7 14.8 19 10 2-Methylnaphthalene 0.190 0.500 75.0 9.5 46 10 2-Methylphenol 0.217 0.500 73.3 11.7 38 10 2-Nitrophenol 0.197 0.500 75.8 12.4 39 11 2.3,4,6-Tetrachlorophenol 0.185 0.500 76.3 9.6 48 10 2.4-Dinitrophenol 0.142 0.500 78.8 20.6 14 13 2.4.5-Trichlorophenol 0.151 0.500	1 3-Dinitrobenzene	0.220	0.000	01.0	10.5	52		
1,4-Dinitrobenzene 0.100 </td <td>1 4-Dichlorobenzene</td> <td>0.225</td> <td>0.500</td> <td>64.8</td> <td>10.9</td> <td>32</td> <td>98</td>	1 4-Dichlorobenzene	0.225	0.500	64.8	10.9	32	98	
2. Chloronaphthalene 0.167 0.500	1 4-Dinitrobenzene	0.225	0.500	01.0	10.5	32	70	
2 - Chlorophenol 0.107 0.500 71.3 11.4 37 10 2-Chlorophenol 0.243 0.500 71.3 11.4 37 10 2-Fluorobiphenyl (Surrogate) 63.7 14.8 19 10 2-Huorophenol (Surrogate) 63.7 14.8 19 10 2-Methylaphthalene 0.190 0.500 75.0 9.5 46 10 2-Methylaphthalene 0.118 0.500 73.3 11.7 38 10 2-Methylphenol 0.118 0.500 81.8 11.2 48 11 2-Nitroaniline 0.1197 0.500 75.8 12.4 39 11 2,3.4,6-Tetrachlorophenol 0.185 0.500 76.3 9.6 48 10 2,4-Dinitrophenol 0.142 0.500 75.8 20.6 14 13 2,4-Dinitrophenol 0.151 0.500 79.7 10.3 49 11 2,4,5-Trichlorophenol 0.156 0.500	2-Chloronaphthalene	0.167	0.500		2		-	
2 - Filorobiphenyl (Surrogate) 79.9 10.6 48 11 2-Fluorobiphenyl (Surrogate) 63.7 14.8 19 10 2-Fluorobiphenyl (Surrogate) 63.7 14.8 19 10 2-Methylnaphthalene 0.190 0.500 75.0 9.5 46 10 2-Methylphenol 0.217 0.500 73.3 11.7 38 10 2-Nitroaniline 0.118 0.500 75.8 12.4 39 11 2,3,4,6-Tetrachlorophenol 0.197 0.500 76.3 9.6 48 10 2,4-Dichlorophenol 0.185 0.500 76.3 9.6 48 10 2,4-Dinitrophenol 0.142 0.500 68.8 13.5 28 10 2,4-Dinitrophenol 0.151 0.500 79.7 10.3 49 11 2,4,5-Trichlorophenol 0.151 0.500 79.7 10.3 49 11 2,4,6-Tribromophenol (Surrogate) 82.9 13.6 42	2-Chlorophenol	0.243	0.500	713	11.4	37	106	
2-Fluorophenol (Surrogate) 63.7 14.8 19 10 2-Fluorophenol (Surrogate) 63.7 14.8 19 10 2-Methylnaphthalene 0.190 0.500 75.0 9.5 46 10 2-Methylphenol 0.217 0.500 73.3 11.7 38 10 2-Methylphenol 0.118 0.500 81.8 11.2 48 11 2-Nitrophenol 0.197 0.500 75.8 12.4 39 11 2,3,4,6-Tetrachlorophenol 0.185 0.500 76.3 9.6 48 10 2,4-Dinklorophenol 0.142 0.500 68.8 13.5 28 10 2,4-Dinitrophenol 2.00 2.00 75.8 20.6 14 13 2,4-Dinitrophenol 0.151 0.500 79.7 10.3 49 11 2,4,5-Trichlorophenol 0.166 0.500 80.7 10.7 49 11 2,4,6-Trichlorophenol 0.166 0.500	2-Eluorobinhenvl (Surrogate)	0.215	0.500	79.9	10.6	48	112	
2-Methylaphthalene 0.190 0.500 75.0 9.5 46 10 2-Methylaphthalene 0.190 0.500 75.0 9.5 46 10 2-Methylaphthalene 0.217 0.500 73.3 11.7 38 10 2-Methylaphthalene 0.118 0.500 81.8 11.2 48 11 2-Nitrophenol 0.197 0.500 75.8 12.4 39 11 2,3,4,6-Tetrachlorophenol 0.185 0.500 76.3 9.6 48 10 2,4-Dinklorophenol 0.142 0.500 68.8 13.5 28 10 2,4-Dinitrophenol 2.00 2.00 75.8 20.6 14 13 2,4-Dinitrophenol 0.151 0.500 79.7 10.3 49 11 2,4,5-Trichlorophenol 0.166 0.500 80.7 10.7 49 11 2,4,6-Trichlorophenol 0.166 0.500 80.7 10.7 49 11	2-Fluorophenol (Surrogate)	6		637	14.8	19	108	
2-Methylphenol 0.130 0.130 13.5 13.6 14.7 2-Methylphenol 0.217 0.500 73.3 11.7 38 10 2-Nitroaniline 0.118 0.500 81.8 11.2 48 11 2-Nitrophenol 0.197 0.500 75.8 12.4 39 11 2.3,4,6-Tetrachlorophenol 0.185 0.500 76.3 9.6 48 10 2,4-Dichlorophenol 0.142 0.500 68.8 13.5 28 10 2,4-Dinitrophenol 0.142 0.500 68.8 13.5 28 10 2,4-Dinitrophenol 0.086 0.500 84.3 11.2 51 11 2,4,5-Trichlorophenol 0.151 0.500 79.7 10.3 49 11 2,4,6-Tribromophenol (Surrogate) 82.9 13.6 42 12 2,4,6-Trichlorophenol 0.166 0.500 80.7 10.7 49 11 2,6-Dinitrotoluene 0.091 <td>2-Methylnanhthalene</td> <td>0.190</td> <td>0.500</td> <td>75.0</td> <td>95</td> <td>46</td> <td>104</td>	2-Methylnanhthalene	0.190	0.500	75.0	95	46	104	
2-Nitroaniline 0.117 0.118 0.100 81.8 11.2 48 11 2.3.4.6-Tetrachlorophenol 0.185 0.500 76.3 9.6 48 100 2.4-Dinitrophenol 0.142 0.500 68.8 13.5 2.8 100 2.4.5-Trichlorophenol 0.086 0.500 84.3 11.2 51 111 2.4.6-Tribromophenol (Surrogate) 82.9 13.6 42 12 2.4.6-Trichlorophenol 0.166 0.500 80.7 10.7 49 11	2-Methylphenol	0.217	0.500	73.3	11.7	38	109	
2-Nitronhenol 0.197 0.500 75.8 12.4 39 11 2,3,4,6-Tetrachlorophenol 0.197 0.500 75.8 12.4 39 11 2,4-Dichlorophenol 0.185 0.500 76.3 9.6 48 10 2,4-Dichlorophenol 0.142 0.500 68.8 13.5 28 10 2,4-Dimitrophenol 0.142 0.500 68.8 13.5 28 10 2,4-Dimitrophenol 2.00 2.00 75.8 20.6 14 13 2,4-Dinitrotoluene 0.086 0.500 84.3 11.2 51 11 2,4,5-Trichlorophenol 0.151 0.500 79.7 10.3 49 11 2,4,6-Tribromophenol (Surrogate) 82.9 13.6 42 12 2,4,6-Trichlorophenol 0.166 0.500 80.7 10.7 49 11 2,6-Dinitrotoluene 0.091 0.500 71.3 13 32 11 3-Obihlorophenol <td>2-Nitroaniline</td> <td>0.118</td> <td>0.500</td> <td>81.8</td> <td>11.2</td> <td>48</td> <td>115</td>	2-Nitroaniline	0.118	0.500	81.8	11.2	48	115	
2.3,4,6-Tetrachlorophenol 0.101 0.	2-Nitrophenol	0 197	0 500	75.8	12.4	39	113	
2,4-Dichlorophenol 0.185 0.500 76.3 9.6 48 10 2,4-Dichlorophenol 0.142 0.500 68.8 13.5 28 10 2,4-Dinitrophenol 2.00 2.00 75.8 20.6 14 13 2,4-Dinitrophenol 2.00 2.00 75.8 20.6 14 13 2,4-Dinitrotoluene 0.086 0.500 84.3 11.2 51 11 2,4,5-Trichlorophenol 0.151 0.500 79.7 10.3 49 11 2,4,6-Tribromophenol (Surrogate) 82.9 13.6 42 12 2,4,6-Trichlorophenol 0.166 0.500 80.7 10.7 49 11 2,6-Dichlorophenol 82.7 11.3 49 11 2,6-Dinitrotoluene 0.091 0.500 - - 3-Methylphenol 0.189 0.500 71.3 13 32 11 3.Nitroaniline 0.394 0.500 72.6 17.7 19 12 3,3'Dichlorobenzidine 65.2 15.3 19	2 3 4 6-Tetrachlorophenol		0.000	10.0	-2.1			
2,4-Dimethylphenol 0.142 0.500 68.8 13.5 28 10 2,4-Dimitrophenol 2.00 2.00 75.8 20.6 14 13 2,4-Dimitrophenol 2.00 2.00 75.8 20.6 14 13 2,4-Dimitrotoluene 0.086 0.500 84.3 11.2 51 11 2,4,5-Trichlorophenol 0.151 0.500 79.7 10.3 49 11 2,4,6-Tribromophenol (Surrogate) 82.9 13.6 42 12 2,4,6-Trichlorophenol 0.166 0.500 80.7 10.7 49 11 2,6-Dichlorophenol 0.166 0.500 80.7 11.3 49 11 2,6-Dinitrotoluene 0.091 0.500 71.3 13 32 11 3-Methylphenol 0.189 0.500 71.3 13 32 11 3.Witroaniline 0.394 0.500 72.6 17.7 19 12 3.7-Dichlorobenzidine 0.500 82.9 10.0 52 11	2.4-Dichlorophenol	0 185	0 500	763	96	48	105	
2.4-Dinitrophenol 2.00 2.00 75.8 20.6 14 13 2.4-Dinitrotoluene 0.086 0.500 84.3 11.2 51 11 2.4.5-Trichlorophenol 0.151 0.500 79.7 10.3 49 11 2.4.6-Tribromophenol (Surrogate) 82.9 13.6 42 12 2.4.6-Trichlorophenol 0.166 0.500 80.7 10.7 49 11 2.6-Dichlorophenol 0.166 0.500 80.7 10.7 49 11 2.6-Dinitrotoluene 0.091 0.500 71.3 13 32 11 3-Methylphenol 0.189 0.500 71.3 13 32 11 3.'Mitroaniline 0.394 0.500 72.6 17.7 19 12 3.'Dichlorobenzidine 65.2 15.3 19 11	2 4-Dimethylphenol	0.142	0.500	68.8	13.5	28	109	
2,4-Dinitrotoluene 0.086 0.500 84.3 11.2 51 11 2,4,5-Trichlorophenol 0.151 0.500 79.7 10.3 49 11 2,4,6-Trichlorophenol 0.151 0.500 79.7 10.3 49 11 2,4,6-Trichlorophenol 0.166 0.500 80.7 10.7 49 11 2,6-Dichlorophenol 0.166 0.500 80.7 10.7 49 11 2,6-Dinitrotoluene 0.091 0.500 82.7 11.3 49 11 2,6-Dinitrotoluene 0.091 0.500 32 11 3-Methylphenol 0.189 0.500 71.3 13 32 11 3,3'Dichlorobenzidine 0.394 0.500 72.6 17.7 19 12 3,3'Dichlorobenzidine 0.500 82.9 10.2 52 11	2.4-Dinitrophenol	2.00	2.00	75.8	20.6	14	138	
2,4,5-Trichlorophenol 0.151 0.500 79.7 10.3 49 11 2,4,6-Tribromophenol (Surrogate) 82.9 13.6 42 12 2,4,6-Trichlorophenol 0.166 0.500 80.7 10.7 49 11 2,4,6-Trichlorophenol 0.166 0.500 80.7 10.7 49 11 2,6-Dichlorophenol 0.091 0.500 82.7 11.3 49 11 2,6-Dinitrotoluene 0.091 0.500 71.3 13 32 11 3-Methylphenol 0.189 0.500 71.3 13 32 11 3-Nitroaniline 0.394 0.500 72.6 17.7 19 12 3,3'-Dichlorobenzidine 0.108 0.500 82.9 10.2 52 11	2 4-Dinitrotoluene	0.086	0 500	843	11.2	51	118	
2,4,6-Tribromophenol (Surrogate) 82.9 13.6 42 12 2,4,6-Tribromophenol (Surrogate) 82.9 13.6 42 12 2,4,6-Trichlorophenol 0.166 0.500 80.7 10.7 49 11 2,6-Dichlorophenol 82.7 11.3 49 11 2,6-Dinitrotoluene 0.091 0.500 13 13 32 11 3-Methylphenol 0.189 0.500 71.3 13 32 11 3-Nitroaniline 0.394 0.500 72.6 17.7 19 12 3,3'-Dichlorobenzidine 0.108 0.500 82.9 10.2 52 11	2.4.5-Trichlorophenol	0.151	0 500	79.7	10.3	49	111	
2,4,6-Trichlorophenol 0.166 0.500 80.7 10.7 49 11 2,6-Dichlorophenol 82.7 11.3 49 11 2,6-Dinitrotoluene 0.091 0.500 82.7 11.3 49 11 2,6-Dinitrotoluene 0.091 0.500 71.3 13 32 11 3-Methylphenol 0.189 0.500 71.3 13 32 11 3-Nitroaniline 0.394 0.500 72.6 17.7 19 12 3,3'-Dichlorobenzidine 65.2 15.3 19 11 4. Brownewny phenyl ather 0.108 0.500 82.9 10.2 52 11	2.4.6-Tribromophenol (Surrogate)	0.101	0.500	82.9	13.6	42	124	
2,6-Dichlorophenol 82.7 11.3 49 11 2,6-Dinitrotoluene 0.091 0.500	2.4.6-Trichlorophenol	0.166	0.500	80.7	10.7	49	113	
2,6-Dinitrotoluene 0.091 0.500 111 122 3-Methylphenol 0.189 0.500 71.3 13 32 11 3-Nitroaniline 0.394 0.500 72.6 17.7 19 12 3,3'-Dichlorobenzidine 65.2 15.3 19 11	2.6-Dichlorophenol			82.7	11.3	49	117	
3-Methylphenol 0.189 0.500 71.3 13 32 11 3-Nitroaniline 0.394 0.500 72.6 17.7 19 12 3,3'-Dichlorobenzidine 65.2 15.3 19 11 4. Bromohewul phanul ather 0.108 0.500 82.9 10.2 52 11	2.6-Dinitrotoluene	0.091	0.500					
3-Nitroaniline 0.394 0.500 72.6 17.7 19 12 3,3'-Dichlorobenzidine 65.2 15.3 19 11 4. Brombewul phenul ether 0.108 0.500 82.9 10.2 52 11	3-Methylphenol	0.189	0.500	71.3	13	32	110	
3,3'-Dichlorobenzidine 65.2 15.3 19 11 A Bromonbewil phanul ather 0.108 0.500 82.9 10.2 52 11	3-Nitroaniline	0 394	0 500	72.6	17.7	19	126	
4 Bromonhenvil abenvil atter 0.108 0.500 92.0 10.2 52 11	3.3'-Dichlorobenzidine			65.2	15.3	19	111	
	4-Bromophenyl phenyl ether	0.108	0.500	82.9	10.2	52	113	
4-Chloroaniline 0.546 1.00 62.2 15.6 15 10	4-Chloroaniline	0.546	1.00	62.2	15.6	15	109	
4-Chloro-3-methylphenol 0.165 0.500 78.6 10.7 47 11	4-Chloro-3-methylphenol	0.165	0.500	78.6	10.7	47	111	
4-Chlorophenyl phenyl ether 0.120 0500 80.6 10.3 50 11	4-Chlorophenyl phenyl ether	0.120	0500	80.6	10.3	50	111	
4-Methylphenol 0.189 0.500 71.3 13.0 32 11	4-Methylphenol	0.189	0.500	71.3	13.0	32	110	
4-Nitroaniline 0.320 0.500 77.2 13.7 36 11	4-Nitroaniline	0.320	0.500	77.2	13.7	36	118	
4-Nitrophenol 0.085 0.500	4-Nitrophenol	0.085	0.500					

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4,4'-DDD						
4,4'-DDE						
4,4'-DDT						
4,4'-Methylenebis (2-						
chloroaniline)						
4,4'-Methylenebis						
(N,Ndimethylaniline)						
4,6-Dinitro-2-methylphenol	0.202	0.500	84.9	15.0	40	130
Acenaphthene	0.147	0.500	77.6	10.1	47	108
Acenaphthylene	0.139	0.500	78.5	9.4	40	107
Acetophenone						
Aldrin						
Aniline						
Anthracene	0.088	0.500	83.0	9.7	54	112
Azinphos-methyl						
Azobenzene	0.102	0.500				
Benzoic acid						
Benz(a)anthracene	0.079	0.500	82.7	8.9	56	109
Benzo(b)fluoranthene	0.081	0.500	81.8	12.1	45	118
Benzo(k)fluoranthene	0.088	0.500	84.6	13.2	45	124
Benzo(g,h,i)perylene	0.098	0.500	80.5	14.1	38	123
Benzo(a)pyrene	0.083	0.500	81.3	9.5	53	110
Benzyl alcohol			71.0	13.8	30	112
α-BHC						
β-BHC						
δ-BHC						
γ-BHC (Lindane)						
Bis(2-chloroethoxy)methane	0.183	0.500	76.2	10.2	46	107
Bis(2-chloroethyl) ether	0.238	0.500	73.3	12.3	37	110
Bis(2-chloroisopropyl) ether	0.426	0.500	78.2	17.5	26	131
Bis(2-ethylhexyl) phthalate	0.500	1.00	84.2	14.0	42	126
Butyl benzyl phthalate	0.190	0.500	81.1	11.7	46	116
Carbaryl						
Carbazole	0.084	0.500	82.5	11.4	48	117
Chlorobenzilate						
Chrysene	0.079	0.500	82.1	8.9	55	109
Dibenz(a,h)anthracene	0.110	0.500	84.7	14.1	42	127
Dibenzofuran	0.133	0.500	80.3	8.8	54	107
Di-n-butyl phthalate	0.153	0.500				
Dichlorovos						
Dieldrin						
Diethyl phthalate	0.099	0.500	79.2	12.9	41	118
Dimethyl phthalate	0.107	0.500	75.9	16.9	25	127
Dinoseb						
Diphenylamine						
Di-n-butyl phthalate			84.8	10.3	54	116
Di-n-octyl phthalate	0.188	0.500	87.4	16.6	37	137
Disulfoton						
Endosulfan I	1					

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E 1 16 H	-					1	1
Endosulfan II						-	4
Endosultan sultate							4
Endrin	-					-	-
Endrin aldehyde							-
Endrin ketone							-
Fluoranthene	0.094	0.500	85.2	10.4	54	116	
Fluorene	0.120	0.500	80.6	10.3	50	112	-
Heptachlor	2	5					
Heptachlor epoxide						0.000	
Hexachlorobenzene	0.116	0.500	82.3	10.0	52	112	
Hexachlorobutadiene	0.225	0.500	65.2	12.6	27	103	
Hexachlorocyclopentadiene	0.202	0.500					
Hexachloroethane	0.196	0.500	60.9	11.1	28	94	
Indeno(1,2,3-cd)pyrene	0.093	0.500	84.3	13.6	43	125	
Isophorone	0.167	0.500	81.0	10.5	50	112	
Malathion							Deleted: athion
Methoxychlor							
Mevinphos		х					
Naphthalene	0.212	0.500	70.8	10.5	39	102	
Nitrobenzene	0.233	0.500	76.8	10.8	44	109	
Nitrobenzene-d5 (Surrogate)			76.0	11.8	41	111	
N-Nitrosodi-n-butylamine	0.187	0.500		i i		8	
N-Nitrosodiethylamine	2						
N-Nitrosodimethylamine			67.9	41.1	26	110	
N-Nitrosodiphenylamine			79.6	10.6	48	111	
N-Nitrosodi-n-propylamine			80.9	15.7	34	128	1
N-Nitrosomethylethylamine		í í		i i			
Parathion							
Pentachlorobenzene							1
Pentachlorophenol	0.199	0.500	77.6	13.3	38	117	1
Phenanthrene	0.107	0.500	84.0	11.0	51	117	1
Phenol	0.246	0.500					
Phorate							1
Pronamide							
Pyrene	0.087	0.500	88.6	13.2	49	128	1
Pyridine	2						
Terbufos	2	2					
Terphenyl-d14 (Surrogate)			92.7	14.0	51	135	1
Trifluralin							1
®-(+)-Limonene	0.054	0.100					
1,3-Dimethyl adamantine	0.028	0.100					
2-Butoxyethanol	0.054	0.100					
Adamantane	0.033	0.100					1
Squalene	0.565	1.00					1
Terpiniol	0.031	0.100					
Tri(2-butoxyethyl)phosphate	0.133	0,200					1
		0.200					1
GRO	$MDL (ug L^{-1})$	MRL (ug L ⁻¹)				·	
		(PB D)					4

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Benzene	1.0	1.0		
Bromofluorobenzene	0.05	1.0		
Ethyl benzene	1.0	1.0		
m,p-Xylene	2.0	2.0		
Methyl tert-butyl ether	1.0	1.0		
Naphthalene	2.0	2.0		
0-Xylene	1.0	1.0		
Toluene	2.0	2.0		
TPH as gasoline	20.0	20.0		

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Measurement	Analysis Method	Blanks (Frequency)	Calibration Checks (Frequency)	Second Source (Frequency)	Duplicates (Frequency)	Matrix Spikes (Frequency)
Dissolved gases	RSKSOP- 194v4 &- 175v5*	MDL (He blank, first and last in sample queue; water blank before samples)	85-115% of known value (After helium blank at first of analysis queue, before helium blank at end of sample set, and every 15 samples)	85-115% of known value (After first calibration check)	(Every 15 samples)	NA
Metals	RSKSOP- 257v2 &213v4 EPA Method 200.7 EPA Method 6020	<ql for<br="">80% of metals; none >10x MDL (Beginning and end of each sample queue)</ql>	90-110% of known value (Beginning and end of each sample queue, 10-15 samples)	PE sample acceptance limits or 90- 110% of known value (Immediately after first calibration check)	RPD<20 for 80% of metals (Every 15 samples)	90-110% Rec. for 80% of metals w/ no individual exceeding 70-130% Rec.
SO ₄ , Cl, F	RSKSOP- 276v3	<mdl (Beginning and end of each sample queue)</mdl 	90-110% Rec. (Beginning, end, and every 10 samples)	PE sample acceptance limits (One per sample set)	RPD<10 (every 15 samples)	80-120% Rec. (one per every 20 samples)
NO ₃ + NO ₂ , NH ₄	RSKSOP- 276v3	<1/2 lowest calib. std. (Beginning and end of each sample queue)	90-110% Rec. (Beginning, end, and every 10 samples)	PE sample acceptance limits (One per sample set)	RPD<10 (every 10 samples)	80-120% Rec. (one per every 20 samples)
DIC/DOC	RSKSOP- 330v0	(after initial calib., every 10-15 samples, and at end)	80-120% of known value (after initial calib., every 10-15 samples, and at end)	80-120% of known value (Immediately after calibration)	RPD<10 (every 15 samples)	80-120% Rec. (one per 20 or every set
Volatile organic compounds (VOQ**	RSKSOP- 299v1	<mdl (Beginning and end of</mdl 	80-120% Rec. (Beginning, end, and every	80-120% of known value (Immediately	RPD<20 (every 20 samples)	70-130% Rec. (every 20 samples)

Table 13. RSKERC Laboratory QA/QC Requirements Summary^{*} from SOPs.

Comment [c137]: For the VOC and SVOC analyses by comparable 8260C or 8270D methods, no tuning requirements or 12 hour clocks are listed in the QC requirements Also, requires continuing calibration checks at beginning AND end of analyses? 12 hour tuning clock referenced? Deleted:)**

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	each sample	20 samples)	after	
	set)		calibration)	
*				 -

*This table only provides a summary; SOPs should be consulted for greater detail. **Surrogate compounds spiked at 100 ug/L: p-bromofluorobenzene and 1,2dichlorobenzene-d4, 85-115% recovery. Corrective actions are outlined in the SOPs. MDL = Method Detection Limit QL = Quantitation Limit

PE = Performance Evaluation

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QC Type	Semivolatiles	DRO	GRO	Frequency
Method Blanks	<rl< td=""><td><rl< td=""><td><rl< td=""><td>One per sample set</td></rl<></td></rl<></td></rl<>	<rl< td=""><td><rl< td=""><td>One per sample set</td></rl<></td></rl<>	<rl< td=""><td>One per sample set</td></rl<>	One per sample set
Solvent blanks	<rl< td=""><td><rl< td=""><td>NA</td><td>One per sample set</td></rl<></td></rl<>	<rl< td=""><td>NA</td><td>One per sample set</td></rl<>	NA	One per sample set
Surrogate Spikes	60-130% of expected value	60-140% of expected value	70-130% of expected value	Every field and QC sample
Initial and Continuing Calibration Checks	80-120% of expected value	80-120% of expected value	80-120% of expected value	At beginning of sample set, every tenth sample, and end of sample set
Second Source Standards	80-120% of expected value	80-120% of expected value	80-120% of expected value	Each time calibration performed
Laboratory Control Samples (LCS)	Statistical Limits from DoD LCS Study (See Table 12)	70-130% of expected value	Values of all analytes in the LCS should be within the limits determined by the supplier.	One per analytical batch or every 20 samples, whichever is greater
Matrix Spikes (MS)	Same as LCS	Same as LCS	70-130% Recovery	One per sample set or every 20 samples, whichever is more frequent
MS/MSD	RPD ≤ 20	RPD ≤ 25	RPD ≤ 25	One per sample set or every 20 samples, whichever is more frequent
Reporting Limits*	$0.1 \ \mu g/L \ (generally)^1$	20 μg/L ¹	20 µg/L ²	NA

Table 14. Region VIII Laboratory QA/QC Requirements for Semivolatiles, GRO, DRO.

¹Based on 1000 mL sample to 1 mL extract ²Based on a 5 mL purge

*see Table 12

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Table 15. Region III Detection and Reporting limits for glycols.

Analyte [‡]	Detection Limit $(\mu g L^{-1})^{\dagger}$	Reporting Limit $(\mu g L^{-1})^{\dagger}$
2-butoxyethanol	NA	NA
diethylene glycol	NA	NA
triethylene glycol	NA	NA
tetraethylene glycol	NA	NA

^{*} Detection and reporting limits are still being determined, most will be between 10 and 50 pbb. ^{*} The samples are analyzed according to OASQA On Demand Procedures- See the QA manual for procedures. See Section 13.1.4.2 Procedure for Demonstration of Capability for "On-Demand" Data (Metzger et al., 2011)

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Table 16. Supplies or consumables needed not listed in SOPs

Vendor Item Part Number Buffer Solution, pH 4 SB101-500 **Fisher Scientific** SB108-500 Buffer Solution, pH 7 **Fisher Scientific** Buffer Solution, pH 10 Fisher Scientific SB115-500 Conductivity Standard, 1413µmho 15-077-951 **Fisher Scientific** Zobell Solution **Fisher Scientific** 15-176-222 15-500-039 **Oakton DO Probe Membranes Fisher Scientific** Bromcresol Green-Methyl Red Indicator HACH 94399 Sulfuric Acid Cartridges, 0.1600N HACH 1438801 1438901 HACH Sulfuric Acid Cartridges, 1.600N **Delivery Tubes for Digital Titrator** HACH 1720500 Iron, Ferrous Reagent HACH 103769 Sulfide 1 Reagent HACH 181632 Sulfide 2 Reagent HACH 181732 POL DO cap Memebrane Kit/ Electrolyte YSI 605307 Solution 77050009 Silicone Tubing, size 24 Fondriest Environmental 77050011 Silicone Tubing, size 36 Fondriest Environmental Polyethylene Tubing 0.25" ID x 0.375" Fondriest Environmental 77050502 OD Polyethylene Tubing 0.375" ID x 0.50" Fondriest Environmental 77050503 OD

*Equivalent products from other vendors can be used if needed.

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7.0 Figures



Figure 1. Organizational chart for the Hydraulic Fracturing Prospective Case Study, Desoto Parish, LA

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Figure 2. EPA HF Study Well Location Map

- Figure 3. Existing Water supply, Oil/Gas wells, and Proposed Monitoring Wells Map
- Figure 4. Proposed soil Sample Locations
- Figure 5. Open Tube Sampling Method

Figure 6. Closed Piston Sampling Method

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n D	Project:	Location: Project Manager/Ph	Shipping Method:	Shipping Tracking 1		Sample Number		Relinguished By: 1	Received By:	Comments:	Relinquished By:]	Received By:	Comments:

Figure 7. Chain of Custody form for submittal of samples to R.S. Kerr Environmental Research Center.

Comment [c139]: Would recommend a "premade/preprinted" COC be used on this project to minimize any spelling or handwritten errors (as much as possible)

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QA ID No.	
QA Category: 1	
Date QAPP submitted:	
Number of Pages:	
Revision No: 0	
Principal Investigator	Date
APPROVALS:	
Division Director	Date
Robert Puls, Technical Lead HF Study	Date
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1.0 Project Management

1.1 Project/Task Organization

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Should consider groundwater flow before reviewed and defined first, and locations	e selecting locations. The local geo selected in conjunction with CHK	logy and hydrogeology should be experts.
Page 11: [4] Comment [c49]	chill4	9/11/2011 11:26:00 PM

The monitoring well design and construction methods should be better defined in this document. CHK has provided some preliminary comments based on current QAPP content.

2" monitoring well may be not be adequate. May require steel casing (preferably stainless). Suggest putting a 1-2 sediment sump below the screen.



SOURCE: Ecology and Environment, Inc. 2011

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Figure 3.2-1 Typical Monitoring Well Construction (from Monitoring Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites USACE Engineer Manual, November 1998)



Figure 3.2-2 Typical Flush-mount Well Construction (from Monitoring Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites USACE Engineer Manual, November 1998)

Security Seals





Group Name	Method	Chemical Name
Volatile Organics	SW8260B	Acetone
Volatile Organics	SW8260B	Ethanol
Volatile Organics	SW8260B	Acetonitrile
Volatile Organics	SW8260B	Acrolein
Volatile Organics	SW8260B	Acrylonitrile
Volatile Organics	SW8260B	Benzene
Volatile Organics	SW8260B	Bromodichloromethane
Volatile Organics	SW8260B	Bromoform
Volatile Organics	SW8260B	Bromomethane
Volatile Organics	SW8260B	2-Butanone
	SW8260B	Carbon disulfide
Volatile Organics	SW8260B	Carbon Tetrachioride
Volatile Organics		Chlorodihramamathana
Volatile Organics	SW8200B	Chloroothono
Volatile Organics	SW6200D SW8260B	Chloroform
Volatile Organics	SW8260B	Chloromethane
Volatile Organics	SW8260B	Chloroprepe
Volatile Organics	SW8260B	3-Chloropropene
Volatile Organics	SW8260B	1 2-Dibromo-3-chloropropane
Volatile Organics	SW8260B	1 2-Dibromoethane (EDB)
Volatile Organics	SW8260B	Dibromomethane
Volatile Organics	SW8260B	trans-1,4-Dichloro-2-butene
Volatile Organics	SW8260B	1.2-Dichlorobenzene
Volatile Organics	SW8260B	1.3-Dichlorobenzene
Volatile Organics	SW8260B	1.4-Dichlorobenzene
Volatile Organics	SW8260B	Dichlorodifluoromethane
Volatile Organics	SW8260B	1,2-Dichloroethane
Volatile Organics	SW8260B	1,1-Dichloroethane
Volatile Organics	SW8260B	cis-1,2-Dichloroethene
Volatile Organics	SW8260B	trans-1,2-Dichloroethene
Volatile Organics	SW8260B	1,1-Dichloroethene
Volatile Organics	SW8260B	1,2-Dichloropropane
Volatile Organics	SW8260B	trans-1,3-Dichloropropene
Volatile Organics	SW8260B	cis-1,3-Dichloropropene
Volatile Organics	SW8260B	1,4-Dioxane
vulatil e Utgatiles	SVVOZUUD	ситурендене
Volatile Organics	SW8260B	Ethyl Methacrylate
Volatile Organics	SW8260B	Hexachlorobutadiene
Volatile Organics	SW8260B	2-Hexanone
Volatile Organics	SW8260B	lodomethane
Volatile Organics	SW8260B	Isobutanol
Volatile Organics	SW8260B	Methodara Chlarida
Volatile Organics	SW8200B	Methylene Chloride
Volatile Organics	SW6200D SW8260B	4 Methyl 2 pontonone
Volatile Organics	SW8260B	Propionitrilo
Volatile Organics	SW8260B	Styrepe
Volatile Organics	SW8260B	1 1 2 2-Tetrachloroethane
Volatile Organics	SW8260B	1 1 1 2-Tetrachloroethane
Volatile Organics	SW8260B	Tetrachloroethene
Volatile Organics	SW8260B	Toluene
Volatile Organics	SW8260B	1.2.4-Trichlorobenzene
Volatile Organics	SW8260B	1,1,1-Trichloroethane
Volatile Organics	SW8260B	1,1,2-Trichloroethane
Volatile Organics	SW8260B	Trichloroethene
Volatile Organics	SW8260B	Trichlorofluoromethane
Volatile Organics	SW8260B	1,2,3-Trichloropropane
Volatile Organics	SW8260B	Vinyl acetate
Volatile Organics	SW8260B	Vinyl chloride
Volatile Organics	SW8260B	Xylenes, total
Semivolatile Organics	SW8270C	2-Butoxyethanol
Semivolatile Organics	SW8270C	a,a-Dimethylphenethylamine
Semivolatile Organics	SW8270C	Acenaphthene
Semivolatile Organics	SW8270C	Acenaphthylene
Semivolatile Organics	SW8270C	Acetophenone
Semivolatile Organics	SW8270C	2-Acetylaminofluorene
Semivolatile Organics	SW8270C	4-Aminobiphenyl
Semivolatile Organics	SW82/0C	Aniline
Semivolatile Organics	SW82/0C	Anthracene
	SVV82/UC	denzo (a) anthracene

Group Name	Method	Chemical Name
Semivolatile Organics	SW8270C	Benzo (a) pyrene
Semivolatile Organics	SW8270C	Benzo (b) fluoranthene
Semivolatile Organics	SW8270C	Benzo (g,h,i) perylene
Semivolatile Organics	SW8270C	Benzo (k) fluoranthene
Semivolatile Organics	SW8270C	Benzyl alcohol
Semivolatile Organics	SW8270C	4-Bromophenyl phenyl ether
Semivolatile Organics	SW8270C	Butyl benzyl phthalate
Semivolatile Organics	SW8270C	Carbazole
Semivolatile Organics	SW8270C	4-Chloro-3-methylphenol
Semivolatile Organics	SW8270C	4-Chloroaniline
Semivolatile Organics	SW8270C	Chlorobenzilate
Semivolatile Organics	SW8270C	Bis(2-chloroethoxy)methane
Semivolatile Organics	SW8270C	Bis(2-chloroethyl)ether
Semivolatile Organics	SW8270C	Bis(2-chloroisopropyl)ether
Semivolatile Organics	SW8270C	2-Chloronaphthalene
Semivolatile Organics	SW8270C	2-Chlorophenol
Semivolatile Organics	SW8270C	4-Chlorophenyl phenyl ether
Semivolatile Organics	SW8270C	Chrysene
Semivolatile Organics	SW8270C	Diallate (cis or trans)
Semivolatile Organics	SW8270C	Dibenz (a,h) anthracene
Semivolatile Organics	SW8270C	Dibenzoturan
Semivolatile Organics	SW8270C	Di-n-butyl phthalate
Semivolatile Organics	SW8270C	1,2-Dichlorobenzene
Semivolatile Organics		1,3-Dichlorobenzene
Semivolatile Organics	SW8270C	1,4-Dichlorobenzene
Semivolatile Organics	SW8270C	3,3-Dichloropenzidine
Semivolatile Organics	SW8270C	2,4-Dichlorophenol
Semivolatile Organics	SW8270C	
Semivolatile Organics	SW8270C	Dietnyi prinalate
Semivolatile Organics	SW8270C	Dimethoate
Semivolatile Organics	SW8270C	
Semivolatile Organics	SW8270C	7, 12-Dimethylbenz (a) anthracene
Semivolatile Organics	SW8270C	3,3-Dimethylpenzidine
Semivolatile Organics	SW8270C	2,4-Dimethylphenol
Semivolatile Organics	SW8270C	Dimetnyi phthalate
	50082700	4,6-Dinitro-z-methylphenol
Semivolatile Organics	SW0270C	2.4 Dinitronhonol
	SW6270C	2,4-Dinitrophenol
Semivolatile Organics	SW8270C	2,4-Dinitrotoluono
Semivolatile Organics	SW8270C	Dinosoh
Semivolatile Organics	SW8270C	Dinoseb Di n octvl phthalato
Semivolatile Organics	SW8270C	
Semivolatile Organics	SW8270C	Disulfoton
Semivolatile Organics	SW8270C	Bis(2-ethylbexyl)nbthalate
Semivolatile Organics	SW8270C	Ethyl Methanesulfonate
Semivolatile Organics	SW8270C	Famphur
Semivolatile Organics	SW8270C	Fluoranthene
Semivolatile Organics	SW8270C	Fluorene
Semivolatile Organics	SW8270C	Hexachlorobenzene
Semivolatile Organics	SW8270C	Hexachlorobutadiene
Semivolatile Organics	SW8270C	Hexachlorocyclopentadiene
Semivolatile Organics	SW8270C	Hexachloroethane
Semivolatile Organics	SW8270C	Hexachlorophene
Semivolatile Organics	SW8270C	Hexachloropropene
Semivolatile Organics	SW8270C	Indeno (1,2,3-cd) pyrene
Semivolatile Organics	SW8270C	Isodrin
Semivolatile Organics	SW8270C	Isophorone
Semivolatile Organics	SW8270C	Isosafrole
Semivolatile Organics	SW8270C	Kepone
Semivolatile Organics	SW8270C	Methapyrilene
Semivolatile Organics	SW8270C	3-Methylcholanthrene
Semivolatile Organics	SW8270C	Methyl Methanesulfonate
Semivolatile Organics	SW8270C	2-Methylnaphthalene
Semivolatile Organics	SW8270C	2-Methylphenol
Semivolatile Organics	SW8270C	3/4-Methylphenol
Semivolatile Organics	SW8270C	Naphthalene
Semivolatile Organics	SW8270C	1,4-Naphthoquinone
Semivolatile Organics	SW8270C	1-Naphthylamine
Semivolatile Organics	SW8270C	2-Naphthylamine
Semivolatile Organics	SW8270C	4-Nitroaniline
Semivolatile Organics	SW8270C	3-Nitroaniline

Group Name	Method	Chemical Name
Semivolatile Organics	SW8270C	2-Nitroaniline
Semivolatile Organics	SW8270C	Nitrobenzene
Semivolatile Organics	SW8270C	2-Nitrophenol
Semivolatile Organics	SW8270C	4-Nitrophenol
Semivolatile Organics	SW8270C	4-Nitroquinoline-n-oxide
Semivolatile Organics	SW8270C	N-Nitrosodi-n-butylamine
Semivolatile Organics	SW8270C	N-Nitrosodiethylamine
Semivolatile Organics	SW8270C	N-Nitrosodimethylamine
Semivolatile Organics	SW8270C	N-Nitrosodiphenylamine
Semivolatile Organics	SW8270C	N-Nitrosodi-n-propylamine
Semivolatile Organics	SW8270C	N-Nitrosomethylethylamine
Semivolatile Organics	SW8270C	N-Nitrosomorpholine
Semivolatile Organics	SW8270C	N-Nitrosopiperidine
Semivolatile Organics	SW8270C	N-Nitrosopyrrolidine
Semivolatile Organics	SW8270C	5-Nitro-o-toluidine
Semivolatile Organics	SW8270C	0,0,0-Triethyl phosphorothioate
Semivolatile Organics	SW8270C	Parathion-ethyl
Semivolatile Organics	SW8270C	Pentachlorobenzene
Semivolatile Organics	SW8270C	Pentachloroethane
Semivolatile Organics	SW8270C	Pentachloronitrobenzene
Semivolatile Organics	SW8270C	Pentachlorophenol
Semivolatile Organics	SW8270C	Phenacetin
Semivolatile Organics	SW8270C	Phenanthrene
Semivolatile Organics	SW8270C	Phenol
Semivolatile Organics	SW8270C	1 4-Phenylenediamine
Semivolatile Organics	SW8270C	Phorate
Semivolatile Organics	SW(8270C	
Semivolatile Organics	SW8270C	Pronamide
Semivolatile Organics	SW8270C	Dyropo
Semivolatile Organics	SW8270C	Porethian methyl
Semivolatile Organics	SW8270C	Duridino
Semivolatile Organics	SW8270C	Sefrele
Semivolatile Organics	SW8270C	Sulfaton
	SW0270C	Suilolep
Semivolatile Organics	SW8270C	1,2,4,5-Tetrachloropenzene
Semivolatile Organics	SW8270C	2,3,4,6- I etrachiorophenol
	5002700	
	SW0270C	
Semivolatile Organics	SW8270C	1,2,4-Thenloropenzene
Semivolatile Organics	SW8270C	2,4,5-Thenlorophenol
	SW8270C	
		Acenaphthulana
		Anunacene Renze (a) enthreeene
		Denzo (b) fluorenthene
		Benzo (b) fluorantnene
		Benzo (g,n,i) perviene
PAH-SIMS		Benzo (K) fluorantnene
	SVV02700_SIM	
		Indeno (1,2,3-cd) pyrene
PAH-SIMS		
PAH-SIMS		
	SW82/UC_SIM	INAPRITAIENE
	5448270C_SIM	
	SVV82/UC_SIM	
Purgeable Petroleum Hydrocarbons	SVV8015	
	SW8015	
	5VV0015	IPH - UII Range
	K5K1/5	
	KSK1/5	
LightGases	RSK1/5	Etnene
LightGases	RSK1/5	Propane
EDB and DBCP	SW8011	1,2-Dibromoethane (EDB)
	SW8011	I,2-Dibromo-3-chloropropane
Alconois	SW8015	
Alcohois	SW8015	Propargyl alcohol
Aldehydes	SW8315A	Gluteraldehyde
Metals	SM2340B	Hardness, CaCO3

Group Name	Method	Chemical Name
Dissolved Motols	SW6010C	Boron
Dissolved Metals	SW6010C	Calaium
	5000100	
Dissolved Metals	SVV6010C	Litnium
Dissolved Metals	SW6010C	Magnesium
Dissolved Metals	SW6010C	Potassium
Dissolved Metals	SW6010C	Sodium
Dissolved Metals	SW6010C	Strontium
Dissolved Metals	SW6010C	Sulfur
Total Metals	SW6010C	Boron
Total Metals	SW6010C	Calcium
	SW6010C	
	SV0010C	
	SVV6010C	Magnesium
l otal Metals	SW6010C	Potassium
Total Metals	SW6010C	Sodium
Total Metals	SW6010C	Strontium
Total Metals	SW6010C	Sulfur
Total Metals	SW6020	Aluminum
Total Metals	SW6020	Antimony
Total Metals	SW6020	Arsenic
Total Metals	SW6020	Barium
Total Motolo	SW0020	Danulli
I otal Metals	SW6020	Chromium
Total Metals	SW6020	Cobalt
Total Metals	SW6020	Copper
Total Metals	SW6020	Iron
Total Metals	SW6020	Lead
Total Metals	SW6020	Manganese
Total Metals	SW6020	Nickel
Total Metals	SW6020	Solonium
Total Matala	SW0020	Selemen
	500020	
l otal Metals	SW6020	l hallium
Total Metals	SW6020	Tin
Total Metals	SW6020	Vanadium
Total Metals	SW6020	Zinc
Dissolved Metals	SW6020	Aluminum
	SYVUUZU	
Dissolved Metals	SW6020	Arsenic
Dissolved Metals	SW/6020	Barium
Dissolved Metals	SW6020	Bondlium
Dissolved Metals	SW0020	
	500020	
Dissolved Metals	SVV6020	Chromium
Dissolved Metals	SW6020	Cobalt
Dissolved Metals	SW6020	Copper
Dissolved Metals	SW6020	Iron
Dissolved Metals	SW6020	Lead
Dissolved Metals	SW6020	Manganese
Dissolved Metals	SW6020	Nickel
Dissolved Metals	SW/6020	Selenium
Dissolved Metals	SW6020	Silvor
Dissolved Metals	SW6020	Thallium
Dissolved Metals	SW6020	Tin
Dissolved Metals	SW6020	Vanadium
Dissolved Metals	SW6020	Zinc
Dissolved Mercury	SW7470A	Mercury
Mercury	SW7470A	Mercury
General Chemistry	E300.0	Bromide
General Chemistry	E300.0	Chloride
General Chemistry	E300.0	Fluoride
General Chemistry	E300.0	Nitrate
Conorol Chomistry		Nitrito
General Chemistry	E300.0	Sultate
General Chemistry	E180.1	lurbidity
General Chemistry	E365.4	Phosphorus
General Chemistry	E410.4	Chemical Oxygen Demand
General Chemistry	HACH8337	Quaternary Ammonium Compounds as CTA
General Chemistry	SM2320B	Bicarbonate Alkalinity as CaCO3
General Chemistry	SM2320B	Carbonate as CaCO3
General Chemistry	SM2310B	Acidity
Conoral Chamietry	SM2370D	Alkalinity Tatal (CaCO2)
General Chemistry	SM2540C	I otal Dissolved Solids

Group Name	Method	Chemical Name			
General Chemistry	SM2540D	Total Suspended Solids			
General Chemistry	SM4500	Ammonia as N			
General Chemistry	E1664A	Oil & Grease HEM			
General Chemistry	SM5540C	MBAS			
General Chemistry	E170.1	Temperature of pH determination			
General Chemistry	SM4500	pH			
Validation Codes					
B(#)=Analyte was detected in the associated					
J=Value is estimated.					
U=Not detected at report limit.					
H(#)=Holding time exceedance.					
L(#)=Laboratory control sample recovery wa	limits.				
N(#)=See case narrative.					
M(#)=Matrix spike and/or matrix spike duplic	otance limits.				
CTAB=Cetyltrimethylammonium Bromide	CTAB=Cetyltrimethylammonium Bromide				
μg/L=Micrograms per liter					
mg/L=Milligrams per liter					

Data subject to final verification

Sample Analysis	Analysis Method (EPA Method)	Holding Time (s)	Water Sample Bottle Type & Number of bottles	Soil Sample Bottle Type & Number of bottles
Potential Hydrogen (pH) + Temperature	SM 4500H+ B / SW-846 9045DH+B & EPA 170.1	15 minutes	2-500mL non-preserved plastic	1- 8oz soil jar
Specific Conductance	SM 5210B/ SW-846 9050A	28 days		
Acidity	SM 2310B	28 days		Not applicable
Total Alkalinity, Carbonate, & Bicarbonate	SM 2320B	14 days		Not applicable
Chloride, Bromide, Sulfate, Nitrate, & Nitrite	EPA 9056	48-hours (NO ₂ & NO ₃) / 28 days		1- 8oz soil jar
Ammonia	SM 4500-NH3 / EPA 350.1 M	28 days	1-250mL H ₂ SO ₄ preserved plastic	
Chemical Oxygen Demand (COD)	EPA 410.1	28 days	1-250mL H ₂ SO ₄ preserved plastic	Not applicable
Total Suspended Solids (TSS)	SM 2540D	7 days		Not applicable
Total Dissolved Solids (TDS)	SM 2540C	7 days	3-1 Liter Non-preserved plastic	Not applicable
Turbidity	EPA 180.1	48-hours		Not applicable
Methylene Blue Active Substances (MBAS) / Detergents	SM 5540C	48-hours		Not applicable
Dissolved Appendix IX Metals (plus Ca, Fe, Li, K, Na, Mg, Mn, S, & Sr)	SW-846 6020 / 7470 (Cations only by SW-846 6010)	180 days / 28 days	2-250mL HNO ₃ (Nitric) preserved plastic (field filtered)	Not applicable
Total Appendix IX Metals (plus Ca, Fe, Li, K, Na, Mg, Mn,	SW-846 6020 / 7470 (Cations only by SW-846 6010)		2-250mL HNO ₃ (Nitric) preserved plastic	2 - 8oz soil jar
Hardness (calculation)	Calculation from Method 6010 (Ca	180 days / 28 days		
Total Phosphorus	EPA 365.4M	28 days	1-250mL H ₂ SO ₄ preserved plastic	
			2 - 1 Liter Clear Glass Wide Mouth with	
Oil & Grease	EPA 1664 / SW-846 9071	28 days	H_2SO_4 preservation	
Total Petroleum Hydrocarbons - Gasoline Range Organics (TPH – GRO)	SW-846 8015	14 days	3 40-mL VOA Vials with HCl preservation	
Total Petroleum Hydrocarbons - Diesel Range Organics & Oil Range Organics (TPH – DRO / ORO)	SW-846 8015	14 days	2-1 Liter Amber Glass non-preserved	
Appendix IX Semi-volatile Organic Compounds (SVOCs) + 2-Butoxyethanol	SW-846 8270	7 days (water)/ 14 days (soils)	2-1 Liter Amber Glass non-preserved	
Polynuclear Aromatic Hydrocarbons - Selective Ion Monitoring (PAH - SIMS)	SW-846 8270 - SIMS	7 days (water)/ 14 days (soils)	2-1 Liter Amber Glass non-preserved	
Light Dissolved Gases (Methane, Ethane, Propane)	RSK-175M	14 days	3 40-mL VOA Vials non-preserved (collected with submerged technique)	Not applicable
Appendix IX Volatile Organic Compounds (VOCs - Iow level) + Ethanol	SW-846 8260	14 days	3 40-mL VOA Vials with HCl preservation	2 Sodium Bisulfate & 1 Methanol VOA Vial (5g aliquot in each)
Ethylene dibromide (EDB) & 1,2-Dibromo -3- chloropropane	SW-846 8011	14 days	3 40-mL VOA Vials with HCl preservation	Not applicable
Alcohol Scan	SW-846 8015	14 days	3 40-mL VOA Vials non-preserved	
Methanol + Propargyl Alcohol 8015	SW-846 8015	14 days	3 40-mL VOA Vials non-preserved	1 - 8oz soil jar
Gluteraldehyde	SW-846 8315M	3-7 days	2-1 Liter Amber Glass non-preserved	
Quarternary Ammonium Salts as CTAB	HACH 8337	N/A	2-1 Liter Amber Glass non-preserved	Not applicable
Total Potassium, Thorium, and Uranium (radiochemistry metals)	SW-846 6020	6 months	1-250mL HNO ₃ (Nitric) preserved plastic (Field filtered)	5 – 8oz soil jars
Radium 226 (Ra ²²⁶)	Method 903.0	6 months		
Radium 228 (Ra ²²⁸)	Method 904.0	6 months		
Gross Alpha & Gross Beta	SW-846 9310	6 months	4 – 1 LITER HNO3 Plastic	
Gamma Spectroscopy	Method 901.1	6 months		
Dissolved Potassium, Thorium, and Uranium (radiochemistry metals)	SW-846 6020	6 months	1-250mL HNO ₃ (Nitric) preserved plastic (Field filtered)	Not applicable
Dissolved Radium 226 (Ra ²²⁶)	Method 903.0	6 months	4 – 1 Liter HNO ₃ Plastic (Field filtered)	
Dissolved Radium 228 (Ra ²²⁸)	Method 904 0	6 months		
Dissolved Gross Alpha & Dissolved Gross Reta	SW-846 9310	6 months		
Dissolved Gamma Spectroscopy	Method 901.1	6 months	1	
Moisture Content	SW-846	14 days	Not applicable	1 – 8oz soil jar
Isotopic Analysis (IsoMethane & IsoEthane)	In-house SOP (Isotech Laboratories)	N/A	1 - Liter Septa Top Plastic Bottle with antimicrobial agent (pill) (provided by Isotech laboratories)	Isotopic Soil Jar (provided by Isotech laboratories)
DATA QUALITY EVALUATION AND VALIDATION

DATA ACQUISTION

Analytical Parameter Selection

The groundwater and surface water samples were analyzed for the following list of analytical parameters.

- Standard Baseline Analytical Parameters List
 - Heavy metals (total and dissolved): arsenic, barium, cadmium, chromium, iron, lead, manganese, mercury, selenium, and silver;
 - o Major cations: sodium, potassium, calcium, and magnesium;
 - Major anions: chloride, carbonate, bicarbonate, and sulfate;
 - o Volatile organics: benzene, toluene, ethylbenzene, and total xylenes;
 - o Light gases: propane, methane, and ethane; and
 - General water quality parameters: oil & grease, sulfur, total suspended solids (TSS), total dissolved solids (TDS), pH, specific conductance, turbidity, and Methylene Blue Active Substances (MBAS).

• Standard Baseline or Expanded Field Parameter List

- Field pH;
- Field water temperature;
- Field dissolved oxygen (DO);
- o Field TDS;
- Field salinity;
- o Field specific conductance; and
- Field turbidity.

• Expanded List of Analytical Parameters

- EPA Appendix IX volatile organic compounds (VOCs);
- EPA Appendix IX semi-volatile organic compounds (SVOCs), including Polycyclic Aromatic Hydrocarbons (PAHs) by SIMS;
- EPA Appendix IX metals;
- Strontium, lithium, bromide, nitrate, nitrite, total phosphorus, and ammonia;
- Hardness calculation;
- Total Petroleum Hydrocarbons (TPH) Diesel Range Organics (Diesel), TPH as Gasoline Range Organics (GRO), and TPH-Oil Range;
- Chemical Oxygen Demand and Carbonaceous Biochemical Oxygen Demand (water only);

- Gross alpha, gross beta, radium-226 (Ra226), radium-228 (Ra228), thorium, potassium, and uranium;
- o Glutaraldehyde;
- Ethylene dibromide (EDB) and 1,2-dibromo-3-chloropropane
- Quaternary ammonium salts; and
- Alcohol scan (methanol and ethanol).

Data-Quality Evaluation

Environmental media data will be subjected to data verification and data validation prior to being presented as usable for assessment purposes. The data verification process is conducted in order to determine if the data was complete, correct, and consistent with specified analytical methods and project requirements. The data validation process is conducted on an analyte- and sample-specific basis to evaluate the quality of the specific data set.

Preliminary analytical data provided electronically by the third party laboratory will be reviewed by senior-level environmental scientists to identify potential data outliers, anomalous data, and sample results that required further evaluation. Analytical values that appeared to be unusual compared to others in the data or baseline data, where available, for the individual sample location were noted. The results of these reviews will be communicated to the laboratory for resolution. In some cases, additional analytes may be requested, e.g. dissolved metals when total suspended solids were elevated or laboratory verification of a specific result needed.

For the partial final data, individual analytical data packages were reviewed by QA/QC personnel by the third-party validators. A summary of QC results, including blanks, matrix spikes, and duplicates, must be available with each partial final data package. Data packages considered to be deficient will be returned to the laboratory. Only <u>validated data</u> will be considered usable.

All relevant and reliable data will be delivered from the laboratory via Electronic Data Delivery (EDD) and hardcopy format. Electronic data were verified against the laboratory report.

Data Quality Evaluation

A third party will validate the analytical data for all samples. The quality of the data will be evaluated using the following criteria:

- 1) Laboratory quality-control elements: the required elements found to be present and all recoveries/results found to be within acceptance limits with few exceptions: and
- 2) Analyte specific results found to be temporally and spatially accurate and precise.

When determining if the laboratory control elements are within acceptance limits the validation data and qualifiers were reviewed. With few exceptions, all laboratory data will be qualified as usable, with most of the quality control discrepancies resulting in a data flag of estimated value. These data flags were assigned if any of the following items impacted the quality of the data:

- 1) Exceeding analytical holding time;
- Poor response to analytical method, resulting in quality control elements being out of acceptance criteria; and
- 3) Temperature associated with sample transit, as well as at the laboratory.

The overall body of analytical data consists of the determination of presence/absence, as well as the analytical determination of quantity for approximately the analytes. The number of analytes showing high levels of variability in data quality (greater than 40% failure in quality control criteria) will be noted. The reasons for the low data quality of these analytes will be explained

Verification and Validation Efforts

The project will require verified and accurate data from both the field and the laboratory. For each data set, the information must accurately reflect all identifying features (date, location, analytical amounts, etc.). Data verification of all the information with clear rationale for all discrepancies noted.

Scope and Methodology

All field data and laboratory data generated from field sampling will undergo quality assurance/quality control reviews to verify reported data for accuracy and completeness against primary and secondary sources. All laboratory data generated subsequently will undergo third party data validation to ensure analytical accuracy and completeness of the reported data, resulting in flagged data to indicate levels of reliability.

Approach

The verification and validation of data is described in detail in the following sections. Upon receipt of information, all data will be checked to insure that the information

was consistent and accurate, as well as verifying against primary sources to insure the reliability of the identifying information.

Data Verification and Data Validation

Field Data Verification Methodology

As each chain-of-custody is received from the laboratory, reviews of the chain of custody and of the field notes will be performed to ensure accuracy. The chain-of-custody information will be placed in a spreadsheet to verify accuracy, and to track which chain-of-custodies have been received. If discrepancies are found within a chain-of-custody, revisions will be made and the chain-of-custody returned to the laboratory. Revisions will be completed by reviewers who would strike a line through the discrepancy, write in the correct information, and initial the edit.

The field notes for every sample collected will be reviewed for discrepancies against the taxing authority parcel codes, Geographic Information Systems (GIS) generated maps, and the client sampling information. If any discrepancies are found, the reviewer will strike through the invalid data and replace with valid data. The person verifying the data will initial every revision made and the data will be updated within the field data database.

A system to track the quality assurance/quality control review will need to be in place. Upon completion of the review for a sampling event, the sample will be marked as verified in the tracking system and subsequently the field data in its entirety will be delivered electronically to the project manager.

Laboratory Data Verification Methodology

The quality assurance/quality control review of laboratory data will be conducted on draft analytical test reports released from the laboratory. The data will undergo initial verification to insure that all the identifying information throughout the report was consistent with the chain-of-custody and recorded field data. This consisted of verifying the congruence of the following reported parameters against the chain-of-custody for each specific sample:

- 1) Sample ID,
- 2) Collection date,
- 3) Collection time,
- 4) Date and time of laboratory receipt,
- 5) Laboratory storage temperature, and

6) Verification that the laboratory methods match the COC requested methods.

All discrepancies discovered during validation will be rectified by contacting the laboratory directly and requesting a re-issue of the report with the necessary revisions. The re-issued report will undergo a quality assurance/quality control verification which would also include a review of case narrative documentation within the reported data to ensure that any discrepancies in methodology and/or analyses were noted and explained, and to document any report changes and the rationale behind them.

When the quality assurance/quality control review of the laboratory data is completed and any data inconsistencies were noted and rectified, data validation will be initiated.

Laboratory Data Validation Methodology

Guidelines and organization:

A Level 2, third party data validation on all reported laboratory data will be conducted. Data validation for all data collected was conducted under the guidelines outlined in the following:

USEPA Laboratory Programs Functional Guidelines for Organic Analytes, and
 USEPA Laboratory Programs Functional Guidelines for Inorganic Analytes.

The data validation effort should be conducted by a team of validators under the supervision of a qualified senior staff supervisor. The data validation will be analyte and sample specific and requested to determine the analytical quality (i.e., accuracy, precision, and reliability) of each specific data set.

Laboratory Data Validation Process

All laboratory data validation efforts will be recorded on sample-specific data validation checklists. There was a chemical validation checklist should be developed for this purpose. The checklist should have the following sample specific information contained in the header portion:

- 1) Laboratory work order number,
- 2) Tax parcel number, and
- 3) Project designation and number.

A separate checklist will be used for every sample validated. The checklist will be used to ensure that each analytical and quality control parameter was checked and verified. The checklist included a quality assurance/quality control verification page which included:

- 1) Sample identification (ID) information
 - a) Resident ID,
 - b) Client Sample number, and
 - c) Sample collection.
- 2) Sample receipt information
 - a) Condition of samples;
 - b) Temperature at receipt;and
 - c) Method specific requirements;
 - i) Preservation;
 - ii) Lack of headspace; and
- 3) Overall analytical quality check.

The remainder of the checklist is used exclusively for validation of analytical data. The sections are:

- Qualifier page a list of all analytical results qualified along with associated validation flags and rationale for qualification.
- Potential qualifier page a detailed list of samples found outside of analytical acceptance limits and the determination of validation flags.
- 3) Holding time page listing all the analytical and preparatory holding times for the analyses requested. This page was used to determine if each test was initiated and analyzed within the prescribed time period.
- Quality Control analyses pages Checklist for every analysis run by the laboratory. This checklist ensures that the following parameters are checked and found sufficient:
 - a) All blanks are present and show no positive detections,
 - b) All laboratory control sample (blank spike), matrix spike and surrogate recoveries are present and fall within acceptance ranges, indicating a reliably accurate result, and
 - c) All duplicates required are present and have results that indicate a reliably precise result.

If any of the above criteria fell outside of the prescribed ranges, the quality control sample was then analyzed to determine if the discrepancy influenced the usability of the sample's analytical result for that analyte.

The criteria used in this project are as follows:

Analytical Blank Shows Positive Result

Analytical blanks indicate if positive detection has occurred, either during transport or analysis of the sample. A positive blank result is assessed depending on the result of the client sample as follows:

- If the client result for that analyte is a non-detect, there is no direct evidence of a positive detection in the sample and the analyte would not be qualified as unusable. However, due to the presence of a detection in the quality control sample or trip blank, the integrity of the sample cannot be positively affirmed - the analyte would be qualified as an estimated non-detect.
- If the client result has a detection for that analyte, but the level is less than five times the blank result or Normalized Absolute Difference (NAD) < 1.96, there is no way to distinguish between the positive detection or a true reading

 the analyte would be qualified as unusable, R.
- 3) If the client result for that analyte is greater than five times the blank result, NAD greater than 2.58, the result is large enough so that the possible positive detection would be relatively insignificant – the analyte would not be qualified.

Note:

$$NAD = \frac{|S - B|}{\sqrt{uncertainty \frac{2}{S} + uncertainty \frac{2}{B}}}$$

Where S = sample and B = blank

Surrogate Recoveries Fall Outside of Acceptance Limits

Surrogate recoveries are used in organic analytical testing to reflect the analytical efficiency of recovery for the analytes being tested. Recoveries that fall outside of the acceptance limits indicate problems with the analytical test and are assessed in the following manner:

1) If the recovery is low out-of-acceptance limits.

- a) The analytical efficiency of the test is in question, all results may be biased low, resulting in all the results from the analytical test being qualified as estimates.
- b) If there are multiple surrogates to represent different classes of analytes being screened in the analytical test and only one surrogate is low, then only results from that analyte class are qualified estimate; the other classes are considered usable data.
- c) If there are multiple surrogates, and two or more fail, the efficiency of the entire test is in question and all results from the analytical test are qualified as estimates.
- d) If one surrogate exhibits greater than 10% recovery, all not-detected results for the analytes of the corresponding compound class are considered unreliable and are therefore qualified R. Positive results for the analytes of the corresponding compound class are qualified as estimates.
- 2) If the recovery is high out-of-acceptance limits
 - a) The analytical efficiency of the test is biased high. All non-detects are usable, all positive detects are qualified as estimated.
 - b) If there are multiple surrogates to represent different classes of analytes being screened in the analytical test and only one surrogate is high, then only results from that analyte class are impacted, the other classes are considered usable data.

Laboratory Spike Recoveries Fall Outside of Acceptance Limits (Analyte Specific)

Laboratory blank spikes are used to show consistency of both analytical efficiencies and reported results across an analytical batch. Any spike recovery that falls outside of acceptance limits indicates inconsistency across a batch and calls into question the reported results for that test.

- 1) The analyte spike recovery is low out-of-acceptance limits
 - a) The analytical efficiency for the analyte is in question, all results (detect and non-detect) are qualified as estimates.
- 2) The analyte spike recovery is high out-of-acceptance limits
 - a) The analytical efficiency of the test is biased high for this analyte. Nondetects are usable, all positive detects are qualified as estimated.

Matrix Spike Recoveries Fall Outside of Acceptance Limits

For the laboratory control matrix spike samples the recoveries only impact the quality assessment of the data under very special circumstances:

- 1) The sample used in the matrix spike is the same as the analytical sample being reported.
 - a) The analyte spike recovery is low out-of-acceptance limits
 - i) The analytical efficiency for the analyte is in question, all results (detect and non-detect) are qualified as estimates.
 - b) The analyte spike recovery is high out-of-acceptance limits
 - The analytical efficiency of the test is biased high for this analyte. Non-detects are usable, all positive detects are qualified as estimated.
- 2) The sample used in the matrix spike is a different sample than the analytical sample being reported.
 - a) Recoveries are not indicative of the analytical sample behavior. The data may not be used to qualify analytical results based on a low or high recovery unless one of the following criteria are met:
 - i) The spikes are run as a matrix spike/matrix spike duplicate pair and the recoveries for the analyte is inconsistent between the two samples (>20% different, with at least one of the recoveries falling outside of acceptance limits), indicating an efficiency problem for that analyte in the test. The analyte is then qualified as an estimate.
 - ii) Matrix spikes run as pairs (MS1 & MS2, indicative of two different matrices). If they both show consistent, out-ofacceptance limits results for multiple analytes (recoveries within 10% of each other), it is indicative of an efficiency problem and the analytes in question may be qualified as estimates.

Relative Percent Difference Analysis Falls Outside of Acceptance Criteria

Relative percent difference is used to determine the precision of the analytical results. It is used to measure consistency using historically determined ranges to ascertain if the difference in results between two subsequent analyses of the same sample indicates that the test may not have given a precise result.

The calculation used to determine the relative percent difference (RPD) number:

RPD = (|S-D|)/(AVG(S+D)) X100

Where:

- RPD = Relative percent difference
- S = Sample results (original)
- D = Duplicate results

This calculated number is compared to a historical limit above which the precision is called into question. If the RPD number exceeded the limit, the following actions were taken:

Duplicate Sample Results	Action for Samples				
Both original sample and duplicate sample >5x the RL and RPD > 120%	Qualify those results that are \geq RL that are impacted as estimated (J) and non-				
Original sample or duplicate sample ≤	Qualify those results that are \geq RL that are				
5x the RL (including non-detects) and absolute difference between sample and duplicate > RL	impacted as estimated (J) and non- detects as estimated (UJ)				

Limitations

Any limitations on the data verification of field data will be explained.

Parameters for Data Qualification

Estimated Results

The following criteria were employed to determine whether the analytical result was qualified as estimated:

- 1) Holding time: The EPA established preparation and analytical holding time for the method employed to analyze the water sample.
- Temperature: The temperature of the sample must be maintained at EPA prescribed levels to insure that no degradation of analytes have occurred. Temperatures in excess of this level result in estimated values on the analytical result.

Quality Control Elements

An evaluation of the laboratory quality control spikes and surrogates run with the analytical batch which included the water sample was done if these controls fall outside of acceptance range, it results in estimated values on the analytical result.

Unusable Results

The following criteria were evaluated to determine the usability of the data:

1) Trip Blanks and Laboratory Control Blanks

The evaluation of the blank control samples was used to ensure no impact to the water sample during both transportation and analytical work-up. When an analytical detect for an analyte has a corresponding blank positive detection, the analytical detect is unusable.

2) Degradation and Sample Hold Time.

If the sample hold time exceeds 2x the prescribed amount, the corresponding reported results are unusable. This is due to analyte degradation over time that has been scientifically determined by storage stability testing.

Analyte specific data was determined to be estimated or unusable in the following situations:

	Analytical Criteria for Sample Validation							
Analytical Result	Outside of method hold time	LCS Low	LCS High	Matrix spike Iow	Matrix spike high	RPD outside prescribe d criteria	2x out of method hold time	Positive Blank
Detect	J	J	J	J	J	J	R	R*
Non- Detect	UJ	UJ	No effect	J	No effect	UJ	R	UJ*

Definitions:

J - Analyte detected result is an estimate

UJ - Analyte non-detected result is an estimate

R - Analyte result is unusable

*Criteria for qualifying any analytical result as either estimates or unusable when a control blank is impacted is dependent upon both the magnitude of the impact, as well as the reported analytical detection of the analyte in the sample. Please see validation methodology for a more detailed description.

PRODUCED WATER/FLUIDS SAMPLING

APPLICABILITY

The information contained in this section applies to produced water/fluids sampling. Produced water/ fluids are defined as all the fluids that flow to the surface after hydraulic fracturing operations, but prior to the production of natural gas from the well. The composition of produced water/fluids varies by formation, but is typically a mixture of the return hydraulic fracturing fluid and the existing deep formation groundwater.

The purpose of the produced water/fluid sampling plan is to collect water quality information to determine disposal options, and to show differences between the produced water/ fluid, and the fluid used in the frac (which is also sampled).

Sampling of produced water/ fluid will be performed at **three** intervals during the flow-back event. Based on the total expected produced water/ volume, a grab sample will be collected from the flow-back manifold and/or separator after approximately 1/3 of the produced water/ volume has been captured, after approximately 2/3 of the produced water/ volume has been captured, and after 3/3 (all) of the produced water/ volume has been captured. Please note that the produced water/ volumes will vary with each well.

PROCEDURE

Produced water/ Fluid Sample Scheduling and Locations

Prior to the sampling event, sampling personnel shall coordinate with the flow-back consultant as to when flow-back is scheduled to begin and arrange the preparation of a sample port on the low pressure side of the flow-back manifold (if possible). If a sampling port is not available, the flow-back sample may be sampled at an alternative location designated by the flow-back consultant (see collection details in following section).

Produced water/ Fluid Sample Collection

The sampling team will consist of one or more experienced individuals that have received training in environmental sample collection techniques, environmental sample collection at natural gas well locations, chain-of-custody documentation, environmental sample preservation, sample packaging, and sample shipment.

Each sample bottle label will be completed with the sample location identification information, sample date and time, parameter or test name, and name of the sampler. Sufficient ice shall be taken to the sample collection locations so that filled containers can be placed on ice immediately following sample collection.

Upon arriving onsite, the sample collection team shall discuss the nature of the sampling activities to be conducted and the site conditions with the flow-back consultant to determine site safety issues. Issues to be discussed may include:

• pressures likely to be encountered during sampling activities,

- nature of the fluids to be sampled (temperature, additives/chemicals added to well, potential for exposure to liquid hydrocarbons
- chemical hazards
- biological hazards
- equipment hazards
- vehicular traffic hazards
- other site specific hazards

Personnel collecting samples shall use good environmental sample collection techniques and appropriate personal protective equipment (PPE) to ensure samples are safely collected and are representative of the source water. Sampling personnel must remain aware of surroundings at all times while on-site. PPE will include, at a minimum, safety glasses, hard hat, steel toe boots and clean nitrile gloves. Sampling personnel shall photograph the well and well identification sign, sample location on blow-off line / temporary separator and/or permanent separator, along with any other pertinent site features.

Sampling personnel shall discuss and arrange appropriate sample collection locations and times with the flow-back consultant prior to sampling. During a typical flow-back event, the minimum required sample collections will be at three separate locations. These separate locations and setup instructions are detailed below:

- Initial Produced water/ Sample: When flow-back is first initiated, there may not be a separator connected to the flow-back lines. In order to collect the initial sample, sampling personnel may need to arrange the installation of a valve and sampling port with the flowback consultant. The valve and sampling port must be installed on the blow-out line connecting the well to the reserve pit.
- 2. Mid-Range Produced water/ Sample: After a few hours/days (one-third and two-thirds of the volume samples) of flow-back directly to the frac tank or reserve pit, the well will begin to flow-back a small volume of natural gas with the fluid. At this point a temporary separator is installed to capture and separate gas and water. Sampling personnel must verify the location of the sampling manifold on the bottom of the temporary separator with the flow-back consultant. Once the location is verified, the valves on the manifold may be manipulated to collect the produced water/ sample. Prior to sample collection, the sampling port should be cleared by purging approximately 0.5 gallon of fluid.
- 3. Late Produced water/ Sample: As the well continues to flow-back, a permanent separator will eventually be setup and installed at the well location. This location will be used to collect the sample of approximately all the flow-back volume and for other time series samples. Most separators have two valves (one near the top, and one near the bottom of the separator). Both these valves should be closed (temporarily) and an additional small valve should be installed where the existing plug is located on the separator. This additional valve is needed to control the flow during sampling. Sampling personnel must verify that the temporary valve is properly installed (upstream of the actuator) with the flow-back consultant prior to flow-back. <u>Mistakenly installing the valve downstream of the actuator</u>

<u>could cause an unexpected spike in water and gas pressure during sampling potentially</u> <u>resulting in injury and equipment damage.</u> Once all valves are installed and verified, the separator valves should be opened, and the temporary valve and sampling port should be used to collect the produced water/ sample. Prior to sample collection, the sampling port should be cleared by purging approximately 0.5 gallon of fluid.

All sample containers should be filled directly from the sample port (if available); this may not be possible. If the sample port is unavailable, the produced water/ fluid sample should be collected in dedicated 5-gallon buckets, 5-gallon buckets with dedicated liners, or dedicated 5-gallon jugs with screw caps. A peristaltic pump and clean dedicated tubing must be used to transfer produced water/fluid from 5-gallon buckets/jugs into laboratory-prepared sample containers. Samples for dissolved metals should be filtered before transferring to laboratory sample containers. Dedicated 45 micron filters will be used for field filtration of dissolved metals samples. Samples for VOCs may need to be transferred into a dedicated clean unpreserved container, and then transferred into the appropriate VOA vial. Note: Zero headspace samples are impossible due to the surface tension of the matrix. If possible the VOA vial should be filled directly from the lined bucket.

Field measurements that must be collected for turbidity and temperature are desirable but may not be possible due to matrix interferences. Sampling personnel shall note the well head pressure and produced water/ rate at the time of sampling. All containers must be labeled indicating source and contents.

All unused produced water/ fluid must be disposed of into the frac tank specified by the flow-back consultant.

PRODUCED WATER SAMPLING

APPLICABILITY

The information contained in this section applies to produced water sampling. Produced water is defined as all water that flows to the well surface during natural gas production. The composition of produced water varies by formation, but is primarily made up of existing deep formation groundwater, but may also include some return hydraulic fracturing fluid.

The purpose of the produced water sampling plan is to collect water quality information to determine disposal options and monitor the variation in produced water quality over time.

PROCEDURE

Produced Water Sample Scheduling and Locations

All produced water samples must be collected on-site at the sampling port on the separator. Sampling personnel shall coordinate with the pumper who will open the appropriate sampling port on the separator (see sample collection details in following section). Chesapeake Operations personnel (pumper, superintendent, etc) must be on location during the sampling event.

Produced Water Sample Collection

The sampling team will consist of one or more experienced individuals that have received training in environmental sample collection techniques, environmental sample collection at natural gas well locations, chain-of-custody documentation, environmental sample preservation, sample packaging, and

sample shipment. Approved consultants that can provide suitable personnel trained to conduct this sampling are listed in the following section.

The sampling team will check the shipping container upon arrival to make sure there was no breakage or leakage during transit. If problems are evident, the laboratory contact personnel will be notified as soon as possible so replacement containers can be shipped. Each sample bottle label will be completed with the sample location identification information, sample date and time, parameter or test name, and name of the sampler. Sufficient ice shall be taken to the sample collection locations so that filled containers can be placed on ice immediately following sample collection.

Upon arriving onsite, personnel collecting samples shall discuss the nature of the sampling activities with the pumper to determine site safety issues. Issues to be discussed may include:

- pressures likely to be encountered during sampling activities,
- nature of the fluids to be sampled (temperature, additives/chemicals added to well, potential for exposure to liquid hydrocarbons)
- chemical hazards
- biological hazards
- equipment hazards
- vehicular traffic hazards
- other site specific hazards

Personnel shall use good environmental sample collection techniques and appropriate personal protective equipment (PPE) to ensure samples are safely collected and are representative of the source fluid. Sampling personnel must remain aware of surroundings at all times while on-site. PPE will include, at a minimum, safety glasses, hard hat, steel toe boots and clean nitrile gloves. Personnel shall photograph the well and well identification sign, production equipment, sample location on the separator, tankage, and other pertinent site features. Personnel shall make note of any additives pumped in to the well (i.e., soap, biocides).

Only the pumper should operate the sampling port on the separator and the pumper should be instructed by the sampling personnel to install the temporary flow control valve.

Most separators have two valves (one near the top, and one near the bottom of the separator). Both these valves should be closed (temporarily) and an additional small valve should be installed where the existing plug is located on the separator. This additional valve is needed to control the flow during sampling. (Please Note: Only the pumper should install the temporary flow control valve and only the pumper should operate the sampling port on the separator). Sampling personnel must verify that the temporary valve is properly installed (upstream of the actuator) prior to sample collection. <u>Mistakenly installing the valve downstream of the actuator could cause an unexpected spike in water and qas pressure during sampling potentially resulting in injury and equipment damage.</u> Once all valves are installed and verified, the separator valves should be opened and sampling personnel shall instruct the pumper to open the appropriate sampling port on the separator (sight glass drain or other port on separator) and purge approximately 0.5 gallon to clear sample port.

If the pressure is low:

• Fill sample containers directly from the port on the separator.

If the pressure is high, OR, if produced water is foamy:

- Collect produced water into dedicated 5-gallon buckets or 5-gallon buckets with dedicated liners and allow foam to settle
- When collecting produced water in 5-gallon buckets, utilize peristaltic pump and clean dedicated tubing to transfer produced water from 5-gallon buckets into laboratory-prepared sample containers.

For consistency, use of the dedicated 5-gallon bucket with dedicated liners and transfer of samples via peristaltic pump may be the most appropriate for all samples.

Samples for VOCs should first be collected in a dedicated clean unpreserved container, and then be filtered and/or transferred to laboratory sample containers. Samples for dissolved metals should be filtered before transferring to laboratory sample containers. Samples for dissolved metals should be filtered using dedicated 45 micron filters.

Due to matrix interferences, the field measurements taken are turbidity and temperature.

In order to obtain an accurate understanding of the characteristics of produced water, sampling at various time intervals is necessary. The specific timing of this sampling is dependent on the shale formation water being sampled. At a minimum the following samples should be included:

- 1. 6 hours after produced water begins flow-back
- 2. 12 hours after produced water begins flow-back
- 3. 5 days after
- 4. 30 days after
- 5. 45 days after
- 6. 60 days after
- 7. 90 days after (sample dependent on if the 60 day sample has a higher chloride and TDS value compared to the 45 day sample)

Sampling needs to be conducted at 30 day intervals until the chloride and TDS stabilize.

All unused produced water must be disposed of into the site produced water tanks.

HYDRAULIC FRACTURE FLUID SAMPLING

APPLICABILITY

The information contained in this section applies to hydraulic fracturing fluid sampling. The purpose of the frac fluid sampling plan is collect information on the chemical makeup of the hydraulic frac fluids. A

list of the analytes should be reviewed and additional parameters added based on the chemicals utilized in the specific fluid being used for the well. The additives utilized vary from site to site and the additives are heavily diluted by fresh water prior to fracturing. As a result, sampling of the frac fluid is necessary to evaluate any impacts, and also to show differences between the fluid used in the frac, and the flowback fluid (which is also sampled). A sample of the source water should be obtained in addition to the hydraulic frac fluid sample in order to differentiate parameters which are associated with recycled source water

PROCEDURE

Frac Fluid Sample Scheduling and Locations

Prior to the sampling event, sampling personnel shall coordinate with the Chesapeake consultant as to when hydraulic fracturing operations will take place. Sampling personnel must also ensure that the frac service company consultant is aware of the need to collect a sample of frac fluid containing all chemicals. The sample should be dispensed from the blender into a dedicated 5-gallon bucket with liner. The proppant will drop to the bottom of the bucket before samples are transferred into containters. In some cases, special mechanical arrangements may need to be made to facilitate collection of the frac fluid sample.

Laboratory contact personnel will schedule the sampling event at the laboratory and will ship precleaned, properly preserved sample containers to the sampling team. The sampling team may choose to maintain a stock of a limited number of sampling containers. It is recommended that no more than a one (1) month supply of containers be kept in stock at any given time. It is very important that any changes in the sampling schedule be communicated to the appropriate laboratory contact personnel.

Frac Fluid Sample Collection

The sampling team will consist of one or more experienced individuals that have received training in environmental sample collection techniques, environmental sample collection at natural gas well locations, chain-of-custody documentation, environmental sample preservation, sample packaging, and sample shipment. Approved consultants that can provide suitable personnel trained to conduct this sampling are listed in the following section.

The sampling team will check the shipping container upon arrival to make sure there was no breakage or leakage during transit. If problems are evident, the laboratory contact personnel will be notified as soon as possible so replacement containers can be shipped. Each sample bottle label will be completed with the sample location identification information, sample date and time, parameter or test name, and name of the sampler. Sufficient ice shall be taken to the sample collection locations so that filled containers can be placed on ice immediately following sample collection.

Upon arriving onsite, the sample collection team shall discuss the nature of the sampling activities to be conducted and the site conditions with the frac service company consultant to determine site safety issues. Please note that only frac service company personnel shall collect the frac fluid sample (details are provided below). Issues to be discussed with the frac service company consultant may include:

 nature of the fluids to be sampled (temperature, additives/chemicals added to well, potential for exposure to liquid hydrocarbons)

- chemical hazards
- biological hazards
- equipment hazards
- vehicular traffic hazards
- other site specific hazards

Personnel collecting samples shall use good environmental sample collection techniques and appropriate personal protective equipment (PPE) to ensure samples are safely collected. Sampling personnel must remain aware of surroundings at all times during the frac fluid sampling event. Hydraulic fracturing operations are an extremely intensive, heavy industrial operation and all personnel must have appropriate PPE while onsite. Appropriate PPE will include, at a minimum: safety glasses, hard hat, steel toe boots, earplugs and clean nitrile gloves. Sampling personnel shall photograph the well and well identification sign and other pertinent site features.

All frac fluid sample collection shall be performed by the frac service company employees. Sampling personnel shall provide two (2) dedicated five-gallon buckets (or jugs) to the frac service company consultant and the buckets shall be filled with approximately four gallons each (eight gallons total) of the frac fluid mixture prior to injection downhole. Once the samples are collected by the frac service company, the samples shall be immediately returned to the sampling personnel for laboratory preparation and shipping.

Sampling personnel shall use a peristaltic pump and clean dedicated tubing to transfer frac fluid from 5gallon buckets/jugs into laboratory-prepared sample containers. Samples for VOCs should first be collected in a dedicated clean unpreserved container prior to filling the VOA vials. Samples for dissolve metals should be filtered prior to transfer to laboratory sample containers. Dedicated 45 micron filters will be used for field filtration of dissolved metals samples.

Due to the matrix interferences, field measurements are limited to turbidity and temperature. All containers must be labeled indicating source and contents.

Upon completion of sample collection, all unused frac fluid must be disposed of into the frac tank specified by the frac service company consultant.

ISOTOPIC METHANE SAMPLING FROM DOMESTIC WATER WELLS, SURFACE WATERS AND COMPLETED NATURAL GAS WELLS.

This section describes the procedures for collecting methane gas or water samples for isotopic analyses from domestic water wells, surface waters, and completed natural gas wells.

Following is a list of equipment needed to conduct isotopic methane sampling:

- Flame ionization detector (FID); used for measuring total volatile organics including methane calibrate to methane standard,
- Lower Explosive Limit (LEL) meter calibrate to methane standard,
- IsoBags,
- Hand pump ,
- Floating gas concentration device for surface water gas collection,
- Disposable tubing (assorted sizes appropriate for connection to gas concentration device, etc.),
- IsoTube,
- IsoTube manifold,
- Well adaptor with associated fittings (must be appropriate for well casings between 4" and 8") for concentrating gas vapor,
- Field Book,
- 1 Liter isotopic water sample collection bottles ,
- 5-gallon bucket, white (do not use any color bucket due to the potential for color dyes to interfere),
- 5-gallon bucket for flow measurement,
- Handheld GPS (3-5m accuracy),
- Calibration gases,
- Tools to access well head (basic tool kit)
- Health and Safety Plan,
- Digital Camera,
- Watch, and
- 50 foot garden hose.

Replicate equipment must be taken to all jobs sites, and must include the following at a minimum:

- Flame Ionization Detector,
- Calibration gases, and
- Lower Explosive Limit (LEL) meter.

Domestic Water Well – Gas Sample for Isotopic Methane

- 1. Set-up for sampling a safe distance (approximately 20 ft or more) from the well.
- 2. Calibrate meters and record appropriate information in field book.
- 3. Monitor gas concentrations during approach to well using appropriate meter
 - a. STOP if readings above 10% LEL are encountered.
 - b. Sampling may continue upon approval from the Sampling Team Lead.

- 4. If <10% LEL, gain access to well (remove well cap, etc) and quickly record the methane concentration via the FID first and then using the LEL.
- 5. Attach the well adaptor to the well casing (if this is not possible then insert tubing 5-7 feet into the casing and improvise seal).
- 6. Connect the FID/LEL to the well adaptor for all readings.
- 7. Check FID and LEL readings and record in the field book.
- 8. Close the sampling valve.
- 9. Activate the water well pump to reduce hydrostatic pressure by pumping the well at a low to moderate rate during the sample collection process steps noted below. This will increase the likelihood of detecting any methane that may be dissolved in the water.
- 10. Leave the sampling valve closed a minimum of 10 minutes to concentrate vapors.
- 11. Open the sampling valve, check FID and LEL readings and record in the field book.
- 12. Close the sampling valve and allow to stand an additional 10 minutes.
- 13. Open the sampling valve, check FID and LEL readings and record in the field book
- 14. IF FID and/or LEL readings have stabilized, proceed to step 17.
- 15. If not stable, repeat steps 12 and 13 until readings stabilize for a maximum of 4 additional iterations.
- 16. If no FID or LEL readings are noted, then notify the Sampling Task Manager for further guidance.
- 17. Connect tubing to sampling valve on well adaptor.
- 18. Connect hand pump to the opposite end of the tubing.
- 19. Open sampling valve and pump hand pump as required to purge the line of air.
- 20. Remove an IsoBag from the shipping container (paint can) and while pumping slowly, insert the male luer fitting on the hand pump outlet into the luer valve on the IsoBag.
- 21. Fill the IsoBag 2/3 full to allow for expansion during shipping.
- 22. Carefully remove IsoBag from the pump.
- 23. Label the IsoBag with the sampling location, date and time.
- 24. Record the sample on the Chain-of-Custody and in the field book.
- 25. Repeat steps as necessary to collect additional samples.
- 26. Remove tubing and adaptor from the well. Replace any items removed to gain access to well.
- 27. Fill out any additional information on the COC
- 28. Pack sample for shipping and ship to Isotech Laboratories.
- 29. Transmit copy of COC and field notes to the QA/QC Department.

Surface Water - Gas Sample for Isotopic Methane

 Position the floating gas concentration device over the bubbling area and proceed similar to the procedure noted in Section on water wells. (Monitor FID and/or LEL readings for increasing trends and collect isotopic sample in IsoBag if methane is suspected based on the reading) Record all observations in the field book.

Domestic Water Well or Surface Water - Water Sample for Isotopic Methane

 If a gas sample was just collected from this sample location then water sampling may proceed if directed by Chesapeake. Otherwise, the well must be pumped to cycle water through the pressure tank prior to sample collection

- 2. Fill a clean 5 gallon bucket with water. Preferably from a source that bypasses any water treatment system.
- 3. Attach a nozzle and a length of tubing to the end of the hose connected to the faucet. Keep the flow rates low to moderate.
- 4. Remove the cap from the 1Liter Isotopic sample bottle and fill it with water. Once the bottle is filled, immerse it in the 5 gallon bucket with the fill tubing at the bottom of the bottle. Continue water flow rate until another 2 volumes of water have been displaced from the bottle.
- 5. Slowly lift the tubing out of the bottle and immediately cap the bottle under the water. No air must be allowed into the 1L bottle.
- 6. Pack the bottle on its SIDE in loose, wet ice and ship to Isotech Laboratories, Inc. under chain-of-custody control. THE SAMPLE BOTTLE MUST BE PACKED ON ITS SIDE.
- 7. Transmit copy of COC and field notes to the QA/QC Department.

Completed Gas Well

- 1. Meet Chesapeake's representative at site.
- 2. The representative is responsible for supplying the appropriate sampling containers (IsoTube) and the sampling manifold (IsoTube manifold).
- 3. Remove IsoTubes from shipping container and label with sample information
- 4. Transfer the labeled IsoTube to client representative and observe sample collection. Observations should be noted in a bound field book.
- 5. Receive filled IsoTube from representative and return to shipping container.
- 6. Complete COC in conjunction with representative.
- 7. Pack sample for shipping and ship to Isotech Laboratories.
- 8. Transmit copy of COC and field notes to QA/QC Department.

Records

The details of each sampling event shall be recorded in a bound field book and any applicable field forms. Any field forms completed must be notated in the field book. At a minimum, the following information shall be recorded:

- Site location,
- Site description (include sketch as appropriate),
- Weather conditions (temperature, wind, precipitation, etc.),
- Homeowner's use of water in the preceeding twelve hours,
- Sample Identification,
- Date and time of sample collection,
- Names of individuals present at sampling site, and
- Field meter identification along with appropriate calibration information:
 - o Lot numbers and expiration dates for all standards, and
 - All calibration results and calibration re-check values.

Photographs shall be taken of each sample location during sampling activities for field documentation. The photo number must be recorded with a description in the field book.

BASELINE WATER SAMPLING

This Section describes the procedures for conducting baseline water and water gas sampling. Baseline sampling is conducted to document water quality conditions prior to drilling activities associated with natural gas development.

Equipment

- Flame ionization detector (FID); used for measuring total volatile organics including methane calibrate to methane standard,
- Lower Explosive Limit (LEL) meter calibrate to methane standard,
- Calibration gases,
- Meters for measuring pH, temperature, conductivity, and turbidity ,
- Calibration standards (pH, conductivity, and turbidity),
- Disposable Bailers,
- Monofilament line for bailers,
- 5 gallon bucket, white,
- 5 gallon bucket for flow measurement,
- Stainless Steel bowl of sufficient capacity to allow for the submerging of VOA vials,
- Decon Kit (DI water, Alconox, brush, etc.),
- Handheld GPS (3-5m accuracy),
- Digital camera,
- Laptop,
- Public information packet,
- Health and Safety Plan,
- Sample containers for the specified parameter list based on state,
- Custody seals, sample labels, shipping labels (FedEx, special handling labels, Saturday delivery, etc.),
- Field Book
- Basic tool kit
- 50 foot garden hose,
- Field Forms, and
- Personal Protective Equipment (nitrile gloves are required for all samples to protect the sample as well as the sampler; see H&S plan for additional requirements .

Replicate equipment must be taken to all jobs sites, and must include the following at a minimum:

- Flame Ionization Detector,
- Calibration gases,
- Lower Explosive Limit (LEL) meter,
- Meters for Measuring pH, conductivity, temperature, and turbidity, and
- Calibration standards for pH, conductivity, and turbidity.

Procedure

The existing water system shall NOT be modified in any way in order to collect samples. If existing equipment is not functional, then note the equipment problems and inability to collect the sample in the field book and on the Sample Collection Form. Determine the approximate size, in gallons, of any pressure or holding tank. Note the presence of treatment systems, such as a water softener, and make sure the selected sample location is **<u>BEFORE</u>** any such system. If the sample cannot be collected before the treatment system, then it should be documented on the Baseline Monitoring Form. Where possible, purge a minimum of at least two times the capacity of the holding tank before filling sample containers. If samples are being collected in an area of limited water resources, try to purge a minimum of 5-10 gallons before filling sample containers. Purge volume can be estimated by bucket fill. Intermediate collection containers should not be used (i.e., sample collection containers should be filled directly from the tap or water source). Observe and document qualitative appearance of water sample. Pre and post purge observations for suspended solids, turbidity, and gas bubbles should be documented from a water sample collected prior to sampling for laboratory analyses.

- 1. Conduct Methane screening.
- 2. Review water system layout and note in field book with appropriate sketches.
- 3. Photograph the water well if possible and all sample location(s) such as faucets, and record GPS coordinates in field book.
- 4. Fill sample containers for Light Gas (dissolved) analysis if required, but inspect containers first to ensure they are not damaged, clean, and have no preservatives:
 - a. Direct the water flow (low to medium stream of water flow) into the precleaned stainless steel bowl until it overflows. Continue the overflow at a low to medium rate through the duration of sample collection.
 - Wearing clean nitrile gloves, submerge an un-opened, non-preserved, 40-ml
 VOA vial in the stainless steel bowl with the cap pointed down.
 - c. Remove the cap and tilt vial until it begins filling. The open top of the vial must remain below the water surface at all times during filling. When the vial is completely full (no headspace or bubbles), replace the cap and tighten. This entire step must be completed with the vial submerged.
 - d. Remove the sealed vial from the water and inspect for headspace or bubbles. If any are observed the vial must be discarded and the sample re-collected.
- 5. Label each sample container, and include date and time of collection, and sample ID.
- 6. If gas bubbles are observed in the water sample and are effervescing, head space samples for methane/ethane and isotopic analyses should be collected following the submerged bottle method as recommended by Isotech Laboratories, Inc. The sampling method can be found on the Isotech website at:

http://www.isotechlabs.com/customersupport/samplingprocedures/DGbottle. pdf

This method requires filling a 1L bottle with well water then submerging the bottle into a 5 gallon bucket filled with well water; invert the bottle and insert ¼ tubing coming from the well faucet; increase the flow rate to 2-3 gpm and allow bubbling gases to displace water in the headspace until 25%-50% of the water has been displaced; seal the

container under water with spetum and screw cap securely tightened. Pack in ice and ship for overnight delivery.

- 7. Fill remaining sample containers provided by certified laboratory. (major anions/cations, metals, etc.) from the water source outlet. Springs without a water collection system should be sampled from the end of the pipe or spring outlet. If a water collection system such as a cistern is present, use a clean, disposable bailer and monofilament line lowered to approximately the mid-depth of the collection container to minimize stagnant water issues. DO NOT PUT ANY TAPE AROUND THE SAMPLE CONTAINER CAP.
- Collect an additional sample in a non-preserved container for pH, temperature, turbidity, and specific conductivity; take field reading using the appropriate calibrated equipment and record readings in the field book.
- 9. Fill out the Baseline Water Sample Collection Form.
- 10. Record all required information on the chain-of custody and pack samples in sufficient loose, wet, ice to maintain required temperature. Please note that each sample container filled should be immediately placed on ice following collection. Include trip blanks if appropriate, and note date on trip blank in field book.
- 11. Ship samples to certified laboratory.
- 12. Complete Field EDD.
- 13. Transmit copy of the field EDD, field notes, field forms, and COC to the QA/QC department within 24 hours of sample collection.

Records

The details of each sampling event shall be recorded in a bound field book and any applicable field forms. Any field forms completed must be notated in the field book. At a minimum, the following information shall be recorded:

- Site location,
- Site description (include sketch as appropriate),
- Homeowner's use of water source during the preceeding twelve hours
- Weather conditions (temperature, wind, precipitation, etc.),
- Sample Identification,
- Date and time of sample collection,
- Names of individuals present at sampling site, and
- Field meter identification along with appropriate calibration information:
 - o Lot numbers and expiration dates for all standards, and
 - o All calibration results and calibration re-check values.

Photographs shall be taken of each sample location during sampling activities for field documentation. The photo number must be recorded with a description in the field book.

AMBIENT METHANE SCREENING SURVEY

This section describes the procedures for conducting an ambient methane screening survey of a designated location. An ambient methane screening survey will be conducted as part of baseline sampling activities to identify the presence of methane gas at <u>sample collection locations</u> ONLY.

Equipment

- Flame ionization detector (FID); used for measuring total volatile organics including methane calibrate to methane standard,
- Lower Explosive Limit (LEL) meter calibrate to methane standard,
- New pint or quart jars with lid,
- Aluminum foil,
- Rubber bands,
- Field Book,
- Field Forms,
- Handheld GPS (3-5m accuracy),
- Calibration gases,
- 50-foot garden hose,
- Tool kit with basic tools,
- Health and Safety Plan,
- 5 gallon bucket,
- Digital camera, and
- Watch.

Replicate equipment must be taken to all jobs sites, and must include the following at a minimum:

- Flame Ionization Detector,
- Calibration gases, and
- Lower Explosive Limit (LEL) meter.

Procedure

The following activities shall only be conducted with landowner permission. If permission is refused, notate the refusal in the field book and on the field form.

Water Wells

- Monitor FID and LEL levels during approach to well and insert the meter tip into the well casing or vent. Record the meter readings along with any observations in the field book. Photograph the well head and note the photo in the field book.
- 2. Activate the water well and pump the well to reduce hydrostatic pressure and monitor methane concentrations during pumping. The reduced water pressure allows methane to be released and increases the likelihood of methane detection.
 - a. Monitor FID and LEL readings during pumping at the well head.
 - b. Note meter readings observed in the field book. Include the duration of the pumping activity and additional observations (approximate pumping rate in gallons per minute (gpm), smells, water coloration, etc.)

- 3. After pumping the well an amount of time sufficient to cycle water through the pressure tank, take FID and LEL readings as indicated below. Attempt to cycle water a minimum of 2 times the capacity of the holding tank, but no less than 5 to 10 gallons.
 - a. Headspace reading
 - 1. Fill two clean jars ¾ full with water from the sample collection location. One jar is for the LEL reading and the second is for the FID reading.
 - 2. Seal with aluminum foil and jar lid or rubber band taking care not to tear the foil; allow to stand for 15 minutes.
 - 3. Remove lid (if used), pierce foil and quickly insert appropriate probe DO NOT ALLOW PROBE TO CONTACT WATER.
 - 4. Record the highest reading from each probe.
 - 5. If the water sample is being collected from a sink, repeat the procedure for the hot water tap.
 - b. Readings at water sample collection point (dissolved gas escaping from running water)
 - 1. If water sample is being collected from a sink, close the sink drain and turn on cold water.
 - 2. Place the probe tip within 6-8" of the faucet and record reading DO NOT ALLOW PROBE TO CONTACT WATER.
 - 3. Move probe around sink with water running and observe readings. Continue monitoring until readings stabilize.
 - 4. Record range of readings observed (readings should be collected for both FID and LEL).
 - 5. Repeat for the hot water tap.
 - 6. For samples collected from location other than a sink, such as an outside faucet, take FID and LEL readings 6-8" from the water stream. Continue to monitor and record readings until the levels stabilize.

Supplemental Screening -

1. Inside Structure

- a. Record readings from various locations inside the structure including:
 - Bathroom (middle of room, under sink, around drains, ceiling, floor)
 - Kitchen (same as bathroom),
 - Basement (middle of room, ceiling, floor, around any cracks, sumps, floor drains),
 - Laundry Room (middle of room, floor, ceiling, drain), and
 - Any other suspect areas.
- 2. Outside Structure
 - a. Record readings from various locations around the property including:
 - Low lying areas,
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- Ponds or other surface water (especially if bubbles are noted),
- Recent excavations,
- Recent landscaping, and
- Any other suspect areas.

Any reading noted during any screening activity greater than 10% LEL must be reported immediately. All other monitoring activities must be stopped pending further instructions.

Records

The details of each sampling event shall be recorded in a bound field book and any applicable field forms. Any field forms completed must be notated in the field book. At a minimum, the following information shall be recorded:

- Site location,
- Site description (include sketch as appropriate),
- Weather conditions (temperature, wind, precipitation, etc.)
- Sample Identification,
- Date and time of sample collection,
- Names of individuals present, and
- Field meter identification along with appropriate calibration information:
 - o Lot numbers and expiration dates for all standards, and
 - o Calibration results and re-check.

Photographs shall be taken of each screening location during screening activities for field documentation. The photo number must be recorded with a description in the field book.

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COMMUNICATION PLAN

for EPA Hydraulic Fracturing Study

September 2011



Confidential

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1.0 INTRODUCTION

Chesapeake Energy (Chesapeake) has developed the following Communication Plan (referred to hereafter as "the Plan") for the Hydraulic Fracturing Prospective Case Study (Case Study) located in the Haynesville Shale, Desoto Parish, Louisiana. This Plan provides the framework and strategy to assure timely and effective communication to all members of the project team, as well as community and public outreach. This document will serve as the basis for the planning and execution of all communication regarding the Case Study. The Plan will include, but is not limited to, Communication Methods and Frequency, Data Validation and Evaluation Discrepancies, Public Outreach, and Security.

1.1. Project Description

The HF Study will investigate the construction of a new well pad, new production well, hydraulic fracturing of said well, management and disposal of wastewater and production of gas from said well for about 1 year following hydraulic fracturing to determine if there is a negative impact to drinking water. The investigation will initially involve sampling of groundwater (monitor and domestic wells), surface water and soil and sediment in the vicinity of the well pad (prior to pad construction) to obtain baseline characteristics. Subsequently, the evaluation of groundwater, surface water and soil characteristics before, during and after key phases of a shale gas well development - pad construction, well drilling, well completion, and production – to identify if there is a significant change in media characteristics will be completed. The Case Study will also sample produced water returned to the surface following fracking.

1.2. Project Team

For purposes of this document, the Project Team will include identified members of EPA, Region 6 and GWERD, Chesapeake management, personnel and selected contractors, and personnel of Ecology and Environment (EPA's selected contractor).

2.0 PURPOSE AND OBJECTIVES

The objective of this Plan is to develop an overall communications strategy for the Project Team, and to identify measures of community and public outreach. Primary objectives include:

- Ensure timely communication to relevant groups or individuals
- Ensure effective communication between groups
- Ensure timely notices for requirements/meetings
- Ensure optimum results for all communications and project expectations
- Measure the results of the communication strategy execution and revise accordingly

3.0 GENERAL REQUIREMENTS

This section outlines methods of communication that may be utilized during the HF Study. Methods of communication will include conference calls, meetings, email, and File Transfer Protocol (FTP) Sites.

Chesapeake has the right to designate confidential information it may gain from access to Chesapeake sites and such information will be kept confidential by EPA.

There will be no photographs, videotaping, recording or any visual or aural depiction or recording of any Chesapeake site, equipment, personnel or activity without Chesapeake's prior written consent, and any such consent will be conditioned on Chesapeake receiving exact copies of the originals of any such recordings regardless of format.

4.0 METHODS OF COMMUNICATION

This section outlines methods of communication that may be utilized during the HF Study. Methods of communication will include conference calls, meetings, email, and File Transfer Protocol (FTP) Sites.

4.1. Conference Calls

Conference calls are held on a weekly basis to facilitate open communication between the Project Team throughout the HF Study. Currently, calls are scheduled for Monday afternoons at 1:00 pm CST. Call information is provided below:



Call in number: (877) 935-0245 Call in code: 745420

Conference call agendas will be provided to the group at least 24 hours prior to the scheduled call. Additionally, meeting minutes will be provided to all participants within the week following the call. The timing and frequency of the conference calls are subject to change base on the Project Teams discretion.

4.2. Meetings

Group meetings will be scheduled as necessary pending the schedules of project team members. Currently, one face-to-face meeting has been scheduled for Monday, September 19, 2011.

As previously mentioned concerning conference calls, agendas and meeting minutes will be provided to all participants at the previously referenced schedule.

4.3. File Transfer Protocol Site

File Transfer Protocol (FTP) Sites are the most secure method to exchange files and data over the internet. The FTP site will be created and maintained by GWERD. Access will be strictly limited to only those directly involved in the HF Study. Each member will receive a unique UserID and Password. All members of the Project Team will upload and share all data generated during the course of the study via the FTP site. The FTP site can be accessed at:

INSERT URL

All data should be uploaded in a timely manner upon receipt. Notifications will be sent to all members upon addition of new data.

4.4. Email

Correspondence via email will be necessary during the HF Study. All meeting agendas or minutes will be provided to the Project Team via email or uploaded to the FTP site. Due to

the nature of the HF Study, project information is to be considered confidential and is not to be disclosed to anyone outside the Project Team unless through proper channels.

5.0 NOTIFICATION REQUIREMENTS

5.1. On-Site Field Activity

On-site (i.e., pad location) sampling activity will be conducted throughout the Case Study. Chesapeake retains the To allow for consistency throughout the Case Study, all sampling by various members of the Project Team will need to be conducted at the same date and time. Therefore, group notification of sampling events will be required at a minimum three (3) days prior to sampling, preferably seven (7) days. All members should coordinate accordingly to provide equal access to the site.

Persons requiring access to site must provide a description of all activity to be conducted at any Chesapeake site where voluntary access is requested. This includes a description of any sampling, testing or other analysis including the method of sampling or analysis to be conducted (which shall be supplemented if the sampling of analysis changes).

All Project Team members visiting a Chesapeake site must be identified in advance and must adhere to all Chesapeake safety protocols. Chesapeake may deny access to areas that, in the judgment of Chesapeake, may present safety issues. Chesapeake will escort any employee, agent, contractor, representative or expert at all times while they have access to Chesapeake's property. With good reason, Chesapeake retains the right to temporarily or permanently deny any specific EPA employee, agent, contractor, representative or expert at contractor, representative or expert access to its property.

EPA agents visiting a Chesapeake site will wear proper safety equipment, as determined by Chesapeake, at all times while on any Chesapeake site. Generally a hard hat, steel-toed shoes, safety glasses and possibly hearing protection will be required.

NOTIFICATION: By entering the Chesapeake site you are releasing and indemnifying Chesapeake from any personal injuries, property damages and claims of any kind arising our of or related to any access to any Chesapeake site by any employee, agent, contractor

or expert of EPA. Access is subject to acknowledgement that EPA has no authority to require Chesapeake's consent to access and Chesapeake's agreement to access does not acknowledge the existence of any such authority.

5.2. Off-Site Field Activity

As with on-site activity, off-site sampling events will also need to be conducted at the same date and time. Group notification of off-site sampling events will also be required at a minimum three (3) days prior to sampling, preferably seven (7) days. All members should coordinate accordingly to provide equal access to the site.

6.0 DATA VALIDATION AND EVALUATION

Data validation will be conducted by the Project Team upon receipt of new data. Chesapeake will conduct data validation to compare all EPA collected samples with samples obtained internally. In the event of a discrepancy, members of the Project Team will be contacted as soon as possible to resolve the issue. Additional conference calls or meetings will be scheduled accordingly.

7.0 PUBLIC OUTREACH AND COMMUNITY INTERACTION

Chesapeake is committed to working with landowners and other stakeholders in an ongoing effort to better understand and address the interests and concerns of these groups regarding HF Study. Chesapeake will work with all landowners, local communities, and governing bodies to ensure that they are generally aware of the HF Study and updated as it progresses. The Project Team will ensure that the Case Study is conducted to meet all safety, environmental, regulatory and legal requirements.

It is important that the Project Team coordinates all public outreach and community interaction in order to minimize the burden to and confusion of the public. All activities under this category will be conducted in collaboration, or at a minimum all Project Team members should be notified and provided an opportunity to participate.

8.0 SECURITY



Security during Case Study design and implementation will be paramount to prevent outside tampering and ensure the integrity of study assets and data is maintained. All groundwater monitoring wells will be secured again unauthorized entry with appropriate locking devices and unique security seals. Monitoring wells will be constructed with a protective casing and surface seal to grout the security casing in place. The protective casing and surface seal are the primary safeguard against unauthorized entry, vandalism or tampering with the well, and also protect against movement of water or contaminants from the surface into the monitoring well.

Security casings will be constructed with heavy gauge metal casing at least four (4) inches in diameter larger than the nominal diameter of the well casing. Locking caps will be installed on the security casing that fully encloses the casing collar.

Chesapeake will also utilize a video surveillance system for all monitoring wells on site to ensure that wells are not accessed by unauthorized persons or vandalized.

9.0 EMERGENCY NOTIFICATION

APPENDIX A – DEFINITIONS APPENDIX B – CONTACT LIST

From:	Ruben Deza
То:	Bob Perciasepe; Amy Battaqlia; Barbara Bennett; Bicky Corman; Brenda Mallory; Bob Sussman; ChristopherBusch; Diane Thompson; Charles Imohiosen; Evangeline Cummings; Fred Hauchman; Gene Pontillo; JohnReeder; Karl Brooks; Kevin Teichman; Lawrence Elworth; Lek Kadeli; Lisa Garcia; Michael Goo; MichelleDePass; Peter Grevatt; Philip Metzger; Ramona Trovato; Scott Fulton; Seth Oster;Rice.William@epamail.epa.gov; Shannon Kenny
Cc:	Teri Porterfield; Denise Anderson; Carla Veney; Lesley Schaaff; Robin Kime; Brigid Lowery; Rhonda Robinson; Walter Muqdan; Abe Ferdas; Shawna Bergman; Janet Woodka; William Nickerson; Becky Brooks
Subject:	ORD Program Update materials for tomorrow - Fri 02/24/2012 3:30 PM - 4:30 PM
Date:	02/23/2012 04:21 PM
Attachments:	Program Update for Feb 24th.docx

Materials are attached for tomorrow's ORD's Program Update with Deputy Perciasepe.

The meeting will take place at ARN 3530, and the Conference line: is code: (b) (b) (c) Personal Privacy





Ruben D. Deza, PhD Strategic Management Division OP - Office of the Administrator

Phone: 202-564-6018 202-566-2200 Fax:

Mailing Address: U.S. Environmental Protection Agency Ariel Rios Building (1803A) 1200 Pennsylvania Avenué, NW Washington, DC 20460

From:Richard WindsorTo:Bob SussmanCc:Bob PerciasepeSubject:Re: Range Mtg with administratorDate:03/01/2012 10:26 AM

(b) (5) Deliberative

▼ Bob Sussman

----- Original Message -----From: Bob Sussman Sent: 03/01/2012 10:11 AM EST To: Richard Windsor Cc: Bob Perciasepe Subject: Fw: Range Mtg with administrator Administrator:

I'm enclosing the outline of issues that I suggested OECA and ORD should cover in today's meeting on Range.



Bob Sussman

----- Original Message -----From: Bob Sussman Sent: 02/29/2012 03:37 PM EST To: Cynthia Giles-AA; Steven Chester; Scott Fulton; Avi Garbow; Ramona Trovato; Lek Kadeli Cc: Bob Perciasepe Subject: Range Mtg with administrator

I had hoped we could get together before tomorrow's meeting with the administrator but it doesn't look like a pre-meeting will work. However, let me offer some thoughts on how to structure the meeting.



Hope this helps. Happy to chat with any of you before the Bmeeting. BOB

From:	Jane Thomas
Reply To:	Jane Thomas
То:	Bob Perciasepe/DC/USEPA/US@EPA
Subject:	Shale Gas Water Management Symposium Grows To Include Technology Gallery, Workshops And Extra E&P Speakers
Date:	03/06/2012 03:24 PM



March 28 - 29, 2012 | Canonsburg | PA

North America's Most Established 2-Day Summit Focusing Purely On Water Management For Marcellus Shale Gas Production With Additional Pre-Conference Workshops (March 27, 2012)

Dear Colleague

Ever wondered how Marcellus' E&Ps continue to produce gas cost effectively while managing water costs?

- Do you want to hear the **techniques and tricks** Marcellus E&Ps are using to drive down the costs of water treatment?
- Do you want to hear real-life <u>case studies</u> showing how E&Ps have managed water chemistry to safely re-use flowback water for fracing?
- Do you want to see and touch the <u>technologies and</u> <u>equipment</u> being used by operators to reach 100% re-use?
- Do you want to be part of **interactive workshops** focusing on decision making for strategic water management issues?

EOG Resources, Chesapeake Energy, Anadarko, Seneca





Resource, Talisman Energy, Consol Energy, Antero Resources are just some of the E&P companies coming to the <u>Second Annual Shale Gas Water Management Marcellus</u> <u>Initiative</u> to deliver the latest solutions for driving down the costs of sourcing, treating, storage, transport and disposal of Marcellus frac water. Presenters from all these companies and more are preparing **in the last three weeks** before the event, gathering data from their companies' operations to include in the speeches they will be presenting in Canonsburg on March 27, 28 & 29.

Please see below for the layout of Shale Gas Water Management Marcellus Initiative 2012. (Plain text readers, <u>click</u> <u>here to view</u>).



Companies attending include:

212 Resources, Anadarko, Antero Resources, Burnett Oil Co. Inc., Caudrilla Resources, Chesapeake Energy, Consol Energy, Dover Energy, Encana, EOG Resources, EQT Production Company, Eureka Resources, EXCO Resources PA, LLC, Layne Energy, Murphy Exploration & Production Co., Noble Energy, PennWest Exploration, , QC Energy Resources, Rex Energy Corporation, Rice Energy, Seneca Resources, Shell Exploration and Production Co., Statoil ASA, Talisman Energy, Vantage Energy, WPX Energy.

With over 460 people at the first event last year, this year participants are geared up to deliver more solutions, more presentations, more insights and more technical knowledge than ever before with an increased number of E&P experts expected to attend. VPs, Directors, Managers and Engineers in every discipline from completions to operations, hydrology, environmental engineering and chemical management will be in attendance at this annual congress to attain practical, takeaway solutions for managing water resources. Once again we are set to sell out, so book now to avoid disappointment.



Bill Burket Regulatory Affairs Manager EOG Resources, Inc.

Windsor.Richard@epa.gov = Secondary e-mail address of former EPA Administrator, Lisa P. Jackson

Ensure you register now HERE to guarantee your place.

If you need any further information at all regarding the Summit or details of group booking discounts, please do not hesitate a member of the American Business Conferences team on (1) 800 721 3915 or **info@american-business-conferences.com**.

We look forward to welcoming you to Shale Gas Water Management Marcellus Initiative 2012 later this month.



Jane Thomas Director **American Business Conferences** T: (1) 800 721 3915 E: info@american-business-conferences.com



Rick McCurdy Sr. Engineering Advisor Chemicals & Water Reclamation Chesapeake Energy



Doug Kepler Director Environmental Engineering Seneca Resources



Matthew Peloquin Sr. Production Engineer Anadarko



Keith Minnich Water Sustainability Advisor Talisman Energy Inc



Gary Slagel Director, Government Affairs Consol Energy Inc



Keith Auman Water Specialist WPX Energy

PARTNERS

Windsor.Richard@epa.gov = Secondary e-mail address of former EPA Administrator, Lisa P. Jackson



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McGrath, Jessica (Intern)
Denise Anderson/DC/USEPA/US@EPA
Teri Porterfield/DC/USEPA/US@EPA; Bob Perciasepe/DC/USEPA/US@EPA
National Ocean Council Meeting
03/20/2012 01:50 PM

Good Afternoon,

The meeting for Deerin Babb-Brott and Mr. Perciasepe is scheduled for Friday, April 13th from 3-4pm, and is located at 730 Jackson Place, in the 1st floor conference room.

Thank you,

Jessie McGrath NOC

From: Denise Anderson [mailto:Anderson.Denise@epamail.epa.gov]
Sent: Tuesday, March 20, 2012 12:06 PM
To: McGrath, Jessica (Intern)
Cc: Teri Porterfield
Subject: Planning National Ocean Council Meeting

Here is Bob Perciasepe's calendar for March 26 thru April 20. I hope this is helpful. Thanks

Denise L. Anderson or Teri Porterfield Office of the Deputy Administrator U.S. Environmental Protection Agency Phone: 202/564-4711

Bob Perciasepe	March 26 - April 20, 2012	Calendar

Monday, March 26, 2012 08:00 AM - 08:30 AM General w/Debbie Dietrich

Location : 3412 ARN 08:45 AM - 09:30 AM Daily Briefing

09:30 AM - 10:15 AM Meeting w/Leadership of Cooper Investors, Australian Enviro. Investment Company Location : 3412 ARN
 10:30 AM - 11:15 AM Monthly Operations Meeting Location : ARN 3412
 11:15 AM Transportation

 11:30 AM - 12:30 PM Retirement Luncheon in honor of Dr. Bill Sanders Location : One Potomac Yard (South Building) 2777 South Crystal Drive, conference Room S-1203-1208, Arlington, VA
 12:30 PM Transportation Return

01:00 PM - 02:00 PM Senior Staff Meeting Location : Bullet Room

02:00 PM - 02:30 PM EMC Subgroup on Efficiency Identification and Review Group Location : 3330 ARN Call In # (0)(6) F Code: 02:15 PM - 02:45 PM Administrator's One on One: Cynthia Giles Location : Administrator's Office 03:00 PM - 03:45 PM Pre-briefing for the National Ocean Council (NOC) Deputies Meeting on Thursday, March 29 Location : 3412 ARN 04:00 PM - 04:30 PM Continuation of the NAS Tool's Study Discussion Location : 3412 ARN 04:30 PM - 05:00 PM One on One w/Mathy Stanislaus Location : 3412 ARN 05:00 PM - 05:30 PM SES Discussions Location : 3412 ARN Tuesday, March 27, 2012 08:15 AM - 08:45 AM One on One Ken Kopocis Location : 3412 ARN 09:00 AM - 09:30 AM Fracking Update Location : 3412 ARN 09:45 AM - 10:15 AM Bi-Weekly w/Peter Grevatt Location : 3412 ARN 10:15 AM - 11:00 AM Conference Call with Conchita Jimenez Location : We will call Ms Jimenez on (○(©) Personal Privacy 11:15 AM - 11:45 AM Meeting to Discuss the EO 13563 Lookback Report Location : 3412 ARN 12:00 PM - 12:45 PM Discussion on NTOC Hydrofracking and it's Impacts and Opportunities for Tr bes Location : 3412 ARN Access 12:45 PM Walk Over 01:00 PM - 02:00 PM Discuss the OSWER and Water Rules as they Relate to CCR - walk over to Cynthia's retirement celebration after this mtg. Location : 3146 EPA West 02:00 PM - 03:00 PM Cynthia Dougherty's Retirement Location : 2123 East 03:00 PM Return to Office Wednesday, March 28, 2012 08:15 AM - 08:45 AM Weekly Touch Base w/Barbara Bennett Location : 3412 10:00 AM - 11:00 AM Holding for DOD Engagement in Environmental Markets w/Harris Sherman, Ann Miles, Jackie Pfannenstiel, bob Perciasepe, Don Schregardus, Jeff Corbin, Nanacy Stoner 11:15 AM - 12:00 PM Discuss NRDC and GAO IRIS Report Location : 3412 ARN 12:00 PM - 01:30 PM Pizza Lunch / Spring Clean-up Day Location : 6402 ARN 12:45 PM Walk Over 01:00 PM - 02:00 PM OSWER Program Update Location : 3146 EPA West (0)(0)(0) Person nal Privacy Code: (0) (6) P 02:00 PM - 02:30 PM Conf Call Alaska RRT & Dispersants - Stay for this meeting Location : 3412 ARN 02:30 PM Walk to RRB 02:30 PM - 03:30 PM Technology Innovation Steering Committee Meeting - Per Charles - the deputy shid try to attend the first half of this meeting. abl Dr Call-in: b) (6) Personal Priva Code: Location : 41213 RRB 03:15 PM Return to Office 03:30 PM - 05:00 PM Senior Policy Location : Bullet Room 05:00 PM - 05:30 PM Northwest Indian Fisheries Commission. Location : 1200 Pennsylvania Avenue, NW - Room 3412 Ariel Rios North Thursday, March 29, 2012 08:45 AM - 10:00 AM Daily Briefing 10:00 AM - 11:00 AM Holding for DOD Engagement in Environmental Markets 11:00 AM - 11:45 AM Holding for Nat'l Environmental Education Team Location : 3412 ARN 12:30 PM - 01:30 PM RA Calls (conference #: (b) (0) Personal Privacy access code: (b) (6) Personal Privacy - the deputy will do the first 30 min of this call.

01:00 PM - 02:00 PM Meet w/Michael Robertson Location : 1200 Pennsylvania Avenue, NW - Room 3412 Ariel Rios North

02:15 PM Transportation

02:30 PM - 04:00 PM National Ocean Council Deputies Location : TGruman Room of the WH Conference Center, 726 Jackson Place 04:00 PM Transportation Return

Friday, March 30, 2012

08:00 AM - 05:00 PM On Leave

08:30 AM - 09:00 AM Michael Goo Location : 3412 ARN 08:45 AM Transportation

09:00 AM - 11:30 AM Holding for Maggie Weiss - Joint PMC/PMAB

01:00 PM - 02:00 PM OARM Program Update Location : 3330 ARN 한아라다네네이어 03:00 PM - 04:00 PM ORD Program Update (b) (6) Location : ARN 3530 Conference line: (b) (b) (6) Personal Privacy code: (b) (6) Personal Privacy Saturday, March 31, 2012 Sunday, April 1, 2012 Monday, April 2, 2012 08:45 AM - 10:00 AM Daily Briefing 10:00 AM - 10:45 AM Peer Review Discussion Location : 3412 ARN 11:00 AM - 12:00 PM Collaboration Tools Update (interim and relationship to unified solutions) Location : 5020 ARN 12:00 PM - 05:00 PM Annapolis Visit 01:00 PM - 02:00 PM Senior Staff Meeting Location : Bullet Room Tuesday, April 3, 2012 09:00 AM - 09:45 AM Gulf Task Force Progress Review Location : 3412 ARN 09:30 AM - 10:30 AM (b)(6) Persona 11:00 AM Return to Office 11:30 AM - 12:00 PM Fracking Update Location : 3412 ARN 12:00 PM - 01:30 PM FYI: Deputy Regional Administrators Teleconference (Call-in #: (b)(6) Personal Pr Location : Washington, D.C., EPA-HQ, Ariel Rios North 6413L (b) (6) 02:00 PM - 03:00 PM General Discussion Location : 3412 03:00 PM - 04:00 PM Discuss Partnership for Sustainable Communities Location : 1200 Pennsylvania Ave., NW, Room 3412 Ariel Rios North 04:00 PM - 05:00 PM OW Program Update Location : 3233 EPA-East -(b)(b)(6) (6) Personal Privacy (b) (6) Wednesday, April 4, 2012 08:00 AM - 05:00 PM Holding for Washington Clean Energy Roundtable - April 4-5, 2012 Location : DC 08:15 AM - 08:45 AM Weekly Touch Base w/Barbara Bennett Location : 3412 09:30 AM - 10:00 AM Bi-Weekly w/Peter Grevatt Location : 3412 ARN 11:00 AM - 11:45 AM FYI: Bi-Weekly Everglades Strategy Call Location : 3309 ARN Call in number: (b)(b)(0) 01:00 PM - 01:45 PM Update on e-Discovery Location : 3412 ARN Call In # (이 Personal Privacy Access Code: 03:30 PM - 05:00 PM Senior Policy Meeting Location : Bullet Room Thursday, April 5, 2012 08:00 AM - 05:00 PM Holding for Washington Clean Energy Roundtable - April 4-5, 2012 Location : DC 08:45 AM - 10:00 AM Daily Briefing 10:00 AM - 10:45 AM Bi-Weekly Chesapeake Bay - TMDL Call Location : 3412 ARN Call In # ^{0} 11:00 AM - 12:00 PM OAR Program Update (b) Location : Conf Rm 5415 ARN Call In # (0)(0) Pe 01:45 PM Walk Over

02:00 PM - 03:00 PM OCSPP Program Update-call in #(b)(b)(6) Personal Pr Location : 3156 EPA East -Update-call in #(b)(b)(6) Personal Privat 03:00 PM Return to Office

(b) (6) (b) (6)

Friday, April 6, 2012 - Anniversary - Good Friday (USA)

08:30 AM - 09:00 AM Michael Goo

Location : 3412 ARN Saturday, April 7, 2012

Sunday, April 8, 2012 - Anniversary - Easter (USA)

<u>Monday, April 9, 2012</u>

08:00 AM - 08:30 AM General w/Debbie Dietrich Location : 3412 ARN 08:00 AM - 05:00 PM Working from the Region

08:45 AM - 10:00 AM Daily Briefing

10:00 AM - 10:30 AM Administrator's One on One: Peter Grevatt Location : Administrator's Office
01:00 PM - 02:00 PM Senior Staff Meeting Location : Bullet Room
02:15 PM - 02:45 PM Administrator's One on One: John Hankinson Location : Administrator's Office
03:00 PM - 04:00 PM Briefing for the Administrator on EPA's Draft Bristol Bay Watershed Assessment

05:00 PM - 06:00 PM Travel to Cornell for Tuesday's meeting

Tuesday, April 10, 2012

09:00 AM - 09:30 AM General w/Arthur E kins Location : 3412 ARN 09:00 AM - 09:30 AM Fracking Update Location : 3412 ARN 09:00 AM - 05:00 PM HOLD: Teaching a Seminar at Cornell Location : Ithaca, NY

Wednesday, April 11, 2012

- 08:00 AM 05:00 PM Hold for Region V Hub Zone Small Business Outreach
- Location : Chicago 08:15 AM - 08:45 AM Weekly Touch Base w/Barbara Bennett
- Location : 3412 09:45 AM - 10:15 AM Operational Issues w/ OP's Strategic Management Division Location : 3412 ARN
- 10:00 AM 10:30 AM Administrator's One on One: Bicky Corman
- Location : Administrator's Office
- 02:00 PM 02:30 PM Administrator's One on One: Cynthia Giles
- Location : Administrator's Office
- 03:30 PM 05:00 PM Senior Policy Location : Bullet Room

Thursday, April 12, 2012

08:45 AM - 10:00 AM Daily Briefing

- 10:00 AM 10:30 AM Administrator's One on One: Jim Jones Location : Administrator's Office
 10:00 AM - 10:45 AM Vapor Intrusion Meeting Location : 3412 ARN
 11:00 AM - 12:00 PM Hold for Deputies EJ - IWG Meeting Location : 3412 ARN
 12:30 PM - 01:00 PM General w/Kate Fay
- Location : 3412 ARN
- 12:30 PM 01:30 PM FYI: RA Calls (conference #: (b) (d) Personal Privacy access code: (b) (d) Personal Privacy
- 01:00 PM 02:00 PM Quarterly Investors Call
- Location : 3412 ARN
- 02:00 PM 02:30 PM Administrator's One on One: Lisa Garcia Location : Administrator's Office
- 02:15 PM 02:45 PM Administrator's One on One: Michelle DePass
- Location : Administrator's Office
- 02:45 PM Walk Over
- 03:00 PM 04:00 PM OW Program Update Location : 3233 EPA-East - (b)(b)(6) Personal Priv

(b) (6)

(b) (6)

04:00 PM Return to Office

04:15 PM - 04:45 PM Administrator's One on One: Mathy Stanislaus Location : Administrator's Office Friday, April 13, 2012 08:30 AM - 09:00 AM Michael Goo Location : 3412 ARN 11:00 AM - 12:00 PM Hold for Deputies EJ - IWG Meeting

01:00 PM - 02:00 PM OEI Program update

Location : 5020 ARN Conference Line: [0] (0) Personal Privacy Saturday, April 14, 2012 Sunday, April 15, 2012 Monday, April 16, 2012

08:45 AM - 10:00 AM Daily Briefing

10:00 AM - 10:30 AM Administrator's One on One: Gina McCarthy Location : Administrator's Office

01:00 PM - 02:00 PM Senior Staff Meeting

Location : Bullet Room

04:00 PM - 04:45 PM Administrator's Discussion re: Issues under Title VI of the Civil Rights Act Location : Bullet Room

Tuesday, April 17, 2012

09:00 AM - 09:30 AM Fracking Update

- Location : 3412 ARN
- 09:00 AM 09:30 AM One on One w/Charles Imohiosen
- Location : 3412

09:30 AM - 10:15 AM Gulf Task Force Progress Review

10:30 AM - 11:30 AM Holding for Possible Sustainable Community Mtg w/Pocari

12:00 PM - 01:30 PM Deputy Regional Administrators Teleconference (Call-in #: ^(b)(6) Reconal Privacy (b) (6) Location : Washington, D.C., EPA-HQ, Ariel Rios North 6413L

01:00 PM - 01:30 PM Administrator's One on One: John Hankinson Location : Administrator's Office

03:30 PM Wa k Over

03:45 PM - 04:45 PM Program Update w/OITA Location : Michelle's Office - Room 31207 Ronald Regan Bldg - 3rd Floor Call In (b)(6) Personal Privacy 04:45 PM Return to Office

Wednesday, April 18, 2012

08:00 AM - 05:00 PM Holding for Possible Region 8 visit

08:15 AM - 08:45 AM Weekly Touch Base w/Barbara Bennett Location : 3412 09:30 AM - 10:00 AM Bi-Weekly w/Peter Grevatt Location : 3412 ARN 11:00 AM - 11:45 AM FYI: Bi-Weekly Everglades Strategy Call Location : 3309 ARN Call in number: (D)(D)(0) Resonal Rivery

- 02:30 PM 03:30 PM OECA Program Update Location : 3216 ARS Call In #^{(b)(b)(6)} Personal Privacy (b) (6)
- Location : 3216 ARS Call In # 000 03:30 PM - 04:30 PM Senior Policy Meeting
- Location : Bullet Room

Thursday, April 19, 2012

08:00 AM - 05:00 PM Holding - Local Government Advisory Committee (LGAC Location : Denver, CO 08:30 AM - 10:00 AM Holding for Jeanette Brown - Participation for one of the WH

08:30 AM - 10:00 AM Holding for Jeanette Brown - Participation for one of the WH asks....2012 Office of Small & Dis-advantage Business Utilization - 8:45 Time Slot - POC: Kimberly Patrick

(b) (6)

08:45 AM - 10:00 AM Daily Briefing

10:00 AM - 10:45 AM Bi-Weekly Chesapeake Bay - TMDL Call

Location : 3412 ARN Call In # ^{(b)(6) Personal Privacy} (b) (6) 11:00 AM - 11:30 AM Administrator's One on One: Barbara Bennett

Location : Administrator's Office

Friday, April 20, 2012

08:00 AM - 05:00 PM On Travel - binoculars

08:30 AM - 09:00 AM Michael Goo

Location : 3412 ARN

10:00 AM - 12:00 PM Attending - EPA's Local Government Advisory Committee (LGAC) Meeting (15 min of remarks addressing

Agency's Charge to Committee and 30 min of discussion - total 45 min Flexible between 10:00 - 12:00) *Location :* Denver, CO 11:30 AM - 12:00 PM Administrator's One on One: Malcolm Jackson *Location :* Administrator's Office

From:Peter RobertsonTo:Bob Perciasepe/DC/USEPA/US@EPASubject:RE: couple of thingsDate:03/22/2012 11:14 AM

Great. Speak with you then.

PDR

Peter D. Robertson ANGA 202-789-1301

probertson@anga.us

www.anga.us

From: Bob Perciasepe [mailto:Perciasepe.Bob@epamail.epa.gov] Sent: Thursday, March 22, 2012 9:22 AM To: Peter Robertson Subject: RE: couple of things

In Boston, looking ahead to events and meetings I will shoot for 2:30 pm. OK?

Bob Perciasepe Deputy Administrator (o) 202 564 4711 (c) (b) (6) Personal Privacy

----- Original Message ------

From : Peter Robertson <<u>probertson@anga.us</u>> To : Bob Perciasepe/DC/USEPA/US@EPA Cc : Sent on : 03/22/2012 08:59:36 AM Subject : RE: couple of things

Absolutely. Afternoon is good; almost any time after 12:30. But could we set a time so that I don't miss you? OK if you just want to keep it as "catch as catch can."

PDR

Windsor.Richard@epa.gov = Secondary e-mail address of former EPA Administrator, Lisa P. Jackson

Peter D. Robertson

ANGA

202-789-1301

probertson@anga.us

www.anga.us

From: Bob Perciasepe [<u>mailto:Perciasepe.Bob@epamail.epa.gov</u>] Sent: Thursday, March 22, 2012 8:58 AM To: Peter Robertson Subject: RE: couple of things

Can we try again today? Sorry for my elusive nature.

Bob Perciasepe Deputy Administrator (o) 202 564 4711 (c) ^{(b) (6)} Personal Privacy

----- Original Message ------

From : Peter Robertson <<u>probertson@anga.us</u>> To : Bob Perciasepe/DC/USEPA/US@EPA Cc : Sent on : 03/21/2012 06:31:11 AM Subject : Re: couple of things

Absolutely. 10:00, 11:30-1:00, 1:30 to 4:00?

Peter D. Robertson ANGA 202-789-1301

Sent from my iPhone

On Mar 21, 2012, at 6:07 AM, "Bob Perciasepe" <<u>Perciasepe.Bob@epamail.epa.gov</u>> wrote:

Time to chat today? Or tomorrow?

----- Forwarded by Bob Perciasepe/DC/USEPA/US on 03/21/2012 06:07:15 AM-----

----- Original Message ------

From : Bob Perciasepe/DC/USEPA/US To : "Peter Robertson" <<u>probertson@anga.us</u>> Cc : Sent on : 03/19/2012 10:40:47 PM Subject : RE: couple of things

I agree it was a good meeting. Lisa is looking forward to the follow-up with her. We are working on rebuttals to API. We have made many improvements to the Oil and Gas NSPS and in no way believe it will have the impact they are suggesting.

Here is a report from OW on seismicity.

"We are working with regions on a technical report of the UIC technical work group (states, regions, and HQ) to provide recommendations to UIC permit writers on how to minimize induced seismicity. We are in the process of revising a draft of the report and are planning on a review by the SAB this summer.

The draft report will summarize existing reports and will contain case studies and recommendations.

You may have heard that we had planned to have those who contributed data (Texas, Chesapeake, USGS and others) to review a draft and we are still working out the details of that review"

I will talk to them about notice and comment, but it seems like they want to do a review with several companies then a SAB review.

Thoughts?

Bob Perciasepe Deputy Administrator (o) 202 564 4711 (c) ^{(b) (6)} Personal Privacy

----- Original Message ------

From : Peter Robertson <<u>probertson@anga.us</u>> To : Bob Perciasepe/DC/USEPA/US@EPA Cc : Sent on : 03/16/2012 10:39:44 AM Subject : couple of things

I don't know what your reaction was, but I thought it was a great meeting (as did our members). Thanks again for being the moving force behind it. We are already gathering information from some CEOs about coming to town to meet with Lisa. We'll offer a(some) date(s) in the near future.

Could I get your help on a couple of things? A recent press piece calls the seismicity guidance "in press" – I take that to mean it's getting printed and will soon be ready for distribution. Will there be no further review of it? As you may recall, this was something that we felt strongly should be put through notice and comment.

Second, Ann Campbell called me once after our meeting to discuss the \$43 million multiagency request for hydraulic fracturing R&D. I've called her several times since, but am not getting a return call. Can you gently remind her to give me a call?

Thanks so much, Bob. Look forward to hearing from you on the seismicity guidance.

PDR

<15639695.jpg>

Peter D. Robertson

Senior Vice President for Legislative

And Regulatory Affairs

701 8th Street NW

Washington, DC 20001

202-789-1301

probertson@anga.us

www.anga.us

From:	Lora Werner
To:	Shawn Garvin
Cc:	Michael DAndrea; Ron Borsellino; Linda Boornazian; Bob Perciasepe
Subject:	CDC-ATSDR Hydraulic Fracturing Workshop in DC - EPA R3 participation?
Date:	04/24/2012 12:59 PM
Attachments:	Agenda CDC-ATSDR Hydraulic Fracturing Health Effects Workshop.docx

Hi, Shawn

I just wanted to send a quick note about the CDC- ATSDR hydraulic fracturing/natural gas meeting coming up on May 1-2 in DC. I know EPA R3 was invited, but I wasn't sure if you planned on sending any one. The goal of this meeting is to help CDC and ATSDR prioritize our public health efforts related to hydraulic fracturing/natural gas and oil sites. Obviously I think EPA Region 3's perspective on this is critical - I want the decision makers at this meeting to hear what EPA R3 really need us to focus on. I attached the current version of the agenda. Unfortunately it is a little heavy on the presentations side as opposed to the focused discussion side, but I really hope this meeting will still achieve our purpose of getting all the participant's perspectives out on the table to help us move forward and set an agenda for the agency. This is a strictly closed, invitation only meeting that will have about 80 or so participants. Last I heard, Jeanne Briskin and Bob Perciasepe would participate for EPA HQ and EPA R8 was not sending any one, and we were to hold an hour after the close of the meeting for a follow up discussion with Bob.

Please let me know what you think or if you would like to discuss any of this further. I was tapped to provide the only ATSDR presentation, which will review our findings in private wells across the different sites we've worked on nationally. My slides are still in clearance at my HQ right now. I do plan to share an advance copy of them with you prior to the meeting since I do mention Chesapeake ATGAS and Dimock; I was careful to refer only to publicly available information in these slides for these sites.

thanks so much, Lora

Lora Siegmann Werner, MPH Senior Regional Representative Agency for Toxic Substances and Disease Registry (ATSDR), Region 3 Department of Health and Human Services 1650 Arch Street, 3HS00, Philadelphia, PA 19103 phone: 215-814-3141, fax: 215-814-3003 (b) (6)

email: lkw9@cdc.gov

CDC.gov is Your Online Source for Credible Health Information. Visit www.cdc.gov.



From:	Ann Campbell
То:	Bob Perciasepe; Bob Sussman; Charles Imohiosen; Janet Woodka; Nena Shaw; Glenn Paulson
Cc:	Teri Porterfield; Denise Anderson; Donald Maddox
Subject:	Agenda and Materials for Tomorrow's Fracking Update
Date:	05/10/2012 08:24 PM
Attachments:	Fracking Update 051112 agenda.docx
	EPA Activities 051112.docx
	CEOs Mtng Executive Summary 051612.docx





AGENDA

Update on Actions (see attached)

CEOs Meeting, 5/16/12 (see attached)

Interagency Collaboration on Oil and Gas Research - implementation update

Appalachian Shale Recommended Practices Group

Ann Campbell Office of the Administrator U.S. Environmental Protection Agency Mail Code: 1101

P: (202) 566-1370

C: (b) (6) Personal Privacy

From:Bob SussmanTo:Bob Perciasepe; Ann CampbellCc:Nena ShawSubject:Re: CEOs Mtng: Feedback from ANGADate:05/14/2012 03:25 PM

(b) (5) Deliberative

Bob Perciasepe

----- Original Message -----From: Bob Perciasepe Sent: 05/14/2012 03:00 PM EDT To: Ann Campbell Cc: Bob Sussman; Nena Shaw Subject: Re: CEOs Mtng: Feedback from ANGA Which EO?

(b) (5) Deliberative

Bob Perciasepe Deputy Administrator

(o) +1 202 564 4711 (c) +1 $^{(b) (6) \text{ Personal Privacy}}$

▼ Ann Campbell---05/14/2012 01:58:26 PM---Bobs, see the message below from Peter. Seems like their agenda for the Wednesday meeting is someth

From: Ann Campbell/DC/USEPA/US To: Bob Perciasepe/DC/USEPA/US@EPA, Bob Sussman/DC/USEPA/US@EPA Cc: Nena Shaw/DC/USEPA/US@EPA Date: 05/14/2012 01:58 PM Subject: CEOs Mtng: Feedback from ANGA

Bobs, see the message below from Peter. Seems like their agenda for the Wednesday meeting is something like this:

President's EO Data Quality HF Study - coordinating with industry Federal interagency coordination - prioritization amongst actions Ongoing EPA regulatory activities

I know you both are quite well-versed in each of these areas. Please advise as to what, if any, materials you'd like prepared for the Administrator. Thanks,

Windsor.Richard@epa.gov = Secondary e-mail address of former EPA Administrator, Lisa P. Jackson

Ann

Ann Campbell Office of the Administrator U.S. Environmental Protection Agency Mail Code: 1101

P:	(202)) 566-	1370
C:	(b) (6) F	Personal	Privacy

F: (202) 501-1428

----- Forwarded by Ann Campbell/DC/USEPA/US on 05/14/2012 01:54 PM -----

From: Peter Robertson <probertson@anga.us> To: Ann Campbell/DC/USEPA/US@EPA Date: 05/11/2012 03:31 PM Subject: Re: Checking In

Hi Ann –

Thanks for the note. We've had a chance to talk to our CEO about the briefing. We've prepared a list of high-level topics we believe will promote good discussion. These include President Obama's recent executive order regarding interagency coordination on the regulation of natural gas production; the use of up-to-date data on supply, price and emissions; the use of sound science and the importance of collaborating with industry experts in the stakeholder process (e.g. the HF study); and the need to prioritize among agency activities. We are also going to provide the CEO's with basic background on recent and ongoing regulatory activities but given the level and duration of the meeting we don't anticipate there will be much in depth conversation.

Please let us know if there are any issues on your list that we should prepare are folks for. Also, can you let me know who will attend the meeting from your side?

Thanks and look forward to seeing you next week,

Peter

Peter D. Robertson ANGA

202-789-1301

Sent from my iPhone

On May 10, 2012, at 9:28 AM, "Ann Campbell" <<u>Campbell.Ann@epamail.epa.gov</u>> wrote:

Peter - I hope the conference is going well. Please let me know when today might be a good chance for us to check in on next week's meeting.

Best, Ann

> Ann Campbell Office of the Administrator U.S. Environmental Protection Agency Mail Code: 1101

P: (202) 566-1370 C: ^{(b) (6)} Personal Privacy

From:	Ann Campbell
To:	Noah Dubin; briefings@epa.gov; Bob Perciasepe; Bob Sussman; Diane Thompson
Cc:	Donald Maddox; Nena Shaw; Teri Porterfield; Denise Anderson; Jose Lozano; Stephanie Washington; Christopher Busch
Subject:	051612: Materials for Meeting with Natural Gas CEOs
Date:	05/15/2012 02:34 PM
Attachments:	CEOs Mtng Executive Summary 051612.docx EPA Activities 051512.docx

Attached are the meeting summary form and a briefing doc with updates on EPA hydraulic fracturing activities around the Agency. I expect 2 more documents which delve into more detail on 2 of the subject by COB today. Thanks, Ann





Ann Campbell Office of the Administrator U.S. Environmental Protection Agency Mail Code: 1101

P: (202) 566-1370 C: ^{(b) (6)} Personal Privacy

From:	Ann Campbell
То:	<u>briefings@epa.gov; Noah Dubin; Bob Perciasepe; Bob Sussman; Diane Thompson</u>
Cc:	Teri Porterfield; Denise Anderson; Donald Maddox; Christopher Busch; Stephanie Washington; Nena Shaw; Linda Chappell
Subject:	051612: ORD Materials for Natural Gas CEOs mtng
Date:	05/15/2012 05:53 PM
Attachments:	coordination of hf research with industry 051512.docx

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fAC2BAAArASsBEdJRjg5YSwBIgDmAAD////o8Pjg6PgwSGDw8PjQ4PjY4PjY6Pjw+PiAoMiQqNCQ sNiguNiguOCYsNiouMioyPDI2PjY4PCIqNBQcKiQoNCYqLigwOCowOCQoLiYqMCYuNiwuNDo6PBw oOiIsOCQsODIyMqoSKAwUKBqmPBomPCAoNCIoNCqsMCqsMiqsNDI0Ojq4ODq4OqqSJq4UGhIYKBQ aKhYcLCAqOiYqNČYsOCYuODĂwMjY2NjY4Ojo6Pjw8PBAWJhIYHhoeJBwgLhwiMB4oOh4qOiAiKCA qOCIoLiIqOCqsNiosMiouNiwyOC4wODAyNjAyODIyNDI2PDQ0NDQ0NjQ2OjQ2PjQ4PDY2PDq6OqQ ÓlggQlggQKÅ4ULA4WJhAWHBAWLBIYKhľaKBIaĽBQYJhQaIBYaIBYaKBYcľBYcKhYcLhgcIhgcJhg eKhgeLhggLBggLhogLBooPBwgIhwgJBwgJhwiLh4iLB4iMB4kMCAkMCAmMiAqNiImKiImLiImMCI oMilqNiQmKqsAAAAACwBIqBACP8AAQqcSLCqwYMIEypcyLChw4cQI0qcSLGixYsYM2rcyLFjjCZ4 fnAqsEKKQScsBEJAAGCFBTRIxPTq8mJÄx5s4c+rcybOnQjVkwqQZ8qdFIAAEAii1AKUFSwQIĆEhV GkCAqA82fWrdyrWrV58WqIpVarWsqAMHDBqowNZD1q9w48qdS7eu3bt483ZVYoaGhL+AAf9AiEKA gRd6EytejBeGChFfBGZZk0PEGQIIooRoobLBhQYgQCRIGsDGW8aoU6vegQFqVKmwYY8tm1bI6dW4 c+uOmIE2WrRq1bJIOyWCceMkbu9ezrw5B4go5DSfTn03HxVSTqgoKKBDByY7BkL/GA9Bg+EnK5RX X89+rmMRVzoAGLECjAsAXnIQuJESAIQLn/IRw2hJMaBeewgmyBMPR8jwXABLACBBBVEF8AAUVhAE IWxKqXCqqiCGyNEOHeiBQxROhHDDiiF0ENtUVJVFxIci1mqjRRa80BZVOpiV1lpu3SjkkBT1ZtaR Z/241nDGIUAjkVBGCUAGPvRQ0wBYZqnllltK6eWXAnEqJqcPlGlmmUqqkUIKKKQA5ptfdlABGxTU aWedcxAmwBhw9nIjDjEsUUUFhFagwKGEuoGQeQY88aSfkC4nQxMK2OEmQjhw5h8AAVBhwQpKKIFB A49GampqHwEhwwoEjEBDDiMA/wBEGwCE0B8EVKwQAAafMeCrgacGu9x7WAjkQh13uEBDHwBYYatK eSxgwwIDkmaasNjixuAIdHDaRQdVaLFCVEw4oWkC6KabAFU1IJrtu3JtkcQeFRRUYQAaFOHAZw0w sIEDDiywAFkewmvwYjvqEAIcKFjqQxxDWPBAvr/+G/ACh1YlqBHuHuyxV60hICoGvDbQr8UCHzrB BFYdMEPHH8cMIIQk97oByhgrsPIEJwAXBMwyB51TWAHw6y/AKeu88gkmmLBkkEJH/VUGPPaIpAA8 N40uWxE4KfXXXBI55G9KDIdAccgBDfbaE2VwABMYJHEECB/U/YERRMwwgxBBeBHgwRsIIEBCcmwX bvjhiK8dEAA7

dv9SADYAAAEAAAkBAAAAAAAAAAAAAAAAAAAAAAAAAGNvb3JkaW5hdGlvbiAgb2YgaGYgcmVzZWFyY2gg d2l0aCBpbmR1c3RyeSAwNTE1MTIuZG9jeA== qgI=

Ann Campbell Office of the Administrator U.S. Environmental Protection Agency Mail Code: 1101

P: (202) 566-1370

C: (b) (6) Personal Privacy

*** Do not copy or forward this information ***

EPA Administrator Lisa P. Jackson

Schedule

06/21/2012 04:50:47 PM

Monday, 6/25/2012

08:00 AM-01:00 PM HOLD: Out of Office

08:45 AM-09:30 AM Daily Briefing Location: Administrator's Office

01:00 PM-02:00 PM Senior Staff Location: Bullet Room

O2:15 PM-O2:45 PM Meeting with EPA's National Partnership Council (NPC) Unions Ct: Kim Wheeler - 202-564-1877

Staff: Craig Hooks (OARM)

Optional: Jose Lozano (OA)

Location: OARM Conference Room, ARN 3330

O3:00 PM-03:45 PM Briefing on Recycling and the Definition of Solid Waste Rule Ct: Nelly Torres - 202-564-5767

Staff: Mathy Stanislaus, Lisa Feldt, Barry Breen, Suzanne Rudzinski, Sandra Connors (OSWER) Jim Jones (OCSPP) Arvin Ganesan (OCIR) Avi Garbow (OGC) Michael Goo, Bicky Corman (OP)

Optional: Diane Thompson, Bob Perciasepe, Bob Sussman, Lisa Garcia (OA) Laura Vaught (OCIR)

Location: Bullet Room

04:00 PM-04:15 PM Video Recording for the Links

Ct: Andra Belknap - 202-564-0369

Staff: Andra Belknap, Ron Slotkin (OEAEE)

Location: MOSS Studio

04:30 PM-05:00 PM One on One with Malcolm Jackson Ct: Georgia Bednar - 202-564-9816

Staff: Malcolm Jackson (OEI)

Optional: Diane Thompson, Bob Perciasepe, Bob Sussman (OA) Location: Administrator's Office

Tuesday, 6/26/2012

08:00 AM-10:00 AM Out of Office

Location: Out of Office

10:10 AM-10:45 AM Follow-up Meeting re: ORD Hydraulic Fracturing Study

Ct: Don Maddox - 202-564-7207

Staff: Bob Sussman, Ann Campbell, Glenn Paulson (OA) Lek Kadeli, Ramona Trovato, Cynthia Sonich-Mullin, Fred Hauchman, Jeanne Briskin, Kevin Teichman, Dorothy Miller (ORD)

Optional: Bob Perciasepe, Diane Thompson, Janet Woodka (OA) Arvin Ganesan, Laura Vaught (OCIR)

Location: Administrator's Office

11:00 AM-11:30 AM Meeting with Luke Daly,CEO & Founder,Ferrate Treatment Technologies

Ct: Ryan Robison - 202-564-2856 Ct: Adam J. Zellner -732-253-7717

Attendees: Luke Daly,CEO & Founder,Ferrate Treatment Technologies Susan Glickman - Grants and Incentives Coordinator Adam J. Zellner -President, Greener by Design

Staff: Nancy Stoner (OW)
Steve Chester (OECA)

Optional: Bob Perciasepe (OA)

Location: Administrator's Office

11:45 AM-12:10 PM One on One with Craig Hooks Ct: Kim Wheeler - 202-564-1877

Staff: Craig Hooks (OARM)

Optional: Diane Thompson, Bob Perciasepe, Bob Sussman (OA)

Location: Administrator's Office

12:10 PM-01:20 PM Out of Office Location: Out of Office

01:20 PM-01:50 PM One on One with Peter Grevatt Ct: Florence Claggett - 202-566-0637

Staff: Peter Grevatt (OCHP)

Optional: Diane Thompson, Bob Perciasepe, Bob Sussman (OA)

Location: Administrator's Office

02:00 PM-02:30 PM One on One with Glenn Paulson Ct: Sharnett Willis - 202-564-7866

Staff: Glenn Paulson (OA)

Location: Administrator's Office

02:45 PM-03:15 PM One on One with Mathy Stanislaus Ct: Nelida Torres - 202-564-5767

Staff: Mathy Stanislaus (OSWER)

Optional: Diane Thompson, Bob Perciasepe, Bob Sussman (OA)

Location: Administrator's Office

03:30 PM-04:00 PM One on One with Cameron Davis

Ct: Veronica Burley - 202-564-7084

Staff: Cameron Davis (GLTF)

The Administrator will call Cameron at 312-405-2249 Location: By Phone

04:15 PM-05:15 PM HOLD: Testimony Prep Ct: Arvin Ganesan or Laura Vaught - 202-564-0304

Staff: Arvin Ganesan, Laura Vaught (OCIR) Location: Administrator's Office

05:30 PM-05:45 PM HOLD:Remarks at the National Women's History Museum for Reta Jo Lewis Ct: Janet Redfern -202.647.7710 RedfernJK@state.gov

Location: National Museum of Women in the Arts -1250 New York Avenue, NW - Elisabeth A. Kasser Board Room

Wednesday, 6/27/2012

08:00 AM-09:45 AM Out of Office

Location: Out of Office

10:00 AM-10:30 AM HOLD: Meeting with Co-Chairs of the Blue Ribbon Commission on America's Nuclear Future Ct: Sharnett Willis - 202-7866

Staff: Glenn Paulsen (OA) Location: Administrator's Office

11:00 AM-11:30 AM HOLD: Sierra Club Youth Club Event Ct: Dru Ealons or Scott Frazier - 202-566-2126 Location: Green Room

11:00 AM-11:30 AM Security Awareness/No Fear Act Training Ct: Ryan Robison - 202-564-2856 Location: Administrator's Office **12:00 PM-01:00 PM No Meetings** Location: Administrator's Office

01:00 PM-02:00 PM Hold: Testimony prep

02:15 PM-02:45 PM Meeting on KY Title V Petition Ct: Don Maddox: 202-564-7207

Staff:

Diane Thompson, Bob Sussman, Janet Woodka (OA) Gina McCarthy, Janet McCabe (OAR) Gwen Keyes-Fleming (R4) Scott Fulton, Avi Garbow (OGC) Brendan Gilfillan (OEAEE) Location: Administrator's Office

03:00 PM-03:30 PM One on One with John Hankinson

Ct: Jody Ramsey - 202-564-564-5754

Staff: John Hankinson (GCTF)

Optional: Diane Thompson (OA) Location: Administrator's Office

03:30 PM-05:00 PM Senior Policy Location: Bullet Room

06:00 PM-07:30 PM White House Congressional Picnic Location: White House

Thursday, 6/28/2012

08:00 AM-10:00 AM Hold: Testimony Prep Ct: Laura Vaught/ Arvin Ganesen

08:45 AM-09:30 AM Daily Briefing Location: Administrator's Office

10:00 AM-01:00 PM Testimony before House Science Committee Ct: Laura Vaught - 202-564-0304

Location: 2318 Rayburn

01:00 PM-02:00 PM No Meetings Location: Administrator's Office

02:00 PM-03:00 PM Cabinet Meeting with Chief of Staff, Jack Lew

Ct: Colleen King - 202-456-2576 Location: WH -Roosevelt Room

04:00 PM-05:30 PM HOLD: Center for Global Development Post-Rio +20 Event

Ct: jottenhoff@cgdev.org Location: Center for Global Development 1800 Massachusetts Ave. NW Washington, DC

Friday, 6/29/2012

08:00 AM-09:15 AM Breakfast with Admiral Robert Papp

Ct: Ryan Robison - 202-564-2856 CG Ct: Jennifer Ey - 202-372-4409 Location: 2100 2nd St. SW, WDC

09:15 AM-09:30 AM Depart for Comcast Studio Location: Ariel Rios

09:45 AM-10:30 AM On-Camera Taped Interview with Roland Martin, Washington Watch Ct: Alisha Johnson - 202-564-4373

Location: 101 Constitution Avenue, NW WDC, Comcast Studio on Lower Level

10:30 AM-10:45 AM Depart for Ariel Rios Location: Comcast Studio

11:30 AM-12:00 PM One on One with Gwen Keyes Fleming Ct: Brenda Beverly - 404-562-8348

Staff: Gwen Keyes Fleming (R4)

Optional: Bob Sussman, Bob Perciasepe, Diane Thompson (OA)

Location: Administrator's Office

12:00 PM-01:00 PM No Meetings Location: Administrator's Office

01:30 PM-02:30 PM 1890 Land-Grant Institutions MOU Signing between USDA and EPA Ct: Dru Ealons - 202-564-7818 USDA Ct: Sally Cluthe - (b) (6) Location: EEOB - Room Indian Treaty Room

03:00 PM-03:30 PM Pre-Brief for the Chesapeake Bay Executive Council Meeting Ct: Jeff Corbin - (215)667-9304

Staff: Bob Sussman (OA) Shawn Garvin (R3) Jeff Corbin, Carin Bisland, Nick Dipasquale (CBP) Sarah Pallone (OCIR)

Location: Administrator's Office

Saturday, 6/30/2012

Sunday, 7/1/2012

08:00 AM-08:00 PM Hld: Travel to Aspen, CO

08:31 AM-12:20 PM En Route to Denver, CO United Airlines Flight 579 Departs Washington, DC (IAD): 8:31 AM EDT Arrives Denver, CO (DEN): 10:20 AM MDT

02:47 PM-03:34 PM En Route to Aspen, CO United Airlines Flight 5363 Departs Denver, CO (DEN): 12:47 PM MDT Arrives Aspen, CO (ASE): 1:34 PM MDT

Monday, 7/2/2012

05:00 AM-08:00 PM Hold: Travel to Aspen, CO

08:45 AM-09:30 AM Daily Briefing

Location: Administrator's Office

12:00 PM-01:00 PM No Meetings Location: Administrator's Office

Tuesday, 7/3/2012

05:00 AM-08:00 PM Hld: Travel to Aspen, CO

11:30 AM-12:00 PM RESCHEDULE: One on One with Nancy Stoner Ct: Martha Workman - 202-564-3774

Staff: Nancy Stoner (OW)

Optional: Diane Thompson, Bob Perciasepe, Bob Sussman (OA) Location: Administrator's Office

12:30 PM-12:40 PM HOLD: Call with Mayor Vincent Grey (DC) Mayor Ct: Alex Simbaña - 202-727-6263 Back-up Mayor Ct: Darin Allen: E-mail - darin.allen@dc.gov

**The Administrator will call 202-727-6263 to be connected to the Mayor. Location: By Phone

Wednesday, 7/4/2012

08:00 AM-09:00 PM Out of Office

Thursday, 7/5/2012

05:00 AM-08:00 PM Hold: Travel to Washington, DC

08:45 AM-09:30 AM Daily Briefing Location: Administrator's Office

12:00 PM-01:00 PM No Meetings

Location: Administrator's Office

05:49 PM-06:40 PM En Route to Denver, CO United Airlines Flight 5623 Departs Aspen, CO (ASE): 3:49 PM MDT Arrives Denver, CO (DEN): 4:40 PM MDT

07:57 PM-11:21 PM En Route to Washington, DC United Airlines Flight 317 Departs Denver, CO (DEN): 5:57 PM MDT Arrives Washington, DC (IAD): 11:21 PM EDT

Friday, 7/6/2012

08:00 AM-09:00 PM Do Not Schedule

12:00 PM-01:00 PM No Meetings Location: Administrator's Office

Saturday, 7/7/2012

Sunday, 7/8/2012

*** END ***

To: Bob Sussman	
Cc: Arvin Ganesan; Bob Perciasepe; Brendan Gilfillan; Laura Vaught	; <u>Richard Windsor</u>
Subject: Re: API/ANGA - EPA HF Study	
Date: 06/22/2012 03:29 PM	

I'm not sure if it's for the interagency group the was set up through the EO, for the interagency science group that we set up through the mou, or for "ours". It would be a good question to ask Heather. (b) (5) Deliberative

Bob Sussman

----- Original Message -----From: Bob Sussman Sent: 06/22/2012 12:05 PM EDT To: Janet Woodka Cc: Arvin Ganesan; Bob Perciasepe; Brendan Gilfillan; Laura Vaught; Richard Windsor Subject: Thanks Janet. (b) (5) Deliberative

Robert M. Sussman Senior Policy Counsel to the Administrator Office of the Administrator US Environmental Protection Agency

▼ Janet Woodka---06/22/2012 11:31:06 AM---Thanks, Bob. Helpful additional perspective. (b) (5) Deliberative

From: Janet Woodka/DC/USEPA/US To: Bob Sussman/DC/USEPA/US@EPA Cc: Arvin Ganesan/DC/USEPA/US@EPA, Bob Perciasepe/DC/USEPA/US@EPA, Brendan Gilfillan/DC/USEPA/US@EPA, Laura Vaught/DC/USEPA/US@EPA, Richard Windsor/DC/USEPA/US@EPA Date: 06/22/2012 11:31 AM Subject: Re: API/ANGA - EPA HF Study





From:	Bob Sussman
To:	Janet Woodka
Cc:	Arvin Ganesan; Bob Perciasepe; Brendan Gilfillan; Laura Vaught; Richard Windsor
Subject:	Re: API/ANGA - EPA HF Study
Date:	06/22/2012 10:36 AM
Attachments:	Document (6).pdf

Thanks Janet --- to add to this story



I see some value in getting more information about the report -- it may help to prepare for the upcoming hearing -- so sitting down with them to hear what's in the report would probably be useful (although I don't think we'll be surprised).



remedied by posting QAPPs on the website. This is after all a scientific study, and the scientists need some room to do their work.



Robert M. Sussman Senior Policy Counsel to the Administrator Office of the Administrator

US Environmental Protection Agency

▼ Janet Woodka---06/22/2012 10:03:34 AM---I just wanted to make sure that everyone had this information. As folks know, API/ANGA hired Batte

From: Janet Woodka/DC/USEPA/US To: Laura Vaught/DC/USEPA/US@EPA, Bob Perciasepe/DC/USEPA/US@EPA, Richard Windsor/DC/USEPA/US@EPA, Bob Sussman/DC/USEPA/US@EPA, Arvin Ganesan/DC/USEPA/US@EPA, Brendan Gilfillan/DC/USEPA/US@EPA Date: 06/22/2012 10:03 AM Subject: API/ANGA - EPA HF Study

I just wanted to make sure that everyone had this information. As folks know, API/ANGA hired Battelle to do a review of our HF study. The review of study plan is complete but has not yet been made public or shared. The only information that has been shared on it so far is provided below. (b) (5) Deliberative

So, I wanted to put this forward to folks to see how y'all wanted to proceed.

Janet

Follow up from our discussion. Attached is the document we left behind during our May 18 meeting with Heather and Bob. Below is some additional information provided to Heather that was not covered in that meeting. Let me know if you have any questions.

With regard to EPA's Study, there appears to be insufficient alignment and nexus between the processes of developing the study design and individual research activities, and those for the development of the Quality Assessment (QA) program that is to ensure systematic planning for design and implementation of the study and its individual research activities. In fact, the Quality Management Plan (QMP) does not provide guidance or requirements for the use of systematic planning. It also does not provide sufficient guidance to ensure all projects are: 1) conducted in a comprehensive, consistent, and coordinated manner and 2) linked to the overall program objectives defined in the study plan, even though this is specifically recognized as an essential requirement by EPA in the study plan. There is wide variability among the individual QA documents in terms of level of detail, consistency, guidance for documents and records and data management, as well as approaches for complying with QA and assessment requirements. And, there is no overarching roadmap laying out the interrelationships among the individual studies among QAPPs or how the intramural and extramural teams working on the individual projects will coordinate different elements of the project.

In addition to the critical review of the EPA Study Plan, API/ANGA will develop five characterization reports, based on the five retrospective sites selected by EPA. The point of each report is to provide context, background, and additional historical information to "ground truth" each of the case sites. The report will characterize groundwater quality and surface water quality at each location, in order to develop an understanding of the water resources within each retrospective study area, which can be used for comparisons to actual data generated as part of the Agency's case study reviews.



From:	Bob Sussman
То:	Bob Perciasepe; Laura Vauqht
Cc:	Arvin Ganesan; Brendan Gilfillan; Janet Woodka; Richard Windsor; Laura Vaught; Administrator Lisa Jackson
Subject:	Re: Re: Re: DRe: API/ANGA study and hearing
Date:	06/27/2012 09:42 AM

(b) (5) at the hearing (b) (5)	Obviously fine to say it

From: Bob Perciasepe Sent: 06/27/2012 09:37 AM EDT To: Laura Vaught Cc: Arvin Ganesan; Bob Sussman; Brendan Gilfillan; Janet Woodka; Richard Windsor; "Laura Vaught" <vaught.laura@epa.gov>; "Administrator Lisa Jackson" <windsor.richard@epa.gov> Subject: Re: Re: Re: DRe: API/ANGA study and hearing

All:

For what it is worth, (b) (5)

If you all think a Deputy level meeting is appropriate, then Monday will be earliest.

b) ((5)			

Bob Perciasepe Deputy Administrator

(o) +1 202 564 4711

(c) +1 (b) (6) Personal Privacy

-----Laura Vaught/DC/USEPA/US wrote: -----

To: Janet Woodka/DC/USEPA/US@EPA, Arvin Ganesan/DC/USEPA/US@EPA, Richard Windsor/DC/USEPA/US@EPA From: Laura Vaught/DC/USEPA/US Date: 06/27/2012 08:18AM Cc: Bob Perciasepe/DC/USEPA/US@EPA, Bob Sussman/DC/USEPA/US@EPA, Brendan Gilfillan/DC/USEPA/US@EPA, "Laura Vaught" <vaught.laura@epa.gov>, "Richard Windsor" <windsor.richard@epa.gov> Subject: Re: Re: DRe: API/ANGA study and hearing

(b) (5)

(b) (5)

From: Janet Woodka Sent: 06/27/2012 08:03 AM EDT To: Arvin Ganesan; Richard Windsor Cc: Bob Perciasepe; Bob Sussman; Brendan Gilfillan; "Laura Vaught" <vaught.laura@epa.gov>; "Richard Windsor" <windsor.richard@epa.gov> Subject: Re: Re: Re: DRe: API/ANGA study and hearing

I don't think the Administrator doing the meetings is necessary(b) (5)

From: Arvin Ganesan Sent: 06/27/2012 07:58 AM EDT

To: Richard Windsor

Cc: Bob Perciasepe; Bob Sussman; Brendan Gilfillan; Janet Woodka; Bob Perciasepe" <perciasepe.bob@epa.gov>; "Laura Vaught" <vaught.laura@epa.gov>; "Lisa Jackson" <windsor.richard@epa.gov>

Subject: Re: Re: DRe: API/ANGA study and hearing

(b) (5)

As for whether it be at your level, I defer to Bob and Janet, but I'd think at least a drop by would be a good thing.

-----Richard Windsor/DC/USEPA/US wrote: -----

To: Arvin Ganesan/DC/USEPA/US@EPA, Bob Perciasepe/DC/USEPA/US@EPA From: Richard Windsor/DC/USEPA/US Date: 06/27/2012 07:49AM Cc: Bob Sussman/DC/USEPA/US@EPA, Brendan Gilfillan/DC/USEPA/US@EPA, Janet Woodka/DC/USEPA/US@EPA, "Arvin Ganesan" <ganesan.arvin@epa.gov>, "Bob Perciasepe" <perciasepe.bob@epa.gov>, "Laura Vaught" <vaught.laura@epa.gov>, "Lisa Jackson" <windsor.richard@epa.gov> Subject: Re: Re: DRe: API/ANGA study and hearing

Subject. Re. Re. Dice. Al IMNON study and I

From: Arvin Ganesan Sent: 06/27/2012 07:29 AM EDT To: Bob Perciasepe

Cc: Bob Sussman; Brendan Gilfillan; Janet Woodka; Richard Windsor; "Arvin Ganesan" <ganesan.arvin@epa.gov>; "Bob Perciasepe" <perciasepe.bob@epa.gov>; "Laura Vaught" <vaught.laura@epa.gov>; "Lisa Jackson" <windsor.richard@epa.gov> **Subject:** Re: Re: DRe: API/ANGA study and hearing

For hearing purposes,(b) (5)
Bob Perciasepe/DC/USEPA/US wrote: To: Richard Windsor/DC/USEPA/US@EPA, Bob Sussman/DC/USEPA/US@EPA, Janet Woodka/DC/USEPA/US@EPA, "Bob Perciasepe" <perciasepe.bob@epa.gov>, "Laura Vaught" <vaught.laura@epa.gov>, "Arvin Ganesan" <ganesan.arvin@epa.gov>, Brendan Gilfillan/DC/USEPA/US@EPA, "Lisa Jackson" <windsor.richard@epa.gov> From: Bob Perciasepe/DC/USEPA/US Date: 06/27/2012 07:20AM Subject: Re: DRe: API/ANGA study and hearing</windsor.richard@epa.gov></ganesan.arvin@epa.gov></vaught.laura@epa.gov></perciasepe.bob@epa.gov>
Agree.
(b) (5)
Bob P
Richard Windsor
Original Message From: Richard Windsor Sent: 06/27/2012 07:05 AM EDT To: Bob Sussman; Janet Woodka; "Bob Perciasepe" <perciasepe.bob@epa.gov>; "Laura Vaught" <vaught.laura@epa.gov>; "Arvin Ganesan" <ganesan.arvin@epa.gov>; Brendan Gilfillan; "Lisa Jackson" <windsor.richard@epa.gov> Subject: Re: DRe: API/ANGA study and hearing I think separate mtgs with them. We should move to set them up today I think but want input from Arvin, Laura, Brendan. Tx.</windsor.richard@epa.gov></ganesan.arvin@epa.gov></vaught.laura@epa.gov></perciasepe.bob@epa.gov>
Bob Sussman
Original Message From: Bob Sussman Sent: 06/27/2012 06:57 AM EDT To: Janet Woodka; "Bob Perciasepe" <perciasepe.bob@epa.gov>; "Laura Vaught" <vaught.laura@epa.gov>; "Arvin Ganesan" <ganesan.arvin@epa.gov>; Brendan Gilfillan; "Richard Windsor" <windsor.richard@epa.gov> Subject: Re: DRe: API/ANGA study and hearing</windsor.richard@epa.gov></ganesan.arvin@epa.gov></vaught.laura@epa.gov></perciasepe.bob@epa.gov>

Good points. Question for LPJ (b) (5)
Janet Woodka
Original Message From: Janet Woodka Sent: 06/26/2012 09:22 PM EDT To: Bob Sussman; "Bob Perciasepe" <perciasepe.bob@epa.gov>; "Laura Vaught" <vaught.laura@epa.gov>; "Arvin Ganesan" <ganesan.arvin@epa.gov>; Brendan Gilfillan; "Richard Windsor" <windsor.richard@epa.gov> Subject: Re: DRe: API/ANGA study and hearing Thanks. That's helpful.</windsor.richard@epa.gov></ganesan.arvin@epa.gov></vaught.laura@epa.gov></perciasepe.bob@epa.gov>
On the letter component, I wonder if that is the best way to "engage". (b) (5)
Btw - also got good feedback from the tour/site visit some of our staff did to Anadarko sites in PA yesterday and today.
Bob Sussman
Original Message From: Bob Sussman Sent: 06/26/2012 09:00 PM EDT To: Janet Woodka; "Bob Perciasepe" <perciasepe.bob@epa.gov>; "Laura Vaught" <vaught.laura@epa.gov>; "Arvin Ganesan" <ganesan.arvin@epa.gov>; Brendan Gilfillan; "Richard Windsor" <windsor.richard@epa.gov> Subject: DRe: API/ANGA study and hearing Janet. We are in fact doing split samples for the retrospective case studies. In addition, when we selected these sites, we provided a full description of our selection methodology. (b) (5)</windsor.richard@epa.gov></ganesan.arvin@epa.gov></vaught.laura@epa.gov></perciasepe.bob@epa.gov>
insights in response to questions. (b) (5)
Administrator should speak to that; she may have discussed the issue in her call today with Heather.
Janet Woodka

Original Message From: Janet Woodka Sent: 06/26/2012 08:09 PM EDT To: "Bob Perciasepe" <perciasepe.bob@epa.gov>; "Laura Vaught" <vaught.laura@epa.gov>; "Arvin Ganesan" <ganesan.arvin@epa.gov>; Brendan Gilfillan; "Richard Windsor" <windsor.richard@epa.gov>; Bob Sussman</windsor.richard@epa.gov></ganesan.arvin@epa.gov></vaught.laura@epa.gov></perciasepe.bob@epa.gov>	
(b) (5)	

From:	Laura Vaught
To:	Bob Perciasepe
Cc:	Bob Sussman; Arvin Ganesan; James O'Hara; Diane Thompson
Subject:	RE: Api letter and mtg
Date:	07/06/2012 02:41 PM

apologies if this is old information (which I'm guessing it may well be since is public), but passing along just in case it is not. The link below goes to a power point Chesapeake gave in a few forums over last couple of months. As of right now, it appears that this is the only actual document that folks on the hill have that mentions the Battelle study and hints at its contents (see page 27). There doesn't seem to be anything new or surprising, but again - just fyi in case folks haven't seen.

http://www.aaee.net/DownloadCenter/2012NJWEAPresentation-ChrisHill.pdf

Also - Stephanie Meadows and Amy Farrell are the two people that I was told would be accompanying Marty and Peter to the meeting on Monday.

▼ Bob Perciasepe---07/05/2012 07:21:12 PM---Yes And as I said, the letter itself simply says we will put a proposal together. So our meeting wit

From: Bob Perciasepe/DC/USEPA/US To: Bob Sussman/DC/USEPA/US, "Diane Thompson" <Thompson.Diane@epamail.epa.gov> Cc: "Arvin Ganesan" <Ganesan.Arvin@epamail.epa.gov>, "Laura Vaught" <Vaught.Laura@epamail.epa.gov>, "James O'Hara" <O'Hara.James@epamail.epa.gov> Date: 07/05/2012 07:21 PM Subject: RE: Api letter and mtg

Yes And as I said, the letter itself simply says we will put a proposal together. (b) (5)

Thanks

Bob Perciasepe Deputy Administrator (o) 202 564 4711 (c) ^{(D) (G) Personal Privacy}

----- Original Message ------

From : Bob Sussman/DC/USEPA/US

To : "Diane Thompson" <Thompson.Diane@epamail.epa.gov>, "Bob Perciasepe" <Perciasepe.Bob@epamail.epa.gov> Cc : "Arvin Ganesan" <Ganesan.Arvin@epamail.epa.gov>, "Laura Vaught" <Vaught.Laura@epamail.epa.gov>, "James O'Hara" <O'Hara.James@epamail.epa.gov> Sent on : 07/05/2012 05:55:15 PM Subject : Api letter and mtg

(b) (5)

We can set in motion an enviro meeting tomorrow. It would not be at the CEO level but with the folks working on fravking issues who are following the issue. I'm happt to get the ball rolling. We could get a meeting set up for later in the week.
 From:
 Peter Robertson

 To:
 LisaP Jackson/DC/USEPA/US@EPA

 Subject:
 ANGA/API Letter to EPA RE: Battelle Study

 Date:
 07/10/2012 12:26 PM

 Attachments:
 Final EPA Study Plan Review 061112.pdf ANGA-API Letter to EPA Battelle Critical Review.pdf

Administrator Jackson,

Please find attached a letter from America's Natural Gas Alliance and the American Petroleum Institute regarding a report from the Battelle Memorial Institute, which is also attached. Please do not hesitate to contact us for any reason.

Regards,

Peter Robertson

Description: Description: ANGA Logo 2010.jpg

Peter D. Robertson Senior Vice President for Legislative And Regulatory Affairs 701 8th Street NW Washington, DC 20001

202-789-1301

probertson@anga.us

www.anga.us

********************** ATTACHMENT NOT DELIVERED * * * * * * * * * * * * * * * * * * * This Email message contained an attachment named image001.jpg which may be a computer program. This attached computer program could contain a computer virus which could cause harm to EPA's computers, network, and data. The attachment has been deleted. This was done to limit the distribution of computer viruses introduced into the EPA network. EPA is deleting all computer program attachments sent from the Internet into the agency via Email. If the message sender is known and the attachment was legitimate, you should contact the sender and request that they rename the file name extension and resend the Email with the renamed attachment. After receiving the revised Email, containing the renamed attachment, you can rename the file extension to its correct name. For further information, please contact the EPA Call Center at (866) 411-4EPA (4372). The TDD number is (866) 489-4900. ********************* ATTACHMENT NOT DELIVERED ********************* ATTACHMENT NOT DELIVERED * * * * * * * * * * * * * * * * * * * This Email message contained an attachment named image001.jpg which may be a computer program. This attached computer program could contain a computer virus which could cause harm to EPA's computers, network, and data. The attachment has been deleted.

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introduced into the EPA network. EPA is deleting all computer program attachments sent from the Internet into the agency via Email. If the message sender is known and the attachment was legitimate, you should contact the sender and request that they rename the file name extension and resend the Email with the renamed attachment. After receiving the revised Email, containing the renamed attachment, you can rename the file extension to its correct name. For further information, please contact the EPA Call Center at (866) 411-4EPA (4372). The TDD number is (866) 489-4900. ********************** ATTACHMENT NOT DELIVERED

<u>- Final_EPA_Study_Plan_Review_061112.pdf</u> <u>- ANGA-API_Letter_to_EPA</u> <u>Battelle_Critical_Review.pdf</u>

From:	Bob Sussman
To:	Bob Perciasepe; Richard Windsor; Janet Woodka; James O'Hara; Diane Thompson; Glenn Paulson; Arvin
	Ganesan; Lek Kadeli
Subject:	Fw: ANGA/API Letter to EPA RE: Battelle Study
Date:	07/10/2012 12:35 PM
Attachments:	Final EPA Study Plan Review 061112.pdf
	ANGA-API Letter to EPA Battelle Critical Review.pdf

Letter from Gerard/Hopper transmitting Battelle report to Administrator.

Robert M. Sussman Senior Policy Counsel to the Administrator Office of the Administrator US Environmental Protection Agency ----- Forwarded by Bob Sussman/DC/USEPA/US on 07/10/2012 12:32 PM -----

> From: Peter Robertson <probertson@anga.us> To: LisaP Jackson/DC/USEPA/US@EPA Date: 07/10/2012 12:26 PM Subject: ANGA/API Letter to EPA RE: Battelle Study

Administrator Jackson,

Please find attached a letter from America's Natural Gas Alliance and the American Petroleum Institute regarding a report from the Battelle Memorial Institute, which is also attached. Please do not hesitate to contact us for any reason.

Regards,

Peter Robertson

Peter D. Robertson Senior Vice President for Legislative And Regulatory Affairs 701 8th Street NW Washington, DC 20001

202-789-1301 probertson@anga.us Windsor.Richard@epa.gov = Secondary e-mail address of former EPA Administrator, Lisa P. Jackson

www.anga.us

This Email message contained an attachment named image001.jpg which may be a computer program. This attached computer program could contain a computer virus which could cause harm to EPA's computers, network, and data. The attachment has been deleted. This was done to limit the distribution of computer viruses introduced into the EPA network. EPA is deleting all computer program attachments sent from the Internet into the agency via Email. If the message sender is known and the attachment was legitimate, you should contact the sender and request that they rename the file name extension and resend the Email with the renamed attachment. After receiving the revised Email, containing the renamed attachment, you can rename the file extension to its correct name. For further information, please contact the EPA Call Center at (866) 411-4EPA (4372). The TDD number is (866) 489-4900.





From:	Bob Perciasepe
To:	Richard Windsor
Cc:	Bob Sussman; Glenn Paulson; Lek Kadeli; James O'Hara; Arvin Ganesan; Janet Woodka
Subject:	FW: ANGA/API Letter to EPA RE: Battelle Study
Date:	07/10/2012 01:02 PM
Attachments:	Final EPA Study Plan Review 061112.pdf
	ANGA-API Letter to EPA Battelle Critical Review.pdf

Just in from ANGA and API. Thoughts on responding?

Bob Perciasepe Deputy Administrator (o) 202 564 4711 (c) (D) (G) Personal Privacy ----- Forwarded by Bob Perciasepe/DC/USEPA/US on 07/10/2012 01:02:44 PM---------- Original Message ------

From : Peter Robertson <probertson@anga.us> To : LisaP Jackson/DC/USEPA/US@EPA Cc : Sent on : 07/10/2012 12:25:56 PM Subject : ANGA/API Letter to EPA RE: Battelle Study

Administrator Jackson,

Please find attached a letter from America's Natural Gas Alliance and the American Petroleum Institute regarding a report from the Battelle Memorial Institute, which is also attached. Please do not hesitate to contact us for any reason.

Regards,

Peter Robertson

From:	Bob Perciasepe
To:	Bob Sussman; Richard Windsor; Janet Woodka; James O'Hara; Diane Thompson; Glenn Paulson; Arvin
	<u>Ganesan; Lek Kadeli</u>
Subject:	RE: ANGA/API Letter to EPA RE: Battelle Study
Date:	07/10/2012 01:04 PM
Attachments:	Final EPA Study Plan Review 061112.pdf
	ANGA-API Letter to EPA Battelle Critical Review.pdf

Whoops, sorry for double send

Bob Perciasepe Deputy Administrator (o) 202 564 4711 (c) ^{(D) (G) Personal Privacy}

----- Original Message ------

From : Bob Sussman/DC/USEPA/US To : Bob Perciasepe/DC/USEPA/US@EPA, Richard Windsor/DC/USEPA/US@EPA, Janet Woodka/DC/USEPA/US@EPA, James O'Hara/DC/USEPA/US@EPA, Diane Thompson/DC/USEPA/US@EPA, Glenn Paulson/DC/USEPA/US@EPA, Arvin Ganesan/DC/USEPA/US@EPA, Lek Kadeli/DC/USEPA/US@EPA Cc : Sent on : 07/10/2012 12:35:40 PM Subject : Fw: ANGA/API Letter to EPA RE: Battelle Study

Letter from Gerard/Hopper transmitting Battelle report to Administrator.

Robert M. Sussman Senior Policy Counsel to the Administrator Office of the Administrator US Environmental Protection Agency ----- Forwarded by Bob Sussman/DC/USEPA/US on 07/10/2012 12:32 PM -----

> From: Peter Robertson <probertson@anga.us> To: LisaP Jackson/DC/USEPA/US@EPA Date: 07/10/2012 12:26 PM Subject: ANGA/API Letter to EPA RE: Battelle Study

Administrator Jackson,

Please find attached a letter from America's Natural Gas Alliance and the American Petroleum Institute regarding a report from the Battelle Memorial Institute, which is also attached. Please do not hesitate to contact us for any reason.

Regards,

From:	Bob Sussman
To:	Bob Perciasepe
Cc:	Arvin Ganesan; Diane Thompson; Glenn Paulson; James O'Hara; Janet Woodka; Lek Kadeli; Richard Windsor
Subject:	RE: ANGA/API Letter to EPA RE: Battelle Study
Date:	07/10/2012 01:12 PM
Attachments:	Final EPA Study Plan Review 061112.pdf
	ANGA-API Letter to EPA Battelle Critical Review.pdf

Better two than none.

I think we can and should write a fairly neutral response similar in tone to the incoming.

We are in the process of reviewing the Battelle study and i will be meeting with ORD this afternoon to get their initial feedback. Most (maybe all) of the points in the Battelle report can be addressed readily ^{(b) (5)}



Thoughts?

We are also meeting with a group of enviros on Thursday. They are aware of and are reviewing the Battelle report.

Robert M. Sussman Senior Policy Counsel to the Administrator Office of the Administrator US Environmental Protection Agency

▼ Bob Perciasepe---07/10/2012 01:04:41 PM---Whoops, sorry for double send Bob Perciasepe

From: Bob Perciasepe/DC/USEPA/US To: Bob Sussman/DC/USEPA/US, Richard Windsor/DC/USEPA/US, Janet Woodka/DC/USEPA/US, James O'Hara/DC/USEPA/US, Diane Thompson/DC/USEPA/US, Glenn Paulson/DC/USEPA/US, Arvin Ganesan/DC/USEPA/US, Lek Kadeli/DC/USEPA/US Date: 07/10/2012 01:04 PM Subject: RE: ANGA/API Letter to EPA RE: Battelle Study

Whoops, sorry for double send

Bob Perciasepe Deputy Administrator (o) 202 564 4711 (c) ^{(D) (G) Personal Privacy} From: To:

Subject: Date: James O'Hara Richard Windsor; Bob Perciasepe; Bob Sussman; Jim Martin; Janet Woodka; Sarah Pallone; Arvin Ganesan; Laura Vaught; Alisha Johnson first story...just the facts 09/26/2012 06:40 PM

Diesel Compounds Found in Water Near Wyoming Fracking Site

By Mark Drajem - Sep 26, 2012 6:22 PM ET



Melanie Stetson Freeman/The Christian Science Monitor via Getty Images

Wyalusing Rocks Overlook is seen on March 20, 2012 just outside Wyalusing, Pennsylvania. Chesapeake Energy owns the drilling rights of this farmland within the Marcellus Shale region that has attracted many oil companies.

A U.S. Geological Survey report on its water testing in Pavillion, Wyoming -- where residents complain that gas drilling and hydraulic fracturing contaminated their drinking supplies -- found levels of methane, diesel-range compounds and other hydrocarbons.

The geological agency retested water in one well after state officials and Encana Corp. (ECA), the driller, complained about a report by the Environmental Protection Agency last

year linking contamination to fracking. The report today is "generally consistent" with what the EPA found, Alisha Johnson, an agency spokeswoman, said in an e-mail. Encana said the USGS's testing was flawed.

The EPA's draft report in December was the first U.S. government finding to link hydraulic fracturing, or fracking, and water contamination. The USGS said it didn't interpret the results, which were given to state officials.

"We are now waiting as analysis of this data is done," Wyoming Governor Matt Mead said in a statement. "It should help inform" the outside review of the EPA study, he said.

Encana, based in Calgary, owns 140 natural-gas wells in an area of cattle and hay farms outside of Pavillion, about 230 miles (370 kilometers) northeast of Salt Lake City. The company has argued that contaminants found in homeowner water wells are naturally occurring, and the two test wells that the EPA drilled in 2010 were improperly constructed.

Well Flaws

The geological agency only tested water from one of the two EPA wells, a decision that bolsters the company's claims about deficiencies with the monitoring wells, Doug Hock, an Encana spokesman, said in an e-mail.

"From a preliminary examination of the data, there appears to be nothing surprising in these results," Hock said.

The wells in Pavillion are different than those in most areas of Pennsylvania, where residents also have complained about tainted water from fracking. These Wyoming gas wells don't go as deep and the aquifer is closer to the gas-production zone.

Hydraulic fracturing, or fracking, uses millions of gallons of chemically treated water and sand to free oil and natural gas trapped in rock. The technology helped the U.S. cut dependence on imported fuels, lower power bills and cut state unemployment from Pennsylvania to North Dakota.

From:	Bob Perciasepe
To:	Bob Sussman
Subject:	Re: first storyjust the facts
Date:	09/26/2012 07:03 PM

(b) (5)

▼ Bob Sussman---09/26/2012 06:47 PM EDT---Note the Encana comment about the data bolstering their critique of the initial EPA results. Robert

From:					Bob Sussman
		To:		James O'Hara	
	Cc:			Alisha Johnson; Ganesan; Bob P Janet Woodka; Martin; Laura Va Richard Windsor Pallone	Arvin erciasepe; Jim lught; ; Sarah
	Date:		09/26/2012 06:4	7 PM EDT	
Subject:				Re: first storyj facts	ust the

Note the Encana comment about the data bolstering their critique of the initial EPA results.

Robert M. Sussman Senior Policy Counsel to the Administrator Office of the Administrator US Environmental Protection Agency

▼ James O'Hara---09/26/2012 06:40:10 PM---Diesel Compounds Found in Water Near Wyoming Fracking Site By Mark Drajem - Sep 26, 2012 6:22 PM ET

From: James O'Hara/DC/USEPA/US To: Richard Windsor/DC/USEPA/US@EPA, Bob Perciasepe/DC/USEPA/US@EPA, Bob Sussman/DC/USEPA/US@EPA, Jim Martin/R8/USEPA/US@EPA, Janet Woodka/DC/USEPA/US@EPA, Sarah Pallone/DC/USEPA/US@EPA, Arvin Ganesan/DC/USEPA/US@EPA, Laura Vaught/DC/USEPA/US@EPA, Alisha Johnson/DC/USEPA/US@EPA Date: 09/26/2012 06:40 PM Subject: first story...just the facts

Diesel Compounds Found in Water Near Wyoming Fracking

Site

By Mark Drajem - Sep 26, 2012 6:22 PM ET

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<u>Print</u> QUEUE

Q

Melanie Stetson Freeman/The Christian Science Monitor via Getty Images

Wyalusing Rocks Overlook is seen on March 20, 2012 just outside Wyalusing, Pennsylvania. Chesapeake Energy owns the drilling rights of this farmland within the Marcellus Shale region that has attracted many oil companies.

A U.S. Geological Survey <u>report</u> on its water testing in Pavillion, Wyoming -where residents complain that gas drilling and hydraulic fracturing contaminated their drinking supplies -- found levels of methane, dieselrange compounds and other hydrocarbons.

The geological agency retested water in one well after state officials and <u>Encana Corp. (ECA)</u>, the driller, complained about a report by the Environmental Protection Agency last year linking contamination to fracking. The report today is "generally consistent" with what the EPA found, Alisha Johnson, an agency spokeswoman, said in an e-mail. Encana said the USGS's testing was flawed.

The EPA's draft report in December was the first U.S. government finding to link hydraulic fracturing, or fracking, and water contamination. The USGS said it didn't interpret the results, which were given to state officials. "We are now waiting as analysis of this data is done," <u>Wyoming</u> Governor Matt Mead said in a statement. "It should help inform" the outside review of the EPA study, he said.

Encana, based in Calgary, owns 140 natural-gas wells in an area of cattle and hay farms outside of Pavillion, about 230 miles (370 kilometers) northeast of <u>Salt Lake City</u>. The company has argued that contaminants found in homeowner water wells are naturally occurring, and the two test wells that the EPA drilled in 2010 were improperly constructed.

Well Flaws

The geological agency only tested water from one of the two EPA wells, a decision that bolsters the company's claims about deficiencies with the monitoring wells, Doug Hock, an Encana spokesman, said in an e-mail. "From a preliminary examination of the data, there appears to be nothing surprising in these results," Hock said.

The wells in Pavillion are different than those in most areas of <u>Pennsylvania</u>, where residents also have complained about tainted water from fracking. These Wyoming gas wells don't go as deep and the aquifer is closer to the

From:	Bob Sussman		
To:	<u>O'Hara.James@epamail.epa.gov;</u>		
	Paulson; Bob Perciasepe; Vaught.Laura@epamail.epa.gov		
Cc:	Mary Hanley		
Subject:	Fw: HF technical workshops/roundtables (updated)		
Date:	12/07/2012 07:32 AM		
Importance:	High		
Attachments:	Workshop Topics Summary.docx		
	Roundtable next steps.docx		
	draft flyer.docx		

Following up on the recent roundtables, ORD is planning to announce on Monday the workshops for the drinking water study. There will be five workshops, all of which were proposed during the roundtables. The first workshop will be on analytical methods and will be on February 25. The others will be in April and June. The plan is to reconvene the roundtables over the summer. The workshops will be all-day events and ORD is expecting 50-60 participants in each. A broad outreach process will be conducted to solicit participation by experts. More details are in the attachments. Let us know whether you need more information before ORD moves forward on Monday.

Lisa Matthews

----- Original Message -----From: Lisa Matthews Sent: 12/06/2012 04:44 PM EST To: Bob Sussman Cc: Mary Hanley; Jeanne Briskin; Dayna Gibbons; Ramona Trovato; Lek Kadeli

Subject: HF technical workshops/roundtables (updated) Target announcement date for the first technical workshop is Monday, December 10:







Lisa Matthews U.S. EPA Office of Research and Development 202-564-6669 (ph)

(b) (6)

matthews.lisa@epa.gov

From: Reply To: To: Subject: Date: Marcellus Shale Coalition Press Marcellus Shale Coalition Press Bob Perciasepe/DC/USEPA/US@EPA What They're Saying: Marcellus Shale "a Game-Changer on a Global Scale" 12/11/2012 11:02 AM



December 11, 2012 | PERMALINK | @MarcellusGas

What They're Saying: Marcellus Shale "a Game-Changer on a Global Scale"

Pittsburgh, Pa. – The clear, undeniable economic, environmental and energy security benefits associated with the safe development of clean-burning natural gas continue to be realized across Appalachia, the United States and as well as overseas. Here's what they're saying about the responsible development of job-creating shale gas, which is <u>Powering an American Renaissance</u>:

NATURAL GAS = JOB CREATION, ENERGY SECURITY

- Public Support for Natural Gas Development Continues to Build: <u>Two new surveys show</u> that a significant percentage of people support drilling in portions of New York and that <u>Pennsylvania residents who live amid heavy drilling think the benefits outweigh the risks</u>. ... Kathryn Klaber, president of the Marcellus Shale Coalition, an industry group, noted that New York residents use large quantities of gas that comes from fracked wells in other states. She noted that <u>New York Mayor Michael Bloomberg has said expanded natural gas use "makes good economic and environmental sense.</u>" Patrick Henderson, Pennsylvania's energy executive in the governor's office, said the Siena College poll shows that <u>New Yorkers "see in</u> <u>Pennsylvania and other states the ability to develop this resource responsibly while protecting the environment.</u>" (Associated Press, <u>12/10/12</u>)
- "Shale Gas Keeps Philadelphia Region's Electric Costs Down": <u>Shale gas has become a game-changer for electric companies in the Northeast. This is good news for Philadelphia</u>. ... The increase in the availability of natural gas is owing to the more-effective use of hydraulic fracturing in conjunction with horizontal drilling. Over the four-year period ending 2010, natural-gas production in the US rose by roughly 20% according to the US Energy Information Administration and most of the increase was due to shale-gas extraction. ... <u>The consumer should continue to benefit from lower natural gas in the near term</u>. In Pennsylvania, the average utility customer's bill in August 2012 was 2% lower than the same month is 2011. (Philadelphia Public Record, <u>12/6/12</u>)
- Natural Gas: Powering Pa.'s Economy: <u>Rural Pennsylvania has an ocean of natural gas below ground and will soon have electricity produced at the surface</u>. Inexpensive, available fuel begets power plants. <u>The exploitation of gas a mile below the surface in the Marcellus Shale rock formation has attracted power generation companies proposing natural gas-fired power plants</u>, each at a cost of hundreds of million of dollars. ... Anthony Ventello, executive director of the Progress Authority, a regional economic development agency, said <u>the power plant will have a significant economic impact</u> much like a manufacturing facility, which supports spin-off jobs. ... "If we can create a permanent market for natural gas and add value to it by turning it into electricity or using it make some other product, <u>we can stabilize the economy</u>." (Times-Tribune, <u>12/9/12</u>)

- Pa.'s Geisinger Health System "Considers Natural Gas Stations": <u>A Geisinger Health</u> System administrator says the company is studying the potential for a business partnership to create a natural gas fueling station. Al Neuner, vice president of facilities operations, said...that the review is part of a continuing evaluation of a state grant program providing incentives for using natural gas to fuel fleet vehicles like large trucks and, in Geisinger's case, shuttle buses. ... Diesel averaged \$4.02 a gallon this week, and regular unleaded gasoline \$3.39 a gallon, a federal agency reported. That's compared to the \$2.16 average for the equivalent of one gallon of compressed natural gas, according to an industry website. (The News-Item, <u>12/9/12</u>)
- "Report: W.Va. Sees Shale Job Growth": Those working in West Virginia's oil and natural gas fields have seen their <u>annual salaries grow by an average of \$8,100 since 2008, thanks to the Marcellus Shale</u> rush. A new report from WorkForce West Virginia also shows that since the Marcellus activity began ramping up in 2008, another 916 state workers were directly employed by the oil and natural gas extraction business. ... "The overall effect on specific industries in West Virginia due to activity within the Marcellus Shale is becoming more evident," the report states. ... In addition to these jobs counted by WorkForce, the presence of the drilling industry does lead to increased employment in certain areas, as restaurant and hotel owners report being very busy these days because of drillers working in the area. ... New businesses to service the oil and gas industry also continue popping up. (Wheeling-Intelligencer, <u>12/6/12</u>)
- Gov. Tomblin: Responsible Marcellus Development "Brings a Great Economic Boost to the State": Governor Earl Ray Tomblin was also at the [MarkWest] plant Thursday. He said plants like this will not only help further gas development in West Virginia but also boost the local economy and provide more jobs. "This is the first phase with the opening of this processing plant," Tomblin said. "There have been hundreds of workers in the construction. There will be at least 20 full time jobs here. It brings a great economic boost to the state, and this one in particular to Doddridge County." (WBOY-TV, 12/7/12)

OPINION PAGES TOUT NATURAL GAS

- Marcellus Shale "a Game-Changer on a Global Scale": Thanks to new drilling technologies and the promise of a low-cost, cleaner form of energy, <u>Marcellus gas promises to be a game-changer on a global scale in terms of both energy production and manufacturing jobs.</u>... MarkWest Energy Partners dedicated its first gas processing center in Doddridge County with six more under construction statewide. ... In 2013, MarkWest will add six more processing facilities in West Virginia. ... MarkWest currently employs about 75 people in West Virginia. Each processing plant will add about 20-30 permanent jobs. ... It looks like <u>development of the Marcellus Shale gas fields could be the catalyst to take us to the next level and provide the state with a very, very bright future</u>. (Exponent-Telegraph editorial, <u>12/8/12</u>)
- "W.Va. Has Opportunity With Natural Gas Vehicles": More than 100,000 natural gas
 vehicles are currently on the road across the United States -- and millions more are being
 utilized around the world. ... With fewer emissions than traditional fuels and lower costs, the
 choice for transportation and heavy truck uses that refuel at the same station every night is
 clear. ... Instead of sending almost half a trillion dollars to foreign countries, we can help turn
 around our own economy by investing in a fuel that literally comes from beneath our own
 mountains. (Charleston Gazette op-ed, 12/10/12)
- American Natural Gas Adds "Significant Economic Benefits": Americans will pay much less than most foreigners for natural gas, giving domestic businesses a competitive advantage.
 Not only does cheap U.S. natural gas hold the possibility of significant economic benefits, it is also already making a positive difference for the environment. (Washington Post editorial, 12/7/12)
- Shale Gas Leads to "a Plunge In U.S. Greenhouse Gas Emissions": <u>One of the primary</u> factors for much of the [CO2 emissions] improvement in the U.S. environmental picture includes the shale gas revolution. <u>The benefits of the shale gas explosion include the newfound</u> <u>abundant supply</u> which will provide more than enough natural gas to meet U.S domestic

consumption needs and provide an expectation for relatively low natural gas prices in the future. (Forbes.com op-ed, $\frac{12/7/12}{12}$)

- London Mayor: Natural Gas is "Green, Cheap and Plentiful": The extraction of shale gas... seems an answer to the nation's prayers. ... By offering the hope of cheap electricity, fracking would make Britain once again competitive in sectors of industry bauxite smelting springs to mind where we have lost hope. The extraction process alone would generate tens of thousands of jobs in parts of the country that desperately need them. And above all, the burning of gas to generate electricity is much, much cleaner. ... As a result of the use of gas. the Americans have cut their CO2 emissions to levels not seen since the Nineties, in spite of a growing population. (The Telegraph op-ed, 12/9/12)
- "Fracking Can Boost NY's Economy, Add to Region's Job Base": <u>Hopefully, New York will</u> make finalize its extensive environmental and health reviews of the drilling process and start issuing permits for wells utilizing high-volume hydraulic fracturing soon. Since 2008, gas companies have established several regional centers in Pennsylvania: Halliburton in Williamsport, Shell in Mansfield and Chesapeake in Sayre. <u>The Southern Tier needs population</u> growth now. The Southern Tier needs jobs now. (Star-Gazette op-ed, <u>12/10/12</u>)

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Marcellus Shale Coalition | 24 Summit Park Drive | Pittsburgh, PA 15275 | www.marcelluscoalition.org

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12/17/2012 03:39 PM



From:

Fw: Final PDFs Susan Burden to: Bob Sussman Cc: Donald Maddox, Jeanne Briskin, Ramona Trovato Susan Burden/DC/USEPA/US

 To:
 Bob Sussman/DC/USEPA/US@EPA

 Cc:
 Donald Maddox/DC/USEPA/US@EPA, Jeanne Briskin/DC/USEPA/US@EPA, Ramona Trovato/DC/USEPA/US@EPA

 History:
 This message has been forwarded.

Hi Bob,

Attached are two PDFs for the progress report:

2012 HF Report_FINAL 121412 contains the full report.

2012 HF Progress Report_Executive Summary_FINAL 121412 contains only the Executive Summary.

Please let me know if you have any questions.

Thanks,

Susan

Susan Burden, Ph.D. Office of Science Policy Office of Research and Development U.S. Environmental Protection Agency Phone: (202) 564-6308 E-mail: burden.susan@epa.gov

2

2012 HF Progress Report_Executive Summary_FINAL 121412.pdf

2012 HF Report_FINAL 121412.pdf

From:	Bob Sussman
To:	Ramona Trovato; Jeanne Briskin
Cc:	Ann Campbell
Subject:	Fw: Meeting on Tuesday
Date:	02/13/2012 03:19 PM

Just sent the enclosed to Paul. He wants a follow-call for staff to report in -probably a good idea. My recollection is that Mike is following up with Chesapeake this week. Is that right and if so, when? Once Mike has this discussion, a call with Paul should be in order.

Robert M. Sussman Senior Policy Counsel to the Administrator Office of the Administrator US Environmental Protection Agency ----- Forwarded by Bob Sussman/DC/USEPA/US on 02/13/2012 03:17 PM -----

> From: Bob Sussman/DC/USEPA/US To: Paul Hagemeier < paul.hagemeier@chk.com> Date: 02/13/2012 03:15 PM Subject: RE: Meeting on Tuesday

Paul -- sorry for being slow to respond. Am still digging out from last week.

Am glad we're getting similar reports on last week's meeting. Let's see if we can arrange time for a report back by our staffs -- perhaps after an additional discussion scheduled for this week, I believe.

The shale school is a promising idea and starting in DC makes sense. When we have our call, we should discuss.

Robert M. Sussman Senior Policy Counsel to the Administrator Office of the Administrator US Environmental Protection Agency

▼ Paul Hagemeier ---02/09/2012 10:48:56 AM---I agree - heard the same thing. Stephanie was impressed and positive about the meeting. My folks t

> From: Paul Hagemeier <paul.hagemeier@chk.com> To: Bob Sussman/DC/USEPA/US@EPA Date: 02/09/2012 10:48 AM Subject: RE: Meeting on Tuesday

I agree - heard the same thing. Stephanie was impressed and positive about the meeting. My folks think Ramona has been a very good add to the discussion, and will be needed as we progress. Thanks for making her available.

I'd suggest that we make some time to discuss some of the other issues you and I have teed up together. Shale school in DC with you and some of your leadership staff could be a good foundation for that. I would be happy to facilitate, and think that it
would be positive for both of us and for our folks that need to work together. Could serve as a model that we could use at the regional level if you think it a good forum.

Perhaps we could line that up in conjunction with a progress report on the study in the near future?

Best - P

----Original Message----From: Bob Sussman [mailto:Sussman.Bob@epamail.epa.gov] Sent: Thursday, February 09, 2012 8:39 AM To: Paul Hagemeier Subject: Meeting on Tuesday

Paul -- I've gotten good reports on the Tuesday meeting here in DC. It sounds like we made good progress on site selection and have another discussion scheduled. I'm crossing my fingers that we're heading in a positive direction and you and I can step back a bit. Let me know if you're hearing anything different.

Robert M. Sussman Senior Policy Counsel to the Administrator Office of the Administrator US Environmental Protection Agency

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Meeting Request and Action Items - CHK Haynesville Prospective Study Site Stephanie Timmermeyer to: Jeanne Briskin, Ramona Trovato 01/27/2012 05:12 PM Cc: John Satterfield Hide Details From: Stephanie Timmermeyer <stephanie.timmermeyer@chk.com>

To: Jeanne Briskin/DC/USEPA/US@EPA, Ramona Trovato/DC/USEPA/US@EPA

Cc: John Satterfield <john.satterfield@chk.com>

6 Attachments



6010-13c.pdf 8015-17.pdf 300 & SM4110 B-8a.pdf 8270-14.pdf 8260-16.pdf Microseismic Data Map.pdf

Ramona and Jeanne:

It was very nice to meet with both of you this week. I would like to check with you on setting up a meeting between your team and CHK for next week. I believe we talked about a conference call or a videoconference (which I believe would work even better). On our end, John Satterfield and I will attend along with Chris Hill our CHK study liaison. Please let me know a couple of days and times that work for you next week, and we will accommodate.

By this email, I am also responding to the items you requested in our conference call prior to our face to face meeting. First, please find in the below table the list of critical analytes, identified by your agency, and the corresponding commercial laboratory SOPs. Please consider this confidential information. You had also asked, Jeanne, about supplying a QAPP for our lab. I have been informed that labs do not have "QAPPs" per se but do have Quality Management (or Quality Assurance) Systems. The lab we use, Test America, is also contractor for the EPA, and given the confidential nature of the information, I wanted to suggest that you may have better luck requesting this information directly. We would be happy to revisit this issue, if necessary. The other item you requested was microseismic data in the vicinity of the Haynesville prospective study site. I forwarded you a map Monday showing two nearby locations for which we have that data. Please let me know whether the microseismic from those two sites will be useful to you. If so, I will send the reports. I have reattached the map for your convenience.

From our perspective, we are still waiting on the following information from your office:

- 1) the definition of critical versus non-critical analytes
- 2) a link to the ORD-TPM-3.4 protocol
- 3) verification of the Region III lab's glycol method
- 4) a schedule on timing for your activities at the site

Thank you for taking the time to meet with us this week. We look forward to a productive meeting next week to continue to move toward the next steps of the study. Stephanie

file://C:\Documents and Settings\jzambran\Local Settings\Temp\notesFCBCEE\~web3432... 6/22/2013

Analyte	EPA Analysis Method	EPA Laboratory Performing the Analysis	CHK Laboratory SOP Attached
Gasoline Range Organics (GRO)	ORGM-506 r1.0, EPA Method 8015D	EPA Region VIII Laboratory	8015-17
Diesel Range Organics (DRO)	ORGM-508 r1.0, EPA Method 8015D	EPA Region VIII Laboratory	8015-17
Volatile Organic Compounds (VOC)*	RSKSOP-299v1	Shaw Environmental	8260-16
Semivolatile Organic Compounds (SVOC)	ORGM-515 r1.1, EPA Method 8270D	EPA Region VIII Laboratory	8270-14
Metals (As, Se, Sr, Ba, B)	RSKSOP-213v4 &- 257v2 or -332v0	Shaw Environmental	6010-13c
Major Cations (Ca, Mg, Na, K)	RSKSOP-213v4	Shaw Environmental	6010-13c
Major Anions (Cl, carbonate, bicarbonate, Br, NO ₃ ⁻ +NO ₂ ⁻ , SO ₄ ⁻²⁻)	RSKSOP-276v3 (NO ₃ ⁻ +NO ₂ ⁻ by RSKSOP- 214v5)	RSKERC general parameters lab	300 & SM4110 B-8

Thank you, Stephanie R. Timmermeyer Director - Federal Regulatory Affairs Chesapeake Energy Corporation Mobile: (304) 941-9879 E-mail: <u>Stephanie.Timmermeyer@chk.com</u> Chesapeake Logo

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Action Items

Stephanie Timmermeyer to: Jeanne Briskin, Ramona Trovato Cc: Bob Sussman, Donald Maddox, Ann Campbell, Paul Hagemeier, John Satterfield

History:



This message has been forwarded.

HF Study Action Items 1-30.pdf

Jeanne and Ramona:

Attached is a list of action items we prepared – please feel free to add or revise items from your notes. Also – I am resending the schedule the we prepared for the HF Work Team. While it is clearly out of date at this point, it is a good estimation on timing for drilling, completions, and other activities on our sites.

In order to facilitate selection of a new site, we still need to understand EPA's site criteria. In speaking with John after the call yesterday, he very quickly listed these site criteria from the EPA HF Team:

1. Rural area (less opportunity for anthropogenic activities to impact drinking water resources)

2. Large contiguous surface land holding (fewer agreements for monitoring wells/access)

3. Low historical oil and gas activity in the area

4. Consideration for depths/thicknesses of drinking water aquifer(s) for costs associated with monitoring well installation and sampling

5. Low HF activity in the area

We understand now that you may be requesting that "no construction activity" be a site criterion. Additionally, because EPA recently asked for microseismic in the vicinity of the Haynesville proposed site, we assume that having that data in some proximity is also a part of site criteria. In any case, please feel free to add to or revise our understanding of EPA's site criteria. The quicker we have that information, the quicker we can respond to you with potential sites. We would primarily be attempting to locate sites in the following plays, once we have EPA's site criteria in hand:

Mississippi Lime Utica Eagle Ford Colony Wash We are available to travel to DC Tuesday February 7, to discuss selection of a new site and to work toward resolution on the other issues listed in the attached update. Please let us know if you could meet that day.

Thank you, Stephanie R. Timmermeyer Director - Federal Regulatory Affairs Chesapeake Energy Corporation Mobile: (304) 941-9879 E-mail: Stephanie.Timmermeyer@chk.com

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Action Items week of 2/6/12 Stephanie Timmermeyer to: Jeanne Briskin, Ramona Trovato 02/06/2012 03:19 PM Cc: John Satterfield Hide Details From: Stephanie Timmermeyer <stephanie.timmermeyer@chk.com>

To: Jeanne Briskin/DC/USEPA/US@EPA, Ramona Trovato/DC/USEPA/US@EPA

Cc: John Satterfield <john.satterfield@chk.com>

History: This message has been replied to.

1 Attachment



HF Study Action Items 2-6.pdf

Jeanne and Ramona:

It is unfortunate that the EPA HF study project schedule and Site Selection Criteria sent February 2, 2012 precludes using the originally proposed site located in the Haynesville Shale. We are disappointed that all our collective work associated with that site cannot be accomplished based on these documents, but will nonetheless work with you to find another prospective site.

We look forward to our meeting tomorrow to focus on selection of a new Chesapeake site for a prospective study. We will come prepared to offer potential sites based upon the new EPA schedule and selection criteria.

We remain hopeful to schedule a meeting soon to resolve other project related issues that were not specific to the study location, such as the QAPP. Perhaps we can schedule a follow up video conference for this coming Thursday? Please let me know of any additions/changes to the attached action item list.

Thank you,

Stephanie R. Timmermeyer Director - Federal Regulatory Affairs Chesapeake Energy Corporation Mobile: (304) 941-9879 E-mail: Stephanie.Timmermeyer@chk.com

X Chesapeake Logo

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*********************** ATTACHMENT NOT DELIVERED ********************************

CHK Technical Review

E & E Technical Memorandum – Installation of groundwater monitoring wells in support of EPA's hydraulic fracturing study.

Executive Summary:

Chesapeake Energy (CHK) has prepared these comments in response to E&E's two technical memorandums prepared for the EPA and transmitted to CHK on March 1, 2012 and March 27, 2011 via email. CHK's detailed response is formatted to follow the technical memorandums; the first bullet paraphrases language from the memorandum and sub-bullets represent CHK comments. General comments are highlighted below:

- Chesapeake Energy understands that the Option #1 (vertical well with off pad access) proposed in the original technical memorandum has been removed as a viable alternative.
- The installation of horizontal monitoring wells after the production well has been installed significantly mitigates the potential risk to the monitoring wells' integrity, and, therefore, the study.
- The limitations of the horizontal monitoring wells require additional consideration to ensure the study's data quality objectives will be met. For example, the fluctuation in groundwater levels and end data use (i.e., modeling) should have specific considerations identified.
- CHK recommends EPA identify the process it will use to differentiate between potential causes (including naturally occurring) should sampling results indicate a significant change in water quality that is otherwise unexplainable.
- CHK does not believe the site characterization activity identified by the EPA will provide the information necessary to determine the groundwater velocity in the deeper bedrock formation.
- Appropriate monitoring well abandonment procedures for non-standard well should be developed.

CHK understands EPA's rationale for using non-standard wells on this highly influential scientific assessment stems from an EPA schedule issue related its 2014 report. CHK has worked with the EPA to identify a second site with what we believe to have favorable groundwater velocity. Based on characterization of the aquifers, the use of horizontal monitoring wells may not be necessary to achieve EPA's study goals.

Detailed comments:

Re: Technical Memorandum – Installation of groundwater monitoring wells in support of EPA's hydraulic fracturing study. (February 24, 2012).

Introduction:

- E&E limited the scope of the study to underground sources of drinking water (USDW), which has a specific definition under the Safe Drinking Water Act (SDWA) (i.e., 10,000 mg/L TDS). The State of OK has defined the base of treatable water (i.e. TDS of 10,000 mg/L) in this area at occurring between approximately 100 to 150 ft below ground level (bgl)., however, the E&E/EPA have proposed monitoring wells at depths up to 300 ft. The Final Study Plan does not limit the boundaries of the study to USDW.
 - EPA should develop clear boundaries for the study. It is recommended EPA use and clearly state that USDW are the boundaries of the study, and not install monitoring wells into zones that have naturally occurring brine or salt water present (TDS >10,000 mg/L)..
 - During the March 23, 2012 meeting, EPA stated it used 300 ft. because CHK previously stated this value as the depth of groundwater in this area. CHK believes it is important that EPA independently validate information (or secondary data) provided by CHK or others in accordance with EPA project specific data quality objectives, QMP, and QAPPs. The 300 ft. value was stated early in the site selection process as an approximation for the depth of USDW in the Mississippi Lime Play, but the Oklahoma Corporation has developed accurate depth to treatable water maps for this specific site, and those maps should be evaluated and used appropriately
- E&E acknowledges that the proposed alternatives are non-standard groundwater monitoring wells.
 - CHK recommends the use of standard vertical groundwater monitoring wells on this study in order to reduce the risk to the study associated with the application of non-standard monitoring wells.
- E&E states that this is a natural gas well pad. This statement is made throughout the memo.
 - This well is not considered a natural gas well. The Mississippi Lime is an oil play.

Background:

- E&E has assumed a 400 ft. by 400 ft. pad, and the ability to install the well approximately 75 ft. from the production well.
 - More accurate well pad dimensions will be provided to the EPA at a later date. There are a number of variables that dictate the size of the pad (i.e., drill rig, number of wells, etc.). Conservative dimensions for the pad are 350 ft. by 400 ft.

- Note that orientation of the pad will not be necessary if EPA plans to use horizontal monitoring wells. The adjustment will impact CHK's operations, and was offered to facilitate the installation of conventional monitoring wells off the pad location.
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 - The limitations of the geo-probe scope of work should be disclosed in terms of the information that will be able to be collected. For example, the piezometer will not be able to determine conditions (i.e., groundwater velocity) for the proposed deep monitoring well in the bedrock formation. It has now been agreed that conventionally drilled monitoring wells will be used in lieu of geo-probe installed wells.
- E&E referenced a 300 ft. exploratory boring (off-pad) to determine the presence or absence of water bearing zones in bedrock.
 - "Water bearing zones" need to be clearly defined (e.g., USDW). The quality and quantity of water is of interest.
 - EPA should set limits, in terms of monitoring drilling capabilities (i.e., accuracy of location), for target water bearing zones.
- The depths of proposed down gradient monitoring wells are stated as 20 ft. (top of the water table), 50 ft. (base of the unconsolidated aquifer), and 300 ft. (within the underlying shale formation).
 - It is understood that E&E made assumptions based on previous conversations, however, CHK would like the methods for determining the depths of the monitoring wells to be clearly stated and the use of best available information to be assured. For example, the top of the water table changes based on seasonal variations and water use, and the underlying bedrock formation varies greatly with depth, and the water quality varies with depth, typically becoming poorer with depth.

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- E&E has stated an approximate sample point, for each of the down gradient wells, 15 ft. horizontally from the production wellbore.
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 - o Certainty of monitoring well locations will effect modeling and data use.
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 There would be a likely physical impact to monitoring wells due to proximity to production wellbore during well construction, which would compromise the study.

Option 1: Vertical Wells with Off-Pad Access

• CHK understands this option is no longer being considered.

Option 2: Horizontal Direction Drilled (HDD) Monitoring Wells and Angle Drilled Wells

- Active wireline guidance will be used to monitor the bit locations.
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 - Details regarding the development of the well should be provided, included parameter stabilization requirements.
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 - It should be stated exactly how the wells will be abandoned. EPA should work with the state to understand its expectations. Without a clear understanding of what is required for proper abandonment, there is no assurance these requirement would not impede CHK operations at a future date.

Groundwater monitoring, purging and sampling procedures

- E&E states development of wells at least 48 hours before sampling.
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Re: Technical Memorandum – Revised groundwater monitoring wells in support of EPA's hydraulic fracturing study. (March 26, 2012)

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 - The monitoring wells may be temporary, and additional monitoring wells would be installed to increase the accuracy of the site characterization.
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 - CHK believes that the appropriate information will be collected to ascertain the groundwater velocity in the alluvial aquifer.
- E & E states that the application of horizontal wells will be based on the need and subject to CHK approval.
 - CHK confirms that the application of horizontal wells is subject to our approval.
- E & E states that the distance from the production well to the horizontal wells will be based on groundwater flow data during the initial monitoring period.
 - There are other variables to be considered besides groundwater velocity. In addition, determining the groundwater flow in the bedrock formation may be problematic.
 - The distance a potential contaminant from the wellbore is not limited solely by groundwater velocity. "The accelerated arrival of contaminants at a discharge point can be a characteristic feature of dispersion that is due to

the fact that some parts of the contaminant plume move faster than the average groundwater velocity" according the a report found on the National Academies Press website (<u>http://www.nap.edu/openbook.php?record_id=1770&page=37</u>).

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 - EPA should set limits, in terms of monitoring drilling capabilities (i.e., accuracy of location), for target water bearing zones.
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assurance these requirement would not impede CHK operations at a future date. Kent Wilkin and Robert Keyes had similar concerns with the lack of clarity regarding abandoning procedures.
 CHK requests that the time between development of well and sampling be

- no less than 5 days.
- The EPA will need to specify calibration requirements for transducers.

From:	Chris Hill (Regulatory)
То:	Michael Overbay/R6/USEPA/US@EPA; Stephanie Timmermeyer
Cc:	David Jewett/ADA/USEPA/US@EPA; Doug Beak/ADA/USEPA/US@EPA; Jeanne Briskin/DC/USEPA/US@EPA; John
	Satterfield; Randall Ross/ADA/USEPA/US@EPA; Steven Acree/ADA/USEPA/US@EPA
Subject:	RE: Phone call Wednesday afternoon at 3:30 pm?
Date:	02/28/2012 08:40 AM

I have sent a meeting invite to everyone on this email distribution. Please let me know if you have any questions or do not receive the invite. I look forward to our discussion.

Thank you, *Chris Hill* Environmental Engineer Chesapeake Energy Corporation Office: (405) 935-2321 Mobile: (405) 388-3907 Fax: (405) 849-2321 E-mail: <u>Chris.Hill@chk.com</u>



From: Michael Overbay [mailto:Overbay.Michael@epamail.epa.gov]
Sent: Tuesday, February 28, 2012 7:32 AM
To: Stephanie Timmermeyer
Cc: Chris Hill (Regulatory); David Jewett; Doug Beak; Jeanne Briskin; John Satterfield; Randall Ross; Steven Acree
Subject: Re: Phone call Wednesday afternoon at 3:30 pm?

I think we can make that work. Can Chris send out a calendar invite?

Michael Overbay, P.G. Regional Ground Water Center Coordinator U.S. Environmental Protection Agency - Region 6 (214)665-6482 (214)665-2191 (FAX) Visit the Ground Water Center on the web at: www.epa.gov/earth1r6/6wq/swp/groundwater/gw.htm

From: Stephanie Timmermeyer <<u>stephanie.timmermeyer@chk.com</u>>

To: Michael Overbay/R6/USEPA/US@EPA, John Satterfield <<u>john.satterfield@chk.com</u>>, "Chris Hill (Regulatory)" <<u>chris.hill@chk.com</u>>, David Jewett/ADA/USEPA/US@EPA, Doug Beak/ADA/USEPA/US@EPA, Steven Acree/ADA/USEPA/US@EPA,

Randall Ross/ADA/USEPA/US@EPA

Cc: Jeanne Briskin/DC/USEPA/US@EPA

Date: 02/27/2012 05:43 PM

Subject: Re: Phone call Wednesday afternoon at 3:30 pm?

Hey Mike

I'm afraid the CHK team has an all day meeting Wednesday - how does 10:30 am Thursday work for you guys? Steph

Stephanie R. Timmermeyer Chesapeake Energy Director, Regulatory Affairs - Federal 304.941.9879

From: Michael Overbay [mailto:Overbay.Michael@epamail.epa.gov]
Sent: Monday, February 27, 2012 04:30 PM
To: John Satterfield; Stephanie Timmermeyer; Chris Hill (Regulatory); David Jewett
<Jewett.David@epamail.epa.gov>; Doug Beak < Beak.Doug@epamail.epa.gov>; Steven Acree
<Acree.Steven@epamail.epa.gov>; Randall Ross < Ross.Randall@epamail.epa.gov>
Cc: Jeanne Briskin < Briskin.Jeanne@epamail.epa.gov>
Subject: Phone call Wednesday afternoon at 3:30 pm?

Hello everbody,

Would Wednesday afternoon at 3:30 pm work for a conference call? Please respond by e-mail.

We hope to be able to provide the technical memo from our contractors to Chesapeake on that call. We have just received it ourselves and want a quick review to make sure it is OK before sharing it.

Also, following the site visit last week to look at the potential sites, we believe that the Oklahoma site is the best candidate for moving forward on. We would like to send an EPA-owned direct-push (Geoprobe) rig to both the Oklahoma and Kansas sites in the next few weeks, just to push down through the terrace deposits and confirm the presence of an aquifer. We anticipate doing one or two holes on each site. This information would not be used as "data" in the study, but is just to make sure we have a usable site. Therefore, we won't be writing a QAPP for that activity and can do it subject to getting the landowner's consent and the availability of our operators. Looks like next week or the week after could work for them. Since they are going that far, and the sites are only 15 miles apart, we think it makes sense just to plan on probing the Kansas site, too. So, we would like Chesapeake to check into getting access for us, if possible.

Doug and I will be doing field work in Texas starting Sunday and all of next week. During that week, we anticipate providing you with the supplemental information on how the decision process will work.

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Regulatory Department



VIA: email trovato.ramona@epa.gov

Ms. Ramona Trovato Office of Research and Development USEPA Headquarters 1200 Pennsylvania Avenue, N.W. Mail Code: 8101R Washington, DC 20460

Re: Horizontal Drilling

Dear Ms. Trovato:

Pursuant to our discussions about the potential need to install horizontal monitoring wells at the proposed prospective study site, attached is a technical memorandum that outlines several issues that should be addressed before Chesapeake could agree to the installation. Four of the critical issues are detailed below:

First and foremost we want to re-emphasize that site characterization may reveal that installation of these non-standard wells is unnecessary.

Second, we have conditionally determined that the best possibility for installing the horizontal monitoring wells, if needed, would be after our Mississippi Limestone well is drilled but prior to hydraulic fracturing. As we have discussed, EPA will be required to accept all liability related to potential damage to the Chesapeake well and the environment related to the installation and use of these wells. This will be an extremely important issue that should be resolved quickly given the multi-million dollar investment Chesapeake has made, and will continue to make, at the location.

The third issue is the ability for EPA's contractor to very accurately steer and map the location of the horizontal monitoring wells and formally agreeing to an anti-collision policy which includes a requirement that the horizontal monitoring wells will not be drilled within a 30 foot radius of Chesapeake's well, regardless of groundwater velocity.

The fourth issue to resolve, as mentioned by the Oklahoma Water Resources Board and the contract water well driller during our March meeting, is a detailed procedure for plugging and abandonment. April 12, 2012 Ms. Ramona Trovato Page 2

Finally, we would request that your agency allow that, should horizontal monitoring wells be required, Chesapeake's comments about the non-standard nature of the wells as well as our attached technical memorandum be included in the final study report.

Thank you for continuing to dedicate resources to this project. Chesapeake remains committed to a study based on sound science and recognized and accepted protocols. Given the importance of domestic oil and natural gas as an energy source for our country's quality of life, independence, and environment, we feel there is no more important task at hand than to continue to bolster the public's confidence that we can, and do, explore and produce this important source of energy safely.

Best regards,

Chesapeake Energy Corporation

Stephanie R. Timmermeyer Director – Federal Regulatory Affairs

SRT:rr

CHK Technical Review

E & E Technical Memorandum – Installation of groundwater monitoring wells in support of EPA's hydraulic fracturing study.

Executive Summary:

Chesapeake Energy (CHK) has prepared these comments in response to E&E's two technical memorandums prepared for the EPA and transmitted to CHK on March 1, 2012 and March 27, 2011 via email. CHK's detailed response is formatted to follow the technical memorandums; the first bullet paraphrases language from the memorandum and sub-bullets represent CHK comments. General comments are highlighted below:

- Chesapeake Energy understands that the Option #1 (vertical well with off pad access) proposed in the original technical memorandum has been removed as a viable alternative.
- The installation of horizontal monitoring wells after the production well has been installed significantly mitigates the potential risk to the monitoring wells' integrity, and, therefore, the study.
- The limitations of the horizontal monitoring wells require additional consideration to ensure the study's data quality objectives will be met. For example, the fluctuation in groundwater levels and end data use (i.e., modeling) should have specific considerations identified.
- CHK recommends EPA identify the process it will use to differentiate between
 potential causes (including naturally occurring) should sampling results indicate a
 significant change in water quality that is otherwise unexplainable.
- CHK does not believe the site characterization activity identified by the EPA will
 provide the information necessary to determine the groundwater velocity in the
 deeper bedrock formation.
- Appropriate monitoring well abandonment procedures for non-standard well should be developed.

CHK understands EPA's rationale for using non-standard wells on this highly influential scientific assessment stems from an EPA schedule issue related its 2014 report. CHK has worked with the EPA to identify a second site with what we believe to have favorable groundwater velocity. Based on characterization of the aquifers, the use of horizontal monitoring wells may not be necessary to achieve EPA's study goals.

Detailed comments:

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 - Details regarding the development of the well should be provided, included parameter stabilization requirements.
 - It should be stated exactly how the wells are to be abandoned. EPA should work with the state to understand its expectations. Without a clear understanding of what is required for proper abandonment, there is no

assurance these requirement would not impede CHK operations at a future date. Kent Wilkin and Robert Keyes had similar concerns with the lack of clarity regarding abandoning procedures.

- CHK requests that the time between development of well and sampling be no less than 5 days.
- The EPA will need to specify calibration requirements for transducers.



Re: Insurance information John Satterfield to: Ramona Trovato 07/18/2012 09:55 AM Hide Details From: John Satterfield <john.satterfield@chk.com>

To: Ramona Trovato/DC/USEPA/US@EPA

History: This message has been forwarded.

Paul is looking to schedule a meeting week of 30 JUL with Bob to discuss our ATGAS report and our report on the retrospective split sampling in Bradford county, pa.

If we get this scheduled, let me know what level of convo you'd like to have. I can cover the technical issues to a certain point, but if you really want to talk about the hydrogeology and statistical correlation of differing parameters, will need to bring a couple of other folks.

Alternately, can have higher level discussions including bob and Paul after we have a technical convo....

Let me know....

John A Satterfield Director Environmental & Regulatory Affairs Chesapeake Energy Corporation

Sent from my iPad

On Jul 17, 2012, at 8:09 AM, "Ramona Trovato" <<u>Trovato.Ramona@epamail.epa.gov</u>> wrote:

Thanks John. I'll move this along.

From: John Satterfield [john.satterfield@chk.com] Sent: 07/17/2012 12:56 PM GMT **To:** Ramona Trovato **Subject:** FW: Insurance information

Ramona – below is our Risk Management Department's review of E&E's insurance information. Hopefully will be easy adjustment on E&E's part.

Please let me know if you have questions or concerns.

From: Chris Hill (Regulatory)
Sent: Monday, July 16, 2012 10:58 PM
To: 'Michael Overbay'
Cc: 'David Jewett'; 'Doug Beak'; 'Susan Mravik'; John Satterfield
Subject: RE: Insurance information

Mike,

Please see CHK's comments regarding EPA's proposed agreement attached. The embedded revisions address all concerns regarding the subcontractor issue. Once EPA has accepted all changes to the agreement, signed the document and provided CHK a new E&E certificate of insurance aligned with the agreement, CHK will consider the contractor liability issues adequately addressed to proceed with field activities. I would be more than happy to setup a conference call in the near future, if there are any issues with the revised agreement that we need to work through.

I have attached a copy of the CHK/Landowner access agreement for your information.

Please let me know if you have any questions or comments, or if there is anything else we can do to help. We look forward to proceeding with the Mississippi Lime prospective study.

Thank you, *Chris Hill* Environmental Engineer Chesapeake Energy Corporation Office: (405) 935-2321 Mobile: (405) 388-3907 Fax: (405) 849-2321 E-mail: <u>Chris.Hill@chk.com</u>

From: John Satterfield
Sent: Thursday, July 12, 2012 3:37 PM
To: 'Michael Overbay'
Cc: Chris Hill (Regulatory); 'Jeanne Briskin'; 'Ramona Trovato'; 'Bob Sussman'; 'Stephen Hess'; 'Lek Kadeli'; 'Steve Pressman'; 'David Jewett'; 'Doug Beak'; 'Susan Mravik'
Subject: RE: Insurance information

Thanks! Will run to ground and get back with you as soon as I can.

From: Michael Overbay [mailto:Overbay.Michael@epamail.epa.gov]
Sent: Thursday, July 12, 2012 3:35 PM
To: John Satterfield
Cc: Chris Hill (Regulatory); Jeanne Briskin; Ramona Trovato; Bob Sussman; Stephen Hess; Lek

Kadeli; Steve Pressman; David Jewett; Doug Beak; Susan Mravik **Subject:** Insurance information

Hello John,

I am happy to finally be able to provide you information about the insurance requirements contained in the EPA contract with our prime contractor for this project, Ecology and Environment (E&E). Attached is a certificate of insurance showing E&E's existing policies, with coverage up to \$15 million. The policies will be carried forward under our existing contract with E&E. If the coverage is sufficient, Chesapeake will be added as an additional insured for the liability coverage.

Per Stephanie's E-mail message June 27th, it appears you will not need insurance information about the drilling subcontractor in order to move forward. I am hoping the above information will be adequate to allow Chesapeake to resolve their concerns about liabilities issues.

Once you have had a chance to share this information and discuss it internally, I would appreciate receiving an E-mail with your confirmation that the liability/indemnification issue is resolved. Also, we would like to receive a copy of the access agreement with the landowner to confirm that we have access to conduct our EPA activities through your agreement. As you know, we would like to make sure all the paperwork is agreed to so that we can move ahead with this project.

Please feel free for either you or Chris Hill to call me if you have any questions.

Best regards,

Mike

Michael Overbay, P.G. Regional Ground Water Center Coordinator U.S. Environmental Protection Agency - Region 6 (214)665-6482 (214)665-2191 (FAX)

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SAIC

April 25, 2012

Mr. Chris Hill Environmental Engineer Chesapeake Energy Corporation P.O. Box 18496 Oklahoma City, Oklahoma 73154-0496

Re: Proposal/Cost Estimate Limited Hydrogeological Investigation Hydraulic Fracturing Prospective Case Study NE/4 Section 15, Township 28 North, Range 11 West Alfalfa County, Oklahoma

Dear Mr. Hill:

SAIC Energy, Environment & Infrastructure, LLC (SAIC), is pleased to present Chesapeake Energy Corporation (Chesapeake) the following Proposal/Cost Estimate to conduct a Limited Hydrogeological Investigation (Investigation) to support the Hydraulic Fracturing Prospective Case Study proposed in the NE/4 of Section 15. Township 28 North, Range 11 West, Alfalfa County, Oklahoma (Site). The Investigation is being conducted to evaluate the Site soil and groundwater background conditions prior to construction of a pad site for gas well drilling/development. Groundwater contained within the Quaternary-age terrace deposits underlie the well pad area, and have been identified as a major alluvial aguifer that is used for agricultural, municipal and domestic purposes. The bedrock (Permian-age) groundwater that underlies the terrace deposits in the area will also be evaluated. The bedrock formations in this area contain naturally-occurring poor water quality of low yield and therefore, groundwater is not typically used from bedrock formations in this area. However, this investigation will evaluate that portion of the bedrock groundwater system that is above the base of treatable groundwater (i.e., groundwater with a TDS of 10,000 mg/L or less). The base of treatable groundwater in the well pad area has initially been determined to be 100 to 150 feet below ground level (bgl) by the Oklahoma Corporation Commission (OCC). The base of treatable groundwater will occur within the Hennessey Group bedrock units. The main objectives of this Investigation will be to: 1) determine the groundwater flow direction and collect hydraulic parameters to estimate groundwater velocity: 2) determine the subsurface geology and groundwater occurrence beneath the Site; 3) collect initial soil samples for limited analytical testing; 4) collect 1 round of groundwater samples for comprehensive analytical testing; and 5) define the variation of groundwater quality with depth within the terrace and bedrock groundwater systems.

Surficial geology at the Site consists of Quaternary-age terrace deposits related to the Salt Fork of the Arkansas River. These deposits consist of light-tan to gray gravel, sand, silt, clay, and volcanic ash, with sand dunes common in places. A review of water well data from wells located within approximately 2 miles of the Site indicates that the terrace deposits at the Site likely range from 20 to 50 feet in thickness and average approximately 35 feet in thickness. Groundwater in the terrace deposits in this area are reported to range from approximately 3 feet bgl to 28 feet bgl, and average approximately 15 feet bgl. Underlying the terrace deposits is Permian-age consolidated bedrock of the Hennessey Group, which includes the Bison Formation, Salt Plains Formation, Kingman Formation, and Fairmont Shale. These units consist of fine-grained sandstone, siltstone, and shale. The Bison Formation is approximately 120 feet thick, the Salt Plans Formation is approximately 160

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feet thick, the Kingman Formation is approximately 70 feet thick, and the Fairmont Shale is approximately 160 feet thick, with a collective thickness of approximately 510 feet. Groundwater in the consolidated bedrock occurs principally within fractures and joints and is typically of very poor quality, becoming more mineralized with depth.

During implementation of the Investigation, SAIC anticipates implementing the following activities on behalf of Chesapeake:

Task 1 - Project Management

The Investigation activities will be managed out of SAIC's Tulsa, Oklahoma office by Mr. Bruce McKenzie. SAIC's on-site hydrogeologist will be Mr. Matt Mugavero, and SAIC technicians will include either Mr. Stan Marshall or Mr. Terry Fisher as schedules allow. QA/QC of the laboratory analytical data will be managed by Ms. Kristin Drucquer. SAIC will prepare a Site-Specific Health and Safety Plan (HSP) that will address all field activities proposed herein.

Task 2 - Monitoring Well Installation and Development

A total of 6 groundwater monitoring wells, 5 shallow (~50 feet) and 1 deep (~150 feet), will be installed to establish and monitor the groundwater quality at or in close proximity to the proposed well pad site. These monitoring wells will be drilled and installed by a licensed well driller (Associated Environmental Industries, Inc., Norman, Oklahoma) in accordance with Oklahoma state regulations.

The shallow groundwater monitoring wells will be installed utilizing a truck-mounted hollow-stem auger drilling rig and CME continuous split-barrel sample system from surface to total depth. Borings will be advanced to the top of the underlying consolidated bedrock. During drilling, lithological descriptions will be made using the Unified Soil Classification System. Field activities will be recorded in a dedicated field logbook, and all hydrogeological information noted documented on permanent soil boring records.

In each borehole, soil samples will be collected from the following depth intervals: 0-0.5 feet bgl, 1-2 feet bgl and 2-3 feet bgl. Upon collection, the soil samples will be placed into laboratory prepared containers, labeled as to source and contents, placed on wet-ice for preservation, and placed under chain-of-custody control for transport to the analytical laboratory (TestAmerica, Inc., Nashville, TN) for volatile organic compound (VOC) (SW 8260B), semi-volatile organic compound (SVOC) (SW 8270C), polycyclic aromatic hydrocarbon (PAH) (SW 8270C-SIM) and total petroleum hydrocarbon (TPH) (TX 1005) analyses. In addition to soil samples for laboratory analysis, an aliquot of each soil sample will be submitted to a soils laboratory (Inter-Mountain Laboratories, Inc., Sheridan, Wyoming) for comprehensive salinity analysis by Saturated Paste Extraction (Cations: sodium, calcium, magnesium, potassium; Anions: nitrate-n, chloride, sulfate, boron, bicarbonate, carbonate; General Chemistry: pH, conductivity, texture; Derived Values: total soluble salts, sodium adsorption ratio, potassium adsorption ratio, exchangeable sodium percentage, exchangeable potassium percentage).

The shallow monitoring wells will be constructed using 2-inch diameter, screw-coupled, Schedule 40 PVC 0.010-inch slot screens and Schedule 40 PVC casing. In general, approximately 30 to 40 feet of screen will be installed in each monitor well such that the top of the screen is situated above (approximately 5 feet) the groundwater saturation level observed at the time of well installation. Once the screen/casing strings are positioned within the open boreholes, a clean silica sand pack will be placed in the annular space between the screen/casing and the open borehole. In each monitor well, the sand pack will extend from total depth to approximately two feet above the top slot of the screen. A 2-foot minimum sodium bentonite pellet seal will be placed immediately above the

sand packs. Following hydration of the bentonite seal, the remaining annular space will be filled with a cement/bentonite grout using pressure-grouting techniques to approximately one foot bgl. A vented cap will be placed on top of the well casing, and a locking steel protective outer casing will be centered upon each well casing. The protective outer casing will be set in a 3-inch thick by 36-inch diameter concrete pad. During well completion, the well identification nomenclature will be placed on or in the well protector. When the well pads have cured, a weep hole will be drilled in each protective outer casing. Well completion details will be recorded on permanent well completion records.

The deep monitoring well will be installed by drilling through the terrace deposits and 5 feet into the underlying bedrock utilizing a truck-mounted hollow-stem auger drilling rig and CME continuous splitbarrel sample system. A 10-inch diameter surface casing will then be set and grouted in-place to isolate the groundwater within the terrace deposits from the groundwater within the underlying bedrock. Once the surface casing grout has cured, air-rotary drilling equipment will be utilized to drill into the underlying bed rock. During bedrock drilling operations, an attempt will be made to collect water quality measurements (i.e., specific conductivity, temperature and pH) from the borehole as these data may be useful in determining the base of treatable water.

Upon reaching total depth, geophysical and water quality logging will be conducted in the deep borehole. The geophysical and water quality logging will be conducted by Century Geophysical Corporation and Earth Data Northeast, Inc., respectively, and will include the following:

- Caliper,
- Natural Gamma,
- Normal Resistivity,
- Single Point Resistance,
- Fluid Resistivity and Temperature,
- Spontaneous Potential (SP),
- Induction Conductivity,
- Magnetic Susceptibility,
- Full Wave Form Sonic,
- Acoustic Borehole Imager with Vertical Deviation and Azimuth,
- Neutron Density,
- Gamma-Gamma Density, and
- Water Quality Logging (pressure, temperature, conductivity, dissolved oxygen, pH and Eh).

The deep monitoring well will be constructed using 4-inch diameter, screw-coupled, Schedule 40 PVC 0.010-inch slot screens and Schedule 40 PVC casing. Approximately 80 to 100 feet of screen will be installed so that the top of the screened interval will terminate at, or just above, the top of the groundwater zone to be monitored. Once the screen/casing assembly is positioned within the borehole, the annular space between the wellbore and the screen/casing will be filled with clean, silica sand to a level approximately two feet above the top slot of the screened interval. Four feet of bentonite will then be placed in the annular space above the silica sand/filter pack and hydrated. Following hydration of the bentonite seal, the remaining annular space will be filled with a cement/bentonite grout using pressure-grouting techniques to approximately one foot bgl. A vented cap will be placed on top of the well casing, and a locking steel protective outer casing will be centered upon the well casing. The protective outer casing will be set in a 3-inch thick by 36-inch diameter concrete pad. During well completion, the well identification nomenclature will be placed on or in the well protector. When the well pad has cured, a weep hole will be drilled in the protective

outer casing just above the concrete pad so that moisture will not accumulated within the protective outer casing. Well completion details will be recorded on a permanent well completion record.

During drilling operations, soil and rock cuttings will be containerized and labeled properly. These cuttings will be stored on-site until proper disposal can be arranged. Drilling equipment will be decontaminated between each monitoring well location.

During well drilling/completion activities, samples of the silica sand, bentonite (pellets and powder), cement and any drill-fluid additives will be collected and archived for future analysis if needed.

Following well completion activities, each monitoring well will be left undisturbed for a minimum of 48 hours to allow the cement/bentonite grout to cure. After this 48-hour period, each of the newly installed monitoring wells will be developed to remove the fine particles that have accumulated in the well casing and annulus. The monitoring wells will be developed utilizing bailers, submersible pumps, surge-blocks or other suitable devices to ensure that the wells are free of suspended sediment and provide representative water samples. Development will be conducted until a minimum of three casing volumes are removed, the water quality parameters of the discharging groundwater are stable (within 10% variance) and the turbidity of the discharging groundwater is 20 NTU or less. All well development water will be containerized, properly labeled and stored on-site until proper disposal can be arranged.

Upon completion of well installation/completion activities, each monitoring well will be surveyed for horizontal and vertical control by an Oklahoma-licensed land surveyor (Jividens Land Survey Company, Woodward, Oklahoma). The coordinate location (within 1 foot), top of case elevation (TOC) (within 0.01 foot) and ground elevation (within 0.01 foot) for each monitoring well will be determined. In addition, to surveying, the location of each monitoring well will be recorded with a sub-meter GIS-compatible GPS.

Task 3 - Groundwater Monitoring

Upon completion of well development activities, the monitoring wells will be left undisturbed for a period of one week. Following this period, two rounds of concurrent depth to groundwater (DTW) measurements will be taken within each of the monitoring wells at the Site. The first DTW event will be conducted immediately prior to conducting groundwater purging/sampling activities, and the second DTW event will be conducted one week following the groundwater sampling event. The water levels will be measured from the surveyed TOC of each monitoring well utilizing a decontaminated electronic water level indicator and will be recorded in a dedicated field logbook. Data from the water level measurements, in conjunction with the TOC elevation data, will be utilized to construct groundwater potentiometric surface maps of the groundwater system being monitored.

Upon completion of well development activities and prior to conducting groundwater purging/sampling activities, vertical water quality logging will be conducted within each monitoring well. During these activities, the specific conductivity, temperature, dissolved oxygen (DO), pH and oxidation/reduction potential (Eh) of the groundwater will be measured on 1-foot increments from the top of the water column to the base of the monitoring well. These measurements will be recorded in a dedicated field logbook.

Reference data for the area indicate that the groundwater within the shallow terrace deposits likely exhibits density and/or chemical stratification. These data also suggest that the deep bedrock groundwater is also likely stratified. Therefore, it is anticipated that two groundwater samples will be collected from each of the monitoring wells completed at the Site. The groundwater sampling zones will be selected based upon the results of the vertical water quality logging conducted within each monitoring well.

Prior to conducting groundwater sampling within each selected zone, the zone will be low-flow purged utilizing a decontaminated bladder-pump with a dedicated bladder. Field measurements of pH, Eh, dissolved oxygen, specific conductance, temperature and turbidity will be collected and documented in a dedicated field logbook during well purging and immediately prior to sample collection. When three consecutive readings of the field parameters taken do not differ by more than 10%, and the turbidity of the discharging groundwater is 20 NTU or less, groundwater samples will be collected. If turbidity values of <20 NTU cannot be achieved, then dissolved analyses of metals, cations and radionuclides will be conducted. Upon collection, the groundwater samples will be placed directly into laboratory prepared sample containers, labeled as to source and contents, placed on wet-ice for preservation, and placed under chain-of-custody control for transport to the analytical laboratory (TestAmerica, Inc., Nashville, Tennessee) for analytical suite developed by Chesapeake for this investigation. This analytical suite is provided in attached Table 1.

All purge water and water not consumed during the sampling process will be containerized, properly labeled and stored on-site until proper disposal can be arranged.

Task 4 - Hydraulic Conductivity Testing

To further characterize the shallow unconfined groundwater system present beneath the Site, singlewell displacement tests (slug) tests will be conducted in the 5 proposed shallow groundwater monitoring wells. During these slug tests, the groundwater within the well will be artificially lowered by rapidly removing groundwater from the well utilizing dedicated bailers. The return of the lowered groundwater level to an equilibrium level will be recorded utilizing a pressure transducer positioned at the bottom of the monitoring well attached to a data logger at the surface.

To further characterize the bedrock groundwater system, a 12-hour constant rate pump test followed by a 12-hour recovery monitored period will be conducted in the proposed deep monitoring well. A 1-hour pumping pre-test will be conducted on the well to determine pumping rate for the 24-hour test and will be conducted at least 1 day prior to the 24-hour test. The deep well will be outfitted with a pressure transducer positioned at the bottom of the monitoring well (placed in the well approximately 2 days prior to initiating pre-test activities) attached to a data logger at the surface to monitor drawdown. A pressure transducer will also be installed in the shallow monitoring well located adjacent to the deep monitoring well to measure any potential change/effect that pumping of the bedrock groundwater system may have upon the shallow groundwater system. Discharge measurements will be taken and the pH, specific conductivity and temperature of the discharging groundwater measured hourly throughout the pump test. A totalizing flow meter will be installed in the discharge line to monitor flow throughout the test.

Data from the pump and slug tests will be interpreted and values for hydraulic conductivity and transmissivity calculated, which will be used to estimate groundwater flow velocities.

Task 5 - Report Preparation

Upon completion of the field activities and receipt of the laboratory analytical data, SAIC will prepare a brief report detailing the results of the investigation. This report will describe the field operations and sampling activities conducted and will include the following:

- A brief discussion of the Site geology,
- A discussion of all field activities performed,
- A summary of results of the well installation activities,
- A discussion of the results of the deep geophysical logs,
- Tables summarizing the laboratory analytical data,
- A Site location and topographic features map,
- A Site map showing the actual locations of the newly installed monitoring wells,
- A depth to water map,
- Two groundwater potentiometric surface maps for the shallow groundwater system,
- Two cross sections (N-S and E-W),
- An evaluation of velocity of the shallow groundwater system beneath the Site,
- Soil boring and monitoring well construction records,
- Copies of the deep geophysical logs,
- Copies of field notes,
- Site photographs, and
- Laboratory analytical reports and chain-of-custody documentation.

A Cost Estimate to implement the scope of work is attached. SAIC's charges will be billed on a timeand-materials basis in accordance with the current Chesapeake/SAIC contract agreement.

SAIC appreciates this opportunity to be of service to Chesapeake. If you have any questions concerning the proposed scope of work or the estimated costs, please do not hesitate to contact me at (918) 599-4383.

Sincerely, SAIC Energy, Environment & Infrastructure, LLC

Burg Milmin

Bruce E. McKenzie, P.G. Project Manager

Attachments: Table 1 - Retrospective Case Study Analytical Suite Figure 1 - Site Location and Topographic Features Figure 2 - Proposed Gas Well Pad Site and Monitoring Well Locations Cost Estimate

Assumptions and Limitations

In preparing the proposed Scope of Work (SOW) and Cost Estimate, SAIC has relied upon verbal and/or written information provided by Chesapeake Energy Corporation (Chesapeake) and/or secondary sources. SAIC has not been tasked to make an independent investigation concerning the accuracy or completeness of the information relied upon. To the extent that SAIC has based its proposed SOW and Cost Estimate on such information, the proposed SOW and Cost Estimate are contingent on the validity of the information provided.

Chesapeake acknowledges that SAIC has not contributed to the presence of hazardous substances, hazardous wastes, petroleum products, asbestos, chemicals, pollutants, contaminants, or any other hazardous or toxic materials (hereinafter Hazardous Materials) that may exist or be discovered in the future at the site at which SAIC's services shall be provided and that SAIC does not assume any liability for the known or unknown presence of Hazardous Materials.

SAIC's investigation will be restricted to collection and analyses of a limited number of environmental samples and visual observations obtained during the physical site visit, and from records made available by Chesapeake or third parties during the investigation. Because the investigation will consist of collecting and evaluating a limited supply of information, SAIC may not identify all potential items of concern. Therefore, SAIC warrants only that the project activities under this SOW and contract have been performed within the parameters and scope communicated by Chesapeake and reflected in the SOW and contract.

The proposed report will be prepared for the sole and intended use of Chesapeake. Any person or entity obtaining, using, or relying on this report hereby acknowledges that they do so at their own risk, and that SAIC shall have no responsibility or liability for the consequences thereof. This report is intended to be used in its entirety and taking or using in any way excerpts from the proposed report are not permitted and any party doing so does so at its own risk. In preparing this proposed report, SAIC will have relied on verbal and written information provided by secondary sources and interviews, including information provided by Chesapeake. Opinions and recommendations that may be presented in this report apply only to site conditions and features as they existed at the time of SAIC's site visit. The opinions and recommendations presented in this report cannot be applied to conditions and features of which SAIC is unaware and has not had the opportunity to evaluate.

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TI C B R IM th	THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER. IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the												
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DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (Attach ACORD 101, Additional Remarks Schedule, if more space is required)													
Specimen					SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.								
					AUTHORIZED REPRESENTATIVE								

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SURFACE DAMAGE AGREEMENT AND RELEASE

KNOW ALL MEN BY THESE PRESENTS:

WHEREAS, Greg Baker, Power of Attorney (POA) for Barbara Ann Bouziden ("Surface Owner") is the Owner of the Northeast Quarter (NE/4) of Section 15, Township 28 North, Range 11 West, Alfalfa County, Oklahoma.

For and in Consideration of the total sum of Fifteen Thousand Dollars (\$15,000.00) to be paid to Surface Owner by CHESAPEAKE OPERATING, INC. ("Operator"), prior to Operator entering said property, Surface Owner hereby releases Operator from all ordinary necessary damages sustained in connection with the drilling, completing, and equipping of the **Baker 15-28-11 1H**, (**Well**) to be located approximately **250** feet from the North line and **660** feet from the East line on the above property according to the attached plat, together with the drilling and installation of monitor water wells provided for in Paragraph 10 below.

As additional consideration for the covenants contained herein, **Operator** expressly agrees to the following as binding terms of this agreement:

1. If the Well is completed as a commercial producer, Operator shall maintain the Well site and road for ingress and egress in a prudent and reasonable manner, including keeping same from erosion and keeping free of noxious weeds. Roadway location shall be agreed to by Lessor.

2. If the Well is not completed as a commercial producer or upon abandonment of the Well, Operator shall, within 90 days, remove all of its equipment and restore all of the Surface Owner's property as nearly as practical to its original condition, Operator shall at all times keep Surface Owner's property, the location and lease road free of trash and debris.

3. Surface Owner and Operator agree that Operator shall limit its use of the above described lands to that area of land necessary for it operations, surrounding or immediately adjacent to the well bore of the Well, and the monitor water wells provided for in Paragraph 10 below. The location will not exceed 375 feet by 325 feet in size. The roadway shall not exceed 20 feet in width for ingress and egress to the well site. Dirt dug pits shall not be allowed and frac trailers must be used for fracing operations.

The production facility of the Well shall be fenced by Operator and cattle guard(s) 4 placed at one entry point where Operator has to cut Surface Owner's fence lines in the construction of a lease road and location. Operator will install at the entrance to Surface Owner's property off of the county road an arm across the cattle guard. Upon abandonment of a Well, the cattle guards shall become the property of Surface Owner. Operator shall repair any fences that are cut on Surface Owner's property in a manner consistent with existing fences to Surface Owner's satisfaction. All corner posts and bracing shall be steel pipe set in concrete, all to be approved by the surface owner. Operator shall install metal pipe H-Braces on each side of the cattle guard to tie and properly stretch all wire to Surface Owners satisfaction into the fence. Operator will at the request of Surface Owner, lock any new entrance made to Surface Owner's property. Operator agrees to rock all lease roads constructed on Surface Owner's property and said roads shall be maintained for the life of the well so as to prevent obstruction of water and spreading of rock off the location and roadways. Operator shall clean up any rock which is scattered to prevent a hazard to Surface Owner's farm equipment. Low areas and ruts occurring in the road will be promptly repaired and employees or agents of Operator' shall not be permitted to by-pass such ruts and low areas by driving around the roadway. Operator shall not allow water to back up on either side and provide proper drainage from same including any necessary water culverts.

5. The aforementioned consideration does not include damages for any gathering lines or pipelines that Operator lays across lands owned by Surface Owner for the Well.

6. Operator will comply with all Oklahoma Corporation Commission rules and regulations with respect to any pits constructed on Surface Owner's property.

7. Operator agrees to conduct its operations on the location and road authorized by this Agreement and **will advise** its employees, representatives, contractors, subcontractors and independent contractors to stay on the road and location built by Operator and not to utilize any of Surface Owner's land, without prior written authorization by the Surface Owner. Violation of this shall be considered trespass. Operator, its employees, representatives, contractors, subcontractors and independent contractors of the Surface Owner's land.

8. Operator agrees to indemnify and hold Surface Owner harmless for all debts, claims, damages and demands incurred in connection with the performance of this Agreement and the operations conducted thereon whether above or below the surface.

9. It is the specific intent of this Release to cover the drilling, completing and equipping insofar and only insofar as to the Well and the monitor water wells described in Paragraph 10 There shall be no other well or borehole situated on Surface Owner's property. This Release does not cover unusual or extraordinary damages of pollution presently or in the future. Operator shall be further liable to Surface Owner for any unusual damages or pollution not covered by this Agreement, whether the same is caused by Operator, its employees, agents. representatives. contractors. subcontractors or independent contractors. Operator shall not be allowed to dispose of any saltwater or other deleterious substances from outside the well site upon or into Surface Owner's property without written permission. Commercial saltwater disposal wells shall not be allowed.

10 Surface Owner agrees that Operator may drill, equip and operate as many water monitoring wells as are necessary to properly characterize the shallow geology/hydrogeology and monitor the water quality through out the complete process of site preparation, drilling, operating and producing the Well. All water monitoring wells will be drilled in accordance with Oklahoma Water Resource Board regulations, and located approximately thirty (30) feet outside the perimeter of the Well location ... Operator and Surface Owner agree that no water will be used from the water monitoring wells to drill or complete the Well without an expressed written agreement with the Surface Owner. If the Well is completed as a well capable of commercial production, the water monitoring wells will remain in place for a minimum of two (2) years from the date of first sales from the Well. Surface Owner hereby expressly grants ingress and egress to Operator, and its designees (including but not limited to representatives of the U.S. Environmental Protection Agency) onto the location to periodically collect water samples, and to maintain or repair the monitor wells. Upon completion of the use of the water wells as provided for herein, the wells shall be proper plugged and abandoned in accordance with Oklahoma Water Resource Board regulations.

11. This Agreement shall bind and inure to the benefit of all parties hereto, their heirs, successors and assigns.

12. This Agreement may be executed in counterpart, each of which counterpart execution shall be deemed an original for purposes of this instrument.

13. Except as provided for in Paragraph 10 above, Lessee may not use fresh water obtained from or under the leased premises without the express written consent of the Surface Owner.

In Witness Whereof, this Agreement has been executed this 2012. day of April, 2012.

SURFACE OWNER:

Barbara Ann Bouziden

By Greg Baker (POA)

OPERATOR

CHESAPEAKE OPERATING, INC.

By: Adam Doty, Field Manager

ACKNOWLEDGMENTS

)ss:

)

STATE OF OKLAHOMA

COUNTY OF WOODS

BEFORE me, the undersigned, a Notary Public in and for said County and State, on this <u>26</u> day of April, 2012 personally appeared Greg Baker as Power of Attorney for Barbara Ann Bouziden, to me known to be the identical person(s) who executed the within and foregoing instrument, and acknowledged to me that he executed the same as his free and voluntary act and deed, for the uses and purposes therein set forth.

Given under my hand and seal the day and year last above written.

Public

My Commission expires:

9-13-15

My Commission #



STATE OF OKLAHOMA

COUNTY OF OKLAHOMA

BEFORE me, the undersigned, a Notary Public in and for said County and State, on this <u>30</u> day of April, 2012, personally appeared Adam Doty, Field Manager of Chesapeake Operating, Inc., to me known to be the identical person who subscribed the name of the maker thereof to the foregoing instrument and acknowledged to me that he executed the same as his free and voluntary act and deed and as the free and voluntary act and deed of such corporation, for the uses and purposes therein set forth.

SS'

)

Given under my hand and seal the day and year last above written.

1-7 Notary Public

My Commission expires:





Doug Beak emails responsibe to #Q-Fo1-01479-12.pdt

Fw: New FOIA Request #01479-12 - please forward your responsive records for review , Doug Beak to: Suzanne Jackson 07/05/2012 07:53 AM Cc: Pam Daggs

Hi Suzanne,

This is part 1 of 2 for the above FOIA request. If you have any questions let me know.

Doug

Dr. Douglas G. Beak

Geochemistry/ Environmental Chemistry USEPA-ORD-NRMRL-GWERD-SRB 919 Kerr Research Dr. Ada, OK 74820

email: beak.doug@epa.gov Phone: 580-436-8813 Fax: 580-436-8703 Blackberry: 580-235-7158 ----- Forwarded by Doug Beak/ADA/USEPA/US on 07/05/2012 06:49 AM -----

From:	"Chris Hill (Regulatory)" <chris.hill@chk.com></chris.hill@chk.com>
To:	Michael Overbay/R6/ÚSEPA/US@EPA, Doug Beak/ADA/USEPA/US@EPA, Randall
	Ross/ADA/USEPA/US@EPA, Steven Acree/ADA/USEPA/US@EPA, Bert Smith
	<pre> <</pre>
Gc:	Stephanie Timmermeyer <stephanie.timmermeyer@chk.com></stephanie.timmermeyer@chk.com>
Date:	04/30/2012 09:51 PM
Subject:	Invitation: EPA Miss Lime Prospective Study (May 1 03:00 PM CDT in Call in: 877-935-0245 Code: 745 420 + Rm 231)

This meeting has been scheduled to have a technical discussion regarding CHK proposed site characterization scope of work. Additional topics of discussion may include the following :

- Status of EPA's formal response to CHK's tech memo comments.
- Access agreement status.
- Schedule.

---- Forwarded by Doug Beak/ADA/USEPA/US on 07/05/2012 06:49 AM -----

"Chris Hill (Regulatory)" <chris.hill@chk.com>

From:

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Forwarded by Doug Beak/ADA/USEPA/US on 07/05/2012 06:49 AM -----From: "Chris Hill (Regulatory)" <chris.hill@chk.com> To: Michael Overbay/R6/USEPA/US@EPA Cc: Stephanie Timmermeyer <stephanie.timmermeyer@chk.com>, John Satterfield <john.satterfield@chk.com>, Tamara Robbins <tamara.robbins@chk.com>, "Bert Smith"

Ce: 04/30/2012 09:49 PM

Date:
04/30/2012 09:49 PM

Subject:
EPA HF Prospective Study

Mike,

As you requested, I have attached the following items:

- 1. A copy of CHK's E&E monitoring well alternatives technical memo comments with "draft" water mark removed.
- 2. A copy of CHK's proposed site characterization scope of work.

We would appreciate EPA's comments and/or approval of the proposed site characterization scope of work at EPA's earliest convenience. Please let me know if you have any questions.

I will be sending you a calendar invite for a conference call tomorrow (Tuesday) at 3 pm, as you requested.

Thank you, Chris Hill Environmental Engineer Chesapeake Energy Corporation Office: (405) 935-2321 Mobile: (405) 388-3907 Fax: (405) 849-2321 E-mail: Chris.Hill@chk.com This email (and attachments if any) is intended only for the use of the individual or entity to which it is addressed, and may contain information that is confidential or privileged and exempt from disclosure under applicable law. If the reader of this email is not the intended recipient, or the employee or agent responsible for delivering this message to the intended recipient, you are hereby notified that any dissemination, distribution or copying of this communication is strictly prohibiled. If you have received this communication in error, please notify the sender immediately by return email and destroy all copies of the email (and attachments if

[attachment "CHK Review - Tech Memo.pdf" deleted by Doug Beak/ADA/USEPA/US] [attachment "Pages from Ltd Hydr Invest Prop 4-25-2012 (2).pdf" deleted by Doug Beak/ADA/USEPA/US]

-- Forwarded by Doug Beak/ADA/USEPA/US on 07/05/2012 06:49 AM -----

From	Doug Beak/ADA/USEPA/US
To:	"Chris Hill (Regulatory)" <chris.hill@chk.com></chris.hill@chk.com>
Cc:	Carlyle Miller/ADA/USEPA/US@EPA, Ralph Ludwig/ADA/USEPA/US@EPA
Date:	05/03/2012 07:30 AM
Subject:	RE: Sampling methods and protocols used in Ne PA

Hi Chris,

I can only speak for the case studies I'm involved with, TX and ND. If you want to know about the other case studies, you will need to contact the PI's on those. The others involved with NE PA case studies have been or will be contacted, we split up the task.

Doug

Dr. Douglas G. Beak

Geochemistry/ Environmental Chemistry USEPA-ORD-NRMRL-GWERD-SRB 919 Kerr Research Dr. Ada, OK 74820

email: beak.doug@epa.gov Phone: 580-436-8813 Fax: 580-436-8703 Blackberry: 580-235-7158

"Chris H	ill (Regulatory)" Hi Doug, I appreciate the quick response. I	05/03/2012 12:16:42 AM
From:	"Chris Hill (Regulatory)" <chris.hill@chk.com></chris.hill@chk.com>	
To:	Doug Beak/ADA/USEPA/US@EPA	
Cc:	Ralph Ludwig/ADA/USEPA/US@EPA, Carlyle Miller/ADA/USEPA/US@	DEPA
Date:	05/03/2012 12:16 AM	
Subject:	RE: Sampling methods and protocols used in Ne PA	

Hi Doug,

I appreciate the quick response. I am working to provide you the same courtesy regarding the information you requested. Please note that I believe some of this information has been provided to

EPA on previous occasions in regards to our prospective study. However, I will have the information verified, compiled and sent to you as soon as possible.

It is interesting to hear that EPA has only requested this information for the TX and ND studies. I know there are other stakeholders (state and industry) that are collecting samples in conjunction with EPA's retrospective sampling events, including in the Susquehanna/Bradford Co. study. Out of curiosity, what is the rationale behind requesting this information from some participating stakeholders and not others?

Please let me know if you think of anything else CHK can do to help.

Thanks, Chris

From: Doug Beak [mailto:Beak.Doug@epamail.epa.gov]
Sent: Wednesday, May 02, 2012 10:46 AM
To: Chris Hill (Regulatory)
Cc: Ralph Ludwig; Carlyle Miller
Subject: Re: Sampling methods and protocols used in Ne PA

Hi Chris,

Yes, we have requested similar information for both the TX and ND studies. For the ND site we have had this information since last July along with their approved QAPP. In TX the state is currently putting this information together since they are the only others sampling and observing.

Since we don't know how the data you are collecting will be used, we are concerned about the comparability and quality of the data you are collecting. Similar to what we are hearing from your side when in the field. Therefore, we need the requested information to be assured that the data you are collecting is comparable and of similar quality.

Doug Dr. Douglas G. Beak USEPA-ORD-NRMRL-GWERD-SRB 919 Kerr Research Dr. Ada, OK 74820

email: <u>beak.doug@epa.gov</u> Phone: 580-436-8813 Fax: 580-436-8703 Blackberry: 580-235-7158

From: "Chris Hill (Regulatory)" [chris.hill@chk.com] Sent: 05/02/2012 03:58 AM GMT To: Doug Beak Cc: Ralph Ludwig; Carlyle Miller Subject: RE: Sampling methods and protocols used in Ne PA

Hi Doug,

I hope you all had a good round of sampling in Bradford County! I was disappointed I was not able to get out there, but hopefully I can make it in July. I am more than happy to round up this information for you, Ralph, and Carl. Similar to your team, we have a number of folks in transit, however, it shouldn't be a problem getting this information to you next week. If you don't mind, could you please inform me how this information will be used by EPA in their study efforts? I would also like to know if EPA has requested similar information from other operators?

Please let me know if you think of anything else CHK can do to help.

Thanks, Chris

From: Doug Beak [mailto:Beak.Doug@epamail.epa.gov]
Sent: Tuesday, May 01, 2012 8:38 PM
To: Chris Hill (Regulatory)
Cc: Ralph Ludwig; Carlyle Miller
Subject: Sampling methods and protocols used in Ne PA

HI Chris,

In October 2011 we asked Dana for the sampling methods and protocols you used for your sampling in NE PA. We never received these, but did receive information on split sampling method. We are again requesting the this Information. We are interested in knowing what analytes were sampled for, the protocols for sampling (including sampling flow rates, how the flow rates are determined, containers used, preservatives used, criteria for determining when samples should be collected, and all methods used for sample collection). In addition, we are interested in knowing what QA samples were collected, the frequency of collection, and the proximity to the sampling location in the case of blanks. Finally, we are requesting the protocols for the calibration of field equipment, the QA types and frequency used for the field equipment and measurements. It would also be helpful to get a copy of the QAPP for this effort. We would also like the same information for the April/May sampling also. Thank you for your attention to this matter.

Doug

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---- Forwarded by Doug Beak/ADA/USEPA/US on 07/05/2012 06:49 AM -----

From:	"Chris Hill (Regulatory)" <chris.hill@chk.com></chris.hill@chk.com>
To:	Michael Overbay/R6/USEPA/US@EPA
Cc:	Doug Beak/ADA/USEPA/US@EPA, David Jewett/ADA/USEPA/US@EPA, John Satterfield
	<john.satterfield@chk.com>, Bert Smith <bert.smith@chk.com>, Tamara Robbins</bert.smith@chk.com></john.satterfield@chk.com>
	<tamara.robbins@chk.com>, Stephanle Timmermeyer <stephanle.timmermeyer@chk.com></stephanle.timmermeyer@chk.com></tamara.robbins@chk.com>
Date:	05/04/2012 10:48 AM
Subject:	RE: QAPP and contact info

Hi Mike,

You are correct, I did owe you Bert's contact information (See below). Please keep John Satterfield and Stephanie Timmermeyer included in email correspondence as well. For your information I believe Bert is out of the office today (5/4/12).

Bert Smith Work: 405-935-1270 Email:bert.smith@chk.com

As you requested, I have attached a copy of our QAPP comments that we sent to Doug Beak on 1/6/12 for your reference. Based on our conversation on Tuesday, it would be beneficial for EPA finalize this QAPP in parallel with the site characterization work. I am comfortable having you incorporate the specific technical comments in to the QAPP, however, I would appreciate a formal response to the critical items listed in the CHK cover letter. Based on our April 18, 2012 conference call, we are operating with the following understanding:

1. EPA agrees with the timing (i.e., after well construction and pre-HF) of the installation of horizontal wells, if they are even necessary.

2. EPA is willing to accept any and all liabilities associated their actions on the project and is self-insured. The EPA project team has initiated discussions with their general counsel.

3. EPA is willing to maintain a buffer of 30 ft. when installing the horizontal wells.

4. EPA will have a detailed procedure for abandoning the horizontal monitoring wells prior to their construction.

5. EPA plans to include language in the final study plan regarding our concern and the limitations of horizontal monitoring wells.

I appreciate you touching base with Steve V. regarding the QA requirements for the site characterization scope of work. This is valuable information for me to communicate to CHK management as they deliberate on whether or not CHK will manage and finance this the scope of work.

I have attached below the subcontractor's estimates for drilling and logging for your reference.

TASK DESCRIPTION	UNITS	UNITS REQUIRED	UNIT COST	ESTIMATED COST \$
Subcontractor - Well Logging (Century Geophysical Corp.)				的。我们的问题
Set Up/Service Charge	LS	1	800	800
Mobilization/Demobilization	LS	2	400	800
Per Diem	Man/Day	4	150	600
Magnetic Susceptibility	Ea	1	325	325
CDL	Ea	2	350	700
Sonic	Ea	1	450	450
Slim Hole Induction	Ea	T	350	350
3-Arm Callper	Ea	1	250	250
E-Log with Neutron	Ea	2	400	800
Televiewer	Ea	1	875	875
Subcontractor - Monitoring Well Drilling/Completion (Associated	Environmenta	i Industries,	Inc.)	ant a second the
Mob/Demob Rig and Support Vehicles	LS	1	3,000	3,000
Decontamination	Ea	6	150	900
Drill Air Rolary w/ 7-7/8 or 8-3/4-Inch Tooth Bit	Ft	450	24.45	11,003
Complete 2-Inch and 4-Inch Diameter PVC Monitoring Weils	FL	450	20	9,000
Ream and Set Surface Casing	FI	50	51.00	2,550
Above Grade Completions	Ea	6	525	3,150
Per Diem	Crew/Day	8	425	3,400

Thank you, Chris Hill Environmental Engineer Chesapeake Energy Corporation Office: (405) 935-2321 Mobile: (405) 388-3907 Fax: (405) 849-2321 E-mail: Chris.Hill@chk.com

From: Michael Overbay [mailto:Overbay.Michael@epamail.epa.gov]
Sent: Thursday, May 03, 2012 10:53 AM
To: Chris Hill (Regulatory)
Cc: Doug Beak; David Jewett
Subject: QAPP and contact info

Hi Chris,

Wanted to remind you that you were going to send me Bert's contact information and the QA comments from Chesapeake.

Also, we have started a review of the proposal and I had a discussion with the Ada crew this morning about it from a QA viewpoint. The QA manager for the HF study project says that these prospective projects are not like the retrospective ones in that as a collaborator on this study, EPA needs your information that we will use to meet the same QA standards as if we generated it, which is what we call Category 1 standards. Here is a link to our QAPP's for the retrospective case studies that you can use as an example.

http://www.epa.gov/hfstudy/gapps.html

28

Since we will be using the hydrogeologic data generated by your efforts to characterize the site, we will definitely have to have information on the well installation and development procedures, water level

measurements, pump testing, etc. Most of that can probably be referenced to either information the driller can provide, or ASTM standard methods. We will also need the information on the procedures the geophysics companies will use to log the wells. I have an example from the USGS on what their procedures would be (note that it includes an example of the log montage at the end):

As to the collection and analysis of environmental media samples, we will be putting our own QAPP together to do that for ourselves, but if Chesapeake wants EPA to be able to consider your sample analytical results, those sample collection and analytical procedures will have to meet our Category 1 QA requirement in order to be included in the study. Again, review the QAPPs at the link above for examples.

Finally, as to the comments Chesapeake had provided earlier, although I would still like a copy sent to me, our contractor has them and will be writing a new version of the QAPP that will consider those comments, as well as new information and procedures EPA has developed. As such, due to the time crunch (in order to construct the pad in July and allow 3 weeks for field work, we have to get the ball moving here), we won't be producing a direct response to those previous comments, but will rely on our revised QAPP to fulfill that role.

We look forward to hearing from you on Monday about Chesapeake's funding decision.

Michael Overbay, P.G. Regional Ground Water Center Coordinator U.S. Environmental Protection Agency - Region 6 (214)665-6482 (214)665-2191 (FAX) Visit the Ground Water Center on the web at: www.epa.gov/earth1r6/6wg/swp/groundwater/gw.htm

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any). [attachment "EPA CHK Case Study QAPP working copy 121611 (CHK Comments 1-6-2012).docx" deleted by Doug Beak/ADA/USEPA/US]

----- orwarded by Doug Beak/ADA/USEPA/US on 07/05/2012 06:49 AM -----

From:	Michael Overbay/R6/USEPA/US
To:	"Chris Hill (Regulatory)" <chris.hill@chk.com></chris.hill@chk.com>
Cc:	Bert Smith bert.smith@chk.com>, David Jewett/ADA/USEPA/US@EPA, Doug
	Beak/ADA/USEPA/US@EPA, John Satterfield <john.satterfield@chk.com>, Stephanie</john.satterfield@chk.com>
	Timmermeyer <stephanie.timmermeyer@chk.com>, Tamara Robbins</stephanie.timmermeyer@chk.com>
	<tamara.robbins@chk.com>, Susan Mravik/ADA/USEPA/US@EPA</tamara.robbins@chk.com>
Date:	05/04/2012 11:16 AM
Subject:	RE: QAPP and contact info

Thanks for the reply Chris.

We do plan on giving y'all back a reply to the letter from Stephanie to Ramona. I have a conference call set up with OGC next week to discuss how we can document the liability, but they have confirmed to me

that the federal government, including EPA, is "self-insured". So we'll get something going on that, but as you noted, it is not on the critical path for beginning the field work. We do agree with the installation timing and location of any horizontal wells, if needed (i.e., at least 30' from the well bore and being installed after the gas well is drilled, but before the hydraulic fracturing). I have tasked E&E with developing a plugging and abandonment plan, which will be generic in some details for now, but will be revised with specifics about well construction details after they are built so the plan will reflect actual conditions. This is another task we talked about not being on the critical path, but it is underway.

Mike

Michael Overbay, P.G. Regional Ground Water Center Coordinator U.S. Environmental Protection Agency - Region 6 (214)665-6482 (214)665-2191 (FAX) Visit the Ground Water Center on the web at: www.epa.gov/earth1r6/6wq/swp/groundwater/gw.htm

"Chris Hill (Regulatory)" Hi Mike, You are correct, I did owe you Be...

05/04/2012 10:48:27 AM

----- Forwarded by Doug Beak/ADA/USEPA/US on 07/05/2012 06:49 AM -----

Research on Potential Impacts of Hydraulic Fracturing on Drinking Water Resources: Coordination with Industry

5/15/12

We appreciate the information industry (as well as states, academia and others) has shared with EPA so far, and look forward to additional exchanges of reliable scientific data and analysis.

Past

- 1. Public input during SAB review of study scope Winter 2010
- 2. Public stakeholder process, included opportunities for oral and written statements Summer 2010
- 3. Technical workshops February-March 2011
- 4. Input during SAB review of draft study plan February August 2011
- 5. Data provided by nine hydraulic fracturing companies in response to request of September 2010

6. Data provided by nine randomly chosen well owner/operator companies in response to request of August 2011.

Ongoing

1. Two prospective case studies underway with Range Resources and Chesapeake

- 2. Duplicate samples offered to relevant stakeholders at five retrospective case study sites
- 3. Collaboration at two waste water treatment plants in Pennsylvania for source apportionment study

4. Discussions with selected hydraulic fracturing service providers to follow up on data provided in response to information request

5. Provide quality assurance project plans (QAPPs) on website for use by industry. These include chemical methods, QA approaches to allow companies to conduct studies comparable to EPA's.

Possible future collaborations/coordination

1. Additional prospective case study (only if additional funds allowed by Congress -- We have discussed this option with Southwestern)

2. We would appreciate working with companies to obtain samples of flowback, produced water, and cores to inform: chemical method development, assessment of effectiveness of waste water treatment methods, and to assess interactions between chemicals used in HF and target formations. (Samples of flowback and produced water are our highest priority request from industry)

3 Does industry have other data to share with EPA (especially data with known QA/QC information)?

4. Public input during SAB review of study reports (expected December 2012 and December 2014)

Current research focuses on potential impacts of hydraulic fracturing on drinking water resources. The President's FY 13 budget requests \$14.1 M: 6.1 M to continue the current study (baseline), and \$8 M (increase) to address air, water, human health and environmental risk.

We will work through our MOU with DOE and DOI/USGS to assure the three agencies coordinate research.

ACCESS AGREEMENT BETWEEN EPA AND [COMPANY] HYDRAULIC FRACTURING PROSPECTIVE CASE STUDY IN [COUNTY], OKLAHOMA

[COMPANY], pursuant to the Surface Damage Agreement and Release between [COMPANY] and the surface owners of the [LOCATION] (attached as Exhibit A, the "Surface Agreement") and pursuant to the necessary rights and privileges arising from [COMPANY]'s ownership interest in the oil and gas leasehold estate, hereby authorizes entry and access on the property in [LOCATION] (as described in Exhibit B, "Property") to the employees and authorized representatives, agents, consultants, contractors and subcontractors of the United States Environmental Protection Agency ("EPA") in order to implement a prospective case study of potential impacts of hydraulic fracturing on drinking water resources (hereinafter the "Project").

- 1. The following activities (hereinafter the "Work") may be conducted on the Property by the EPA and its contractors and representatives, and are covered by this authorization:
 - Staging equipment and supplies
 - Installation and sampling of ground water monitoring wells
 - Collection of environmental media samples (e.g., soil, surface water)
 - Measurement of geophysical properties
 - Related Activities

The activities conducted by EPA are undertaken as part of a national scientific study. EPA shall, in the exercise of the rights and privileges granted by this agreement, adhere to and comply with good engineering practices and all laws, ordinances, rules, regulations and orders applicable to EPA's activities, operations and work performed upon, or use of, the Property.

2. The Work shall be coordinated and approved in advance with [COMPANY], and a [COMPANY] representative shall accompany the EPA at all times the EPA enters the Property. Therefore, EPA shall provide [COMPANY] a copy of the schedule for the Work with 5 business days notice prior to commencement.

The initial notice, any subsequent notices or communications shall be provided to:

[COMPANY]'s Representative: [REPRESENTATIVE CONTACT INFORMATION]

EPA Representative: [REPRESENTATIVE CONTACT INFORMATION]

[COMPANY] does not intend, and EPA shall not be required to follow the provision in this paragraph two (2) if and when it enters the Property in its official enforcement and inspection

capacity.

3. [COMPANY] shall provide the Property to EPA in "as-is" condition. EPA has inspected the Property and is satisfied that it is fit for EPA's purpose. [COMPANY] shall not be responsible for repairing, maintaining or removing any alterations to or installations on the Property by EPA or its contractors.

4. EPA's access to the Property is non-exclusive. EPA shall access the Property and perform the Work at all times so as not to unreasonably interfere with the use of the Property by [COMPANY] or any owner, tenant, licensee or other occupant of the Property. The Surface Agreement, recorded at Book [XXXX], Page [XXXX] of the records of the [LOCATION] intended to and shall constitute a covenant running with the Property for the term hereof.

5. Upon the completion of either of the activities included in the Work on the Property or upon the expiration of this Access Agreement, whichever shall earlier occur, EPA's contractors shall restore the portions of the Property disturbed by the Work to the same or substantially similar condition, based upon photographs to be taken by EPA's contractors prior to the commencement of the Work, as existed prior to the commencement of the Work. The foregoing will not apply to any wells and appurtenances required to be maintained by EPA on the Property.

6. EPA's contractors shall provide the following insurance for the Work:

(a) Certificates of Insurance for EPA's prime contractor, Ecology and Environment, have been furnished to and accepted by [COMPANY] as evidence that such contractor maintains adequate insurance coverage. The drilling subcontractor will be required to maintain the insurance coverage described in Exhibit C. All other professional services subcontractors will be required to maintain the insurance coverage described in Exhibit D. Prior to entering the Property the subcontractors must submit to [COMPANY] certificates of insurance showing that the subcontractor has the proper insurance coverage, as described above, and that [COMPANY] has been named as an "additional Insured" on all policies except Workers Compensation and Professional Liability where applicable, and that [COMPANY] is extended a waiver of subrogation on all those policies.

(b) Said certificates should be forwarded to:

[REPRESENTATIVE CONTACT INFORMATION]

7. Nothing contained in this Access Agreement shall be deemed or construed to create the relationship of principal and agent, or a partnership, or any form of joint venture between the parties, it being understood and agreed that there is no relationship between the parties.

8. By giving consent, [COMPANY] does not waive or otherwise compromise its rights under federal, state or local law, nor under common law, with the exception of those rights waived in giving this consent.

9. This Access Agreement shall expire on December 31, 2015, unless earlier withdrawn, in which case notice of such withdrawal shall be made at least 30 days in advance. The expiration date may be extended by mutual agreement, confirmed in writing, prior to the expiration date.

10. This Access Agreement constitutes the entire agreement between the parties as to the subject matter and there are no verbal or collateral understandings, agreements, representations or warranties not expressly set forth herein. This Access Agreement may not be changed or terminated orally but only by an instrument in writing signed by the party against whom enforcement is sought.

11. These terms, conditions, covenants, releases, provisions and undertakings shall be binding upon and inure to the benefit of the parties to this Access Agreement and their respective heirs, successors, representatives and assigns, and is intended to and shall constitute a covenant running with the Property for the term hereof.

12. If any provision of this Access Agreement is held invalid under any applicable statute or rule of law, whether now existing or hereinafter passed or adopted, such invalidity shall not affect any other provision of this Access Agreement that can be given effect without the invalid provision, and, to this end, the provisions of this Access Agreement are declared to be severable. In such event, the particular provision held invalid shall be renegotiated and redrafted so as to comply with the particular statute or rule of law. In no event, however, shall this severability provision operate as to alter in any material respect the basic understandings to the parties as to their respective obligations hereunder.

13. EPA, an agency of the federal government, shall be liable for claims, damages and injuries which may occur under this Access Agreement as provided in subsections a. and b. below:

a. The Federal Tort Claims Act (28 U.S.C. 2671, 2680) provides coverage for damage or loss of property, or personal injury or death, caused by the negligent or wrongful act or omission of an employee of EPA while acting within the scope of his or her employment, under circumstances where EPA, if a private person, would be liable to the claimant in accordance with the law of the place where the act or omission occurred.

b. If an employee of EPA is injured while acting within the scope of his or her employment, government liability for that injury will generally be dictated by the provisions of the Federal Employees Compensation Act (5 U.S.C. 1801).

- 14. List of Exhibits:
 - A. Surface Damage Agreement and Release between [COMPANY] and the surface owners of the [LOCATION]
 - B. Property description
 - C. Insurance Requirements Drilling Subcontractor

D. Insurance Requirements - Professional Services Subcontractors

[Remainder of Page Intentionally Blank]

OWNER:

[COMPANY]

Signature

Date

Printed or Typed Name

Title

U.S. Environmental Protection Agency

Signature

Date

Printed or Typed Name

Title



Fw: Comments on the CHK proposal for site characterization Michael Overbay to: Claudia Meza-Cuadra

01/29/2013 11:22 AM

Here is the second E-mail.

Michael Overbay, P.G. Regional Ground Water Center Coordinator U.S. Environmental Protection Agency - Region 6 (214)665-6482 (214)665-2191 (FAX)

----- Forwarded by Michael Overbay/R6/USEPA/US on 01/29/2013 10:21 AM -----

From:	Michael Overbay/R6/USEPA/US
To:	Chris Hill <chris.hill@chk.com>, Bert Smith <bert.smith@chk.com></bert.smith@chk.com></chris.hill@chk.com>
Cc:	Doug Beak/ADA/USEPA/US@EPA, Steven Acree/ADA/USEPA/US@EPA, Randall
	Ross/ADA/USEPA/US@EPA, David Jewett/ADA/USEPA/US@EPA
Date:	05/18/2012 01:01 PM
Subject:	Comments on the CHK proposal for site characterization

Hi Chris and Bert,

Below are the comments from Steve Acree, our hydrogeologist working on this project, on the proposal Chesapeake sent on conducting the initial site hydrogeologic characterization. We will still need to look at the geochemical parameters.

Regards,

Michael Overbay, P.G. Regional Ground Water Center Coordinator U.S. Environmental Protection Agency - Region 6 (214)665-6482 (214)665-2191 (FAX) Visit the Ground Water Center on the web at: www.epa.gov/earth1r6/6wq/swp/groundwater/gw.htm

Mike,

I have reviewed the proposal for site characterization provided on April 30 by Mr. Chris Hill and have the following comments and recommendations to offer regarding the proposed hydrogeologic methodology. I will leave review of the geochemical aspects, particularly Table 1, to others.

Task 2 Monitoring Well Installation and Development

1. The plan proposes to obtain samples for lithologic logging using a split barrel sampling system during the drilling of the shallow monitoring wells. The methodology is appropriate. For clarity, the plan should explicitly state that samples will be obtained continuously from land surface to the total depth of the boring.

2. The plan proposes to install the shallow monitoring wells with continuous screens positioned across the entire saturated thickness of the terrace aquifer. Depending on the actual thickness of the aquifer, this could result in wells screening as much as 30 to 50 ft of saturated materials. Given that vertical stratification in water quality is anticipated (page 4 of the plan) and that there will likely be differences in hydraulic conductivity of aquifer materials with depth, this type of construction combined with the

characterization methods proposed in the plan would result in bulk characterization data appropriate for estimating aquifer yield and bulk quality for purposes such as agricultural use assessments but not for estimating groundwater velocities or background quality in specific intervals of interest. If the saturated thickness is found to be greater than approximately 15 ft, it is recommended that well pairs, with one well screened across the water table and one well screened at the bottom of the terrace aquifer, be installed rather than a continuously screened well.

3. The plan lacked specific details regarding some aspects of well construction. With respect to the shallow wells, the proposed borehole diameter and HSA size should be specified. The size distribution of the filter pack material should be specified. The method for placing the filter pack and bentonite pellets should be described (e.g., placement using a tremie pipe through the augers). The plan should also describe the general methodology for installing the well, presumably through the augers. Similar detailed information should be provided regarding drilling and installation of the deep monitoring well installed in the Hennessey Group.

4. The plan states that an attempt will be made to collect water quality measurements during drilling of the deep well. Obtaining discrete water samples representative of specific intervals during drilling can be difficult. Details regarding the tools to be used and the methodology should be provided.

5. Water quality logging is proposed in conjunction with the suite of geophysical logs. More information should be provided concerning the proposed tool to be used, its calibration, and the methodology. In addition, it is likely that there will be vertical flow of groundwater within the borehole given the length of the open hole and the geology of the site. In order to interpret the information from the water quality log, it will be necessary to also have a vertical flow log using a tool such as the electromagnetic borehole flowmeter produced by Century Geophysical. This addition should not be a problem since the plan proposes to use Century Geophysical to do the logging. Depending on the magnitude of the observed flow, it may be necessary to run the tool in stationary mode as well as trolling mode. Details regarding the calibration and proposed methodology for use of the flowmeter should be provided.

6. The plan states that soil and rock cuttings will be containerized and stored until disposal can be arranged. It is recommended that the split spoon samples from a representative number of the shallow wells and samples of the cuttings from the deep well be retained for the duration of the project.

7. Well development is only discussed in general terms. More details concerning the specific methods to be used should be provided. In general, development should be sufficiently aggressive to remove any accumulation of fine-grained materials from the well and to result in water flow in and out of the screen. Water velocity should be sufficient to remove fines from the filter pack and repair damage to the borehole wall. This will often require methods such as surging and over pumping and often require removal of significantly more than three borehole volumes of water.

Task 3 - Groundwater Monitoring

8. The plan proposes water quality logging in each well on a 1-ft interval within the screen. More information should be provided concerning the proposed tool to be used, its calibration, and the methodology. It should be noted that some of the larger diameter tools that are currently available can result in water mixing within a 2-in ID well during tool positioning. This factor should be considered during the design of the measurement methodology. In addition, it is quite possible that there will be vertical flow of groundwater within the well screen, particularly if screens longer than 10 to 20 ft are used. In order to interpret the information from the water quality log, it will be necessary to also have a flow log obtained under non-pumping conditions using a sensitive vertical-component borehole flowmeter.

9. The plan states that low-flow techniques will be used during well sampling. Details concerning equipment, pumping rates, stabilization criteria, and the proposed methodology should be provided. Due to the potential range in geologic heterogeneity of aquifer materials adjacent to long-screened wells and the potential existence of vertical groundwater flow within such wells, low-flow sampling methods often result in water samples being obtained from a very limited zone in the well which is not understood, not

necessarily adjacent to the pump, and not necessarily representative of either a zone of greatest interest or of the bulk water chemistry. Therefore, caution should be exercised in using this methodology with the proposed well construction. Information regarding the vertical flow in the well at the time of sampling and the hydraulic conductivity distribution of the aquifer materials adjacent to the screen, not simply the bulk hydraulic conductivity, would be needed to properly interpret these data.

10. Slug tests performed by removal of water using a bailer are proposed to estimate hydraulic conductivity of materials adjacent to the shallow wells. It is recommended that this procedure be revised to reflect the use of solid slug (e.g., PVC rods) to allow both falling head and rising head tests to be performed and to alleviate data bias caused by leaking bailers. In addition, it is recommended that the methodology be revised to conform to the recommendations of Butler (1997), particularly with respect to the performance of tests with different displacements and to repetition of displacements to allow better evaluation of data quality. It is also noted that this methodology would only provide an estimate of the average or bulk hydraulic conductivity of the aquifer materials. The values obtained from this type of test in a long-screened well would not provide a reliable estimate of groundwater velocity for any particular interval of interest (e.g., water table) if significant heterogeneity were present. Additional studies, such as estimation of the hydraulic conductivity distribution using borehole flowmeter techniques or multi -level slug testing, would be required to provide such information in a long-screened well.

11. A 12-hour pumping and recovery test is proposed to estimate transmissivity in the deep well. In a well screened over the proposed 80-100 ft interval, such data would be appropriate for estimating yield but not for estimating groundwater velocity or for identifying potential contaminant transport pathways in a heterogeneous setting such as this is likely to be the case in this setting. If a long-screened well is used, it is recommended that borehole flow logging be performed using a sensitive vertical component borehole flowmeter to determining the relative contribution of flow as a function of depth in the screen during the pumping test (Young et al., 1998) and under static conditions. This information can be used to estimate the differences in hydraulic conductivity of the materials adjacent to the screen and allow more targeted sampling.

References:

Butler, J.J., Jr., (1997). *The Design, Performance, and Analysis of Slug Tests*. Lewis Publishers, Boca Raton, FL.

Young, S.C., H.E. Julian, H.S. Pearson, F.J. Molz, and G.K. Boman, (1998). Application of the electromagnetic borehole flowmeter. EPA/600/R-98/058. Environmental Protection Agency, Cincinnati, OH.

Steven D. Acree, Hydrologist Robert S. Kerr Environmental Research Center P.O. Box 1198 / 919 Kerr Research Drive Ada, OK 74821 (580) 436-8609 (voice) / (580) 436-8614 (FAX)

Stephanie Timmermeyer
Jeanne Briskin/DC/USEPA/US@EPA
<u>Chris Hill (Regulatory);</u> John Satterfield; <u>Ramona Trovato/DC/USEPA/US@EPA</u>
Re: OGC
06/07/2012 01:31 PM

That time works for us - thanks Stephanie R. Timmermeyer Chesapeake Energy Director, Regulatory Affairs - Federal 304.941.9879

From: Jeanne Briskin [mailto:Briskin.Jeanne@epamail.epa.gov]
Sent: Thursday, June 07, 2012 12:18 PM
To: Stephanie Timmermeyer
Cc: Chris Hill (Regulatory); John Satterfield; Ramona Trovato < Trovato.Ramona@epamail.epa.gov > Subject: Re: OGC

Hi Stephanie,

How about 2 pm EDT on Tuesday June 12? Our general counsel's office will participate. I can provide a conference call line.

To assist the discussion, please provide us in advance with a draft of any access agreement or other similar document they anticipate using in connection with this project.

Thanks,

Jeanne Jeanne Briskin Office of Science Policy Office of Research and Development U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, N.W. (8104R) Washington, D.C. 20460 (202) 564-4583 - office (202) 565-2911 - fax briskin.jeanne@epa.gov

Address for Deliveries: US EPA Ronald Reagan Building --Room 51144 Washington DC 20004

Stephanie Timmermeyer ---06/06/2012 08:33:17 PM---Just heard back - we can do anytime between 3-5CT Monday or 1-4CT Tues or Wed. Thanks. Stephanie R.

From: Stephanie Timmermeyer <stephanie.timmermeyer@chk.com> To: Jeanne Briskin/DC/USEPA/US@EPA Cc: "Chris Hill (Regulatory)" <chris.hill@chk.com>, John Satterfield <john.satterfield@chk.com>, Ramona Trovato/DC/USEPA/US@EPA Date: 06/06/2012 08:33 PM Subject: Re: OGC Just heard back - we can do anytime between 3-5CT Monday or 1-4CT Tues or Wed. Thanks.

Stephanie R. Timmermeyer Chesapeake Energy Director, Regulatory Affairs - Federal 304.941.9879

From: Jeanne Briskin [mailto:Briskin.Jeanne@epamail.epa.gov]
Sent: Wednesday, June 06, 2012 06:17 PM
To: Stephanie Timmermeyer
Cc: Chris Hill (Regulatory); John Satterfield; Ramona Trovato < Trovato.Ramona@epamail.epa.gov > Subject: RE: OGC

That sounds fine. Thanks!

-----Stephanie Timmermeyer <stephanie.timmermeyer@chk.com> wrote: -----

To: Jeanne Briskin/DC/USEPA/US@EPA From: Stephanie Timmermeyer <stephanie.timmermeyer@chk.com> Date: 06/06/2012 01:13PM Cc: "Chris Hill (Regulatory)" <chris.hill@chk.com>, John Satterfield <john.satterfield@chk.com>, Ramona Trovato/DC/USEPA/US@EPA Subject: RE: OGC

Friday we have a shareholders meeting on campus so all will be very busy – we are checking the team's schedules for Mon through Wed and will let you know best times first thing in the morning

From: Jeanne Briskin [mailto:Briskin.Jeanne@epamail.epa.gov]
Sent: Wednesday, June 06, 2012 3:05 PM
To: Stephanie Timmermeyer
Cc: Chris Hill (Regulatory); John Satterfield; Ramona Trovato
Subject: Re: OGC

Hi Stephanie,

As we discussed today, EPA would like to confirm that, as we stated in our letter of 5/23, the federal government self insures, and that this arrangement is acceptable to Chesapeake before we invest in the site characterization. I will set up a meeting with our general counsel's office. What is your availability for Friday and early next week?

Thanks,

Jeanne

Jeanne Briskin Office of Science Policy Office of Research and Development U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, N.W. (8104R) Washington, D.C. 20460 (202) 564-4583 - office (202) 565-2911 - fax

briskin.jeanne@epa.gov

Address for Deliveries: US EPA Ronald Reagan Building --Room 51144 Washington DC 20004

Stephanie Timmermeyer ---06/06/2012 03:59:23 PM---Ramona and Jeanne - It did come as a surprise that EPA is not moving forward with site characterizat

From: Stephanie Timmermeyer <<u>stephanie.timmermeyer@chk.com</u>> To: Jeanne Briskin/DC/USEPA/US@EPA, Ramona Trovato/DC/USEPA/US@EPA Cc: John Satterfield <<u>john.satterfield@chk.com</u>>, "Chris Hill (Regulatory)" <<u>chris.hill@chk.com</u>> Date: 06/06/2012 03:59 PM Subject: OGC

Ramona and Jeanne -

It did come as a surprise that EPA is not moving forward with site characterization due to the liability issue associated with the horizontal wells which may or may not be drilled. Given this information, we now appreciate the need to resolve this issue post-haste. We believe we will require a conversation with your attorneys – could you send us their contact information or set up a meeting for our attorneys with yours? At a minimum, we will require something written from OGC I believe. In any case, a phone conference would be helpful to schedule as soon as possible.

Thanks, Stephanie

Thank you, Stephanie R. Timmermeyer Director - Federal Regulatory Affairs Chesapeake Energy Corporation Mobile: (304) 941-9879 E-mail: <u>Stephanie.Timmermeyer@chk.com</u>

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This Email message contained an attachment named image001.jpg which may be a computer program. This attached computer program could contain a computer virus which could cause harm to EPA's computers, network, and data. The attachment has been deleted.

This was done to limit the distribution of computer viruses introduced into the EPA network. EPA is deleting all computer program attachments sent from the Internet into the agency via Email.

If the message sender is known and the attachment was legitimate, you should contact the sender and request that they rename the file name extension and resend the Email with the renamed attachment. After receiving the revised Email, containing the renamed attachment, you can rename the file extension to its correct name.

For further information, please contact the EPA Call Center at

(866) 411-4EPA (4372). The TDD number is (866) 489-4900.

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error, please notify the sender immediately by return email and destroy all copies of the email (and attachments if any).

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Meeting Invitation Accepted:

Calendar Entry				
Subject:	catch up re: prospective case study			
When				
Date:	Monday 07/16/2012			
Time:	10:30 AM - 11:00 AM (0 hours 30 minutes)			
Chair:	Jeanne Briskin			
Invitees				
Required (to):	sroy@rangeresources.com			
Optional (cc):	ckiray@rangeresources.com			
Where				
Location:	Jeanne will call Scott			

Meeting Confirmed: Susan Sharkey has confirmed this meeting

Calendar Entry Subject: Rob Kirsch (in person) When Date: Tuesday 06/26/2012 02:00 PM - 03:00 PM (1 hour) Time: Chair: Susan Sharkey Invitees Jeanne Briskin/DC/USEPA/US@EPA Required (to): Optional (cc): Where Location: Conference Room 51109-1/DC-Ronald Reagan-OSP

Pattersone-UTI

Meeting Invitation Accepted:

Calendar Entry	
Subject:	EPA hydraulic fracturing research
When	
Date:	Tuesday 06/12/2012
Time:	09:30 AM - 10:00 AM (0 hours 30 minutes)
Meeting is in time zone	e (GMT-06:00) Central Time (US & Canada)
Here:	09:30 AM - 10:00 AM
There:	08:30 AM - 09:00 AM
Chair:	Jeanne Briskin
Invitees	
Required (to):	matt.armstrong@bakerhughes.com
Optional (cc):	
Where	
Location:	I'll call you at 202-569-1130

Thanks for sending this; sorry we've kept missing each other.

Matt

Meeting Invitation Accepted:

Calendar Entry	
Subject:	Prospective case study: Chesapeake question re: indemnification
When	
Date:	Tuesday 06/12/2012
Time:	02:00 PM - 03:00 PM (1 hour)
Chair:	Jeanne Briskin
Sent By:	<u>cara.maschmeier@chk.com</u>
Invitees	
Required (to):	chris.hill@chk.com; Cvnthia Sonich-Mullin/CI/USEPA/US@EPA; David Jewett/ADA/USEPA/US@EPA; Doug Beak/ADA/USEPA/US@EPA; Michael Overbay/R6/USEPA/US@EPA; Pooja Parikh/DC/USEPA/US@EPA; stephanie.timmermeyer@chk.com; Stephen Hess/DC/USEPA/US@EPA; Susan Mravik/ADA/USEPA/US@EPA
Optional (cc): Where	john.satterfield@chk.com; Ramona_Trovato/DC/USEPA/US@EPA
Location:	(b) (6) conf (b) (6)

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From:	Jeanne Briskin
To:	Stephanie Timmermeyer
Cc:	John Satterfield; Ramona Trovato
Subject:	FW: Information Update - Description has changed: Prospective case study: Chesapeake question re: indemnification
Date:	06/11/2012 08:10 PM

Hi Stephanie,

I was able to forward this to our attorney yesterday in preparation for our meeting.

Looking forward to our conversation later today.

Jeanne

-----Stephanie Timmermeyer <stephanie.timmermeyer@chk.com> wrote: -----To: Jeanne Briskin/DC/USEPA/US@EPA, Ramona Trovato/DC/USEPA/US@EPA From: Stephanie Timmermeyer <stephanie.timmermeyer@chk.com> Date: 06/11/2012 04:29PM Cc: John Satterfield <john.satterfield@chk.com> Subject: FW: Information Update - Description has changed: Prospective case study: Chesapeake question re: indemnification

Were you guys able to track down any of the standard agreements we requested below? In the meantime, we think the following questions will help inform our discussions tomorrow – you could forward to your attorneys ahead of time. These are issues be believe we need to talk through –

Thanks Steph

Questions for Consideration

- 1. What limits if any does sovereign immunity place upon the EPA's ability to indemnify and hold CHK harmless
- 2. Who at the EPA can "accept" liability on behalf of the agency?
- 3. If the EPA itself cannot or is unwilling to indemnify CHK, is subcontractor insurance and/or an EPA bond sufficient?
- 4. What has the EPA done before in situations like this?
- 5. What are the EPA's suggestions?
- 6. What does self-insured mean precisely to the EPA?
- 7. What effect does being self-insured have on CHK's ability to collect on a claim given the EPA's protection under sovereign immunity and the federal tort claims act?

From: Stephanie Timmermeyer Sent: Friday, June 08, 2012 8:48 AM To: 'Jeanne Briskin/DC/USEPA/US'; Chris Hill (Regulatory); Cynthia Sonich-Mullin/CI/USEPA/US; David Jewett/ADA/USEPA/US; Doug Beak/ADA/USEPA/US; Michael Overbay/R6/USEPA/US; Pooja Parikh/DC/USEPA/US; Stephen Hess/DC/USEPA/US; Susan Mravik/ADA/USEPA/US Cc: John Satterfield; Ramona Trovato/DC/USEPA/US Subject: RE: Information Update - Description has changed: Prospective case study: Chesapeake auestion re: indemnification Jeanne and Team: Our legal department is in the process of preparing for our meeting next week regarding the potential liability and indemnity issues with respect to the EPA's prospective study. In an effort to facilitate discussions, they have asked whether you can provide a "sample" or "standard" agreement the EPA uses with its non-government vendors or partners. Specifically, they are looking for EPA standard provisions around premises liability, personal injury, safety, subcontractor indemnity, and environmental hazard/pollution, etc. By making this request, the legal department is hoping that they may be able to work from your standard provisions in creating an agreement to address any concerns more quickly than might be the case in starting fresh. Thanks Stephanie -----Original Appointment-----From: Jeanne Briskin/DC/USEPA/US [mailto:Briskin.Jeanne@epamail.epa.gov] Sent: Friday, June 08, 2012 8:27 AM To: Jeanne Briskin/DC/USEPA/US; Chris Hill (Regulatory); Cynthia Sonich-Mullin/CI/USEPA/US; David Jewett/ADA/USEPA/US; Doug Beak/ADA/USEPA/US; Michael Overbay/R6/USEPA/US; Pooja Parikh/DC/USEPA/US; Stephanie Timmermeyer; Stephen Hess/DC/USEPA/US; Susan Mravik/ADA/USEPA/US Cc: John Satterfield; Ramona Trovato/DC/USEPA/US Subject: Information Update - Description has changed: Prospective case study: Chesapeake question re: indemnification When: Tuesday, June 12, 2012 2:00 PM-3:00 PM Eastern. Where: (b) (6) conf code(b) (6)

To assist the discussion, please provide to EPA in advance with a draft of any access agreement or other similar document Chesapeake anticipates using in connection with this project. << File: ATT00001.htm >> << File: c092647.ics >>

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From:	Chris Hill (Regulatory)
To:	Michael Overbay/R6/USEPA/US@EPA
Cc:	John Satterfield; Stephanie Timmermeyer; Jeanne Briskin/DC/USEPA/US@EPA; David Jewett/ADA/USEPA/US@EPA; Susan Mravik/ADA/USEPA/US@EPA; Doug Beak/ADA/USEPA/US@EPA
Subject:	RE: Follow-up on the liability issues
Date:	06/15/2012 06:09 PM

Hi Mike,

We appreciate you looking in to having CHK included as an additional insured within the Master Service Agreement (MSA) (or equivalent) between E&E and EPA, as requested during our conference call. After discussing this topic with CHK's Risk Management department, it appears a \$10MM value would be appropriate. The CHK RM department also requested a copy of the MSA (or equivalent) between E&E and EPA for their review. This additional information will provide a better understanding of the liabilities association with the project, which would be valuable for CHK to make an informed decision regarding our willingness to proceed with the project.

Please let me know if you have any questions.

Thank you, *Chris Hill* Environmental Engineer Chesapeake Energy Corporation Office: (405) 935-2321 Mobile: (405) 388-3907 Fax: (405) 849-2321 E-mail: <u>Chris.Hill@chk.com</u>



From: Michael Overbay [mailto:Overbay.Michael@epamail.epa.gov]
Sent: Friday, June 15, 2012 3:24 PM
To: Chris Hill (Regulatory)
Cc: John Satterfield; Stephanie Timmermeyer; Jeanne Briskin; David Jewett; Susan Mravik; Doug Beak
Subject: Follow-up on the liability issues

Hi Chris,

Just wanted to check in after our call earlier this week. We have E&E looking into the potential issuance of that insurance certificate naming Chesapeake as an additional insured (I think I have that term correct). Have y'all finished putting together the \$ value we talked about? Did John get any feedback from Chesapeake management about their willingness to proceed with the project under the liability scenarios we discussed?

Hope all is well.

Mike

Michael Overbay, P.G. Regional Ground Water Center Coordinator U.S. Environmental Protection Agency - Region 6 (214)665-6482 (214)665-2191 (FAX)

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From: Michael Overbay [mailto:Overbay.Michael@epamail.epa.gov]
Sent: Friday, July 27, 2012 2:41 PM
To: Bob Costello; Chris Hill (Regulatory); John Satterfield
Cc: Stephen Hess; Susan Mravik; Doug Beak; Jeanne Briskin; Florentino, Gene
Subject: Draft Access Agreement

Hi Bob, Chris and John,

As we just discussed, here is the draft access agreement with edits from counsels representing EPA, CHK and E&E.

I had discussed the recent revisions with Chris Hill on Wednesday, July 18th, regarding the changes to the insurance language requirements. I am still waiting on E&E to get cost information so that I can go forward to EPA management to approve the additional insurance costs for liability and well control insurance. Also, based on our discussions today, CHK will make additional revisions to address the issue of allowing EPA continued access to the property should CHK no longer own the mineral interests in the future. Bob Costello will also send Steve Hess information relating to the title opinion he discussed. Since it seems that is something that we may be able to do in just a few days, I will wait to make sure that we are comfortable with our understanding of that issue before pushing forward for final OK. Hopefully, we can this all resolved next week.

Michael Overbay, P.G. Regional Ground Water Center Coordinator U.S. Environmental Protection Agency - Region 6 (214)665-6482 (214)665-2191 (FAX)

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[attachment "draft EPA Chesapeake access agreement July 27 12.docx" deleted by Michael Overbay/R6/USEPA/US] [attachment "Scanned Document.pdf" deleted by Michael Overbay/R6/USEPA/US]

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ed from Superior
>

Nathan,

I have the facility going back to hard copy records for the month and pulling all jobs. I believe we should be able to identify the customer and well from the records. I should have this to you by the February 22nd. I believe -Regards John Srock HSE Director Health, Safety, and Environmental SUPERIOR WELL SERVICES INC. A Nabors Industries Company W: 724.403.9066 | C: 724.541.7822 | F: 866.691.8298 | www.swsi.com | www.nabors.com | ----Original Message----From: Nathan Wiser [mailto:Wiser.Nathan@epamail.epa.gov] Sent: Monday, February 13, 2012 1:02 PM To: Srock, John Cc: Jeanne Briskin Subject: Re: 2-13-12-RE: Some additional well ID information needed from Superior Thank you John, I will forward the two MDS well information sets to Randy Morris, of MDS Energy. On the last well, the data came to EPA from Superior with that information, in Superior's response to EPA's Sept 2010 letter to Superior seeking information on hydraulic fracturing. That information included the list of all wells that Superior frac'd in the year prior to EPA's Sept 2010 letter. This particular well was one of those picked at random from that list. Although in Superior's submission it was identified as an EQT Production well, it seems that it either is not an EQT well or if it is, then the well's location is wrong and it is not located in Uintah County, Utah. How would you like to proceed on this very last well? --Nathan Wiser --Nathan Wiser Environmental Scientist U.S. EPA, Office of Research and Development Office of Science Policy (303) 312-6953 fax wiser.nathan@epa.gov mailing address: U.S. EPA Region 8 (Mail Code 8ENF-UFO) 1595 Wynkoop Street Denver, Colorado 80202 "Srock, John" <John.Srock@nabors.com> Nathan Wiser/R8/USEPA/US@EPA Jeanne Briskin/DC/USEPA/US@EPA 02/13/2012 10:55 AM : 2-13-12-RE: Some additional well ID information needed from From: To: Cc: Date: Subject: Superior Nathan, Below is the information on MDS Energy. The EQT well is not a Utah well. If I was able to get more specific information on the well I could let you know the customer in Utah if you need it. I do not have the email address for the MDS individual overseeing this project. Could you please send this along to him or send me the contact email and I can send it along. MDS Energy - Edward Dunmire #2-331 - 08-13-09 MDS Energy - Gilbert Querio #1-43 - 08-29-10 - 2 22-026568 22-026802 -Regards John Srock HSE Director Health, Safety, and Environmental SUPERIOR WELL SERVICES INC. A Nabors Industries Company W: 724.403.9066 | C: 724.541.7822 | F: 866.691.8298 | www.swsi.com | www.nabors.com |

----Original Message-----From: Nathan Wiser [mailto:Wiser.Nathan@epamail.epa.gov] Sent: Monday, February 13, 2012 11:38 AM To: Srock, John Cc: Jeanne Briskin Subject: Fw: Some additional well ID information needed from Superior To John Srock, Superior Well Services Hi John. Has there been any news to report about better identifying these three well IDs from Superior? We'd like to be able to get back to the operators so they can compile well data to send to EPA. --Nathan Wiser --Nathan Wiser Environmental Scientist U.S. EPA, Office of Research and Development Office of Science Policy (303) 312-6953 fax wiser.nathan@epa.gov mailing address: U.S. EPA Region 8 (Mail Code 8ENF-UFO) 1595 Wynkoop Street Denver, Colorado 80202 ----- Forwarded by Nathan Wiser/R8/USEPA/US on 02/13/2012 09:26 AM -----From: Nathan Wiser/R8/USEPA/US "Srock, John" <John.Srock@nabors.com> 01/27/2012 10:26 AM RE: Some additional well ID information needed from то: Date: Subject: Superior Hi John, Here is the well data that we're trying to correct: 1. MDS Energy
Well ID supplied by Superior: 22-026568
Date: 8/13/2009 Armstrong County, PA 2. MDS Energy Well ID supplied by Superior: 22-026802 Date: 8/29/2010 Armstrong County, PA 3. EQT Production Well ID supplied by Superior: Neilson 3-22 Date: 12/7/2009 Unitah County, UT For the MDS wells, they cannot recognize the well ID (I assume this is actually Superior's job ticket number). For the EQT Production well, they told us they've never had Utah operations and thus claim that cannot be their well. Jeanne and I still plan to contact you today. Thanks for your help on this. --Nathan Wiser Environmental Scientist U.S. EPA, Office of Research and Development Office of Science Policy (303) 312-6211 office (303) 312-6953 fax wiser.nathan@epa.gov mailing address: U.S. EPA Region 8 (Mail Code 8ENF-UFO) 1595 Wynkoop Street Denver, Colorado 80202 "Srock, John" <John.Srock@nabors.com> Nathan Wiser/R8/USEPA/US@EPA Jeanne Briskin/DC/USEPA/US@EPA From: To: Cc: Date: 01/26/2012 05:34 PM RE: Some additional well ID information needed from Subject: Superior Nathan, Nathan, I am just returning from vacation. I will be back in the office Friday. I was able to receive emails but not send them for the last week due to size limitations. I will be available for a call at 1:30 EST for about 1/2 hour. I am OK with you sending me the well data like before. This way I can get our appropriate sales member to pull the hard copy information if we have it. The call may be more beneficial after I have the data. Either way I am good. Have a great evening.

- John

-Regards

John Srock HSE Director Health, Safety, and Environmental SUPERIOR WELL SERVICES INC. A Nabors Industries Company W: 724.403.9066 | C: 724.541.7822 | F: 866.691.8298 | From: Nathan Wiser [Wiser.Nathan@epamail.epa.gov] Sent: Thursday, January 26, 2012 6:19 PM To: Srock, John Cc: Jeanne Briskin Subject: Fw: Some additional well ID information needed from Superior Hi John. Jeanne Briskin and I plan to call you tomorrow (Friday, Jan 27) at 1:30 $\rm pm$ Eastern time to see if we can follow up on this matter. Will that work for you? --Nathan Wiser Environmental Scientist U.S. EPA, Office of Research and Development Office of Science Policy (303) 312-6953 fax wiser.nathan@epa.gov mailing address: U.S. EPA Region 8 (Mail Code 8ENF-UFO) 1595 Wynkoop Street Denver, Colorado 80202 ----- Forwarded by Nathan Wiser/R8/USEPA/US on 01/26/2012 04:17 PM -----From: Nathan Wiser/R8/USEPA/US
To: "Srock, John" <John.Srock@nabors.com>
Date: 01/25/2012 01:02 PM
Subject: Fw: Some additional well ID information needed from
Comparison Subject: Superior Hi John, I have not heard from you about this matter. I have confirmed that there are mis-identification issues at three wells (two operators) where the originating data came from Superior's answer to EPA's Sep 2010 letter, yet these two operators cannot ID their well(s) as we that original identification on to them. This would, I assume, be a fairly simple matter to Superior which could be handled in much the same way we addressed the three Sand Ridge well IDs before. Please let me know if I should set up a call with you or others at Superior, or if (with your permission) emailing you the well IDs as originally supplied by Superior along with the operator might be sufficient. Thank you. --Nathan Wiser --Nathan Wiser Environmental Scientist U.S. EPA, Office of Research and Development Office of Science Policy (303) 312-6953 fax wiser.nathan@epa.gov mailing address: U.S. EPA Region 8 (Mail Code 8ENF-UFO) 1595 Wynkoop Street Denver, Colorado 80202 ----- Forwarded by Nathan Wiser/R8/USEPA/US on 01/25/2012 12:56 PM -----Nathan Wiser/R8/USEPA/US "Srock, John" <John.Srock@nabors.com> 01/18/2012 03:14 PM From: To: Date: Some additional well ID information needed from Superior Subject: Hi John, I need to identify to Superior some information about well IDs that pose a problem much like the Sand Ridge examples we dealt with earlier. I want to honor confidentiality of information, so I do not wish to place that information in this email. Might I be able to contact you and provide it over the phone in the near future? Or, with your permission, I could send you the operator name and well ID as provided to EPA by Superior. This applies only to 2 or 3 wells. Thanks. --Nathan Wiser Environmental Scientist U.S. EPA, Office of Research and Development Office of Science Policy (303) 312-6953 fax wiser.nathan@epa.gov

mailing address:

transactions.

Mary:

Thank you for the prompt response. I think Don can just get in contact with me to help organize the session. My contact information is included.

Happy holidays to everyone.

Stephanie

Stephanie R. Meadows Senior Policy Advisor Upstream American Petroleum Institute 1220 L Street, NW Washington, DC 20005 Phone: 202-682-8578 Fax: 202-682-8426 Email: meadows@api.org

From: Hanley.Mary@epamail.epa.gov [mailto:Hanley.Mary@epamail.epa.gov]
Sent: Thursday, December 13, 2012 11:01 AM
To: Amy Farrell; Stephanie Meadows
Cc: Briskin.Jeanne@epamail.epa.gov; Maddox.Donald@epamail.epa.gov;
Matthews.Lisa@epamail.epa.gov
Subject: Fw: Meeting

Amy, Stephanie,

We look forward to having this meeting. Don Maddox will work to set this up in early January. Would you kindly reply with the name of the person Don can work with in your organization to get this on the calendar?

Wishing you a very Happy Holiday!

Mary

Mary Hanley Special Assistant Office of the Administrator US EPA (Mail Code 1101A) 1200 Pennsylvania Ave, NW Washington DC, 20460 Ph: 202-564-0316 FAX: 202-501-1428

----- Forwarded by Mary Hanley/DC/USEPA/US on 12/13/2012 10:34 AM -----

From: Mary Hanley/DC/USEPA/US To: "Amy Farrell" <<u>afarrell@anga.us</u>>, Lisa Matthews/DC/USEPA/US@EPA Cc: Jeanne Briskin/DC/USEPA/US@EPA, "Stephanie Meadows" <<u>Meadows@api.org</u>> Date: 12/11/2012 03:08 PM Subject: Re: Meeting

Amy, Thank you for this opportunity. We look forward to getting back to you with some possible dates. Mary

From: Amy Farrell [afarrell@anga.us]
Sent: 12/11/2012 03:00 PM EST
To: Mary Hanley; Lisa Matthews
Cc: Jeanne Briskin; "'Stephanie Meadows' (Meadows@api.org)" <<u>Meadows@api.org</u>>
Subject: Meeting

Hi Mary and Lisa -

Thanks for sending around the information on the workshop. We'll get the word out so we can send a good set of technical experts your way.

I'm actually writing because we are close to having some final deliverables from Battelle and we'd like to come in to brief you all. I've briefly described the effort to Jeanne and mentioned it to Bob when we last spoke. I think it would be beneficial for us to meet and for you all to have a chance to review the materials in advance of your retrospective data release. Given holiday travel I think the best thing would be to start looking for days in the new year – basically the week of the 31st or soon after.

Please email to let us know a few options that might work on your end and Stephanie and I will work to get Battelle and some of our members lined up.

Thanks! Amy

Amy L. Farrell VP of Regulatory Affairs America's Natural Gas Alliance 202-789-2642 (office) 202-715-1742 (direct) 202-997-7012 (mobile) afarrell@anga.us



Re: Insurance information John Satterfield to: Ramona Trovato 07/18/2012 09:55 AM Hide Details From: John Satterfield <john.satterfield@chk.com>

To: Ramona Trovato/DC/USEPA/US@EPA

History: This message has been forwarded.

Paul is looking to schedule a meeting week of 30 JUL with Bob to discuss our ATGAS report and our report on the retrospective split sampling in Bradford county, pa.

If we get this scheduled, let me know what level of convo you'd like to have. I can cover the technical issues to a certain point, but if you really want to talk about the hydrogeology and statistical correlation of differing parameters, will need to bring a couple of other folks.

Alternately, can have higher level discussions including bob and Paul after we have a technical convo....

Let me know....

John A Satterfield Director Environmental & Regulatory Affairs Chesapeake Energy Corporation

Sent from my iPad

On Jul 17, 2012, at 8:09 AM, "Ramona Trovato" <<u>Trovato.Ramona@epamail.epa.gov</u>> wrote:

Thanks John. I'll move this along.

From: John Satterfield [john.satterfield@chk.com] Sent: 07/17/2012 12:56 PM GMT **To:** Ramona Trovato **Subject:** FW: Insurance information

Ramona – below is our Risk Management Department's review of E&E's insurance information. Hopefully will be easy adjustment on E&E's part.

Please let me know if you have questions or concerns.

From: Chris Hill (Regulatory)
Sent: Monday, July 16, 2012 10:58 PM
To: 'Michael Overbay'
Cc: 'David Jewett'; 'Doug Beak'; 'Susan Mravik'; John Satterfield
Subject: RE: Insurance information

Mike,

Please see CHK's comments regarding EPA's proposed agreement attached. The embedded revisions address all concerns regarding the subcontractor issue. Once EPA has accepted all changes to the agreement, signed the document and provided CHK a new E&E certificate of insurance aligned with the agreement, CHK will consider the contractor liability issues adequately addressed to proceed with field activities. I would be more than happy to setup a conference call in the near future, if there are any issues with the revised agreement that we need to work through.

I have attached a copy of the CHK/Landowner access agreement for your information.

Please let me know if you have any questions or comments, or if there is anything else we can do to help. We look forward to proceeding with the Mississippi Lime prospective study.

Thank you, *Chris Hill* Environmental Engineer Chesapeake Energy Corporation Office: (405) 935-2321 Mobile: (405) 388-3907 Fax: (405) 849-2321 E-mail: <u>Chris.Hill@chk.com</u>

From: John Satterfield
Sent: Thursday, July 12, 2012 3:37 PM
To: 'Michael Overbay'
Cc: Chris Hill (Regulatory); 'Jeanne Briskin'; 'Ramona Trovato'; 'Bob Sussman'; 'Stephen Hess'; 'Lek Kadeli'; 'Steve Pressman'; 'David Jewett'; 'Doug Beak'; 'Susan Mravik'
Subject: RE: Insurance information

Thanks! Will run to ground and get back with you as soon as I can.

From: Michael Overbay [mailto:Overbay.Michael@epamail.epa.gov]
Sent: Thursday, July 12, 2012 3:35 PM
To: John Satterfield
Cc: Chris Hill (Regulatory); Jeanne Briskin; Ramona Trovato; Bob Sussman; Stephen Hess; Lek

Kadeli; Steve Pressman; David Jewett; Doug Beak; Susan Mravik **Subject:** Insurance information

Hello John,

I am happy to finally be able to provide you information about the insurance requirements contained in the EPA contract with our prime contractor for this project, Ecology and Environment (E&E). Attached is a certificate of insurance showing E&E's existing policies, with coverage up to \$15 million. The policies will be carried forward under our existing contract with E&E. If the coverage is sufficient, Chesapeake will be added as an additional insured for the liability coverage.

Per Stephanie's E-mail message June 27th, it appears you will not need insurance information about the drilling subcontractor in order to move forward. I am hoping the above information will be adequate to allow Chesapeake to resolve their concerns about liabilities issues.

Once you have had a chance to share this information and discuss it internally, I would appreciate receiving an E-mail with your confirmation that the liability/indemnification issue is resolved. Also, we would like to receive a copy of the access agreement with the landowner to confirm that we have access to conduct our EPA activities through your agreement. As you know, we would like to make sure all the paperwork is agreed to so that we can move ahead with this project.

Please feel free for either you or Chris Hill to call me if you have any questions.

Best regards,

Mike

Michael Overbay, P.G. Regional Ground Water Center Coordinator U.S. Environmental Protection Agency - Region 6 (214)665-6482 (214)665-2191 (FAX)

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error, please notify the sender immediately by return email and destroy all copies of the email (and attachments if any).

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FW: Insurance information John Satterfield to: Ramona Trovato 07/17/2012 08:56 AM Hide Details From: John Satterfield <john.satterfield@chk.com>

To: Ramona Trovato/DC/USEPA/US@EPA

History: This message has been replied to and forwarded.

3 Attachments





Draft Access Agreement with Chesapeake v1 by MO CBH2.docx Scanned Document.pdf



Eand E insurance certificate.pdf

Ramona – below is our Risk Management Department's review of E&E's insurance information. Hopefully will be easy adjustment on E&E's part.

Please let me know if you have questions or concerns.

From: Chris Hill (Regulatory)
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Cc: 'David Jewett'; 'Doug Beak'; 'Susan Mravik'; John Satterfield
Subject: RE: Insurance information

Mike,

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I have attached a copy of the CHK/Landowner access agreement for your information.

Please let me know if you have any questions or comments, or if there is anything else we can do to help. We look forward to proceeding with the Mississippi Lime prospective study.

Thank you, *Chris Hill* Environmental Engineer Chesapeake Energy Corporation Office: (405) 935-2321 Mobile: (405) 388-3907 Fax: (405) 849-2321 E-mail: <u>Chris.Hill@chk.com</u>

From: John Satterfield
Sent: Thursday, July 12, 2012 3:37 PM
To: 'Michael Overbay'
Cc: Chris Hill (Regulatory); 'Jeanne Briskin'; 'Ramona Trovato'; 'Bob Sussman'; 'Stephen Hess'; 'Lek Kadeli'; 'Steve Pressman'; 'David Jewett'; 'Doug Beak'; 'Susan Mravik'
Subject: RE: Insurance information

Thanks! Will run to ground and get back with you as soon as I can.

From: Michael Overbay [mailto:Overbay.Michael@epamail.epa.gov]
Sent: Thursday, July 12, 2012 3:35 PM
To: John Satterfield
Cc: Chris Hill (Regulatory); Jeanne Briskin; Ramona Trovato; Bob Sussman; Stephen Hess; Lek Kadeli; Steve Pressman; David Jewett; Doug Beak; Susan Mravik
Subject: Insurance information

Hello John,

I am happy to finally be able to provide you information about the insurance requirements contained in the EPA contract with our prime contractor for this project, Ecology and Environment (E&E). Attached is a certificate of insurance showing E&E's existing policies, with coverage up to \$15 million. The policies will be carried forward under our existing contract with E&E. If the coverage is sufficient, Chesapeake will be added as an additional insured for the liability coverage.

Per Stephanie's E-mail message June 27th, it appears you will not need insurance information about the drilling subcontractor in order to move forward. I am hoping the above information will be adequate to allow Chesapeake to resolve their concerns about liabilities issues.

Once you have had a chance to share this information and discuss it internally, I would appreciate receiving an E-

mail with your confirmation that the liability/indemnification issue is resolved. Also, we would like to receive a copy of the access agreement with the landowner to confirm that we have access to conduct our EPA activities through your agreement. As you know, we would like to make sure all the paperwork is agreed to so that we can move ahead with this project.

Please feel free for either you or Chris Hill to call me if you have any questions.

Best regards,

Mike

Michael Overbay, P.G. Regional Ground Water Center Coordinator U.S. Environmental Protection Agency - Region 6 (214)665-6482 (214)665-2191 (FAX)

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all copies of the email (and attachments if any).

From:	walter.postula@shell.com
То:	Jeanne Briskin/DC/USEPA/US@EPA
Subject:	RE: Query on Potential Paper/Presentation for 2013 Ethylene Producers' Conference on EPA Hydraulic Fracturing
	Study
Date:	08/31/2012 12:04 PM

Thanks for the reply Jeanne. Sorry to hear the EPA will not be able to participate on this topic.

Kind regards, Walter

From: Jeanne Briskin [mailto:Briskin.Jeanne@epamail.epa.gov]
Sent: Friday, August 31, 2012 9:08 AM
To: Postula, Walter S GSUSI-PTD/TCB
Subject: RE: Query on Potential Paper/Presentation for 2013 Ethylene Producers' Conference on EPA Hydraulic Fracturing Study

Dear Walter,

Thank you for your kind invitation. I have checked with our folks and we will need to decline your offer to participate in the 2013 Ethylene Producer's Conference. Thank you for considering us as part of the agenda.

Best,

Jeanne

Jeanne Briskin Office of Science Policy Office of Research and Development U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, N.W. (8104R) Washington, D.C. 20460 (202) 564-4583 - office (202) 565-2911 - fax briskin.jeanne@epa.gov

Address for Deliveries: US EPA Ronald Reagan Building --Room 51144 Washington DC 20004

---08/30/2012 07:00:28 PM---Dear Jeanne, Just wanted to follow up on EPA interest in a paper/presentation as detailed in my note

From: <walter.postula@shell.com> To: Jeanne Briskin/DC/USEPA/US@EPA Date: 08/30/2012 07:00 PM Subject: RE: Query on Potential Paper/Presentation for 2013 Ethylene Producers' Conference on EPA Hydraulic Fracturing Study Just wanted to follow up on EPA interest in a paper/presentation as detailed in my note below. We are about two months away from the abstract submission deadline and I would like to firm up my list of authors/papers to know if I need to pursue other possibilities.

Kind regards, Walter

From: Postula, Walter S GSUSI-PTD/TCB
Sent: Thursday, August 09, 2012 1:44 PM
To: 'Briskin.jeanne@Epa.gov'
Subject: Query on Potential Paper/Presentation for 2013 Ethylene Producers' Conference on EPA Hydraulic Fracturing Study

Dear Jeanne,

I am a member of the Ethylene Producers' Environmental Sub-Committee. Each year the Ethylene Producers' Conference takes place in conjunction with the Spring Meeting of the American Institute of Chemical Engineers. At this conference, 12-13 sessions are organized by various sub-committees to present material of general (non-confidential) interest to US Ethylene Producers. The 2013 conference is being held in San Antonio at the end of April, 2013.

I found your name via a "podcast" on hydraulic fracturing and am writing to begin the discussion on someone from the EPA making a presentation (writing paper too) at our conference on the current knowledge on environmental impact of hydraulic fracturing. This is especially topical because of the recent announcements for ethylene plant expansions and new construction, based on availability of shale gas from hydraulic fracturing.

Please let me know if this is possible.

Kind regards, Walter

Walter S. Postula

Shell Projects and Technology - Global Solutions Downstream Lower Olefins and Aromatics (GSUSI-PTD/TCB) Westhollow Technology Center, D-3 Q10 3333 Highway 6 South, Houston, TX 77082 Tel: +01 281 544-8313 Email: walter.postula@shell.com, 9/80 Schedule B www.shell.com/globalsolutions

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From:	<u>Jeanne Briskin</u>
To:	John Satterfield
Cc:	Dayna Gibbons
Subject:	RE: draft Alfalfa County desk statement.docx
Date:	08/15/2012 07:45 AM

thanks for the update.

Jeanne Briskin Office of Science Policy Office of Research and Development U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, N.W. (8104R) Washington, D.C. 20460 (202) 564-4583 - office (202) 565-2911 - fax briskin.jeanne@epa.gov

Address for Deliveries: US EPA Ronald Reagan Building --Room 51144 Washington DC 20004

▼ John Satterfield ---08/15/2012 07:40:39 AM---It's in Paul's hands. He may want to discuss with Bob. Sorry can't be more help. From: Jeanne Bris

From: John Satterfield <john.satterfield@chk.com> To: Jeanne Briskin/DC/USEPA/US@EPA Cc: Dayna Gibbons/DC/USEPA/US@EPA Date: 08/15/2012 07:40 AM Subject: RE: draft Alfalfa County desk statement.docx

It's in Paul's hands. He may want to discuss with Bob. Sorry can't be more help.

From: Jeanne Briskin [mailto:Briskin.Jeanne@epamail.epa.gov]
Sent: Tuesday, August 14, 2012 3:41 PM
To: John Satterfield
Cc: Dayna Gibbons
Subject: Re: draft Alfalfa County desk statement.docx

Hi John,

Any word on whether the proposed desk statement is still ok or suggested edits? I understand that Paul Hagemeier may have a call in to Bob Sussman, so we would appreciate being able to let Bob S know the latest, soon.

thanks!

Jeanne Jeanne Briskin Office of Science Policy Office of Research and Development U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, N.W. (8104R) Washington, D.C. 20460 (202) 564-4583 - office (202) 565-2911 - fax briskin.jeanne@epa.gov

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yv+LAH8AAAAAAAAAASW5hY3RpdmUgaGlkZSBkZXRhaWxzIGZvciBKZWFubmUgQnJpc2tpbi0tLTA4 LzEwLzIwMTIgMDQ6MDc6NDUgUE0tLS1IaSBKb2huLCBJIHRoaW5rIHdIIGFyZSBvbiB0aGUgdmVy Z2Ugb2YgcmVzb2x2aW5nIGFsbCB0aGUgbw== Jeanne Briskin---08/10/2012 04:07:45 PM---Hi John, I think we are on the verge of resolving all the outstanding questions regarding our collab

From: Jeanne Briskin/DC/USEPA/US To: John Satterfield <<u>john.satterfield@chk.com</u>> Cc: Dayna Gibbons/DC/USEPA/US@EPA Date: 08/10/2012 04 07 PM Subject: draft Alfalfa County desk statement.docx

Hi John,

I think we are on the verge of resolving all the outstanding questions regarding our collaboration on our prospective case study in Oklahoma. Several months ago, Stephanie Timmermeyer and I worked out the attached text so that we could update our website and explain why we are changing locations. The attachment contains the language we agreed to at that time. Would you please review the proposed text to make sure that it still works for Chesapeake and let me know whether it is ok as is?

Thanks,

Jeanne

Jeanne Briskin Office of Science Policy Office of Research and Development U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, N.W. (8104R) Washington, D.C. 20460 (202) 564-4583 - office (202) 565-2911 - fax briskin.jeanne@epa.gov

Address for Deliveries: US EPA Ronald Reagan Building --Room 51144 Washington DC 20004 (See attached file: draft Alfalfa County desk statement.docx)

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Due to scheduling conflicts, the prospective case study of the hydraulic fracturing site near Mansfield in DeSoto Parish, Louisiana, will be replaced by an alternative site. Sampling to establish baseline conditions for the study could not be completed before drilling was to begin on the site. While it was not a factor in the decision to cancel this case study, the site was also not ideal for collection of certain baseline samples, due in part to the anticipated slow rate of groundwater flow. We have been working closely with Chesapeake Energy (our industry partner on this project) to identify a replacement site that meets the criteria for EPA's hydraulic fracturing study. A new site has been selected in Alfalfa County, Oklahoma.

Draft Questions and Answers

1. Why was the newly selected prospective case study site not in the Haynesville Shale area?

EPA was not able to replace this site with another one in the Haynesville Shale area because there were no available sites that satisfy our criteria while fitting into the schedules of both EPA and Chesapeake Energy. Therefore, we have worked with Chesapeake to evaluate potential replacement sites they have provided in areas where drilling activities remain high.

2. Why was the Alfalfa County site selected?

The site in Alfalfa County meets the technical considerations for a site which EPA had outlined as relevant to a prospective case study. This includes factors such as being in an area without significant pre-existing development, and having relatively shallow depths to good quality groundwater. Additionally, the site schedule for development is compatible with the EPA schedule for investigation.

2. Will this delay results for the final Hydraulic Fracturing Report?

EPA intends to establish a schedule, in agreement with our industry partner, that would make results available in 2014.



Invitation: Fw: EPA Prospective Study Conf Call

 Thu 11/01/2012 10:00 AM - 11:00 AM

 Attendance is required for Ramona Trovato

 Chair:
 chris.hill@chk.com

 Sent By:
 John Satterfield <john.satterfield@chk.com>

 Location:
 877-935-0245 (745420)

chris.hill@chk.com chris.hill has invited Ramona Trovato to a meeting.		
Required:	trovato.ramona@epa.gov	
Time zones:	This entry was created in a different time zone. The time in that time zone is: Thu 11/01/2012 9:00 AM CDT - 10:00 AM CDT	

Description

Fyi from chris.....

I have schedule this meeting to ensure we continue forward progress regarding the EPA/CHK Prospective Study. The proposed topics of discussion are identified in the agenda below.

Agenda

- Site Selection
- QAPP Development
- Access Agreement

Please let me know if you have any questions prior to the conference call. I look forward to our discussion.

Thank you, Chris Hill Environmental Engineer Chesapeake Energy Corporation Office: (405) 935-2321 Mobile: (405) 388-3907 Fax: (405) 849-2321 E-mail: Chris.Hill@chk.com<mailto:Chris.Hill@chk.com>

Thanks, John Satterfield Director, Environmental and Regulatory Affairs Chesapeake Energy Corporation

Sent from my BlackBerry

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EPA HF Study - Prospective Study

Tue 03/27/2012 4:00 PM - 4:30 PM Attendance is required for Ramona Trovato Chair: chris.hill@chk.com Location: Conference Call (877-935-0245 + 745420)

Required:	Michael Overbay/R6/USEPA/US, stephanie.timmermeyer@chk.com, john.satterfield@chk.com, Jeanne Briskin/DC/USEPA/US, beak.doug@epa.gov, David Jewett/ADA/USEPA/US, trovato.ramona@epa.gov	
Time zones:	This entry was created in a different time zone. The time in that time zone is: Tue 03/27/2012 3:00 PM CDT - 3:30 PM CDT	

Description

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Personal Notes

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Quality Assurance Project Plan for the Haynesville Shale Prospective Case Study United States Environmental Protection Agency Hydraulic Fracturing Study

December 2011



Prepared for: United States Environmental Protection Agency Office of Research and Development National Risk Management Research Laboratory Robert S. Kerr Environmental Research Center Ada, Oklahoma

Prepared by:

ECOLOGY AND ENVIRONMENT, INC. 368 Pleasant View Drive Lancaster, New York 14086 able of Contents

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1

Project Management

1.1 Project/Task Organization

The organizational structure for the Hydraulic Fracturing Prospective Case Study located in the Haynesville Shale, in Desoto Parish Louisiana is shown in Figure 1. The responsibilities of the principal personnel associated with this case study are listed below.

Dr. Robert Puls, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Robert S. Kerr Environmental Research Center (RSKERC), Ada, OK. Dr. Puls is the overall technical lead on the Hydraulic Fracturing Study. He is the principal investigator of this project and is responsible for preparing and maintaining the Quality Assurance Project Plan (QAPP) and ensuring completion of all aspects of this QAPP, including overall responsibility for QA. He will lead the collection, analysis, and interpretation of groundwater and surface water samples.

Mr. Steve Vandegrift, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, RSKERC, Ada, OK. Mr. Vandegrift is responsible for quality assurance review/approval of the QAPP, conducting audits, and QA review/approval of the final report. His HAZWOPER certification is current.

Dr. Randall Ross, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, RSKERC, Ada, OK. Dr. Ross will assist in the analysis of hydrologic conditions at the Haynesville site and will assist in the development of the site hydrologic conditions. His HAZWOPER certification is current.

Mr. Steve Acree, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, RSKERC, Ada, OK. Mr. Acree will assist in the analysis of hydrologic conditions at the Haynesville site and will assist in the development of the site hydrologic conditions. His HAZWOPER certification is current.

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1. Project Management

Mr. Russell Neill, Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, RSKERC, Ada, OK. Mr. Neill is responsible for assisting in ground water sampling. His HAZWOPER certification is current.

Dr. Sujith Kumar, Shaw Environmental, Ada, OK. Dr. Kumar is responsible for overseeing the analytical work performed under Ground Water and Ecosystems Restoration Division's (GWERD) on site analytical contract (VOC's, dissolved gases, and metals).

Ms. Shauna Bennett, Shaw Environmental, Ada, OK. Dr. Ms. Bennett is the QC Coordinator for Shaw Environmental and will coordinate QC for Shaw Environmental portion of this study.

Ms. Cynthia Caporale, USEPA Region 3 Analytical Laboratory, Laboratory Branch Chief/Technical Director. Ms. Caporale will act as a liaison between the Region 3 Lab and RSKERC.

Mr. Christopher Hill, Chesapeake Energy, Oklahoma City, OK. Mr. Hill will be the single point of contact for Chesapeake Energy throughout the Haynesville prospective study.

Dr. Puls is responsible for initiating contact with appropriate project participants as he deems necessary. Other project participants will keep Dr. Puls informed whenever significant developments or changes occur. Lines of communication among project participants may be conducted via in person conversations, electronic mail, phone conversations, conference calls, and periodic meetings.

1.2 Problem Definition/Background

The prospective case study in the Haynesville Shale (see Figure 2) will investigate the construction of a new production well, hydraulic fracturing of said well, management and disposal of wastewater and production of gas from said well for about 1 year following hydraulic fracturing to determine if there is a negative impact to drinking water. The investigation will initially involve sampling ground water, surface water and soil and sediment sampling in the vicinity of the well pad to determine baseline characteristics. This study will be conducted in conjunction with the Louisiana Department of Environmental Quality (LDEQ), Chesapeake Energy, U.S. Environmental Protection Agency, Region 6 (EPA R6); and U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory (NRMRL), Ground Water and Ecosystems Restoration Division (GWERD). GWERD will be the lead organization for this case study. In addition, the EPA will undertake a review of all other potential sources of contamination in the area, and identify those sources before the project proceeds. Potential sources that will be identified include USTs, historical oil and

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Comment [CV2]: All potential sources of contamination should be identified before the project during Tier 1 activities as identified the the Final Study Plan (11/3/2011). A EDR/Phase I data review should be used to identify any potential sources such as USTs, landfills, spills along the railroad easement, salt storage yards, septic tanks, sewer lines, stormwater lines, etc within a 3-mile radius of the site.

Comment [nc3]: I thought it was decided to not to do the sediment sampling
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gas wells/pits/pipelines/storage area,- landfills, releases, salt storage yards, septic tanks, sewer lines, stormwater lines, eettc. within a 2 mile radius of the site.

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1. Project Management

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1

Organizational Chart for the Hydraulic Fracturing Prospective Case Study, Desoto Parish, LA

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1. Project Management

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1. Project Management

Insert Figure (color) page 1 of 2

2 EPA HF Prospective Case Study Location Map

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The proposed pad location is in De <u>S</u>oto Parish in north western LA and has an estimated population of 26,656 individuals (2010). The area surrounding the proposed site is currently experiencing extensive natural gas exploration using horizontal drilling technology and hydraulic fracturing is being employed to stimulate production in these wells. In addition, this area was part of-historical oil and gas field developed in the 1950's and 1960's. Prior to proceeding any sampling and monitor well installation as part of Tier 1 & 2 activities (described in the final Study Plan 11/3/2011), all historical oil/gas infrastructure will be identified, such as tank batteries, pipelines, existing and plugged/abandoned oil/gas wells, and pits. Following identification, the final location of monitoring wells and sample sites will be selected.

The objectives of this case study are listed below.

- Primary Objective: Evaluate ground water, surface water and soil characteristics before, during and after key phases of a shale gas well development; well drilling, well completion, and production to identify if there is a significant change in media characteristics.
- Secondary Objective 1: Determine the appropriate baseline characteristics of ground water, surface water, and soil.
- Secondary Objective 2: Determine characteristics of ground water, surface water, and soil throughout the key phases of the gas well development; post-pad construction to approximately one year after initial gas production.
- Secondary Objective 3: Determine the chemistry, volumes and rates of produced water, specifically flowback, over a period of months from the production well following hydraulic fracturing.
- Secondary Objective 4: Compare data gathered for secondary objectives 1 and 2 to determine if significant changes were observed in the media baseline characterisitics, and if this change could be attributed to the gas well development.
- Secondary Objective 5: Review wastewaters site management and disposal practices during drilling and hydraulic fracturing, and qualitatively identify risks to drinking water sources.

1.3 Project/Task Description

In order to accomplish the primary objective of the study, the established monitoring well network, along with any pertinent domestic wells and municipal supply wells will be sampled for the components found in Table 1. In addition, select

Comment [CV4]: Should also note history of the area, as has experienced extensive oil and gas development in the 1950s-60s.

Comment [CV5]: Case study objectives should be the same as objectives listed in the Final Study Plan.

Comment [c6]: The SAB specifically requested that the study be limited to hydraulic fracturing. It appears the EPA has expanded the scope of the study to include all development activities. CHK recommends that the EPA focus on hydraulic fracturing.

Comment [c7]: The definition of a significant change needs to be defined. It is equally important to determine the cause of all changes; natural or anthropogenic.

Comment [CV8]: Given the current schedule, there does not appear to be enough time to capture seasonal variations in sample characteristics, , however, this is critical to determining if a change is significant.

Comment [CV9]: It remains CHK's position that the QAPP be as complete as possible prior to study commencement. As such, Secondary Objectives 3-5 should be included if they are in fact objectives of this study.

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hydraulic fracturing fluid components (such as potassium (K), barium (Ba), alcohols, naphthalene, and boron), potentially mobilized naturally occurring substances (such as arsenic (As), selenium (Se), strontium (Sr), and other trace metals) will also be tested along with changes in background water quality (pH, major anions and cations). In addition, during future samplings soil and stream samples will be taken and the critical analytes for these sample types are the same as listed previously.

In order to address secondary objective 1, groundwater sampling, surface water sampling and soil sampling will be necessary. The target parameters listed in the primary objective will be needed to address this objective. <u>At least 3 rounds of</u> <u>baseline sampling should be conducted on monitoring wells, streams, and area</u> water wells following completion of the pad.

Secondary objective 2 will entail re-sampling of groundwater, surface water, and soils for the same suite of parameters to see if there was any adverse impact.

The data collected from this case study will be incorporated into the larger Hydraulic Fracturing report to Congress. It is also anticipated that this data will be utilized in EPA reports, conference proceedings and journal articles. <u>Work group</u> <u>members, including Chesapeake, will have an opportunity to review and comment</u> on any and all products, including draft reports, related to this prospective study <u>prior to their public release.</u> In addition, the data collected in this case study may be used by policy and decision makers in EPA and state regulatory agencies.

Table 1 Critical Analytes

Analyte	Analysis Method	Laboratory Performing the Analysis
Gasoline Range Organics	ORGM-506 r1.0,	EPA Region VIII Laboratory
(GRO)	EPA Method 8015D	
Diesel Range Organics (DRO)	ORGM-508 r1.0,	EPA Region VIII Laboratory
	EPA Method 8015D	
Volatile Organic Compounds	RSKSOP-299v1	Shaw Environmental
(VOC)*		
Semivolatile Organic Com-	ORGM-515 r1.1,	EPA Region VIII Laboratory
pounds (SVOC)	EPA Method 8270D	
Metals (As, Se, Sr, Ba, B)	RSKSOP-213v4 &-257v2 or	Shaw Environmental
	-332v0	
Major Cations (Ca, Mg, Na, K)	RSKSOP-213v4	Shaw Environmental

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Comment [nc11]: These elements are not necessarily mobilized but rather are naturally present in the formation waters.

Comment [c12]: As experience has shown, multiple samplings of surface water and groundwater is needed to define the variability of parameter consituents, which will vary depending on climatic conditions, sampling methodology, sample collection depth, and laboratory variability in sample results. Suggest at least 3 baseline samplings be conducted at a minimum to define the water-quality variability.

Comment [n13]: Will probably only be able to do 2 rounds of baseline given slips in schedule

Comment [WU14]: I would agree to 2 based on budget. If CHK wants 3, they can pay for it

Comment [c15]: All analytes and methods should be consistent for baseline and non-baseline sampling.

Comment [WU16]: I agree

Comment [n17]: Given time constraints we can commit to one and maybe 2 post well construction

Comment [c18]: The number of sampling events between key phases of the gas well development should be indentified.

Comment [WU19]: E&E please add Ra and U to tables, text

Comment [n20]: Can discuss this on down the road, lets get the baseline stuff covered under the QAPP so we can do private well sampling before years end

Comment [WU21]: We will consider this

Comment [c22]: Chesapeake would appreciate the opportunity to be included in the production and review of these reports. We request that we discuss our role up front.

Comment [n23]: This is assumed but if you (CHK) wish to propose some language here do so

Comment [WU24]: CHK would be involved in the review of any report or publication coming from this case study. With respect to the reports to Congress, I will raise it up the line but cannot commit to it now

Comment [n25]: Rads will be added on later update of QAPP

Comment [c26]: Radon and radium are mentioned in the discussion but no methods are identified for use.

Comment [WU27]: Need to add

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1. Project Management

Major Anions (Cl, carbonate,	RSKSOP-276v3 (NO ₃ ⁻ +NO ₂ ⁻	RSKERC general parameters	
bicarbonate, Br, NO ₃ +NO ₂ ,	by RSKSOP-214v5)	lab	
SO ₄ ²⁻)			

*Ethanol, isopropyl alcohol, tert-butyl alcohol, naphthalene.

Only those SVOC compounds in Table 10 that have DL, RL, and Control Limits listed may be used as critical analytes; all others will be used only as screening data.

Both VOC and SVOC have many target analytes and initially all are considered critical (with exception for SVOC noted above). A tiered approach will be used to further refine the identification of specific compounds as critical. Data from the first sampling events will be evaluated by the PI to determine if there are specific compounds that are identified in these samples which would warrant their specific identification as critical to narrow the list. These will be identified in a subsequent QAPP revision. GRO analysis provides data for not only TPH as gasoline, but several other compounds. Only TPH as gasoline will be considered critical from this analysis.

1.4 Project Quality Objectives and Criteria

As part of this case study, detailed site history has been collected and is continuing to be collected. This data has been collected from Chesapeake and other sources of public information. The site history will be used to determine the background conditions at the site as well as the potential for other activities in the area to be a potential source of the impact to the local aquifer. Natural sources of contaminants or other human activities need to be considered in all interpretations of the data.

The installed monitoring well soil sampling and surface water sampling should yield a representative data set that will be analyzed to determine if significant changes were observed in the media baseline characteristics, and if these changes could be attributed to the gas well development. Data from private wells will also be considered but are not considered to be part of the monitoring network. To date EPA has received limited information on the hydrologic conditions near the proposed well pad. During the initial and subsequent sampling events water level measurements will be taken in order to address the hydrologic setting, flow direction and velocity.

Other project quality objectives, such as precision, accuracy, sensitivity, and etc. will be discussed primarily in sections 2, 3, and 4.

1.5 Special Training/Certification

A current HAZWOPER certification is required for on-site work. HAZWOPER training and yearly refresher training is provided to GWERD personnel at an appropriate training facility chosen by GWERD SHEMP (Safety, Health, and Environmental Management Program) manager. The HAZWOPER certificate and wallet card is provided to each person completing the training. All EPA contractor personnel will also be required to have HAZWOPER training and up-to-date training certificates. In addition to HAZWOPER training, Chesapeake is requiring that all field personnel undergo hydrogen sulfide training. This training will be provided by Chesapeake. All work performed must comply with professional licensing requirement for the State of Louisiana, and those include laboratory.

Comment [CV28]: Add carbonate and bicarbonate and bromide.

Comment [c29]: The study should be designed to ensure a representative data set is collected. Will EPA be collecting enough samples to statistically say that the samples are representative and changes are significant?

Comment [c30]: Geophysical techniques will also be used, correct?

Comment [c31]: Consider using water-quality trolls such as Specific Conductivity and water level recording trolls to use in-situ in select wells in an area to provide pre-drill baseline data—tontinuous water-level and water quality data—this is a cheap way of collecting data. Same on streams in area. Need good baseline data that defines variability in sampling, which can be significant, especially for some metals such as iron and manganese.

Comment [WU32]: If CHK wants to buy and deploy they can-you guys are part of the team hereplease write things in as you see fit

Comment [CV33]: Should add to this section that the geological field work may require supervision by a Louisiana licensed Professional Geologist (depending on when the work is performed). In addition, the monitoring wells and geoprobe borings must be installed and constructed by a licensed driller in Louisiana.

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drilling, engineering, and professional geological certifications/registrations. All geologists surpervising supervising the monitoring well installation should be registered in the State of Louisiana.

The laboratories performing critical analyses in support of this case study must demonstrate their competency in the fields of analyses to be conducted, prior to performing such analyses. Competency may be demonstrated through documentation of certification/accreditation or some other means as determined to be acceptable by project participants. The EPA GP laboratory and the Shaw laboratories, the on-site contractor laboratory at RSKERC, will be used to analyze select critical analytes listed in Table 1. These laboratories have demonstrated competency through the implementation of ORD PPM 13.4, *Minimum QA/QC Practices for ORD Laboratories Conducting Research* which includes external independent assessments. These laboratories are also routinely subjected to internal laboratory assessments and performance evaluation (PE) samples.

The USEPA Region VIII Laboratory will be used to analyze those critical analytes listed in Table 1. This laboratory has been subjected to the National Environmental Laboratory Accreditation Program (NELAP) accreditation process through the state of Texas and is expected to soon be granted approval.

The Region III Laboratory will be used to analyze glycols, which is not identified as critical at this time. However, it is accredited under the NELAP through the state of New Jersey as the Accrediting Body. The particular method being used by Region III for these analyses are not accredited, but the laboratory follows all the requirements for an accredited method. However, initial data reported from the glycol analysis will be flagged as "screening" data from a method that is currently being developed. Once the data is validated, it will no longer be flagged as screening" data.

1.6 Documents and Records

Data reports will be provided electronically as Excel spreadsheets. Shaw's raw data is kept on-site at the GWERD and will be provided on CD/DVD to Dr. Puls. Raw data for sub-contracted laboratories shall be included with the data reports. Calibration and QC data and results shall be included. Field notebooks will be kept as well as customized data entry forms if needed. Data will be uploaded to a FTP website that Chesapeake has access within two weeks of receipt of data by the EPA.

Records and documents expected to be produced include: field data, chain-ofcustody (COC), QA audit reports for field and laboratory activities, data reports, raw data, calibration data, QC data, interim reports, and a final report. **Comment [c34]:** Has this lab been approval for their NELAP accreditation.

Comment [c35]: EPA Region III Laboratory needs to provide a detailed comparison of the result of their method and a more accepted method to provide documentation that the analytical method is adequate. CHK requests a copy of all nonpromuleated EPA method.

Comment [WU36]: OK

Comment [c37]: CHK doesn't believe data from testing prior to method validation should be used for the study

Comment [CV38]: CHK is operating under the assumption that EPA will make all data associate with the Haynesville site available on an FTP website in a timely manner.

Comment [c39]: Geophysical, well mechanical integrity data needs to be included in this section.

Comment [c40]: Secondary Data Gathering and Evaluations needs to be included in this QAPPs.

Comment [nc41]: Need to add acknowledgement that this is a trademark. Section No.: 1 Revision No.: 00 Date: <u>May October 21, 2013August 6, 2013January 6, 2012January 6, 2012January 6, 2012December 20, 2011</u>

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All field and laboratory documentation shall provide enough detail to allow for reconstruction of events. Documentation practices shall adhere to ORD PPM 13.2, "Paper Laboratory Records."

Since this is a QA Category 1 project, all project records require permanent retention per Agency Records Schedule 501, *Applied and Directed Scientific Research* They shall be stored in Dr. Puls's office in the GWERD until they are transferred to GWERD's Records Storage Room. At an as yet to be determined time in the future the records will be transferred to a National Archive facility.

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2. Data Generation and Acquisition

Quarterly Sampling (Assuming Hydraulic Fracturing Occurs in September 2012)

- December 2012 MW Sampling
- March 2013 MW and Domestic Well Sampling
- June 2013 MW Sampling
- September 2013 MW and Domestic Well Sampling

2.1.1 Background Geologic and Hydrological Information

Geology

Surface exposures consist of Pleistocene and Holocene sediment. Sandy, gravelly and muddy alluvium from rivers and coastal marsh deposits make up the Holocene while terraces of glacial sand, gravel and mud deposits from the North make up the Pleistocene. Underlying the Pleistocene units are the units of the Eocene and Paleocene. Two formations from these periods that are of note are Claiborne group and the underlying Wilcox group. These groups are composed primarily of sandstones and are an important aquifer in Louisiana and Texas. This aquifer will be discussed in greater detail below. Underlying the Wilcox formation is the Midway formation which is a confining layer composed of clays. Underlying this are Upper Cretaceous formations which contain marl, chalk, limestone and shale and some groups which are known for hydrocarbon production in the area. These units, in order from top down are the Navarro, Taylor, Austin, Eagle Ford, Tuscaloosa and the top of the Washita. The Lower Cretaceous is composed of the limestone, chalk, marl, shales and sandstones of the Washita-Fredericksburg and Trinity Groups. Underlying the Lower Cretaceous is the Upper Jurassic which contains the Cotton Valley Group's shallow marine shales. The Haynesville Formation lies below the Cotton Valley group and is a hydrocarbon producing black shale and the equivalent of the Lower Bossier Formation in Texas. Underlying the Haynesville is the calcareous shelf/reef/lagoon formations of the Smackover limestone which is underlain by the Norphlet mudstone. The Louann Salt and Werner red shale and sandstone formations are located underneath the Norphlet mudstone. The underlying Upper Triassic contains the thick red beds of the Eagle Mills Group which are above the undifferentiated rock of the Paleozoic (LAGS 2008 and AKGS).

Desoto Parish

Desoto Parish is located in the northwestern region of Louisiana in a geologically significant area called the Sabine Uplift. The Sabine Uplift area was created as a result of the combination of the rifting events which created the Gulf of Mexico and shearing forces resulting from tectonics in North America. These same forces are the cause of multiple salt domes that occur in the county. While the strati-graphic sequence is the same in the county as the rest of the state, the Jurassic age formations of the Haynesville and Bossier shales are of note as both are well-known as hydrocarbon producers. The Bossier Shale is dark, calcareous,

02:02233_0696_SGTG-B3494 2-2 <u>4_attachment_EPA_CHK_Case_Study_QAPP_working_copy_121611_(CEPA_CHK_Case_Study_QAPP_working_copy_121611.doc</u>-10/21/2013<u>8/6/20131/6/20121/6/20121/2/202011</u> Comment [c46]: CHK provided EPA and E&E more site specific reference that should be integrated into the background geology and hydrological information. (e.g., well logs) Section No.: 2 Revision No.: 00 Date: May October 21, 2013August 6, 2013January 6, 2012January 6, 2012January 6, 2012December 20, 2011

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fossiliferous marine shale in sequence with sandstone that is determined to be the source rock for the gas accumulation in upper formations. The Haynesville Shale is a carbonaceous, ultra-low permeability/high porosity black shale below the Bossier Shale with the thin Gilmer Lime separating the two formations (LAGS 2008 and AKGS).

Hydrology

The Carrizo-Wilcox is an Eocene and Paleocene age aquifer and is comprised of hydraulically connected, well sorted, fine to medium grained, cross bedded sands and silts from the Wilcox Group and the Carrizo Formation of the Claiborne Group (Ashworth and Hopkins, 1995). The origins of the sands which compose the Carrizo-Wilcox are both fluvial and fluvial-deltaic in origin. The Carrizo-Wilcox aguifer extends across Texas from the Rio Grande in the southwest to Red River the northeast including Desoto Parish in Louisiana. The aquifer is bounded at its base by the confining clays of the Midway group and is overlain by the confining clays and silty clays of Cane River formation. The aquifer has a down-dip trend to the south which is the primary factor in ground water flow direction. Brackish water found in the aquifer is most likely the result of dissolution of salt domes found in the area and most likely also plays a role in the direction of groundwater flow because density differences. Water also moves between overlying alluvial and terrace aquifers, the Sparta aquifer, and the Carrizo-Wilcox aquifer, according to hydraulic head differences and in some places artesian pressures within the aquifer were originally sufficient to drive water above ground. Water level fluctuations are mostly seasonal, and the hydraulic conductivity varies between 2 and 40ft./day. Primary recharge of the Carrizo-Wilcox aquifer occurs from direct infiltration of rainfall in upland outcrop-subcrop areas. Maximum depths of occurrence of freshwater in the Carrizo-Wilcox range from 200ft. above sea level to 1,100ft. below sea level. Based on literature review, and available well logs, the base of the Carrizo-Wilcox aquifer appears to be between 600 to 800 feet deep near the study location. Drinking water wells in the immediate vicinity of the site are screened from between 181 feet to 360 feet below ground surface. The deepest boring in the area, a USGS well (DS-315) extended to a depth of 570 and was still in the Carizzo-Wilcox aquifer. Shallow groundwater in the study area is anticipated to be less than 40 feet bgs (Page, 1964). Analysis of the quality of the water from the Carrizo-Wilcox aguifer shows it to be soft and of good quality with an average pH of 8.31, total dissolved solids (TDS) of 0.48 g/L, a salinity of 0.36 ppt and chloride content of 66.4 mg/L. Further information about the water quality from the Carrizo-Wilcox can be found in Table 2 (LDEQ 2009).

Comment [c47]: Addition resources are available regarding the groundwater and surface water quality. This information should be complied and tabulated. Examples include USGS NWIS and NURE sites.

Comment [WU48]: I think what we have is sufficient

Comment [nc49]: Need to be consistent throughout the document in the use of ft., ft or feet

Comment [c50]: The base of USDW from SONRIS should be sited. I believe it was approximately 780 ft.

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Table 2 Water Quality of the Carizzo-Wilcox Aquifer. Data from LDEQ 2009						
		FY 1995	FY 1998	FY 2001	FY 2004	FY 2007
	Parameter	Average	Average	Average	Average	Average
	Temperature (^O C)	21.44	21.30	21.98	21.39	21.83
plé	pH (SU)	7.53	7.65	7.87	7.75	8.31
	Specific Conductance	0.676	0.732	0.808	0.80	0.740
шĔ	(mmhos/cm)					
	Salinity (ppt)	0.35	0.36	0.40	0.39	0.36
	TDS (g/L)	-	-	-	0.520	0.480
	Alkalinity (mg/L)	267.2	251.5	249.4	273.5	283.4
	Chloride (mg/L)	59.2	71.6	69.7	66.5	66.4
	Color (PCU)	25.8	13.8	24.1	14.8	8.2
	Specific Conductance	726.4	772.4	748.1	799.5	739
	(<u>µ</u> umhos/cm)					
Ž	Sulfate (mg/L)	30.1	30.5	28.7	26.6	13.1
ato	TDS (mg/L)	434.7	435.7	449.6	481.2	429.7
0 0	TSS (mg/L)	<4	4.9	<4	<4	<4
Lal	Turbidity (NTU)	2.6	5.2	2.3	1.6	1.9
	Ammonia, as N (mg/L)	0.42	0.64	0.64	0.81	0.63
	Hardness (mg/L)	52.4	42.2	31.3	41.0	33.5
	Nitrite - Nitrate, as N (mg/L)	0.08	0.07	0.07	0.07	0.10
	TKN (mg/L)	0.78	0.96	0.82	0.97	0.77
	Total Phosphorus (mg/L)	0.29	0.24	0.26	0.33	0.26

Comment [c51]: Has EPA discussed with LA DEQ how they can collaborate on future data gather exercise that would benefit the state and EPA? Since this work the final report for this work is not expect until the end of 2014, there appears to be time to work with the state on this effort. CHK would appreciate the opportunity to participate in any collaborative effort that could benefit the EPA HF Study and the State of LA.

Comment [nc52]: Need to use consistent units for specific conductance throughout the document

2.1.2 Ground-Water Monitoring

Groundwater sampling and analysis will provide data that can be used to identify significant changes in water quality and investigate if these changes have potentially been caused by the introduction of drilling fluids, hydraulic fracturing fluids, and formation fluids and gases to underground sources of drinking water. This sampling will aid in the understanding of the potential chemicals constituents that could contaminate shallow ground water as well as the potential future impacts to shallow groundwater that may occur as the result of the transport of contaminants to the site. The groundwater sampling component of this project is intended to provide a survey of water quality in the area of investigation throughout the key phases of the gas well development; post well construction to approximately one year after hydraulic fracturing activities have been completed. Location, distribution, and number of sampling sites can affect the quality and applicability of the resulting data. Therefore, the following criteria may be used to determine groundwater water sampling locations: study objectives and sampling methods; all available historical information; physical characteristics of the area, such as size and shape, land use, geology, point and nonpoint sources of contamination, hydraulic conditions, climate, water depth, historical oil and gas wells/pipeline/storage areas; chemical characteristics of the area; and the types of equipment that will be needed for sampling (USGS, 2010). GWERD, EPA R6,

Comment [c53]: The study should be focused on hydraulic fracturing. If the EPA chooses against Congresses request and SAB recommendation to expand the scope of the study, it is necessary to ensure differentiation between potential sources of contaminations.

Comment [CV54]: The list of analytes should be the chemical constituents that could potentially contaminate ground water. The data will aid in determining **<u>IF</u>** there has been a contamination.

Comment [CV55]: Should also factor in preexisting oil/gas development in the area.

02:002233_0696_SGTG-B3494 2-4 4_attachment_EPA CHK Case Study QAPP working copy 121611 (CEPA CHK Case Study QAPP-working copy 121611.doe 10/21/20138/6/20131/6/20121/6/20121/2/202011 Section No.: 2 Revision No.: 40 Date: May October 21, 20<u>13August 6, 2013January 6, 2012January 6, 2012January 6, 2012December 20, 2011</u>

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LADEQ, and Chesapeake will survey the existing data and speak to landowners near the proposed pad to determine if ground water wells in the area could be sampled for the study. The domestic wells will be sampled directly from the well casing (if possible) with the sampling pump just above the well pump. In cases where this is not possible, the sampling pump will be placed as close as possible to well pump. If access to the well is limited or the sampling pump cannot be lowered to the desired depth, the sample will be collected from the tap from at the closest port to the wellhead. It is believed that most domestic wells are screened in the Carizzo-Wilcox aquifer between 100 and 500 ft below ground surface. Similarly, any water supplymonitoring wells will be sampled similar to the domestic wells. It is anticipated that the monitoring wells will be sampled quarterly by EPA until approximately one year after hydraulic fracturing activities. The minimum number of post-baseline sampling events to determine if an impact to the aquifer happened is estimated to be three sampling events.

It is estimated that 11 monitoring wells will be installed to monitor groundwater quality near the study location. An initial deep boring will be completed and logged using downhole wireline logging techniques to evaluate actual aquifer thickness, zone of preferential flow, and flow direction (see Section 2.2.2.1). This well will then be converted to a deep monitoring well and included as part of the groundwater monitoring well network. Monitoring wells will be clustered to capture up to three water bearing zones (shallow, intermediate and deep) to monitor the full thickness of the aquifer (see Table 3). Proposed monitoring well locations will include:

- A well cluster upgradient of the drilling location;
- A directionally drilled well (from an off-pad location) screened beneath the production well pad, downgradient from the proposed production well.
- Two clusters immediately down gradient of the well pad; and
- One deep well approximately mid-way along the lateral

Table 3The Physical Characteristics of the Monitoring Wells Near the
Proposed Well Pad

	Screen Interval	Screen Length	
Monitoring Well	(ft)	(ft)	Total Depth (ft)
MW-1	TBD	TBD	TBD
MW-2	TBD	TBD	TBD
MW-3	TBD	TBD	TBD
MW-4	TBD	TBD	TBD
MW-5	TBD	TBD	TBD
MW-6	TBD	TBD	TBD
MW-7	TBD	TBD	TBD

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<u>4_autenmen_EFA Cirk Case study QAFF working copy 121011 (CEFA Cirk Case study QAF</u> 10/21/20138/6/20131/6/20121/6/20121/6/201212/20/2011 **Comment [c56]:** Has LADEQ been consulted regarding this statement? Chesapeake is more than happy to work with EPA on conducting a survey and speaking to land owners, however, this is an EPA an therefore, EPA should have responsibility for this task with support for LADEQ and Chesapeake.

Comment [GF57]: Is there an EPA SOP for domestic well sampling?

Comment [CV58]: Experience has shown that depending on the use of a domestic water well by the landowner before sampling, the baseline results can vary widely. Heavy use before baseline sampling event affects the sampling results different than samples collected from a well with no prior domestic use before baseline sampling. Information on the landowner pump setting is also very important, along with accurate records on well construction and components between the well and tap. Much of these data will not be available unless a downhole survey is done in each water well. Multiple sampling are required under differing pumping conditions to define the variability in analytical results during base-line sampling.

Comment [CV59]: Should emphasize more that this is the **minimum** number of sampling events.

Comment [c60]: Chesapeake request additional information on the design and construction of this well. In addition, we would appreciate addition information on the application of this technology for monitoring wells.

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	MW-8	TBD	TBD	TBD	Comment [CV61]: There is discrepancy in the number of wells proposed, one said 8 another says 11. Must clarify.			
The study area and proposed locations of monitoring wells as well as existing domestic water wells and gas wells is illustrated in Figure 3. Prior to installation of groundwater monitoring wells, approximately 7 temporary piezometers will be installed and surveyed. Depth to groundwater measurements will be collected to calculate shallow groundwater flow direction. Temporary piezometers will be installed using a direct push drilling rig or other suitable technology and will be abandoned by plugging with a cement bentonite grout to ground surface prior to pad construction. Testing of the piezometers may be conducted to determine aqui-								
	fer properties.							
	2.1.3 Surface Wat While surface water not appear to serve as underground source of provide data that can if these changes have ids, hydraulic fractur	ter Sampling in the vicinity of the p s a source of drinking of drinking water. Su be used to identify ch potentially been caus ing fluids, and format	roposed production water, it could be in face water samplin anges in water qua- ed by the introduct ion fluids and gases	well location does n contact with the g and analysis will lity and investigate ion of drilling flu- to surface water or	 Comment [CV63]: Consider using continuous recording sondes for basic water quality parameters for baseline characterization, and during monitoring. With periodic sampling for more comprehensive analytical list per seasonal or local flow conditions—high flow vs low flow, consider if base flow occurs in stream and its affect on local gw quality. Comment [c64]: The study should be focused on hydraulic fracturing 			
	surface water sources ing of the potential c that may occur as the	s of drinking water. I hemicals constituents result of the transpor	his sampling will a that could contamin t of contaminants to	id in the understand- hate surface water the site.	Comment [c65]: It is understood from this statement that only drinking water sources will be investigated.			
	There are several wa result of hydraulic fractional several ways and the several ways are severa	ys in which surface w acturing. One possibl	ater quality could b e mechanism is the	e impacted as the direct contamina-	Comment [CV66]: The list of analytes should be the chemical constituents that could potentially contaminate ground water. The data will aid in determining <u>IF</u> there has been a contamination.			
	tion caused by the sp into the surface wate drilling, hydraulic fra pacts to surface wate	illage of drilling, hydr r body. In addition, ru acturing, or formation r.	aulic fracturing, or moff and or subsurf fluid through the so	formation fluids face transport of bil could cause im-	Comment [c67]: A clear definition of hydraulic fracturing should be provided because it is used incorrectly to describe oil and gas development throughout this document.			
 	Each surface water le fied and considered i sample locations acc year and flow rate or study objectives. In or point is not adequa and abundance of che sampling sites can af 2010). Therefore, th sampling locations: cal information, inclu acteristics of the area acteristics, geology, j ditions, climate, wate	bocation has a unique s n the sample selectior urately represent the i stage) of the aqueous most bodies of flowin ate to describe the phy emical constituents. L fect the quality and ap e following criteria m study objectives and s iding historical oil/gar a, such as size and sha point and nonpoint so er depth, and fluvial-so	et of conditions that process. Therefore intended conditions system being studi ag or still water, a si sical properties and ocation, distribution plicability of the re ay be used to deterr ampling methods; a <u>soperations in the a</u> pe, land use, tributa pres of contaminat	a needs to be identi- b, it is important that (such as time of ed with respect to ingle sampling site I the distribution h, and number of sulting data (USGS, nine surface water all available histori- rea; physical char- ry and runoff char- ion, hydraulic con- maracteristics; chem-				

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ical characteristics of the area; and the types of equipment that will be needed for sampling (USGS, 2010).

Comment [c68]: CHK agrees with this paragraph, however, it is not well understood how the study will incorporate these criteria. Sampling locations should be prescribed in the QAPP.

Comment [WU69]: We can make some tentative selections of locations subject to change-see below

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Insert Figure (color) page 1 of 2

3A Proposed Monitoring Well Location Map

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Figure 3A page 2 of 2

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Insert Figure (color) page 1 of 2

3B Expanded View of Proposed Monitoring Wells in Close Proximity to the Proposed Gas Well Section No.: 2 Revision No.: 00 Date: <u>May October 21, 2013August 6, 2013January 6, 2012January 6, 2012January 6, 2012December 20, 2011</u>

2. Data Generation and Acquisition

Figure 3B page 2 of 2

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4_attachment_EPA_CHK_Case_Study_QAPP_working_copy_121611_(CEPA_CHK_Case_Study_QAPP_working_copy_121611.doe10/21/20138/6/20131/6/20121/6/20121/2/20/2011

2. Data Generation and Acquisition

Surface water bodies are of two basic types: flowing water bodies (intermittent and perennial flow) and still water bodies (e.g., lakes and ponds). Flowing-water sites can refer to streams (fast or slow, intermittent, ephemeral, or perennial), canals, ditches, and flumes of all sizes and shapes, or to any other surface feature in which water moves unidirectionally (USGS, 2010). Still-water sites refer to all sizes and shapes of lakes, reservoirs, ponds, swamps, marshes, riverine backwaters, or any other body of surface water where water generally does not move unidirectionally (USGS, 2010).

For flowing water the optimal sampling locations is in straight reaches having uniform flow and stable bottom contours; far enough above and below confluences of streamflow or point sources of contamination to avoid sampling a cross section where flows are poorly mixed or not unidirectional; and in reaches upstream from bridges or other structures, to avoid contamination from the structure or from a road surface (USGS, 2010). Similarly, for still water sampling sites the optimal locations should avoid areas near structures <u>or historical oil/gas</u> <u>operationssuch as harbors, boat ramps, piers, fuel docks, and moored houseboats</u> (to avoid point sources of contamination), unless these structures are part of the study. (USGS, 2010).

Baseline <u>surface</u> water quality will be assessed in order to establish a <u>benchmark</u> <u>baseline</u> for water quality changes that have occurred as the result of drilling and hydraulic fracturing process in <u>surface water resources</u>. The baseline <u>surface water quality</u> will be collected based on historical data, if available, or both upstream and downstream of the potentially impacted area. At this site, surface water samples will be collected from the stream located west of the drilling pad. Surface water sampling locations are shown in Figure 4. Surface water samples will be collected in Appendix A.1 (ENV 3.12).

2.1.4 Soil Sampling

Soil sampling will be part of the monitoring utilized in the prospective case study. Soil sampling and analysis will provide data that can be used to identify changes in soil characteristics and investigate if these changes have potentially been caused by the transport and release of contaminants during the development process. Not only can soils potentially act as a sink for the contaminants in the environment but, soils could also serve as a source of contaminants to surface water and shallow groundwater through their gradual release back into surface water and shallow groundwater. Therefore, it is important to investigate if there is an accumulation of contaminants in soil as the result of hydraulic fracturing, understand the potential chemicals constituents that could contaminate drinking water; and provide information to understand the risk (frequency and magnitude) to drinking water impacts resulting from hydraulic fracturing operations.

Baseline soil samples will be assessed in order to establish a benchmark for impacts to soil that have occurred as the result of drilling and hydraulic fracturing

02:002233_0696_SGTG-B3494 2-12 <u>4_attachment_EPA_CHIK Case Study QAPP working copy 121611 (CEPA CHIK Case Study QAPP working copy 121611.doe-</u> 1021/201386/20131/6/20121/6/20121/6/20121/202011 **Comment [CV70]:** None of these are present in the area, so is this necessary? Or can be modified to describe structures that actually may be present in the area?

Comment [c71]: Baseline downstream information should be collected as well. Comment [WU72]: OK

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processes. The baseline soil samples will be collected in and around the pad once pad construction has been completed. NRMRL-Ada and Chesapeake will survey the area and speak to stakeholders in Keatchie to determine the location of sampling points. It is anticipated that the soils will be sampled following pad construction and prior to well construction and again (at the same locations) following the hydraulic fracturing of the well. The latitude and longitude and elevation of the sampling locations will be recorded so that the locations can be consistently sampled throughout the study.

Soil samples will consist of surface samples collected from 0 to 6 – inches below ground surface. Sampling locations are shown in Figure 4 and have been selected to provide equal representation of existing soil types surrounding the well pad. Soil types include the Keithville very fine sandy loam and Metcalf silt loam as mapped and described in the Soil Survey of De Soto Parish, LA. <u>A sufficient number of background samples should be collected from each soil type present in order to statistically evaluate data collected from this investigation through back-ground comparison.</u>

2.2 Sampling Methods

2.2.1 Installation of Temporary Piezometers Piezometer installations will be accomplished using a GeoProbe 6610DT direct push rig using 2.25" rods and expendable points. Depth of screen placement will be determined by use of the Soil Electrical Conductivity (EC) Logging system by GeoProbe Systems (see RSKSOP 219 in Appendix A.2) and/or by a few soil cores taken using the GeoProbe Macro-Core System (see RSKSOP 221 in Appendix A.3) to locate the local water table level. For the purposes of purchasing well installation supplies the water table depth has been estimated to be no more than 70' below ground surface. It is anticipated that approximately 7 temporary piezometers will be installed around the site as shown in Figure 4.

Installations will begin by driving the 2.25" rods with an expendable point to the desired depth. The well (.75" ID, 1.4" OD pre-packed screen 10' in length with a 4" bottom plug/sump) will then be lowered into the rods. The well will be held in position while the rods are retracted 10.5' to allow natural collapse to contact the pre-packed screen. If natural collapse does not occur, sand will be placed around the pre-packed screen via gravity placement. A minimum 2' bentonite seal of granular bentonite slurry will then be installed from the bentonite seal to the ground surface via gravity placement. The well riser will be cut leaving 36" of stickup above ground surface and capped with a vented well cap. A painted steel locking well protector will be installed into the bentonite grout column and secured with a

Comment [CV73]: It is recommended that other potential sources of contamination are identified and tested

Comment [c74]: A sub-meter GPS should be used for all sample locations.

Comment [c75]: Suggest we do an EM-38 survey of the well pad area first (the pad and a 100 foot buffer surrounding the pad footprint), then use those results in conjunction with the soil types to collect representative baseline samples with depth and soil type/horizon. The baseline EM survey can be repeated adjacent to the pad once completed. The EM-38 is an extremely sensitive tool to changes in the conductivity of soils caused by fluid releases containing salts or brines.

Comment [WU76]: OK-CHK willing to fund and do it?

Comment [CV77]: No mention of QA/QC samples (splits, duplicates, field blanks, equipment blanks etc.) in any of the sampling sections.

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4" thick concrete slab that has a radius of at least 12" from the well protector. The concrete slab will slope away from the protector for drainage purposes. An "X" will be made in the concrete near the protector and a mark made on the well stickup to serve as a reference point for water elevation surveys and the well ID number will be etched into the slab. A threaded hole with drain plug will be installed into the steel protective casing just above the slab surface to allow drainage of any water that may collect between the well stickup and protective casing.

Samples of the filter sand, bentonite pellets, and grout will be collected and analyzed for the list of soil and groundwater analytical parameters.

_Insert Figure (color) page 1 of 2

4

Proposed Soil, Surface Water and Piezometer Locations

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Figure 4 page 2 of 2

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The hydraulic conductivity of geologic materials near the water table will be estimated using slug tests performed in each of the shallow piezometers. These data will be used in conjunction with measured hydraulic heads to estimate shallow groundwater flow direction and rate. The slug tests will be performed by RSKSOP-260 using solid slugs constructed of either PVC or stainless steel or, alternatively, RSKSOP-256 using pneumatic slug testing techniques (see Appendix A.4 and A.5). Both methods provide equivalent data, if hydraulic conductivity is less than 0.02 cm/s. If the estimated hydraulic conductivity of the shallow aquifer materials is greater than 0.02 cm/s, only RSKSOP-256 will be used. These procedures are based on recommendations derived from Butler (1997). The aquifer response data will be analyzed using the methods of Bouwer and Rice (1976) and, if inertial effects are observed, Springer and Gelhar (1991).

2.2.2 Installation of Monitoring Wells

The monitoring well network will consist of clusters with up to three wells (shallow, intermediate and deep) based on data collected from an initial exploratory boring. As mentioned above, the initial exploratory boring will be completed as one of the deep monitoring wells. Downhole geophysical logging will be performed on the exploratory boring as described below in section 2.2.2.1.

2.2.2.1 Geophysical Logging

Geophysical logging will be conducted by **T**the USGS at the request of the U.S. Environmental Protection Agency Office of Research and Development (ORD). Borehole geophysical data collection and analysis will be conducted on one deep well to be drilled in northwestern Louisiana study area for the purpose of monitoring groundwater in the vicinity of hydraulic fracturing operations of the Haynesville Shale as mentioned in Section 2.1.2. The planned well will be drilled into the Carrizo-Wilcox aquifer under the direction of ORD or their contractor. The targeted depth is about 600 to 800 feet below land surface which is expected to penetrate the freshwater/salinewater interface near the base of the aquifer.

2.2.2.2 Approach

The approach is divided into two phases, one phase with data collected at the conclusion of drilling the open hole (before casing is set) and one phase with data collected after the well has been constructed with PVC casing and screen.

Phase 1

The proposed borehole geophysical logging methods include basic and advanced logging techniques (listed below) which will be collected in the uncased open borehole shortly after drilling has concluded. Geophysical logging entails the lowering of geophysical probes on a wireline to the total depth of the borehole and the collection of geophysical measurements either during the lowering of the probe or during retrieval of the probe to surface. Several logging runs will be required to collect the proposed parameters. The collection of these logs will require removal of the drill string and will require the borehole to be stabilized with drill-

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Comment [c78]:

The monitoring well design and construction methods should be better defined in this document. CHK has provided some preliminary comments based on current QAPP content. 2" monitoring well may be not be adequate. May require steel casing (preferably stainless). Suggest putting a 1-2 sediment sump below the screen.

Comment [CV79]: During the 10/11/2011 F2F meeting it was discussed that samples of the materials brought on site for completion of the piezometers and monitoring wells (e.g. water, drilling mud, bentonite, cement, etc.) were to be sampled.

Comment [WU80]: E&E insert mods here based on discussions by team on 091911

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Comment [c81]: Should this be a subsection of 2.2.2.1 because it is the geophysical logging approach?

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ing fluid and free of obstructions. If the borehole becomes unstable and begins to collapse during logging runs, additional circulation or mud conditioning by the drilling crew may be necessary before logging can continue. The optional use of sealed radioactive sources to collect density and neutron logs (depending on hole conditions) has also been included to better assess the porosity of the formations to aid in the placement of screen openings.

The following is a list of proposed logs to be collected in the uncased borehole shortly after drilling has concluded and before casing is set. About eight logging runs will be necessary to collect these logs.

1. Caliper;

2. Natural Gamma;

3. Normal Resistivity;

4. Single Point Resistance (SPR);

5. Fluid resistivity and temperature;

6. Spontaneous Potential (SP);

7. Induction Conductivity;

8. Magnetic Susceptibility (MS);

9. Full Wave Sonic with post-processing to compute acoustic velocity;

10. Acoustic Borehole Imager with Vertical Deviation and Azimuth;

11. Neutron (optional); and

12. Gamma-Gamma Density (optional).

Phase 2

Additional logs such as nuclear magnetic resonance (NMR) and induction conductivity will be collected after the well has been cased with PVC casing. Nuclear magnetic resonance data is useful to assess permeability and total porosity including percent volume of bound and free fluid in the formation. Induction conductivity will be used to locate the fresh water/saline water interface and assess movement of this interface before and after the hydraulic fracturing operation. One additional trip to the wellsite will be necessary to complete the Phase 2 logging after the nearby hydraulic fracturing is completed.

The following is a list of proposed logs to be collected in the PVC-cased borehole shortly after the well has been constructed.

1. Magnetic susceptibility;

2. Nuclear Magnetic Resonance;

3. Induction Conductivity (repeated after hydro-fracturing); and

4. Water Quality Logging – conductivity, temperature, DO, PhpH, EeH, etc.

Outputs from this effort will included those listed below. Descriptions of each logging method are included in Appendix A.6.

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- Geophysical well log montage including natural gamma, caliper, SP, long and short normal resistivity, SPR, induction conductivity, MS, full wave sonic processed to include acoustic velocity, density (if collected), neutron (if collected), an azimuth-oriented acoustic borehole image, with deviation, nuclear magnetic resonance data.
- 2. A time series plot of induction conductivity logs collected at the time of drilling, after well is constructed before nearby hydraulic fracturing and after nearby hydraulic fracturing.

Digital data of logs listed above.

2.2.2.3 Monitoring Well construction

Monitoring wells will be constructed using a minimum of 2.54 to 3-inch schedule 80 PVC casing and slotted PVC screens for both intermediate and deep monitoring wells. Depending on depth (< 100 feet), shallow monitoring wells may be constructed of 2-inch diameter schedule 40 PVC screen and casing. All casing and screen will utilized threaded connections. Screen intervals will be determined based on data collected from the initial exploratory boring. PVC screen will consist of 0.010 factory slotted screen.

Monitoring wells will be drilled using conventional mud rotary techniques (see Geo 4.7 in Appendix A.7) and installed in accordance with all State of Louisiana regulations, by a licensed driller, and under supervision of a Louisiana licensed Professional Geologist, if applicable. Typical Mmonitoring well construction is depicted in Figure 5. In general, monitoring well construction will be as follows described below (see Geo 4.10 in Appendix A.8)=.

- 1-foot PVC blank section will be threaded to the bottom of the PVC screen to act as a sump for fines which may collect in the well.
- The annular space between the borehole wall and the well screen/sump will backfilled with 10-20 silica sand, to approximately two feet above the screened interval.
- The annular space above the sand pack will be sealed with a 3 foot bentonite pellet seal, which will be placed by tremie pipe.
- The remaining annular space will be filled with bentonite cement grout to within 3 feet below ground surface. Bentonite cement grout will consist of 6 percent by weight of a pH neutral bentonite (e.g. pure-gold brand).
- All permanent wells will be finished as above ground completions (where possible). The above ground completion will consist of an outer (un-painted)

Comment [c82]: Cleaning up of the monitoring wells should be included in the QAPP. This topic was discussed at the F2F meetings.

Comment [CV83]: Is this available? Are these correct?

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steel protective casing extending at least 3 feet below ground surface and approximately 3 feet above ground. Each stickup will include a lockable cover and keyed padlock. Protective custody seals will also be utilized at each well location, such that a well cannot be opened without tearing the seal.

- A square concrete pad will be placed around each well. The pad will measure 3 feet square (1.5 feet from the center of the well) and extend a minimum of 3.5 to 4-inches below ground surface.
- The annular space between the well and protective casing will be filled with silica sand to with 6-inches of the well top, and a drain hole will be drilled approximately two inches above the well pad
- A minimum of three protective steel bollards will be placed around the well. Additional well protective measures such as chain between the bollards may also be utilized depending on well location.
- Samples of the filter sand, bentonite pellets, and grout will be collected and analyzed for the list of soil and groundwater analytical parameters. In addition, at different times during the drilling process, samples of the drilling fluids will be collected for comprehensive analyses.

The designated measuring point and elevation datum at each monitoring well is defined as the ground surface immediately adjacent to the surficial concrete pad to the north and the top of the inner PVC well casing on the north side. These points will be surveyed in the horizontal position to within 1.0 foot accuracy and to within 0.01 foot vertically.

The installed wells will be developed by the <u>water well</u> driller and the EPA contractor (E & E) according to procedures in Appendix A.9 (GEO 4.11)_{τ}.

2.2.3 Monitoring Well Sampling

EPA low flow sampling procedures will be used to sample the wells as described below (see Appendix A.10). For all duplicate and split samples, an in-line "T" shall be installed on the sample discharge tubing so that the original sample an duplicate sample bottles can be filled simultaneously. When split samples are collected at locations with duplicate samples, multiple inline "T's" will be utilized so that the original, duplicate, and split sample bottles can all be filled simultaneously:

:

Comment [c84]: The contractors experience needs to be vetted for drilling deep wells, along with the contractors experience. CHK should be involved in this process.

Comment [CV85]: Methane should be baseline sampled in monitoring wells. If methane is present, isotopic analysis should be performed.

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1. Water level measurements will be taken prior to and during the pumping of the wells. The water level measurements will follow the RSKSOP-326 standard operating procedure (see Appendix A.11). Water levels will be recorded in the field notebook prior to and during sampling.

Comment [c86]: Consider installing trolls in select wells to monitor water levels long term and in getting a baseline.

Comment [WU87]: Up to CHK

Comment [GF88]: Need from EPA

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5 Typical Groundwater Monitoring Well

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6 Open Tube Sampling Method

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7 Closed Piston Sampling Method

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- 2. A new piece of tubing will be connected to the sampling port of the well and the dedicated pump will be powered on. It is expected that the pump will yield a maximum initial flow rate of approximately 1 L min⁻¹). This flow will pass through a flow cell equipped with an YSI 5600 multi-parameter probe (or equivalent probes). The rate of pumping will be determined by measuring the water volume collected after approximately 15 seconds into a 4 L graduated cylinder; the desirable pumping rate through the flow cell should be less than 1 L/min. The pumping rate will ideally maintain minimal drawdown. Water levels will be taken throughout sampling to confirm the drawdown caused by pumping.
- 3. The YSI probe (or equivalent probes and electrodes) will be used to track the stabilization of pH, oxidation-reduction potential (ORP), specific conductance (SC), dissolved oxygen (DO), and temperature. In general, the guidelines in Table 4 will be used to determine when parameters have stabilized. These criteria are initial guidelines; professional judgment in the field will be used to determine on a well-by-well basis when stabilization occurs. Field readings must be recorded at no more than 5 minute intervals, or continuously if continuous recordings are being used, until stabilization occurs.

Comment	[CV89]:	What kind	of pump? Specify.
Certain pumr	os are not	well suited	for VOC samples.

Comment [c90]: Measurement must be taken during the actual sampling, not just afterwards. A warning, in a stratified environment, low flow purging will not result in representative samples.

Comment [CV91]: The frequency of recording should be specified.

Parameter	Stabilization Criteria	Calibration Standards		
pН	≤0.02 pH units min ⁻¹	pH 4, 7, and 10 buffers		
Oxidation Reduction Po- tential (ORP)	$\leq 2 \text{mV min}^{-1}$	Zobells Solution		
Specific Conductance (SC)	$\leq 1\% \text{ min}^{-1}$	1413 µS Conductivity Standard		

Table 4 Field Parameter Stabilization Criteria and Calibration Standards

- 4. Once stabilization occurs, the final values for pH, ORP, specific conductance, dissolved oxygen, and temperature will be recorded. Turbidity will also be recorded immediately prior to sampling, and also just before the collection of the metals and radiological samples.
- 5. After the values for pH, ORP, SC, DO, and temperature have been recorded, the flow cell will be disconnected. A series of unfiltered samples will be collected as follows:
 - a. Duplicate 40 mL VOA vials (amber glass) will be collected, without headspace, for VOC analysis using RSKSOP-299v1. Tribasic Sodium Phosphate (TSP) will be added to the VOA vial prior to shipping to the field for sampling as a preservative. (Acid will not be used as a preservative due to a concern of acid hydrolysis of some analytes.) The samples will be stored and shipped on ice to Shaw, NRMRL-Ada's on-site contractor for GC-MS analysis.

testing comments in this general section. It does not appear that any of these analyses include notations of split samples/ bottleware exceptions, method references, etc...outside of what the EPA is proposing. Is that to be included in this document or elsewhere? Comment [c93]: Method is equivalent to SW846

Comment [CV92]: MDH: This applies to all

method 8260B. While TSP is an acceptable preservative, it should not be used if brominated compounds are of critical interest due to possible degradation in the analytical process. Suggest either both HCL and TSP vials be collected (for brominated compounds) or no preservation and a 7 day holding time

Comment [n94]: Our analytical chemists differ on this. We may want to consider this for flowback sampling however

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- b. Duplicate 60 mL serum bottles will be collected, without headspace, for dissolved gas analysis (e.g., hydrogen, carbon dioxide, ethane, methane, butane, propane). The bottles will contain trisodium phosphate as a preservative and will be filled with no head space and sealed with a crimp cap. The samples will be stored and shipped on ice to Shaw, NRMRL-Ada's on-site contractor for analysis. Samples will be collected in accordance with procedures outlined in Appendix A.12.
- c. Duplicate 1 L amber glass bottles will be collected for semi-volatile organic compounds. These samples will be stored and shipped on ice to EPA Region VIII Laboratory for analysis.
- d. Duplicate 1L amber glass bottles will be collected for diesel range organic (DRO) analysis. These samples will be preserved with HCl, pH <2, and shipped on ice to EPA Region VIII Laboratory for analysis.
- e. Duplicate 40 mL amber VOA vials will be collected without headspace for gasoline range organic analysis (GRO). These samples will be preserved with HCl, pH <2, and shipped on ice to EPA Region VIII Laboratory for analysis.
- f. Duplicate 40 mL amber VOA vials will be collected for glycol analysis. These samples will be stored and shipped on ice to EPA Region III Laboratory for analysis.
- g. Duplicate 40 mL glass VOA vials will be collected for low molecular weight acids using RSKSOP-112v6. Tribasic Sodium Phosphate (TSP) will be added to the VOA vial prior to shipping to the field for sampling as a preservative. The samples will be stored and shipped on ice to Shaw, NRMRL-Ada's on-site contractor for GC-MS analysis.
- h. A 1-liter plastic beaker will be filled for selected analyses to be conducted in the field. Field measurements will consist of turbidity, alkalinity, ferrous iron, and dissolved sulfide (Table 5). Turbidity (Standard Method 180.1) will be measured using a HACH 2100Q portable turbidimeter (or equivalent instrument). Alkalinity will be measured by titrating ground water with 1.6N H₂SO₄ to the bromcresol green-methyl red endpoint using a HACH titrator (HACH method 8203, equivalent to Standard Method 2320B for alkalinity). Ferrous iron will be measured using the 1,10phenanthroline colorimetric method (HACH DR/2010 spectrometer, HACH method 8146, equivalent to Standard Method 3500-Fe B for wastewater). Dissolved sulfide will be measured using the methylene blue colorimetric method (HACH DR/2010 spectrometer; HACH method 8131, equivalent to Standard Method 4500-S²⁻ D for wastewater).

02:002233_0696_SGTG-B3494 2-28 4_attachment_EPA CHK Case Study QAPP working copy 121611 (CEPA CHK Case Study QAPP working copy 121611.doe 10/21/201386-2013146-2012146/201216/201212-202011 **Comment [CV95]:** MDH: Again, we would recommend a different set of bottleware for the methodologies we would recommend.

Comment [CV96]: Field tests for alkalinity and dissolved sulfide particularly may be suitable for baseline samples but not for flow back samples. High salt and dissolved solids content and matrix color interferences will make these Hach colorimetric method unsuitable with the more complex matrices. Suggest consistent with all matrices using fixed based lab methods for these analyses.

Comment [CV97]: What about the other field parameters, going to use the flow cell values, or collect the actual water from the actual time of sampling for these parameters? Section No.: 2 Revision No.: 90 Date: May October 21, 201<u>3August 6, 2013January 6, 2012January 6, 2012January 6, 2012December 20, 2011</u>

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Parameter	Method	Equipment			
Alkalinity	EPA Standard Method 2320B;	HACH Model AL-DT Digital Titrator			
	HACH method 8203	(or equivalent device)			
Ferrous Fe	EPA Standard Method 3500-	HACH DR890 Portable Colorimeter (or			
	Fe B; HACH Method 8146	equivalent device)			
Dissolved Sulfide	EPA Standard Method 4500-	HACH DR890 Portable Colorimeter (or			
	S ²⁻ D; HACH Method 8131	equivalent device)			
Turbidity	EPA Standard Method 180.1	HACH 2100Q Portable Turbidity meter			

Table 5 Groundwater Field Analytical Methods

- 6. After the unfiltered samples have been collected a high-capacity cartridge ground-water filter (0.45µm, Pall Corporation, or equivalent manufacturer) will be placed on the end of the pump tubing and filtered samples will be collected into pre-labeled sample bottles. First, approximately 100 mL of ground water will be filtered and sent to waste and next the following series of samples will be collected:
 - a. 125 mL plastic bottle for metals analysis by ICP-OES for Al, Ag, As, B, Be, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Sr, Ti, Tl, V, Zn, Si, and S; this sample will also be used for ICP-MS analysis for Cd, Cr, As, Cu, Pb, Ni, Se, Hg, and Tl. This sample will be filtered and preserved by adding 5 drops of concentrated HNO₃ (pH test strips will be used to confirm that the sample pH is <2). Test strips for pH will be used on every sample to insure that a proper preservation pH is attained. A small amount of sample will be poured into a separate container to test pH. This is especially important in case high alkalinity samples are encountered during the ground-water sampling. The samples will be stored and shipped on ice to Shaw, NRMRL-Ada's on-site contractor for analysis.
 - b. One 60 mL clear plastic bottle for CE (capillary electrophoresis) sulfate, chloride, bromide and fluoride. This sample will be filtered, no preservative added. The samples will be stored and shipped on ice to the RSKERC general parameters lab.
 - c. One 60 mL clear plastic bottle for nitrate + nitrite and ammonium. This sample will be filtered, 2 drops of sulfuric acid added as preservative (pH test strips will be used to confirm that the sample pH is <2; see note above regarding use of pH test strips). The samples will be stored and shipped on ice to the RSKERC general parameters lab.
 - d. Duplicate 40 mL glass VOA vial in duplicate for analysis of dissolved inorganic carbon (DIC). This sample will be filtered, no preservative added.

Comment [CV98]: Measure turbidity of filtered sample in field and record in log book to ensure and document did not have sediment breakthrough in filters

Comment [CV99]: Add carbonate and bicarbonate; and turbidity, and TSS to insure no sediment was in sample analyzed for dissolved cations and metals.

Comment [c100]: Are the pH test strip contaminant free, need to see documentation on this.

Comment [n101]: Agree – we should add text to insure no contamination from strips

Comment [CV102]: MDH: The proper technique for verifying pH of a bottle would be to use disposable glass capillary tubes and use that tube to disperse the sample aliquot onto the pH paper strip

Comment [CV103]: Suggest we also test for organic nitrogen or TKN, useful in evaluating septic impacts.

Comment [c104]: It is not understood why and how this parameter will be used in the EPA study.

Comment [n105]: This gets to the issue of accurate carbonate/bicarbonate numbers. We do not feel that lab alkalinity is the best way to go-prefer field alkalinity together with other analysis to then arrive at accurate numbers

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The samples will be stored and shipped on ice to the RSKERC general parameters lab.

e. Duplicate 40 mL glass VOA vial in duplicate for analysis of dissolved organic carbon (DOC). This sample will be filtered, phosphoric acid added to pH<2. A duplicate set of 40 mL VOA vials will be collected without preservation in case acid preservation interferes with the analysis or primary instrument is unavailable. VOA vials will indicate if preservative was added. The samples will be stored and shipped on ice to the RSKERC general parameters lab.

Comment [c106]: It is not understood why and how this parameter will be used in the EPA study.

Comment [n107]: An important parameter in terms of binding of organic compounds

Comment [CV108]: Add description for gross alpha, gross beta, Uranium, Thorium, Radium 226/228. Very important to include.

Filter radioactive samples also f.

See Tables 6 and 7 for numbers of sample bottles needed for each sample type and field QC samples for ground and surface water sampling.

	Analysis Method	Sample Bottles/# of	Preservation/	Holding
Sample Type	(EPA Method)	bottles [*]	Storage	Time(s)
Dissolved gases	RSKSOP-194v4 &-	60 mL serum bottles/2	No Headspace	14 days
	1/303		ISP', pH>10; refrig-	
	(No EPA Method)		erate 6°C ^{††}	
Metals (filtered)	RSKSOP-213v4 &-	125 mL plastic bottle/1	HNO ₃ , pH<2; room	6 months
(intered)	257v3 or 332v0 (EPA		temperature	(Hg 28
	Methods 220.7 and		·····F ······	days)
	6020)			
Metals (unfiltered)	RSKSOP179v2;	125 mL plastic bottle/1	HNO ₃ , pH<2; room	6 months
	RSKSOP-213v4 &-		temperature	(Hg 28
	257v3 or 332v0 (EPA			days)
	Methods 220.7 and			
	6020)			
SO ₄ , Cl, F, Br	RSKSOP-276v3 (EPA	30 mL plastic/1	Refrigerate <u><</u> 6°C	28 days
	Method 6500)			
$NO_3 + NO_2, NH_4$	RSKSOP-214v5	30 mL plastic/1	H ₂ SO ₄ , pH<2; refrig-	28 days
	(EPA Method 350.1)		erate <u><</u> 6°C	
DIC	RSKSOP-330v0	40 mL clear glass VOA	refrigerate <u><</u> 6°C	14 days
	(EPA Method 9060A)	vial/2		
DOC	RSKSOP-330v0	40 mL clear glass VOA	H ₃ PO ₄ , pH<2; refrig-	28 days
	(EPA Method 9060A)	vial/2	erate <u><</u> 6°C	
Volatile organic	RSKSOP-299v1 or	40 mL amber glass	No Headspace	14 days
compounds (VOC)	259v1 (EPA Method	VOA vial/2	TSP [†] , pH>10; refrig-	
	5021A plus 8260C)		erate <u><</u> 6°C	
Low Molecular	RSKSOP-112V6	40 mL glass VOA vi-	TSP [†] , pH>10; refrig-	30 days
Weight Acids	(No EPA Method)	al/2	erate <6°C	
O, H stable iso-	RSKSOP-296v0	20 mL glass VOA vi-	Refrigerate at <6°C	stable
topes of water	(No EPA Method)	al/1?		

Tabla 6 Ground and Surface Water Sample Collection

2 - 3002:002233_0696_SGTG-B3494 4_attachment_EPA CHK Case Study QAPP working copy 121611 (CEPA CHK (121611.d

10/21/20138/6/20131/6/20121/6/20121/6/201212/20/2011

Comment [CV109]: Where are the radionuclides, analyses must be done on both filtered and unfiltered samples

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Table 6 Groun	d and Surface Water	Sample Collection		
Sample Type	Analysis Method (EPA Method)	Sample Bottles/# of bottles*	Preservation/ Storage	Holding Time(s)
δ^{13} C of inorganic carbon	Isotech: gas stripping and IRMS (No EPA Method)	60 mL plastic bottle/1?	Refrigerate <u><</u> 6°C	No infor- mation
δ^{13} C and δ^{2} H of methane	Isotech: gas stripping and IRMS (No EPA Method)	1 L plastic bottle/1?	Caplet of benzalkonium chlo- ride; refrigerate ≤6°C	No infor- mation
⁸⁷ Sr/ ⁸⁶ Sr analysis	Thermal ionization mass spectrometry (No EPA Method)	500 mL plastic bottle/1?	Refrigerate <u><</u> 6°C	No infor- mation
Semi-volatile or- ganic compounds	ORGM-515 r1.1, EPA Method 8270D	1L Amber glass bottle/2 and for every 10 sam- ples of ground water need 2 more bottles for one selected sample, or if <10 samples collect- ed, collect 2 more bot- tles for one select sam- ple	Refrigerate <u><</u> 6°C	7 days until extraction, 30 days af- ter extrac- tion
DRO	ORGM-508 r1.0, EPA Method 8015D	1L Amber glass bottle/2 and for every 10 sam- ples of ground water need 2 more bottles for one selected sample, or if <10 samples collect- ed, collect 2 more bot- tles for one select sam- ple	HCl, pH<2; refrigerate <u>≤</u> 6°C	7 days until extraction, 40 days af- ter extrac- tion
GRO	ORGM-506 r1.0, EPA Method 8015D	40 mL amber glass VOA vial/2 and for every 10 sam- ples of ground water need 2 more bottles for one selected sample, or if <10 samples collect- ed, collect 2 more bot- tles for one select sam- ple	No headspace; HCl, pH<2; refrigerate ≤6°C	14 days
21Glycols	Region III method** (No EPA Method)	40 mL amber glass VOA vial/2	Refrigerate <u><</u> 6°C	14 days
Microbial	NA	1 L plastic amber/2 Autoclaved	Refrigerate <u><</u> 6°C	NA

Comment [CV109]: Where are the radionuclides, analyses must be done on both filtered and unfiltered samples

[†] trisodium phosphate
 ^{††} above freezing point of water
 ^{**} Spare bottles made available for laboratory QC samples and for replacement of compromised samples (broken bottle, QC fail-

ures, etc.).

** under development

2-31 02:002233_0696_SGTG-B3494 4_attachment_EPA CIIK Case Study QAPP working copy 121611 (CEPA CHK Co 10/21/20138/6/20131/6/20121/6/20121/6/20121/2/20/2011 OADD ppy 121611.doc Section No.: 2 Revision No.: 90 Date: May October 21, 2013August 6, 2013January 6, 2012January 6, 2012January 6, 2012December 20, 2011

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			Acceptance Cr	
QC Sample	Purpose	Method	Frequency	Corrective Action*
Trip Blanks	Assess contamina-	Fill bottles with	One in each ice	<rl*; if="">RL, PI will</rl*;>
(VOCs and Dis-	tion during trans-	reagent water and	chest with VOA	determine if signifi-
solved Gases only)	portation.	preserve, take to	and dissolved gas	cant relative to sample
		field and returned	samples.	data.
		without opening.		
Equipment Blanks	Assess contamina-	Apply only to	One every two	<rl; if="">RL, PI will</rl;>
	tion from field	samples collected	days of sampling.	determine if signifi-
	equipment, sam-	via equipment,		cant relative to sample
	pling procedures,	such as filtered		data.
	decon procedures,	samples: Reagent		
	sample container,	water is filtered		
	preservative, and	and collected into		
	shipping.	bottles and pre-		
		served same as		
F'11D 1' (D ()	filtered samples.	0 10	
Field Duplicates	Represent preci-	One or more sam-	One in every 10	Report duplicate data;
	sion of field sam-	ples collected im-	samples, or 11 <10	RPD > 50 for results
	ping, analysis, and	original comple	for a water type	offected data will be
	site neterogeneity.	original sample.	for a water type	flagged as peeded
			(ground or sur-	naggeu as neeueu.
			duplicate for one	
			sample	
Temperature	Measure tempera-	Water sample that	One per cooler	Record temperature:
Blanks	ture of samples in	is transported in	one per cooler.	condition noted on
Dimino	the cooler.	cooler to lab.		COC form***
Field Blanks**	Assess contamina-	In the field, rea-	One per day of	<rl*; if="">RL, PI will</rl*;>
	tion introduced	gent water is col-	sampling.	determine if signifi-
	from sample con-	lected into sample	10	cant relative to sample
	tainer with appli-	containers with		data.
	cable preservative.	preservatives.		
	-			

Table 7 Field QC Samples for Water Samples

*- Reporting limit or Quantitation Limit

** - Blank samples will not be collected for isotope measurements, including O, H, C, and Sr.

*** - The PI should be notified immediately if samples arrive with no ice and/or if the temperature recorded from temperature blanks is greater than or equal to 12 °C. These samples will be flagged accordingly.

2.2.4 Domestic Wells, Water Supply Wells, and Municipal Supply Well Sampling

Domestic wells will be sampled directly from the <u>well or the tap (if necessary)</u>, by accessing the well directly using pumps lowered down the well casing to immediately above the existing pump. Drawdown of the water table will be tracked by taking water level measurements during well purging and sampling. The water level measurements will follow the RSKSOP-326 standard operating procedure

02:002233_0696_SGTG-B3494 2-32 <u>4_attachment_EPA CHK Case Study QAPP working copy 121611 (CEPA CHK Case Study QAPP working copy 121611.doe</u> <u>10/21/20138/6/20131/6/20121/6/20121/2/20/2011</u> **Comment [c110]:** Need to define how the intake location will be determined, purging times and volumes, and be aware of any in-home water softeners or other treatment units or filters. It is preferable to collect from before the pressure tank, if possible. Use of the well by the landowner in the proceeding 24 hour period must be identified, and experience has shown that use by homeowner can dramatically affect the results, especially heavy use in a low yielding well. Must document this prior to sampling.

Comment [CV111]: Type of pump? Some pumps not well suited for the collection of groundwater samples for VOC analyses. Section No.: 2 Revision No.: 00 Date: May October 21, 2013August 6, 2013January 6, 2012January 6, 2012January 6, 2012December 20, 2011

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(see Appendix A.11). Water levels will be recorded in a field notebook. If the well cannot be accessed directly, the sample will be collected from the closest port to the well, preferably before the pressure tank, any water softeners, treatments systems, and filters. Use of the well by the landowner in the preceding 24 hour will be documented. In addition, the homeowner will be interviewed regarding historical water quality issues (e.g., iron or Mn staining, scale buildup, odors, salty tasting water, turbidity issues, and yield issues). The interview will also include questions about well construction, depth, when drilled, driller, etc. For all duplicate and split samples, an in-line "T" shall be installed on the sample discharge tubing so that the original sample and duplicate sample bottles can be filled simultaneously. When split samples are collected at locations with duplicate samples, multiple inline "T"s" will be utilized so that the original, duplicate, and split sample bottles can all be filled simultaneously:

- 1. At each sampling site, GPS coordinates will be collected with a handheld device. Photos will be taken and stamped with the date. Pertinent information about well will (as described above) be recorded where possible. The groundwater level will next be measured using a Solinst water level indicator (or equivalent) and recorded. In cases where a remote pump can be used, the pump will be hooked up with new polyethylene tubing. Tubing will be changed in between each well and the pump will be rinsed with distilled water. The pump (Proactive Hurricane or equivalent) will be lowered down the well casing to a level selected in the field and powered on. In most cases, well construction details will not be available. The goal in domestic well sampling is generally to purge sufficient water to access native aquifer water prior to sampling. Professional judgment will be used in the field and consider variables such as water volume pumped, water level drawdown, and stabilization of geochemical parameters. In all cases, the water volume pumped will be tracked by recording time and purge rate. It is expected that the pump will yield an initial flow rate of approximately 1-2 L/min. This flow will pass through a flow cell equipped with a YSI 5600 multiparameter probe (or equivalent probes). The rate of pumping will be determined by measuring the water volume collected after approximately 15 seconds into a 4 L graduated cylinder; the desirable pumping rate through the flow cell should be less than 2 L/min. The pumping rate will ideally maintain minimal drawdown. Draw down will be monitored by measuring the water level (where possible) approximately every 10 to 15 minutes.
- 2. The YSI probe (or equivalent probes and electrodes) will be used to track the stabilization of pH, oxidation-reduction potential (ORP), specific conductance (SC), dissolved oxygen (DO), and temperature. In general, the following guidelines in Table 4 will be used to determine when parameters have stabilized. These criteria are initial guidelines; professional judgment in the field will be used to determine on a well-by-well basis when stabilization occurs.

Comment [CV112]: Sub-meter unit.

Comment [CV113]: Is this pump well suited for collecting groundwater samples for VOC analyses?

Comment [CV114]: The frequency of recording should be specified.

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<u>Field readings must be recorded at no more than 5 minute intervals, or contin</u>uously if continuous recordings are being used, until stabilization occurs.

- 3. Once stabilization occurs, the final values for pH, ORP, specific conductance, dissolved oxygen, and temperature will be recorded. For these well types it will be assumed that once stabilization occurs that the samples collected will be water from the formation and not water entrained in the well bore.
- 4. After the values for pH, ORP, SC, DO, and temperature have been recorded, the flow cell will be disconnected. A series of unfiltered samples and filtered samples will be collected as in section 2.2.1.1 number 5. Following completion of the field filtration for metals, a small portion will be collected and tested for turbidity to document that sediment pass through did not occur.

See Tables 6 and 7 for numbers of sample bottles needed for each sample type and field QC samples for ground and surface water sampling.

2.2.5 Surface Water Sampling

Two surface water samples will be collected from the locations depicted on Figure 4 using the direct method typically used for stream sampling. Following completion of hydraulic fracturing activities, two confirmation samples will also be collected from the same locations. Sampling stations will be accessed from the bank or if necessary using waders.

Methods will be provided if there is a surface water body present that can serve as a source of drinking water.

Sample bottles will be submerged into the surface water just below the surface and filled as grab samples. The locations of the sampling sites will be recorded with a handheld GPS device. The site will be photographed. General observations about the flow and the stream depth will be recorded in a field notebook. The sampling will be performed as to minimize any capture of sediment into the sam-

pling bottles. In cases where clear (turbidity <<u>20-10</u> NTUs) water cannot be retrieved, water samples for metals, all isotope analyses, anions, nutrients, and inorganic/organic carbon will be filtered using a peristaltic pump and a high-capacity (0.45 micron) capsule filter. Clean tubing will be used prior to any sampling and filtration. The readings from the YSI will be recorded by inserting the probe set with protective cover directly into the surface water body and allowing readings to stabilize. Again the logging function will be utilized and readings will be recorded in a field notebook. Following completion of the field filtration for metals, a small portion will be collected and tested for turbidity to document that sediment pass through did not occur.

2.2.6 Soil Sampling

Soil sampling will be accomplished using hand held samplers since all samples will be surface soil samples collected from 0 to 6 – inches in depth-<u>Using sampling procedures outline below and in Appendix A.13 (ENV 3.13)</u>

02:002233_0696_SGTG-B3494 2-34 4_attachment_EPA_CHK_Case Study_QAPP_working_copy_121611_(CEPA_CHK_Case Study_QAPP_working_copy_121611.doe-10/21/20138/6/20131/6/20121/6/20121/2/202011 **Comment [CV115]:** As previously stated, measure turbidity of filtered sample in field and record in log book to insure and document did not have sediment breakthrough in filters.

Comment [n116]: See new sentence above regarding gw-sw interactions

Comment [CV117]: Submerging sample containers will allow preservatives to escape. Possibly utilize Kemmerer sampler or other applicable methods.

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2.2.6.1 Soil Sampling Procedures. Comment [CV118]: Why not use Terra-core samplers Composite surface soil samples will be collected from the locations shown on Figure 4. Additionally, discreet samples will be collected from the same locations for volatile organic analysis. Dedicated sampling equipment will be used at each location for sample collection. Soil samples will be collected using the following procedure: 1. Carefully remove the top layer of soil/vegetation to the desired sample depth with a pre-cleaned spade; Comment [CV119]: MDH: Is a rinse/decon blank performed on any "pre-cleaned" device used in between sampling events? 2. Using a stainless-steel scoop, spoon, trowel, or plastic spoon, remove and discard the thin layer of soil from the area that came into contact with the shovel; 3. Transfer the sample into an appropriate container (stainless steel bowl) using a stainless-steel or plastic lab spoon or equivalent. Composite samples will be placed in a stainless-steel bowl and mixed thoroughly to obtain a homogeneous sample representative of the entire sampling interval. Place the soil samples into labeled containers; 4. VOA samples will be collected directly from the bottom of the hole before mixing the sample to minimize volatilization of contaminants; 5. Check to ensure that the VOA vial Teflon liner is present in the cap, if reguired. Fill the VOA vial fully to the top to reduce headspace. Secure the cap tightly. The chemical preservation of solids is generally not recommended. Refrigeration is usually the best approach, supplemented by a minimal holding time; Comment [CV120]: MDH: For soil sampling, EPA Method 5035 should be used for VOC analysis. Filling a 40-mL VOA vial to the top does not allow 6. Ensure that a sufficient sample size has been collected for the desired analysis; room for chemical preservative and/or purge water for proper purge and trap analysis. Method 5035 should be strictly followed in these cases 7. Split the homogenized sample into appropriate containers a. Metals; b. General parameters (pH, Eh, electrical conductivity, BOD, total organic Comment [c121]: Needs to be conducted using the saturated paste method. carbon, total inorganic carbon); Comment [c122]: The purpose of soil BOD, TOC, TIC is not understood c. Chemical Analysis (CEC, amporphous Al, Fe, Mn, acid volatile sulfur); Comment [c123]: ? I d. VOC and semi-VOC; e. Organic chemical analysis (for example THP, DRO, GRO, PAH, etc.);

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f.	Isotopic analysis	·	ſ	Comment [c124]: In bullet f, please define iso-
				topic analyses intended, section h define mineralogi- cal analyses intended
g.	Particle size analysis	Ì		Comment [c125]: This needs to be defined.
			1	Comment [c126]: This needs to be defined.
h. Mi	neralogical Analysis	·	-{	Comment [c127]: Add moisture content.

2. Data Generation and Acquisition

8. Fill in the hole and replace grass turf, if necessary.

2.2.7 Mechanical Well Integrity Testing

Mechanical Integrity Test Meeting Summary

- The information provided in this summary is general in nature to the Haynesville shale play; however, it should be noted that each well within the play is designed and constructed fit-for-purpose and for the specifics of the location.
- The USDW depths very throughout the Haynesville shale play, however, within the study area the base of the USDW has been identified as 780 ft (<u>http://sonris.com/</u>).
- Conductor Casing
 - The conductor casing is set at 80 ft and cemented to surface.
- Surface Casing
 - The surface casing is set at approximately 1,850 ft and cemented to the surface, per LA State regulations greater than 1,800 ft (Title 43 Part XIX §109).
 - Cement is allowed to cure.
 - A pressure test is conducted on the casing at a pressure of 1,500 psi for 30 min.
 - Shoe is drilled out.
 - A pressure test (or shoe test) is conducted by sealing the volume between the well head and a packer located just below the surface casing shoe and applying an equivalent mud weight of 12 lb/gal.
 - Wellbore is drilled to the desired intermediate casing depth (typically 10,500 11,500 ft).
 - A pressure test is conducted on the surface casing by sealing the volume between the well head and a packer located just above the surface casing shoe and a pressure of 1,500 psi for 30 min.
- Intermediate Casing (7 5/8")

Comment [c128]: A meeting summary CHK provided to the EPA was simply pasted below. EPA needs to determine based on the objectives of the study the exact information need. This has not been clearly communicated to CHK. Date: May October 21, 2013August 6, 2013January 6, 2012January 6, 2012January 6, 2012December 20, 2011

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- The intermediate casing is installed and cemented to cover oil and gas bearing zones, which varies by location.
- A broader discussion of the isolation of oil and gas bearing zones can be found in API STD 65-2 Isolating Potential Flow Zones During Well Construction (<u>http://www.api.org/policy/exploration/hydraulicfracturing/</u>)
- The staging of cement is not typically required for this particular area.
- The designed extent of cement above oil and gas bearing zones is typically 500 ft.
- After the cement has cured, a pressure test is conducted on the intermediate casing with 16.5 – 17.5 lb/gal equivalent mud weight (typical 15.5 lb/gal with appropriate pressure applied at surface).
- The shoe is drilled out approximately 10 ft.
- A pressure test (shoe test) is conducted for 30 min with 16.5 17.5 lb/gal equivalent mud weight (typical 15.5 lb/gal with appropriate pressure applied at surface).
- Production Casing (5 ¹/₂")
 - Directionally drill production wellbore. Laterals are typically 5,000 ft with 4,500 ft in target zone. (standard sq. mi. sections)
 - Run casing string and cement. The designed extent of cement above the intermediate shoe is typically a minimum of 500 ft.
 - Drilling rig demobilization
 - Clean up lateral and prepare for completion, displacing oil based mud with clear fluid.
 - Conduct cement bond log (CBL) in production casing
 - Basic acoustic CBL tool
 - Run tool as it will run on $\frac{1}{2}$ wireline. Typically 30° to 60°.
 - Run under zero pressure to identify top of cement
 - Re-run with applied pressure if the result of initial run is not definitive.
 - Pressure test production casing for 30 min at maximum fracture pressure (12,500 psi).
 - Pressure test production and intermediate casing annulus for 30 min at 2,500 psi.
- Completion
 - Well is stimulated with multiple fracturing stages utilizing the "plug and perf" method. Frac plugs are set between each stage.
 - Continuous monitoring of backside pressure.
 - 2,000 2,500 psi applied pressure maintained on the production- intermediate casing annulus.
 - Pressure monitoring of annulus between production and intermediate casing.
 - Drill out plugs with coil tubing

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- Install packer (with ceramic disk in the bottom of the packer) between top perforation and top of the cement.
- Pressure test packer
 - Apply 4,000 psi above packer (also applied to production casing).
 - Negative pressure test by bleeding off pressure and creating a differential from formation pressure.
- Install 2 3/8" production tubing and tree
 - Test tree to 10,000 psi
 - Test tubing to 6,000 6,500 psi
 - Test tubing casing annulus to 2,500 psi
- Ceramic disk is removed.
- Operating pressure
 - Well is ready for production.
 - Typical shut-in tubing pressure after flowback is 7,000 8,000 psi.
 - Telemetry is used to continuously monitor flows and pressures.
 - Tubing pressure
 - Production casing pressure
 - Tubing and production casing annular pressure.
 - Production and intermediate casing annular pressure.
 - Intermediate and surface casing annular pressures.
 - Annular pressure is managed throughout the life of the well. (API RP-90 Annular Casing Pressure Management)

2.2.8 Flow Back Sampling

Quarterly flowback water sampling will be conducted over a period of 120, beginning immediately following the completion of hydraulic fracturing activities. The process for collecting flowback/produced water is described in Appendix A.14.

2.3 Sample Handling and Custody

2.3.1 Sampling Labeling

Each well, surface water body and soil sample location will be uniquely labeled. Samples collected from each of these locations will also include the unique label, well # or name of sample location, the date, the initials of the sampler, and designation of the sample type, e.g., "metals" and preservation technique (when applicable). This information will be recorded onto labeling tape, using water-insoluble ink, affixed to each sample bottle.

2.3.2 Sample Packing and Shipping

All samples will placed together in a sealed Ziploc plastic bag. The bags will be placed on <u>wet</u> ice in coolers. Glass bottles will be packed with bubble wrap to prevent breakage. The coolers will be sent via <u>FedEx</u>, overnight, to the appropriate lab with chain of custody forms (see Figure 8) and custody seal.

02:002233_0696_SGTG-B3494 2-38 <u>4_attachment_EPA_CHIK Case Study QAPP working copy 121611 (CEPA CHK Case Study QAPP working copy 121611.doc</u> 10/21/20138/c20131/6/20121/6/20121/2/202011 Comment [nc129]: Appears to be misplaced.

Comment [CV130]: No mention of QA/QC samples, e.g. duplicates, trip blanks, field blanks, etc.

Comment [CV131]: Flowback/Produced water samples.

Comment [CV132]: MDH: No information is provided on where to send split samples...is this to be included

Comment [CV133]: The flowback/produced water samples may need to be pre-chilled prior to packaging for shipment as the temperature of these samples are often quite warm at the time of collection.

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R.S. Kerr Environmental Research Center
919 Kerr Research Drive
Ada, OK 74820
1-580-436-8920
ATTN: Andrew Greenwood
(for samples analyzed by both Shaw and EPA General Parameters Laboratory)

EPA Region 8 Lab 16194 West 45th Drive Golden, CO 80403 1-303-312-7775 ATTN: Mark Murphy Sample receipt and log-in at the Region 8 laboratory shall be conducted as described in their SOP, *Sample Receipt and Control Procedure*, #GENLP-808 Rev. 1.0 and the Region 8 Quality Manual, # QSP-001 Rev. 1.0

EPA Region 3 Lab 701 Maples Road Ft. Meade, MD 20755 1-410-305-2835 ATTN: Jennie Gundersen

Sample receipt and log-in at the Region 3 laboratory shall be conducted as described in their SOP, *Sample Scheduling, Receipt, Log-In, Chain of Custody, and Disposal Procedures*, R3-QA061.

2.4 Analytical Methods

Ground-water samples will be collected and analyzed using RSKERC standard operating procedures (RSKSOPs) at RSKERC and EPA Methods at the Region VIII laboratory (Table 6).

Region III's LC-MS-MS method for glycols is under development with the intent to eventually have a validated, documented method. Aqueous samples are injected directly on the HPLC after tuning MS/MS with authentic standards (2butoxyethanol, di-, tri-, and tetraethylene glycols) and development of the HPLC gradient. HPLC column is Waters (Milford MA) Atlantis dC18 3um, 2.1 x 150mm column (p/n 186001299). HPLC gradient is with H₂O and CH₃CN with 0.1% formic acid. The 3 glycols are run on a separate gradient than the 2butoxyethanol. All details of instrument conditions will be included in case file. EPA SW-846 Method 8000B and C are used for basic chromatographic procedures. A suitable surrogate has not been identified. Since there is no extraction or concentration step in sample preparation, extraction efficiency calculations using a surrogate are not applicable. If a suitable surrogate is found, it will be used **Comment [nc134]:** Need to be consistent on references throughout the document on use of roman numerals or not

Comment [CV135]: LC-MS-MS for glycols is a suitable method currently under evaluation but not widely accepted or validated. May be suitable for baseline analyses but potential interferences from high solids and salt content in flowback water and produced water may be an issue with this method. Regardless, all methods used should be validated prior to use.

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to evaluate matrix effects. Custom standard mix from Ultra Scientific, (Kingstown RI) is used for the instrument calibration (IC). The working, linear range varies for each compound but is about 10-100 μ g L⁻¹ and may change with further development. Initial Calibration (IC) is performed before each day's sample set, calibration verification is done at the beginning, after every 10 sample injections, and at the end of a sample set. The correlation coefficient (r^2) of the calibration curve must be >0.99. An instrument blank is also run after every 10 sample injections. The performance criteria are provided in Table 8. The system is tuned with individual authentic standards (at 1mg L^{-1} concentration) of each compound according to the manufacturer's directions using the Waters Empower "Intellistart" tune/method development program in the MRM (multiple reaction monitoring) ESI+ (electrospray positive) mode. Tune data is included in the case file. Target masses, transition data and voltages determined in each tune for each compound are compiled into one instrument method. Only one MS tune file (which determines gas flow rates and source temperatures) may be used during a sample set. For these samples, the tetraethylene glycol tune is used as it provides adequate response for all targets. Due to differences in optimal chromatographic separation, the three glycols are analyzed in one run and 2-butoxyethanol is analyzed separately. Exact mass calibration of the instrument is done annually with the preventive maintenance procedure. Mass calibration was successfully performed according to manufacturer's specifications with NaCsI on 6/17/2010 by a certified Waters Corp Service technician. Custom mix supplied by Accustandard (New Haven, CT) is used as a second source verification (SSV). The SSV is run after IC. Matrix spikes and matrix spike duplicates are also performed.

QC Type	Performance Criteria	Frequency
Method Blanks	<rl< td=""><td>One per every 20 samples</td></rl<>	One per every 20 samples
Solvent Blanks	<rl< td=""><td>One per every 10 samples</td></rl<>	One per every 10 samples
Initial and Continuing	80-120% of expected	At beginning of sample set, every tenth
Calibration Checks	value	sample, and end of sample set
Second Source Stand-	80-120% of expected	Each time calibration performed
ards	value	
Laboratory Control	80-120% of expected	One per analytical batch or every 20 sam-
Samples (LCS)	value	ples, whichever is greater
Matrix Spikes (MS)	70-130% of expected	One per sample set or every 20 samples,
	value	whichever is more frequent
MS/MSD	RPD <u><</u> 25	One per sample set or every 20 samples,
		whichever is more frequent

Table 8	Region III Laboratory	y QA/QC Req	luirements f	for Gly	/cols
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Analysis at RSKERC includes inductively coupled plasma – optical emission spectroscopy (ICP-OES; for cations), inductively coupled plasma – mass spectroscopy (ICP-MS; for trace metals), capillary electrophoresis (CE, for anions), carbon analysis using combustion and infrared detection, gas chromatography (GC, for dissolved gas analysis) and gas chromatography-mass spectroscopy (GC-

02:002233_0696_SGTG-B3494 2-40 4_attachment_EPA CIIK Case Study QAPP working copy 121611 (CEPA CHK Case Study QAPP working copy 121611.doc 10/21/20138/6/20131.%20121/6/20121/2/20/2011 Section No.: 2 Revision No.: 00 Date: <u>May October 21, 2013August 6, 2013January 6, 2012January 6, 2012January 6, 2012December 20, 2011</u>

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MS) for VOCs. Analysis by the EPA Region VIII laboratory includes GC for GRO, DRO, and GC-MS for semivolatiles with appropriate sample preparation and introduction techniques. These analytical methods are presented in Table 6.

The RSKSOPs and their associated target analyte list are presented in Table 9. For these analyses, the only surrogates used are for the VOC analysis. Surrogate compounds used are p-bromofluorobenzene and 1,2-dichlorobenzene-d4, spiked at 100 ug/L.

Comment [nc136]: Need to be consistent in references to SVOCs as SVOC or semi-VOC or semivolatiles

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Insert Figure (color) page 1 of 2

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Chain of Custody Form for Submittal of Samples to R.S. Kerr Environmental Research Center

02:002233_0696_SGTG-B3494 2-42 <u>4_attachment_EPA CHK Case Study QAPP working copy 121611 (CEPA CHK Case Study QAPP working copy 121611.doe-10/21/20138/6/20131/6/20121/6/20121/2/20/2011</u> Section No.: 2 Revision No.: 90 Date: <u>May October 21, 2013August 6, 2013January 6, 2012January 6, 2012January 6, 2012December 20, 2011</u>

2. Data Generation and Acquisition

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02:002233_0696_SGTG-B3494 2-43 <u>4_attachment_EPA_CIIK_Case_Study_QAPP_working_copy_121611_(CEPA_CHK_Case_Study_QAPP_working_copy_121611.doe-</u> 10/21/20138/6/20131-6/20121/6/20121/2/20/2011

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Analyta	Mathad		QL or LOQ
VOCs	Metriod		(µg/⊏)
Vinyl chloride	RSKSOP-299v1	0.18	0.50
Ethanol	RSKSOP-299v1	18.0	100
1.1-Dichloroethene	RSKSOP-299v1	0.12	0.50
Acetone	RSKSOP-299v1	3.45	10.0
Isopropyl alcohol	RSKSOP-299v1	2.37	10.0
Carbon disulfide	RSKSOP-299v1	0.21	0.50
Methylene chloride	RSKSOP-299v1	0.21	1.00
t-Butyl alcohol	RSKSOP-299v1	2.41	10.0
Methyl t-butyl ether	RSKSOP-299v1	0.09	1.00
t-1.2-Dichloroethene	RSKSOP-299v1	0.10	0.50
1.1-Dichloroethane	RSKSOP-299v1	0.13	0.50
Diisopropyl ether	RSKSOP-299v1	0.11	1.00
Ethyl t-butyl ether	RSKSOP-299v1	0.08	1.00
c-1.2-Dichloroethene	RSKSOP-299v1	0.14	0.50
Chloroform	RSKSOP-299v1	0.13	0.50
1.1.1-Trichloroethane	RSKSOP-299v1	0.13	0.50
Carbon tetrachloride	RSKSOP-299v1	0.12	0.50
Benzene	RSKSOP-299v1	0.06	0.50
1.2-Dichloroethane	RSKSOP-299v1	0.21	0.50
t-Amyl methyl ether	RSKSOP-299v1	0.09	1.00
Trichloroethene	RSKSOP-299v1	0.09	0.50
Toluene	RSKSOP-299v1	0.08	0.50
1,1,2-Trichloroethane	RSKSOP-299v1	0.21	0.50
Tetrachloroethene	RSKSOP-299v1	0.13	0.50
Chlorobenzene	RSKSOP-299v1	0.08	0.50
Ethyl benzene	RSKSOP-299v1	0.06	0.50
m/p-Xylene	RSKSOP-299v1	0.09	1.00
o-Xylene	RSKSOP-299v1	0.08	0.50
Isopropyl benzene	RSKSOP-299v1	0.05	0.50
1,3,5-Trimethylbenzene	RSKSOP-299v1	0.05	0.50
1,2,4-Trimethylbenzene	RSKSOP-299v1	0.05	0.50
1,3-Dichlorobenzene	RSKSOP-299v1	0.16	0.50
1,4-Dichlorobenzene	RSKSOP-299v1	0.17	0.50
1,2,3-Trimethylbenzene	RSKSOP-299v1	0.07	0.50
1,2-Dichlorobenzene	RSKSOP-299v1	0.10	0.50
Naphthalene	RSKSOP-299v1		1.00
Vinyl chloride	RSKSOP-259v1	0.31	0.5
Ethanol	RSKSOP-259v1	54.7	100
1,1-Dichloroethene	RSKSOP-259v1	0.10	0.5
Analyte	Method	MDL (µg/L)	QL or LOQ

Table 9 **RSKERC Detection Limits for Various Analytes**

2-44

02:002233_0696_SGTG-B3494 2--<u>4_attachment_EPA_CHK_Case_Study_QAPP_working_copy_121611_(CEPA_CHK_Case_10/21/20138/6/20131/6/20121/6/20121/2/20/2011</u> ly QAPP working copy 121611.docSection No.: 2 Revision No.: 90 Date: <u>May October 21, 2013August 6, 2013January 6, 2012January 6, 2012January 6, 2012December 20, 2011</u>

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			(µg/L)
Acetone	RSKSOP-259v1	3.97	5.0
Isopropyl Alcohol	RSKSOP-259v1	14.2	50.0
Methylene Chloride	RSKSOP-259v1	0.10	0.5
t-Butyl alcohol	RSKSOP-259v1	0.38	1.0
Methyl t-butyl ether	RSKSOP-259v1	0.10	0.5
t-1,2-Dichloroethene	RSKSOP-259v1	0.10	1.0
1,1-Dichloroethane	RSKSOP-259v1	0.10	0.5
Diisopropyl ether	RSKSOP-259v1	0.27	1.0
Ethyl-t-butyl ether	RSKSOP-259v1	0.17	1.0
c-1,2-Dichloroethene	RSKSOP-259v1	0.10	0.5
Chloroform	RSKSOP-259v1	0.10	0.5
1,1,1-Trichloroethane	RSKSOP-259v1	0.10	1.0
Carbon tetrachloride	RSKSOP-259v1	0.10	0.5
Benzene	RSKSOP-259v1	0.10	1.0
1,2-Dichloroethane	RSKSOP-259v1	0.10	1.0
t-Amyl methyl ether	RSKSOP-259v1	0.10	0.5
Trichloroethene	RSKSOP-259v1	0.10	1.0
Toluene	RSKSOP-259v1	0.10	0.5
Tetrachloroethene	RSKSOP-259v1	0.10	1.0
Chlorobenzene	RSKSOP-259v1	0.10	0.5
Ethyl benzene	RSKSOP-259v1	0.10	0.5
m/p-Xylene	RSKSOP-259v1	0.10	1.0
o-Xylene	RSKSOP-259v1	0.10	0.5
1,3,5-Trimethylbenzene	RSKSOP-259v1	0.10	0.5
1,2,4-Trimethylbenzene	RSKSOP-259v1	0.10	1.0
1,3-Dichlorobenzene	RSKSOP-259v1	0.10	0.5
1,4-Dichlorobenzene	RSKSOP-259v1	0.10	0.5
1,2,3-Trimethylbenzene	RSKSOP-259v1	0.10	0.5
1,2-Dichlorobenzene	RSKSOP-259v1	0.10	1.0
Naphthalene	RSKSOP-259v1	0.16	0.5
Metals ICP-MS			
As	RSKSOP-257v3/-332v0	0.050	0.167
Be	RSKSOP-257v3/-332v0	0.005	0.015
Cd	RSKSOP-257v3/-332v0	0.020	0.067
Cr	RSKSOP-257v3/-332v0	0.037	0.124
Cu	RSKSOP-257v3/-332v0	0.287	0.957
Fe	RSKSOP-257v3/-332v0	0.105	0.350
Hg	RSKSOP-257v3/-332v0	0.019	0.064
Mn	RSKSOP-257v3/-332v0	0.037	0.124
Мо	RSKSOP-257v3/-332v0	0.008	0.027
Ni	RSKSOP-257v3/-332v0	0.048	0.160

Table 9	RSKERC Detection Limits for Va	rious Analytes
		nious Analytes

02:002233_0696_SGTG-B3494 2-45 <u>4_attachment_EPA_CHK_Case_Study_QAPP_working_copy_121611_(CEPA_CHK_Case_Study_QAPP_working_copy_121611.doe-</u> 10/21/20138/6/20131-6/20121/6/20121/6/20121/2/20/2011

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RSKERC Detection Limits for Various Analytes Table 9

			QL or LOQ
Analyte	Method	MDL (µg/L)	(µg/L)
Pb	RSKSOP-257v3/-332v0	0.043	0.143
Sb	RSKSOP-257v3/-332v0	0.014	0.047
Se	RSKSOP-257v3/-332v0	0.159	0.530
Sr	RSKSOP-257v3/-332v0	0.012	0.040
Tl	RSKSOP-257v3/-332v0	0.04	0.013
V	RSKSOP-257v3/-332v0	0.003	0.010
Zn	RSKSOP-257v3/-332v0	0.072	0.240
U	RSKSOP-257v3/-332v0	0.002	0.007
Ce	RSKSOP-257v3/-332v0	0.006	0.020
			QL or LOQ
Metals ICP-OES	Method	MDL (mg/L)	(mg/L)
Na	RSKSOP-213v4	0.046	0.154
K	RSKSOP-213v4	0.029	0.097
Ca	RSKSOP-213v4	0.026	0.087
Mg	RSKSOP-213v4	0.013	0.044
Fe	RSKSOP-213v4	0.013	0.044
Mn	RSKSOP-213v4	0.001	0.004
Со	RSKSOP-213v4	0.001	0.004
Мо	RSKSOP-213v4	0.001	0.004
Al	RSKSOP-213v4	0.024	0.080
As	RSKSOP-213v4	0.007	0.024
Se	RSKSOP-213v4	0.007	0.024
Cd	RSKSOP-213v4	0.001	0.004
Be	RSKSOP-213v4	0.001	0.004
Cu	RSKSOP-213v4	0.002	0.007
Sb	RSKSOP-213v4	0.008	0.027
Cr	RSKSOP-213v4	0.001	0.004
Ni	RSKSOP-213v4	0.001	0.004
Zn	RSKSOP-213v4	0.005	0.017
Ag	RSKSOP-213v4	0.003	0.010
Tl	RSKSOP-213v4	0.009	0.030
Pb	RSKSOP-213v4	0.003	0.010
Sr	RSKSOP-213v4	0.001	0.004
V	RSKSOP-213v4	0.002	0.007
Ba	RSKSOP-213v4	0.001	0.004
В	RSKSOP-213v4	0.005	0.017
Ti	RSKSOP-213v4	0.001	0.004
Si	RSKSOP-213v4	0.019	0.064
Р	RSKSOP-213v4	0.011	0.037
S	RSKSOP-213v4	0.026	0.087
U	RSKSOP-213v4	0.009	0.030

Comment [CV137]: MDH: I believe this is to be Cs for Cesium and not Ce for Cerium.

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Table 9 RSKERC Detection Limits for Various Analytes

			QL or LOQ
Metals ICP-OES	Method	MDL (mg/L)	(mg/L)
Methane	RSKSOP-194v4 &	0.08	1.5
	RSKSOP-175v5		
Ethylene	RSKSOP-194v4 &	0.56	4.11
-	RSKSOP-175v5		
Ethane	RSKSOP-194v4&	0.20	2.91
	RSKSOP-175v5		
Acetylene	RSKSOP-194v4 &	2	18.7
	RSKSOP-175v5		
Carbon Dioxide	RSKSOP-194v4&	20.4	262
	RSKSOP-175v5		
Propane	RSKSOP-194v4&	0.24	4.1
	RSKSOP-175v5		
Butane	RSKSOP-194v4&	0.22	5.22
	RSKSOP-175v5		
Hydrogen	RSKSOP-194v4&	0.01	0.33
	RSKSOP-175v5		
			QL or LOQ
Anions/Nutrients	Method	MDL (mg/L)	QL or LOQ (mg/L)
Anions/Nutrients Br ⁻	Method RSKSOP-276v3	MDL (mg/L) 0.248	QL or LOQ (mg/L) 1.00
Anions/Nutrients Br ⁻ Cl ⁻	Method RSKSOP-276v3 RSKSOP-276v3	MDL (mg/L) 0.248 0.118	QL or LOQ (mg/L) 1.00 1.00
Anions/Nutrients Br Cl SO4 ²⁻	Method RSKSOP-276v3 RSKSOP-276v3 RSKSOP-276v3	MDL (mg/L) 0.248 0.118 0.226	QL or LOQ (mg/L) 1.00 1.00 1.00
Anions/NutrientsBrCl' $SO_4^{2^2}$ $NO_3^- + NO_2^-$	Method RSKSOP-276v3 RSKSOP-276v3 RSKSOP-276v3 RSKSOP-214v5	MDL (mg/L) 0.248 0.118 0.226 0.014	QL or LOQ (mg/L) 1.00 1.00 1.00 0.10
Anions/NutrientsBrCl $SO_4^{2^-}$ $NO_3^- + NO_2^-$ F	Method RSKSOP-276v3 RSKSOP-276v3 RSKSOP-276v3 RSKSOP-214v5 RSKSOP-276v3	MDL (mg/L) 0.248 0.118 0.226 0.014 0.052	QL or LOQ (mg/L) 1.00 1.00 0.10 0.20
Anions/NutrientsBrCI $SO_4^{2^-}$ $NO_3^- + NO_2^-$ F NH_4^+	Method RSKSOP-276v3 RSKSOP-276v3 RSKSOP-276v3 RSKSOP-214v5 RSKSOP-276v3 RSKSOP-214v5	MDL (mg/L) 0.248 0.118 0.226 0.014 0.052 0.012	QL or LOQ (mg/L) 1.00 1.00 0.10 0.20 0.05
Anions/NutrientsBrCI $SO_4^{2^-}$ $NO_3^- + NO_2^-$ FNH4^+Low Molecular	Method RSKSOP-276v3 RSKSOP-276v3 RSKSOP-276v3 RSKSOP-214v5 RSKSOP-276v3 RSKSOP-214v5	MDL (mg/L) 0.248 0.118 0.226 0.014 0.052 0.012	QL or LOQ (mg/L) 1.00 1.00 0.10 0.20 0.05
$\begin{tabular}{lllllllllllllllllllllllllllllllllll$	Method RSKSOP-276v3 RSKSOP-276v3 RSKSOP-276v3 RSKSOP-214v5 RSKSOP-276v3 RSKSOP-214v5	MDL (mg/L) 0.248 0.118 0.226 0.014 0.052 0.012 MDL (mg/L)	QL or LOQ (mg/L) 1.00 1.00 0.10 0.20 0.05 QL (mg/L)
Anions/NutrientsBrCl $SO_4^{2^-}$ $NO_3^- + NO_2^-$ FNH4^+Low Molecular Weight AcidsLactate	Method RSKSOP-276v3 RSKSOP-276v3 RSKSOP-276v3 RSKSOP-214v5 RSKSOP-214v5 RSKSOP-214v5 RSKSOP-214v5	MDL (mg/L) 0.248 0.118 0.226 0.014 0.052 0.012 MDL (mg/L) 0.020	QL or LOQ (mg/L) 1.00 1.00 0.10 0.20 0.05 QL (mg/L) 0.100
Anions/NutrientsBrCl $SO_4^{2^-}$ $NO_3^- + NO_2^-$ FNH4^+Low Molecular Weight AcidsLactateIsobutyrate	Method RSKSOP-276v3 RSKSOP-276v3 RSKSOP-276v3 RSKSOP-214v5 RSKSOP-214v5 RSKSOP-214v5 RSKSOP-214v5 RSKSOP-112v6 RSKSOP-112v6	MDL (mg/L) 0.248 0.118 0.226 0.014 0.052 0.012 MDL (mg/L) 0.020 0.018	QL or LOQ (mg/L) 1.00 1.00 0.10 0.20 0.05 QL (mg/L) 0.100 0.100
Anions/NutrientsBrCl $SO_4^{2^2}$ $NO_3^- + NO_2^-$ FNH4^+Low Molecular Weight AcidsLactateIsobutyrate	Method RSKSOP-276v3 RSKSOP-276v3 RSKSOP-276v3 RSKSOP-214v5 RSKSOP-214v5 RSKSOP-214v5 RSKSOP-214v5 RSKSOP-112v6 RSKSOP-112v6	MDL (mg/L) 0.248 0.118 0.226 0.014 0.052 0.012 MDL (mg/L) 0.020 0.018	QL or LOQ (mg/L) 1.00 1.00 0.10 0.20 0.05 QL (mg/L) 0.100 0.100 QL or LOQ
Anions/Nutrients Br Cl SO4 ²⁻ NO3 ⁻ + NO2 ⁻ F NH4 ⁺ Low Molecular Weight Acids Lactate Isobutyrate Analyte	Method RSKSOP-276v3 RSKSOP-276v3 RSKSOP-276v3 RSKSOP-214v5 RSKSOP-214v5 RSKSOP-214v5 RSKSOP-214v5 RSKSOP-112v6 RSKSOP-112v6 Method	MDL (mg/L) 0.248 0.118 0.226 0.014 0.052 0.012 MDL (mg/L) 0.020 0.018 MDL (mg/L) 0.011	QL or LOQ (mg/L) 1.00 1.00 0.10 0.10 0.20 0.05 QL (mg/L) 0.100 QL or LOQ (mg/L)
Anions/Nutrients Br Cl Cl SO4 ²⁻ NO3 ⁻ + NO2 ⁻ F NH4 ⁺ Low Molecular Weight Acids Lactate Isobutyrate Analyte Acetate	Method RSKSOP-276v3 RSKSOP-276v3 RSKSOP-276v3 RSKSOP-214v5 RSKSOP-214v5 RSKSOP-214v5 RSKSOP-112v6 RSKSOP-112v6 Method RSKSOP-112v6	MDL (mg/L) 0.248 0.118 0.226 0.014 0.052 0.012 MDL (mg/L) 0.020 0.018 MDL (mg/L) 0.011 0.011	QL or LOQ (mg/L) 1.00 1.00 0.10 0.20 0.05 QL (mg/L) 0.100 QL or LOQ (mg/L) 0.100 0.100
Anions/Nutrients Br Cl SO ₄ ²⁻ NO ₃ ⁻ + NO ₂ ⁻ F NH ₄ ⁺ Low Molecular Weight Acids Lactate Isobutyrate Acetate Propionate E	Method RSKSOP-276v3 RSKSOP-276v3 RSKSOP-276v3 RSKSOP-214v5 RSKSOP-214v5 RSKSOP-214v5 RSKSOP-112v6 RSKSOP-112v6 RSKSOP-112v6 RSKSOP-112v6 RSKSOP-112v6	MDL (mg/L) 0.248 0.118 0.226 0.014 0.052 0.012 MDL (mg/L) 0.020 0.018 MDL (mg/L) 0.011 0.022 0.011	QL or LOQ (mg/L) 1.00 1.00 0.10 0.20 0.05 QL (mg/L) 0.100 QL or LOQ (mg/L) 0.100 0.100 0.100
Anions/NutrientsBrCl $SO_4^{2^-}$ $NO_3^- + NO_2^-$ FNH4^+Low Molecular Weight AcidsLactateIsobutyrateAnalyteAcetatePropionateFormate	MethodRSKSOP-276v3RSKSOP-276v3RSKSOP-216v3RSKSOP-214v5RSKSOP-214v5RSKSOP-214v5RSKSOP-112v6RSKSOP-112v6RSKSOP-112v6RSKSOP-112v6RSKSOP-112v6RSKSOP-112v6RSKSOP-112v6RSKSOP-112v6RSKSOP-112v6RSKSOP-112v6RSKSOP-112v6RSKSOP-112v6RSKSOP-112v6RSKSOP-112v6RSKSOP-112v6RSKSOP-112v6RSKSOP-112v6	MDL (mg/L) 0.248 0.118 0.226 0.014 0.052 0.012 MDL (mg/L) 0.020 0.018 MDL (mg/L) 0.011 0.022 0.015 0.015	QL or LOQ (mg/L) 1.00 1.00 0.10 0.20 0.05 QL (mg/L) 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100 0.100

* Aqueous concentrations are dependent on headspace volume, aqueous volume, temperature, pressure, etc. These limits were calculated based on a 60 mL bottle, 6 mL headspace, 25 degrees C, headspace pressure of 1 atm, and using the "created" headspace calculations.

For the semivolatiles the target analyte list is presented in Table 10. Surrogates used include phenol-d6, 2-fluorophenol, 2,4,6-tribromophenol, nitrobenzene-d5, 2-fluorobiphenyl, and p-terphenyl-d14. The concentrations used for the surrogates shall be spiked at $5 \,\mu g \, mL^{-1}$. For samples containing components not associated

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with the calibration standards, non-target peaks will be reported as tentatively identified compounds (TICs) based on a library search. Only after visual comparison of sample spectra with the nearest library search results will tentative identifications be made. Guidelines for making tentative identification are:

- A peak must have an area at least 10% as large as the area of the nearest internal standard.
- Major ions in the reference spectrum (ions > 10% of the most abundant ion) should be present in the sample spectrum.
- The relative intensities of the major ions should agree within ± 20%. (Example: For an ion with an abundance of 50 % in the reference spectrum, the corresponding sample ion abundance must be between 30 and 70 %.)
- Molecular ions present in the reference spectrum should be present in the sample spectrum.
- Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination or presence of co-eluting compounds. Ions present in the reference spectrum but not in the sample spectrum should be reviewed for possible subtraction from the sample spectrum because of background contamination or coeluting peaks. Data system library reduction programs can sometimes create these discrepancies.

Table 10 Region VIII Detection and Reporting limits and LCS and MS Control Limits for Semivolatile Organic Compounds (SVOC) using Method 8270

	Delectic					
Analyte	DL (µg/L)	RL (µg/L)	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
1-Chloronaphthalene						
1,2-Dibromo-3-chloropropane						
1,2-Dichlorobenzene	0.218	0.500	67.3	11.4	33	102
1,2-Dinitrobenzene						
1,2-Diphenylhydrazine			84.8	9.4	57	113
1,2,4-Trichlorobenzene	0.208	0.500	71.7	11.6	37	107
1,2,4,5-Tetrachlorobenzene						
1,3-Dichlorobenzene	0.226	0.500	64.8	10.9	32	98
1,3-Dinitrobenzene						
1,4-Dichlorobenzene	0.225	0.500	64.8	10.9	32	98
1,4-Dinitrobenzene						
2-Chloronaphthalene	0.167	0.500				
2-Chlorophenol	0.243	0.500	71.3	11.4	37	106
2-Fluorobiphenyl (Surrogate)			79.9	10.6	48	112

Comment [c138]: Not recommend: The analysis of TICs is only at best "estimated" data and CHK would not recommend any study to be performed or replicated on the basis of "estimated data". This will only be suspect data at best and not valid data by a chemist review. This would apply to any GC/MS (i.e. VOC or SVOC analyses) method performed.

Comment [CV139]: MDH: We would not recommend TICs be analyzed for or reported since they are at best "estimated values. Is there any specific number of TICs that is being proposed to be evaluated?

Comment [n140]: Appropriate qualifiers can be added

Comment [n141]: Not sure what is meant by 'define'-these are analytes identified in prior studies and standards have been obtained and equipment calibrated.

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Table 10 Region VIII Detection and Reporting limits and LCS and MS Control Limits for Semivolatile Organic Compounds (SVOC) using Method 8270

	Detectio	on Limits	Control Limits			
					Lower	Upper
				Standard	Control	Control
Analyte	_DL (µg/L)_	_RL (µg/L)_	Mean	Deviation	Limit	Limit
2-Fluorophenol (Surrogate)			63.7	14.8	19	108
2-Methylnaphthalene	0.190	0.500	75.0	9.5	46	104
2-Methylphenol	0.217	0.500	73.3	11.7	38	109
2-Nitroaniline	0.118	0.500	81.8	11.2	48	115
2-Nitrophenol	0.197	0.500	75.8	12.4	39	113
2,3,4,6-Tetrachlorophenol						
2,4-Dichlorophenol	0.185	0.500	76.3	9.6	48	105
2,4-Dimethylphenol	0.142	0.500	68.8	13.5	28	109
2,4-Dinitrophenol	2.00	2.00	75.8	20.6	14	138
2,4-Dinitrotoluene	0.086	0.500	84.3	11.2	51	118
2,4,5-Trichlorophenol	0.151	0.500	79.7	10.3	49	111
2.4.6-Tribromophenol (Surro-			82.9	13.6	42	124
gate)						
2,4,6-Trichlorophenol	0.166	0.500	80.7	10.7	49	113
2,6-Dichlorophenol			82.7	11.3	49	117
2,6-Dinitrotoluene	0.091	0.500				
3-Methylphenol	0.189	0.500	71.3	13	32	110
3-Nitroaniline	0.394	0.500	72.6	17.7	19	126
3,3'-Dichlorobenzidine			65.2	15.3	19	111
4-Bromophenyl phenyl ether	0.108	0.500	82.9	10.2	52	113
4-Chloroaniline	0.546	1.00	62.2	15.6	15	109
4-Chloro-3-methylphenol	0.165	0.500	78.6	10.7	47	111
4-Chlorophenyl phenyl ether	0.120	0500	80.6	10.3	50	111
4-Methylphenol	0.189	0.500	71.3	13.0	32	110
4-Nitroaniline	0.320	0.500	77.2	13.7	36	118
4-Nitrophenol	0.085	0.500				
4.4'-DDD						
4.4'-DDE						
4,4'-DDT						
4.4'-Methylenebis (2-						
chloroaniline)						
4.4'-Methylenebis						
(N,Ndimethylaniline)						
4,6-Dinitro-2-methylphenol	0.202	0.500	84.9	15.0	40	130
Acenaphthene	0.147	0.500	77.6	10.1	47	108
Acenaphthylene	0.139	0.500	78.5	9.4	40	107
Acetophenone						
Aldrin						
Aniline						
Anthracene	0.088	0.500	83.0	9.7	54	112

Comment [n141]: Not sure what is meant by 'define'-these are analytes identified in prior studies and standards have been obtained and equipment calibrated.

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Table 10 Region VIII Detection and Reporting limits and LCS and MS Control Limits for Semivolatile Organic Compounds (SVOC) using Method 8270

	Detectio	on Limits	Control Limits			
				Of any dama	Lower	Upper
Apolyto			Moon	Standard	Control	Control
Analyte	DL (μg/L)	κτ (μg/τ)	Intean	Deviation		
Azobonzono	0.102	0.500				
Panzoia agid	0.102	0.300				
Benz(a)anthracana	0.070	0.500	07 T	8.0	56	100
Denze(h)fluerenthene	0.079	0.300	02.7	0.9		109
Benzo(b)Huoranthene	0.081	0.300	81.8 84.6	12.1	43	118
Denzo(k)Huorantinene	0.088	0.300	84.0	15.2	43	124
Benzo(g,n,1)perylene	0.098	0.500	80.5	14.1	38 52	125
Benzo(a)pyrene	0.083	0.500	81.3	9.5	53 20	110
Benzyl alconol			/1.0	13.8	30	112
a-BHC						
β-BHC						
δ-BHC						
γ-BHC (Lindane)		0.500		10.0		107
Bis(2-chloroethoxy)methane	0.183	0.500	76.2	10.2	46	107
Bis(2-chloroethyl) ether	0.238	0.500	73.3	12.3	37	110
Bis(2-chloroisopropyl) ether	0.426	0.500	78.2	17.5	26	131
Bis(2-ethylhexyl) phthalate	0.500	1.00	84.2	14.0	42	126
Butyl benzyl phthalate	0.190	0.500	81.1	11.7	46	116
Carbaryl						
Carbazole	0.084	0.500	82.5	11.4	48	117
Chlorobenzilate						
Chrysene	0.079	0.500	82.1	8.9	55	109
Dibenz(a,h)anthracene	0.110	0.500	84.7	14.1	42	127
Dibenzofuran	0.133	0.500	80.3	8.8	54	107
Di-n-butyl phthalate	0.153	0.500				
Dichlorovos						
Dieldrin						
Diethyl phthalate	0.099	0.500	79.2	12.9	41	118
Dimethyl phthalate	0.107	0.500	75.9	16.9	25	127
Dinoseb						
Diphenylamine						
Di-n-butyl phthalate			84.8	10.3	54	116
Di-n-octyl phthalate	0.188	0.500	87.4	16.6	37	137
Disulfoton						
Endosulfan I						
Endosulfan II						
Endosulfan sulfate						
Endrin						
Endrin aldehyde	1					
Endrin ketone						
	1			1		

Comment [n141]: Not sure what is meant by 'define'-these are analytes identified in prior studies and standards have been obtained and equipment calibrated.

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Table 10 Region VIII Detection and Reporting limits and LCS and MS Control Limits for Semivolatile Organic Compounds (SVOC) using Method 8270

	Detectio	on Limits	Control Limits			
					Lower	Upper
A market a				Standard	Control	Control
Analyte	DL (µg/L)	RL (µg/L)	Mean	Deviation		
Fluorantnene	0.094	0.500	85.2	10.4	54	110
Fluorene	0.120	0.500	80.6	10.3	50	112
Heptachlor						
Heptachlor epoxide	0.11.5	0.500	02.2	10.0		112
Hexachlorobenzene	0.116	0.500	82.3	10.0	52	112
Hexachlorobutadiene	0.225	0.500	65.2	12.6	27	103
Hexachlorocyclopentadiene	0.202	0.500	10.0		• •	
Hexachloroethane	0.196	0.500	60.9	11.1	28	94
Indeno(1,2,3-cd)pyrene	0.093	0.500	84.3	13.6	43	125
Isophorone	0.167	0.500	81.0	10.5	50	112
Malathion						
Methoxychlor						
Mevinphos						
Naphthalene	0.212	0.500	70.8	10.5	39	102
Nitrobenzene	0.233	0.500	76.8	10.8	44	109
Nitrobenzene-d5 (Surrogate)			76.0	11.8	41	111
N-Nitrosodi-n-butylamine	0.187	0.500				
N-Nitrosodiethylamine						
N-Nitrosodimethylamine			67.9	41.1	26	110
N-Nitrosodiphenylamine			79.6	10.6	48	111
N-Nitrosodi-n-propylamine			80.9	15.7	34	128
N-Nitrosomethylethylamine						
Parathion						
Pentachlorobenzene						
Pentachlorophenol	0.199	0.500	77.6	13.3	38	117
Phenanthrene	0.107	0.500	84.0	11.0	51	117
Phenol	0.246	0.500				
Phorate						
Pronamide						
Pyrene	0.087	0.500	88.6	13.2	49	128
Pyridine						
Terbufos						
Terphenyl-d14 (Surrogate)			92.7	14.0	51	135
Trifluralin						
®-(+)-Limonene	0.054	0.100				
1,3-Dimethyl adamantine	0.028	0.100				
2-Butoxyethanol	0.054	0.100				
Adamantane	0.033	0.100				
Squalene	0.565	1.00				
Terpiniol	0.031	0.100				
•				1		

Comment [n141]: Not sure what is meant by 'define'-these are analytes identified in prior studies and standards have been obtained and equipment calibrated.

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Table 10 Region VIII Detection and Reporting limits and LCS and MS Control Limits for Semivolatile Organic Compounds (SVOC) using Method 8270

	Detectio	n Limits		Control Limits			
					Lower	Upper	
				Standard	Control	Control	
Analyte	_DL (µg/L)		Mean	Deviation	Limit	Limit	
Tri(2-butoxyethyl)phosphate	0.133	0.200					

Commercial standards for DRO calibration is locally procured DF #2 (source: Texaco station). Surrogates used in DRO include o-terphenyl at spiking concentrations of 10 μ g L⁻¹.

Commercial standards for GRO calibration are BTEX, MTBE, naphthalene, and gasoline range hydrocarbons (purchased as certified solutions) and unleaded gasoline from Supelco (product number 47516-U). Surrogates used in GRO include 4- bromofluorobenzene at spiking concentrations of $50 \ \mu g \ L^{-1}$.

2.5 Quality Control

2.5.1 Quality Metrics for Aqueous Analysis

For analyses done at RSKERC, QA/QC practices (e.g., blanks, calibration checks, duplicates, second source standards, matrix spikes, and surrogates) are described in various in-house Standard Operating Procedures (RSKSOPs) and summarized in Table 11. Matrix spikes sample spiking levels are determined at the discretion of the individual analysts (based on sample concentrations) and are included with the sample results. Corrective actions are outlined in the appropriate SOPs and when corrective actions occur in laboratory analysis it will be documented and the PI will be notified as to the nature of the corrective action and the steps taken to correct the problem. The PI will review this information and judge if the corrective action was appropriate.

QC samples identified in this study are defined as:

Field Duplicate: Independent samples which are collected as close as possible to the same point in space and time. They are two separate samples taken from the same source, stored in separate containers, and analyzed independently.

Equipment Blank: A sample of analyte-free media which has been used to rinse the sampling equipment. It is collected after completion of decontamination and prior to sampling. This blank is useful in documenting adequate decontamination of sampling equipment.

Method Blank: An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank should be carried through the complete sample preparation and analytical proce-

Comment [n141]: Not sure what is meant by 'define'-these are analytes identified in prior studies and standards have been obtained and equipment calibrated.

Comment [CV142]: Is this the certified standard for Fuel Oil #2?

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dure. The method blank is used to document contamination resulting from the analytical process.

Trip Blank: A sample of analyte-free media taken from a laboratory to the sampling site and returned to the laboratory unopened. A trip blank is used to document contamination attributable to shipping and field handling procedures.

Matrix Spike: An aliquot of sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike is used to document the bias of a method in a given sample matrix.

Matrix Spike Duplicates: Intralaboratory split samples spike with identical concentrations of target analyte(s). The spiking occurs prior to sample preparation and analysis. They are used to document the precision and bias of a method in a given sample matrix.

Split Samples: Aliquots of sample taken from the same container and analyzed independently. These are usually taken after mixing or compositing and are used to document intra- or interlaboratory precision.

Laboratory Control Sample: A known matrix spiked with compound(s) representative of the target analytes. This is used to document laboratory performance.

Quality Control Sample: A sample introduced into a process to monitor the performance of a system.

For analyses done by the Region VIII laboratory, QA/QC requirements are:

- 1. Samples shall be processed and analyzed within the following holding times (from date sampled):
 - Semivolatiles: 7 days until extraction, 30 days after extraction
 - DRO: 14 days until extraction*, 40 days after extraction
 - GRO: 14 days*
 - *With acid preservation
- 2. Data verification shall be performed by the Region VIII laboratory to ensure data meets their SOP requirements.
- 3. Complete data package shall be provided electronically on disk, including copies of chain-of-custody forms, copy of method or Standard Operating Procedure used, calibration data, raw data (including notebook pages), QC data, data qualifiers, quantitation (reporting) and detection limits, deviations from method, and interpretation of impact on data from deviations from QC or

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method requirements. (All documentation needed to be able to re-construct analysis.)

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Table 11 RSKERC Laboratory QA/QC Requirements Summary from SO

Measurement	Analysis Method	Blanks (Frequency)	Calibration Checks (Frequency)	Second Source (Frequency)	Duplicates (Frequency)	Matrix Spikes (Frequency)
Dissolved gases	RSKSOP- 194v4 &- 175v5*	<pre>≤MDL (He/Ar blank, first and last in sample queue; water blank be- fore samples)</pre>	85-115% of known value (After helium/Ar blank at first of analysis queue, before helium/Ar blank at end of sample set, and every 15 sam- ples)	85-115% of known value (After first cali- bration check)	RPD≤20 (Every 15 sam- ples)	NA
Metals (undigest- ed)	RSKSOP- 213v4	<ql 80%="" for="" of<br="">metals; (Beginning and end of each sam- ple queue, 10-15 samples)</ql>	90-110% of known value (Beginning and end of each sam- ple queue, 10-15 samples)	PE sample ac- ceptance limits or 90-110% of known value (Immediately after first calibra- tion check)	RPD<10 for 80% of metals; for results $<5x$ QL, difference of \leq QL(Every 15 samples)	90-110% Rec. for 80% of metals w/ no individual exceeding 50-150% Rec. (one per sample set, 10- 15 samples)
Metals (digested)	RSKSOP- 213v4	<10xMDL	See "undigested"	See "undigested"	RPD<20 for 80% of metals; for results <5x QL, difference of \leq QL (Every 15 sam- ples)	80-120% Rec. for 80% of metals w/ no individual exceeding 50-150% Rec. (one per sample set, 10- 15 samples)

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Table 11	RSKERC Laborator	y QA/QC Red	uirements S	Summary [*] f	rom SOPs
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			Calibration			
Measurement	Analysis Method	Blanks (Frequency)	Checks (Frequency)	Second Source (Frequency)	Duplicates (Frequency)	Matrix Spikes (Frequency)
Metals (undigest- ed)	RSKSOP- 257v3 and -332v0	<ql 80%="" for="" of<br="">metals; none>10xMDL (Beginning and end of each sam- ple queue, 10-15 samples)</ql>	90-110% of known value (Beginning and end of each sam- ple queue, 10-15 samples)	PE sample ac- ceptance limits or 90-110% of known value (Immediately after first calibra- tion check)	RPD<10 for 80% of metals for metals >5xQL (Every 15 sam- ples)	90-110% Rec. for 80% of metals w/ no individual exceeding 70-130% (one per sample set, 10-15 samples)
Metals (digested)	RSKSOP- 257v3 and -332v0	<icp for<br="" mdl="">RSKSOP-213v4</icp>	See "undigested"	See "undigested"	RPD<20* for 80% of metals above 5xQL; for results <5x QL, difference of \leq QL (Every 15 sam- ples) *35 for solids	80-120% average rec. with at least 50% of individuals within 50-150% rec. for pre-digestions and 70-130% rec. for all results for post- digestions (one per sample set, 10-15 samples)
SO4, Cl, F, Br	RSKSOP- 276v3	<mdl (Beginning and end of each sam- ple queue)</mdl 	90-110% Rec. (Beginning, end, and every 10 samples)	PE sample ac- ceptance limits (One per sample set)	RPD<10 (every 15 sam- ples)	80-120% Rec. (one per every 20 samples)
NO ₃ + NO ₂ , NH ₄	RSKSOP- 214v5	< ¹ / ₂ lowest calib. std. (Beginning and end of each sam- ple queue)	90-110% Rec. (Beginning, end, and every 10 samples)	PE sample ac- ceptance limits (One per sample set)	RPD<10 (every 10 sam- ples)	80-120% Rec. (one per every 20 samples)

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Table 11 RSKERC Laboratory QA/QC Requirements Summary from SOPs

Measurement	Analysis Method	Blanks (Frequency)	Calibration Checks (Frequency)	Second Source (Frequency)	Duplicates (Frequency)	Matrix Spikes (Frequency)
DIC/DOC	RSKSOP- 330v0	< ¹ / ₂ QL (after initial calib., every 10- 15 samples, and at end)	80-120% of known value (after initial calib., every 10- 15 samples, and at end)	80-120% of known value (Immediately after calibration)	RPD<10 (every 15 sam- ples)	80-120% Rec. (one per 20 or every set
Volatile organic compounds (VOC)**	RSKSOP- 299v1	<mdl (Beginning and end of each sam- ple set)</mdl 	80-120% Rec. (Beginning, end, and every 20 samples)	80-120% of known value (Immediately after calibration)	RPD<20 (every 20 samples)	70-130% Rec. (eve- ry 20 samples)
Low Molecular Weight Acids	RSKSOP- 112v6	<mdl (Beginning of a sample queue; every 10 sam- ples; and end of sample queue)</mdl 	85-115% of the recovery (Prior to sample analysis; every 10 samples; end of sample queue)	85-115% of re- covery (Prior to sample analysis)	< 15 RPD (Every 20 sam- ples through a sample queue)	80-120 % recovery (Every 20 samples through a sample queue)
O, H stable iso- topes of water***	RSKSOP- 296v1	NA	Difference of calibrated/true < 1% for δ^2 H & < 0.2‰ for δ^{18} O (Beginning, end and every tenth sample)	Working stds calibrated against IAEAstds.† (Beginning, end, and every tenth sample)	Standard devia- tion $\leq 1\%$ for δ^2 H and $< 0.2\%$ for δ^{18} O (every sample)	NA

This table only provides a summary; SOPs should be consulted for greater detail.
 ** Surrogate compounds spiked at 100 ug/L: p-bromofluorobenzene and 1,2-dichlorobenzene-d4, 85-115% recovery.

*** Additional checks: internal reproducibility prior to each sample set, std dev ≤ 1 ‰ for δ^2 H and ≤ 0.1 for δ^{18} O † International Atomic Energy Agency (VSMOW, GISP, and SLAP)

Corrective actions are outlined in the SOPs.

Key:

MDL = Method Detection Limit

OL = Quantitation Limit

PE = Performance Evaluation

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- 4. Detection limits (DL) and quantitation (reporting) limits (RL) for the semivolatiles are as provided in Table 10. The DL and RL for DRO and GRO are both at $20 \ \mu g/L$.
- 5. The laboratory shall be subject to an on-site QA audit and analysis of Performance Evaluation samples. If the laboratory is currently analyzing Performance Evaluation (aka Proficiency Testing) samples, a request will be made for this data. If they are not actively involved in analyzing these samples, then they shall be provided by RSKERC.
- 6. See Table 12 for QC types and performance criteria.

QC Type	Semivolatiles	DRO	GRO	Frequency
Method Blanks	<rl< td=""><td><rl< td=""><td><rl< td=""><td>One per sample</td></rl<></td></rl<></td></rl<>	<rl< td=""><td><rl< td=""><td>One per sample</td></rl<></td></rl<>	<rl< td=""><td>One per sample</td></rl<>	One per sample
				set
Solvent blanks	<rl< td=""><td><rl< td=""><td>NA</td><td>One per sample</td></rl<></td></rl<>	<rl< td=""><td>NA</td><td>One per sample</td></rl<>	NA	One per sample
				set
Surrogate Spikes	60-130% of ex-	60-140% of ex-	70-130% of ex-	Every field and
	pected value	pected value	pected value	QC sample
Initial and Con-	80-120% of ex-	80-120% of ex-	80-120% of ex-	At beginning of
tinuing Calibra-	pected value	pected value	pected value	sample set, every
tion Checks				tenth sample,
				and end of sam-
				ple set
Second Source	80-120% of ex-	80-120% of ex-	80-120% of ex-	Each time cali-
Standards	pected value	pected value	pected value	bration per-
				formed
Laboratory Con-	Statistical Limits	70-130% of ex-	Values of all	One per analyti-
trol Samples	from DoD LCS	pected value	analytes in the	cal batch or eve-
(LCS)	Study (See table		LCS should be	ry 20 samples,
	11)		within the limits	whichever is
			determined by	greater
			the supplier.	
Matrix Spikes	Same as LCS	70-130% of ex-	70-130% Recov-	One per sample
(MS)		pected value	ery	set or every 20
				samples, which-
				ever is more fre-
				quent
MS/MSD	RPD <u><</u> 20	RPD <u><</u> 25	RPD <u><</u> 25	One per sample
				set or every 20
				samples, which-
				ever is more fre-
				quent

Table 12 Region VIII Laboratory QA/QC Requirements for Semivolatiles, GRO, DRO

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Table 12	Region VIII Laborator	v QA/QC Requirements for Semivolatiles, GRO, DRO	
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QC Type	Semivolatiles	DRO	GRO	Frequency
Reporting Lim-	0.1 µg/L (gener-	$20 \mu g/L^1$	$20 \mu g/L^2$	NA
its*	ally) ¹			

Based on 1000 mL sample to 1 mL extract

² Based on a 5 mL purge

* see Table 11

Corrective Actions: If any samples are affected by failure of a QC sample to meet its performance criteria, the problem shall be corrected and samples will be reanalyzed. If re-analysis is not possible (such as lack of sample volume), the PI shall be notified. The data will be qualified with a determination as to impact on the sample data. Failures and resulting corrective actions shall be reported.

For analyses done by the Region III laboratory, QA/QC requirements are:

- 1. Samples shall be analyzed within the holding time of 14 days.
- 2. Data verification shall be performed by the Region III laboratory to ensure data meets the method requirements.
- 3. Complete data package shall be provided electronically on disk, including copies of chain-of-custody forms, copy of method or Standard Operating Procedure used, calibration data, raw data (including notebook pages), QC data, data qualifiers, quantitation (reporting) and detection limits, deviations from method, and interpretation of impact on data from deviations from QC or method requirements. (All documentation needed to be able to re-construct analysis.)
- 4. Detection and reporting limits are still be determined, but most will be between 10 and 50 ppb.
- 5. The laboratory shall be subject to an on-site QA audit if the glycol data becomes "critical" at a later data after method validation.
- 6. See Table 13 for QC types and performance criteria.
- 7. Until the method is validated, the data will be considered "screening" data.

Corrective Actions: If any samples are affected by failure of a QC sample to meet its performance criteria, the problem shall be corrected and samples will be reanalyzed. If re-analysis is not possible (such as lack of sample volume), the PI shall be notified. The data will be qualified with a determination as to impact on the sample data. Failures and resulting corrective actions shall be reported. **Comment [c143]:** Detection and reporting limits should be establish prior to conducting field activity.

Comment [CV144]: MDH: Should this be "date"?

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Table 13	Region	III Detection	and Re	porting	Limits	for Gl	ycols

Analyte [‡]	Detection Limit (μg L ⁻¹) [†]	Reporting Limit (μg L ⁻¹) [†]
2-butoxyethanol	NA	NA
diethylene glycol	NA	NA
triethylene glycol	NA	NA
tetraethylene glycol	NA	NA

[†] Detection and reporting limits are still being determined, most will be between 10 and 50 pbb.
 [†] The samples are analyzed according to OASQA On Demand Procedures- See the QA manual for procedures. See Section 13.1.4.2 Procedure for Demonstration of Capability for "On-Demand" Data (Metzger et al., 2011)

2.5.2 Measured and Calculated Solute Concentration Data Evaluation

The computer program AqQA (RockWare Inc., version 1.1.1) will be used as a check on the quality of solute concentration data. Two methods will be used. First, the specific conductance values measured in the field will be compared to a calculated value that is based on anion- and cation-specific resistivity constants and the measured concentrations of anions and cations in specific ground-water samples. The agreement between the measured and calculated values should be within 15%. The second method will be to calculate the charge balance for each solution. This is done by summing and comparing the net positive and negative charge from the measured concentrations of anions and cations. The agreement should be within 10%. Poor agreement would suggest that some major solute(s) is not accounted for in the analytical measurements. At the discretion of the PI, discrepancies in this manner will be either flagged or the identity of other sample components and/or reason(s) for poor agreement will be investigated.

2.5.3 Detection Limits

Detection limits for the various analytes are listed in the RSKERC Standard Operating Procedures for these methods and are not repeated here. Updated detection limits are provided in the data reports. Detection limits for the analytes, including those to be done by the contract lab are given in Table 9. They are adequate for project objectives.

2.5.4 QA/QC Calculations

% Recovery or Accuracy

$$\%$$
REC= $\frac{m}{n} \times 100$

Where:

m = measurement result n = True Value (a certified or known value) of standard or reference **Comment [c145]:** Detection limits for Region III glycols are not provided. Is this adequate for project objectives?

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2. Data Generation and Acquisition

Section No.: 2

Precision

Precision is described by Relative Percent Difference (RPD) as previously defined.

The Relative Percent Difference (RPD) is calculated based on the following:

$$RPD = \frac{2(a-b)}{a+b} \times 100$$

where:

a = sample measurement and b = duplicate sample measurement and a > b.

Matrix Spike Recovery

Matrix spikes sample spiking levels are determined at the discretion of the individual analysts (based on sample concentrations) and are included with the sample results.

%Recovery= spiked sample concentration-native sample concentration spiked sample concentration ×100

2.6 Instrument/Equipment Testing, Inspection, and Maintenance

RSKERC laboratory instrumentation used for analysis of project analytes are in routine use and are tested for acceptable performance prior to analyzing actual samples through the analysis of standards and QC samples. Field instruments are tested prior to use in the field by calibrating or checking calibration with standards. Routine inspection and maintenance of these instruments is documented in instrument logbooks. RSKSOPs provide details on instrument testing and corrective actions.

2.7 Instrument/Equipment Calibration and Frequency

RSKERC calibration and calibration frequency are described in RSKSOPs (RSKERC Standard Operating Procedures). For the sub-contracted laboratory, these requirements are identified in the EPA Methods and the SOW (Statement of Work) included with the purchase requisition (PR) as well as in Table 12 Standards used for GRO and DRO calibration will be acquired from a commercial source. The SOW will be reviewed by the QAM for QA requirements prior to issuing the PR.

Field instruments are calibrated or checked for calibration daily prior to use, midday, and at the end of the day after the last sample measurement. Calibration standards shall be traceable to NIST, if available and all dated calibration standards are not beyond their expiration date and will not expire during the field trip.

2. Data Generation and Acquisition

Prior to the sampling event each test meter will be check that it is in good working order. Calibration data will be recorded in a bound waterproof notebook and personnel making entries will adhere to the GWERD Notebook policy. Calibration of instruments will be performed daily prior to initiation of sample collection and will be performed according to manufacturer's instructions and will be recorded in the field notebook. In addition calibration checks will be performed using known standards or buffers before use, mid-day and at the end of the day. With the exception of pH all checks must be exceed ± 10 % of known concentrations and in the case of pH must be within ± 0.2 pH units. These calibration checks will be recorded in the field notebook. If a calibration check fails, this will be recorded in the field notebook and the possible causes of the failure will be investigated. Upon investigation corrective action will be taken and the instrument will be recalibrated. Samples taken between the last good calibration check and the failed calibration check will be flagged to indicate there was a problem. Duplicate field measurements are not applicable to measurements in flow through cell (RSKSOP-211).

Hach spectrophotometers and turbidity meters will inspected prior to going to the field and there function verified. Calibration of these instruments are internal and calibration will be checked in the lab prior to going to the field. Standards for redox sensitive species such as sulfide and ferrous iron are difficult to use in the field because once exposed to atmospheric oxygen there concentrations can change. Similarly calibration standards for alkalinity are sensitive to atmospheric carbon dioxide. Duplicates will be performed once a day or on every tenth sample. Duplicates acceptance criteria are ± 15 % RPD. The values obtained for each duplicate sample will be recorded in the field notebook and RPD will be calculated (section 2.5.4) and recorded in the field notebook. If the duplicate samples fail and additional duplicate sample will be taken and reanalyzed. If the additional duplicate samples fail to meet the QC criteria, then the instruments will be checked and corrective action taken. The corrective actions will be recorded in the field notebook. Samples collected between the last valid duplicate sample and the failed duplicate sample will be flagged.

2.8 Inspection/Acceptance of Supplies and Consumables

RSKSOPs provide requirements for the supplies and consumables needed for each method. The analyst is responsible for verifying that they meet the RSKSOP requirements. The supplies or consumables not addressed by the RSKSOPs that are critical to this project are listed in Table 14. It should be noted that the vendors listed in Table 14 are suggest vendor and equivalent parts may be available from other vendors or substitute for based on purchasing rules. Dr. Puls is responsible for ensuring these are available and to ensure they are those as listed previously. If subcontractors are responsible for sampling, they will be responsible for providing the PI with information on their sample containers to ensure they meet project requirements.
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2. Data Generation and Acquisition

ltem	Vendor	Part Number		
Buffer Solution, pH 4	Fisher Scientific	SB101-500		
Buffer Solution, pH 7	Fisher Scientific	SB108-500		
Buffer Solution, pH 10	Fisher Scientific	SB115-500		
Conductivity Standard, 1413µmho	Fisher Scientific	15-077-951		
Zobell Solution	Fisher Scientific	15-176-222		
Oakton DO Probe Membranes	Fisher Scientific	15-500-039		
Bromcresol Green-Methyl Red	НАСН	94399		
Indicator				
Sulfuric Acid Cartridges, 0.1600N	НАСН	1438801		
Sulfuric Acid Cartridges, 1.600N	НАСН	1438901		
Delivery Tubes for Digital	НАСН	1720500		
Titrator				
Iron, Ferrous Reagent	НАСН	103769		
Sulfide 1 Reagent	НАСН	181632		
Sulfide 2 Reagent	НАСН	181732		
POL DO cap Memebrane Kit/	YSI	605307		
Electrolyte Solution				
Silicone Tubing, size 24	Fondriest Environmental	77050009		
Silicone Tubing, size 36	Fondriest Environmental	77050011		
Polyethylene Tubing 0.25" ID x	Fondriest Environmental	77050502		
0.375" OD				
Polyethylene Tubing 0.375" ID x	Fondriest Environmental	77050503		
0.50" OD				

Table 14 Supplies or Consumables Needed Not Listed in SOPs*

^{*}Equivalent products from other vendors can be used if needed.

2.9 Non-direct Measurements

At this stage of the project, there are no non-direct measurements anticipated.

2.10 Data Management

The PI is responsible for maintaining data files, including their security and integrity. All files (both electronic and hard copy) will be labeled such that it is evident that they are for the hydraulic fracturing project in Desoto Parish, LA.

Data will be submitted to Dr. Puls as either hard copies (field notes), or electronically (laboratory data) in Excel spreadsheets on CD or DVD or via email. Data in

hard copy form will be manually entered into Excel spreadsheets on Dr. Puls's computer or designated GWERD staff computer and will be given to Dr. Puls. Either, Dr. Puls or a technician or student will conduct this task. Data will be spot-checked by Dr. Puls to ensure accuracy. If errors are detected during the

02:002233_0696_SGTG-B3494 2-63 <u>4_attachment_EPA_CHK_Case_Study_QAPP_working_copy_121611_(CEPA_CHK_Case_Study_QAPP_working_copy_121611.doc-</u> <u>10/21/20138/6/20131/4/20121/6/20121/6/201212/20/2011</u> **Comment [CV146]:** Electronic Data delivery should be used. Field notes should be digitized.

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2. Data Generation and Acquisition

spot-check, the entries will be corrected. Detection of an error will prompt a more extensive inspection of the data, which could lead to a 100% check of the data set being entered at that time if multiple errors are found.

Data in electronic form shall be electronically transferred to the spreadsheets. Data will be spot-checked by Dr. Puls to ensure accuracy of the transfer. If errors are detected during the spot-check, the entries will be corrected. Detection of an error will prompt a more extensive inspection of the data, which could lead to a 100% check of the data set being entered at that time if multiple errors are found.

2.10.1 Data Analysis, Interpretation, and Management

Data validation will consist of initial and final review of data. Initial review will include continuous oversight during field collection of data by the principal investigator to avoid common transcription errors associated with recording of data. Final review will include evaluation of all collected data for suitability in data interpretation. It will include but is not limited to the following activities: (1) assessment of data completeness, (2) review of log books and forms used for data logging, and (3) review of calibration and standard checks.

2.10.2 Data Recording

Data collected during the ground-water investigation will be recorded into field notebooks and entered into EXCEL spreadsheets. Water quality data will also be entered into AqQA a program for evaluating ground water quality and for evaluating data validity. Graphs will be produced using EXCEL or Origin to show key data trends.

2.10.3 Data Storage

As this is a Category I project, all data and records associated with this project will be kept permanently and will not be destroyed. All data generated in this investigation will be stored electronically in Microsoft EXCEL and backed up in RSKERC's local area network 'M' drive. All paper-based records will be kept in the PI's offices. If the project records are archived, Dr. Puls will coordinate with GWERD management and GWERD's records liaison and contract support the compiling of all data and records.

2.10.4 Analysis of Data

All data collected associated with groundwater and surface water sampling will be summarized in EXCEL spreadsheets. Data in spreadsheets will be spot-checked against original data reports by selecting random data points for comparison to verify accuracy of data transfer. When possible, data sets will be graphically displayed using EXCEL to reveal important trends. **Comment [c147]:** Need an outlier data resolution program that is agreeable to both parties. There will be outliers in the data, or unrealistic results, that likely will be traced to sampling or lab error. Needs to be provided in report.

Is the data going to be shared with the landowners. A discussion, clarification, and description on this issue is needed.

Comment [n148]: Data from private sampling of homeowner wells will be shared with them once quality assured and verified.

Comment [n149]: All data needs to be reviewed by the PI and any outliers (unusual results) will be reviewed to determine why (lab error, etc.)

Comment [c150]: Should also be part of final review and final acceptance of data.

Comment [nc151]: Need to be consistent in citing of Excel and need to include trademark identificatioin

Comment [CV152]: The handling of produced fluids and samples of hydraulic stimulation fluid are not mentioned in this section

Comment [CV153]: If comparisons are made to standards, appropriate standards should be used, e.g. drinking water standards are not appropriate for surface water resources which are not directly consumed as human drinking water. The comparison should focus more on comparison to background levels. EPA does need to identify what actions if any will be taken to notify residents if baseline sampling has parameters which are higher than drinking water standards.

A discussion on recommendations to a randowner in say nitrate is exceeded (due to septic impacts. This needs to be spelled out in the document, and would recommend the landowner be notified as soon as the baseline result is available that a MCL or SMCL is exceeded, or an organic compound found in their well at high levels.) Section No.: 3 Revision No.: 90 Date: May October 21, 201<u>3August 6, 2013January 6, 2012January 6, 2012January 6, 2012December 20, 2011</u>

3

Assessment and Oversight

3.1 Assessments and Response Actions

Technical Systems Audits (TSAs), Audits of Data Quality (ADQs), and Performance Evaluations will be conducted early in the project to allow for identification and correction of any issues that may affect data quality. TSAs will be conducted on both field and laboratory activities. Detailed checklists, based on the procedures and requirements specified in this QAPP, related SOPs, and SOWs, will be prepared and used during these TSAs. These audits will be conducted with contract support from Neptune and Co., with oversight by Steve Vandegrift, QAM, for those that are done outside of RSKERC. Those at RSKERC will be done by the QAM. See Section 4.2 for additional discussion on ADQs.

Laboratory TSAs will focus on the critical target analytes at sub-contract laboratories. A laboratory TSA will be conducted at RSKERC for critical target analytes.

ADQs will be conducted on a representative sample of data for the critical target analytes. These will also be performed by the Neptune and Co., with oversight by Steve Vandegrift, QAM.

Performance Evaluations will be conducted on critical target analytes for those that are available commercially. The QAM shall acquire and submit the PE samples. These shall be coordinated with the PI for the contract laboratory.

See Section 3.2 for how and to whom assessment results are reported.

Assessors do not have stop work authority; however, they can advise the PI if a stop work order is needed in situations where data quality may be significantly impacted, or for safety reasons. The PI makes the final determination as to whether or not to issue a stop work order.

For assessments that identify deficiencies requiring corrective action, the audited party must provide a written response to each finding and observation to the QA Manager, which shall include a plan for corrective action and a schedule. The PI is responsible for ensuring that audit findings are resolved. The QA Manager will

02:002233_0696_SGTGC-B3494 3-1 4_attachment_EPA CHK Case Study QAPP working copy 121611 (CEPA CHK Case Study QAPP working copy 121611.doe-10/21/20138/6/20131/6/20121/6/20121/2/20/2011 Comment [c154]: And project specific QMP?

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3. Assessment and Oversight

review the written response to determine their appropriateness and provide, if necessary. If the audited party is other than the PI, then the PI shall also review and concur the corrective actions. The QA Manager will track implementation and completion of corrective actions. After all corrective actions have been implemented and confirmed to be completed, the QA Manager shall send documentation to the PI and their supervisor that the audit is closed. Audit reports and responses shall be maintained by the PI in the project file and the QA Manager in the QA files, including QLOG.

3.1.1 Assessments

TSAs will be conducted on both field and laboratory activities. Detailed checklists, based on the procedures and requirements specified in this QAPP, SOPs, EPA Methods, and SOW will be prepared and used during these TSAs. One field TSA will be done. The laboratory audit will take place when samples are anticipated to be in the laboratory's possession and being processed.

Laboratory TSAs will focus on the critical target analytes (Table 1) and will be conducted on-site at RSKERC (involves both EPA and contractor-operated labs) and at an off-site contract laboratory which will analyze for semi-volatile organic, DRO and GRO analyses. It is anticipated this will take place in the summer of 2011. At this time, EPA Region III Laboratory and EPA Region VIII Laboratory are be the off-site laboratories.

ADQs will be conducted on a representative sample of data for the critical target analytes. . These will begin with the first data packages to ensure there are no issues with the data and to allow for appropriate corrective actions on subsequent data sets if needed.

Performance Evaluations will be conducted on critical target analytes for those that are available commercially. These are anticipated to be done in the summer of 2011.

3.1.2 Assessment Results

At the conclusion of a TSA, a debriefing shall be held between the auditor and the PI or audited party to discuss the assessment results. Assessment results will be documented in reports to the PI, the PIs first-line manager, and the GWERD Division Director. If any serious problems are identified that require immediate action, the QAM will verbally convey these problems at the time of the audit to the PI.

The PI is responsible for responding to the reports as well ensuring that corrective actions are implemented, if needed, in a timely manner to ensure that quality impacts to project results are minimal.

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3. Assessment and Oversight

3.2 Reports to Management

All final audit reports shall be sent to the GWERD Division Director, and copied to Dr. Puls. Audit reports will be prepared by the QA Manager or the QA support contractor, which will be reviewed and approved prior to release. Specific actions will be identified in the reports.

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4

Data Validation and Usability

4.1 Data Review, Verification, and Validation

Criteria that will be used to accept, reject, or qualify data will include specifications presented in this QAPP, including the methods used and the measurement performance criteria presented in Tables 6, 7, and 8. In addition, sample preservation and holding times will be evaluated against requirements Table 6.

Data will not be released outside of RSKERC until all study data have been reviewed, verified and validated as described below. The PI is responsible for deciding when project data can be shared with interested stakeholders in conjunction with the GWERDs Director's approval.

4.2 Verification and Validation Methods

Data verification will evaluate data at the data set level for completeness, correctness, and conformance with the method. Data verification will be done by those generating the data. This will begin with the analysts in the laboratory and the personnel in the field conducting field measurements, monitoring the results in real-time or near real-time. At RSKERC, Shaw's, verification includes team leaders, the QC coordinator, and the program manager. For the EPA GP Lab at RSKERC, data verification includes peer analysts in the GP lab and the team leader. Shaw's and the EPA GP Lab's process goes beyond the verification level, as they also evaluate the data at the analyte and sample level by evaluating the results of the QC checks against the RSKSOP performance criteria.

For the Region VIII laboratory, QA/QC requirements include data verification prior to reporting and detailed description can be found in the QSP-001-10 QA Manual (Burkhardt and Datschelet, 2010). Results are reported to the client electronically, unless requested otherwise. Electronic test results reported to the client include the following: Data release memo from the analysts, LQAO, Laboratory Director (or their Designees) authorizing release of the data from the Laboratory, and a case narrative prepared by the analysts summarizing the samples received, test methods, QC notes with identification of noncompliance issues and their impact on data quality, and an explanation of any data qualifiers applied to the data.

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4. Data Validation and Usability

The Region III laboratory data verification and validation procedure is described in detail in their Laboratory Quality Manual (Metzger et al., 2011). Briefly, the procedure is as follows. The actual numeric results of all quality control procedures performed must be included in the case file. The data report and narrative must describe any limitations of the data based on a comprehensive review of all quality control data produced. A written procedure or reference must be available for the method being performed and referenced in the narrative. If the method to be performed is unique, the procedures must be fully documented and a copy included in the case file. Verify that the calibration and instrument performance was checked by analyzing a second source standard (SCV). (The concentration of the second source standard must be in the range of the calibration.) Results must be within the method, procedure, client or in-house limits. At least one blank (BLK), duplicate analysis, and spiked sample must be carried through the entire method or procedure. Peer reviewers complete the On-Demand Data Checklist. The data report must document the accuracy and precision of the reported data by applying qualifier codes, if applicable, and include a summary of the quality control in the case file.

For field measurements, Dr. Puls, E & E staff and Chesapeake field staff will verify the field data collected.

The laboratories shall contact the PI upon detection of any data quality issues which significantly affect sample data. They shall also report any issues identified in the data report, corrective actions, and their determination of impact on data quality.

Data validation is an analyte- and sample-specific process that evaluates the data against the project specifications as presented in the QAPP. Data validation will be performed by a party independent of the data collection activity. Neptune and Company, a QA support contractor, will conduct data validation on a representative sample of the critical analytes with oversight by the QAM. Data packages for the critical analytes that have been accepted by Doug Beak as ready to use or report shall be provided to Steve Vandegrift, QAM, who will coordinate the data validation with Neptune. Neptune shall evaluate data against the QAPP specifications. Neptune will use NRMRL SOP #LSAS-QA-02-0, "Performing Audits of Data Quality" as a guide for conducting the data validation. The outputs from this process will include the validated data and the data validation report. The report will include a summary of any identified deficiencies, a summary statement regarding the adequacy of the data for its intended use, and a discussion on each individual deficiency and any effect on data quality and recommended corrective action.

As part of the data validation process, the synthesis of data and conclusions drawn from the data will be reviewed by the RSKERC Case Study Team (minimally will include case study PIs, Technical Research Lead for case studies, and GWERD

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4. Data Validation and Usability

Director) prior to release of this information or data to entities outside of RSKERC. Once reviewed by the RSKERC Case Study Team in coordination with the GWERD Director, the GWERD Director will approve its release.

4.3 Reconciliation with User Requirements

The PI, Dr. Puls, shall analyze the data, as presented below. Dr. Puls shall also review the results from the data verification and validation process. Dr. Puls shall make a determination as to whether or not the data quality has met project requirements and thereby the user requirements. If there are data quality issues that impact their use, the impact will be evaluated by the PI. If corrective actions are available that would correct the issue, Dr. Puls will make the determination to implement such actions. For example, the PI may have the option to re-sample or re-analyze the affected samples. If not, then the PI will document the impact in the final report such that it is transparent to the data users how the conclusions from the project are affected.

The types of statistical analyses that will be performed include summary statistics (mean, median, standard deviation, minimum, maximum, etc.) if applicable. In addition, the data will be plotted graphically over time and trends in the data will be analyzed, for example increasing or decreasing concentrations of a particular analyte.

Data will be presented in both graphical and tabular form. Tabular forms of the data will include Excel spreadsheets for raw data and tables containing the processed data. Graphical representations of the data will not only include time series plots as previously described, but also Durov and Piper Diagrams for major anions and cations. In addition, concentrations of data could be plotted on surface maps of the Killdeer site showing well locations and concentrations of analytes and contours may be developed to show "analyte plumes", if present.

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5

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5. References

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- Page, L.V., and Pree', H.L., Jr., 1964, Water resources of De Soto Parish, Louisiana: U.S. Geological Survey Water-Supply Paper 1774, 152 p.
- RSKSOP-152v3. Ground-Water Sampling. 5 p.
- RSKSOP-175v5. Sample Preparation and Calculations for Dissolved Gas Analysis in Water Samples Using a GC Headspace Equilibration Technique. 33 p.
- RSKSOP-194v4. Gas Analysis by Micro Gas Chromatograph (Agilent Micro 3000). 13 p.
- RSKSOP-211v3. Field Analytical QA/QC. 4 p.
- RSKSOP-212v6. Standard Operating Procedure for Quantitative Analysis of Low Molecular Weight Acids in Aqueous Samples by HPLC. 22 p.
- RSKSOP-213v4. Standard Operating Procedure for Operation of Perkin Elmer Optima 3300 DV ICP-OES. 22 p.
- RSKSOP-216v2. Sample Receipt and Log-In Procedures for the On-Site Analytical Contractor. 5 p.
- RSKSOP-257v3. Operation of Thermo Elemental PQ Excell ICP-MS. 16 p.
- RSKSOP-275v1. Collection of Water Samples from Monitoring Wells. 10 p.
- RSKSOP-276v3. Determination of Major Anions in Aqueous Samples Using Capillary Ion Electrophoresis with Indirect UV Detection and Empower 2 Software. 11 p.
- RSKSOP-299v1. Determination of Volatile Organic Compounds (Fuel Oxygenates, Aromatic and Chlorinated Hydrocarbons) in Water Using Automated Headspace Gas Chromatography/Mass Spectrometry (Agilent 6890/5973 Quadrupole GC/MS System). 25 p.
- RSKSOP-326v0. Manual Measurement of Groundwater Levels for Hydrogeologic Characterization. 4 p.
- RSKSOP-330v0. Determination of Various Fractions of Carbon in Aqueous Samples Using the Shimadzu TOC-VCPH Analyzer. 15 p.

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5. References

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Comment [nc156]: Without all the Figures and Appendices to review, it is difficult to totally review this document. A Standard Operating Procedures A-1 02:002233_0696_SGTG-B3494 OADD opy 121611.doc

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Research on Potential Impacts of Hydraulic Fracturing on Drinking Water Resources: Coordination with Industry

5/15/12

We appreciate the information industry (as well as states, academia and others) has shared with EPA so far, and look forward to additional exchanges of reliable scientific data and analysis.

Past

- 1. Public input during SAB review of study scope Winter 2010
- 2. Public stakeholder process, included opportunities for oral and written statements Summer 2010
- 3. Technical workshops February-March 2011
- 4. Input during SAB review of draft study plan February August 2011
- 5. Data provided by nine hydraulic fracturing companies in response to request of September 2010

6. Data provided by nine randomly chosen well owner/operator companies in response to request of August 2011.

Ongoing

1. Two prospective case studies underway with Range Resources and Chesapeake

- 2. Duplicate samples offered to relevant stakeholders at five retrospective case study sites
- 3. Collaboration at two waste water treatment plants in Pennsylvania for source apportionment study

4. Discussions with selected hydraulic fracturing service providers to follow up on data provided in response to information request

5. Provide quality assurance project plans (QAPPs) on website for use by industry. These include chemical methods, QA approaches to allow companies to conduct studies comparable to EPA's.

Possible future collaborations/coordination

1. Additional prospective case study (only if additional funds allowed by Congress -- We have discussed this option with Southwestern)

2. We would appreciate working with companies to obtain samples of flowback, produced water, and cores to inform: chemical method development, assessment of effectiveness of waste water treatment methods, and to assess interactions between chemicals used in HF and target formations. (Samples of flowback and produced water are our highest priority request from industry)

3 Does industry have other data to share with EPA (especially data with known QA/QC information)?

4. Public input during SAB review of study reports (expected December 2012 and December 2014)

Current research focuses on potential impacts of hydraulic fracturing on drinking water resources. The President's FY 13 budget requests \$14.1 M: 6.1 M to continue the current study (baseline), and \$8 M (increase) to address air, water, human health and environmental risk.

We will work through our MOU with DOE and DOI/USGS to assure the three agencies coordinate research.



RE: May 14 - Would the May 15th work?

Stephanie Timmermeyer to: Ramona Trovato Cc: Dorothy Miller 05/08/2012 05:16 PM

From:Stephanie Timmermeyer <stephanie.timmermeyer@chk.com>To:Ramona Trovato/DC/USEPA/US@EPACc:Dorothy Miller/DC/USEPA/US@EPA

OK – I will try to catch her another time – thanks for checking Dotti! Steph

From: Dorothy Miller [mailto:Miller.Dorothy@epamail.epa.gov] On Behalf Of Ramona Trovato Sent: Tuesday, May 08, 2012 2:29 PM To: Stephanie Timmermeyer Cc: Ramona Trovato; Dorothy Miller Subject: Re: May 14 - Would the May 15th work?

Hi Stephanie,

Sigh, Ramona is in North Carolina on Thursday and out of the office Friday.

Dotti

Stephanie Timmermeyer ---05/08/2012 03:17:22 PM---Hello - she has not and just today my trip changed to Thurs and Fri this week. How does Thursday lat

From: Stephanie Timmermeyer <stephanie.timmermeyer@chk.com> To: Ramona Trovato/DC/USEPA/US@EPA Date: 05/08/2012 03:17 PM Subject: Re: May 14 - Would the May 15th work?

Hello - she has not and just today my trip changed to Thurs and Fri this week. How does Thursday late look for her? Or Friday early afternoon? I realize it's extremely short notice.

Stephanie R. Timmermeyer Chesapeake Energy Director, Regulatory Affairs - Federal 304.941.9879

From: Ramona Trovato [mailto:Trovato.Ramona@epamail.epa.gov] Sent: Tuesday, May 08, 2012 10:23 AM To: Stephanie Timmermeyer Cc: Ramona Trovato <Trovato.Ramona@epamail.epa.gov> Subject: Re: May 14 - Would the May 15th work? Hi Stephanie,

I don't know if Ramona has gotten back with you regarding dinner. If not, I can let you know that she will be out of the office on the 14th but may be able to make time on the 15th, if your day is still pretty open. I will see what could be worked in. Would 4:30pm on the 15th work?

Have a great day, Dotti

Dorothy J. Miller, Ph.D. Office of Research and Development Environmental Protection Agency ph: 202-564-5192 cell: 202-306-4706 miller.dorothy@epa.gov

Stephanie Timmermeyer ---05/02/2012 03:40:59 PM---Hi Ramona I will be on DC on the 14th and 15th. Let me know if you want to grab dinner on the 14th

From: Stephanie Timmermeyer <stephanie.timmermeyer@chk.com> To: Ramona Trovato/DC/USEPA/US@EPA Date: 05/02/2012 03:40 PM Subject: May 14

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Re: May 14 - Would the May 15th work? Ramona Trovato to: Stephanie Timmermeyer Sent by: Dorothy Miller Cc: Ramona Trovato, Dorothy Miller

05/08/2012 03:28 PM

From:	Ramona Trovato/DC/USEPA/US
To:	Stephanie Timmermeyer < stephanie.timmermeyer@chk.com>
Cc:	Ramona Trovato/DC/USEPA/US@EPA, Dorothy Miller/DC/USEPA/US@EPA

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any). graycol.gif



 From:
 Stephanie Timmermeyer <stephanie.timmermeyer@chk.com>

 To:
 Ramona Trovato/DC/USEPA/US@EPA

 History:
 This message has been replied to.

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Re: May 14 - Would the May 15th work? Ramona Trovato to: Stephanie Timmermeyer Sent by: Dorothy Miller Cc: Ramona Trovato

05/08/2012 11:23 AM

From:Ramona Trovato/DC/USEPA/USTo:Stephanie Timmermeyer <stephanie.timmermeyer@chk.com>Cc:Ramona Trovato/DC/USEPA/US@EPA

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From: To: Date: Subject:	Stephanie Timme Ramona Trovato/I 05/02/2012 03:40 May 14	rmeyer <stephanie.timmermeyer@chk.com DC/USEPA/US@EPA PM</stephanie.timmermeyer@chk.com 	>

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May 14 Stephanie Timmermeyer to: Ramona Trovato

 From:
 Stephanie Timmermeyer <stephanie.timmermeyer@chk.com>

 To:
 Ramona Trovato/DC/USEPA/US@EPA

 History:
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EPA Retrospective Study in Bradford County , PA - Weston Solutions Evaluation of Data John Satterfield to: Ramona Trovato 05/17/2012 Cc: Jeanne Briskin, Stephanie Timmermeyer

05/17/2012 02:03 PM

Ramona:

As you know, Chesapeake's consultants collected split samples from residential drinking water sources during EPA's retrospective study field work in Bradford County, PA in October and November 2011. Though EPA sampled 37 total residential drinking water sources during this effort, Chesapeake's consultants were only able to obtain split samples from 14 residential wells and 1 spring. Access to collect splits from the other EPA sampling sites was denied Chesapeake's consultant by the associated landowners.

Chesapeake commissioned WESTON Solutions to evaluate the data in respect to previously collected Chesapeake samples from some of the studied drinking water sources and historic regional drinking water quality as available from the United States Geologic Survey. Based upon this evaluation, WESTON concludes these 15 residential drinking water sources do not appear to be impacted by Marcellus Shale natural gas drilling or production activities - including hydraulic stimulation.

Please note that we have begun disseminating this report to other appropriate stakeholders (i.e., landowners, PA DEP) and will make the document available to the public via the internet in the near future.

Chesapeake understands and supports EPA's critical evaluation of all sources of secondary information used in its hydraulic fracturing study. We hope you will consider the attached as you review and interpret your own sets of data and certainly welcome any comments or questions you may have regarding the WESTON report.

Please feel free to contact Stephanie or me if you'd like to discuss further.

Thank you, John Satterfield Director Environmental and Regulatory Affairs Chesapeake Energy Corporation Office: (405) 935-3171 Fax: (405) 849-3171 E-mail: john.satterfield@chk.com

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anv). CHK.Report_041312.pdf

Meza-Cuadra, Claudia

From: Sent: To: Subject: Attachments: Briskin, Jeanne Thursday, June 27, 2013 8:24 AM Meza-Cuadra, Claudia FW: Materials Needed for Wednesday Meeting with Natural Gas CEO's coordination of hf research with industry 051512.docx

From: Jeanne Briskin [mailto:Briskin.Jeanne@epamail.epa.gov]
Sent: Thursday, June 27, 2013 8:23 AM
To: Briskin, Jeanne
Subject: Fw: Materials Needed for Wednesday Meeting with Natural Gas CEO's

Jeanne Briskin Office of Science Policy Office of Research and Development U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, N.W. (8104R) Washington, D.C. 20460 (202) 564-4583 - office (202) 565-2911 - fax briskin.jeanne@epa.gov

Address for Deliveries: US EPA Ronald Reagan Building --Room 51144 Washington DC 20004 ----- Forwarded by Jeanne Briskin/DC/USEPA/US on 06/27/2013 08:23 AM -----

From: Jeanne Briskin/DC/USEPA/US To: Ann Campbell/DC/USEPA/US@EPA Cc: Bruce Moore/RTP/USEPA/US@EPA, Don Zinger/DC/USEPA/US@EPA, Fred Hauchman/DC/USEPA/US@EPA, KarenL Martin/DC/USEPA/US@EPA, Linda Chappell/DC/USEPA/US@EPA, Nena Shaw/DC/USEPA/US@EPA, Ashley Gels/DC/USEPA/US@EPA, Dorothy Miller/DC/USEPA/US@EPA, Ramona Trovato/DC/USEPA/US@EPA Date: 05/15/2012 05:13 PM Subject: Re: Materials Needed for Wednesday Meeting with Natural Gas CEO's

Here is our material. I will bring a map of US showing location of case studies tomorrow.

-----Ann Campbell/DC/USEPA/US wrote: -----

To: Don Zinger/DC/USEPA/US@EPA, Jeanne Briskin/DC/USEPA/US@EPA, Fred Hauchman/DC/USEPA/US@EPA, Bruce Moore/RTP/USEPA/US@EPA From: Ann Campbell/DC/USEPA/US Date: 05/14/2012 03:11PM Cc: Nena Shaw/DC/USEPA/US@EPA, KarenL Martin/DC/USEPA/US@EPA, Linda Chappell/DC/USEPA/US@EPA Subject: Materials Needed for Wednesday Meeting with Natural Gas CEO's

Folks - as has been mentioned during the weekly Hydraulic Fracturing calls, the CEOs of QEP, Apache and

Southwestern, along with representatives of ANGA, will be meeting with the Administrator and Deputy Administrator. This group has indicated an interested in discussing, amongst other topics, coordination with industry on the HF study (ORD) and quality of data used on on supply, price and emissions (OAR). If your offices could prepare background information and talking points on these topics by COB tomorrow, I would greatly appreciate it. The information need not go into great depth; a half page or no more than a page would be appropriate.

If you have any questions, please don't hesitate to shoot me an email or call. Thanks, Ann

Ann Campbell Office of the Administrator U.S. Environmental Protection Agency Mail Code: 1101

P: (202) 566-1370 C: (202) 657-3117 F: (202) 501-1428

(See attached file: coordination of hf research with industry 051512.docx)

--- Forwarded by Doug Beak/ADA/USEPA/US on 07/05/2012 06:49 AM -----

From:	"Chris Hill (Regulatory)" <chris.hill@chk.com></chris.hill@chk.com>
To:	Michael Overbay/R6/USEPA/US@EPA
Cc:	Doug Beak/ADA/USEPA/US@EPA, David Jewett/ADA/USEPA/US@EPA, John Satterfield
	<john.satterfield@chk.com>, Bert Smith <bert.smith@chk.com>, Tamara Robbins</bert.smith@chk.com></john.satterfield@chk.com>
	<tamara.robbins@chk.com>, Stephanie Timmermeyer <stephanie.timmermeyer@chk.com></stephanie.timmermeyer@chk.com></tamara.robbins@chk.com>
Date:	05/04/2012 10:48 AM
Subject:	RE: QAPP and contact info

Hi Mike,

You are correct, I did owe you Bert's contact information (See below). Please keep John Satterfield and Stephanie Timmermeyer included in email correspondence as well. For your information I believe Bert is out of the office today (5/4/12).

Bert Smith Work: 405-935-1270 Email:bert.smith@chk.com

As you requested, I have attached a copy of our QAPP comments that we sent to Doug Beak on 1/6/12 for your reference. Based on our conversation on Tuesday, it would be beneficial for EPA finalize this QAPP in parallel with the site characterization work. I am comfortable having you incorporate the specific technical comments in to the QAPP, however, I would appreciate a formal response to the critical items listed in the CHK cover letter. Based on our April 18, 2012 conference call, we are operating with the following understanding:

1. EPA agrees with the timing (i.e., after well construction and pre-HF) of the installation of horizontal wells, if they are even necessary.

2. EPA is willing to accept any and all liabilities associated their actions on the project and is self-insured. The EPA project team has initiated discussions with their general counsel.

3. EPA is willing to maintain a buffer of 30 ft. when installing the horizontal wells.

4. EPA will have a detailed procedure for abandoning the horizontal monitoring wells prior to their construction.

5. EPA plans to include language in the final study plan regarding our concern and the limitations of horizontal monitoring wells.

I appreciate you touching base with Steve V. regarding the QA requirements for the site characterization scope of work. This is valuable information for me to communicate to CHK management as they deliberate on whether or not CHK will manage and finance this the scope of work.

I have attached below the subcontractor's estimates for drilling and logging for your reference.

TASK DESCRIPTION	UNITS	UNITS REQUIRED	UNIT COST S	ESTIMATED COST \$
Subcontractor - Well Logging (Century Geophysical Corp.)			·	
Set Up/Service Charge	LS	1	800	800
Mobilization/Demobilization	LS	2	400	800
Per Diem	Man/Day	4	150	600
Magnetic Susceptibility	Ea	1	325	325
CDL	Ea	2	350	700
Sonic	Ea	1	450	450
Slim Hole Induction	Ea	1	350	350
3-Arm Caliper	Ea	1	250	250
E-Log with Neutron	Ea	2	400	800
Televiewer	Ea	1	875	875
Subcontractor - Monitoring Well Driting/Completion (Associated I	Environmenta	il Industries,	Inc.)	an Garagell
Mob/Demob Rig and Support Vehicles	LS	1	3,000	3,000
Decontamination	Ea	6	150	900
Drill Air Rotary w/ 7-7/8 or 8-3/4-Inch Tooth Bit	Ft	450	24.45	11,003
Complete 2-Inch and 4-Inch Diameter PVC Monitoring Wells	FL	450	20	9,000
Ream and Set Surface Casing	FI	50	51.00	2,550
Above Grade Completions	Ea	6	525	3,150
Per Diem	Crew/Day	8	425	3,400

Thank you, Chris Hill Environmental Engineer Chesapeake Energy Corporation Office: (405) 935-2321 Mobile: (405) 388-3907 Fax: (405) 849-2321 E-mail: <u>Chris.Hill@chk.com</u>

From: Michael Overbay [mailto:Overbay.Michael@epamail.epa.gov]
Sent: Thursday, May 03, 2012 10:53 AM
To: Chris Hill (Regulatory)
Cc: Doug Beak; David Jewett
Subject: QAPP and contact info

Hi Chris,

Wanted to remind you that you were going to send me Bert's contact information and the QA comments from Chesapeake.

Also, we have started a review of the proposal and I had a discussion with the Ada crew this morning about it from a QA viewpoint. The QA manager for the HF study project says that these prospective projects are not like the retrospective ones in that as a collaborator on this study, EPA needs your information that we will use to meet the same QA standards as if we generated it, which is what we call Category 1 standards. Here is a link to our QAPP's for the retrospective case studies that you can use as an example.

http://www.epa.gov/hfstudy/gapps.html

Since we will be using the hydrogeologic data generated by your efforts to characterize the site, we will definitely have to have information on the well installation and development procedures, water level

measurements, pump testing, etc. Most of that can probably be referenced to either information the driller can provide, or ASTM standard methods. We will also need the information on the procedures the geophysics companies will use to log the wells. I have an example from the USGS on what their procedures would be (note that it includes an example of the log montage at the end):

As to the collection and analysis of environmental media samples, we will be putting our own QAPP together to do that for ourselves, but if Chesapeake wants EPA to be able to consider your sample analytical results, those sample collection and analytical procedures will have to meet our Category 1 QA requirement in order to be included in the study. Again, review the QAPPs at the link above for examples.

Finally, as to the comments Chesapeake had provided earlier, although I would still like a copy sent to me, our contractor has them and will be writing a new version of the QAPP that will consider those comments, as well as new information and procedures EPA has developed. As such, due to the time crunch (in order to construct the pad in July and allow 3 weeks for field work, we have to get the ball moving here), we won't be producing a direct response to those previous comments, but will rely on our revised QAPP to fulfill that role.

We look forward to hearing from you on Monday about Chesapeake's funding decision.

Michael Overbay, P.G. Regional Ground Water Center Coordinator U.S. Environmental Protection Agency - Region 6 (214)665-6482 (214)665-2191 (FAX) Visit the Ground Water Center on the web at: www.epa.gov/earth1r6/6wg/swp/groundwater/gw.htm

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any). [attachment "EPA CHK Case Study QAPP working copy 121611 (CHK Comments 1-6-2012).docx" deleted by Doug Beak/ADA/USEPA/US]

Forwarded by Doug Beak/ADA/USEPA/US on 07/05/2012 06:49 AM -----

Thanks for the reply Chris.

We do plan on giving y'all back a reply to the letter from Stephanie to Ramona. I have a conference call set up with OGC next week to discuss how we can document the liability, but they have confirmed to me

that the federal government, including EPA, is "self-insured". So we'll get something going on that, but as you noted, it is not on the critical path for beginning the field work. We do agree with the installation timing and location of any horizontal wells, if needed (i.e., at least 30' from the well bore and being installed after the gas well is drilled, but before the hydraulic fracturing). I have tasked E&E with developing a plugging and abandonment plan, which will be generic in some details for now, but will be revised with specifics about well construction details after they are built so the plan will reflect actual conditions. This is another task we talked about not being on the critical path, but it is underway.

Mike

Michael Overbay, P.G. Regional Ground Water Center Coordinator U.S. Environmental Protection Agency - Region 6 (214)665-6482 (214)665-2191 (FAX) Visit the Ground Water Center on the web at: www.epa.gov/earth1r6/6wq/swp/groundwater/gw.htm

"Chris Hill (Regulatory)" Hi Mike, You are correct, I did owe you Be...

05/04/2012 10:48:27 AM

----- Forwarded by Doug Beak/ADA/USEPA/US on 07/05/2012 06:49 AM -----

From	Doug Beak/ADA/USEPA/US
To:	"Chris Hill (Regulatory)" <chris.hill@chk.com></chris.hill@chk.com>
Cc:	Carlyle Miller/ADA/USEPA/US@EPA, Ralph Ludwig/ADA/USEPA/US@EPA
Date:	05/03/2012 07:30 AM
Subject:	RE: Sampling methods and protocols used in Ne PA

Hi Chris,

I can only speak for the case studies I'm involved with, TX and ND. If you want to know about the other case studies, you will need to contact the PI's on those. The others involved with NE PA case studies have been or will be contacted, we split up the task.

Doug

Dr. Douglas G. Beak

Geochemistry/ Environmental Chemistry USEPA-ORD-NRMRL-GWERD-SRB 919 Kerr Research Dr. Ada, OK 74820

email: beak.doug@epa.gov Phone: 580-436-8813 Fax: 580-436-8703 Blackberry: 580-235-7158

"Chris H	ill (Regulatory)" Hi Doug, I appreciate the quick response. I	05/03/2012 12:16:42 AM
From:	"Chris Hill (Regulatory)" <chris.hill@chk.com></chris.hill@chk.com>	
To:	Doug Beak/ADA/USEPA/US@EPA	
Cc:	Ralph Ludwig/ADA/USEPA/US@EPA, Carlyle Miller/ADA/USEPA/US@	DEPA
Date:	05/03/2012 12:16 AM	
Subject:	RE: Sampling methods and protocols used in Ne PA	

Hi Doug,

I appreciate the quick response. I am working to provide you the same courtesy regarding the information you requested. Please note that I believe some of this information has been provided to

EPA on previous occasions in regards to our prospective study. However, I will have the information verified, compiled and sent to you as soon as possible.

It is interesting to hear that EPA has only requested this information for the TX and ND studies. I know there are other stakeholders (state and industry) that are collecting samples in conjunction with EPA's retrospective sampling events, including in the Susquehanna/Bradford Co. study. Out of curiosity, what is the rationale behind requesting this information from some participating stakeholders and not others?

Please let me know if you think of anything else CHK can do to help.

Thanks, Chris

From: Doug Beak [mailto:Beak.Doug@epamail.epa.gov]
Sent: Wednesday, May 02, 2012 10:46 AM
To: Chris Hill (Regulatory)
Cc: Ralph Ludwig; Carlyle Miller
Subject: Re: Sampling methods and protocols used in Ne PA

Hi Chris,

Yes, we have requested similar information for both the TX and ND studies. For the ND site we have had this information since last July along with their approved QAPP. In TX the state is currently putting this information together since they are the only others sampling and observing.

Since we don't know how the data you are collecting will be used, we are concerned about the comparability and quality of the data you are collecting. Similar to what we are hearing from your side when in the field. Therefore, we need the requested information to be assured that the data you are collecting is comparable and of similar quality.

Doug Dr. Douglas G. Beak USEPA-ORD-NRMRL-GWERD-SRB 919 Kerr Research Dr. Ada, OK 74820

email: <u>beak.doug@epa.gov</u> Phone: 580-436-8813 Fax: 580-436-8703 Blackberry: 580-235-7158

From: "Chris Hill (Regulatory)" [chris.hill@chk.com]
Sent: 05/02/2012 03:58 AM GMT
To: Doug Beak
Cc: Ralph Ludwig; Carlyle Miller
Subject: RE: Sampling methods and protocols used in Ne PA

Hi Doug,

I hope you all had a good round of sampling in Bradford County! I was disappointed I was not able to get out there, but hopefully I can make it in July. I am more than happy to round up this information for you, Ralph, and Carl. Similar to your team, we have a number of folks in transit, however, it shouldn't be a problem getting this information to you next week. If you don't mind, could you please inform me how this information will be used by EPA in their study efforts? I would also like to know if EPA has requested similar information from other operators?

Please let me know if you think of anything else CHK can do to help.

Thanks, Chris

From: Doug Beak [mailto:Beak.Doug@epamail.epa.gov]
Sent: Tuesday, May 01, 2012 8:38 PM
To: Chris Hill (Regulatory)
Cc: Ralph Ludwig; Carlyle Miller
Subject: Sampling methods and protocols used in Ne PA

HI Chris,

In October 2011 we asked Dana for the sampling methods and protocols you used for your sampling in NE PA. We never received these, but did receive information on split sampling method. We are again requesting the this Information. We are interested in knowing what analytes were sampled for, the protocols for sampling (including sampling flow rates, how the flow rates are determined, containers used, preservatives used, criteria for determining when samples should be collected, and all methods used for sample collection). In addition, we are interested in knowing what QA samples were collected, the frequency of collection, and the proximity to the sampling location in the case of blanks. Finally, we are requesting the protocols for the calibration of field equipment, the QA types and frequency used for the field equipment and measurements. It would also be helpful to get a copy of the QAPP for this effort. We would also like the same information for the April/May sampling also. Thank you for your attention to this matter.

Doug

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any).
SAIC

April 25, 2012

Mr. Chris Hill Environmental Engineer Chesapeake Energy Corporation P.O. Box 18496 Oklahoma City, Oklahoma 73154-0496

Re: Proposal/Cost Estimate Limited Hydrogeological Investigation Hydraulic Fracturing Prospective Case Study NE/4 Section 15, Township 28 North, Range 11 West Alfalfa County, Oklahoma

Dear Mr. Hill:

SAIC Energy, Environment & Infrastructure, LLC (SAIC), is pleased to present Chesapeake Energy Corporation (Chesapeake) the following Proposal/Cost Estimate to conduct a Limited Hydrogeological Investigation (Investigation) to support the Hydraulic Fracturing Prospective Case Study proposed in the NE/4 of Section 15. Township 28 North, Range 11 West, Alfalfa County, Oklahoma (Site). The Investigation is being conducted to evaluate the Site soil and groundwater background conditions prior to construction of a pad site for gas well drilling/development. Groundwater contained within the Quaternary-age terrace deposits underlie the well pad area, and have been identified as a major alluvial aguifer that is used for agricultural, municipal and domestic purposes. The bedrock (Permian-age) groundwater that underlies the terrace deposits in the area will also be evaluated. The bedrock formations in this area contain naturally-occurring poor water quality of low yield and therefore, groundwater is not typically used from bedrock formations in this area. However, this investigation will evaluate that portion of the bedrock groundwater system that is above the base of treatable groundwater (i.e., groundwater with a TDS of 10,000 mg/L or less). The base of treatable groundwater in the well pad area has initially been determined to be 100 to 150 feet below ground level (bgl) by the Oklahoma Corporation Commission (OCC). The base of treatable groundwater will occur within the Hennessey Group bedrock units. The main objectives of this Investigation will be to: 1) determine the groundwater flow direction and collect hydraulic parameters to estimate groundwater velocity: 2) determine the subsurface geology and groundwater occurrence beneath the Site; 3) collect initial soil samples for limited analytical testing; 4) collect 1 round of groundwater samples for comprehensive analytical testing; and 5) define the variation of groundwater quality with depth within the terrace and bedrock groundwater systems.

Surficial geology at the Site consists of Quaternary-age terrace deposits related to the Salt Fork of the Arkansas River. These deposits consist of light-tan to gray gravel, sand, silt, clay, and volcanic ash, with sand dunes common in places. A review of water well data from wells located within approximately 2 miles of the Site indicates that the terrace deposits at the Site likely range from 20 to 50 feet in thickness and average approximately 35 feet in thickness. Groundwater in the terrace deposits in this area are reported to range from approximately 3 feet bgl to 28 feet bgl, and average approximately 15 feet bgl. Underlying the terrace deposits is Permian-age consolidated bedrock of the Hennessey Group, which includes the Bison Formation, Salt Plains Formation, Kingman Formation, and Fairmont Shale. These units consist of fine-grained sandstone, siltstone, and shale. The Bison Formation is approximately 120 feet thick, the Salt Plans Formation is approximately 160

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feet thick, the Kingman Formation is approximately 70 feet thick, and the Fairmont Shale is approximately 160 feet thick, with a collective thickness of approximately 510 feet. Groundwater in the consolidated bedrock occurs principally within fractures and joints and is typically of very poor quality, becoming more mineralized with depth.

During implementation of the Investigation, SAIC anticipates implementing the following activities on behalf of Chesapeake:

Task 1 - Project Management

The Investigation activities will be managed out of SAIC's Tulsa, Oklahoma office by Mr. Bruce McKenzie. SAIC's on-site hydrogeologist will be Mr. Matt Mugavero, and SAIC technicians will include either Mr. Stan Marshall or Mr. Terry Fisher as schedules allow. QA/QC of the laboratory analytical data will be managed by Ms. Kristin Drucquer. SAIC will prepare a Site-Specific Health and Safety Plan (HSP) that will address all field activities proposed herein.

Task 2 - Monitoring Well Installation and Development

A total of 6 groundwater monitoring wells, 5 shallow (~50 feet) and 1 deep (~150 feet), will be installed to establish and monitor the groundwater quality at or in close proximity to the proposed well pad site. These monitoring wells will be drilled and installed by a licensed well driller (Associated Environmental Industries, Inc., Norman, Oklahoma) in accordance with Oklahoma state regulations.

The shallow groundwater monitoring wells will be installed utilizing a truck-mounted hollow-stem auger drilling rig and CME continuous split-barrel sample system from surface to total depth. Borings will be advanced to the top of the underlying consolidated bedrock. During drilling, lithological descriptions will be made using the Unified Soil Classification System. Field activities will be recorded in a dedicated field logbook, and all hydrogeological information noted documented on permanent soil boring records.

In each borehole, soil samples will be collected from the following depth intervals: 0-0.5 feet bgl, 1-2 feet bgl and 2-3 feet bgl. Upon collection, the soil samples will be placed into laboratory prepared containers, labeled as to source and contents, placed on wet-ice for preservation, and placed under chain-of-custody control for transport to the analytical laboratory (TestAmerica, Inc., Nashville, TN) for volatile organic compound (VOC) (SW 8260B), semi-volatile organic compound (SVOC) (SW 8270C), polycyclic aromatic hydrocarbon (PAH) (SW 8270C-SIM) and total petroleum hydrocarbon (TPH) (TX 1005) analyses. In addition to soil samples for laboratory analysis, an aliquot of each soil sample will be submitted to a soils laboratory (Inter-Mountain Laboratories, Inc., Sheridan, Wyoming) for comprehensive salinity analysis by Saturated Paste Extraction (Cations: sodium, calcium, magnesium, potassium; Anions: nitrate-n, chloride, sulfate, boron, bicarbonate, carbonate; General Chemistry: pH, conductivity, texture; Derived Values: total soluble salts, sodium adsorption ratio, potassium adsorption ratio, exchangeable sodium percentage, exchangeable potassium percentage).

The shallow monitoring wells will be constructed using 2-inch diameter, screw-coupled, Schedule 40 PVC 0.010-inch slot screens and Schedule 40 PVC casing. In general, approximately 30 to 40 feet of screen will be installed in each monitor well such that the top of the screen is situated above (approximately 5 feet) the groundwater saturation level observed at the time of well installation. Once the screen/casing strings are positioned within the open boreholes, a clean silica sand pack will be placed in the annular space between the screen/casing and the open borehole. In each monitor well, the sand pack will extend from total depth to approximately two feet above the top slot of the screen. A 2-foot minimum sodium bentonite pellet seal will be placed immediately above the

sand packs. Following hydration of the bentonite seal, the remaining annular space will be filled with a cement/bentonite grout using pressure-grouting techniques to approximately one foot bgl. A vented cap will be placed on top of the well casing, and a locking steel protective outer casing will be centered upon each well casing. The protective outer casing will be set in a 3-inch thick by 36-inch diameter concrete pad. During well completion, the well identification nomenclature will be placed on or in the well protector. When the well pads have cured, a weep hole will be drilled in each protective outer casing. Well completion details will be recorded on permanent well completion records.

The deep monitoring well will be installed by drilling through the terrace deposits and 5 feet into the underlying bedrock utilizing a truck-mounted hollow-stem auger drilling rig and CME continuous splitbarrel sample system. A 10-inch diameter surface casing will then be set and grouted in-place to isolate the groundwater within the terrace deposits from the groundwater within the underlying bedrock. Once the surface casing grout has cured, air-rotary drilling equipment will be utilized to drill into the underlying bed rock. During bedrock drilling operations, an attempt will be made to collect water quality measurements (i.e., specific conductivity, temperature and pH) from the borehole as these data may be useful in determining the base of treatable water.

Upon reaching total depth, geophysical and water quality logging will be conducted in the deep borehole. The geophysical and water quality logging will be conducted by Century Geophysical Corporation and Earth Data Northeast, Inc., respectively, and will include the following:

- Caliper,
- Natural Gamma,
- Normal Resistivity,
- Single Point Resistance,
- Fluid Resistivity and Temperature,
- Spontaneous Potential (SP),
- Induction Conductivity,
- Magnetic Susceptibility,
- Full Wave Form Sonic,
- Acoustic Borehole Imager with Vertical Deviation and Azimuth,
- Neutron Density,
- Gamma-Gamma Density, and
- Water Quality Logging (pressure, temperature, conductivity, dissolved oxygen, pH and Eh).

The deep monitoring well will be constructed using 4-inch diameter, screw-coupled, Schedule 40 PVC 0.010-inch slot screens and Schedule 40 PVC casing. Approximately 80 to 100 feet of screen will be installed so that the top of the screened interval will terminate at, or just above, the top of the groundwater zone to be monitored. Once the screen/casing assembly is positioned within the borehole, the annular space between the wellbore and the screen/casing will be filled with clean, silica sand to a level approximately two feet above the top slot of the screened interval. Four feet of bentonite will then be placed in the annular space above the silica sand/filter pack and hydrated. Following hydration of the bentonite seal, the remaining annular space will be filled with a cement/bentonite grout using pressure-grouting techniques to approximately one foot bgl. A vented cap will be placed on top of the well casing, and a locking steel protective outer casing will be centered upon the well casing. The protective outer casing will be set in a 3-inch thick by 36-inch diameter concrete pad. During well completion, the well identification nomenclature will be placed on or in the well protector. When the well pad has cured, a weep hole will be drilled in the protective

outer casing just above the concrete pad so that moisture will not accumulated within the protective outer casing. Well completion details will be recorded on a permanent well completion record.

During drilling operations, soil and rock cuttings will be containerized and labeled properly. These cuttings will be stored on-site until proper disposal can be arranged. Drilling equipment will be decontaminated between each monitoring well location.

During well drilling/completion activities, samples of the silica sand, bentonite (pellets and powder), cement and any drill-fluid additives will be collected and archived for future analysis if needed.

Following well completion activities, each monitoring well will be left undisturbed for a minimum of 48 hours to allow the cement/bentonite grout to cure. After this 48-hour period, each of the newly installed monitoring wells will be developed to remove the fine particles that have accumulated in the well casing and annulus. The monitoring wells will be developed utilizing bailers, submersible pumps, surge-blocks or other suitable devices to ensure that the wells are free of suspended sediment and provide representative water samples. Development will be conducted until a minimum of three casing volumes are removed, the water quality parameters of the discharging groundwater are stable (within 10% variance) and the turbidity of the discharging groundwater is 20 NTU or less. All well development water will be containerized, properly labeled and stored on-site until proper disposal can be arranged.

Upon completion of well installation/completion activities, each monitoring well will be surveyed for horizontal and vertical control by an Oklahoma-licensed land surveyor (Jividens Land Survey Company, Woodward, Oklahoma). The coordinate location (within 1 foot), top of case elevation (TOC) (within 0.01 foot) and ground elevation (within 0.01 foot) for each monitoring well will be determined. In addition, to surveying, the location of each monitoring well will be recorded with a sub-meter GIS-compatible GPS.

Task 3 - Groundwater Monitoring

Upon completion of well development activities, the monitoring wells will be left undisturbed for a period of one week. Following this period, two rounds of concurrent depth to groundwater (DTW) measurements will be taken within each of the monitoring wells at the Site. The first DTW event will be conducted immediately prior to conducting groundwater purging/sampling activities, and the second DTW event will be conducted one week following the groundwater sampling event. The water levels will be measured from the surveyed TOC of each monitoring well utilizing a decontaminated electronic water level indicator and will be recorded in a dedicated field logbook. Data from the water level measurements, in conjunction with the TOC elevation data, will be utilized to construct groundwater potentiometric surface maps of the groundwater system being monitored.

Upon completion of well development activities and prior to conducting groundwater purging/sampling activities, vertical water quality logging will be conducted within each monitoring well. During these activities, the specific conductivity, temperature, dissolved oxygen (DO), pH and oxidation/reduction potential (Eh) of the groundwater will be measured on 1-foot increments from the top of the water column to the base of the monitoring well. These measurements will be recorded in a dedicated field logbook.

Reference data for the area indicate that the groundwater within the shallow terrace deposits likely exhibits density and/or chemical stratification. These data also suggest that the deep bedrock groundwater is also likely stratified. Therefore, it is anticipated that two groundwater samples will be collected from each of the monitoring wells completed at the Site. The groundwater sampling zones will be selected based upon the results of the vertical water quality logging conducted within each monitoring well.

Prior to conducting groundwater sampling within each selected zone, the zone will be low-flow purged utilizing a decontaminated bladder-pump with a dedicated bladder. Field measurements of pH, Eh, dissolved oxygen, specific conductance, temperature and turbidity will be collected and documented in a dedicated field logbook during well purging and immediately prior to sample collection. When three consecutive readings of the field parameters taken do not differ by more than 10%, and the turbidity of the discharging groundwater is 20 NTU or less, groundwater samples will be collected. If turbidity values of <20 NTU cannot be achieved, then dissolved analyses of metals, cations and radionuclides will be conducted. Upon collection, the groundwater samples will be placed directly into laboratory prepared sample containers, labeled as to source and contents, placed on wet-ice for preservation, and placed under chain-of-custody control for transport to the analytical laboratory (TestAmerica, Inc., Nashville, Tennessee) for analytical suite developed by Chesapeake for this investigation. This analytical suite is provided in attached Table 1.

All purge water and water not consumed during the sampling process will be containerized, properly labeled and stored on-site until proper disposal can be arranged.

Task 4 - Hydraulic Conductivity Testing

To further characterize the shallow unconfined groundwater system present beneath the Site, singlewell displacement tests (slug) tests will be conducted in the 5 proposed shallow groundwater monitoring wells. During these slug tests, the groundwater within the well will be artificially lowered by rapidly removing groundwater from the well utilizing dedicated bailers. The return of the lowered groundwater level to an equilibrium level will be recorded utilizing a pressure transducer positioned at the bottom of the monitoring well attached to a data logger at the surface.

To further characterize the bedrock groundwater system, a 12-hour constant rate pump test followed by a 12-hour recovery monitored period will be conducted in the proposed deep monitoring well. A 1-hour pumping pre-test will be conducted on the well to determine pumping rate for the 24-hour test and will be conducted at least 1 day prior to the 24-hour test. The deep well will be outfitted with a pressure transducer positioned at the bottom of the monitoring well (placed in the well approximately 2 days prior to initiating pre-test activities) attached to a data logger at the surface to monitor drawdown. A pressure transducer will also be installed in the shallow monitoring well located adjacent to the deep monitoring well to measure any potential change/effect that pumping of the bedrock groundwater system may have upon the shallow groundwater system. Discharge measurements will be taken and the pH, specific conductivity and temperature of the discharging groundwater measured hourly throughout the pump test. A totalizing flow meter will be installed in the discharge line to monitor flow throughout the test.

Data from the pump and slug tests will be interpreted and values for hydraulic conductivity and transmissivity calculated, which will be used to estimate groundwater flow velocities.

Task 5 - Report Preparation

Upon completion of the field activities and receipt of the laboratory analytical data, SAIC will prepare a brief report detailing the results of the investigation. This report will describe the field operations and sampling activities conducted and will include the following:

- A brief discussion of the Site geology,
- A discussion of all field activities performed,
- A summary of results of the well installation activities,
- A discussion of the results of the deep geophysical logs,
- Tables summarizing the laboratory analytical data,
- A Site location and topographic features map,
- A Site map showing the actual locations of the newly installed monitoring wells,

- A depth to water map,
- Two groundwater potentiometric surface maps for the shallow groundwater system,
- Two cross sections (N-S and E-W),
- An evaluation of velocity of the shallow groundwater system beneath the Site,
- Soil boring and monitoring well construction records,
- Copies of the deep geophysical logs,
- Copies of field notes,
- Site photographs, and
- Laboratory analytical reports and chain-of-custody documentation.

A Cost Estimate to implement the scope of work is attached. SAIC's charges will be billed on a timeand-materials basis in accordance with the current Chesapeake/SAIC contract agreement.

SAIC appreciates this opportunity to be of service to Chesapeake. If you have any questions concerning the proposed scope of work or the estimated costs, please do not hesitate to contact me at (918) 599-4383.

Sincerely, SAIC Energy, Environment & Infrastructure, LLC

Burg Milmin

Bruce E. McKenzie, P.G. Project Manager

Attachments: Table 1 - Retrospective Case Study Analytical Suite Figure 1 - Site Location and Topographic Features Figure 2 - Proposed Gas Well Pad Site and Monitoring Well Locations Cost Estimate

Assumptions and Limitations

In preparing the proposed Scope of Work (SOW) and Cost Estimate, SAIC has relied upon verbal and/or written information provided by Chesapeake Energy Corporation (Chesapeake) and/or secondary sources. SAIC has not been tasked to make an independent investigation concerning the accuracy or completeness of the information relied upon. To the extent that SAIC has based its proposed SOW and Cost Estimate on such information, the proposed SOW and Cost Estimate are contingent on the validity of the information provided.

Chesapeake acknowledges that SAIC has not contributed to the presence of hazardous substances, hazardous wastes, petroleum products, asbestos, chemicals, pollutants, contaminants, or any other hazardous or toxic materials (hereinafter Hazardous Materials) that may exist or be discovered in the future at the site at which SAIC's services shall be provided and that SAIC does not assume any liability for the known or unknown presence of Hazardous Materials.

SAIC's investigation will be restricted to collection and analyses of a limited number of environmental samples and visual observations obtained during the physical site visit, and from records made available by Chesapeake or third parties during the investigation. Because the investigation will consist of collecting and evaluating a limited supply of information, SAIC may not identify all potential items of concern. Therefore, SAIC warrants only that the project activities under this SOW and contract have been performed within the parameters and scope communicated by Chesapeake and reflected in the SOW and contract.

The proposed report will be prepared for the sole and intended use of Chesapeake. Any person or entity obtaining, using, or relying on this report hereby acknowledges that they do so at their own risk, and that SAIC shall have no responsibility or liability for the consequences thereof. This report is intended to be used in its entirety and taking or using in any way excerpts from the proposed report are not permitted and any party doing so does so at its own risk. In preparing this proposed report, SAIC will have relied on verbal and written information provided by secondary sources and interviews, including information provided by Chesapeake. Opinions and recommendations that may be presented in this report apply only to site conditions and features as they existed at the time of SAIC's site visit. The opinions and recommendations presented in this report cannot be applied to conditions and features of which SAIC is unaware and has not had the opportunity to evaluate.

Analyte	EPA Method	CHK's Lab Method
$\delta^{13}C$ and δ^2H of methane	Isotech: gas stripping and IRMS	Isotech: gas stripping and IRMS
$\delta^{13}C$ of inorganic carbon	Isotech: gas stripping and IRMS	Isotech: gas stripping and IRMS
δ^{86} Sr & δ^{87} Sr	??	Geo Chron
Turbidity	NA	E180.1
Fecal Coliform	NA	SM20 9222D
Total Coliform	NA	SM20 9223B
MBAS	NA	SM5540C
Carbon Dioxide	RSKSOP-194v4& RSKSOP-175v5	SW8000B
Acetate	RSKSOP-112v6	SW8015
Butyrate	RSKSOP-112v6	SW8015
Formate	RSKSOP-112v6	SW8015
Isobutyrate	RSKSOP-112v6	SW8015
Lactate	RSKSOP-112v6	SW8015
Propionate	RSKSOP-112v6	SW8015
Diethylene glycol	Region III Method	SW8015
tetraethylene glycol	Region III Method	SW8015
triethylene glycol	Region III Method	SW8015
®-(+)-Limonene	ORGM 515r1.1	SW8270
1,2,4,5-Tetrachlorobenzene	ORGM 515r1.1	SW8270
1,2-Diphenylhydrazine (Azobenzene)	ORGM 515r1.1	SW8270
1,3-Dimethyl adamantine	ORGM 515r1.1	SW8270
1,3-Dinitrobenzene	ORGM 515r1.1	SW8270
1,4-Dinitrobenzene	ORGM 515r1.1	SW8270
1-Chloronaphthalene	ORGM 515r1.1	SW8270
2,3,4,6-Tetrachlorophenol	ORGM 515r1.1	SW8270
2,4,5-Trichlorophenol	ORGM 515r1.1	SW8270
2,4,6-Trichlorophenol	ORGM 515r1.1	SW8270
2,4-Dichlorophenol	ORGM 515r1.1	SW8270
2,4-Dimethylphenol	ORGM 515r1.1	SW8270
2,4-Dinitrophenol	ORGM 515r1.1	SW8270
2,4-Dinitrotoluene	ORGM 515r1.1	SW8270
2,6-Dichlorophenol	ORGM 515r1.1	SW8270
2,6-Dinitrotoluene	ORGM 515r1.1	SW8270
2-Butoxyethanol	ORGM 515r1.1	SW8270
2-Chloronaphthalene	ORGM 515r1.1	SW8270
2-Chlorophenol	ORGM 515r1.1	SW8270
2-Methylnaphthalene	ORGM 515r1.1	SW8270
2-Methylphenol	ORGM 515r1.1	SW8270
2-Nitroaniline	ORGM 515r1.1	SW8270

Analyte	EPA Method	CHK's Lab Method
2-Nitrophenol	ORGM 515r1.1	SW8270
3,3-Dichlorobenzidine	ORGM 515r1.1	SW8270
3/4-Methylphenol	ORGM 515r1.1	SW8270
3-Nitroaniline	ORGM 515r1.1	SW8270
4,4'-Methylenebis (2-	ORGM 515r1.1	SW8270
4,4'-Methylenebis (N,N-dimethylaniline)	ORGM 515r1.1	SW8270
4,6-Dinitro-2-methylphenol	ORGM 515r1.1	SW8270
4-Bromophenyl phenyl ether	ORGM 515r1.1	SW8270
4-Chloro-3-methylphenol	ORGM 515r1.1	SW8270
4-Chloroaniline	ORGM 515r1.1	SW8270
4-Chlorophenyl phenyl ether	ORGM 515r1.1	SW8270
4-Nitroaniline	ORGM 515r1.1	SW8270
4-Nitrophenol	ORGM 515r1.1	SW8270
Acenaphthene	ORGM 515r1.1	SW8270
Acenaphthylene	ORGM 515r1.1	SW8270
Acetophenone	ORGM 515r1.1	SW8270
Adamantane	ORGM 515r1.1	SW8270
Aniline	ORGM 515r1.1	SW8270
Anthracene	ORGM 515r1.1	SW8270
Benzo (a) anthracene	ORGM 515r1.1	SW8270
Benzo (a) pyrene	ORGM 515r1.1	SW8270
Benzo (b) fluoranthene	ORGM 515r1.1	SW8270
Benzo (g,h,i) perylene	ORGM 515r1.1	SW8270
Benzo (k) fluoranthene	ORGM 515r1.1	SW8270
Benzoic acid	ORGM 515r1.1	SW8270
Benzyl alcohol	ORGM 515r1.1	SW8270
Bis(2-chloroethoxy)methane	ORGM 515r1.1	SW8270
Bis(2-chloroethyl)ether	ORGM 515r1.1	SW8270
Bis(2-chloroisopropyl)ether	ORGM 515r1.1	SW8270
Bis(2-ethylhexyl)phthalate	ORGM 515r1.1	SW8270
Butyl benzyl phthalate	ORGM 515r1.1	SW8270
Carbazole	ORGM 515r1.1	SW8270
Chloroaniline	ORGM 515r1.1	SW8270
Chlorobenzilate	ORGM 515r1.1	SW8270
Chrysene	ORGM 515r1.1	SW8270
Diallate (cis or trans)	ORGM 515r1.1	SW8270
Dibenz (a,h) anthracene	ORGM 515r1.1	SW8270
Dibenzofuran	ORGM 515r1.1	SW8270
Diethyl phthalate	ORGM 515r1.1	SW8270
Dimethyl phthalate	ORGM 515r1.1	SW8270

Analyte	EPA Method	CHK's Lab Method
Di-n-butyl phthalate	ORGM 515r1.1	SW8270
Di-n-octyl phthalate	ORGM 515r1.1	SW8270
Dinoseb	ORGM 515r1.1	SW8270
Diphenylamine	ORGM 515r1.1	SW8270
Disulfoton	ORGM 515r1.1	SW8270
Fluoranthene	ORGM 515r1.1	SW8270
Fluorene	ORGM 515r1.1	SW8270
Hexachlorobenzene	ORGM 515r1.1	SW8270
Hexachlorobutadiene	ORGM 515r1.1	SW8270
Hexachlorocyclopentadiene	ORGM 515r1.1	SW8270
Hexachloroethane	ORGM 515r1.1	SW8270
Indeno (1,2,3-cd) pyrene	ORGM 515r1.1	SW8270
Isophorone	ORGM 515r1.1	SW8270
Naphthalene	ORGM 515r1.1	SW8270
Nitrobenzene	ORGM 515r1.1	SW8270
N-Nitrosodiethylamine	ORGM 515r1.1	SW8270
N-Nitrosodimethylamine	ORGM 515r1.1	SW8270
N-Nitrosodi-n-butylamine	ORGM 515r1.1	SW8270
N-Nitrosodi-n-propylamine	ORGM 515r1.1	SW8270
N-Nitrosodiphenylamine	ORGM 515r1.1	SW8270
N-Nitrosomethylethylamine	ORGM 515r1.1	SW8270
Parathion	ORGM 515r1.1	SW8270
Parathion-ethyl	ORGM 515r1.1	SW8270
Parathion-methyl	ORGM 515r1.1	SW8270
Pentachlorobenzene	ORGM 515r1.1	SW8270
Pentachlorophenol	ORGM 515r1.1	SW8270
Phenanthrene	ORGM 515r1.1	SW8270
Phenol	ORGM 515r1.1	SW8270
Phorate	ORGM 515r1.1	SW8270
Pronamide	ORGM 515r1.1	SW8270
Pyrene	ORGM 515r1.1	SW8270
Pyridine	ORGM 515r1.1	SW8270
Squalene	ORGM 515r1.1	SW8270
Terbufos	ORGM 515r1.1	SW8270
Terpiniol	ORGM 515r1.1	SW8270
Tri(2-butoxyethyl)phosphate	ORGM 515r1.1	SW8270
Trifluralin	ORGM 515r1.1	SW8270
Carbaryl	ORGM 515r1.1	SW8270 (EPA531.1 optional)
1,2-Dinitrobenzene	ORGM 515r1.1	SW8270 (SW8330 optional)

Analyte	EPA Method	CHK's Lab Method	
Bromide	RSKSOP-276v3	SW9056	
Chloride	RSKSOP-276v3	SW9056	
Fluoride	RSKSOP-276v3	SW9056	
Nitrate	RSKSOP-214v5	SW9056	
Nitrite	RSKSOP-214v5	SW9056	
Sulfate	RSKSOP-276v3	SW9056	
Hydrogen	RSKSOP-194v4& RSKSOP-175v5	??	
BART Kit (IRB,SRB,SFB)	NA	BART	
Diesel	ORGM 508 r 1.0	SW8015	
GRO as Gasoline	ORGM 506 r 1.0	SW8015	
Oil & Grease HEM	NA	E1664A	
Temperature of pH determination	NA	E170.1	
Phosphorus	RSKSOP-213v4	E365.4	
Dissolved Organic Carbon (DOC)	RSKSOP 330v0	SW9060 or SM20 5310C / 415.1M	
Acetylene	RSKSOP-194v4 & RSKSOP-175v5	RSK175	
Butane	RSKSOP-194v4& RSKSOP-175v5	RSK175	
Ethane	RSKSOP-194v4& RSKSOP-175v5	RSK175	
Ethylene	RSKSOP-194v4 & RSKSOP-175v5	RSK175	
Methane	RSKSOP-194v4 & RSKSOP-175v5	RSK175	
Propane	RSKSOP-194v4& RSKSOP-175v5	RSK175	
Alkalinity, Total (CaCO3)	NA	SM2320B	
Bicarbonate Alkalinity as CaCO3	NA	SM2320B	
Carbonate as CaCO3	NA	SM2320B	
Specific conductance	NA	SM2510B	
Total Dissolved Solids	NA	SM2540C	
Total Suspended Solids	NA	SM2540D	
рН	NA	SM4500HB	
Dissolved Inorganic Carbon (DIC) RSKSOP 330v0		SW9060 or Standard Methods (SM20) or equivalent	
Ammonia as N	RSKSOP-214v5	SM4500NH3BG	
Silicon	Silicon RSKSOP-213v4 SW6010		
Boron	RSKSOP-213v4	SW6010C	
Magnesium RSKSOP-213v4		SW6010C	
Potassium	RSKSOP-213v4	SW6010C	
Sodium	RSKSOP-213v4	SW6010C	

Analyte	FPA Method	CHK's Lab Method
Andryce		crik s Lub Method
Strontium	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6010C
Sulfur	RSKSOP-213v4	SW6010C
Calcium	RSKSOP-213v4	SW6010C
Aluminum	RSKSOP-213v4	SW6020
Antimony	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6020
Arsenic	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6020
Barium	RSKSOP-213v4	SW6020
Beryllium	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6020
Cadmium	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6020
Cesium	RSKSOP-257v3/-332v0	SW6020
Chromium	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6020
Cobalt	RSKSOP-213v4	SW6020
Copper	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6020
Iron	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6020
Lead	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6020
Manganese	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6020
Molybdenum	RSKSOP-213v4	SW6020
Nickel	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6020
Potassium		SW6020
Selenium	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6020
Silver	RSKSOP-213v4	SW6020
Thallium	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6020
Thorium	NA	SW6020
Titanium	RSKSOP-213v4	SW6020
Uranium	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6020
Vanadium	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6020
Zinc	RSKSOP-213v4 / RSKSOP-257v3/-332v0	SW6020

Analyte	EPA Method	CHK's Lab Method
Mercury	RSKSOP-257v3/-332v0	SW7470A
1,2-Dibromo-3-chloropropane	ORGM 515r1.1	SW8011
4,4'-DDD	ORGM 515r1.1	SW8081
4,4'-DDE	ORGM 515r1.1	SW8081
4,4'-DDT	ORGM 515r1.1	SW8081
Aldrin	ORGM 515r1.1	SW8081
Dieldrin	ORGM 515r1.1	SW8081
Endosulfan I	ORGM 515r1.1	SW8081
Endosulfan II	ORGM 515r1.1	SW8081
Endosulfan sulfate	ORGM 515r1.1	SW8081
Endrin	ORGM 515r1.1	SW8081
Endrin aldehyde	ORGM 515r1.1	SW8081
Endrin ketone	ORGM 515r1.1	SW8081
Heptachlor	ORGM 515r1.1	SW8081
Heptachlor epoxide	ORGM 515r1.1	SW8081
Methoxychlor	ORGM 515r1.1	SW8081
α-BHC	ORGM 515r1.1	SW8081
β-ВНС	ORGM 515r1.1	SW8081
γ-BHC (Lindane)	ORGM 515r1.1	SW8081
δ-BHC	ORGM 515r1.1	SW8081
Azinphos-methyl	ORGM 515r1.1	SW8141
Dichlorovos	ORGM 515r1.1	SW8141
Malathion	ORGM 515r1.1	SW8141
Mevinphos	RSKSOP-213v4	SW8141
1,1,1-Trichloroethane	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
1,1,2-Trichloroethane	RSKSOP-299v1	SW8260B
1,1-Dichloroethane	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
1,1-Dichloroethene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
1,2,4-Trimethylbenzene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
1,2-Dibromo-3-chloropropane	NA	SW8260B
1,2-Dichlorobenzene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
1,2-Dichloroethane	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
1,3,5-Trimethylbenzene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
1,3-Dichlorobenzene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
1,4-Dichlorobenzene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Acetone	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Benzene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Carbon disulfide	RSKSOP-299v1	SW8260B
Carbon Tetrachloride	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Chlorobenzene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B

Analyte	EPA Method	CHK's Lab Method
Chloroform	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
cis-1,2-Dichloroethene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Diisopropyl ether	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Ethanol	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Ethyl t-butyl ether	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Ethylbenzene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Isopropyl Alcohol	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Isopropyl benzene	RSKSOP-299v1	SW8260B
m/p-Xylene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Methyl t-butyl ether	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Methylene Chloride	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Naphthalene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
o-Xylene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
t-Amyl methyl ether	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
t-Butyl alcohol	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Tetrachloroethene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Toluene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
trans-1,2-Dichloroethene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Trichloroethene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Vinyl chloride	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Xylenes, total	NA	SW8260B
1,2,3-Trimethylbenzene	RSKSOP-259v1 / RSKSOP-299v1	SW8260B
Radiochemistry: Gamma Spectroscopy	NA	EPA 901.1
Radiochemistry: Ra 226	NA	EPA 903.0
Radiochemistry: Ra 228	NA	EPA 904.0
Radiochemistry: Gross Alpha	NA	SW9310
Radiochemistry: Gross Beta	NA	SW9310

Footnotes:

NA = Not Analyzed



24, Apr 0:\Enviro\TUL\PR0P0SAL\2012\2602299041-_CHK_AlfalfaCo\CAD\20120423_F01_Topo.dwg



CHK Technical Review

E & E Technical Memorandum – Installation of groundwater monitoring wells in support of EPA's hydraulic fracturing study.

Executive Summary:

Chesapeake Energy (CHK) has prepared these comments in response to E&E's two technical memorandums prepared for the EPA and transmitted to CHK on March 1, 2012 and March 27, 2011 via email. CHK's detailed response is formatted to follow the technical memorandums; the first bullet paraphrases language from the memorandum and sub-bullets represent CHK comments. General comments are highlighted below:

- Chesapeake Energy understands that the Option #1 (vertical well with off pad access) proposed in the original technical memorandum has been removed as a viable alternative.
- The installation of horizontal monitoring wells after the production well has been installed significantly mitigates the potential risk to the monitoring wells' integrity, and, therefore, the study.
- The limitations of the horizontal monitoring wells require additional consideration to ensure the study's data quality objectives will be met. For example, the fluctuation in groundwater levels and end data use (i.e., modeling) should have specific considerations identified.
- CHK recommends EPA identify the process it will use to differentiate between potential causes (including naturally occurring) should sampling results indicate a significant change in water quality that is otherwise unexplainable.
- CHK does not believe the site characterization activity identified by the EPA will provide the information necessary to determine the groundwater velocity in the deeper bedrock formation.
- Appropriate monitoring well abandonment procedures for non-standard well should be developed.

CHK understands EPA's rationale for using non-standard wells on this highly influential scientific assessment stems from an EPA schedule issue related its 2014 report. CHK has worked with the EPA to identify a second site with what we believe to have favorable groundwater velocity. Based on characterization of the aquifers, the use of horizontal monitoring wells may not be necessary to achieve EPA's study goals.

Detailed comments:

Re: Technical Memorandum – Installation of groundwater monitoring wells in support of EPA's hydraulic fracturing study. (February 24, 2012).

Introduction:

- E&E limited the scope of the study to underground sources of drinking water (USDW), which has a specific definition under the Safe Drinking Water Act (SDWA) (i.e., 10,000 mg/L TDS). The State of OK has defined the base of treatable water (i.e. TDS of 10,000 mg/L) in this area at occurring between approximately 100 to 150 ft below ground level (bgl)., however, the E&E/EPA have proposed monitoring wells at depths up to 300 ft. The Final Study Plan does not limit the boundaries of the study to USDW.
 - EPA should develop clear boundaries for the study. It is recommended EPA use and clearly state that USDW are the boundaries of the study, and not install monitoring wells into zones that have naturally occurring brine or salt water present (TDS >10,000 mg/L)..
 - During the March 23, 2012 meeting, EPA stated it used 300 ft. because CHK previously stated this value as the depth of groundwater in this area. CHK believes it is important that EPA independently validate information (or secondary data) provided by CHK or others in accordance with EPA project specific data quality objectives, QMP, and QAPPs. The 300 ft. value was stated early in the site selection process as an approximation for the depth of USDW in the Mississippi Lime Play, but the Oklahoma Corporation has developed accurate depth to treatable water maps for this specific site, and those maps should be evaluated and used appropriately
- E&E acknowledges that the proposed alternatives are non-standard groundwater monitoring wells.
 - CHK recommends the use of standard vertical groundwater monitoring wells on this study in order to reduce the risk to the study associated with the application of non-standard monitoring wells.
- E&E states that this is a natural gas well pad. This statement is made throughout the memo.
 - This well is not considered a natural gas well. The Mississippi Lime is an oil play.

Background:

- E&E has assumed a 400 ft. by 400 ft. pad, and the ability to install the well approximately 75 ft. from the production well.
 - More accurate well pad dimensions will be provided to the EPA at a later date. There are a number of variables that dictate the size of the pad (i.e., drill rig, number of wells, etc.). Conservative dimensions for the pad are 350 ft. by 400 ft.

- Note that orientation of the pad will not be necessary if EPA plans to use horizontal monitoring wells. The adjustment will impact CHK's operations, and was offered to facilitate the installation of conventional monitoring wells off the pad location.
- E&E states that piezometers will be used to determine actual subsurface conditions, including groundwater flow direction, depth to water and depth to bedrock.
 - The limitations of the geo-probe scope of work should be disclosed in terms of the information that will be able to be collected. For example, the piezometer will not be able to determine conditions (i.e., groundwater velocity) for the proposed deep monitoring well in the bedrock formation. It has now been agreed that conventionally drilled monitoring wells will be used in lieu of geo-probe installed wells.
- E&E referenced a 300 ft. exploratory boring (off-pad) to determine the presence or absence of water bearing zones in bedrock.
 - "Water bearing zones" need to be clearly defined (e.g., USDW). The quality and quantity of water is of interest.
 - EPA should set limits, in terms of monitoring drilling capabilities (i.e., accuracy of location), for target water bearing zones.
- The depths of proposed down gradient monitoring wells are stated as 20 ft. (top of the water table), 50 ft. (base of the unconsolidated aquifer), and 300 ft. (within the underlying shale formation).
 - It is understood that E&E made assumptions based on previous conversations, however, CHK would like the methods for determining the depths of the monitoring wells to be clearly stated and the use of best available information to be assured. For example, the top of the water table changes based on seasonal variations and water use, and the underlying bedrock formation varies greatly with depth, and the water quality varies with depth, typically becoming poorer with depth.

Monitoring Well Installation:

- E&E has stated an approximate sample point, for each of the down gradient wells, 15 ft. horizontally from the production wellbore.
 - There are numerous potential sources of contamination, both associated with and not associated with oil development operations. CHK does not believe EPA has incorporated systematic planning into the study design to ensure the study objective can be met and the appropriate data will be collected. For example, it is not clearly identified how EPA would differentiate the potential sources of contamination.
 - Data quality objectives for modeling and use of data need to be identified.
 - o Certainty of monitoring well locations will effect modeling and data use.
 - Certainty of production well location will effect modeling and data use.

 There would be a likely physical impact to monitoring wells due to proximity to production wellbore during well construction, which would compromise the study.

Option 1: Vertical Wells with Off-Pad Access

• CHK understands this option is no longer being considered.

Option 2: Horizontal Direction Drilled (HDD) Monitoring Wells and Angle Drilled Wells

- Active wireline guidance will be used to monitor the bit locations.
 - EPA should state the tolerances and accuracies of bore path required to meet its data quality objectives and intended use of data (i.e., modeling). Robert Keyes stated that the technology could be navigated within a +/- 3 ft. horizontal and vertical tolerance. However, the tolerances associated with the monitoring well drilling technology are not inclusive of all variables that could affect the total spatial accuracy.
- Minimal starting distances of 100 ft. for the 20 ft. well and 250 ft. for the 50 ft. well.
 - The minimal starting distances will complicate the land owner access agreements and assessments.
- The goal of the 20 ft. well is to intersect the top of the water table.
 - The use of horizontal wells only allows for the sampling of a small vertical interval. There is a very likely risk that the water level will change causing the water table to drop below the shallow well. A vertical well is more appropriate well type for monitoring the top of the water. In this geological setting it is not uncommon to see yearly water level fluctuations on the order of 5 to 10 feet occur.
- Development of the wells:
 - Details regarding the development of the well should be provided, included parameter stabilization requirements.
- The wells are stated to be abandoned after study/sampling activities are completed in accordance with state regulations.
 - It should be stated exactly how the wells will be abandoned. EPA should work with the state to understand its expectations. Without a clear understanding of what is required for proper abandonment, there is no assurance these requirement would not impede CHK operations at a future date.

Groundwater monitoring, purging and sampling procedures

- E&E states development of wells at least 48 hours before sampling.
 - CHK requests that the time between development of well and sampling be no less than 5 days.
- The use of pressure transducers.
 - The EPA will need to specify calibration requirements.
 - The pressure transducers in option one will not be accessible. How will the risk of equipment failure be mitigated. In addition, the use of offset monitoring wells to monitor water levels would not allow the use of the provided low-flow sampling procedure.

Pervious use of HDD Techniques for Groundwater Monitoring

- E & E has listed previous use of HDD monitoring wells.
 - CHK acknowledges HDD monitoring wells have been used on previous projects as a last alternative to monitoring groundwater quality. Note one of the examples provided choose to use HDD if the application of standard wells was possible.
 - Limited detail information could be found publically available for the examples provided, however, the information found stressed the limitation of HDD technology and completely understanding the application of HDD technology prior to use.

Re: Technical Memorandum – Revised groundwater monitoring wells in support of EPA's hydraulic fracturing study. (March 26, 2012)

Introduction

- E & E based the depth of the USDW on statements made by CHK in the meeting.
 - CHK recommends EPA and its contractors independently verify information CHK provides when possible. This recommendation is related to the public perception issues associated with the study. In addition, CHK believes it is important that both EPA and its contractors are familiar with the wealth of information the state provides to the public.
- E & E has stated, for the purposes of discussion, assumed groundwater screen intervals.
 - CHK would prefer that the logic used to determine the groundwater screen intervals are described, as well as, how this information will be collected and the quality of this information will be assured. This preference is aligned with EPA's Quality policies, procedures, and guidelines.
- E & E states that three permanent monitoring wells will be installed to characterize the site.
 - The monitoring wells may be temporary, and additional monitoring wells would be installed to increase the accuracy of the site characterization.
- E & E stated that CHK will drill, log and complete a deep monitoring well.
 The parties have not determined that CHK will drill the well.
- E & E has stated that the need for the installation of horizontal monitoring wells will be made based on the results from groundwater monitoring.
 - CHK believes that the appropriate information will be collected to ascertain the groundwater velocity in the alluvial aquifer.
- E & E states that the application of horizontal wells will be based on the need and subject to CHK approval.
 - CHK confirms that the application of horizontal wells is subject to our approval.
- E & E states that the distance from the production well to the horizontal wells will be based on groundwater flow data during the initial monitoring period.
 - There are other variables to be considered besides groundwater velocity. In addition, determining the groundwater flow in the bedrock formation may be problematic.
 - The distance a potential contaminant from the wellbore is not limited solely by groundwater velocity. "The accelerated arrival of contaminants at a discharge point can be a characteristic feature of dispersion that is due to

the fact that some parts of the contaminant plume move faster than the average groundwater velocity" according the a report found on the National Academies Press website (<u>http://www.nap.edu/openbook.php?record_id=1770&page=37</u>).

- The following comments and concerns from the original February 24, 2012 Technical Memorandum remain outstanding:
 - There is not the necessity for CHK to orientate the pad to accommodate a minimum distance of 75 ft., if EPA plans to use one of the alternative well designs. The adjustment will impact CHK's operations, and was offered to facilitate the installation of conventional monitoring wells off the pad location.
 - The limitations of the site characterization scope of work should be disclosed in terms of the information that will be able to be collected. For example, the piezometer well will not be able to determine conditions (i.e., groundwater velocity) for the proposed deep monitoring well in the bedrock formation.
 - "Water bearing zones" need to be clearly defined (e.g., USDW). The quality and quantity of water is of interest.
 - EPA should set limits, in terms of monitoring drilling capabilities (i.e., accuracy of location), for target water bearing zones.
 - We recommend EPA identify the process it will use to differentiate between potential causes (including naturally occurring) should sampling results indicate a significant change in water quality that is otherwise unexplainable.
 - We recommend data quality objectives for modeling and use of data be identified.
 - Certainty of monitoring well location will effect modeling and data use.
 - Certainty of production well location will effect modeling and data use.
 - We recommend EPA state the tolerances and accuracies of bore path required to meet its data quality objectives and intended use of data (i.e., modeling). Robert Keyes stated that the technology could be navigated within a +/- 3 ft. horizontal and vertical tolerance. However, the tolerances associated with the monitoring well drilling technology are not inclusive of all variables that could affect the total spatial accuracy.
 - The minimal starting distances will complicate the land owner access agreements and assessments.
 - The use of horizontal wells only allows for the sampling of a small vertical interval. There is a very likely risk that the water level will change causing the water table to drop below the shallow well. A vertical well, screened at intervals is more appropriate well type for monitoring the top of the water.
 - Details regarding the development of the well should be provided, included parameter stabilization requirements.
 - It should be stated exactly how the wells are to be abandoned. EPA should work with the state to understand its expectations. Without a clear understanding of what is required for proper abandonment, there is no

assurance these requirement would not impede CHK operations at a future date. Kent Wilkin and Robert Keyes had similar concerns with the lack of clarity regarding abandoning procedures.
 CHK requests that the time between development of well and sampling be

- no less than 5 days.
- The EPA will need to specify calibration requirements for transducers.

To:	Doug Beak/ADA/USEPA/US@EPA
Date:	04/30/2012 10:14 PM
Subject:	RE: Invitation: EPA Miss Lime Prospective Study (May 1 03:00 PM CDT in Call in: 877-935-0245
	Code: 745 420 + Rm 231)

Doug,

Mike Overbay mentioned you would be out when he requested that I schedule this meeting for this time. I will be in an all-day meeting on Thursday and out from Friday (5/4) until the following Wednesday (5/16), therefore, it would be beneficial to keep the meeting as schedule and have Mike et al. give you a download (I can give you a download as well if you would like). However, I am more than willing to try and move some things around on my schedule to accommodate your schedule, if you would like to coordinate with Mike et al. on the EPA side. Please let me know what your prefer.

Thanks,

Chris

From: Doug Beak [mailto:Beak.Doug@epamail.epa.gov]
Sent: Monday, April 30, 2012 9:57 PM
To: Chris Hill (Regulatory)
Subject: Re: Invitation: EPA Miss Lime Prospective Study (May 1 03:00 PM CDT in Call in: 877-935-0245 Code: 745 420 + Rm 231)

I'm out of the office until Thursday. Can we reschedule? Dr. Douglas G. Beak USEPA-ORD-NRMRL-GWERD-SRB 919 Kerr Research Dr. Ada, OK 74820

email: <u>beak.doug@epa.gov</u> Phone: 580-436-8813 Fax: 580-436-8703 Blackberry: 580-235-7158 "Chris Hill (Regulatory)"

----- Original Message -----From: "Chris Hill (Regulatory)" [chris.hill@chk.com] Sent: 05/01/2012 02:51 AM GMT To: Michael Overbay; Doug Beak; Randall Ross; Steven Acree; Bert Smith < bert.smith@chk.com>; Tamara Robbins <tamara.robbins@chk.com> Cc: Stephanie Timmermeyer <stephanie.timmermeyer@chk.com> Subject: Invitation: EPA Miss Lime Prospective Study (May 1 03:00 PM CDT in Call in: 877-935-0245 Code: 745 420 + Rm 231) This meeting has been scheduled to have a technical discussion regarding CHK proposed site characterization scope of work. Additional topics of discussion may include the following:

Status of EPA's formal response to CHK's tech memo comments.

· Access agreement status.

• Schedule.

Doug Beak emails responsible to #Q-FOI-01479-12.pdt

Fw: New FOIA Request #01479-12 - please forward your responsive records for review , Doug Beak to: Suzanne Jackson 07/05/2012 07:53 AM Cc: Pam Daggs

Hi Suzanne,

This is part 1 of 2 for the above FOIA request. If you have any questions let me know.

Doug

Dr. Douglas G. Beak

Geochemistry/ Environmental Chemistry USEPA-ORD-NRMRL-GWERD-SRB 919 Kerr Research Dr. Ada, OK 74820

email: beak.doug@epa.gov Phone: 580-436-8813 Fax: 580-436-8703 Blackberry: 580-235-7158 ----- Forwarded by Doug Beak/ADA/USEPA/US on 07/05/2012 06:49 AM -----

From:	"Chris Hill (Regulatory)" <chris.hill@chk.com></chris.hill@chk.com>
To:	Michael Overbay/R6/ÚSEPA/US@EPA, Doug Beak/ADA/USEPA/US@EPA, Randall
	Ross/ADA/USEPA/US@EPA, Steven Acree/ADA/USEPA/US@EPA, Bert Smith
Cc:	Stephanie Timmermeyer <stephanie.timmermeyer@chk.com></stephanie.timmermeyer@chk.com>
Date:	04/30/2012 09:51 PM
Subject:	Invitation: EPA Miss Lime Prospective Study (May 1 03:00 PM CDT in Call in: 877-935-0245 Code:
	745 420 + Rm 231)

This meeting has been scheduled to have a technical discussion regarding CHK proposed site characterization scope of work. Additional topics of discussion may include the following :

- Status of EPA's formal response to CHK's tech memo comments.
- Access agreement status.
- Schedule.

From:

----- Forwarded by Doug Beak/ADA/USEPA/US on 07/05/2012 06:49 AM -----

"Chris Hill (Regulatory)" <chris.hill@chk.com>

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foia response Jeanne Briskin to: Leigh DeHaven

06/21/2012 03:28 PM

I will send you responsive records with FOIA response in the header .

Jeanne Briskin Office of Science Policy Office of Research and Development U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, N.W. (8104R) Washington, D.C. 20460 (202) 564-4583 - office (202) 565-2911 - fax briskin.jeanne@epa.gov

Address for Deliveries: US EPA Ronald Reagan Building --Room 51144 Washington DC 20004 ----- Forwarded by Jeanne Briskin/DC/USEPA/US on 06/21/2012 03:28 PM -----

From:	Andrew Paterson <apaterson@marcelluscoalition.org></apaterson@marcelluscoalition.org>
To:	Jeanne Briskin/DC/USEPA/US@EPA
Cc:	Dayna Gibbons/DC/USEPA/US@EPA
Date:	05/01/2012 12:01 PM
Subject:	RE: Request for a Presentation at the MSC Conference in September

Jeanne,

I notified the API/ANGA EPA HF Study Steering Committee that you are interested in hearing more about their efforts and you can expect to hear from them in the near future. If that doesn't happen, please let me know and I will follow up.

Also, they have confirmed their participation in the MSC conference. Thanks, Andrew

From: Andrew Paterson
Sent: Monday, April 30, 2012 8:54 AM
To: 'Jeanne Briskin'
Cc: Dayna Gibbons; Helen Goodman
Subject: RE: Request for a Presentation at the MSC Conference in September

Jeanne,

Your participation is much appreciated and thanks for the quick response. Yes, API is working with Batelle. I will get back to you with an API contact shortly. Andrew

5

From: Jeanne Briskin [mailto:Briskin.Jeanne@epamail.epa.gov]
Sent: Monday, April 30, 2012 8:47 AM
To: Andrew Paterson
Cc: Dayna Gibbons; Helen Goodman
Subject: Re: Request for a Presentation at the MSC Conference in September



Hi Andrew,

I would be happy to provide an update at the September meeting. Could you recommend who I might contact to learn more about the API study? I believe Batelle is working on this, but I am not sure who is the best person to contact.

thanks,

Jeanne

Jeanne Briskin Office of Science Policy Office of Research and Development U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, N.W. (8104R) Washington, D.C. 20460 (202) 564-4583 - office (202) 565-2911 - fax briskin.jeanne@epa.gov

Address for Deliveries: US EPA Ronald Reagan Building --Room 51144 Washington DC 20004

Andrew Paterson ---04/30/2012 08:43:57 AM---Jeanne, Further to my previous e-mail, the Marcellus Shale Coalition's annual conference is in Phila

From: Andrew Paterson <a paterson @marcelluscoalition.org To: Jeanne Briskin/DC/USEPA/US@EPA Cc: Dayna Gibbons/DC/USEPA/US@EPA, Helen Goodman <<u>hqoodman@marcelluscoalition.org</u>> Date: 04/30/2012 08:43 AM Subject: Request for a Presentation at the MSC Conference in September

Jeanne,

Further to my previous e-mail, the Marcellus Shale Coalition's annual conference is in Philadelphia on Sep 20 and 21, 2012. I am inviting you (EPA Office of Research and Development) to participate in a Shale Gas Forum on the Hydraulic Fracturing Study. What I have in mind is a half hour presentation from the ORD and a half hour presentation from API on their companion study followed by a Q&A session. Could you please confirm your availability? If you need more time, we could also consider a Shale Gas Insight Session. The generic descriptions of the different sessions are as follows:

Shale Gas Insight Session - 1 hour in length, should be designed for a targeted or technical

audience. Research papers and technical work should drive this session in order to satisfy continuing education/professional development requirements.

Shale Gas Forum $-1\frac{1}{2}$ hours in length, panel discussion appropriate for broad audience. Speakers should include executives or senior level personnel.

I would appreciate a response by May 11. Please phone me at 724-814-6801 if you would like to discuss in more detail.

Thanks, Andrew

From: Andrew Paterson
Sent: Sunday, March 25, 2012 12:16 PM
To: 'Jeanne Briskin'
Cc: Dayna Gibbons
Subject: RE: MSC's Presentation on the Pre-Drill Database and a Question

Jeanne,

Yes that's what I had in mind. We had a large turnout at our conference last year and expect it to be even bigger in 2012, so this would be a great forum to get your message out.

Thanks, Andrew

From: Jeanne Briskin [mailto:Briskin.Jeanne@epamail.epa.gov]
Sent: Saturday, March 24, 2012 9:34 PM
To: Andrew Paterson
Cc: Dayna Gibbons
Subject: Re: MSC's Presentation on the Pre-Drill Database and a Question

Hi Andrew,

Thanks for the slides. I'm checking to see our potential availability for the annual meeting in September. As a representative of the Office of Research and Development, I would be talking about our study, not any regulatory or similar topics.

Jeanne

-----Andrew Paterson <apaterson@marcelluscoalition.org> wrote: -----To: Jeanne Briskin/DC/USEPA/US@EPA From: Andrew Paterson <apaterson@marcelluscoalition.org> Date: 03/23/2012 11:41AM Subject: MSC's Presentation on the Pre-Drill Database and a Question Jeanne, As requested, here is a copy of the presentation from the MSC meeting you attended on Mar 21. Please let me know if you or your staff have additional questions. I have a question for you with respect to the Hydraulic Fracturing Study... are you interested in participating on a panel discussion on this topic? The forum would be the MSC's annual "Shale Gas Insights" conference in Philadelphia in September of 2012. This is a two day event covering a broad range of shale topics - technical, regulatory, public affairs, etc. Attendees will include industry, state and federal regulators, academics, elected officials, media and members of the public. At this point I'm not asking for a firm commitment, just an expression of interest and if so, we can discuss more details.

Thanks, Andrew

[attachment "PowerPoint Pre-drill Database.ppt" removed by Jeanne Briskin/DC/USEPA/US]



From;

To:

final access conditions Jeanne Briskin to: Natenna.Dobson

Jeanne Briskin/DC/USEPA/US Natenna.Dobson@hq.doe.gov



Range revised access conditions 043012.doc

05/11/2012 03:20 PM

×

CONFIDENTIAL // DELIBERATIVE // DO NOT RELEASE // 043012

Conditions for access

1. EPA shall provide a description of all activity to be conducted at any Range site where voluntary access is requested for the purposes of EPA's hydraulic fracturing study, including a description of any sampling, testing or other analysis, including the method of sampling or analysis to be conducted (which shall be supplemented if the sampling or analysis changes). This information is reflected in EPA's Quality Assurance Project Plan (QAPP).

2. In allowing access for the purposes of EPA's hydraulic fracturing study, Range does not acknowledge the existence of any regulatory or statutory authority to compel such access. Range retains all rights to contest EPA's access to Range property for purposes other than carrying out EPA's hydraulic fracturing study.

3. EPA shall provide three days prior written or email notice to Range's designated representative before conducting any activity on Range property.

4. EPA will provide opportunities for Range to collect samples in conjunction with EPA's sampling events. The manner of collection of samples shall be in accordance with the relevant Quality Assurance Project Plans (QAPPs) and Quality Management Plans (QMPs) EPA has established for the purposes of its hydraulic fracturing study.

6. EPA employees, agents, contractors, representatives or experts visiting a Range site must be identified in advance and must adhere to all Range safety protocols and may be denied access to areas that, in the judgment of Range, Range determines may present safety issues. Range will escort any employee, agent, contractor, representative or expert at all times while they have access to Range's property. Range retains the right to temporarily or permanently deny any specific EPA employee, agent, contractor, representative or expert access to its property if Range reasonably determines that the acts and omissions of such employee, agent, contractor, representative or expert create a risk of harm to persons at or near the Range site.

7. EPA employees, agents, contractors, representatives or experts visiting a Range site will wear proper safety equipment, as determined by Range, at all times while on any Range site. Generally a hard hat, steel toed shoes, safety glasses and, possibly, hearing protection will be required. If additional safety equipment is required, Range will either (a) identify such equipment to EPA in advance of the planned visit with sufficient time for EPA to acquire appropriate equipment or (b) provide such additional safety equipment to EPA employees, agents, contractors, representatives or experts while such persons are on-site.

8. EPA shall provide Range with exact copies of all test reports, analyses and data within five (5) business days of EPA's completion of its quality assurance and quality control protocols on such reports, analyses or data. Where raw data suggest the presence of chemicals in exceedance of MCLs or other health-based standards, EPA shall endeavor to conduct an accelerated quality assurance and quality control protocol

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and will release data to Range in accordance with this agreement after completion of any such accelerated quality assurance and control protocol.

9. Range shall provide EPA with exact copies of any QAPPs it intends to utilize for sampling and analysis and provide exact copies of all test reports, analyses and data within five (5) business days of its completion of its quality assurance and quality control protocols on such reports, analyses or data.

10. EPA will provide Range with an advance copy of any draft report utilizing data obtained from Range facilities or property thirty (30) days before expected publication of such report. During the prepublication period, Range agrees to keep confidential the contents and conclusions of any such report. Range will provide EPA with an advance copy of any draft report using data obtained from the samples taken in concert with EPA's samples (30) days before expected publication of such report. During the prepublication period, EPA agrees to keep confidential the contents and conclusions of any such report.

11. (a) Range may assert a claim of confidentiality for any proprietary information EPA may gain from access to Range sites in connection with the hydraulic fracturing study. Any such claim of confidentiality must be made at the time the information is provided to EPA and in accordance with the provisions of 40 CFR Part 2, Subpart B.

(b) EPA agrees to keep any such information confidential unless it determines either (a) that disclosure of such information is necessary to carry out the hydraulic fracturing study or (b) in response to a Freedom of Information Act (FOIA) request, that such material is not entitled to confidential treatment, in accordance with 40 CFR § 2.205.

(c) Range understands that the purpose of the study is to understand and inform the public of the impacts, if any, of hydraulic fracturing on drinking water resources.

(d) Range understands that samples and analysis of environmental media are not subject to claims of confidentiality.

(e) Range understands that EPA may disclose claimed confidential information to its authorized representatives, including contractors. Any such representative or contractor shall be required to keep such material confidential in accordance with the terms of this paragraph.

12. There will be no photographs, videotaping, recording or any visual or aural depiction or recording of any Range site including any equipment, personnel or activity on the site without Range's consent which shall not be unreasonably withheld. Range agrees it will only withhold consent to photographs, videotaping, recording or any visual or aural depiction or recording of the site to the extent necessary to comply with restrictions imposed by Range's contractors on photographs, videotaping, recording or any visual or aural depiction or personnel and Range will use reasonable efforts (without any obligation to pay money) to request consent from any contractors who restrict photographs, videotaping, recording or any visual or aural depiction or recording to obtain permission for reasonable recording of activity. Range will be provided a copy of any such recordings.



06/22/2012 03:55 PM

Jeanne Briskin Office of Science Policy Office of Research and Development U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, N.W. (8104R) Washington, D.C. 20460 (202) 564-4583 - office (202) 565-2911 - fax briskin.jeanne@epa.gov

Address for Deliveries: US EPA Ronald Reagan Building --Room 51144 Washington DC 20004 ----- Forwarded by Jeanne Briskin/DC/USEPA/US on 06/22/2012 08:46 AM -----

From:	"King, George" < George.King@apachecorp.com>
To:	Jeanne Briskin/DC/USEPA/US@EPA
Date:	05/23/2012 02:16 PM
Subject:	RE: SPE HF course

Jeanne,

Absolutely, I'm free most of next week from Tuesday through Thursday.

As background, the shale course can be one day or two day depending on the level of detail needed. A course description is attached and I can provide a full set of slides on request.

If we have the Society of Petroleum Engineers as the main provider (doesn't change anything in the course), they can give continuing education credit for the course. If not through them, it's the same materials without credit.

My background and publication list is at <u>www.GEKengineering.com</u> My Estimating and Evaluating Frac Risk is in the Downloads section.

I am an approved reviewer for DOE's Geothermal Projects and attended the DOE Review meeting in Denver, 7-10 April 2012.

George

George E. King Apache Corporation Distinguished Engineering Advisor 1 713 296 6281 (office)
1 281 851 8095 (mobile)

From: Jeanne Briskin [mailto:Briskin.Jeanne@epamail.epa.gov] Sent: Wednesday, May 23, 2012 12:51 PM To: King, George Subject: SPE HF course

Hi George,

It was good to see you at the recent NSF workshop. We would be interested in having the SPE course on hydraulic fracturing in shale presented at EPA in Washington. Is there a convenient time we could talk in the next week or so, so I can gather more information so I may figure out with our admin folks on how we might proceed with this?

Thanks,

Jeanne

Jeanne Briskin Office of Science Policy Office of Research and Development U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, N.W. (8104R) Washington, D.C. 20460 (202) 564-4583 - office (202) 565-2911 - fax briskin.jeanne@epa.gov

Address for Deliveries: US EPA Ronald Reagan Building --Room 51144



Washington DC 20004SPE Shale Gas Completions Fracturing and Production.docx ----- Forwarded by Jeanne Briskin/DC/USEPA/US on 06/22/2012 08:46 AM -----

From:	"King, George" < George.King@apachecorp.com
To:	Jeanne Briskin/DC/USEPA/US@EPA
Date:	05/23/2012 02:47 PM
Subject:	RE: SPE HF course

Jeanne,

I forgot to include the detail on objectives (attached).

George E. King Apache Corporation Distinguished Engineering Advisor 1 713 296 6281 (office)

1 281 851 8095 (mobile)

From: Jeanne Briskin [mailto:Briskin.Jeanne@epamail.epa.gov] Sent: Wednesday, May 23, 2012 12:51 PM To: King, George Subject: SPE HF course

Hi George,

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Jeanne

Jeanne Briskin Office of Science Policy Office of Research and Development U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, N.W. (8104R) Washington, D.C. 20460 (202) 564-4583 - office (202) 565-2911 - fax briskin.jeanne@epa.gov

Address for Deliveries: US EPA Ronald Reagan Building --Room 51144

Washington DC 20004SPE Shale Course Description.xlsx

10 .

Shale Selection, Completions, Fracturing, and Production

George E. King, PE

Description

This 2-day course acquaints participants with the basics of oil and gas shale evaluation and current shale selection, well completion, fracturing, and production technologies for shale reservoirs. The interactive format includes field data, current approaches and use of technologies suited for shale developments. Technologies include logging, frac interval selection, multi-stage fracturing in horizontal wells, and a summary of field data from many shale plays. Topics include:

- Candidate selection criteria to identify shale "sweet spots"
- Complex fractures and role of geomechanics
- Well orientation, optimum length and perf cluster design
- Optimizing well completions and stimulations
- Fracturing risk estimation: strengths and areas to improve
- Water sources, treatment, reuse and disposal
- Predicting production, estimating decline and well start-up suggestions
- Surface equipment and production operations

Who Should Attend

This course is for all well completion and production engineers, managers, geologists and regulators working with shale reserves.

Why You Should Attend

The technology for recovering oil and gas reserves from shale is changing the face of the industry worldwide. If shale reserves are part of your portfolio, this course is for you.

Special Requirements

There are no special requirements for this course.

CEUs

1.6 CEUs (Continuing Education Units) are awarded for this 2-day course.

George E. King, PE, worked for Amoco production from 1971 to 1999 and BP from 1999 to 2008. He is now with Apache, where he assists on shale stimulations, production chemistry and workovers. Mr. King has written more than 65 technical papers and a book on completions and workovers. He was a 1985 SPE Distinguished Lecturer, and 1999 SPE Short Course Lecturer. Industry positions include Technical Chair of 1992 SPE Annual Meeting, API subcommittee chair on perforating, Adjunct Professor at the University of Tulsa (teaching well completions and fracturing), and numerous SPE committees. He was awarded the 2004 SPE Production Operations Award and is the 2012 Engineer of the Year for the Greater Houston Region of the Texas Society of Professional Engineers.

Mr. King holds a bachelor's in Chemistry from Oklahoma State University, a bachelor's degree in Chemical Engineering, and a master's degree in Petroleum Engineering from the University of Tulsa.

Section	Description	Delivery Outcome Sought	Time
	Brief intro to shales - what they are, where		
	they are, gas and oil in place and supply	General knowledge of shale's potential in supplying	
1	potential	energy. Know the main selection criteria and how, where and	1/2 hr.
	Assess General Gas and Oil Production	through what methods to attain it. This is an intro to the	
	Potential and Select Limiting Factors in Shale	critical shale factors needed to produce gas or oil from	
2	Hydrocarbon Production	from a shale	1 E hra
			1.51115
	Estimate potential for initial production.		
	Explain IP(30), EUR, Stimulated rock volume,	Know enough about shale gas and oil flow to assess a	
	stress dependent complex fracturing, basics	moderately complex shale development. Know what is	
3	of fluid flow through the shale.	behind the SRV estimations and the EUR projections.	1.5 hrs
	Formulation of a basic snale development	De elle te describe the environment environment to sufficient of a	
	wells and on through hads, gas and oil	Be able to describe the general approach to selection of a	
	transport, water supplies for drilling and	Linderstand the basic layout and requirements of an	
4	fracturing	operating shale development	1 hr
. 4			L nr.
	Well Completion design including well		
	orientation, length, pipe size, toe-up or toe		
	down, and azimuth. Completion design		
	includes basics of casing and tubing	Be able to review a new completion design for basic	
	selection, cementing requirements and	fitness of production and raise awareness of risk elements	
	general well architecture and how	of completion and following operations. Know the quality	
5	completions vary with geology.	and longevity of basic barriers.	2.0 hrs
	Pre Frac considerations including fracture	Be able to take logs, mud logs, gas shows, geologic	
	stage selection, perforation design for	studies and other critical shale information from data	
	cluster location, spacing, charge type and	gathering steps and select locations for the stages and	
	hydraulic diversion needs. Determine if	clusters. Select initial well and frac monitoring methods	
	there are potential frac barriers and how	and demonstrate a knowledge on how and when to use	
6	they can be tested.	monitoring.	1.5 hrs
		Be able to design a basic fract select a fluid, estimate	-
	Fracturing design, including fluid and	volumes read a frac chart and evolain what monitoring	~
	proppant selection, pressure limits, rates	methods can answer frac placement questions. Know	
	proppant loading and volumes. What	how to spot frac problems and warning signs as well as	
	formation factors suggest that a complex or	how to estimate frac risk impact and occurrence. What	
	planar frac is expected. Refrac potential and	monitoring methods are useful at what stage of	
7	simul stimulation methods.	development.	4 hr
		Estimate a flow back rate and what volumes would be	
		expected over what time. What are the elements in frac	
1		and produced water, what are the risks and when is	
	Howback strategies and realities of	tiowback over? How can real emissions be curtailed or	
8	Operation. Water for fracs: replacing fresh water with	leiminated.	1 hr.
	Isaltine source water and produced	Have a working knowledge of how to select or generate a	
	saltwater. What is involved and what are the	quality frac water source from produced or source salt	
9	resources?	water.	1 hr.
	Hot Button Issues - what are the facts and	Cover methane migration, fugative emissions, water	
10	what d we need to improve.	issues, reduction of trucks and greener chemicals	1 hr.

06/22/2012 03:52 PM

Jeanne Briskin Office of Science Policy Office of Research and Development U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, N.W. (8104R) Washington, D.C. 20460 (202) 564-4583 - office (202) 565-2911 - fax briskin.jeanne@epa.gov

Address for Deliveries: US EPA Ronald Reagan Building --Room 51144 Washington DC 20004 ----- Forwarded by Jeanne Briskin/DC/USEPA/US on 06/22/2012 08:35 AM -----

From:	"Daniel Soeder" < Daniel.Soeder@NETL.DOE.GOV>
To:	"Deborah Glosser" <deborah.glosser@contr.netl.doe.gov>, "Robert Dilmore"</deborah.glosser@contr.netl.doe.gov>
	<robert.dilmore@netl.doe.gov></robert.dilmore@netl.doe.gov>
Cc:	Jeanne Briskin/DC/USEPA/US@EPA, Angela McFadden/R3/USEPA/US@EPA
Date:	05/16/2012 10:11 AM
Subject:	Fwd: Marcellus Incident Report

Debb: This Penn State report looks like a good place to start with incident assessment. The numbers still seem a little high, like they included everything from a spilled can of motor oil to a leak from a 10,000 gallon frac tank. Not only the number of incidents is important, but also the seriousness or significance of each should be ranked.

I suggest the following scheme for classifying incidents: Administrative events are things such as missing signage, poor record-keeping, incorrect permit applications or other missing or wrong "paperwork." Minor incidents are small spills or leaks that require clean up, but are contained on site, do not enter the groundwater, and can be remediated by the local rig crew. Significant incidents are larger spills or leaks that could potentially leave the site but did not, and required outside assistance (such as a HAZMAT team) to help clean up. Serious incidents can be defined as events involving an explosion, fire, stream damage or fish kill, human injury or fatality, significant property damage, and contamination of a drinking water supply, either surface or groundwater. Finally, catastrophic events involve the destruction of the well site and serious damage to surrounding areas. As a first cut, binning reported incidents in such a manner will help us understand the different things that are happening out there.

I've copied Jeanne Briskin of the EPA, who is pulling together similar data on drinking water impacts. We should collaborate and compare methodologies to make sure we're going at this the same way.

- Dan

Daniel J. Soeder U.S. Department of Energy National Energy Technology Laboratory Morgantown, WV 26507 (304) 285-5258 Daniel.Soeder@netl.doe.gov

>>> Richard Hammack 5/16/2012 9:19 AM >>> FYI

>>> James Ammer 5/16/2012 8:02 AM >>> All:

I have only glanced through this report but based on figures and data reported and analysis of actual incidents from 2008-2011 this appears to be an excellent resource.

1

Jim Environmental Impacts During Marcellus Drlg 2008-2011.pdf

May 15, 2012

Environmental Impacts

DURING MARCELLUS SHALF GAS DRILLING: CAUSES, IMPACTS, AND REMEDIES

TIMOTHY CONSIDINE

NICHOLAS CONSIDINE

CENTER FOR ENERGY ECONOMICS AND PUBLIC POLICY SCHOOL OF ENERGY RESOURCES | THE UNIVERSITY OF WYOMING **ROBERT WATSON** THE PENNSYLVANIA STATE UNIVERSITY **CENTER FOR ENERGY ECONOMICS AND PUBLIC POLICY** JOHN MARTIN SHALE RESOURCES AND SOCIETY INSTITUTE | STATE UNIVERSITY OF NEW YORK AT BUFFALO



ENVIRONMENTAL IMPACTS

DURING MARCELLUS SHALE GAS DRILLING: CAUSES, IMPACTS, AND REMEDIES REPORT 2012 - 1

TIMOTHY CONSIDINE

CENTER FOR ENERGY ECONOMICS AND PUBLIC POLICY SCHOOL OF ENERGY RESOURCES | THE UNIVERSITY OF WYOMING

ROBERT WATSON

THE PENNSYLVANIA STATE UNIVERSITY

NICHOLAS CONSIDINE

CENTER FOR ENERGY ECONOMICS AND PUBLIC POLICY

JOHN MARTIN

SHALE RESOURCES AND SOCIETY INSTITUTE STATE UNIVERSITY OF NEW YORK AT BUFFALO

* The authors gratefully acknowledge comments from Scott Anderson of the Environmental Defense Fund, Andrew Hunter of Cornell University, Robert Jacobi of the State University of New York at Buffalo, Brigham McCown of United Transportation Advisors, LLC, and George Rusk of Ecology and Environment, Inc. with the usual disclaimer that the authors accept full responsibility for any remaining errors and omissions.

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Executive Summary

The development of shale gas through hydraulic fracturing has awakened what some have described as an American energy renaissance. Shale gas formations thought to be economically unrecoverable as recently as a decade ago now provide nearly 25 percent of our nation's total natural gas supply. According to the Energy Information Administration's reference case forecast of April 2011, natural gas production from shale formations will comprise 46.5 percent of total U.S. dry gas production in 2035.

The investments under way for developing these shale resources are generating tens of thousands of jobs, billions in state and local tax revenues, and hundreds of billions in direct economic activity. Indirect benefits to oil and gas suppliers, to U.S. manufacturers that utilize natural gas as a feed-stock, and to consumers enjoying lower electricity and heating bills multiply the already substantial direct economic gains. In short, the incentives for states to encourage and facilitate development are substantial.

But surprisingly little comprehensive analysis exists to quantify the success or failure of states in effectively and safely managing natural gas development. Without such information, it is very difficult for regulators, elected officials, and citizens to engage in productive dialogue around natural gas development and the process of hydraulic fracturing. Whether considering regulatory changes in a state where development is already under way, or debating the permitting of natural gas development where it has not yet occurred, quantifying measurements of success are necessary for building consensus and making sound decisions.

To address this question, this study provides a detailed analysis of notices of violations (NOVs) from the Pennsylvania Department of Environmental Protection (PA DEP) from January 2008 through August 2011, categorizing each violation. Of the 2,988 violations, 1,844, or 62 percent, were for administrative or preventative reasons. The remaining 38 percent, or 1,144 NOVs, were for environmental violations. The number of these environmental violations, however, is a misleading metric

The incidence of polluting environmental events [in Pennsylvania] declined 60 percent between 2008 and August 2011 ...

because an individual event may be associated with multiple environmental violations. As such, the 845 unique environmental events considered in this study were associated with 1,144 NOVs.

To produce an accurate accounting of the environmental impacts of these 845 unique events, this study defines major and non-major environmental events through a detailed examination of NOV records.

Major environmental events are defined in this study to include major site restoration failures, serious contamination of local water supplies, major land spills, blowouts and venting, and gas migration. Our evaluation of NOV records identified 25 such events. In all but six cases, the resulting environmental impacts from major events have been mitigated.

Non-major environmental events concern site restoration, water contamination, land spills, and cement and casing events that do not involve what is classified as having major environmental impact. Many of the NOVs in this category, while resulting in measurable pollution, were rather





minor, involving, for example, a gallon of diesel fuel or antifreeze spilled on the ground. The 820 non-major events identified, comprise the overwhelming majority of environmental NOV's issued by the PA DEP, as shown in figure ES 1.

Significantly, the incidence of polluting environmental events declined 60 percent between 2008 and August 2011, from 52.9 percent of all wells drilled in 2008 to 20.8 percent through August 2011 (Figure ES2). On this basis, the Marcellus industry has cut its incidence of environmental violations by more than half in three years, a rather notable indicator of improvement by the industry and oversight by the regulators.

FIGURE ES2:





In conclusion, this study demonstrates that the odds of non-major environmental events and the much smaller odds of major environmental events are being reduced even further by enhanced regulation and improved industry practice. Moreover, the environmental impacts of most of these events have been almost completely mitigated by remedial actions taken by the companies.

The observed impacts of development in Pennsylvania captured within the paper provide a metric to gauge the regulatory proposal, known as the *Supplemental Generic Environmental Impact Statement* or SGEIS, currently under review in New York State. The last part of this study compares each of the 25 major incidents that occurred in Pennsylvania against New York's proposed SGEIS guidelines. Findings indicate that each of the underlying causes associated with these specific events could have been either entirely avoided or mitigated under New York State's proposed regulatory framework. This suggests that regulators are not only responding effectively within their states, but are learning and acting on the experiences of other states as well – a positive sign for the continued successful state regulation of natural gas development through hydraulic fracturing.

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Introduction

There are a growing number of states that are reviewing their regulations regarding shale energy development. This study examines New York as a representative example, since it has just completed a three-month public comment period addressing proposed environmental regulations governing shale gas development. A majority of citizens of New York may be supportive of oil and natural gas resource development if the environmental impacts appear manageable in light of the anticipated economic benefits. There is, however, a void of factual information concerning the environmental impacts, inadequate data on assessing the risks from development, and an incomplete articulation of strategies on how regulation may mitigate these impacts and risks.

Existing research previously conducted by Considine, et al. (2011a) provides a categorization of incidents in the Pennsylvania Marcellus Shale, parsing administrative failures from physical environmental events. There is, however, a noticeable lack of digestible research classifying physical incidents, and specific explanations of the causes and impacts associated with each category of physical incident. Offering this information is an important precursor to understanding the safeguards New York has adopted, and in communicating how regulation can prevent future incidents and protect local residents.

This study provides an extension of the research by Considine, et al. (2011a) with a more detailed analysis of notice of environmental violations (NOV) from the Pennsylvania Marcellus Shale industry. Not all environmental violations result in environmental pollution because many violations are citations for administrative failures or are issued to prevent pollution from occurring. Accordingly, this study makes the critical distinction between environmental violations and events, providing a complete enumeration and classification of environmental violations and the corresponding subset of events that resulted in actual, measurable pollution during drilling and completion operations in the Pennsylvania Marcellus. The categories for violations and events include drilling or well construction failures, surface handling and treatment of fluids, and failures in the drilling and completion process itself. Based upon this analysis, this study then examines how New York's proposed regulatory regime addresses these different categories of concern.

Coupling known risk with existing responses will both: 1) help the public differentiate between largely unrealized threats, such as migration of fracturing fluids out of a formation, and existing issues of concerns, such as improper surface disposal or wellhead and well casing failures, and 2) enable regulators to demonstrate strengths and potentially identify areas where state rules should be strengthened.

To quantify these risks and assess their impacts, this study provides a detailed analysis of environmental violations incurred during the drilling of natural gas wells in the Pennsylvania Marcellus from 2008 through 2011. The analysis of environmental violations estimates their probability of occurrence and severity, and identifies their causes, describing the response of natural gas production companies, available technologies to remedy these problems, and the implications for regulation.

The structure of this study is as follows. The next section provides an overview of the emergence of the shale energy industry. The study then provides a primer on the economic impacts from developing and producing energy from shale formations. What follows next is an overview of shale energy development, which is then followed by a discussion of complications associated with shale energy drilling and completion operations. The next three sections of the report provide the core analysis of the environmental violations and environmental events. A detailed discussion of 25 major environmental events appears in Appendix B. The implications for New York State regulatory policy are presented in section eight. The study concludes with a summary of the main findings and recommendations.

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2. Emergence of Shale Energy

The U.S. economy is powered by fossil fuels, with slightly more than 83 percent of domestic energy consumption supplied by oil, natural gas, and coal. Oil leads with a share of 36.7 percent, natural gas is second with 25.2 percent, and coal provides 21.3 percent of total energy consumption (see Figure 1). Nuclear energy supplies 8.62 percent of total consumption, with biomass and hydroelectricity providing 4.39 percent and 2.56 percent, respectively. Wind energy provided 0.94 percent of total energy consumption during 2010, up from 0.76 percent in 2009. Geothermal energy furnished 0.22 percent of total consumption during 2010. Finally, solar photovoltaic provided 0.11 percent during 2010 (see Figure 1).



FIGURE 1: SHARES OF TOTAL ENERGY CONSUMPTION BY SOURCE, 2010

Source: U.S. Energy Information Administration

The contribution from natural gas in total energy consumption has been rising in recent years, expanding from 22.3 percent in 2006 to 25.2 percent in 2010. Much of this increase has been due to greater use of natural gas in electric power generation. Since 2005, natural gas use in electricity production has increased 25 percent. In 2010, more than a third of U.S. end-use natural gas consumption occurred in electric power generation. The electricity industry is now the single largest user of natural gas, and will likely expand consumption significantly in future years to meet higher demand for electricity and to replace aging coal-fired power plants. Since natural gas electric power generation has only 41 percent of the carbon dioxide emissions of coal-fired power generation, such a transition could significantly reduce greenhouse gas emissions.¹

1 According to data from the U.S. Energy Information Administration, net electricity generation from coal and natural gas in 2009 was 1,755,904 and 920,929 thousand megawatt hours, respectively, while emissions of carbon dioxide were 1,742.2 and 372.6 million metric tons from coal and natural gas, respectively.

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These additional demands for natural gas have been increasingly supplied by shale gas production. There are three major shale gas plays in the United States. The Barnett shale in Texas was the first to be developed and produced 1.936 billion cubic feet (BCF) of natural gas during 2011.² The Haynesville shale now appears to be the largest shale gas-producing field, according to the Energy Information Administration.³ The third-largest producing field is the Marcellus in Pennsylvania and West Virginia, with estimated production of 1.2 BCF during 2011 (Considine, et al. 2011b). As conventional natural gas deposits deplete, the role of shale gas in the U.S. natural gas supply is likely to continue to increase. Indeed, the Energy Information Administration projects that the share of shale gas in total U.S. dry gas production will rise from 24.8 percent in 2011 to 46.5 percent in 2035.⁴

Shale resources also contain crude oil and petroleum liquids. The Marcellus Shale in Appalachia is emerging as a major producer of natural gas liquids such as propane and butane. These fuels are a critical input in petrochemical industries. Production of crude oil from the Bakken shale play in North Dakota is also increasing rapidly. For example, crude oil production from North Dakota rose from an average of 123,620 barrels per day during 2007 to 418,923 barrels per day dur-

This large reserve base suggests that it will take decades to fully develop the shale energy potential.

ing 2011 (North Dakota, 2011). From negligible amounts in 2007, the Eagle Ford shale play in south Texas produced 83,434 barrels per day during 2011 (Texas Railroad Commission, 2011). The Niobrara plays in eastern Colorado and Wyoming are also promising. Production from these new oil-producing areas and the deep waters of the Gulf of Mexico are reversing the long-term decline in U.S. oil production that began in the early 1970s.

According to the Energy Information Administration (2011), there are nearly 24 billion barrels of technically recoverable oil and 862 trillion cubic feet of natural gas from shale resources. The Potential Gas Committee (2011) estimated that the total natural gas resource base for the United States is even larger at 1,898 trillion cubic feet. This large reserve base suggests that it will take decades to fully develop the shale energy potential.

2 http://www.rrc.state.tx.us/barnettshale/index.php

3 http://205.254.135.7/todayinenergy/detail.cfm?id=570

4 http://205.254.135.7/analysis/projection-data.cfm#annualproj

3. Economic Impacts of **3.** Shale Energy Development

Shale gas production is different from conventional natural gas production from shallow fields because the production decline curve is much steeper, with output declining roughly 50 percent during the first few years of production before leveling out. This high rate of output early during the production period often implies very high rates of return, even at low prices. These high rates of return provide the incentive to continue drilling, which allows shale energy-producing companies to maintain or increase production as they bring new wells on stream to offset the steep production decline of older wells. Accordingly, shale energy development resembles continuous energy manufacturing, unlike conventional natural gas development with an intensive three- to seven-year period of well and pipeline infrastructure development, and relatively little labor and resource use afterward.

The continuity of drilling effort and the economic activity that it generates set shale resource development apart from other energy development activities. Developing coal mines, wind turbines, hydroelectric resources, and solar energy involves

significant job creation during construction. Once the facilities are in place, however, their operation requires relatively few workers. In contrast, the labor-intensive aspects of shale gas development accelerate over time and can persist for decades, if the reserves in place are large enough, and market prices for natural gas justify continued investment.

Transportation costs are high for key materials used in the exploration, drilling, and construction of gas-processing plants and pipelines. Shale energy resources during 2010 alone supported more than 600,000 jobs, increased gross domestic product or value added by \$76 billion ...

Therefore, support industries, including well support, steel, sand and gravel, concrete, trucking, and scientific and engineering services, often arise locally. Most of these support activities are not easily outsourced to foreign suppliers. And in regions with private mineral rights, shale gas development requires lease and bonus payments to landowners, who in turn pay taxes and spend this income on local goods and services. While the footprint of a shale well site is small, the shale deposits occupy an extensive geographical area, necessitating the leasing of large tracts of land.

Economic-impact studies have been conducted for the Barnett, Fayetteville, Haynesville, and Marcellus Shale gas plays. These studies employ input-output models to estimate the direct, indirect, and induced impacts on regional value added (the regional equivalent of contribution to the nation's gross domestic product), employment, and tax revenues. "Direct impacts" constitute the purchases by natural gas companies from other sectors of the economy. "Indirect impacts" refer to the supply chain. For example, a natural gas company contracts with a drilling supply company, which then hires workers and other companies to supply it with materials, equipment, and services. "Induced impacts" constitute the rounds of transactions throughout the economy set off by the spending of workers, hired directly or indirectly, on goods and services. "Induced impacts" also result from landowners' spending of lease, bonus, and royalty payments.

The development of these shale energy resources during 2010 alone supported more than 600,000 jobs, increased gross domestic product or value added by \$76 billion, and generated more than \$18.6 billion in tax revenues at the local, state, and federal levels (IHS, 2011). Similarly, the study by Considine, et al. (2011) finds that development of the Marcellus Shale in Pennsylvania

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supported nearly 140,000 jobs and generated \$11.6 billion and \$1.1 billion in value added and state and local taxes, respectively.

If shale gas development was allowed in New York State, Considine (2010, 2011a) estimates that the accumulated value added from 2012 to 2021 would come to more than \$11.4 billion, with more than 18,000 additional jobs in 2021 and approximately \$214 million in state and local taxes by 2016 (see Appendix A).

4. Producing Energy from Shale Formations

Two distinct technologies - horizontal drilling and hydraulic fracture stimulation - enable shale energy development. Horizontal drilling involves vertically drilling down to the shale-bearing strata and then drilling horizontally to establish lateral well sections that may be up to a mile in length. This approach allows greater surface contact with the energy-bearing shale layer. Producers then inject a water-based solution that contains between 2 and 4 percent sand and chemicals under high pressure into the well, which cracks the rock and increases the permeability of the reservoir. Most of the gas reserves in the Marcellus Shale are only economically recoverable using horizontal wells and hydraulic fracturing. Companies are constantly increasing the speed and efficiency of these operations. The first step in drilling a well is to install a well pad to support a drilling rig. Land is cleared, an area for the well is leveled off, and gravel roads are laid. After a well is completed, all surrounding land is restored and replanted, typically required under regulatory and bond release programs.

Two types of wells can be constructed: a vertical well in which a large drilling rig rotates a steel pipe with a drill bit on the end; and a horizontal well in which a drilling motor pushes fluid through a stationary drill pipe, causing the bit to rotate. In either case, as the well is drilled, a new length of pipe is connected to the one already in use so that the latter can be pushed deeper into the hole. Currently, both vertical and horizontal wells are being drilled in most shale plays. Both types of wells are drilled to a predetermined vertical depth, but the latter then makes a turn, permitting it to be drilled sideways for several thousand feet. While the cost of a horizontal well is three to four times that of a vertical well, they are much more productive because they have far more contact with the gas-bearing rock (Figure 2).

Standard drilling practice includes several measures intended to protect the environment. Oil and gas wells penetrate the water table, generally extending several thousand feet below potable water supplies. As the well is drilled, steel pipe called casing is inserted into the well bore and then

FIGURE 2: HORIZONTAL AND VERTICAL WELLS





cemented into place to form a barrier that protects subsurface groundwater from contamination. Well drillers are also responsible for ensuring that any fluids or chemicals used or produced during drilling and completion of the well do not contaminate surface waters such as streams, rivers, or lakes. In Pennsylvania, all fluids on a well site are now contained within plastic tarpaulins, plasticlined pits, or steel tanks, facilitating the recycling or transportation of these fluids to well-disposal sites permitted by the U.S. Environmental Protection Agency.

After the well is drilled to its final depth, another steel pipe is installed inside of larger ones above it and cemented into place. The drilling rig then leaves the site, and a wellhead is installed on the surface. The wellhead is a collection of valves, often referred to as a Christmas tree, which controls the flow of gas and allows it to be turned off completely if necessary and allows the use of equipment for performing well stimulation and maintenance.

Once drilling is complete, hydraulic fracturing, which stimulates the well to produce more gas by creating new fractures that intersect and connect to as many of the natural fractures to the well as possible, can occur. The first step in this process is to use shaped explosive charges to perforate the bottom section of the steel pipe. Doing so allows hydraulic fracturing fluid to be pumped into the rock to fracture the shale, and then allows hydraulic fracturing fluid and gas into the pipe casing and to the wellhead at the surface. The resulting well is a set of pipes within pipes known as casing strings. The point where one casing string ends and another extends is known as the "shoe." Most companies use multiple strings of casings of varying lengths, diameters, and grades (Figure 3).



FIGURE 3: GROUNDWATER PROTECTION THROUGH PROPER WELL CONSTRUCTION

5. Complications Associated With Natural Gas Development

The extraction, processing, and transportation of natural gas all affect the environment. Koomey and Krause (1997) outline the basic steps for estimating environmental externalities⁵ and the costs they impose on society, involving these general steps:

- Identifying insults to the physical and human environment;
- Charting pathways that convert the insults to stresses;
- Estimating the physical or social consequences of the stresses; and
- Valuing the environmental and social costs of the stresses.

The first three steps collectively can be referred to as environmental-impact assessment and can be accomplished with varying degrees of accuracy or confidence. As a result, most studies estimating environmental externalities specify a degree of uncertainty.

Some upstream negative externalities of natural gas production are unavoidable. They involve the clearing of land for well pads and pipelines; local congestion due to truck traffic; and noise and dust. Lease and bonus payments to landowners or direct outlays by companies to repair infrastructure damage caused by gas drilling activity compensate for most of these impacts. Nonetheless, the sheer presence of gas wells has effects on the ecosystem.

Environmental hazards associated with natural gas production are infrequent, but can lead to contamination of local water supplies and impairment of air quality. Perhaps the most publicized environmental risk arises from the use and disposal of fluids used in hydraulic fracturing. The New York City Department of Environmental Protection (2009) study of the potential impacts of natural gas drilling on the New York City watershed raised the possibility that water from hydraulic fracturing could migrate from the gas-bearing layers, which are 5,000 feet below the surface, up to water tables less than 500 feet from the surface.

The presence of 4,500 feet of rock above the hydraulic fractured zone makes such an eventuality unlikely. Indeed, there exists no documented evidence of such an event since hydraulic fracturing was first introduced approximately 60 years ago. Vaughan (2010) argues that water-supply contamination from so-called stray gas occurs more often from failures in well design and construction, breaches in spent hydraulic-fracturing water-containment ponds, and spills of leftover natural gas liquids used in drilling.

Where groundwater has been impacted, the PA DEP has concluded that the issue stems not from hydraulic fracturing per se, but poorly formulated cement and improperly designed wells – traits that should be of concern in all wells, not just high-volume hydraulic fracture (HVHF) wells. Methane contamination of water is manageable with the use of water treatment systems that remove methane and metals related to methane contamination. Migration of natural gas into structures, however, poses a serious risk of explosions, which have happened on a number of occasions.

Stray gas events can be significantly mitigated by proper well construction. These methods, however, cannot entirely eliminate stray gas emissions because there are many sources of stray gas,

⁵ Environmental externalities refer to effects external to production and consumption activities by firms or households. For example, water pollution from natural gas production is a production externality, while air pollution during combustion of natural gas for home heating is a consumption externality.



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entirely unrelated to shale gas drilling, such as shallow gas reserves, unplugged orphan wells, decaying plant and animal materials, and septic fields. To address this issue, mandatory standards for water-well construction should be adopted in Pennsylvania, which surprisingly do not yet exist due to strong opposition from rural communities and the agricultural industry. To determine the frequency of environmental incidents, a detailed examination of the environmental violations reported in the Pennsylvania Marcellus appears in the next section.

6. Notice of Violations in the Pennsylvania Marcellus

The Pennsylvania Department of Environmental Protection (PA DEP) regulates natural gas development in the Commonwealth of Pennsylvania. The responsibility of the PA DEP is to enforce a body of regulations that date back to the 1930s that recently have been updated to reflect the environmental impact of the development of the Marcellus Shale and other unconventional sources of natural gas. If an operating company fails to comply with these regulations, the PA DEP issues a Notice of Violation (NOV).

These violations are indicative of many different situations. To fully understand the effectiveness of current regulations in mitigating the environmental impacts of Marcellus Shale development and the various incidents that garnished an NOV, a closer examination of these violations is required. A notice of environmental violation often does not indicate an actual environmental event because many of these citations are for administrative violations or are issued to prevent pollution from occurring. Consequently, to estimate the actual environmental impact of shale gas drilling, a careful analysis is required of the environmental violations to determine what actually happened, which appears in section seven below and in greater detail in Appendix B. Meanwhile, this section provides an overview of environmental violations to provide a context for the identification and discussion of the environmental events that resulted in measurable pollution or harm to the environment that are discussed below.

The database for this inquiry includes NOVs issued to operators from January 2008 through August of 2011.⁶ Each NOV is analyzed by first determining the legal statute that prompted its issuance, and then by comparing the statute with the descriptions of the violation provided by the PA DEP and its well site inspectors. This study classifies the violations into seven categories: cement & casing, blowouts & venting, major and non-major spills on land, gas migration, site restoration, and water contamination. More detailed definitions of these categories appear in Table 1 below.

Violation Type	Description			
Cement & casing	Cement and casing job cited as defective and the cause of the pollution			
Blowouts & venting	Citation for a blowout or hazardous venting			
Major spills on land	Citation for major (> 400 gallons) spills of materials on land			
Minor spills on land	Citation for minor (< 400 gallons) spills of materials on land			
Gas migration	Citation for migration of gas in underground aguifers or substrates			
Site restoration	Citation for violations of site restoration regulations			
Water contamination	Citation for tainted water as the primary focus of the citation			

TABLE 1: CLASSIFICATION OF ENVIRONMENTAL VIOLATIONS

The next step reconciles the legal citation with the description of the violation to determine if pollution took place. For example, if a statute discussed discharges of material into waters of the Commonwealth, then the NOV would be classified as a violation involving water contamination as long as this matched the PADEP description and inspector's comments. This close scrutiny of each

6 http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Oil_Gas/OG_Compliance

violation allows a more precise determination of the frequency of NOVs that result in measurable pollution or damage to the environment.

This approach also allows the identification of those violations that affected the environment. To identify these violations, our analysis used a series of indicators developed from the well inspector's comments for each NOV. These violations stood out based upon the amount of fluids spilled, the amount of water or land disturbed, and the potential threat to human health or safety. Once these violations had been identified, our analysis employed the Environmental Facility Applications Tracking System (eFACTS) from the PADEP to classify the violations into those that did and did not involve actual environmental harm.

The raw number of NOVs does not tell the whole story. Our analysis of the NOVs reveals that only a fraction of them were issued for a violation that involved an environmental impact. Among the 2,988 violations issued, only 1,144 were for a violation that involved an environmental event. The other 1,844 violations issued were administrative violations or citations to prevent pollution. Hence, 38.3 percent of the 2,988 NOVs issued were for environmental violations of some type, which is illustrated below in Figure 4. Determining what proportion of these environmental violations were preventative in nature is problematic because it is nearly impossible to assess whether pollution would have occurred had these violations not been issued. Regardless, the number of these violations that did not involve pollution should be considered as a good metric for regulatory oversight. While some in the industry may find these NOVs a nuisance, state oversight through robust regulation does provide incentives for companies to more closely comply with environmental regulations and, most importantly, adopt technological innovations to avoid these citations altogether.



FIGURE 4: SHARES OF ADMINISTRATIVE AND ENVIRONMENTAL VIOLATIONS

A further disaggregation of the environmental violations using the six categories of violations identified above in Table 1 is displayed below in Figure 5. Understanding the distinctions of these categories is important to understanding the key risks of concern to regulators. The environmental violations constitute 38.3 percent of all NOVs and are split seven ways in Figure 5. For example, the largest portion is the 13.4 percent of all NOVs arising from breaking site restoration rules (Figure 5). The next largest category is water contamination with 11.6 percent of all NOVs. Minor spills on land constitute 7.9 percent of all violations. Cement and casing violations comprise 3.3 percent of all NOVs. Violations for major land spills, blowouts and venting, and gas migration constitute 1.5, 0.3, and 0.2 percent of all violations, respectively (Figure 5).

FIGURE 5:

SHARES OF ADMINISTRATIVE VIOLATIONS AND ENVIRONMENTAL VIOLATIONS BY CATEGORY



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Figure 6 below displays a disaggregation of the environmental violations. Of these 1,144 violations, 35 percent involved site restoration issues, slightly more than 30 percent entailed surface water contamination, and almost 21 percent were for minor spills on land. Cement and casing violations constituted 8.7 percent of violations that resulted in pollution. Major land spills comprised 4 percent of these violations, while blowouts and venting and gas migration comprised 0.9 and 0.5 percent, respectively (Figure 6).



FIGURE 6: COMPOSITION OF ENVIRONMENTAL VIOLATIONS

Many of the NOVs that resulted in measurable pollution, however, were rather minor, involving, for example, a gallon of diesel fuel or antifreeze spilled on the ground. The next section identifies the incidents that presented or had the potential to present significant environmental impact.

Significantly, the record of environmental violations in Pennsylvania shows that the rate of environmental violations expressed as a percentage of wells drilled declined over time. For example, in 2008 there were 170 wells drilled and 99 environmental violations, or more than 58 percent of all wells drilled in that year incurred some violation. In the first eight months of 2011, there were 331 recorded violations, or 26.5 percent of the

The Marcellus industry has cut its incidence of environmental violations by more than half in three years, a rather notable indicator of improvement by the industry ...

1,248 wells drilled during the first eight months of 2011. So, on this basis, the Marcellus industry has cut its incidence of environmental violations by more than half in three years, a rather notable indicator of improvement by the industry and oversight by the regulators. While a 26.5 percent rate of environmental violations appears high, it is important to note that most of these violations are not major.



FIGURE 7: WELLS DRILLED AND ENVIRONMENTAL VIOLATIONS

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While difficult to conclusively illustrate causation between regulatory actions and decreases in environmental violations, the history of regulations in Pennsylvania suggests such a relationship may exist. The PA DEP has made significant regulatory changes over the four-year time frame. The agency opened up a new field office, hired additional staff, and made a number of rule changes that were heavily advertised. These regulatory milestones are summarized in Table 2. This trend is expected to continue as stronger regulatory requirements are promulgated, enforcement efforts become well established, and industry gains a better understanding of the new regulatory requirements.

TABLE 2: REGULATORY DECISIONS AND INCIDENCE OF ENVIRONMENTAL VIOLATIONS

Date	Decisions by Pennsylvania Department of Environmental Protection	Wells with Environmental Violations
2008		58.2%
August	Required companies to identify treatment and storage of wastewater	
December	Imposed permitting fees to facilitate the hiring of additional regulators	
2009		40.3%
January	Partnered with industry for new wastewater treatment plants and technologies	
February	Opened Scranton office for regulatory oversight of northeastern Marcellus	
April	Announced new standards for wastewater discharges with dissolved solids	
2010		26.5%
Мау	Announced new discharge rules and well construction standards	
June	Enforcement campaign to ensure compliance by trucks hauling wastewater	
October	"Operation FracNet," for compliance by vehicles hauling wastewater	

While the distinction between administrative and other violations is important, an additional delineation is required because some environmental events generate multiple environmental violations. Using a count of environmental violations, therefore, would over-estimate the number of actual environmental events that took place. Accordingly, to fully understand the effectiveness of current regulations on mitigating environmental impacts of Marcellus Shale development and the various incidents that garnished an NOV, an even closer examination of these events is required.

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7. Environmental Events

In this section, the notices of environmental violation are analyzed to determine how many actual events took place that resulted in environmental pollution. These events were found by examining each individual inspection report and determining what took place based upon the various NOVs issued. The classification system for environmental events is the same as it is for environmental violations. Below is a closer look at each category of environmental event and their nature.

7.1 Blowouts & Venting

Blowout and venting events are among the most serious, and are classified as major for two primary reasons. First, they are uncontrolled in nature and, thus, innately dangerous. Blowouts are usually the result of excess pressure in the well and, as a result, often occur in a violent manner. The other reason blowout and venting events are considered major is their environmental impacts. When a blowout or uncontrolled venting occurs, the potential exists for large amounts of fluids and gases to be released from the wells, despite initial mitigation efforts by operators. In such cases, negative environmental impacts are almost impossible to avoid.

7.2 Spills on Land

As the title suggests, these events are spills in which a drilling substance is spilled onto a surface other than water. These spills often took place on the drilling pad itself and did not have environmental impacts as they are contained within the boundaries of the pad site. The majority of spills were small, and the average amount of fluid spilled was approximately 176 gallons for non-major events. This was determined by taking the average amount of fluid spilled from the events that reported the spilled fluid volumes. The types of fluids spilled vary greatly among the environmental events. The most common type of fluid spilled was diesel fuel. Other fluids spilled included drilling mud, production fluid, hydrochloric acid, drilling soap, produced water, freshwater, and gel friction reducer.

7.3 Gas Migration

Gas migration into freshwater is very rare but serious, usually occurring due to a flaw in the cement and casing of a well. These flaws can be repaired, and the volume of gas escaping from vents is very small. The environmental impacts of gas migration can be mitigated and, therefore, gas migration incidents do not necessarily represent a long-term or permanent environmental impairment. Gas migration, however, is a real danger to public safety because sequestered methane is very volatile and can be explosive. The highly publicized case of gas migration in Dimock, Pennsylvania, illustrates these environmental, health and safety, and public relations impacts. As the discussion below illustrates, however, the environmental impacts can be repaired and, therefore, diligent monitoring and inspection are typically required to minimize these occurrences to the extent possible, and the associated environmental, health, and safety impacts that could potentially result from gas migration.



7.4 Cement & Casing

In almost all cases of cement and casing violations, there was some measurable amount of gas escaping from the well itself. This is not to be confused with a blowout or gas migration, as gas venting from these wells is vented in a less extreme manner. The venting that took place is the primary environmental impact of these events, but the amount of gas that was released is difficult to quantify. The amount of time and quantity of gas was not listed in any of the well inspectors' comments in the NOVs, but in 73 of the 86 instances of casing and cementing events, it was explicitly noted that gas was vented from the well. In the other 13 cases, the pollution observed constituted small leaks coming from the casing. Cement and casing violations are in nature less dangerous than blowouts or gas migration, but in some cases can lead to those events.

7.5 Site Restoration

Our analysis above defines site restoration events when a company did not restore a drilling site properly under guidelines issued by the PA DEP. To properly restore a site, a company needs to restore 70 percent of the perennial vegetation cover, and remove all drilling equipment and waste from the site within nine months after drilling is completed. In most cases, the NOVs indicated how much land was disturbed or what types of problems existed. In most cases, erosion was a problem, and in some cases vegetation was not restored or equipment was left on-site. While these land disturbances had an impact on the environment, they were not as serious in nature as spills or water contamination events and can be completely rectified through minor reclamation efforts.

7.6 Surface Water Contamination

Water contamination events result from spills that impact bodies of water directly. In most cases, these events are minor. Our analysis tracks all types of spills from a gallon of diesel fuel to hundreds of barrels spilled into the many small creeks and ponds in rural Pennsylvania. The spilled substances included many of the same materials spilled on land: fuels, drilling mud, production fluids, hydrochloric acid, sediments, and produced fluids.

The impacts of these events varied by the amount of fluids spilled. Our analysis indicates that on average 105 gallons of fluid were spilled for minor water contamination events. Water contamination events could have direct negative environmental effects or none at all. In areas with sensitive ecosystems, like wetlands, certain forms of aquatic life could be adversely affected by the spill. In other instances, the impacts of the spills can be mitigated with no observable damage to plants or wildlife.

7.7 Analysis of Environmental Events

Our analysis of the environmental records from the PA DEP indicates the total number of unique incidents that resulted in environmental pollution is 845 over our sample period from January 2008 through August 2011, tabulated below in Table 3. Note from above that the total number of environmental violations is 1,144. Based upon our evaluation of the environmental impacts associated with each environmental event, there were 25 incidents that resulted in major environmental impact. Of these 25 incidents, nine involve major spills of materials on land, another eight entail spills that contaminated local water supplies, four incidents concern well blowouts and venting, two events incur major site restoration impacts, and two events concern gas migration. There were no reported cases of hydraulic fracturing fluid migrating into potable water supplies.

TABLE 3:

POLLUTING ENVIRONMENTAL EVENTS IN THE PENNSYLVANIA MARCELLUS SHALE

	2008	2009	2010	Jan - Aug 2011	2008 to 2011
Major Impacts					
Blowouts & Venting	0	0	2	2	4
Major Land Spills	0	2	2	5	9
Gas Migration	0	1	1	0	2
Site Restoration	1	0	0	1	2
Water Contamination	0	5	1	2	8
Subtotal	1	8	6	10	25
Minor Impacts					
Cement & Casing	0	2	27	56	85
Site Restoration	72	68	90	98	328
Minor Land Spills	4	56	66	23	149
Water Contamination	13	39	133	73	258
Subtotal	89	165	316	250	820
Grand Total	90	173	322	260	845

Of all the polluting environmental events, 38.8 percent involved site restoration, 30.5 percent involved spills contaminating surface water, 17.6 percent were nonmajor land spills, and 10.1 percent involved cement and casing problems. Three percent of all environmental events created major problems for the environment, 1.1 percent from major land spills, 0.9 percent involving major water contamination, 0.5 percent from blowouts and venting, 0.2 percent involving major site restoration problems, and 0.2 percent from gas migration (see Figure 8 below).



FIGURE 8: POLLUTING ENVIRONMENTAL EVENTS BY CATEGORY

Like the environmental violations, the number of environmental events varied with the number of wells drilled, as illustrated in Figure 9 below. The incidence of these events, however, steadily declined over the past four years. For example, more than half of all wells involved some level of environmental pollution in 2008, albeit most instances were minor, but that proportion declined to slightly over a fifth of all wells in 2011.


FIGURE 9: WELLS DRILLED AND POLLUTING ENVIRONMENTAL EVENTS

These findings are based solely on the Pennsylvania Marcellus record and are not necessarily indicative of the incidence of polluting environmental events one would expect to find in the future in other regulatory jurisdictions or involving other drilling companies. As indicated previously, however, enforcement activity and awareness of new regulatory requirements by the regulated community is likely to result in a decline in the incidence of polluting environmental events as illustrated above. Moreover, as the analysis presented in Appendix B illustrates, the long-term environmental impacts of these events are almost completely mitigated by remedial actions taken by the companies.

In most cases, due to the severity of these 25 major environmental events, information is available to determine what went wrong, who was responsible, and how the impact was remediated. Appendix B discusses each of the major environmental events that occurred during Marcellus Shale development in Pennsylvania.

The first major conclusion that can be reached from this analysis is that there are only two documented cases in which subsurface potable water supplies were tainted from Marcellus gas drilling activity. These subsurface water contamination events resulted from stray gas or gas migration into potable water supplies due to improper casing of multiple wells in the areas. According to our analysis, local water supplies have been completely restored to one of the affected areas, and in the second area the impacts are still being mitigated. Further, additional safety protocols and engineering measurements through proper state-based regulation can and should eliminate future incidents.

The second finding is that there were four serious well blowouts, implying a 0.11 percent probability of a well blowout. In other words, there is roughly a one-tenth of one percent chance of a serious



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well blowout in the Pennsylvania Marcellus gas drilling industry. To put this in some context and relative perspective, there are 40,000 highway deaths in America each year. If an individual drives an average amount each year for 50 years, there is a one percent chance of dying in an accident, roughly 12 times higher than the odds of a well blowout in the Pennsylvania Marcellus. Also, it is important to keep in mind that these four well blowouts did not result in loss of life.

The third major conclusion is the environmental damages resulting from these events were mitigated with the exception of six cases, two of which are too early to determine if remediation has been completed and for the other four cases, remediation efforts have been undertaken but not verified as completely effective. Hence, even when there are serious environmental impacts, regulators and drilling companies act to completely remediate the environmental damages. This implies that the PA DEP is acting effectively to minimize and in many cases prevent environmental harm from occurring. Hence, the Pennsylvania data shows that of the polluting environmental events that resulted in environmental damage, the regulatory agencies and drilling companies acted to completely remediate those damages.

The fourth and final conclusion is that the majority of the events were due to operator error, negligence, or a failure to follow proper procedures when drilling. This suggests that the industry has room for improvement, and the frequency of environmental events can be reduced. The following subsections discuss the implications of these findings for Pennsylvania and New York.

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7.8 Pennsylvania Regulatory Response to Environmental Events

Since 2008, more than 3,500 Marcellus wells have been drilled in Pennsylvania from more than 100 drilling rigs. The sudden creation of a multibillion-dollar industry of well development, including drilling and completion activities and major infrastructure construction – of pipelines, dehydration systems, gas-processing facilities, and compressor stations – had a range of environmental impacts that caught state regulators by surprise. This section discusses the environmental issues created, the response by regulators and industry, and the implications for regulatory policy for Pennsylvania and New York.

There is little debate that Marcellus Shale development caught the PA DEP unprepared with up-todate environmental regulations for unconventional production from the Marcellus Shale despite ongoing conventional oil and gas industry activity that drilled thousands of wells annually.

The response of the PA DEP to Marcellus Shale development and its associated impacts on Pennsylvania land and potable water was predictable and justified. As noted above, NOVs of all types were issued, and significant monetary fines were assessed to the industry for the more serious violations. Coincidental to these actions, the PA DEP, through collaboration with its Technical Advisory Board and by working in concert with its various stakeholders, has moved to update its oil and gas regulations. These stakeholders include representatives from industry, academia, and various environmental groups. As such, its regulations have evolved with respect to well construction and protection of the environment. These regulations, like all good regulatory regimes, will likely undergo almost continuous refinement. The Commonwealth of Pennsylvania's efforts to update its regulations have involved audits of its regulations by members of the American Petroleum Institute (API).

In addition, the Commonwealth, with support from industry, has moved to add to the number of field inspectors. This addition was financed through a significant increase in permit fees. Also, the Corbett administration recently announced that the PA DEP itself has been reorganized, and that Oil and Gas Management has been elevated in stature and is now managed by a Deputy Secretary. Ostensibly, these changes reflect the Commonwealth's efforts for more consistent enforcement of the regulations from region to region and at the same time recognize regional differences.

In summary, the regulations associated with oil and gas development in Pennsylvania remain a work in progress. Much has been accomplished in terms of updating the regulatory framework that had effectively functioned for more than 70 years. New regulations reflect the development of unconventional oil and gas resources. It should be noted that the industry has responded in positive fashion to complex geography and water-related challenges in Pennsylvania that are not common elsewhere. Revisions in the regulatory framework through significant improvements in well site construction and completion methodologies are a positive development, and must continue to address lessons learned.

8 Implications for Regulatory Policy in New York State

The oil and gas industry in New York dates back to the early 1800s, and the state has formally regulated the industry since 1963. New York State regulates the oil and gas industry using a combination of statute, regulation, and a generic environmental impact statement with authority under the State Environmental Quality Review Act (SEQRA) passed in 1976.

The Environmental Conservation Law, Article 23 – Mineral Resources, and Article 71 – Enforcement, govern the industry. Regulations affecting oil and gas are found in Title 6 of the New York State Register and Official Compilation of Codes, Rules and Regulations of the State of New York (NYCRR) Chapter V – Resource Management Services, Subchapter B: Mineral Resources.⁷ At first glance, these seem somewhat limited in breadth. However, SEQRA gave state regulators significant authority to develop a robust regulatory program to identify potential environmental risks and provided the flexible framework to mitigate them.

Adopted in 1976, SEQRA was designed to "encourage productive and enjoyable harmony between man and his environment." SEQRA requires that government agencies "review the environmental impact of its actions, not limited to a specific environmental medium, such as air or water, but includes all environmental and many socioeconomic issues that arise in considering the result of any governmental action." The agency must disclose and address impacts that can be reasonably anticipated and, to the best of their ability, attempt to avoid or minimize adverse environmental impacts. The goal of the SEQRA process is not to eliminate all activities that may have risk, but to identify potential adverse impacts and ways to mitigate them. Ultimately, this is a subjective decision making legal challenges complex and difficult.

Until three decades ago, New York's oil and gas industry was regulated through inconsistent state and municipal requirements for drilling. This approach resulted in a few well site issues and generally inconsistent state and local rules governing the industry. In 1980, state legislators chose to revise the regulatory program using its SEQRA authority rather than promulgate new regulations. The process started in 1980 and ended in 1992 with the adoption of the final Generic Environmental Impact Statement (GEIS). The GEIS abrogated the right of municipalities to regulate any aspect of oil and gas development, and provided a flexible permitting program that could react quickly to changes on the ground and allow the issuance of permits in a timely fashion.

The 1992 GEIS looked at all common impacts deemed significant, including surface waters, groundwater, agriculture, historical sites, archaeological sites, significant habitats, floodplains, freshwater wetlands, state lands, coastal zones, streams, and general habitat loss. A unique environmental assessment form for drilling was developed from the GEIS.

8.1 Supplemental Generic Environmental Impact Statement (SGEIS)

In 2008, the New York State Department of Environmental Conservation (NYS DEC) began reviewing the 1992 Generic Environmental Impact Statement for oil, gas, and solution mining (GEIS) to determine the extent to which it should be supplemented to address the potential environmental

7 http://www.dos.ny.gov/info/nycrr.html

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impacts of the high-volume hydraulic fracture stimulations (HVHF) used to develop the natural gas resources in the Marcellus Shale formation.

In accordance with SEQRA, the purpose of the 2009 draft SGEIS (DSGIES) was to inventory the potential environmental risks, determine which impacts are significant, and provide mitigation measures. This process is routinely used to address the environmental impacts of many industrial processes. The host of complex environmental impacts analyzed in the draft SGEIS range from the initial water withdrawals to the ultimate disposal of the waste products. In preparing the DSGEIS, NYS DEC sought to recognize, characterize, and provide appropriate mitigation measures based upon sound science, engineering, and experience.

The 2009 DSGEIS was put forth for public comment, a process that ended December 31, 2009, with the receipt of more than 13,000 comments. Comment evaluation lasted through 2010 and well into a new state executive administration.

In 2011, the DEC released a revised DSGEIS (RDSGEIS), which outlines a much more procedural approach to regulating wells using high-volume hydraulic fracture stimulations (HVHF), defined in the RDSGEIS as a completion using 300,000 gallons of water or more. Concurrently, NYSDEC issued revised draft regulations based on the RDSGEIS. This can be seen as a major change in approach. Since 1992, the GEIS has been used as a flexible regulatory tool allowing real-time modernization of regulations to match industry innovation. Now, a much more detailed and formal regulatory structure is proposed for wells using HVHF.

The most productive way to evaluate whether this framework will be ultimately successful is to study prior environmental incidents using the new RDSGEIS. The Department has indicated that they have done this. In 2011, DEC staff studied high-volume hydraulic fracturing incidents throughout Pennsylvania to assess their causes and identify solutions. Given the above analysis that aggregates all environmental incidents occurring in Pennsylvania, we will be able to assess the degree to which New York regulators have been successful in incorporating lessons learned into the RDSGEIS.

8.2 New York Regulations and Environmental Events

Through statutes, regulations, and permit conditions derived from the 1992 GEIS, New York State's program for regulating the oil and gas industry is quite comprehensive. The RDSGEIS and proposed regulations dramatically increase regulatory scrutiny of wells using HVHF. Using the categories defined in *Table 1: Classification of Environmental Violations*, this section will summarize how the regulatory structure of New York State is designed to avoid or mitigate these types of events.

8.21 Blowouts & Venting

Both New York State's existing and proposed regulations acknowledge the potential environmental damage caused by emissions of methane into the atmosphere, and the potential health, safety, and environmental hazards of blowouts. Consideration is given both to avoidance and mitigation.

New York State's regulatory emphasis is placed on avoiding uncontrolled emissions of hydrocarbons. Since the 1992 GEIS, the state has required blowout preventers, equipment inspections, equipment testing, and permits to flare. The RDSGEIS and proposed regulations build on this by requiring advanced equipment, redundant systems, certified staff, and systematic equipment testing to avoid blowout preventer failure and reduce blowout severity:

"The current DSGEIS requires pressure testing of blowout prevention equipment, the use of at least two mechanical barriers that can be tested, the use of specialized equipment designed for entering the wellbore when pressure is anticipated, and the on-site presence of a certified well control specialist." (NYS DEC 2011A, p. ES-25)

"A remote blowout preventer actuator, which is powered by a source other than rig hydraulics, shall be located at least 50 feet from the wellhead. All lines, valves and fittings between the blowout preventer and the remote actuator and any other actuator must be flame resistant and have an appropriate rated working pressure." (NYS DEC 2011B)

Rigorous testing may prevent problems with blowout preventers. Also, requiring properly certified staff and remote actuation also may limit the severity of a blowout. Berms and other secondary containment may help mitigate the impact. These types of systems may help prevent blowouts similar to those described in Appendix B.

8.22 Spills on Land

Site design guidelines included in both the 1992 GEIS and subsequent supplemental drafts include detailed descriptions of site design, operations design, and containment technology to avoid and mitigate the impact of spills. Predrilling inspections by NYS DEC staff are and will continue to be required. In the RDSGEIS, it is clear that well design reviews will be a critical part of the permitting process:

"Before a permit is issued, Department staff would review the proposed layout of the well site based on analysis of application materials and a site visit. Risky site plans would either not be approved or would be subject to enhanced site-specific construction requirements." (NYS DEC 2011A, p. ES-24)

Also, the RDSGEIS requires testing of equipment used for hydraulic fracture stimulation:

"Fracturing equipment components would be pressure tested with fresh water, mud or brine prior to the introduction of chemical additives." (NYS DEC 2011A, p. ES-25)

With this approach, any faulty equipment should be identified prior to the commencement of completion operations. The foregoing requirements are likely to have a positive impact in avoiding or reducing the occurrence of the impacts of the types of spills identified in Appendix B.

8.23 Gas Migration, and Casing & Cementing

Gas migration issues were a concern before the GEIS was finalized in 1992. In the 1980s, in order to avoid hydrocarbon migration into shallower zones, NYS DEC felt it important to require submission of a casing and cementing plan to help assess the appropriateness of the design, given the local geology. Ultimately, the regulation developed requires a minimum of two casing strings, except in aquifers where three are required. NYS DEC conducts inspections of the casing during operations. In the case of an aquifer area, NYS DEC must be on-site to witness the cement returning to the surface.

The revised DSGEIS continues this practice, but adds a wellbore integrity review for wells proposing to use HVHF:

"The Department's staff reviews the proposed casing and cementing plan for each well prior to permit issuance. Permits are not issued for improperly designed wells, and in the case of high-volume hydraulic fracturing the as-built wellbore construction would be verified before the operation is allowed to proceed." (NYS DEC 2011A, p. ES-23- 24)

In the proposed regulations, NYS DEC will also require extensive testing of the casing to make sure it can adequately ensure a sufficient margin of safety in HVHF operations, avoiding a casing breach, and potential migration of methane and fluids. These proposed regulations also set boundaries on how hard a well can be pushed during operations:

"If hydraulic fracturing operations are performed down casing, prior to introducing hydraulic fracturing fluid into the well, the casing extending from the surface of the well to the top of the treatment interval must be tested with fresh water, mud or brine to at least the maximum anticipated treatment pressure for at least 30 minutes with less than a 5 percent pressure loss. This pressure test may not commence for at least 7 days after the primary cementing operations are completed on this casing string. A record of the pressure test must be maintained by the operator and made available to the department upon request. The actual hydraulic fracturing treatment pressure must not exceed the test pressure at any time during hydraulic fracturing operations." (NYS DEC 2011B)

Under the proposed regulations, the operator must sample water wells within a 1,000- to 2,000foot radius before any site disturbance, and for a period after drilling and completion of a well using HVHF. If gas migration is detected, NYS DEC, like the PA DEP, can begin an enforcement action to force the operator to mitigate the problem. The proposed regulations also give NYS DEC the authority to revoke previously issued permits and approvals for noncompliance (as described in proposed regulations 750-3.5).

8.24 Site Restoration

Existing and proposed regulations outline detailed site restoration requirements, including how to mitigate erosion, sedimentation, and general agricultural issues such as topsoil stockpiling. The RDSGEIS and proposed regulations are much more specific as to the impacts on site locations by identifying specific areas such as Grassland and Forest Focus Areas that require extensive predevelopment studies. The proposed regulations are explicit in terms of site restoration after drilling. Partial site reclamation is defined as having occurred after:

- all planned wells at the well pad have been completed, and a DEC inspector verifies that the drilling/fracturing equipment has been removed,
- pits used for those operations have been reclaimed, and surface disturbances not associated with production activities have been scarified or ripped to alleviate compaction prior to replacement of topsoil, and
- 3) reclaimed areas are seeded and mulched after topsoil replacement, and vegetative cover reestablished that will ultimately return the site to pre-construction conditions (as described in proposed regulations 750-3.11 (e) (1) (vi)).

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As with the PA DEP's approach, an improperly restored site would subject the operator to fines and other enforcement actions. This enforcement power rests in statute and regulation.

8.25 Water Contamination

Section 553.2 of the Environmental Conservation Law defines offsets from streams and other water bodies at a minimum of 50 feet and offsets from water wells at a minimum of 150 feet. In practice, proposed sites near water bodies usually trigger an enhanced review due to the presence of flood-plains, aquifers, and other sensitive areas. This approach allows the conditions on the ground to define locations. For non-stimulated and low-volume hydraulic fracture stimulations, this remains the case.

Under the RDSGEIS and proposed regulations, wells proposing to use HVHF will be required to follow very strict "bright line" setbacks from water bodies and aquifers. Surface locations, including drilling and ancillary equipment, are prohibited in the following areas:

- within 2,000 feet of public drinking water supplies;
- on the state's 18 primary aquifers and within 500 feet of their boundaries;
- within 500 feet of private wells, unless waived by landowner;
- in floodplains;
- on principal aquifers without site-specific reviews; and
- within the Syracuse and New York City watersheds.

Looking at the incidences described in Appendix B, it is not clear that these offsets alone would necessarily eliminate contamination of streams or aquifers. Topography and the severity of the incident played a role. It seems that improved site design and better containment, if used in conjunction with "bright line" setbacks, is likely to avoid or reduce the occurrence of these impacts.

8.26 Commentary

New York State has the luxury of learning from the experience of Pennsylvania. As shown above, some of the strict procedures included in the RDSGEIS and proposed regulations may indeed help avoid or mitigate the impact of well site events. Many others, however, might provide little extra protection, while creating restrictions that ultimately stifle industry and investment. The 1992 GEIS recognized the need for flexibility when complex engineered systems are involved. Only time will tell if this strict approach fares as well or better than the landmark 1992 GEIS. Below in Table 4 is a summary of some of the major environmental events discussed in Appendix B if SGEIS requirements had been applied to the five polluting environmental categories.

Category	PA Event	Example 2011 NY SGEIS Requirements
Blowouts & Venting	Incident B.12: Chief Oil and Gas - Bradford County uncontrolled flowback Incident B.13: EOG Resources - Clearfield County well blowout Incident B.17: Talisman Energy - Tioga County blowout Incident B.23: Chesapeake Energy - Leroy Township blowout	 Pressure testing of blowout prevention equipment Using at least two mechanical barriers that can be tested Using specialized equipment designed for entering the wellbore when pressure is anticipated A certified well control specialist to be present during post-fracturing cleanout activities Requiring a remote blowout preventer actuator, which is powered by a source other than rig hydraulics Requiring that all lines, valves, and fittings between the blowout preventer and the remote actuator and any other actuator must be flame resistant, and have an appropriate rated working pressure
Spilis on Land	Incident B.7: Atlas Resources - Diesel spill Incident B.12: Chief Oil and Gas - Susquehanna County fluid spill Incident B.11: Anadarko - Clinton County mud spill Incident B.14: JW Operating Company - Mud spill Incident B.15: Cabot Oil & Gas - Susquehanna County hose failure Incident B.18: Talisman - Jackson production fluid release Incident B.19: Carrizo - Monroe mud spill Incident B.20: Carrizo - Wyoming County drilling mud spill Incident B.22: Ultra Resources - Flowback spill	 Requiring a Spill Prevention Control and Countermeasure Plan (SPCC) Completing a regulatory review of the proposed layout of the well site Requiring a site visit by DEC staff to make sure the site can be designed for adequate containment Prior to the initiation of HVHF operations, pressure test all fracturing equipment components Approval of risky site plans would be subject to enhanced site-specific construction requirements Bans surface access on most state lands The authority by regulators to revoke previously issued permits and approvals for noncompliance (e.g., chemical spills)
Spills into Surface Water	Incident B.2: PA General Energy - Creek discharge Incident B.4: Cabot Oil & Gas - Stevens Creek fish kill Incident B.5: Range Resources - Stream discharge into Brush Run Incident B.6: EOG Resources - Clearfield County stream discharge Incident B.8: Talisman Energy - Armenia pit overflow Incident B.9: Atlas Resources - Hopewell pit overflow into Dunkle Creek Incident B.16: Chief Oil and Gas - Susquehanna County fluid spill Incident B.24:	 Require a State Pollutant Discharge Elimination System (SPDES) permit covering HVHF operations Including restrictions on siting of surface locations will take substantial acreage out of possible production, including (1) within 4,000 feet of, and including, the unfiltered surface water supply watersheds; (2) within 500 feet of, and including, a primary aquifer; (3) within 100-year floodplains; (4) within 2,000 feet of any public (municipal or otherwise) water supply, including wells, reservoirs, natural lakes, or manmade impoundments, and river or stream intakes; and (5) in the New York City and Skaneateles Lake watersheds Demonstrate a source to treat or otherwise legally dispose of wastewater associated with flowback and production water

TABLE 4: MAJOR ENVIRONMENTAL EVENTS AND NY SGEIS REQUIREMENTS

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TABLE 4: MAJOR ENVIRONMENTAL EVENTS AND NY SGEIS REQUIREMENTS

Category	PA Event	Example 2011 NY SGEIS Requirements
Gas Migration, Casing & Cementing	Incident B.3: Cabot Oil & Gas - Dimock gas migration Incident B.10: Chesapeake Energy - Bradford County gas migration incident	 Regulatory preapproval of casing and cementing plan Additional layers of cement and steel casing around each underground well Cement and steel casings to extend at least 75 feet below the deepest freshwater zone - going beyond regulations required in other natural gas producing states Require extensive testing of the casing to make sure it can adequately handle HVHF operations Set hydraulic fracture stimulation operating boundaries to never exceed test pressure to protect casing from excessive pressure Water samples within a 1,000- to 2,000-foot radius before any site disturbance for a period after drilling and completion of a well using HVHF Identify any abandoned wells within the proposed spacing unit and within one mile of the proposed surface location The authority by regulators to revoke previously issued permits and approvals for noncompliance
Site Restoration	 Incident B.1: Atlas Resources - Major site restoration failure Incident B.21: Chesapeake Energy - Washington County pit fire Incident B.25: Ultra Resources - Major site restoration failure 	 Sites must be designed to mitigate erosion, sedimentation During operations, topsoil must be stockpiled Require partial site reclamation after all planned wells at the well pad have been completed Department inspectors must verify that the drilling/fracturing equipment has been removed; pits used for those operations have been reclaimed, and surface disturbances not associated with production activities have been scarified or ripped to alleviate compaction prior to replacement of topsoil Reclaimed areas must be seeded and mulched after topsoil replacement, and vegetative cover reestablished that will ultimately return the site to pre-construction conditions

9. Conclusions

Since 2008, more than 3,533 Marcellus wells have been drilled in Pennsylvania from more than 100 drilling rigs. This study assesses the effectiveness of the state's regulations in mitigating environmental impacts associated with the development of Marcellus Shale in Pennsylvania by surveying records of notices of violations from the Pennsylvania Department of Environmental Protection (PA DEP) from January 2008 through August 2011. The major findings are as follows:

- Of the 2,988 notices of environmental violations (NOVs), the majority (62 percent) are administrative violations or violations issued to prevent pollution from occurring. The remaining citations (38 percent) were in response to an event that impacted the surrounding environment.
- Of the 845 incidents that caused measurable amounts of pollution, 820 were classified as non-major, and only 25 involved major impacts to air, water, and land resources. <u>This implies</u> <u>that over the 44 months surveyed</u>, there was a [0.7 percent] probability of a major environmental event.
- Of the 25 problematic incidents that involved major environmental impacts, six cases did not have their environmental impacts completely mitigated.
- Both the number of environmental violations and subsequent environmental events that caused some physical impact on the environment steadily declined over the past four years, in conjunction with action by state regulators. Notably, the percentage of wells resulting in a major environmental event declined significantly; an indicator that the attention of regulators was focused on the areas of greatest concern. The foregoing suggests that surface activity, rather than the drilling or development process itself, remains the greatest ongoing risk.

The findings are significant as they illustrate how the PA DEP has been able to effectively manage the brisk pace of unconventional gas development, while preserving the economic opportunity that development has afforded the community.

Pennsylvania provides a strong metric to gauge the regulatory proposal being proposed for New York State. Our research classifying the 25 major events that occurred in Pennsylvania with the 2011 New York SGEIS guidelines demonstrates that each of these specific events would be avoided or mitigated under New York State's regulatory framework currently in place.

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APPENDIX

A. Economic Impact Analysis

The development path for New York shale energy will likely follow one similar to that experienced in northern Pennsylvania. During 2008, 52 Marcellus wells were drilled in five counties in northern Pennsylvania: McKean, Potter, Tioga, Bradford, and Susquehanna. The number of Marcellus wells drilled in the same five counties during 2009 was 296 (see Considine et al. 2011b). The New York counties due north of this zone include, from west to east: Allegany, Steuben, Chemung, Tioga, and Broome. As the Marcellus Shale formation extends northward into New York State, it comes closer to the surface, making it less attractive to drilling companies to exploit. Therefore, drilling would probably be concentrated in the southern half of the New York border counties mentioned above.

The Utica shale is another promising natural gas resource extending into New York, but there is no evidence to date that the New York Utica shale is productive. Range Resources completed and tested a horizontal Utica well in western New York, but the results are confidential. Range's only comment is that it plans to drill additional Utica wells. Hence, prospects for the Utica shale in New York are promising, but there is simply not enough evidence of commercial prospects that would justify its inclusion in the scenarios developed below. Leasing activity in the Utica shale in northeastern Ohio, however, is rather intense, given the prospects of rich deposits of oil and natural gas liquids, especially in Stark County. In light of these considerations, a safe assumption is that the Marcellus Shale will be the first formation to be developed in New York State if horizontal drilling with hydraulic fracturing is allowed. Hypothetical trajectory of future drilling appears in Table A1 (Considine, et al. 2011a).

Millio	Millions of Current Dollars		
2012	2016	2021	
172.6	1,899.9	2,209.9	
66.6	502.2	502.2	
5.9	68.9	73.8	
78.2	918.5	984	
19.1	224.5	240.5	
0	152.3	373.5	
2.9	33.5	35.9	
Assun	ned Number of	Wells*	
14	304	330	
28	9	10	
42	314	340	
Gas Equivalents of Million Cubic Feet per Day			
0.1	487.6	952.1	
	Millio 2012 172.6 66.6 5.9 78.2 19.1 0 2.9 Assum 14 28 42 6 6 8 Million 0.1	Additions of Current Doc 2012 2016 172.6 1,899.9 66.6 502.2 5.9 68.9 78.2 918.5 19.1 224.5 0 152.3 2.9 33.5 Assumed Number of V 14 304 28 9 42 314 Gas Equivalents o Million Cubic Feet per 0.1 487.6	

TABLE A1: PROJECTED MARCELLUS ACTIVITY IN NEW YORK (2012, 2016, 2021)

Under this scenario, 42 wells would be drilled in the first year, 314 wells four years later, and 340 wells in 2021. Horizontal drilling's share is based on the observed ratio in northern Pennsylvania (Considine, et al. 2011a). Total spending under this scenario would start out at \$172.6 million; increase eleven fold, to \$1.9 billion by 2016; and reach \$2.2 billion in 2021 (Table A1). The value added that such activity from direct, indirect, and induced effects would create is \$1.7 billion in 2016 (see Table A2). Note that the impacts are spread across a broad array of industries, which reflects the stimulus that natural gas investments have on the supply chain, boosting output in key shale energy supply chain industries, such as construction, wholesale trade, truck transportation, and engineering and scientific services (see Table A2). Similar gains in employment are achieved with Marcellus development supporting more than 15,000 jobs in 2016 alone. Assuming a 3 percent discount rate, the accumulated value added from 2012 to 2021 would come to more than \$11.4 billion. There would be more than 18,000 additional jobs in 2021 (see Table A2). And local and state tax revenues would have grown by more than \$214 million in 2010 dollars by 2016 (Considine, et al. 2011a).

Sector	Millions of 2010 Dollars		
	2012	2016	2021
Ag., forestry, fishing, and hunting	0.3	3.3	3.8
Mining	19.8	232.3	249.2
Utilities	3.5	38.1	44.8
Construction	14	163.4	175.7
Manufacturing	4	44.8	51.1
Wholesale trade	16.4	189.1	207
Retail trade	9.9	107.4	125.9
Transportation and warehousing	3.9	43.6	48.9
Information	4.9	53.9	62.9
Finance and insurance	12.5	136.9	158.6
Real estate and rental	21	224	268.3
Professional/scientific and tech services	13.2	150.1	166.5
Business management	2.3	25.9	28.8
Administrative and waste services	4.1	45.5	51.6
Educational services	3.1	32.1	40.6
Health and social services	10.6	112.1	135.3
Arts/entertainment and recreation	1.2	13.1	15.7
Hotel and food services	3.3	35	42.1
Other services	3.4	35.8	42.9
Government and misc.	1.7	18.4	21.6
Total	153	1,704.8	1,941.2

TABLE A2: PROJECTED VALUE ADDED IN NEW YORK BY SECTOR (2012, 2016, 2021)

APPENDIX

B. Detailed Discussion of Major Environmental Events

The sections below explain the nature of the 25 major environmental events and their impacts. For each event, this discussion explains what went wrong, why, who was responsible, and what remedies were followed.

B.1 Atlas Resources – Major site restoration failure

On December 4, 2008, Atlas Resources was issued an NOV for failing to properly restore a site after drilling had been completed earlier that year (PA DEP 2008). This instance was considered major because Atlas allowed 15 acres of land to remain disturbed after drilling was completed (PA DEP 2008). This amount of land disturbance was the second-largest site restoration failure in the sample and for this reason is considered a major environmental event. After receiving the NOV, Atlas did eventually clean up the site and mitigate the impacts that the drilling had in the area. Atlas was fined \$9,641 for the violation, and was at fault because there were no circumstances that prevented it from restoring the site (PA DEP 2008).

B.2 PA General Energy – Creek discharge

On March 15, 2009, PA General Energy was cited for discharging Airfoam into a stream in Lycoming County, Pennsylvania (Swift 2011). Airfoam is a substance used to help lift water and drill cuttings to the surface during drilling. The Airfoam escaped when snowmelt and rain washed over the well pad, causing the substance to migrate to a nearby stream (Swift 2011). The site was restored, and the impacts of the Airfoam runoff were mitigated. PA General Energy was fined \$28,960 for the event because of impacts on the waters of the Commonwealth.

The pollution caused by the event was difficult to avoid because the operator did not anticipate the level of snowmelt and rain that occurred. Preventing such events, however, is possible. Once the event happened, the operator was able to mitigate the impacts by placing a protective barrier around the stream that had been contaminated by Airfoam. While barriers like this are not always feasible, they can be effective when used in such situations.

B.3 Cabot Oil & Gas – Dimock gas migration

On May 13, 2009, the Pennsylvania Department of Environmental Protection issued multiple environmental violations to Cabot Oil & Gas because 19 families in Dimock had their water wells contaminated with methane. This contamination arose from gas migration that occurred after Cabot improperly cemented multiple gas wells in the area (PA DEP 2010a). Cabot was initially fined \$120,000, but later was fined more than \$500,000 by the PA DEP. In addition to the \$500,000 fine, Cabot later settled for \$4.1 million with the residents who had their water affected (PA DEP 2010a).

This incident carried the largest fine of any environmental event in the Pennsylvania Marcellus and could be considered the most severe. The gas migration contaminated a large amount of drinking

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water. The three wells that were found to be the source of the migrating gas were plugged, and since then there has been a noticeable improvement in the water quality of the affected water wells.

B.4 Cabot Oil & Gas - Stevens Creek fish kill

In Dimock, Pennsylvania, on September 16, 2009, the Pennsylvania Department of Environmental Protection reported that approximately 8,000 gallons of produced fracturing fluids spilled into Stevens Creek (Lustgarten 2009). The cause of the spill was reportedly linked to the failure of a supply pipe near the creek and resulted in reports of fish swimming erratically in the affected area. Some fish were also found dead in the creek, and the PA DEP reported that the surrounding wetland area was affected as well. Cabot Oil & Gas eventually cleaned up the impacted area, but received a \$56,650 fine for the spill.

The Stevens Creek fish kill was considered to be a major event because of the large volume of fracturing fluid that was spilled, and the incident was classified as water contamination. The environmental impacts of this event were very severe. Equipment failure is a part of any industry, and natural gas drilling is no different. However, this event still had such a significant environmental impact that Cabot was still held responsible. The impacts of this event were not easily mitigated, and significant effort was required to restore the site, but eventually the area was restored. This event was severe and the regulatory actions of the PA DEP reflected this reality.

B.5 Range Resources – Stream discharge into Brush Run

On October 10, 2009, Range Resources reported that a temporary aboveground water transfer line had a connection failure that resulted in the accidental release of 250 barrels, or 10,500 gallons, of partially recycled flowback water into Brush Run creek (PA DEP 2010b). Approximately 300 minnows were killed by the spill, but other aquatic life in the stream survived. Range was fined \$141,175 for the spill (PA DEP 2010b), which resulted from equipment failure. The site was restored under supervision of the PA DEP, and the environmental impacts have been mitigated.

This event was major due to its direct impact on waters of the Commonwealth and was classified as water contamination. Equipment failure is something that cannot be avoided in most cases, and Range Resources was able to quickly mitigate the impacts from this spill. The reason Range was fined so heavily for the event is twofold. The first reason is that the spill occurred in a high-quality watershed that fed multiple fisheries in the area, and the second is the fact that Range did not report the spill immediately (PA DEP 2010b). This event is interesting because while Range was not entirely responsible for the event, they failed to follow proper procedures for dealing with the spill.

B.6 EOG Resources – Clearfield County stream discharge

On October 12, 2009, an independent consultant found that a cap on a holding tank had gone bad and allowed approximately 190 barrels, or 7,980 gallons, of produced fluid to enter Little Laurel Creek (PA DEP 2009a). EOG Resources was unaware of the leak until it was reported to the company, and a quantity of a foamy substance was observed in the creek that the produced fluid had entered. EOG Resources was fined \$99,125 for the incident but was able to mitigate some of the impacts by flushing the stream (PAFBC 2009). EOG Resources was at fault for this event and could have prevented it by better inspecting its storage tanks. This event was considered a water contamination event and is another example of a company being negligent. The area that was affected by this spill was also heavily used for fishing, so the Fish and Boat Commission was also present during the evaluation of this incident. The impacts from the incident were mitigated, but the area is still undergoing testing to ensure that water quality is normal. With better training of crews and the paying of more attention to details like storage containers, events like this one can easily be prevented in the future.

B.7 Atlas Resources – Diesel spill

On October 30, 2009, Atlas Resources experienced a 790-gallon diesel fuel spill due to the improper connection of a fuel line at its drilling site in Westmoreland County (PA DEP 2009b). Atlas was able to recover 250 gallons of fuel from the spill, but the rest was unaccounted for (PA DEP 2009b). Atlas also placed other collection devices around the spill in hopes of mitigating the impacts further, but was unable to successfully clean up the entire spill. The PA DEP found Atlas at fault and fined the company \$17,500 for the spill (PA DEP 2009b). This event could have been prevented by following procedures for equipment inspection.

B.8 Talisman Energy – Armenia pit overflow

On November 23. 2009, Talisman Energy experienced a pit overflow into a small un-named waterway in Bradford County (PA DEP 2010c). Between 4,200 to 6,300 gallons of fracturing fluid were spilled into the waterway, which is upstream from a fishery. The flowback was caused when a pump failed and sand collected around the valve, causing fluid to flow uncontrolled toward the waterway (PA DEP 2010c). Talisman Energy was fined \$15,506 for the event and was able to clean up the spill (PA DEP 2010c).

This event is considered a major water contamination event because it affected a high-quality watershed. Talisman was not at fault for this event because the equipment failure was not due to negligence and was unavoidable. Talisman also responded quickly to the spill and was able to mitigate most of the impacts of the spill.

B.9 Atlas Resources - Hopewell pit overflow into Dunkle Creek

On December 5. 2009, the Pennsylvania Department of Environmental Protection discovered multiple environmental violations that led to the contamination of a high-quality watershed in Hopewell County, Pennsylvania (PA DEP 2010d). This event was severe due to the type of watershed that was affected. While the overflow of the pit had significant environmental effects, the pollution impacts were mitigated. Atlas Resources was fined \$97,350 for allowing diluted fracturing fluids to overflow from a wastewater pit (PA DEP 2010d). This incident violated the Pennsylvania Oil and Gas Act, as well as the Solid Waste Management Act, and although the impacts were mitigated, Atlas failed to notify the PA DEP (PA DEP 2010d).

This event is considered a major water contamination because a significant amount of high-quality water was tainted by the spill. A large fine is usually indicative of a significant amount of pollution. A large amount of pit fluid flowed directly into Dunkle Creek and despite the ability of Atlas to clean up the spill, a large fine was assessed. This large fine was likely due to the fact that Atlas could have prevented this incident by better maintaining the storage pit that held the diluted fracturing fluid. Also,



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the situation was exacerbated by the fact that Atlas failed to report this event to the PA DEP. The cause of this event was considered negligence on the part of Atlas Resources and should have been prevented. This event is an example of what can go wrong when an operator fails to follow regulations and guidelines for pit construction. In conclusion, this event could have been avoided.

B.10 Chesapeake Energy – Bradford County gas migration incident

On May 17, 2011, the PA DEP fined Chesapeake Energy \$900,000 for violations related to natural gas drilling activities in Bradford County (PA DEP 2011g). This was the largest fine issued by the PA DEP to date and was issued due to the severity of the gas migration. At various times throughout 2010, the PA DEP investigated private water well complaints from residents of Bradford County's Tuscarora, Terry, Monroe, Towanda, and Wilmot townships near Chesapeake's drilling operations (PA DEP 2011g). Gas was also observed to have been bubbling up from the Susquehanna River during the initial investigation (Efstathiou 2010g). The PA DEP determined that due to improper well casing and cementing in shallow zones, natural gas from non-shale shallow gas formations had experienced localized migration into groundwater and contaminated 16 families' drinking water supplies (PA DEP 2011g). Chesapeake has agreed to take corrective action to mitigate the impacts of this migration and restore water supplies (PA DEP 2011g). Currently, the impacts have yet to be fully mitigated, and the 16 families are currently receiving alternative water supplies from Chesapeake (PA DEP 2011g).

B.11 Anadarko – Clinton County mud spill

On April 23, 2010, Anadarko Resources spilled 9,300 gallons of drilling mud at its drilling site in Clinton County (PA DEP 2010e). The spill was restricted mostly to the well pad, and the effects were completely mitigated (PA DEP 2010e). The PA DEP confirmed that there was no impact on the land or water on or around the site. The cause of the spill was operator error, but even though there were no impacts on the surrounding water or land, Anadarko was fined \$58,000 for the event (PA DEP 2010e). Events like this one can be avoided, but Anadarko did make the best of a bad situation and cleaned up the spill very quickly.

B.12 Chief Oil and Gas - Bradford County uncontrolled flowback

On May 27, 2010, Chief Oil and Gas experienced an uncontrolled flow-back in Bradford County. Pennsylvania (PA DEP 2010f). This flow-back caused more than 1,000 feet of dead vegetation adjacent to the well pad and was found to be major due to this impact on land (PA DEP 2010f). Uncontrolled flow-back falls under the category of blowouts and venting using our classification system, and thus is considered to be a serious event. This event, in particular, was interesting because of the amount of vegetation that was killed. Blowouts are typically caused when there is an excess amount of pressure in the well; however, no official report was filed on the cause of this event. Given the absence of a report of what caused the uncontrolled flow-back, it is difficult to determine if the operator was at fault or not. This event also caused the soil surrounding the well to be considered residual waste, which means that the same containment procedures had to be used for this soil as diluted fracturing fluids (PA DEP 2010f). There is no report of this event being resolved, and it is likely that it will be difficult for Chief to fully restore the site.

B.13 EOG Resources – Clearfield County well blowout

On June 3. 2010, EOG Resources experienced a well blowout at its Punxsutawney Hunting Club well in Clearfield County, Pennsylvania (WJACTV 2010). The blowout lasted for 16 hours, and spewed both gas and produced chemicals onto the surrounding countryside (WJACTV 2010). The blowout was caused when blowout equipment failed due to lack of maintenance, and the spill went unchecked due to excess pressure in the well. An estimated 1 million gallons of fracturing fluid were spilled, and fortunately the impacts have been mitigated (WJACTV 2010). Proper maintenance of well blowout equipment could have prevented this event, and EOG Resources was fined \$353,419 for the event, making it the second-largest fine issued by the PA DEP to Marcellus operators.

What makes the Clearfield well blowout such a significant event was the poor response by EOG Resources. The company was not able to get control of the situation for a significant period after the initial event occurred, and an evacuation of the area was required. Moreover, the impacts of this event were also very severe, with a large amount of forest contaminated by the fluids that were released. This event was entirely preventable and could have had a far less damaging effect on the area had it been properly handled by EOG.

B.14 JW Operating Company - Mud spill

On July 30, 2010, The JW Operating Company spilled 1,500 gallons of drilling mud at its site in Cameron County (PA DEP 2010g). The impacts of the spill were mitigated, and JW was fined \$8,000 for the event (PA DEP 2010g). The PA DEP records do not indicate the cause of the event. Due to the large volume of drilling mud spilled, this event is major. The JW Operating Company also failed to notify the PA DEP, who was notified by a contractor working on the site.

B.15 Cabot Oil & Gas – Susquehanna County hose failure

On November 3, 2010, Cabot Oil and Gas reported a spill of 135 barrels, or 5,670 gallons, of drilling mud onto plastic (PA DEP 2010h). Cabot was quick to act and was able to vacuum up all of the drilling mud before any major environmental impacts occurred. This event was indeed Cabot's fault, so an NOV was issued, but since all environmental impacts were mitigated, no fine was issued. We consider this a major event given the large volume of drilling mud that was spilled. There was no environmental impact because remedial action was taken.

B.16 Chief Oil and Gas - Susquehanna County fluid spill

On January 10, 2011, Chief Oil and Gas reported a release of production fluid at its drill site in Susquehanna County (PA DEP 2011a). The PA DEP reported that 150 barrels of production fluid were spilled, but there is no information on whether the environmental impacts had been mitigated (PA DEP 2011a). The PA DEP conducted an Act 2 assessment of the site to determine if the polluted land should be considered solid waste and whether it should be removed from the site (PA DEP 2011a). This event was caused by a partially open valve and was the fault of Chief Oil and Gas. The PA DEP has yet to assess a fine for this incident. Chief did follow the proper protocol for reporting the spill.

B.17 Talisman Energy – Tioga County blowout

On January 17, 2011, Talisman Energy experienced a minor well blowout in Tioga County, Pennsylvania. The blowout lasted for several hours and spilled a large amount of fracturing fluids on the well pad located in a state forest (Levy 2011). The blowout was caused when blowout preventers failed due to excess pressure. This pressure buildup could have been avoided had Talisman properly monitored the well. The impacts of this spill were mitigated, and Talisman was able to clean up the well site. Talisman was fined \$51,478 for the event, and was cited for an uncontrolled discharge and hazardous venting (Levy 2011).

The root cause of this event was failure of blowout prevention equipment to contain the pressures that were encountered. This was preventable, and the reason that Talisman was at fault was the fact that the pressure buildup was allowed to continue as long as it did, leading to the blowout.

B.18 Talisman Energy – Jackson production fluid release

On January 26, 2011, Talisman Energy released production fluid at its drilling site in Tioga County. Approximately 500 barrels, or 21,000 gallons, of production fluid were spilled into state forestland (PA DEP 2011b). PA DEP found that Talisman was responsible for this spill. Talisman complied with the PA DEP's investigation of the site and conducted sampling of the site to determine if the land that was affected needs to be removed (PA DEP 2011b). Due to the swift action of the PA DEP and Talisman, much of the possible impacts of this spill was avoided. This event is still considered serious due to the large amount of fluid that was spilled and its proximity to state forestland.

B.19 Carrizo – Monroe mud spill

On January 25, 2011, Carrizo, LLC experienced a mud spill at its drilling location in Washington County near the town of Monroe (PA DEP 2011c). Approximately 1,500 gallons of drilling mud and cuttings were spilled when mixing the substance. The spill was completely confined to plastic beneath the rig, so any potential impacts were mitigated (PA DEP 2011c). The spill was unavoidable and not the fault of Carrizo because it was following proper procedures. Carrizo also reported this spill to the PA DEP in a timely manner, and as of now, there has not been a fine issued to Carrizo.

B.20 Carrizo - Wyoming County drilling mud spill

On February 14, 2011, Carrizo, LLC received an NOV for spilling 1,500 gallons of drilling mud outside of a containment area (PA DEP 2011d). Drilling mud can consist of many different things, but it is typically made of bentonite clay, water, and other drilling additives. This mud spill was considered major given the volume of mud released. Carrizo cleaned up the spill, but did not follow proper procedures for reporting it. The PA DEP found Carrizo responsible for the spill, but no information is yet available on the penalty or if the impacts of the spill have been mitigated.

B.21 Chesapeake Energy – Washington County pit fire

On February 23, 2011, while testing and collecting fluid from wells on a drill site in Washington County, three condensate separators caught fire, injuring three subcontractors working on the site (PA DEP 2011g). The PA DEP conducted an investigation of the incident and determined that the cause was improper handling of condensate, which is a wet gas found only in certain geological areas. Chesapeake was fined \$188,000 for the event, which was the maximum penalty that could be assessed for a fire of this type (PA DEP 2011g). There was minimal environmental damage, according to the PA DEP, and the fire was contained (WTAE 2011). To ensure the fire was contained, approximately 20 acres of land was cleared and will need to be restored (WTAE 2011). The men who were injured in the fire were wearing flame-resistant clothing at the time the fire erupted, and it was stated that none of their injuries were life threatening (CBS 2011).

B.22 Ultra Resources – Flowback spill

On March 15, 2011, Ultra Resources left a valve to a storage tank open and allowed 5,300 gallons of produced fluid to spill (Myers 2011). This spill was cleaned up, but did present a high threat to a nearby high-quality water source in Tioga County. Ultra also waited two hours to contact the PA DEP, and although the impacts from this spill have been mitigated, Ultra was still issued an NOV for the event, due to negligence on its part. This event was major given its impact on the environment and the large amount of fluid spilled. Ultra also could have handled the situation much better, and events like this one should be easy to avoid.

B.23 Chesapeake Energy – Leroy Township blowout

On March 19, 2011, Chesapeake Energy experienced a well blowout in Bradford County, Pennsylvania. The cause of this incident was equipment failure and resulted in a large amount of produced water flowing into nearby Towanda Creek (Hamill 2011). The impacts of this event are still being monitored, but no aquatic life was harmed, and the water quality of the surrounding wetlands is still normal. Blowouts are significant events because they are indicative of both environmental damage, and a threat to human health and safety. In some instances, blowouts can be prevented, but in this case, it was beyond the operator's control. Equipment failure was the cause of the blowout, and despite careful measures taken by Chesapeake, the equipment still failed.

B.24 CNX Gas Company – Mud spill

On July 5, 2011, CNX Gas Company spilled 2,400 gallons of drilling mud into an unnamed tributary that feeds into Ten Mile Creek (PA DEP 2011e). This spill was significant given the size of the spill and the area affected. Any time a substance is leaked into water, serious environmental impacts are likely. In this case, the extent of the damage has yet to be fully reported, but water contamination has been cited. The cause of this spill is also still unknown, but the event was cited as a violation of the Pennsylvania Clean Streams Act, and NOVs were issued. The impacts of this event have yet to be fully mitigated, and the PA DEP will be investigating this incident further to determine the extent of any damage.

B.25 Ultra Resources – Major site restoration failure

On August 16, 2011, Ultra Resources was issued an NOV for failing to restore 21 acres of land affected by drilling activity in Tioga County (PA DEP 2011f). This was the largest amount of land not restored after drilling activities. Site restoration is important because it allows the local ecosystem to return to its natural condition, and if it is not completed, major erosion can take place and damage more land than was originally affected by drilling. Ultra did eventually clean the site. Given the large amount of land that was disturbed, Ultra was fined \$58,000 for the incident (PA DEP 2011f). This event was both the fault of Ultra and preventable, and shows how seriously the PA DEP takes site restoration.

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ENVIRONMENTAL IMPACTS

DURING MARCELLUS SHALE GAS DRILLING: CAUSES, IMPACTS, AND REMEDIES

TIMOTHY CONSIDINE

CENTER FOR ENERGY ECONOMICS AND PUBLIC POLICY SCHOOL OF ENERGY RESOURCES | THE UNIVERSITY OF WYOMING

ROBERT WATSON

THE PENNSYLVANIA STATE UNIVERSITY

NICHOLAS CONSIDINE CENTER FOR ENERGY ECONOMICS AND PUBLIC POLICY

JOHN MARTIN

SHALE RESOURCES AND SOCIETY INSTITUTE STATE UNIVERSITY OF NEW YORK AT BUFFALO



Hydraulic Fracturing (HF)



WASHINGTON, D.C. MAY 14, 2012



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INSTITUTE FOR 21ST CENTURY ENERGY U.S. CHAMBER OF COMMERCE









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API Workshop on Hydraulic Fracturing Recommended Practices

- 8:15 a.m. 9:00 a.m. Continental Breakfast
- PROGRAM
- 9:00 a.m. 9:20 a.m. Welcoming Remarks, Marty Durbin, API
- 9:20 a.m. 9:25 a.m. Hydraulic Fracturing Video
- 9:25 a.m. 9:45 a.m. API Standards Process Overview, David Miller, API
- 9:45 a.m. 10:15 a.m. HF Standards and Guidance Documents, Glen Benge, Benge Consulting
- 10:15 a.m. 10:30 a.m. Questions
- 10:30 a.m. 10:45 a.m. Break
- 10:45 a.m. 11:30 a.m. HF Standards and Guidance Documents (Continued), Glen Benge, Benge Consulting
- 11:30 a.m. 11:45 a.m. Questions
- 12:00 p.m. 1:00 p.m. Lunch

Speaker Introduction, Jack Gerard, API

Keynote Speaker, Heather Zichal Assistant to the President for Energy and Climate Change

1:00 p.m. Adjourn



Industry, working through organizations like the American Petroleum Institute (API), has a long history of developing consensus based "best practices." These best practices are developed by industry experts in a varlety of areas of technology and operations and go through a rigorous review process before being adopted. They are then evaluated regularly to incorporate evolving technology and operational practices.

Building on existing APi standards and practices pertaining to oil and gas extraction, we have developed a set of 5 documents which specifically address the risk management issues accompanying unconventional well construction and management. These robust practices help to protect the public by providing a blueprint for strong, carefully tended wells. They were created to meetor exceed federal requirements while remaining flexible enough to accommodate the variations in state regulatory frameworks that often occur due to fundamental differences in regional geology and other factors.

Copies of the documents are available at **www.api.org**.



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Overview of Industry Guidance/Best Practices on Hydraulic Fracturing (HF)

HF1 - Hydraulic Fracturing Operations - Well Construction and Integrity Guidelines, 1st Edition, October 2009, (API)

- Highlights industry practices for well construction and integrity for wells that will be hydraulically fractured.
- The guidance identifies actions to protect shallow groundwater aquifers, while also enabling economically viable development of oil and natural gas resources.

HF2 - Water Management Assoclated with Hydraulic Fracturing, 1st Edition, June 2010, (API)

- Identifies best practices used to minimize environmental and societal impacts associated with the acquisition, use, management, treatment, and disposal of water and other fluids associated with the process of hydraulic fracturing.
- Focuses primarily on issues associated with hydraulic fracturing pursued in deep shale gas development, but also describes the important distinctions related to hydraulic fracturing in other applications.

HF3 – Practices for Mitigating Surface Impacts Associated with Hydraulic Fracturing, 1st Edition, February 2011, (API)

- Identifies the best practices for minimizing surface environmental impacts associated with hydraulic fracturing operations.
- Focused on protecting surface water, soils, wildlife, other surface ecosystems, and nearby communities.
 - Includes API's policy on chemical disclosure:
 - API supports transparency regarding the disclosure of the chemical ingredients;
 - States are the proper authority to determine reporting requirements and formatting of reporting and public disclosure;
 - · Proprietary information should be protected; and
 - Hydraulic fracturing is effectively regulated by numerous federal, state and local requirements. Hydraulic fracturing should not be placed exclusively under the purview of the Safe Drinking Water Act (SDWA) or any other federal statute.

Std 65 Part 2 - Isolating Potential Flow Zones During Well Construction, 2nd Edition, December 2010, (API)

- Helps ensure the well is properly designed and constructed to contain the hydrocarbons through the well bore and isolate them from ground water aquifers. This is accomplished though the use of casing, cement, and mechanical barriers.
- Included is information on industry cementing practices. A well-designed cement job optimizes cement placement through considerations such as laboratorytested slurry design, honoring pore pressure/fracture gradient window, use of spacers/pre-flushes, proper density and rheological hierarchy, fluid compatibility and adequate centralization.

RP 51R – Environmental Protection for Onshore OII and Gas Production Operations and Leases, 1st Edition, July 2009, (API)

- Provides environmentally sound practices for domestic onshore oil and gas production operations, including fracturing. Applies to all production facilities, including produced water handling facilities. Operational coverage begins with the design and construction of access roads and well locations, and includes reclamation, abandonment, and restoration operations.
- Annex A provides guidance for a company to consider as a "Good Neighbor."

API's documents specific to hydraulic fracturing build on years of industry's best practice work by incorporating and citing the following additional standards, recommended practices and technical reports:

- API RP 4G, Recommended Practice for Use and Procedures for Inspection, Maintenance, and Repair of Drilling Well Service Structures
- API RP 5A3 / ISO 13678, Recommended Practice on Thread Compounds for Casing, Tubing, and Line Pipe
- API RP 5A5 / ISO 15463, Field Inspection of New Casing, Tubing, and PlaIn-end Drill Pipe
- API RP 5B1, Gauging and Inspection of Casing, Tubing, and Line Pipe Threads
- API RP 5C1, Recommended Practice for Case and Use of Casing and Tubing
- API RP 5C5 / ISO 13679, Recommended Practice on Procedures for Testing Casing and Tubing Connections
- API RP 5C6, Welding Connections to Pipe
- API RP 7C11F, Recommended Practice for Installation, Maintenance, and Operation of Internal-Combustion Engines
- API RP 11ER, Recommended Practice for Guarding of Pumping Units
- API RP 10B2 / ISO 10426-2, Recommended Practice for Testing Well Cements
- API RP 10B3 / ISO 10426-3, Recommended Practice on Testing of Deepwater Well Cement Formulations
- API RP 10B4 / ISO 10426-4, Recommended Practice on Preparation and Testing of Foams and Cement Slurries at Atmospheric Pressure
- API RP 10B5 / ISO 10426-5, Recommended Practice on Determination of Shrinkage and Expansion of Well Cement Formulations at Atmospheric Pressure
- API RP 10B6 / ISO 10426-6, Recommended Practice on Determining the Static Gel Strength of Cement Formulations
- API RP 10D2 / ISO 10427-2, Recommended Practice for Centralizer Placement and Stop Collar Testing
- API RP 10F / ISO 10427-3, Recommended Practice for Performance Testing of Cementing Float Equipment
- API RP 12N, Recommended Practice for the Operation, Maintenance, and Testing of Flame Arresters
- API RP 12R1, Recommended Practice for Setting, Maintenance, Inspection, Operation, and Repair of Tanks in Production Service
- API RP 13B1 / ISO 10414-1, Recommended Practice for Field Testing Water-Based Drilling Fluids
- API RP 13B2 / ISO 10414-2, Recommended Practice for Field Testing Oil-based Drilling Fluids
- API RP 13C, Recommended Practice on Drilling Fluid Processing Systems
 Evaluation
- API RP-13D, Recommended Practice on the Rheology and Hydraulics of Oil-well
 Drilling Fluids
- API RP 13I / ISO 10416, Recommended Practice for Laboratory Testing Drilling Fluids
- API RP 13J / ISO 13503-3, Testing of Heavy Brines
- API RP 13M / ISO 13503-1, Recommended Practice for the Measurement of Viscous Properties of Completion Fluids
- API RP 13M4 / ISO 13503-4, Recommended Practice for Measuring Simulation and Gravel-pack Fluid Leakoff Under Static
- API RP 19B, Evaluation of Well Perforators
- API RP 19C / ISO 13503-2, Recommended Practice for Measurement of Properties of Proppants Used in Hydraulic Fracturing and Gravel-packing Operations
- API RP 19D / ISO 13503-5, Recommended Practice for Measuring the Long-term Conductivity of Proppants
- API RP 49, Recommended Practice for Drilling and Well Servicing Operations
 Involving Hydrogen Sulfide
- API RP 53, Recommended Practices for Blowout Prevention Equipment Systems
 for Drilling Operations
- API RP 54, Occupational Safety for Oil and Gas Well Drilling and Servicing Operations
- API RP 55, Recommended Practices for Oil and Gas Producing and Gas Processing Operations Involving Hydrogen Suifide

Selected Industry Guidance/Best Practices on Hydraulic Fracturing (HF)

Copies of the documents are available at **www.api.org**.



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Selected Industry Guidance/Best Practices on Hydraulic Fracturing (HF)

Copies of the documents are available at **www.api.org**.

- API RP 65, Cementing Shallow Water Flow Zones in Deep Water Wells
- API RP 67, Recommended Practice for Oilfield Explosives Study
- API RP 74, Occupational Safety for Oil and Gas Well Drilling and Servicing Operations
- API RP 75L, Guidance Document for the Development of a Safety and Environmental Management System for Onshore Oil and Natural Gas Production Operation and Associated Activities
- API RP 76, Contractor Safety Management for Oil and Gas Drilling and Production Operations
- · API RP 90, Annular Casing Pressure Management for Offshore Wells
- API RP 2350, Overfill Protection for Storage Tanks in Petroleum Facilities
- API Spec 4F, Drilling and Well Servicing Structures
- API Spec 5B, Specification for Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads
- API Spec 5CT / ISO 11960, Specification for Casing and Tubing
- API Spec 6A, Specification for Wellhead and Christmas Tree Equipment
- API Spec 7B11C, Specification for Internal Combustion Reciprocating Engines for Oil-Field Service
- API Spec 10A / ISO 10426-1, Specification for Cements and Materials for Well Cementing
- API Spec 10D / ISO 10427-1, Specification for Bow Spring Casing Centralizers
- API Spec 10D2 / ISO 10427-2, Specification for Centralizer Placement and Stop Collar Tracing
- API Spec 11N, Specification for Lease Automatic Custody Transfer (LACT) Equipment
- API Spec 12B, Specification for Bolted Tanks for Storage of Production Liquids
- API Spec 12D, Specification for Field Welded Tanks for Storage of Production Liquids
- API Spec 12F, Specification for Shop Weided Tanks for Storage of Production Liquids
- API Spec 12J, Specification for Oil and Gas Separators
- API Spec 12K, Specification for Indirect Type Oilfield Heaters
- API Spec 12L, Specification for Vertical and Horizontal Emulsion Treaters
- API Spec 12P, Specification for Fiberglass Reinforced Plastic Tanks
- API Spec 13A, Specification for Drilling Fluid Materials
- API TR 5C3, Technical Report on Equations and Calculations for Casing, Tubing, and Line Pipe Used as Casing or Tubing; and Performance Properties Tables for Casing and Tubing
- API TR 10TR1, Cement Sheath Evaluation
- API TR 10TR2, Shrinkage and Expansion in Oilwell Cements
- API TR 10TR3, Temperatures for API Cement Operating Thickening Time Tests
- API TR 10TR4, Technical Report on Considerations Regarding Selection of Centralizers for Primary Cementing Operations
- API TR 10TR5, Technical Report on Methods for Testing of Solid and Rigid Centralizers
- API Guidelines for Commercial Exploration and Production Waste Management Facilities
- API Environmental Guidance Document E5, Waste Management in Exploration and Production Operations
- API Bulletin E2, Bulletin on Management of Naturally Occurring Radioactive Waste Materials (NORM) in Oil and Gas Production
- API Bulletin E3, Environmental Guidance Document: Well Abandonment and Inactive Well Practices for U.S. Exploration and Production Operations
- API Bulletin 11K, Data Sheet for Design of Air Exchange Coolers
- API Bulletin 75L, Guidance Document for the Development of a Safety and Environmental Management System for Onshore Oil and Natural Gas Production Operations and Associated Activities
- API Publication 4663, Remediation of Salt-Affected Soils at Oil and Gas Production Facilities



Evaluation of Geology and Water Well Data Associated with the EPA Hydraulic Fracturing Retrospective Case Study Bradford County, Pennsylvania

Prepared for:



Chesapeake Energy P.O. Box 18496 Oklahoma City, OK 73118

Prepared by:



1400 Weston Way P.O. Box 2653 West Chester, PA 19380

April 13, 2012



Evaluation of Geology and Water Well Data Associated with the EPA Hydraulic Fracturing Retrospective Case Study Bradford County, Pennsylvania

Jebouch M. Watterne

Deborah M. Watkins, P.E. WESTON – Program/Project Manager

Thomas Cornut

Thomas S. Cornuet, P.G. WESTON- Professional Geologist PA State Registration No. PG003189G

4/13/2012

Date

4/13/2012

Date





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EXECUTIVE SUMMARY

The EPA is conducting a retrospective study regarding the relationship, if any, between hydraulic fracturing and drinking water resources as described in EPA's "Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources" dated November 2011 (EPA Study). The scope of this report includes the evaluation of analytical data collected by Chesapeake Energy contractors and analyzed by commercial laboratories from 14 water wells and 1 spring (EPA Study Wells) that were included in EPA's October and November 2011 Bradford County, Pennsylvania sampling events and were located within the vicinity of Chesapeake Energy's operating area. These 14 water wells and 1 spring are not inclusive of all EPA sample locations (37 total) but were limited to the sample locations at which Chesapeake Energy was permitted to collect split samples with the EPA in Bradford County. Chesapeake Energy requested that an evaluation be completed of the sample results for the Chesapeake Energy contractor-sampled locations by Weston Solutions, Inc. (WESTON_®).

EPA Study Well water quality data provided by Chesapeake Energy were assessed to meet the following objectives:

- To determine whether any of the parameters of interest had experienced significant changes following Chesapeake Energy baseline sampling;
- To compare EPA Study Well water quality with historic water-quality data obtained prior to the commencement of Marcellus Shale activities in Bradford County, PA (approximately 2007);
- To identify any EPA Study Well exceedances of various screening criteria derived from EPA MCLs and SMCLs, PADEP Act 2 Land Recycling Program, and EPA Regional Screening Levels and contrast these EPA Study Well exceedances with historic water well exceedances; and
- To provide general observations regarding the EPA Study Well water-quality data contrasted with historic water quality in Bradford County, and Chesapeake Energy's baseline data for nearby water wells.

Time series plots for each of the wells have been prepared for the following water-quality parameters: total barium, chloride, total iron, total manganese, dissolved methane, sodium, and TDS. Chloride, total barium, sodium, TDS, and methane were chosen as key indicator parameters that could indicate the presence of constituents from natural gas drilling or


production operations. Total iron and total manganese were selected because they are commonly found in northeastern Pennsylvania groundwater at naturally-occurring levels that commonly exceed their respective water-quality screening criteria (e.g. EPA SMCL or PADEP Act 2).

Two publically available USGS groundwater data sets - NWIS and NURE - were used to conduct a statistical analysis of historical pre-natural gas development groundwater quality in Bradford County, Pennsylvania between 1935 and 2007. The two groundwater data sets are both maintained by the USGS. In addition, data from a USGS and PGS report (William et al. 1998) and Chesapeake Energy's Baseline Sampling Program for samples located in the vicinity of the EPA Study Wells under consideration were used to further develop the descriptive statistical summaries for the EPA Study Well area.

The descriptive statistical summaries for these data sets were compared to screening criteria developed from the PADEP Act 2 Land Recycling Program, EPA MCLs and SMCLs, and EPA Regional Screening Levels for Tap Water (Chronic). Many of the parameters in these historical or background data sets (such as total manganese, total arsenic, chloride, total lead, total lithium, TDS, total aluminum, and total iron) exceed the screening criteria. The EPA Study Well analytical results were summarized and compared to these same screening criteria. As would be expected based on historic water quality in the region, these data demonstrate that many of the water samples collected from the EPA Study Wells exceed the screening criteria for both baseline and subsequent analyses for these same parameters.

Durov and Piper diagrams were generated for each of the EPA Study Wells and the two primary aquifer formations (Catskill and Lock Haven) to graphically illustrate the chemical distribution of major cations and anions for baseline and subsequent sampling timeframes and to verify the formations that these wells were completed within. Formation-specific mean and median values of constituent concentrations were calculated from the historic water well quality databases (e.g., NURE, NWIS, Williams et al.) and were plotted on the Catskill and Lock Haven diagrams for comparison purposes. The plots show that the EPA Study Well water quality is relatively consistent over time, and that there is no significant deviation in water quality from baseline to post-drilling sampling.

ES-2



Based upon review of the analytical data for each of 14 water wells and one spring presented in this report, and subsequent comparison of these results with regional historical and baseline water-quality databases, this study concludes that these fifteen water sources do not appear to be impacted by natural gas drilling or production activities including hydraulic stimulation.

With the few exceptions noted within the report, there are no significant increases in inorganic parameters when comparing current analyses with baseline conditions or from historical databases. None of the 14 wells or one spring show significant increases in dissolved methane when comparing current analyses with baseline conditions or area-wide baseline databases. Note that the Property Owner A, Property Owner I (142-feet), and Property Owner F wells showed levels of methane that could not be compared to baseline methane concentrations due to the absence of baseline samples. There were also a few detections of organic compounds in some of the wells, but these are not attributable to natural gas drilling, stimulation, or production activities including hydraulic stimulation. The analyses for each of the fifteen water sources demonstrated that most of the individual parameters fell within the ranges and were similar to the mean concentrations for the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for selected areas in Bradford County (and selected areas in western Susquehanna County for the Chesapeake Energy baseline database).



1. INTRODUCTION

The United States Environmental Protection Agency (EPA) is conducting a retrospective study regarding the relationship, if any, between hydraulic fracturing and drinking water resources as described in EPA's "Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources" dated November 2011 (EPA Study). The scope of this report includes the evaluation of data related to water samples collected by Chesapeake Energy contractors, and analysis of water samples by commercial laboratories from 14 water wells and one spring (EPA Study Wells) that were included in EPA's October and November 2011 Bradford County, Pennsylvania (PA) sampling events and were located within the vicinity of Chesapeake Energy's operating area. These 14 water wells and one spring are not inclusive of all EPA sample locations (37 total) but are limited to the sample locations at which Chesapeake Energy was permitted to collect split samples with the EPA in Bradford County, PA. The sample locations at which the property owner would not allow Chesapeake Energy to collect split samples, those EPA deemed confidential, or those that were outside Chesapeake Energy's operating area are not discussed in this report, but their locations are provided on prepared maps within this report.

Chesapeake Energy requested that an evaluation be completed of the sample results by Weston Solutions, Inc. (WESTON_®) for the Chesapeake Energy contractor-sampled locations. All laboratory analyses were performed by Eurofins Lancaster Laboratories, Lancaster, Pennsylvania and TestAmerica Laboratory, Nashville, Tennessee. Both laboratories maintain National Environmental Laboratory Accreditation Program (NELAP) accreditation. Chesapeake Energy provided the analytical data for each of the EPA Study Wells; these data are included in the data tables contained in **Appendix A**.

The locations of the 14 water wells and one spring being evaluated in this report have been superimposed on maps of geologic formations, aerial imagery, shaded relief, and topography (**Appendix B, Figures B-1 through B-4**).

This report contains the results of WESTON's evaluation, and includes discussions of the following:



- The geological characteristics and impact of rural activities on groundwater quality in Bradford County (Section 2);
- Evaluation of historic groundwater quality in Bradford County considering geological formations and conditions (Section 3) and exceedances of various screening criteria derived from EPA Maximum Contaminant Levels (MCLs) and Secondary Maximum Contaminant Levels (SMCLs), Pennsylvania Department of Environmental Protection (PADEP) Act 2 Land Recycling Program, and EPA Regional Screening Levels;
- Assessment of the EPA Study Well water-quality data (Section 4) to establish:
 - Comparison of EPA Study Well water quality with historic water-quality data prior to the commencement of Marcellus Shale activities (approximately 2007) in Bradford County, PA;
 - Any significant changes in water quality following baseline sampling;
 - Exceedances of various screening criteria derived from EPA MCLs and SMCLs, PADEP Act 2 Land Recycling Program, and EPA Regional Screening Levels; and
 - General observations regarding the EPA Study Well water-quality data and historic groundwater quality in Bradford County, PA.
- Preparation of Piper tri-linear and Durov diagrams to compare EPA Study Well general water quality with historical data collected from Bradford County to verify aquifers of completion and to determine any significant changes between sampling events (Section 5);
- Summary of observations (Section 6); and
- Conclusions (Section 7).



2. SUMMARY OF BACKGROUND GEOLOGY, HYDROGEOLOGY, HYDROGEOCHEMICAL SYSTEM AND WATER QUALITY FOR BRADFORD COUNTY, PENNSYLVANIA

2.1 GEOLOGY

The data and information provided in this summary were developed from a review of the United States Geological Survey (USGS) and Pennsylvania Geological Survey (PGS) Water Resource Report 68, "Hydrogeology and Groundwater Quality of the Glaciated Valleys of Bradford, Tioga and Potter Counties, Pennsylvania" (Williams, 1998) and other significant documents as referenced in the following sections. The study area (Bradford County) is shown on **Figure B-1** of **Appendix B**, which includes the locations of the 14 water wells and one spring of interest and the underlying surficial or bedrock geology. Bradford County lies within the Susquehanna River drainage basin. The vast majority of the water wells shown on **Figure B-1** are completed in the Catskill Formation, Lock Haven Formation, and/or Glacial Stratified-Drift aquifer systems.

The Catskill and Lock Haven Formations commonly consist of interbedded shale, siltstone, and sandstone of Devonian-Pennsylvanian-age, while the Stratified-Drift aquifer systems are glacial or post-glacial in origin and consist of unconsolidated sand and gravel of Pleistocene age that form extensive unconfined or confined aquifers in the valleys. The outwash is underlain in most major valleys by silt, clay and very fine sand of lacustrine origin that comprise extensive confining units. Bedrock and till are the basal confining units of the Stratified-Drift aquifer systems. The Lock Haven Formation underlies most of the major valleys. The Catskill Formation underlies some of the major valleys in the southern and eastern parts of the study area and much of the uplands. In general, the Catskill Formation is less calcareous and coarser grained than the Lock Haven Formation.

2.2 HYDROGEOLOGY

According to Williams, 1998, the most productive sources of groundwater in Bradford County are the Stratified-Drift aquifers. Specific capacity data from 95 USGS-studied wells indicate that most wells that are completed in the Stratified-Drift aquifers have specific capacities an order of magnitude greater than those completed in till and bedrock. In general, the Stratified-Drift



aquifers have the highest domestic well yields and bedrock aquifers (Catskill and Lock Haven Formations) have the lowest. Yields of most domestic wells completed in till are less than those completed in Stratified-Drift aquifers, but greater than those completed in bedrock. Most domestic well yields are greater in the Catskill Formation than in the Lock Haven Formation. The coarser grained Catskill Formation typically has larger, deeper, and more open natural fractures than the Lock Haven Formation.

2.3 HYDROGEOCHEMICAL SYSTEM

There are two major hydrogeochemical systems within the glaciated valleys of the study area. The **<u>unrestricted groundwater flow zone</u>** is of the calcium bicarbonate type water, and is present within the unconfined and confined Stratified-Drift aquifers, and in the till and shallow bedrock systems. The **<u>restricted groundwater flow zone</u>** is of the sodium chloride type water, and is found in the bedrock, and occasionally in the till and confined Stratified-Drift aquifers. The restricted flow zone water wells identified in the Williams 1998 study are typically in major stream and river valleys. The restricted flow zone water wells containing naturally occurring sodium chloride type water, as identified in the Williams 1998 report for Bradford County, and are shown on **Figure B-1** in **Appendix B**.

In the restricted flow zones, the sulfate concentrations are low, allowing for naturally elevated concentrations of dissolved barium, strontium, and radium. It is hypothesized that anaerobic bacteria convert the sulfate to hydrogen sulfide and methane, which explains the observation of the presence of hydrogen sulfide and methane in water wells completed within the restricted flow zones (Williams 1998). The Williams 1998 study identified 44 water wells that were completed at relatively shallow depths (37 to 720 feet [ft] below ground surface [bgs]; median depth of 200 ft bgs) that contained naturally-occurring sodium chloride type groundwater. Of these 44 water wells, 38 were completed in bedrock formations (23 wells in the Lock Haven Formation and 15 wells in the Catskill Formation), and 6 wells were completed in the confined portions of the glacial stratified drift or till.



2.4 WATER QUALITY

Historic water samples from water wells that penetrate zones having restricted flow contain median concentrations for total dissolved solids (TDS), chloride, dissolved barium, and dissolved strontium, which are 840 milligrams per liter (mg/L), 350 mg/L, 2.1 mg/L, and 1.35 mg/L, respectively (Williams, 1998). Other than strontium, all of these historical median values exceed health-based screening criteria. The TDS and chloride exceed the EPA SMCLs of 500 mg/L and 250 mg/L, respectfully. Barium exceeds the PADEP Act 2 criterion of 2 mg/L for residential use aquifers, and the EPA MCL of 2.0 mg/L. About 50 percent of the wells included in the Williams 1998 report contain water having iron and manganese concentrations that exceed the EPA SCMLs of 0.3 mg/L and 0.05 mg/L, respectively (Williams, 1998). Only water in the unconfined Stratified-Drift aquifers and the Catskill Formation has median concentrations lower than these limits for iron and manganese. Wells completed in till typically yield water having the highest concentrations of both iron and manganese. Williams 1998 also states that "Wells that penetrate zones containing highly saline groundwater commonly produce hydrogen-sulfide and/or methane gas."

2.5 ARSENIC AND COLIFORM

A study of over 700 private water wells in Pennsylvania was conducted in 2006 and 2007 by The Center for Rural Pennsylvania titled "Drinking Water Quality in Rural Pennsylvania and the Effect of Management Practices" (Swistock 2009). Some of the key findings from this report as related to arsenic and coliform concentrations in the tested wells are summarized below.

- Total coliform was present in 33% of the wells.
- Total coliform concentrations correlated with elevated soil moisture associated with wetter periods.
- *E. coli* was present in 14% of the wells.
- *E. coli* was attributed to animal sources impacting surface water that in time reaches groundwater.
- 11% of the wells contained arsenic concentrations at or greater than 6 micrograms per liter (µg/L).
- 2% of wells exceeded an arsenic concentration of $10 \mu g/L$.



- Wells with elevated arsenic concentrations occurred mostly in northern Pennsylvania.
- 41% of wells failed at least one safe drinking-water standard.

The presence of arsenic in drinking-water supplies was described in the USGS publication, "A Retrospective Analysis on the Occurrence of Arsenic in Ground-Water Resources of the United States and Limitations in Drinking-Water-Supply Characterizations" (Focazio, 2000). This report presents the findings of the National Arsenic Occurrence Survey (NAOS; Frey and Edwards, 1997) that was completed in 1995, incorporating the results of stratified random sampling of 275 public water supplies. The report indicates that approximately 15% of the Mid-Atlantic region samples exceeded arsenic levels of 5 μ g/L.

"Reconnaissance of Arsenic Concentrations in Ground Water from Bedrock and Unconsolidated Aquifers in Eight Northern-Tier Counties of Pennsylvania" (Low, 2007) discusses a study that included the evaluation of 22 wells and one spring in Bradford County for the presence of arsenic. Total arsenic was detected above the quantitation limit of 0.004 mg/L in three of the wells at concentrations of 0.0053 mg/L, 0.0394 mg/L, and 0.117 mg/L. The latter two of these wells are completed within the Lock Haven Formation. For the eight studied counties in northeastern Pennsylvania, 20% of the wells within the Lock Haven Formation had detectable levels of arsenic and 7% of the wells within the Catskill Formation had detectable levels of arsenic. Where arsenic was detected in the Lock Haven Formation water wells, total arsenic concentrations ranged from 4.5 to 117 μ g/L; the median was 14.2 μ g/L (Low, 2006). Low, 2007 noted that total arsenic was found with statistically greater frequency if the water well was located in a valley, as compared to a slope or hilltop. Low, 2007 also stated that arsenic was detected with greater frequency in the water of wells completed in the Lock Haven Formation than in the water of wells completed in other formations in these 8 northeast Pennsylvania Counties, including Bradford County. Low, 2007 points out that the Lock Haven Formation is known for its brackish water or saline water and the presence of hydrogen sulfide, and that these waters represent areas where groundwater flow is controlled in part by low-permeability material where sodium and chloride are the dominant anions.

2.6 REFERENCES

The following references were reviewed in the preparation of this document:



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3. GROUNDWATER DATABASES

Two publically available groundwater databases were used to conduct the historical (pre-2007) statistical analysis of groundwater quality in the study area (Bradford County). The two groundwater databases are both maintained by the USGS and are the National Water Information System (NWIS) and National Uranium Resource Evaluation (NURE). In addition, data published in the USGS and PGS Water Resources Report 68 titled, "Hydrogeology and Groundwater Quality of the Glaciated Valleys of Bradford, Tioga, and Potter Counties, Pennsylvania" (Williams 1998) were also used to conduct a historical descriptive statistical analysis. The locations of the water wells evaluated in these databases are shown on the figures in **Appendix B**. Additionally, descriptive statistical analyses gathered from Chesapeake Energy's Baseline Sampling Program were reviewed for samples located in the immediate vicinity of the wells under consideration. Descriptive statistical summaries for each of the four data sets are included in **Appendix C**.

3.1 NATIONAL WATER INFORMATION SYSTEM (NWIS)

As part of the USGS's program of disseminating water data to the public, the Water Resources Division (WRD) maintains a distributed network of computers and file servers for the storage and retrieval of water data collected through its activities at approximately 1.4 million sites. This system is called the NWIS. The NWIS trace metals and general water-quality parameters include alkalinity, ammonia, arsenic, barium, cadmium, calcium, chloride, chromium, iron, lead, lithium, magnesium, mercury, nitrate, nitrate/nitrite, potassium, silver, sodium, strontium, sulfate, and TDS. A total of 169 water wells were sampled in Bradford County, Pennsylvania between 1935 and 2006 in the Catskill and Lock Haven Formations. These data are available on line from the USGS. These well locations are plotted on the figures in **Appendix B**; data and descriptive statistics have been summarized in tabular form by geologic formation in **Appendix C**.

3.2 NATIONAL URANIUM RESOURCE EVALUATION (NURE)

The NURE program, as a part of a program to identify domestic uranium resources, conducted analyses of groundwater samples from water wells for trace metals and general water-quality

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parameters, including alkalinity, bromide, chloride, magnesium, manganese, pH, and sodium. Out of the 164 water wells in this database for Bradford County, 19 or 11.6 percent of the water wells were reported to have hydrogen sulfide odors present at the time of sampling in October, 1977. As noted by Williams (1998) hydrogen sulfide is often associated with the restricted flow zones that contain sodium chloride type groundwater and methane. A total of 160 of the 164 water well samples collected in Bradford County, Pennsylvania during October 1977 were from the Catskill and Lock Haven Formations. These well locations are plotted on the figures in **Appendix B**; summary statistics for these data have been summarized in tabular form by geologic formation in **Appendix C**.

3.3 USGS WATER RESOURCES REPORT 68 (WILLIAMS 1998)

As a part of a study of the hydrogeology and groundwater quality of the glaciated valleys of Bradford, Tioga, and Potter Counties, Pennsylvania, USGS, in cooperation with the PGS, evaluated historical groundwater quality collected from 1935 to 1986. These published data, referred to as the Williams 1998 report data, were used to prepare a database, allowing for plotting of the well locations on the figures (**Appendix B**) and development of descriptive statistical analyses for the various geologic formations (**Appendix C**). The data used for this evaluation were taken from the following tables in the Williams 1998 report and are summarized in tabular form in **Appendix C**:

- Table 12 Inventory of Well That Produce Water of the Sodium Chloride Type from Restricted-Flow Zones;
- Table 20 Chemical Analysis of Water from Selected Wells; and
- Table 21 Record of Wells and Test Holes.

For Bradford County, there are 108 wells that were sampled. These wells were identified as being located in the Catskill Formation, Lock Haven Formation, Stratified Drift – confined, and Stratified Drift – unconfined. In addition, using the data in Table 12 of the Williams report, wells that are located within a restricted flow zone (containing sodium chloride type groundwater) were segregated for a descriptive statistical analysis. The parameters that are included in this database are pH, calcium, magnesium, sodium, potassium, alkalinity, sulfate,



chloride, fluoride, TDS, nitrates, aluminum, arsenic, barium, cadmium, chromium, iron, lead, manganese, nickel, strontium, and zinc.

3.4 CHESAPEAKE ENERGY BASELINE DATA

Chesapeake Energy has been conducting a baseline monitoring program to establish baseline water-quality conditions in nearby water wells prior to drilling and completing gas wells in Pennsylvania. There are nearly 2,000 samples collected in the selected areas considered in this evaluation between 9/17/2009 and 1/10/2012. For the purposes of this report, these well sample locations have been evaluated in three data groups based on geographic proximity to the EPA Study Wells that were allowed to be sampled by Chesapeake Energy's independent contractor:

- Central;
- Eastern; and
- Western.

These areas are shown on a Chesapeake Energy baseline location map and in tabular form in **Appendix C**.

3.5 EVALUATION OF DATABASES

A descriptive statistical analysis was performed on each of the four databases to determine for each parameter the number of detections and the minimum, maximum, median, and mean values. The results of this evaluation are included in **Appendix C**. There is one summary table for each database used.

This evaluation included the following considerations:

- The NURE, NWIS, and Williams 1998 evaluation only included groundwater from water wells;
- The Chesapeake Energy baseline data was for groundwater water wells;
- All water wells and springs are located in Bradford County (except some of the Chesapeake Energy baseline data were gathered from western Susquehanna County since some of the EPA Study Wells were near the county line);



- The NURE, NWIS, and Williams 1998 databases only included data collected prior to 2007 (before significant Marcellus Shale activity began in Bradford County);
- The nitrate data from 1935 (NWIS) was not used since analytical methods and reporting conventions differ from those currently in use;
- Only detected parameters were included in the descriptive statistical analyses;
- Data for total metals and other parameters were used to the maximum extent possible to provide for a consistent comparison with data from the EPA Study Well analyses, which primarily included total metals and other parameters. Exceptions are noted below:
 - Dissolved chloride, lithium, and sulfate values were used from the NWIS database; and
 - All Williams 1998 metals data were reported as dissolved, including arsenic, barium, chloride, iron, manganese, and sodium.

3.6 GEOLOGIC CLASSIFICATION

Geologic classification was performed for both the study wells and the NWIS and NURE database wells to which the study wells were compared. The classification was required for the purposes of developing geochemical statistics for the pertinent geologic units. All classification was based on the Bradford County portions of the following publicly available statewide geologic datasets described below.

- Pennsylvania statewide groundwater information system (PAGWIS). This database contains information as to the geologic zone, or aquifer, of completion for many of the wells contained within; and
- The PGS geologic coverage. The lateral extent of mapped bedrock and glacial deposits are available as shape files, which are an industry standard for sharing geospatial information.

The geologic zone of completion was performed for the NWIS wells using the following procedure.

1. Obtained the PAGWIS aquifer code for 83% (122 of 146) of the NWIS wells present in the PAGWIS database. This was performed using a simple query that links the location identification fields in the two databases;



- 2. Performed a spatial query for the remaining 17% of the NWIS wells using the bedrock shape file to obtain the bedrock unit within which the well is potentially completed;
- 3. For those locations having a well depth less than or equal to 120-ft below ground, performed a spatial query to determine if they fall within the footprint of the stratified drift polygon shape file and reassigned the tentative bedrock classification to stratified drift if they fall within the polygon; and
- 4. If the well depth was unknown or listed as zero or one in the NWIS database, then the well defaulted to the bedrock classification in the database.

The geologic zone of completion for the study water wells and NURE database water wells was determined using steps 2 through 4 of this procedure since none of these wells could be identified in the PAGWIS database using either location identification or proximity.

Eight of the 14 study water wells plus the Property Owner B spring were determined to be completed within the Catskill Formation, or likely obtained water from the Catskill Formation. The remaining six locations were classified as Lock Haven Formation wells. However, geochemical data suggests that the Property Owner C water well is actually completed within a restricted flow zone of the Lock Haven Formation identified by the USGS (Williams, 1998). Also, this well is within 2,000 ft of a well (Br-271) identified by the Williams 1998 report as being in a restricted flow zone, and both wells contain sodium chloride type water consistent with the restricted flow zone described by Williams, 1998. Water well Br-271 is 110 feet bgl in depth, and contained a chloride level of 3,500 mg/L and a TDS level of 6,100 mg/L in a July 20, 1982 sample.

Despite the fact that none of the study water wells were determined conclusively to be completed within glacial units, identification of those NWIS and NURE locations suspected to be completed within glacial units was still required so that these wells could be excluded from statistical evaluations of the bedrock geochemistry.

Information pertaining to completion formation and location within Bradford County (relative to the Chesapeake Energy baseline database) for the 14 study water wells and one spring are summarized in **Table 3-1**:

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Table 3-1

Property Owner	Bedrock Formation	Special Condition	Location in Bradford Co.*		
Property Owner A (300-ft)	Catskill	-	Central		
Property Owner B (spring)	Catskill	-	Eastern		
Property Owner C (260-ft)	Lock Haven	Restricted Flow Zone	Central		
Property Owner D (250-ft)	Lock Haven	-	Central		
Property Owner F (200-ft)	Lock Haven	-	Western		
Property Owner G (unknown)	Catskill	-	Central		
Property Owner E (115-ft)	Catskill	-	Central		
Property Owner E (185-ft)	Catskill	-	Central		
Property Owner H (340-ft)	Catskill	-	Central		
Property Owner I (142-ft)	Catskill	-	Central		
Property Owner I (203-ft)	Catskill	-	Central		
Property Owner J (unknown)	Lock Haven	-	Central		
Property Owner K (175-ft)	Lock Haven	-	Central		
Property Owner L (225-ft)	Lock Haven	-	Central		
Property Owner M (440-ft)	Catskill	-	Central		

*Per Chesapeake Energy map in Appendix C



4. EVALUATION OF EPA STUDY WELL WATER QUALITY

EPA Study Well water-quality data from samples collected by Chesapeake Energy's independent contractors were assessed to meet the following objectives:

- To determine whether any of the parameters of interest had experienced significant changes following Chesapeake Energy baseline sampling;
- To compare EPA Study Well water quality with historic water-quality data obtained prior to the commencement of Marcellus Shale activities in Bradford County, PA (approximately 2007);
- To identify any EPA Study Well exceedances of various screening criteria derived from EPA MCLs and SMCLs, PADEP Act 2 Land Recycling Program, and EPA Regional Screening Levels and contrast these EPA Study Well exceedances with historic water well exceedances; and
- To provide general observations regarding the EPA Study Well water-quality data and historic groundwater quality in Bradford County.

This section addresses the process used to complete the evaluation.

Fourteen water wells and one spring were included in the evaluation. The property owners and their sources included:

- Property Owner A (300-ft well);
- Property Owner B (spring);
- Property Owner C (260-ft well);
- Property Owner D (250-ft well);
- Property Owner E (115-ft and 185-ft wells);
- Property Owner F (200-ft well);
- Property Owner G (well, depth unknown);
- Property Owner H (340-ft well);
- Property Owner I (142-ft and 203-ft wells);
- Property Owner J (well, depth unknown);
- Property Owner K (175-ft well);
- Property Owner L (225-ft well); and
- Property Owner M (440-ft well).



Study Well data were received from Chesapeake Energy in an Excel file format (**Appendix A**). The locations of the wells included in this evaluation are shown on the figures in **Appendix B**. Preprocessing of the data was performed to convert the data to file formats suitable for time versus concentration plotting (time plots) and descriptive statistical analysis using Microsoft Excel and geochemical analysis using AquaChem software.

4.1 TIME PLOTS AND COMPARISON WITH HISTORIC STATISTICS

For the time plotting of key analytical parameters and associated descriptive statistical analysis, processing included separation of numeric concentration values from data qualifier flags and conversion of data qualifiers to non-detect and detected values; estimated values were recorded as detected values. Analytes that were not detected were recorded at their sample quantitation limits. Analytes not detected in any of the samples were excluded from further consideration. Post-treatment data were excluded from the data set since these data are not representative of naturally-occurring groundwater conditions.

Time series plots for several water-quality parameters for each of the wells have been prepared and are included in **Appendix D**. Plots have been completed for:

- Total Barium;
- Chloride;
- Total Iron;
- Total Manganese;
- Methane;
- Sodium; and
- TDS.

Chloride, total barium, sodium, TDS, and methane were chosen as key indicator parameters that could indicate the presence of constituents potentially associated with natural gas operations. Total iron and total manganese were selected because they are commonly found in northeastern Pennsylvania groundwater at naturally-occurring levels that commonly exceed their respective water-quality screening parameters. The concentrations of total iron and total manganese were compared and contrasted with the key indicator parameters to determine if there was an associated change in these key parameters that could be related to the total iron and total



manganese values. In addition, baseline data were available for these six analytical parameters. Baseline analytical data existed for eleven of the water wells and the Property Owner B spring split sampled by Chesapeake Energy's contractor during the EPA retrospective sampling. The Property Owner A, Property Owner F, and Property Owner I (142 ft) water wells did not have baseline samples since they were not located within the baseline sampling distance for any Chesapeake Energy natural gas well at the time of their construction.

The Center for Rural Pennsylvania study notes that the key indicator parameters commonly used to indicate impact from gas well drilling brines and waste fluids are chloride, barium, and total dissolved solids. This study also goes on to state that the high concentration of these 3 parameters in brines and waste fluids in relation to typical background concentrations in Pennsylvania groundwater make them useful indicator parameters. According to this study, the approximate median concentrations of chloride, TDS, and barium in Marcellus produced water are 41,850 mg/L, 67,300 mg/L, and 686 mg/L, respectively.

The first data point on each time plot represents baseline conditions (with the exception of the Property Owner A, Property Owner F, and Property Owner I (142 ft) well plots). The plots also provide lines that portray the range of values and some descriptive statistics for each parameter from the NURE, NWIS, and Williams 1998 databases for comparison purposes.

Each of the plots includes statistics from the various databases used for evaluation of historic groundwater-quality conditions in Bradford County, PA. Additionally, these plots also incorporate descriptive statistics derived from Chesapeake Energy's baseline sampling program in Bradford County. These databases are described in Section 3 and statistics are summarized in **Appendix C**.

4.2 COMPARISON OF EPA STUDY WELL DATA WITH SCREENING CRITERIA

The EPA Study Well analyses are summarized and compared to human health risk-based criteria developed from the PADEP Act 2 Land Recycling Program (Residential Used Wells < 2,500 mg/L TDS), EPA MCLs and SMCLs, and/or EPA Regional Screening Levels for Tap Water (Chronic). These criteria values are considered to be conservative risk-based concentrations



which are protective of human health. These summaries are included in **Appendix E** and include the following tables:

- **Table E-1** (Summary of Inorganic Parameters in Chesapeake Energy Split Samples from the EPA Retrospective Study Wells that Exceed the Most Stringent of the Applicable Screening Levels);
- **Table E-2** (Summary of Organic Parameters Detected in Chesapeake Energy Split Samples from the EPA Retrospective Study Wells Compared to Applicable Screening Levels); and
- **Table E-3** (Summary of Dissolved Gases Detected in Chesapeake Energy Split Samples from the EPA Retrospective Study Wells).

Table E-1 includes sample events and inorganic analytical results for the analytes that were detected above the most stringent of the applicable screening criteria for each analyte. For the analytes above the screening criteria for a given well, the baseline, pre-treatment, post-treatment, and dissolved results were also included as available. Parameters such as total barium and total strontium did not exceed the screening criteria for any of the wells, and thus were not included in this table. As would be expected, iron, manganese, and turbidity concentrations exceeded the more stringent screening criteria in a significant portion of the EPA Study Wells: this finding is consistent with the finding for the historical and Chesapeake baseline databases discussed in Section 3.

Table E-2 includes all organic parameter detections, and the baseline, pre-treatment, and posttreatment results for that analyte and well. Of the organics detected, toluene is the only organic parameter that has an EPA or PADEP screening criterion. The PADEP Act 2 standard for toluene is 1,000 μ g/L, the EPA MCL is 1,000 μ g/L, and the EPA regional screening value (tap water) is 856 μ g/L. The other organic chemical detections were all "K" or "JB" qualified data.

Table E-3 includes all light gas detections with corresponding baseline data for each analyte and well. There are no EPA screening criteria for the light gases. The PADEP has a screening level of 7 mg/L (Title 25, Chapter 78.89 (d) 4) where if sustained dissolved methane readings greater than or equal to 7 mg/L are noted, then the PADEP and operator will notify the landowner, and appropriate measures would be undertaken. Four EPA Study Wells; Property Owner C, Property Owner E (115-ft), Property Owner F, and Property Owner I (203-ft); had dissolved methane



concentrations in the baseline and/or subsequent samples which were over 20 mg/L. Two additional EPA Study Wells; Property Owner A and Property Owner E (185-ft); had dissolved methane concentrations in the baseline and/or subsequent samples which were over the PADEP 7 mg/L screening level, but below 20 mg/L. The Property Owner D water well had dissolved methane values present in baseline and/or subsequent samples greater than 3 mg/L but less than 7 mg/L. All of the remaining eight water supply samples had dissolved methane concentrations below 3 mg/L.

The findings for individual EPA Study Wells are discussed in the appropriate section of Section 6.



5. PRESENTATION OF DUROV AND PIPER DIAGRAMS

5.1 PURPOSE OF DUROV AND PIPER DIAGRAMS

Piper and Durov diagrams are commonly used to evaluate groundwater quality and both analytical methods were used to evaluate the groundwater quality in the study area. The Piper diagram provides a simple visual method to present the cation and anion compositions of many different groundwater samples on a single graphic, which can be used to discern data groupings and patterns. The cation and anion concentrations are represented as percentages in order to illuminate the relative proportions of the ions of interest regardless of the total or absolute concentrations. Each sample result is represented by a single point allowing results from many samples to be plotted and evaluated on one graphic. Because the Piper diagram plot only utilizes concentrations represented as percentages, water samples with very different total concentrations can have the same percentage concentrations and plot on the identical location on the diagram.

Durov diagrams were also used to evaluate the study area groundwater-quality data. The Durov diagrams are very similar to the Piper diagrams with the addition of a square and/or two rectangular scaled diagrams located adjacent to the base of two triangles similar to those used in the Piper diagrams. The purpose of the additional square and/or rectangular diagrams is to also present the total or absolute concentrations of two selected parameters such as total cation or ion concentration, total TDS or pH. The concentration of the two selected parameters is depicted on the Durov diagram by extending a straight line from the dot plotted on the triangle representing the relative percentage of three ions, to a line on the diagram representing a concentration of the selected parameter. In this manner, the Durov diagram can be used to present the relative percentage of cations and ions, present the pH values, and present the TDS concentration in mg/L of multiple samples on one graphic.

When the geochemistry of large datasets is evaluated, groupings of samples may be observed which represent similar geochemical characteristics. Often times, there is a correlation between the sample groupings and the geologic regime from which the groundwater samples were collected. For example, groundwater samples collected from shallow unconfined flow zones may represent geochemistry affected by surface runoff, agriculture, and shallow soil chemistry. Whereas, groundwater samples collected from deeper confined and/or bedrock flow zones may



represent geochemistry affected by the geochemistry of the bedrock formation and overlying confining unit.

Geochemical properties and major inorganic ions are calcium, magnesium, sodium, potassium, bicarbonate, carbonate, chloride, and sulfate, which typically occur in natural water in concentrations of 1 mg/L or greater. These constituents exist in pairs of cations and anions, which are typically indicative of the mineralogy of the hydrogeologic setting through which the water has flowed. For instance, calcium-bicarbonate dominant groundwater is indicative of a limestone aquifer, calcium-magnesium bicarbonate dominant water may be indicative of a dolomite aquifer, and sodium-chloride dominant groundwater is typical of a sedimentary setting rich in evaporite salts. Geochemical characterization becomes more complex where the aquifer system consists of a mixture of rock types, if the groundwater has flowed through differing types of rock units, or if groundwater are of different ages and have differing recharge areas. Groundwater quality is largely affected by the composition of the rocks in the aquifer.

5.2 GEOCHEMICAL SIGNATURES IN BRADFORD COUNTY

The study area encompasses two principal bedrock formations, the Devonian-age Lock Haven Formation and the Catskill Formation. The Lock Haven Formation is reported to contain shallow brackish or saline groundwater with the associated presence of hydrogen sulfide and methane in the restricted flow zones (Williams 1998). The Catskill Formation produces groundwater that is generally considered soft and acceptable for most uses, although there are occasions where elevated concentrations of iron, manganese, and TDS can be present in water wells (Williams 1998). The Catskill Formation can also contain naturally occurring sodium-chloride type water in the restricted-flow zones. Approximately 10% of the water wells (11 wells) sampled in the Williams 1998 study were found to be completed in part within the restricted flow zone that contain sodium chloride type water within Bradford County. There were seven other wells listed in the Williams 1998 study in Bradford County where the well was reported salty by the landowner, but no analyses were available. These 18 wells are provided in Table 12 of the Williams 1998 report.

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Based on the proportion and actual concentrations of the cations and anions, geochemical signatures for the primary bedrock aquifers underlying Bradford County consist of five general types:

- Calcium-bicarbonate dominant groundwater type; indicative of the unrestricted groundwater flow zones in the Catskill and Lock Haven Formations, and in glacial stratified drift and till;
- Sodium-bicarbonate dominant groundwater type; indicative of the unrestrictive and/or restrictive flow zones in the Catskill and Lock Haven Formations;
- Mixed calcium-sodium bicarbonate groundwater type; indicative of mixtures of water from the restricted and unrestricted flow zones in the Catskill and Lock Haven Formations;
- Calcium-magnesium bicarbonate dominant groundwater type; indicative of the unrestricted groundwater flow zones in the Catskill and Lock Haven Formations, and in glacial stratified drift and till; and
- Sodium-chloride dominant groundwater type; indicative of groundwater within the restricted flow zones of the Lock Haven and Catskill Formations, and in some areas of the glacial stratified drift and till deposits.

Geochemical characterization becomes more complex where the aquifer system consists of a mixture of rock types or if the groundwater has flowed through differing types of rock units. This is especially the case with the Catskill and Lock Haven Formations, which are highly heterogeneous and consist of interbeds of sandstone, conglomerates, siltstone, and shale of differing cementation, permeability, and fracturing. Groundwater quality is largely affected by composition and residence time within each of the rock types comprising the aquifer unit.

5.3 EPA STUDY WELLS

Durov and Piper diagrams were generated for each of the EPA Study Wells to graphically illustrate the chemical distribution of major cations and anions for baseline and post-drilling timeframes. In addition, the wells within the Catskill Formation were plotted together, and the wells within the Lock Haven Formation were plotted together. Mean and median values of constituent concentrations for the historic water well quality databases were also plotted on each of these diagrams for comparison purposes. The Piper and Durov diagrams developed for the study area are included in **Appendix F**.



Catskill Formation

The Catskill Formation typically contains sodium or calcium bicarbonate type groundwater, or a mixed sodium or calcium bicarbonate type groundwater. The eight wells and one spring within the Catskill Formation show a relatively consistent water type (geochemical signature). The water types for the eight wells and one spring completed in the Catskill Formation are noted below:

- Calcium-bicarbonate type (unrestricted): Property Owner G (unknown well depth), and Property Owner I (142-ft);
- Calcium-magnesium bicarbonate type (unrestricted): Property Owner M (440-ft) and Property Owner B (spring); and
- Mixed sodium or calcium bicarbonate type (unrestricted and/or restrictive mixture): Property Owner A (300-ft), Property Owner E (115-ft), Property Owner E (185-ft), Property Owner H (340-ft), and Property Owner I (203-ft).

Overall, the groundwater quality in the Catskill Formation wells is typically good. As illustrated in the Piper and Durov plots, the samples collected from these wells are typically low in sulfate and chloride. The plots show that the water quality is relatively consistent over time as shown by the clustering of the samples and indicates there is no significant deviation in water quality from baseline to post-drilling sampling. There is also no significant deviation of the historical waterquality databases (NWIS and Williams, 1998) for the Catskill Formation in Bradford County.

Lock Haven Formation

The six wells within the Lock Haven Formation show a greater range of variability with respect to the water type (geochemical signature) ranging from water quality consistent with the groundwater quality of the Catskill Formation (sodium or calcium bicarbonate type groundwater, or mixed sodium and calcium bicarbonate type groundwater) to the more restrictive-flow type groundwater (sodium chloride) geochemical signatures identified by Williams 1998, as follows:

- Sodium bicarbonate type groundwater (unrestrictive and/or restrictive flow zone): Property Owner D (250-ft) and Property Owner F (200-ft);
- Calcium-magnesium bicarbonate type: (unrestricted flow zone groundwater): Property Owner L (225-ft);



- Mixed sodium or calcium bicarbonate type (unrestricted and/or restricted groundwater flow zone): Property Owner K (175-ft) and Property Owner J (unknown well depth); and
- Sodium-chloride type (restricted flow zone): Property Owner C (260-ft).

Five of the water wells completed in the Lock Haven Formation (Property Owner J, Property Owner K, Property Owner F, Property Owner D, and Property Owner L) showed groundwater of good quality, nearly identical in constituent concentrations to wells located in the Catskill Formation. The sixth well, Property Owner C, contains high naturally occurring concentrations of chloride, sodium, and TDS, and this well is completed in the restrictive flow zone as described by Williams, 1998. As illustrated in the Piper and Durov plots, the samples collected from these wells are typically low in sulfate and chloride (except chloride in the Property Owner C well). The plots show that the EPA Study Well water quality is relatively consistent over time, and that there is no significant deviation in water quality from baseline to post-drilling sampling. There is also no significant deviation of the historical water quality databases (NWIS and Williams, 1998) for the Lock Haven Formation in Bradford County. However, the NWIS Lock Haven mean value on the Piper and Durov diagrams differs significantly from the NWIS median value. The median value is consistent with Lock Haven groundwater quality. The mean value is influenced significantly by approximately 4 data points that exhibit very high chloride values, and those values are more similar to the restrictive flow zone in the Lock Haven. These high chloride values skew the mean significantly for the NWIS Lock Haven data. The NWIS median value is more representative of the water quality present in the unrestrictive flow zone of the Lock Haven Formation.

The Property Owner F and Property Owner D wells showed higher proportions of sodium and chloride compared to the Property Owner J, Property Owner K, and Property Owner L wells, indicating that these wells may be hydraulically connected to a restricted flow zone. As noted in Williams 1998, wells containing mixed groundwater of both the restricted and unrestricted flow zones are common to the Catskill and Lock Haven Formations. The plots show that the EPA Study Well water quality is relatively consistent over time, and that there is no significant deviation in water quality from baseline to post-drilling sampling.

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One sodium-chloride type well in the Lock Haven Formation (Property Owner C) exhibits high salinity with elevated concentrations of sodium and chloride for both baseline and post-drill samples compared to the other wells. The Property Owner C well groundwater quality indicates there is a primary contribution of groundwater from the restricted flow zone as described by Williams, 1998. The location of this well is within 2,000 feet of one of the restricted flow zone wells (Br-271) identified in the Williams 1998 report (**Appendix B**), which contains very high concentrations of sodium (2,000 mg/L) and chloride (3,500 mg/L) in a July 20, 1982 sample. The plots show that the EPA Study Well water quality is relatively consistent over time, and that there is no significant deviation in water quality from baseline to post-drilling sampling.



6. SUMMARY OF EPA STUDY WELL EVALUATION

Each EPA Study Well is discussed below to address:

- Any significant changes in concentrations of key indicator parameters that include: methane, chloride, sodium, TDS, and total barium; plus total iron and total manganese that occur naturally throughout the area;
- Any significant changes or differences in water quality since the baseline sample was collected;
- Whether analytes are representative or within ranges of the local historical groundwater quality from various geological formations in the area; or within local baseline ranges for the areas of the retrospective wells sampled by Chesapeake Energy's contractors;
- Any exceedances of screening levels derived from EPA MCLs and SMCLs, PADEP Act 2 Land Recycling Program, and EPA Regional Screening Levels; and
- General observations.

The baseline sample parameters and the EPA retrospective study split sample parameters are listed in **Appendix F**. All analytical results for these water sources are included in **Appendix A**.

Natural groundwater quality in the area of the retrospective EPA wells sampled by Chesapeake Energy's contractors is variable and is principally dependent upon geological formation that the water well is completed within. As noted, Chesapeake Energy has conducted extensive baseline sampling in the area surrounding the EPA retrospective wells, and those data have been evaluated and compared to the retrospective analytical data, along with historical groundwater-quality data for Bradford County. A brief summary of the key baseline analytical data for the areas (Western-W, Central-C, and Eastern-E) surrounding the retrospective wells sampled by Chesapeake Energy's contractors is noted in **Table 6-1**.



Table 6-1

Summary Statistics for Key Parameters – Chesapeake Energy Baseline Database

Parameter and Standard	Number of Baseline Samples		Number of Detections		Number Exceeding Standard			Percent Exceeding Standard				
Area	W	С	Е	W	С	Е	W	С	Ε	W	С	Е
Arsenic (0.010 mg/L)	1220	1953	542	83	71	10	83	70	10	6.8%	3.6%	1.8%
Barium (2.0 mg/L)	1238	1961	562	1207	1926	557	89	100	15	7.2%	5.1%	2.7%
Iron (0.3 mg/L)	1238	1961	562	843	1103	262	402	419	88	32.5%	21.4%	15.7%
Manganese (0.05 mg/L)	1238	1961	562	880	936	262	663	644	143	53.6%	32.8%	25.4%
Lead (0.005 mg/L)	1220	1953	542	155	179	60	152	174	60	12.5%	8.9%	11.1%
Lithium (0.031 mg/L)	277	254	37	71	40	7	71	40	57	25.6%	15.7%	18.9%
Methane	1238	1965	570	504	526	157	>3:149	>3:135	>3:15	>3:12.0%	>3:6.9%	>3:2.6%
				40.7%	26.8%	27.5%	>7:95	>7:73	>7:19	>7:7.7%	>7:3.7%	>7:3.3%
							>20:30	>20:25	>20:11	>20:2.4%	>20:1.3%	>20:1.9%
Chloride (250 mg/L)	1238	1960	562	1004	1440	392	54	32	4	4.4%	1.6%	0.7%
TDS (500 mg/L)	1238	1961	562	1236	1961	562	141	54	6	11.4%	2.8%	1.1%

Note: C: Central; W: Western; E: Eastern



As noted in the summary table of key baseline parameters for the areas surrounding the EPA retrospective wells sampled by Chesapeake Energy's contractors, the total arsenic, total barium, total iron, total manganese, total lead, total lithium, dissolved methane, chloride, and TDS are commonly found in groundwater from water wells in these areas at concentrations that **naturally** exceed applicable screening standards. As an example, naturally-occurring dissolved methane was found in detectable levels in groundwater in 1,187 of the 3,773 (31.5%) baseline sample analyzed collectively for the Western, Central, and Eastern areas evaluated in this study. Dissolved methane values over 3 mg/L were found in 299 of the 3,773 (7.9%) baseline samples from these 3 areas. In addition, dissolved methane over 7 mg/L were found in 187 of the 3,773 (5%) baseline samples for these 3 areas. Clearly, methane occurs in groundwater of the area, and at levels that frequently exceed 3 mg/L.

It is important to point out that common key indicator parameters associated with produced water, drilling fluids, and/or hydraulic stimulation fluids are chloride, sodium, TDS, barium, strontium, bromide, and specific conductance. These parameters would have to be significantly elevated over baseline or regional historical levels to indicate an impact to groundwater sources from these fluids. The total iron and total manganese changes that do not correlate to associated changes with these key water-quality parameters noted above cannot be related to impacts that could be caused by produced water, drilling fluids, and/or hydraulic stimulation fluids. The presence of total iron and total manganese does not by itself indicate an impact from produced water, drilling fluids, or hydraulic stimulation fluids. Total iron and total manganese commonly occur naturally in groundwater from water wells in Bradford County above EPA SMCLs. Williams, 1998 states in the USGS/PGS report that 50% of the wells sampled yielded dissolved iron and dissolved manganese results that exceeded the EPA SMCL. Due to the variability in the sediment content of the individual samples, it is not uncommon to see a wide range in variability between individual sample results, especially total metals results compared to dissolved metals results for both iron and manganese. The variability in the sediment content of the individual samples could be caused by the sample collection methodology (i.e., excessive purge rates) and/or weather conditions (i.e., large storm events).

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A discussion of the water quality found in each of the EPA retrospective wells sampled by Chesapeake Energy's contractors is provided in the following paragraphs.

6.1 PROPERTY OWNER A (300-FT WELL)

The Property Owner A well is approximately 300 feet in depth and completed in the Devonianage Catskill Formation in southeastern Bradford County. Baseline sampling was not completed for this well due to the fact it was not within the baseline sampling boundary for any of the Chesapeake Energy gas wells drilled in the area. Therefore, due to lack of baseline data for this well, analytical results were compared and contrasted to historical values and local baseline values (from the Chesapeake baseline database) from water wells surrounding the Property Owner A water well.

Analytical results were available for the extensive parameters list from the Chesapeake Energy split sample collected on November 4, 2011 in conjunction with the EPA retrospective study. Chesapeake Energy also collected samples from this same well on October 13, 2010 and July 18, 2011 and analyzed these samples for the standard Chesapeake Energy baseline parameter list. Three additional samples were collected for light gas analysis (including methane, ethane, and propane) on August 4, 2011, August 18, 2011, and September 1, 2011. Analytical results were compared to NURE, NWIS, and Williams 1998 databases for the Catskill Formation and the Chesapeake Energy baseline analytical database for the Central core drilling region.

In a review of the figures in **Appendix D-1**, which are time plots of key inorganic parameters and dissolved methane, the detected concentrations of these parameters were evaluated. The November 4, 2011 sample exhibited extremely high turbidity (865 Nephelometric Turbidity Units [NTU]) and total suspended solids (TSS) (1,430 mg/L and 312 mg/L). It was noted by the sampling contractor that the flow (estimated at 10 gallons per minute [gpm]) could not be regulated and the turbidity varied between 4 and 1,200 NTU during the purging. Also, the pump was not operating properly as evidenced by the well pump quitting and a noticeable burning smell. In previous samples, the turbidity readings were noted at 33 NTU (October 13, 2010) and 36 NTU (July 18, 2011). The EPA MCL for turbidity is 5 NTU for finished public drinking-water supplies. More importantly, high turbidity and TSS values can affect the total metal



results. The evaluation presented below indicates that the high turbidity and TSS significantly impacted the concentration of other parameters of interest.

Total barium and total manganese concentrations are higher in the November 4, 2011 sample as compared to the October 13, 2010 sample. Especially for barium and to a lesser extent for manganese, these higher values on November 4, 2011 appear to be associated with high turbidity. For the November 4, 2011 sample, the total barium and total manganese concentrations were measured at 0.616 mg/L (total barium) and 1.15 and 1.34 mg/L (total manganese). Dissolved barium and dissolved manganese were measured at 0.354 mg/L (dissolved barium) and 0.959 and 1.02 and 1.03 mg/L (dissolved manganese), respectively. Total iron was measured at 6.19 mg/L (October 13, 2010), 0.786 mg/L (July 18, 2011), and 3.88 mg/L and 14.5 mg/L (November 4, 2011). Dissolved iron was measured at <0.05 mg/L (July 18, 2011) and 0.0845 mg/L (November 4, 2011), indicating that most of the iron is in the suspended solids associated with the high turbidity.

The total manganese and total iron results are generally higher than the historical background data mean value available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases. However, the total iron and total manganese values are still well within the baseline ranges for these parameters for the Central core area. The total barium results also fall within the range of concentrations in the Chesapeake Energy baseline database. As noted, the higher levels of total iron, and to a lesser extent, total manganese are likely due to the suspended sediment in those samples. Total metals analyses are performed on raw samples that have been preserved with nitric acid; the preservation process causes the metals that occur naturally in the suspended solids to dissolve into the aqueous phase. Correspondingly, dissolved metals are measured on a sample that is filtered in the field to remove suspended sediment prior to field preservation with nitric acid. Due to the variability in the sediment content of the individual samples, it is not unexpected to see variability between individual sample results, especially total metals results compared to dissolved metals results for iron and manganese. Based upon the analytical data presented in this report this well does not appear to be impacted from natural gas drilling and production activities including hydraulic stimulation.

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The concentrations for chloride and TDS were stable over the three sampling events. Sodium showed a slight decline in concentration over time. The time plots in **Appendix D-1** show that the concentrations of these parameters generally fall well within the range of concentrations for each of these parameters as compared to the historical background data available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County.

Total aluminum, total arsenic, total iron, total lead, total manganese, and turbidity exceeded the screening criteria (**Table E-1**) for this well. Total and dissolved aluminum analyses were only available for the November 4, 2011 sample, which had unusually high turbidity and TSS. It was apparent, upon evaluation of the total aluminum (1.44 and 6.26 mg/L) and dissolved aluminum (0.0566 mg/L) results, a majority of the aluminum was associated with suspended solids in the November 4, 2011 sample. The dissolved aluminum concentration was found to be well below the most stringent screening criterion (EPA MCL) of 0.2 mg/L; however, the total aluminum concentration caused by high turbidity exceeded this value. It should be noted that, based on the Williams 1998 database containing data from 1935 through 1986, 67% of the wells located in the Catskill Formation had aluminum concentrations that exceeded the EPA SMCL for aluminum.

Total arsenic was analyzed for the Chesapeake Energy and EPA split samples collected on October 13, 2010 and November 4, 2011, respectively. The October 13, 2010 sample indicated a concentration of 0.01 mg/L, which is above the most stringent criterion (EPA regional screening value) of 0.000045 mg/L, and at the MCL for arsenic of 0.01 mg/L. The November 4, 2011 sample contained 0.0122 mg/L total arsenic and 0.00416 mg/L dissolved arsenic when the turbidity and TSS were unusually high, which are also above the EPA regional screening value, but the dissolved arsenic value was below the EPA MCL. Based on the NWIS, Williams 1998, and Chesapeake Energy baseline databases, 100% of the wells with <u>detected</u> arsenic exceeded the EPA regional screening value for arsenic. Based on the Chesapeake Energy baseline water wells sampled in the Central area, 70 of 1,953 (3.6%) baseline samples had arsenic levels that naturally exceeded the EPA MCL.

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Total iron exceeded the most stringent criterion (EPA SMCL) of 0.3 mg/L on all three samples, with concentrations of 6.19 mg/L (October 13, 2010), 0.786 mg/L (July 18, 2011), and 3.88 and 14.5 mg/L (November 4, 2011). The latter two samples had significantly lower dissolved iron concentrations, which were below the detection limit of 0.05 mg/L (July 18, 2011 sample) and at 0.0845 mg/L (November 4, 2011 sample), both well below the EPA SMCL. Based on the NWIS, Williams 1998, and Chesapeake Energy baseline databases, 40%, 50%, and 38% of the wells with <u>detected</u> iron exceeded the EPA SMCL for iron, respectively.

Total lead was analyzed for the samples collected on October 13, 2010 and November 4, 2011. Total lead in the October 13, 2010 sample was below the detection limit of 0.005 mg/L. The November 4, 2011 sample contained 0.0353 and 0.0377 mg/L total lead when the turbidity and TSS were unusually high, which is above the most stringent screening criterion (Pennsylvania Department of Environmental Protection [PADEP] Act 2) of 0.005 mg/L and the EPA action level of 0.015 mg/L. However, dissolved lead was below the detection level of 0.002 mg/L for this November 4, 2011 sample. Based on the Williams 1998 and Chesapeake Energy baseline databases, 100% and 97% of the wells with <u>detected</u> lead exceeded the PADEP Act 2 value for lead, respectively. In the Chesapeake Energy baseline database, approximately 36.9% of wells with <u>detected</u> lead exceeded the EPA action level of 0.015 mg/L. Out of the 1,953 baseline water well samples in the central core area, 66 total lead values exceeded the EPA action level of 0.015 mg/L or approximately 3.4% of the baseline samples collected in this area.

Total manganese exceeded the most stringent criterion (EPA SMCL) of 0.05 mg/L on all three samples, with concentrations of 0.369 mg/L (October 13, 2010), 0.912 mg/L (July 18, 2011), and 1.15 and 1.34 mg/L (November 4, 2011). The July 18, 2011 sample contained 0.788 mg/L dissolved manganese and the November 4, 2011 sampled contained 0.959, 1.02, and 1.03 mg/L dissolved manganese. The sodium, TDS, and chloride do not correspond with the apparent change in total manganese concentration, suggesting that the change in manganese levels are not related to natural gas drilling or production activities including hydraulic stimulation. Based on the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline databases, 100%, 47%, 50%, and 69% of the wells with <u>detected</u> manganese exceeded the EPA SMCL for manganese, respectively. Out of the 1,961 baseline water well samples in the Central core area, 644 total



manganese values exceeded the EPA SMCL of 0.050 mg/L or approximately 32.8% of the baseline samples collected in this area.

Turbidity has exceeded the EPA MCL of 5 NTU on all three sampling events. The turbidity results for these three events are 33 NTU (October 13, 2010), 36 NTU (July 18, 2011), and 865 NTU (November 4, 2011). Based on the Chesapeake Energy baseline database, 29% of the wells with <u>measureable</u> turbidity exceeded the EPA MCL for turbidity.

The Piper and Durov diagrams for this well in **Appendix F** indicate the water is of a calciumsodium bicarbonate type. These diagrams confirm that the water quality in the Property Owner A well is consistent between the individual samples of the well and is also of a type consistent with the background water quality from the NWIS, Williams 1998, and Chesapeake Energy baseline databases.

Light gases were measured six times as indicated in **Table E-3**. Methane concentrations steadily declined from the October 13, 2010 value of 8.36 mg/L to a value of 1.86 mg/L in the November 4, 2011 sample (see figure in **Appendix D-1**). Ethane followed a similar decline from its October 13, 2010 value of 0.192 mg/L to a value of 0.0117 mg/L in the November 4, 2011 sample. No other light gases were detected in the Property Owner A well samples. The light gases detected in these samples are likely naturally occurring, and, based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation when compared to Chesapeake baseline data for the Central core area.

Tests for the presence of fecal coliform and total coliform bacteria were positive for the one sample that was analyzed for this consistuent (November 4, 2011). This is not unusual for rural wells in Pennsylvania as discussed in Section 2. Total coliform was reported to be present in 33% of Pennsylvania rural drinking water wells (Swistock 2009). *E. coli* was not detected in the well sample.

No glycols, pesticides, purgeable or extractable petroleum hydrocarbons, dissolved organic carbon (DOC), or low molecular weight acids were detected in the November 4, 2011 EPA retrospective split sample. Dissolved inorganic carbon (DIC) was detected at a concentration of



25.9 mg/L. Toluene, the only volatile organic compound detected, was measured in the October 13, 2010 sample at a concentration of 100 μ g/L, but was not detected in the EPA retrospective split sample. Toluene is a common laboratory contaminant and is not generally utilized in hydraulic stimulations. Squalene, the only semi-volatile organic compound detected, was measured at an estimated concentration of 6 J mg/L in the EPA retrospective split sample. Squalene is not used in hydraulic stimulation formulations. Squalene is a pharmaceutical and naturally-occurring substance in plants and animals as part of the cholesterol synthesis process. It is also present in cosmetics.

Because no baseline data were available for this water well, other data were reviewed and contrasted with the analytical data collected from the Property Owner A water well. Based on the analytical data presented in this report and review of the historical and baseline data sets, and comparison to other parameters present in the water well (such as sodium, chloride, and TDS levels), it is considered unlikely that there has been impact to this water well from natural gas drilling and production activities including hydraulic stimulation. The two organics detected are not associated with natural gas operations.

6.2 PROPERTY OWNER B (SPRING)

The Property Owner B spring is located within the Catskill Formation in southeastern Bradford County. Analytical results for the Chesapeake Energy baseline parameter list were available for a baseline sample collected on October 14, 2010 from this spring. Analytical results were also available for the more extensive parameters list from the Chesapeake Energy split sample collected on November 4, 2011 in conjunction with the EPA retrospective study. Analytical results were compared to NURE, NWIS, and Williams 1998 databases for the Catskill Formation and the Chesapeake Energy baseline analytical database for the Eastern core drilling region.

The analytical results for the inorganics and total metals were consistent between the two sampling events. Total iron and total manganese were not detected in these samples. As can be noted from a review of the figures in **Appendix D-2**, which are time plots of key inorganic parameters and methane, the concentrations for chloride, TDS, sodium, and total barium were stable over the two sampling events. Time plots show that the concentrations of these parameters are very similar to the baseline sample concentrations collected from this spring. The analytical



results for this spring also fall well within the range of concentrations for each of these parameters as compared to the historical background data available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases. All metals and other inorganic constituents found in water from this spring are naturally occurring, and based on the analytical data presented in this report; this spring does not appear to be impacted by natural gas drilling, and production activities including hydraulic stimulation.

The only metals or general water-quality parameter that was not within the screening criteria was pH. The pH was measured at 6.3 (baseline) and 6.1 (EPA retrospective study split sample). The EPA SMCL for pH is between 6.5 and 8.5 pH units. The pH values associated with wells in Bradford County have been observed as low as 6.2 (NURE - Catskill), 6.5 (Williams 1998 - Catskill), and 5.6 (Chesapeake Energy baseline – Eastern region).

The Piper and Durov diagrams for this spring are provided in **Appendix F and** indicate the water is of a calcium-magnesium bicarbonate type.. These diagrams confirm that the water quality of the Property Owner B spring is consistent between the individual samples of the spring and is also consistent with the background water quality from the NWIS (Bradford County), Williams 1998 (Bradford County), and Chesapeake Energy baseline (selected samples from Bradford and western Susquehanna Counties) databases.

No light gases were detected in any of the samples from this spring.

Tests for the presence of *E. coli*, fecal coliform, and total coliform bacteria were positive for the one sample analyzed (the EPA retrospective well split sample). The *E. coli* and total coliform were confirmed present and the fecal coliform was measured at 5/100 ml. This is not unusual for surface waters or springs.

No glycols, pesticides, purgeable or extractable petroleum hydrocarbons, low molecular weight acids, semi-volatile organic compounds, or volatile organic compounds were detected in the November 4, 2011 EPA retrospective split sample. DIC was detected at a concentration of 5.24 mg/L. DOC was detected at a concentration of 1.08 mg/L.

Based on the analytical data presented in this report, this spring does not appear to be impacted by natural gas drilling or production activities including hydraulic stimulation.


6.3 PROPERTY OWNER C (260-FT WELL)

The Property Owner C well is approximately 260 feet in depth and completed in the Devonianage Lock Haven Formation in southeastern Bradford County. Based on its groundwater quality and location (within 2,000 feet of one of the restricted flow zone wells identified in the Williams 1998 report), it is believed to be screened within the restricted flow zone described in Section 2. This well is within 2000 feet of Br-271 as described in the Williams 1998 report, which contained high levels of sodium (2,000 mg/L) and chloride (3,500 mg/L) in a July 20, 1982 sample. Analytical results for the Chesapeake Energy baseline parameter list were available for a baseline sample collected on April 29, 2011 from this water well. Analytical results were also available for the more extensive parameters list from the Chesapeake Energy split sample collected on October 27, 2011 in conjunction with the EPA retrospective study. Analytical results were compared to NURE and NWIS databases for the Lock Haven Formation and the Chesapeake Energy baseline analytical database for the Central core drilling region. Analytical results were also compared to the restricted flow zone well analytical results from the Williams 1998 database, and even more specifically to analytical results for nearby well Br-271 in the Williams 1998 database, which is also located in the restricted flow zone.

As can be noted from a review of the figures in **Appendix D-3**, which are time plots of key inorganic parameters and methane, the concentrations for chloride, TDS, sodium, total iron, total manganese, and total barium were stable over the two sampling events. Time plots show that the concentrations of these parameters are very similar to the baseline sample concentrations collected from this well. The analytical results for this well also generally fall well within the range of concentrations for each of these parameters as compared to the historical background data available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases. Sodium and chloride concentrations for this well are outside the NURE range of concentrations because the Property Owner C well is located within a restricted flow zone, but do fall within the NWIS, Williams 1998 database used for the Property Owner C well (which exclusively incorporated wells in a restrictive flow zone) are most appropriate for comparison, especially for total barium, sodium, chloride, and TDS. The total and dissolved metals results for the October 27, 2011 sample were consistent with baseline levels. All metals



and other inorganic constituents found in groundwater from this well are naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

The total aluminum, total arsenic, chloride, total iron, and TDS exceeded the screening criteria (**Table E-1**). Total aluminum was measured once on October 27, 2011 and exceeded the most stringent screening criterion (EPA SMCL) of 0.2 mg/L. Total aluminum was measured at 0.262 mg/L and dissolved aluminum was not detected at <0.02 mg/L, indicating that most of the aluminum is associated with the suspended solids in the sample. The dissolved aluminum is well below the EPA SMCL value. Note that the sample from nearby well Br-271 contained 0.16 mg/L of dissolved aluminum (Williams 1998).

Samples collected on April 29, 2011 (baseline) and October 27, 2011 were analyzed for total arsenic. Total arsenic was not detected in the baseline sample (<0.010 mg/L), but the October 27, 2011 sample contained 0.0076 mg/L total arsenic and 0.00456 mg/L dissolved arsenic, which are above the most stringent criterion (EPA regional screening value) of 0.000045 mg/L, but both were below the EPA MCL of 0.01 mg/L, and also below the baseline detection limit of 0.010 mg/L. Based on the NWIS, Williams 1998, and Chesapeake Energy baseline databases, 100% of the wells with <u>detected</u> arsenic exceeded the EPA regional screening value for arsenic. Based on the NWIS, Williams 1998, and Chesapeake Energy baseline databases, 78%, 67%, and 99% of the wells with <u>detected</u> arsenic exceeded the EPA MCL. Arsenic results were not available for nearby well Br-271 (Williams 1998).

Both samples were analyzed for chloride, which was detected at 413 mg/L in the baseline sample and 351 mg/L in the October 27, 2011 sample. These values exceed the SMCL value of 250 mg/L for chloride. Based on the Williams 1998 database (restricted flow zone), 64% of the wells exceeded the SMCL for chloride for wells completed in this restricted flow zone. Chloride was measured at 3,500 mg/L for nearby well Br-271 (Williams 1998).

Both samples were analyzed for TDS, which was detected at 842 mg/L in the baseline sample and 726 mg/L in the October 27, 2011 sample. These values exceed the SMCL value of 500 mg/L for TDS. Based on the Williams 1998 database (restricted flow zone), 78% of the wells



exceeded the SMCL for TDS for wells completed in the restricted flow zone. TDS was measured at 6,100 mg/L for nearby well Br-271 (Williams 1998).

Total iron exceeded the most stringent criterion (EPA SMCL) of 0.3 mg/L in the October 27, 2011 sample. It was detected at 0.285 mg/L (baseline) and 0.368 mg/L (October 27, 2011). The dissolved iron concentration for the October 27, 2011 sample was below the detection limit of <0.05 mg/L. Based on the NWIS, Williams 1998 (restricted flow zone), and Chesapeake Energy baseline databases, 61%, 67%, and 38% of the wells with <u>detected</u> iron exceeded the EPA SMCL for iron. Dissolved iron was measured at 0.8 mg/L for nearby well Br-271 (Williams 1998).

The Piper and Durov diagrams for this well are provided in **Appendix F and** indicate the water is of a sodium-chloride type. These diagrams confirm that the water quality in the Property Owner C well is consistent between the individual samples of the well and is also consistent with the background water quality from the Williams 1998 restricted flow zone well data for Bradford County.

Light gases were measured two times as indicated in **Table E-3**. Methane was detected in both samples (see figure in **Appendix D-3**) at 21.5 mg/L (baseline) and 22.5 mg/L (October 27, 2011). No other light gases were detected in the Property Owner C well samples. As noted in Williams 1998, elevated levels of methane and hydrogen sulfide are associated with the restricted flow zone groundwater. The light gases detected in these samples are naturally occurring, and, based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation. In addition, naturally-occurring dissolved methane values >20 mg/L have been detected in 25 of the baseline samples in the Central core area evaluated.

Tests for the presence of *E. coli*, fecal coliform and total coliform bacteria were negative for the one sample that was analyzed (October 27, 2011).

No volatile organic compounds, semi-volatile compounds, glycols, pesticides, purgeable or extractable petroleum hydrocarbons, DOC, or low molecular weight acids were detected in the October 27, 2011 EPA retrospective split sample. DIC was detected at a concentration of 36.4 mg/L.



6.4 PROPERTY OWNER D (250-FT WELL)

The Property Owner D well is approximately 250 feet in depth and completed in the Devonianage Lock Haven Formation in southeastern Bradford County. Analytical results for the Chesapeake Energy baseline parameter list were available for a baseline sample collected on January 10, 2010 from this water well. Analytical results were also available for the more extensive parameters list from the Chesapeake Energy split sample collected on October 28, 2011 in conjunction with the EPA retrospective study. Chesapeake Energy also collected a sample from this same well on June 10, 2011 and analyzed that sample for the standard Chesapeake Energy baseline parameter list. Analytical results were compared to NURE, NWIS, and Williams 1998 databases for the Lock Haven Formation and the Chesapeake Energy baseline analytical database for the Central core drilling region.

The analytical results for the inorganics, dissolved methane, and total metals were consistent between the three sampling events. As can be noted from a review of the figures in **Appendix D-4**, which are time plots of key inorganic parameters and dissolved methane, the concentrations for total barium, chloride, TDS, total iron, total manganese, and sodium were stable over the three sampling events. Time plots show that the concentrations of these parameters are very similar to the baseline sample concentrations collected from this well. The analytical results for this well also fall well within the range of concentrations for each of these parameters as compared to the historical background data available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County. All metals and other inorganic constituents found in groundwater from this well are naturally occurring, and, based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

The only metals or general water-quality parameter that was not within the screening criteria was pH. The pH was measured at 8.2 (baseline) and 8.8 (June 10, 2011). The EPA SMCL for pH is between 6.5 and 8.5 pH units. Note that pH values associated with wells in Bradford County have been observed as high as 8.8 (NURE – Lock Haven), 8.6 (Williams 1998 – Lock Haven), and 8.5 (Chesapeake Energy baseline – Central region).



The Piper and Durov diagrams for this well in **Appendix F** indicate the water is of a mixed calcium-sodium bicarbonate type. These diagrams confirm that the water quality of the Property Owner D is consistent between the individual samples from this well, but is also influenced to some extent by water coming from a restricted flow zone as seen by higher proportions of sodium as compared with calcium.

Light gases were measured three times as indicated in **Table E-3**. Methane was detected in all samples (see figure in **Appendix D-4**) at concentrations of 3.55 mg/L (baseline), 4.81 mg/L (June 10, 2011), and 2.11 mg/L (October 28, 2011), showing no significant change from baseline. No other light gases were detected in the Property Owner D well samples. The light gases detected in these samples are naturally occurring, and, based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

The test for the presence of total coliform bacteria was positive for the one sample that was analyzed (EPA retrospective study split sample). This is not unusual for rural wells in Pennsylvania as discussed in Section 2. Total coliform was reported to be present in 33% of Pennsylvania rural drinking water wells (Swistock 2009). *E. coli* and fecal coliform were not detected in the well sample.

No glycols, pesticides, purgeable or extractable petroleum hydrocarbons, DOC, low molecular weight acids, semi-volatile organic compounds, or volatile organic compounds were detected in the October 28, 2011 EPA retrospective split sample. DIC was detected at a concentration of 50.6 mg/L.

6.5 PROPERTY OWNER E (115-FT WELL)

The shallower of the two Property Owner E wells is approximately 115 feet in depth and completed in the Devonian-age Catskill Formation in southeastern Bradford County. Analytical results for the Chesapeake Energy baseline parameter list were available for a baseline sample collected on April 1, 2010 from this water well. Analytical results were also available for the more extensive parameters list from the Chesapeake Energy split sample collected on November 4, 2011 in conjunction with the EPA retrospective study. Chesapeake Energy also collected two



additional samples from this same well on August 12, 2010 and January 8, 2011, and analyzed the samples for the standard Chesapeake Energy baseline parameter list. Analytical results were compared to NURE, NWIS, and Williams 1998 databases for the Catskill Formation and the Chesapeake Energy baseline analytical database for the Central core drilling region.

The analytical results for the inorganics, dissolved methane, and total metals were consistent between the four sampling events. As can be noted from a review of the figures in **Appendix D-5**, which are time plots of key inorganic parameters and dissolved methane, the concentrations for total barium, chloride, total manganese, total iron, TDS, and sodium were stable over the four sampling events. Time plots show that the concentrations of these parameters are very similar to the baseline sample concentrations collected from this well. The analytical results for this well also fall well within the range of concentrations for each of these parameters as compared to the historical background data available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County. All metals and other inorganic constituents found in groundwater from this well are naturally occurring, and, based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

The only metals or general water-quality parameter that was not within the screening criteria was total manganese. Total manganese exceeded the most stringent criterion (EPA SMCL) of 0.05 mg/L for all of the samples. It was detected at 0.118 mg/L (baseline), 0.127 mg/L (August 12, 2010), 0.133 mg/L (January 8, 2011), and 0.116 mg/L (November 4, 2011). The last sample was also analyzed at 0.113 mg/L for dissolved manganese. There was no significant change noted in total manganese between baseline and the samples collected afterwards. Based on the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline databases, 100%, 47%, 50%, and 69% of the wells with <u>detected</u> manganese exceeded the EPA SMCL, respectively.

The Piper and Durov diagrams for this well in **Appendix F** indicate the water is of a mixed sodium-calcium bicarbonate type. These diagrams confirm that the water quality of the Property Owner E 115-ft well is consistent between the individual samples of the well and is also consistent with the background water quality from the NWIS, Williams 1998, and Chesapeake Energy baseline databases for Bradford County.



Methane and ethane are the only two light gases that have been detected in the well water. Methane has stayed consistent at measurements of 33.8 mg/L (baseline), 34.7 mg/L (August 12, 2010), 35.8 mg/L (January 8, 2011), and 37.1 mg/L (November 4, 2011). This is shown on the methane figure in **Appendix D-5**. Ethane has been detected at low concentrations of 0.49 mg/L (baseline), 0.0495 mg/L (August 12, 2010), 0.0838 mg/L (January 8, 2011), and 0.0816 mg/L (November 4, 2011). The light gases detected in these samples are naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

Tests for the presence of *E. coli*, fecal coliform and total coliform bacteria were negative for the one sample that was analyzed (November 4, 2011).

No pesticides, purgeable or extractable petroleum hydrocarbons, DOC, low molecular weight acids, semi-volatile organic compounds, or volatile organic compounds were detected in the November 4, 2011 EPA retrospective split sample. DIC was detected at a concentration of 25.5 mg/L. Diethylene, tetraethylene, and triethylene glycols were reported in the November 4, 2011 sample at the estimated values of 13J mg/L, 26J mg/L, and 20J mg/L, respectively. These compounds were also found in the laboratory blanks, indicating analytical laboratory contamination. Thus, there is concern regarding the validity of these results. Note that glycols were not found in the deeper Property Owner E well. Chesapeake Energy conducted a review of hydraulic stimulation materials used in this area and has determined that diethylene, triethylene, and tetraethylene glycol were not used as hydraulic stimulation additives on well sites in this area. Glycols are utilized in numerous industrial and consumer products. The estimated detections of these compounds are believed to be an analytical contamination issue.

6.6 PROPERTY OWNER E (185-FT WELL)

The deeper of the two Property Owner E wells is approximately 185 feet in depth and completed in the Devonian-age Catskill Formation in southeastern Bradford County. Analytical results for the Chesapeake Energy baseline parameter list were available for a baseline sample collected on April 1, 2010 from this water well. Analytical results were also available for the more extensive parameters list from the Chesapeake Energy split sample collected on November 4, 2011 in conjunction with the EPA retrospective study. Chesapeake Energy also collected two additional



samples from this same well on August 12, 2010 and January 8, 2011, and analyzed the samples for the standard Chesapeake Energy baseline analytical parameter list. Analytical results were compared to NURE, NWIS, and Williams 1998 databases for the Catskill Formation and the Chesapeake Energy baseline analytical database for the Central core drilling region.

The analytical results for the inorganics and total metals were consistent between the four sampling events. As can be noted from a review of the figures in **Appendix D-6**, which are time plots of key inorganic parameters and dissolved methane, the concentrations for total barium, chloride, total manganese, total iron, TDS, and sodium were stable over the four sampling events. Time plots show that the concentrations of these parameters are very similar to the baseline sample concentrations collected from this well. The analytical results for this well also fall well within the range of concentrations for each of these parameters as compared to the historical background data available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County. All metals and other inorganic constituents found in groundwater from this well are naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

The only metals or general water-quality parameter that was not within the screening criteria was total manganese. Total manganese exceeded the most stringent criterion (EPA SMCL) of 0.05 mg/L for two of the samples. It was detected at 0.0647 mg/L (baseline) and 0.0788 mg/L (August 12, 2010). There is no significant change in total manganese levels from baseline. Based on the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline databases, 100%, 47%, 50%, and 69% of the wells with <u>detected</u> manganese exceeded the EPA SMCL, respectively.

The Piper and Durov diagrams for this well in **Appendix F** indicate the water is of a mixed calcium-sodium bicarbonate type. These diagrams confirm that the water quality of the Property Owner E 185-ft well is consistent between the individual samples of the well and is also consistent with the background water quality from the NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County.



Methane is the only light gas that has been detected in the well water. Methane has shown a significant decline from baseline conditions with measurements of 8.88 mg/L (baseline), 9.68 mg/L (August 12, 2010), 0.239 mg/L (January 8, 2011), and 0.609 mg/L (November 4, 2011). The change in methane values noted may be due to natural variability or sample variability, and also may be related to well use. Well use can considerably change the dissolved methane content in groundwater, due to changes in head during prior well use or during sampling events. This is shown on the methane figure in **Appendix D-6**. The light gases detected in these samples are naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

Tests for the presence of *E. coli*, fecal coliform and total coliform bacteria were negative for the one sample that was analyzed (November 4, 2011).

No glycols, pesticides, purgeable or extractable petroleum hydrocarbons, DOC, low molecular weight acids, semi-volatile organic compounds, or volatile organic compounds were detected in the November 4, 2011 EPA retrospective split sample. DIC was detected at a concentration of 27.9 mg/L.

6.7 PROPERTY OWNER F (200-FT WELL)

The Property Owner F well is approximately 200 feet in depth and completed in the Devonianage Lock Haven Formation in southwestern Bradford County. No baseline sample is available from this well since it was located outside of the standard baseline sampling radius. Therefore, evaluation of analytical data from this water well was made by contrasting data from this well with historical databases; review of other parameters such as chloride, TDS, and sodium from this well; and review of the local Chesapeake Energy baseline database surrounding this water well. Analytical results were available for the extensive parameters list from the Chesapeake Energy split sample collected on October 25, 2011 in conjunction with the EPA retrospective study. Chesapeake Energy collected samples from this same well on March 10, 2011 and November 11, 2011 and analyzed these samples for the standard Chesapeake Energy baseline analytical parameter list. Analytical results were compared to NURE, NWIS, and Williams 1998



databases for the Lock Haven Formation and the Chesapeake Energy baseline analytical database for the Western core drilling region.

The analytical results for the inorganics, dissolved methane, and total metals were consistent between the three sampling events. As can be noted from a review of the figures in **Appendix D-7**, which are time plots of key inorganic parameters and dissolved methane, the concentrations for chloride, TDS, sodium, total iron, total manganese, and total barium were stable over the three sampling events. Time plots show that the concentrations of these parameters show little change with time. The analytical results for this well also generally fall well within the range of concentrations for each of these parameters as compared to the historical background data available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County. Barium concentrations within the water well were higher than the Williams 1998 range of values for the Lock Haven Formation unrestrictive flow zone. However, it is believed based upon the water-quality from this well, that this well is completed in both the restricted flow zone and unrestrictive flow zones as described by Williams, and therefore, is a mixture of water from these flow zones. Other than total lithium (described below), none of the metals or general water-quality parameters exceed an EPA MCL or SMCL or PADEP Act 2 drinking water standard. All metals and other inorganic constituents found in groundwater from this well appear to be naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

The Piper and Durov diagrams for this well in **Appendix F** indicate the water is of a sodium bicarbonate type. These diagrams confirm that the water quality of the Property Owner F well is consistent between the individual samples of the well, but is also influenced to some extent by water coming from a restricted flow zone as seen by higher proportions of sodium as compared with calcium.

Methane concentrations were relatively high but very stable over the three sampling events (see figure in **Appendix D-7**). The concentrations of dissolved methane were 53.4 mg/L, 55.3 mg/L, and 51.8 mg/L on March 10, 2011, October 25, 2011, and November 11, 2011, respectively. Ethane was not detected (<0.026 mg/L) in the sample collected on March 10, 2011. The



dissolved ethane result for the sample collected on October 25, 2011 was 0.0202 mg/L and the result for the November 11, 2011 sample was 0.202 mg/L. No other light gases were detected in the October 25, 2011 sample. Since the dissolved methane and ethane results have been consistent, the analytical result for ethane in the November 11, 2011 sample is suspected to be an outlier due to laboratory error. The light gases detected in these samples are likely naturally occurring, and, based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation. In addition, naturally-occurring dissolved methane values >20 mg/L have been detected in 30 of the baseline samples in the Western core area evaluated.

Tests for the presence of *E. coli*, fecal coliform, and total coliform bacteria were negative.

No pesticides, purgeable or extractable petroleum hydrocarbons, DOC, low molecular weight acids, semi-volatile organic compounds, or volatile organic compounds were detected in the October 25, 2011 EPA retrospective split sample. DIC was detected at a concentration of 63.2 mg/L and diethylene and triethylene glycols were not detected in the October 25, 2011 sample. An estimated (J value) detection of tetraethylene glycol, 11J mg/L, was noted in the October 25, 2011 sample. This value is only slightly above the analytical detection limit of 10 mg/L. Due to issues with analytical laboratory blank contamination with several other samples for glycol analyses from this sampling event, there is concern regarding the validity of this result. Chesapeake Energy conducted a review of hydraulic stimulation materials used in this area and has determined that tetraethylene glycol was not used as a hydraulic stimulation additive on well sites in this area. Tetraethylene glycol is utilized in numerous industrial and consumer products. The estimated detection of this compound is believed to be an analytical laboratory contamination issue.

As noted in **Table E-1**, the total lithium result for the November 11, 2011 sample (0.10 mg/L) exceeded the PADEP Act 2 criteria for groundwater of 0.073 mg/L and the EPA regional screening value of 0.031 mg/L. Based on the results from 277 Chesapeake Energy baseline samples collected in the general area of the Property Owner F well, total lithium was detected in 71 (25.6%) of these samples. Total lithium detected in the baseline samples in this area have been found to range between 0.0501 mg/L to 0.398 mg/L (mean 0.12 mg/L, median 0.09 mg/L).



Further, total lithium was found to exceed the EPA regional screening criterion in 25.6 percent of these 277 baseline samples, and in 100 percent of the 71 samples where lithium was <u>detected</u>. Compared to the PADEP Act 2 standard of 0.073 mg/L, 48 of the 71 samples (67.6%) where total lithium was <u>detected</u> exceeded this PADEP standard. Therefore, the total lithium results for the Property Owner F well fall within this area-wide background range. Based on available data, this total lithium value is believed to be naturally occurring and not related to natural gas drilling or production activities including hydraulic stimulation. There were no other exceedances of any other drinking water standard, as noted previously.

6.8 PROPERTY OWNER G (WELL DEPTH UNKNOWN)

The Property Owner G well, depth unknown, is completed in the Devonian-age Catskill Formation in southeastern Bradford County. Analytical results for the Chesapeake Energy baseline parameter list were available for a baseline sample collected on April 2, 2010 from this water well. Analytical results were also available for the more extensive parameters list from the Chesapeake Energy split sample collected on October 27, 2011 in conjunction with the EPA retrospective study. Chesapeake Energy also collected six additional samples from this same well, including one post-treatment sample, and analyzed the samples for the standard Chesapeake Energy baseline analytical parameter list. Analytical results were compared to NURE, NWIS, and Williams 1998 databases for the Catskill Formation and the Chesapeake Energy baseline analytical database for the Central core drilling region.

The analytical results for total barium, chloride, and sodium were relatively consistent for the various sampling events, as can be noted from a review of the figures in **Appendix D-8**, which are time plots of key inorganic parameters and dissolved methane. Time plots show that the concentrations of these parameters are very similar to the baseline sample concentrations collected from this well. The October 1, 2010 and November 10, 2010 samples showed temporary increases in TDS, total iron, and total manganese. The TDS value of 274 mg/L on October 1, 2010 appears to be an outlier. The specific conductance and major ion concentrations are too low to provide for a TDS concentration of 274 mg/L. This is based on: 1) this sample had a similar specific conductance as compared to other samples from this well (specific conductance is proportional to the TDS concentration), and 2) the cation and anion



concentrations for the major geochemistry parameters (calcium, magnesium, sodium, bicarbonate, chloride, and sulfate) are similar for this sample as compared to other samples from this well. Thus, the TDS would be expected to be similar for the October 1, 2010 sampling event.

Total iron continued to be elevated in the June 28, 2011, September 1, 2011, and October 13, 2011 samples. All of these parameters were measured at concentrations similar to baseline concentrations for the last sample event (October 27, 2011). With the exception of the high total iron value on October 1, 2010, the analytical results for this well fall well within the range of concentrations for each of these parameters as compared to the historical background data available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County. Note that a significant storm event occurred immediately prior to the 10/1/2010 sampling event resulting in 3.9 inches of rainfall. All metals and other inorganic constituents found in groundwater from this well are naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling, or production activities including hydraulic stimulation. However, there is indication of some variability in water quality during 2010 and 2011 related to the total iron and total manganese concentrations, which was likely due to the presence of sediment in the samples, as the dissolved analyses for manganese and iron are much lower than the total iron values. The key indicator parameters of barium, sodium, chloride, and TDS were stable during this time period, and at very low levels, further suggesting that the variability in total iron and total manganese were related to sediment in the samples. For the October 1, 2010 sampling event, the TSS concentration was measured at 157 mg/L, indicating that the higher levels of total iron and total manganese are likely due to the suspended sediment in those samples.

The metals or general water-quality parameters that were not within the screening criteria include total iron, total lead, total manganese, and turbidity. Turbidity exceeded the EPA MCL on numerous occasions and impacted the metals values discussed in the following paragraphs. Turbidity was measured at <1 NTU (baseline), 24 NTU (November 10, 2010), 91.2 NTU (June 28, 2011), 16.1 NTU (September 1, 2011), 37.1 NTU (October 13, 2011 pretreatment), and 13 NTU (October 27, 2011). Based on the Chesapeake Energy baseline analytical database, 29% of the wells with measureable turbidity exceeded the EPA MCL for turbidity.



Total iron exceeded the most stringent screening criteria of 0.3 mg/L (EPA SMCL) on several occasions, measured at 10.6 mg/L (October 1, 2010), 3.58 mg/L (November 10, 2010), 2.68 mg/L (June 28, 2011), 3.08 mg/L (September 1, 2011), 4.13 mg/L (October 13, 2011 pretreatment), and 0.343 mg/L (October 27, 2011). Dissolved iron was below the screening criteria, measured at <0.05 mg/L (November 10, 2010), 0.109 mg/L (September 1, 2011), 0.0549 mg/L (October 13, 2011 pretreatment), and <0.05 mg/L (October 27, 2011), indicating that iron was present mostly in the suspended solids associated with these samples. Based on the NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases, 40%, 50%, and 38% of the wells with detected iron exceeded the EPA SMCL for iron, respectively.

Total lead was detected once at a concentration above the screening criteria. It was measured at 0.0061 mg/L in the sample collected on October 13, 2011 (pretreatment). This value exceeds the PADEP Act 2 standard of 0.005 mg/L, but is below the EPA action level of 0.015 mg/L. Based on the Williams 1998 and Chesapeake Energy baseline analytical databases, 100% and 97% of the wells, respectively, with <u>detected</u> lead exceeded the PADEP Act 2 value for lead.

Total manganese exceeded the most stringent criterion (EPA SMCL) of 0.05 mg/L for two of the samples. It was detected at 0.153 mg/L (October 1, 2010) and 0.123 mg/L (November 10, 2010). The dissolved manganese concentration was below the quantitation limit, measured at <0.015 mg/L for the November 10, 2010 sample, indicating that manganese was present mostly in the suspended solids associated with this sample. No dissolved analysis for manganese was conducted on the October 1, 2010 sample. Based on the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases, 100%, 47%, 50%, and 69% of the wells with <u>detected</u> manganese exceeded the EPA SMCL, respectively.

The Piper and Durov diagrams for this well in **Appendix F** indicate the water is of a calcium bicarbonate type. These diagrams confirm that the water quality of the Property Owner G well is consistent between the individual samples of the well and is also consistent with the background water quality from the NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County.

Methane is the only light gas that has been detected in the well water. Methane has been detected at concentrations of 0.035 mg/L (baseline) and 0.0126 mg/L (September 1, 2011) which



is slightly lower than the baseline value. All other methane values were below the detection limit. This is shown on the methane figure in **Appendix D-8**. The light gases detected in these samples are naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

Tests for the presence of *E. coli*, fecal coliform and total coliform bacteria were positive for the one sample analyzed (the EPA retrospective well split sample). The *E. coli* and total coliform were confirmed present and the fecal coliform was measured at 2/100 ml. This is not unusual for rural wells in Pennsylvania as discussed in Section 2. Total coliform was reported to be present in 33% of Pennsylvania rural drinking water wells (Swistock 2009).

No glycols, pesticides, purgeable or extractable petroleum hydrocarbons, DOC, low molecular weight acids, semi-volatile organic compounds, or volatile organic compounds were detected in the October 27, 2011 EPA retrospective split sample. DIC was detected at a concentration of 18.1 mg/L.

6.9 PROPERTY OWNER H (340-FT WELL)

The Property Owner H well is approximately 340 feet in depth and is completed in the Devonian-age Catskill Formation in southeastern Bradford County. Analytical results for the Chesapeake Energy baseline parameter list were available for a baseline sample collected on April 1, 2010 from this water well. Analytical results were also available for the more extensive parameters list from the Chesapeake Energy split sample collected on October 28, 2011 in conjunction with the EPA retrospective study. Chesapeake Energy also collected ten additional samples from this same well, including three post-treatment samples, and analyzed the samples for the standard Chesapeake Energy baseline parameter list. Analytical results were compared to NURE, NWIS, and Williams 1998 databases for the Catskill Formation and the Chesapeake Energy baseline analytical database for the Central core drilling region.

The analytical results for the inorganics, dissolved methane, and total metals were relatively consistent for the various sample events. The October 1, 2010, November 10, 2010, and December 2, 2010 samples showed temporary changes in total iron, total manganese and TDS,



and variability in the sodium concentrations. However, as can be noted from a review of the figures in Appendix D-9, which are time plots of key inorganic parameters, the concentrations for total barium, chloride, total manganese, total iron, and TDS were stable otherwise. Time plots show that the concentrations of these parameters are very similar to the baseline sample concentrations collected from this well. The analytical results for this well also fall well within the range of concentrations for each of these parameters as compared to the historical background data available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County. All metals and other inorganic constituents found in groundwater from this well are naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation. However, there is indication of some variability in water quality during 2010 related to the total iron and total manganese concentrations, which was likely due to the presence of sediment in the samples, as the dissolved analyses for manganese and iron are much lower than the total iron values. The key indicator parameters of barium, sodium, chloride, and TDS were generally stable during this time period, and at very low levels, further suggesting that the variability in total iron and total manganese were related to sediment in the samples.

The metals or general water-quality parameters that were not within the screening criteria include total aluminum, total iron, total lead, total manganese, and turbidity. Turbidity exceeded the EPA MCL on numerous occasions and impacted the metals values discussed in the following paragraphs. Turbidity was measured at 2 NTU (April 2, 2010 - baseline), 31.2 NTU (October 1, 2010), 26.4 NTU (November 10, 2010), 11.7 NTU (December 2, 2010), 7.3 NTU (May 10, 2011 pretreatment), and 6.8 NTU (October 28, 2011). Based on the Chesapeake Energy baseline analytical database, 29% of the wells with <u>measureable</u> turbidity exceeded the EPA MCL for turbidity.

Total aluminum was measured once on October 28, 2011 and exceeded the most stringent screening criterion (EPA SMCL) of 0.2 mg/L. Total aluminum was measured at 0.322 mg/L (October 28, 2011) and dissolved aluminum on this date was below the detection limit of <0.02 mg/L, indicating that the aluminum is associated with the suspended solids in the sample. The

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dissolved aluminum is well below the SMCL value. Based on the Williams 1998 database, 67% of the wells located in Catskill formation exceeded the SMCL for aluminum.

Total iron exceeded the most stringent screening criteria of 0.3 mg/L (EPA SMCL) on several occasions, measured at 0.0546 mg/L (April 2, 2010 - baseline), 2.54 mg/L (October 1, 2010), 0.982 mg/L (November 10, 2010), and 0.829 mg/L (December 2, 2010). Dissolved iron was below the screening criteria, measured at <0.05 mg/L on both October 1, 2010 and November 10, 2010, indicating that iron was present mostly in the suspended solids associated with this sample. Note that the highest total iron and total manganese results were detected in the sample collected on 10/1/2010 and a significant storm event occurred immediately prior to that sampling event resulting in 3.9 inches of rainfall. No dissolved metal analyses for iron were conducted on the December 2, 2010 sample. Based on the NWIS, Williams 1998, and Chesapeake Energy baseline databases, 40%, 50%, and 38% of the wells with <u>detected iron exceeded the EPA SMCL</u> for iron, respectively.

Total lead was detected on three occasions at a concentration above the screening criteria. It was measured at 0.0089 mg/L (November 10, 2010), 0.0076 mg/L (March 1, 2011 pretreatment), and 0.0738 mg/L (May 10, 2011 pretreatment). These values exceed the PADEP Act 2 standard of 0.005 mg/L. The November 10, 2010 and March 1, 2011 results were below the EPA Action Level of 0.015 mg/L; however, the May 10, 2011 pretreatment result was above this action level. The November 10, 2010 sample was also analyzed for dissolved lead, which was below the detection limit of <0.005 mg/L. Based on the Williams 1998 and Chesapeake Energy baseline databases, respectively, 100% and 97% of the wells with <u>detected</u> lead exceeded the PADEP Act 2 value for lead.

Total manganese exceeded the most stringent criterion (EPA SMCL) of 0.05 mg/L for three of the samples. It was detected at 0.214 mg/L (October 1, 2010), 0.0607 mg/L (November 10, 2010), and 0.095 mg/L (December 2, 2010). The dissolved manganese concentration was measured at 0.0213 mg/L for the November 10, 2010 sample, indicating that manganese was present mostly in the suspended solids associated with this sample. No analyses for dissolved manganese were conducted on the October 1, 2010 or December 2, 2010 samples. Based on the



NURE, NWIS, Williams 1998, and Chesapeake Energy baseline databases, 100%, 47%, 50%, and 69% of the wells with <u>detected</u> manganese exceeded the EPA SMCL, respectively.

The Piper and Durov diagrams for this well in **Appendix F** indicate the water is of a mixed sodium-calcium bicarbonate type. These diagrams confirm that the water quality of the Property Owner H well is consistent between the individual samples of the well and is also consistent with the background water quality from the NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County.

Methane is the only light gas that has been detected in the well water. Methane has been detected at concentrations of 0.045 mg/L (baseline), 0.0535 mg/L (September 13, 2010), 0.183 mg/L (November 10, 2010), 0.00607 mg/L (October 28, 2011), 0.0655 mg/L (November 8, 2011 pretreatment), and 0.0258 mg/L (November 8, 2011 post-treatment). This is shown on the methane figure in **Appendix D-9**. These detections of methane have been relatively consistent and similar to baseline. The light gases detected in these samples are naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling and production activities including hydraulic stimulation.

Tests for the presence of total coliform bacteria were positive for the one sample analyzed (the EPA retrospective well split sample). This is not unusual for rural wells in Pennsylvania as discussed in Section 2. Total coliform was reported to be present in 33% of Pennsylvania rural drinking water wells (Swistock 2009). The *E. coli* and fecal coliform were not found.

No pesticides, purgeable or extractable petroleum hydrocarbons, DOC, low molecular weight acids, or semi-volatile organic compounds were detected in the October 28, 2011 EPA retrospective split sample. DIC was detected at a concentration of 17.1 mg/L. Toluene was the only volatile organic compound detected in the sample. It was measured at $1.13 \mu g/L$. Toluene is a common laboratory contaminant and is not generally utilized in hydraulic stimulations. Because toluene was not found in the first three samples and the last sample, it is believed to be a laboratory contaminant.

Tetraethylene and triethylene glycol were the only glycols reported for the October 28, 2011 sample. An estimated (J value) detection of tetraethylene glycol, 20J mg/L, and an estimated



detection of triethylene glycol, 12J mg/L, were noted. The triethylene glycol value is only slightly above the analytical detection limit of 10 mg/L. Due to issues with analytical laboratory blank contamination with several other samples for glycol analyses from this sampling event, there is concern regarding the validity of this result. The estimated detections of these compounds are believed to be an analytical laboratory contamination issue. Chesapeake Energy conducted a review of hydraulic stimulation materials used in this area and has determined that triethylene and tetraethylene glycol were not used as hydraulic stimulation additives on well sites in this area. Glycols are utilized in numerous industrial and consumer products.

6.10 PROPERTY OWNER I (142-FT WELL)

The shallower of the two Property Owner I wells is approximately 142 feet in depth and is completed in the Catskill Formation in southeastern Bradford County. No baseline sample was available for this water well since it fell outside of the baseline sampling radius for Chesapeake natural gas wells. Therefore, evaluation of analytical data from this water well was made by contrasting data from this well with historical databases; review of other parameters such as chloride, TDS, and sodium from this well; and review of the local Chesapeake baseline database surrounding this water well. Analytical results were available for the extensive parameters list from the Chesapeake Energy split sample collected on October 31, 2011 in conjunction with the EPA retrospective study. Chesapeake Energy also collected samples from this same well on August 10, 2010 and September 15, 2010 and analyzed these samples for the standard Chesapeake Energy baseline parameter list. Two additional samples were collected for light gas analysis on October 6, 2010 and October 20, 2010. Analytical results were compared to NURE, NWIS, and Williams 1998 databases for the Catskill Formation and the Chesapeake Energy baseline analytical core drilling region.

The analytical results for the inorganics and total metals were consistent between the three sampling events. Total manganese was not detected in these samples. As can be noted from a review of the figures in **Appendix D-10**, which are time plots of key inorganic parameters and dissolved methane, the concentrations for total iron, chloride, TDS, sodium, and total barium were stable over the three sampling events. Time plots show that the concentrations of these parameters are very similar and relatively stable over time. The analytical results for this well



also fall well within the range of concentrations for each of these parameters as compared to the historical background data available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County. All metals and other inorganic constituents found in groundwater from this well are naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

The only metals or general water-quality parameter that was not within the screening criteria was pH. The pH was measured at 6.4 (August 3, 2010) and 6.4 (October 31, 2011). The EPA SMCL for pH is between 6.5 and 8.5 pH units. Note that pH values associated with wells in Bradford County have been observed as low as 6.2 (NURE - Catskill), 6.5 (Williams 1998 - Catskill), and 5.4 (Chesapeake Energy baseline – Central region).

The Piper and Durov diagrams for this well in **Appendix F** indicate the water is of a calciumbicarbonate type. These diagrams confirm that the water quality of the Property Owner I 142-ft well is consistent between the individual samples of the well and is also consistent with the background water quality from the NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County.

Methane and ethane were the only light gases detected in the samples. Methane was detected at 0.0957 mg/L (August 3, 2010), 1.41 mg/L (September 15, 2010), 2.78 J mg/L (October 6, 2010), and 1.78 mg/L (October 20, 2010). Methane was not detected (<0.005 mg/L) in the last sample date on October 31, 2011. Ethane was detected at 0.0953 mg/L (September 15, 2010), 0.195 mg/L (October 6, 2010), and 0.103 mg/L (October 20, 2010). It was not detected in the August 3, 2010 or the October 31, 2011 sample. This is shown on the methane figure in **Appendix D-10**. These detections of methane have been relatively consistent, and some variability in sample results is expected, as noted earlier. The light gases detected in these samples are likely naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

Testing for the presence of total coliform bacteria was positive for the one sample analyzed (the EPA retrospective well split sample). This is not unusual for rural wells in Pennsylvania as



discussed in Section 2. Total coliform was reported to be present in 33% of Pennsylvania rural drinking water wells (Swistock 2009). *E. coli* and fecal coliform testing was negative.

No glycols, pesticides, purgeable or extractable petroleum hydrocarbons, DOC, low molecular weight acids, semi-volatile organic compounds, or volatile organic compounds were detected in the October 31, 2011 EPA retrospective split sample. DIC was detected at a concentration of 19 mg/L.

6.11 PROPERTY OWNER I (203-FT WELL)

The deeper of the two Property Owner I wells is approximately 203 feet in depth and is completed in the Catskill Formation in southeastern Bradford County. Analytical results for the Chesapeake Energy baseline parameter list were available for a baseline sample collected on September 14, 2010 from this water well, shortly after it was drilled. There are no Chesapeake Energy gas wells located within the baseline sampling radius, so upon completion of this water well, a baseline sample was collected. Analytical results were also available for the more extensive parameters list from the Chesapeake Energy split sample collected on October 31, 2011 in conjunction with the EPA retrospective study. Chesapeake Energy also collected an additional seven samples (from 4 sample events) from this same well on November 18, 2010, March 1, 2011 (pretreatment and post-treatment), April 7, 2011 (pretreatment and post-treatment), and May 23, 2011 (pretreatment and post-treatment), and analyzed the samples for the standard Chesapeake Energy baseline analytical parameter list. Seventeen additional samples were collected for light gas analyses during 2010 and 2011. Analytical results were compared to NURE, NWIS, and Williams 1998 databases for the Catskill Formation and the Chesapeake Energy baseline analytical database for the Central core drilling region.

The analytical results for the inorganics, dissolved methane, and total metals were consistent between the six sampling events. As can be noted from a review of the figures in **Appendix D-11**, which are time plots of key inorganic parameters and dissolved methane, the concentrations for total iron, total manganese, chloride, TDS, and total barium were steady or slightly declining over the six sampling events. Time plots show that the concentrations of these parameters are very similar to the baseline sample concentrations collected from this well. Sodium showed a small increase during the sampling time period. However, the analytical results for all of these



parameters fall well within the range of concentrations for each of these parameters as compared to the historical background data available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County. The analytical data indicates that the detected inorganic parameters are naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

The metals or general water-quality parameters that were not below the most stringent screening criteria include total aluminum, total iron, total lead, total manganese, and turbidity. Turbidity exceeded the EPA MCL on numerous occasions and impacted the metals values discussed in the following paragraphs. Turbidity was measured at 68 NTU (baseline), 5.1 NTU (March 1, 2011 pretreatment), 7.2 NTU (March 1, 2011 post-treatment), 12.2 NTU (April 7, 2011 pretreatment), 6.6 NTU (May 23, 2011 pretreatment), and 5.4 NTU (October 31, 2011). Based on the Chesapeake Energy baseline database, 29% of the wells with <u>measureable</u> turbidity exceeded the EPA MCL for turbidity.

Total aluminum was measured once on October 31, 2011 and exceeded the most stringent screening criterion (EPA SMCL) of 0.2 mg/L. Total aluminum was measured at 0.31 mg/L and 0.112 mg/L and dissolved aluminum was not detected (<0.02 mg/L), indicating that most of the aluminum is associated with the suspended solids in the sample. The dissolved aluminum is well below the EPA SMCL value. Based on the Williams 1998 database, 67% of the wells located in Catskill Formation exceeded the EPA SMCL for aluminum.

Total iron exceeded the most stringent screening criteria of 0.3 mg/L (SMCL) on several occasions, measured at 2.29 J mg/L (baseline), 0.434 mg/L (November 18, 2010), 2.18 mg/L (March 1, 2011 pretreatment), and 1.05 mg/L (April 7, 2011 pretreatment). Dissolved iron was below the screening criteria, measured at <0.05 mg/L on September 14, 2010 (baseline) and 0.148 mg/L on November 18, 2010. Based on the NWIS, Williams 1998, and Chesapeake Energy baseline databases, 40%, 50%, and 38% of the wells with <u>detected</u> iron exceeded the EPA SMCL for iron, respectively.

Total lead was detected twice at concentrations above the PADEP Act 2 screening criteria. It was measured at 0.0075 mg/L (April 7, 2011 pretreatment) and 0.0051 mg/L (April 7, 2011 post-



treatment). These values exceed the PADEP Act 2 standard of 0.005 mg/L, but are below the EPA Action Level of 0.015 mg/L. No dissolved lead analyses are available for this sample date. Based on the Williams 1998 and Chesapeake Energy baseline databases, 100% and 97% of the wells with <u>detected</u> lead exceeded the PADEP Act 2 value for lead, respectively.

Total manganese exceeded the most stringent criterion (EPA SMCL) of 0.05 mg/L for three of the samples. It was detected at 0.145 mg/L (March 1, 2011 pretreatment), 0.0992 mg/L (April 7, 2011 pretreatment), and 0.0662 mg/L (May 23, 2011 post-treatment). Total manganese was detected at 0.0429 mg/L in the September 14, 2010 baseline sample with the dissolved manganese concentration measuring 0.0214 mg/L, indicating that manganese was present mostly in the suspended solids associated with this sample. Based on the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline databases, 100%, 47%, 50%, and 69% of the wells with detected manganese exceeded the EPA SMCL, respectively

The Piper and Durov diagrams for this well in **Appendix F** indicate the water is of a mixed sodium-calcium bicarbonate type. These diagrams confirm that the water quality of the Property Owner I 203-ft well is consistent between the individual samples of the well and is also consistent with the background water quality from the NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County.

Methane, ethane, and propane were the only light gases detected in the samples (**Table E-3**). Dissolved methane was detected at 10.9 mg/L (baseline), 25.4 mg/L (October 6, 2010), and 20.6 mg/L (October 13, 2010) before steadily decreasing to 3.6 mg/L (December 7, 2011). This is shown on the methane figure in **Appendix D-11**. Ethane was found at 1.59 mg/L (baseline), 1.84 mg/L (October 6, 2010), and 1.47 mg/L (October 13, 2010), followed by a sharp decline in concentration in subsequent sampling events. Propane was detected in the baseline sample at 0.101 mg/L, and subsequently at levels of 0.117 mg/L (October 6, 2010), 0.0841 mg/L (October 13, 2010), and 0.0388 mg/L (October 20, 2010 post-treatment). As noted previously, it is not uncommon to see variability in methane values due to several factors discussed in earlier sections. The light gases detected in these samples are naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted by natural gas drilling or production activities including hydraulic stimulation.



Tests for the presence of *E. coli*, fecal coliform, and total coliform bacteria were negative.

No glycols, pesticides, purgeable or extractable petroleum hydrocarbons, DOC, DIC, low molecular weight acids, or semi-volatile organic compounds were detected in the November 4, 2011 EPA retrospective split sample. Toluene was the only volatile organic compound detected. It was detected at 1.71 μ g/L in the March 1, 2011 pretreatment sample, and at 0.95 μ g/L in the April 7, 2011 pretreatment sample. Toluene is a common laboratory contaminant and may have been present in materials utilized in the installation of the new well and pump.

6.12 PROPERTY OWNER J (WELL DEPTH UNKNOWN)

The Property Owner J well, depth unknown, is likely completed in the Devonian-age Lock Haven Formation in central Bradford County. Analytical results for the Chesapeake Energy baseline parameter list were available for a baseline sample collected on July 2, 2010 from this water well. Analytical results were also available for the more extensive parameters list from the Chesapeake Energy split sample collected on November 3, 2011 in conjunction with the EPA retrospective study. Chesapeake Energy also collected a sample from this same well on February 8, 2011 and analyzed that sample for the standard Chesapeake Energy baseline analytical parameter list. Analytical results were compared to NURE, NWIS, and Williams 1998 databases for the Lock Haven Formation and the Chesapeake Energy baseline analytical database for the Central core drilling region.

The analytical results for the inorganics, dissolved methane, and total metals were consistent between the three sampling events. As can be noted from a review of the figures in **Appendix D-12**, which are time plots of key inorganic parameters and dissolved methane, the concentrations for total iron, total manganese, chloride, sodium, TDS, and total barium were steady or slightly declining over the three sampling events. Time plots show that the concentrations of these parameters are very similar to the baseline sample concentrations collected from this well. The analytical results for all of these parameters fall well within the range of concentrations for each of these parameters as compared to the historical background data available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County. All metals and other inorganic constituents found in groundwater from this well are naturally occurring, and based on the analytical data presented in



this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

The metals or general water-quality parameters that were not within the screening criteria include total iron, total lead, total manganese, and turbidity. Turbidity exceeded the EPA MCL of 5 NTU on two occasions and may have impacted the metals values discussed in the following paragraphs. Turbidity was measured at 5.7 NTU (baseline) and 9.8 NTU (February 8, 2011). Based on the Chesapeake Energy baseline database, 29% of the wells with <u>measureable</u> turbidity exceeded the EPA MCL for turbidity.

Total iron exceeded the most stringent screening criteria of 0.3 mg/L (SMCL) in the 3 samples collected from this well, measured at 0.676 mg/L (baseline), 0.888 mg/L (February 8, 2011), and 0.583 mg/L (November 3, 2011). Dissolved iron was measured at 0.316 mg/L on November 3, 2011. Based on the NWIS, Williams 1998, and Chesapeake Energy baseline databases, 40%, 50%, and 38% of the wells with <u>detected</u> iron exceeded the EPA SMCL for iron, respectively.

Total lead was detected two times at a concentration above the PADEP Act 2 screening criteria of 0.005 mg/L, but below the EPA Action Level of 0.015 mg/L. It was measured at 0.0114 mg/L (baseline) and 0.009 mg/L (February 8, 2011). Based on the Williams 1998 and Chesapeake Energy baseline databases, respectively, 100% and 97% of the wells with <u>detected</u> lead exceeded the PADEP Act 2 value for lead.

Total manganese exceeded the most stringent criterion (EPA SMCL) of 0.05 mg/L for all three samples. It was detected at 0.249 mg/L (baseline), 0.29 mg/L (February 8, 2011), and 0.22 mg/L (November 3, 2011). The dissolved manganese concentration was measured at 0.216 mg/L for the latter sample. Based on the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline databases, 100%, 47%, 50%, and 69% of the wells with <u>detected</u> manganese exceeded the EPA SMCL, respectively.

The Piper and Durov diagrams for this well in **Appendix F** indicate the water is of a mixed calcium-sodium bicarbonate type. These diagrams confirm that the water quality of the Property Owner J well is consistent between the individual samples of the well and is also consistent with



the background water quality from the NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County.

No light gases were detected in any of the samples.

Tests for the presence of *E. coli*, fecal coliform, and total coliform bacteria were negative.

No glycols, pesticides, purgeable or extractable petroleum hydrocarbons, DOC, low molecular weight acids, volatile organic compounds, or semi-volatile organic compounds were detected in the November 3, 2011 EPA retrospective split sample. DIC was detected at 46.9 mg/L.

6.13 PROPERTY OWNER K (175-FT WELL)

The Property Owner K well is approximately 175 feet in depth and is completed in the Devonian-age Lock Haven Formation in southeastern Bradford County. Analytical results for the Chesapeake Energy baseline parameter list were available for a baseline sample collected on January 7, 2010 from this water well. Analytical results were also available for the more extensive parameters list from the Chesapeake Energy split sample collected on October 27, 2011 in conjunction with the EPA retrospective study. Chesapeake Energy also collected a sample from this same well on May 31, 2011 (post-treatment) and analyzed that sample for the standard Chesapeake Energy baseline analytical parameter list. Analytical results were compared to NURE, NWIS, and Williams 1998 databases for the Lock Haven Formation and the Chesapeake Energy baseline database for the Central core drilling region.

The analytical results for the inorganics, dissolved methane, and total metals were consistent between the two sampling events. As can be noted from a review of the figures in **Appendix D-13**, which are time plots of key inorganic parameters and dissolved methane, the concentrations for total iron, chloride, sodium, TDS, and total barium were steady over the three sampling events. Time plots show that the concentrations of these parameters are very similar to the baseline sample concentrations collected from this well. The total manganese concentration increased slightly from baseline. However, the analytical results for all of these parameters fall well within the range of concentrations for each of these parameters as compared to the historical background data available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County. All metals and other inorganic constituents



found in groundwater from this well are naturally occurring, and based on the analytical data presented in this report, this well has not been impacted from natural gas drilling or production activities including hydraulic stimulation.

The only metals or general water-quality parameter that was not within the screening criteria was total manganese. Total manganese exceeded the most stringent criterion (EPA SMCL) of 0.05 mg/L for the two samples. It was detected at 0.102 mg/L (May 31, 2011 post-treatment) and 0.168 mg/L (October 27, 2011). The dissolved manganese concentration was measured at 0.119 mg/L for the latter sample, similar to baseline. Based on the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases, 96%, 65%, 65%, and 69% of the wells with detected manganese exceeded the EPA SMCL, respectively.

The Piper and Durov diagrams for this well in **Appendix F** indicate the water is of a mixed calcium-sodium bicarbonate type. These diagrams confirm that the water quality of the Property Owner K well is consistent between the individual samples of the well and is also consistent with the background water quality from the NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County.

Methane was the only light gas that was detected in samples from the Property Owner K well. It was measured at 0.00674 mg/L in the October 27, 2011 sample. Methane may have been present in the earlier baseline sample; however, the limit of quantitation for that sample was 0.0260 mg/L. The light gases detected in this sample are naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

Testing for the presence of total coliform bacteria was positive for the one sample analyzed (the EPA retrospective well split sample). This is not unusual for rural wells in Pennsylvania as discussed in Section 2. Total coliform was reported to be present in 33% of Pennsylvania rural drinking water wells (Swistock 2009). *E. coli* and fecal coliform testing was negative.

No glycols, pesticides, purgeable or extractable petroleum hydrocarbons, DOC, low molecular weight acids, volatile organic compounds, or semi-volatile organic compounds were detected in the November 3, 2011 EPA retrospective split sample. DIC was detected at 43.7 mg/L.



6.14 PROPERTY OWNER L (225-FT WELL)

The Property Owner L well is approximately 225 feet in depth and is completed in the Devonianage Lock Haven Formation in central Bradford County. Analytical results for the Chesapeake Energy baseline parameter list were available for a baseline sample collected on April 18, 2010 from this water well. Analytical results were also available for the more extensive parameters list from the Chesapeake Energy split sample collected on November 3, 2011 in conjunction with the EPA retrospective study. Analytical results were compared to NURE, NWIS, and Williams 1998 databases for the Lock Haven Formation and the Chesapeake Energy baseline analytical database for the Central core drilling region.

The analytical results for the inorganics, dissolved methane, and total metals were consistent between the two sampling events. As can be noted from a review of the figures in **Appendix D-14**, which are time plots of key inorganic parameters and dissolved methane, the concentrations for chloride, sodium, TDS, and total barium were steady over the two sampling events. Total iron and total manganese were not detected in either of the samples. Time plots show that the concentrations of these parameters are very similar to the baseline sample concentrations collected from this well. The analytical results for all of these parameters fall well within the range of concentrations for each of these parameters as compared to the historical background data available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County. All metals and other inorganic constituents found in groundwater from this well are naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

All metals and general water-quality parameters were within the screening criteria as listed in **Table E-1**.

The Piper and Durov diagrams for this well in **Appendix F** indicate the water is of a calciummagnesium bicarbonate type. These diagrams confirm that the water quality of the Property Owner L well is consistent between the individual samples of the well and is also consistent with the background water quality from the NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County.



Methane was the only light gas that was detected in samples from the Property Owner L well. It was measured at 0.048 mg/L in the baseline sample. The methane detected in this sample is naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling and production activities including hydraulic stimulation.

Testing for the presence of total coliform bacteria was positive for the one sample analyzed (the EPA retrospective well split sample). This is not unusual for rural wells in Pennsylvania as discussed in Section 2. Total coliform was reported to be present in 33% of Pennsylvania rural drinking water wells (Swistock 2009). *E. coli* and fecal coliform testing was negative.

No pesticides, purgeable or extractable petroleum hydrocarbons, DOC, low molecular weight acids, volatile organic compounds, or semi-volatile organic compounds were detected in the November 3, 2011 EPA retrospective split sample. DIC was detected at 38.9 mg/L. Tetraethylene glycol was the only glycol reported for the EPA retrospective split sample. It was reported as an estimated value at 15J mg/L, but was also detected in the laboratory blank. Due to issues with analytical laboratory blank contamination with several other samples for glycol analyses from this sampling event, there is concern regarding the validity of this result. The estimated detection of this compound is believed to be an analytical laboratory contamination issue. To the best of Chesapeake Energy's knowledge, tetraethylene glycol was not utilized in any of the hydraulic stimulation formulations used in the study area. Chesapeake Energy conducted a review of hydraulic stimulation materials used in this area and has determined that tetraethylene glycol was not used as a hydraulic stimulation additive on well sites in this area. Tetraethylene glycol is utilized in numerous industrial and consumer products.

6.15 PROPERTY OWNER M (440-FT WELL)

The Property Owner M well is approximately 440 feet in depth and is completed in the Devonian-age Catskill Formation in southeastern Bradford County. Analytical results for the Chesapeake Energy baseline parameter list were available for a baseline sample collected on January 6, 2010 from this water well. Analytical results were also available for the more extensive parameters list from the Chesapeake Energy split sample collected on October 28, 2011 in conjunction with the EPA retrospective study. Chesapeake Energy also collected two



additional samples: a sample from this same well on December 2, 2010 analyzed for the standard Chesapeake Energy baseline parameter list, and another sample on April 11, 2011 analyzed for total lead. Analytical results were compared to NURE, NWIS, and Williams 1998 databases for the Catskill Formation and the Chesapeake Energy baseline analytical database for the Central core drilling region.

The analytical results for the inorganics, dissolved methane, and total metals were consistent between the four sampling events. As can be noted from a review of the figures in **Appendix D-15**, which are time plots of key inorganic parameters and dissolved methane, the concentrations for total iron, total manganese, chloride, sodium, TDS, and total barium were steady over the four sampling events. Time plots show that the concentrations of these parameters are very similar to the baseline sample concentrations collected from this well. The analytical results for all of these parameters fall well within the range of concentrations for each of these parameters as compared to the historical background data available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County. All metals and other inorganic constituents found in groundwater from this well are naturally occurring, and based on the analytical data presented in this report, this well does not appear to be impacted from natural gas drilling or production activities including hydraulic stimulation.

All metals and general water-quality parameters were within the screening criteria as listed in **Table E-1** with the exception of total lead. Total lead was detected above the most stringent criteria of 0.005 mg/L (PADEP Act 2) for two of the sampling events, but below the EPA Action Level of 0.015 mg/L. Total lead concentrations of 0.011 mg/L (December 2, 2010) and 0.0124 mg/L (April 11, 2011) were detected. No dissolved lead analysis was conducted on these two samples. Based on the Williams 1998 and Chesapeake Energy baseline databases, respectively, 100% and 97% of the wells with <u>detected</u> lead exceeded the PADEP Act 2 value for lead.

The Piper and Durov diagrams for this well in **Appendix F** indicate the water is of a calciummagnesium bicarbonate type. These diagrams confirm that the water quality of the Property Owner M well is consistent between the individual samples of the well and is also consistent with the background water quality from the NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for Bradford County.



No light gases were detected in any of the samples.

Tests for the presence of *E. coli*, fecal coliform, and total coliform bacteria were positive for the one sample analyzed (the EPA retrospective well split sample). The *E. coli* and total coliform were confirmed present and the fecal coliform was measured at 3/100 ml. This is not unusual for rural wells in Pennsylvania as discussed in Section 2. Total coliform was reported to be present in 33% of Pennsylvania rural drinking water wells (Swistock 2009).

No glycols, pesticides, purgeable or extractable petroleum hydrocarbons, DOC, low molecular weight acids, volatile organic compounds, or semi-volatile organic compounds were detected in the October 28, 2011 EPA retrospective split sample. DIC was detected at 34.6 mg/L.



7. CONCLUSIONS

Based upon review of the analytical data for each of the 14 water wells and one spring presented in this report, and subsequent comparison of these results with regional historical and baseline water-quality databases, this study concludes that these fifteen water sources do not appear to be impacted by natural gas drilling or production activities including hydraulic stimulation. A summary of conclusions for these water sources is included in **Table 7-1**.

With the few exceptions noted herein, there are no significant increases in inorganic parameters when comparing current analyses with baseline conditions or from historical databases. None of the wells show significant increases in dissolved methane when comparing current analyses with baseline conditions or area-wide baseline databases. Note that the Property Owner A, Property Owner I (142-feet), and Property Owner F wells showed levels of methane that could not be compared to baseline methane concentrations due to the absence of baseline samples. Therefore, methane data from those wells were compared to the Chesapeake Energy baseline databases. There were also a few detections of organic compounds in some of the wells, but these are not attributable to natural gas drilling, or production activities including hydraulic stimulation. The analyses for each of the fifteen water sources demonstrated that most of the individual parameters fell within the ranges and were similar to the mean concentrations for the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases for selected areas in Bradford County (and selected areas in western Susquehanna County for the Chesapeake Energy baseline database).

The Property Owner A water well was possibly over-stressed during the EPA retrospective sampling or purging activities, resulting in very high turbidity levels. Review of the field notes indicate that the turbidity changed or increased with time of pumping. The Property Owner I 203-ft well has demonstrated a slight increase in sodium from baseline sample results; however, the sodium level remains low and stable, indicating that it is naturally occurring. The Property Owner K well has demonstrated a slight increase in total manganese from baseline conditions; however, the total manganese level is below typical values for the formation, indicating that it is naturally occurring.



Table 7-1

Water Source	Inorganics Observations	Dissolved Methane Observations	Regional Comparison	Conclusion
Property Owner A	Total iron and total manganese concentrations are variable and the variability is partly due to excessive sediment in the samples. Sodium declined slightly with time. Barium, chloride, and TDS were relatively stable with time.	Baseline sampling was not completed for this well. Methane concentration declined significantly during the sampling period.	Total manganese and total iron results are somewhat higher than the historical background data mean values available from the NURE, NWIS, Williams 1998, and Chesapeake Energy baseline analytical databases, likely due to high sediment content in samples. Barium, sodium, chloride, and TDS mostly fall within documented ranges in NURE, NWIS, Williams 1998, and Chesapeake Energy analytical databases.	Baseline sampling was not completed for this well. Based on the analytical data presented in this report water well does not appear to be impacted by natural gas drilling and production activities including hydraulic stimulation.
Property Owner B (spring)	No significant increases or decreases from baseline are observed.	No methane has been observed.	Parameters fall within documented ranges in NURE, NWIS, Williams 1998, and Chesapeake Energy analytical databases.	Based on the analytical data presented in this report, spring does not appear to be impacted by natural gas drilling and production activities including hydraulic stimulation.



Table 7-1 (Cont.)

Water Source	Inorganics Observations	Dissolved Methane Observations	Regional Comparison	Conclusion
Property Owner C	No significant increases from baseline are observed. Slight decreases from baseline observed for barium, chloride, manganese, TDS, and sodium. Groundwater is from restricted flow zone.	No significant increase or change from baseline is observed.	Parameters generally fall within documented ranges in NURE, NWIS, Williams 1998, and Chesapeake Energy analytical databases. Sodium and chloride fall outside the NURE range due to well location within restricted flow zone.	Based on the analytical data presented in this report, water well does not appear to be impacted by natural gas drilling and production activities including hydraulic stimulation.
Property Owner D	No significant increases from baseline are observed. Slight decrease in sodium observed.	No significant increase or change from baseline is observed.	Parameters fall within documented ranges in NURE, NWIS, Williams 1998, and Chesapeake Energy analytical databases.	Based on the analytical data presented in this report, water well does not appear to be impacted by natural gas drilling and production activities including hydraulic stimulation.
Property Owner E (115-ft well)	No significant increases or decreases from baseline are observed.	Slight but insignificant increase from baseline is observed.	Parameters fall within documented ranges in NURE, NWIS, Williams 1998, and Chesapeake Energy analytical databases.	Based on the analytical data presented in this report, water well does not appear to be impacted by natural gas drilling and production activities including hydraulic stimulation.



Table 7-1 (Cont.)

Water Source	Inorganics Observations	Dissolved Methane Observations	Regional Comparison	Conclusion
Property Owner E (185-ft well)	No significant increases from baseline are observed. Slight decreases from baseline are noted for sodium, TDS, and manganese.	Methane declined significantly from baseline to current conditions.	Parameters fall within documented ranges in NURE, NWIS, Williams 1998, and Chesapeake Energy analytical databases.	Based on the analytical data presented in this report, water well does not appear to be impacted by natural gas drilling or production activities including hydraulic stimulation.
Property Owner F	All parameters are stable and no significant increases or decreases are noted in the data. Well likely completed in both the restricted flow zone and unrestricted flow zone as evidenced by higher sodium and chloride levels found in this well.	Baseline sampling was not completed for this well. Methane concentration remained high and constant, during the sampling period.	Parameters generally fall within documented ranges in NURE, NWIS, Williams 1998, and Chesapeake Energy analytical databases. Barium concentrations exceed the range in the Williams 1998 database for unrestricted flow zone.	Baseline sampling was not completed for this well. Based on the analytical data presented in this report, it does not appear that this water well was impacted by natural gas drilling and production activities including hydraulic stimulation.
Property Owner G	Total iron and total manganese concentrations are variable and the variability is due to excessive sediment in the samples. A significant storm event occurred immediately prior to the 10/1/2010 sampling event resulting in 3.9 inches rainfall. Note that the TDS value of 274 mg/L on October 1, 2010 is considered an outlier.	No significant increase or change from baseline is observed.	Parameters generally fall within documented ranges in NURE, NWIS, Williams 1998, and Chesapeake Energy analytical databases. The iron concentration from the October 1, 2010 sample was higher than the ranges of the NWIS and Williams 1998 data, but likely due to sediment in sample.	Based on the analytical available data presented in this report, water well does not appear to be impacted by natural gas drilling and production activities including hydraulic stimulation.



Table 7-1 (Cont.)

Water Source	Inorganics Observations	Dissolved Methane Observations	Regional Comparison	Conclusion
Property Owner H	Total iron and total manganese concentrations are variable and the variability is due to excessive sediment in the samples. A significant storm event occurred immediately prior to the 10/1/2010 sampling event resulting in 3.9 inches rainfall. Sodium has fluctuated during the various sampling events, but is currently at a slightly lower concentration than baseline.	No significant increase or change from baseline is observed.	Parameters fall within documented ranges in NURE, NWIS, Williams 1998, and Chesapeake Energy analytical databases.	Based on the analytical data presented in this report, water well does not appear to be impacted by natural gas drilling and production activities including hydraulic stimulation.
Property Owner I (142-ft well)	Some minor variability in analytical data but no significant increases are observed.	Baseline sampling was not completed for this well. Slight variability in methane values observed, however no significant increase is observed.	Parameters fall within documented ranges in NURE, NWIS, Williams 1998, and Chesapeake Energy analytical databases.	Baseline sampling was not completed for this well. Based on the analytical data presented in this report, water well does not appear to be impacted by natural gas drilling and production activities including hydraulic stimulation.


Table 7-1 (Cont.)

Summary of Conclusions for EPA Study Wells

Water Source	Inorganics Observations	Dissolved Methane Observations	Regional Comparison	Conclusion
Property Owner I (203-ft well)	Total iron and total manganese concentrations are variable and the variability is due to excessive sediment in the samples. Sodium has shown a small increase in concentration from baseline to current conditions. However, the sodium level remains low and stable. Chloride levels have show a small decrease from baseline, but are also stable.	Methane is variable but overall has declined slightly from baseline to current conditions.	Parameters fall within documented ranges in NURE, NWIS, Williams 1998, and Chesapeake Energy analytical databases.	Based on the analytical data presented in this report, water well does not appear to be impacted by natural gas drilling and production activities including hydraulic stimulation.
Property Owner J	No significant increases from baseline are observed. Sodium, chloride, and TDS declined from baseline.	No significant increase or change from baseline is observed.	Parameters fall within documented ranges in NURE, NWIS, Williams 1998, and Chesapeake Energy analytical databases.	Based on the analytical data presented in this report, water well is not impacted by natural gas drilling or production activities including hydraulic stimulation
Property Owner K	No significant increases or decreases from baseline are observed. Total manganese concentrations are variable and the variability is due to excessive sediment in the samples, Dissolved result similar to baseline.	No significant increase or change from baseline is observed.	Parameters fall within documented ranges in NURE, NWIS, Williams 1998, and Chesapeake Energy analytical databases.	Based on the analytical data presented in this report, water well does not appear to be impacted by natural gas drilling and production activities including hydraulic stimulation.



Table 7-1 (Cont.)

Summary of Conclusions for EPA Study Wells

Water Source	Inorganics Observations	Dissolved Methane Observations	Regional Comparison	Conclusion
Property Owner L	No significant increases or decreases from baseline are observed.	Slight but insignificant decrease from baseline is observed.	Parameters fall within documented ranges in NURE, NWIS, Williams 1998, and Chesapeake Energy analytical databases.	Based on the analytical data presented in this report, water well does not appear to be impacted by natural gas drilling and production activities including hydraulic stimulation.
Property Owner M	No significant increases or decreases from baseline are observed.	No significant increase or change from baseline is observed.	Parameters fall within documented ranges in NURE, NWIS, Williams 1998, and Chesapeake Energy analytical databases.	Based on the analytical data presented in this report, water well does not appear to be impacted by natural gas drilling and production activities including hydraulic stimulation.



APPENDIX A EPA STUDY WELLS



APPENDIX A-1 EPA STUDY WELL DATA PROPERTY OWNER A

	Property Owner	PROPERTY OWNER A					
		PRESSURE TANK, SAMPLED WATER					
		DIRECTLY FROM WELL	WELL	WELL	WELL	WELL	DIRECTLY FROM WELL
	Well Denth	300	300	300	300	300	300
	Sampled Before Treatment?	Pre-Treatment	NA	NA	NA	NA	NA
	Sample ID	1013201000201	0718201120201	0804201122804	0818201120203	0901201120201	1104201120202
Parameter and units	Sample Date	10/13/2010	7/18/2011	8/4/2011	8/18/2011	9/1/2011	11/4/2011
Aldabudas							
Gluteraldehyde	UG/L						
Bacteria							
E. coli	colonies/100ml						Absent
Fecal coliform bacteria	colonies/100ml						Present
Total Coliform Bacteria	colonies/100ml						Present
DRCP							
1,2-Dibromo-3-chloropropa	ane UG/L						< 0.1003 U
Extractable Datraloum Uni	draaarbana						
Diesel	UG/L						< 95.2 U
Comonal Observation							
General Chemistry	10.4						110
	MG/L						1 22
Ricarbonate Alkalinity as C		 108	101				1.32
Bromide	MG/I						< 2.5.11
Carbonate as CaCO3	MG/L	< 10.0 []	< 10.0 U				< 10.0 U
Chloride	MG/L	10.2	< 5.00 U				6.3
CO2 by Headspace	UG/L						< 12000 U
Cyanide	MG/L						
Fluoride	MG/L						< 0.50 U
MBAS	MG/L	< 0.0500 U	< 0.0500 U				< 0.12 U
Nitrate	MG/L						
Nitrate Nitrogen	MG/L						< 0.50 U
Nitrite Nitrogen	MG/L						< 0.50 U
Oil & Grease HEM	MG/L	< 6.85 U	< 6.33 U				< 4.71 U
рН	pH UNITS	7.20 J	7.10 H				6.80 H
Phosphorus	MG/L						0.249
Specific conductance	UMHO/CM	230	251				255
Sulfate	MG/L	15.3	15.3				14
Temperature of pH determ	nination CELSIUS	21.4 J	21.3 H				22.0 H
Total Dissolved Solids	MG/L	145	142				1430 B12 H
	MG/L	33	36				865
	NIG		30				003
1.2 Pronulono Clucol	MC /I						
Diethylene Glycol	MG/L						 - 10
Ethylene Glycol	MG/L						
Tetraethylene glycol	MG/L						< 10 UJ
Triethylene glycol	MG/L						< 10 U
Light Gases							
Acetylene	MG/L						< 0.00500 U
Ethane	MG/L	0.192	0.0861	0.0904	0.0964	0.0556	0.0117
Ethene	MG/L						< 0.00500 U
Methane	MG/L	8.36	5.21	4.82	4.95	1.51	1.86
n-Butane	MG/L						< 0.00500 U
Propane	MG/L	< 0.0340 U	< 0.0340 U	< 0.0340 U	< 0.0340 U	< 0.00500 U	< 0.00500 U
Low Molecular Weight Aci	ds						
Acetic Acid	UG/L						< 10000 U
Butyric Acid	UG/L						< 10000 U
Formic Acid	UG/L						< 10000 U
Isobutyric acid	UG/L						< 10000 U
	UG/L						< 5000 U
Propionic Acid	UG/L						< 13000 U

Note of all of		Property Owner	PROPERTY OWNER A					
Instrict Develoa Direct To and Vall Direct To			ON WATER SUPPLY, BYPASSED					
Society Tools Will Will Will Will Will Will Will Sorge Monitor None 300 0000 000 0000		Location Description	DIRECTLY FROM WELL					
Number of the Deck 300		Source Type	WELL	WELL	WELL	WELL	WELL	WELL
Sequel bloc Part Featmer MA MA </th <th></th> <th>Well Depth</th> <th>300</th> <th>300</th> <th>300</th> <th>300</th> <th>300</th> <th>300</th>		Well Depth	300	300	300	300	300	300
Sengel D Display DOI Display DOI <thdisplay doi<="" th=""> <thdisplay doi<="" th=""> <t< th=""><th></th><th>Sampled Before Treatment?</th><th>Pre-Treatment</th><th>NA</th><th>NA</th><th>NA</th><th>NA</th><th>NA</th></t<></thdisplay></thdisplay>		Sampled Before Treatment?	Pre-Treatment	NA	NA	NA	NA	NA
Presente an La Mais Sample Lale (11/20/11) <		Sample ID	1013201000201	0718201120201	0804201122804	0818201120203	0901201120201	1104201120202
Metab. (2026) Image: Metab. Image: Metab. Image: Metab. Metab. Image: Metab. Metab. Image: Metab. Imag	Parameter and units	Sample Date	10/13/2010	7/18/2011	8/4/2011	8/18/2011	9/1/2011	11/4/2011
Genum Mach. Mathematical and the second	Metals, 6020x							
General Disponsibility Biol. <th>Cesium</th> <th>MG/L</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>< 0.1 U</th>	Cesium	MG/L						< 0.1 U
Photon Model Model <t< th=""><th>Cesium, Dissolved</th><th>MG/L</th><th></th><th></th><th></th><th></th><th></th><th>< 0.1 U</th></t<>	Cesium, Dissolved	MG/L						< 0.1 U
Promose Disk m <th< th=""><th>Potassium</th><th>MG/L</th><th></th><th></th><th></th><th></th><th></th><th>< 100 U</th></th<>	Potassium	MG/L						< 100 U
Since Disabled Mar	Silicon	MG/L						< 100 U
Thorum, Solved 494,	Silicon Dissolved	MG/L						< 2500 U
IPotenum Mad.	Thorium	MG/L						< 2 U
Umrine Mail	Thorium, Dissolved	MG/L						< 2 U
Uning, Displayed Main	Uranium	MG/L						< 1 U
Joseph Control Joseph	Uranium, Dissolved	MG/L						< 1 U
Methy Total Mith Mail								
Metab. Total Image: Constraint of the second s								
meteor. meteor. <t< th=""><th>Matola Tatal</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th></t<>	Matola Tatal							
Antimun Bob. .	Metals, Iotal	104						1 // 6:26
Instruct		MG/L						< 0.00200 []
Barum Mod. 0.388 0.262 ···· ···· ···· ···· 0.616 Berylum Mod. ···· ···· ···· ···· ···· ···· 0.0000 U Boron Mod. ···· ···· ···· ···· ···· 0.0050 U Cadhum Mod. ···· ···· ···· ···· ···· 0.0054 Control U ···· ···· 0.00247 Cobalt Mod. ···· ···· ···· ···· ···· 0.00247 Cobalt Mod. ···· ···· ···· ···· 0.00221 Cobalt Mod. ···· ···· ···· ···· 0.00221 Cobalt Mod. ···· ···· ···· ···· 0.00221 Itam Mod. ···· ···· ···· ···· 0.00350 U Marganese Mod. 0.369 0.912 ····· ····· ···· ···· ··	Arsenic	MG/L	0.01	< 0.0100 U				0.0122
Bergen NGC, ···· ···· ···· ···· ···· ···· ···· 0.0055 Cadrum MGA, < 0.0010 U < 0.0010 U ···· ···· ···· ···· ···· ···· ···· 0.0055 Cadrum MGA, 24.5 26.9 ···· ···· ···· ···· 24.6 Cronnium MGA, ···· ···· ···· ···· 0.00271 Cobalt MGA, ···· ···· ···· ···· ···· 0.00272 Copper MGA, ···· ···· ···· ···· 0.00283 Hardness, GaO3 MGA, ···· ···· ···· ···· 0.0383 0.0372 Ibbam MGA, ···· ···· ···· ···· ···· 0.0486 ···· ····· 0.0383 0.0372 Ibbam MGA, ···· ···· ····· ···· ····· ···· ···· <t< th=""><td>Barium</td><td>MG/L</td><td>0.388</td><td>0.262</td><td></td><td></td><td></td><td>0.616</td></t<>	Barium	MG/L	0.388	0.262				0.616
Boron Mol. ··· ··· ··· ··· ··· ··· 0.055 Cadnum Mol. 245 20.91 ··· ··· ··· 24.0 Chronium Mol. <0.00500 U ··· ··· ··· 24.0 Cobait Mol. ··· ··· ··· ··· 0.00247 Cobait Mol. ··· ··· ··· ··· 0.00822 Cobait Mol. ··· ··· ··· ··· 0.00824 Hardness, GLO3 Mol. ··· ··· ··· ··· ··· 0.00838 Hardness, GLO3 Mol. ··· ··· ··· ··· ··· 0.00838 0.0383 Itan Mol. ··· ··· ··· ··· ··· ··· ··· 0.0383 0.0373 Margareset Mol. ··· ··· ··· ··· ··· ··· ··· ··· ··· <td>Beryllium</td> <td>MG/L</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>< 0.00200 U</td>	Beryllium	MG/L						< 0.00200 U
Cathum Woll, <	Boron	MG/L						0.055
Calcum MGL 24.5 26.9 0.000247 Cobalt MGA 0.000247 Cobalt MGA 0.04866 Hardness, CaCO3 MGA 0.04866 Hardness, CaCO3 MGA 0.04866 Hardness, CaCO3 MGA 0.0383, 0.0377 Lihum MGA 0.0383, 0.0377 Lihum MGA 0.0383, 0.0377 Mangarese MGA	Cadmium	MG/L	< 0.00100 U	< 0.00100 U				< 0.00100 U
Chromium M6A <	Calcium	MG/L	24.5	26.9				24.6
Cobalt MOL 0.00922 Gopper MOL 0 0.00922 Hardness, CaC03 MOL 0.00922 Hardness, CaC03 MOL	Chromium	MG/L	< 0.00500 U	< 0.00500 U				0.00247
Copper MOL	Cobalt	MG/L						0.00922
Hardness, CaUQ3 Mol, Annotation Annotat	Copper	MG/L						0.0486
Indi Mail COMBOUL COMBOUL Common com	Hardness, CacO3	MG/L		0.786				3.88 14.5
Lithum NGA Dot	Lead	MG/L MG/L	< 0.00500 []	< 0.00500 U				0.0353, 010377
Maggnesium Mod. 5.18 5.19 6.7 Marganese Mod. 0.369 0.912 115.134 Marganese Mod. < 0.000200 U 0.000200 U	Lithium	MG/L						
Marganese NGL 0.369 0.912 1.15, 134 Mercury MGL <0.000200 U <0.000200 U < < < < < < < < < < < < < < < < < < < < < < 0.0137 < 0.0137 < 0.0137 < 0.0137 < 0.0137 < 0.0137 < 0.0137 < 0.0137 < <.0.0137 < <.0.0137 < <.0.0137 < < <.0.0137 < <.0.0137 < < < < < < < < < < < < < < < <	Magnesium	MG/L	5.18	5.19				6.7
Mercury Mod. <	Manganese	MG/L	0.369	0.912				1.15, fl.34
Mödydenum Möd, 0.0530 Nickel Möd, 2.25 1.74 0.0137 Stennum Möd, 2.25 1.74 0.0137 Silver Möd, <0.00500 U <0.0100 U < <.0.00200 U Soldum Möd, 35.3 17.3 0.641 Sufur Möd, 10 4.44 0.641 Sufur Möd, 10 4.44 < 0.0615 Vanadium Möd, 0.00415 Vanadium Möd, 0.00451 Zinc Möd, 0.00415 Munony, Dissolved Möd, <t< th=""><th>Mercury</th><th>MG/L</th><th>< 0.000200 U</th><th>< 0.000200 U</th><th></th><th></th><th></th><th>< 0.000200 U</th></t<>	Mercury	MG/L	< 0.000200 U	< 0.000200 U				< 0.000200 U
Nickel Mod.L 1.74 1.74 Selenium Mod.L < 0.0100 U < 0.0100 U	Molybdenum	MG/L						< 0.00500 U
Potassium MGR. 2.25 1.74 1.83 Selenium MGR. < 0.0100 U < 0.0100 U 0.00200 U Silver MGR. 35.3 17.3 19.6 0.641 Suffur MGR. 0.657 0.641 0.641 Suffur MGR. 10 4.44 3.82 Thallum MGR. 0.0200 U Titanium MGR. 0.00415 Vanadium MGR. 0.00451 0.00451 Zinc MGR. 0.00466 Antimory. Dissolved MGR. 0.00416<	Nickel	MG/L						0.0137
Selentum MG/L < 0.0100 U	Potassium	MG/L	2.25	1.74				1.83
Sinter Mod. < 0.00000 U	Selenium	MG/L	< 0.0100 U	< 0.0100 U				< 0.00200 U
Strontium Mol. Job Ind	Silver	MG/L	< 0.00500 0	< 0.00500 0				< 0.00200 0
Suffur Mat Outring Outring Outring Outring Suffur MG/L 10 4.44 3.82 Thallium MG/L < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < < <	Strontium	MG/L		0.657				0.641
Thallium MG/L ···· ···· ···· ···· ····	Sulfur	MG/L	10	4.44				3.82
Titanium MG/L 0.00415 Vanadium MG/L 0.00451 Zinc MG/L 0.0616 Metals, Dissolved MG/L 0.0616 Metals, Dissolved MG/L 0.0566 Antimorny, Dissolved MG/L 0.0566 Antimory, Dissolved MG/L 0.0566 Antimory, Dissolved MG/L 0.0566 Barium, Dissolved MG/L 0.0354 Beryllium, Dissolved MG/L 0.0571 Cadmium, Dissolved MG/L 0.0671 Cadmium, Dissolved MG/L 0.00100 U Calcium, D	Thallium	MG/L						< 0.00200 U
Vanadium MG/L 0.00451 Zinc MG/L 0.0616 Metals, Dissolved MG/L 0.0566 Atuminum, Dissolved MG/L 0.0566 Attimony, Dissolved MG/L 0.0566 Attimony, Dissolved MG/L 0.0566 Assenic, Dissolved MG/L 0.00416 Barium, Dissolved MG/L 0.0354 Beryllium, Dissolved MG/L 0.03671 Cadmium, Dissolved MG/L 0.0671 Cadmium, Dissolved MG/L 0.00571	Titanium	MG/L						0.00415
Zinc MG/L 0.0616 Metals, Dissolved MG/L 0.0566 Aluminum, Dissolved MG/L 0.0566 Antimony, Dissolved MG/L 0.00200 U Arsenic, Dissolved MG/L 0.00416 Barium, Dissolved MG/L 0.234 0.0354 Beryllium, Dissolved MG/L 0.00200 U Boron, Dissolved MG/L 0.05671 Cadmium, Dissolved MG/L 0.00010 U Calcium, Dissolved MG/L 24.4 Chromium, Dissolved MG/L 24.4 Chromium,	Vanadium	MG/L						0.00451
Metals, Dissolved MG/L 0.0566 Antimony, Dissolved MG/L 0.00200 U Arsenic, Dissolved MG/L 0.00416 Barium, Dissolved MG/L 0.0354 Barium, Dissolved MG/L 0.0354 Barium, Dissolved MG/L 0.234 0.00200 U Boron, Dissolved MG/L 0.0671 Cadmium, Dissolved MG/L 0.0671 Cadmium, Dissolved MG/L 24.4 Chromium, Dissolved MG/L 24.4 Chromium, Dissolved MG/L 24.0000 U Cobalt, Dissolved MG/L	Zinc	MG/L						0.0616
Aluminum, Dissolved MG/L 0.0566 Antimony, Dissolved MG/L 0.0566 Antimony, Dissolved MG/L 0.00200 U 0.00416 0.00416 0.00416 0.00416 0.00200 U 0.0354 0.0354 0.0354 0.0354 0.0350 0.00200 U 0.00200 U <td< th=""><th>Metals, Dissolved</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th></td<>	Metals, Dissolved							
Antimony, Dissolved MG/L <th<< th=""><th>Aluminum, Dissolved</th><th>MG/L</th><th></th><th></th><th></th><th></th><th></th><th>0.0566</th></th<<>	Aluminum, Dissolved	MG/L						0.0566
Arsenic, Dissolved MG/L 0.00416 Barium, Dissolved MG/L 0.234 0.354 Beryllium, Dissolved MG/L 0.234 0.354 Beryllium, Dissolved MG/L 0.00200 U Boron, Dissolved MG/L 0.0671 Cadmium, Dissolved MG/L	Antimony, Dissolved	MG/L						< 0.00200 U
Barium, Dissolved MG/L 0.234 0.354 Beryllium, Dissolved MG/L 0.00200 U 0.00200 U 0.00200 U 0.00200 U 0.00200 U 0.00210 U 0.00200 U 0.00200 U 0.00210 U	Arsenic, Dissolved	MG/L						0.00416
Beryllium, Dissolved MG/L <td>Barium, Dissolved</td> <td>MG/L</td> <td></td> <td>0.234</td> <td></td> <td></td> <td></td> <td>0.354</td>	Barium, Dissolved	MG/L		0.234				0.354
Boron, Dissolved MG/L 0.0671 Cadmium, Dissolved MG/L 0.00100 U Calcium, Dissolved MG/L 27.5 24.4 Chromium, Dissolved MG/L 24.4 Chromium, Dissolved MG/L 24.4 Choolalt, Dissolved MG/L 24.4 Cobalt, Dissolved MG/L 24.4 Copper, Dissolved MG/L 24.4 Copper, Dissolved MG/L 24.4 Iron, Dissolved MG/L 24.4 Iron, Dissolved MG/L 24.0000000 Iron, Dissolved MG/L	Beryllium, Dissolved	MG/L						< 0.00200 U
Cadmium, Dissolved MG/L	Boron, Dissolved	MG/L						0.0671
Calculati, Dissolved MG/L 21.3 24.4 Chromium, Dissolved MG/L	Calcium, Dissolved	MG/L		 				
Construction MG/L	Calcium, Dissolved	MG/L		27.5				24.4
Copper, Dissolved MG/L < 0.00200 U	Cohalt Dissolved	MC/L						
Iron, Dissolved MG/L < 0.0500 U	Copper. Dissolved	MG/L						< 0.00500 U
Lead. Dissolved MG/L	Iron, Dissolved	MG/L		< 0.0500 U				0.0845
	Lead, Dissolved	MG/L						< 0.00200 U

	Property Owner	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER DIRECTLY FROM WELL	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER DIRECTLY FROM WELL	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER DIRECTLY FROM WELL	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER DIRECTLY FROM WELL	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER DIRECTLY FROM WELL	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER DIRECTLY FROM WELL
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	300	300	300	300	300	300
	Sampled Before Treatment?	Pre-Treatment	NA	NA	NA	NA	NA
	Sample ID	1013201000201	0718201120201	0804201122804	0818201120203	0901201120201	1104201120202
Parameter and units	Sample Date	10/13/2010	7/18/2011	8/4/2011	8/18/2011	9/1/2011	11/4/2011
Magnesium, Dissolved	MG/L		5.25				4.9
Manganese, Dissolved	MG/L		0.788				0.959, m02,m05
Melvbdopum Dissolved	MG/L						0.00578
Nickel Dissolved	MG/L						< 0.00578
Potassium Dissolved	MG/L		1 53				1 51
Selenium, Dissolved	MG/L						< 0.00200 U
Silver, Dissolved	MG/L						< 0.00200 U
Sodium, Dissolved	MG/L		18.2				23.8
Strontium, Dissolved	MG/L		0.671				0.665
Sulfur, Dissolved	MG/L						3.77
Thallium, Dissolved	MG/L						< 0.00200 U
Titanium, Dissolved	MG/L						0.00294
Vanadium, Dissolved	MG/L						< 0.00400 U
Zinc, Dissolved	MG/L						< 0.0500 U
Miscellaneous Organics							
Inorganic Carbon Dissol	ved MC/I						25.9
Organic Carbon, Dissolve	ed MG/L						< 1.00 U
Posticidos and PCPs							
	LIG/I						< 0.023811
4 4'-DDF							< 0.0238 U
4.4'-DDT	UG/I						< 0.0238 U
Aldrin	UG/L						< 0.0238 U
alpha-BHC	UG/L						< 0.0238 U
Azinphos-methyl	UG/L						< 0.95 U
beta-BHC	UG/L						< 0.0238 U
Carbaryl	UG/L						< 6.0 U
delta-BHC	UG/L						< 0.0238 U
Dichlorvos	UG/L						< 0.95 U
Dieldrin	UG/L						< 0.0238 U
Disulfoton	UG/L						< 0.95 U
Endosulfan I	UG/L						< 0.0238 U
Endosulfan II	UG/L						< 0.0238 U
Endosulfan sulfate	UG/L						< 0.0238 U
Endrin	UG/L						< 0.0238 U
Endrin aldehyde	UG/L						< 0.0238 U
Endrin Ketone	UG/L						< 0.0238 U
Hentachlor	UG/L						
Heptachlor enovide							< 0.0230 0
Malathion							< 0.95 []
Methoxychlor	UG/L						< 0.0238 U
Mevinphos	UG/L						< 0.95 U
Puraeable Petroleum Hv	drocarbons						
GRO as Gasoline							< 100 []
	00/2						
Semivolatile Organics							
1,2,4,5-Tetrachlorobenze	ene UG/L						< 0.9 U
1,2-Dinitrobenzene	UG/L						< 5 U
1,2-Diphenylhydrazine	UG/L						< 0.9 U
1,3-Dimethyl adamatane	UG/L						< 5 U
	UG/L						< 5 U
	UG/L						
							< 0.9 U
2, 3, 4, 0- retraction opnetic					· ····		< 0.70
2.4 6-Trichloronhenol							< 0.911
2,4-Dichlorophenol	LIG/I						< 0.9 U
2,4-Dimethylphenol	UG/L						< 0.9 U
J							

	Property Owner	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER
	Location Description	DIRECTLY FROM WELL					
	Source Type	200	200	200	200	200	200
Sampled	Refore Treatment?	Pre-Treatment	NA	NA	NA	500 NA	
Sampleu	Sample ID	1013201000201	0718201120201	0804201122804	0818201120203	0901201120201	1104201120202
Parameter and units	Sample Date	10/13/2010	7/18/2011	8/4/2011	8/18/2011	9/1/2011	11/4/2011
2 4-Dinitrophenol							< 28 U
2.4-Dinitrotoluene	UG/L						< 5 U
2.6-Dichlorophenol	UG/L						< 0.9 U
2.6-Dinitrotoluene	UG/L						< 0.9 U
2-Butoxyethanol	UG/L						< 5 UJ
2-Chloronaphthalene	UG/L						< 0.9 U
2-Chlorophenol	UG/L						< 0.9 U
2-Methylnaphthalene	UG/L						< 0.5 U
2-Methylphenol	UG/L						< 0.9 U
2-Nitroaniline	UG/L						< 0.9 U
2-Nitrophenol	UG/L						< 0.9 U
3,3-Dichlorobenzidine	UG/L						< 5 U
3-Nitroaniline	UG/L						< 0.9 U
4,4'-Methylenebis(2-chloroaniline)	UG/L						< 14 UJ
4,4'-Methylenebis(N,N-dimethylanil	in UG/L						< 14 UJ
4,6-Dinitro-2-methylphenol	UG/L						< 14 U
4-Bromophenyl phenyl ether	UG/L						< 0.9 U
4-Chloro-3-methylphenol	UG/L						< 0.9 UJ
4-Chloroaniline	UG/L						< 0.9 U
4-Chlorophenyl phenyl ether	UG/L						< 0.9 U
4-Methylphenol	UG/L						< 0.9 U
4-Nitroaniline	UG/L						< 0.9 U
4-Nitrophenol	UG/L						< 28 U
Acenaphthene	UG/L						< 0.5 U
Acenaphthylene	UG/L						< 0.5 U
Acetophenone	UG/L						< 0.9 U
Adamantane	UG/L						< 5 U
Aniline	UG/L						< 0.9 U
Anthracene	UG/L						< 0.5 U
Benzo (a) anthracene	UG/L						< 0.5 UJ
Benzo (a) pyrene	UG/L						< 0.5 U
Benzo (b) fluoranthene	UG/L						< 0.5 U
Benzo (g,n,i) perylene	UG/L						< 0.5 U
Benzo (K) fluorantnene	UG/L						< 0.5 U
	UG/L						< 14 UJ
Bis(2-chloroethow)mothene	UG/L						< 14 U
Bis(2-chloroethyl)ether							< 0.9 U
his(2-Chloroisopronyl)ether			· · · · ·				< 0.7 0
Bis(2-ethylbexyl)nhtbalate							< 5.111
Butyl benzyl phthalate							< 5 []]
Carbazole							< 0.9 []
Chlorobenzilate	UG/L						< 9 []
Chrysene	UG/L						< 0.5 UJ
Diallate (cis or trans)	UG/L						< 5 U
Dibenz (a,h) anthracene	UG/L						< 0.5 U
Dibenzofuran	UG/L						< 0.9 U
Diethyl phthalate	UG/L						< 5 U
Dimethyl phthalate	UG/L						< 5 U
Di-n-butyl phthalate	UG/L						< 5 U
Di-n-octyl phthalate	UG/L						< 5 U
Dinoseb	UG/L						< 5 U
Disulfoton	UG/L						< 47 U
d-Limonene	UG/L						< 5 U
Fluoranthene	UG/L						< 0.5 U
Fluorene	UG/L						< 0.5 U
Hexachlorobenzene	UG/L						< 0.5 U
Hexachlorobutadiene	UG/L						< 0.9 U
Hexachlorocyclopentadiene	UG/L						< 14 U
Hexachloroethane	UG/L						< 5 U

	Property Owner	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER	PROPERTY OWNER A ON WATER SUPPLY, BYPASSED PRESSURE TANK, SAMPLED WATER
	Source Type	WFII	WFII	WFII	WFII	WFII	WFII
	Well Depth	300	300	300	300	300	300
	Sampled Before Treatment?	Pre-Treatment	NA	NA	NA	NA	NA
	Sample ID	1013201000201	0718201120201	0804201122804	0818201120203	0901201120201	1104201120202
Parameter and units	Sample Date	10/13/2010	7/18/2011	8/4/2011	8/18/2011	9/1/2011	11/4/2011
Indeno (1,2,3-cd) pyrene	UG/L						< 0.5 U
Isophorone	UG/L						< 0.9 U
Naphthalene	UG/L						< 0.5 U
Nitrobenzene	UG/L						< 0.9 U
N-Nitrosodiethylamine	UG/L						< 0.9 U
N-Nitrosodimethylamine	UG/L						< 5 U
N-Nitrosodi-n-butylamine	UG/L						< 5 U
N-Nitrosodi-n-propylamin	e UG/L						< 0.9 U
N-Nitrosodiphenylamine	UG/L						< 0.9 U
N-Nitrosomethylethylami	ne UG/L						< 5 U
Parathion-ethyl	UG/L						< 5 U
Parathion-methyl	UG/L						< 5 U
Pentachlorobenzene	UG/L						< 0.9 U
Pentachlorophenol	UG/L						< 5 U
Phenanthrene	UG/L						< 0.5 U
Phenol	UG/L						< 0.9 U
Phorate	UG/L						< 0.9 U
Pronamide	UG/L						< 0.9 U
Pyrene	UG/L						< 0.5 U
Pyridine	UG/L						< 5 U
Squalene	UG/L						6 J
Terbufos	UG/L						< 5 UJ
I erpineol	UG/L						< 5 U
Tributoxyetnyi phosphate	e UG/L						< 5 U
	UG/L						< 5 UJ
TICs							
1,2,3-Trimethylbenzene	UG/L						
Valatila Organica							
Volatile Organics	110.4						. 1.00.11
1,1,1-Trichloroethane	UG/L						< 1.00 U
1,1,2-11chloroothane	UG/L						< 1.00 U
1,1-Dichloroethene							< 1.00 U
1,1-Dichloroethene							< 1.00 U
1,2,3-Trichlorobenzene							< 1.00 0
1 2 4-Trimethylbenzene							< 1.00 U
1 2-Dibromo-3-chloropro							< 0.1003 []
1.2-Dichlorobenzene							< 1.00 U
1,2-Dichloroethane	UG/I						< 1.00 U
1,2-Dichloropropane	UG/L						
1,3,5-Trimethylbenzene	UG/L						< 1.00 U
1,3-Dichlorobenzene	UG/L						< 1.00 U
1,4-Dichlorobenzene	UG/L						< 1.00 U
Acetone	UG/L						< 50.0 U
Benzene	UG/L	< 0.500 U	< 0.500 U				< 1.00 U
Carbon disulfide	UG/L						< 1.00 U
Carbon Tetrachloride	UG/L						< 1.00 U
Chlorobenzene	UG/L						< 1.00 U
Chloroform	UG/L						< 1.00 U
cis-1,2-Dichloroethene	UG/L						< 1.00 U
Diisopropyl Ether	UG/L						< 1.00 U
Ethanol	UG/L						< 100 U
Ethyl tert-Butyl Ether	UG/L						< 1.00 U
Ethylbenzene	UG/L	< 0.500 U	< 0.500 U				< 1.00 U
Hexachlorobutadiene	UG/L						< 0.9 U
Isopropyl alcohol	UG/L						< 50.0 U
Isopropylbenzene	UG/L						< 1.00 U
m,p-Xylene	UG/L						< 2.00 U
Methoxychlor	UG/L						< 0.0238 U
Methyl tert-Butyl Ether	UG/L						< 1.00 U

	Property Owner	PROPERTY OWNER A					
		ON WATER SUPPLY, BYPASSED					
		PRESSURE TANK, SAMPLED WATER					
	Location Description	DIRECTLY FROM WELL					
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	300	300	300	300	300	300
	Sampled Before Treatment?	Pre-Treatment	NA	NA	NA	NA	NA
	Sample ID	1013201000201	0718201120201	0804201122804	0818201120203	0901201120201	1104201120202
Parameter and units	Sample Date	10/13/2010	7/18/2011	8/4/2011	8/18/2011	9/1/2011	11/4/2011
Methylene Chloride	UG/L						< 5.00 U
Naphthalene	UG/L						< 5.00 U
o-Xylene	UG/L						< 1.00 U
Styrene	UG/L						
Tert-Amyl Methyl Ether	UG/L						< 1.00 U
Tertiary Butyl Alcohol	UG/L						< 10.0 U
Tetrachloroethene	UG/L						< 1.00 U
Tetrahydrofuran	UG/L						< 20.0 U
Toluene	UG/L	100	< 0.500 U				< 1.00 U
trans-1,2-Dichloroethene	e UG/L						< 1.00 U
Trichloroethene	UG/L						< 1.00 U
Vinyl chloride	UG/L						< 1.00 U
Xylenes, total	UG/L	< 0.500 U	< 0.500 U				< 3.00 U

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended holding time

J : Estimated value

--- : Parameter not analyzed.B : Blank qualified

ug/L : Micrograms per liter mg/L : Milligrams per liter NA : Not Available NTU : Nephelometric Turbidity Unit umho/cm : Micromhos per centimeter

colonies/100 ml : Colonies per 100 millileters



APPENDIX A-2 EPA STUDY WELL DATA PROPERTY OWNER B

	Property Owner	PROPERTY OWNER B	PROPERTY OWNER B
	Location Description		THE SPRING IS LOCATED NORTHWEST OF THE HOUSE; THE OWNER RECENTLY SHOCKED THE SPRING TWO WEEKS AGO WITH CHLORINE; IT HAS A CONCRETE SLAB USED AS A COVER THAT WAS INSTALLED TWO WEEKS AGO.
	Source Type	SPRING	SPRING
	Well Depth	Not Applicable	Not Applicable
Sa	mpled Before Treatment?	NA	Pre-Treatment
	Sample ID	1014201012005	1104201120201
Parameter and units	Sample Date	10/14/2010 (Baseline)	11/4/2011
Ndahydas			
Clutoraldobydo			
Glateraldenyde	00/L		
Bacteria			
E. coli	colonies/100ml		Present
Fecal coliform bacteria	colonies/100ml		5
Total Coliform Bacteria	colonies/100ml		Present
1 2-Dibromo-3-chloropropan			< 0.1000 []
1,2-Distorne-5-chioropropan	5 00/L		< 0.1000 0
Extractable Petroleum Hydro	ocarbons		
Diesel	UG/L		< 95.2 U
General Chemistry			
Alkalinity Total (CaCO3)	MC/I		25.2
Ammonia as N	MG/L		1 22
Ricarbonato Alkalinity as CaC			25.2
Bical bollate Aikalifiity as Cac	OS MG/L	21.2	23.2
	MG/L	< 10.0.11	< 2.5 U
Calibonate as Cacios	MG/L	< 10.0 0	< 10.0 0
	MG/L	< 5.00 UH	2.8
CU2 by Headspace	UG/L		24000
Cyanide	MG/L		
Fluoride	MG/L		< 0.50 U
MBAS	MG/L	0.0611	< 0.12 0
Nitrate	MG/L		
Nitrate Nitrogen	MG/L		1.6
	MG/L		< 0.50 U
OII & Grease HEM	MG/L	< 6.41 U	< 5.13 U
pH	pH UNITS	6.30 H	6.10 H
Phosphorus	MG/L		< 0.100 0
Specific conductance	UMHO/CM	82.6	92.3
Sulfate	MG/L	11.0 H	12.3
Temperature of pH determin	ation CELSIUS	21.1 H	22.0 H
Total Dissolved Solids	MG/L	64	61.0 J
Total Suspended Solids	MG/L	< 1.00 U	< 1.00 U
Turbidity	NTU	< 1.00 U	0.89
Glvcols			
1,2-Propylene Glycol	MG/L		
Diethylene Glycol	MG/L		< 10 U
Ethylene Glycol	MG/L		
Tetraethylene glycol	MG/L		< 10 UJ
Triethylene glycol	MG/L		< 10 U
, , , , ,			
Light Gases			
Acetylene	MG/L		< 0.00500 U
Ethane	MG/L	< 0.0260 0	< 0.00500 U
LINENE	MG/L		< 0.00500 U
	MG/L	< 0.0260 U	< 0.00500 U
n-Butane	MG/L		< 0.00500 U
Propane	MG/L	< 0.0340 U	< 0.00500 U
Low Molecular Weight Acids			
Acetic Acid	UG/L		< 10000 U
Butyric Acid	UG/L		< 10000 U
Formic Acid	UG/L		< 10000 U
Isobutyric acid	UG/L		< 10000 U
Lactic acid	UG/L		< 5000 U

	Property Owner	PROPERTY OWNER B	PROPERTY OWNER B
	Location Description		THE SPRING IS LOCATED NORTHWEST OF THE HOUSE; THE OWNER RECENTLY SHOCKED THE SPRING TWO WEEKS AGO WITH CHLORINE; IT HAS A CONCRETE SLAB USED AS A COVER THAT WAS INSTALLED TWO WEEKS AGO.
	Source Type	SPRING	SPRING
	Well Depth	Not Applicable	Not Applicable
	Sampled Before Treatment?	NA	Pre-Treatment
	Sample ID	1014201012005	1104201120201
Parameter and units	Sample Date	10/14/2010 (Baseline)	11/4/2011
Propionic Acid	UG/L		< 13000 U
Matals 6020v			
Cesium	MG/I		< 0.1.11
Cesium, Dissolved	MG/L		< 0.1 U
Potassium	MG/L MG/L		< 100 U
Potassium, Dissolved	MG/L		< 100 U
Silicon	MG/L		< 2500 U
Silicon, Dissolved	MG/L		< 2500 U
Thorium	MG/L		< 2 U
Thorium, Dissolved	MG/L		< 2 U
Uranium	MG/L		< 1 U
Uranium, Dissolved	MG/L		< 1 U
Metals, Total			
Aluminum	MG/L		< 0.0200 U
Antimony	MG/L		< 0.00200 U
Arsenic	MG/L	< 0.0100 U	< 0.00200 U
Barium	MG/L	0.144	0.14
Beryllium	MG/L		< 0.00200 U
Boron	MG/L		< 0.0500 U
Cadmium	MG/L	< 0.00100 U	< 0.00100 0
Calcium	MG/L	9.34	9.04
	MG/L	< 0.00500 0	< 0.00200 0
Coppor	MG/L		< 0.00200 0
Hardness CaCO3	MG/L		< 0.00300 0
Iron	MG/L	< 0.0500 []	< 0.0500 U
Lead	MG/L MG/L	< 0.00500 U	< 0.00200 []
Lithium	MG/L MG/I		
Magnesium	MG/L MG/I	2,72	2.49
Manganese	MG/L	< 0.0150 U	< 0.00500 U
Mercury	MG/L	< 0.000200 U	< 0.000200 U
Molybdenum	MG/L		< 0.00500 U
Nickel	MG/L		< 0.00500 U
Potassium	MG/L	< 1.00 U	< 1.00 U
Selenium	MG/L	< 0.0100 U	< 0.00200 U
Silver	MG/L	< 0.00500 U	< 0.00200 U
Sodium	MG/L	2	2
Strontium	MG/L		< 0.0500 U
Sulfur	MG/L	3.1	2.96
	MG/L		< 0.00200 U
Titanium	MG/L		< 0.00200 U
Vanadium	MG/L		< 0.00400 U
Zinc Metals, Dissolved	MG/L		< 0.0500 U
Aluminum, Dissolved	MG/L		< 0.0200 U
Antimony, Dissolved	MG/L		< 0.00200 U
Arsenic, Dissolved	MG/L		< 0.00200 U
Barium, Dissolved	MG/L		0.14
Beryllium, Dissolved	MG/L		< 0.00200 U
Boron, Dissolved	MG/L		< 0.0500 U
Calaium, Dissolved	MG/L		< 0.00100 0
Calcium, DISSOIVED	MG/L		10.2

	Property Owner	PROPERTY OWNER B	PROPERTY OWNER B
	Location Description		THE SPRING IS LOCATED NORTHWEST OF THE HOUSE; THI OWNER RECENTLY SHOCKED THI SPRING TWO WEEKS AGO WITH CHLORINE; IT HAS A CONCRETE SLAB USED AS A COVER THAT WA INSTALLED TWO WEEKS AGO.
	Source Type	SPRING	SPRING
	Well Depth	Not Applicable	Not Applicable
	Sampled Before Treatment?	NA	Pre-Treatment
Devenuetor and units	Sample ID	1014201012005	1104201120201
Chromium Dissolved	Sample Date	10/14/2010 (Baseline)	11/4/2011
Cohalt Dissolved	MG/L		< 0.00200 0
Conner Dissolved	MG/L		< 0.00200 0
Iron. Dissolved	MG/L		< 0.0500 U
Lead, Dissolved	MG/L		< 0.00200 U
Magnesium, Dissolved	MG/L		2.86
Manganese, Dissolved	MG/L		< 0.00500 U
Mercury, Dissolved	MG/L		< 0.000200 U
Molybdenum, Dissolved	MG/L		< 0.00500 U
Nickel, Dissolved	MG/L		< 0.00500 U
Potassium, Dissolved	MG/L		< 1.00 U
Selenium, Dissolved	MG/L		< 0.00200 U
Silver, Dissolved	MG/L		< 0.00200 U
Sodium, Dissolved	MG/L		3.04
Strontium, Dissolved	MG/L		< 0.0500 U
Sulfur, Dissolved	MG/L		3.32
Thallium, Dissolved	MG/L		< 0.00200 U
Titanium, Dissolved	MG/L		< 0.00200 U
Vanadium, Dissolved	MG/L		< 0.00400 U
ZINC, DISSOIVED	MG/L		< 0.0500 0
Miscellaneous Organics			
Inorganic Carbon, Disso	lved MG/L		5.24
Organic Carbon, Dissolve	ed MG/L		1.08
Posticidos and PCRs			
			< 0.024011
4.4'-DDE	UG/L		< 0.0240 U
4.4'-DDT	UG/L		< 0.0240 U
Aldrin	UG/L		< 0.024 U
alpha-BHC	UG/L		< 0.0240 U
Azinphos-methyl	UG/L		< 0.96 U
beta-BHC	UG/L		< 0.0240 U
Carbaryl	UG/L		< 6.0 U
delta-BHC	UG/L		< 0.0240 U
Dichlorvos	UG/L		< 0.96 U
Dieldrin	UG/L		< 0.0240 U
Disulfoton	UG/L		< 0.96 U
Endosulfan I	UG/L		< 0.0240 U
Endosulfan II	UG/L		< 0.0240 U
Endosulian sullate			< 0.0240 U
Endrin aldebyde			< 0.0240 0
Endrin ketone			< 0.0240 0
gamma-BHC (Lindane)			< 0.0240 U
Heptachlor	UG/L		< 0.0240 U
Heptachlor epoxide	UG/L		< 0.0240 U
Malathion	UG/L		< 0.96 U
Methoxychlor	UG/L		< 0.0240 U
Mevinphos	UG/L		< 0.96 U
Durgooble Datalaum II.	droaarbana		
CPO as Casolino			2 100 U
ORU as Gasuillie	UG/L		< 100.0
Semivolatile Organics			
1,2,4,5-Tetrachlorobenze	ene UG/L		< 1 U
1,2-Dinitrobenzene	UG/L		< 5 U
1,2-Diphenylhydrazine	UG/L		< 1 U

	Property Owner	PROPERTY OWNER B	PROPERTY OWNER B
	Location Description	SDDING	THE SPRING IS LOCATED NORTHWEST OF THE HOUSE; THE OWNER RECENTLY SHOCKED THE SPRING TWO WEEKS AGO WITH CHLORINE; IT HAS A CONCRETE SLAB USED AS A COVER THAT WAS INSTALLED TWO WEEKS AGO.
	Source Type	SPRING Not Applicable	SPRING Not Appliaghte
	weil Depth		
Sampled B	erore Treatment?	NA 1014001010005	Pre-Treatment
Demonstration and surface	Sample ID	1014201012005	1104201120201
Parameter and units		10/14/2010 (Baseline)	11/4/2011
1,3-Dimetryi adamatane	UG/L		< 5 U
	UG/L		< 5 U
1,4-Dilliti Oberizerie	UG/L		
2,3,4,0-Tetrachiorophenol			
2,4,5-Trichlorophenol			
2 4-Dinitrophenol			< 29 []
2 4-Dinitrophenol			< 511
2 6-Dichlorophenol			< 1
2.6-Dinitrotoluene			< 1 []
2-Butoxyethanol	UG/L		< 5 UJ
2-Chloronaphthalene	UG/L		< 1 U
2-Chlorophenol	UG/L		< 1 U
2-Methylnaphthalene	UG/L		< 0.5 U
2-Methylphenol	UG/L		< 1 U
2-Nitroaniline	UG/L		< 1 U
2-Nitrophenol	UG/L		< 1 U
3.3-Dichlorobenzidine	UG/L		< 5 U
3-Nitroaniline	UG/L		< 1 U
4,4'-Methylenebis(2-chloroaniline)	UG/L		< 15 UJ
4,4'-Methylenebis(N,N-dimethylanilin	UG/L		< 15 UJ
4,6-Dinitro-2-methylphenol	UG/L		< 15 U
4-Bromophenyl phenyl ether	UG/L		< 1 U
4-Chloro-3-methylphenol	UG/L		< 1 UJ
4-Chloroaniline	UG/L		< 1 U
4-Chlorophenyl phenyl ether	UG/L		< 1 U
4-Methylphenol	UG/L		< 1 U
4-Nitroaniline	UG/L		< 1 U
4-Nitrophenol	UG/L		< 29 U
Acenaphthene	UG/L		< 0.5 U
Acenaphthylene	UG/L		< 0.5 U
Acetophenone	UG/L		< 1 U
Adamantane	UG/L		< 5 U
Aniline	UG/L		< 1 U
Anthracene	UG/L		< 0.5 U
Benzo (a) anthracene	UG/L		< 0.5 UJ
Benzo (a) pyrene	UG/L		< 0.5 U
Benzo (b) fluoranthene	UG/L		< 0.5 U
Benzo (g,h,i) perylene	UG/L		< 0.5 U
Benzo (k) fluoranthene	UG/L		< 0.5 U
Benzoic acid	UG/L		< 15 UJ
Benzyl alcohol	UG/L		< 15 U
Bis(2-chloroethoxy)methane	UG/L		< 1 U
Bis(2-chloroethyl)ether	UG/L		< 1 U
bis(2-Chioroisopropyi)ether	UG/L		< 1 U
Bis(2-ethylhexyl)phthalate	UG/L		< 5 UJ
Butyl benzyl phthalate	UG/L		< 5 UJ
Carbazole	UG/L		< 1 U
Chlorobenzilate	UG/L		< 10 U
Chrysene	UG/L		< 0.5 UJ
Dialiate (cis or trans)	UG/L		< 5 U
	UG/L		< 0.5 U
Ulbenzoluran	UG/L		< I U

	Property Owner	PROPERTY OWNER B	PROPERTY OWNER B
	Location Description		THE SPRING IS LOCATED NORTHWEST OF THE HOUSE; THE OWNER RECENTLY SHOCKED THE SPRING TWO WEEKS AGO WITH CHLORINE; IT HAS A CONCRETE SLAB USED AS A COVER THAT WAS INSTALLED TWO WEEKS AGO.
	Source Type	SPRING	SPRING
	Well Depth	Not Applicable	Not Applicable
	Sampled Before Treatment?	NA	Pre-Treatment
	Sample ID	1014201012005	1104201120201
Parameter and units	Sample Date	10/14/2010 (Baseline)	11/4/2011
Diethyl phthalate	UG/L		< 5 U
Dimethyl phthalate	UG/L		< 5 U
Di-n-butyl phthalate	UG/L		< 5 U
Di-n-octyl phthalate	UG/L		< 5 U
Dinoseb	UG/L		< 5 U
Disulfoton	UG/L		< 48 U
d-Limonene	UG/L		< 5 U
Fluoranthene	UG/L		< 0.5 U
Fluorene	UG/L		< 0.5 U
Hexachlorobenzene	UG/L		< 0.5 U
Hexachlorobutadiene	UG/L		< 1 U
Hexachlorocyclopentadiene	e UG/L		< 15 U
Hexachloroethane	UG/L		< 5 U
Indeno (1,2,3-cd) pyrene	UG/L		< 0.5 U
Isophorone	UG/L		
Nitrobopzopo			< 0.5 0
NILLODENZENE N. Nitrosodiothylamino			
N-Nitrosodimethylamine			< 5 11
N-Nitrosodi-n-butylamine			< 5 U
N-Nitrosodi-n-propylamine	UG/L		< 1 U
N-Nitrosodiphenylamine	UG/L		< 1 U
N-Nitrosomethylethylamine	e UG/L		< 5 U
Parathion-ethyl	UG/L		< 5 U
Parathion-methyl	UG/L		< 5 U
Pentachlorobenzene	UG/L		< 1 U
Pentachlorophenol	UG/L		< 5 U
Phenanthrene	UG/L		< 0.5 U
Phenol	UG/L		< 1 U
Phorate	UG/L		< 1 U
Pronamide	UG/L		< 1 U
Pyrene Duridine	UG/L		< 0.5 U
Pyridine Squalopo	UG/L		< 5 U
			< 5 UJ
Ternineol			< 5 05
			< 5 11
Trifluralin			< 5 UJ
TICs			
1,2,3-Trimethylbenzene	UG/L		
Volatile Organics			
1,1,1-Trichloroethane	UG/L		< 1.00 U
1,1,2-Trichloroethane	UG/L		< 1.00 U
1,1-Dichloroethane	UG/L		< 1.00 U
1,1-Dichloroethene	UG/L		< 1.00 U
1,2,3-Trimethylbenzene	UG/L		< 1.00 U
1,2,4-Irichlorobenzene	UG/L		
1,2,4-Trimethylbenzene	UG/L		< 1.00 U
1.2 Dioklandhar	ane UG/L		< 0.1000 U
1,2-DICHIOFODENZENE	UG/L		< 1.00 U
	UG/L		< 1.00 0
1 3 5-Trimethylbenzene			
1.3-Dichlorohenzene			< 1.00 0
1,4-Dichlorobenzene			< 1.00 U
	55,L		1 100 0

	Property Owner	PROPERTY OWNER B	PROPERTY OWNER B
	Location Description		THE SPRING IS LOCATED NORTHWEST OF THE HOUSE; THE OWNER RECENTLY SHOCKED THE SPRING TWO WEEKS AGO WITH CHLORINE; IT HAS A CONCRETE SLAB USED AS A COVER THAT WAS INSTALLED TWO WEEKS AGO.
	Source Type	SPRING	SPRING
	Well Depth	Not Applicable	Not Applicable
	Sampled Before Treatment?	NA	Pre-Treatment
	Sample ID	1014201012005	1104201120201
Parameter and units	Sample Date	10/14/2010 (Baseline)	11/4/2011
Acetone	UG/L		< 50.0 U
Benzene	UG/L	< 0.500 U	< 1.00 U
Carbon disulfide	UG/L		< 1.00 U
Carbon Tetrachloride	UG/L		< 1.00 U
Chlorobenzene	UG/L		< 1.00 U
Chloroform	UG/L		< 1.00 U
cis-1,2-Dichloroethene	UG/L		< 1.00 U
Diisopropyl Ether	UG/L		< 1.00 U
Ethanol	UG/L		< 100 U
Ethyl tert-Butyl Ether	UG/L		< 1.00 U
Ethylbenzene	UG/L	< 0.500 U	< 1.00 U
Hexachlorobutadiene	UG/L		< 1 U
Isopropyl alcohol	UG/L		< 50.0 U
Isopropylbenzene	UG/L		< 1.00 U
m,p-Xylene	UG/L		< 2.00 U
Methoxychlor	UG/L		< 0.0240 U
Methyl tert-Butyl Ether	UG/L		< 1.00 U
Methylene Chloride	UG/L		< 5.00 U
Naphthalene	UG/L		< 5.00 U
o-Xylene	UG/L		< 1.00 U
Styrene	UG/L		
Tert-Amyl Methyl Ether	UG/L		< 1.00 U
Tertiary Butyl Alcohol	UG/L		< 10.0 U
Tetrachloroethene	UG/L		< 1.00 U
Tetrahydrofuran	UG/L		< 20.0 U
Toluene	UG/L	< 0.500 U	< 1.00 U
trans-1,2-Dichloroethene	e UG/L		< 1.00 U
Irichloroethene	UG/L		< 1.00 U
Vinyl chloride	UG/L		< 1.00 U
xylenes, total	UG/L	< 0.500 U	< 3.00 U

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended holding time

J : Estimated value --- : Parameter not analyzed. B : Blank qualified ug/L : Micrograms per liter mg/L : Milligrams per liter NA : Not Available

NTU : Nephelometric Turbidity Unit umho/cm : Micromhos per centimeter colonies/100 ml : Colonies per 100 millileters



APPENDIX A-3 EPA STUDY WELL DATA PROPERTY OWNER C

	Property Owner Location Description Source Type	PROPERTY OWNER C WELL LOCATED 5 FEET OFF OF NE CORNER OF HOUSE; INACCESSIBLE-WELL HEAD IS BURIED; SAMPLED FROM BASEMENT SPIGOT WELL	PROPERTY OWNER C WELL LOCATED 5 FEET OFF OF NE CORNER OF HOUSE; INACCESSIBLE-WELL HEAD IS BURIED; SAMPLED FROM BASEMENT SPIGOT WELL
	Well Depth	260	260
c	Sampled Before Treatment?	Pre-Treatment	Pre-Treatment
	Sampled Defore Treatment:	0429201113403	1027201120201
Parameter and units	Sample Date	1/20/2011 (Baseline)	10/27/2011
	Sample Date		10/2//2011
Aldehydes			
Gluteraldehyde	UG/L		
Postaria			
			Absent
E. COII	colonies/100ml		Absent
Fecal colliform Dacteria	colonies/100ml		
Total Collform Bacteria	colonies/100ml		Absent
DBCP			
1,2-Dibromo-3-chloropropa	ane UG/L		< 0.1009 U
Extractable Petroleum Hyd	frocarbons		
Diesel	UG/L		< 94.3 U
General Chemistry			
Alkalinity, Total (CaCO3)	MG/I		166
Ammonia as N	MG/L		0.131
Bicarbonate Alkalinity as C		161	156
Bromide	MG/L		3 3
Carbonate as CaCO3	MG/L	< 10.011	12.2
Chloride	MG/L	/13	351
CO2 by Headspace			< 12000 []
Cvanide	MG/L		< 12000 0
Fluoride	MG/L		0.68
MBAS	MG/L	< 0.0500 []	< 0.12
Nitrate	MG/L	< 0.0300 0	
Nitrate Nitrogen	MG/L		< 0.50 []
Nitrite Nitrogen	MG/L		< 0.50 0
	MG/L	< 5.011	
nH	nH UNITS	8 50 H	8 30 H
Phosphorus	MG/I	0.50 11	< 0.100 []
Specific conductance		1780	1270
Sulfate	MG/I	10.3	21.4
Temperature of pH determ		21.1 H	21.43
Total Dissolved Solids	MG/I	842	726
Total Suspended Solids	MG/L	2	2.8
Turbidity	NTH	3	5
Tarblarty	NIC	5	3
Glycols			
1,2-Propylene Glycol	MG/L		
Diethylene Glycol	MG/L		< 10 U
Ethylene Glycol	MG/L		
Tetraethylene glycol	MG/L		< 10 UJ
Triethylene glycol	MG/L		< 10 U
Light Gases			
Acetylene	MG/I		< 0.00500 U
Ethane	MG/L	< 0.0260 U	< 0.00500 U
Ethene	MG/L		< 0.00500 U
Methane	MG/L	21.5	22.5
n-Butane	MG/L		< 0.00500 U
Propane	MG/L	< 0.0340 U	< 0.00500 U
Low Molecular Weight Acid	ds		
Acetic Acid	UG/L		< 10000 U
Butyric Acid	UG/L		< 10000 U
Formic Acid	UG/L		< 10000 U
Isobutyric acid	UG/L		< 10000 U
Lactic acid	UG/L		< 5000 U
Propionic Acid	UG/L		< 13000 U

Parameter and units	Property Owner Location Description Source Type Well Depth Sampled Before Treatment? Sample ID Sample Date	PROPERTY OWNER C WELL LOCATED 5 FEET OFF OF NE CORNER OF HOUSE; INACCESSIBLE-WELL HEAD IS BURIED; SAMPLED FROM BASEMENT SPIGOT WELL 260 Pre-Treatment 0429201113403 4/29/2011 (Baseline)	PROPERTY OWNER C WELL LOCATED 5 FEET OFF OF NE CORNER OF HOUSE; INACCESSIBLE-WELL HEAD IS BURIED; SAMPLED FROM BASEMENT SPIGOT WELL 260 Pre-Treatment 1027201120201 10/27/2011
	Sumple Date		10/2//2011
Cesium	MC/I		0.0013
Cesium, Dissolved	MG/L		0.00071
Potassium	MG/L		2.96
Potassium, Dissolved	MG/L		2.68
Silicon	MG/L		3.64
Silicon, Dissolved	MG/L		3.27
Thorium	MG/L		< 0.002 U
I horium, Dissolved	MG/L		< 0.002 U
Uranium Dissolvod	MG/L		< 0.001 U
	MG/L		< 0.001 0
Metals, Total			
Aluminum	MG/L		0.262
Antimony	MG/L		< 0.00200 U
Arsenic	MG/L	< 0.0100 U	0.00746
Barum	MG/L	1.95	1.58
Boron	MG/L		0 334
Cadmium	MG/L	< 0.00100 U	< 0.00100 U
Calcium	MG/L	14.2	11.7
Chromium	MG/L	< 0.00500 U	< 0.00200 U
Cobalt	MG/L		< 0.00200 U
Copper	MG/L		< 0.00500 U
Hardness, CaCO3	MG/L		
Iron	MG/L	0.285	0.368
Lead	MG/L	< 0.00500 0	< 0.00200 U
Magnesium	MG/L	2.8	2.38
Manganese	MG/L	0.0249	0.0106
Mercury	MG/L	< 0.00200 U	< 0.000200 U
Molybdenum	MG/L		< 0.00500 U
Nickel	MG/L		< 0.00500 U
Potassium	MG/L	3.57	2.84
Selenium	MG/L	< 0.0100 U	< 0.00200 U
Silver	MG/L	< 0.00500 U	< 0.00200 U
Sodium	MG/L	312	268
Sulfur	MG/L		1.67
Thallium	MG/L	0.748	< 0.00200 U
Titanium	MG/L		0.00475
Vanadium	MG/L		< 0.00400 U
Zinc	MG/L		< 0.0500 U
Metals, Dissolved			
Aluminum, Dissolved	MG/L		< 0.0200 U
Antimony, DISSOIVED	MG/L		< 0.00200 0
Barium Dissolved	MG/L		1 28
Beryllium, Dissolved	MG/L		< 0.00200 [J
Boron, Dissolved	MG/L		0.328
Cadmium, Dissolved	MG/L		< 0.00100 U
Calcium, Dissolved	MG/L		9.14
Chromium, Dissolved	MG/L		< 0.00200 U
Cobalt, Dissolved	MG/L		< 0.00200 U
Copper, Dissolved	MG/L		< 0.00500 U

	Property Owner Location Description	PROPERTY OWNER C WELL LOCATED 5 FEET OFF OF NE CORNER OF HOUSE; INACCESSIBLE-WELL HEAD IS BURIED; SAMPLED FROM BASEMENT SPIGOT	PROPERTY OWNER C WELL LOCATED 5 FEET OFF OF NE CORNER OF HOUSE; INACCESSIBLE-WELL HEAD IS BURIED; SAMPLED FROM BASEMENT SPIGOT
	Source Type	WELL	WELL
	Well Depth	260	260
	Sampled Defere Treatment?	Dro Trootmont	Dro Trootmont
	Sampled before freatment?	Pre-mediment	Pre-mediment
	Sample ID	0429201113403	1027201120201
Parameter and units	Sample Date	4/29/2011 (Baseline)	10/27/2011
Iron, Dissolved	MG/L		< 0.0500 U
Lead, Dissolved	MG/L		< 0.00200 U
Magnesium Dissolved	MG/I		19
Manganasa Dissolved			0.0110
wanganese, Dissolved	MG/L		0.0118
Mercury, Dissolved	MG/L		< 0.000200 U
Molybdenum, Dissolved	MG/L		< 0.00500 U
Nickel, Dissolved	MG/L		< 0.00500 U
Potassium, Dissolved	MG/L		2.5
Selenium Dissolved	MG/I		< 0.00200.11
Silver Disselved			
Sliver, Dissolved	MG/L		< 0.00200 0
Sodium, Dissolved	MG/L		244
Strontium, Dissolved	MG/L		1.37
Sulfur, Dissolved	MG/L		< 0.500 U
Thallium Dissolved	MG/I		< 0.00200.11
Titanium, Dissolved	MG/L		< 0.00200 U
Titanium, Dissolveu	MG/L		< 0.00200 0
Vanadium, Dissolved	MG/L		< 0.00400 U
Zinc, Dissolved	MG/L		< 0.0500 U
Miscellaneous Organics			
Inorganic Carbon, Dissolve	ed MG/L		36.4
Organic Carbon, Dissolved	MG/L		< 1.00 U
Pesticides and PCBs			
4,4'-DDD	UG/L		< 0.0472 U
4.4'-DDE	UG/L		< 0.0472 U
1 4'-DDT			< 0.047211
	00/L		0.0472 U
Aldrin	UG/L		< 0.0472 U
alpha-BHC	UG/L		< 0.0472 U
Azinphos-methyl	UG/L		< 0.94 U
beta-BHC	UG/L		< 0.0472 U
Carbaryl			< 6.0.11
	110/1		< 0.017211
	UG/L		< 0.0472 0
Dichlorvos	UG/L		< 0.94 U
Dieldrin	UG/L		< 0.0472 U
Disulfoton	UG/L		< 0.94 U
Endosulfan I	UG/L		< 0.0472 U
Endosulfan II			< 0.0472 []
	00/2		< 0.0472 U
	UG/L		< 0.0472 0
Endrin	UG/L		< 0.04/2 U
Endrin aldehyde	UG/L		< 0.0472 U
Endrin ketone	UG/L		< 0.0472 U
gamma-BHC (Lindane)			< 0.0472 []
Hentachlor			< 0.047211
	00/L		
Heptachior epoxide	UG/L		< 0.0472 0
Malathion	UG/L		< 0.94 U
Methoxychlor	UG/L		< 0.0472 U
Mevinphos	UG/L		< 0.94 U
Purgeable Petroleum Hydi	rocarbons		
GRO as Gasoline	UG/L		< 100 U
	50,2		
Semivolatile Organics			
1,2,4,5-Tetrachlorobenzen	e UG/I		< 1 U
1.2_Dinitrobonzono			- 5 11
	00/L		
	UG/L		< I U
1,3-Dimethyl adamatane	UG/L		< 5 U
1,3-Dinitrobenzene	UG/L		< 5 U
1,4-Dinitrobenzene	UG/L		< 5 U
1-Chloronaphthalene			< 1 []
2216 Totrachlaranhanal			- 111
2,3,4,0-18110100000000	UG/L		<u> </u>

	Property Owner	PROPERTY OWNER C WELL LOCATED 5 FEET OFF OF NE CORNER OF HOUSE; INACCESSIBLE-WELL HEAD IS BURIED; SAMPLED FROM	PROPERTY OWNER C WELL LOCATED 5 FEET OFF OF NE CORNER OF HOUSE; INACCESSIBLE-WELL HEAD IS BURIED; SAMPLED FROM
	Location Description	BASEMENT SPIGOT	BASEMENT SPIGOT
	Source Type	WELL	WELL
C	Well Depth	260	260
Sampled	Before Treatment?	Pre-Treatment	Pre-Treatment
Demonstern en dumite	Sample ID	0429201113403	10/27/2011/20201
Parameter and units	Sample Date	4/29/2011 (Baseline)	
			< 10
2 4-Dichlorophenol	UG/L		< 1
2,4-Dimethylphenol	UG/L		< 1 U
2,4-Dinitrophenol	UG/L		< 29 U
2,4-Dinitrotoluene	UG/L		< 5 U
2,6-Dichlorophenol	UG/L		< 1 U
2,6-Dinitrotoluene	UG/L		< 1 U
2-Butoxyethanol	UG/L		< 5 U
2-Chloronaphthalene	UG/L		< 1 U
2-Chlorophenol	UG/L		< 1 U
2-Methylnaphthalene	UG/L		< 0.5 U
2-Methylphenol	UG/L		< 1 U
2-Nitroaniline	UG/L		< 1 U
2-Nitrophenoi	UG/L		< 1 U
2 Nitroapilipo	UG/L		< 5 U
4 4'-Methylenebis(2-chloroaniline)			
4 4'-Methylenebis(N N-dimethylani			< 14 11
4.6-Dinitro-2-methylphenol	UG/I		< 14 U
4-Bromophenyl phenyl ether	UG/L		< 1 U
4-Chloro-3-methylphenol	UG/L		< 1 U
4-Chloroaniline	UG/L		< 1 U
4-Chlorophenyl phenyl ether	UG/L		< 1 U
4-Methylphenol	UG/L		< 1 U
4-Nitroaniline	UG/L		< 1 U
4-Nitrophenol	UG/L		< 29 U
Acenaphthene	UG/L		< 0.5 U
Acenaphthylene	UG/L		< 0.5 U
Adamantana	UG/L		
Anthracene			< 0.511
Benzo (a) anthracene	UG/L		< 0.5 U
Benzo (a) pyrene	UG/L		< 0.5 U
Benzo (b) fluoranthene	UG/L		< 0.5 U
Benzo (g,h,i) perylene	UG/L		< 0.5 U
Benzo (k) fluoranthene	UG/L		< 0.5 U
Benzoic acid	UG/L		< 14 U
Benzyl alcohol	UG/L		< 14 U
Bis(2-chloroethoxy)methane	UG/L		< 1 U
Bis(2-chloroethyl)ether	UG/L		< 1 U
bis(2-Chloroisopropyl)ether	UG/L		< 1 U
Bis(2-ethylhexyl)phthalate	UG/L		< 5 U
	UG/L		< 5 U
Chlorobenzilate			
Chrysene			< 0.5 U
Diallate (cis or trans)	UG/L		< 5 U
Dibenz (a,h) anthracene	UG/L		< 0.5 U
Dibenzofuran	UG/L		< 1 U
Diethyl phthalate	UG/L		< 5 U
Dimethyl phthalate	UG/L		< 5 U
Di-n-butyl phthalate	UG/L		< 5 U
Di-n-octyl phthalate	UG/L		< 5 U
Dinoseb	UG/L		< 5 U
Disultoton	UG/L		< 48 U
	UG/L		< 5 U
Fluorantnene	UG/L		< 0.5 U

	Property Owner	PROPERTY OWNER C WELL LOCATED 5 FEET OFF OF NE CORNER OF HOUSE; INACCESSIBLE-WELL HEAD IS BURIED; SAMPLED FROM	PROPERTY OWNER C WELL LOCATED 5 FEET OFF OF NE CORNER OF HOUSE; INACCESSIBLE-WELL HEAD IS BURIED; SAMPLED FROM
	Location Description	BASEMENT SPIGOT	BASEMENT SPIGOT
	Source Type	VVELL	VVELL
	Sompled Defere Treatment?	200 Dro Trootmont	200 Dro Trootmont
	Sampled before Treatment?	0420201112402	1027201120201
Parameter and units	Sample TD Sample Date	1/20/2011 (Baseline)	10/27/2011
Fluorene			< 0.5 U
Hexachlorobenzene	UG/L		< 0.5 U
Hexachlorobutadiene	UG/L		< 1 U
Hexachlorocyclopentadier	Ne UG/L		< 14 U
Hexachloroethane	UG/L		< 5 U
Indeno (1,2,3-cd) pyrene	UG/L		< 0.5 U
Isophorone	UG/L		< 1 U
Naphthalene	UG/L		< 0.5 U
Nitrobenzene	UG/L		< 1 U
N-Nitrosodiethylamine	UG/L		< 1 U
N-Nitrosodimethylamine	UG/L		< 5 U
N-Nitrosodi-n-butylamine	UG/L		< 5 U
N-Nitrosodi-n-propylamin	e UG/L		< 1 U
N-Nitrosodiphenylamine	UG/L		< 1 U
N-Nillosomethylethylamir			< 5 U
Parathion mothyl			< 5 U
Pentachlorobenzene			
Pentachlorophenol			< 5 11
Phenanthrene	UG/L		< 0.5 U
Phenol	UG/L		< 1 U
Phorate	UG/L		< 1 U
Pronamide	UG/L		< 1 U
Pyrene	UG/L		< 0.5 U
Pyridine	UG/L		< 5 U
Squalene	UG/L		< 5 U
Terbufos	UG/L		< 5 U
Terpineol	UG/L		< 5 U
Tributoxyethyl phosphate	UG/L		< 5 U
Irifiuralin	UG/L		< 5 U
TICs			
1,2,3-Trimethylbenzene	UG/L		< 100 U
Volatile Organics			
1 1 1-Trichloroethane	LIG/I		< 1.00 []
1.1.2-Trichloroethane	UG/L		< 1.00 U
1,1-Dichloroethane	UG/L		< 1.00 U
1,1-Dichloroethene	UG/L		< 1.00 U
1,2,3-Trimethylbenzene	UG/L		< 1.00 U
1,2,4-Trichlorobenzene	UG/L		
1,2,4-Trimethylbenzene	UG/L		< 1.00 U
1,2-Dibromo-3-chloroprop	oane UG/L		< 0.1009 U
1,2-Dichlorobenzene	UG/L		< 1.00 U
1,2-Dichloroethane	UG/L		< 1.00 U
1,2-Dichloropropane	UG/L		
1,3,5-1 rimetnyibenzene	UG/L		< 1.00 U
	UG/L		< 1.00 U
			< 50.0 U
Benzene		< 0.500 []	< 1.00.11
Carbon disulfide	UG/I		< 1.00 U
Carbon Tetrachloride	UG/L		< 1.00 U
Chlorobenzene	UG/L		< 1.00 U
Chloroform	UG/L		< 1.00 U
cis-1,2-Dichloroethene	UG/L		< 1.00 U
Diisopropyl Ether	UG/L		< 1.00 U
Ethanol	UG/L		< 100 U
Ethyl tert-Butyl Ether	UG/L		< 1.00 U
Ethylbenzene	UG/L	< 0.500 U	< 1.00 U

	Property Owner Location Description Source Type Well Depth	PROPERTY OWNER C WELL LOCATED 5 FEET OFF OF NE CORNER OF HOUSE; INACCESSIBLE-WELL HEAD IS BURIED; SAMPLED FROM BASEMENT SPIGOT WELL 260	PROPERTY OWNER C WELL LOCATED 5 FEET OFF OF NE CORNER OF HOUSE; INACCESSIBLE-WELL HEAD IS BURIED; SAMPLED FROM BASEMENT SPIGOT WELL 260
	Sampled Before Treatment?	Pre-Treatment	Pre-Treatment
	Sample ID	0429201113403	1027201120201
Parameter and units	Sample Date	4/29/2011 (Baseline)	10/27/2011
Hexachlorobutadiene	UG/L		< 1 U
Isopropyl alcohol	UG/L		< 50.0 U
Isopropylbenzene	UG/L		< 1.00 U
m,p-Xylene	UG/L		< 2.00 U
Methoxychlor	UG/L		< 0.0472 U
Methyl tert-Butyl Ether	UG/L		< 1.00 U
Methylene Chloride	UG/L		< 5.00 U
Naphthalene	UG/L		< 5.00 U
o-Xylene	UG/L		< 1.00 U
Styrene	UG/L		
Tert-Amyl Methyl Ether	UG/L		< 1.00 U
Tertiary Butyl Alcohol	UG/L		< 10.0 U
Tetrachloroethene	UG/L		< 1.00 U
Tetrahydrofuran	UG/L		
Toluene	UG/L	< 0.500 U	< 1.00 U
trans-1,2-Dichloroethene	UG/L		< 1.00 U
Trichloroethene	UG/L		< 1.00 U
Vinyl chloride	UG/L		< 1.00 U
Xylenes, total	UG/L	< 0.500 U	< 3.00 U

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended holding time

J : Estimated value

J : Estimated value --- : Parameter not analyzed. B : Blank qualified ug/L : Micrograms per liter mg/L : Milligrams per liter NA : Not Available NTU : Nephelometric Turbidity Unit umho/cm : Micromhos per centimeter colonies/100 ml : Colonies per 100 millileters



APPENDIX A-4 EPA STUDY WELL DATA PROPERTY OWNER D

	Property Owner	PROPERTY OWNER D	PROPERTY OWNER D	PROPERTY OWNER D
	Location Description	WELL	\A/ELL	WELL
	Source Type	2EO	250	2EO
S	ampled Refore Treatment?	NA	Pre-Treatment	Pre-Treatment
5		NTA0535-01102010-1600	0610201124603	1028201120201
Parameter and units	Sample Date	1/10/2010 (Baseline)	6/10/2011	10/28/2011
	Sumple Date		0/10/2011	10/20/2011
Aldehydes				
Gluteraldehyde	UG/L			
Bacteria				
E. coli	colonies/100ml			Absent
Fecal coliform bacteria	colonies/100ml			< 1 U
Total Coliform Bacteria	colonies/100ml			Present
0000				
1.2 Dibromo 2 obloropropo	no 110 <i>1</i> 1			. 0 1014 11
I,2-Dibromo-3-chioropropai	ne UG/L			< 0.1014 0
Extractable Petroleum Hydi	rocarbons			
Diesel	UG/L			< 95.2 U
Conoral Chamisters				
Alkalinity Total (CaCO2)	MC/I			224
Ammonia as N	MG/L			< 0.100 U
Bicarbonate Alkalinity as Ca		248	216	221
Bromide	MG/L	240		< 2.5 []
Carbonate as CaCO3	MG/L	21.2	55.7	< 10.0 []
Chloride	MG/L	13.2 F	22.3.1	12.6
CO2 by Headspace	UG/L			< 12000 U
Cyanide	MG/L			
Fluoride	MG/L			0.66
MBAS	MG/L	0.0985	< 0.0500 U	< 0.12 U
Nitrate	MG/L			
Nitrate Nitrogen	MG/L			< 0.50 U
Nitrite Nitrogen	MG/L			< 0.50 UJ
Oil & Grease HEM	MG/L	< 5.81 U	< 6.02 U	< 4.30 U
рН	pH UNITS	8.20 H	8.80 H	8.10 H
Phosphorus	MG/L			< 0.100 U
Specific conductance	UMHO/CM	532	614	462
Sulfate	MG/L	7.79	5.23	12.1 J
Temperature of pH determine	nation CELSIUS	21.2 H	23.0 H	21.0 H
Total Dissolved Solids	MG/L	310	335	211
	MG/L	< 1.00 U	< 1.00 0	< 1.00 0
Turblatty	NIU	< 1.00 0	1.74	0.89
Glycols				
1,2-Propylene Glycol	MG/L			
Diethylene Glycol	MG/L			< 10 U
Ethylene Glycol	MG/L			
Tetraethylene glycol	MG/L			< 10 UJ
Triethylene glycol	MG/L			< 10 U
Light Gases				
Acetylene	MG/L			< 0.00500 U
Ethane	MG/L	< 0.0260 U	< 0.0260 U	< 0.00500 U
Ethene	MG/L			< 0.00500 U
Methane	MG/L	3.55	4.81	2.11 J
n-Butane	MG/L			< 0.00500 U
Propane	MG/L	< 0.0340 U	< 0.0340 U	< 0.00500 U
Low Molecular Weight Acid	۲ ۵			
Acetic Acid	UG/I			< 10000 U
Butyric Acid	UG/I			< 10000 U
Formic Acid	UG/L			< 10000 U
Isobutyric acid	UG/L			< 10000 U
Lactic acid	UG/L			< 5000 U
Propionic Acid	UG/L			< 13000 U

	Property Owner	PROPERTY OWNER D	PROPERTY OWNER D	PROPERTY OWNER D
	Location Description	WELL	\//ELL	\\/ELL
	Source Type	VVELL	VVELL	VVELL
	Sampled Refere Treatment?	250	Dro Troatmont	250 Pro Troatmont
	Sampled before Treatment?	NTA0525 01102010 1600	0610201124603	1028201120201
Parameter and units	Sample Date	1/10/2010 (Baseline)	6/10/2011	10/28/2011
	Sample Date		0/10/2011	10/20/2011
Metals, 6020x				
Cesium	MG/L			0.00023
Cesium, Dissolved	MG/L			0.00022
Potassium Dissolved	MG/L			1.9
Potassium, Dissolved	MG/L			Γ.1
Silicon Dissolvod	MG/L			5
Thorium	MG/L			< 0.002 []
Thorium Dissolved	MG/L			< 0.002.0
Uranium	MG/L			< 0.002.0
Uranium, Dissolved	MG/L			< 0.001 U
Metals, Total				< 0.0200.11
Arsenic	MG/L	< 0.0100 []	< 0.0100 []	
Barium	MG/L	0.327	0.297	0.291
Bervllium	MG/L			< 0.00200 U
Boron	MG/L			0.234
Cadmium	MG/L	< 0.00100 U	< 0.00100 U	< 0.00100 U
Calcium	MG/L	8.3	11.2	26.8
Chromium	MG/L	< 0.00500 U	< 0.00500 U	< 0.00200 U
Cobalt	MG/L			< 0.00200 U
Copper	MG/L			< 0.00500 U
Hardness, CaCO3	MG/L			
Iron	MG/L	0.0534	< 0.0500 U	< 0.0500 U
Lead	MG/L	< 0.00500 U	< 0.00500 U	< 0.00200 U
Lithium	MG/L			
Magnesium	MG/L	3.72	3.64	8.48
Manganese	MG/L	< 0.0150 U	< 0.0150 U	0.0127
Mercury	MG/L	< 0.000200 U	< 0.000200 U	< 0.000200 U
Molybdenum	MG/L			< 0.00500 U
Nickel	MG/L			< 0.00500 0
Potassium	MG/L	1.93	1.53	
Silvor	MG/L	< 0.0100 0	< 0.00500 U	< 0.00200 0
Sodium	MG/L	109	11/	65.6
Strontium	MG/L		0.672	0.705
Sulfur	MG/L	< 5.000 U	8.09	3.39
Thallium	MG/L			< 0.00200 U
Titanium	MG/L			< 0.00200 U
Vanadium	MG/L			< 0.00400 U
Zinc	MG/L			< 0.0500 U
Metals, Dissolved				< 0.0200 H
Antimony Dissolved	MG/L			
Arconic Dissolved				
Barium Dissolved				0.00200 0
Beryllium Dissolved	MG/L			< 0.00200 11
Boron. Dissolved	MG/L			0.239
Cadmium. Dissolved	MG/I			< 0.00100 []
Calcium, Dissolved	MG/L			26.2
Chromium, Dissolved	MG/L			< 0.00200 U
Cobalt, Dissolved	MG/L			< 0.00200 U
Copper, Dissolved	MG/L			< 0.00500 U
Iron, Dissolved	MG/L			< 0.0500 U
Lead, Dissolved	MG/L			< 0.00200 U
Magnesium, Dissolved	MG/L			8.24

	Property Owner	PROPERTY OWNER D	PROPERTY OWNER D	PROPERTY OWNER D
	Leasting Description			
		WELL	WELL	W/FLI
	Well Depth	250	250	250
S	ampled Before Treatment?	NA	Pre-Treatment	Pre-Treatment
	Sample ID	NTA0535-01102010-1600	0610201124603	1028201120201
Parameter and units	Sample Date	1/10/2010 (Baseline)	6/10/2011	10/28/2011
Manganese, Dissolved	MG/L			0.0112
Mercury, Dissolved	MG/L			< 0.000200 U
Molybdenum, Dissolved	MG/L			< 0.00500 U
Nickel, Dissolved	MG/L			< 0.00500 U
Potassium, Dissolved	MG/L			1.69
Selenium, Dissolved	MG/L			< 0.00200 U
Silver, Dissolved	MG/L			< 0.00200 U
Sodium, Dissolved	MG/L			64.6
Strontium, Dissolved	MG/L			0.694
Sulfur, Dissolved	MG/L			3.46
Titanium, Dissolved	MG/L			< 0.00200 U
Vanadium Dissolved	MG/L			< 0.00200 0
	MG/L			< 0.0500 U
	IVIO/L			< 0.0300 0
Miscellaneous Organics				
Inorganic Carbon, Dissolved	d MG/L			50.6
Organic Carbon, Dissolved	MG/L			< 1.00 U
Pesticides and PCRs				
4.4'-DDD	LIG/I			< 0.0481 []
4.4'-DDE	UG/L			< 0.0481 U
4.4'-DDT	UG/L			< 0.0481 U
Aldrin	UG/L			< 0.0481 U
alpha-BHC	UG/L			< 0.0481 U
Azinphos-methyl	UG/L			< 1.0 UHJ
beta-BHC	UG/L			< 0.0481 U
Carbaryl	UG/L			< 6.0 U
delta-BHC	UG/L			< 0.0481 U
Dichlorvos	UG/L			< 1.0 UHJ
Dieldrin	UG/L			< 0.0481 U
Disulfoton	UG/L			< 1.0 UHJ
Endosulfan I	UG/L			< 0.0481 U
Endosulfan II	UG/L			< 0.0481 U
Endosulfan sulfate	UG/L			< 0.0481 U
Endrin Endrin oldobydo	UG/L			< 0.0481 U
Endrin aldenyde	UG/L			< 0.0481 U
amma_BHC (Lindane)	UG/L			< 0.0481 0
Hentachlor				< 0.04010
Heptachlor epoxide				< 0.0481 []
Malathion	UG/I			< 1.0 UHJ
Methoxychlor	UG/L			< 0.0481 U
Mevinphos	UG/L			< 1.0 UHJ
Purgeable Petroleum Hydro	ocarbons			100.11
GRU as Gasoline	UG/L			< 100 U
Semivolatile Organics				
1,2,4,5-Tetrachlorobenzene	UG/L			< 1 U
1,2-Dinitrobenzene	UG/L			< 5 U
1,2-Diphenylhydrazine	UG/L			< 1 U
1,3-Dimethyl adamatane	UG/L			< 5 U
1,3-Dinitrobenzene	UG/L			< 5 U
1,4-Dinitrobenzene	UG/L			< 5 U
1-Chloronaphthalene	UG/L			< 1 U
2,3,4,6-Tetrachlorophenol	UG/L			< 1 U
2,4,5-Irichlorophenol	UG/L			< 1 U
2,4,6- I richlorophenol	UG/L			< 1 U
2,4-Dichlorophenol	UG/L			< 1 U
2,4-Dimethylphenol	UG/L			< 1 U
2,4-Dinitrophenol	UG/L			< 29 U
2,4-DINITrotoluene	UG/L			< 5 U

	Property Owner	PROPERTY OWNER D	PROPERTY OWNER D	PROPERTY OWNER D
	Location Description)A/EL1	\A/ELL	\\/ELL
	Woll Dopth	250	250	250
Sampled F	Refore Treatment?	NΔ	Pre-Treatment	250 Pre-Treatment
Sampled L		NTA0535-01102010-1600	0610201124603	1028201120201
Parameter and units	Sample Date	1/10/2010 (Baseline)	6/10/2011	10/28/2011
2 6-Dichlorophenol				< 1
2.6-Dinitrotoluene	UG/I			< 1 U
2-Butoxvethanol	UG/L			< 5 UJ
2-Chloronaphthalene	UG/L			< 1 U
2-Chlorophenol	UG/L			< 1 U
2-Methylnaphthalene	UG/L			< 0.5 U
2-Methylphenol	UG/L			< 1 U
2-Nitroaniline	UG/L			< 1 U
2-Nitrophenol	UG/L			< 1 U
3,3-Dichlorobenzidine	UG/L			< 5 U
3-Nitroaniline	UG/L			< 1 U
4,4'-Methylenebis(2-chloroaniline)	UG/L			< 14 U
4,4 - Methylehebis(N,N-dimethylanilin	UG/L			< 14 UJ
4.Bromonbenyl phenyl ather				< 14 U 2 1 I I
4-Chloro-3-methylphenol				< 1
4-Chloroaniline	UG/L			< 1 U
4-Chlorophenyl phenyl ether	UG/L			< 1 U
4-Methylphenol	UG/L			< 1 U
4-Nitroaniline	UG/L			< 1 UJ
4-Nitrophenol	UG/L			< 29 U
Acenaphthene	UG/L			< 0.5 U
Acenaphthylene	UG/L			< 0.5 U
Acetophenone	UG/L			< 1 U
Adamantane	UG/L			< 5 U
Aniline	UG/L			< 1 U
Anthracene Renze (a) anthracene	UG/L			< 0.5 U
Benzo (a) antinacene	UG/L			< 0.5 U
Benzo (b) fluoranthene				< 0.5 U
Benzo (g.h.i) pervlene	UG/I			< 0.5 U
Benzo (k) fluoranthene	UG/L			< 0.5 U
Benzoic acid	UG/L			< 14 U
Benzyl alcohol	UG/L			< 14 U
Bis(2-chloroethoxy)methane	UG/L			< 1 U
Bis(2-chloroethyl)ether	UG/L			< 1 U
bis(2-Chloroisopropyl)ether	UG/L			< 1 U
Bis(2-ethylhexyl)phthalate	UG/L			< 5 U
Butyl benzyl phthalate	UG/L			< 5 U
Chlorobonzilata	UG/L			< 1 U
Chrysone	UG/L			
Diallate (cis or trans)				< 0.5 0
Dibenz (a.h) anthracene				< 0.5 U
Dibenzofuran	UG/L			< 1 U
Diethyl phthalate	UG/L			< 5 U
Dimethyl phthalate	UG/L			< 5 U
Di-n-butyl phthalate	UG/L			< 5 U
Di-n-octyl phthalate	UG/L			< 5 U
Dinoseb	UG/L			< 5 U
Disulfoton	UG/L			< 48 U
d-Limonene	UG/L			< 5 U
	UG/L			< 0.5 U
	UG/L			< U.5 U
Hexachlorobutadiono	UG/L			< U.3 U _ 1 II
Hexachlorocyclopentadiepo				< T U 2 1/11
Hexachloroethane	LIG/I			< 5
Indeno (1.2.3-cd) pyrene	UG/L			< 0.5 U
Isophorone	UG/L			< 1 U
Naphthalene	UG/L			< 0.5 U
				-

	Property Owner	PROPERTY OWNER D	PROPERTY OWNER D	PROPERTY OWNER D
	Location Description	WELL	\A/ELL	\//ELL
	Well Dopth	250	250	250
S	Sampled Before Treatment?	250 NA	Dro-Troatmont	Dro-Troatmont
J		NTA0535-01102010-1600	0610201124603	1028201120201
Parameter and units	Sample TD	1/10/2010 (Baseline)	6/10/2011	10/28/2011
Nitrobenzene			0/10/2011	< 1
N-Nitrosodiethylamine				< 1
N-Nitrosodimethylamine	UG/L			< 5 U
N-Nitrosodi-n-butylamine	UG/L			< 5 U
N-Nitrosodi-n-propylamine	UG/L			< 1 U
N-Nitrosodiphenylamine	UG/L			< 1 U
N-Nitrosomethylethylamine	e UG/L			< 5 U
Parathion-ethyl	UG/L			< 5 U
Parathion-methyl	UG/L			< 5 U
Pentachlorobenzene	UG/L			< 1 U
Pentachlorophenol	UG/L			< 5 UJ
Phenanthrene	UG/L			< 0.5 U
Phenol	UG/L			< 1 U
Phorate	UG/L			< 1 U
Pronamide	UG/L			< 1 U
Pyrene	UG/L			< 0.5 U
Pyridine	UG/L			< 5 U
Squalene	UG/L			< 5 UJ
	UG/L			< 5 U
Ierpineol	UG/L			< 5 U
Tributoxyethyi phosphate	UG/L			< 5 UJ
	UG/L			< 5 U
TICs				
1,2,3-Trimethylbenzene	UG/L			
Valatila Organias				
1 1 1 Trichloroothano				< 1.00 []
1,1,1-Trichloroothano				< 1.00 U
1,1,2-11chloroothano				< 1.00 U
1 1-Dichloroethene				< 1.00 U
1 2 3-Trimethylbenzene				< 1.00 U
1 2 4-Trichlorobenzene				
1,2,4-Trimethylbenzene	UG/L			< 1.00 U
1,2-Dibromo-3-chloropropa	ane UG/L			< 0.1014 U
1,2-Dichlorobenzene	UG/L			< 1.00 U
1,2-Dichloroethane	UG/L			< 1.00 U
1,2-Dichloropropane	UG/L			
1,3,5-Trimethylbenzene	UG/L			< 1.00 U
1,3-Dichlorobenzene	UG/L			< 1.00 U
1,4-Dichlorobenzene	UG/L			< 1.00 U
Acetone	UG/L			< 50.0 U
Benzene	UG/L	< 0.500 U	< 0.500 U	< 1.00 U
Carbon disulfide	UG/L			< 1.00 U
Carbon Tetrachloride	UG/L			< 1.00 U
Chlorobenzene	UG/L			< 1.00 U
Chlorotorm	UG/L			< 1.00 U
CIS-1,2-DICNIOROEThene	UG/L			< 1.00 U
Ethanol	UG/L			< 1.00 U
Ethyl tort Dutyl Ethor	UG/L			< 100 U
Ethyllenzene	UG/L			
Hexachlorohutadiene	UG/L	< 0.000 0	< 0.000 0	2 1 11
				< 50.011
Isopropylbenzene				< 1.00 []
m,p-Xvlene	UG/I			< 2.00 U
Methoxychlor	UG/I			< 0.0481 U
Methyl tert-Butvl Ether	UG/L			< 1.00 U
Methylene Chloride	UG/L			< 5.00 U
Naphthalene	UG/L			< 5.00 U
o-Xylene	UG/L			< 1.00 U
Styrene	UG/L			

	Property Owner	PROPERTY OWNER D	PROPERTY OWNER D	PROPERTY OWNER D
	Location Description			
	Source Type	WELL	WELL	WELL
	Well Depth	250	250	250
	Sampled Before Treatment?	NA	Pre-Treatment	Pre-Treatment
	Sample ID	NTA0535-01102010-1600	0610201124603	1028201120201
Parameter and units	Sample Date	1/10/2010 (Baseline)	6/10/2011	10/28/2011
Tert-Amyl Methyl Ether	UG/L			< 1.00 U
Tertiary Butyl Alcohol	UG/L			< 10.0 U
Tetrachloroethene	UG/L			< 1.00 U
Tetrahydrofuran	UG/L			
Toluene	UG/L	< 0.500 U	< 0.500 U	< 1.00 U
trans-1,2-Dichloroethene	UG/L			< 1.00 U
Trichloroethene	UG/L			< 1.00 U
Vinyl chloride	UG/L			< 1.00 U
Xylenes, total	UG/L	< 0.500 U	< 0.500 U	< 3.00 U

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended

holding time

holding time J : Estimated value --- : Parameter not analyzed. B : Blank qualified ug/L : Micrograms per liter mg/L : Milligrams per liter NA : Not Available NTU : Nephelometric Turbidity Unit umho/cm : Micromhos per centimeter colonies/100 ml : Colonies per 100 millileters



APPENDIX A-5 EPA STUDY WELL DATA PROPERTY OWNER E

	Property Owner	PROPERTY OWNER E WELL IS LOCATED NORTH OF	PROPERTY OWNER E	PROPERTY OWNER E WELL IS LOCATED NORTH OF	PROPERTY OWNER E WELL IS LOCATED NORTH OF	PROPERTY OWNER E WELL IS LOCATED NORTH OF	PROPERTY OWNER E	PROPERTY OWNER E WELL IS LOCATED IN BUSHES IN	PROPERTY OWNER E WELL IS LOCATED IN BUSHES IN
	Location Description	BARN.		BARN.	BARN.	BARN.		FRONT OF HOUSE.	FRONT OF HOUSE.
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	115	115	115	115	185	185	185	185
				0109201150102	110/201120206	NA NTD0202 04012010 1545		0109201150101	1104201120204
Daramator and units	Sample ID	1/1/2010 (Pasalina)	0/12/2010	1/9/2011	11/4/2011	1/1/2010 (Paceline)	0/12/2010	1/9/2011	11/4/2011
	Sample Date	4/1/2010 (Baseline)	8/12/2010	1/8/2011	11/4/2011	4/1/2010 (Baseline)	8/12/2010	1/8/2011	11/4/2011
Aldehydes									
Gluteraldehyde	UG/L								
Racteria									
F. coli	colonies/100ml				Absent				Absent
Fecal coliform bacteria	colonies/100ml				< 1 U				< 1 U
Total Coliform Bacteria	colonies/100ml				Absent				Absent
					0.4040.11				0.1002.11
1,2-Dibromo-3-chioropro	pane UG/L				< 0.1012 U				< 0.1003 0
Extractable Petroleum H	ydrocarbons								
Diesel	UG/L				< 94.3 U				< 94.3 U
Conoral Chamiotry									
					110				100
	MG/L				1 00				0.503
Bicarbonate Alkalinity as		134	125	118	1.07	147	131 H2	128	126
Bromide	MG/L				< 2.5 U				< 2.5 U
Carbonate as CaCO3	MG/L	< 10.0 U	ND	< 10 U	< 10.0 U	< 10.0 U	ND H2	< 10 U	< 10.0 U
Chloride	MG/L	31.4	32.4	30.2	30.8 J	20.1	21.2	8.4	17.4 J
CO2 by Headspace	UG/L				< 12000 U				< 12000 U
Cyanide	MG/L								
Fluoride	MG/L				< 0.50 U				< 0.50 U
MBAS	MG/L	< 0.0500 U	ND	< 0.05 UJH	< 0.12 U	< 0.0500 U	ND	< 0.05 UJH	< 0.12 U
Nitrate	MG/L								
Nitrate Nitrogen	MG/L				< 0.50 U				2.3
Nitrite Nitrogen	MG/L				< 0.50 U				< 0.50 U
Oil & Grease HEM	MG/L	< 5.75 U	ND	< 5.56 U	< 5.56 U	< 5.75 U	ND	< 6.33 U	< 5.00 U
pH	pH UNITS	7.70 H	7.90 HTI	8.3 JH	7.90 H	7.70 H	7.80 HTI	8.1 JH	7.50 H
Phosphorus	MG/L				< 0.100 U				< 0.100 U
Specific conductance	UMHO/CM	331	329	375	319	328	321	334	306
Sulfate	MG/L	< 1.00 U		< 5 U	< 5.0 0	5.43	6.26 22.0.11TL	13.8	12.1
Temperature of pH deter		23.1 П	100	22.3 H	21.0 H	22.9 H	22.0 ΠΠ	22 F	21.0 H
Total Suspended Solids	MG/L		ND			< 1.00 U	ND	11	152 J
Turbidity	NTI	< 1.00 U	ND	< 1 H	< 0.30 []	17	14	1.8 IH	4.9
Tarbiarty	NIG			< 1 0511	< 0.50 0		1.4	1.0 311	
Glycols									
1,2-Propylene Glycol	MG/L								
Diethylene Glycol	MG/L				13 JB				< 10 U
Ethylene Glycol	MG/L								
Tetraetnylene glycol	MG/L				20 IB 50 JRJ				< 10 UJ
	MG/L				20 JB				< 10 0
Light Gases									
Acetylene	MG/L				< 0.00500 U				< 0.00500 U
Ethane	MG/L	0.049	0.0495	0.0838	0.0816	< 0.0260 U	ND	< 0.026 U	< 0.00500 U
Ethene	MG/L				< 0.00500 U				< 0.00500 U
Methane	MG/L	33.8	34.7	35.8	37.1 J	8.88	9.68	0.239	0.609
n-Butane	MG/L				< 0.00500 U				< 0.00500 U
Propane	MG/L	< 0.0340 U	ND	< 0.034 U	< 0.00500 U	< 0.0340 U	ND	< 0.034 U	< 0.00500 U
Low Molecular Weight A	cids								
Acetic Acid	UG/L				< 10000 U				< 10000 U
Butyric Acid	UG/L				< 10000 U				< 10000 U
Formic Acid	UG/L				< 10000 U				< 10000 U
Isobutyric acid	UG/L				< 10000 U				< 10000 U
Lactic acid	UG/L				< 5000 U				< 5000 U
Propionic Acid	UG/L				< 13000 U				< 13000 U

	Property Owner	PROPERTY OWNER E	PROPERTY OWNER E	PROPERTY OWNER E	PROPERTY OWNER E	PROPERTY OWNER E	PROPERTY OWNER E	PROPERTY OWNER E	PROPERTY OWNER E
	Location Description	WELL IS LOCATED NORTH OF		WELL IS LOCATED NORTH OF	WELL IS LOCATED NORTH OF	WELL IS LOCATED NORTH OF		WELL IS LOCATED IN BUSHES IN	WELL IS LOCATED IN BUSHES IN
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	115	115	115	115	185	185	185	185
	Sampled Before Treatment?	NA	NA	NA	NA	NA	NA	Pre-Treatment	Pre-Treatment
	Sample ID	NTD0308-04012010-1625	NTH1162-PROPERTY OWNER E 002	0108201150103	1104201120206	NTD0293-04012010-1545	NTH1160-PROPERTY OWNER E 001	0108201150101	1104201120204
Parameter and units	Sample Date	4/1/2010 (Baseline)	8/12/2010	1/8/2011	11/4/2011	4/1/2010 (Baseline)	8/12/2010	1/8/2011	11/4/2011
Metals, 6020x									
Cesium	MG/L				< 0.1 U				< 0.1 U
Cesium, Dissolved	MG/L				< 0.1 U				< 0.1 U
Potassium Dissolved	MG/L				< 100 U				< 100 U
Silicon	MG/L				< 2500 []				< 2500 U
Silicon, Dissolved	MG/L				< 2500 U				< 2500 U
Thorium	MG/L				< 2 U				< 2 U
Thorium, Dissolved	MG/L				< 2 U				< 2 U
Uranium	MG/L				< 1 U				< 1 U
Uranium, Dissolved	MG/L				< 1 U				< 1 U
Motals Total									
Aluminum	MG/I				< 0.020011				0.0424
Antimony	MG/L				< 0.00200 U				< 0.00200 U
Arsenic	MG/L	< 0.0100 U	ND	< 0.01 U	< 0.00200 U	< 0.0100 U	ND	< 0.01 U	< 0.00200 U
Barium	MG/L	0.965	1	1.04	0.947	0.36	0.352	0.278	0.28
Beryllium	MG/L				< 0.00200 U				< 0.00200 U
Boron	MG/L				0.063				< 0.0500 U
Cadmium	MG/L	< 0.00100 U	ND 20.4	< 0.001 U	< 0.00100 U	< 0.00100 U	ND 20.1	< 0.001 U	< 0.00100 U
Chromium	MG/L	<u></u>	28.4	<u> </u>	30.2	30.6	30. I	41.6	43.9
Cobalt	MG/L	< 0.00500 0		< 0.005 0	< 0.00200 0	< 0.00500 0		< 0.005 0	< 0.00200 U
Copper	MG/L				< 0.00500 U				0.00776
Hardness, CaCO3	MG/L								
Iron	MG/L	0.0629	0.106	< 0.05 U	< 0.0500 U	< 0.0500 U	ND	< 0.05 U	0.069
Lead	MG/L	< 0.00500 U	ND	< 0.005 U	< 0.00200 U	< 0.00500 U	ND	< 0.005 U	< 0.00200 U
Lithium	MG/L								
Magnesium	MG/L	2.92	3.02	3.15	3.16	4.01	4.17	5.58	5.73
Manganese	MG/L	0.118	0.127	0.133	0.00020011		0.0788	< 0.015 0	
Molybdenum	MG/L	< 0.000200 0		< 0.0002 0	< 0.000200 0	< 0.000200 0		< 0.0002 0	< 0.000200 0
Nickel	MG/L				< 0.00500 U				< 0.00500 U
Potassium	MG/L	1.09	1.2	1.32	1.16	< 1.00 U	1.02	1.03	< 1.00 U
Selenium	MG/L	< 0.0100 U	ND	< 0.01 U	< 0.00200 U	< 0.0100 U	ND	< 0.01 U	< 0.00200 U
Silver	MG/L	< 0.00500 U	ND	< 0.005 U	< 0.00200 U	< 0.00500 U	ND	< 0.005 U	< 0.00200 U
Sodium	MG/L	34	36.2	37.1	35.5	27.7	32.9 MHA	15.6	15
Sulfur	MG/L		 ND		0.857			2 00	0.577
Thallium	MG/L	< 5.000 0			< 0.00200 []		0.4	2.77	< 0.00200.11
Titanium	MG/L				< 0.00200 U				< 0.00200 U
Vanadium	MG/L				< 0.00400 U				< 0.00400 U
Zinc	MG/L				< 0.0500 U				< 0.0500 U
Metals Dissolved									
Aluminum, Dissolved	MG/L				< 0.0200 U				< 0.0200 U
Antimony, Dissolved	MG/L				< 0.00200 U				< 0.00200 U
Arsenic, Dissolved	MG/L				< 0.00200 U				< 0.00200 U
Barium, Dissolved	MG/L				0.938				0.273
Beryllium, Dissolved	MG/L				< 0.00200 U				< 0.00200 U
Boron, Dissolved	MG/L				0.0636				< 0.0500 U
Calcium, Dissolved	MG/L				< 0.00100 U				< 0.00100 U
Chromium Dissolved	MG/L								
Cobalt. Dissolved	MG/L				< 0.00200 U				< 0.00200 U
Copper, Dissolved	MG/L				< 0.00500 U				< 0.00500 U
Iron, Dissolved	MG/L				< 0.0500 U				< 0.0500 U
Lead, Dissolved	MG/L				< 0.00200 U				< 0.00200 U
Magnesium, Dissolved	MG/L				2.98				5.51

	Property Owner Location Description	PROPERTY OWNER E WELL IS LOCATED NORTH OF BARN.	PROPERTY OWNER E	PROPERTY OWNER E WELL IS LOCATED NORTH OF BARN.	PROPERTY OWNER E WELL IS LOCATED NORTH OF BARN.	PROPERTY OWNER E WELL IS LOCATED NORTH OF BARN.	PROPERTY OWNER E	PROPERTY OWNER E WELL IS LOCATED IN BUSHES IN FRONT OF HOUSE.	PROPERTY OWNER E WELL IS LOCATED IN BUSHES IN FRONT OF HOUSE.
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	115	115	115	115	185	185	185	185
	Sampled Before Treatment?	NA	NA	NA	NA	NA	NA	Pre-Treatment	Pre-Treatment
	Sample ID	NTD0308-04012010-1625	NTH1162-PROPERTY OWNER E 002	0108201150103	1104201120206	NTD0293-04012010-1545	NTH1160-PROPERTY OWNER E 001	0108201150101	1104201120204
Parameter and units	Sample Date	4/1/2010 (Baseline)	8/12/2010	1/8/2011	11/4/2011	4/1/2010 (Baseline)	8/12/2010	1/8/2011	11/4/2011
Manganese, Dissolved	MG/L				0.113				0.017
Mercury, Dissolved	MG/L				< 0.000200 U				< 0.000200 U
Molybdenum, Dissolved	MG/L				< 0.00500 U				< 0.00500 U
Nickel, Dissolved	MG/L				< 0.00500 U				< 0.00500 U
Potassium, Dissolved	MG/L				1.14				< 1.00 U
Selenium, Dissolved	MG/L				< 0.00200 U				< 0.00200 U
Silver, Dissolved	MG/L				< 0.00200 U				< 0.00200 U
Sodium, Dissolved	MG/L				34.5 J				15
Strontium, Dissolved	MG/L				0.806				0.559
Sulfur, Dissolved	MG/L				< 0.500 U				2.94
Thallium, Dissolved	MG/L				< 0.00200 U				< 0.00200 U
Titanium, Dissolved	MG/L				< 0.00200 U				< 0.00200 U
Vanadium, Dissolved	MG/L				< 0.00400 U				< 0.00400 U
Zinc, Dissolved	MG/L				< 0.0500 U				< 0.0500 U
Missollanoous Organias									
Inorgania Carbon Disaste	od No."								27.0
Organic Carbon, Dissolv					20.0				21.9
	u MG/L				< 1.00 0				< 1.00 0
Pesticides and PCBs									
4,4'-DDD	UG/L				< 0.0236 U				< 0.0236 U
4,4'-DDE	UG/L				< 0.0236 U				< 0.0236 U
4,4'-DDT	UG/L				< 0.0236 U				< 0.0236 U
Aldrin	UG/L				< 0.0236 U				< 0.0236 U
alpha-BHC	UG/L				< 0.0236 U				< 0.0236 U
Azinphos-methyl	UG/L				< 0.96 U				< 0.96 U
beta-BHC	UG/L				< 0.0236 U				< 0.0236 U
Carbaryl	UG/L				< 6.0 U				< 6.0 U
delta-BHC	UG/L				< 0.0236 U				< 0.0236 U
Dichlorvos	UG/L				< 0.96 U				< 0.96 U
Dieldrin	UG/L				< 0.0236 U				< 0.0236 U
Disulfoton	UG/L				< 0.96 U				< 0.96 U
Endosulfan I	UG/L				< 0.0236 U				< 0.0236 U
Endosulfan II	UG/L				< 0.0236 U				< 0.0236 U
Endosulfan sulfate	UG/L				< 0.0236 U				< 0.0236 U
Endrin	UG/L				< 0.0236 U				< 0.0236 U
Endrin aldehyde	UG/L				< 0.0236 U				< 0.0236 U
Endrin ketone	UG/L				< 0.0236 U				< 0.0236 U
gamma-BHC (Lindane)	UG/L				< 0.0236 U				< 0.0236 U
Heptachlor	UG/L				< 0.0236 U				< 0.0236 U
Heptachlor epoxide	UG/L				< 0.0236 U				< 0.0236 U
Malathion	UG/L				< 0.96 U				< 0.96 U
Methoxychlor	UG/L				< 0.0236 U				< 0.0236 U
Mevinphos	UG/L				< 0.96 U				< 0.96 U
Durgooble Detrolours II.	Irocarbanc								
Purgeable Petroleum Hyd	rocarbons				. 100 II				100.11
GRU as Gasoline	UG/L				< 100 0				< 100 0
Semivolatile Organics									
1,2,4,5-Tetrachlorobenzer	ne UG/L				< 1 U				< 0.9 U
1,2-Dinitrobenzene	UG/L				< 5 U				< 5 U
1,2-Diphenylhydrazine	UG/L				< 1 U				< 0.9 U
1,3-Dimethyl adamatane	UG/L				< 5 U				< 5 U
1,3-Dinitrobenzene	UG/L				< 5 U				< 5 U
1,4-Dinitrobenzene	UG/L				< 5 U				< 5 U
1-Chloronaphthalene	UG/L				< 1 U				< 0.9 U
2,3,4,6-Tetrachlorophenol	UG/L				< 1 U				< 0.9 U
2,4,5-Trichlorophenol	UG/L				< 1 U				< 0.9 U
2,4,6-Trichlorophenol	UG/L				< 1 U				< 0.9 U
2,4-Dichlorophenol	UG/L				< 1 U				< 0.9 U
2,4-Dimethylphenol	UG/L				< 1 U				< 0.9 U
2,4-Dinitrophenol	UG/L				< 29 U				< 28 U
2,4-Dinitrotoluene	UG/L				< 5 U				< 5 U

	Property Owner	PROPERTY OWNER E WELL IS LOCATED NORTH OF BARN.	PROPERTY OWNER E	PROPERTY OWNER E WELL IS LOCATED NORTH OF BARN.	PROPERTY OWNER E WELL IS LOCATED NORTH OF BARN.	PROPERTY OWNER E WELL IS LOCATED NORTH OF BARN.	PROPERTY OWNER E	PROPERTY OWNER E WELL IS LOCATED IN BUSHES IN FRONT OF HOUSE.	PROPERTY OWNER E WELL IS LOCATED IN BUSHES IN FRONT OF HOUSE.
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	115	115	115	115	185	185	185	185
	Sampled Before Treatment?	NA	NA	NA	NA	NA	NA	Pre-Treatment	Pre-Treatment
	Sample ID	NTD0308-04012010-1625	NTH1162-PROPERTY OWNER E 002	0108201150103	1104201120206	NTD0293-04012010-1545	NTH1160-PROPERTY OWNER E 001	0108201150101	1104201120204
Parameter and units	Sample Date	4/1/2010 (Baseline)	8/12/2010	1/8/2011	11/4/2011	4/1/2010 (Baseline)	8/12/2010	1/8/2011	11/4/2011
2,6-Dichlorophenol	UG/L				< 1 U				< 0.9 U
2,6-Dinitrotoluene	UG/L				< 1 U				< 0.9 U
2-Butoxyethanol	UG/L				< 5 UJ				< 5 UJ
2-Chloronaphthalene	UG/L				< 1 U				< 0.9 U
2-Chiorophenoi					< 10				< 0.9 U
2-Methylphopol									< 0.5 0
2-Nitroaniline									< 0.9 U
2-Nitrophenol					< 1				< 0.9 []
3.3-Dichlorobenzidine	UG/I				< 5 U				< 5 U
3-Nitroaniline	UG/L				< 1 U				< 0.9 U
4,4'-Methylenebis(2-chlo	roaniline) UG/L				< 14 UJ				< 14 UJ
4,4'-Methylenebis(N,N-di	methylanilin UG/L				< 14 UJ				< 14 UJ
4,6-Dinitro-2-methylpher	nol UG/L				< 14 U				< 14 U
4-Bromophenyl phenyl e	ther UG/L				< 1 U				< 0.9 U
4-Chloro-3-methylpheno	UG/L				< 1 UJ				< 0.9 UJ
4-Chloroaniline	UG/L				< 1 U				< 0.9 U
4-Chlorophenyl phenyl e	ther UG/L				< 1 U				< 0.9 U
4-Methylphenol	UG/L				< 1 U				< 0.9 U
4-Nitroaniline	UG/L				< 1 U				< 0.9 U
4-Nitrophenol	UG/L				< 29 U				< 28 U
Acenaphthene	UG/L				< 0.5 U				< 0.5 U
Acenaphthylene	UG/L				< 0.5 U				< 0.5 U
Acetophenone					< 1 U				< 0.9 0
									< 5 0
Anthracene					< 0.5.11				< 0.5 U
Benzo (a) anthracene					< 0.5 UJ				< 0.5 U
Benzo (a) pyrene	UG/L				< 0.5 U				< 0.5 U
Benzo (b) fluoranthene	UG/L				< 0.5 U				< 0.5 U
Benzo (g,h,i) perylene	UG/L				< 0.5 U				< 0.5 U
Benzo (k) fluoranthene	UG/L				< 0.5 U				< 0.5 U
Benzoic acid	UG/L				< 14 UJ				< 14 UJ
Benzyl alcohol	UG/L				< 14 U				< 14 U
Bis(2-chloroethoxy)meth	ane UG/L				< 1 U				< 0.9 U
Bis(2-chloroethyl)ether	UG/L				< 1 U				< 0.9 U
bis(2-Chloroisopropyl)eth	ner UG/L				< 1 U				< 0.9 U
Bis(2-ethylhexyl)phthalat	te UG/L				< 5 UJ				< 5 UJ
Butyl benzyl phthalate	UG/L				< 5 UJ				< 5 UJ
Chlorobenzilate	UG/L				< I U _ 10 II				< U.9 U
Chrysene					< 0.5 []]				< 0.5
Diallate (cis or trans)	UG/I				< 5 U				< 5 U
Dibenz (a,h) anthracene	UG/L				< 0.5 U				< 0.5 U
Dibenzofuran	UG/L				< 1 U				< 0.9 U
Diethyl phthalate	UG/L				< 5 U				< 5 U
Dimethyl phthalate	UG/L				< 5 U				< 5 U
Di-n-butyl phthalate	UG/L				< 5 U				< 5 U
Di-n-octyl phthalate	UG/L				< 5 U				< 5 U
Dinoseb	UG/L				< 5 U				< 5 U
Disulfoton	UG/L				< 48 U				< 47 U
d-Limonene	UG/L				< 5 U				< 5 U
Fluoranthene	UG/L				< 0.5 U				< 0.5 U
Hoveehlereherzene	UG/L				< U.5 U				< U.5 U
Hexachlorobutadiona	UG/L				< U.5 U				< U.5 U
Heyachlorocyclopoptadia									< 0.7 U 2 1/ II
Hexachloroethane					2 5 11				2 5 11
Indeno (1.2.3-cd) nvrene					< 0.5 []				< 0.5 U
Isophorone	UG/I				< 1 U				< 0.9 U
Naphthalene	UG/L				< 0.5 U				< 0.5 U
	Property Owner Location Description	PROPERTY OWNER E WELL IS LOCATED NORTH OF BARN.	PROPERTY OWNER E	PROPERTY OWNER E WELL IS LOCATED NORTH OF BARN.	PROPERTY OWNER E WELL IS LOCATED NORTH OF BARN.	PROPERTY OWNER E WELL IS LOCATED NORTH OF BARN.	PROPERTY OWNER E	PROPERTY OWNER E WELL IS LOCATED IN BUSHES IN FRONT OF HOUSE.	PROPERTY OWNER E WELL IS LOCATED IN BUSHES IN FRONT OF HOUSE.
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	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	115	115	115	115	185	185	185	185
	Sampled Before Treatment?	NA	NA	NA	NA	NA	NA	Pre-Treatment	Pre-Treatment
	Sample ID	NTD0308-04012010-1625	NTH1162-PROPERTY OWNER E 002	0108201150103	1104201120206	NTD0293-04012010-1545	NTH1160-PROPERTY OWNER E 001	0108201150101	1104201120204
Parameter and units	Sample Date	4/1/2010 (Baseline)	8/12/2010	1/8/2011	11/4/2011	4/1/2010 (Baseline)	8/12/2010	1/8/2011	11/4/2011
Nitrobenzene	UG/L				< 1 U				< 0.9 U
N-Nitrosodiethylamine	UG/L				< 1 U				< 0.9 U
N-Nitrosodimethylamine	UG/L				< 5 U				< 5 U
N-Nitrosodi-n-butylamine	UG/L				< 5 U				< 5 U
N-Nitrosodi-n-propylamine	e UG/L				< 1 U				< 0.9 U
N-Nitrosodiphenylamine	UG/L				< 1 U				< 0.9 U
N-Nitrosometnyletnylamin	ie UG/L				< 5 U				< 5 U
Parathion-ethyl	UG/L				< 5 U				< 5 U
Paratnion-metnyi					< 5 U				
Pentachiorophonol					< 10				< 0.9 0
Pentachiorophenoi					< 5 0				
Phonol									< 0.5 0
Phorato									< 0.90
Pronamide									< 0.90
Pyrene					< 0.5.11				< 0.5 U
Pyridine					< 5				< 5 U
Squalene					< 5 111				< 5 U.I
Terbufos	UG/L				< 5 UJ				< 5 UJ
Terpineol	UG/L				< 5 U				< 5 U
Tributoxyethyl phosphate	UG/L				< 5 U				< 5 U
Trifluralin	UG/L				< 5 UJ				< 5 UJ
11Cs									
1,2,3-Trimethylbenzene	UG/L								
Volatile Organics									
1,1,1-Trichloroethane	UG/L				< 1.00 U				< 1.00 U
1,1,2-Trichloroethane	UG/L				< 1.00 U				< 1.00 U
1,1-Dichloroethane	UG/L				< 1.00 U				< 1.00 U
1,1-Dichloroethene	UG/L				< 1.00 U				< 1.00 U
1,2,3-Trimethylbenzene	UG/L				< 1.00 U				< 1.00 U
1,2,4-Trichlorobenzene	UG/L								
1,2,4-Trimethylbenzene	UG/L				< 1.00 U				< 1.00 U
1,2-Dibromo-3-chloroprop	bane UG/L				< 0.1012 U				< 0.1003 U
1,2-Dichlorobenzene	UG/L				< 1.00 U				< 1.00 U
1,2-Dichloroethane	UG/L				< 1.00 U				< 1.00 U
1,2-Dichloropropane	UG/L								
1,3,5-1rimethylbenzene	UG/L				< 1.00 U				< 1.00 U
1,3-Dichlorobenzene	UG/L				< 1.00 U				< 1.00 U
	UG/L								< 1.00 0
Benzene		< 0.500 U	ND		< 1.00 U		ND		< 1.00 U
Carbon disulfide		~ 0.300 0			< 1.00 U				< 1.00 0
Carbon Tetrachloride					< 1.00 U				< 1.00 U
Chlorobenzene	UG/L				< 1.00 U				< 1.00 U
Chloroform	UG/L				< 1.00 U				< 1.00 U
cis-1,2-Dichloroethene	UG/L				< 1.00 U				< 1.00 U
Diisopropyl Ether	UG/L				< 1.00 U				< 1.00 U
Ethanol	UG/L				< 100 U				< 100 U
Ethyl tert-Butyl Ether	UG/L				< 1.00 U				< 1.00 U
Ethylbenzene	UG/L	< 0.500 U	ND	< 0.5 UJH	< 1.00 U	< 0.500 U	ND	< 0.5 U	< 1.00 U
Hexachlorobutadiene	UG/L				< 1 U				< 0.9 U
Isopropyl alcohol	UG/L				< 50.0 U				< 50.0 U
Isopropylbenzene	UG/L				< 1.00 U				< 1.00 U
m,p-Xylene	UG/L				< 2.00 U				< 2.00 U
Methoxychlor	UG/L				< 0.0236 U				< 0.0236 U
Methyl tert-Butyl Ether	UG/L				< 1.00 U				< 1.00 U
Methylene Chloride	UG/L				< 5.00 U				< 5.00 U
Naphthalene	UG/L				< 5.00 U				< 5.00 U
o-Xylene	UG/L				< 1.00 U				< 1.00 U
Styrene	UG/L								

	Property Owner	PROPERTY OWNER E	PROPERTY OWNER E	PROPERTY OWNER E	PROPERTY OWNER E	PROPERTY OWNER E	PROPERTY OWNER E	PROPERTY OWNER E	PROPERTY OWNER E
		WELL IS LOCATED NORTH OF		WELL IS LOCATED NORTH OF	WELL IS LOCATED NORTH OF	WELL IS LOCATED NORTH OF		WELL IS LOCATED IN BUSHES IN	WELL IS LOCATED IN BUSHES IN
	Location Description	BARN.		BARN.	BARN.	BARN.		FRONT OF HOUSE.	FRONT OF HOUSE.
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	115	115	115	115	185	185	185	185
	Sampled Before Treatment?	NA	NA	NA	NA	NA	NA	Pre-Treatment	Pre-Treatment
	Sample ID	NTD0308-04012010-1625	NTH1162-PROPERTY OWNER E 002	0108201150103	1104201120206	NTD0293-04012010-1545	NTH1160-PROPERTY OWNER E 001	0108201150101	1104201120204
Parameter and units	Sample Date	4/1/2010 (Baseline)	8/12/2010	1/8/2011	11/4/2011	4/1/2010 (Baseline)	8/12/2010	1/8/2011	11/4/2011
Tert-Amyl Methyl Ether	UG/L				< 1.00 U				< 1.00 U
Tertiary Butyl Alcohol	UG/L				< 10.0 U				< 10.0 U
Tetrachloroethene	UG/L				< 1.00 U				< 1.00 U
Tetrahydrofuran	UG/L								
Toluene	UG/L	< 0.500 U	ND	< 0.5 U	< 1.00 U	< 0.500 U	ND	< 0.5 U	< 1.00 U
trans-1,2-Dichloroethene	UG/L				< 1.00 U				< 1.00 U
Trichloroethene	UG/L				< 1.00 U				< 1.00 U
Vinyl chloride	UG/L				< 1.00 U				< 1.00 U
Xylenes, total	UG/L	< 0.500 U	ND	< 0.5 U	< 3.00 U	< 0.500 U	ND	< 0.5 U	< 3.00 U

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended

holding time



APPENDIX A-6 EPA STUDY WELL DATA PROPERTY OWNER F

	Proporty Ownor			
	Property Owner			
		PADEP ON SITE TO COLLECT	PADEP ON SITE TO COLLECT	PADEP ON SITE TO COLLECT
	Location Description	SAMPLE.	SAMPLE.	SAMPLE.
	Source Type	WELL	WELL	WELL
	Well Depth	200	200	200
	Sampled Before Treatment?	NA	NA	NA
· · · · · · · · · · · · · · · · · · ·	Sampled Derore Treatment:	0310201150104	1025201120201	1111201124301
Parameter and units	Sample Date	3/10/2011	10/25/2011	11/11/2011
	Sample Date	5/10/2011	10/23/2011	11/11/2011
Aldehydes				
Gluteraldehyde	UG/L			
Bactoria				
E coli	colonies/100ml		Absent	
E. coli	colonies/100ml			
Tetal Coliform Pactoria	colonies/100ml		Abcont	
	colonies/Toomi		Absent	
DBCP				
1,2-Dibromo-3-chloropropa	ane UG/L		< 0.1036 U	
Friday adapted Deday Lawren Ultra				
Diosel			- 04 2 11	
DIE261	UG/L		< 94.3 U	
General Chemistry				
Alkalinity, Total (CaCO3)	MG/L		231	
Ammonia as N	MG/L		0.981	
Bicarbonate Alkalinity as Ca	aCO3 MG/L	221	231	220
Bromide	MG/L		< 2.5 U	< 5.00 U
Carbonate as CaCO3	MG/L	11.3	< 10.0 U	25.2
Chloride	MG/L	45	56.0 J	44
CO2 by Headspace	UG/L		< 12000 U	
Cyanide	MG/L			
Fluoride	MG/L		< 0.50 U	
MBAS	MG/L	< 0.05 U	< 0.12 U	< 0.0500 U
Nitrate	MG/L			
Nitrate Nitrogen	MG/L		< 0.50 U	
Nitrite Nitrogen	MG/L		< 0.50 U	
Oil & Grease HEM	MG/L	< 6.02 U	< 4.71 U	< 6.10 U
рН	pH UNITS	8.3 J	7.90 H	8.30 H
Phosphorus	MG/L		< 0.100 U	
Specific conductance	UMHO/CM	600	641	609
Sulfate	MG/L	< 5 U	< 5.0 UJ	< 5.00 U
Temperature of pH determ	ination CELSIUS	21.2	21.5 H	21.4 H
Total Dissolved Solids	MG/L	346	348	340
Total Suspended Solids	MG/L	< 1 U	< 1.00 U	< 1.00 U
Turbidity	NTU	1.3	0.54	< 1.00 U
Church				
1.2 Dranulana Chuad	NO //			
Distbylops Clycol	MG/L			
Ethylopo Clycol	MG/L		< 10 0	
	MG/L			
	MG/L		< 10	
	NIG/L			
Light Gases				
Acetylene	MG/L		< 0.00500 U	
Ethane	MG/L	< 0.026 U	0.0202	0.202
Ethene	MG/L		< 0.00500 U	
Methane	MG/L	53.4	55.3	51.8
n-Butane	MG/L		< 0.00500 U	
Propane	MG/L	< 0.034 U	< 0.00500 U	< 0.00500 U
Low Molecular Weight Acid	ds			
Acetic Acid	13 110/1	•	< 10000 U	
Butyric Acid			< 10000 U	
Formic Acid			< 10000 U	
Isobutvric acid			< 10000 U	
			< 5000 U	
Propionic Acid			< 13000 U	
	00/L	1	1 10000 0	I

	Property Owner	PROPERTY OWNER F WELL LOCATED NORTH OF HOUSE. PADEP ON SITE TO COLLECT SAMPLE.	PROPERTY OWNER F WELL LOCATED NORTH OF HOUSE. PADEP ON SITE TO COLLECT SAMPLE.	PROPERTY OWNER F WELL LOCATED NORTH OF HOUSE. PADEP ON SITE TO COLLECT SAMPLE.
	Source Type	WELL	WELL	WELL
	Well Depth	200	200	200
	Sampled Before Treatment?	NA	NA	NA
	Sample ID	0310201150104	1025201120201	1111201124301
Parameter and units	Sample Date	3/10/2011	10/25/2011	11/11/2011
Metals 6020x				
Cesium	MG/I		0.00074	
Cesium Dissolved	MG/L		0.0007	
Potassium	MG/L		1 88	
Potassium Dissolved	MG/L		1 85	
Silicon	MG/L		4	
Silicon Dissolved	MG/L		0 404	
Thorium	MG/L		< 0.002 []	
Thorium Dissolved	MG/L		< 0.002 U	
Uranium	MG/L		< 0.002.0	
Uranium Dissolved	MG/L		< 0.001 U	
	WO/L		< 0.001 0	
Metals, Total				
Aluminum	MC/I		< 0.0200.11	
Antimony	MG/L		< 0.0200 0	
Arsenic	MC/L	< 0.01 II	< 0.00200 0	< 0.0100 U
Barium	MG/L	0.010	0.00200 0	0.0100 0
Borullium	MG/L	0.944	< 0.00200 []	0.724
Beron	MG/L		0.00200 0	
Codmium	MG/L		0.00100.11	
Calcium	MG/L	< 0.001 0		
Chromium	MG/L	12.5	12.8	12.7
Chiomium	MG/L	< 0.005 0	< 0.00200 U	< 0.00500 0
Copper	MG/L		< 0.00200 0	
	MG/L		0.0482	
Hardness, CacO3	MG/L			
	MG/L	0.0542	0.113	0.0707
	MG/L	< 0.005 0	< 0.00200 0	< 0.00500 0
	MG/L			0.1
Magnesium	MG/L	1.98	2.05	2.23
Manganese	MG/L	< 0.015 U	0.00749	< 0.0150 0
Mercury	MG/L	< 0.0002 U	< 0.000200 U	< 0.000200 U
Molybdenum	MG/L		< 0.00500 U	
NICKEI	MG/L		< 0.00500 U	
Potassium	MG/L	1.93	1.83	1.87
Selenium	MG/L	< 0.01 U	< 0.00200 U	< 0.0100 U
Silver	MG/L	< 0.005 U	< 0.00200 U	< 0.00500 U
Sodium	MG/L	122	122 J	118
Strontium	MG/L		1.74	1.76
Sulfur	MG/L	< 0.5 U	< 0.500 U	< 0.500 U
	MG/L		< 0.00200 U	
Titanium	MG/L		< 0.00200 U	
Vanadium	MG/L		< 0.00400 U	
Zinc	MG/L		< 0.0500 U	
Metals, Dissolved				
Aluminum, Dissolved	MG/L		< 0.0200 U	
Antimony, Dissolved	MG/I		< 0.00200 []	
Arsenic. Dissolved	MG/L		< 0.00200 U	
Barium, Dissolved	MG/L		0.843	
Beryllium, Dissolved	MG/I		< 0.0020011	
Boron, Dissolved	MG/L		0.578	
Cadmium Dissolved	MG/L MC/L		< 0.00100 U	
Calcium Dissolved	MC/L		12.8	
Chromium Dissolvad	MG/L		< 0.0020011	
Cohalt Discolved	MC/L		< 0.00200 0	
Conner Dissolved	MC/L		< 0.00200 0	
Iron Dissolved	MC/L		0.00300 0	
Load Dissolved			< 0.00200 11	
	MG/L		< 0.00200 U	

	Property Owner	PROPERTY OWNER F	PROPERTY OWNER F	PROPERTY OWNER F
	. ,	WELL LOCATED NORTH OF HOUSE.	WELL LOCATED NORTH OF HOUSE.	WELL LOCATED NORTH OF HOUSE.
		PADEP ON SITE TO COLLECT	PADEP ON SITE TO COLLECT	PADEP ON SITE TO COLLECT
	Location Description	SAMPLE.	SAMPLE.	SAMPLE.
	Source Type	WELL	WELL	WELL
	Well Depth	200	200	200
	Sampled Before Treatment?	ΝΔ	ΝΔ	ΝΔ
	Sampled Derore Treatment:	0210201150104	1025201120201	1111201124201
Descent to a second second	Sample ID	0310201130104	1025201120201	11/12/01/24301
Parameter and units	Sample Date	3/10/2011	10/25/2011	11/11/2011
Magnesium, Dissolved	MG/L		2.15	
Manganese, Dissolved	MG/L		0.00698	
Mercury, Dissolved	MG/L		< 0.000200 U	
Molybdenum, Dissolved	MG/L		< 0.00500 U	
Nickel Dissolved	MG/L		< 0.00500 U	
Detassium Dissolved	MG/L		1 75	
Potassium, Dissolved	MG/L		1.75	
Selenium, Dissolved	MG/L		< 0.00200 U	
Silver, Dissolved	MG/L		< 0.00200 U	
Sodium, Dissolved	MG/L		118	
Strontium, Dissolved	MG/L		1.75	
Sulfur, Dissolved	MG/L		< 0.500 U	
Thallium Dissolved	MC/I		< 0.0020011	
Titanium Dissolved			< 0.00200 U	
Vanadium Dissolved	WG/L			
	MG/L		< 0.00400 0	
Zinc, Dissolved	MG/L		< 0.0500 U	
Miscellaneous Organics				
Inorganic Carbon Dissolu	ved Mc/I		62.2	
Organic Carbon, Dissolv			. 1.00.11	
	u MG/L		< 1.00 0	
Pesticides and PCBs				
			< 0.047211	
			< 0.0472 U	
			< 0.0472 U	
4,4-001	UG/L		< 0.0472 0	
Aldrin	UG/L		< 0.0472 U	
alpha-BHC	UG/L		< 0.0472 U	
Azinphos-methyl	UG/L		< 0.94 UH	
beta-BHC	UG/L		< 0.0472 U	
Carbaryl	UG/L		< 6.0 U	
delta-BHC	UG/L		< 0.0472 U	
Dichlorvos	UG/L		< 0.94 UH	
Dieldrin	UG/L		< 0.0472 U	
Disulfoton			< 0.94 UH	
Endosulfan I			< 0.047211	
Endosulfan II			< 0.0472 U	
	0G/L		< 0.0472 U	
	UG/L		< 0.0472 0	
Endrin	UG/L		< 0.04/2 U	
Endrin aldehyde	UG/L		< 0.0472 U	
Endrin ketone	UG/L		< 0.0472 U	
gamma-BHC (Lindane)	UG/L		< 0.0472 U	
Heptachlor	UG/L		< 0.0472 U	
Heptachlor epoxide	UG/L		< 0.0472 U	
Malathion	UG/L		< 0.94 UH	
Methoxychlor	UG/L		< 0.0472 U	
Mevinphos	UG/I		< 0.94 UH	
	00/2			
Purgeable Petroleum Hyd	lrocarbons			
GRO as Gasoline	UG/L		< 100 U	
Combiglia Alla Como d				
Semivolatile Urganics				
I,2,4,5-Ietrachlorobenzei	ne UG/L		< 1 U	
1,2-Dinitrobenzene	UG/L		< 5 U	
1,2-Diphenylhydrazine	UG/L		< 1 U	
1,3-Dimethyl adamatane	UG/L		< 5 U	
1,3-Dinitrobenzene	UG/L		< 5 U	
1,4-Dinitrobenzene	UG/L		< 5 U	
1-Chloronaphthalene	UG/L		< 1 U	
2,3,4,6-Tetrachloropheno	UG/L		< 1 U	
2,4,5-Trichlorophenol	UG/I		< 1 IJ	
2.4.6-Trichlorophenol			< 1 []	
2 4-Dichloronhenol			< 111	
2.1. Dimethylphonol			- 111	
	UG/L			

	Property Owner	PROPERTY OWNER F WELL LOCATED NORTH OF HOUSE. PADEP ON SITE TO COLLECT	PROPERTY OWNER F WELL LOCATED NORTH OF HOUSE. PADEP ON SITE TO COLLECT	PROPERTY OWNER F WELL LOCATED NORTH OF HOUSE. PADEP ON SITE TO COLLECT
	Location Description	SAMPLE.	SAMPLE.	SAMPLE.
	Source Type	WELL	WELL	WELL
	Well Depth	200	200	200
Sampled B	sefore Treatment?	NA	NA	NA
	Sample ID	0310201150104	1025201120201	1111201124301
Parameter and units	Sample Date	3/10/2011	10/25/2011	11/11/2011
2,4-Dinitrophenol	UG/L		< 29 U	
2,4-Dinitrotoluene	UG/L		< 5 U	
2,6-Dichlorophenol	UG/L		< 1 U	
2,6-Dinitrotoluene	UG/L		< 10	
2-Butoxyetnanol	UG/L		< 5 U	
2-Chlorophonol	UG/L		< 1 U	
2-Chiorophenol	UG/L			
2 Mothylphopol			< 0.5 0	
2-Nitrophenol				
3 3-Dichlorobenzidine			< 5 []	
3-Nitroaniline			< 1 []	
4,4'-Methylenebis(2-chloroaniline)	UG/L		< 14 U.J	
4,4'-Methylenebis(N.N-dimethylanilin	UG/L		< 14 U	
4,6-Dinitro-2-methylphenol	UG/L		< 14 U	
4-Bromophenyl phenyl ether	UG/L		< 1 U	
4-Chloro-3-methylphenol	UG/L		< 1 U	
4-Chloroaniline	UG/L		< 1 U	
4-Chlorophenyl phenyl ether	UG/L		< 1 U	
4-Methylphenol	UG/L		< 1 U	
4-Nitroaniline	UG/L		< 1 U	
4-Nitrophenol	UG/L		< 29 U	
Acenaphthene	UG/L		< 0.5 U	
Acenaphthylene	UG/L		< 0.5 U	
Acetophenone	UG/L		< 1 U	
Adamantane	UG/L		< 5 U	
Aniline	UG/L		< 1 U	
Anthracene	UG/L		< 0.5 U	
Benzo (a) anthracene	UG/L		< 0.5 U	
Benzo (a) pyrene	UG/L		< 0.5 U	
Benzo (b) fluoranthene	UG/L		< 0.5 U	
Benzo (g,h,i) perylene	UG/L		< 0.5 U	
Benzo (K) fluoranthene	UG/L		< 0.5 U	
	UG/L		< 14 U	
Bis(2 chloroothoxy)mothano	UG/L		< 14 0	
Bis(2-chlorootbyl)otbor	UG/L			
bis(2-Chloroisopropyl)ether				
Bis(2-ethylbexyl)nbthalate			< 5	
Butyl benzyl phthalate			< 511	
Carbazole	UG/L		< 1 U	
Chlorobenzilate	UG/L		< 10 U	
Chrysene	UG/L		< 0.5 U	
Diallate (cis or trans)	UG/L		< 5 U	
Dibenz (a,h) anthracene	UG/L		< 0.5 U	
Dibenzofuran	UG/L		< 1 U	
Diethyl phthalate	UG/L		< 5 U	
Dimethyl phthalate	UG/L		< 5 U	
Di-n-butyl phthalate	UG/L		< 5 U	
Di-n-octyl phthalate	UG/L		< 5 U	
Dinoseb	UG/L		< 5 U	
Disulfoton	UG/L		< 48 U	
d-Limonene	UG/L		< 5 U	
Fluoranthene	UG/L		< 0.5 U	
Fluorene	UG/L		< 0.5 U	
Hexachiorobenzene	UG/L		< 0.5 U	
Hexachiorobutadiene	UG/L		< U	
Hexachiorocyclopentadiene	UG/L		< 14 U	
Hexachioroethane	UG/L		< 5 U	

	Property Owner	PROPERTY OWNER F	PROPERTY OWNER F	PROPERTY OWNER F
		WELL LOCATED NORTH OF HOUSE.	WELL LOCATED NORTH OF HOUSE.	WELL LOCATED NORTH OF HOUSE.
		PADEP ON SITE TO COLLECT	PADEP ON SITE TO COLLECT	PADEP ON SITE TO COLLECT
	Location Description	SAMPLE.	SAMPLE.	SAMPLE.
	Source Type	WELL	WELL	WELL
	Well Depth	200	200	200
	Sampled Before Treatment?	NA	NA	NA
	Sample ID	0310201150104	1025201120201	1111201124301
Parameter and units	Sample Date	3/10/2011	10/25/2011	11/11/2011
Indeno (1,2,3-cd) pyrene	UG/L		< 0.5 U	
Isophorone	UG/L		< 1 U	
Naphthalene	UG/L		< 0.5 U	
Nitrobenzene	UG/L		< 1 U	
N-Nitrosodiethylamine	UG/L		< 1 U	
N-Nitrosodimethylamine	UG/L		< 5 U	
N-Nitrosodi-n-butylamine	UG/L		< 5 U	
N-Nitrosodi-n-propylamin	e UG/L		< 1 U	
N-Nitrosodiphenylamine	UG/L		< 1 U	
N-Nitrosomethylethylamir	ne UG/L		< 5 U	
Parathion-ethyl	UG/L		< 5 U	
Parathion-methyl	UG/L		< 5 U	
Pentachlorobenzene	UG/L		< 1 U	
Pentachlorophenol	UG/L		< 5 U	
Phenanthrene	UG/I		< 0.5 U	
Phenol			< 1 U	
Phorate			< 1	
Pronamide			2 1 11	
Durono			< 0.5.11	
Dyridino			< 5.11	
Squalopo	06/L		< 5 U	
Torbufoo			< 5 U	
Terpineel	UG/L		< 5 U	
	UG/L		< 5 U	
Tributoxyetnyi phosphate	e UG/L		< 5 U	
Innuralin	UG/L		< 5 U	
TICs				
1.2.3-Trimethylbenzene	UG/L		< 100 U	
Volatile Organics				
1,1,1-Trichloroethane	UG/L		< 1.00 U	
1,1,2-Trichloroethane	UG/L		< 1.00 U	
1,1-Dichloroethane	UG/L		< 1.00 U	
1,1-Dichloroethene	UG/L		< 1.00 U	
1,2,3-Trimethylbenzene	UG/L		< 1.00 U	
1,2,4-Trichlorobenzene	UG/L			
1,2,4-Trimethylbenzene	UG/L		< 1.00 U	
1,2-Dibromo-3-chloroproj	pane UG/L		< 0.1036 U	
1,2-Dichlorobenzene	UG/L		< 1.00 U	
1,2-Dichloroethane	UG/L		< 1.00 U	
1,2-Dichloropropane	UG/L			
1,3,5-Trimethylbenzene	UG/L		< 1.00 U	
1,3-Dichlorobenzene	UG/L		< 1.00 U	
1,4-Dichlorobenzene	UG/L		< 1.00 U	
Acetone	UG/L		< 50.0 U	
Benzene	UG/L	< 0.5 U	< 1.00 U	< 0.500 U
Carbon disulfide	UG/L		< 1.00 U	
Carbon Tetrachloride	UG/L		< 1.00 U	
Chlorobenzene	UG/I		< 1.00 U	
Chloroform			< 1.00 U	
cis-1.2-Dichloroethene			< 1.00 U	
Diisonronyl Ether			< 1.00 U	
Fthanol			< 100 U	
Ethyl tert-Rutyl Ether			< 1.00 U	
Ethylhenzene			< 1.00 U	< 0.500 U
Hovachlorobutadiana		<u> </u>		<u> </u>
			<u> </u>	
	UG/L			
	UG/L			
Mothoweblar	UG/L		< 2.00 U	
Wethout text Durbul Fills	UG/L		< 0.0472 0	
weinyi tert-Butyi Ether	UG/L		< 1.00 U	

	Property Owner	PROPERTY OWNER F	PROPERTY OWNER F	PROPERTY OWNER F
		WELL LOCATED NORTH OF HOUSE.	WELL LOCATED NORTH OF HOUSE.	WELL LOCATED NORTH OF HOUSE.
		PADEP ON SITE TO COLLECT	PADEP ON SITE TO COLLECT	PADEP ON SITE TO COLLECT
	Location Description	SAMPLE.	SAMPLE.	SAMPLE.
	Source Type	WELL	WELL	WELL
	Well Depth	200	200	200
	Sampled Before Treatment?	NA	NA	NA
	Sample ID	0310201150104	1025201120201	1111201124301
Parameter and units	Sample Date	3/10/2011	10/25/2011	11/11/2011
Methylene Chloride	UG/L		< 5.00 U	
Naphthalene	UG/L		< 5.00 U	
o-Xylene	UG/L		< 1.00 U	
Styrene	UG/L			
Tert-Amyl Methyl Ether	UG/L		< 1.00 U	
Tertiary Butyl Alcohol	UG/L		< 10.0 U	
Tetrachloroethene	UG/L		< 1.00 U	
Tetrahydrofuran	UG/L			
Toluene	UG/L	< 0.5 U	< 1.00 U	< 0.500 U
trans-1,2-Dichloroethene	UG/L		< 1.00 U	
Trichloroethene	UG/L		< 1.00 U	
Vinyl chloride	UG/L		< 1.00 U	
Xylenes, total	UG/L	< 0.5 U	< 3.00 U	< 0.500 U

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended holding time

J : Estimated value

--- : Parameter not analyzed.



APPENDIX A-7 EPA STUDY WELL DATA PROPERTY OWNER G

	Property Owner Location Description	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.
	Source Type	WELL							
	Well Depth	UNKNOWN							
	Sampled Before Treatment?	NA	NA	NA	NA	NA	Pre-Treatment	Post-Treatment	Pre-Treatment
	Sample ID	NTD0310-04022010-0840	1001201021403	1110201020203	0628201122901	0901201120204	1013201120201	1013201120202	1027201120204
Parameter and units	Sample Date	4/2/2010 (Baseline)	10/1/2010	11/10/2010	6/28/2011	9/1/2011	10/13/2011	10/13/2011	10/27/2011
Aldabudaa									
Clutoraldobydo									
Cluteraldenyde	00/2								
Bacteria									
E. coli	colonies/100ml								Present
Fecal coliform bacteria	colonies/100ml								2
Total Coliform Bacteria	colonies/100ml								Present
DBCP									
1,2-Dibromo-3-chloroprop	ane UG/L								< 0.1014 U
Extractable Petroleum H	ydrocarbons								
Diesel	UG/L								< 94.3 U
General Chemistrv									
Alkalinity, Total (CaCO3)	MG/L								43.6
Ammonia as N	MG/L								< 0.100 U
Bicarbonate Alkalinity as C	CaCO3 MG/L	47.8	39.5	43.6 HJ	48.2	58.5	54.1	57.4	42.6
Bromide	MG/L								< 2.5 U
Carbonate as CaCO3	MG/L	< 10.0 U							
Chloride	MG/L	1.23	< 5.00 U	2.2					
CO2 by Headspace	UG/L								25000
Cyanide	MG/L			< 0.0500 U					
Fluoride	MG/L								< 0.50 U
MBAS	MG/L	0.142	< 0.0500 U	0.0611	< 0.0500 U	< 0.0500 U	< 0.0500 UH	< 0.0500 UH	< 0.12 U
Nitrate	MG/L								
Nitrate Nitrogen	MG/L								0.84
Nitrite Nitrogen	MG/L								< 0.50 U
OII & Grease HEM	MG/L	< 5.75 U	< 6.85 U	< 5.81 U	< 5.88 U	< 6.49 U	< 7.04 U	< 5.95 U	< 4.82 U
pH Dheenherus	ph UNITS	6.60 H	0.00 H	6.50 HJ	6.70 H	6.90 H	7.00 H	6.50 H	6.50 H
Specific conductance						170			
Sulfate		107	107	117	142	170	149	154	10.1.1
Temperature of pH deterr		із./ 231Ц	12.2 21.4 H	 21 0 Ц I	12.4 21.0 H	15.0 24.6 H	10.5 21.6 Ц	10.1 21.6 H	19.1 J 21 О Н
Total Dissolved Solids		77	21.411	21.7113	111	96	90.9	68	68.1.1
Total Suspended Solids	MG/L	< 1.00 []	157	15.8	58	4.9	13.8		2.8
Turbidity	NTU	< 1.00 U	4.6	24	91.2	16.1	37 1 H	1 18 H	13
	ATO	1000	110	2,	/ 1.2	10.1	0,,,,,,,		
Glycols									
1,2-Propylene Glycol	MG/L								
Diethylene Glycol	MG/L								< 10 U
Ethylene Glycol	MG/L								. 10.111
	MG/L								< 10 UJ
	MG/L								
Light Gases									
Acetylene	MG/L								< 0.00500 U
Ethane	MG/L	< 0.0260 U	< 0.0260 U	< 0.0260 U	< 0.0260 U	< 0.00500 U	< 0.00500 U	< 0.00500 U	< 0.00500 U
Ethene	MG/L				< 0.0260 U	< 0.00500 U			< 0.00500 U
Methane	MG/L	0.035	< 0.0260 U	< 0.0260 U	< 0.0260 U	0.0126	< 0.00500 U	< 0.00500 U	< 0.00500 U
n-Butane	MG/L								< 0.00500 U
Propane	MG/L	< 0.0340 U	< 0.0340 U	< 0.0340 U	< 0.0340 U	< 0.00500 U	< 0.00500 U	< 0.00500 U	< 0.00500 U
Low Molecular Weight A	cids								
Acetic Acid									< 10000 11
Butyric Acid	UG/I								< 10000 U
Formic Acid	UG/L								< 10000 U
Isobutyric acid	UG/L								< 10000 U
Lactic acid	UG/L								< 5000 U
Propionic Acid	UG/L								< 13000 U

	Property Owner Location Description Source Type Well Depth Sampled Defere Treatment?	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN
	Sampled Before Treatment?	NA NTD0310-04022010-0840	1001201021403	NA 1110201020203	0628201122901	0901201120204	1013201120201	1013201120202	1027201120204
Parameter and units	Sample Date	4/2/2010 (Baseline)	10/1/2010	11/10/2010	6/28/2011	9/1/2011	10/13/2011	10/13/2011	10/27/2011
Metals, 6020x									
Cesium	MG/L								< 0.0001 U
Cesium, Dissolved	MG/L								< 0.0001 U
Potassium	MG/L								0.966
Potassium, Dissolved	MG/L								0.924
Silicon Silicon Dissolved	MG/L								4.43
Thorium	MG/L								4.78
Thorium, Dissolved	MG/L								< 0.002 U
Uranium	MG/L								< 0.001 U
Uranium, Dissolved	MG/L								< 0.001 U
Motola Total									
	MC/I								0.0633
Antimony	MG/I								< 0.00200 []
Arsenic	MG/L	< 0.0100 U	< 0.00200 U						
Barium	MG/L	0.116	0.296	0.168	0.156	0.162	0.177	0.0616	0.145
Beryllium	MG/L								< 0.00200 U
Boron	MG/L								< 0.0500 U
Cadmium	MG/L	< 0.00100 U							
Calcium	MG/L	13.6	17.3	17.6	18.3	22.3	19.6	21.6	16.6
Cobalt	MG/L	< 0.00500 0	0.0054	< 0.00500 0	< 0.00500 0	< 0.00500 0	< 0.00500 0	< 0.00500 0	< 0.00200 U
Copper	MG/L								0.00519
Hardness, CaCO3	MG/L								
Iron	MG/L	0.281	10.6	3.58	2.68	3.08	4.13	0.185	0.343
Lead	MG/L	< 0.00500 U	0.005	< 0.00500 U	< 0.00500 U	< 0.00500 U	0.0061	< 0.00500 U	< 0.00200 U
Lithium	MG/L								
Magnesium	MG/L	2.19	4.07	3.07	3.43	3.58	3.24	3.47	2.84
Mercury	MG/L	< 0.0150 0	< 0.0020011	< 0.00020011	< 0.00200 []	< 0.0150 0	< 0.00218	< 0.0150 0	< 0.00200 U
Molybdenum	MG/L								< 0.00500 U
Nickel	MG/L								< 0.00500 U
Potassium	MG/L	< 1.00 U	2.16	1.33	1.84	< 1.00 U	< 1.00 U	1.06	< 1.00 U
Selenium	MG/L	< 0.0100 U	< 0.00200 U						
Silver	MG/L	< 0.00500 U	< 0.00200 U						
Sodium	MG/L	1.71	2.14	2.55	3.87	3.49	3.13	3.52	2.38
Strontium	MG/L				0.0933	0.126	0.121	0.137	0.0883
Thallium	MG/L			4.7		4.5	4.23	4.44	< 0.00200 U
Titanium	MG/L								< 0.00200 U
Vanadium	MG/L								< 0.00400 U
Zinc	MG/L								< 0.0500 U
Metals, Dissolved									
Aluminum, Dissolved	MG/L								< 0.0200 U
Antimony, Dissolved	MG/L								< 0.00200 U
Arsenic, Dissolved	MG/L			< 0.0100 U					< 0.00200 U
Barium, Dissolved	MG/L			0.147					0.145
Boron Dissolved	MG/L								< 0.00200 U
Cadmium Dissolved	MG/L								
Calcium. Dissolved	MG/L			17.9					16.7
Chromium, Dissolved	MG/L			< 0.00500 U					< 0.00200 U
Cobalt, Dissolved	MG/L								< 0.00200 U
Copper, Dissolved	MG/L								< 0.00500 U
Iron, Dissolved	MG/L			< 0.0500 U		0.109	0.0549		< 0.0500 U
Lead, Dissolved	MG/L			< 0.00500 U					< 0.00200 U
Magnesium, Dissolved	MG/L			3.05					2.75

	Property Owner Location Description	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE.
	Source Type	WELL							
	Well Depth	UNKNOWN							
	Sampled Before Treatment?		NA 1001201021403	NA 1110201020203	NA 0629201122001	NA 0001201120204	Pre-Treatment	Post-Treatment	
Parameter and units	Sample TD Sample Date	1/2/2010 (Baseline)	10/1/2010	11/10/2010	6/28/2011	0/1/201120204	10/13/2011	10/13/2011	10/27/2011
Manganese Dissolved	MG/I	4/2/2010 (Baseline)		< 0.0150 U		0.02	< 0.0150 U		< 0.00500 U
Mercury, Dissolved	MG/L			< 0.000200 U					< 0.000200 U
Molybdenum, Dissolved	MG/L								< 0.00500 U
Nickel, Dissolved	MG/L								< 0.00500 U
Potassium, Dissolved	MG/L			< 1.00 U					< 1.00 U
Selenium, Dissolved	MG/L			< 0.0100 U					< 0.00200 U
Silver, Dissolved	MG/L			< 0.00500 U					< 0.00200 U
Sodium, Dissolved	MG/L			2.77					2.38
Strontium, Dissolved	MG/L								0.0897
Sulfur, Dissolved	MG/L								4.12
Thailium, Dissolved	MG/L								< 0.00200 U
Vanadium Dissolved	MG/L								< 0.00200 0
Zinc. Dissolved	MG/L								< 0.0500 U
	MO/L								
Miscellaneous Organics									
Inorganic Carbon, Dissol	ved MG/L								18.1
Organic Carbon, Dissolve	d MG/L								< 1.00 U
Pesticides and PCBs									
4,4'-DDD	UG/L								< 0.0472 U
4,4'-DDE	UG/L								< 0.0472 U
4,4'-DDT	UG/L								< 0.0472 U
Aldrin	UG/L								< 0.0472 U
alpha-BHC	UG/L								< 0.0472 U
Azinphos-methyl	UG/L								< 0.94 U
Deta-BHC Carbanyl	UG/L								< 0.0472 0
delta-BHC									< 0.00
Dichloryos									< 0.0472.0
Dieldrin	UG/L								< 0.0472 U
Disulfoton	UG/L								< 0.94 U
Endosulfan I	UG/L								< 0.0472 U
Endosulfan II	UG/L								< 0.0472 U
Endosulfan sulfate	UG/L								< 0.0472 U
Endrin	UG/L								< 0.0472 U
Endrin aldehyde	UG/L								< 0.0472 U
Endrin ketone	UG/L								< 0.04/2 U
gamma-BHC (Lindane)	UG/L								< 0.0472 U
									< 0.0472 0
Malathion	UG/I								< 0.94 U
Methoxychlor	UG/L								< 0.0472 U
Mevinphos	UG/L								< 0.94 U
Durgeeble Detroloum II	udrosorbono								
GPO as Casolino									< 100 U
GRU as Gasoline	06/L								< 100 0
Semivolatile Organics									
1,2,4,5-Tetrachlorobenze	ne UG/L								< 1 U
1,2-Dinitrobenzene	UG/L								< 5 U
1,2-Diphenylhydrazine	UG/L								< 1 U
1,3-Dimethyl adamatane	UG/L								< 5 U
	UG/L								< 5 U - 5 U
									< 0 U 2 1 II
2.3.4.6-Tetrachloronhend									< 1
2,4,5-Trichlorophenol									< 1 U
2,4,6-Trichlorophenol	UG/L								< 1 U
2,4-Dichlorophenol	UG/L								< 1 U
2,4-Dimethylphenol	UG/L								< 1 U
2,4-Dinitrophenol	UG/L								< 29 U
2,4-Dinitrotoluene	UG/L								< 5 U

	Property Owner Location Description Source Type Well Depth	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN
	Sampled Before Treatment?		NA 1001001001	NA	NA	NA	Pre-Treatment	Post-Treatment	Pre-Treatment
Daramotor and units	Sample ID	NTD0310-04022010-0840	10/1/201021403	11/10/2010	6/29/2011	0/1/2011	10/13/2011/20/201	1013201120202	1027201120204
2 6-Dichlorophenol			10/1/2010			9/1/2011			< 1 []
2.6-Dinitrotoluene	UG/L								< 1 U
2-Butoxyethanol	UG/L								< 5 U
2-Chloronaphthalene	UG/L								< 1 U
2-Chlorophenol	UG/L								< 1 U
2-Methylnaphthalene	UG/L								< 0.5 U
2-Methylphenol	UG/L								< 1 U
2-Nitroaniline	UG/L								< 1 U
2-Nitrophenoi									
3-Nitroaniline									< 1
4.4'-Methylenebis(2-chlo	roaniline) UG/L								< 14 UJ
4,4'-Methylenebis(N,N-di	imethylanilin UG/L								< 14 U
4,6-Dinitro-2-methylpher	nol UG/L								< 14 U
4-Bromophenyl phenyl e	ther UG/L								< 1 U
4-Chloro-3-methylpheno	l UG/L								< 1 U
4-Chloroaniline	UG/L								< 1 U
4-Chlorophenyl phenyl e	ther UG/L								< 1 U
4-Metnyiphenoi									
4-Nitrophenol	UG/L								< 29 []
Acenaphthene	UG/L								< 0.5 U
Acenaphthylene	UG/L								< 0.5 U
Acetophenone	UG/L								< 1 U
Adamantane	UG/L								< 5 U
Aniline	UG/L								< 1 U
Anthracene	UG/L								< 0.5 U
Benzo (a) anthracene	UG/L								< 0.5 U
Benzo (a) pyrene									< 0.5 U
Benzo (a h i) pervlene									< 0.5 U
Benzo (k) fluoranthene	UG/L								< 0.5 U
Benzoic acid	UG/L								< 14 U
Benzyl alcohol	UG/L								< 14 U
Bis(2-chloroethoxy)meth	ane UG/L								< 1 U
Bis(2-chloroethyl)ether	UG/L								< 1 U
bis(2-Chloroisopropyl)eth	ner UG/L								< 1 U
Bis(2-ethylnexyl)phthalat	te UG/L								< 5 U
Carbazole	UG/L								< 1
Chlorobenzilate	UG/L								< 10 U
Chrysene	UG/L								< 0.5 U
Diallate (cis or trans)	UG/L								< 5 U
Dibenz (a,h) anthracene	UG/L								< 0.5 U
Dibenzofuran	UG/L								< 1 U
Diethyl phthalate	UG/L								< 5 U
Dimetnyi phthalate	UG/L								< 5 U
									< 5 U
Dinoseb	UG/I								< 5 U
Disulfoton	UG/L								< 48 U
d-Limonene	UG/L								< 5 U
Fluoranthene	UG/L								< 0.5 U
Fluorene	UG/L								< 0.5 U
Hexachlorobenzene	UG/L								< 0.5 U
Hexachlorobutadiene	UG/L								< 1 U
Hexachlorocyclopentadie	ene UG/L								< 14 U
Indepo (1.2.2.cd) pyropy									< 5 U ~ 0 5 H
									< 1 []
Naphthalene	UG/L								< 0.5 U

	Property Owner Location Description Source Type Well Depth	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN	PROPERTY OWNER G THE WELL IS LOCATED ON THE SOUTH SIDE OF THE HOUSE. WELL UNKNOWN
	Sampled Before Treatment?		NA	NA	NA	NA	Pre-Treatment	Post-Treatment	Pre-Treatment
Description	Sample ID	NTD0310-04022010-0840	1001201021403	1110201020203	0628201122901	0901201120204	1013201120201	1013201120202	1027201120204
Parameter and units	Sample Date	4/2/2010 (Baseline)	10/1/2010	11/10/2010	6/28/2011	9/1/2011	10/13/2011	10/13/2011	10/27/2011
Nitropenzene	UG/L								< 1 U
N-Nitrosodietnylamine	UG/L								< 10
N Nitrosodi n butylamine									< 5 U
N Nitrosodi p propylamire									< 5 0
N-Nitrosodinhenvlamine									< 1
N-Nitrosomethylethylami									< 5 []
Parathion-ethyl									< 5 U
Parathion-methyl	UG/L								< 5 U
Pentachlorobenzene	UG/L								< 1 U
Pentachlorophenol	UG/L								< 5 U
Phenanthrene	UG/L								< 0.5 U
Phenol	UG/L								< 1 U
Phorate	UG/L								< 1 U
Pronamide	UG/L								< 1 U
Pyrene	UG/L								< 0.5 U
Pyridine	UG/L								< 5 U
Squalene	UG/L								< 5 U
Terbufos	UG/L								< 5 U
Terpineol	UG/L								< 5 U
Tributoxyethyl phosphat	e UG/L								< 5 U
Trifluralin	UG/L								< 5 U
TICs									
1.2.3-Trimethylbenzene	UG/L								
Volatile Organics									
1,1,1-Trichloroethane	UG/L								< 1.00 U
1,1,2-Trichloroethane	UG/L								< 1.00 U
1,1-Dichloroethane	UG/L								< 1.00 U
1, 1-Dichloroethene	UG/L								< 1.00 U
1,2,3-Trichlorohonzono	UG/L								< 1.00 0
1 2 <i>A</i> -Trimethylbenzene									< 1.00 U
1 2-Dibromo-3-chloropro									< 0.1014 []
1.2-Dichlorobenzene									< 1.00 U
1.2-Dichloroethane	UG/L								< 1.00 U
1,2-Dichloropropane	UG/L								
1,3,5-Trimethylbenzene	UG/L								< 1.00 U
1,3-Dichlorobenzene	UG/L								< 1.00 U
1,4-Dichlorobenzene	UG/L								< 1.00 U
Acetone	UG/L								< 50.0 U
Benzene	UG/L	< 0.500 U	< 1.00 U						
Carbon disulfide	UG/L								< 1.00 U
Carbon Tetrachloride	UG/L								< 1.00 U
Chlorobenzene	UG/L								< 1.00 U
Chloroform	UG/L								< 1.00 U
cis-1,2-Dichloroethene	UG/L								< 1.00 U
Dilsopropyi Ether	UG/L								< 1.00 U
Ethyl tort Putyl Ethor	UG/L								< 1.00 U
Ethylbonzono		 < 0.500 U	< 0.500 []		< 0.500.11	< 0.500.11	 < 0.500 LL		< 1.00 U
Hexachlorobutadiono		< 0.000 U			< 0.000 U		< 0.000 U		2 1 11
Isopropyl alcohol									< 50.0 []
Isopropylbenzene									< 1.00 U
m,p-Xvlene	UG/L								< 2.00 U
Methoxychlor	UG/L								< 0.0472 U
Methyl tert-Butyl Ether	UG/L								< 1.00 U
Methylene Chloride	UG/L								< 5.00 U
Naphthalene	UG/L								< 5.00 U
o-Xylene	UG/L								< 1.00 U
Styrene	UG/L								

	Property Owner	PROPERTY OWNER G							
		THE WELL IS LOCATED ON THE							
	Location Description	SOUTH SIDE OF THE HOUSE.							
	Source Type	WELL							
	Well Depth	UNKNOWN							
	Sampled Before Treatment?	NA	NA	NA	NA	NA	Pre-Treatment	Post-Treatment	Pre-Treatment
	Sample ID	NTD0310-04022010-0840	1001201021403	1110201020203	0628201122901	0901201120204	1013201120201	1013201120202	1027201120204
Parameter and units	Sample Date	4/2/2010 (Baseline)	10/1/2010	11/10/2010	6/28/2011	9/1/2011	10/13/2011	10/13/2011	10/27/2011
Tert-Amyl Methyl Ether	UG/L								< 1.00 U
Tertiary Butyl Alcohol	UG/L								< 10.0 U
Tetrachloroethene	UG/L								< 1.00 U
Tetrahydrofuran	UG/L								
Toluene	UG/L	< 0.500 U	< 1.00 U						
trans-1,2-Dichloroethene	UG/L								< 1.00 U
Trichloroethene	UG/L								< 1.00 U
Vinyl chloride	UG/L								< 1.00 U
Xylenes, total	UG/L	< 0.500 U	< 3.00 U						

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended

holding time



APPENDIX A-8 EPA STUDY WELL DATA PROPERTY OWNER H

	Property Owner	PROPERTY OWNER H	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	340	340	340	340	340	340	340	340	340
Sa	impled Before Treatment?	NA	NA	Pre-Treatment	NA	NA	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment
	Sample ID	NTD0189-04012010-1125	0913201020201	1001201021405	1110201020201	1202201020201	0301201124902	0301201124903	0510201120201	0510201120202
Parameter and units	Sample Date	4/1/2010 (Baseline)	9/13/2010	10/1/2010	11/10/2010	12/2/2010	3/1/2011	3/1/2011	5/10/2011	5/10/2011
Aldehydes										
Giuteraidenyde	UG/L									
Bacteria										
E. coli	colonies/100ml									
Fecal coliform bacteria	colonies/100ml									
Total Coliform Bacteria	colonies/100ml									
1,2-Dibromo-3-chloropropan	UG/L									
Extractable Petroleum Hvo	Irocarbons									
Diesel	UG/I									
General Chemistry										
Alkalinity, Total (CaCO3)	MG/L									
Ammonia as N	MG/L									
Bicarbonate Alkalinity as Ca	CO3 MG/L	101	141	60.2	93.6	75.8	35.2	36.5	42.3	44.9
Bromide	MG/L									
Carbonate as CaCO3	MG/L	< 10.0 U	< 10.0 U	< 10.0 U	< 10.0 U	< 10.0 U	< 10.0 U	< 10.0 U	< 10.0 U	< 10.0 U
Chloride	MG/L	1.52	10.2	< 5.00 UJ	8.34	12.4	5	5.08	< 5.00 U	< 5.00 UJ
CO2 by Headspace	UG/L									
Cyanide	MG/L				< 0.0500 U					
Fluoride	MG/L									
MBAS	MG/L	< 0.0500 U	< 0.0500 0	< 0.0500 0	0.0516	< 0.0500 0	< 0.0500 0	< 0.0500 0	< 0.0500 0	< 0.0500 0
Nitrate Nitragon	MG/L									
Nitrate Nitrogen	MG/L									
	MG/L									
	MG/L	< 5.49 U	< 5.43 U	< 0.10 0	< 5.49 U	< 0.10 U	< 5.95 U	7 20 41		< 0.49 U
Phosphorus		7.70 H	0.20 HJ	0.80 HJ	0.80 HJ	0.70 H	7.40 HJ	7.20 HJ	7.80 FJ	7.00 HJ
Specific conductance		101	225		190	124	107	108	120	
Sulfato		12 7	15.0	10.9.1	107	21 5	17.1	100	127	
Temperature of pH determin	nation CELSUIS	23 O H	22 / HI	21 / HI	21.0 H I	21.5 22.5 H	21.0 HI	21 / HI	23.0 HT	23.5.4.1
Total Dissolved Solids	MG/I	118	176	250	107	76	70	76	82	65
Total Suspended Solids	MG/L	< 1.00 []	27.5	46	88.3	33.4	21	< 1.00 []	1 70 1	1 1
Turbidity	NTU	2	27	31.2	26.4	11 7	5	4 5	7.3	3.6
		_			2011					
Glycols										
1,2-Propylene Glycol	MG/L									
Diethylene Glycol	MG/L									
Etnylene Glycol	MG/L									
l etraethylene glycol	MG/L									
	MG/L									
Light Gases										
Acetylene	MG/L									
Ethane	MG/L	< 0.0260 U	< 0.0260 U	< 0.0260 U	< 0.0260 U	< 0.0260 U	< 0.0260 U	< 0.0260 U	< 0.0260 U	< 0.0260 U
Ethene	MG/L									
Methane	MG/L	0.045	0.0535	< 0.0260 U	0.183	< 0.0260 U				
n-Butane	MG/L									
Propane	MG/L	< 0.0340 U	< 0.0340 U	< 0.0340 U	< 0.0340 U	< 0.0340 U	< 0.0340 U	< 0.0340 U	< 0.0340 U	< 0.0340 U
Low Molecular Metable Ant										
Low Molecular Weight Acid	15									
	UG/L									
Eormic Acid	UG/L									
	UG/L									
Lactic acid										
	UG/L									

	Property Owner Location Description Source Type	PROPERTY OWNER H 907691-PROPERTY OWNER H-001 WFLI	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE. WFI I	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE. WFL1	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE. WELL	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE. WFI I	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE. WFI I	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE. WFI I	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE. WFI I	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE. WFI I
	Well Depth	340	340	340	340	340	340	340	340	340
	Sampled Before Treatment?	NA NTD0189-04012010-1125	NA 0913201020201	Pre-Treatment	NA 1110201020201	NA 1202201020201	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment
Parameter and units	Sample Date	4/1/2010 (Baseline)	9/13/2010	10/1/2010	11/10/2010	12/2/2010	3/1/2011	3/1/2011	5/10/2011	5/10/2011
Metals, 6020x										
Cesium	MG/L									
Cesium, Dissolved	MG/L									
Potassium Disselved	MG/L									
Silicon	MG/L MG/I									
Silicon, Dissolved	MG/L									
Thorium	MG/L									
Thorium, Dissolved	MG/L									
Uranium Dissolved	MG/L									
	MG/L									
Metals, Total										
Aluminum	MG/L									
Anumony	MG/L	 < 0.0100 U	< 0.0100 U	< 0.0100 []	< 0.0100 U	 < 0.0100 U	< 0.0100 LL	< 0.0100 []	< 0.0100 U	< 0.0100 U
Barium	MG/L	0.214	0.31	0.263	0.27	0.17	0.168	0.142	0.162	0.164
Beryllium	MG/L									
Boron	MG/L									
Cadmium	MG/L	< 0.00100 U	< 0.00100 U	< 0.00100 U	< 0.00100 U	< 0.00100 U	< 0.00100 U	< 0.00100 U	< 0.00100 U	< 0.00100 U
Calcium	MG/L	12.4	24.3	15.1	14.8	31.3	13.3	13.7	14.7	15.1
Cobalt	MG/L	< 0.00500 0	< 0.00500 0	< 0.00500 0	< 0.00500 0	< 0.00500 0	< 0.00500 0	< 0.00500 0	< 0.00500 0	< 0.00500 0
Copper	MG/L									
Hardness, CaCO3	MG/L									
Iron	MG/L	0.0546	0.275	2.54	0.982	0.829	0.228	0.0971	0.149	0.0756
Lead	MG/L	< 0.00500 U	< 0.00500 U	< 0.00500 U	0.0089	< 0.00500 U	0.0076	< 0.00500 U	0.0738	< 0.00500 U
Lithium	MG/L									
Manganese	MG/L	< 0.0150 U	0.0209	0.214	0.0607	0.095	< 0.0150 U	< 0.0150 U	< 0.0150 U	< 0.0150 U
Mercury	MG/L	< 0.000200 U	< 0.000200 U	< 0.000200 U	< 0.000200 U	< 0.000200 U	< 0.000200 U	< 0.000200 U	< 0.000200 U	< 0.000200 U
Molybdenum	MG/L									
Nickel	MG/L									
Potassium	MG/L	< 1.00 U	1.41	1.31	1.16	1.47	< 1.00 U	< 1.00 U	< 1.00 U	< 1.00 U
Selenium	MG/L	< 0.0100 0	< 0.0100 0	< 0.0100 0	< 0.0100 0	< 0.0100 0	< 0.0100 0	< 0.0100 0	< 0.0100 0	< 0.0100 0
Sodium	MG/L	28	40.4	6.84	20.8	7.24	5.02	5.21	5.56	5.35
Strontium	MG/L									
Sulfur	MG/L	5.1	3.7	3.4	6	4.5	4.66	4.59	4.36	4.42
Thallium	MG/L									
l itanium Vapadium	MG/L									
	MG/L MG/L									
Metals, Dissolved	110/2									
Aluminum, Dissolved	MG/L									
Antimony, Dissolved	MG/L									
Arsenic, Dissolved	MG/L				< 0.0100 U					
Beryllium Dissolved	MG/L				0.218					
Boron, Dissolved	MG/L									
Cadmium, Dissolved	MG/L				< 0.00100 U					
Calcium, Dissolved	MG/L				17.1					
Chromium, Dissolved	MG/L				< 0.00500 U					
Cobalt, Dissolved	MG/L									
Lopper, Dissolved	MG/L			 - 0 0500 U	 - 0.0500 U					
	IVIG/L			< 0.0500 U	< 0.0000 U					
Lead. Dissolved	MG/I				< 0.00500 U					
Lead, Dissolved Magnesium, Dissolved	MG/L MG/L				< 0.00500 U 2.56					

	Property Owner Location Description	PROPERTY OWNER H 907691-PROPERTY OWNER H-001	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	340	340	340	340	340	340	340	340	340
S	Sampled Before Treatment?	NA	NA	Pre-Treatment	NA	NA	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment
	Sample ID	NTD0189-04012010-1125	0913201020201	1001201021405	1110201020201	1202201020201	0301201124902	0301201124903	0510201120201	0510201120202
Parameter and units	Sample Date	4/1/2010 (Baseline)	9/13/2010	10/1/2010	11/10/2010	12/2/2010	3/1/2011	3/1/2011	5/10/2011	5/10/2011
Manganese, Dissolved	MG/L				0.0213					
Mercury, Dissolved	MG/L				< 0.000200 U					
Molybaenum, Dissolved	MG/L									
Nickel, Dissolved	MG/L									
Solonium Dissolved	MG/L				- 0.0100 II					
Silver Dissolved	MG/L				< 0.0100 0					
Sodium Dissolved	MG/L				21.9					
Strontium Dissolved	MG/L									
Sulfur, Dissolved	MG/L									
Thallium, Dissolved	MG/L									
Titanium, Dissolved	MG/L									
Vanadium, Dissolved	MG/L									
Zinc, Dissolved	MG/L									
Miscellaneous Organics	od MC/I									
Organic Carbon, Dissolved	MG/L									
Pesticides and PCBs	MG/L									
4,4'-DDD	UG/L									
4,4'-DDE	UG/L									
4,4'-DDT	UG/L									
Aldrin	UG/L									
alpha-BHC	UG/L									
Azinphos-methyl	UG/L									
beta-BHC	UG/L									
Carbaryl	UG/L									
delta-BHC	UG/L									
Dichlorvos	UG/L									
Dieldrin	UG/L									
Disultoton	UG/L									
	UG/L									
Endosulfan II	UG/L									
Endrin ketone										
gamma-BHC (Lindane)										
Heptachlor										
Heptachlor epoxide	UG/L									
Malathion	UG/L									
Methoxychlor	UG/L									
Mevinphos	UG/L									
Purgeable Petroleum Hyd	drocarbons									
GRO as Gasoline	UG/L									
Semivolatile Organics	0									
1.2-Dinhenvlhvdrazine										
1.3-Dimethyl adamatane										
1.3-Dinitrohenzene										
1,4-Dinitrobenzene										
1-Chloronaphthalene	UG/I									
2,3,4,6-Tetrachlorophenol	UG/L									
2,4,5-Trichlorophenol	UG/L									
2,4,6-Trichlorophenol	UG/L									
2,4-Dichlorophenol	UG/L									
2,4-Dimethylphenol	UG/L									
2,4-Dinitrophenol	UG/L									
2,4-Dinitrotoluene	UG/L									

	Property Owner Location Description	PROPERTY OWNER H 907691-PROPERTY OWNER H-001	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	340	340	340	340	340	340	340	340	340
	Sampled Before Treatment?	NA	NA	Pre-Treatment	NA	NA	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment
	Sample ID	NTD0189-04012010-1125	0913201020201	1001201021405	1110201020201	1202201020201	0301201124902	0301201124903	0510201120201	0510201120202
Parameter and units	Sample Date	4/1/2010 (Baseline)	9/13/2010	10/1/2010	11/10/2010	12/2/2010	3/1/2011	3/1/2011	5/10/2011	5/10/2011
2,6-Dichlorophenol	UG/L									
2,6-Dinitrotoluene	UG/L									
2-Butoxyethanol	UG/L									
2-Chloronaphthalene	UG/L									
2-Chiorophenol	UG/L									
2-Methylnaphthalene	UG/L									
2 Nitroanilino										
2-Nitrophenol										
3 3-Dichlorobenzidine										
3-Nitroaniline	UG/L									
4,4'-Methylenebis(2-chloro	aniline) UG/L									
4,4'-Methylenebis(N,N-dim	ethylanilin UG/L									
4,6-Dinitro-2-methylpheno	UG/L									
4-Bromophenyl phenyl eth	er UG/L									
4-Chloro-3-methylphenol	UG/L									
4-Chloroaniline	UG/L									
4-Chlorophenyl phenyl eth	er UG/L									
4-Methylphenol	UG/L									
4-Nitroaniline	UG/L									
4-Nitrophenol	UG/L									
Acenaphthene	UG/L									
Acenaphthylene	UG/L									
Acetophenone	UG/L									
Adamantane	UG/L									
Aniline	UG/L									
Anthracene Ronzo (a) anthracono	UG/L									
Benzo (a) antinacene	UG/L									
Benzo (b) fluoranthene										
Benzo (g h i) pervlene										
Benzo (k) fluoranthene										
Benzoic acid	UG/L									
Benzyl alcohol	UG/L									
Bis(2-chloroethoxy)methar	ne UG/L									
Bis(2-chloroethyl)ether	UG/L									
bis(2-Chloroisopropyl)ethe	r UG/L									
Bis(2-ethylhexyl)phthalate	UG/L									
Butyl benzyl phthalate	UG/L									
Carbazole	UG/L									
Chlorobenzilate	UG/L									
Chrysene	UG/L									
Diallate (cis or trans)	UG/L									
Dibenz (a,h) anthracene	UG/L									
Dibenzofuran	UG/L									
Diethyl phthalate	UG/L									
Dimetnyi phthalate	UG/L									
Di-n-butyi phthalate	UG/L									
Dinosoh	UG/L									
Diriosed										
d-l imonene										
Fluoranthene										
Fluorene										
Hexachlorobenzene	UG/I									
Hexachlorobutadiene	UG/L									
Hexachlorocyclopentadiene	e UG/L									
Hexachloroethane	UG/L									
Indeno (1,2,3-cd) pyrene	UG/L									
Isophorone	UG/L									
Naphthalene	UG/L									

	Property Owner Location Description	PROPERTY OWNER H 907691-PROPERTY OWNER H-001	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	340	340	340	340	340	340	340	340	340
	Sampled Before Treatment?	NA	NA	Pre-Treatment	NA	NA	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment
	Sample ID	NTD0189-04012010-1125	0913201020201	1001201021405	1110201020201	1202201020201	0301201124902	0301201124903	0510201120201	0510201120202
Parameter and units	Sample Date	4/1/2010 (Baseline)	9/13/2010	10/1/2010	11/10/2010	12/2/2010	3/1/2011	3/1/2011	5/10/2011	5/10/2011
Nitrobenzene	UG/L									
N-Nitrosodiethylamine	UG/L									
N-Nitrosodimethylamine	UG/L									
N-Nitrosodi-n-butylamine	UG/L									
N-Nitrosodi-n-propylamine	e UG/L									
N-Nitrosodipnenylamine	UG/L									
N-Nitrosometnyietnyiamin										
Parathion mothyl	UG/L									
Parathion-methyr	UG/L									
Pentachiorophonol										
Pentachiorophenoi	UG/L									
Phopol										
Phorato	UG/L									
Pronamide	UG/L									
Pyrene	UG/L					· ····				
Pyridine	UG/L									
Squalene	UC/I									
Terbufos	UC/I									
Terpineol										
Tributoxyethyl phosphate										
Trifluralin										
TICs										
1,2,3-Trimethylbenzene	UG/L									
Volatile Organics										
1 1 1-Trichloroethane	LIG/I									
1 1 2-Trichloroethane										
1 1-Dichloroethane										
1 1-Dichloroethene										
1,2,3-Trimethylbenzene										
1.2.4-Trichlorobenzene	UG/L									
1,2,4-Trimethylbenzene	UG/L									
1,2-Dibromo-3-chloroprop	bane UG/L									
1,2-Dichlorobenzene	UG/L									
1,2-Dichloroethane	UG/L									
1,2-Dichloropropane	UG/L									
1,3,5-Trimethylbenzene	UG/L									
1,3-Dichlorobenzene	UG/L									
1,4-Dichlorobenzene	UG/L									
Acetone	UG/L									
Benzene	UG/L	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U
Carbon disulfide	UG/L									
Carbon Tetrachloride	UG/L									
Chlorobenzene	UG/L									
Chloroform	UG/L									
cis-1,2-Dichloroethene	UG/L									
Diisopropyl Ether	UG/L									
Ethanol	UG/L									
Ethyl tert-Butyl Ether	UG/L									
Ethylbenzene	UG/L	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U
Hexachlorobutadiene	UG/L									
Isopropyl alcohol	UG/L									
Isopropylbenzene	UG/L									
m,p-Xylene	UG/L									
Methoxychlor	UG/L									
Methyl tert-Butyl Ether	UG/L									
Methylene Chloride	UG/L									
	UG/L									
o-Xylene	UG/L									
Styrene	UG/L									

	Property Owner	PROPERTY OWNER H	PROPERTY OWNER H	PROPERTY OWNER H	PROPERTY OWNER H	PROPERTY OWNER H	PROPERTY OWNER H	PROPERTY OWNER H	PROPERTY OWNER H	PROPERTY OWNER H
			WELL IS LOCATED TO THE SOUTH							
	Location Description	907691-PROPERTY OWNER H-001	OF THE RESIDENCE.							
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	340	340	340	340	340	340	340	340	340
	Sampled Before Treatment?	NA	NA	Pre-Treatment	NA	NA	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment
	Sample ID	NTD0189-04012010-1125	0913201020201	1001201021405	1110201020201	1202201020201	0301201124902	0301201124903	0510201120201	0510201120202
Parameter and units	Sample Date	4/1/2010 (Baseline)	9/13/2010	10/1/2010	11/10/2010	12/2/2010	3/1/2011	3/1/2011	5/10/2011	5/10/2011
Tert-Amyl Methyl Ether	UG/L									
Tertiary Butyl Alcohol	UG/L									
Tetrachloroethene	UG/L									
Tetrahydrofuran	UG/L									
Toluene	UG/L	< 0.500 U	< 0.500 U	< 0.500 U	1.13	< 0.500 U				
trans-1,2-Dichloroethene	UG/L									
Trichloroethene	UG/L									
Vinyl chloride	UG/L									
Xylenes, total	UG/L	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U

Notes:

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended

holding time

	Property Owner	PROPERTY OWNER H	PROPERTY OWNER H	PROPERTY OWNER H
	rioperty owner	WELL IS LOCATED TO THE SOUTH	WELL IS LOCATED TO THE SOUTH	WELL IS LOCATED TO THE SOUTH
	Location Description	OF THE RESIDENCE.	OF THE RESIDENCE.	OF THE RESIDENCE.
	Source Type	WELL	WELL	WELL
	Well Depth	340	340	340
S	Sampled Before Treatment?	Pre-Treatment	Pre-Treatment	Post-Treatment
	Sample ID	1028201120204	1108201120208	1108201120209
Parameter and units	Sample Date	10/28/2011	11/8/2011	11/8/2011
Aldebudee				
Aldenyaes				
Giuteraidenyde	UG/L			
Bacteria				
E. coli	colonies/100ml	Absent		
Fecal coliform bacteria	colonies/100ml	< 1 U		
Total Coliform Bacteria	colonies/100ml	Present		
0000				
		0 1017 11		
1,2-Dibromo-3-chioropropa	ane UG/L	< 0.1017 0		
Extractable Petroleum Hy	drocarbons			
Diesel	UG/L	< 94.3 U		
General Chemistry				
Alkalinity, Total (CaCO3)	MG/L	62.3		
Ammonia as N	MG/L	< 0.100 U		
Bicarbonate Alkalinity as Ca	aCO3 MG/L	63.9	86.6	55
Bromide	MG/L	< 2.5 U	< 5.00 U	< 5.00 U
Carbonate as CaCO3	MG/L	< 10.0 U	< 10.0 U	< 10.0 U
Chloride	MG/L	9.8 J	< 5.00 U	< 5.00 U
CO2 by Headspace	UG/L	16000		
Cyanide	MG/L			
Fluoride	MG/L	< 0.50 U		
MBAS	MG/L	< 0.12 U	< 0.0500 UH	< 0.0500 UH
Nitrate	MG/L			
Nitrate Nitrogen	MG/L	0.52		
Nitrite Nitrogen	MG/L	< 0.50 UJ		
Oil & Grease HEM	MG/L	< 5.48 U	< 6.41 U	< 6.76 U
pH	pH UNITS	6.80 H	6.80 H	6.50 H
Phosphorus	MG/L	< 0.100 U		
Specific conductance	UMHO/CM	162	177	141
Sulfate	MG/L	16.0 J	9.3	10.3
Temperature of pH determ	ination CELSIUS	22.0 H	21.0 H	21.0 H
Total Dissolved Solids	MG/L	67	111	88
Total Suspended Solids	MG/L	5.4	< 1.00 U	< 1.00 U
Turbidity	NTU	6.8	1.92 H	1.10 H
Glycols				
1.2-Propylene Glycol	MG/L			
Diethylene Glycol	MG/L	< 10 U		
Ethylene Glycol	MG/L			
Tetraethylene glycol	MG/L	20 J		
Triethylene glycol	MG/L	12 J		
Light Gases				
Acetylene	MG/L	< 0.00500 U		
Ethane	MG/L	< 0.00500 U	< 0.00500 U	< 0.00500 U
Lthene	MG/L	< 0.00500 U		
Methane	MG/L	0.00607	0.0655	0.0258
n-Butane	MG/L	< 0.00500 U		
Propane	MG/L	< 0.00500 U	< 0.00500 U	< 0.00500 U
Low Molecular Weight Ac	cids			
Acetic Acid	UG/I	< 10000 U		
Butyric Acid	LIG/I	< 10000 U		
Formic Acid	UG/I	< 10000 U		
Isobutyric acid	LIG/I	< 10000 U		
Lactic acid	UG/I	< 5000 U		
Propionic Acid		< 13000 U		
	00/L		1	1

	Property Owner Location Description Source Type Woll Dopth	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE. WELL 340	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE. WELL 340	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE. WELL 340
	Sampled Pefere Treatment?	Dro Troatmont	Dro Troatmont	Doct Trootmont
	Sampled Derore Treatment:	1029201120204	1109201120209	1109201120200
Decemptor and units	Sample ID	10/20/2011	11/0/2011	11/0/2011
Parameter and units	Sample Date	10/28/2011	11/8/2011	11/8/2011
Metals, 6020x				
Cesium	MG/L	< 0.25 U		
Cesium, Dissolved	MG/L	< 0.25 U		
Potassium	MG/I	< 250 U		
Potassium Dissolved	MG/L	< 250 U		
Silicon	MG/L	< 6250 U		
Silicon Dissolved	MG/L	< 6250 U		
Thorium	MG/L	< 5.11		
Thorium Dissolved	MG/L	< 50		
	MG/L			
	MG/L	< 2.5 U		
Uranium, Dissolved	MG/L	< 2.5 U		
Metals, Total				
Aluminum	MG/L	0.322		
Antimony	MG/L	< 0.00200 U		
Arsenic	MG/L	< 0.00200 U	< 0.0100 U	< 0.0100 U
Barium	MG/L	0.213	0.19	0.21
Beryllium	MG/L	< 0.00200 U		
Boron	MG/L	0.0556		
Cadmium	MG/L	< 0.00100 U	< 0.00100 U	< 0.00100 U
Calcium	MG/L	16.3	12.2	15.4
Chromium	MG/L	< 0.00200 U	< 0.00500 U	< 0.00500 U
Cobalt	MG/L	< 0.00200 U		
Copper	MG/L	0.0143		
Hardness CaCO3	MG/L			
	MG/L	0.267	0.0582	< 0.0500 []
	MG/L	< 0.00200 II	< 0.00500 II	
	MG/L	< 0.00200 0	< 0.00500 0	< 0.00300 0
	MG/L			
Magnesium	MG/L	2.4	1.85	2.36
Manganese	MG/L	0.0216	< 0.0150 U	< 0.0150 U
Mercury	MG/L	< 0.000200 U	< 0.000200 U	< 0.000200 U
Molybdenum	MG/L	< 0.00500 U		
Nickel	MG/L	< 0.00500 U		
Potassium	MG/L	1.05	< 1.00 U	< 1.00 U
Selenium	MG/L	< 0.00200 U	< 0.0100 U	< 0.0100 U
Silver	MG/L	< 0.00200 U	< 0.00500 U	< 0.00500 U
Sodium	MG/L	13.5	25.8	9.2
Strontium	MG/L	0.212	0.173	0.204
Sulfur	MG/L	4.07	3.6	4.04
Thallium	MG/I	< 0.00200 U		
Titanium	MG/L	0.00602		
Vanadium	MG/L	< 0.00400 11		
Zinc	MG/L	< 0.00400 0		
Metals, Dissolved	WO/L			
Aluminum, Dissolved	MG/L	< 0.0200 U		
Antimony, Dissolved	MG/L	< 0.00200 U		
Arsenic, Dissolved	MG/L	< 0.00200 U		
Barium, Dissolved	MG/L	0.195		
Beryllium, Dissolved	MG/L	< 0.00200 U		
Boron, Dissolved	MG/L	< 0.0500 U		
Cadmium, Dissolved	MG/L	< 0.00100 U		
Calcium, Dissolved	MG/L	15.7		
Chromium, Dissolved	MG/L	< 0.00200 U		
Cobalt. Dissolved	MG/I	< 0.00200 U		
Copper Dissolved	MC/L	0.0102		
Iron Dissolvad	MC/L	< 0.0500 11		
Load Dissolved	IVIG/L	< 0.0300 0		
Magnacium Disselved	MG/L			
waynesium, Dissolved	MG/L	2.20		

	Property Owner Location Description	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.
	Source Type	WELL	WELL	WELL
	Well Depth	340	340	340
Sampled	Before Treatment?	Pre-Treatment	Pre-Treatment	Post-Treatment
	Sample ID	1028201120204	1108201120208	1108201120209
Parameter and units	Sample Date	10/28/2011	11/8/2011	11/8/2011
Manganese, Dissolved	MG/L	< 0.00500 U		
Mercury, Dissolved	MG/L	< 0.000200 U		
Molybdenum, Dissolved	MG/L	< 0.00500 U		
Nickel, Dissolved	MG/L	< 0.00500 U		
Potassium, Dissolved	MG/L	< 1.00 U		
Selenium, Dissolved	MG/L	< 0.00200 U		
Silver, Dissolved	MG/L	< 0.00200 U		
Sodium, Dissolved	MG/L	12.6		
Strontium, Dissolved	MG/L	0.203		
Sulfur, Dissolved	MG/L	3.81		
Thallium, Dissolved	MG/L	< 0.00200 U		
Titanium, Dissolved	MG/L	< 0.00200 U		
Vanadium, Dissolved	MG/L	< 0.00400 U		
Zinc, Dissolved	MG/L	< 0.0500 U		
Miscellaneous Organics				
Inorganic Carbon, Dissolved	MG/L	17.1		
Organic Carbon, Dissolved	MG/L	< 1.00 U		
Posticidos and PCRs				
		< 0.0226.11		
4,4-DDD		< 0.0236 U		
	UG/L	< 0.0236 U		
	UG/L	< 0.0236 U		
	UG/L	< 0.0236 U		
alpha-BHC	UG/L	< 0.0236 U		
Azinpnos-metnyi	UG/L	< 0.94 U		
beta-BHC	UG/L	< 0.0236 U		
Carbaryl	UG/L	< 6.0 U		
delta-BHC	UG/L	< 0.0236 U		
Dichlorvos	UG/L	< 0.94 U		
Dieldrin	UG/L	< 0.0236 U		
Disulfoton	UG/L	< 0.94 U		
Endosulfan I	UG/L	< 0.0236 U		
Endosulfan II	UG/L	< 0.0236 U		
Endosulfan sulfate	UG/L	< 0.0236 U		
Endrin	UG/L	< 0.0236 U		
Endrin aldehyde	UG/L	< 0.0236 U		
Endrin ketone	UG/L	< 0.0236 U		
gamma-BHC (Lindane)	UG/L	< 0.0236 U		
Heptachlor	UG/L	< 0.0236 U		
Heptachlor epoxide	UG/L	< 0.0236 U		
Malathion	UG/L	< 0.94 U		
Methoxychlor	UG/L	< 0.0236 U		
Mevinphos	UG/L	< 0.94 U		
Purneable Petroleum Hydrocerbe	2005			
GPO as Gasoline		< 100 []		
GRO as Gasoline	06/L	< 100 0		
Semivolatile Organics				
1,2,4,5-Tetrachlorobenzene	UG/L	< 1 U		
1,2-Dinitrobenzene	UG/L	< 5 U		
1,2-Diphenylhydrazine	UG/L	< 1 U		
1,3-Dimethyl adamatane	UG/L	< 5 U		
1,3-Dinitrobenzene	UG/L	< 5 U		
1,4-Dinitrobenzene	UG/L	< 5 U		
1-Chloronaphthalene	UG/L	< 1 U		
2,3,4,6-Tetrachlorophenol	UG/L	< 1 U		
2,4,5-Trichlorophenol	UG/L	< 1 U		
2,4,6-Trichlorophenol	UG/L	< 1 U		
2,4-Dichlorophenol	UG/L	< 1 U		
2,4-Dimethylphenol	UG/L	< 1 U		
2,4-Dinitrophenol	UG/L	< 29 U		
2,4-Dinitrotoluene	UG/L	< 5 U		

P	roperty Owner cation Description	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH OF THE RESIDENCE.
	Source Type	WELL	WELL	WELL
	Well Depth	340	340	340
Sampled Befo	ore Treatment?	Pre-Treatment	Pre-Treatment	Post-Treatment
	Sample ID	1028201120204	1108201120208	1108201120209
Parameter and units	Sample Date	10/28/2011	11/8/2011	11/8/2011
2,6-Dichlorophenol	UG/L	< 1 U		
2,6-Dinitrotoluene	UG/L	< 1 U		
2-Butoxyethanol	UG/L	< 5 UJ		
2-Chloronaphthalene	UG/L	< 1 U		
2-Chlorophenol	UG/L	< 1 U		
2-Methylnaphthalene	UG/L	< 0.5 U		
2-Methylphenol	UG/L	< 1 U		
2-Nitroaniline	UG/L	< 1 U		
2-Nitrophenol	UG/L	< U		
3,3-Dichlorobenzidine	UG/L	< 5 U		
3-NILLOAMIME	UG/L	< 1 U		
4,4 - Methylenebis (2-Chioroaniline)	UG/L	< 14 U		
		< 14 UJ		
4-Bromonhenvl nhenvl ether		< 14 U 2 1 I I		
4-Chloro-3-methylphenol		< 111		
4-Chloroaniline	UG/I	< 111		
4-Chlorophenyl phenyl ether	UG/I	< 1 []		
4-Methylphenol	UG/I	< 1 U		
4-Nitroaniline	UG/L	< 1 UJ		
4-Nitrophenol	UG/L	< 29 U		
Acenaphthene	UG/L	< 0.5 U		
Acenaphthylene	UG/L	< 0.5 U		
Acetophenone	UG/L	< 1 U		
Adamantane	UG/L	< 5 U		
Aniline	UG/L	< 1 U		
Anthracene	UG/L	< 0.5 U		
Benzo (a) anthracene	UG/L	< 0.5 U		
Benzo (a) pyrene	UG/L	< 0.5 U		
Benzo (b) fluoranthene	UG/L	< 0.5 U		
Benzo (g,h,i) perylene	UG/L	< 0.5 U		
Benzo (k) fluoranthene	UG/L	< 0.5 U		
Benzul alashal	UG/L	< 14 U		
Benzyi alconol	UG/L	< 14 U		
Bis(2-chloroethoxy)methane	UG/L	< 1 U		
bis(2 Chloroisopropyl)othor		< 1 U		
Bis(2-ethylbeyyl)phtbalate		< 5 11		
Butyl benzyl phthalate		< 511		
Carbazole		< 1		
Chlorobenzilate	UG/L	< 10 U		
Chrysene	UG/L	< 0.5 U		
Diallate (cis or trans)	UG/L	< 5 U		
Dibenz (a,h) anthracene	UG/L	< 0.5 U		
Dibenzofuran	UG/L	< 1 U		
Diethyl phthalate	UG/L	< 5 U		
Dimethyl phthalate	UG/L	< 5 U		
Di-n-butyl phthalate	UG/L	< 5 U		
Di-n-octyl phthalate	UG/L	< 5 U		
Dinoseb	UG/L	< 5 U		
	UG/L	< 48 U		
a-Limonene	UG/L	< 5 U		
Fluoranthene	UG/L	< 0.5 U		
Hovachlorobonzono	UG/L	< U.5 U		
Heyachlorobutadiono		< 0.0 U		
Heyachlorocyclopentadiono		< I U > 1/ II		
Hexachloroethane		< 14 U 2 5 H		
Indeno (1.2.3-cd) pyrene		< 0.5 []		
Isophorone	UG/L	< 1 U		
Naphthalene	UG/L	< 0.5 U		

	Property Owner	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH	PROPERTY OWNER H WELL IS LOCATED TO THE SOUTH
	Location Description	OF THE RESIDENCE.	OF THE RESIDENCE.	OF THE RESIDENCE.
	Source Type	VVELL	VVELL 240	VVELL
Comm	Well Deptn	340 Dro Trootmont	340	340
Samp		Pre-Treatment	Pre-Treatment	Post-freatment
Decemptor and units	Sample ID	10/28/2011/20/204	11/0/2011	11/0/2011
Nitrobonzono	Sample Date	10/28/2011	11/8/2011	11/8/2011
Nill Oberizerie	UG/L	< 1 U		
N-Nitrosodiechylamino	UG/L	< 10		
N Nitrosodi n butylamina	UG/L	< 5 U		
N-Nitrosodi n propulamino	UG/L	< 5 0		
N. Nitrosodinhonylamino	UG/L	< 1 U		
		< 5 11		
Darathion othyl	UG/L	< 5 U		
Parathion mothyl		< 5 U		
Pontachlorohonzono	00/L	< 5.0		
Pentachiorophonol	UG/L			
Pentachiorophenoi				
Phenol		< 0.5 U		
Phorate		> 1 11		
Pronamido		< T U 2 1 II		
Pyriding	UG/L	< 0.0 U		
Squalepo	UG/L	< 0 U > F III		
Torbufos	UG/L	< 0 UJ		
Terpineel	UG/L	< 5 U		
	UG/L	< 5 U		
	UG/L	< 5 UJ		
	UG/L	< 5 0		
TICs				
1,2,3-Trimethylbenzene	UG/L			
N. I. I.I. O				
Volatile Organics		1.00.11		
1, 1, 1-1 Fichleresthere	UG/L	< 1.00 U		
1,1,2-1 Fichloroethane	UG/L	< 1.00 U		
1, 1-Dichloroethane	UG/L	< 1.00 U		
	UG/L	< 1.00 U		
1,2,3-11methylbenzene	UG/L	< 1.00 U		
	UG/L			
1,2,4-11inetityidenzene	UG/L	< 1.00 0		
1,2-Diblomo-3-chioroproparie	UG/L	< 1.00.11		
1,2-Dichloroothano		< 1.00 U		
1.2 Dichloropropapo		< 1.00 0		
1 3 5-Trimethylbenzene		< 1.00 []		
1 3-Dichlorobenzene		< 1.00 U		
1 <i>A</i> -Dichlorobenzene		< 1.00 U		
Acetone		< 50.011		
Benzene		< 1.00 []	< 0.500 11	< 0.500 11
Carbon disulfide		< 1.00 U		
Carbon Tetrachloride		< 1.00 U		
Chlorobenzene	UG/L	< 1.00 U		
Chloroform	UG/I	< 1.00 U		
cis-1,2-Dichloroethene	UG/L	< 1.00 U		
Diisopropyl Ether	UG/L	< 1.00 U		
Ethanol	UG/L	< 100 U		
Ethyl tert-Butyl Ether	UG/L	< 1.00 U		
Ethylbenzene	UG/L	< 1.00 U	< 0.500 U	< 0.500 U
Hexachlorobutadiene	UG/L	< 1 U		
Isopropyl alcohol	UG/L	< 50.0 U		
Isopropylbenzene	UG/L	< 1.00 U		
m,p-Xylene	UG/L	< 2.00 U		
Methoxychlor	UG/L	< 0.0236 U		
Methyl tert-Butyl Ether	UG/L	< 1.00 U		
Methylene Chloride	UG/L	< 5.00 U		
Naphthalene	UG/L	< 5.00 U		
o-Xylene	UG/L	< 1.00 U		
Styrene	UG/L			

			-	
	Property Owner	PROPERTY OWNER H	PROPERTY OWNER H	PROPERTY OWNER H
		WELL IS LOCATED TO THE SOUTH	WELL IS LOCATED TO THE SOUTH	WELL IS LOCATED TO THE SOUTH
	Location Description	OF THE RESIDENCE.	OF THE RESIDENCE.	OF THE RESIDENCE.
	Source Type	WELL	WELL	WELL
	Well Depth	340	340	340
	Sampled Before Treatment?	Pre-Treatment	Pre-Treatment	Post-Treatment
	Sample ID	1028201120204	1108201120208	1108201120209
Parameter and units	Sample Date	10/28/2011	11/8/2011	11/8/2011
Tert-Amyl Methyl Ether	UG/L	< 1.00 U		
Tertiary Butyl Alcohol	UG/L	< 10.0 U		
Tetrachloroethene	UG/L	< 1.00 U		
Tetrahydrofuran	UG/L			
Toluene	UG/L	< 1.00 U	< 0.500 U	< 0.500 U
trans-1,2-Dichloroethene	UG/L	< 1.00 U		
Trichloroethene	UG/L	< 1.00 U		
Vinyl chloride	UG/L	< 1.00 U		
Xylenes, total	UG/L	< 3.00 U	< 0.500 U	< 0.500 U

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended

holding time

J : Estimated value --- : Parameter not analyzed. B : Blank qualified ug/L : Micrograms per liter mg/L : Milligrams per liter NA : Not Available NTLL : Nephelometric Turbidity

NTU : Nephelometric Turbidity Unit umho/cm : Micromhos per centimeter

colonies/100 ml : Colonies per 100 millileters



APPENDIX A-9 EPA STUDY WELL DATA PROPERTY OWNER I

	Property Owner	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I NEW WELL-SAMPLE TAKEN AT			
		WELL WELL	ULD WELL		ULD WELL		1/15 \//ELL	1/15 WELL	1/15 W/ELL	1/15 W/ELL
	Well Dopth	142	142	142	142	142	202	202	202	202
	Sampled Pefere Treatment?	Dro Troatmont	Dro Troatmont	Dro Troatmont	Dro Troatmont	14Z	203	203	203	Dro Troatmont
	Sampled before freatment?		PTe-Treatment	Pre-Treatment	1020201000102	1021201120202	NA 001420100010E	1006201000001	INA 1012201000001	101220100002
Development and another	Sample ID	NTH0172-08032010-1100	0915201000103	1006201000902	1020201000102	1031201120202	0914201000105	10/6201000901	10/13/201000901	10/13/2010/09/02
Parameter and units	Sample Date	8/3/2010	9/15/2010	10/6/2010	10/20/2010	10/31/2011	9/14/2010 (Baseline)	10/6/2010	10/13/2010	10/13/2010
Aldehydes										
Gluteraldehyde	UG/L									
Bacteria										
E. coli	colonies/100ml					Absent				
Fecal coliform bacteria	colonies/100ml					< 1 U				
Total Coliform Bacteria	colonies/100ml					Present				
DBCP										
1 2-Dibromo-3-chloroprop	ane UG/I					< 0.1017 []				
Extractable Petroleum Hyd	drocarbons									
Diesel	UG/L					< 94.3 U				
Conoral Chamistry										
Alkaliaity Tatal (02002)	10.1					47.4				
	MG/L					07.4				
Annonia as N	MG/L									
Bicarbonate Aikalinity as C	acU3 MG/L	121	08.5			07.5	113			
Bromide	MG/L	10.0.11				< 2.5 UJ	10.0.11			
Carbonate as CaCO3	MG/L	< 10.0 U	< 10.0 0			< 10.0 0	< 10.0 0			
	MG/L	44.3	57.3			26.2 J	28.8			
CO2 by Headspace	UG/L					20000				
	MG/L									
Fluoride	MG/L					< 0.50 UJ				
MBAS	MG/L	< 0.0500 0	< 0.0500 U			< 0.12 U	< 0.0500 U			
Nitrate	MG/L									
Nitrate Nitrogen	MG/L					0.75				
Nitrite Nitrogen	MG/L					< 0.50 UJ				
OII & Grease HEM	MG/L	< 5.43 U	< 5.81 U			< 4.60 U	< 5.95 U			
pH	pH UNITS	6.40 J	6.70 J			6.40 H	7.60 J			
Phosphorus	MG/L					< 0.100 U				
Specific conductance	UMHO/CM	340	398			265	327			
Sulfate	MG/L	16.6	18			26.3 J	13.4			
Temperature of pH detern	nination CELSIUS	22.0 J	23.0 J			21.6 H	23.1 J			
Total Dissolved Solids	MG/L	214	264			156	166			
Total Suspended Solids	MG/L	< 1.00 U	< 1.00 U			< 1.00 U	41.2			
lurbidity	NTU	< 1.00 U	3.8			< 0.30 U	68			
Glycols										
1,2-Propylene Glycol	MG/L									
Diethylene Glycol	MG/L					< 10 U				
Ethylene Glycol	MG/L									
Tetraethylene glycol	MG/L					< 10 UJ				
Triethylene alvcol	MG/L					< 10 U				
Light Gases										
Acetylene	MG/L					< 0.00500 U				
Ethane	MG/L	< 0.0260 U	0.0953	0.195	0.103	< 0.00500 U	1.59	1.84	1.47	0.254
Ethene	MG/L					< 0.00500 U				
Methane	MG/L	0.0957	1.41	2.78 J	1.78	< 0.00500 U	10.9	25.4	20.6	4.58
n-Butane	MG/L					< 0.00500 U				
Propane	MG/L	< 0.0340 U	< 0.0340 U	< 0.0340 U	< 0.0340 U	< 0.00500 U	0.101	0.117	0.0841	< 0.0340 U
Low Molecular Weight Asi	de									
	U 3					- 10000 11				
	UG/L					< 10000 U				
	UG/L					< 10000 U				
	UG/L					< 10000 U				
	UG/L					< 10000 U				
	UG/L					< 5000 U				
Propionic Acid	UG/L					< 13000 U				

	Property Owner	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I NEW WELL-SAMPLE TAKEN AT			
	Location Description	OLD WELL	OLD WELL	OLD WELL	OLD WELL	OLD WELL	1715	1715	1715	1715
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Sampled Pefere Treatment?	I42	I42	I42	I42	142	203	203	203	203 Dro Troatmont
	Sampled before Treatment?	NTH0172-08032010-1100	0915201000103	1006201000902	1020201000102	1031201120202	091/201000105	1006201000901	1013201000901	1013201000902
Paramotor and units	Sample TD Sample Date	8/2/2010	9/15/2010	10/6/2010	10/20/2010	10/31/2011	0,14201000103 0,14,2010 (Basolino)	10/6/2010	10/13/2010	10/13/2010
	Sample Date	0/3/2010	9/13/2010	10/0/2010	10/20/2010	10/31/2011	9/14/2010 (Baseline)	10/0/2010	10/13/2010	10/13/2010
Metals, 6020x										
Cesium	MG/L					< 0.1 U				
Cesium, Dissolved	MG/L					< 0.1 U				
Potassium	MG/L					< 100 U				
Potassium, Dissolved	MG/L					< 100 U				
Silicon	MG/L					< 2500 U				
Silicon, Dissolved	MG/L					< 2500 0				
Thorium Dissolved	MG/L					< 2 U				
	MG/L									
	MG/L									
	WOL									
Metals, Total										
Aluminum	MG/L					< 0.0200 U				
Antimony	MG/L					< 0.00200 U				
Arsenic	MG/L	< 0.0100 U	< 0.0100 U			< 0.00200 U	< 0.0100 U			
Barium	MG/L	0.116	0.136			0.0856	0.297			
Beryllium	MG/L					< 0.00200 U				
Boron	MG/L					< 0.0500 U				
Cadmium	MG/L	< 0.00100 U	< 0.00100 U			< 0.00100 U	< 0.00100 U			
Calcium	MG/L	44.1	51.6			35.4	41			
Chromium	MG/L	< 0.00500 U	< 0.00500 U			< 0.00200 U	< 0.00500 U			
Cobalt	MG/L					< 0.00200 U				
Lopper	MG/L					< 0.00500 0				
Hardness, CacO3	MG/L	 < 0.0500 U	0.0527			< 0.0500 U	2.20 1			
	MG/L	< 0.0500 0	< 0.00500 11			< 0.0300 0	< 0.00500 U			
	MG/L	< 0.00500 0	< 0.00500 0			< 0.00200 0	< 0.00300 0			
Magnesium	MG/L	61	7 17			4 95	6.43			
Manganese	MG/L	< 0.0150 U	< 0.0150 U			< 0.00500 U	0.0429			
Mercury	MG/L	< 0.000200 U	< 0.000200 U			< 0.000200 U	< 0.000200 U			
Molybdenum	MG/L					< 0.00500 U				
Nickel	MG/L					< 0.00500 U				
Potassium	MG/L	< 1.00 U	1.05			< 1.00 U	2.48			
Selenium	MG/L	< 0.0100 U	< 0.0100 U			< 0.00200 U	< 0.0100 U			
Silver	MG/L	< 0.00500 U	< 0.00500 U			< 0.00200 U	< 0.00500 U			
Sodium	MG/L	12.2	14.8			7.68	14.6			
Strontium	MG/L					0.0576				
Sulfur	MG/L	5.3	5.5			4.68	3.7			
I hallium Titanium	MG/L					< 0.00200 U				
	MG/L					< 0.00200 U				
	MG/L					< 0.00400 U				
	MG/L					< 0.0500 0				
Metals, Dissolved										
Aluminum, Dissolved	MG/L					< 0.0200 U				
Antimony, Dissolved	MG/L					< 0.00200 U				
Arsenic, Dissolved	MG/L					< 0.00200 U	< 0.0100 U			
Barium, Dissolved	MG/L					0.0868	0.256			
Beryllium, Dissolved	MG/L					< 0.00200 U				
Boron, Dissolved	MG/L					< 0.0500 U				
Cadmium, Dissolved	MG/L					< 0.00100 U	< 0.00100 U			
Calcium, Dissolved	MG/L					34.6	41.6			
Coholt Dissolved	MG/L					< 0.00200 U	< 0.00500 U			
	MG/L					< 0.00200 U				
Iron Dissolved	MG/L						< 0.0500 U			
Lead Dissolved	MC/L					< 0.0300 0				
Magnesium Dissolved	MG/L					4 91	6 25			
green and brook			1	1	1		5120		1	1

	Property Owner	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I NEW WELL-SAMPLE TAKEN AT			
	Location Description	OLD WELL	OLD WELL	OLD WELL	OLD WELL	OLD WELL	1715	1715	1715	1715
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	142	142	142	142	142	203	203	203	203
5	ampled Before Treatment?	Pre-Treatment	Pre-Treatment	Pre-Treatment	Pre-Treatment	NA	NA	NA	NA	Pre-Treatment
	Sample ID	NTH0172-08032010-1100	0915201000103	1006201000902	1020201000102	1031201120202	0914201000105	1006201000901	1013201000901	1013201000902
Parameter and units	Sample Date	8/3/2010	9/15/2010	10/6/2010	10/20/2010	10/31/2011	9/14/2010 (Baseline)	10/6/2010	10/13/2010	10/13/2010
Manganese, Dissolved	MG/L					< 0.00500 U	0.0214			
Mercury, Dissolved	MG/L					< 0.000200 U	< 0.000200 U			
Molybdenum, Dissolved	MG/L					< 0.00500 U				
Nickel, Dissolved	MG/L					< 0.00500 U				
Potassium, Dissolved	MG/L					< 1.00 U	1.68			
Selenium, Dissolved	MG/L					< 0.00200 U	< 0.0100 U			
Silver, Dissolved	MG/L					< 0.00200 U	< 0.00500 U			
Sodium, Dissolved	MG/L					7.4	15.1			
Strontium, Dissolved	MG/L					0.0567				
Sulfur, Dissolved	MG/L					4.47				
Thallium, Dissolved	MG/L					< 0.00200 U				
Titanium, Dissolved	MG/L					< 0.00200 U				
Vanadium, Dissolved	MG/L					< 0.00400 U				
Zinc, Dissolved	MG/L					< 0.0500 U				
Miscellaneous Organics						10				
Inorganic Carbon, Dissolved	MG/L					19				
Organic Carbon, Dissolved	MG/L					< 1.00 U				
Pesticides and PCRs										
						< 0.0236.11				
4 4'-DDF						< 0.0236 U				
4 4'-DDT						< 0.0236 U				
Aldrin						< 0.0236 U				
alpha-BHC						< 0.0236 U				
						< 0.0230 0				
heta-BHC						< 0.023611				
Carbaryl						< 6.011				
delta_BHC						< 0.00				
						< 0.0230 0				
Dichlorvos						< 0.94 0				
Disulfaton						< 0.0230 0				
Endosulfan I						< 0.94 0				
Endosulfan II						< 0.0230 0				
Endosulfan sulfato						< 0.0236 U				
Endosulari sullate						< 0.0230 0				
Endrin aldebyde						< 0.0230 U				
						< 0.0230 U				
						< 0.0230 U				
Ganna-Bhor (Lindane)						< 0.0230 U				
						< 0.0230 U				
Melathian						< 0.0230 U				
Mathoxychlor						< 0.94 0				
Meyipphos						< 0.0236 0				
Interniphos	06/L					< 0.94 0				
Purgeable Petroleum Hydro	ocarbons									
GRO as Gasoline	UG/L					< 100 U				
Semivolatile Organics										
1,2,4,5-Tetrachlorobenzene	UG/L					< 1 U				
1,2-Dinitrobenzene	UG/L					< 5 U				
1,2-Diphenylhydrazine	UG/L					< 1 U				
1,3-Dimethyl adamatane	UG/L					< 5 U				
1,3-Dinitrobenzene	UG/L					< 5 U				
1,4-Dinitrobenzene	UG/L					< 5 U				
1-Chloronaphthalene	UG/L					< 1 U				
2,3,4,6-Tetrachlorophenol	UG/L					< 1 U				
2,4,5-Trichlorophenol	UG/L					< 1 U				
2,4,6-Trichlorophenol	UG/L					< 1 U				
2,4-Dichlorophenol	UG/L					< 1 U				
2,4-Dimethylphenol	UG/L					< 1 U				
2,4-Dinitrophenol	UG/L					< 29 U				
2,4-Dinitrotoluene	UG/L					< 5 U				

	Property Owner	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I NEW WELL-SAMPLE TAKEN AT			
	Location Description	OLD WELL	OLD WELL	OLD WELL	OLD WELL	OLD WELL	1715	1715	1715	1715
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth Sampled Pefere Treatment?	142 Dro Trootmont	I42	I42	I42	142	203	203	203	203
		NTH0172-08032010-1100	0915201000103	1006201000902	1020201000102	1031201120202	091/201000105	1006201000901	1013201000901	1013201000902
Parameter and units	Sample Date	8/3/2010	9/15/2010	10/6/2010	10/20/2010	10/31/2011	9/14/2010 (Baseline)	10/6/2010	10/13/2010	10/13/2010
2.6-Dichlorophenol	UG/L					< 1 U				
2,6-Dinitrotoluene	UG/L					< 1 U				
2-Butoxyethanol	UG/L					< 5 UJ				
2-Chloronaphthalene	UG/L					< 1 U				
2-Chlorophenol	UG/L					< 1 U				
2-Methylnaphthalene	UG/L					< 0.5 U				
2-Methylphenol	UG/L									
2-Nitrophenol										
3 3-Dichlorobenzidine						< 5				
3-Nitroaniline	UG/L					< 1 U				
4,4'-Methylenebis(2-chlore	oaniline) UG/L					< 14 U				
4,4'-Methylenebis(N,N-din	methylanilin UG/L					< 14 UJ				
4,6-Dinitro-2-methylphene	ol UG/L					< 14 U				
4-Bromophenyl phenyl eth	her UG/L					< 1 U				
4-Chloro-3-methylphenol	UG/L					< 1 U				
4-Chloroaniline	UG/L					< 1 U				
4-Chlorophenyl phenyl etr	ner UG/L					< 1 U				
	UG/L									
4-Nitrophenol						< 29				
Acenaphthene	UG/L					< 0.5 U				
Acenaphthylene	UG/L					< 0.5 U				
Acetophenone	UG/L					< 1 U				
Adamantane	UG/L					< 5 U				
Aniline	UG/L					< 1 U				
Anthracene	UG/L					< 0.5 U				
Benzo (a) anthracene	UG/L					< 0.5 U				
Benzo (a) pyrene	UG/L					< 0.5 U				
Benzo (g h i) pervlene						< 0.5 U				
Benzo (k) fluoranthene	UG/L					< 0.5 U				
Benzoic acid	UG/L					< 14 U				
Benzyl alcohol	UG/L					< 14 U				
Bis(2-chloroethoxy)metha	ine UG/L					< 1 U				
Bis(2-chloroethyl)ether	UG/L					< 1 U				
bis(2-Chloroisopropyl)ethe	er UG/L					< 1 U				
Bis(2-ethylhexyl)phthalate	e UG/L					< 5 U				
Carbazolo	UG/L					< 5 U				
Chlorobenzilate						< 10				
Chrysene	UG/L					< 0.5 U				
Diallate (cis or trans)	UG/L					< 5 U				
Dibenz (a,h) anthracene	UG/L					< 0.5 U				
Dibenzofuran	UG/L					< 1 U				
Diethyl phthalate	UG/L					< 5 U				
Dimethyl phthalate	UG/L					< 5 U				
Di-n-butyl phthalate	UG/L					< 5 U				
Di-n-octyl phthalate	UG/L									
Disulfoton						< 48				
d-Limonene	UG/L					< 5 U				
Fluoranthene	UG/L					< 0.5 U				
Fluorene	UG/L					< 0.5 U				
Hexachlorobenzene	UG/L					< 0.5 U				
Hexachlorobutadiene	UG/L					< 1 U				
Hexachlorocyclopentadien	ne UG/L					< 14 U				
Hexachloroethane	UG/L					< 5 U				
Indeno (1,2,3-cd) pyrene	UG/L					< 0.5 U				
Naphthalano	UG/L									
	00/L					< 0.0 U				

	Property Owner	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I NEW WELL-SAMPLE TAKEN AT			
	Location Description	OLD WELL	OLD WELL	OLD WELL	OLD WELL	OLD WELL	1715	1715	1715	1715
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	142	142	142	142	142	203	203	203	203
	Sampled Before Treatment?	NTU0172 09032010 1100	Pre-Treatment	Pre-Treatment	Pre-Treatment	NA 1021201120202	NA 0014201000105	NA 1006201000001	NA 1012201000001	Pre-Treatment
Denometer and units	Sample ID	NTH0172-08032010-1100	0915201000103	1006201000902	10/20/2010	10/21/2011	0914201000105	1006201000901	10/12/2010	10/13/201000902
Nitrobonzono	Sample Date	8/3/2010	9/15/2010	10/6/2010	10/20/2010	10/31/2011	9/14/2010 (Baseline)	10/6/2010	10/13/2010	10/13/2010
Nili Oberizerie						< 1 U				
N-Nitrosodimothylamino						< 10				
N Nitrosodi n butylamino						< 50				
N-Nitrosodi-n-propylamine										
N-Nitrosodinbenylamine						< 111				
N-Nitrosomethylethylamir						< 511				
Parathion-ethyl						< 5 U				
Parathion-methyl	UG/L					< 5 U				
Pentachlorobenzene	UG/L					< 1 U				
Pentachlorophenol	UG/L					< 5 UJ				
Phenanthrene	UG/L					< 0.5 U				
Phenol	UG/L					< 1 U				
Phorate	UG/L					< 1 U				
Pronamide	UG/L					< 1 U				
Pyrene	UG/L					< 0.5 U				
Pyridine	UG/L					< 5 U				
Squalene	UG/L					< 5 UJ				
Terbufos	UG/L					< 5 U				
Terpineol	UG/L					< 5 U				
Tributoxyethyl phosphate	e UG/L					< 5 UJ				
Trifluralin	UG/L					< 5 U				
TICO										
1.2.2 Trimothylhonzono										
1,2,3- minethyibenzene	UG/L									
Volatile Organics										
1,1,1-Trichloroethane	UG/L					< 1.00 U				
1,1,2-Trichloroethane	UG/L					< 1.00 U				
1,1-Dichloroethane	UG/L					< 1.00 U				
1,1-Dichloroethene	UG/L					< 1.00 U				
1,2,3-Trimethylbenzene	UG/L					< 1.00 U				
1,2,4-Trichlorobenzene	UG/L									
1,2,4-Trimethylbenzene	UG/L					< 1.00 U				
1,2-Dibromo-3-chloroprop	pane UG/L					< 0.1017 U				
1,2-Dichlorobenzene	UG/L					< 1.00 U				
1,2-Dichlerennen	UG/L					< 1.00 U				
1,2-Dichloropropane	UG/L									
1.2 Disblorshonzono						< 1.00 U				
						< 1.00 U				
						< 50.011				
Benzene		< 0.500 []	< 0.500 11			< 1.00.11	< 0.500 []			
Carbon disulfide						< 1.00 U				
Carbon Tetrachloride						< 1.00 U				
Chlorobenzene	UG/L					< 1.00 U				
Chloroform	UG/L					< 1.00 U				
cis-1,2-Dichloroethene	UG/L					< 1.00 U				
Diisopropyl Ether	UG/L					< 1.00 U				
Ethanol	UG/L					< 100 U				
Ethyl tert-Butyl Ether	UG/L					< 1.00 U				
Ethylbenzene	UG/L	< 0.500 U	< 0.500 U			< 1.00 U	< 0.500 U			
Hexachlorobutadiene	UG/L					< 1 U				
Isopropyl alcohol	UG/L					< 50.0 U				
Isopropylbenzene	UG/L					< 1.00 U				
m,p-Xylene	UG/L					< 2.00 U				
Methoxychlor	UG/L					< 0.0236 U				
Methyl tert-Butyl Ether	UG/L					< 1.00 U				
Methylene Chloride	UG/L					< 5.00 U				
Naphthalene	UG/L					< 5.00 U				
o-Xylene	UG/L					< 1.00 U				
Styrene	UG/L									

	Property Owner	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I
							NEW WELL-SAMPLE TAKEN AT			
	Location Description	OLD WELL	OLD WELL	OLD WELL	OLD WELL	OLD WELL	1715	1715	1715	1715
	Source Type	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL	WELL
	Well Depth	142	142	142	142	142	203	203	203	203
	Sampled Before Treatment?	Pre-Treatment	Pre-Treatment	Pre-Treatment	Pre-Treatment	NA	NA	NA	NA	Pre-Treatment
	Sample ID	NTH0172-08032010-1100	0915201000103	1006201000902	1020201000102	1031201120202	0914201000105	1006201000901	1013201000901	1013201000902
Parameter and units	Sample Date	8/3/2010	9/15/2010	10/6/2010	10/20/2010	10/31/2011	9/14/2010 (Baseline)	10/6/2010	10/13/2010	10/13/2010
Tert-Amyl Methyl Ether	UG/L					< 1.00 U				
Tertiary Butyl Alcohol	UG/L					< 10.0 U				
Tetrachloroethene	UG/L					< 1.00 U				
Tetrahydrofuran	UG/L									
Toluene	UG/L	< 0.500 U	< 0.500 U			< 1.00 U	< 0.500 U			
trans-1,2-Dichloroethene	UG/L					< 1.00 U				
Trichloroethene	UG/L					< 1.00 U				
Vinyl chloride	UG/L					< 1.00 U				
Xylenes, total	UG/L	< 0.500 U	< 0.500 U			< 3.00 U	< 0.500 U			

Notes:

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended

holding time
	Property Owner	PROPERTY OWNER I								
		NEW WELL-SAMPLE TAKEN AT								
	Location Description	1715	1715	1715	1715	1715	1715	1715	1715	1715
	Source Type	VVELL	WELL 202	VVELL	VVELL	WELL	VVELL	WELL	VVELL	VVELL
c	ampled Pefere Treatment?	203	203	203 Dro Troatmont	203	203 Dro Troatmont	203 Dest Treatment	203 Dro Troatmont	203 Doct Troatmont	203 Dro Troatmont
3		1020201000101	1119201000301	0301201124001	0301201124002	0407201120201	0407201120202	0522201120205	0523201120206	0608201120203
Paramotor and units	Sample TD	10/20/2010	11/18/2010	3/1/2011	3/1/2011	4/7/2011	4/7/2011	5/23/2011	5/23/2011	6/8/2011
	Sample Date	10/20/2010	11/10/2010	5/ 1/2011	5/1/2011	4/7/2011	4/7/2011	5/25/2011	5/25/2011	0/0/2011
Aldenydes								50.0.1	50.0.U	
Gluteraldehyde	UG/L							< 50.0 U	< 50.0 U	
Bacteria										
E. coli	colonies/100ml									
Fecal coliform bacteria	colonies/100ml									
Total Coliform Bacteria	colonies/100ml									
DRCP										
1 2-Dibromo-3-chloropropa										
Extractable Petroleum Hyd	rocarbons									
Diesel	UG/L									
General Chemistry										
Alkalinity, Total (CaCO3)	MG/I									
Ammonia as N	MG/L									
Bicarbonate Alkalinity as Ca	CO3 MG/L		111	132	117	134	133	135	132	
Bromide	MG/L									
Carbonate as CaCO3	MG/L		< 10.0 U	< 10.0 U	23.5	< 10.0 U	< 10.0 U	< 10.0 U	< 10.0 U	
Chloride	MG/L		35.5	18.6	16.4	11.2	13.5	13.5	12.1	
CO2 by Headspace	UG/L									
Cyanide	MG/L									
Fluoride	MG/L									
MBAS	MG/L		< 0.0500 U	< 0.0500 U	0.0764	< 0.0500 U	< 0.0500 U	< 0.0500 U	< 0.0500 U	
Nitrate	MG/L							< 0.100 0	< 0.100 U	
Nitrate Nitrogen	MG/L									
	MG/L									
nH			7 30 1	8 10 HI	8 40 HI	8 00 HI	8 30 H I	7 90 H	7 70 H	
Phosphorus	рномпз		7.50 5	0.10115	0.40115	8.00115	0.30115	7.7011	7.7011	
Specific conductance	UMHO/CM		326	311	338	325	334			
Sulfate	MG/L		18	15.8	13.2	7.95	7.8	15.2	14.9	
Temperature of pH determi	nation CELSIUS		21.5 J	21.0 HJ	21.0 HJ	22.8 HJ	22.8 HJ	21.9 H	21.9 H	
Total Dissolved Solids	MG/L		201	200	204	194	183	173	174	
Total Suspended Solids	MG/L		< 1.00 U	45.6	1.9	1.8	1.2	4.3	1.5	
Turbidity	NTU		3.4	5.1	7.2	12.2	2.7	6.6	4	
Glycols										
1 2-Propylene Glycol	MG/I							< 10.0 []	< 10.0 []	
Diethylene Glycol	MG/L									
Ethylene Glycol	MG/L							< 10.0 U	< 10.0 U	
Tetraethylene glycol	MG/L									
Triethylene glycol	MG/L									
Light Cases										
Light Gases	MC/I									
Ethane	MG/L	0.754	0.593	0.959.1	< 0.026011	0.613	0.048	0.624	0.0625	0.437
Ethene	MG/L		0.373	0.7373	< 0.0200 0	0.015	0.040	0.024	0.0023	0.437
Methane	MG/L	8.82	7.47	17.1	1.76	14.2	2.82	9.21	1.2	3.09
n-Butane	MG/L									
Propane	MG/L	0.0388	< 0.0340 U							
,										
Low Molecular Weight Acid	S									
ACETIC ACIO	UG/L									
Eormic Acid	UG/L									
	UG/L									
Propionic Acid			 							
	00/L									

	Property Owner	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I						
	1 5	NEW WELL-SAMPLE TAKEN AT	NEW WELL-SAMPLE TAKEN AT	NEW WELL-SAMPLE TAKEN AT						
	Location Description	1715	1715	1715	1715	1715	1715	1715	1715	1715
	Source Type	WELL	WELL	WELL						
	Well Depth	203	203	203	203	203	203	203	203	203
	Sampled Before Treatment?	NA 1020201000101	NA 1110201000201	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment	Pre-Treatment
Decemptor and units	Sample ID	10/20/2010	11/19/2010	2/1/2011	2/1/2011	0407201120201	4/7/2011	0523201120205 E (22)(2011	523201120206 5/22/2011	6/9/2011
	Sample Date	10/20/2010	11/18/2010	3/1/2011	3/1/2011	4/7/2011	4/7/2011	5/23/2011	5/23/2011	0/0/2011
Metals, 6020x										
Cesium	MG/L									
Cesium, Dissolved	MG/L									
Potassium	MG/L									
Potassium, Dissolved	MG/L									
Silicon	MG/L									
Silicon, Dissolved	MG/L									
Thorium Dissolved	MG/L									
	MG/L									
	MG/L									
	NG/L									
				1			1		1	
Metals Total										
Aluminum	MG/L									
Antimony	MG/L									
Arsenic	MG/L		< 0.0100 U	< 0.002 U	< 0.002 U					
Barium	MG/L		0.208	0.331	0.0358	0.291	0.229	0.252	0.239	
Beryllium	MG/L									
Boron	MG/L									
Cadmium	MG/L		< 0.00100 U							
Calcium	MG/L		50.5	34	30.1	31.4	32.6	32.4	32.4	
Chromium	MG/L		< 0.00500 U							
Cobalt	MG/L									
Copper	MG/L									
Hardness, CaCO3	MG/L							99.8	99.4	
Iron	MG/L		0.00500.11	2.18	0.179	1.05	0.0937	0.171	< 0.0500 0	
	MG/L		< 0.00500 0	< 0.00500 0	< 0.00500 0	0.0075	0.0051			
Magnesium	MG/L		7.76	5 11	5.57	4.76	4.55	4 58	4.48	
Magnesian	MG/L		0.0383	0 145	< 0.0150 U	0.0992	< 0.0150 U	0.0391	0.0662	
Mercury	MG/L		< 0.000200 U							
Molybdenum	MG/L									
Nickel	MG/L									
Potassium	MG/L		1.54	2.22	16.7	2.01	1.8	1.88	1.7	
Selenium	MG/L		< 0.0100 U							
Silver	MG/L		< 0.00500 U							
Sodium	MG/L		8.15	29.8	26.7 J	33.7	32.5	31.7	31.3	
Strontium	MG/L							1.45	1.39	
Sulfur	MG/L		4.3	3.01	2.96	2.87	2.81			
Titanium	MG/L									
Vanadium	MG/L									
Zinc	MG/L									
	WO/L									
Metals, Dissolved										
Aluminum, Dissolved	MG/L									
Antimony, Dissolved	MG/L									
Arsenic, Dissolved	MG/L									
Barium, Dissolved	MG/L									
Bergillum, Dissolved	MG/L									
Cadmium Dissolved	MG/L									
Calcium Dissolved	IVIG/L									
Chromium Dissolved	MC/I									
Cobalt, Dissolved	MG/L									
Copper, Dissolved	MG/L									
Iron, Dissolved	MG/L		0.148							
Lead, Dissolved	MG/L									
Magnesium, Dissolved	MG/L									

	Property Owner	PROPERTY OWNER I NEW WELL-SAMPLE TAKEN AT								
	Location Description	1715	1715	1715	1715	1715	1715	1715	1715	1715
	Source Type	202	202	202	202	202	202	202	202	202
c	ampled Refere Treatment?	203	203	203 Dro Troatmont	203 Dost Troatmont	203 Dro Troatmont	203 Doct Troatmont	203 Dro Troatmont	203 Doct Troatmont	203 Dro Troatmont
3		1020201000101	1119201000201	0201201124001	0301201124002	0407201120201	0407201120202	0522201120205	0522201120206	
Daramator and units	Sample Date	10/20/2010	11/19/2010	2/1/2011	2/1/2011	4/7/2011	4/7/2011	5/22/2011	5/22/2011	6/9/2011
Manganasa Dissolved	Sample Date	10/20/2010	0.0406	3/1/2011	5/1/2011	4/7/2011	4/7/2011	5/23/2011	5/23/2011	0/0/2011
Margury Dissolved	MG/L		0.0408							
Melybdonum Disselved	MG/L									
Nickel Disselved	MG/L									
Dotassium Dissolved	MG/L									
Solonium Dissolved	MG/L									
Silver Dissolved	MG/L									
Sodium Dissolved	MG/L									
Strontium Dissolved	MG/L									
Sulfur Dissolved	MG/L									
Thallium Dissolved	MG/L									
Titanium Dissolved	MG/L									
Vanadium Dissolved	MG/L									
Zine Dissolved	MG/L									
	WIG/L									
Miscellaneous Organics										
Inorganic Carbon, Dissolved	d MG/L									
Organic Carbon, Dissolved	MG/L							< 1.00 U	< 1.00 U	
Pesticides and PCBs										
4,4'-DDD	UG/L									
4,4'-DDE	UG/L									
4,4'-DD1	UG/L									
Aldrin	UG/L									
alpha-BHC	UG/L									
Azinphos-methyl	UG/L									
beta-BHC	UG/L									
Carbaryl	UG/L									
delta-BHC	UG/L									
Dichlorvos	UG/L									
Dieidrin	UG/L									
Disuifoton	UG/L									
	UG/L									
Endosultati sultate										
Endrin aldobydo										
Endrin kotopo										
damma_BHC (Lindane)										
Hentachlor										
Heptachlor epoxide										
Malathion										
Methoxychlor										
Mevinphos										
	00,2									
Purgeable Petroleum Hydro	ocarbons									
GRO as Gasoline	UG/L									
Semivolatile Organics										
1 2 4 5-Tetrachlorobenzene										
1 2-Dinitrobenzene										
1 2-Diphenylbydrazine										
1 3-Dimethyl adamatane										
1.3-Dinitrohenzene										
1.4-Dinitrobenzene	UG/I									
1-Chloronaphthalene										
2.3.4.6-Tetrachloronhenol										
2.4.5-Trichlorophenol	LIG/I									
2,4,6-Trichlorophenol	UG/L									
2,4-Dichlorophenol	LIG/I									
2,4-Dimethylphenol	UG/L									
2,4-Dinitrophenol	UG/L									
2,4-Dinitrotoluene	UG/L									

	Property Owner Location Description	PROPERTY OWNER I NEW WELL-SAMPLE TAKEN AT 1715								
	Source Type	WELL								
	Well Depth	203	203	203	203	203	203	203	203	203
Samp	ed Before Treatment?	NA	NA	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment	Pre-Treatment
	Sample ID	1020201000101	1118201000301	0301201124001	0301201124002	0407201120201	0407201120202	0523201120205	0523201120206	0608201120203
Parameter and units	Sample Date	10/20/2010	11/18/2010	3/1/2011	3/1/2011	4/7/2011	4/7/2011	5/23/2011	5/23/2011	6/8/2011
2,6-Dichlorophenol	UG/L									
2,6-Dinitrotoluene	UG/L									
2-Butoxyethanol	UG/L									
2-Chloronaphthalene	UG/L									
2-Child Ophenol	UG/L									
2-Nitroaniline										
2-Nitrophenol	UG/L									
3,3-Dichlorobenzidine	UG/L									
3-Nitroaniline	UG/L									
4,4'-Methylenebis(2-chloroaniline	e) UG/L									
4,4'-Methylenebis(N,N-dimethyla	nilin UG/L									
4,6-Dinitro-2-methylphenol	UG/L									
4-Bromophenyl phenyl ether	UG/L									
4-Chloro-3-methylphenol	UG/L									
4-Chloroaniline	UG/L									
4-Chlorophenyl phenyl ether	UG/L									
4-Methylphenol	UG/L									
4-Nitroaniline	UG/L									
4-Nitrophenol	UG/L									
Acenaphthene	UG/L									
Acenaphthylene	UG/L									
Ademontano	UG/L									
	UG/L									
Anthracene										
Benzo (a) anthracene										
Benzo (a) pyrene	UG/L									
Benzo (b) fluoranthene	UG/L									
Benzo (g,h,i) perylene	UG/L									
Benzo (k) fluoranthene	UG/L									
Benzoic acid	UG/L									
Benzyl alcohol	UG/L									
Bis(2-chloroethoxy)methane	UG/L									
Bis(2-chloroethyl)ether	UG/L									
bis(2-Chloroisopropyl)ether	UG/L									
Bis(2-ethylhexyl)phthalate	UG/L									
Butyl benzyl phthalate	UG/L									
	UG/L									
Chrysepe										
Diallate (cis or trans)										
Dibenz (a.h) anthracene	LIG/I									
Dibenzofuran	UG/L									
Diethyl phthalate	UG/L									
Dimethyl phthalate	UG/L									
Di-n-butyl phthalate	UG/L									
Di-n-octyl phthalate	UG/L									
Dinoseb	UG/L									
Disulfoton	UG/L									
d-Limonene	UG/L									
Fluoranthene	UG/L									
Fluorene	UG/L									
Hexachlorobenzene	UG/L									
Hexachlorobutadiene	UG/L									
Hexachlorocyclopentadiene	UG/L									
	UG/L									
Nanhthalene										
Maprinalelle	00/L									

	Property Owner	PROPERTY OWNER I NEW WELL-SAMPLE TAKEN AT								
	Source Type	WFII	WELL	WELL	WELL	WFII	WELL	WFLI	WFLI	WFLI
	Well Depth	203	203	203	203	203	203	203	203	203
	Sampled Before Treatment?	NA	NA	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment	Pre-Treatment
	Sample ID	1020201000101	1118201000301	0301201124001	0301201124002	0407201120201	0407201120202	0523201120205	0523201120206	0608201120203
Parameter and units	Sample Date	10/20/2010	11/18/2010	3/1/2011	3/1/2011	4/7/2011	4/7/2011	5/23/2011	5/23/2011	6/8/2011
Nitrobenzene	UG/L									
N-Nitrosodiethylamine	UG/I									
N-Nitrosodimethylamine										
N-Nitrosodi-n-butylamine	UG/I									
N-Nitrosodi-n-propylamine	e UG/L									
N-Nitrosodiphenylamine										
N-Nitrosomethylethylamin										
Parathion-ethyl	UG/I									
Parathion-methyl										
Pentachlorobenzene										
Pentachlorophenol										
Phenanthrene										
Phenol										
Phorate										
Pronamide										
Pyrene										
Pyridine										
Squalene										
Terbufos										
Ternineol										
Tributoxyetbyl phosphate										
Trifluralin										
	00/L									
TICs										
1,2,3-Trimethylbenzene	UG/L									
Volatile Organics								0.500.11	0.500.11	
1,1,1-1 richloroethane	UG/L							< 0.500 U	< 0.500 U	
1,1,2-Trichloroethane	UG/L							< 0.500 U	< 0.500 U	
1,1-Dichloroethane	UG/L									
1,1-Dichloroethene	UG/L							< 0.500 U	< 0.500 U	
1,2,3-Trimethylbenzene	UG/L									
1,2,4-Trichlorobenzene	UG/L							< 0.500 U	< 0.500 U	
1,2,4-Trimethylbenzene	UG/L									
1,2-Dibromo-3-chloroprop	bane UG/L									
1,2-Dichlorobenzene	UG/L							< 0.500 U	< 0.500 U	
1,2-Dichloroethane	UG/L							< 0.500 U	< 0.500 U	
1,2-Dichloropropane	UG/L							< 0.500 U	< 0.500 U	
1,3,5-Trimethylbenzene	UG/L									
1,3-Dichlorobenzene	UG/L									
1,4-Dicniorobenzene	UG/L							< 0.500 U	< 0.500 U	
Acetone	UG/L									
Benzene	UG/L		< 0.500 U	< 0.500 U	< 0.500 0	< 0.500 U	< 0.500 U	< 0.500 U	< 0.500 U	
	UG/L									
	UG/L							< 0.500 U	< 0.500 U	
Chloroform	UG/L							< 0.500 U	< 0.500 U	
	UG/L									
Discorregul Ether	UG/L							< 0.500 0	< 0.500 0	
Dilsopropyi Ether	UG/L									
Ethalioi	UG/L									
Ethyl tert-Butyl Ether	UG/L									
Ethylbenzene	UG/L		< 0.500 U	< 0.500 U	< 0.500 0	< 0.500 0	< 0.500 U	< 0.500 U	< 0.500 U	
Hexacniorobutadiene	UG/L									
Isopropyi alconol	UG/L									
Isopropylbenzene	UG/L									
m,p-xylene	UG/L							< 0.500 U	< 0.500 U	
Method to the Deck of Still	UG/L									
Wetholese Older	UG/L							< 0.500 U	< 0.500 U	
Methylene Chloride	UG/L							< 5.00 U	< 5.00 U	
	UG/L									
o-Xylene	UG/L							< 0.500 U	< 0.500 U	
Styrene	UG/L							< 0.500 U	< 0.500 U	

	Property Owner	PROPERTY OWNER I								
		NEW WELL-SAMPLE TAKEN AT								
	Location Description	1715	1715	1715	1715	1715	1715	1715	1715	1715
	Source Type	WELL								
	Well Depth	203	203	203	203	203	203	203	203	203
	Sampled Before Treatment?	NA	NA	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment	Pre-Treatment
	Sample ID	1020201000101	1118201000301	0301201124001	0301201124002	0407201120201	0407201120202	0523201120205	0523201120206	0608201120203
Parameter and units	Sample Date	10/20/2010	11/18/2010	3/1/2011	3/1/2011	4/7/2011	4/7/2011	5/23/2011	5/23/2011	6/8/2011
Tert-Amyl Methyl Ether	UG/L									
Tertiary Butyl Alcohol	UG/L									
Tetrachloroethene	UG/L							< 0.500 U	< 0.500 U	
Tetrahydrofuran	UG/L									
Toluene	UG/L		< 0.500 U	1.71	< 0.500 U	0.95	< 0.500 U	< 0.500 U	< 0.500 U	
trans-1,2-Dichloroethene	e UG/L							< 0.500 U	< 0.500 U	
Trichloroethene	UG/L							< 0.500 U	< 0.500 U	
Vinyl chloride	UG/L							< 0.500 U	< 0.500 U	
Xylenes, total	UG/L		< 0.500 U							

Notes:

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended

holding time

holding time J : Estimated value --- : Parameter not analyzed. B : Blank qualified ug/L : Micrograms per liter mg/L : Milligrams per liter NA : Not Available NTU : Nephelometric Turbidity Unit umho/cm : Micromhos per centimeter colonies/100 ml : Colonies per 100 millileters

	Property Owner	PROPERTY OWNER I								
		NEW WELL-SAMPLE TAKEN AT								
	Location Description	1715	1715	1715	1715	1715	1715	1715	1715	1715
	Source Type	202	202	202	202	202	202	202	202	202
c	ampled Before Treatment?	Dro Troatmont								
J		0622201124401	0706201124202	0720201120201	0903201122903	0917201120203		001/201120201		1012201122102
Parameter and units	Sample To	6/22/2011	7/6/2011	7/20/2011	8/3/2011	8/17/2011	9/2/2011	9/14/2011	9/29/2011	10/12/2011
	Sample Date	0/22/2011	110/2011	112012011	0/3/2011	0/1//2011	77272011	//14/2011	//2//2011	10/12/2011
Aldehydes										
Gluteraldehyde	UG/L									
Bacteria										
E. coli	colonies/100ml									
Fecal coliform bacteria	colonies/100ml									
Total Coliform Bacteria	colonies/100ml									
DRCD										
1 2 Dibromo 3 chloropropa										
1,2-Dibiomo-3-chioropropa										
Extractable Petroleum Hyd	rocarbons									
Diesel	UG/L									
General Chemistry										
Alkalinity, Total (CaCO3)	MG/L									
Ammonia as N	MG/L									
Bicarbonate Alkalinity as Ca	CO3 MG/L									
Bromide	MG/L									
Carbonate as CaCO3	MG/L									
Chloride	MG/L									
CO2 by Headspace	UG/L									
Cyanide	MG/L									
Fluoride	MG/L									
MBAS	MG/L									
Nitrate	MG/L									
Nitrate Nitrogen	MG/L									
Nitrite Nitrogen	MG/L									
	MG/L									
Phosphorus										
Specific conductance										
Sulfate	MG/I									
Temperature of pH determi	nation CELSIUS									
Total Dissolved Solids	MG/L									
Total Suspended Solids	MG/L									
Turbidity	NTU									
Glycols										
1 2-Propylene Glycol	MC/I									
Diethylene Glycol	MG/I									
Ethylene Glycol	MG/L									
Tetraethylene glycol	MG/L									
Triethylene glycol	MG/L									
Light Gases										
Acetylene Ethano	MG/L	 0 E42		 0 E11	0.244					
Ethopo	MG/L	0.543	0.8	0.511	0.364	0.421	0.424	0.467	0.445	0.19
Methane	MG/L	10 4	10.8	6.65	10 4	8.88	6.23	9.87 1	9.62	 / 1
n-Butane	MG/I									
Propane	MG/L	< 0.0340 U	< 0.0340 U	< 0.0340 LJ	< 0.0340 U	< 0.0340 U	< 0.00500 U	< 0.00500 U	< 0.00500 U	< 0.00500 U
	mo, E									
Low Molecular Weight Acid	S									
Acetic Acid	UG/L									
Butyric Acid	UG/L									
	UG/L									
	UG/L									
	UG/L									
	UG/L									

	Property Owner	PROPERTY OWNER I								
		NEW WELL-SAMPLE TAKEN AT								
		WFII								
	Well Depth	203	203	203	203	203	203	203	203	203
	Sampled Before Treatment?	Pre-Treatment								
	Sample ID	0622201124401	0706201124303	0720201120201	0803201122803	0817201120203	0902201120206	0914201120201	0929201120202	1012201122103
Parameter and units	Sample Date	6/22/2011	7/6/2011	7/20/2011	8/3/2011	8/17/2011	9/2/2011	9/14/2011	9/29/2011	10/12/2011
Metals, 6020x										
Cesium	MG/L									
Cesium, Dissolved	MG/L									
Potassium	MG/L									
Potassium, Dissolved	MG/L									
Silicon	MG/L									
Thorium	MG/L									
Thorium Dissolved	MG/L									
Uranium	MG/L									
Uranium, Dissolved	MG/L									
									·	
Metals, Total										
Aluminum	MG/L									
Antimony	MG/L									
Barium	MG/I									
Beryllium	MG/L									
Boron	MG/L									
Cadmium	MG/L									
Calcium	MG/L									
Chromium	MG/L									
Cobalt	MG/L									
Lopper	MG/L									
Iron	MG/L									
Lead	MG/L									
Lithium	MG/L									
Magnesium	MG/L									
Manganese	MG/L									
Mercury	MG/L									
Molybdenum	MG/L									
NICKEI Dotassium	MG/L									
Selenium	MG/L									
Silver	MG/L									
Sodium	MG/L									
Strontium	MG/L									
Sulfur	MG/L									
Thallium	MG/L									
l itanium	MG/L									
	MG/L									
	MO/L									
Metals, Dissolved										
Aluminum, Dissolved	MG/L									
Antimony, Dissolved	MG/L									
Barjum. Dissolved	MG/I									
Bervllium, Dissolved	MG/L									
Boron, Dissolved	MG/L									
Cadmium, Dissolved	MG/L									
Calcium, Dissolved	MG/L									
Chromium, Dissolved	MG/L									
Cobalt, Dissolved	MG/L									
Copper, Dissolved	MG/L									
Lead Dissolved	MG/L									
Magnesium Dissolved	MG/I									
J. J. Staning Biosonrod	1113/ L	1	1	1	1	1		1	1	1

	Property Owner	PROPERTY OWNER I NEW WELL-SAMPLE TAKEN AT								
		WELL	WELL	WELL	WELL	WFLI	WELL	WFII	WFLI	WELL
	Well Depth	203	203	203	203	203	203	203	203	203
S	Sampled Before Treatment?	Pre-Treatment								
	Sample ID	0622201124401	0706201124303	0720201120201	0803201122803	0817201120203	0902201120206	0914201120201	0929201120202	1012201122103
Parameter and units	Sample Date	6/22/2011	7/6/2011	7/20/2011	8/3/2011	8/17/2011	9/2/2011	9/14/2011	9/29/2011	10/12/2011
Manganese, Dissolved	MG/L									
Mercury, Dissolved	MG/L									
Molybdenum, Dissolved	MG/L									
Nickel, Dissolved	MG/L									
Potassium, Dissolved	MG/L									
Selenium, Dissolved	MG/L									
Silver, Dissolved	MG/L									
Sodium, Dissolved	MG/L									
Strontium, Dissolved	MG/L									
Sulfur, Dissolved	MG/L									
Thallium, Dissolved	MG/L									
Titanium, Dissolved	MG/L									
Vanadium, Dissolved	MG/L									
Zinc, Dissolved	MG/L									
Miscellaneous Organics	d									
Inorganic Carbon, Dissolve	d MG/L									
Organic Carbon, Dissolved	MG/L									
Pesticides and PCBs										
4,4'-DDD	UG/L									
4,4'-DDE	UG/L									
4,4'-DDT	UG/L									
Aldrin	UG/L									
alpha-BHC	UG/L									
Azinphos-methyl	UG/L									
beta-BHC	UG/L									
Carbaryl	UG/L									
delta-BHC	UG/L									
Dichlorvos	UG/L									
Dieldrin	UG/L									
Disulfoton	UG/L									
Endosulfan I	UG/L									
Endosulfan II	UG/L									
Endosulfan sulfate	UG/L									
Endrin	UG/L									
Endrin aldehyde	UG/L									
Endrin ketone	UG/L									
gamma-BHC (Lindane)	UG/L									
Heptachlor	UG/L									
Heptachlor epoxide	UG/L									
Malathion	UG/L									
Methoxychior	UG/L									
Mevinphos	UG/L									
Purgeable Petroleum Hydro	ocarbons									
GRO as Gasoline	UG/L									
Semivolatile Organics										
1,2,4,5-letrachlorobenzene	e UG/L									
1,2-Dinitrobenzene	UG/L									
1,2-Diphenylhydrazine	UG/L									
1,3-Dimethyl adamatane	UG/L									
	UG/L									
	UG/L									
	UG/L									
2,3,4,0- I etrachiorophenol	UG/L									
2,4,5-11101000pnen01	UG/L									
2,4,0- ITICIIOI OPTIENOI	UG/L									
	UG/L									
2,Dinietrophenol										
2,4-Dinitrotoluono										
	00/L		1	1						

	Property Owner	PROPERTY OWNER I NEW WELL-SAMPLE TAKEN AT 1715								
	Source Type	WELL								
	Well Depth	203	203	203	203	203	203	203	203	203
S	ampled Before Treatment?	Pre-Treatment								
	Sample ID	0622201124401	0706201124303	0720201120201	0803201122803	0817201120203	0902201120206	0914201120201	0929201120202	1012201122103
Parameter and units	Sample Date	6/22/2011	7/6/2011	7/20/2011	8/3/2011	8/17/2011	9/2/2011	9/14/2011	9/29/2011	10/12/2011
2,6-Dichlorophenol	UG/L									
2,6-Dinitrotoluene	UG/L									
2-Butoxyethanol	UG/L									
2-Chloronaphthalene	UG/L									
2-Chlorophenol	UG/L									
2-Methylnaphthalene	UG/L									
2-Methylphenol	UG/L									
2-Nitroaniline	UG/L									
2-Nitrophenol	UG/L									
3,3-Dichlorobenzidine	UG/L									
3-Nitroaniline	UG/L									
4,4'-Methylenebis(2-chloroa	aniline) UG/L									
4,4'-Methylenebis(N,N-dime	ethylanilin UG/L									
4,6-Dinitro-2-methylphenol	UG/L									
4-Bromophenyl phenyl ethe	er UG/L									
4-Chloro-3-methylphenol	UG/L									
4-Chloroaniline	UG/L									
4-Chlorophenyl phenyl ethe	er UG/L									
4-Methylphenol	UG/L									
4-Nitroaniline	UG/L									
4-Nitrophenol	UG/L									
Acenaphthene	UG/L									
Acenaphthylene	UG/L									
Acetophenone	UG/L									
Adamantane	UG/L									
Aniline	UG/L									
Anthracene	UG/L									
Benzo (a) anthracene	UG/L									
Benzo (a) pyrene	UG/L									
Benzo (b) fluoranthene	UG/L									
Benzo (g,h,i) perylene	UG/L									
Benzo (k) fluoranthene	UG/L									
Benzoic acid	UG/L									
Benzyl alcohol	UG/L									
Bis(2-chloroethoxy)methan	e UG/L									
Bis(2-chloroethyl)ether	UG/L									
bis(2-Chloroisopropyl)ether	UG/L									
Bis(2-ethylhexyl)phthalate	UG/L									
Butyl benzyl phthalate	UG/L									
Carbazole	UG/L									
Chlorobenzilate	UG/L									
Chrysene	UG/L									
Diallate (cis or trans)	UG/L									
Dibenz (a,h) anthracene	UG/L									
Dibenzofuran	UG/L									
Diethyl phthalate	UG/L									
Dimethyl phthalate	UG/L									
Di-n-butyl phthalate	UG/L									
Di-n-octyl phthalate	UG/L									
Dinoseb	UG/L									
Disulfoton	UG/L									
d-Limonene	UG/L									
Fluoranthene	UG/L									
Fluorene	UG/L									
Hexachlorobenzene	UG/L									
Hexachlorobutadiene	UG/L									
Hexachlorocyclopentadiene	UG/L									
Hexachloroethane	UG/L									
Indeno (1,2,3-cd) pyrene	UG/L									
Isophorone	UG/L									
Naphthalene	UG/L									

	Property Owner	PROPERTY OWNER I NEW WELL-SAMPLE TAKEN AT								
	Source Type	WELL								
	Well Depth	203	203	203	203	203	203	203	203	203
	Sampled Before Treatment?	Pre-Treatment								
	Sample ID	0622201124401	0706201124303	0720201120201	0803201122803	0817201120203	0902201120206	0914201120201	0929201120202	1012201122103
Parameter and units	Sample Date	6/22/2011	7/6/2011	7/20/2011	8/3/2011	8/17/2011	9/2/2011	9/14/2011	9/29/2011	10/12/2011
Nitrobenzene	UG/L									
N-Nitrosodiethylamine	UG/L									
N-Nitrosodimethylamine	UG/L									
N-Nitrosodi-n-butylamine	UG/L									
N-Nitrosodi-n-propylamine	e UG/L									
N-Nitrosodiphenylamine	UG/L									
N-Nitrosometnyletnylamin	le UG/L									
Parathion mothyl	UG/L									
Pontachlorohonzono										
Pentachlorophenol										
Phenanthrene										
Phenol										
Phorate	UG/L									
Pronamide	UG/L									
Pyrene	UG/L									
Pyridine	UG/L									
Squalene	UG/L									
Terbufos	UG/L									
Terpineol	UG/L									
Tributoxyethyl phosphate	UG/L									
Trifluralin	UG/L									
TICs										
1 2 3-Trimethylbenzene										
1,2,3-Thimethylderizerie	00/2									
Volatile Organics										
1,1,1-Trichloroethane	UG/L									
1,1,2-Trichloroethane	UG/L									
1,1-Dichloroethane	UG/L									
1,1-Dichloroethene	UG/L									
1,2,3-Trimethylbenzene	UG/L									
1,2,4- I richlorobenzene	UG/L									
1,2,4-Trimetnyibenzene										
1.2 Dichlorohonzono										
1 2-Dichloroethane										
1 2-Dichloropropage										
1.3.5-Trimethylbenzene	UG/L									
1.3-Dichlorobenzene	UG/L									
1,4-Dichlorobenzene	UG/L									
Acetone	UG/L									
Benzene	UG/L									
Carbon disulfide	UG/L									
Carbon Tetrachloride	UG/L									
Chlorobenzene	UG/L									
Chloroform	UG/L									
cis-1,2-Dichloroethene	UG/L									
Diisopropyl Ether	UG/L									
Ethanol	UG/L									
Ethyl tert-Butyl Ether	UG/L									
Hovesblorebutediane	UG/L									
	UG/L									
m n-Xvlene										
Methoxychlor										
Methyl tert-Butyl Ether	UG/L									
Methylene Chloride	UG/I									
Naphthalene	UG/L									
o-Xylene	UG/L									
Styrene	UG/L									

	Property Owner	PROPERTY OWNER I								
		NEW WELL-SAMPLE TAKEN AT								
	Location Description	1715	1715	1715	1715	1715	1715	1715	1715	1715
	Source Type	WELL								
	Well Depth	203	203	203	203	203	203	203	203	203
	Sampled Before Treatment?	Pre-Treatment								
	Sample ID	0622201124401	0706201124303	0720201120201	0803201122803	0817201120203	0902201120206	0914201120201	0929201120202	1012201122103
Parameter and units	Sample Date	6/22/2011	7/6/2011	7/20/2011	8/3/2011	8/17/2011	9/2/2011	9/14/2011	9/29/2011	10/12/2011
Tert-Amyl Methyl Ether	UG/L									
Tertiary Butyl Alcohol	UG/L									
Tetrachloroethene	UG/L									
Tetrahydrofuran	UG/L									
Toluene	UG/L									
trans-1,2-Dichloroethene	UG/L									
Trichloroethene	UG/L									
Vinyl chloride	UG/L									
Xylenes, total	UG/L									

Notes:

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended

holding time

holding time J : Estimated value --- : Parameter not analyzed. B : Blank qualified ug/L : Micrograms per liter mg/L : Milligrams per liter NA : Not Available NTU : Nephelometric Turbidity Unit umho/cm : Micromhos per centimeter colonies/100 ml : Colonies per 100 millileters

	Property Owner	PROPERTY OWNER I NEW WELL-SAMPLE TAKEN AT						
	Location Description	1715	1715	1715	1715			
	Source Type	WELL	WELL	WELL	WELL			
	Well Depth	203	203	203	203			
	Sampled Before Treatment?	Pre-Treatment	Pre-Treatment	Pre-Treatment	Pre-Treatment			
	Sample ID	1031201120201	1109201124303	1122201124301	1207201122202			
Parameter and units	Sample Date	10/31/2011	11/9/2011	11/22/2011	12/7/2011			
Aldehvdes								
Gluteraldehvde	UG/L							
Bacteria								
E. coli	colonies/100ml	Absent						
Fecal coliform bacteria	colonies/100ml	< 1 U						
Total Coliform Bacteria	colonies/100ml	Absent						
DBCP								
1.2-Dibromo-3-chloropro	ppane UG/I	< 0.1014 U						
Extractable Petroleum H	ydrocarbons							
Diesel	UG/L	< 95.2 U						
General Chemistry								
Alkalinity Total (CaCO2)	MC/I	137						
Ammonia as N	MG/L	< 0.100 []						
Bicarbonate Alkalinity as		137						
Bromide	MG/L	< 2.5 111						
Carbonate as CaCO3	MG/L	< 10.0						
Chloride	MG/L	13.5						
CO2 by Headspace		< 12000 []						
Cvanide	MG/L							
Fluoride	MG/L	< 0.50 UJ						
MBAS	MG/L	< 0.12 []						
Nitrate	MG/L							
Nitrate Nitrogen	MG/L	< 0.50 U						
Nitrite Nitrogen	MG/L	< 0.50 UJ						
Oil & Grease HEM	MG/L	< 5.33 U						
рН	pH UNITS	7.50 H						
Phosphorus	MG/L	< 0.100 U						
Specific conductance	UMHO/CM	318						
Sulfate	MG/L	12.3 J						
Temperature of pH dete	rmination CELSIUS	21.6 H						
Total Dissolved Solids	MG/L	172						
Total Suspended Solids	MG/L	3.5						
Turbidity	NTU	5.4						
Chucole								
1.2-Pronylene Clycol	MC/I							
Diethylene Glycol	MG/L	< 10						
Ethylene Glycol	MG/L							
Tetraethylene glycol	MG/L	< 10 UJ						
Triethylene glycol	MG/L	< 10 U						
Light Gases								
Acetylene	MG/L	< 0.00500 U						
Ethane	MG/L	0.402	0.395	0.418	0.118			
Ethene	MG/L	< 0.00500 U						
Methane	MG/L	6.09	4.94	5.51	3.6			
n-Butane	MG/L	< 0.00500 U						
Propane	MG/L	< 0.00500 U	< U.UU5UU U	< U.UU5UU U	< 0.00500 U			
Low Molecular Weight Ad	Low Molecular Weight Acids							
Acetic Acid	UG/L	< 10000 U						
Butyric Acid	UG/L	< 10000 U						
Formic Acid	UG/L	< 10000 U						
Isobutyric acid	UG/L	< 10000 U						
Lactic acid	UG/L	< 5000 U						
Propionic Acid	UG/L	< 13000 U						

	Property Owner	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I
		NEW WELL-SAMPLE TAKEN AT			
	Location Description	1715	1715	1715	1715
	Source Type	WELL	WELL	WELL	WELL
	Well Depth	203	203	203	203
	Sampled Before Treatment?	Pre-Treatment	Pre-Treatment	Pre-Treatment	Pre-Treatment
	Sample ID	1031201120201	1109201124303	1122201124301	1207201122202
Parameter and units	Sample Date	10/31/2011	11/9/2011	11/22/2011	12/7/2011
Metals, 6020x					
Cesium	MG/L	< 0.25 U			
Cesium, Dissolved	MG/L	< 0.1 U			
Potassium	MG/L	< 250 U			
Potassium, Dissolved	MG/L	< 100 U			
Silicon	MG/L	< 6250 U			
Silicon, Dissolved	MG/L	< 2500 U			
Thorium	MG/L	< 5 U			
Thorium, Dissolved	MG/L	< 2 U			
Uranium	MG/L	< 2.5 U			
Uranium, Dissolved	MG/L	< 1 U			
Metals, Total					
Aluminum	MG/L	0.310, 0.112			
Antimony	MG/L	< 0.00200 U			
Arsenic	MG/L	< 0.00200 0			
Bandlium	MG/L	0.227			
Borop	MG/L	0.00200 0			
Cadmium	MG/L	< 0.00100 []			
Calcium	MG/L	30.6			
Chromium	MG/L	< 0.00200 []			
Cobalt	MG/L	< 0.00200 U			
Copper	MG/L	< 0.00500 U			
Hardness, CaCO3	MG/L				
Iron	MG/L	0.184			
Lead	MG/L	< 0.00200 U			
Lithium	MG/L				
Magnesium	MG/L	4.29			
Manganese	MG/L	0.019			
Mercury	MG/L	< 0.000200 U			
Molybdenum	MG/L	< 0.00500 U			
Nickel	MG/L	< 0.00500 U			
Potassium	MG/L	1.62			
Selenium	MG/L	< 0.00200 U			
Silver	MG/L	< 0.00200 U			
Strontium	MG/L	33.7			
Sulfur	MG/L	2.74			
Thallium	MG/L	< 0.00200 []			
Titanium	MG/L	0.00773			
Vanadium	MG/L	< 0.00400 U			
Zinc	MG/L	< 0.0500 U			
Metals, Dissolved					
Aluminum, Dissolved	MG/L	< 0.0200 U			
Antimony, Dissolved	MG/L	< 0.00200 U			
Arsenic, Dissolved	MG/L	< 0.00200 U			
Barium, Dissolved	MG/L	0.223			
Beryllium, Dissolved	MG/L	< 0.00200 U			
Boron, Dissolved	MG/L	0.0839			
Cadmium, Dissolved	MG/L	< 0.00100 U			
Calcium, Dissolved	MG/L	28.6			
Chromium, Dissolved	MG/L	< 0.00200 U			
Cobalt, Dissolved	MG/L	< 0.00200 U			
Copper, Dissolved	MG/L	< 0.00500 U			
Iron, Dissolved	MG/L	< 0.0500 U			
Lead, Dissolved	MG/L	< 0.00200 U			
iviagnesium, Dissolved	MG/L	4.04			

	Property Owner	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I
		NEW WELL-SAMPLE TAKEN AT			
	Location Description	1715	1715	1715	1715
	Source Type	WELL	WELL	WELL	WELL
	Well Depth	203	203	203	203
	Sampled Before Treatment?	Pre-Treatment	Pre-Treatment	Pre-Treatment	Pre-Treatment
	Sample ID	1031201120201	1109201124303	1122201124301	1207201122202
Parameter and units	Sample Date	10/31/2011	11/9/2011	11/22/2011	12/7/2011
Manganese, Dissolved	MG/L	< 0.00500 U			
Mercury, Dissolved	MG/L	< 0.000200 U			
Molybdenum, Dissolved	MG/L	< 0.00500 U			
Nickel, Dissolved	MG/I	< 0.00500 U			
Potassium, Dissolved	MG/I	1.49			
Selenium Dissolved	MG/L	< 0.0020011			
Silver Dissolved	MG/L MG/L	< 0.00200 U			
Sodium Dissolved	MG/L	34.8			
Strontium Dissolved	MG/L	1 24			
Sulfur Dissolved	MG/L	2 47			
Thallium Dissolved	MG/L	< 0.00200 []			
Titanium Dissolved	MG/L	< 0.00200 U			
Vanadium Dissolved	MG/L	< 0.00200 0			
Zine Dissolved	MG/L	< 0.00400 0			
	MG/L	< 0.0500 0			
Miscellaneous Organics					
Inorganic Carbon, Dissolv	MG/L	31.4			
Organic Carbon, Dissolved	d MG/L	< 1.00 U			
Pesticides and PCBs		0.000/11			
4,4'-DDD	UG/L	< 0.0236 U			
4,4'-DDE	UG/L	< 0.0236 U			
4,4'-DDT	UG/L	< 0.0236 U			
Aldrin	UG/L	< 0.0236 U			
alpha-BHC	UG/L	< 0.0236 U			
Azinphos-methyl	UG/L	< 0.94 U			
beta-BHC	UG/L	< 0.0236 U			
Carbaryl	UG/L	< 6.0 U			
delta-BHC	UG/L	< 0.0236 U			
Dichlorvos	UG/L	< 0.94 U			
Dieldrin	UG/L	< 0.0236 U			
Disulfoton	UG/L	< 0.94 U			
Endosulfan I	UG/L	< 0.0236 U			
Endosulfan II	UG/L	< 0.0236 U			
Endosulfan sulfate	UG/L	< 0.0236 U			
Endrin	UG/L	< 0.0236 U			
Endrin aldehyde	UG/L	< 0.0236 U			
Endrin ketone	UG/L	< 0.0236 U			
gamma-BHC (Lindane)	UG/L	< 0.0236 U			
Heptachlor	UG/L	< 0.0236 U			
Heptachlor epoxide	UG/L	< 0.0236 U			
Malathion	UG/L	< 0.94 U			
Methoxychlor	UG/L	< 0.0236 U			
Mevinphos	UG/L	< 0.94 U			
Puraophia Dataolaum II.	rocarbonc				
CDO as Casalina		< 100 U			
GRU as Gasoline	UG/L	< 100 0			
Semivolatile Organics					
1,2,4,5-Tetrachlorobenzer	ne UG/L	< 1 U			
1,2-Dinitrobenzene	UG/L	< 5 U			
1,2-Diphenylhydrazine	UG/L	< 1 U			
1,3-Dimethyl adamatane	UG/L	< 5 U			
1,3-Dinitrobenzene	UG/L	< 5 U			
1,4-Dinitrobenzene	UG/L	< 5 U			
1-Chloronaphthalene	UG/I	< 1 U			
2,3,4.6-Tetrachlorophenol	UG/L	< 1 U			
2.4.5-Trichlorophenol	UG/I	< 1 []			
2.4.6-Trichlorophenol		< 1 []			
2.4-Dichlorophenol		< 1			
2.4-Dimethylphenol		< 1			
2 4-Dinitronhenol		< 2011			
2 4-Dinitrotoluene		2511			
	00/L	< 5.0			

Property Owner	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I
	NEW WELL-SAMPLE TAKEN AT			
Location Description	1715	1715	1715	1715
Source Type	WELL	WELL	WELL	WELL
Well Depth	203	203	203	203
Sampled Before Treatment?	Pre-Treatment	Pre-Treatment	Pre-Treatment	Pre-Treatment
Sample ID	1031201120201	1109201124303	1122201124301	1207201122202
Parameter and units Sample Date	10/31/2011	11/9/2011	11/22/2011	12/7/2011
2,6-Dichlorophenol UG/L	< 1 U			
2,6-Dinitrotoluene UG/L	< 1 U			
2-Butoxyethanol UG/L	< 5 UJ			
2-Chloronaphthalene UG/L	< 1 U			
2-Chlorophenol UG/L	< 1 U			
2-Methylnaphthalene UG/L	< 0.5 U			
2-Methylphenol UG/L	< 1 U			
2-Nitroaniline UG/L	< 1 U			
2-Nitrophenol UG/L	< 1 U			
3,3-Dichlorobenzidine UG/L	< 5 U			
3-Nitroaniline UG/L	< 1 U			
4,4'-Methylenebis(2-chloroaniline) UG/L	< 14 U			
4,4'-Methylenebis(N,N-dimethylanilin UG/L	< 14 UJ			
4,6-Dinitro-2-methylphenol UG/L	< 14 U			
4-Bromophenyl phenyl ether UG/L	< 1 U			
4-Chloro-3-methylphenol UG/L	< 1 U			
4-Chloroaniline UG/L	< 1 U			
4-Chlorophenyl phenyl ether UG/L	< 1 U			
4-Methylphenol UG/L	< 1 U			
4-Nitroaniline UG/L	< 1 UJ			
4-Nitrophenoi UG/L	< 29 U			
	< 0.5 U			
	< 0.5 0			
Adamantane UC/L	< 5 11			
Aniline UG/L	< 1			
Anthracene UG/L	< 0.5 U			
Benzo (a) anthracene UG/L	< 0.5 U			
Benzo (a) pyrene UG/L	< 0.5 U			
Benzo (b) fluoranthene UG/L	< 0.5 U			
Benzo (g,h,i) perylene UG/L	< 0.5 U			
Benzo (k) fluoranthene UG/L	< 0.5 U			
Benzoic acid UG/L	< 14 U			
Benzyl alcohol UG/L	< 14 U			
Bis(2-chloroethoxy)methane UG/L	< 1 U			
Bis(2-chloroethyl)ether UG/L	< 1 U			
bis(2-Chloroisopropyl)ether UG/L	< 1 U			
Bis(2-ethylhexyl)phthalate UG/L	< 5 U			
	< 5 U			
	< 10 []			
	~ 0.5.11			
Diallate (cis or trans)	< 5.11			
Dibenz (a,h) anthracene	< 0.5 []			
Dibenzofuran UG/L	< 1 U			
Diethyl phthalate UG/L	< 5 U			
Dimethyl phthalate UG/L	< 5 U			
Di-n-butyl phthalate UG/L	< 5 U			
Di-n-octyl phthalate UG/L	< 5 U			
Dinoseb UG/L	< 5 U			
Disulfoton UG/L	< 48 U			
d-Limonene UG/L	< 5 U			
Fluoranthene UG/L	< 0.5 U			
Fluorene UG/L	< 0.5 U			
Hexachlorobenzene UG/L	< 0.5 U			
Hexachlorobutadiene UG/L	< 1 U			
Hexachlorocyclopentadiene UG/L	< 14 U			
Hexachloroethane UG/L	< 5 U			
Indeno (1,2,3-cd) pyrene UG/L	< 0.5 U			
Isophorone UG/L	< U			
ivapntnaiene UG/L	< 0.5 U			

Property O	wner PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I
	NEW WELL-SAMPLE TAKEN AT			
Location Desc	ription 1715	1715	1715	1715
Source	Type WELL	WELL	WELL	WELL
Well E	epth 203	203	203	203
Sampled Before Treatn	Pre-Treatment	Pre-Treatment	Pre-Treatment	Pre-Treatment
Samp	le ID 1031201120201	1109201124303	1122201124301	1207201122202
Parameter and units Sample	Date 10/31/2011	11/9/2011	11/22/2011	12/7/2011
Nitrobenzene UG/L	< 1 U			
N-Nitrosodiethylamine UG/I	< 1 U			
N-Nitrosodimethylamine UG/L	< 5 U			
N-Nitrosodi-n-butylamine	< 5 U			
N-Nitrosodi-n-propylamine	< 1			
N-Nitrosodinhenvlamine	< 1			
N-Nitrosomethylethylamine	< 5 []			
Parathion-ethyl	< 5			
Parathion-methyl IIG/I	< 5 U			
Pentachlorobenzene				
Pentachlorophenol	< 5 111			
Phenanthrope UC/	< 0.5 11			
Phenol UC/				
Phorate UC/L				
Pronamide				
Dvriding UG/L				
Pyridine 06/L	< 5 U			
Tarbufas UG/L				
Terpineel UG/L				
Telpineoi UG/L				
I ributoxyetnyi phosphate UG/L	< 5 UJ			
I rifluralin UG/L	< 5 U			
TICs				
1.2.3-Trimethylbenzene UG/L				
Volatile Organics				
1,1,1-Trichloroethane UG/L	< 1.00 U			
1,1,2-Trichloroethane UG/L	< 1.00 U			
1,1-Dichloroethane UG/L	< 1.00 U			
1,1-Dichloroethene UG/L	< 1.00 U			
1,2,3-Trimethylbenzene UG/L	< 1.00 U			
1,2,4-Trichlorobenzene UG/L				
1,2,4-Trimethylbenzene UG/L	< 1.00 U			
1,2-Dibromo-3-chloropropane UG/L	< 0.1014 U			
1,2-Dichlorobenzene UG/L	< 1.00 U			
1,2-Dichloroethane UG/L	< 1.00 U			
1,2-Dichloropropane UG/L				
1,3,5-Trimethylbenzene UG/L	< 1.00 U			
1,3-Dichlorobenzene UG/L	< 1.00 U			
1,4-Dichlorobenzene UG/L	< 1.00 U			
Acetone UG/L	< 50.0 U			
Benzene UG/L	< 1.00 U			
Carbon disulfide UG/L	< 1.00 U			
Carbon Tetrachloride UG/L	< 1.00 U			
Chlorobenzene UG/L	< 1.00 U			
Chloroform UG/L	< 1.00 U			
cis-1,2-Dichloroethene UG/L	< 1.00 U			
Diisopropyl Ether UG/L	< 1.00 U			
Ethanol UG/L	< 100 U			
Ethyl tert-Butyl Ether UG/L	< 1.00 U			
Ethylbenzene UG/L	< 1.00 U			
Hexachlorobutadiene UG/L	< 1 U			
Isopropyl alcohol UG/L	< 50.0 U			
Isopropylbenzene UG/L	< 1.00 U			
m,p-Xylene UG/L	< 2.00 U			
Methoxychlor UG/L	< 0.0236 U			
Methyl tert-Butyl Ether UG/L	< 1.00 U			
Methylene Chloride UG/L	< 5.00 U			
Naphthalene UG/L	< 5.00 U			
o-Xylene UG/L	< 1.00 U			
Styrene UG/L				

Property Owner		PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I	PROPERTY OWNER I
		NEW WELL-SAMPLE TAKEN AT			
	Location Description	1715	1715	1715	1715
	Source Type	WELL	WELL	WELL	WELL
	Well Depth	203	203	203	203
	Sampled Before Treatment?	Pre-Treatment	Pre-Treatment	Pre-Treatment	Pre-Treatment
	Sample ID	1031201120201	1109201124303	1122201124301	1207201122202
Parameter and units	Sample Date	10/31/2011	11/9/2011	11/22/2011	12/7/2011
Tert-Amyl Methyl Ether	UG/L	< 1.00 U			
Tertiary Butyl Alcohol	UG/L	< 10.0 U			
Tetrachloroethene	UG/L	< 1.00 U			
Tetrahydrofuran	UG/L				
Toluene	UG/L	< 1.00 U			
trans-1,2-Dichloroethene	e UG/L	< 1.00 U			
Trichloroethene	UG/L	< 1.00 U			
Vinyl chloride	UG/L	< 1.00 U			
Xylenes, total	UG/L	< 3.00 U			

Notes:

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended

holding time

J : Estimated value --- : Parameter not analyzed. B : Blank qualified ug/L : Micrograms per liter mg/L : Milligrams per liter NA : Not Available NTLL : Nephelometric Turbidity

NTU : Nephelometric Turbidity Unit umho/cm : Micromhos per centimeter

colonies/100 ml : Colonies per 100 millileters



APPENDIX A-10 EPA STUDY WELL DATA PROPERTY OWNER J

	Property Owner Location Description	PROPERTY OWNER J	PROPERTY OWNER J WELL LOCATED 5 FEET WEST OF PORCH; NO HOT WATER	PROPERTY OWNER J WELL LOCATED 5 FEET WEST OF PORCH; NO HOT WATER
	Source Type	WELL	WELL	WELL
Sar	well Deptn		UNKNOWN Pro-Treatment	DINKNOWN Pre-Treatment
Jai	Sample ID		0208201112301	1103201120202
Parameter and units	Sample Date	7/2/2010 (Baseline)	2/8/2011	11/3/2011
	Sumple Date		2/0/2011	11/3/2011
Aldehydes				
Gluteraldehyde	UG/L			
Bacteria				
F coli	colonies/100ml			Absent
E. coliform bacteria	colonies/100ml			
Total Coliform Bacteria	colonies/100ml			Absent
	colonics/room			Absolution
DBCP				
1,2-Dibromo-3-chloropropane	e UG/L			< 0.1026 U
Extractable Potroloum Hydro	carbons			
Discol				. 04.2.11
Diezei	UG/L			< 74.3 U
General Chemistry				
Alkalinity, Total (CaCO3)	MG/L			211
Ammonia as N	MG/L			< 0.100 U
Bicarbonate Alkalinity as CaC	O3 MG/L	247	217	224
Bromide	MG/L			< 2.5 U
Carbonate as CaCO3	MG/L	ND	< 10.0 U	< 10.0 U
Chloride	MG/L	37.9	< 5.00 U	2.2 J
CO2 by Headspace	UG/L			< 12000 U
Cyanide	MG/L			
Fluoride	MG/L			< 0.50 U
MBAS	MG/L	ND	< 0.0500 U	< 0.12 U
Nitrate	MG/L			
Nitrate Nitrogen	MG/L			< 0.50 U
Nitrite Nitrogen	MG/L			< 0.50 U
Oil & Grease HEM	MG/L	ND	< 5.95 U	< 5.00 U
Hq	pH UNITS	7.40 HTI	7.80 H	7.40 H
Phosphorus	MG/L			< 0.100 U
Specific conductance	UMHO/CM	590	505	460
Sulfate	MG/L	38.2	36.8	42.2
Temperature of pH determina	ation CELSIUS	22.2 HTI	21.7 H	21.0 H
Total Dissolved Solids	MG/L	336	259	269
Total Suspended Solids	MG/L	1.5	2.2	3.5
Turbidity	NTU	5.7	9.8	5
Glycols				
1,2-Propylene Glycol	MG/L			
Diethylene Glycol	MG/L			< 10 U
Ethylene Glycol	MG/L			
I etraethylene glycol	MG/L			< 10 UJ
I riethylene glycol	MG/L			< 10 U
Light Gases				
Acetylene	MG/I			< 0.00500 U
Ethane	MG/L	ND	< 0.0260 U	< 0.00500 U
Ethene	MG/I			< 0.00500 U
Methane	MG/L	ND	< 0.0260 U	< 0.00500 U
n-Butane	MG/L			< 0.00500 U
Propane	MG/L	ND	< 0.0340 U	< 0.00500 U
Low Molecular Weight Acids				
Acetic Acid	UG/L			< 10000 U
Butyric Acid	UG/L			< 10000 U
Formic Acid	UG/L			< 10000 U
Isobutyric acid	UG/L			< 10000 U
Lactic acid	UG/L			< 5000 U
Propionic Acid	UG/L			< 13000 U

	Property Owner Location Description	PROPERTY OWNER J	PROPERTY OWNER J WELL LOCATED 5 FEET WEST OF PORCH; NO HOT WATER	PROPERTY OWNER J WELL LOCATED 5 FEET WEST OF PORCH; NO HOT WATER
	Source Type	WELL	WELL	WELL
	Well Depth	UNKNOWN	UNKNOWN	UNKNOWN
	Sampled Before Treatment?	NA	Pre-Treatment	Pre-Treatment
	Sample ID	NTG0332-PROPERTY OWNER J-001	0208201112301	1103201120202
Parameter and units	Sample Date	7/2/2010 (Baseline)	2/8/2011	11/3/2011
Metals, 6020x				
Cesium	MG/L			< 0.0001 U
Cesium, Dissolved	MG/L			< 0.0001 U
Potassium	MG/L			1.2
Potassium, Dissolved	MG/L			1.3
Silicon	MG/L			5.5
Silicon, Dissolved	MG/L			5.5
Thorium	MG/L			< 0.002 U
Thorium, Dissolved	MG/L			< 0.002 U
Uranium	MG/L			0.0032
Uranium, Dissolved	MG/L			0.0031
Matals Tatal				
	MC /I			< 0.0200 []
Antimony	MC/L			
Arsenic	MG/L	ND	< 0.0100 U	< 0.00200 0
Barium	MC/L	0.0651	0.010.0	0.00200 0
Beryllium	MG/L	0.0031	0.000	< 0.0073
Boron	MG/L			0.055
Cadmium	MG/L	ND	< 0.00100 []	< 0.00100 []
Calcium	MG/L	53.8	55.5	55.4
Chromium	MG/L	ND	< 0.00500 U	< 0.00200 U
Cobalt	MG/L			< 0.00200 U
Copper	MG/L			< 0.00500 U
Hardness, CaCO3	MG/L			
Iron	MG/L	0.676	0.888	0.583
Lead	MG/L	0.0114	0.009	< 0.00200 U
Lithium	MG/L			
Magnesium	MG/L	14.3	15.6	15.2
Manganese	MG/L	0.249	0.29	0.22
Mercury	MG/L	ND	< 0.000200 U	< 0.000200 U
Molybdenum	MG/L			< 0.00500 U
Nickel	MG/L			< 0.00500 U
Potassium	MG/L	1.13	1.17	1.17
Selenium	MG/L	ND	< 0.0100 U	< 0.00200 U
Silver	MG/L	ND	< 0.00500 U	< 0.00200 U
Sodium	MG/L	39	22.6	22.8
Strontium	MG/L			0.575
Sulfur	MG/L	13	11.6	12
Thallium	MG/L			< 0.00200 U
Titanium	MG/L			< 0.00200 U
Vanadium	MG/L			< 0.00400 U
Zinc	MG/L			0.237
<i>Metals, Dissolved</i> Aluminum, Dissolved	MG/L			< 0.0200 U
Antimony, Dissolved	MG/L			< 0.00200 U
Arsenic, Dissolved	MG/L			< 0.00200 U
Barium, Dissolved	MG/L			0.0649
Beryllium, Dissolved	MG/L			< 0.00200 U
Boron, Dissolved	MG/L			0.0575
Cadmium, Dissolved	MG/L			< 0.00100 U
Calcium, Dissolved	MG/L			59.4
Chromium, Dissolved	MG/L			< 0.00200 U
Cobalt, Dissolved	MG/L			< 0.00200 U
Copper, Dissolved	MG/L			< 0.00500 U
Iron, Dissolved	MG/L			0.316
Lead, Dissolved	MG/L			< 0.00200 U
Magnesium, Dissolved	MG/L			16.2

	Property Owner	PROPERTY OWNER J	PROPERTY OWNER J	PROPERTY OWNER J
			WELL LOCATED 5 FEET WEST OF	WELL LOCATED 5 FEET WEST OF
	Location Description		PORCH; NO HOT WATER	PORCH; NO HOT WATER
	Source Type	WELL	WELL	WELL
	Well Depth	UNKNOWN	UNKNOWN	UNKNOWN
Sam	pled Before Treatment?	NA	Pre-Treatment	Pre-Treatment
	Sample ID	NTG0332-PROPERTY OWNER J-001	0208201112301	1103201120202
Parameter and units	Sample Date	7/2/2010 (Baseline)	2/8/2011	11/3/2011
Manganese, Dissolved	MG/L			0.216
Mercury, Dissolved	MG/L			< 0.000200 U
Molybdenum, Dissolved	MG/L			< 0.00500 U
Nickel, Dissolved	MG/L			< 0.00500 U
Potassium, Dissolved	MG/L			1.35
Selenium, Dissolved	MG/L			< 0.00200 U
Silver, Dissolved	MG/L			< 0.00200 U
Sodium, Dissolved	MG/L			26.2
Strontium, Dissolved	MG/L			0.623
Sulfur, Dissolved	MG/L			13
Thallium, Dissolved	MG/L			< 0.00200 U
Titanium, Dissolved	MG/L			< 0.00200 U
Vanadium, Dissolved	MG/L			< 0.00400 U
Zinc, Dissolved	MG/L			0.0592
Miscellaneous Organics				
Inorganic Carbon, Dissolved	MG/L			46.9
Organic Carbon, Dissolved	MG/L			< 1.00 U
Pesticides and PCBs				
4.4'-DDD	LIG/I			< 0.0236 []
4 4'-DDF				< 0.0236 U
4 4'-DDT				< 0.0236 U
Aldrin				< 0.0236 U
alpha-BHC				< 0.0236 U
				< 0.0230 0
hota_BHC				< 0.0236 []
Carbaryl				< 6.011
dolta_BHC				< 0.036 []
				< 0.0230 0
Dioldrin				< 0.026 []
Disulfoton				< 0.0230 0
Endosulfan I				< 0.0236 []
Endosulfan II				< 0.0236 U
Endosulfan sulfate				< 0.0236 U
Endrin				< 0.0236 U
Endrin aldohydo				< 0.0236 U
Endrin kotopo	UG/L			< 0.0236 0
	UG/L			< 0.0236 0
	UG/L			< 0.0236 0
	UG/L			< 0.0236 U
Malathion	UG/L			< 0.0230 0
Mathoxychlor				< 0.94 0
Methoxychiol	UG/L			< 0.0230 0
	UG/L			< 0.74 0
Purgeable Petroleum Hydrocar	rbons			
GRO as Gasoline	UG/L			< 100 U
Semivolatile Organics				
1,2,4,5- l etrachlorobenzene	UG/L			< 0.9 U
1,2-Dinitrobenzene	UG/L			< 5 U
1,2-Diphenylhydrazine	UG/L			< 0.9 U
1,3-Dimethyl adamatane	UG/L			< 5 U
1,3-Dinitrobenzene	UG/L			< 5 U
1,4-Dinitrobenzene	UG/L			< 5 U
1-Chloronaphthalene	UG/L			< 0.9 U
2,3,4,6-Tetrachlorophenol	UG/L			< 0.9 U
2,4,5-Trichlorophenol	UG/L			< 0.9 U
2,4,6-Trichlorophenol	UG/L			< 0.9 U
2,4-Dichlorophenol	UG/L			< 0.9 U
2,4-Dimethylphenol	UG/L			< 0.9 U
2,4-Dinitrophenol	UG/L			< 28 U
2,4-Dinitrotoluene	UG/L			< 5 U

	Property Owner	PROPERTY OWNER J	PROPERTY OWNER J	PROPERTY OWNER J
	Location Description		PORCH; NO HOT WATER	PORCH; NO HOT WATER
	Source Type	WELL	WELL	WELL
	Well Depth	UNKNOWN	UNKNOWN	UNKNOWN
Sampled B	efore Treatment?		Pre-Treatment	Pre-Treatment
Decomptor and units	Sample ID	NIGU332-PROPERTY OWNER J-001	0208201112301	11/2/2011
Parameter and units	Sample Date	//2/2010 (Baseline)	2/8/2011	
2,6-Dichiol opnenoi	UG/L			< 0.9 0
	UG/L			< 0.9 0
2-Chloronanhthalene				< 0.911
2-Chlorophenol	UG/L			< 0.9 U
2-Methylnaphthalene	UG/L			< 0.5 U
2-Methylphenol	UG/L			< 0.9 U
2-Nitroaniline	UG/L			< 0.9 U
2-Nitrophenol	UG/L			< 0.9 U
3,3-Dichlorobenzidine	UG/L			< 5 U
3-Nitroaniline	UG/L			< 0.9 U
4,4'-Methylenebis(2-chloroaniline)	UG/L			< 14 UJ
4,4'-Methylenebis(N,N-dimethylanilir	UG/L			< 14 UJ
4,6-Dinitro-2-methylphenol	UG/L			< 14 U
4-Bromophenyl phenyl ether	UG/L			< 0.9 U
4-Chloro-3-methylphenol	UG/L			< 0.9 UJ
4-Unioroaniline	UG/L			< 0.9 U
4-Uniorophenyl phenyl ether	UG/L			< 0.9 U
	UG/L			< 0.9 U
4-Nitronbonol	UG/L			< 0.9 0
				< 0.5
				< 0.5 U
Acetophenone	UG/L			< 0.9 U
Adamantane	UG/L			< 5 U
Aniline	UG/L			< 0.9 U
Anthracene	UG/L			< 0.5 U
Benzo (a) anthracene	UG/L			< 0.5 UJ
Benzo (a) pyrene	UG/L			< 0.5 U
Benzo (b) fluoranthene	UG/L			< 0.5 U
Benzo (g,h,i) perylene	UG/L			< 0.5 U
Benzo (k) fluoranthene	UG/L			< 0.5 U
Benzoic acid	UG/L			< 14 UJ
Benzyl alcohol	UG/L			< 14 U
Bis(2-chloroethoxy)methane	UG/L			< 0.9 U
Bis(2-chloroethyl)ether	UG/L			< 0.9 U
bis(2-Chloroisopropyl)ether	UG/L			< 0.9 U
Bis(2-ethylnexyl)phthalate	UG/L			< 5 UJ
	UG/L			< 5 UJ
Chlorobenzilate				< 0.9 0
Chrysene				< 0.5
Diallate (cis or trans)	UG/I			< 5 []
Dibenz (a.h) anthracene	UG/L			< 0.5 U
Dibenzofuran	UG/L			< 0.9 U
Diethyl phthalate	UG/L			< 5 U
Dimethyl phthalate	UG/L			< 5 U
Di-n-butyl phthalate	UG/L			< 5 U
Di-n-octyl phthalate	UG/L			< 5 U
Dinoseb	UG/L			< 5 U
Disulfoton	UG/L			< 47 U
d-Limonene	UG/L			< 5 U
Fluoranthene	UG/L			< 0.5 U
Huorene	UG/L			< 0.5 U
Hexachiorobenzene	UG/L			< U.5 U
	UG/L			< U.9 U
Hevechloreethane	UG/L			< 14 U
Indeno (1.2.3-cd) pyropo				
	UG/L			< 0.50
Naphthalene	LIG/I			< 0.5 []
Haphalaiono	00/L		<u> </u>	

	Property Owner	PROPERTY OWNER J	PROPERTY OWNER J	PROPERTY OWNER J
	. ,		WELL LOCATED 5 FEET WEST OF	WELL LOCATED 5 FEET WEST OF
	Location Description		PORCH; NO HOT WATER	PORCH; NO HOT WATER
	Source Type	WELL	WELL	WELL
	Well Depth	UNKNOWN	UNKNOWN	UNKNOWN
Sampled	Before Treatment?	NA	Pre-Treatment	Pre-Treatment
	Sample ID	NTG0332-PROPERTY OWNER J-001	0208201112301	1103201120202
Parameter and units	Sample Date	7/2/2010 (Baseline)	2/8/2011	11/3/2011
Nitrobenzene	UG/I			< 0.9 U
N-Nitrosodiethylamine				< 0.911
N Nitrosodimothylamino				< 5.11
N Nitrosodi n butylomino	UG/L			< 50
N-Nitrosodi-n-butyiamine	UG/L			< 5 U
N-Nitrosodi-n-propylamine	UG/L			< 0.9 U
N-Nitrosodiphenylamine	UG/L			< 0.9 U
N-Nitrosomethylethylamine	UG/L			<u>< 5 U</u>
Parathion-ethyl	UG/L			< 5 U
Parathion-methyl	UG/L			< 5 U
Pentachlorobenzene	UG/L			< 0.9 U
Pentachlorophenol	UG/L			< 5 U
Phenanthrene	UG/L			< 0.5 U
Phenol				< 0.9 []
Phorate				< 0.011
Pronamido				- 0.011
Durono	UG/L			
Pyrene Duridina	UG/L			< U.5 U
Pyriaine	UG/L			< 5 U
Squalene	UG/L			< 5 UJ
Terbufos	UG/L			< 5 UJ
Terpineol	UG/L			< 5 U
Tributoxyethyl phosphate	UG/L			< 5 U
Trifluralin	UG/L			< 5 UJ
TICs				
1,2,3-Trimethylbenzene	UG/L			
Volatile Organics				
1,1,1-Trichloroethane	UG/L			< 1.00 U
1,1,2-Trichloroethane	UG/L			< 1.00 U
1,1-Dichloroethane	UG/L			< 1.00 U
1,1-Dichloroethene	UG/L			< 1.00 U
1,2,3-Trimethylbenzene	UG/L			< 1.00 U
1.2.4-Trichlorobenzene	UG/L			
1 2 4-Trimethylbenzene				< 1.00 U
1 2-Dibromo-3-chloropropape				< 0.1026 []
	UG/L			< 1.00.11
1,2-Dichloroothono	UG/L			< 1.00 U
1,2-Dichloroethane	UG/L			< 1.00 U
1,2-Dichloropropane	UG/L			
1,3,5-Trimethylbenzene	UG/L			< 1.00 U
1,3-Dichlorobenzene	UG/L			< 1.00 U
1,4-Dichlorobenzene	UG/L			< 1.00 U
Acetone	UG/L			< 50.0 U
Benzene	UG/L	ND	< 0.500 U	< 1.00 U
Carbon disulfide	UG/L			< 1.00 U
Carbon Tetrachloride	UG/L			< 1.00 U
Chlorobenzene	UG/L			< 1.00 U
Chloroform				< 1.00 U
cis-1 2-Dichloroethene				< 1.00 U
	UG/L			
	UG/L			< 1.00 U
	UG/L			
Ethyl tert-Butyl Ether	UG/L			< 1.00 U
Ethylbenzene	UG/L	ND	< 0.500 U	< 1.00 U
Hexachlorobutadiene	UG/L			< 0.9 U
Isopropyl alcohol	UG/L			< 50.0 U
Isopropylbenzene	UG/L			< 1.00 U
m,p-Xylene	UG/L			< 2.00 U
Methoxychlor	UG/L			< 0.0236 U
Methyl tert-Butyl Ether	LIG/I			< 1,00 U
Methylene Chloride				< 5.00.11
Nanhthalana				< 5.00 U
	UG/L			
0-Xyiene	UG/L			< 1.00 U
Styrene	UG/L			

	Property Owner	PROPERTY OWNER J	PROPERTY OWNER J	PROPERTY OWNER J
			WELL LOCATED 5 FEET WEST OF	WELL LOCATED 5 FEET WEST OF
	Location Description		PORCH; NO HOT WATER	PORCH; NO HOT WATER
	Source Type	WELL	WELL	WELL
	Well Depth	UNKNOWN	UNKNOWN	UNKNOWN
	Sampled Before Treatment?	NA	Pre-Treatment	Pre-Treatment
	Sample ID	NTG0332-PROPERTY OWNER J-001	0208201112301	1103201120202
Parameter and units	Sample Date	7/2/2010 (Baseline)	2/8/2011	11/3/2011
Tert-Amyl Methyl Ether	UG/L			< 1.00 U
Tertiary Butyl Alcohol	UG/L			< 10.0 U
Tetrachloroethene	UG/L			< 1.00 U
Tetrahydrofuran	UG/L			
Toluene	UG/L	ND	< 0.500 U	< 1.00 U
trans-1,2-Dichloroethene	UG/L			< 1.00 U
Trichloroethene	UG/L			< 1.00 U
Vinyl chloride	UG/L			< 1.00 U
Xylenes, total	UG/L	ND	< 0.500 U	< 3.00 U

Notes:

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended

holding time

holding time J : Estimated value --- : Parameter not analyzed. B : Blank qualified ug/L : Micrograms per liter mg/L : Milligrams per liter NA : Not Available NTU : Nephelometric Turbidity Unit umho/cm : Micromhos per centimeter colonies/100 ml : Colonies per 100 millileters



APPENDIX A-11 EPA STUDY WELL DATA PROPERTY OWNER K

	Property Owner	PROPERTY OWNER K	PROPERTY OWNER K	PROPERTY OWNER K
		THE WELL IS LOCATED ON THE SOUTH SIDE OF THE MILK HOUSE; IT FEEDS BOTH THE MILK HOUSE	THE WELL IS LOCATED ON THE SOUTH SIDE OF THE MILK HOUSE; IT FEEDS BOTH THE MILK HOUSE	THE WELL IS LOCATED ON THE SOUTH SIDE OF THE MILK HOUSE; IT FEEDS BOTH THE MILK HOUSE
	Location Description	AND THE RESIDENCE.	AND THE RESIDENCE.	AND THE RESIDENCE.
	Source Type	175	175	175
	Sampled Pefere Treatment?	175	Doct Troatmont	Dro Troatmont
		NA NTA0254 01072010 0855	0531201120201	1027201120202
Daramotor and units	Sample ID	1/7/2010 (Pasolino)	5/21/2011	10/27/2011
Farameter and units	Sample Date	TTTZOTO (Baseline)	5/51/2011	10/2//2011
Aldehydes				
Gluteraldehyde	UG/L			
Pactoria				
	colonies/100ml			Absont
E. coll Fecal colliform bacteria	colonies/100ml			
Total Coliform Bacteria	colonies/100ml			Present
	colonies/room			Fresent
DBCP				
1,2-Dibromo-3-chloropropa	ane UG/L			< 0.1003 U
Extractable Petroleum Hvi	drocarbons			
Diesel				< 94 3 11
	00/L			S / T.U U
General Chemistry				
Alkalinity, Total (CaCO3)	MG/L			194
Ammonia as N	MG/L			0.107
Bicarbonate Alkalinity as C	aCO3 MG/L	194	188	189
Bromide	MG/L			< 2.5 U
Carbonate as CaCO3	MG/L	< 10.0 U	< 10.0 U	< 10.0 U
Chloride	MG/L	4.57	6.13	4.8
CO2 by Headspace	UG/L			< 12000 U
Cyanide	MG/L			
Fluoride	MG/L			< 0.50 U
MBAS	MG/L	< 0.0500 U	< 0.0500 U	< 0.12 U
Nitrate	MG/L			
Nitrate Nitrogen	MG/L			< 0.50 U
	MG/L			< 0.50 U
		< 5.43 U	< 5.95 U	< 4.94 U
Phosphorus		7.10 H	7.70 H	< 0.100 H
Specific conductance		400	411	389
Sulfate	MG/I	17.6	19.8	20.7.1
Temperature of pH determ		21 7 H	21.8 H	20.7 S
Total Dissolved Solids	MG/I	225	223	215
Total Suspended Solids	MG/L	< 1.00 U	1.1	1.7
Turbidity	NTU	< 1.00 U	< 1.00 U	0.48
Glycols				
I,2-Propylene Glycol	MG/L			
Dietnylene Glycol	MG/L			< 10 0
Ethylene Glycol	MG/L			
	MG/L			< 10 UJ
	MG/L			< 10 0
Light Gases				
Acetylene	MG/L			< 0.00500 U
Ethane	MG/L	< 0.0260 U	< 0.0260 U	< 0.00500 U
Ethene	MG/L			< 0.00500 U
Methane	MG/L	< 0.0260 U	< 0.0260 U	0.00674
n-Butane	MG/L			< 0.00500 U
Propane	MG/L	< 0.0340 U	< 0.0340 U	< 0.00500 U
Low Molecular Weight Aci	ds			
Acetic Acid				< 10000 U
Butyric Acid	UG/L			< 10000 U
Formic Acid	UG/L			< 10000 U
Isobutyric acid	UG/L			< 10000 U
Lactic acid	UG/L			< 5000 U
Propionic Acid	UG/L			< 13000 U
· ·			-	

	Property Owner	PROPERTY OWNER K	PROPERTY OWNER K	PROPERTY OWNER K
		THE WELL IS LOCATED ON THE SOUTH SIDE OF THE MILK HOUSE; IT FEEDS BOTH THE MILK HOUSE	THE WELL IS LOCATED ON THE SOUTH SIDE OF THE MILK HOUSE; IT FEEDS BOTH THE MILK HOUSE	THE WELL IS LOCATED ON THE SOUTH SIDE OF THE MILK HOUSE; IT FEEDS BOTH THE MILK HOUSE
	Location Description	AND THE RESIDENCE.	AND THE RESIDENCE.	AND THE RESIDENCE.
	Source Type	WELL	WELL	WELL
	Well Depth	1/5	175	175
	Sampled Before Treatment?	NA	Post-Treatment	Pre-Treatment
	Sample ID	NTA0354-01072010-0855	0531201120201	1027201120202
Parameter and units	Sample Date	1/7/2010 (Baseline)	5/31/2011	10/27/2011
Matala (020x				
				0.00014
Cesium	MG/L			0.00014
Cesium, Dissolved	MG/L			0.00011
Potassium	MG/L			1.45
Potassium, Dissolved	MG/L			1.5
Silicon	MG/L			6.22
Silicon, Dissolved	MG/L			6.42
Thorium	MG/L			< 0.002 U
Thorium, Dissolved	MG/I			< 0.002 U
Uranium	MG/L			< 0.001 U
				< 0.001 U
	MG/L			< 0.001 0
Matala Tatal				
	10.4			< 0.0200 U
	MG/L			
Antimony	MG/L			< 0.00200 U
Arsenic	MG/L	< 0.0100 U	< 0.0100 U	< 0.00200 U
Barium	MG/L	0.111	0.126	0.125
Beryllium	MG/L			< 0.00200 U
Boron	MG/L			0.0941
Cadmium	MG/L	< 0.00100 U	< 0.00100 U	< 0.00100 U
Calcium	MG/L	36.9	40	41.6
Chromium	MG/I	< 0.00500 U	< 0.00500 U	< 0.00200 U
Cobalt	MG/L			< 0.00200 U
Coppor	MC/L			< 0.00200 0
	MG/L			< 0.00500 0
Hardness, CacO3	MG/L			
Iron	MG/L	< 0.0500 0	< 0.0500 U	0.0514
Lead	MG/L	< 0.00500 U	< 0.00500 U	< 0.00200 U
Lithium	MG/L			
Magnesium	MG/L	14.1	15	15.3
Manganese	MG/L	0.0321	0.102	0.168
Mercury	MG/L	< 0.000200 U	< 0.000200 U	< 0.000200 U
Molybdenum	MG/I			< 0.00500 []
Nickol	MG/L			< 0.00500 U
Detassium	MO/L	1 16	1 20	1 46
Polassium	MG/L	1.40	1.39	1.40
	MG/L			
Sliver	MG/L	< 0.00500 0	< 0.00500 0	< 0.00200 0
Sodium	MG/L	20.2	22.8	21.1
Strontium	MG/L			1.14
Sulfur	MG/L	8.04	5.3	5.43
Thallium	MG/L			< 0.00200 U
Titanium	MG/L			< 0.00200 U
Vanadium	MG/L			< 0.00400 U
Zinc	MG/L			< 0.0500 U
Metals, Dissolved				
Aluminum Dissolved	MG/I			< 0.0200 U
Antimony Dissolved	MG/L			< 0.00200.01
Arsonic Dissolved	MC/L			< 0.00200 U
Desilver Dissolved	MG/L			0.124
	100			0.124
Barlum, Dissolved	MG/L			0.000001
Beryllium, Dissolved	MG/L MG/L			< 0.00200 U
Barlum, Dissolved Beryllium, Dissolved Boron, Dissolved	MG/L MG/L MG/L			< 0.00200 U 0.09
Barlum, Dissolved Beryllium, Dissolved Boron, Dissolved Cadmium, Dissolved	MG/L MG/L MG/L MG/L			< 0.00200 U 0.09 < 0.00100 U
Barlum, Dissolved Beryllium, Dissolved Boron, Dissolved Cadmium, Dissolved Calcium, Dissolved	MG/L MG/L MG/L MG/L MG/L	 	 	< 0.00200 U 0.09 < 0.00100 U 39.9
Barlum, Dissolved Beryllium, Dissolved Boron, Dissolved Cadmium, Dissolved Calcium, Dissolved Chromium, Dissolved	MG/L MG/L MG/L MG/L MG/L	 	 	< 0.00200 U 0.09 < 0.00100 U 39.9 < 0.00200 U
Barlum, Dissolved Beryllium, Dissolved Boron, Dissolved Cadmium, Dissolved Calcium, Dissolved Chromium, Dissolved Cobalt, Dissolved	MG/L MG/L MG/L MG/L MG/L MG/L	 	 	< 0.00200 U 0.09 < 0.00100 U 39.9 < 0.00200 U < 0.00200 U

	Property Owner	PROPERTY OWNER K	PROPERTY OWNER K	PROPERTY OWNER K
		THE WELL IS LOCATED ON THE SOUTH SIDE OF THE MILK HOUSE; IT FEEDS BOTH THE MILK HOUSE	THE WELL IS LOCATED ON THE SOUTH SIDE OF THE MILK HOUSE; IT FEEDS BOTH THE MILK HOUSE	THE WELL IS LOCATED ON THE SOUTH SIDE OF THE MILK HOUSE; IT FEEDS BOTH THE MILK HOUSE
	Location Description	AND THE RESIDENCE.	AND THE RESIDENCE.	AND THE RESIDENCE.
	Source Type	WELL	WELL	WELL 175
Com	Well Deptn	1/5	I/5	I/5
San			Post-freatment	1027201120202
Decemptor and units	Sample ID	1/7/2010 (Pasalina)	E/21/2011	10/27/201120202
			5/31/2011	< 0.0500 []
Lead Dissolved	MG/L			< 0.00200 []
Magnesium, Dissolved	MG/L			14.6
Manganese, Dissolved	MG/L			0.119
Mercury, Dissolved	MG/L			< 0.000200 U
Molybdenum, Dissolved	MG/L			< 0.00500 U
Nickel, Dissolved	MG/L			< 0.00500 U
Potassium, Dissolved	MG/L			1.41
Selenium, Dissolved	MG/L			< 0.00200 U
Silver, Dissolved	MG/L			< 0.00200 U
Sodium, Dissolved	MG/L			19.9
Strontium, Dissolved	MG/L			1.11
Sulfur, Dissolved	MG/L			5.36
Thallium, Dissolved	MG/L			< 0.00200 U
Vanadium Dissolved	MG/L			< 0.00200 0
Zinc Dissolved	MG/L			< 0.00400 0
	MO/L			< 0.0300 0
Miscellaneous Organics				
Inorganic Carbon, Dissolved	MG/L			43.7
Organic Carbon, Dissolved	MG/L			< 1.00 U
Pesticides and PCBs				
4,4'-DDD	UG/L			< 0.0472 U
4,4'-DDE	UG/L			< 0.0472 U
4,4'-DDT	UG/L			< 0.0472 U
Aldrin	UG/L			< 0.0472 U
alpha-BHC	UG/L			< 0.0472 U
Azinphos-methyl	UG/L			< 0.94 U
Deta-BHC	UG/L			< 0.0472 0
	UG/L			< 0.0 U
Dichloryos				< 0.0472.0
Dieldrin				< 0.0472 []
Disulfoton	UG/L			< 0.94 U
Endosulfan I	UG/L			< 0.0472 U
Endosulfan II	UG/L			< 0.0472 U
Endosulfan sulfate	UG/L			< 0.0472 U
Endrin	UG/L			< 0.0472 U
Endrin aldehyde	UG/L			< 0.0472 U
Endrin ketone	UG/L			< 0.0472 U
gamma-BHC (Lindane)	UG/L			< 0.0472 U
Heptachlor	UG/L			< 0.0472 U
Malathion	UG/L			< 0.0472 0
Methoxychlor				< 0.94 0
Mevinphos	UG/L			< 0.94
Purgeable Petroleum Hydroc	arbons			100.11
GRU as Gasoline	UG/L			< 100 0
Semivolatile Organics				
1,2,4,5-Tetrachlorobenzene	UG/L			< 1 U
1,2-Dinitrobenzene	UG/L			< 5 U
1,2-Diphenylhydrazine	UG/L			< 1 U
1,3-Dimethyl adamatane	UG/L			< 5 U
	UG/L			< 5 U
	UG/L			
2 3 4 6-Tetrachlorophonol				2111
	UG/L			< I U

	Property Owner	PROPERTY OWNER K	PROPERTY OWNER K	PROPERTY OWNER K
	Location Description	THE WELL IS LOCATED ON THE SOUTH SIDE OF THE MILK HOUSE; IT FEEDS BOTH THE MILK HOUSE AND THE RESIDENCE	THE WELL IS LOCATED ON THE SOUTH SIDE OF THE MILK HOUSE; IT FEEDS BOTH THE MILK HOUSE AND THE RESIDENCE	THE WELL IS LOCATED ON THE SOUTH SIDE OF THE MILK HOUSE IT FEEDS BOTH THE MILK HOUSE AND THE RESIDENCE
		WFII	WFII	WFI I
	Woll Dopth	175	175	175
		175	1/5	1/5
Sampled E	Before Treatment?	NA	Post-Treatment	Pre-Treatment
	Sample ID	NTA0354-01072010-0855	0531201120201	1027201120202
Parameter and units	Sample Date	1/7/2010 (Baseline)	5/31/2011	10/27/2011
2.4.5-Trichlorophenol	UG/I			< 1 U
2.4.6-Trichlorophenol				< 111
2.4 Dichlorophonol	00/L			
	UG/L			< 1 U
2,4-Dimethylphenol	UG/L			< 1 U
2,4-Dinitrophenol	UG/L			< 30 U
2,4-Dinitrotoluene	UG/L			< 5 U
2,6-Dichlorophenol	UG/L			< 1 U
2 6-Dinitrotoluene	UG/I			< 1 []
2 Butowyothanol				< 5 11
	UG/L			< 5 U
2-Chloronaphthalene	UG/L			< 1 U
2-Chlorophenol	UG/L			< 1 U
2-Methylnaphthalene	UG/L			< 0.5 U
2-Methylphenol	UG/L			< 1 U
2-Nitroaniline				< 1
2-Nitrophonol				- 111
	UG/L			< 1 U
3,3-Dichlorobenzidine	UG/L			< 5 U
3-Nitroaniline	UG/L			< 1 U
4,4'-Methylenebis(2-chloroaniline)	UG/L			< 15 UJ
4.4'-Methylenebis(N.N-dimethylanilir	UG/L			< 15 U
4 6-Dinitro-2-methylphenol				< 15 []
4 Promonhonyl nhonyl othor	00/L			
4-Bromophenyi phenyi ether	UG/L			< U
4-Chloro-3-methylphenol	UG/L			< 1 U
4-Chloroaniline	UG/L			< 1 U
4-Chlorophenyl phenyl ether	UG/L			< 1 U
4-Methylphenol	UG/I			< 1 U
				< 1
	00/L			
4-Nitrophenol	UG/L			< 30 0
Acenaphthene	UG/L			< 0.5 U
Acenaphthylene	UG/L			< 0.5 U
Acetophenone	UG/L			< 1 U
Adamantane	UG/L			< 5 U
Aniline				< 1
Anthropopo	00/L			
Anthracene	UG/L			< 0.5 U
Benzo (a) anthracene	UG/L			< 0.5 U
Benzo (a) pyrene	UG/L			< 0.5 U
Benzo (b) fluoranthene	UG/L			< 0.5 U
Benzo (a.h.i) pervlene	UG/I			< 0.5 U
Benzo (k) fluoranthene				< 0.5 U
	UG/L			
Benzoic acid	UG/L			< 15 U
Benzyl alcohol	UG/L			< 15 U
Bis(2-chloroethoxy)methane	UG/L			< 1 U
Bis(2-chloroethyl)ether	UG/L			< 1 U
bis(2-Chloroisopropyl)ether	UG/L			< 1 U
Bis(2-ethylbeyyl)nhthalate				- 5 11
	UG/L			< 5 0
butyi benzyi phthalate	UG/L			< 5 U
Carbazole	UG/L			< 1 U
Chlorobenzilate	UG/L			< 10 U
Chrysene	UG/L			< 0.5 U
Diallate (cis or trans)	UG/I			< 5 U
Dihonz (a b) anthracono				- 0.5.11
	UG/L			
Dibenzoturan	UG/L			< 1 U
Diethyl phthalate	UG/L			< 5 U
Dimethyl phthalate	UG/L			< 5 U
Di-n-butyl phthalate	UG/L			< 5 U
Di-n-octyl nhthalate				< 5 11
	UG/L			
	UG/L			< 5 U
Disulfoton	UG/L			< 50 U
	LIG/I			< 5 U
a-Limonene	00/L			

	Property Owner	PROPERTY OWNER K	PROPERTY OWNER K	PROPERTY OWNER K
	Location Description	THE WELL IS LOCATED ON THE SOUTH SIDE OF THE MILK HOUSE; IT FEEDS BOTH THE MILK HOUSE	THE WELL IS LOCATED ON THE SOUTH SIDE OF THE MILK HOUSE; IT FEEDS BOTH THE MILK HOUSE	THE WELL IS LOCATED ON THE SOUTH SIDE OF THE MILK HOUSE; IT FEEDS BOTH THE MILK HOUSE
		AND THE RESIDENCE.	AND THE RESIDENCE.	AND THE RESIDENCE.
	Woll Dopth	175	175	175
	Commission Defense Transferrent	175	175 Deet Treetweet	
	Sampled Before Treatment?		Post-Treatment	Pre-Treatment
	Sample ID	NTA0354-01072010-0855	0531201120201	1027201120202
Parameter and units	Sample Date	1/7/2010 (Baseline)	5/31/2011	10/27/2011
Fluorene	UG/L			< 0.5 U
Hexachlorobenzene	UG/L			< 0.5 U
Hexachlorobutadiene	UG/L			< 1 U
Hexachlorocyclopentadien	UG/L			< 15 U
Hexachloroethane	UG/L			< 5 U
Indeno (1,2,3-cd) pyrene	UG/L			< 0.5 U
Isophorone	UG/L			< 1 U
Naphthalene	UG/I			< 0.5 U
Nitrobenzene				< 1
N Nitrosodiothylamino				< 1.11
N Nitrosodimothylamino				
N Nitroood's but have	UG/L			
IN-INITrosoal-n-butylamine	UG/L			< 5 U
N-Nitrosodi-n-propylamine	e UG/L			< 1 U
N-Nitrosodiphenylamine	UG/L			< 1 U
N-Nitrosomethylethylamin	UG/L			< 5 U
Parathion-ethyl	UG/L			< 5 U
Parathion-methyl	UG/L			< 5 U
Pentachlorobenzene	UG/L			< 1 U
Pentachlorophenol	UG/L			< 5 U
Phenanthrene	UG/L			< 0.5 U
Phenol				< 111
Phorate				< 1
Pronamido				
Pronamide				
Pyrene	UG/L			< 0.5 0
Pyridine	UG/L			< 5 U
Squalene	UG/L			< 5 U
Terbufos	UG/L			< 5 U
Terpineol	UG/L			< 5 U
Tributoxyethyl phosphate	UG/L			< 5 U
Trifluralin	UG/L			< 5 U
7/0-				
1,2,3-Trimethylbenzene	UG/L			
Volatile Organics				
1 1 1 Trichloroothano				< 1.00 U
	UG/L			
	UG/L			< 1.00 U
	UG/L			< 1.00 U
I, I-Dichloroethene	UG/L			< 1.00 U
1,2,3-Trimethylbenzene	UG/L			< 1.00 U
1,2,4-Trichlorobenzene	UG/L			
1,2,4-Trimethylbenzene	UG/L			< 1.00 U
1,2-Dibromo-3-chloroprop	oane UG/L			< 0.1003 U
1,2-Dichlorobenzene	UG/L			< 1.00 U
1,2-Dichloroethane	UG/L			< 1.00 U
1,2-Dichloropropane	UG/L			
1,3,5-Trimethylbenzene	UG/I			< 1.00 U
1.3-Dichlorobenzene				< 1,00 U
1.4-Dichlorobenzene				< 1.00 U
				< 50.011
Bonzono	00/L			- 1.00
Carbon disulfida	UG/L	< 0.000 0	< 0.000 0	
	UG/L			
	UG/L			< 1.00 U
Chlorobenzene	UG/L			< 1.00 U
Chloroform	UG/L			< 1.00 U
cis-1,2-Dichloroethene	UG/L			< 1.00 U
Diisopropyl Ether	UG/L			< 1.00 U
Ethanol	UG/L			< 100 U
Ethyl tert-Butyl Ether	UG/L			< 1.00 U
Ethylbenzene	UG/L	< 0.500 U	< 0.500 U	< 1.00 U

	Property Owner	PROPERTY OWNER K	PROPERTY OWNER K	PROPERTY OWNER K
		THE WELL IS LOCATED ON THE	THE WELL IS LOCATED ON THE	THE WELL IS LOCATED ON THE
		SOUTH SIDE OF THE MILK HOUSE;	SOUTH SIDE OF THE MILK HOUSE;	SOUTH SIDE OF THE MILK HOUSE;
	Location Description			
	Source Type	WFLI	WFI I	WFI I
	Well Denth	175	175	175
	Sampled Before Treatment?	NA	Post-Treatment	Pro-Treatment
	Sampled Derore Treatment:	NTA0254 01072010 0855	0521201120201	1027201120202
Paramotor and units	Sample ID	1/7/2010 (Pasolino)	5/21/2011	10/27/2011
	Sample Date	1/1/2010 (Baseline)	5/31/2011	
	06/L			< 10
	UG/L			< 50.0 0
Isopropyidenzene	UG/L			< 1.00 U
m,p-Xylene	UG/L			< 2.00 U
Methoxychlor	UG/L			< 0.0472 U
Methyl tert-Butyl Ether	UG/L			< 1.00 U
Methylene Chloride	UG/L			< 5.00 U
Naphthalene	UG/L			< 5.00 U
o-Xylene	UG/L			< 1.00 U
Styrene	UG/L			
Tert-Amyl Methyl Ether	UG/L			< 1.00 U
Tertiary Butyl Alcohol	UG/L			< 10.0 U
Tetrachloroethene	UG/L			< 1.00 U
Tetrahydrofuran	UG/L			
Toluene	UG/L	< 0.500 U	< 0.500 U	< 1.00 U
trans-1,2-Dichloroethene	UG/L			< 1.00 U
Trichloroethene	UG/L			< 1.00 U
Vinyl chloride	UG/L			< 1.00 U
Xylenes, total	UG/L	< 0.500 U	< 0.500 U	< 3.00 U
		-	-	-

Notes:

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended

holding time

J : Estimated value --- : Parameter not analyzed.

--- : Parameter not analyzed. B : Blank qualified ug/L : Micrograms per liter mg/L : Milligrams per liter NA : Not Available NTU : Nephelometric Turbidity Unit umho/cm : Micromhos per centimeter colonies/100 ml : Colonies per 100 millileters



APPENDIX A-12 EPA STUDY WELL DATA PROPERTY OWNER L

	Property Owner	PROPERTY OWNER L	PROPERTY OWNER L
	Source Type	WELL	WELL
	Well Depth	225	225
	Sampled Before Treatment?	NA	Pre-Treatment
	Sample ID	NTD1742-04182010-1910	1103201120201
Parameter and units	Sample Date	4/18/2010 (Baseline)	11/3/2011
Aldehydes			
Gluteraldenyde	UG/L		
Bacteria			
E. coli	colonies/100ml		Absent
Fecal coliform bacteria	colonies/100ml		< 1 U
Total Coliform Bacteria	colonies/100ml		Present
0.0.00			
			0.1010.11
1,2-Dibromo-3-chioroproj	pane UG/L		< 0.1012 0
Extractable Petroleum H	ydrocarbons		
Diesel	UG/L		< 94.3 U
General Chemistry			477
Alkalinity, Total (CaCO3)	MG/L		1//
Ammonia as N	MG/L		0.629
Bicarbonate Alkalinity as	CaCO3 MG/L	184	179
Bromide	MG/L		< 2.5 U
Carbonate as CaCO3	MG/L	< 10.0 U	< 10.0 U
Chloride	MG/L	6.62	7.6 J
CO2 by Headspace	UG/L		< 12000 U
Cyanide	MG/L		
Fluoride	MG/L		< 0.50 U
MBAS	MG/L	< 0.0500 U	< 0.12 0
Nitrate	MG/L		
Nitrate Nitrogen	MG/L		1.1
	MG/L		< 0.50 0
		7 50 4	< 4.02 U
Dhosphorus		7.50 H	7.50 H
Specific conductance		209	202
Sulfate	MG/I	22.6	273 22 A
Temperature of pH deter	mination CELSIUS	22.0	22.4
Total Dissolved Solids	MG/I	21.011	21.011
Total Suspended Solids	MG/L	< 1.00 []	< 1.00
Turbidity	NTL	< 1.00 U	< 0.30 []
Tarbiary			
Glycols			
1,2-Propylene Glycol	MG/L		
Diethylene Glycol	MG/L		< 10 U
Ethylene Glycol	MG/L		
Tetraethylene glycol	MG/L		15 JBJ
Triethylene glycol	MG/L		< 10 U
Light Gases			
Acetylene	MG/L		< 0.00500 U
Ethane	MG/L	< 0.0260 U	< 0.00500 U
Ethene	MG/L		< 0.00500 U
Methane	MG/L	0.048	< 0.00500 U
n-Butane	MG/L		< 0.00500 U
Propane	MG/L	< 0.0340 U	< 0.00500 U
Low Molecular Weight Ad	cias		400001
Acetic Acid	UG/L		< 10000 U
Butyric Acid	UG/L		< 10000 U
Formic Acid	UG/L		< 10000 U
	UG/L		< 10000 U
Lactic acid	UG/L		< 5000 U
Ριοριοπις Αςία	UG/L		< 13000 U

	Property Owner	PROPERTY OWNER L	PROPERTY OWNER L
	Location Description Source Type	WELL	WFLL
	Well Depth	225	225
	Sampled Before Treatment?	NA	Pre-Treatment
	Sample ID	NTD1742-04182010-1910	1103201120201
Parameter and units	Sample Date	4/18/2010 (Baseline)	11/3/2011
Metals, 6020x			
Cesium	MG/L		< 0.0001 U
Cesium, Dissolved	MG/L		< 0.0001 U
Potassium	MG/L		1.6
Potassium, Dissolved	MG/L		1.5
Silicon Silicon	MG/L		4.6
Thorium	MG/L		4.5
Thorium Dissolved	MG/L		< 0.002 U
Uranium	MG/L		0.0014
Uranium, Dissolved	MG/L		0.0014
Metals. Total			
Aluminum	MG/L		< 0.0200 U
Antimony	MG/L		< 0.00200 U
Arsenic	MG/L	< 0.0100 U	< 0.00200 U
Barium	MG/L	0.165	0.168
Beryllium	MG/L		< 0.00200 U
Boron	MG/L		< 0.0500 U
Cadmium	MG/L	< 0.00100 U	< 0.00100 U
Chromium	MG/L	47.3	4/
Cobalt	MG/L	< 0.00500 0	< 0.00200 0
Copper	MG/L		< 0.00500 U
Hardness, CaCO3	MG/L		
Iron	MG/L	< 0.0500 U	< 0.0500 U
Lead	MG/L	< 0.00500 U	< 0.00200 U
Lithium	MG/L		
Magnesium	MG/L	15.5	15.2
Manganese	MG/L	< 0.0150 U	< 0.00500 U
Mercury	MG/L	< 0.000200 0	< 0.000200 U
Nickel	MG/L		< 0.00500 U
Potassium	MG/L	1.93	1.45
Selenium	MG/L	< 0.0100 U	< 0.00200 U
Silver	MG/L	< 0.00500 U	< 0.00200 U
Sodium	MG/L	14.6	14
Strontium	MG/L		0.987
Sulfur	MG/L	7.6	6.23
I hallium	MG/L		< 0.00200 U
Vanadium	MG/L		< 0.00200 U
Zinc	MG/L		< 0.00400 0
Zinc	WO/L		< 0.0300 0
Metals, Dissolved			
Aluminum, Dissolved	MG/L		< 0.0200 U
Antimony, Dissolved	MG/L		< 0.00200 U
Barium Dissolved	MG/L MG/L		0.00200 0
Bervllium, Dissolved	MG/L		< 0.00200 U
Boron, Dissolved	MG/L		0.0525
Cadmium, Dissolved	MG/L		< 0.00100 U
Calcium, Dissolved	MG/L		51.8
Chromium, Dissolved	MG/L		< 0.00200 U
Cobalt, Dissolved	MG/L		< 0.00200 U
Copper, Dissolved	MG/L		< 0.00500 U
Iron, Dissolved	MG/L		< 0.0500 U
Lead, DISSOIVed	MG/L		< 0.00200 U
Manganese Dissolved	MG/L		< 0.00500 11
Manganese, Dissolved	IVIO/L	-	< 0.00000 0

	Property Owner	PROPERTY OWNER L	PROPERTY OWNER L
	Location Description	\A/ELL	\A/ELL
	Source Type	225	22E
	Sampled Pofere Treatment?	225 NA	Dro Troatmont
	Sampled before freatments	NTD17/2-0/182010-1910	1103201120201
Parameter and units	Sample TD	1/18/2010 (Baseline)	11/3/2011
Mercury Dissolved			< 0.000200 []
Molybdenum Dissolved	MG/L		< 0.00500 U
Nickel Dissolved	MG/L		< 0.00500 U
Potassium, Dissolved	MG/L		1.69
Selenium, Dissolved	MG/L		< 0.00200 U
Silver, Dissolved	MG/L		< 0.00200 U
Sodium, Dissolved	MG/L		15.5
Strontium, Dissolved	MG/L		1.1
Sulfur, Dissolved	MG/L		6.96
Thallium, Dissolved	MG/L		< 0.00200 U
Titanium, Dissolved	MG/L		< 0.00200 U
Vanadium, Dissolved	MG/L		< 0.00400 U
Zinc, Dissolved	MG/L		< 0.0500 U
Miscellaneous Organics			
Inorganic Carbon, Dissolv	ved MG/L		38.9
Organic Carbon, Dissolved	d MG/L		< 1.00 U
Posticidos and DCRs			
			< 0.0236.11
4 4'-DDF			< 0.0236 U
4 4'-DDT			< 0.0236 U
Aldrin	UG/L		< 0.0236 U
alpha-BHC	UG/L		< 0.0236 U
Azinphos-methyl	UG/L		< 0.94 U
beta-BHC	UG/L		< 0.0236 U
Carbaryl	UG/L		< 6.0 U
delta-BHC	UG/L		< 0.0236 U
Dichlorvos	UG/L		< 0.94 U
Dieldrin	UG/L		< 0.0236 U
Disulfoton	UG/L		< 0.94 U
Endosulfan I	UG/L		< 0.0236 U
Endosulfan II	UG/L		< 0.0236 U
Endosulfan sulfate	UG/L		< 0.0236 U
Endrin	UG/L		< 0.0236 U
Endrin aldehyde	UG/L		< 0.0236 U
Endrin ketone	UG/L		< 0.0236 U
gamma-BHC (Lindane)	UG/L		< 0.0236 U
Heptachlor	UG/L		< 0.0236 U
Heptachlor epoxide	UG/L		< 0.0236 U
Malathion	UG/L		< 0.94 U
Methoxychlor	UG/L		< 0.0236 U
Mevinphos	UG/L		< 0.94 U
Purgeable Petroleum Hyd	drocarbons		
GRO as Gasoline	UG/L		< 100 U
Semivolatile Organics			
1.2.4.5-Tetrachlorobenzer	ne UG/L		< 1 U
1.2-Dinitrobenzene	UG/L		< 5 U
1,2-Diphenvlhvdrazine	UG/L		< 1 U
1,3-Dimethyl adamatane	UG/L		< 5 U
1,3-Dinitrobenzene	UG/L		< 5 U
1,4-Dinitrobenzene	UG/L		< 5 U
1-Chloronaphthalene	UG/L		< 1 U
2,3,4,6-Tetrachloropheno	UG/L		< 1 U
2,4,5-Trichlorophenol	UG/L		< 1 U
2,4,6-Trichlorophenol	UG/L		< 1 U
2,4-Dichlorophenol	UG/L		< 1 U
2,4-Dimethylphenol	UG/L		< 1 U
2,4-Dinitrophenol	UG/L		< 29 U
2,4-Dinitrotoluene	UG/L		< 5 U
2,6-Dichlorophenol	UG/L		< 1 U
2,6-Dinitrotoluene	UG/L		< 1 U
SUMMARY TABLE OF LABORATORY ANALYTICAL DATA FOR THE CHESAPEAKE SPLIT SAMPLE FROM EPA RETROSPECTIVE WELL PROPERTY OWNER L

Pro	perty Owner	PROPERTY OWNER L	PROPERTY OWNER L
Locat	ion Description	\//FLL	\//FLI
	Well Depth	225	225
Sampled Before	Treatment?	NA	Pre-Treatment
	Sample ID	NTD1742-04182010-1910	1103201120201
Parameter and units	Sample Date	4/18/2010 (Baseline)	11/3/2011
2-Butoxyethanol	UG/L		< 5 UJ
2-Chloronaphthalene	UG/L		< 1 U
2-Chlorophenol	UG/L		< 1 U
2 Methylphopol	UG/L		< 0.5 U
2-Nitroaniline	UG/L		< 1
2-Nitrophenol	UG/L		< 1 U
3,3-Dichlorobenzidine	UG/L		< 5 U
3-Nitroaniline	UG/L		< 1 U
4,4'-Methylenebis(2-chloroaniline)	UG/L		< 14 UJ
4,4'-Methylenebis(N,N-dimethylanilin	UG/L		< 14 UJ
4,6-Dinitro-2-methylphenol	UG/L		< 14 U
4-Biomophenyi phenyi ether	UG/L		
4-Chloroaniline			< 1 []
4-Chlorophenyl phenyl ether	UG/L		< 1 U
4-Methylphenol	UG/L		< 1 U
4-Nitroaniline	UG/L		< 1 U
4-Nitrophenol	UG/L		< 29 U
Acenaphthene	UG/L		< 0.5 U
Acenaphthylene	UG/L		< 0.5 U
Acetophenone	UG/L		< 1 U
	UG/L		< 1
Anthracene	UG/L		< 0.5 U
Benzo (a) anthracene	UG/L		< 0.5 UJ
Benzo (a) pyrene	UG/L		< 0.5 U
Benzo (b) fluoranthene	UG/L		< 0.5 U
Benzo (g,h,i) perylene	UG/L		< 0.5 U
Benzo (k) fluoranthene	UG/L		< 0.5 U
Benzul alcohol	UG/L		< 14 UJ
Bis(2-chloroethoxy)methane	UG/L		< 1 U
Bis(2-chloroethyl)ether	UG/L		< 1 U
bis(2-Chloroisopropyl)ether	UG/L		< 1 U
Bis(2-ethylhexyl)phthalate	UG/L		< 5 UJ
Butyl benzyl phthalate	UG/L		< 5 UJ
Carbazole	UG/L		< 1 U
Chiorobenzilate	UG/L		< 10 0
Diallate (cis or trans)	UG/L		< 5 U
Dibenz (a,h) anthracene	UG/L		< 0.5 U
Dibenzofuran	UG/L		< 1 U
Diethyl phthalate	UG/L		< 5 U
Dimethyl phthalate	UG/L		< 5 U
Di-n-butyl phthalate	UG/L		< 5 U
Dinoseh	UG/L		< 5 U
Disulfoton	UG/L		< 48 U
d-Limonene	UG/L		< 5 U
Fluoranthene	UG/L		< 0.5 U
Fluorene	UG/L		< 0.5 U
Hexachlorobenzene	UG/L		< 0.5 U
Hexachlorobutadiene	UG/L		< 1 U
Hexachloroctyclopentadiene	UG/L		< 14 U
Indeno (1.2.3-cd) pyrene	UG/I		< 0.511
Isophorone	UG/L		< 1 U
Naphthalene	UG/L		< 0.5 U
Nitrobenzene	UG/L		< 1 U
N-Nitrosodiethylamine	UG/L		< 1 U
N-Nitrosodimethylamine	UG/L		< 5 U

	Property Owner	PROPERTY OWNER L	PROPERTY OWNER L		
	Source Type	WELL	WELL		
	Well Depth	225	225		
S	ampled Before Treatment?	NA	Pre-Treatment		
	Sample ID	NTD1742-04182010-1910	1103201120201		
Parameter and units	Sample Date	4/18/2010 (Baseline)	11/3/2011		
N-Nitrosodi-n-butylamine	UG/L		< 5 U		
N-Nitrosodi-n-propylamine	UG/L		< 1 U		
N-Nitrosodiphenylamine	UG/L		< 1 U		
N-Nitrosomethylethylamine	UG/L		< 5 U		
Parathion-ethyl	UG/L		< 5 U		
Parathion-methyl	UG/L		< 5 U		
Pentachlorophanal	UG/L		< 1 U		
Pentachiorophenol	UG/L		< 5 U		
Phenol			< 111		
Phorate			< 111		
Pronamide	UG/I		< 1 U		
Pyrene	UG/L		< 0.5 U		
Pyridine	UG/L		< 5 U		
Squalene	UG/L		< 5 UJ		
Terbufos	UG/L		< 5 UJ		
Terpineol	UG/L		< 5 U		
Tributoxyethyl phosphate	UG/L		< 5 U		
Trifluralin	UG/L		< 5 UJ		
TICs					
1 2 3-Trimethylbenzene	LIG/I				
1,2,3-minetryibenzene	00/2				
Iolatile Organics					
1,1,1-Trichloroethane	UG/L		< 1.00 U		
1,1,2-Trichloroethane	UG/L		< 1.00 U		
1,1-Dichloroethane	UG/L		< 1.00 U		
1, I-Dichloroethene	UG/L		< 1.00 U		
1.2.4 Trichlorohonzono	UG/L		< 1.00 0		
	UG/L		 < 1.00		
1 2-Dibromo-3-chloropropa			< 0.1012 []		
1.2-Dichlorobenzene	UG/I		< 1.00 U		
1.2-Dichloroethane	UG/L		< 1.00 U		
1,2-Dichloropropane	UG/L				
1,3,5-Trimethylbenzene	UG/L		< 1.00 U		
1,3-Dichlorobenzene	UG/L		< 1.00 U		
1,4-Dichlorobenzene	UG/L		< 1.00 U		
Acetone	UG/L		< 50.0 U		
Benzene	UG/L	< 0.500 U	< 1.00 U		
Carbon disulfide	UG/L		< 1.00 U		
Carbon Tetrachloride	UG/L		< 1.00 U		
Chlorobenzene	UG/L		< 1.00 U		
chloroform	UG/L		< 1.00 U		
	UG/L		< 1.00 U		
Ethanol	UG/L		< 1.00 U		
Ethyl tert-Butyl Ether			< 1.00 U		
Ethylbenzene	UG/L	< 0.500 U	< 1.00 U		
Hexachlorobutadiene	UG/L		< 1 U		
Isopropyl alcohol	UG/L		< 50.0 U		
Isopropylbenzene	UG/L		< 1.00 U		
m,p-Xylene	UG/L		< 2.00 U		
Methoxychlor	UG/L		< 0.0236 U		
Methyl tert-Butyl Ether	UG/L		< 1.00 U		
Methylene Chloride	UG/L		< 5.00 U		
Naphthalene	UG/L		< 5.00 U		
o-Xylene	UG/L		< 1.00 U		
Styrene	UG/L				
Tertian Data Ale	UG/L		< 1.00 U		
Tetrachlara athar	UG/L		< 10.0 U		
Totrabudrofuran	UG/L		< 1.00 U		
reuanyurururan	UG/L				

-			
	Property Owner	PROPERTY OWNER L	PROPERTY OWNER L
	Location Description		
	Source Type	WELL	WELL
	Well Depth	225	225
	Sampled Before Treatment?	NA	Pre-Treatment
	Sample ID	NTD1742-04182010-1910	1103201120201
Parameter and units	Sample Date	4/18/2010 (Baseline)	11/3/2011
Toluene	UG/L	< 0.500 U	< 1.00 U
trans-1,2-Dichloroethene	e UG/L		< 1.00 U
Trichloroethene	UG/L		< 1.00 U
Vinyl chloride	UG/L		< 1.00 U
Xylenes, total	UG/L	< 0.500 U	< 3.00 U

Notes:

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended

holding time

J : Estimated value

J : Estimated value --- : Parameter not analyzed. B : Blank qualified ug/L : Micrograms per liter mg/L : Milligrams per liter NA : Not Available NTU : Nephelometric Turbidity Unit umho/cm : Micromhos per centimeter calonios (100 ml : Colonios per 100 milli)

colonies/100 ml : Colonies per 100 millileters



APPENDIX A-13 EPA STUDY WELL DATA PROPERTY OWNER M

	Property Owner	PROPERTY OWNER M	PROPERTY OWNER M	PROPERTY OWNER M	PROPERTY OWNER M		
	Location Description	THE WELL IS LOCATED NORTH OF THE HOUSE.	THE WELL IS LOCATED NORTH OF	THE WELL IS LOCATED NORTH OF	THE WELL IS LOCATED NORTH OF		
	Source Type	WELL	WELL	WELL	WELL		
	Well Depth	440	440	440	440		
	Sampled Before Treatment?	NA	Pre-Treatment	Pre-Treatment	Pre-Treatment		
	Sample ID	NTA0325-01062010-1605	1202201012501	0411201112403	1028201120202		
Parameter and units	Sample Date	1/6/2010 (Baseline)	12/2/2010	4/11/2011	10/28/2011		
Aldahudaa							
Aldenyaes Cluteroldebude							
Giuteraidenyde	UG/L						
Bacteria							
E. coli	colonies/100ml				Present		
Fecal coliform bacteria	colonies/100ml				3		
Total Coliform Bacteria	colonies/100ml				Present		
DRCP							
1 2-Dibromo-3-chloroprop	ane lic/l				< 0.1020 []		
1,2-Dibi offio-5-chioroprop					< 0.1020 0		
Extractable Petroleum Hydro	carbons						
Diesel	UG/L				< 95.2 U		
Conoral Chomistry							
	MC/I				150		
Ammonia as N	MG/L				< 0.100 []		
Bicarbonate Alkalinity as C		159	142		150		
Bromide	MG/L				< 2.5 []		
Carbonate as CaCO3	MG/L	< 10.0 U	< 10.0 U		< 10.0 U		
Chloride	MG/L	4.3	7.31		861		
CO2 by Headspace	UG/L				< 12000 U		
Cyanide	MG/L						
Fluoride	MG/L				< 0.50 U		
MBAS	MG/L	< 0.0500 U	< 0.0500 U		< 0.12 U		
Nitrate	MG/L						
Nitrate Nitrogen	MG/L				1.4		
Nitrite Nitrogen	MG/L				< 0.50 UJ		
Oil & Grease HEM	MG/L	< 5.49 U	< 6.02 U		< 4.76 U		
рН	pH UNITS	7.00 H	7.60 H		7.40 H		
Phosphorus	MG/L				< 0.100 U		
Specific conductance	UMHO/CM	340	336		330		
Sulfate	MG/L	14.7	15.7		12.6 J		
Temperature of pH detern	nination CELSIUS	21.7 H	21.8 H		21.0 H		
Total Dissolved Solids	MG/L	198	173		176		
Total Suspended Solids	MG/L	< 1.00 U	1		< 1.00 U		
Turbidity	NTU	< 1.00 U	1.1		1.9		
Glycols							
1,2-Propylene Glycol	MG/L						
Diethylene Glycol	MG/L				< 10 U		
Ethylene Glycol	MG/L						
Tetraethylene glycol	MG/L				< 10 UJ		
Triethylene glycol	MG/L				< 10 U		
Light Cases							
Acotylopo	MC/I				< 0.00500 U		
Ethano	MG/L	< 0.0260 []	< 0.0260.11		< 0.00500 U		
Ethono	MG/L	< 0.0200 0	< 0.0200 0		< 0.00500 U		
Methane	MG/L	< 0.0260.11	< 0.0260 []		< 0.00500 U		
n-Butane	MG/L				< 0.00500 U		
Propane	MG/L	< 0.0340 []	< 0.0340 []		< 0.00500 U		
	MOL						
Low Molecular Weight Acids							
Acetic Acid	UG/L				< 10000 U		
Butyric Acid	UG/L				< 10000 U		
Formic Acid	UG/L				< 10000 U		
Isobutyric acid	UG/L				< 10000 U		
Lactic acid	UG/L				< 5000 U		
Propionic Acid	UG/L				< 13000 U		

	Property Owner	PROPERTY OWNER M	PROPERTY OWNER M	PROPERTY OWNER M	PROPERTY OWNER M
		THE WELL IS LOCATED NORTH OF			
	Location Description	THE HOUSE.	THE HOUSE.	THE HOUSE.	THE HOUSE.
	Source Type	WELL	WELL	WELL	WELL
	Well Depth	440	440	440	440
	Sampled Before Treatment?	NA	Pre-Treatment	Pre-Treatment	Pre-Treatment
	Sample ID	NTA0325-01062010-1605	1202201012501	0411201112403	1028201120202
Parameter and units	Sample Date	1/6/2010 (Baseline)	12/2/2010	4/11/2011	10/28/2011
Metals, 6020x					
Cesium	MG/L				< 0.0001 U
Cesium, Dissolved	MG/L				< 0.0001 U
Potassium	MG/L				1.2
Potassium, Dissolved	MG/L				1.14
Silicon	MG/L				4.46
Silicon, Dissolved	MG/L				4.25
Thorium	MG/L				< 0.002 U
Thorium, Dissolved	MG/L				< 0.002 U
Uranium	MG/L				< 0.001 U
Uranium, Dissolved	MG/L				< 0.001 U
Metals, Total					
Aluminum	MG/L				0.0295
Antimony	MG/L				< 0.00200 U
Arsenic	MG/L	< 0.0100 U	< 0.0100 U		< 0.00200 U
Barium	MG/L	0.17	0.18		0.171
Beryllium	MG/L				< 0.00200 U
Boron	MG/L				< 0.0500 U
Cadmium	MG/L	< 0.00100 U	< 0.00100 U		< 0.00100 U
Calcium	MG/L	44.6	46.7		48.8
Chromium	MG/L	< 0.00500 U	< 0.00500 U		< 0.00200 U
Cobalt	MG/L				< 0.00200 U
Copper	MG/L				0.025
Hardness, CaCO3	MG/L				
Iron	MG/L	0.103	0.235		0.143
Lead	MG/L	< 0.00500 U	0.011	0.0124	0.003
Lithium	MG/L				
Magnesium	MG/L	12.6	12		11.9
Manganese	MG/L	< 0.0150 U	< 0.0150 U		0.00754
Mercury	MG/L	< 0.000200 U	< 0.000200 U		< 0.000200 U
Molybdenum	MG/L				< 0.00500 U
Nickel	MG/L				< 0.00500 U
Potassium	MG/L	1.13	1.12		1.03
Selenium	MG/L	< 0.0100 U	< 0.0100 U		< 0.00200 U
Silver	MG/L	< 0.00500 U	< 0.00500 U		< 0.00200 U
Sodium	MG/L	3.65	3.36		2.72
Strontium	MG/L				0.194
Sulfur	MG/L	7.27	3.5		3.23
	MG/L				< 0.00200 U
	MG/L				< 0.00200 U
	MG/L				< 0.00400 U
Zinc	MG/L				< 0.0500 U
Metals, Dissolved					
Aluminum, Dissolved	MG/L				< 0.0200 U
Antimony, Dissolved	MG/L				< 0.00200 U
Arsenic, Dissolved	MG/L				< 0.00200 U
Barium, Dissolved	MG/L				0.172
Beryllium, Dissolved	MG/L				< 0.00200 U
Boron, Dissolved	MG/L				< 0.0500 U
Cadmium, Dissolved	MG/L				< 0.00100 U
Calcium, Dissolved	MG/L				48.4
Chromium, Dissolved	MG/L				< 0.00200 U
Cobalt, Dissolved	MG/L				< 0.00200 U
Copper, Dissolved	MG/L				0.0197
Iron, Dissolved	MG/L				< 0.0500 U
Lead, Dissolved	MG/L				< 0.00200 U
Magnesium, Dissolved	MG/L				11.6

	Property Owner	PROPERTY OWNER M	PROPERTY OWNER M	PROPERTY OWNER M	PROPERTY OWNER M
		THE WELL IS LOCATED NORTH OF			
	Location Description	THE HOUSE.	THE HOUSE.	THE HOUSE.	THE HOUSE.
	Source Type	WELL	WELL	WELL	WELL
	Well Depth	440	440	440	440
	Sampled Before Treatment?	NA	Pre-Treatment	Pre-Treatment	Pre-Treatment
	Sample ID	NTA0325-01062010-1605	1202201012501	0411201112403	1028201120202
Parameter and units	Sample Date	1/6/2010 (Baseline)	12/2/2010	4/11/2011	10/28/2011
Manganese, Dissolved	MG/L				< 0.00500 0
Melvedenum Disselved	MG/L				< 0.000200 0
Nickel Dissolved	MG/L				< 0.00500 U
Potassium Dissolved	MG/L				< 0.00500 0
Selenium Dissolved	MG/L				< 0.00200 []
Silver Dissolved	MG/L				< 0.002000
Sodium Dissolved	MG/L				2 65
Strontium, Dissolved	MG/L				0.195
Sulfur, Dissolved	MG/L				3.31
Thallium, Dissolved	MG/L				< 0.00200 U
Titanium, Dissolved	MG/L				< 0.00200 U
Vanadium, Dissolved	MG/L				< 0.00400 U
Zinc, Dissolved	MG/L				< 0.0500 U
Miccollanoous Organias					
Inorganic Carbon Discolu	ind high				24.4
Inorganic Carbon, Dissolv	MG/L				34.0
	u MG/L				< 1.00 0
Pesticides and PCBs					
4,4'-DDD	UG/L				< 0.0476 U
4,4'-DDE	UG/L				< 0.0476 U
4,4'-DDT	UG/L				< 0.0476 U
Aldrin	UG/L				< 0.0476 U
alpha-BHC	UG/L				< 0.0476 U
Azinphos-methyl	UG/L				< 0.95 U
beta-BHC	UG/L				< 0.0476 U
Carbaryl	UG/L				< 6.0 U
delta-BHC	UG/L				< 0.0476 U
Dichlorvos	UG/L				< 0.95 U
Dieldrin	UG/L				< 0.0476 U
Disulfoton	UG/L				< 0.95 U
Endosulfan II					< 0.0476 U
Endosulfan sulfate					< 0.0476 U
Endrin					< 0.0476 U
Endrin aldehyde					< 0.0476 U
Endrin ketone					< 0.0476 U
gamma-BHC (Lindane)	UG/L				< 0.0476 U
Heptachlor	UG/L				< 0.0476 U
Heptachlor epoxide	UG/L				< 0.0476 U
Malathion	UG/L				< 0.95 U
Methoxychlor	UG/L				< 0.0476 U
Mevinphos	UG/L				< 0.95 U
Purapable Potroloum Under	arhons				
GPO as Casolino					< 100 U
	00/L				< 100 0
Semivolatile Organics					
1,2,4,5-Tetrachlorobenzer	ne UG/L				< 0.9 U
1,2-Dinitrobenzene	UG/L				< 5 U
1,2-Diphenylhydrazine	UG/L				< 0.9 U
1,3-Dimethyl adamatane	UG/L				< 5 U
1,3-Dinitrobenzene	UG/L				< 5 U
1,4-Dinitrobenzene	UG/L				< 5 U
1-Chloronaphthalene	UG/L				< 0.9 U
2,3,4,6-1 etrachloropheno	I UG/L				< 0.9 U
2,4,5-1 richlorophenol	UG/L				< 0.9 U
	UG/L				< 0.9 U
	UG/L				< 0.9 U
					< 0.7 U 2 20 II
					< 20 U
	00/L				< J U

SUMMARY TABLE OF LABORATORY ANALYTICAL DATA FOR THE CHESAPEAKE SPLIT SAMPLE FROM EPA RETROSPECTIVE WELL PROPERTY OWNER M

	Property Owner	PROPERTY OWNER M	PROPERTY OWNER M	PROPERTY OWNER M	PROPERTY OWNER M
		THE WELL IS LOCATED NORTH OF			
	Location Description	THE HOUSE.	THE HOUSE.	THE HOUSE.	THE HOUSE.
	Source Type	WELL	WELL	WELL	WELL
	Well Depth	440	440	440	440
Sampl	ed Before Treatment?	NA	Pre-Treatment	Pre-Treatment	Pre-Treatment
	Sample ID	NTA0325-01062010-1605	1202201012501	0411201112403	1028201120202
Parameter and units	Sample Date	1/6/2010 (Baseline)	12/2/2010	4/11/2011	10/28/2011
2,6-Dichlorophenol	UG/L				< 0.9 U
2,6-Dinitrotoluene	UG/L				< 0.9 U
2-Butoxyethanol	UG/L				< 5 UJ
2-Chloronaphthalene	UG/L				< 0.9 U
2-Chlorophenol	UG/L				< 0.9 U
2-Methylnaphthalene	UG/L				< 0.5 U
2-Methylphenol	UG/L				< 0.9 U
2-Nitroaniline	UG/L				< 0.9 U
2-Nitrophenol	UG/L				< 0.9 U
3,3-Dichlorobenzidine	UG/L				< 5 U
3-Nitroaniline	UG/L				< 0.9 U
4.4'-Methylenebis(2-chloroaniline	e) UG/L				< 14 U
4.4'-Methylenebis(N.N-dimethyla	anilin UG/L				< 14 UJ
4,6-Dinitro-2-methylphenol	UG/L				< 14 U
4-Bromophenvl phenvl ether	UG/L				< 0.9 U
4-Chloro-3-methylphenol	UG/L				< 0.9 U
4-Chloroaniline	UG/L				< 0.9 U
4-Chlorophenyl phenyl ether	UG/I				< 0.9 U
4-Methylphenol					< 0.9 []
4-Nitroaniline	UG/L				< 0.9 []]
4-Nitrophenol					< 28 []
					< 0.5 []
					< 0.5 U
					< 0.9 []
Adamantane					< 511
					< 0.911
Anthracene					< 0.5 []
Benzo (a) anthracene					< 0.5 U
Benzo (a) pyrene					< 0.5 U
Benzo (b) fluoranthene					< 0.5 U
Benzo (a h i) pervlepe					< 0.5 U
Benzo (k) fluoranthene					< 0.5 U
Benzoic acid					
Benzyl alcohol					< 14
Bis(2-chloroethoxy)methane					< 0.911
Bis(2-chloroethyl)ether					< 0.911
his(2-Chloroisonronyl)ether					< 0.911
Bis(2-othylboxyl)phthalate					< 5.11
Butyl benzyl phthalate					< 5 U
Carbazolo					< 0.911
Chlorobenzilate					< 911
Chrysene					< 0.5.11
Diallate (cis or trans)					< 511
Dibenz (a, h) anthracene					< 0.5 U
Dibenzofuran	UG/I				< 0.9 U
Diethyl phthalate	UG/I				< 5 U
Dimethyl phthalate	UG/L				< 5 U
Di-n-butyl phthalate	UG/L				< 5 U
Di-n-octyl phthalate	UG/L				< 5 U
Dinoseb	UG/L				< 5 U
Disulfoton	UG/L				< 47 U
d-Limonene	UG/L				< 5 U
Fluoranthene	UG/L				< 0.5 U
Fluorene	UG/L				< 0.5 U
Hexachlorobenzene	UG/L				< 0.5 U
Hexachlorobutadiene	UG/L				< 0.9 U
Hexachlorocyclopentadiene	UG/L				< 14 U
Hexachloroethane	UG/L				< 5 U
Indeno (1.2.3-cd) pyrene					< 0.5 U
Isophorone					< 0.9 []
Naphthalene					< 0.5.11
нартнионо	00/L				× 0.0 0

SUMMARY TABLE OF LABORATORY ANALYTICAL DATA FOR THE CHESAPEAKE SPLIT SAMPLE FROM EPA RETROSPECTIVE WELL PROPERTY OWNER M

	Property Owner	PROPERTY OWNER M	PROPERTY OWNER M	PROPERTY OWNER M	PROPERTY OWNER M
		THE WELL IS LOCATED NORTH OF			
	Location Description	THE HOUSE.	THE HOUSE.	THE HOUSE.	THE HOUSE.
	Source Type	WELL	WELL	WELL	WELL
	Well Depth	440	440	440	440
	Sampled Before Treatment?	NA	Pre-Treatment	Pre-Treatment	Pre-Treatment
Decementar and units	Sample ID	NTA0325-01062010-1605	12/2/2010	0411201112403	1028201120202
Parameter and units	Sample Date	1/6/2010 (Baseline)	12/2/2010	4/11/2011	10/28/2011
Nitrocediethylamine	UG/L				< 0.9 U
N-Nitrosodiethylamine	UG/L				< 0.9 0
N. Nitrosodi n. hutvlamine					< 5 U
N-Nitrosodi-n-propylamir					< 0.911
N-Nitrosodinhenvlamine					< 0.70
N-Nitrosomethylethylami					< 511
Parathion-ethyl					< 5 []
Parathion-methyl	UG/L				< 5 U
Pentachlorobenzene	UG/L				< 0.9 U
Pentachlorophenol	UG/L				< 5 UJ
Phenanthrene	UG/L				< 0.5 U
Phenol	UG/L				< 0.9 U
Phorate	UG/L				< 0.9 U
Pronamide	UG/L				< 0.9 U
Pyrene	UG/L				< 0.5 U
Pyridine	UG/L				< 5 U
Squalene	UG/L				< 5 UJ
Terbufos	UG/L				< 5 U
Terpineol	UG/L				< 5 U
Tributoxyethyl phosphate	e UG/L				< 5 UJ
Trifluralin	UG/L				< 5 U
TICo					
1 2 2 Trimothylhonzono					
1,2,3-11111ettTylbenzene	06/L				
Volatile Organics					
1,1,1-Trichloroethane	UG/L				< 1.00 U
1,1,2-Trichloroethane	UG/L				< 1.00 U
1,1-Dichloroethane	UG/L				< 1.00 U
1,1-Dichloroethene	UG/L				< 1.00 U
1,2,3-Trimethylbenzene	UG/L				< 1.00 U
1,2,4-Trichlorobenzene	UG/L				
1,2,4-Trimethylbenzene	UG/L				< 1.00 U
1,2-Dibromo-3-chloropro	ppane UG/L				< 0.1020 U
1,2-Dichlorobenzene	UG/L				< 1.00 U
1,2-Dichlenennen	UG/L				< 1.00 U
1,2-Dichloropropane	UG/L				
1,3,5-11methylbenzene	UG/L				< 1.00 U
					< 1.00 U
					< 50.011
Benzene		< 0.500 []	< 0.500 []		< 1.00.01
Carbon disulfide					< 1.00 U
Carbon Tetrachloride	UG/I				< 1.00 U
Chlorobenzene	UG/L				< 1.00 U
Chloroform	UG/L				< 1.00 U
cis-1,2-Dichloroethene	UG/L				< 1.00 U
Diisopropyl Ether	UG/L				< 1.00 U
Ethanol	UG/L				< 100 U
Ethyl tert-Butyl Ether	UG/L				< 1.00 U
Ethylbenzene	UG/L	< 0.500 U	< 0.500 U		< 1.00 U
Hexachlorobutadiene	UG/L				< 0.9 U
Isopropyl alcohol	UG/L				< 50.0 U
Isopropylbenzene	UG/L				< 1.00 U
m,p-Xylene	UG/L				< 2.00 U
Methoxychlor	UG/L				< 0.0476 U
Methyl tert-Butyl Ether	UG/L				< 1.00 U
Methylene Chloride	UG/L				< 5.00 U
Naphthalene	UG/L				< 5.00 U
o-Xylene	UG/L				< 1.00 U
Styrene	UG/L				

	Property Owner	PROPERTY OWNER M	PROPERTY OWNER M	PROPERTY OWNER M	PROPERTY OWNER M
		THE WELL IS LOCATED NORTH OF			
	Location Description	THE HOUSE.	THE HOUSE.	THE HOUSE.	THE HOUSE.
	Source Type	WELL	WELL	WELL	WELL
	Well Depth		440	440	440
	Sampled Before Treatment?	NA	Pre-Treatment	Pre-Treatment	Pre-Treatment
	Sample ID	NTA0325-01062010-1605	1202201012501	0411201112403	1028201120202
Parameter and units	Sample Date	1/6/2010 (Baseline)	12/2/2010	4/11/2011	10/28/2011
Tert-Amyl Methyl Ether	UG/L				< 1.00 U
Tertiary Butyl Alcohol	UG/L				< 10.0 U
Tetrachloroethene	UG/L				< 1.00 U
Tetrahydrofuran	UG/L				
Toluene	UG/L	< 0.500 U	< 0.500 U		< 1.00 U
trans-1,2-Dichloroethene	UG/L				< 1.00 U
Trichloroethene	UG/L				< 1.00 U
Vinyl chloride	UG/L				< 1.00 U
Xylenes, total	UG/L	< 0.500 U	< 0.500 U		< 3.00 U

Notes:

U : Parameter not detected at posted limit

< : Parameter not detected at posted limit

ND : Parameter not detected

H : Parameter analyzed beyond method recommended

holding time

J : Estimated value

J : Estimated Value --- : Parameter not analyzed. B : Blank qualified ug/L : Micrograms per liter mg/L : Milligrams per liter NA : Not Available NTU : Nephelometric Turbidity Unit umho/cm : Micromhos per centimeter colonies/100 ml : Colonies per 100 millileters



APPENDIX B FIGURES



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APPENDIX C SUMMARY STATISTICS



Summary of Sample Count, Minimum, Maximum, Mean, Median, and Standard Deviation of Parameters in Various Formations using USGS NURE Historical (Sept. - Oct. 1977) Water Well Data Base for Bradford County, PA

Constituent Name	Geology	Fraction	Count	Min	Max	Mean	Median	StDev	Screening Level	Unit	ND > SC	PD > SC
Alkalinity, Total (CaCO3)	Catskill	Т	51	0.3	5.36	2.30	2.20	1.14	-	mg/L	-	-
Alkalinity, Total (CaCO3)	LockHaven	Т	92	0.36	5.6	2.79	2.80	1.30	-	mg/L	-	- 1
Alkalinity, Total (CaCO3)	StratDrift	Т	17	0.55	4.4	2.34	2.25	1.17	-	mg/L	-	-
Bromide	Catskill	Т	28	0.0097	2.9	0.15	0.03	0.54	-	mg/L	-	-
Bromide	LockHaven	Т	53	0.0098	2.214	0.13	0.03	0.34	-	mg/L	-	-
Bromide	StratDrift	Т	9	0.0148	0.3508	0.08	0.05	0.11	-	mg/L	-	-
Chloride	Catskill	Т	51	3.2	87.5	11.57	7.20	13.49	250	mg/L	0	0%
Chloride	LockHaven	Т	91	0.1	228.4	15.97	8.80	28.54	250	mg/L	0	0%
Chloride	StratDrift	Т	17	4.2	98.6	14.98	8.20	22.43	250	mg/L	0	0%
Magnesium	LockHaven	Т	1	0.44	0.44	0.44	0.44		-	mg/L	-	-
Manganese	Catskill	Т	51	0.0502	0.2549	0.10	0.10	0.04	0.05	mg/L	51	100%
Manganese	LockHaven	Т	90	0.0386	0.7955	0.18	0.14	0.14	0.05	mg/L	86	96%
Manganese	StratDrift	Т	16	0.0463	0.2484	0.11	0.10	0.05	0.05	mg/L	15	94%
рН	Catskill	Т	51	6.2	8.8	7.31	7.30	0.52	6.5-8.5	pH Units	5	10%
рН	LockHaven	Т	92	6	8.8	7.25	7.25	0.54	6.5-8.5	pH Units	10	11%
рН	StratDrift	Т	17	6	9.1	7.50	7.50	0.76	6.5-8.5	pH Units	4	24%
Sodium	Catskill	Т	51	2.77	144.58	14.0	8.58	20.90	-	mg/L	-	-
Sodium	LockHaven	Т	91	1.18	137.16	19.19	9.27	22.10	-	mg/L	-	-
Sodium	StratDrift	Т	17	4.91	76.22	20.10	13.47	18.76	-	mg/L	-	-

T = Total

mg/L = Milligrams per Liter

StDev = Standard Deviation

ND > SC = Number of Detections Above Screening Criteria

PD > SC = Percent of Detections Above Screening Criteria

Screening Criteria Include MCLs, SMCLs, EPA Regional Screening Values (Tap Water), and PADEP Act 2 Values (Groundwater)



Summary of Sample Count, Minimum, Maximum, Mean, Median, and Standard Deviation of Parameters in Various Formations using USGS NWIS Historical (Pre-2007) Water Well Data Base for Bradford County, PA

Constituent Name	Geology	Fraction	Count	Min	Max	Mean	Median	StDev	Screening Level	Unit	ND > SC	PD > SC
Alkalinity, Total (CaCO3)	Catskill	Т	17	42	300	145	132	61.11	-	mg/L	-	-
Alkalinity, Total (CaCO3)	LockHaven	Т	21	104	350	182	170	58.62	-	mg/L	-	-
Alkalinity, Total (CaCO3)	StratDrift	Т	3	70	160	127	150	49.33	-	mg/L	-	-
Alkalinity, Total (CaCO3)	Till	Т	2	180	260	220	220	56.57	-	mg/L	-	-
Ammonia as N	Catskill	D	17	0.01	0.68	0.10	0.02	0.17	-	mg/L	-	-
Ammonia as N	Catskill	Т	1	0.08	0.08	0.08	0.08		-	mg/L	-	-
Ammonia as N	LockHaven	D	21	0.01	3.2	0.30	0.12	0.69	-	mg/L	-	-
Ammonia as N	LockHaven	Т	7	0.01	1.87	0.44	0.23	0.64	-	mg/L	-	-
Ammonia as N	StratDrift	D	3	0.01	0.05	0.02	0.01	0.02	-	mg/L	-	-
Ammonia as N	StratDrift	Т	5	0.01	0.32	0.13	0.15	0.12	-	mg/L	-	-
Ammonia as N	Till	D	2	0.1	0.37	0.24	0.24	0.19	-	mg/L	-	-
Ammonia as N	Till	Т	2	0.06	0.09	0.08	0.08	0.02	-	mg/L	-	-
Arsenic	Catskill	D	1	0.008	0.008	0.01	0.01		0.000045	mg/L	1	100%
Arsenic	Catskill	Т	3	0.004	0.0053	0	0	0	0.000045	mg/L	3	100%
Arsenic	LockHaven	D	4	0.022	0.178	0.07	0.03	0.07	0.000045	mg/L	4	100%
Arsenic	LockHaven	Т	5	0.009	0.117	0.04	0.04	0.04	0.000045	mg/L	5	100%
Arsenic	StratDrift	D	1	0.003	0.003	0	0		0.000045	mg/L	1	100%
Arsenic	StratDrift	Т	7	0.004	0.072	0.03	0.01	0.03	0.000045	mg/L	7	100%
Arsenic	Till	D	1	0.009	0.009	0.01	0.01		0.000045	mg/L	1	100%
Arsenic	Till	Т	2	0.023	0.026	0.02	0.02	0.00	0.000045	mg/L	2	100%
Barium	LockHaven	Т	10	0.2	98	11.94	0.45	30.69	-	mg/L	-	-
Barium	StratDrift	D	1	0.05	0.05	0.05	0.05		-	mg/L	-	-
Barium	StratDrift	Т	15	0.1	3.9	0.63	0.20	1.02	-	mg/L	-	-
Barium	Till	Т	3	0.3	1.9	1.07	1.0	0.80	-	mg/L	-	-
Calcium	Catskill	D	19	2.9	135	42.42	36	34.33	-	mg/L	-	-
Calcium	LockHaven	D	29	10	235	56.72	44	45.84	-	mg/L	-	-
Calcium	LockHaven	Т	14	8.2	349	66.41	36.20	86.42	-	mg/L	-	-
Calcium	StratDrift	D	9	20	101	50	48	26.42	-	mg/L	-	-
Calcium	StratDrift	Т	39	0.5	199	46.89	40.40	34.84	-	mg/L	-	-
Calcium	Till	D	4	13	69	45.35	49.70	24.15	-	mg/L	-	-
Calcium	Till	Т	11	13.8	59.9	37.05	35.50	12.99	-	mg/L	-	-
Chloride	Catskill	D	20	2	408	43.38	12	89.99	250	mg/L	1	5%
Chloride	LockHaven	D	43	1	5050	318	6	940	250	mg/L	7	16%
Chloride	StratDrift	D	43	1	224	28.95	12	47.66	250	mg/L	0	0%
Chloride	Till	D	14	2	336	55.36	6.50	116	250	mg/L	2	14%
Chromium	Catskill	D	6	0.01	0.02	0.01	0.01	0	-	mg/L	-	-
Chromium	LockHaven	D	8	0.01	0.02	0.01	0.01	0.01	-	mg/L	-	-
Chromium	LockHaven	Т	7	0.01	0.12	0.03	0.01	0.04	-	mg/L	-	-
Chromium	StratDrift	D	3	0.01	0.03	0.02	0.01	0.01	-	mg/L	-	-
Chromium	StratDrift	Т	12	0.01	0.11	0.03	0.01	0.04	-	mg/L	-	-
Iron	Catskill	D	20	0.04	5.6	0.62	0.12	1.30	0.3	mg/L	8	40%
Iron	LockHaven	D	23	0.04	3.4	0.88	0.56	0.98	0.3	mg/L	14	61%
Iron	LockHaven	Т	20	0.03	1.08	0.37	0.25	0.32	0.3	mg/L	7	35%
Iron	StratDrift	D	6	0.01	12.9	2.41	0.25	5.15	0.3	mg/L	3	50%
Iron	StratDrift	Т	38	0.01	56.4	2.56	0.36	9.19	0.3	mg/L	21	55%
Iron	Till	D	2	0.5	15.9	8.20	8.20	10.89	0.3	mg/L	2	100%
Iron	Till	Т	12	0.1	3.55	1.28	0.77	1.14	0.3	mg/L	9	75%
Lead	LockHaven	D	1	0.1	0.1	0.10	0.10		0.005	mg/L	1	100%
Lead	StratDrift	Т	1	0.5	0.5	0.50	0.50		0.005	mg/L	1	100%
Lithium	StratDrift	D	1	0.05	0.05	0.05	0.05		0.031	mg/L	1	100%



Summary of Sample Count, Minimum, Maximum, Mean, Median, and Standard Deviation of Parameters in Various Formations using USGS NWIS Historical (Pre-2007) Water Well Data Base for Bradford County, PA

Constituent Name	Geology	Fraction	Count	Min	Max	Mean	Median	StDev	Screening Level	Unit	ND > SC	PD > SC
Magnesium	Catskill	D	18	0.6	46	10.38	5.75	12.27	-	mg/L	-	-
Magnesium	LockHaven	D	29	2.4	35	13.84	12	8.78	-	mg/L	-	-
Magnesium	LockHaven	Т	14	2.4	45.8	13.97	8.30	13.62	-	mg/L	-	-
Magnesium	StratDrift	D	10	4.3	27	13.03	9.70	8.31	-	mg/L	-	-
Magnesium	StratDrift	Т	38	0.1	39.3	9.03	8.10	6.42	-	mg/L	-	-
Magnesium	Till	D	4	2.7	22	12.00	11.65	7.97	-	mg/L	-	-
Magnesium	Till	Т	11	3.5	16.4	8.73	8.60	4.35	-	mg/L	-	-
Manganese	Catskill	D	15	0.01	0.3	0.09	0.03	0.10	0.05	mg/L	7	47%
Manganese	LockHaven	D	17	0.01	2.6	0.29	0.09	0.61	0.05	mg/L	11	65%
Manganese	LockHaven	Т	17	0.02	0.41	0.13	0.10	0.10	0.05	mg/L	13	76%
Manganese	StratDrift	D	4	0.25	2.36	0.91	0.52	0.98	0.05	mg/L	4	100%
Manganese	StratDrift	Т	29	0.01	7.37	0.46	0.14	1.35	0.05	mg/L	23	79%
Manganese	Till	D	2	0.02	0.41	0.22	0.22	0.28	0.05	mg/L	1	50%
Manganese	Till	Т	9	0.08	0.69	0.34	0.26	0.23	0.05	mg/L	9	100%
Nitrate as N	Catskill	D	19	0.02	2.4	0.48	0.09	0.77	-	mg/L	-	-
Nitrate as N	LockHaven	D	42	0.019	4.4	0.36	0.04	0.85	-	mg/L	-	-
Nitrate as N	LockHaven	Т	2	0.48	8.35	4.42	4.42	5.56	-	mg/L	-	-
Nitrate as N	StratDrift	D	41	0.009	13.9	1.72	0.41	2.95	-	mg/L	-	-
Nitrate as N	Till	D	10	0.019	1.55	0.40	0.14	0.53	-	mg/L	-	-
Nitrate/Nitrite as N	LockHaven	D	19	0.02	4.4	0.54	0.04	1.18	-	mg/L	-	-
Nitrate/Nitrite as N	StratDrift	D	35	0.01	13.9	1.53	0.41	2.69	-	mg/L	-	-
Nitrate/Nitrite as N	Till	D	8	0.02	1.55	0.49	0.22	0.56	-	mg/L	-	-
Potassium	Catskill	D	17	0.2	13	3.30	3	2.92	-	mg/L	-	-
Potassium	LockHaven	D	22	2	25	3.79	3	4.79	-	mg/L	-	-
Potassium	LockHaven	Т	20	0.6	19.8	3.21	1.45	4.49	-	mg/L	-	-
Potassium	StratDrift	D	5	1.1	2	1.74	2	0.40	-	mg/L	-	-
Potassium	StratDrift	Т	42	0.4	6	1.31	1.05	0.99	-	mg/L	-	-
Potassium	Till	D	2	2	4	3	3	1.41	-	mg/L	-	-
Potassium	Till	Т	13	0.4	3.1	1.28	1.10	0.71	-	mg/L	-	-
Sodium	Catskill	D	17	4	829	85.09	23	197	-	mg/L	-	-
Sodium	LockHaven	D	22	6.1	2000	126	23	421	-	mg/L	-	-
Sodium	LockHaven	Т	20	3.2	2510	248	35.20	560	-	mg/L	-	-
Sodium	StratDrift	D	5	6.4	21	12.36	11	6.12	-	mg/L	-	-
Sodium	StratDrift	Т	42	2.1	112	25.52	11.35	28.68	-	mg/L	-	-
Sodium	Till	D	2	16	143	79.50	79.50	89.80	-	mg/L	-	-
Sodium	Till	Т	13	5.3	252	61.57	27	79.34	-	mg/L	-	-
Strontium	LockHaven	Т	13	0.08	80	7.68	0.45	22.05	-	mg/L	-	-
Strontium	StratDrift	Т	34	0.02	0.92	0.20	0.12	0.21	-	mg/L	-	-
Strontium	Till	Т	11	0.03	0.98	0.31	0.18	0.32	-	mg/L	-	-
Sulfate	Catskill	D	18	2	250	25.56	12.50	56.55	-	mg/L	-	-
Sulfate	LockHaven	D	40	1	210	28.40	15	36.58	-	mg/L	-	-
Sulfate	StratDrift	D	47	8	77	26.17	25	14.90	-	mg/L	-	-
Sulfate	Till	D	15	10	85	29.27	25	19.52	-	mg/L	-	-



Summary of Sample Count, Minimum, Maximum, Mean, Median, and Standard Deviation of Parameters in Various Formations using USGS NWIS Historical (Pre-2007) Water Well Data Base for Bradford County, PA

Constituent Name	Geology	Fraction	Count	Min	Max	Mean	Median	StDev	Screening Level	Unit	ND > SC	PD > SC
Total Dissolved Solids	Catskill	D	35	76	4050	362	212	661	500	mg/L	4	11%
Total Dissolved Solids	LockHaven	D	65	134	9200	676	246	1504	500	mg/L	14	22%
Total Dissolved Solids	StratDrift	D	52	64	1130	268	221	181	500	mg/L	3	6%
Total Dissolved Solids	Till	D	17	112	846	360	266	201	500	mg/L	3	18%

T = Total

D = Dissolved

mg/L = Milligrams per Liter

StDev = Standard Deviation

ND > SC = Number of Detections Above Screening Criteria

PD > SC = Percent of Detections Above Screening Criteria

Screening Criteria Include MCLs, SMCLs, EPA Regional Screening Values (Tap Water), and PADEP Act 2 Values (Groundwater)



Summary of Sample Count, Minimum, Maximum, Mean, Median, and Standard Deviation of Parameters in Various Formations using Williams 1998 Historical (1935-1986) Water Well Data Base for Bradford County, PA

Constituent Name	Geology	Fraction	Count	Min	Max	Mean	Median	StDev	Screening Level	Units	ND > SC	PD > SC
Aluminum	Catskill	D	9	0.05	3.8	1.22	0.74	1.31	0.2	mg/l	6	67%
Aluminum	Lockhaven	D	19	0.05	1.3	0.21	0.14	0.28	0.2	mg/l	5	26%
Aluminum	RestrictedFlow	D	6	0.02	0.16	0.08	0.07	0.05	0.2	mg/l	0	0%
Aluminum	StratifiedDrift	D	29	0.04	1.55	0.18	0.10	0.29	0.2	mg/l	4	14%
Aluminum	Till	D	5	0.05	0.2	0.09	0.06	0.06	0.2	mg/l	0	0%
Arsenic	Catskill	D	1	0.008	0.008	0.01	0.01		0.000045	mg/l	1	100%
Arsenic	Lockhaven	D	3	0.005	0.025	0.02	0.02	0.01	0.000045	mg/l	3	100%
Arsenic	RestrictedFlow	D	3	0.009	0.067	0.03	0.02	0.03	0.000045	mg/l	3	100%
Arsenic	StratifiedDrift	D	7	0.004	0.072	0.02	0.01	0.02	0.000045	mg/l	7	100%
Arsenic	Till	D	2	0.009	0.026	0.02	0.02	0.01	0.000045	mg/l	2	100%
Barium	Lockhaven	D	8	0.03	0.46	0.23	0.20	0.15	-	mg/l	-	-
Barium	RestrictedFlow	D	7	0.56	98	15.40	1.62	36.44	-	mg/l	-	-
Barium	StratifiedDrift	D	32	0.02	0.62	0.16	0.12	0.14	-	mg/l	-	-
Barium	Till	D	3	0.06	0.34	0.16	0.09	0.15	-	mg/l	-	-
Calcium	Catskill	D	11	2.9	54	35.26	39.00	13.97	-	mg/L	-	-
Calcium	Lockhaven	D	20	8.2	87	42.51	40.50	21.76	-	mg/L	-	-
Calcium	RestrictedFlow	D	10	10	235	64.90	29.00	76.35	-	mg/L	-	-
Calcium	StratifiedDrift	D	52	9.2	199	47.89	40.50	31.67	-	mg/L	-	-
Calcium	Till	D	12	14	95	48.42	46.50	20.82	-	mg/L	-	-
Cadium	Lockhaven	D	4	0.001	0.002	0	0	0	-	mg/l	-	-
Cadium	StratifiedDrift	D	10	0.001	0.001	0	0		-	mg/l	-	-
Cadium	Till	D	1	0.001	0.001	0	0	0	-	mg/l	-	-
Chloride	Catskill	D	12	2	74	25.13	13	24.33	250	mg/L	0	0%
Chloride	Lockhaven	D	18	1	132	16.56	5.50	30.81	250	mg/L	0	0%
Chloride	RestrictedFlow	D	11	125	3500	693	336	979	250	mg/L	7	64%
Chloride	StratifiedDrift	D	47	1	224	27.19	14	43.32	250	mg/L	0	0%
Chloride	Till	D	11	2	15	5.45	4	4.61	250	mg/L	0	0%
Chromium	Catskill	D	4	0.01	0.01	0.01	0.01	0	-	mg/l	-	-
Chromium	Lockhaven	D	6	0.01	0.12	0.03	0.01	0.04	-	mg/l	-	-
Chromium	RestrictedFlow	D	2	0.01	0.02	0.02	0.02	0.01	-	mg/l	-	-
Chromium	StratifiedDrift	D	14	0.01	0.11	0.03	0.01	0.04	-	mg/l	-	-
Chromium	Till	D	1	0.01	0.01	0.01	0.01		-	mg/l	-	-
Iron	Catskill	D	12	40	5600	833	315	1634	0.3	mg/L	6	50%
Iron	Lockhaven	D	20	40	1400	393	245	359	0.3	mg/L	8	40%
Iron	RestrictedFlow	D	9	150	3550	1293	670	1403	0.3	mg/L	6	67%
Iron	StratifiedDrift	D	47	10	11200	1043	340	2011	0.3	mg/L	24	51%
Iron	Till	D	11	40	15900	2417	770	4572	0.3	mg/L	9	82%
Bicarbonate Alk (CaCO3)	Catskill	D	3	148	172	159	158	12.06	-	mg/L	-	-
Bicarbonate Alk (CaCO3)	Lockhaven	D	12	82	292	165	156	75.79	-	mg/L	-	-
Bicarbonate Alk (CaCO3)	RestrictedFlow	D	9	184	258	214	208	24.80	-	mg/L	-	-
Bicarbonate Alk (CaCO3)	StratifiedDrift	D	50	20	308	133	124	68.48	-	mg/L	-	-
Bicarbonate Alk (CaCO3)	Till	D	11	62	240	168	170	54.60	-	mg/L	-	-
Potassium	Catskill	D	10	0.2	5	2.49	2.50	1.54	-	mg/L	-	-
Potassium	Lockhaven	D	20	0.58	7	2.18	2	1.56	-	mg/L	-	-
Potassium	RestrictedFlow	D	9	1.7	25	5.80	3.10	7.47	-	mg/L	-	-
Potassium	StratifiedDrift	D	52	0.38	6	1.25	1.05	0.88	-	mg/L	-	-
Potassium	Till	D	12	0.8	3.2	1.33	1.15	0.68	-	mg/L	-	-
										0.		



Summary of Sample Count, Minimum, Maximum, Mean, Median, and Standard Deviation of Parameters in Various Formations using Williams 1998 Historical (1935-1986) Water Well Data Base for Bradford County, PA

Constituent Name	Geology	Fraction	Count	Min	Max	Mean	Median	StDev	Screening Level	Units	ND > SC	PD > SC
Magnesium	Catskill	D	11	0.6	12	6.77	6	3.49	-	mg/L	-	-
Magnesium	Lockhaven	D	20	2.4	41	11.61	10	9.06	-	mg/L	-	-
Magnesium	RestrictedFlow	D	10	2.4	33	12.10	8.05	11.07	-	mg/L	-	-
Magnesium	StratifiedDrift	D	52	2.1	39	9.90	8.10	6.74	-	mg/L	-	-
Magnesium	Till	D	12	3.5	22	10.90	12	5.42	-	mg/L	-	-
Manganese	Catskill	D	10	0.01	0.3	0.08	0.06	0.09	0.05	mg/l	5	50%
Manganese	Lockhaven	D	17	0.01	2.6	0.26	0.10	0.61	0.05	mg/l	11	65%
Manganese	RestrictedFlow	D	8	0.03	0.44	0.12	0.07	0.14	0.05	mg/l	5	63%
Manganese	StratifiedDrift	D	35	0.01	1.03	0.24	0.14	0.27	0.05	mg/l	27	77%
Manganese	Till	D	7	0.13	0.69	0.38	0.35	0.23	0.05	mg/l	7	100%
Sodium	Catskill	D	10	5	132	41.95	18.50	47.44	-	mg/L	-	-
Sodium	Lockhaven	D	20	3.2	165	38.65	22	43.78	-	mg/L	-	-
Sodium	RestrictedFlow	D	10	90	2000	431	249	565	-	mg/L	-	-
Sodium	StratifiedDrift	D	52	2.1	112	20.55	8.95	25	-	mg/L	-	-
Sodium	Till	D	12	5.3	89	28.03	23	23	-	mg/L	-	-
Nickel	Catskill	D	3	0.01	0.02	0.02	0.02	0.01	-	mg/l	-	-
Nickel	Lockhaven	D	10	0.01	0.03	0.02	0.01	0.01	-	mg/l	-	-
Nickel	RestrictedFlow	D	6	0.01	0.03	0.02	0.02	0.01	-	mg/l	-	-
Nickel	StratifiedDrift	D	18	0.01	0.14	0.02	0.02	0.03	-	mg/l	-	-
Nickel	Till	D	2	0.02	0.02	0.02	0.02	0.00	-	mg/l	-	-
Nitrate-N	Catskill	D	7	0.04	2.38	0.69	0.42	0.83	-	mg/L	-	-
Nitrate-N	Lockhaven	D	13	0.02	46	4.28	0.22	12.61	-	mg/L	-	-
Nitrate-N	RestrictedFlow	D	2	0.02	0.04	0.03	0.03	0.01	-	mg/L	-	-
Nitrate-N	StratifiedDrift	D	36	0.01	13.9	1.68	0.90	2.54	-	mg/L	-	-
Nitrate-N	Till	D	7	0.1	6.38	1.46	0.82	2.23	-	mg/L	-	-
Lead	Catskill	D	4	0.006	0.016	0.01	0.01	0	0.005	mg/l	4	100%
Lead	Lockhaven	D	6	0.005	0.02	0.01	0.01	0.01	0.005	mg/l	4	67%
Lead	RestrictedFlow	D	4	0.005	0.007	0.01	0.01	0	0.005	mg/l	3	75%
Lead	StratifiedDrift	D	15	0.004	0.023	0.01	0.01	0.01	0.005	mg/l	13	87%
Lead	Till	D	5	0.004	0.031	0.01	0.01	0.01	0.005	mg/l	2	40%
рН	Catskill	D	11	6.5	8.8	7.51	7.40	0.61	6.5-8.5	pH units	1	9%
рН	Lockhaven	D	20	5.2	8.6	7.17	7.15	0.70	6.5-8.5	pH units	2	10%
pH	RestrictedFlow	D	8	6.6	8.4	7.80	8.10	0.65	6.5-8.5	pH units	0	0%
рН	StratifiedDrift	D	52	6.2	8.6	7.28	7.20	0.55	6.5-8.5	pH units	3	6%
рН	Till	D	12	6.6	8.1	7.61	7.80	0.52	6.5-8.5	pH units	0	0%
Sulfate	Catskill	D	11	5	35	13.45	10	9.07	-	mg/L	-	-
Sulfate	Lockhaven	D	19	10	85	28.53	20	23.29	-	mg/L	-	-
Sulfate	RestrictedFlow	D	8	1	22	9.63	10.50	6.97	-	mg/L	-	-
Sulfate	StratifiedDrift	D	52	10	77	26.17	23.50	14.51	-	mg/L	-	-
Sulfate	Till	D	12	10	55	28.50	29	12.18	-	mg/L	-	-
Strontium	Lockhaven	D	9	0.08	1.58	0.46	0.29	0.49	-	mg/l	-	-
Strontium	RestrictedFlow	D	8	0.14	80	12.45	1.04	27.68	-	mg/l	-	-
Strontium	StratifiedDrift	D	37	0.02	0.92	0.18	0.12	0.18	-	mg/l	-	-
Strontium	Till	D	9	0.03	0.52	0.17	0.11	0.14	-	mg/l	-	-
TDS	Catskill	D	10	100	680	263	208	177	500	mg/L	1	10%
TDS	Lockhaven	D	20	142	512	275	227	120	500	mg/L	1	5%
TDS	RestrictedFlow	D	9	400	6100	1510	760	1831	500	mg/L	7	78%
TDS	StratifiedDrift	D	52	64	1130	260	229	174	500	mg/L	2	4%
TDS	Till	D	12	112	620	308	263	146	500	mg/L	2	17%



Summary of Sample Count, Minimum, Maximum, Mean, Median, and Standard Deviation of Parameters in Various Formations using Williams 1998 Historical (1935-1986) Water Well Data Base for Bradford County, PA

Constituent Name	Geology	Fraction	Count	Min	Max	Mean	Median	StDev	Screening Level	Units	ND > SC	PD > SC
Zinc	Catskill	D	10	0.01	1.23	0.30	0.04	0.48	-	mg/l	-	-
Zinc	Lockhaven	D	20	0.01	0.08	0.02	0.02	0.02	-	mg/l	-	-
Zinc	RestrictedFlow	D	8	0.01	0.67	0.15	0.04	0.24	-	mg/l	-	-
Zinc	StratifiedDrift	D	46	0.01	0.47	0.05	0.03	0.08	-	mg/l	-	-
Zinc	Till	D	12	0.01	0.11	0.04	0.03	0.03	-	mg/l	-	-

D = Dissolved

ug/L = Micrograms per Liter

mg/L = Milligrams per Liter

StDev = Standard Deviation

ND > SC = Number of Detections Above Screening Criteria

PD > SC = Percent of Detections Above Screening Criteria

Screening Criteria Include MCLs, SMCLs, EPA Regional Screening Values (Tap Water), and PADEP Act 2 Values (Groundwater)



Appendix C

Regional Baseline Summary, Groundwater (WESTERN)

Southside Road Area		
Sample Date Range	8/11/2009	1/9/2012
Property Owners	1004	
Unique sources tested	1196	
Total Tests	1238	
42 sources were tested more	than once as bas	eline

Source Type		Count
Wells		1180
Dug Wells		42
Artesian Wells		16
	Total Tests	1238

											Percent of
				Number of	Number of	Minimum	Maximum	Mean Detected	Median Detected	Count Exceeding	Samples Over
Parameter	Units	Standard	Standard Limit	Samples	Detections	Detected Value	Detected Value	Value	Value	Standard	Standard
Arsenic	mg/L	Primary	0.01	1220	83	0.0101	0.371	0.05	0.03	83	6.8
Barium	mg/L	Primary	2	1238	1207	0.0101	46.7	0.75	0.16	89	7.2
Benzene	µg/L	Primary	5	1238	2	0.79	1.33	1.06	1.06	0	N/A
Bicarbonate Alkalinity as CaCO3	mg/L			1238	1226	11	446	173.32	174.00		
Bromide	mg/L			299	19	1.04	8.75	3.35	2.62		
Cadmium	mg/L	Primary	0.005	1220	6	0.0011	0.0088	0.00	0.00	1	0.1
Calcium	mg/L			1238	1212	1.06	420	50.34	46.10		
Carbonate as CaCO3	mg/L			1238	47	10.2	70.6	27.84	23.60		
Chloride	mg/L	Secondary	250	1238	1004	1.06	2200	66.03	15.85	54	4.4
Chromium	mg/L	Primary	0.1	1220	11	0.005	0.0235	0.01	0.01	0	N/A
Ethane	mg/L			1238	41	0.00506	0.477	0.10	0.06		
Ethyl-benzene	µg/L	Primary	700	1238	0	0	0	N/A	N/A	0	N/A
Iron	mg/L	Secondary	0.3	1238	843	0.05	350	1.81	0.27	402	32.5
Lead	mg/L	Action Level	0.015	1220	155	0.005	0.131	0.02	0.01	38	3.1
Lithium	mg/L	Action Level	0.073	277	71	0.0501	0.398	0.12	0.09	48	17.3
Magnesium	mg/L			1238	1179	1	135	11.82	10.20		
Manganese	mg/L	Secondary	0.05	1238	880	0.015	10.2	0.35	0.13	663	53.6
MBAS (mol.wt 320)	mg/L	Secondary	0.5	1238	191	0.0501	63	0.44	0.08	4	0.3
Mercury	mg/L	Primary	0.002	1220	0	0	0	N/A	N/A	0	N/A
Oil & Grease HEM	mg/L			1237	6	1.5	118	38.35	23.40		
рН	pH units	Secondary	6.5-8.5	1238	1238	4.3	9	7.67	7.70		
Potassium	mg/L			1238	1046	1	11.3	2.08	1.73		
Propane	mg/L			1238	0	0	0	N/A	N/A		
Selenium	mg/L	Primary	0.05	1220	2	0.0466	0.169	0.11	0.11	1	0.1
Silver	mg/L	Secondary	0.1	1220	0	0	0	N/A	N/A	0	N/A
Sodium	mg/L			1238	1208	1	1120	52.22	27.40		
Specific conductance	umho/cm			1238	1238	23.2	12300	584.85	457.00		
Strontium	mg/L			676	627	0.0501	64.4	1.55	0.76		
Sulfate	mg/L	Secondary	250	1238	1095	1	1070	30.13	18.50	14	1.1
Sulfur	mg/L			1220	1091	0.52	362	10.17	6.09		
Temp of pH determ.	Deg C			1238	1238	21	25	21.91	21.70		
Toluene	μg/L	Primary	1000	1238	14	0.5	8.75	1.53	0.93	0	N/A
TDS	mg/L	Secondary	500	1238	1236	14	4600	317.08	248.00	141	11.4
TSS	mg/L			1238	559	1	2360	14.19	2.20		
Turbidity	NTU	CHK Arbitrary	5	1238	766	1	553	11.48	3.10	283	
Xylenes, total	µg/L	Primary	10000	1238	1	1.13	1.13	1.13	1.13	0	N/A

				Number of	Methane	Percent Methane	Maximum	Mean Detected	Median Detected	Number over 3	Number Over 7	Number over 20
Parameter	Units	Standard	Standard Limit	Samples	Detections	Detections	Detected Value	Value	Value	mg/L	mg/L	mg/L
Methane	mg/L	СНК	3, 7, 20	1238	504	40.7	72.1	4.12	0.703	149	95	30

Regional Baseline Summary, Groundwater (EASTERN) 5 Mile Radius of Brotzman's Cistern

5 Mile Radius of Brotzman's Cistern		
Sample Date Range	6/24/2009	1/4/2012
Property Owners	502	
Unique sources tested	570	

Source Type		Count
Wells		552
Dug Wells		15
Artesian Wells		3
	Total Tests	570

											Percent of
				Number of	Number of	Minimum	Maximum	Mean Detected	Median Detected	Count Exceeding	Samples Over
Parameter	Units	Standard	Standard Li	Samples	Detections	Detected Value	Detected Value	Value	Value	Standard	Standard
Arsenic	mg/L	Primary	0.01	542	10	0.0103	0.199	0.04	0.02	10	1.8
Barium	mg/L	Primary	2	562	557	0.0217	6.46	0.40	0.18	15	2.7
Benzene	µg/L	Primary	5	562	1	0.61	0.61	0.61	0.61	0	N/A
Bicarbonate Alkalinity as CaCO3	mg/L			562	560	11.3	303	134.52	140.00		
Bromide	mg/L			39	1	11.1	11.1	11.10	11.10		
Cadmium	mg/L	Primary	0.005	542	2	0.0012	0.0013	0.00	0.00	0	N/A
Calcium	mg/L			562	555	1.07	82.7	31.23	29.70		
Carbonate as CaCO3	mg/L			562	23	10.1	81.4	28.37	19.00		
Chloride	mg/L	Secondary	250	562	392	1.11	848	22.46	8.58	4	0.7
Chromium	mg/L	Primary	0.1	542	6	0.0056	0.0748	0.03	0.02	0	N/A
Ethane	mg/L			570	7	0.0281	0.123	0.08	0.09		
Ethyl-benzene	µg/L	Primary	700	562	0	0	0	N/A	N/A	0	N/A
Iron	mg/L	Secondary	0.3	562	262	0.0512	91.4	1.07	0.16	88	15.7
Lead	mg/L	Action Level	0.015	542	60	0.0051	0.589	0.03	0.01	18	3.3
Lithium	mg/L	Action Level	0.073	37	7	0.0613	0.381	0.17	0.13	5	13.5
Magnesium	mg/L			562	548	1.01	27.4	8.98	8.22		
Manganese	mg/L	Secondary	0.05	562	262	0.0152	124	0.66	0.06	143	25.4
MBAS (mol.wt 320)	mg/L	Secondary	0.5	562	94	0.0501	5.42	0.15	0.07	1	0.2
Mercury	mg/L	Primary	0.002	542	1	0.00027	0.00027	0.00	0.00	0	N/A
Oil & Grease HEM	mg/L			561	2	109	110	109.50	109.50		
pH	pH units	Secondary	6.5-8.5	562	562	5.6	9.4	7.64	7.70		
Potassium	mg/L			562	487	1	86.8	1.86	1.53		
Propane	mg/L			570	0	0	0	N/A	N/A		
Selenium	mg/L	Primary	0.05	542	0	0	0	N/A	N/A	0	N/A
Silver	mg/L	Secondary	0.1	542	0	0	0	N/A	N/A	0	N/A
Sodium	mg/L			562	560	1.19	732	27.17	15.90		
Specific conductance	umho/cm			562	562	31.2	3440	347.49	324.00		
Strontium	mg/L			104	100	0.0573	3.21	0.76	0.58		
Sulfate	mg/L	Secondary	250	562	513	1.22	77.9	16.11	14.70	0	N/A
Sulfur	mg/L			528	480	0.55	24.8	5.17	4.40		
Temp of pH determ.	Deg C			562	562	21	25	21.96	21.85		
Toluene	µg/L	Primary	1000	562	1	1.64	1.64	1.64	1.64	0	N/A
TDS	mg/L	Secondary	500	562	562	12	1760	187.22	176.00	6	1.1
TSS	mg/L			562	172	0.4	339	13.09	2.30		
Turbidity	NTU	CHK Arbitrary	5	562	214	1	204	8.85	2.20	55	
Xylenes, total	µg/L	Primary	10000	562	1	0.81	0.81	0.81	0.81	0	N/A

			Standard	Number of	Methane	Methane Percent	Maximum	Mean Detected	Median Detected	Number over 3	Number Over 7	Number over 20
Parameter	Units	Standard	Limit	Samples	Detections	Detections	Detected Value	Value	Value	mg/L	mg/L	mg/L
Methane	mg/L	СНК	3, 7, 20	570	157	27.5	40.7	4.14	0.518	15	19	11

Regional Baseline Summary, Groundwater (CENTRAL)

3 Mile Buffer around Terry Twp EPA Split Sampling Residents							
Sample Date Range	9/17/2009	1/10/2012					
Property Owners	1686						
Unique sources tested	1933						
32 sources were tested more than once as baseline							

Source Type		Count
Wells		1886
Dug Wells		58
Artesian Wells		21
	Total Tests	1965

			Chandend	Niume have af	Ni wala a sef	Minimum	Maximum	Mean	Median	Count
Deremeter	Unite	Stondard	Standard	Number of	Number of	Detected	Detected	Detected	Value	Exceeding
Arsonic	Units ma/l	Drimory	0.01	1052	71		0.166			70
Barium	mg/L	Primary	0.01	1961	1926	0.0104	32.5	0.04	0.02	100
Benzene	Ing/L	Primary	2	1960	0	0.0104	0	N/A	N/A	0
Picarbonato Alkalinity as CaCO2	µy/L	Filindiy	5	1900	1056	11 5	267	1/0 /1	151.00	0
Bicarbonate Aikalinity as cacos	mg/L			204	5	1 06	9 57	6.62	7 55	
Cadmium	mg/L	Drimony	0.005	1052	0	0.0012	0.04	0.03	7.55	
Calcium	mg/L	Primary	0.005	1955	1022	1.00	220	30.88	40.20	
Carbonato as CaCO2	mg/L			1960	72	1.07	77.0	27.01	24.40	
Chlorido	mg/L	Coopdon	250	1900	1440	1.04	1090	27.01	24.40	
Chromium	mg/L	Drimory	250	1900	1440	0.0054	0.0220	0.01	9.07	
Ethano	mg/L	Primary	0.1	1955	25	0.00525	0.0220	0.01	0.01	0
Ethyl bonzono	mg/L	Drimony	700	1905	20	0.00525	0.404	0.10	0.07	
Iron	µg/L	Filindiy	700	1900	1103	0.05	65	0.00	0.00	/10
Load	mg/L	Secondary	0.3	1052	170	0.005	0.46	0.73	0.21	417
Lithium	mg/L	Action Level	0.015	254	40	0.000	0.40	0.03	0.01	25
Magnosium	mg/L	ACTION Level	0.073	1061	40	0.0505	0.99 41 4	9.50	7.40	20
Manganoso	mg/L	Coopdon	0.05	1901	026	0.015	41.4	0.30	0.10	
MPAS (mol wt 220)	mg/L	Secondary	0.05	1901	930	0.015	4.01	0.23	0.10	044
Moreury	mg/L	Secondary	0.5	1900	209	0.0003	0.000	0.12	0.09	4
	mg/L	Primary	0.002	1905	5	1 /	452	101.46	0.00	0
	mg/L	Consulation		1901	1061	5.4	452	7.62	7.50	
pn Potassium	pH units	Secondary	0.5-8.5	1901	1446	1	7.3	1.03	1.70	
Propapo	mg/L			1901	2	0.0204	0.020	0.02	0.02	
Solonium	mg/L	Drimony	0.05	1905	<u>ງ</u>	0.0204	0.038	0.03	0.03	
Silver	mg/L	Filindiy	0.05	1953	2	0.0218	0.109	0.10	0.10 N/A	0
Sodium	mg/L	Secondary	0.1	1955	1058	1	1610	33.1/	14.00	0
Specific conductance	Ing/L			1901	1950	10.7	9200	409.02	355.00	
Strontium	unno/cm			775	722	49.7	13 /	0.78	0.46	
Sulfato	mg/L	Secondary	250	1061	1825	1.05	350	17.65	1/ 00	2
Sulfur	mg/L	Secondary	230	1035	1821	0.5	120	5 78	14.70	2
Temp of pH determ	Dog C			1061	1021	21	211	21.06	21 70	
Toluene	Deg C	Drimony	1000	1960	1701	0.56	18.8	/ 89	1 30	0
	µg/L mg/l	Secondary	500	1961	1961	17	5/10	222.72	195.00	54
TSS	mg/L	Secondary	500	1961	662	1	1370	13 17	2 /0	54
Turbidity	NTU	CHK Arbitrary	F	1961	962	1	077	9.64	2.40	280
Xylenes total		Drimony	10000	1960	2	0.61	2 05	1 47	1 11	0
Ayienes, iulai	µy/L	Primary	10000	1700	3	0.01	2.70	1.07	1.44	U

						Percent	Maximum	Mean	Median			
			Standard	Number of	Methane	Methane	Detected	Detected	Detected	Number over	Number Over	Number over
Parameter	Units	Standard	Limit	Samples	Detections	Detections	Value	Value	Value	3 mg/L	7 mg/L	20 mg/L
Methane	mg/L	СНК	3, 7, 20	1965	526	26.8	43.3	3.27	0.3585	135	73	25

Percent of
Samples Over
Standard
3.6
5.0
5.1 N/A
IN/A
0.1
0.1
1.6
N/A
N/A
21.4
3.4
9.8
32.8
0.2
N/A
0.1
N/A
0.1
0.1
IN/A
2.8
N/A

		Cer	ntral	Eas	tern	Western		
Paramotor	Standard	Count Exceeeding Percent of Standard Detections		Count Exceeding Percent of Standard Datactions		Count Exceeeding Standard	Percent of	
Parameter	Stanuaru	Stanuaru	Detections	Stanuaru	Detections	Stanuaru	Detections	
Lead	0.005	174	8.9	60	11.1	152	12.5	
Lithium	0.031	40	15.7	7	18.9	71	25.6	

Groundwater only Bradford county



APPENDIX D TIME PLOTS



APPENDIX D-1 TIME PLOTS PROPERTY OWNER A





Appendix D-1



Property Owner A Well Chloride Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data







Appendix D-1


















APPENDIX D-2 TIME PLOTS PROPERTY OWNER B







Property Owner B Spring Chloride Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 150 150 Williams '98 CI -Catskill NURE NWIS **Baseline Eastern** 848 408 140 140 51 20 Count 12 392 Std. Dev. 13.5 90 24.3 NA 130 130 3.2 2 2 1.11 Min 87.5 Max 408 74 848 120 120 11.6 43.4 25.1 22.5 Mean 110 110 Median 7.2 12 13 8.58 100 100 90 90 Chloride, mg/L 80 80 70 70 60 60 50 50 43.4 40 40 30 30 25.1 22.5 20 20 11.6 Baseline 10 10 0 0 NURE NWIS 10/14/2010 11/4/2011 Williams '98 Baseline Sample Dates, Data Ranges, and Means



Property Owner B Spring Methane Concentrations vs. Time Compared to NURE, NWIS Data, Williams '98, and Baseline Data













APPENDIX D-3 TIME PLOTS PROPERTY OWNER C































APPENDIX D-4 TIME PLOTS PROPERTY OWNER D



Property Owner D Well Barium Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 5 5 98 Max 32.5 Ba - Lock Haven NURE NWIS Williams '98 **Baseline Central** 11.9 Mean NA 8 Count 10 1926 4.5 4.5 Std. Dev. NA 30.7 0.148 NA 0.2 Min NA 0.03 0.010 98 4 4 Max NA 0.46 32.5 Mean NA 11.9 0.227 0.47 Median NA 0.45 0.197 0.17 3.5 3.5 3 3 Barium, mg/L 2.5 2.5 2 2 1.5 1.5 1 1 0.5 0.5 0.47 0.227 Baseline 0 0 1/10/2010 10/28/2011 NURE 6/10/2011 NWIS Williams '98 Baseline Sample Dates, Data Ranges, and Means



Property Owner D Well Chloride Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data

















Property Owner D Well Sodium Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 200 200 Na - Lock Haven NURE NWIS Williams '98 **Baseline Central** 2510 Max 1610 91 20 1958 Count 20 248 Mean 180 180 Std. Dev. 22.1 560 44 NA Min 1.18 3.2 3.2 1 2510 Max 137 165 1610 160 160 248 19.2 38.6 33.1 Mean Median 9.27 35.2 22 14 140 140 120 120 Sodium, mg/L 100 100 Baseline 80 80 60 60 40 40 38.6 33.1 20 20 19.2 0 0 10/28/2011 NURE 1/10/2010 6/10/2011 NWIS Williams '98 Baseline Sample Dates, Data Ranges, and Means







APPENDIX D-5 TIME PLOTS PROPERTY OWNER E (115-FT)







Property Owner E (115 ft.) Well Chloride Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 150 150 CI -Catskill NURE Williams '98 **Baseline Central** NWIS 1980 408 140 140 51 20 12 1440 Count Std. Dev. 24.3 13.5 90 NA 130 130 3.2 2 2 1.04 Min 87.5 408 74 Max 1980 120 120 11.6 43.4 25.1 33.5 Mean 110 110 7.2 13 Median 12 9.07 100 100 90 90 Chloride, mg/L 80 80 70 70 60 60 50 50 43.4 40 40 33.5 30 30 25.1 Baseline 20 20 11.6 10 10 0 0 4/1/2010 8/12/2010 1/8/2011 11/4/2011 NURE Williams '98 **NWIS** Baseline Sample Dates, Data Ranges, and Means











Property Owner E (115 ft.) Well Methane Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 100 100 CH4 -Catskill Williams '98 **Baseline Central** NURE NWIS NA 526 Count NA NA 90 90 Std. Dev. NA NA NA NA 0.005 Min NA NA NA 80 Max NA NA NA 43.3 80 3.27 Mean NA NA NA Median NA NA NA 0.359 70 70 60 60 Methane, mg/L 50 50 40 40 Baseline 30 30 20 20 10 10 3.27 0 0 11/4/2011 4/1/2010 8/12/2010 1/8/2011 NURE NWIS Williams '98 Baseline Sample Dates, Data Ranges, and Means











APPENDIX D-6 TIME PLOTS PROPERTY OWNER E (185-FT)







Property Owner E (185 ft.) Well Chloride Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 150 150 Cl -Catskill NURE NWIS Williams '98 **Baseline Central** 408 1980 140 140 Count 51 20 12 1440 Std. Dev. 13.5 90 24.3 NA 130 130 Min 3.2 2 2 1.04 74 120 Max 87.5 408 1980 120 25.1 Mean 11.6 43.4 33.5 110 110 7.2 12 13 Median 9.07 100 100 90 90 Chloride, mg/L 80 80 70 70 60 60 50 50 43.4 40 40 **—** 33.5 30 30 25.1 20 20 Baseline 11.6 10 10 0 0 8/12/2010 1/8/2011 11/4/2011 4/1/2010 NURE NWIS Williams '98 Baseline Sample Dates, Data Ranges, and Means



Property Owner E (185 ft.) Well Iron Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 10 10 Williams '98 **Baseline Central** NWIS Fe -Catskill NURE 65 Count NA 20 12 1103 9 9 Std. Dev. NA 1.3 1.63 NA Min 0.04 0.04 0.05 NA 8 Max NA 5.6 5.6 65 8 Mean NA 0.616 0.833 0.93 0.115 0.315 0.21 Median NA 7 7 6 6 Iron, mg/L 5 5 4 4 3 3 2 2 1 1 0.93 • 0.833 -0.616 Baseline 0 0 4/1/2010 1/8/2011 11/4/2011 NURE NWIS Williams '98 Baseline Sample Dates, Data Ranges, and Means


















APPENDIX D-7 TIME PLOTS PROPERTY OWNER F







Property Owner F Well Chloride Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 150 150 Williams '98 Baseline Western NURE Cl - Lock Haven NWIS 228 5050 Max 2200 140 140 Count 43 91 18 1004 318 Mean 28.5 940 Std. Dev. 30.8 NA 130 130 Min 0.1 1 1 1.06 Max 228 5050 132 2200 120 120 16.0 318 16.6 66.0 Mean Median 8.8 6 5.5 15.9 110 110 100 100 90 90 Chloride, mg/L 80 80 70 70 66.0 -60 60 50 50 40 40 30 30 20 20 **16.6** 16.0 10 10 0 0 3/10/2011 10/25/2011 11/11/2011 NURE NWIS Williams '98 Baseline Sample Dates, Data Ranges, and Means







Property Owner F Well Manganese Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 1 1 Williams '98 Baseline Western Mn - Lock Haven NURE NWIS 10.2 2.6 17 17 90 880 Count 0.9 0.9 Std. Dev. 0.097 0.139 0.610 NA 0.01 0.015 Min 0.039 0.02 0.796 0.412.6 10.2 0.8 Max 0.8 Mean 0.182 0.128 0.264 0.35 0.137 0.1 0.1 0.13 Median 0.7 0.7 Manganese, mg/L 0.5 0.4 0.6 0.5 0.4 0.35 0.3 0.3 0.264 -0.2 0.2 0.182 • 0.128 0.1 0.1 0 0 3/10/2011 10/25/2011 11/11/2011 NURE NWIS Williams '98 Baseline Sample Dates, Data Ranges, and Means















APPENDIX D-8 TIME PLOTS PROPERTY OWNER G







Property Owner G Chloride Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data









Property Owner G Well Manganese Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 1 1 Mn -Catskill NURE NWIS Williams '98 **Baseline Central** 4.01 Count 15 936 51 10 0.9 0.9 Std. Dev. 0.037 0.095 0.087 NA Min 0.050 0.01 0.01 0.015 Max 0.255 0.3 0.3 4.01 0.8 0.8 Mean 0.103 0.093 0.083 0.23 Median 0.098 0.03 0.06 0.1 0.7 0.7 **Manganese, mg/l** 0.6 0.5 0.4 0.6 0.5 0.4 Dissolved Manganese < 0.015 mg/LU 0.3 0.3 0.23 0.2 0.2 0.1 0.103 0.1 0.093 • 0.083 Baseline 0 0 9/1/2011 10/13/2011 10/27/2011 4/2/2010 10/1/2010 11/10/2010 6/28/2011 NURE NWIS Williams '98 Bseline Sample Dates, Data Ranges, and Means



Property Owner G Well Methane Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data













APPENDIX D-9 TIME PLOTS PROPERTY OWNER H



Property Owner H[,] Well Barium Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 5 5 Ba -Catskill NURE Williams '98 **Baseline Central** NWIS 32.5 1926 NA NA NA Count 4.5 4.5 Std. Dev. NA NA NA NA 0.010 Min NA NA NA 4 4 Max NA NA NA 32.5 0.47 Mean NA NA NA NA NA 0.17 Median NA 3.5 3.5 3 3 Barium, mg/L 2.5 2 2 1.5 1.5 1 1 0.5 **0.4**7 0.5 Baseline 0 0 Williams '98 Baseline NWIS $4|1|^{2010} 9|13|^{2010} 10|1|^{2010} 11|10|^{2010} 12|2|^{2010} 3|1|^{2011} 5|10|^{2011} 10|^{28|^{2011}} 11|^{8|^{2011}}$ NURE Sample Dates, Data Ranges, and Means



Property Owner H Well Chloride Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 150 150 CI -Catskill NURE NWIS Williams '98 **Baseline Central** 1980 408 140 140 Count 51 20 12 1440 Std. Dev. 13.5 90 24.3 NA 130 130 2 2 Min 3.2 1.04 120 87.5 74 120 Max 408 1980 43.4 25.1 Mean 11.6 33.5 110 110 7.2 12 13 9.07 Median 100 100 90 Chloride, mg/L 90 80 80 70 70 60 60 50 50 43.4 40 40 33.5 30 30 25.1 20 20 11.6 10 10 Baseline 0 0 Williams '98 NWIS Baseline $4|1|^{2010} 9|13|^{2010} 10|1|^{2010} 11|10|^{2010} 12|2|^{2010} 3|1|^{2011} 5|10|^{2011} 10|^{28|^{2011}} 11|^{8|^{2011}}$ NURE Sample Dates, Data Ranges, and Means



















Property Owner H Well TDS Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data





APPENDIX D-10 TIME PLOTS PROPERTY OWNER I (142-FT)







Property Owner I (142 ft.) Well Chloride Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 150 150 Cl -Catskill Williams '98 NURE NWIS **Baseline Central** 1980 408 140 140 51 Count 20 12 1440 13.5 90 24.3 NA Std. Dev. 130 130 3.2 2 1.04 Min 2 87.5 74 408 1980 Max 120 120 43.4 Mean 11.6 25.1 33.5 110 110 7.2 13 9.07 Median 12 100 100 90 90 Chloride, mg/L 80 80 70 70 60 60 50 50 43.4 40 40 33.5 30 30 25.1 20 20 11.6 10 10 0 0 10/31/2011 8/3/2010 9/15/2010 NURE NWIS Williams '98 Baseline Sample Dates, Data Ranges, and Means



















APPENDIX D-11 TIME PLOTS PROPERTY OWNER I (203-FT)






Property Owner I (203 ft.) Well Chloride Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 150 150 1980 CI -Catskill Williams '98 NWIS NURE **Baseline Central** 408 140 140 Count 51 20 12 1440 Std. Dev. 13.5 90 24.3 NA 130 130 Min 3.2 2 2 1.04 120 Max 87.5 408 74 1980 120 Mean 11.6 43.4 25.1 33.5 110 110 7.2 13 Median 12 9.07 100 100 90 90 Chloride, mg/L 80 80 70 70 60 60 50 50 43.4 40 40 33.5 30 30 25.1 Baseline 20 20 11.6 10 10 0 0 4/7/2011 5/23/2011 10/31/2011 9/14/2010 11/18/2010 3/1/2011 NURE Williams '98 NWIS Baseline Sample Dates, Data Ranges, and Means



Property Owner I (203 ft) Well Iron Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 10 10 Fe -Catskill NURE NWIS Williams '98 **Baseline Central** 65 Count NA 20 12 1103 9 9 Std. Dev. 1.3 1.63 NA NA Min NA 0.04 0.04 0.05 8 8 Max 5.6 65 NA 5.6 0.616 0.833 0.93 Mean NA Median NA 0.115 0.315 0.21 7 7 6 6 Iron, mg/L 5 5 Dissolved Iron 20.05 mg/LU Dissolvedtron=0.148 mg/L 4 4 3 3 2 2 Baseline 1 • 0.93 1 0.833 0.616 0 0 11/18/2010 3/1/2011 4/7/2011 5/23/2011 10/31/2011 9/14/2010 NURE Williams '98 NWIS Baseline Sample Dates, Data Ranges, and Means







Property Owner I (203 ft.) Well Methane Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 100 100 CH4 -Catskill **Baseline Central** NURE NWIS Williams '98 Count NA NA NA 526 90 90 Std. Dev. NA NA NA NA Min NA NA NA 0.005 80 80 NA NA NA 43.3 Max Mean NA NA NA 3.27 70 70 Median NA NA NA 0.359 Methane, mg/L 60 60 50 50 40 40 30 30 20 20 10 10 3.27 Baseline 5123/2012 618/2012 0 0 1112812010 10/13/2010 10/13/2010 2012012010 61212011 71612011 1/20/2012 2016/2020 3/1/2012 AM2011 81312011 81712011 2013-12012 9/14/2010 91212012 9/14/2011 912912011 119/2011 22/1/2011 williams.98 201222011 11/22/2011 NURE MUL Sample Dates, Data Ranges, and Means







Property Owner I (203 ft.) Well TDS Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 1000 1000 TDS -Catskill NURE NWIS Williams '98 **Baseline Central** 5410 4050 35 Count NA 10 1961 900 900 Std. Dev. NA 661 177 NA Min 76 100 17 NA 4050 Max NA 680 5410 800 800 362 263 223 Mean NA Median NA 212 208 195 700 700 600 600 TDS, mg/L 500 500 400 400 362 300 300 263 223 200 200 Baseline 100 100 0 0 4/7/2011 5/23/2011 10/31/2011 9/14/2010 11/18/2010 3/1/2011 NURE NWIS Williams '98 Baseline Sample Dates, Data Ranges, and Means



APPENDIX D-12 TIME PLOTS PROPERTY OWNER J



















Property Owner J Well Methane Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data









APPENDIX D-13 TIME PLOTS PROPERTY OWNER K







Property Owner K Well Chloride Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 150 150 5050 Max Williams '98 Baseline Central 1980 Cl - Lock Haven NURE NWIS 228 318 Mean 140 140 91 43 18 1440 Count Std. Dev. 28.5 940 30.8 NA 130 130 Min 0.1 1 1 1.04 120 120 132 Max 228 5050 1980 16.0 16.6 33.5 Mean 318 110 110 Median 8.8 6 5.5 9.07 100 100 90 90 Chloride, mg/L 80 80 70 70 60 60 50 50 40 40 **33.5** 30 30 20 20 16.6 16.0 -Baseline 10 10 0 0 10/27/2011 1/7/2010 NURE NWIS Williams '98 Baseline Sample Dates, Data Ranges, and Means











Property Owner K Well Methane Concentrations vs. Time Compared to NURE, NWIS Data, Williams '98, and Baseline Data





Property Owner K Well Sodium Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 100 100 Williams '98 Baseline Central Na - Lock Haven NURE NWIS 2510 Max 137 1610 165 91 20 20 1958 248 Mean Count 90 90 22.1 Std. Dev. 560 44 NA Min 3.2 3.2 1 1.18 137 80 Max 2510 165 1610 80 19.2 248 38.6 33.1 Mean Median 9.27 35.2 22 14 70 70 60 60 Sodium, mg/L 50 50 40 40 **—** 38.6 **3**3.1 30 30 Baseline 20 20 19.2 10 10 0 0 1/7/2010 10/27/2011 NURE NWIS Williams '98 Baseline Sample Dates, Data Ranges, and Means



Property Owner K Well TDS Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 1000 1000 TDS - Lock Haven NURE NWIS Williams '98 **Baseline Central** 9200 5410 Count NA 65 20 1961 900 900 Std. Dev. NA 1504 120 NA 17 Min NA 134 142 5410 9200 512 Max NA 800 800 676 275 223 Mean NA Median 246 227 195 NA 700 700 676 600 600 TDS, mg/L 500 500 400 400 300 300 275 **2**23 200 200 Baseline 100 100 0 0 1/7/2010 10/27/2011 NURE NWIS Williams '98 Baseline Sample Dates, Data Ranges, and Means



APPENDIX D-14 TIME PLOTS PROPERTY OWNER L



Property Owner L Well Barium Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 5 5 Ba - Lock Haven NURE NWIS Williams '98 **Baseline Central** 98 Max 32.5 11.9 Mean NA 10 8 1926 Count 4.5 4.5 NA Std. Dev. NA 30.7 0.148 Min NA 0.2 0.03 0.010 4 4 Max NA 98 0.46 32.5 0.47 Mean NA 11.9 0.227 Median 0.197 3.5 NA 0.45 0.17 3.5 3 3 Barium, mg/L 2.5 2.5 2 2 1.5 1.5 1 1 0.5 0.5 0.47 0.227 Baseline 0 0 4/18/2010 11/3/2011 NURE NWIS Williams '98 Baseline Sample Dates, Data Ranges, and Means



Property Owner L Well Chloride Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data





Property Owner L Well Methane Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 1 1 CH4- Lock Haven Williams '98 **Baseline Central** NURE NWIS 43.3 Max 3.27 Mean NA NA 526 Count NA 0.9 0.9 Std. Dev. NA NA NA NA Min NA NA NA 0.005 0.8 0.8 Max NA NA NA 43.3 NA NA Mean NA 3.27 NA NA 0.359 Median NA 0.7 0.7 0.6 **Methane, mg/L** 0.5 0.5 0.4 0.6 0.5 0.4 0.3 0.3 0.2 0.2 0.1 0.1 Baseline 0 0 11/3/2011 NURE 4/18/2010 NWIS Williams '98 Baseline Sample Dates, Data Ranges, and Means











APPENDIX D-15 TIME PLOTS PROPERTY OWNER M







Property Owner M Well Chloride Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data













Property Owner M Well Methane Concentrations vs. Time Compared to NURE, NWIS Data, Williams '98, and Baseline Data





Property Owner M Well Sodium Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data 100 100 Williams '98 **Baseline Central** Na -Catskill NURE NWIS 829 1610 145 132 Count 51 17 10 1958 90 90 47.4 Std. Dev. 20.9 197 NA **#** 85.1 Min 2.77 5 1 4 80 80 145 829 132 1610 Max 42.0 14.0 85.1 33.1 Mean Median 8.58 23 18.5 14 70 70 60 60 Sodium, mg/L 50 50 42.0 40 40 33.1 30 30 20 20 14.0 10 10 Baseline 0 0 1/6/2010 12/2/2010 10/28/2011 NURE NWIS Williams '98 Baseline Sample Dates, Data Ranges, and Means



Property Owner M Well TDS Concentrations vs. Time Compared to NURE, NWIS, Williams '98, and Baseline Data





APPENDIX E SCREENING CRITERIA
Summary of Inorganic Parameters in Chesapeake Energy Split Samples from the EPA Retrospective Study Wells that Exceed the Most Stringent of the Applicable Screening Levels

						T	T					
ITEM	Date	Aluminum	Arsenic	Chloride	Iron	Lead	Lithium	Manganese	рН	TDS	Turbidity	Total Coliform
		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(pH units)	(mg/L)	NTU	# positives/mo
SCREENING LEVELS	PADEP Act 2*	-	0.01	-	-	0.005	0.073	0.3	-	-	-	-
	FPA MCLS	-	0.01	_	-	0.015***	-	_	-	_	5	1
		0.2	0.01	250	0.3	-	-	0.05	6 5-8 5	500	5	-
	EDA Bogional**	15.5	0.000045	250	10.0		0.021	0.03	0.5 0.5	500		
MELLS & CODING (well double)	EPA Regional	15.5	0.000043	-	10.9	-	0.031	0.322		-	-	-
WELLS & SPRING (Well depth)												
Property Owner A (300-ft)	10/13/2010	NA	0.01		6.19	<0.005 U		0.369			33	NA
	7/18/2011				0.786			0.912				
	//10/2011				(<0.05 U D)			(0.788 D)			36	
		1.44, 6.26	0.0122		3.88, 14.5	0.0353, 0.0377		1.15, 1.34				
	11/4/2011	(0.0566 D)	(0.00416 D)		(0.0845 D)	(<0.002 U D)		(0.959 D. 1.02 D. 1.03 D)			865	Present
Property Owner B (spring)	10/14/2010 (baseline)	(,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,							6.3			NA
i toperty office o (opting)	11/4/2011								6.1			Brocont
Dronorty Owner C (200 ft)	11/4/2011 (headline)	DIA.	-0.01.11	412	0.385				0.1	842		Flesent
Property Owner C (260-ft)	4/29/2011 (Baseline)	NA 0.000	<0.010	413	0.285					842		
		0.262	0.00746		0.368							
	10/27/2011	(<0.02 U D)	(0.00456 D)	351	(<0.05 U D)					726		
Property Owner D (250-ft)	1/10/2010 (baseline)								8.2			NA
	6/10/2011								8.8			
	10/28/2011											Present
Property Owner E (115-ft)	4/1/2010 (baseline)							0 118				
	8/12/2010							0.127				
	8/12/2010							0.127				
	1/8/2011							0.133				
								0.116				
	11/4/2011							(0.113 D)				
Property Owner E (185-ft)	4/1/2010 (baseline)							0.0647				
	8/12/2010							0.0788				
Property Owner F (200-ft)	3/10/2011						NA					
	11/11/2011						0.1					
	11/11/2011 4/2/2010 (beseline)				0.381	<0.005 U	0.1	40.015 U			-111	NA
Property Owner & (unknown)	4/2/2010 (baseline)				0.281	<0.003 0		0.013 0			<10	NA
	10/1/2010				10.6			0.153				
	11/10/2010				3.58			0.123				
	11, 10, 2010				(< 0.05 U D)			(< 0.015 D)			24	
	6/28/2011				2.68						91.2	
					3.08							
	9/1/2011				(0.109 D)						16.1	
					4.12						1011	
	10/13/2011 (pre-treatment)				4.13	0.0001					27.1	
					(0.0549 D)	0.0061					37.1	
	10/13/2011 (post-treatment)											
	10/27/2011				0.343							
	10/2//2011				(<0.05 U D)						13	Present
Property Owner H (340-ft)	4/1/2010 (baseline)	NA			0.0546	<0.005 U		<0.015 U			2	NA
					2.54							
	10/1/2010				(<0.05 U D)			0.214			31.2	
					0.982	0.0089		0.0607				
	11/10/2010				(<0.05 (1.0))	(<0.005 (1.D)		(0.0213 D)			26.4	
					(<0.03 0 D)	(<0.003 0 D)		(0.0213 D)			20.4	
	12/2/2010				0.829			0.095			11.7	
	3/1/2011 (pre-treatment)					0.0076						
	3/1/2011 (post-treatment)											
	5/10/2011 (pre-treatment)					0.0738					7.3	
	5/10/2011 (post-treatment)											
		0.322										
	10/28/2011	(<0.02 U D)									6.8	Present
	11/8/2011 (nost-treatment)	, = = = ,									5.0	
Broporty Owner 1 (142 ft)	9/2/2010					<u> </u>			6.4.1			NIA
Property Owner I (142-It)	8/3/2010								0.4 J			NA .
	10/31/2011								6.4		-	Present
	9/14/2010 (baseline)				2.29 J			0.0429				
Property Owner I (203-ft)	5/14/2010 (buseline)	NA			(<0.05 U D)	<0.005 U		(0.0214 D)			68	
	11/18/2010				0.434							
	11/18/2010				(0.148 D)							
	3/1/2011 (pre-treatment)				2.18			0.145			5.1	
	3/1/2011 (post-treatment)										7.2	
	4/7/2011 (pro treatment)				1.05	0.0075		0.0992			12.2	
	4/7/2011 (pre-treatment)				1.05	0.0073		0.0992			12.2	
	4///2011 (post-treatment)					0.0051	-					
	5/23/2011 (pre-treatment)										6.6	
	5/23/2011 (post-treatment)							0.0662				
		0.31, 0.112										
	10/31/2011	(<0.02 U D)									5.4	
Property Owner J (unkown)	7/2/2010 (baseline)				0.676	0.0114		0.249			5.7	
,,	2/8/2011				0.889	0.009		0.29			0.8	
	2/0/2011		1		0.500	0.003		0.23			5.0	
	11/3/2011		1		0.583			0.22				
					(0.316 D)			(0.216 D)				



Summary of Inorganic Parameters in Chesapeake Energy Split Samples from the EPA Retrospective Study Wells that Exceed the Most Stringent of the Applicable Screening Levels

ITEM	Date	Aluminum	Arsenic	Chloride	Iron	Lead	Lithium	Manganese	рН	TDS	Turbidity	Total Coliform
		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(pH units)	(mg/L)	NTU	# positives/mo
SCREENING LEVELS	PADEP Act 2*	-	0.01	-	-	0.005	0.073	0.3	-	-	-	-
	EPA MCLs	-	0.01	-	-	0.015***	-	-	-	-	5	1
	EPA SMCLs	0.2	-	250	0.3	-	-	0.05	6.5-8.5	500	-	-
	EPA Regional**	15.5	0.000045	-	10.9	-	0.031	0.322	-	-	-	-
WELLS & SPRING (well depth)												
Property Owner K (175-ft)	1/7/2010 (baseline)							0.0321				
	5/31/2011 (post-treatment)							0.102				
	10/27/2011							0.168				
	10/27/2011							(0.119 D)				Present
Property Owner L (225-ft)	4/18/2010 (baseline)											NA
	11/3/2011											Present
Property Owner M (440-ft)	1/6/2010 (baseline)					<0.005 U						NA
	12/2/2010					0.011						
	4/11/2011					0.0124						
	10/28/2011											Present

*Residential used Wells <2,500 mg/l TDS ** Screening Levels for Tap Water (chronic) *** Action Level NA = Not Analyzed U = Less Than Detection Limit

D = Dissolved (all metals are total unless marked with D)

mg/L = Milligrams per Liter

NTU = Nephelometric Turbidity Units





Summary of Organic Parameters Detected in Chesapeake Energy Split Samples from the EPA Retrospective Study Wells Compared to Applicable Screening Levels

ITEM	Date	Diethylene Glycol	Tetraethylene Glycol	Triethylene Glycol	Squalene	Toluene
		(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
SCREENING LEVELS	PADEP Act 2*	-	-	-	-	1000
	EPA MCLs	-	-	-	-	1000
	EPA SMCLs	-	-	-	-	-
	EPA Regional**	-	-	-	-	856
WELLS & SPRING (well depth)						
Property Owner A (300-ft)	10/13/2010				NA	100
	11/4/2011				6 J	
Property Owner B (spring)						
Property Owner C (260-ft)						
Property Owner D (250-ft)						
Property Owner E (115-ft)	4/1/2010 (baseline)	NA	NA	NA		
	11/4/2011	13 JB	26 JB	20 JB		
Property Owner E (185-ft)						
Property Owner F (200-ft)	3/10/2011		NA			
	10/25/2011		11 J			
Property Owner G (unknown)						
Property Owner H (340-ft)	4/1/2010 (baseline)		NA	NA		<0.5 U
	11/10/2010					1.13
	10/28/2011		20 J	12 J		
Property Owner I (142-ft)						
Property Owner I (203-ft)	9/14/2010 (baseline)					<0.5 U
	3/1/2011 (pre-treatment)					1.71
	4/7/2011 (pre-treatment)					0.95
Property Owner J (unkown)						
Property Owner K (175-ft)						
Property Owner L (225-ft)	4/18/2010 (baseline)		NA			
	11/3/2011		15 JB			
Property Owner M (440-ft)						

*Residential used Wells <2,500 mg/l TDS

** Screening Levels for Tap Water (chronic)

NA = Not Analyzed

U = Less Than Detection Limit

J = Estimated Value

B = Blank Contained Analyte

ug/L = Micrograms per Liter



ITEM	Date	Ethane	Methane	Propane
		(mg/L)	(mg/L)	(mg/L)
WELLS & SPRING (well depth)				
Property Owner A (300-ft)	10/13/2010	0.192	8.36	
	7/18/2011	0.0861	5.21	
	8/4/2011	0.0904	4.82	
	8/18/2011	0.0964	4.95	
	9/1/2011	0.0556	1.51	
	11/4/2011	0.0117	1.86	
Property Owner B (spring)				
Property Owner C (260-ft)	4/29/2011 (baseline)		21.5	
	10/27/2011		22.5	
Property Owner D (250-ft)	1/10/2010 (baseline)		3.55	
	6/10/2011		4.81	
	10/28/2011		2.11 J	
Property Owner E (115-ft)	4/1/2010 (baseline)	0.049	33.8	
	8/12/2010	0.0495	34.7	
	1/8/2011	0.0838	35.8	
	11/4/2011	0.0816	37.1 J	
Property Owner E (185-ft)	4/1/2010 (baseline)		8.88	
	8/12/2010		9.68	
	1/8/2011		0.239	
	11/4/2011		0.609	
Property Owner F (200-ft)	3/10/2011	< 0.026 U	53.4	
	10/25/2011	0.0202	55.3	
	11/11/2011	0.202	51.8	
Property Owner G (unknown)	4/2/2010 (baseline)		0.035	
	9/1/2011		0.0126	
Property Owner H (340-ft)	4/1/2010 (baseline)		0.045	
	9/13/2010		0.0535	
	11/10/2010		0.183	
	10/28/2011		0.00607	
	11/8/2011 (pre-treatment)		0.0655	
	11/8/2011 (post-treatment)		0.0258	
Property Owner I (142-ft)	8/3/2010	< 0.0260 U	0.0957	
	9/15/2010	0.0953	1.41	
	10/6/2010	0.195	2.78 J	
	10/20/2010	0.103	1.78	

Summary of Dissolved Gases Detected in Chesapeake Energy Split Samples from the EPA Retrospective Study Wells



ITEM	Date	Ethane	Methane	Propane
		(mg/L)	(mg/L)	(mg/L)
WELLS & SPRING (well depth)				
Property Owner I (203-ft)	9/14/2010 (baseline)	1.59	10.9	0.101
	10/6/2010	1.84	25.4	0.117
	10/13/2010	1.47	20.6	0.0841
	10/13/2010 (pre-treatment)	0.254	4.58	
	10/20/2010	0.754	8.82	0.0388
	11/18/2010	0.593	7.47	
	3/1/2011 (pre-treatment)	0.959 J	17.1	
	3/1/2011 (post-treatment)		1.76	
	4/7/2011 (pre-treatment)	0.613	14.2	
	4/7/2011 (post-treatment)	0.048	2.82	
	5/23/2011 (pre-treatment)	0.624	9.21	
	5/23/2011 (post-treatment)	0.0625	1.2	
	6/8/2011	0.437	3.09	
	6/22/2011	0.543	10.4	
	7/6/2011	0.6	10.8	
	7/20/2011	0.511	6.65	
	8/3/2011	0.364	10.4	
	8/17/2011	0.421	8.88	
	9/2/2011	0.424	6.23	
	9/14/2011	0.467	9.87 J	
	9/29/2011	0.445	9.62	
	10/12/2011	0.19	4.1	
	10/31/2011	0.402	6.09	
	11/9/2011	0.395	4.94	
	11/22/2011	0.418	5.51	
	12/7/2011	0.118	3.6	
Property Owner J (unkown)				
Property Owner K (175-ft)	1/7/2010 (baseline)		<0.026 U	
	10/27/2011		0.00674	
Property Owner L (225-ft)	4/18/2010 (baseline)		0.048	
Property Owner M (440-ft)				

Summary of Dissolved Gases Detected in Chesapeake Energy Split Samples from the EPA Retrospective Study Wells

U = Less Than Detection Limit

J = Estimated Value

mg/L = Milligrams per Liter



APPENDIX F DUROV AND PIPER DIAGRAMS





































APPENDIX G ANALYTE LISTS

Daramatar	Chesapeake Energy	EPA Retrospective		
Parameter	Baseline Parameter List	Study Parameter List		
Aldehydes	•			
Gluteraldehyde		Х		
Bacteria				
E. coli		Х		
Fecal coliform bacteria		Х		
Total Coliform Bacteria		х		
DBCP				
1,2-Dibromo-3-chloropropane		Х		
Extractable Petroleum Hydrocarbons				
Diesel		Х		
General Chemistry				
Alkalinity, Total (CaCO3)		Х		
Ammonia as N		X		
Bicarbonate Alkalinity as CaCO3	X	Х		
Bromide		X		
Carbonate as CaCO3	X	Х		
Chloride	X	Х		
CO2 by Headspace		Х		
Cyanide		Х		
Fluoride		Х		
MBAS	Х	Х		
Nitrate		Х		
Nitrate Nitrogen		Х		
Nitrite Nitrogen		Х		
Oil & Grease HEM	Х	Х		
рН	Х	Х		
Phosphorus		Х		
Specific conductance	Х	Х		
Sulfate	Х	Х		
Temperature of pH determination	Х	Х		
Total Dissolved Solids	Х	Х		
Total Suspended Solids	Х	Х		
Turbidity	Х	Х		
Glycols				
1,2-Propylene Glycol		Х		
Diethylene Glycol		Х		
Ethylene Glycol		Х		
Tetraethylene glycol		Х		
Triethylene glycol		Х		
Light Gases				
Acetylene		Х		
Ethane	Х	Х		
Ethene		Х		
Methane	Х	Х		
n-Butane		Х		
Propane	Х	Х		

Baramatar	Chesapeake Energy	EPA Retrospective		
Parameter	Baseline Parameter List	Study Parameter List		
Low Molecular Weight Acids				
Acetic Acid		Х		
Butyric Acid		Х		
Formic Acid		Х		
Isobutyric acid		Х		
Lactic acid		Х		
Propionic Acid		Х		
Metals, 6020x		-		
Cesium		Х		
Cesium Dissolved		х		
Potassium		х		
Potassium, Dissolved		х		
Silicon		х		
Silicon Dissolved		х		
Thorium		х		
Thorium. Dissolved		х		
Uranium		х		
Uranium. Dissolved		x		
Metals, Total				
Aluminum		X		
Antimony		X		
Arsenic	X	x		
Barium	X	x		
Bervllium		x		
Boron		x		
Cadmium	x	x		
Calcium	X	x		
Chromium	X	x		
Cobalt		x		
Copper		x		
Hardness CaCO3		x		
Iron	×	X		
Lead	X	X		
Lithium		x		
Magnesium	×	x		
Magnesian	X	X		
Mercury	×	×		
Molybdenum		x		
Nickel		×		
Potassium	×	x		
Selenium	×	×		
Silver	×	×		
Sodium	×	×		
Strontium		^ У		
Sulfur	 v	^ V		
Thallium	^	^ V		
Titanium		^ 		
Vanadium		^ V		
Zinc		^ V		
		٨		

Deremeter	Chesapeake Energy	EPA Retrospective	
Parameter	Baseline Parameter List	Study Parameter List	
Metals, Dissolved	•		
Aluminum, Dissolved		Х	
Antimony, Dissolved		Х	
Arsenic, Dissolved		Х	
Barium, Dissolved		Х	
Beryllium, Dissolved		Х	
Boron, Dissolved		Х	
Cadmium, Dissolved		Х	
Calcium, Dissolved		Х	
Chromium, Dissolved		Х	
Cobalt, Dissolved		Х	
Copper, Dissolved		Х	
Iron, Dissolved		Х	
Lead, Dissolved		Х	
Magnesium, Dissolved		Х	
Manganese, Dissolved		Х	
Mercury, Dissolved		Х	
Molybdenum, Dissolved		Х	
Nickel, Dissolved		Х	
Potassium, Dissolved		Х	
Selenium, Dissolved		Х	
Silver, Dissolved		Х	
Sodium, Dissolved		Х	
Strontium, Dissolved		Х	
Sulfur, Dissolved		Х	
Thallium, Dissolved		Х	
Titanium, Dissolved		Х	
Vanadium, Dissolved		Х	
Zinc, Dissolved		Х	
Miscellaneous Organics			
Inorganic Carbon, Dissolved		Х	
Organic Carbon, Dissolved		Х	
Pesticides and PCBs			
4,4'-DDD		Х	
4,4'-DDE		Х	
4,4'-DDT		Х	
alpha-BHC		Х	
Azinphos-methyl		Х	
beta-BHC		Х	
Carbaryl		Х	
delta-BHC		Х	
Dichlorvos		Х	
Dieldrin		Х	
Disulfoton		Х	
Endosulfan I		Х	
Endosulfan II		Х	
Endosulfan sulfate		Х	
Endrin		Х	
Endrin aldehyde		Х	

Deventer	Chesapeake Energy	EPA Retrospective
Parameter	Baseline Parameter List	Study Parameter List
Endrin ketone		X
gamma-BHC (Lindane)		Х
Heptachlor		X
Heptachlor epoxide		Х
Malathion		Х
Methoxychlor		Х
Mevinphos		Х
Purgeable Petroleum Hydrocarbons	-	
GRO as Gasoline		X
Semivolatile Organics		
1,2,4,5-Tetrachlorobenzene		X
1,2-Dinitrobenzene		X
1,2-Diphenylhydrazine		X
1,3-Dimethyl adamatane		X
1,3-Dinitrobenzene		X
1,4-Dinitrobenzene		X
1-Chloronaphthalene		X
2,3,4,6-Tetrachlorophenol		X
2,4,5-Trichlorophenol		X
2,4,6-Trichlorophenol		X
2,4-Dichlorophenol		X
2,4-Dimethylphenol		Х
2,4-Dinitrophenol		X
2,4-Dinitrotoluene		X
2,6-Dichlorophenol		X
2,6-Dinitrotoluene		X
2-Butoxyethanol		X
2-Chloronaphthalene		X
2-Chlorophenol		X
2-Methylnaphthalene		X
2-Methylphenol		X
2-Nitroaniline		X
2-Nitrophenol		X
3,3-Dichlorobenzidine		X
3-Nitroaniline		X
4,4'-Methylenebis(2-chloroaniline)		X
4,4'-Methylenebis(N,N-dimethylaniline)		X
4,6-Dinitro-2-methylphenol		X
4-Bromophenyl phenyl ether		X
4-Chloro-3-methylphenol		X
4-Chloroaniline		X
4-Chlorophenyl phenyl ether		X
4-Methylphenol		Х
4-Nitroaniline		X
4-Nitrophenol		Х
Acenaphthene		X
Acenaphthylene		X
Acetophenone		X
Adamantane		X

Baramotor	Chesapeake Energy	EPA Retrospective
Parameter	Baseline Parameter List	Study Parameter List
Aniline		Х
Anthracene		Х
Benzo (a) anthracene		Х
Benzo (a) pyrene		Х
Benzo (b) fluoranthene		Х
Benzo (g,h,i) perylene		Х
Benzo (k) fluoranthene		Х
Benzoic acid		Х
Benzyl alcohol		Х
Bis(2-chloroethoxy)methane		Х
Bis(2-chloroethyl)ether		Х
bis(2-Chloroisopropyl)ether		Х
Bis(2-ethylhexyl)phthalate		Х
Butyl benzyl phthalate		Х
Carbazole		Х
Chlorobenzilate		Х
Chrysene		Х
Diallate (cis or trans)		Х
Dibenz (a,h) anthracene		Х
Dibenzofuran		Х
Diethyl phthalate		Х
Dimethyl phthalate		Х
Di-n-butyl phthalate		Х
Di-n-octyl phthalate		Х
Dinoseb		Х
Disulfoton		Х
d-Limonene		Х
Fluoranthene		Х
Fluorene		Х
Hexachlorobenzene		Х
Hexachlorobutadiene		Х
Hexachlorocyclopentadiene		Х
Hexachloroethane		Х
Indeno (1,2,3-cd) pyrene		Х
Isophorone		Х
Naphthalene		Х
Nitrobenzene		Х
N-Nitrosodiethylamine		Х
N-Nitrosodimethylamine		Х
N-Nitrosodi-n-butylamine		Х
N-Nitrosodi-n-propylamine		Х
N-Nitrosodiphenylamine		Х
N-Nitrosomethylethylamine		X
Parathion-ethyl		X
Parathion-methyl		X
Pentachlorobenzene		X
Pentachlorophenol		X
Phenanthrene		X
Phenol		X

Chesapeake Energy EPA Retrospective Parameter **Baseline Parameter List** Study Parameter List Phorate ---Х Х Pronamide ---Х Pyrene ---Х Pyridine ---Squalene Х ---Terbufos ---Х Х Terpineol ---Tributoxyethyl phosphate ---Х Trifluralin Х ---TICs 1,2,3-Trimethylbenzene х ---Volatile Organics 1,1,1-Trichloroethane Х ---1,1,2-Trichloroethane ---Х 1,1-Dichloroethane Х ---Х 1,1-Dichloroethene ---Х 1,2,3-Trimethylbenzene ---Х 1,2,4-Trichlorobenzene ---1,2,4-Trimethylbenzene Х ---Х 1,2-Dibromo-3-chloropropane ___ Х 1,2-Dichlorobenzene ---Х 1,2-Dichloroethane ---Х 1,2-Dichloropropane ---Х 1,3,5-Trimethylbenzene ---1,3-Dichlorobenzene Х ---1,4-Dichlorobenzene ---Х Х Acetone ---Х Benzene Х Carbon disulfide ---Х Carbon Tetrachloride Х ---Chlorobenzene Х ___ Х Chloroform --cis-1,2-Dichloroethene Х ---**Diisopropyl Ether** Х ---Х Ethanol ---Ethyl tert-Butyl Ether Х ---Х Ethylbenzene Х Hexachlorobutadiene Х ---Х Isopropyl alcohol ---Х Isopropylbenzene --m,p-Xylene Х ___ Х Methoxychlor ---Methyl tert-Butyl Ether Х ---Х Methylene Chloride ----Naphthalene Х ___ Х o-Xylene ---Х Styrene ---Tert-Amyl Methyl Ether Х ---**Tertiary Butyl Alcohol** ---Х

Parameter	Chesapeake Energy	EPA Retrospective
rarameter	Baseline Parameter List	Study Parameter List
Tetrachloroethene		Х
Tetrahydrofuran		Х
Toluene	Х	Х
trans-1,2-Dichloroethene		Х
Trichloroethene		Х
Vinyl chloride		Х
Xylenes, total	X	Х