
MEMORANDUM

TO: Shane Deforest, Pinedale Field Office Field Manager

FROM: Merry Gamper, BLM-Wyoming State Office, Physical Scientist, Project Lead: Interim Groundwater/Aquifer Pollution Prevention, Monitoring and Mitigation Plan (IGMP); Pinedale Anticline (PAPA) Supplemental Environmental Impact Statement, Record of Decision (ROD) (2008)

SUBJECT: Recommendations resulting from review of *Evaluation of Potential Sources of Low Level Petroleum Hydrocarbon Compounds Detected in Groundwater Technical Report (LLPHC)* received from AMEC/NewFields. The LLPHC report was prepared on behalf of Ultra Resources, SWEPI, and QEP (USQ) to fulfill requirements of the PAPA ROD and IGMP.

Following review of the Interim Groundwater/Aquifer Pollution Prevention, Monitoring and Mitigation Plan, *Evaluation of Potential Sources of Low Level Petroleum Hydrocarbon Compounds Detected in Groundwater (LLPHC)* technical report, the following recommendations are provided for your consideration. I make these recommendations as the lead BLM-WY scientist for implementation of the IGMP and all associated documents prepared thereunder, including the LLPHC. These recommendations are my own.

Before proceeding, acknowledgement of the efforts provided by the team who was involved in the implementation, document preparation, and review of this report is warranted. The production of this report was no small effort, and the team should be commended for the professionalism and dedication they have provided to not just this study, but to the entire groundwater characterization process. The following recommendations are not intended to detract from the quality of the work, the conclusions of AMEC/NewFields, or the quantities of new and useful information provided within this particular report. The results provide a solid, scientifically credible, baseline for continued discussions.

The following specific recommendations relate to Subtask3B – Evaluate Potential Operational Sources of Contamination and Level of Risk to the Various Hydrostratigraphic Units (HSU) as identified in the IGMP, and are a direct result of information provided by the LLPHC technical report. The following recommendations likely will require additional field verification and/or records review, and the results of any further review should be considered in the design of a groundwater-monitoring plan as required by the PAPA ROD. Further, an additional work plan under Subtask 3B should be prepared to address how the field verification and/or record review should occur and which operational or regulatory controls should be assessed utilizing the previously prepared Operational matrixes. Results from implementation of the work plan should be considered for inclusion in the Final Groundwater/Aquifer Pollution Prevention, Monitoring and Mitigation Plan (FGMP).

- ◇ Intermediate gas signatures are a mixture of thermogenic (Lance formation) gas and biogenic gas. Several water wells sampled under this study exhibit this gas signature, both with and without an altered thermogenic signature. While I acknowledge that an altered signature generally represents conditions only obtained over geologic time, a slightly altered signature (versus complete alteration) may also indicate that gas is migrating up the annular space of the production well(s). The wells of concern, which exhibit this "slightly altered" thermogenic signature, include: Boulder 12A-33, Warbonnet 7-4, and Warbonnet 7-5; a well integrity check of these wells is recommended.

- ◇ No casing gas samples were collected from water wells in the Northern Anticline because there was insufficient gas present in water well casings per the procedures specified in the LLPHC Sampling and Analysis Plan (SAP). Dissolved gas samples collected in the Northern Anticline contain concentrations of hydrocarbon gas that were too low to perform isotope analysis (threshold concentration for analysis is 1 milligram per liter of methane). The Technical Reviewers selected by AMEC/Newfields, note that dilution of casing gas samples may have caused this and it was recommended that the samples be taken closer to the water column to confirm whether this is a true natural condition. As such, it is recommended that where practical, these wells be resampled with an attempt to collect the casing gas samples closer to the water column in the water wells. These wells should be considered for additional sampling to determine whether a modification to the LLPHC SAP is warranted for the FGMP.
- ◇ The Gasoline Range Organics (GRO) hydrocarbon signature is distinguishable and consistent among T-4-RWa, T-4-RWb, Antelope 11-10D, and Highway 7 wells. The report concludes that the source of this GRO hydrocarbon signature is altered thermogenic gas. The source of the GRO hydrocarbon signature appears to also be altered thermogenic gas at the Rainbow 16-30 but the presence of alkenes in this well is not similar to other wells and the source remains unknown. The GRO hydrocarbon signature in these 5 wells does not appear to be related to the Diesel Range Organics (DRO) hydrocarbon signature in these wells either. Further, the report concludes that the DRO hydrocarbon signature in these wells is not strong enough to allow source differentiation, but is most similar to substances used in pump installation and operation; the source was further posited by the contractor to potentially be related to well installation materials or naturally-occurring organic matter.

Any potential contribution made by suspended organic matter or other well installation materials was not investigated in this study and cannot be confirmed with the data collected. Because of the uncertainty in this finding, the operational history of the aforementioned wells, including well construction/drilling history cannot be ruled out as a potential source at these locations. As such, additional evaluation of these potential sources would assist in determining whether current or historic operational practices are contributing to the GRO hydrocarbon detections at these specific locations, or whether the DRO signature is related to water well pump materials, other well installation materials, or naturally occurring suspended organic matter.

- ◇ Based on the contractors response to comments provided during the review process, it appears that portions of the Wasatch Formation are being exposed to oil-based mud (OBM), and potentially other completion fluids, during drilling operations and prior to casing and cementing operations. This leads me to question whether surface casing is set at a depth necessary to adequately protect "usable" water zones in the Wasatch Formation. Until and unless the State of Wyoming designates the lower Wasatch Formation as containing unusable water, operators should be required to either set surface casing to isolate the entire Wasatch Formation, or they should be required to use only water-based materials in the completion process in this zone unless these practices are evaluated and found to not be contributing to the hydrocarbon detections and do not necessitate any further action.
- ◇ Information contained within the report also suggest that a portion of the unnamed confining unit located between the productive Lance and the Fort Union Formations, is committed to the productive Lance Pool and has been subjected to well completion operations. While producing from this portion of the confining unit does not appear to be contributing to the ongoing low level hydrocarbon detections, it may introduce an unnecessary level of risk to formations containing usable water zones by providing a potential pathway, and in my scientific opinion, should be evaluated further. Removal of the lower third of this confining formation from the Lance Pool would minimize the potential contribution from unintended

migration of production fluids into the Wasatch Formation and aquifer.

When redesigning the PAPA groundwater-monitoring plan under the FGMP, it is further recommended that the following general points should be taken into consideration:

- ◇ The results of the study indicate that several of the sampled study wells contain gas that is solely thermogenic (Lance Formation) in origin but has been altered over time; this study did not specifically evaluate the amount of time necessary to produce such an altered signature but literature cited by the report authors suggests that it is solely a geologic (100-thousands of years) occurrence. Because the amount of time necessary to produce an altered signature was not evaluated by the study, it is recommended that this issue (whether the movement of thermogenic gas into water wells is occurring naturally over time from the Lance Formation or whether the migration of Lance Formation gas is related to well cementing operations) be addressed through the FGMP or if the results of investigation into the intermediate signature wells discussed above reveals that the production wells are indeed leaking.
- ◇ Due to the lack of apparent clustering of low-level hydrocarbon detections in relation to areas where high levels of hydrocarbons have been confirmed, it does not appear that these high-level hydrocarbon detections are contributing to other low-level detections. Information gathered under the Interim Plan does not indicate that groundwater travel times within the Wasatch aquifer are fast enough to be the cause of the low level detections from water wells known to have high levels of hydrocarbons nor are the signatures comparable enough to draw this conclusion. Regardless, continued site characterization, in cooperation with the BLM, under the direction of the Wyoming Department of Environmental Quality Voluntary Remediation Program, is recommended for the identified high-level wells and the results should be considered during preparation of the FGMP.
- ◇ It is my recommendation that monitoring of areas not proximal to oil and gas exploration and production and natural springs in the PAPA be considered for inclusion in the FGMP. Further characterization of springs in the PAPA will bolster the understanding of the potential connection between perched, shallow, and deeper groundwater in the Wasatch Formation and continued monitoring of locations outside of the PAPA will further our ability to differentiate between naturally occurring hydrocarbon signatures and those associated with oil and gas development.
- ◇ Because the current Wasatch flow model (top 1000') did not consider what portion of horizontal groundwater flow in the Southern Anticline contributes to baseflow in the Big Sandy River, if at all, it is recommended that additional information be gathered by the monitoring program considered under the FGMP to characterize any surface water/groundwater interaction and to ensure proper design of a monitoring network capable of detecting undesirable changes in groundwater quality as a result of continued oil and gas development. This recommendation is made in consideration of the fact that per the Pinedale Resource Management Plan, the majority of the western and eastern portions of the PAPA are currently unleased and unavailable for future leasing; the one exception is the suspended leases in development area 5 (DA5) as a result of the PAPA ROD, and the flanks. I recommend that characterization of this relationship occur prior to further development in these areas.
- ◇ Two wells were installed in the gravel cap of the Mesa. These two wells could not be sampled and incorporated into the analysis because they lacked sufficient water volumes. These wells should continue to be monitored and if sufficient water resources are found, sampled and incorporated into the hydrogeologic conceptual model to help further differentiate the shallow Wasatch HSU.

- ◇ A moratorium prohibiting the installation of new water wells remains in effect under the SEIS ROD; per the PAPA ROD, the moratorium is in place until "the Groundwater Characterization is completed and the causes of the hydrocarbon detections have been determined and effectively mitigated." A recommendation to continue or lift the moratorium, and any conditions for such should be provided in the FGMP, in consideration of the above and any additional information garnered as a result.
- ◇ Rick Schuler, BLM-WY Hydrologist (retired), identified several other items that should be considered during drafting of the groundwater-monitoring plan under the FGMP. I support these recommendations as recorded in the LLPHC comments response matrices.

Other general recommendations include:

- ◇ OBM is identified as the source of hydrocarbons at the Riverside 11-25 and Riverside 15-12 well locations. The detections at the Riverside 11-25 are attributed to a historic backflow event associated with a dirty tank or open fluid reserve pit. The OBM in the Riverside 15-12 is attributed to some other, unidentified and inadvertent, input to the well according to the well operator. Continued compliance with the ROD requirements to lock/prevent access and provide backflow prevention for industrial water supply wells is a priority for compliance inspections. Requirements for PAPA operators to submit a yearly status report of all industrial water supply wells including use, condition, and maintenance actions completed or needed, should be instituted where it is not already occurring under the PAPA Annual Planning process.
- ◇ Previous sampling efforts in the PAPA have utilized varying sample analysis and collection methods and did not occur prior to development of oil and gas on the PAPA; this has caused previously collected data to have limited utility for determining groundwater conditions. As such, it is my recommendation that baseline sampling (utilizing the LLPHC SAP) prior to development occur in areas currently undeveloped, but proposed for drilling operations. Consistency in sampling analysis and collection methodologies is critical for ensuring that data are comparable across time and space and would greatly assist in determining whether impacts from oil and gas are occurring or, are a result of natural hydrogeologic processes.
- ◇ I recommended that the NM be rerun at a future time if sufficient data has been collected that would improve our understanding of the fate and transport of contaminants released into the Wasatch Formation and if future groundwater monitoring indicates a sustained change which is contrary to the accepted hydrogeologic conceptual.

In summary, my recommendations are not meant to detract in any way from the report findings, but are provided as a way to further validate the findings and/or validate that operational controls are adequate for protecting usable waters within the Wasatch Formation. Again I commend and thank everyone who has contributed to this report and the Interim Plan process.

Respectfully submitted,


11/14/13