Office of Research and Development
Office of Science Policy

National Hydraulic Fracturing Study
Evaluation of Existing
Production Well File Contents

Quality Assurance Project Plan

August 19, 2013

A. Project Management

This section addresses project management, including project background and purpose, roles and responsibilities, and key research questions and objectives.

A.1. Title and Approval Sheet

Signatures indicate approval of this Quality Assurance Project Plan and commitment to follow the applicable procedures noted:

/s/	8/19/2013
Nathan Wiser, Technical Project Manager	Date
/s/	8/19/2013
Susan Burden, Data Analysis Technical Research Lead	Date
/s/	8/19/2013
Jeanne Briskin, Study Coordinator	Date
/s/	8/19/2013
Stephen Watkins, Quality Assurance Manager, Office of Science Policy	Date
/s/	8/23/2013
Mimi Dannel, Deputy Director, Office of Science Policy	Date

A.2. Table of Contents

Disclaimer

EPA does not consider this internal planning document an official Agency dissemination of information under the Agency's Information Quality Guidelines, because it is not being used to formulate or support a regulation or guidance; or to represent a final Agency decision or position. This planning document describes the overall quality assurance approach that will be used during the research study. Mention of trade names or commercial products in this planning document does not constitute endorsement or recommendation for use.

The EPA Quality System and the Hydraulic Fracturing Research Study

EPA requires that all data collected for the characterization of environmental processes and conditions are of the appropriate type and quality for their intended use. This is accomplished through an Agency-wide quality system for environmental data. Components of the EPA quality system can be found at http://www.epa.gov/quality/. EPA policy is based on the national consensus standard ANSI/ASQ E4-2004 *Quality Systems for Environmental Data and Technology Programs: Requirements with Guidance for Use*. This standard recommends a tiered approach that includes the development and use of Quality Management Plans (QMPs). The organizational units in EPA that generate and/or use environmental data are required to have Agency-approved QMPs. Programmatic QMPs are also written when program managers and their QA staff decide a program is of sufficient complexity to benefit from a QMP, as was done for the study of the potential impacts of hydraulic fracturing (HF) on drinking water resources. The HF QMP describes the program's organizational structure, defines and assigns quality assurance (QA) and quality control (QC) responsibilities, and describes the processes and procedures used to plan, implement and assess the effectiveness of the quality system. The HF QMP is then supported by project-specific QA project plans (QAPPs). The QAPPs provide the technical details and associated QA/QC procedures for the research projects that address questions posed by EPA about the HF water cycle and as described in the *Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources* (EPA/600/R-11/122/November 2011/www.epa.gov/hydraulic fracturing). The results of the research projects will provide the foundation for EPA's 2014 study report.

This QAPP provides information concerning the **all stages** of the HF water cycle as found in Figure 1 of the HF QMP and as described in the Study Plan. Appendix A of the HF QMP includes the links between the HF Study Plan questions and those QAPPs available at the time the HF QMP was published.

A.3. Distribution List

This Quality Assurance Project Plan (QAPP) will be distributed to staff of the U.S. Environmental Protection Agency (EPA), Cadmus Group, Inc., and Westat, Inc. (Table A.1). A copy of the document will be provided to all well file reviewers, including those who join the project after publication of the QAPP.

Table A.1. QAPP Distribution

Name and Title	Contact Information	Mailing Address
Nathan Wiser Technical Project Manager	303-312-6211 wiser.nathan@epa.gov	U.S. Environmental Protection Agency 1595 Wynkoop Street (8ENF-UFO) Denver, CO 80202-1129
Chuck Tinsley Petroleum Engineer	303-312-6266 tinsley.chuck@epa.gov	
Jeanne Briskin Study Coordinator	202-564-4583 briskin.jeanne@epa.gov	U.S. Environmental Protection Agency 1200 Pennsylvania Ave., N.W. (8104R) Washington, DC 20460
Susan Burden Data Analysis Technical Research Lead	202-564-6308 burden.susan@epa.gov	
Jill Dean Work Assignment Manager	202-564-8241 dean.jill@epa.gov	
Stephen Watkins Quality Assurance Manager	202-564-3744 watkins.stephen@epa.gov	
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David Bernstein	732-321-4462 bernstein.david@epa.gov	U.S. Environmental Protection Agency 2890 Woodbridge Ave., Edison, NJ 08837
Guy Cole Contractor	cole.guy@epa.gov	
Chi Ho Sham Cadmus Program Manager	617-673-7156 chiho.sham@cadmusgroup.com	The Cadmus Group, Inc. 57 Water Street Watertown, MA 02472
Glen Boyd Engineer	206-284-7038 glen.boyd@cadmusgroup.com	The Cadmus Group, Inc. 1411 Fourth Ave., Suite 1106 Seattle, WA 98101
Amanda Ereth Analyst	703-842-5521 amanda.ereth@cadmusgroup.com	

David Marker Project Manager	301-251-1500 markerd1@westat.com	Westat, Inc. 1600 Research Boulevard Rockville, MD 20850

A.4. Project Organization

The purpose of this QAPP is to describe how staff from two extramural organizations (Cadmus and Westat), a student contractor, and EPA employees from the Office of Research and Development (ORD) work together to collect, extract, organize, summarize and analyze well file data collected by EPA as part of EPA's *Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources*.[1] Each extramural organization has an existing EPA-approved QAPP that will provide the basis for their individual contributions to the well file review (Table A.2). Work conducted by EPA technical staff is guided by the quality assurance and quality control (QA/QC) requirements described in this document. No original measurement data will be generated by this effort, therefore this QAPP will focus on data synthesis, project logistics, and QA/QC requirements.

Table A.2. Other Organization's Quality Assurance Project Plans

Other Organization	Contract No.	QAPP Date
Cadmus	EP-C-08-015 Work Assignment 5-58	April 2, 2013
Westat	EP-C-10-023	July 14, 2011

Project organization is depicted in Figure A.1. The EPA Technical Project Manager will be responsible for the development, coordination, and execution of well file review analysis and summarizing the findings, and will thus be responsible for ensuring that the quality of work meets the requirements of EPA's study. The well file review team members will be responsible for reviewing well file contents as assigned and for transmitting information to each. The EPA Work Assignment Manager will be responsible for providing technical direction and administrative aspects of the work performed by EPA contractors. The EPA Technical Project Manager, in coordination with the Work Assignment Manager, will also be responsible for technical communications with Project/Program Managers at Westat and Cadmus, regarding their work. The EPA Technical Project Manager and the well file review team will keep the QA Manager advised on any quality problems that arise during the well file review. The QA Manager is responsible for ensuring this QAPP meets EPA's requirements and for ensuring that team members adhere to practices and procedures set forth in this QAPP.

[1] EPA's *Plan to Study the Potential Impact of Hydraulic Fracturing on Drinking Water Resources* (EPA/600/R-11/122) is available at http://www2.epa.gov/sites/production/files/documents/hf_study_plan_110211_final_508.pdf.

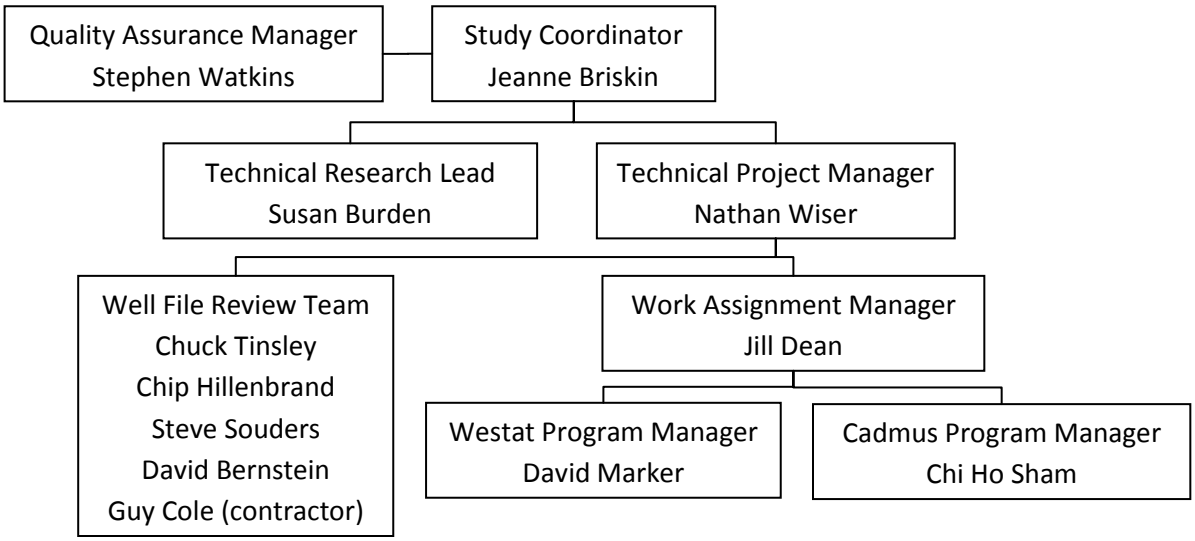

Figure A.1. Project Organization

A.5. Problem Definition / Background

Hydraulic fracturing is a technique used to increase production of oil and gas. Hydraulic fracturing increases the permeability of a geologic formation by pumping a pressurized fluid into the formation and creating fractures in the rock that allow gas to be extracted. Fracturing fluids typically contain a mixture of water, chemical additives, and proppants.

In response to the growing use of hydraulic fracturing in the United States, Congress requested EPA to research the potential impacts of hydraulic fracturing on drinking water resources. EPA responded to Congress' request by producing the Draft Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources in February 2011. The draft plan was reviewed and commented on by EPA's Science Advisory Board (SAB), and the final *Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources* (EPA/600/R-11/122) was completed in November 2011.

In August 2011, EPA requested information from nine oil and gas operators on wells hydraulically fractured between October 2009 and September 2010 (Appendix 1). As part of the request, EPA asked for information on 24 specific topics that range from background water quality data that may have been collected prior to drilling through the final disposition of flowback. The process used to select the operators and wells is described in Section 3.4 of EPA's *Study of the Potential Impacts of Drinking Water Resources: Progress Report* (EPA/601/R-12/011), which was released in December 2012.[2] The nine operators are Clayton Williams Energy, ConocoPhillips, EQT Production, Hogback Exploration, Laramie Energy, MDS Energy, Noble Energy, SandRidge Energy, and Williams Production. EPA received

[2] The *Progress Report* is available at http://www2.epa.gov/sites/production/files/documents/hf-report20121214.pdf.

information on 334 wells located within 13 states: Arkansas, Colorado, Kentucky, Louisiana, New Mexico, North Dakota, Oklahoma, Pennsylvania, Texas, Utah, Virginia, West Virginia, and Wyoming.

The analysis described in this QAPP crosses all stages of the hydraulic fracturing water cycle: water acquisition, chemical mixing, well injection, flowback and produced water, and wastewater treatment and waste disposal.[3]

A.6. Project Description

This research involves a standardized examination of the contents of hydrocarbon production well files received from nine oil and gas operating companies. The objectives of the well file review research include:

- Identifying any driving factors that pose a potential for impacts to drinking water resources;
- Identifying any evidence that there were impacts; and
- Describing the diversity of wells, geology, and hydraulic fracturing fluids and management practices employed at the wells reviewed.

Some of the information received by EPA was claimed as confidential business information (CBI) under the Toxic Substances Control Act (TSCA). Therefore, the analyses described in this section will be performed using CBI procedures and the results will be considered CBI until appropriate determinations are made or until appropriate masking has been done to prevent release of CBI information.

A.6.1. Intermediate Questions

EPA has developed intermediate questions as part of the well file review research project. Answers to these questions are expected to support the objectives of this research project and inform the overall research questions posed in EPA's *Plan to Study Hydraulic Fracturing and Its Impact on Drinking Water Resources* (EPA/600/R-11/122). These intermediate questions include:

- Is there data contained in the well files describing drinking water resources that could be affected by the well?
- Is there any evidence of potential hazards to drinking water resources identified by the geologic and site location data provided?
- What are the different types of hydrocarbon production environments and how do they relate to different types of well construction and hydraulic fracturing?
- Is the construction and completion of the well protective of drinking water resources?
- Were there any events identified during the drilling of the well that could potentially affect drinking water resources?
- Was there any change in surface or subsurface water quality before drilling and after completion of the well?
- Did the fluid injected or produced during and after stimulation of the well affect drinking water resources?

[3] See Table 22 of the *Progress Report* (EPA/601/R-12/011).

- What volumes of produced or flowback water were recovered, and what percent of recovered flowback and produced water was recycled?
- Did the outcome of the fracture stimulation fit the fracture design?
- Is there any evidence of spills, releases or problems, in the surface or subsurface?
- Is there other information relevant to potential impacts to drinking water that should be noted?

The methodology to be employed by the well file review team for answering these questions is described in Section A.6.2.

A.6.2. Data Review Methodology

Information obtained and recorded from the well file review has been and will continue to be captured in a database with appropriate controls established to protect CBI. Well file review team members individually exhibit competency to understand all well file contents in genera and are reviewing all subject areas within the files according to Table A.3. Ten percent of well file subject areas, per operating company, will be re-reviewed as part of the data quality process.

The well file reviewers will record findings methodically in either a spreadsheet for download to a Microsoft Access relational database or directly into a Microsoft Access relational database, which will then be used to analyze the resultant data obtained from all well files. The well file review team's initial list of data fields to record in the Microsoft Access database is shown in Appendix 2. The list of data fields may change as the team makes progress reviewing files and finds the need to further refine these data fields based on data actually supplied in the files. To the extent possible, recorded information will be quantitative. Information that cannot be described quantitatively will be recorded in an organized format if the information is relevant to the objectives. Individual queries will be developed for the database to provide output quantification of the results.

Table A.3. Well File Review Work Distribution

Subject Area Responsibility	File Reviewer
All except open hole interpretation	Glen Boyd
Database management and statistics	Guy Cole, David Bernstein
All including open hole interpretation	Charles Hillenbrand
All including open hole interpretation	Steve Souders
All except open hole interpretation	Chuck Tinsley
All except open hole interpretation	Nathan Wiser

A.6.2.1. Water Quality Monitoring

Files will be reviewed for evidence of initial baseline and follow up water quality monitoring. Initial baseline monitoring refers to water quality samples collected before drilling or prior to fracturing of the production well. Follow-up monitoring refers to water quality samples collected after drilling,

completion, and fracturing of the production well. Files will be reviewed for monitoring information associated with ground water resources, offset water wells, and nearby surface water resources as described below. Cadmus will perform a GIS overlay of the locations of the production wells for which EPA received well files and publicly available surface and ground water resources to identify water resources located within 0.5 mile of each production well.

Ground Water Resources. Files will be reviewed for evidence of ground water resources as identified during drilling and completion of the production well. Recorded data will include, if available, a description of the drinking water resources and their depth, available data and information about sampling date(s), analytical results (i.e., major anions and cations, organic chemicals, gases, and other analyses), and documentation regarding quality assurance and quality control.

Offset Water Wells. Files will be reviewed for evidence of offset water wells near the production well. Recorded data will include, if available, the source of information, a description of the offset well (e.g., well identifier, state of construction or abandonment), the location of the offset well (e.g., latitude, longitude, street address), total depth, and the available data and information about sampling date(s), analytical results (i.e., major anions and cations, organic chemicals, gases, and other analyses), and documentation regarding quality assurance and quality control.

Nearby Surface Water Resources. Files will be reviewed for evidence of surface water resources near the production well. Recorded data will include, if available, the source of information, a description of the surface water resource (e.g., lakes and streams), the location of the surface water resource, and available information about any sampling date(s), the sampling location (latitude, longitude, street address, other), analytical results (i.e., major anions and cations, organic chemicals, gases, and other analyses), and documentation regarding quality assurance and quality control.

Changes in Ground or Surface Water Quality. Files will be reviewed and evaluated for water quality change by comparing available initial baseline and follow-up water quality data collected from ground water resources, offset water wells, and nearby surface water bodies. This evaluation will include a description of the quality of the data based on available quality assurance and quality control information. As described in Section A.7, data will not be rejected unless it is obviously inconsistent with the well file being reviewed.

A.6.2.2. Well Siting Location and Geology

Files will be reviewed for information associated with well siting and geology, including surface locations, down hole locations, geologic target information, and nearby geologic and man-made features (e.g., surrounding production wells or geological faults) as described below.

Surface Locations. Well files are expected to contain location maps describing the proposed production well location using latitude and longitude coordinates, a public lands survey system (PLSS) convention description, or a location description within a state's own survey system. This information will be

tracked and compared with the final well location as reported in the completion report, if present. If latitude and longitude decimal degree coordinates are only available on the proposed location map and the location description from the survey system are consistent with the latitude and longitude coordinates, these decimal degree coordinates will be used. If there are no geographic coordinates provided, the survey system data will be plotted in ArcMap to produce the decimal degree coordinate. The source of the offset information and coordinates will be noted.

Down Hole Locations. If a deviation survey is provided, this will be used to identify the main kick-out depths and bottom hole location and corrected depths. "Kick-out" true vertical depth and true measured depth will be defined by the depth of the beginning of the intentional deviation.
If the completion report or another record indicates the bottom hole location is laterally within 500 feet of the surface location, the hole will be considered vertical for description purposes. Wells whose completions laterally follow a single geologic layer using directional drilling techniques are considered horizontal wells. Wells that are not horizontal, but whose bottom hole location is laterally equal to or greater than 500 feet from the surface location are considered deviated wells. If necessary, a calculation of lateral distance between the surface location and the bottom hole location will be done using triangulation, where the hypotenuse of the triangle is the reported measured total depth and the angle between vertical and the bottom hole location from the surface location is reported in the well record as the well's deviation or inclination angle. Variations on this calculation may be employed depending on which triangulation features are available from the file.

If no final completion report is available, the following expected sources of information will be relied upon , if available, and in decreasing order: driller's log, wellbore diagram, reviewer's best professional judgment based on any other information available in the file. There may be instances where the calculation of lateral distance between the surface location and the bottom hole location is not performed owing to a lack of information or insufficient confidence in the available information.

Geologic Target Information. If available from the well file, the geologic target map and accompanying cross-sections will be used to record the target formation name and to determine if a fault has been mapped and, if so, the shortest distance from the nearest portion of the wellbore to the fault. This will be done through use of display scales and a ruler.

Nearby Geologic and Man-Made Features. The longest fracture half length reported within the area will be used to define any possible well intersections between the well reviewed and nearby geologic (e.g., faults) and man-made features (e.g., offset wells).

A.6.2.3. Well Drilling Review

Well files are expected to contain information relating to drilling each well, including:

- Daily drilling records that describe each day's drilling progress,
- Casing tallies that list detailed descriptions of the casing joints installed,
- Casing integrity tests, and

- Reports on the mud or other drilling fluids used.

These records will be reviewed for the type of hole drilled, drilling fluid characteristics, and any notes regarding blow outs, kicks, shows or lost circulation. Mud logging records will also be reviewed to determine if any zones of significant formation pressure exist as signified by blow outs, kicks and zones of substantial mud weight increase. Mud logging records will also be reviewed to record data addressing hydrocarbon shows and zones of lost circulation. Drilling records will also be reviewed to determine if a surface casing shoe test was performed. In addition, the drilling and completion records will be reviewed to record perforation depths, as well as open hole completion information including the use of slotted casing set on formation packers.

A.6.2.4. Open-Hole Log Identification of Water and Hydrocarbon Resources.

The well files are expected to contain open-hole logs run in the wellbore, which are designed to measure the geophysical properties of rock. In most cases, the file will contain a log designed for the porosity determination (porosity logs) and a log designed to obtain formation fluid characteristics (resistivity logs). The suite of open-hole logs is expected to include caliper, gamma ray, neutron/density porosity, resistivity and often spontaneous potential or photoelectric measurements.

Open-hole logs in combination with mud logs (if available) will be reviewed to determine pay zone porosity and lithology. Natural gas indicators such as neutron-density crossover will be identified. Resistivity and porosity logs will be reviewed with respect to hydrocarbon production zone properties using accepted principles and methods, such as those described in Dewan (1983), Krygowski (2004), and Schlumberger (1991).

If a porous formation is present in the upper portion of the open hole, resistivity and porosity logs will be used to calculate formation apparent water resistivity (Rwa) as described in Dewan (1983) and Krygowski (2004). If a formation is fully saturated with connate water, Rwa will equal Rw, the true resistivity of formation water. However, the presence of hydrocarbons in a formation will produce a Rwa higher than the actual Rw. Spontaneous potential resistivity logs may also be used to calculate water resistivity (Rw) if hydrocarbons are not present in the formation. Rw and Rwa will be converted to a surface temperature of 75^{o} F and converted to NaCl salinity equivalent in parts per million. The presence of shallow gas may also be identified via neutron-density crossover on the porosity logs.

A.6.2.5. Casing and Cementing Procedures

Well files are expected to contain information describing how casing was cemented into the wellbore, including:

- Invoices detailing the amount and types of cement and other fluids used,
- Post-cement reports from service companies containing information such as cement yield (the amount of volume the hardened cement will occupy per sack of cement),
- Pump pressures used to circulate cement and other fluids into the wellbore to cement the casing, and

- Cement curing times before drilling the next deeper hole commenced.

The reviewer will use, if present, caliper logs run following each different drill bit size, as well as the record of casing installed in the well to calculate an approximate annular volume between the outside of the casing and the wall of the wellbore. The reviewer will calculate the hardened volume of cement pumped into the wellbore behind the casing, taking into consideration the cement yield for the given cement type used. These two volumes will be compared to provide an estimate of where the top of the cement behind the casing should be located for each string of casing installed.

Well files will be reviewed to determine whether any information was submitted regarding quality of cement sheath or other information indicating the location of the top of the cement sheath in a given portion of casing. Information expected to be contained in the well files includes at least one of the following:

- Standard acoustic cement bond logs run on production casing and possibly on other casing strings,
- Temperature logs run to locate thermal signature of heat of hydration when cement cures, or
- Radially directed acoustic cement bond logs which provide a circumferential evaluation of acoustic dampening in casing.

The most common log expected is the standard acoustic cement bond log. Review of standard acoustic cement bond logs will follow accepted principles and procedures (see Chapter 10 in Smolen 1995). The team will calculate the bond index at 10 foot intervals covering the first 100 feet immediately above the uppermost zone hydraulically fractured (if that part of the wellbore was logged) and at 50 foot intervals covering the remaining uphole portion of the log.

If temperature logs are found following cementing operations, the log will be evaluated to locate the signature of the top of cement behind the casing, which will be observed as warmth detected by the tool adjacent to cement curing and emitting heat in the exothermic hydration reaction of cement curing, and cooler temperatures observed when the tool is no longer adjacent to cement curing. This will look like a sudden deflection toward cooler temperatures once the tool has left the cement-curing environment.

If radially directed acoustic cement bond logs are present, they will be evaluated following similar principles used for reviewing standard acoustic cement bond logs, but will differ in that calculation of a bond index may not be possible to determine for each separate track representing its fraction of the casing circumference. Instead, the log will be viewed to locate overall changes in acoustic response that can be attributed, as applicable, to moving from denser to lighter cement, as well as vertical channels that can be identified by looking for differing acoustic responses in the separate log tracks representing different portions of the well's casing circumference. The top of overall cement behind the logged casing will be identified using best professional judgment unless otherwise depicted in noted on the logs.

In all cases where the top of cement can be observed on one of these logs, EPA's record of that depth will match the operator's reported cement top unless it is clear that the operator's reported cement top is in error. An example of this would be if the cement bond log shows the cement top at approximately 3,000 feet depth but the operator's report or wellbore diagram stated the top to be at 2,000 feet depth, then EPA would use the log's value. If, however, in this same example, the operator reported the cement top at 2,950 feet, then EPA would record that same value.

If no information exists in the well file regarding cement sheath quality or location of top of cement, then there can be no evaluation performed on quality of cement bond or vertical location of the top of cement and the reviewer will not perform any such review. The absence of such information will be noted.

A.6.2.7. Hydraulic Fracturing Procedures

Well file contents associated with the production well stimulation event will be reviewed and available values will be recorded. Anticipated information available to review from among the well files includes pre-frac reports containing recommended pumping procedures and estimated induced fracture dimensions, and post-frac reports containing data collected during fracture stimulation, which may include microseismic monitoring using geophone arrays and tiltmeter monitoring using sensitive tiltmeters. Data manipulation will be limited to simple mathematical summations or averaging if necessary, such as adding together individual volumes injected in given hydraulic fracturing stages to calculate the total amount injected. Identity and volumes of fluids and names of additives used will be recorded. Reports will also be reviewed to record the monitoring result, if any, in the annulus behind the casing used for hydraulic fracturing treatment.

Subjective reviews are anticipated for two areas within the hydraulic fracturing portion of the well file: pump-in charts showing the injection pressure and rate during fracturing and radioactive tracer surveys conducted. Review of the pump-in chart will include an interpretation of the submitted pressure graphs to identify unexpected decreases or increases of pressure which may indicate failure(s) in the subsurface geologic environment caused by the fracturing operations. Review of submitted radioactive tracer surveys will include an interpretation detecting where radioactive material was placed and whether such placement indicates there may be an endangerment to drinking water resources. These files will also be reviewed to record, for each hydraulic fracturing stage, the maximum and average treatment pressures, and the instantaneous shut in pressure following each stage.

In addition, files will be reviewed to record information about equipment pressure testing before or after fracture stimulation, management of hydraulic fracturing flowback fluids, and whether spills occurred (including noting any responses taken).

A.6.2.8. Management of Hydraulic Fracturing Fluid Flowback Subsequent to Well Stimulation

Well file contents associated with managing flowback fluids following fracture stimulation will be evaluated and available values will be recorded. Anticipated information to review includes volume of flowback fluid measured, date and duration of flowback, disposition of flowback fluid, analysis of flowback, descriptions of surface location where flowback fluid is stored, evidence of flowback recycling, and transportation methods used to convey flowback fluids away from the production wellbore. Data manipulation will be limited to simple mathematical summations or averaging if necessary, such as adding together individual volumes of flowback after hydraulic fracturing to calculate the total amount of flowback. The reviewer will also note, if available, whether any spills or other upset conditions are reported at the well site following hydraulic fracturing and describe the response taken.

A.6.2.9. Complaints

Well file contents will be reviewed for evidence of any complaints made by nearby residents or other interested parties. If present, these reports will be reviewed to determine the date of the complaint, the nature of the complaint and what type of environmental medium was alleged to have been impacted (e.g., air, water, soil, etc.), what response was taken and whether any determination was made regarding the source of the alleged impact.

A.7. Quality Objectives and Criteria

All of the analyses performed by EPA will be based on data submitted by the production companies, except for data provided to EPA by Cadmus as described in Section A.6.3. EPA does not make any claims on the quality or accuracy of the data or information received directly from the nine oil and gas operators as part of the information request. The goal of this QAPP is to ensure that the analyses described in Section A.6 are conducted properly using the available secondary information. Table A.5 describes EPA's acceptance criteria for data submitted by the nine oil and gas operators.

Table A.5. Well File Data Acceptance Criteria

Acceptance Criterion	Description/Definition	Specification
Unambiguous	For each submission of data responsive to each of the 24 different questions posed in Enclosure 4 of the August 11, 2011, letter, can the response be interpreted without confusion?	Where applicable, units of measure are identified. Responses to open-ended questions are clear. The question was interpreted consistently by the nine different oil and gas operators. The submission follows a logical time sequence.
Timeframe of data provided meets expectations	Is the hydraulic fracturing date consistent with the date provided by the hydraulic fracturing service companies?	The submission supplies hydraulic fracturing data indicating hydraulic fracturing occurred between September 2009 and October 2010, the responsive timeframe to EPA's September 2010 letter written to nine hydraulic fracturing service companies which generated the list of approximately 24,000 wells hydraulically fractured during this period.
Internal consistency	For an individual response, are the answers to one question consistent with answers to other questions?	Responses to multiple questions asking for similar or related information are comparable.
Completeness	For a given oil and gas operator, were all 24 questions answered? If no data was provided for a given question, did the operator explain why?	The data is expected to be among the potential data an operator might have in their files. If there is no responsive data, the operator should explain why not. There is no minimum amount of supplied data required in order to be useful for the project. Individual weights for each well file were assigned by Westat when the list of 350 wells was first compiled. For each well having responsive data, that data will carry an extrapolation weight factor calculated by Westat.
Representativeness	To what extent is the list of wells chosen representative of on-shore wells across the nation?	Westat prepared the list of 350 wells following the procedure explained in the *Progress Report* (EPA 601/R-12/011).
Comparability	Is the information provided from a given operator consistent with submissions from other operators?	Operators are expected to report data using similar drilling, completion, and hydraulic fracturing methods. Differences between operators will be noted by the well file review team as part of its report, but such differences will not render data unusable, but may limit comparisons between operators.

EPA will conduct a completeness review to ensure that available information requested was submitted, or if it was not submitted because it is claimed not to exist. Because this research necessarily involves review of existing data generated or collected by others, the quality of data within a well file will be acceptable for use in this research unless data inconsistency is so obvious its use is precluded, such as indicated if the wrong well's file was submitted. Furthermore, if the information reviewed indicates that

there was a failure of equipment that was none-the-less used to generate data provided, EPA will note this in its review as suspicious data and may elect to reject that data as unreasonable.

EPA will also consider the accuracy, precision and biases associated with the planned analyses of the data in the following ways:

Accuracy. Accuracy is defined as the agreement between technical experts on the correct interpretation of well file data. The well file reviews will be based primarily on data generated by production companies reviewed under the procedures described in Section A.6. The well file review team will review these files and extract as much relevant information as possible and record the data in standardized spreadsheets. To help ensure accuracy, the data reviewers will record information on spreadsheets that will contain data elements that will clearly identify important well inventory information (e.g., unique well identifiers), to ensure data is not mistakenly attributed to a different well. Further, a random subset of 10% of the well files reviewed will be reviewed again by a well file review team member different from the first reviewer, in order to ensure that the correct well file was reviewed and to compare data recorded by the different reviewers. In the event of discrepancies in data interpretation between the reviewers, the well file review team will meet to discuss the issues and agree to a common approach. These reviews will be documented using the form shown in Appendix 3 or an equivalent. The goal is to have 100% accuracy of data transcription from the industry submitted files to the well file reviewer's spreadsheets to the well file database.

Data Precision. Precision for the well file review effort will be defined as correct entry of data into spreadsheets and databases as determined though duplicate data entry or similar procedures. The goal is to have 100% agreement on duplicate data entries. Analysis of key data fields for those files that have undergone duplicate reviews will include calculation of a standard error, where differences between the original and duplicate review are found. The standard error will then be applied to all values of that key data field.

Bias. As noted under "accuracy" above, the team will re-examine a random subset of 10% of the well files for review by a different person, and the results will determine whether any significant bias was introduced by the review team. In this project, "bias" means different interpretations of the same data by different reviewers.

A.8. Special Training and Certification

The well file review team staff who work on this project exhibit competency to understand all well file contents. Each reviewer has spent many years either working in the oil and gas industry or overseeing the oil and gas industry in such manner that the contents of well files, including the information on well construction, geology, cementing and fracturing, is within their area of expertise.

During the course of the analysis, all well file reviewers will access and analyze confidential business information (CBI) authorized under the Toxic Substances Control Act (TSCA). Reviewers will adhere to

CBI procedures when handling CBI and will manage all reports, documents, and other materials developed in accordance with the procedures set forth in EPA's *TSCA CBI Protection Manual*.[4] Reviewers will maintain active TSCA CBI clearance, and all work involving TSCA CBI will be completed on the approved TSCA CBI computer assigned to the reviewer.

A.9. Documentation and Records

The well file review team will maintain its record of results using either individual spreadsheets or by individual copies of a Microsoft Access database built to provide multiple types of query results. Each spreadsheet will contain the following elements to ensure proper database downloads: well name, API number, field, state, county, and well operator.

All personnel working on this task will receive this QAPP. If there are amendments to the QAPP, personnel will also receive those updates via electronic mail to ensure they have the most recent version.

CBI data-handling will be conducted using TSCA CBI procedures in the EPA's *TSCA CBI Protection Manual*.

B. Data Generation and Acquisition

This section addresses data acquisition and management activities.

B.1. & B.2. Sampling & Sampling Methods

The process used to select the operators and wells is described in Section 3.4 of EPA's *Study of the Potential Impacts of Drinking Water Resources: Progress Report* (EPA/601/R-12/011).

B.3. Sample Handling and Custody

"Samples" within this research project refer to data submitted by the nine oil and gas operators in response to letters sent on August 11, 2011, requesting well file information expected to be in their possession. Data was originally submitted to EPA's contractor, ERG, where it was logged in and, if a claim of confidentiality accompanied the data, a document control number assigned to the submission unless one was already assigned by the company sending the data. ERG performed a completeness check to determine which of the 24 specific questions in EPA's letter had a response and to determine which of the wells EPA specified in the letter were among the wells included in the submitted data. Future data submissions, if necessary, will be sent directly to EPA offices in Washington, DC. In all cases, information claimed as CBI will be handled and transmitted according to the procedures described in EPA's *TSCA CBI Protection Manual*.

[4] The *TSCA CBI Protection Manual* is available online at http://www.epa.gov/oppt/pubs/tsca-cbi-protection-manual.pdf.

B.4. Analytical Methods

Data submitted by the nine oil and gas operators is being analyzed using the methodology described in Section A.6.2. Further analyses will be performed on the data saved in the Microsoft Access database described in Appendix 2 to address the intermediate questions listed in Section A.6.1. Analyses will include, but not be limited to, the following types of queries on the data:

- How many wells are located near or pass through drinking water resources?
- How many spill incidents were recorded and what follow up happened?
- How many and of what nature are complaints associated with these wells?
- How many wells had pressure irregularities noted during hydraulically fracturing?
- How many wells were constructed in a manner protective of drinking water resources?
- The distribution of length spans of cement sheath above the uppermost hydraulically fractured zone.
- The distribution of the quality of cement bond above zones hydraulically fractured
- How many wells were pressure-tested for mechanical integrity before hydraulic fracturing?
- How many wells were pressure-tested for mechanical integrity after hydraulic fracturing?
- How many wells were monitored at the wellhead during hydraulic fracturing and what type of monitoring took place?
- How many wells had other monitoring methods and what were the types of monitoring that took place before, during and after hydraulic fracturing?
- How many wells reported an event that implied an impact to a drinking water resource?
- How much flowback was reported at each well after it was hydraulically fractured?
- How much flowback was disposed and what were the disposal types used?
- How much flowback was recycled and what were the recycling methods used?
- How many wells had created fractures of a known length, height, and azimuth?
- What types of fluid additives were used in each hydraulic fracturing event?
- Is there a distribution pattern of fluid additives used in hydraulic fracturing, either by geography or reservoir type, and if so, what is the pattern?
- The distribution of different lithologies hydraulically fractured
- The distribution of different well completion types, vertical and horizontal
- The distribution of depth spans separating hydraulic fracturing zones and underground sources of drinking water

B.5. Quality Assurance and Quality Control

As noted in Section A.7 (under “accuracy”), a random 10% of the well files will be reviewed by different reviewers to ensure accuracy and that lack of bias is maintained by the well file review team. Further, when the database is queried to answer questions such as those posed in Section B.4, if any irregularities appear from the query results, the data in the fields used for the queries will be re-examined for possible data entry error. If errors are detected, they will be corrected in the database and the query re-run.

The use of standardized data fields to record the research findings including field definitions will also ensure that well file review team records data in a reliable fashion. The data fields include standardized units of data, such as feet or gallons, to ensure consistent values are recorded.

B.6. Instrument / Equipment Testing, Inspection and Maintenance

Laptop computers used to review CBI data have been scanned for viruses. From time to time, as new data may be transmitted to the well file review team, virus scans will be updated through consultation with local information technology support. Back up versions of spreadsheets containing the recorded data will be made by burning the file to a disk.

B.7. Instrument / Equipment Calibration and Frequency

This section does not apply because there are no direct measurements/experiments anticipated for this project. Therefore, no instruments will be used.

B.8. Inspection / Acceptance of Supplies and Consumables

Computers used to record well file data claimed as confidential are configured to ensure they meet protocols in the TSCA CBI Protection Manual, including removing the machine's ability to connect to servers and the internet. Most of the submitted data is in an electronic format that can be transferred to these configured laptop computers using supplied disks. Each incoming submission from the nine oil and gas companies is visually examined to determine whether a claim of confidentiality is made.

B.9. Non-Direct Measurement Data

This project, by its nature of reviewing existing data generated elsewhere, entails the use of non-direct measurement data. Section A.6.2 describes the origin of the data being reviewed and Section A.7 describes that data will generally be accepted for inclusion in the review unless an obvious error precludes its use, such as the data is from the wrong well file.

B.10. Data Management

The *Hydraulic Fracturing Plan Quality Management Plan*[5] sets forth several descriptions of data management, including use of a centralized O:\ drive to store important records, file naming conventions, email disposition, and use of a science file transfer protocol site for larger electronic files. Since much of the data reviewed and summarized in this project will be treated as CBI, use of the many of these types of data management areas will not be permissible unless the CBI claim is lifted. The file review team will maintain, handle, and transmit CBI in accordance with the applicable requirements found in the TSCA CBI Protection Manual, which includes storage of paper and electronic data on disks locked in secure storage areas such as a combination safe. For data not considered CBI, the file review team will use a combination of email to the Technical Project Manager and storage of data on the O:\ drive.

[5] The *Quality Management Plan* is available online at http://www2.epa.gov/sites/production/files/documents/HF-QMP-1-19-2012.pdf.

C. Assessment and Oversight

This section describes the audits and other assessments needed to determine whether this QAPP is being implemented as approved and to increase confidence in the information obtained and produced as a result of this project.

C.1. Assessment and Response Actions

Audits of the data recorded by the well file review team, as well as the database in which the data is maintained, will be performed in a manner consistent with the December 12, 2011, the *Hydraulic Fracturing Quality Management Plan.* Audits will, at a minimum, consist of technical system audits, to be performed by the project QA Manager. Results of audits will be incorporated into QAPP revisions, if warranted.

C.2. Reports to Management

The Technical Project Manager will provide updates to management as requested and will provide a final report. Periodic updates will occur during monthly and quarterly meetings or video/teleconferences among other principal investigators working on other research projects associated with EPA's study. The final report(s) will include:

- Quality assurance activities performed during the period,
- Identification of any problems encountered,
- Identification of any deviations from the QAPP, and
- Identification of problem resolution and/or corrective actions taken during the period, if any.

D. Data Validation and Usability

This section addresses the quality of the completed final report to see if this product will conform to the objectives outlined in this QAPP, especially given this project's use of existing datasets.

D.1. Data Review, Verification and Validation

EPA requirements for QAPPs specify that there be two types of analysis for each data item:

1. Process for verification. Verification confirms that the required quality control acceptance criteria have been met, as described in section A.7.
2. Process for validation. Validation confirms that the requirements for a specific intended use have been fulfilled and determines whether specific user needs have been met.

These analyses typically apply to data such as field or laboratory measurements. Data verification and validation for this project requires the review team to:

1. Perform a completeness check of the submitted data from the production companies to determine whether each of the 24 items EPA requested is present or, if not, if it is claimed not to exist.
2. Perform a second review of a random 10% of the well files to ensure accuracy and lack of bias.

D.2. Verification and Validation Methods

The verification procedures consist primarily of examination of the well file data in the first instance to ensure data is consistent with its intended use (i.e., the correct well is identified) and also to examine a random 10% of well files by a second well file team member to ensure accuracy and lack of bias.

The EPA Technical Project Manager will examine spreadsheet contents from well file reviewers and also examine data entered into the database to ensure proper downloads take place. The project QA Manager may also examine information entered into the database as well as a spreadsheets used by well file reviewers to ensure accurate downloads occur.

D.3. Reconciliation with User Requirements

Following the methods for verification and validation described in sections D.1 and D.2, the well file review team and EPA Technical Project Manager will perform the necessary verification and validation to determine whether data is of sufficient quality for use in database query analyses. Since acceptance criteria for data submitted in well files, as defined in Section A.7, is to generally accept data, the remaining data validation will be that described in Sections A.7 and D.2 (re-reviewing a random 10% of well files). This process ensures that different file reviewers reach the same conclusions about data recorded and, therefore, ensures that data entering the database is accurate, precise, and unbiased. After this has taken place, data will be fully reconciled and can be used for data analyses using database queries.

Revision History

Revision Number	Date Approved	Revision
0	Jan. 4, 2012	New document
1	Aug. 19, 2013	• Update to Table A.3. Well File Review Work Distribution • Update to Table A.4. Projected Schedule for Research • Modifications and updates to Section A.6.2

References

Dewan, J.T. 1983. Essentials of Modern Open-Hole Log Interpretation. PennWell Corp, Tulsa, Oklahoma.

Jorgensen, D.G. 1991. Estimating Geohydrologic Properties from Borehole-Geophysical Logs. *Groundwater Monitoring & Remediation* 11 (3): 123-129.

Krygowski, D. 2004. Basic Well Log Analysis. 2nd ed. American Association of Petroleum Geologists, Tulsa, Oklahoma.

Schlumberger. 1991. Log Interpretation Principles/Applications. Schlumberger, Sugar Land, Texas.

Smolen, J.J. 1995. Cased Hole and Production Log Evaluation. PennWell Corp, Tulsa, Oklahoma.

Appendix 1. Information Request Letter

«Title» «First_Name» «Last_Name» «Company_Name»
«Address_Line_1»
«Address_Line_2»
«City», «State» «ZIP_Code»

Dear «Title» «Last_Name»:

I am writing to request your cooperation in a study being conducted by the U.S. Environmental Protection Agency (EPA, or the Agency) on the potential relationship between hydraulic fracturing and drinking water resources. Additional information on the study can be found at www.epa.gov/hydraulicfracturing.

As part of our study, we are collecting information to improve our understanding of the role of well performance during hydraulic fracturing as it relates to well design, construction, and completion practices. EPA's peer-reviewed *Draft Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources*, which underwent extensive public comment, explains the purpose of the study, our goals, and our intent to analyze a selection of hydraulically fractured wells.[6]

In late 2010, EPA received information from nine hydraulic fracturing service companies in response to a letter sent to them in September 2010. The companies identified wells for which they had provided hydraulic fracturing services and the operator of each well. Using a random sample and commonly accepted statistical procedures, EPA arrived at a list of wells operated by nine companies that reflect both geographic diversity and operator size. The list enclosed in this letter includes wells selected for this analysis that are wells owned and/or operated by your company.

The enclosures provide additional background information and a list of the items requested by EPA. This information—together with a literature review, assessment of data and information from states and communities, case studies, laboratory work, and computer modeling—will allow EPA to perform a more thorough assessment of the potential impacts of hydraulic fracturing on drinking water resources. Unless otherwise specified, we are not requesting that you create new data or information.

Natural gas is a key part of the portfolio for our nation's energy future, and your assistance will help us to ensure that the development of domestic sources of energy proceeds in a way that protects our environment and our health. As a next step, I'd like to arrange a meeting to discuss this information request and how we can most effectively work together to inform this important scientific study. Because the thoroughness of our study depends on timely access to detailed information about well design, construction, and completion practices, we would like to receive the well files requested in this letter within thirty (30) days of the date of this request.

[6] U.S. EPA. *Draft Plan to Study the Potential Impacts on Drinking Water Resources.* EPA/600/D-11/001. February 2011. Page 32.

If you have any questions, your staff may contact Jeanne Briskin (202-564-4583 or briskin.jeanne@epa.gov) or Nathan Wiser (303-312-6211 or wiser.nathan@epa.gov) in the Office of Research and Development.

Sincerely,

Kevin Y. Teichman
Deputy Assistant Administrator for Science
Office of Research and Development

Enclosures

1. Information Request Details
2. Information Request Instructions
3. Information Request Definitions
4. Information Requested
5. List of Wells
6. List of Approved Contractors to Review Data
7. Two blank CDs

ENCLOSURE 1
INFORMATION REQUEST DETAILS

The U.S. Environmental Protection Agency is conducting a study to investigate the potential impact that hydraulic fracturing may have on drinking water resources and public health.

The Agency is undertaking the hydraulic fracturing study at the request of the U. S. Congress, specifically the Appropriations Conference Committee of the House of Representatives. In its Fiscal Year 2010 budget report, the Committee asked EPA to carry out a study on the "relationship between hydraulic fracturing and drinking water, using a credible approach that relies on the best available science, as well as independent sources of information." EPA requests your cooperation in providing information to support the study. We understand that well design and construction is integrally related to the potential for drinking water impacts from hydraulic fracturing. Therefore, we are requesting detailed information on well design and construction for hydraulically fractured wells.

To help EPA evaluate the potential impact of hydraulic fracturing on drinking water resources and public health, EPA requests that you provide full and complete information in response to the questions set forth in this enclosure. **Please provide the information within thirty (30) days of the date of this request.**

EPA has contracted with Eastern Research Group (Contract Number EP-C-10-023) to assist in the review of the documentation you provide, including documents which you claim as Confidential Business Information (CBI). Please see Enclosure 6 of this letter for complete information regarding contractor access to CBI.

All submissions should be addressed to:

Carissa Erickson,
Toxic Substances Control Act Document Control Officer
U.S. Environmental Protection Agency
Hydraulic Fracturing Information Request
Care of:
Eastern Research Group
14555 Avion Parkway, Suite 200
Chantilly, VA 20151

Additionally, EPA requests that within seven (7) days of receipt of this request, you provide notice as to whether or not you will submit all of the information requested. *Please notify Nathan Wiser regarding your decision at* wiser.nathan@epa.gov.

Data provided in response to this request may be claimed as CBI and if so, will be handled in accordance with EPA confidentiality regulations at 40 CFR Part 2, Subpart B. All responses that contain information claimed as CBI must be clearly marked as such. Persons submitting information, any portion of which they believe is entitled to treatment as CBI by EPA, must assert a business confidentiality claim in accordance with 40 CFR 2.203(b) for each such portion. This claim must be made at the time that the information is submitted to EPA. If a submitter does not assert a confidentiality claim at the time of

submission, EPA will consider this as a waiver of any confidentiality claim and the information may be made available to the public by EPA without further notice to the submitter.

The Agency is requesting that you provide this information voluntarily; however, to the extent that EPA does not receive sufficient data in response to this letter, EPA will be exploring legal alternatives to compel submission of the needed information. Since EPA will be considering using its legal authorities to require submission if necessary, the standard for any determination of eligibility for confidential treatment will be that which applies to information that has been submitted pursuant to a requirement by EPA. By submitting information in response to this letter, you are agreeing to this standard.

Please read this enclosure carefully and follow the directions provided. Directions for properly submitting information responsive to this request and for claiming CBI are included in the enclosure. Depending on the information you may provide in response to this request, EPA may follow up with a request for your voluntary submittal of additional information.

The Agency requests that the information you submit be verified by, and submitted under an authorized signature by, a responsible corporate officer,[7] with the following certification:

> I certify that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, I certify that the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

[7] The term "responsible corporate officer," as used herein, means a president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision-making functions for the corporation.

ENCLOSURE 2
INFORMATION REQUEST INSTRUCTIONS

EPA requests that you follow the instructions below in developing and submitting responses to this information request:

A. Respond to Each Request Completely. Each request is numbered and may contain subparts identified by lowercase letters. Each question posed should be answered. If the appropriate response is "none" or "not applicable," that information should be so stated. You should also submit any documents you relied on in preparing your response.

B. Source(s) of Response. Include with response, the name, position, and title of each person(s) who provided information responsive to the request.

C. Electronic Submittal. You are encouraged to submit your responses as one or more electronic files on a CD or similar media storage device in a form that allows EPA to readily retrieve and utilize the information using commercially available software. To that end, EPA requests that your responses be provided on the CDs enclosed with this request. Your electronic files should be accompanied by a letter that identifies the file software and version, file name(s), size(s), date(s), and time(s) of creation. Your electronic files should include any documents you relied on in preparing your responses.

D. Paper Submittal. To the extent you cannot provide responses in an electronic format, you may provide paper copies of responsive documents.

E. Submitting Maps. When submitting maps, identify the scale of the map, the map title and an explanation of what the map depicts. When identifying features on the map, either label the feature at its location on the map or include in the map's legend the symbol used for identifying the feature.

F. Submission of Documents. Label each document submitted with the request number and subpart (if applicable) to which it corresponds. Date stamp each document you submit. If anything is deleted from a document produced in response to this request, state the reason for and the subject matter of the deletion.

G. Documents Responsive to More than One Request. If a document you submit is responsive to more than one request, please provide one copy of the document and identify all the requests, by number and subpart, to which it corresponds.

H. Do Not Substitute Derivative or Summary Documents. Where a document is requested, please provide the responsive document. You may, if you wish, provide additional or explanatory documents to accompany the responsive document(s).

I. Provide the Best Information Available. Unless otherwise specified, we are not requesting that you create new data or information. However, you should provide responses to the best of your ability, even if the information sought was never put down in writing or if the written

documents are no longer available. You should seek responsive information from current and former employees and/or agents. If you cannot provide a precise answer to any questions, please approximate and state the reason for your inability to be specific.

J. Unavailability of Records. If you are unable to respond to a request in a detailed and complete manner, or if you are unable to provide any of the information requested, indicate the reason for your inability to do so. If a record(s) responsive to a request is not in your possession, custody, or control and you have reason to believe that another person may be able to provide it, state the reasons for your belief and provide the person's name, address, telephone number, and any information available (i.e., author, date, or subject matter) about the record(s).

K. Documents That Have Been Transferred. If any records responsive to a request have been transferred or otherwise disposed of, identify the document, identify the person to whom it was transferred, describe the circumstances surrounding such transfer or other disposition, and state the date or approximate date of such transfer or other disposition.

L. Provide and/or Correct Information on a Continuing Basis. If any records responsive to a request are not known or are not available to you at the time you submitted your response, but later become known or available to you, you should submit the new information as a supplement to your response. If at any time after submission of your response you learn that any portion is or becomes false, incomplete, or misrepresents the facts, you should notify EPA of this fact as soon as possible and provide a corrected response. If any part of the response to this information request is found to be false, the signatory to the response and the company may be subject to criminal prosecution.

M. Identify Personal Privacy Information. Personnel and medical files, and similar files, the disclosure of which to the general public may constitute an invasion of privacy, should be segregated from your responses, included on separate sheet(s), and marked as "Personal Privacy Information." You should note, however, that unless prohibited by law, EPA may disclose this information to the general public without further notice to you.

N. Indicate Objections to Requests. While you may indicate that you object to certain requests contained in this information request, EPA requests that you provide responsive information notwithstanding those objections.

O. Claims of Privilege. If you claim that an entire document responsive to this information request is a communication for which you assert that a privilege exists, identify the document and provide the basis for asserting the privilege. For any document for which you assert that a privilege exists for a portion of it, provide the portion of the document for which you are not asserting a privilege; identify the portion of the document for which you are asserting the privilege; and provide the basis for such an assertion. Please note that regardless of the assertion of any privilege, any facts contained in the document which are responsive to this information request should be disclosed in your response.

P. Confidential Business Information. You should provide the information requested even though you consider it confidential information or trade secrets. You may assert a business

confidentiality claim for part or all of the information requested, as described below and set forth in 40 C.F.R. Part 2, Subpart B. Information covered by such a claim will be disclosed by EPA only to the extent and only by the procedures set forth in 40 C.F.R. Part 2, Subpart B. If no confidentiality claim accompanies the information when EPA receives it, the information may be made available to the public by EPA without further notice to you.

If you wish EPA to treat any information or response as "confidential," you must advise EPA and comply with the following procedures. Place on or attach to the information at the time it is submitted to EPA a cover sheet, stamped or typed legend, or other suitable form of notice employing such language as *trade secret, proprietary,* or *company confidential*. You must clearly identify allegedly confidential portions of otherwise non-confidential documents. Please submit these separately to facilitate identification and handling by EPA. The Agency will ask you to substantiate each claim of confidential business information by separate letter in accordance with applicable EPA regulations, 40 C.F.R. Part 2, Subpart B.

ENCLOSURE 3
INFORMATION REQUEST DEFINITIONS

Please use the following definitions for purposes of responding to the questions set forth below:

Except as otherwise defined below, terms in this information request have the same definition used in the CWA, 33 U.S.C. §§ 1251 through 1387, and TSCA, 15 U.S.C. §§ 2601 through 2695d, and the regulations promulgated thereunder.

A. The terms "and" and "or" shall be construed either disjunctively or conjunctively as necessary to bring within the scope of this information request any information which might otherwise be construed to be outside its scope.

B. The term "any," as in "any documents," for example, shall mean "any and all."

C. The term "base fluid" means the liquid or gas to which additives are mixed and pumped into a well for fracturing purposes. A base fluid may or may not be aqueous.

D. The term "cement" means cement or other grouting material used within the well to anchor well casing and isolate geologic strata.

E. The term "Company" shall mean the entity identified as the addressee on the cover letter to this information request, and all related and affiliated corporate entities (including, but not limited to, parent corporations, subsidiaries, joint ventures, partnerships, and affiliates) that control the operation of wells listed in Enclosure 5.

F. The term "describe" means to detail, depict, or give an account of the requested information, or to report the content of any oral and/or written correspondence, communication, or conversation, or to report the contents of any document, including the title, the author, the position or title of the author, the addressee, the position or title of the addressee, indicated or blind copies, date, subject matter, number of pages, attachment or appendices, and all persons to whom the document was distributed, shown, or explained.

G. The term "documentation" shall mean any information subject to any method of recording, storage, or transmittal, and shall include any information now or formerly in your possession, custody or control, or now or formerly in the possession, custody or control of any agent acting on your behalf. "Document" shall include, but not be limited to:

    1. Writings of any kind, formal or informal, whether or not wholly or partially in handwriting, typed form, or printed form, including drafts, originals, and nonconforming copies that contain deletions, insertions, handwritten notes or comments, and including (by way of illustration and not by way of limitation) any of the following:

        a. invoices, receipts, endorsements, checks, bank drafts, canceled checks, deposit slips, withdrawal slips, orders;

b. letters, correspondences, faxes, telegrams, telexes, electronic communications including, but not limited to, e-mails and other correspondence using computers or other electronic communication devices;
c. minutes, memoranda of meetings and telephone and other conversations, telephone messages;
d. agreements, contracts, and the like;
e. log books, diaries, calendars, desk pads, journals;
f. bulletins, circulars, forms, pamphlets, statements;
g. reports, notice, analysis, notebook;
h. graphs, charts; or
i. records, pamphlets, surveys, manuals, statistical compilations, pictures.

2. Microfilm or other film record, photograph, or sound recording on any type of device.

3. Any tape, disc, or other type of memory generally associated with computers and data processing, together with:

   a. the programming instructions and other written material necessary to use such disc, disc pack, tape, or other type of memory; and
   b. printouts of such disc, disc pack, tape, or other type of memory.

4. Attachments to or enclosures with any document.

H. The term "field" means the formally designated and named, or generally understood, oil or gas field, where the objective of drilling a well is to extract hydrocarbons from one or more geologic horizons. A "field" is usually contiguous, may or may not be unitized, and represents a uniquely identified reservoir of hydrocarbons indentified for production.

I. The term "flowback" as used in this information request refers to the water mixture produced when the hydraulic fracturing procedure is completed and pressure is released, and the direction of fluid flow reverses. The well is "cleaned up" by allowing the spent fracturing fluid mixture and excess proppant to flow up through the wellbore to the surface. This term is sometimes interchangeably used with "produced water" as defined in section M below.

J. The term "identify" or "provide the identity of" means, with respect to a person to set forth: (a) the person's full name, (b) present or last known business and home addresses and telephone numbers; (c) present or last known employer (including the full name and address), with job title, and position or business;

K. The term "identify" or "provide the identity of" means, with respect to a corporation, partnership, business trust, government office or division, or other entity (including a sole proprietorship), to set forth: (a) its full name; (b) complete street address; (c) legal form (e.g. corporation, partnership); (d) the state under whose laws the entity was organized; and (e) a brief description of its business.

L. The term “identify” or “provide the identity of” means, with respect to a document, to provide: (a) its customary business description (e.g., letter, invoice); (b) its date; (c) its number if any (e.g., invoice or purchase order number); (d) the identity of the author(s), the address, and the addressee(s) and/or recipient(s); (e) and a summary of the substance or the subject matter.

M. The term “produced water” as used in this information request refers to the water mixture produced when the drilling and fracturing of the well are completed, and the well is being developed or has been placed on production following a period when “flowback” fluids are produced. Some of this water may be returned fracture fluid otherwise meeting the “flowback” definition in section I above.

N. The term “site” means a property where natural gas or oil drilling and related activities occur, including all areas within the exterior boundaries of that property. Multiple wells may be located at a single site.

O. The term “well” or “wellbore” means each uniquely named and numbered drilled hole with conveyed casing and completed for the purpose of extracting or aiding in the extraction of oil or gas from the subsurface.

ENCLOSURE 4
INFORMATION REQUESTED

Your response to the following questions is requested within thirty (30) days of receipt of this information request:

For each well listed in Enclosure 5 of this letter, provide any and all of the following information:

Geologic Maps and Cross Sections

1. Prospect geologic maps of the field or area where the well is located. The map should depict, to the extent known, the general field area, including the existing production wells within the field, preferably showing surface and bottom-hole locations, names of production wells, faults within the area, locations of delineated source water protection areas, and geologic structure.

2. Geologic cross section(s) developed for the field in order to understand the geologic conditions present at the wellbore, including the directional orientation of each cross section such as north, south, east, and west.

Drilling and Completion Information

3. Daily drilling and completion records describing the day-by-day account and detail of drilling and completion activities.

4. Mud logs displaying shows of gas or oil, losses of circulation, drilling breaks, gas kicks, mud weights, and chemical additives used.

5. Caliper, density, resistivity, sonic, spontaneous potential, and gamma logs.

6. Casing tallies, including the number, grade, and weight of casing joints installed.

7. Cementing records for each casing string, which are expected to include the type of cement used, cement yield, and wait-on-cement times.

8. Cement bond logs, including the surface pressure during each logging run, and cement evaluation logs, radioactive tracer logs or temperature logs, if available.

9. Pressure testing results of installed casing.

10. Up-to-date wellbore diagram.

Water Quality, Volume, and Disposition

11. Results from any baseline water quality sampling and analyses of nearby surface or groundwater prior to drilling.

12. Results from any post-drilling and post-completion water quality sampling and analyses of nearby surface or groundwater.

13. Results from any formation water sampling and analyses, including data on composition, depth sampled, and date collected.

14. Results from chemical, biological, and radiological analyses of "flowback," including date sampled and cumulative volume of "flowback" produced since fracture stimulation.

15. Results from chemical, biological, and radiological analyses of "produced water," including date sampled and cumulative volume of "produced water" produced since fracture stimulation.

16. Volume and final disposition of "flowback."

17. Volume and final disposition of "produced water."

18. If any of the produced water or flowback fluids were recycled, provide information, including, but not limited to, recycling procedure, volume of fluid recycled, disposition of any recycling waste stream generated, and what the recycled fluids were used for.

Hydraulic Fracturing

19. Information about the acquisition of the base fluid used for fracture stimulation, including, but not limited to, its total volume, source, and quality necessary for successful stimulation. If the base fluid is not water, provide the chemical name(s) and CAS number(s) of the base fluid.

20. Estimate of fracture growth and propagation prior to hydraulic fracturing. This estimate should include modeling inputs (e.g., permeability, Young's modulus, Poisson's ratio) and outputs (e.g., fracture length, height, width).

21. Fracture stimulation pumping schedule or plan, which would include the number, length, and location of stages; perforation cluster spacings; and the stimulation fluid to be used, including the type and respective amounts of base fluid, chemical additives and proppants planned.

22. Post-fracture stimulation report containing, but not limited to, a chart showing all pressures and rates monitored during the stimulation; depths stimulated; number of stages employed during stimulation; calculated average width, height, and half-length of fractures; and fracture stimulation fluid actually used, including the type and respective amounts of base fluid, chemical additives and proppants used.

23. Micro-seismic monitoring data associated with the well(s) listed in Enclosure 5, or conducted in a nearby well and used to set parameters for hydraulic fracturing design.

Environmental Releases

24. Spill incident reports for any fluid spill associated with this well, including spills by vendors and service companies. This information should include, but not be limited to, the volume spilled, volume recovered, disposition of any recovered volume, and the identification of any waterways or groundwater that was impacted from the spill and how this is known.

ENCLOSURE 5
LIST OF WELLS

Well Identifier	State	County

Appendix 2. Well File Review Database

Microsoft Access Database

A Microsoft Access database will be used to house the data recorded by the well file review team. Database queries will be constructed to address objectives listed in Section A.6 and including the specific questions posed in Section B.4. The database is built to include the list of database fields shown below. Each well file review team member will attempt to record or calculate, as necessary, the information to complete each data field for each well file. If data is not available or cannot be computed from a given well file for a given data field, it will be left blank for that well. The list of data fields may change as the team makes progress reviewing files and finds the need to further refine these data fields based on data actually supplied in the files.

Table 2.1. Potential Data Fields

FIELD NAME	DESCRIPTION
Operator	Well operator
Well_name	Well name
API_No	API number (22-333-55555; entered as number, formated as ##"-"###"-"#####)
Production_Field_Name	Name of oil or gas field
Production well location	
State	State where well is located
County	County where well is located
Sec	Production well section number from S-T-R
Twn	Production well township number and direction from S-T-R
Rge	Production well range number and direction from S-T-R
Accuracy	Accuracy of surface location
Fsl	Offset from section boundary; from the south line (ft), only entered if no coordinates found and available
Fel	Offset from section boundary; from the east line (ft), only entered if no coordinates found and available
Fnl	Offset from section boundary; from the north line (ft), only entered if no coordinates found and available
Fwl	Offset from section boundary; from the west line (ft), only entered if no coordinates found and available
Latitude	Production well latitude (degree, decimel convention)

Table 2.1. Potential Data Fields	
FIELD NAME	**DESCRIPTION**
Longitude	Production well longitude (degree, decimel convention)
Projection	Lat/long coordinate system base (e.g., NAD83, WGS84, etc)
GL_msl	Production well elevation above sea level
KB	KB elevation (above sea level)
Survey	Survey or lease name, only entered if no coordinates found and available
Abstract	Abstract or next division of lease description, only entered if no coordinates found and available
Block	Block number or next division of lease description, only entered if no coordinates found and available
Ls_Sec	Lease section number if given, only entered if no coordinates found and available
L_FSL	Offset from lease boundary; from the south line (ft), only entered if no coordinates found and available
L_FEL	Offset from lease boundary; from the east line (ft), only entered if no coordinates found and available
L_FNL	Offset from lease boundary; from the north line (ft), only entered if no coordinates found and available
L_FWL	Offset from lease boundary; from the west line (ft), only entered if no coordinates found and available
Directional data	
Vertical	Is the well vertical? No, means deviated. Yes, bottomhole within 5% offset of surface location.
Kick_TVD	Production well kickoff point TVD (True Vertical Depth)
Kick_MD	Production well kickoff point TMD (True Measured Depth)
Kick_fsl	Offset (feet) from surface location, if available
Kick_fnl	Offset (feet) from surface location, if available
Kick_fwl	Offset (feet) from surface location, if available
Kick_fel	Offset (feet) from surface location, if available
Kick_latitude	Production well latitude kickoff point (degree, decimel convention)
Kick_longitude	Production well longitude kickoff point (degree, decimel convention)
Bhl_latitude	Production well bottom hole latitude

Table 2.1. Potential Data Fields	
FIELD NAME	**DESCRIPTION**
Bhl_longitude	Production well bottom hole longitude
Bhl_fsl	Offset (feet) from surface location, if available
Bhl_fnl	Offset (feet) from surface location, if available
Bhl_fwl	Offset (feet) from surface location, if available
Bhl_fel	Offset (feet) from surface location, if available
Map data	
Map_bh	Is production well spotted on provided map
Map_S_ft	If relevant, shortest distance from wellbore to fault (ft)
Other_wells_on_map_boolean	Other wells that have penetrated target formation within maximum fracture length estimated / measured within field?
Other_types	Are other well types (e.g. production, injection, other) present within 1/4 mile?
Other_status	Are well status (PA, PR, AC, etc) symbols shown within 1/4 mile?
Count_wells	Count of other wells in 1/4 mile by status
Geology	
Geol_points	Any critical and relevant information obtained from the geology
Drinking water resources GIS	
Count_of_GW_wells	Number of GW wells within 1/2 mile of well surface location
GW_well_max_depth	Maximum depth of deepest GW well within 1/2 mile of surface location
Count_of_surface_water_drinking_water resources	Number of surface water bodies within 1/2 mile of surface location that may serve as drinking water
Count_of_all_surface_water	Number of all surface water features within 1/2 mile of surface location
Count_of_surface_water_down_gradient_features	Number of all surface water features within 1/2 mile of surface location that are downgradient from well location
Name_of_surface_water_bodies	Names of all surface water features within 1/2 mile of surface location
Count_of_prod_well_over_sensitive_geology_aquifer	Is location over unconsolidated, karstic or fractured bedrock aquifers
Name_of_aquifer	Name of aquifer under surface location and within 1/2 mile
Drilling	
Spud_date	Production well spud date (date drilling first commenced)

Table 2.1. Potential Data Fields	
FIELD NAME	**DESCRIPTION**
Drilling_fluid_containment_description	Description of the drilling fluid containment
Drilling_fluid_containment_reserve_pit_boolean	Whether there was use of one or more reserve pits
Drilling_fluid_containment_closed_loop_boolean	Whether there was use of a closed-loop tank system
Drilling_fluid_spill_boolean	Whether there was reported any spills during drilling
Open_hole_log_depth_to_base_USDW	Bottom depth of deepest zone displaying TDS less than or equal to10,000 mg/L if present in well (TMD)
Hole	
Hole_type	Hole Type (apply to each casing string as applicable) use pick list of [conductor, surface, intermediate, longstring, other]
Hole_size_diameter	Hole size for each hole section drilled, in inches of diameter
Hole_depth_TMD	Depth of drilled hole for each hole section (TMD)
Hole_depth_TVD	Depth of drilled hole for each hole section (TVD)
Surf_shoe_test_boolean	Whether operator performed surface casing shoe test
Surf_shoe_test_pressure	If yes, downhole pressure equivalent (psi),
Surf_shoe_test_result	Whether shoe test was a pass or fail
Drilling_fluid_type	Type of drilling fluid use of pick list [mud, air, oil, chemical, foam, other]
Drilling_fluid_weight_start	If mud used, mud weight at start of hole (lbs/gal)
Drilling_fluid_weight_finish	If mud used, mud weight at finish of hole (lbs/gal)
Drilling_fluid_weight_max	If mud used, maximum mud weight during drilling of hole (lbs/gal)
Mud_log_blow_out_boolean	Whether there was a blow out during drilling
Open_hole_log_boolean	Whether there was open hole logging
Washouts	
Open_hole_tool	Type of open hole logging tool used
WashOutZone_top	Depth to top of wash out zone (TMD)
WashOutZone_bottom	Depth to bottom of wash out zone (TMD)
WashOutMax	Maximum diameter of wash out zone (in)
Mudlog	
Mud_log_indicator_type	Description of type of hydrocarbon indicator: blow out, kick, show, or lost circulation
Mud_log_indicator_depth_top_TMD	Depth to top of indication of hydrocarbon (TMD)
Mud_log_indicator_depth_bottom_TMD	Depth to bottom of indication of hydrocarbon (TMD)

Table 2.1. Potential Data Fields	
FIELD NAME	**DESCRIPTION**
Mud_log_Mudweight	Reported mud weight (lb/gal)
Mud_log_oil_or_gas	Whether indicator shows evidence of mainly gas or mainly oil
Spills	
Drilling_fluid_spill_boolean	Whether there was a drilling fluid spill
Spill_Number	Assigned number to spill of drilling fluids
Drilling_fluid_spill_description	Description of the cause of drilling fluid spill
Drilling_fluid_spill_date	Drilling fluid spill date
Drilling_fluid_spill_volume_spilled	Volume spilled as described during drilling (bbl)
Drilling_fluid_spill_response	Described response to spill
Open hole logs	
Open_hole_log_fluid_in_hole	Description of the type of fluid in hole during open hole logging
Open_hole_log_date	Open hole log date
Open_hole_log_depth_bottom_logger	Open hole log depth – logger (from log header)
Open_hole_log_depth_bottom_logged	Open hole log top depth logged – logger (from log header)
Open_hole_log_depth_top_logged	Open hole log bottom depth logged – logger (from log header)
Open_hole_log_resistivity_log	Whether there was an open hole resistivity log
Open_hole_log_porosity_log	Whether there was an open hole porosity log
Open hole logs aquifer investigation	
Open_hole_log_zone_type	Description that this portion of the open hole log analysis regards water
Open_hole_log_zone_top_depth_TMD	Depth interval investigated - top - in TMD
Open_hole_log_zone_top_depth_TVD	Depth interval investigated - top - in TVD
Open_hole_log_zone_bottom_depth_TMD	Depth interval investigated - bottom - in TMD
Open_hole_log_zone_bottom_depth_TVD	Depth interval investigated - bottom - in TVD
Open_hole_log_zone_lithology	Type of lithology of depth interval
Open_hole_log_zone_porosity	Measured porosity of depth interval
Open_hole_log_N_D_crossover	Whether the log exhibits neutron density crossover
Open_hole_Rw_calculated	Calculated resistivity of water from log analysis
Open_hole_Rw_calculated_Method	Indication of which method used to calculate Rw (SP or Rwa method)
Open_hole_log_calculated_salinity	Salinity (NaCl equivalent) at this depth interval
Open_hole_log_USDW_confidence_factor	Confidence factor (1-5) in this analysis

Table 2.1. Potential Data Fields	
FIELD NAME	**DESCRIPTION**
Open hole logs production investigation	
Open_hole_zone_type	Description of whether the zone was actually stimulated or is a potential zone (not perfed) for hydrocarbons located above stimulated zone
Open_hole_log_zone_top_depth_TMD	Depth interval investigated - top - in TMD
Open_hole_log_zone_top_depth_TVD	Depth interval investigated - top - in TVD
Open_hole_log_zone_bottom_depth_TMD	Depth interval investigated - bottom - in TMD
Open_hole_log_zone_bottom_depth_TVD	Depth interval investigated - bottom - in TVD
Open_hole_log_zone_lithology	Type of lithology of depth interval
Open_hole_log_zone_name	Name of lithologic unit
Open_hole_log_zone_porosity	Measured porosity of depth interval
Open_hole_log_N_D_crossover	Whether the log exhibits neutron density crossover
Casing program (repeat for each casing string)	
Bit_Size_in	Bit diameter (in)
Well_TD_Ft	Well's total depth (ft)
Well_PBTD_Ft	Well's plugged back total depth (ft), or depth at time of setting surface casing
Casing_Size_OD_in	Casing outside diameter (OD) (in)
Casing_Grade	Casing type
Casing_Weight _lbs/Ft	Casing weight (lbs/ft)
Number_of_Centralizers	Number of centralizers used
Centralizer_Spacing_Ft	Depth distance between centralizers (ft)
Cement program (repeat for each casing string)	
Cement_Class	Type of cement used
Gauge_Hole_Annulus_Volume_(Cemented_Interval)_CuFt	Volume of annular space for gauge borehole along cemented interval (no washout, no leaks)
Number_of_Sacks_of_Cement	Sacks of cement used (sks)
Cement_Yield_CuFt/Sk	Slurry volume per sack of cement (cu ft/sk)
Volume_of_Pumped_Slurry_CuFt	Total volume of slurry pumped into well (cu ft)
Excess_Cement_Used_%	Amount of cement needed to compensate for borehole washout/leakage in cemented interval (%)
Cement job evaluation (soft MIT test) (repeat for each casing string)	
CBL_Date	Date CBL was run which provides duration of cement curing at time of CBL logging
CBL_TOC_Ft	Top of cement as indicated by CBL (ft)
Calc_TOC_Ft	Only if no CBL is present, top of cement as calculated from data within the file

Table 2.1. Potential Data Fields	
FIELD NAME	**DESCRIPTION**
Perforated_Interval_Ft	Perforated interval across productive horizon (ft)
BI_Review_CBL_Depth_Interval_Ft	Selected CBL depth interval for evaluation of cement bonding via bond indices
Range_BI_Values_%_API_Fig5.12_Curve	Range of bond index values as estimated using the curve in Figure 5.12 in API 10-TR1 report
Range_BI_Values_%_A-B_Curve_Fig10.17-Smolen	Range of bond index values as estimated using the A-B curve in Figure 10.17-Smolen
Range_BI_Values_%_A-C_Curve_Fig10.17-Smolen	Range of bond index values as estimated using the A-C curve in Figure 10.17-Smolen
Remarks_on_Casing_Cement_Job	Comments on unusual events/facets of casing cement job
HF program	
HF_fluid_containment_boolean	Whether there was secondary containment around stored HF fluids and chemicals
HF_fluid_type	HF fluid type use pick list [slickwater, gel, hybrid (cross linked gel), foam, diesel fuel as main fluid, other]
HF_fluid_type_other	If other fluid type, describe
HF_base_fluid_volume_used	Total volume of base fluid used in wellbore stimulation - all stages combined (gal)
	Describe source of base fluid used if base fluid is water
HF_base_fluid_fresh_water_boolean	Whether the base fluid water is fresh water
HF_base_fluid_water_source_description	If yes, describe if source of fresh water was from surface water, ground water or purchased drinking water
HF_base_fluid_fresh_water_volume_used	Volume of fresh water used (gal)
HF_base_fluid_water_recycled_boolean	Whether any water used was recycled
HF_base_fluid_water_recycled_volume_used	If yes, provide recycle volume used (gal)
HF_injection_stages_number_countof	Total number of stages in wellbore stimulation
HF_injection_stage_number	Stage number
HF_injection_stage_date	Date of stage number
HF_injection_stage_top_true_measured_depth	Depth to top of frac stage (TMD)
HF_injection_stage_bottom_true_measured_depth	Depth to bottom of frac stage (TMD)
HF_injection_stage_top_true_vertical_depth	Depth to top of frac stage (TVD)
HF_injection_stage_bottom_true_vertical_depth	Depth to bottom of frac stage (TVD)
HF_injection_stage_water_used_volume	Volume of fluid injected during stage (gal)
HF_injection_stage_proppant_used_amount	Amount of proppant used during stage (lbs)
HF_injection_stage_proppant_used_type	Type of proppant used during stage use pick list [sand, resin-coated sand, manufacured proppant]

Table 2.1. Potential Data Fields	
FIELD NAME	**DESCRIPTION**
HF fluid additives	
HF_injection_stage_fluid_used_type	HF fluid additive, repeat as needed for each additive, use pick list [acid, breaker, gellant, scale inhibitor, clay control, iron control, surfactant, friction reducer, pH control, foamant, emulsion control, biocide, cross linker, more…]
HF_injection_stage_fluid_used_trade_name	Additive trade name (e.g. "superslick")
HF_injection_stage_fluid_used_trade_code	Additive trade name code if provided separately from trade name (e.g. BA-7)
HF_injection_stage_fluid_used_volume	Additive volume used (gal)
HF_injection_interval_uppermost	Uppermost depth in well of fracture treated interval (ft)
HF_injection_interval_lowermost	Lowermost depth in well of fracture treated interval (ft)
From pressure response graph	
HF_injection_break_down_pressure_mini_frac	Breakdown Pressure from a mini-frac (psi)
HF_injection_ISIP_pressure_mini_frac	Instantaneous Shut-In Pressure from a mini-frac (psi)
From main pump-in chart (carrying proppant)	
HF_injection_break_down_pressure_main_pump_in	Stage maximum injection pressure (psi)
HF_injection_sudden_pressure_change_boolean	Whether there is a sudden change in pressure during stage
HF_injection_sudden_pressure_change_type	If yes, type of sudden change in pressure use pick list [increase, decrease]
HF_injection_sudden_pressure_change_response_time	If yes, record shut down response time (min)
HF_injection_sudden_pressure_change_rate	If yes, record pumping rate at time of shut down incident (bpm)
HF_injection_radioactive_tracer_boolean	Whether there was a radioactive tracer run to verify fracture location
HF_injection_radioactive_tracer_date	if yes, radioactive tracer log date
HF_injection_radioactive_tracer_top_depth	if yes, depth to top of interval confirmed from tracer survey
HF_injection_radioactive_tracer_bottom_depth	if yes, depth to bottom of interval confirmed from tracer survey
HF_injection_post_frac_geometry_calc_boolean	Whether there is a post-frac calculated fracture geometry
HF_injection_post_frac_geometry_calc_dimension_type	If yes, note if average or maximum dimensions are reported
HF_injection_post_frac_geometry_calc_dimension_height	If yes, provide calculated frac height (ft)
HF_injection_post_frac_geometry_calc_dimension_length	If yes, provide calculated frac half-length (ft)
HF_injection_post_frac_geometry_calc_dimension_width	If yes, provide calculated frac width (in)

Table 2.1. Potential Data Fields	
FIELD NAME	**DESCRIPTION**
HF_injection_post_frac_geometry_calc_dimension_azi	If yes, provide calculated frac azimuth, angle [360 degrees]
HF_injection_special_monitoring_technique_boolean	Whether there was any special monitoring technique used on the stimulation
HF_injection_special_monitoring_tilt_boolean	If yes, was the special monitoring a tiltmeter survey
HF_injection_special_monitoring_tilt_frac_height	If yes, provide maximum frac height (ft) from tiltmeter
HF_injection_special_monitoring_tilt_frac_half_length	If yes, provide maximum frac half-length (ft) from tiltmeter
HF_injection_special_monitoring_tilt_frac_azi	If yes, provide frac azimuth, angle [360 degrees] from tiltmeter
HF_injection_special_monitoring_micros_boolean	If yes, was the special monitoring a microseismic survey
HF_injection_special_monitoring_micros_frac_height	If yes, provide maximum frac height (ft) from microseismic
HF_injection_special_monitoring_micros_frac_half_length	If yes, provide maximum frac half-length (ft) from microseismic
HF_injection_special_monitoring_micros_frac_azi	If yes, provide frac azimuth, angle [360 degrees] from microseismic
HF_injection_special_monitoring_micros_frac_magnitude	If yes, maximum recorded magnitude from microseismic monitoring
HF_injection_monitored_annulus_boolean	Whether there was an annulus monitored during fracture stimulation
HF_injection_monitored_annulus_description	If yes, describe which annuli is/are monitored
HF_injection_monitored_annulus_max_pressure	If yes, provide maximum recorded annular pressure (psi)
HF_injection_monitored_annulus_min_pressure	If yes, provide minimum recorded annular pressure (psi)
HF_injection_other_problem_indicator	Describe any other indicator of upset conditions during stimulation
Spills or releases during stimulation	
HF_spills_equipment_failure_boolean	Whether there was any equipment failure reported during stimulation
HF_spills_equipment_failure_type	If yes, equipment that failed use pick list [surface equipment, downhole equipment]
HF_spills_equipment_failure_type_description	If yes, provide more detail about what failed
HF_spills_spill_boolean	If yes, whether there was an actual spill
HF_spills_fluid_type	If yes, describe what spilled
HF_spills_spill_response	If yes, describe response to spill
Pressure testing of fracturing equipment	
HF_surface_line_pressure_test_boolean	If yes, whether surface lines and equipment was pressure tested prior to stimulation

Table 2.1. Potential Data Fields	
FIELD NAME	**DESCRIPTION**
HF_subsurface_line_pressure_test_boolean	If yes, whether subsurface apparatus was pressure tested prior to stimulation
Flowback management	
Flowback_boolean	Whether there was flowback of injected HF fluids
Flowback_duration_before_well_open	Duration of shut in period after frac and prior to flowback
Flowback_duration_before_well_open_units	Unit of time for duration above
Flowback_duration_after_well_open	Duration of flowback period after frac with well opened
Flowback_duration_after_well_open_units	Unit of time for duration above
Flowback_container_type	Flowback container use pick list [pit, tank, other]
Flowback_container_volume	Volume capacity of flowback container (bbl)
Flowback_container_pit_liner_thickness	If on-site pit is the flowback container, provide liner thickness
Flowback_container_pit_liner_thickness_units	Unit of thickness from above
Flowback_total_volume	Total volume flowed back (bbl)
Flowback_recycled_boolean	Whether any flowback was recycled
Flowback_recycled_volume	Recycled volume (bbl)
Flowback_recycled_method	Describe method used for recycling flowback
Flowback_transportation_method	Flowback transportation method use pick list [trucked, piped, other]
Flowback_transportation_trucking_trips	If trucked, record number of truck trips
Flowback_disposed_boolean	Whether the flowback was disposed
Flowback_disposed_volume	Flowback disposed volume (bbl)
Flowback_disposal_method	Flowback disposal method use pick list [injection well, evaporation, POTW, Central treatment facility, other]
Flowback_disposal_transportation_method	Flowback transportation method use pick list [trucked, piped, other]
Flowback_disposal_transportation_trucked_trips	If trucked, record number of truck trips
Baseline_injected_fluid_test_boolean	Whether chemical monitoring of flowback fluid was done
Baseline_injected_fluid_test_sample_date	Sampled flowback fluid sample date
Baseline_injected_fluid_test_result_name	Sampled flowback fluid sample result parameter name
Baseline_injected_fluid_test_result_result	Sampled flowback fluid sample result analytical result
Baseline_injected_fluid_test_result_units	Sampled flowback fluid sample result units
Baseline_injected_fluid_test_result_parameter_type	Sampled flowback fluid sample result parameter type (organic, inorganic, gas, other)
Baseline_injected_fluid_test_result_QAQC	Sampled flowback fluid test result QAQC

Table 2.1. Potential Data Fields	
FIELD NAME	**DESCRIPTION**
Flowback_equipment_failure_boolean	Whether there was a flowback equipment failure reported
Flowback_equipment_failure_type	If yes, type of failure - describe what failed
Flowback_equipment_failure_spill_boolean	Whether there was a spill during flowback
Flowback_equipment_failure_spill_fluid_spilled	If yes, describe what fluid spilled
Flowback_equipment_failure_spill_fluid_spilled_response	Describe response to spill
Drilling_mud_final_disposition	Describe final disposition of drilling mud use pick list [buried on site, annular disposal, land farm, land fill, road applied, recycled, other]
Drilling_mud_final_disposition_other_description	If "other" from pick list above, describe
Shut_in_pressure_after_drilling	Shut in pressure following drilling (psi)
Production	
Shut_in_pressure_after_stimulation	Surface shut in reservoir pressure following stimulation and flow back (psi)
Production_rate_total_boolean	Whether a production rate for total fluids is provided
Production_rate_oil	Oil production rate (bpd)
Production_rate_gas	Gas production rate (mcf/day)
Production_rate_condensate	Condensate production rate (bpd)
Production_rate_water	Produced wastewater production rate (bpd)
Bradenhead_venting_boolean	Whether there is information of an annular venting program between surface casing and intermediate/production string
Bradenhead_venting_description	If yes, describe venting program
Production_equipment_failure_boolean	Whether there is any information indicating a surface equipment failure during production
Production_equipment_failure_description	If yes, describe failure
Production_equipment_failure_spill_boolean	Whether there was a spill associated with production
Production_equipment_failure_spill_fluid_spilled	If yes, described the fluid spilled
Production_equipment_failure_spill_volume	If yes, provide the volume spilled (gal)
Production_equipment_failure_spill_response	If yes, describe any response to spilled production fluids
Production_equipment_failure_spill_disposition_boolean	If yes, whether the final disposition of spilled production fluid is provided
Production_equipment_failure_spill_disposition_location	If yes, provide location of final disposition of spilled production fluid
Complaints	
Complaints_boolean	Whether any complaints are noted from public or other (Yes/No)

Table 2.1. Potential Data Fields	
FIELD NAME	**DESCRIPTION**
Complaints_media_impacted	From complaint, alleged media impacted use pick list [air, surface water, ground water, other]
Complaints_description	Nature of complaint (describe)
Complaints_complaint_date	Date of complaint
Complaints_impacted_media_location_latitude	Latitude of alleged media impacted (degree, decimel format)
Complaints_impacted_media_location_longitude	Longitude of alleged media impacted (degree, decimel format)
Complaints_impacted_media_location_coord_system	Lat/long coordinate system base (e.g NAD83, WGS84, etc)
Complaints_impacted_media_location_street_no	Street number of impacted media
Complaints_impacted_media_location_street_name	Street name of impacted media
Complaints_impacted_media_location_city	City of impacted media
Complaints_impacted_media_location_state	State of impacted media
Complaints_impacted_media_location_zip	Zip code of impacted media
Complaints_response_boolean	Whether there was any response to complaint taken
Complaints_determination_boolean	Whether there was any determination of cause made
Complaints_final_resolution	Description of final resolution of complaint
Groundwater resources described	
Ground_water_resource_identified_boolean	Whether the file contains any information about identified ground water resource
Ground_water_resource_description	File description of ground water resource information
Ground_water_resource_USDW_name	File description of USDW name based on 10,000 mg/L
Ground_water_resource_USDW_depth	File description of USDW depth (ft)
Ground_water_resource_other_name	File description of other defined resource (provide definition)
Ground_water_resource_other_depth	File description of depth to other defined resource (ft)
Injected fluid quality monitoring	
Baseline_injected_fluid_test_boolean	Whether baseline monitoring of injected fluid was done
Baseline_injected_fluid_test_sample_date	Sampled baseline injected fluid sample date
Baseline_injected_fluid_test_result_name	Sampled baseline injected fluid sample result parameter name
Baseline_injected_fluid_test_result_result	Sampled baseline injected fluid sample result analytical result
Baseline_injected_fluid_test_result_units	Sampled baseline injected fluid sample result units

Table 2.1. Potential Data Fields	
FIELD NAME	**DESCRIPTION**
Baseline_injected_fluid_test_result_parameter_type	Sampled baseline injected fluid sample result parameter type (organic, inorganic, gas, other)
Baseline_injected_fluid_test_result_QAQC	Sampled baseline injected fluid test result QAQC
Offset baseline surface water quality monitoring	
Baseline_monitoring_surface_boolean	Whether baseline monitoring or surface water was done
Baseline_monitoring_surface_name	Sampled baseline surface water ID
Baseline_monitoring_surface_latitude	Sampled baseline surface water latitude
Baseline_monitoring_surface_longitude	Sampled baseline surface water longitude
Baseline_monitoring_surface_other_location	Sampled baseline surface water other location
Baseline_monitoring_surface_street_no	Sampled baseline surface water street number
Baseline_monitoring_surface_street_name	Sampled baseline surface water street name
Baseline_monitoring_surface_city_name	Sampled baseline surface water city
Baseline_monitoring_surface_state	Sampled baseline surface water state
Baseline_monitoring_surface_zip	Sampled baseline surface water zip code
Baseline_monitoring_surface_depth	Sampled baseline surface water depth (ft)
Baseline_monitoring_surface_sample_date	Sampled baseline surface water sample date
Baseline_monitoring_surface_result_name	Sampled baseline surface water result parameter name
Baseline_monitoring_surface_result_result	Sampled baseline surface water result analytical result
Baseline_monitoring_surface_result_units	Sampled baseline surface water result units
Baseline_monitoring_surface_result_parameter_type	Sampled baseline surface water result parameter type (organic, inorganic, gas, other)
Baseline_monitoring_surface_result_QAQC	Sampled baseline surface water result QAQC
Offset baseline groundwater quality monitoring	
Baseline_offset_well_boolean	Whether baseline monitoring at offset well(s) was done (Yes/No)
Baseline_offset_well_name	Sampled baseline offset well ID
Baseline_offset_well_latitude	Sampled baseline offset well latitude
Baseline_offset_well_longitude	Sampled baseline offset well longitude
Baseline_offset_well_other_location	Sampled baseline offset well other location
Baseline_offset_well_street_no	Sampled baseline offset well street number
Baseline_offset_well_street_name	Sampled baseline offset well street name
Baseline_offset_well_city_name	Sampled baseline offset well city
Baseline_offset_well_state	Sampled baseline offset well state
Baseline_offset_well_zip	Sampled baseline offset well zip code
Baseline_offset_well_depth	Sampled baseline offset well depth (ft)

Table 2.1. Potential Data Fields	
FIELD NAME	**DESCRIPTION**
Baseline_offset_well_sample_date	Sampled baseline offset well sample date
Baseline_offset_well_result_name	Sampled baseline offset well result parameter name
Baseline_offset_well_result_result	Sampled baseline offset well result analytical result
Baseline_offset_well_result_units	Sampled baseline offset well result units
Baseline_offset_well_parameter_type	Sampled baseline offset well result parameter type (organic, inorganic, gas, other)
Baseline_offset_well_QAQC	Sampled baseline ground water resource QAQC
Water quality from production wellbore	
Baseline_produced_water_test_boolean	Whether baseline monitoring of production water was done (Yes/No)
Baseline_produced_water_test_name	Sampled baseline produced water formation ID
Baseline_produced_water_test_depth	Sampled baseline produced water formation depth (ft)
Baseline_produced_water_test_sample_date	Sampled baseline produced water sample date
Baseline_produced_water_test_result_name	Sampled baseline produced water test result parameter name
Baseline_produced_water_test_result_result	Sampled baseline produced water test result analytical result
Baseline_produced_water_test_result_units	Sampled baseline produced water test result units
Baseline_produced_water_test_result_parameter_type	Sampled baseline produced water test result parameter type (organic, inorganic, gas, other)
Baseline_produced_water_test_result_QAQC	Sampled baseline produced water test result QAQC

Appendix 3. Data Accuracy Resolution Form

The following form will be used, if needed, to address differences in interpretation among different well file reviewers of the same data.

Data Accuracy Resolution Form	
Well name	
API Number	
Nature of well file data or data interpretation	
Original well file reviewer	
Original well file data or interpretation recorded	
Final well file data or interpretation recorded	
Description of how matter was resolved	
Description of whether or how the nature of how this was resolved diminishes the data accuracy	