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MEMORANDUM

DATE: April 15, 2015 **Revised January 13, 2016** **PROJECT NO.** 350.0092.000

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FROM: K. Bill Clark, Project Manager/Hydrogeologist
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SUBJECT: Comment Category Responses
Draft Groundwater Pollution Prevention, Monitoring and Response Action Plan
Pinedale Anticline Project Area, Sublette County, Wyoming

This memorandum presents draft responses to categories of comments made to the draft Groundwater Pollution Prevention, Monitoring and Response Action Plan (draft Plan), issued December 17, 2014 for the Pinedale Anticline Project Area (PAPA). The BLM received 564 comments on the draft plan and the Project Oversight Team met on March 6, 2015 to discuss responses to comment categories. This memorandum provides those responses.

> **Note: Two minor revisions were made to Attachments F and M on January 13, 2016: 1) the new paragraph for SOP-12, Annex C-1, shown on Page F-3 (Attachment F) was slightly reworded to improve clarity; and 2) the reference to Section 3.0 in the last bullet point on Page M-3 (Attachment M) was changed from Section 3.0 to Section 3.7 to be more specific.**

BACKGROUND

BLM determined that Step 2 (groundwater characterization studies) of the three-step Groundwater Resources section of their 2008 Record of Decision (ROD) was complete in November 2013. An Administration Plan for Step 3 – Groundwater Resources was issued by BLM in April 2014. The Administration Plan defined two project teams: a Project Oversight Team (POT) and a Review Team. The POT is composed of Shane DeForest (BLM's Authorized Officer), Janet Bellis (BLM Project Lead), Kelly Bott (Operator Coordinator/Contract Manager) and K. Bill Clark (Contractor Project Manager). The Review Team is composed of representatives of five regulatory agencies (BLM, Wyoming Department of Environmental Quality [DEQ], Wyoming State Engineer's Office [SEO], Wyoming Oil and Gas Conservation Commission [WOGCC], and the US Environmental Protection Agency [EPA]) and the Operators (Ultra Petroleum and QEP Energy). Roles for regulatory representatives and operators are described in Sections 1.4 (Agencies Involved and Jurisdictions) and 1.5.2 (Review Team) of the draft Plan.

The BLM, DEQ and EPA Review Team members were actively involved and engaged during the development, execution, review and approval of the Step 2 groundwater characterization studies. (Note

that the SEO and WOGCC joined the project in 2014). In early 2014, regulatory agency representatives of the Review Team developed goals and objectives for the draft Plan; the Operators and NewFields were not involved. Plan goals and objectives were approved by BLM in June 2014. NewFields developed the three-program draft Plan to satisfy the regulatory agency goals and objectives. These programs include: Groundwater Pollution Prevention Program; Groundwater Monitoring Program; and, Response Action Program. The Review Team was provided the draft Plan for review and comment on December 17, 2014 and by January 23, 2015 provided their comments to BLM. A total of 247 Review Team comments were received.

In late December 2015, BLM posted the draft Plan on the Pinedale Field Office website and provided public notification in local media of the draft Plan's availability for comment. Due to issues beyond BLM's control, the media notices were not made until January 2015 and BLM extended the public comment period to February 6, 2015. A total of 317 public comments were received from individuals, public entities and non-governmental organizations.

Table 1 in **Attachment A** presents a series of steps outlining the "comment content assessment" process followed by the POT. These steps describe: 1) compiling and evaluating each individual comment made by the Review Team or the Public; 2) identifying comment themes relative to particular sections of the draft Plan; and then 3) identifying key comment categories. The result of the POT's comment content assessment are the tables provided as **Enclosure 1**, which sorts the entire list of comments into 16 comment categories. The spreadsheet is organized to present each comment relative to order of the draft Plan (e.g., in a particular category, a comment to Section 1 is presented before a comment to Section 4). Eight comment categories were considered by the POT to be common to both the Review Team and Public, whereas eight comment categories were unique to either the Review Team or Public (four each).

This memorandum provides responses to the 16 comment categories and identifies revisions that were made to finalize the Plan. The POT discussed these responses during their meeting on March 6, 2015, in consideration of several tenets of the draft Plan:

- **Step 2, 2008 PAPA ROD, Groundwater Characterization Studies**
  - Plans for and findings from the three studies (Hydrogeologic Data Gaps Investigation, Numerical Groundwater Modeling, and Evaluation of Potential Sources of Low-Level Petroleum Hydrocarbons Detected in Groundwater [LLPHC]) completed between 2008 and 2013 were accepted by BLM, DEQ and EPA.
  - Groundwater quality data from sampling conducted pursuant to the 2000 ROD between 2004 and 2013 has established background water quality (including dissolved methane) for the PAPA.
  - No further investigation was necessary to develop the Groundwater Monitoring Program for the PAPA.

- The LLPHC study did not produce any evidence of widespread impact to groundwater in the PAPA as a result of exploration and production activities.

- **Goals and Objectives**
  - Project-specific goals and objectives were developed by representatives of five Agencies (BLM, DEQ, SEO, WOGCC and EPA).
  - NewFields organized the goals and objectives into the three programs of the draft Plan (Groundwater Pollution Prevention Program, Groundwater Monitoring Program; and, Response Action Program).
  - Agency representatives reviewed the goals and objectives, and they were approved by the BLM in June 2014.
  - The draft Plan was developed to fulfill the Agency's goals and objectives.

- **Administration Plan and Process Steps**
  - A Project Oversight Team and a Review Team composed of Agency representatives, Operator representatives and the contractor (NewFields) were created by an Administration Plan (April 2014) to guide development of the draft Plan.
  - A series of process steps were established by the Administration Plan that were to be followed to complete the Plan.
  - Periodic conference calls and meetings were held in 2014 to inform the Review Team of progress, and to discuss and debate components of the three programs.

- **Reliance on Pollution Prevention Program**
  - The LLPHC study concluded that no additional mitigation measures (beyond those in the 2008 ROD) were necessary to mitigate the existing low-level volatile or semivolatile organic constituents detected in water wells in the PAPA.
  - Pollution prevention practices in-place during the groundwater characterization studies indicate that the groundwater resource is being protected by those practices.
  - The Pollution Prevention Program in the draft Plan specifies a comprehensive list of best practices for all phases of oil and gas activities that are required to protect groundwater.
  - The groundwater resource can be protected by implementation of and adherence to the best management practices in the Pollution Prevention Program.
  - The Pollution Prevention Program is the most important program in the draft Plan.

- **Reliance on the Monitoring Parameter List and Thresholds to Detect Change/Degradation**
  - The Groundwater Monitoring Program includes 19 water quality parameters selected according to the following criteria:
    - 1) most hazardous to public health and the environment;

        - 2) most indicative of impacts from oil and gas activities; and,
        - 3) most likely to appear first at monitoring sites.
    - As many of these parameters are co-associated (e.g., a produced water impact would involve at least elevated chloride and total dissolved solids), any observed groundwater degradation is expected to be represented by more than one parameter.
    - Absolute value water quality thresholds are assigned to each parameter, and are either based on a water quality standard, statistical analysis of background concentrations in the PAPA, or a WOGCC notification level (only for methane). The Response Action Program is launched if an absolute value threshold is exceeded. In addition, water quality will be evaluated on an intra-well basis using the Mann-Kendall statistical test. The test will be performed on each parameter from each well after six samples have been collected to determine if parameter concentrations are increasing over time. A statistically significant increasing trend is a threshold triggering the Response Action Program.

- **Reliance on the Review Team and Annual Plan Review Cycles**
    - The Review Team (composed of representatives of five regulatory agencies, operators and a contractor) is required to remain engaged and involved at a minimum of an annual basis as the Plan is being implemented.
    - Both the Groundwater Monitoring and Response Action Programs require annual review cycle meetings. These meetings dictate continual involvement, review and input from the Review Team.
    - The Review Team will oversee the Response Action Program and make determinations if evidence is available that any one of the following three conditions occurred and require action:
        - 1) water quality threshold exceeded;
        - 2) existing hydrogeologic conceptual model needs revision; and/or
        - 3) BMP failed or is absent.
    - The Plan was specifically designed to be dynamic with continual feed-in/feed-back loops. It is not a walk-away plan and will be improved if necessary.

ORGANIZATION

Attachments B through **Q** present responses to comment categories. The following chart shows the order of responses being presented in the attachments of this memorandum, identifies comment categories, and assigns comment categories to either: "both" the Review Team and Public; the Review Team; or the Public.

Att.	No.	Comment Category Description	By
B	2	Monitoring boundary	Both
C	1	Monitoring locations (geography, existing wells, new wells, alluvial wells, RCE)	Both
D	13	Keep existing program (domestic/stock wells, existing well density, existing data)	Public
E	15	Early detection/warning and use of 110 year groundwater travel time	Public
F	10	Existing well sampling methods	Review Team
G	3	Vertical monitoring	Both
H	4	Threshold analyses	Both
I	14	Concerns with groundwater studies completed under Step 2 of the ROD	Public
J	9	Monitoring frequency	Review Team
K	16	Public participation, public notification	Public
L	12	Public involvement in the Response Action Program	Review Team
M	6	Operator practices	Both
N	5	Concerns with monitoring methods/SOPs/QAPP	Both
O	11	When is the end?	Review Team
P	7	Editorial/improvement comments	Both
Q	8	No change necessary; not applicable; addressed elsewhere	Both

In the responses to comment categories provided in **Attachments B** through **Q**, revised portions of the draft Plan are included where possible and appropriate. These revisions are provided in blue font. Changes made to the document in regard to editorial comments (Category No. 7, above) are not included herein. Other significant portions of the Plan that were modified and revised are enclosed: **Enclosure 2** contains revised Appendix 4-A; **Enclosure 3** contains revised Appendix 4-B; and **Enclosure 4** contains revised SOPs.

Enclosures:

1 Comments Sorted by Category
2 Revised Appendix 4-A
3 Revised Appendix 4-B
4 Revised SOPs

Attachments:

A Process Steps, Comment Content Assessment
B Response – Monitoring Boundary
C Response – Monitoring Locations
D Response – Keep Existing Program
E Response – Early Detection/Warning
F Response – Existing Well Sampling Methods
G Response – Vertical Monitoring
H Response – Threshold Analysis
I Response – Concerns with Groundwater Studies Completed under Step 2 of the ROD
J Response – Monitoring Frequency
K Response – Public Participation, Public Notification
L Response – Public Involvement in the Response Action Program
M Response – Operator Practices
N Response – Concerns with Monitoring Methods/SOPs/QAPP
O Response – When is the end?
P Response – Editorial/Improvement Comments
Q Response – No Change Necessary; Not Applicable; Addressed Elsewhere

Attachment A

Process Steps, Comment Content Assessment

TABLE 1. PROCESS STEPS FOR THE COMMENT CONTENT ASSESSMENT
DRAFT, GROUNDWATER POLLUTION PREVENTION, MONITORING AND RESPONSE ACTION PLAN (DECEMBER 2014)

STEP	DESCRIPTION
1	NewFields issues Draft Plan to Review Team via ShareFile site on 12/17/2014; comments due 1/23/15
2	BLM notifies local papers of Draft Plan availability on 12/23/14; notices online and in papers not made
3	Notice of Draft Plan posted in Pinedale OnLine! on 1/8/15
4	Review Team discussion of Key Questions on Draft Plan via go-to-meeting on January 15, 2015
5	Notice of Draft Plan posted in Pinedale Roundup on 1/16/15
6	Notice of Draft Plan posted in Sublette Examiner on 1/20/15
7	Public comment period extended to 2/6/15
8	All comments from Review Team transmitted to BLM by January 23, 2015; comments provided to NewFields
9	BLM posts Frequently Asked Questions document to Pinedale Field Office website on 1/28/15
10	NewFields assembles all (247) Review Team comments into a single Master Review Team Comment spreadsheet
11	For each comment, individual Review Team member is identified, and unique comment ID assigned
12	NewFields reviews each comment and identifies "comment themes" with respect to each Section of Draft Plan
13	Initial comment themes identified by NewFields and provided to Project Oversight Team (POT)
14	NewFields hosts individual meeting with BLM to obtain clarification on several comments on 2/3/15
15	NewFields hosts individual meetings with both the Operators (Ultra Petroleum and QEP Energy) and EPA to obtain clarification on several comments on 2/5/15
16	Review Team comment themes refined [see tab "Themes-Review Team"]
17	Public comments transmitted to BLM by 2/6/15 in a variety of hardcopy and electronic formats; comments emailed to NewFields
18	NewFields OCRs comments as necessary and organizes all public comments into a spreadsheet
19	NewFields QCs data/information entries and assigns comments to a General category and according to Section of Draft Plan
20	NewFields assembles all (317) Public comments into a single Master Public Comment spreadsheet
21	For each comment, individuals or entities are identified (19 total), and unique comment ID assigned
22	NewFields reviews each comment and identifies "comment themes" with respect to each Section of Draft Plan , or General
23	Initial comment themes identified by NewFields and provided to Project Oversight Team (POT) [see tab "Themes-Public"]
24	A comparison of Review Team and Public Comment "Themes" provided to POT [see tab "Summary-Themes"]
25	BLM provides presentation of the process from 2007 through February 2015 to develop Draft Plan at APM on 2/19/15

TABLE 1. PROCESS STEPS FOR THE COMMENT CONTENT ASSESSMENT
DRAFT, GROUNDWATER POLLUTION PREVENTION, MONITORING AND RESPONSE ACTION PLAN (DECEMBER 2014)

STEP	DESCRIPTION
26	The POT discusses providing responses to groups or categories of similar comments, and requests NewFields identify categories
27	NewFields reviews Review Team comments and themes, and identifies 12 "Comment Categories"
28	NewFields assigns each of the 247 Review Team comments to a "Comment Category"
29	NewFields sorts Master Review Team Comment spreadsheet according to the 12 categories
30	NewFields reviews the Public comments and themes, and identifies 12 "Comment Categories"
31	NewFields assigns each of the 317 Public comments to a "Comment Category"
32	NewFields sorts Master Public Comment spreadsheet according to the 12 categories
33	Of the 12 Comment Categories, eight (8) are common to both the Review Team and Public; four (4) Comment Categories are unique to the Review Team and four (4) to the Public. A total of 16 comment categories to be addressed [see tab "Final Sort Categories"]
34	NewFields combines the two (Review Team and Public) category-sorted Master Comment files into a single file on 2/27/15
35	Working Draft of the outcome of the process described herein is transmitted to the Project Oversight Team on 2/27/15
36	POT meets on 3/6/15 at BLM's District Office in Idaho Falls, ID to discuss Comment Content Assessment (i.e., comment categories)and agrees to how Public and Review Team comments were sorted into the 16 comment categories
37	In response to Public and Review Team comments, NewFields modifies Appendices 4-A and 4-B, revises Standard Operating Procedures in Annex 4C-1 , and makes necessary modifications to various sections of the Plan
38	NewFields' issues a draft memorandum providing responses to the 16 "comment categories" on 4/8/15 which includes revisions made to Sections 1 – 5 of the Plan
39	By 4/14/15, the POT provides comments to the "responses" memorandum
40	Memorandum of Comment Category Responses finalized and issued on 4/15/15 to BLM's Project Lead along with the following enclosures: 1) Comments Sorted by Category; 2) Revised Appendix 4-A; 3) Revised Appendix 4-B; and 4) Revised SOPs (Annex 4C-1)
41	BLM's Project Lead issues Memorandum of Comment Category Responses and enclosures to Review Team for evaluation prior to 4/29/15 Review Team meeting

ATTACHMENT B

Response – Monitoring Boundary

RESPONSE – MONITORING BOUNDARY (CATEGORY 2)

Ten Review Team and Public comments were assigned to the category of monitoring boundary. In reviewing the comments, it became apparent that Section 4.2.3 of the Groundwater Monitoring Program (GMP) should be retitled and expanded. This section is now titled *Monitoring Boundary and Well Network Design* and clearly defines the monitoring boundary. The revised text:

- Describes those areas where monitoring is necessary to fulfill GMP objectives O2.3, O2.5 and O2.6;
- Explains why wells in some areas of the PAPA (particularly those areas north of Development Area 1 and east of Development Areas 1 and 2) that have been previously monitored are excluded from the GMP; and
- Indicates the GMP does not include private domestic or stock wells within the monitoring boundary because: they are potential receptors; the GMP requires monitoring to detect potential impacts before reaching a potential receptor; and access, security and operational control for wells included in the GMP will need to be strictly controlled.

Further, the Plan is dynamic. As provided for in Section 4.8 (Monitoring Program Review Cycle) and Section 5.3 (Plan Review Cycle and Measures of Success), the Review Team will continually evaluate the GMP for effectiveness, relevance and appropriateness. Should findings from executing the Plan's three programs suggest that changes to the monitoring program may be warranted, the Review Team is obligated to make changes as necessary. These changes could be varied and GMP modifications could include additional monitoring locations based on expansions to the Development Areas, changes to the monitoring parameter list, or changes to water quality thresholds.

The following text in blue font is the revised Section 4.2.3:

4.2.3 Monitoring Boundary and Well Network Design

The Conditions of Approval for the 2000 ROD (BLM 2000) stated that all water wells within a one-mile radius of existing and proposed oil and gas development be monitored on an annual basis. BLM's 2008 ROD (BLM 2008a) supersedes in its entirety the 2000 ROD but required an Interim Plan (Geomatrix 2008) for continued groundwater monitoring until this Plan was completed and approved. The annual groundwater monitoring program has been continued through 2015. Maps provided in annual water quality reports issued by SCCD show areas north of DA-1 boundary and east of the boundaries for DA-1 and DA-2 where existing private water wells have been monitored per the 2000 ROD (SCCD's annual groundwater data summary reports are available at: http://www.blm.gov/wy/st/en/field_offices/Pinedale/pawg/DataResults.html). Some of these areas with existing private wells also coincide with high priority aquifers mapped by Bedessem et al. (2005; see **Figure 4-2**).

The GMP monitoring boundary (defined below) does not include some of the areas where existing private water wells had been previously monitored under requirements of BLM's 2000 ROD. As stated in **Section 2.2** and in the beginning of **Section 4.0**, the goal developed by the regulatory agencies for the GMP includes monitoring groundwater for impacts from oil and gas activities based on the PAPA groundwater characterization. The areas north of the DA-1 boundary and east of the boundaries of DA-1 and DA-2 are hydraulically upgradient of potential contaminant sources associated with natural gas development based on maps presented in Martin (1996), as determined from groundwater elevations measured during the Hydrogeologic Data Gaps Study (see **Section 1.6.1** and AMEC 2012) and as numerically modeled (see **Section 1.6.2** and AMEC 2013a). As a result, the areas north of the boundary of DA-1 and east of the boundaries of DA-1 and DA-2 are not included in the GMP monitoring boundary.

Information presented in **Sections 4.2.1** and **4.2.2**, above, was used to determine the monitoring boundary for the GMP. In accordance with the stated goal of the GMP (see **Section 2.2**), the GMP is to be based on the groundwater studies completed for Step 2 of the ROD including consideration of groundwater flow direction determined for the PAPA. Areas in the PAPA to be monitored under the GMP are described in three objectives:

- Objective O2.3 – monitor the area proximal to active development and in areas with greatest environmental risk;
- Objective O2.5 – monitor to provide early detection in areas of greatest environmental sensitivity; and
- Objective O2.6 – monitor to provide spatial coverage in the PAPA.

The area of active natural gas development in the PAPA is defined by the borders of DA-1 through DA-5. The area that is considered to be of greatest environmental sensitivity and greatest relative risk of being impacted from natural gas development is the River Corridor Envelope, which was determined by the following:

- Locations of high priority aquifers mapped by Bedessem et al. (2005; **Figure 4-2**).
- Results of numerical particle tracking from potential receptors identified by the agencies (BLM, DEQ and EPA) and the Operators in 2011 (AMEC 2013a). Receptors included private domestic and stock water wells and the New Fork River.
- Locations of potential oil and gas sources relative to these receptors (i.e., hydraulically upgradient).

Based on these factors, the monitoring boundary for the GMP is described as the area bound by DA-1 through DA-5 and the River Corridor Envelope (**Figure 4-3**).

NewFields divided the PAPA groundwater monitoring boundary into areas both north and south of the River Corridor Envelope. The North Zone includes DA-1 and a portion of DA-2, and the South Zone includes a portion of DA-3, all of DA-4 and DA-5. These three general monitoring zones (River Corridor Envelope, North Zone, and South Zone) of the PAPA are shown on **Figure 4-3**.

Within the monitoring boundary, there are several existing private domestic, private stock and Operator-owned industrial water supply wells. As noted above, private domestic and stock wells are considered potential receptors of groundwater impacts from oil and gas activities. Based on the GMP objective to provide early detection of potential impacts (Objective O2.5), the GMP monitoring well network was designed to monitor groundwater upgradient of these potential receptors. This strategy aims to identify groundwater degradation issues before they reach and impact potential receptors (e.g., domestic and stock wells, and the New Fork River).

PAPA Operators are being required by this Plan to monitor wells for the GMP and, consequently, certain wells were excluded from consideration into the GMP well network if the Operators would not be reasonably able to:

- Control security and access to the monitoring wells, and
- Operate and maintain monitoring wells in accordance with BMPs listed in **Table 3-2**.

Qualitative and quantitative approaches were used to select well locations for the monitoring network. NewFields applied a combination of analytical tools to design the monitoring network to fulfill the three well-siting objectives listed at the beginning of **Section 4.2**. These tools were used in consideration of the hydrogeologic conceptual model for the PAPA and included: GIS coupled with the project's Environmental Data Management System (EDMS; **Section 1.7.3**); PAPA numerical groundwater model to conduct advective particle track simulations; and a geospatial utility in Visual Sample Plan (VSP, Version 7.0; PNNL 2014). The subsections below describe selection of well locations in the three monitoring zones:

- River Corridor Envelope downgradient of potential sources and upgradient of potential receptors to monitor the Wasatch HSU;
- Core of the River Corridor Envelope to monitor the Alluvial HSU;
- Area encompassing DA-1 and a portion of DA-2 north of the River Corridor Envelope to monitor the Wasatch HSU (i.e., North Zone); and
- Area encompassing a portion of DA-3, and all of DA-4 and DA-5 south of the River Corridor Envelope to monitor the Wasatch HSU (i.e., South Zone).

Consideration of using existing wells (completed at various depths with various screened/perforated intervals) for the GMP well network outside of the River Corridor Envelope was made for the following reasons:

- The WOGCC specifies use of existing wells to fulfill requirements of their baseline monitoring rule;

- Existing wells were required to be sampled by the 2000 ROD and have been through 2014; and,

- Results from water quality sampling of existing wells have been used for regulatory decisions made by both BLM and DEQ.

As part of the selection process for the GMP well network, water quality data from wells completed at various depths in the Wasatch Formation in the PAPA were evaluated to assess if statistically significant relationships are evident between well depth and select water quality parameters.

A statistical test (t-test) was performed using data produced by SCCD between 2004 and 2013 to evaluate similarity in concentrations of chloride and total dissolved solids (TDS) versus the depth (depth below ground surface) of the midpoint of the well screen interval and the absolute elevation of the midpoint in the well screen interval. These two depth variables were analyzed due to the relief present in the PAPA, as the ground surface elevations of some natural gas well pads on the Mesa in the North Zone are approximately 7,600 feet and the elevation of the New Fork River in the center of the PAPA is about 6,900 feet. A description and results of the t-test are presented in **Appendix 4-A**.

The following data were used in the t-test:

- Water quality sample results stored in the project geodatabase (e.g., EDMS) that included data collected by SCCD from 2004-2013 and data collected during the completion of the Step 2 groundwater studies.

- Water quality data were used from industrial water supply, stock, domestic and study wells completed in the Wasatch Formation that are located within the GMP monitoring boundary as described above.

- Data from wells enrolled in DEQ's Voluntary Remediation Program were not used in the t-test. In addition, quartile-quartile probability plots were used to visually inspect the datasets and remove outliers.

- After removal of outliers, chloride data were available from 820 samples and TDS data from 811 samples that were collected from 95 wells within the GMP monitoring boundary.

- The depth of the midpoint of well screens in the 95 wells ranges from 54 to 1,210 feet below ground surface whereas the elevation ranges from 6,306 to 7,263 feet above mean sea level. The average elevation of the midpoints of well screens for the 95 wells is 6,700 feet.

Results of the analysis indicate that there is no statistically significant relationship between concentrations of chloride or TDS with mid-screen depth or elevation based on samples from 95 wells located within the GMP monitoring boundary. Consequently, comparing sample results from wells completed in the Wasatch Formation at the depth ranges listed above with new Wasatch Formation wells for the GMP, appears appropriate.

ATTACHMENT C

Response – Monitoring Locations

RESPONSE – MONITORING LOCATIONS (CATEGORY 1)

The Review Team and Public provided 15 comments associated with groundwater monitoring locations. Comments were varied and some related to the use of existing wells and the relatively less dense GMP well network in some areas of the PAPA as compared to the network of wells monitored pursuant to BLM's 2000 ROD. Some commenters questioned if GMP well locations would provide early warning of potential groundwater degradation and if groundwater velocity data calculated for the Hydrogeologic Data Gaps Investigation and the use of advective transport simulations from the Numerical Groundwater Model were appropriate to site GMP wells. The response to the monitoring boundary definition (above) addresses some of these comments.

The POT believes that monitoring a number of existing industrial water supply wells in the North and South Zones in the monitoring boundary is appropriate for several reasons. Analytical results from sampling existing industrial water supply wells (located at various locations in the PAPA, completed to various depths, screened/perforated across various [multiple] water-bearing Wasatch Formation sandstone units and sampled using various methods) have already been relied on for regulatory decisions, including:

- BLM required sampling of existing wells for their 2000 ROD (continued through 2015);
- DEQ used sampling results from existing wells to require Operators to re-sample each of their wells in late 2006;
- BLM used data collected from existing wells (SCCD sample results) to prepare sections of the 2008 ROD; and
- Conclusions from the LLPHC Study (one of groundwater characterization studies in Step 2 of the 2008 ROD), which relied on chemical evidence collected from existing industrial water supply wells, were accepted by BLM, DEQ and EPA.

In addition, the WOGCC would require sampling of existing industrial water supply wells according to their baseline groundwater monitoring rule if the wells were located within ½-mile of a new or deepened gas well. Lastly, the GMP relied on analytical data collected from existing industrial water supply wells to perform statistical analyses and develop water quality thresholds for six parameters for the GMP.

For the reasons presented above, the GMP will include monitoring existing industrial water supply wells in the North and South zones, and seven new wells. The process of selecting locations for these wells is described in the GMP and detailed in the technical memorandum appended to the GMP (Appendix 4-A). However, based on comments received a number of revisions were made to Appendix 4-A (see **Enclosure 2**), including:

- Graphics showing the spatial analysis process were improved to better show disturbed areas (i.e., natural gas well pads).

- Additional detail was provided to describe the process of optimizing monitoring locations within particular "hot spots" (i.e., sample areas) and explain the slight increase in the target hot spot radius of 4,400 feet to the final radius of 4,421 feet (note: locations for many wells included in the project geodatabase were determined with non-resource grade GPS units and their locations are not precise).

Several comments also pertained to monitoring the alluvial groundwater system. Some of these comments are addressed through the revision to Section 4.2.3 of the GMP regarding the monitoring boundary (see **Attachment B**). The draft Plan (Section 4.2.3.2) specified monitoring the alluvial system in the River Corridor Envelope (RCE) by monitoring wells located downgradient of potential sources on four existing natural gas well pads. Based on the methodology presented in the GMP, 13 new monitoring wells are planned to monitor the groundwater system upgradient of the New Fork River floodplain (north and south of the floodplain). It is envisioned that these 13 wells will serve as early detection monitoring points to discover potential groundwater impacts before they would affect potential receptors, including the alluvial groundwater system and the New Fork River (see Objective 02.5).

Attachment D

Response – Keep Existing Program

RESPONSE – KEEP EXISTING PROGRAM (CATEGORY 13)

Many comments were received from the public with a general concern regarding differences in the GMP monitoring well network as compared to wells that have been sampled pursuant to the 2000 ROD. Noted differences include a decrease in the number of wells involved for monitoring and absence of private domestic and stock wells in the GMP well monitoring network.

There were concerns that the GMP did not honor the requirements in the groundwater resources section of the 2008 ROD and that the existing groundwater data set would be abandoned/discarded. In addition, the monitoring program that has been conducted pursuant to the 2000 ROD would not be applicable under the new WOGCC rules. The POT believes that the GMP fulfills the groundwater resources requirements of the ROD by stipulating a comprehensive Groundwater Pollution Prevention Program, a Groundwater Monitoring Program relying on specific existing wells and water quality thresholds, and by establishing a Response Action Program that could be triggered based on three conditions, including exceedance of a water quality threshold. Regarding the existing groundwater data, all the data are housed in a geodatabase and are available to the public. No data have been discarded and data collected by the SCCD were explicitly used to develop the GMP including background threshold values for a variety of parameters (refer to **Enclosure 3**). The water quality data generated from 2004 to 2013 and all new data collected during implementation of GMP are to be publically available as described in Section 4.6 of the GMP.

Several comments to the draft Plan indicated concern that groundwater will not be monitored along the entire New Fork River Valley in the PAPA. The PAPA numerical model report presented findings that the area most susceptible to groundwater quality impacts from natural gas activities was along the New Fork River in the central portion of the PAPA. Section 4.2.2 of the draft Plan presents an evaluation of risk and environmental sensitivity for the PAPA and includes a map (Figure 4-2) showing Wyoming's aquifer prioritization for the PAPA. Besides using the Wyoming aquifer prioritization map as a basis the draft Plan, the evaluation of risk and environmental sensitivity considered the groundwater flow system in the PAPA and specific potential sources of groundwater impacts from oil and gas activities. Many regions along the New Fork River are mapped as high or moderate-high priority aquifers, but not all of these areas have potential sources from oil and gas activities located hydraulically upgradient of the high priority aquifer. If an area has a high/moderate-high aquifer priority designation and potential sources of groundwater pollution from oil and gas activities located hydraulically upgradient, the draft Plan considered the area to be environmentally sensitive with the greatest relative risk of being impacted. These areas were included within the monitoring boundary. Revisions to text in Section 4.2.2, shown below, have been made to clarify how the RCE was determined.

The POT believes the GMP satisfies objectives related to monitoring environmentally sensitive areas through establishment of the RCE and the network of Wasatch Formation and alluvial wells in that area. The monitoring boundary discussion included in revised Section 4.2.3 (see **Attachment B**) defines which areas in the PAPA will be monitored during execution of the GMP and those areas of the PAPA that will not be monitored because they do not possess oil and gas activities that are hydraulically upgradient of

potential receptors. Private domestic and stock wells within the monitoring boundary will not be monitored because GMP wells upgradient of these wells will be used to satisfy the GMP objective of providing for early detection of potential impacts from oil and gas activities.

The following text in blue font is the revised text for Section 4.2.2:

4.2.2 Evaluation of Risk and Environmental Sensitivity

NewFields evaluated studies aimed at designating aquifer sensitivity/vulnerability and aquifer prioritization for Wyoming. NewFields considered work completed by Hamerlinck and Ameson (1998) and summarized by AMEC Geomatrix (2009) to evaluate groundwater vulnerability relative to oil and gas activities in the PAPA. Hamerlinck and Ameson (1998) developed the Wyoming Sensitivity/Vulnerability model which defines sensitivity as "the relative ease with which contaminants can move from the surface through various substrates to pollute groundwater." The term vulnerability is defined as incorporating "aquifer sensitivity and the potential for a contaminant to be spilled on the surface." According to AMEC Geomatrix (2009), 'sensitivity' describes an aquifer's susceptibility to contamination based solely on natural physical properties (i.e., depth, soil, geology); whereas 'vulnerability' describes susceptibility to contamination based on both natural physical properties and human activities on the surface (e.g., herbicide use on irrigated cropland).

Using the model Hamerlinck and Ameson (1998) developed for Wyoming, Geomatrix (2002) produced an aquifer sensitivity map for the PAPA. This map was included as Figure 3 in the Interim Plan (Geomatrix 2008) and shows areas of greatest sensitivity being portions of the Mesa, areas along the New Fork and Green rivers, and an area coincident with Sand Draw.

In addition to the aquifer sensitivity map prepared by Geomatrix (2008), NewFields considered work completed by Bedessem et al. (2005), which focused on identifying high priority aquifers for Wyoming's ambient groundwater monitoring strategy. Their work includes an evaluation of aquifer sensitivity, current water use, and the potential for surface contamination from known land uses. This approach combines physical factors used to determine aquifer sensitivity with information on aquifers that are used for drinking water sources, and with aquifers that are most susceptible to point and non-point source pollution. Bedessem et al. (2005) identifies high priority aquifers as those used for drinking water sources and which are most susceptible to pollution. **Figure 4-2** shows the aquifer prioritization map for the PAPA based on Bedessem et al. (2005). High priority aquifers in the PAPA are primarily associated with those located in the New Fork River valley.

The approaches described above to identify sensitive/vulnerable aquifers and high priority aquifers for the area encompassing the PAPA do not consider the three dimensional groundwater flow system, specific potential sources of groundwater impacts from oil and gas activities, and the potential fate of contaminants if they entered the groundwater system. However, results produced by a groundwater flow and transport model of the PAPA (AMEC 2013a) help further define those areas that possess the greatest risk of being impacted from oil and gas activities.

The PAPA numerical model (AMEC 2013a) is a three-dimensional model of the groundwater flow system and can be used to identify areas located hydraulically downgradient of oil and gas activities. The model can also be used to predict the areas within the PAPA where groundwater could potentially be impacted by oil and gas activities.

NewFields expanded on work reported by AMEC (2013a) by simulating the movement of particles through the PAPA groundwater flow field for a period of 110 years (see **Section 4.2.3** and **Appendix 4-A**), which is approximately twice the production life of the Pinedale Anticline (BLM 2008a). The particle track simulations included 110 year-long forward particle tracks from potential oil and gas source areas, and 110 year-long reverse particle tracks from those areas identified as sensitive/vulnerable to groundwater contamination (note: these sensitive/vulnerable areas generally coincide with high priority aquifers mapped by Bedessem et al. [2005]). NewFields' particle tracking simulations addressed uncertainty in the model that was discussed by AMEC (2013a). Results of particle track simulations focused on the area considered to be of greatest environmental sensitivity and with the greatest relative risk of being impacted, and only involved those areas with potential receptors (e.g., New Fork River) that had a potential oil and gas source located hydraulically upgradient. **Figure 4-3** shows this area which is hereafter referred to as the "River Corridor Envelope". The area comprises the zone enveloping potential sources located hydraulically upgradient of their potential receptors over a 110-year travel time from potential source to potential receptor.

Attachment E

Response – Early Detection/Warning

RESPONSE – EARLY DETECTION/WARNING, USE OF 110-YEAR TRAVEL TIME TO POTENTIAL RECEPTOR (CATEGORY 15)

A number of public comments were received regarding the period of 110-years which was used for several purposes including:

- Particle tracking analyses with the PAPA groundwater model to help define the boundary of the RCE;
- Positioning monitoring wells between potential sources and receptors in the RCE based on results of solute transport modeling; and
- Locating monitoring wells in the North and South Zones based on spatial analysis.

It is important to highlight again that widespread groundwater impacts from oil and gas activities in the PAPA is not evident. Findings from the three groundwater characterization studies (Hydrogeologic Data Gaps Investigation, Numerical Modeling and LLPHC) did not produce evidence of existing widespread groundwater contamination, existing point sources of pollution, nor discrete zones or areas of high permeability in the Wasatch Formation hydrostratigraphic unit that may cause preferential groundwater flow paths. To that end, the draft Plan concentrates on continued prevention of groundwater pollution and consequently, the hallmark program in the draft Plan is the Pollution Prevention Program. Operators had been implementing best management practices (BMPs) that are detailed in Tables 3-1 through 3-5 and Appendix 3-B at the time that Step 2 groundwater characterization studies were being completed. Once the Plan is approved, these BMPs will be required for all Operators in the PAPA. Continued implementation of these pollution prevention practices is intended to prevent or minimize potential future impacts to groundwater.

Within the monitoring boundary, there are several existing private domestic, private stock and Operator-owned industrial water supply wells. Private domestic and stock wells are considered potential receptors of groundwater impacts from oil and gas activities. Based on the GMP objective to provide early detection of potential impacts from oil and gas activities in areas of greatest environmental sensitivity (Objective O2.5), the GMP monitoring well network was designed to monitor wells upgradient of these potential receptors. This strategy aims to identify any groundwater degradation issue before reaching and impacting potential receptors (e.g., domestic and stock wells, and the New Fork River). This description is included in revised Section 4.2.3 of the GMP (see **Attachment B**).

The "110-year-travel-time" term was introduced and described in the numerical modeling report (November 2013). The model was developed based on direct input received by technical representatives from BLM, EPA and DEQ in 2012 and 2013. The report was thoroughly reviewed by these three agencies and, at the request of EPA, by modeling specialists from the US Geological Survey. The groundwater velocity of the Wasatch Formation used to calculate a 110-year groundwater travel time is based on hydraulic conductivity values produced from aquifer tests completed during the Hydrogeologic Data Gaps Investigation, measured hydraulic gradients and literature estimates of

effective porosity for sandstones. As the 110-year groundwater travel time concept was thoroughly developed in the modeling report and accepted by the regulatory agencies, the draft Plan used this same approach to help define the RCE boundary and locate GMP monitoring locations. The 110-year groundwater travel time is described as follows:

Time Period:

- The PAPA ROD states that natural gas well drilling is expected through 2025 and that natural gas production would continue through 2065;
- The beginning of the time period is set as the Hydrogeologic Data Gaps study well installation in 2010 and the end of the period is set as the end of production (2065), which totals 55 years; and
- The 55-year period was doubled to 110 years to account for uncertainty as discussed below.

Wasatch Formation Groundwater Velocity Determinations:

- During the Hydrogeologic Data Gaps study, 11 aquifer tests were conducted in Wasatch Formation wells completed in sandstones units to determine hydraulic properties.
- Hydraulic conductivity ranged from 0.02 to 9.5 feet/day.
- Darcy's law was used to calculate groundwater velocity using the highest hydraulic conductivity value determined from aquifer tests, literature values for effective porosity, and the measured hydraulic gradient. The maximum groundwater velocity was calculated at 40 feet per year in Wasatch Formation sandstone.
- For the velocity determination in the GMP, it was assumed that groundwater flow occurs in Wasatch Formation sandstone units, that the sandstone units (or lenses) are interconnected, and that one hydraulic conductivity value applies to all sandstone units.
- Because secondary permeability features that may affect groundwater velocity were not discovered, a single groundwater velocity of 40 feet/day was used in the GMP.
- As a check to the empirical determination of groundwater velocity from measured gradients and hydraulic conductivities, groundwater flow velocities were analyzed using the PAPA numerical groundwater flow model. The numerical model is based on the hydrogeologic conceptual model, and calibrated to measured groundwater elevations and estimated flux. Model calibration resulted in hydraulic conductivity values for Wasatch Formation sandstone ranging between 1.0 and 30 feet/day.

110-year Groundwater Travel Time:

- Doubling the travel time from 55 to 110 years was a conservative assumption used for advective and transport modeling, and modeling results were considered while selecting locations for GMP monitoring wells. Increasing the travel time accounts for uncertainty regarding groundwater flow and secondary porosity which is discussed in the numerical modeling report. If currently unidentified faults, fractures, and joints exist in the saturated portion of the Wasatch

Formation, are oriented in the direction of groundwater flow, and act as conduits to flow instead of barriers, potential groundwater contaminants may move faster than estimated groundwater velocities discussed above.

- The size of the sample area ("hot spot") used to locate monitoring wells in the North and South Zones is based on a 110-year time of groundwater travel. A single "110-year radius of monitoring" can detect an area of potential groundwater degradation that is less than 5 percent of the total area of the North and South monitoring zones.
- The RCE boundary was established based on a 110-year groundwater travel time between potential source and potential receptor. This means that the RCE boundaries were extended hydraulically upgradient, further than if just a 55-year travel time was used. This resulted in a larger area to monitor in the environmentally sensitive RCE.

As noted earlier in this memorandum, the Plan obligates the Review Team to be continually involved in the implementation of the Plan during regular review cycles. The Plan is dynamic and if it becomes apparent through analysis of data collected while implementing the Plan that the monitoring network is inadequate, the Review Team is charged to modify the Plan. Conceivably, this could include adding monitoring wells to the well network.

Attachment F

Response – Existing Well Sampling Methods

RESPONSE – EXISTING WELL SAMPLING METHODS (CATEGORY 10)

Comments related to sampling methods for existing wells included in the GMP well network were provided by the Review Team. According to the Operators, the 17 existing industrial water supply wells included in the GMP have or had been equipped with fixed rate submersible pumps to deliver water. Samples collected from these wells since ROD-required monitoring began in 2004 have been collected from existing pumps or in the absence of pumps, by bailer. Other samples were collected during the LLPHC study using HydraSleeves. Water quality data produced from sampling these wells by a variety of sampling methods over several years have been approved by agencies and used to make a variety of regulatory decisions as described earlier in this memorandum.

The GMP Sampling and Analysis Plan (SAP) provided as Appendix 4-C of the draft Plan is based on WOGCC's sampling and analysis procedure (Appendix K) which is included in their baseline groundwater monitoring rule. The rule requires sampling of existing wells using the existing water delivery system (e.g., pump), if present. Although the rule does not require a specialized pump for sampling nor does it specify where the pump should be located in a well, it does suggest that if a pump is equipped with a variable flow controller, the flow rate should be reduced for sampling as noted in Section 2.3.2 [Sample Collection] of WOGCC's Appendix K:

> "Groundwater samples shall be collected immediately after purging the well. Once purging is complete, the flow rate should be reduced in order to minimize the potential for loss of VOCs. Reducing the flow rate by adjusting a valve should be avoided. Closing of a valve does not decrease the flow rate of the pump, and may induce turbulence into the water column. If a pump is equipped with a variable flow controller, the flow rate should be reduced, and the new flow rate calculated."

A typical variable frequency drive (or variable flow controller) for a submersible pump motor used in industrial water supply wells in the PAPA could vary the frequency delivered to the pump from about 30 cycles per second (hertz; Hz) to 70 Hz. This will vary the speed at which the motor spins, which in turn changes the pumping rate. Normal pump operation is typically 60 Hz, so pumps are rated for a desired pumping rate that is produced at 60 Hz. Decreasing the frequency from 60 to 30 Hz will typically cut the pumping rate in half. As an example, given the static water levels common to the PAPA, a pump that provides 100 gallons per minute (gpm) at 60 Hz would provide about 50 gpm at 30 Hz.

Pumps in existing industrial water supply wells are sized to provide water for various drilling and completion activities on the order of 100 gpm. However, the range of pumping rates that can be achieved by varying the frequency of the power supply is not great enough for the same pump to be used to produce a flow rate high enough for practical water supply needs and low enough for sampling rates desired for low flow environmental sampling (~100-200 milliliters per minute).

Public water supply systems that use groundwater typically have access to sample water at well heads. Similarly, well heads on many of the existing industrial water supply wells in the PAPA are equipped for sampling with sampling ports (brass ports with a ball valve) set through the bottom of backflow

prevention devices. This allows samplers to run the pumps to purge wells prior to sampling and then sample through the sampling ports after purging and stabilization of field parameters. The photographs below show a typical brass sampling port and field technician collecting a water sample from the port.

Brass sampling port, with ball valve, installed in bottom of backflow prevention device on existing water supply well.

Collecting a water sample for VOC analysis from sampling port on existing water supply well.

Additional detail is being added to the SAP (Appendix 4-C of the Groundwater Monitoring Program) and in SOP-12 (Annex 4C-1) to further describe the sampling ports on existing industrial water supply wells as follows:

<u>Revision to first paragraph of Section 3.6 (Groundwater Sampling Procedures), Appendix 4-C (Sampling and Analysis Plan)</u>

> Most of the existing wells in the GMP network are industrial supply wells with submersible pumps installed to facilitate collection of groundwater samples; these include the 17 existing wells in the North and South Zones. Pumps are installed at depths indicated in **Table 4C-1**. Should pumps in existing wells need to be removed for maintenance or replacement, Operators would reinstall pumps at the approximate middle of the screened interval in the well.

<u>New Paragraph after the bullet list in Section 3.6.1 (Well Purging), Appendix 4-C (Sampling and Analysis Plan)</u>

> Existing industrial water supply wells will be sampled using a slip-stream method at the well head from discharge piping connected to submersible fixed-rate pumps. If not already equipped, a brass or stainless steel quill-type sampling port will be installed in

the bottom of the discharge piping at the well head. The sampling port will be equipped with a ball valve to control flow rates to approximately 100 milliliters per minute for sampling. The port will have a nipple or other type of connection to allow disposable tubing to be attached between the sample port and a flow-through cell. The flow-through cell will be equipped with various probes/sensors to measure field water quality parameters.

New Paragraph in "Collecting Groundwater Quality Samples", SOP-12, Annex 4C-1 (Sampling and Analysis Plan)

For wells equipped with electric submersible pumps (wells located in the North and South Zones), samples will be obtained using a slip-stream method at the well head from discharge piping connected to submersible fixed-rate pumps. If not already equipped, a brass or stainless steel quill-type sampling port will be installed in the bottom of the discharge piping at the well head. The sampling port will be equipped with a ball valve to control flow rates to approximately 100 milliliters per minute for sampling. The port will have a nipple or other type of connection to allow disposable tubing to be attached between the sample port and a flow-through cell. The flow-through cell will be equipped with various probes/sensors to measure field water quality parameters that are noted above.

Lastly, the initial Annual Summary Report for the GMP (see Section 4.7) will report on the new well and pump installations, including installation of any sampling ports required for existing industrial water supply wells. The EDMS will be updated with new well and pump information and it is anticipated that Table 4C-1 from Appendix 4-C will be revised to summarize the information in the Annual Summary Report.

Attachment G

Response – Vertical Monitoring

RESPONSE – VERTICAL MONITORING (CATEGORY 3)

The Review Team and Public made a variety of comments regarding the depth of wells included in the GMP monitoring network, for both existing and new wells. Some comments were on the varying screen lengths in GMP wells and others related to the ability of the GMP to detect potential deep contaminant releases associated with natural gas well cement and casing failures or from deep waste water injection wells.

The well selection process for the GMP focused on the geographic position of wells relative to fulfilling GMP objectives O2.3, O2.5 and O2.6 related to selecting monitoring areas based on risk, early detection and spatial coverage. Section 4.2.2 (**Attachment D**) and the revised Section 4.2.3 (**Attachment B**) of the Plan address this topic. However, while designing the GMP well network the following were considered:

- The upper approximately 1,000 feet of Wasatch Formation was conceptually and numerically modeled as a single system – the Wasatch Hydrostratigraphic Unit (HSU) - using hydrogeologic information and data developed from completing the Step 2 groundwater characterization studies. An understanding of the three-dimensional groundwater flow system in the Wasatch HSU was developed based on measured groundwater elevations and results of a synoptic flow study on the New Fork River. This understanding includes groundwater discharge from the Wasatch HSU to the alluvial groundwater system associated with the New Fork River in the center of the PAPA (groundwater flows towards the river from the north and south). Wasatch HSU study wells located in the New Fork River floodplain are artesian. The reader is referred to the Hydrogeologic Data Gaps Investigation and Numerical Modeling reports for further details.

- The Wasatch Formation consists primarily of fluvially-deposited sandstones, representing channel deposits, and shale/siltstone representing overbank deposits. About one-third of the Wasatch Formation in the study area consists of sandstones, with an average thickness of about 18 feet. About two-thirds of the Wasatch Formation consists of siltstone/shale with an average thickness of 33 feet. Sandstone and siltstone/shale are interbedded and laterally discontinuous on a scale of 1,000 feet. The majority of groundwater flow in the Wasatch HSU occurs in the relatively more permeable sandstone units.

- Consideration of using existing wells (completed at various depths with various screened/perforated intervals) for the GMP well network outside of the RCE was made for several reasons including: the WOGCC specifies use of existing wells to fulfill requirements of their baseline monitoring rule; existing wells were required to be sampled by the 2000 ROD and have been through 2014; and, results from water quality sampling of existing wells have been used for regulatory decisions made by both BLM and DEQ. Selections of existing wells for the GMP well network is based on their geographic location relative to satisfying the spatial coverage objective for those areas within the PAPA development area boundaries and outside of the more environmentally sensitive River Corridor Envelope. Neither well depth nor completion characteristics (screened/perforated intervals) were used to select wells for the North and South Zones. Specific details for each of the 17 wells in the North and South Zone,

and the 4 existing alluvial wells in the GMP, are presented on well logs contained in Annex 4C-3 to Appendix 4-C.

- It is acknowledged that the 17 existing wells selected for the GMP were constructed as water supply wells and have varying lengths of screened intervals and intercept multiple saturated sandstone (Annex 4C-3 of Appendix 4-C).

- Depths for the 20 new monitoring wells to be included in the GMP well network (13 in the RCE, 1 the North Zone and 6 in the South Zone) were generally specified in Section 4.2.3 of the draft Plan and Section 3.3 of Appendix 4-C as follows: a sandstone unit in the uppermost portion of continuously saturated Wasatch Formation with an estimated thickness of 20 to 40 feet. Specific details on geologic materials and groundwater occurrence at the 20 locations for the new wells is not available, so actual depths for new wells cannot be predicted until wells are drilled. The uppermost saturated portion of the Wasatch HSU was selected for monitoring at these 20 locations for several reasons including:

    - Groundwater flow gradients are upward in the locations for the 13 RCE wells.

    - The relative risk of surface releases of potential groundwater contaminants (e.g., from tank batteries, buried flow lines and LGS pipelines, central gathering facilities, etc.) appears to be greater than from deeper sources (e.g. casing and cement seal failure).

    - It was assumed that any deep release from a natural gas well would include methane: buoyant forces would tend to direct methane upward to the surface (refer to conceptual model for natural gas generation and seepage presented in the LLPHC report); methane is a GMP monitoring parameter with a threshold; and Wasatch HSU monitoring wells would appear to be suitable to detect a release from a leaking natural gas well even if the well is shallower than the point of release.

    - The 17 existing wells including in the GMP network are completed at greater depths providing a range of depth monitoring within the GMP monitoring boundary.

To more fully address concerns regarding the vertical aspect of monitoring for the GMP, a statistical analysis (t-test) was performed using data produced by SCCD between 2004 and 2013 to evaluate similarity in concentrations of chloride and total dissolved solids (TDS) versus both depth (depth below ground surface) of the midpoint of the well screen interval and the absolute elevation of the midpoint in the well screen interval. These two depth variables were analyzed due to the relief present in the PAPA, as the ground surface elevations of some natural gas well pads on the Mesa in the North Zone are approximately 7,600 feet and the elevation of the New Fork River in the center of the PAPA is about 6,900 feet. Chloride and TDS were only evaluated for wells in the Wasatch Formation as all but four wells in the GMP network are completed in the Wasatch Formation.

The following data were used in the t-test:

- Water quality sample results stored in the project geodatabase (e.g., EDMS) that included data collected by SCCD from 2004-2013 and data collected during the completion of the Step 2 groundwater studies.

- Water quality data were used from industrial water supply, stock, domestic and study wells completed in the Wasatch Formation that are located within the GMP monitoring boundary as described above.

- Data from wells enrolled in DEQ's Voluntary Remediation Program were not used in the t-test. In addition, quantile-quantile probability plots were used to visually inspect the datasets and remove outliers.

- After removal of outliers, chloride data were available from 820 samples and TDS data from 811 samples that were collected from 95 wells within the GMP monitoring boundary.

- The depth of the midpoint of well screens in the 95 wells ranges from 54 to 1,210 feet below ground surface whereas the elevation ranges from 6,306 to 7,263 feet above mean sea level. The average elevation of the midpoints of well screens for the 95 wells is 6,700 feet.

Results of the analysis indicate that there is no statistically significant relationship between concentrations of chloride or TDS with mid-screen depth or elevation based on samples from 95 wells located within the GMP monitoring boundary. Consequently, comparing sample results from wells completed in the Wasatch Formation at the depth ranges listed above with new Wasatch Formation wells for the GMP, appears appropriate.

Based on the comments regarding vertical sampling, Section 4.2.3 has been revised (see **Attachment B**) and a presentation of the t-tests and results has been added to revised Appendix 4-A (see **Enclosure 2**).

Attachment H

Response – Threshold Analysis

RESPONSE – THRESHOLD ANALYSIS (CATEGORY 4)

Comments were received that included concerns with the method used to calculate background threshold values (BTVs) for six of the 19 parameters included for analysis in the GMP. Replies to several comments, including how/where the Plan is revised based on comments, are provided below:

- Data generated from samples collected pursuant to the 2000 ROD (available 2004 through 2013) are housed in the project geodatabase (e.g., EDMS) and was not disregarded or discarded, but was used to develop BTVs for six of the 19 water quality parameters included in the GMP.

- As described in Section 4.4, shown on Figure 4-13 and presented in Table 4-4 (revised to present thresholds), the GMP specifies thresholds based on absolute values for each parameter (excluding bromide as discussed below) as well as statistically significant trend using the Mann-Kendall test. Data will be analyzed for each monitoring event to determine if analytical results from any of the 19 parameters measured in any sample from the 41 wells is exceeded, and then evaluated by the Review Team during the annual review cycle.

- As noted on page 4-12 of the GMP, insufficient data were available to calculate a BTV for bromide and there is no applicable regulatory standard for bromide (see Table 4-3). Consequently, the threshold for bromide will be based on a statistically significant trend using the Mann-Kendall test. This explanation will also be included in the revised Appendix 4-B.

- Insufficient alluvial water quality data are available within the monitoring boundary to determine BTVs for the alluvial system. Therefore, statistically significant trend analysis using the Mann-Kendall test will be used to evaluate the six parameters without BTVs. An explanation regarding the alluvial system and BTVs will be included in Section 4.4.1 (see below) and in the revised Appendix 4-B.

- Intra-well BTVs were not used for several reasons: only 17 of the 41 GMP wells have water quality results (up to 10 records); all available data for Wasatch Formation wells within the monitoring boundary were used to calculate BTVs; no water quality data are available for the 20 new wells; and, the Mann-Kendall test (an intra-well test) will be applied to results from sampling each of the 41 wells once adequate data have been obtained (six sampling events).

- In consideration of technical comments on the statistical evaluation of BTVs, Appendix 4-B has been revised and is contained in **Enclosure 3**. It further describes how existing historical water quality data from Wasatch Formation wells within the monitoring boundary were used in the statistical evaluation to determine BTVs for each of the six parameters based on three geographic regions of the PAPA: North Zone, RCE and South Zone. Graphical representations of the analysis are also improved along with additional text describing how data below the analytical method detection limit and outliers were handled.

The following text in blue font is the revised text for Section 4.4.1:

4.4.1 ABSOLUTE VALUE

Table 4-4 presents absolute value thresholds for each parameter on the Core and Supplemental sampling lists. Absolute value thresholds are single, parameter-specific numerical values applied to all wells in the monitoring network. If a water quality result exceeds an absolute value threshold for a given parameter and is confirmed by resampling (**Figure 4-12**), the Response Action Program (**Section 5.0**) will be launched.

Figure 4-13 presents a flow chart depicting how absolute value thresholds were determined for parameters specified in WOGCC's Rule and listed in **Table 4-3**. If a parameter is not included in the Core or Supplemental sampling lists (**Figure 4-11** and **Table 4-3**), an absolute value threshold is not required. For parameters that have a National Primary Drinking Water Standard (EPA 2009), DEQ (2005) groundwater classification standard, DEQ (2014) VRP groundwater cleanup level, or WOGCC (2014a) action and notification level, and are not likely to appear first at monitoring points, the absolute value threshold was set as one-half the applicable standard. For the remaining parameters, absolute value thresholds were established through statistical analysis of existing groundwater quality data contained in the EDMS (**Section 1.7.3**).

An absolute value threshold was not calculated for bromide because a standard does not exist and there is insufficient existing data within the PAPA to calculate a value. This parameter will be evaluated on an intra-well basis using a statistically significant trend threshold (see **Section 4.4.2**). In addition, absolute value thresholds were calculated using Wasatch Formation data and are not applicable to monitoring wells screened in alluvial material. Absolute value thresholds were not calculated for alluvial monitoring wells because insufficient water quality data exists for alluvial groundwater in the monitoring boundary. Data collected from alluvial monitoring wells will be evaluated using one-half the applicable standard or on an intra-well basis using a statistically significant trend threshold.

NewFields applied statistical background techniques to calculate absolute value thresholds for six (6) of the 19 parameters involved in the GMP, including: alkalinity, calcium, chloride, potassium, sodium, and total dissolved solids. AMEC (2013b) concluded that no widespread impact to groundwater in the PAPA is evident as a result of natural gas activities. Despite this conclusion, groundwater quality data collected pursuant to BLM's 2000 and 2008 RODs (BLM, 2000; BLM, 2008a; BLM 2008b) was subjected to a series of rigorous and thorough outlier analyses. The objective of these analyses was to exclude and remove any measurement which is actually or potentially above background conditions in the PAPA. The investigated dataset included annual groundwater samples collected by the Sublette County Conservation District (SCCD) on behalf of the Operators from 2004 to 2013 and data collected as part of AMEC (2012) and AMEC (2013) from 2010 through 2012.

For calculating absolute value thresholds, sample results from the Pinedale EDMS were compiled for each parameter listed above into separate datasets. The objective of the analysis is to determine background groundwater quality thresholds for previously defined monitoring areas in the PAPA (see

Section 4.2.3). Sample results from wells located outside of these monitoring areas were not considered in the analysis. These exclusions were made in order to avoid any undue bias or distortion associated with unrepresentative data collected outside of the monitoring areas.

To remove sample results that may bias or distort threshold values and determine if geographical differences exists for the evaluated parameters in the PAPA, outlier and spatial analyses were performed on each dataset prior to establishing absolute value thresholds. After completion of these analyses, a background threshold analysis was performed using ProUCL (EPA, 2013b) to establish the absolute value threshold for the six parameters.

Statistical analyses of the investigated data were initiated by identifying potential outlier values. Outlier data points can distort statistics and yield inflated background threshold values. Outliers can occur for several reasons, including: 1) measurement recording errors; 2) measurement from an impacted well; or 3) rare or unexpected event (Helsel and Hirsch, 2002). To avoid inflated or unrepresentative background threshold values, all outliers were removed from the datasets.

Outliers were determined by inventorying wells enrolled in DEQ's VRP, and using quantile-quantile (Q-Q) probability plots to visually identify outliers. Groundwater samples for wells in DEQ's VRP were assumed to be potentially impacted, and thus, their associated data were removed from the datasets. On a Q-Q plot, elevated measurements that are separated from the majority of data were considered outliers and removed from the dataset. Additional information regarding outliers is provided in **Appendix 4-B**.

After outliers were removed, the remaining data were separated based on the defined monitoring areas (see **Section 4.2.3**) into North Zone, South Zone, and RCE. An analysis of variance (ANOVA) test was then performed for each parameter to determine if statistically significant differences exist between measurements in the three areas.

The ANOVA test is a commonly used method of comparing the means of multiple groups of data (Field, 2009). The test is performed by producing an F statistic, which is associated with a p-value which is the probability of obtaining that F statistic. The p-value is compared to a pre-defined significance level to determine if a statistically significant difference exists between the group means. In this work, a 5 percent significance level was used for the test, thus if the calculated p-value is less than or equal to 0.05, there is a statistically significant difference between the mean values in the three areas.

Based on results of the ANOVA test, there is a statistically significant difference between the three monitoring areas for a majority of the parameters. Therefore, area-specific absolute value thresholds were calculated for each parameter.

Prior to absolute threshold analysis, parameter datasets in each monitoring area were re-analyzed using Q-Q plots to remove remaining area-specific outliers. Upon completion of thorough analyses of outliers and spatial differences, absolute value thresholds were established. Given the fact that there is no evidence of widespread contamination in the PAPA from natural gas activities (AMEC 2013), the

datasets, excluding outliers, were considered as representative of background conditions for each of the three monitoring areas.

Two methods were used to calculate absolute value thresholds:

a) Method A - Using all available data for a monitoring area as a single population. This is a common approach where the upper threshold value of the dataset is set as the absolute value threshold.

b) Method B - Using only the highest concentration subpopulation, as determined based on visual identification of a 'break' in the Q-Q plot. Consistent with Singh et. al. (2014), a 'break' in a dataset is defined as a visually discernable jump or change in slope of the Q-Q plot.

ProUCL was used to calculate upper tolerance limits (UTL) with 95 percent confidence and 95 percent coverage. ProUCL provides UTL calculated based on normal, gamma and log-normal distributions, as well as non-parametric UTL. The software also provides statistical tests to identify if the data follow normal, gamma, or log-normal distribution. When data follow normal or gamma distribution, the corresponding distribution-specific UTL was used; otherwise, non-parametric UTL was used. In addition, when there are non-detects in the data, Kaplan-Meier method was used to calculate more accurate UTL values.

In general, absolute value thresholds calculated using the highest background subpopulations were selected. These choices were driven by the following facts:

- Throughout the background analysis, absolute care was taken to remove any actual and potential outliers from background datasets. These exclusions and removals were performed at multiple stages by first identifying and removing potentially impacted wells, followed by parameter- and area-specific outlier analyses, resulting in the removal of 64 measured values from the background datasets.

- The remaining background datasets clearly consisted of multiple subpopulations. Under such conditions, absolute value thresholds must accommodate all of the background subpopulations present in the datasets. This means that only the thresholds associated with the highest subpopulation would meet such criterion.

Appendix 4-B provides further detail regarding establishment of absolute value thresholds.

Attachment I

Response – Concerns with Groundwater Studies Completed under Step 2 of the ROD

RESPONSE –CONCERNS WITH GROUNDWATER STUDIES COMPLETED UNDER STEP 2 OF THE ROD (CATEGORY 14)

Public reviewers of the draft Plan had a large number of comments and concerns related to the Step 2 groundwater studies that were completed in the PAPA between 2008 and 2013. The Review Team did not have concerns with the previous studies presumably because representatives of BLM, DEQ, EPA and the Operators were involved in reviewing, vetting and accepting work plans, plans of studies, sampling and analysis plans, and multiple versions of each technical study report completed pursuant to the 2008 ROD. Draft versions of the LLPHC study report were also scientifically reviewed by two independent technical experts and their comments were incorporated into the final version of the LLPHC report. Further, final reports for each of the Step 2 groundwater studies were accepted by BLM, DEQ and EPA.

Results of the groundwater characterization studies were presented in public meetings at the BLM Pinedale Field Office on several occasions including to the Pinedale Anticline Working Group on February 7 and May 22-23, 2012 and to the public during a special meeting held November 22, 2013. Project updates were also provided during Annual Planning Meetings open to the public on four occasions between August 2011 and August 2014. Other opportunities the public had to become informed of the previous studies are presented in **Attachment K**.

It is important to note that Section 1.6 of the draft Plan explicitly stated that Sections 1.6.1 through 1.6.3 provide excerpts from the executive summaries of the Hydrogeologic Data Gaps Investigation, Numerical Groundwater Modeling and LLPHC study. Section 1.6 was not intended to describe details of the three studies but rather to present summaries of the studies. Results of these studies are the foundation for the Plan. In Section 1.6, the reader was referred to BLM's website to access each of the complete reports for review or download.

Based on the foregoing and the Plan tenets presented on Page 2 of this memorandum, no changes are being made to the Plan based on Public comments related to the previous PAPA groundwater studies. The POT believes that the Plan provides ample and continual opportunity to modify/adapt any one or more of the three Programs, as necessary, based on results of executing the Plan. During annual review cycles, the Review Team (representatives of five regulatory agencies and operators) are charged with determining if changes to the Plan Programs are needed, including revisions to the existing hydrogeologic conceptual model (see Section 5.0 of the Plan).

ATTACHMENT J

Response – Monitoring Frequency

RESPONSE – MONITORING FREQUENCY (CATEGORY 9)

Several Review Team comments were received related to the frequency of groundwater monitoring. The POT believes that because estimated groundwater velocity in the Wasatch Formation was considered and used to determine the "hot spot" radius (i.e., area of potential groundwater degradation, or sample area) and groundwater travel times for monitoring in the North and South Zones (see Appendix 4-A), that an annual monitoring frequency is appropriate for Wasatch Formation wells.

Locations for the 13 Wasatch Formation wells in the RCE were also selected based on hydrogeologic properties of the Wasatch Formation and through the use of the numerical model (refer to Section 4.2.3.1 of the GMP). The maximum width of a simulated chloride plume from the numerical model was used to laterally space RCE wells on the north and south portions of the RCE. Based on potential receptor locations and potential sources, well locations were adjusted as necessary to ensure adequate coverage of potential sources upgradient of potential receptors. Because the estimated groundwater flow velocity of the Wasatch Formation was used in the analysis for these 13 Wasatch Formation wells, the POT believes that an annual monitoring frequency is appropriate.

Each of the four alluvial wells included in the GMP are located on existing natural gas pads that have above ground storage tank facilities. Wells are located on the perimeter of pads generally downgradient of most pad facilities, including tankage. To further assess the monitoring frequency for the four GMP alluvial monitoring wells, NewFields completed an additional analysis that included the following steps:

- Using hydraulic conductivity values representing alluvial material from the calibrated numerical flow model (400 feet/day), a measured groundwater gradient from the Hydrogeologic Data Gaps Investigation (0.0034 feet/feet) and an effective porosity value from the Yu et. al. (1993; referenced in Table 23 of the Numerical Modeling Report), an average advective groundwater velocity in alluvium is about 5 feet/day.
- The width (roughly parallel to the alluvial groundwater flow direction) of each of the four natural gas pads with alluvial monitoring wells is about 770-800 feet.
- Assuming a potential release could occur on the upgradient edge of a pad furthest from a monitoring well, the travel time of a non-retarded constituent such as chloride to the well would be on the order of 160 days.

As a result of the analysis, it appears appropriate that the monitoring frequency for the four alluvial wells be semi-annual.

It is also important to recall that during the annual Groundwater Monitoring Program review cycles (see Section 4.8) the Review Team will be continually evaluating the GMP for effectiveness, relevance and appropriateness. Should monitoring results suggest that changes to monitoring frequency of any of the

41 monitoring wells may be warranted, the Review Team would make necessary changes. These changes would be recorded by BLM's Project Lead and posted to the Pinedale Field Office website.

The text in blue font below is added at the end of Section 4.3.2 (Monitoring Frequency):

> Based on these considerations and the hydrogeologic characteristics of the Wasatch Formation (i.e., maximum advective groundwater velocity calculated to be 40 feet/year), the frequency of groundwater monitoring for the GMP wells completed in the Wasatch Formation shall be annually.
>
> The four alluvial monitoring wells included in the GMP are each located on the perimeter of natural gas pads, downgradient of most pad facilities including above ground storage tanks. Using hydrogeologic data for the alluvial system reported in AMEC (2013a), the average advective groundwater velocity in alluvium is about 5 feet per day. Assuming a potential release could occur on the upgradient edge of a pad furthest from a monitoring well, the travel time of a non-retarded constituent such as chloride to the well would be on the order of 160 days. Based on this reasoning, the frequency of groundwater monitoring in alluvial wells will be semi-annual.
>
> Summer months are the ideal time for monitoring given weather conditions in the high-altitude setting of the PAPA. Besides summer, alluvial GMP wells will be monitored at the beginning of each calendar year and any necessary confirmation re-sampling (e.g., threshold exceedance; see Section 4.4) would occur before the summer monitoring event. If alluvial GMP well sampling is conducted at the beginning of the year and then all GMP wells are monitored in the summer, and considering a typical 3-week turn-around-time for laboratory analytical results, any necessary confirmation re-sampling could be easily accomplished by early fall. Obtaining groundwater data from all wells in the summer would also permit reporting and accommodate periodic Review Team meetings in the same calendar year in which monitoring is conducted.

The last paragraph of Section 3.5 (Groundwater Monitoring Parameters) of Appendix 4-C (Sampling and Analysis Plan) will be revised as follows in blue text:

> The 41 wells included in the GMP will be sampled annually in the summer for parameters listed on the Core List and/or Supplemental List. All wells will be analyzed for Core List parameters; whereas, wells located in the River Corridor Envelope will also be analyzed for Supplemental List parameters. As noted in Section 4.3.2 of the GMP (NewFields 2015), the four alluvial monitoring wells will also be sampled at the beginning of each calendar year (semi-annual frequency). In addition, for the new monitoring wells and any existing wells in the GMP that have not previously been analyzed for the inorganic compounds, hydrocarbons, and dissolved methane listed in **Table 4C-2**, the initial groundwater sample from these wells will be subject to further analysis if the dissolved methane concentration is greater than 5 milligrams per liter (mg/L). The

additional analysis will include dissolved ethane and propane, fixed gases C1-C6, and stable isotopes of carbon and hydrogen in methane as shown on Figure 4-12 in NewFields (2014).

The first paragraph of Section 3.6.2 (Sample Collection) of Appendix 4-C (SAP) will be revised as follows in blue text:

For this GMP, groundwater samples will be collected on an annual basis during the summer season (refer to Section 4.3.2 in NewFields 2015). The four alluvial monitoring wells will also be sampled at the beginning of each calendar year. Groundwater samples will be collected immediately after purging each well. Groundwater sampling procedures are described in SOP-12 (**Annex 4C-1**), and a field form to document sampling information is included in **Annex 4C-2**. The parameters to be analyzed by the laboratory are listed in **Table 4C-2**, including analytical methods, sample container and preservative requirements, filtration requirements, laboratory reporting limits, and sample holding times.

Attachment K

Response – Public Participation, Public Notification

RESPONSE – PUBLIC PARTICIPATION/NOTIFICATION (CATEGORY 16)

The Public provided a number of comments regarding public participation and/or public notification. These included general comments to the draft Plan and specific comments to the Response Action Program.

General comments indicated that information to fully understand the draft Plan was not provided to the public, such as in a public meeting or public forum. Based on the public record, BLM identified the following opportunities to learn about the status and results of surface water and groundwater monitoring, groundwater characterization, and the draft Plan through a variety of methods:

1. Annual Planning Meetings - Socio-Economics, Air, and Water:
    a. August 8, 2011 (Interim Plan);
    b. August 9, 2012 (Hydrogeologic Data Gaps Investigation);
    c. August 20, 2013 (Low-Level Petroleum Hydrocarbon Compounds Study); and,
    d. August 5, 2014 (Final Plan).

    SCCD staff gave the results of their surface water and groundwater monitoring at all annual planning meetings on air, water, and socioeconomic meetings.

2. Detailed presentations at special meetings:
    a. February 7, 2012 to PAWG (PAPA SEIS Groundwater Study), SCCD presentations on surface water and groundwater monitoring;
    b. May 22-23, 2012 to PAWG (Groundwater Characterization and Groundwater Pollution Prevention, Monitoring, and Mitigation Plan). SCCD staff gave the results of their surface water and groundwater monitoring; and,
    c. November 22, 2013 rollout meeting (Hydrogeologic Data Gaps Investigation, Numerical Groundwater Flow and Transport Model, and Low Level Petroleum Hydrocarbon Compounds Study), at which the BLM Authorized Officer accepted the three reports and fulfillment of Step 2 of the 2008 PAPA ROD.

3. Monthly or quarterly PAWG meeting updates, specifically, November 5, 2009, when Geomatrix gave a presentation on the status of the Interim Plan, groundwater characterization, and next steps.

4. BLM Website hosting SCCD annual reports at: http://www.blm.gov/wy/st/en/field_offices/Pinedale/pawg/DataResults.html

5. The following studies conducted under the 2008 PAPA ROD, Steps 1 and 2, posted at: http://www.blm.gov/wy/st/en/field_offices/Pinedale/anticline/water.html.

a. *Preliminary Ground Water Characterization Study*, Dynamac Corporation, December 2002;
b. *Hydrogeologic Conceptual Model Report,* Geomatrix, March 2008;
c. *Interim Groundwater/Aquifer Pollution Prevention, Mitigation, and Monitoring Plan (Interim Plan),* AMEC Geomatrix, December 2008;
d. The *Hydrogeologic Data Gaps Investigation* (HDG) AMEC, May 2012;
e. The *Numerical Groundwater Flow and Transport Model* (Numerical Model) AMEC/NewFields, October 2013; and,
f. The *Low Level Petroleum Hydrocarbon Compound (LLPHC) Study*, AMEC, October 2013.

Several comments were made to the Response Action Program regarding public notification and public participation. Data collected and reports pursuant to the Groundwater Monitoring Program (GMP) as noted in for the Annual Summary Report in Section 4.7 of the GMP will become public:

> *On an annual basis, and within three months of the sampling event, a summary report will be prepared for submittal to WOGCC, BLM and Review Team members. In consideration of reporting requirements specified by WOGCC (2014a), the report will include:*
>
> - *A description of the sampling event, including figures showing sampled wells and the potentiometric surface determined from groundwater elevation data;*
> - *A tabular summary of analytical results referenced to wells and their spatial coordinates, with a comparison to DEQ water quality standards and the three threshold conditions;*
> - *Graphical displays of parameter concentrations versus time for each well;*
> - *A discussion of data quality including results of field and analytical laboratory data reviews, and results of data validation;*
> - *A discussion of any outstanding concerns including notifications made (e.g., required notifications to WOGCC and well owners), new data outliers, water quality exceedences, indications that the existing hydrogeologic model needs to be revised, and/or unforeseen circumstances that were encountered;*
> - *Recommendations for modifications to the GMP, if any; and*
> - *Supporting information appended to the report, including:*
> - *Copies of field documentation (e.g., field log books, sampling forms, instrument calibration records),*
> - *Analytical laboratory reports, and*
> - *Electronic data deliverables (EDD).*

Data generated through annual sampling may also be reported electronically to DEQ for upload into its RBDMS. NewFields developed a query to convert data from EDMS into a format that can be uploaded into DEQ's RBDMS.

Comments were also made regarding public notice if GMP monitoring results confirm either: 1) a water quality standard was exceeded; or, 2) if the Response Action Program was triggered (water quality threshold exceeded, existing hydrogeologic conceptual model needs revision, or BMP failed or is absent). For the first circumstance (i.e., well sample indicates a water quality standard was exceeded), it is the well owner's obligation to notify both DEQ and the BLM Project Lead (see Section 5.1 and Figure 5-1). Although the public is not specifically notified, they have access to BLM and DEQ representatives and documentation of sample results will be included in Annual Summary Reports and in Annual Plan Review meeting notes, which will be available to the public.

For the second circumstance (i.e., Response Action Program triggered), technical representatives of five regulatory agencies and Operators (i.e., the Review Team) will be involved and the public has ready access to agency representatives. Further, should the Response Action Program be triggered due to any one or more of the three conditions identified in Section 5.1 in any given monitoring year, the situation and response will be fully recorded in Annual Plan Review meetings.

According to BLM, the 2008 ROD does not prescribe an annual planning meeting discussion on water resources outside of the Interim Plan (Geomatrix 2008) and the draft Plan development process. The BLM has an option to include, at their discretion, additional topics in the regular meetings or to schedule a separate meeting on some topic. In addition, the BLM has committed to a public meeting to roll-out the Plan once it is finalized.

Attachment L

Response – Public Involvement in the Response Action Program

RESPONSE – PUBLIC INVOLVEMENT IN THE RESPONSE ACTION PROGRAM (CATEGORY 12)

A Review Team comment was received that public involvement was not specified in Section 4.3 of the draft Plan (i.e., Plan Review Cycle and Measures of Success). Further, the chart in Section 5.3 showing Responsibilities for Notification and Communication identified that the Public would be notified should the Review Team determine revisions are necessary to either the PAPA hydrogeologic conceptual model or groundwater pollution prevention practices. The intention was to release the revised portions of the Plan to the public for informational purposes only. The following paragraph in blue font will be added to the end of Section 5.3:

> During the Annual Plan Review meeting, the Review Team will discuss if any information or data produced from executing the Plan indicate the need to revise either the PAPA hydrogeologic conceptual model or groundwater pollution prevention practices. If it is determined that revisions to either are necessary, the BLM Authorized Officer would approve of such revisions as shown in **Figure 5-1**. Any required Plan revisions would be recorded by BLM's Project Lead in Annual Plan Review meetings and any revision to the PAPA hydrogeologic conceptual model or groundwater pollution prevention practices would be posted to the BLM Pinedale Field Office website. As noted on the chart identifying Responsibilities for Notification and Communication, the public would be notified of any Plan revisions. Public notification would be for informational purposes only and would be provided via BLM's Pinedale Field Office website.

ATTACHMENT M

Response – Operator Practice

RESPONSE – OPERATOR PRACTICES (CATEGORY 6)

A variety of comments were made to specific pollution prevention practices (i.e., Best Management Practices, or BMPs) in Section 3 (Groundwater Pollution Prevention Program) of the draft Plan including Tables 3-1 through 3-5 and Appendix 3-B.

There were also comments related to the definition of "fresh water" and "usable water" and "fresh water-bearing and usable water", for which BLM and WOGCC have different definitions based on the total dissolved solids concentration (TDS). Section 3.5.1 (Drilling Muds) of the Pollution Prevention Program was adapted from Section 4.1.1.1 (Drilling Muds) in the LLPHC report (AMEC 2013b). Although the terminology used in Section 3.5.1 is somewhat confusing, it accurately defines "water terms" in BLM and WOGCC regulations. BLM established that the surface casing for natural gas wells (drilled using water-based drilling mud) be set at a depth to protect fresh, usable water. This depth, as noted in Section 3.5.1 is 2,500 feet true vertical depth.

Comments were made regarding buried pipelines and leak detection. Practice ID Nos. 4.4 through 4.6 and 4.22 (refer to Appendix 3-B and also Table 3-4) address measures to minimize the potential for and severity of any pipeline releases. In particular, Practice ID 4.5 requires SCADA systems be installed, monitored and maintained on the Operator's liquid gathering systems on a 24 hour/7 days a week basis.

Several comments questioned if former voluntary practices will be required practices, and who in particular will be required by BLM to implement the Pollution Prevention Program in the PAPA. Any practice (BMP) listed in Section 3.0, Tables 3-1 through 3-5 and Appendix 3-B will be required pollution prevention practices after the Plan is approved by BLM. The following sentence in blue font is added to the end of the introduction of Section 3.0 (Pollution Prevention Program).

> This Plan, including the Pollution Prevention Program, is part of the decision framework related to ROD implementation. All Operators and their subcontractors, workers, and anyone else doing work on behalf of the operators in the PAPA are required to implement the pollution prevention practices (i.e., BMPs) described in this Program. This includes any pollution prevention practice listed herein that was formerly performed on a voluntary basis by Operators. Also as part of the decision framework related to ROD Implementation, the requirements of this Plan will apply to any successors and assigns.

Based on specific comments, the following changes have been made:

- The last paragraph in Section 3.6 is revised as follows:
    - Additional BMPs related to the Production phase include: use of closed tank storage systems in areas where shallow groundwater is present; and use of drip buckets on tank load-out lines throughout the PAPA. Although a liquids gathering system is used to

collect and transport liquids in the PAPA, a small number of natural gas wells are not connected to the system. These wells are primarily located in the southern-most portion of the PAPA. In these areas, trucks are occasionally used to haul liquids from the sites and blowdown tanks to centralized gathering facilities. For any trucking of liquids, Operators verify proper transporter training with contracted trucking companies.

- Page 3-6, line 22-24 – the requirement to steam clean sampling equipment has been removed as sampling equipment will be decontaminated in accordance with the Sampling and Analysis Plan (Appendix 4-C).

- In response to a comment on SPPC plans, the last paragraph of *Step 5* in Section 3.3 is revised as follows:

    - Operator staff members are trained on the SPCC Plan and SRP when newly hired and thereafter on an annual basis. These plans are both field-wide and tailored to address site-specific conditions on individual well pad locations. Original SPPC plans are kept at Operator's corporate headquarters and at Operator field offices, with additional copies maintained at facilities that are attended at least 4 hours per day; or at the nearest field office if the facility is not so attended. SPCC plans and SRPs provide detailed reporting procedures for spills, including a reporting chain and structure for onsite and offsite personnel. Plans are available to BLM or any other agency upon request.

- In response to a comment on HDPE liners for pits, and additional reference to Appendix 3-B is made in Section 3.4 (Construction). The full description of Practice IDs 2.13 and 2.14 includes the liner requirement specified in WOGCC Rule, Chapter 4, Section 1.

- Practice ID 2.26 has been modified in Table 3-2 and Appendix 3-B as follows:

    - Use approved sampling protocols to collect groundwater samples in consideration of length of well screen, lithology/hydrogeology, and analytes of interest.

- Operator Mitigation Measure for Practice IDs 3.2 and 3.24 has been modified in Table 3-3 and Appendix 3-B as follows:

    - Ensure safe on-site storage of oil-based drilling mud in quantities appropriate to use.

- Operator Mitigation Measure for Practice ID 3.3 has been modified in Table 3-3 and Appendix 3-B as follows:

    - Ensure that strength and integrity of materials used are protective of usable groundwater, and ensure that placement of casing and cement isolates usable groundwater.

- Operator Mitigation Measure for Practice ID 3.19 has been modified in Table 3-3 and Appendix 3-B as follows:
    - Limit potential for frac fluids to impact usable groundwater via improper disposal.
- Practice ID 3.7 has been removed from Table 3-3 and Appendix 3-B as oil-based fluids would not be located or placed in mouse hole. Practice IDs in Table 3-3 and Appendix 3-B were not reordered in an effort to minimize potential errors and confusion.
- An additional paragraph is included in Section 3.5.1 (Drilling Muds) to define closed loop and semi-closed loop techniques as follows:
    - Closed loop drilling systems utilize a mud and solids control system to efficiently recycle the circulated mud using specialized equipment without the need for a reserve pit. The only waste discarded includes moist drill cuttings (rock formation materials) stored on the surface of the pad, which are solidified and buried after leachate testing required by the WOGCC. A semi-closed drilling system is similar, except that it includes a small pit for storage and disposal of drill cuttings.
- The Operator practice for Practice ID 4-15 has been modified in Table 3-4 and Appendix 3-B as follows:
    - Produced water is directed to the LGS system.
- The Operator practice for Practice ID 5.2 has been modified in Table 3-5 and Appendix 3-B as follows:
    - Comply with BLM and WOGCC requirements for pit closure.
- The following paragraph has been added to the end of Section 3.7:
    - This section on the Closure phase, in addition to the previous sections on the Planning, Construction, Drilling and Production phases, explains BMPs applicable to prevent or minimize the potential for future groundwater impacts in the PAPA from E&P activities as required by Objective O1.1 of this Plan. BMPs are explicitly listed in **Tables 3-1** through **3-5**, with details of each practice, mitigation measure and applicable regulatory references provided in the P2 Matrix (**Appendix 3-B**). The intention of implementing the specific BMPs identified for this Pollution Prevention Program is to continue to protect groundwater resources in the PAPA.

Attachment N

Response – Concerns with Monitoring Methods/SOPs/QAPP

RESPONSE – CONCERNS WITH MONITORING METHODS/SOPS/QAPP (CATEGORY 5)

A number of comments were made to monitoring methods specified in the Sampling and Analysis Plan (SAP; Appendix 4-C) and Standard Operating Procedures (SOPs; Annex 4C-1). Several comments were also offered for the Quality Assurance Project Plan (QAPP; Appendix 4-D).

The following changes have been made in Appendix 4-C:

- In Section 3.3, the following paragraph has been added:
    - Drill cuttings will be logged continuously for lithology while drilling. Unconsolidated materials will be described according to the Unified Soil Classification System as indicated in SOP-15 (**Annex 4C-1**). Once the Wasatch Formation is encountered in each borehole, lithologic descriptions of cuttings (e.g., siltstone, mudstone, shale, sandstone) will be continuously logged and recorded. Other information recorded will include: rock color; grain size; description of induration or consolidation; descriptions of any fracture zones encountered; water-bearing intervals; estimated water yields; and an estimate of any potable water added to borehole to aid in cuttings removal. A field guide for logging water-well boreholes is provided in **Annex 4C-2**.
- In Section 3.3, the following paragraph has been modified:
    - For all new wells to be completed in the Wasatch Formation, an approximately 20-ft length of screen will be placed within one or more zones of sandstone that are located in the uppermost part of continuously saturated Wasatch Formation. A silica-sand filter pack will be emplaced in the annulus of the borehole via tremied slurry made with potable water from the bottom of the annulus to 5 feet above the top of well screen. Bentonite chips or pellets will be installed into the borehole annulus above the sand filter pack to a depth of 5 feet above the top of the sand pack, and hydrated with potable water. Neat cement grout slurry made with potable water will be pumped into the annulus using a tremie pipe from the bottom to top of the remaining open annulus in one continuous upward operation.
- In Section 3.4, the following paragraph has been modified:
    - Once installed, a minimum of 10 casing volumes of water will be removed by the surge-and-bail or surge-and-pump technique (SOP-18, **Annex 4C-1**) to develop each new well and remove excess fines from the screened interval. The quantity of water developed from the well will include the estimated volume of any water added to the borehole during drilling. The goal is to obtain water from the aquifer adjacent to the well screen that has low turbidity (<10 nephelometric turbidity units [NTU]). Water samples will not be taken immediately after well development. The well will be allowed to equilibrate to

initial static water level conditions for at least 24 hours prior to sampling. A field form for documenting well development procedures and results is included in **Annex 4C-2**. **Section 3.6.8,** below, describes how investigation derived waste will be handled, including development water.

- The last paragraph of Section 3.6.7 has been modified:
  - Heavy equipment (e.g., drill rig and support vehicles) will be decontaminated in conformance with SOP-2 (**Annex 4C-1**). Steel well casing will be cleaned using a brush and detergent (e.g., Alconox® or Simple Green®), followed by steam cleaning inside and outside, and prior to the casing being placed in each borehole. Blank PVC casing and PVC and stainless steel screens will be new and certified clean by the manufacturer. All equipment will be decontaminated prior to arriving on site and before exiting a drilling location. Water for decontamination will be supplied from a potable water source (e.g., Pinedale, Wyoming municipal water supply). Decontamination should be done far enough away from the area of sampling so that rinsate generated does not affect future anticipated samples as part of the investigation. The area should also allow for the infiltration of the rinsate into the soil. If field personnel observe any oily residue associated with rinsate, the rinsate will be containerized until proper disposal can be determined in consultation with DEQ and BLM.

Comments were made to a number of SOPs (Annex 4C-1) including SOP-1, -3, -11, -12, -15, -18, -24, -25 and -40. The following changes were made in response to comments received:

- The word "NewFields" was deleted from SOP-1, -3, -15 and -40.

- SOP-12 (Groundwater Sampling) has been revised in response to comments and is included in **Enclosure 4**. Modifications included adding guidance contained in a January 2010 procedure from EPA Region 1, Quality Assurance Unit for "*Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells*", listing additional equipment for operating bladder sampling pumps, removing the section "Sampling from Temporary Boreholes", and removing references to bailer use.

- SOP-15, -18 and -24 have been revised and are included in **Enclosure 4.**

Several comments were made to the Quality Assurance Project Plan (QAPP; Appendix 4-D). The following clarifying changes were made:

- Section 2.1, first bullet regarding the Primary Contractor Project Manager's responsibilities:
  - Implement the Sampling and Analysis Plan (SAP; Appendix 4-C in NewFields 2015) which conforms to GMP objectives (see Section 2.2 in NewFields 2015) and schedule;

- The following paragraph has been added to the end of Section 4.1:

- The results of assessments, oversight activities (i.e., checks) and any response action pursuant to this QAPP will be documented in the Annual Summary Report (see Section 4.7 in NewFields 2015) and reported to the Review Team during the Annual Monitoring Program Review (see Section 4.7 in NewFields 2015). Based on Review Team discussions during the first monitoring program review, BLM's Project Lead may require a Review Team member to conduct assessments and checks of activities rather than an individual employed by the Primary Contractor.

Attachment O

Response – When is the End?

RESPONSE – WHEN IS THE END (CATEGORY 11)

Several comments addressed the status of study wells installed during 2009-2010 for the Hydrogeologic Data Gaps (HDG) Investigation and when groundwater monitoring in the PAPA under this Plan is anticipated to cease. The objectives established by regulatory agencies for the Groundwater Monitoring Program (see Section 2.2 of the Plan) do not require groundwater elevation data to be collected for wells that are not included in the Groundwater Monitoring Program (GMP). Only one study well from the group of 43 study wells and piezometers installed for the HDG met the criteria to be included in the GMP. As noted in Section 4.9 of the Plan, during the first GMP review cycle after the Plan is approved by BLM's AO, the disposition of the 42 study wells/piezometers will be discussed and plans for plugging and abandonment, or future use, would be made.

Groundwater monitoring as described by the GMP will be completed for the foreseeable future. However, eventually natural gas production in the PAPA will cease and the reasons for the Plan will end. The last paragraph of Section 4.9 has been revised as follows:

- In subsequent regular review cycle meetings, the status of each GMP well will continue to be discussed in terms of its relevance and appropriateness to the GMP well network. It is projected that natural gas production will be completed in different portions of the PAPA at different times in the future. Besides the natural gas production wells, facilities associated with that production will no longer be necessary (e.g., above ground tanks, LGS pipelines) and the collective disturbance related to the completed gas production activities will be reclaimed in accordance with state and federal requirements (see **Section 3.7**). At that time during a regular review cycle meeting, the Review Team will evaluate the GMP monitoring well(s) downgradient of that area and determine the continued need for groundwater monitoring. Any well determined by the Review Team to be unnecessary will be plugged and abandoned by the Operators in accordance with SEO (2011) regulations. It is not known when E&P activities in the PAPA will cease, but eventually each well in the GMP network will be plugged and abandoned, and well sites will be reclaimed.

Attachment P

Response – Editorial/Improvement Comments

RESPONSE – EDITORIAL/IMPROVEMENTS (CATEGORY 7)

Over 230 comments made by the Review Team and Public were categorized by the Project Oversight Team as "editorial/improvement" comments. Editorial (e.g., punctuation and grammar) and document formatting comments included word usage, tense and emphasis. Many others were offered to improve the readability of the document and clarify certain points. Revisions and improvements to the Plan have been made in response to a majority of these comments.

Attachment Q

Response – No Change Necessary; Not applicable; Addressed Elsewhere

RESPONSE – NO CHANGE, NOT APPLICABLE, ADDRESSED ELSEWHERE (CATEGORY 8)

Comments were received by the Review Team and Public that did not result in changes to the draft Plan. Many of these comments are addressed in other parts of this response document but do not fit into a specific response category. Other comments either are not commensurate with the Plan's goals and objectives, are not substantive enough to warrant changing the document, or are general comments that do not require modification of the Plan.