STATE OF MAINE

DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF REMEDIATION AND WASTE MANAGEMENT

M E M O R A N D U M

TO: Kathy Tarbuck, P.E., Senior Environmental Engineer
Division of Technical Services
Bureau of Remediation and Waste Management

FROM: Richard S. Behr, Environmental Hydrogeology Specialist
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Bureau of Remediation and Waste Management

DATE: April 1, 2016

RE: Response to Department Staff's Review Comments on the Juniper Ridge Landfill Expansion Application, MEDEP #S-020700-WD-BI-N, Transmittal Letter Exhibit B - BGS and NEWSME'S Response to DEP's January 15, 2016 Technical Review Memorandum, March 2016

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On January 15, 2016 I issued my technical review comments related to specific sections of the Juniper Ridge Landfill Expansion Application[1]. On behalf of the State of Maine's Bureau of General Services and NEWSME, Sevee & Maher, Inc. (SME) have provided detailed responses to my individual comments. I have reviewed the prepared responses and find that with a few exceptions, SME's responses provide a thorough and comprehensive response to all of the comments and recommendations outlined in my January 15, 2016 memorandum. Hereafter, I refer to BGS, NEWSME and SME collectively as the Juniper Ridge Landfill (i.e., JRL).

Where appropriate, this memorandum outlines my follow-on responses. My additional comments are preceded by the applicable page number and section heading along with JRL's response to my initial comment. As noted, the majority of my comments have been satisfactorily addressed. Therefore, this

[1] Technical Review Memorandum from Richard S. Behr to Michael Parker, January 15, 2016, Juniper Ridge Landfill Expansion Application, Volume II, Site Assessment Report, Volume III, Design Report Volume IV, Operations Manual, July 2015.

memorandum only includes those comments that require further comment and consideration by JRL.

If you have any questions about the content of this memorandum, please contact me.

Pg 2-6 2.6.1 Surficial Soils.

JRL's Response: We have reviewed the LiDAR imagery of the Expansion site and surrounding region. The imagery supports the interpretation that the hill on which the JRL is positioned is a drumlin. There are numerous other glacial streamforms or drumlin-like features apparent in the imagery with their long-axes oriented towards the south-southeast (i.e., direction of ice sheet movement). Some of the streamforms appear to be associated with shallow bedrock based on the imagery. From the imagery, surficial soils over much of the area surrounding the landfill can be interpreted as glacial till based on the topography and presence of these streamform features. The imagery confirms shallow bedrock outside the west side of the Expansion. The bedrock appears to be shallow beneath the hills west of the Expansion, as well. There is a northeast-southwest textural pattern in some areas of shallow bedrock. This pattern is consistent with the principal bedrock fracture set identified beneath the Expansion site and infers the regional nature of this fracture set. The principal fracture set is associated with foliation of the clay minerals of the phyllite. The imagery also confirms the sandy glacial outwash deposit mapped east of the site along Route 16. The esker associated with this outwash deposit can also be identified on the LiDAR imagery east of Route 16.

MEDEP Follow-on Response

For completeness, JRL should augment this response with a copy of the LiDAR imagery they used for their interpretations.

Pg 3-18 3.2.8 Groundwater Age-Dating

JRL's Response: The groundwater velocities used in our travel-time calculations were estimated on the conservative side. That is, the velocities were biased towards higher velocities resulting in faster arrival times. The time-of-travel calculations assumed only horizontal flow in the bedrock. Not accounting for the vertical travel time effectively shortens the calculated times; therefore, the calculations under-estimate the travel-times and are conservative. In the contaminant transport analysis in Section 4 of Volume III of the Application, a similar assumption of only a horizontal flow path was applied and the velocity was assumed at 5 feet/day. Even with these conservative assumptions, the requirements of Chapter 401(1) (C) (c) and (d) (travel time and risk to sensitive receptors) were met.

A location for age-dating of groundwater was sought to estimate the vertical travel-time through the glacial till. Based on groundwater levels measured in wells and *piezometers, groundwater flow-nets were constructed to estimate where groundwater seepage would be vertical or nearly vertical. As can be seen on Figure 5-2, Profile C-C,' the equipotential contours at P-04-06A and -B are nearly horizontal except for the more weathered, permeable till at the ground surface. This is why this location was selected for age-dating the groundwater at two depths across the till. The assumed seepage pathway through the till can be adjusted to remain more perpendicular to the interpreted equipotential contours. This would lengthen the flow path through the till by possibly 20 to 40 percent. The longer flow path results in a 20 to 40 percent increase in the estimated groundwater velocity. Assuming the hydraulic conductivity of the upper weathered five or so feet of till is likely somewhat more permeable than the unweathered, deeper till, the calculated average vertical hydraulic conductivity through the till ranges from the previously calculated 1.3×10^{-6} cm/sec up to 1.8×10^{-6} cm/sec (see Page 5-10 of the Site Assessment Report). This is a relatively small change given the natural range of hydraulic conductivities measured for the till. This result does not affect any of our travel-time calculation results or conclusions.*

SME has applied the tritium-helium age-dating methods on numerous sites inside and outside Maine over the past twenty years. It has been used to estimate the rate of groundwater travel, to examine aquifer vulnerability to surface contamination, to determine potential sources of groundwater contamination to water supply wells, and to estimate if a solvent groundwater plume is still expanding or near steady-state. It has proven to be a useful tool when used along with the other investigatory techniques.

The tritium-helium age-dating method is a relatively simple method to collect data (Clark, I. D. and P. Fritz, 1997. Environmental Isotopes of Hydrogeology, Lewis Publishers; Aeschbach-Hertig, W., Groundwater Sampling for Helium/Noble Gases Using Copper Tubing, Institute of Environmental Physics, University of Heidelberg, Germany). A liter sample of groundwater is collected in a plastic bottle for the tritium analysis. A 10 to 40 milliliter sample of groundwater is collected in a copper tube, being careful to continually tap the tube to remove air bubbles. Once the air bubbles have been completely removed from the tube, each end is sealed by pinching the copper. This tube sample is used to measure inert gases in the sample. The tritium is measured by the in-growth method, wherein all gases are removed from a specimen of the groundwater, the specimen is sealed and allowed to sit for two to three months as the tritium in the specimen decays to helium-3. The amount of helium-3 in the specimen is used to determine the tritium content of the groundwater at the time of sampling. The inert gases are measured by mass spectrometer from a specimen of groundwater taken from the copper tube. Some of the inert gases are used to estimate the precipitation recharge temperature of the specimen and others are used to estimate specimen total helium-3. The results are used to correct the helium-3 for excess air, atmospheric helium-3 and terragenic helium after which the tritium and corrected helium-3 concentrations are used to calculate groundwater age. By examining the various gas components, an evaluation of the utility and accuracy of the results can be made. The results of the analysis at the Expansion site proved to be useful but there is still a slight variability that must be recognized in applying the results (R. Poreda, 2002 through 2014, personal communications; USGS, The Reston Groundwater Dating Laboratory, Reston Virginia).

We used the tritium-helium age-dating method at the JRL Expansion site to corroborate groundwater velocities determined using the slug test data. The groundwater velocity is calculated from groundwater seepage gradients, hydraulic conductivities and effective porosity. Groundwater gradients are determined using wells and piezometers and can be calculated relatively precisely. Hydraulic conductivity of some soil and rock can range over several orders of magnitude and is typically resolved into a geometric mean or average hydraulic conductivity of the representative geologic formation. Effective porosities of fine grained soils and bedrock can be difficult to estimate. Therefore, estimating the groundwater velocity using the age-dating method described above, provides a check on all three inputs to the groundwater velocity calculation and provides confidence in the calculations.

MEDEP Follow-on Response

JRL provides a thorough response to my concern regarding the groundwater age testing methodology. The description of the tests is very helpful but JRL's description of previous experience using the methodology lacks specifics. While I am aware of the client-consultant confidentiality, JRL's consultant, SME, has likely completed groundwater age estimates for some project applications that are part of the public record. If so, project specific references should be included.

There is one additional aspect of the response that requires further clarification. In its response, JRL includes a statement about a slight variability in the analytical data that must be recognized in applying the results. JRL should elaborate on the nature of the variability and its influence on the results.

It would also be instructive for JRL to provide a table summarizing the velocity estimates obtained from the various methods used at this site.

Pg 4-4 <u>4.1.1 Basal Till</u>

<u>JRL's Response</u>: As illustrated in the LiDAR imagery there are both well-defined esker segments and broader sand and gravel outwash areas associated with the eskers. This is a common relationship, particularly near glacial ice margins. In either case, how it is described is less important than the fact that sand and gravel deposits exist local to Route 16.

MEDEP Follow-on Response

JRL's response appears to dismiss the importance of differentiating the depositional environment of the sand and gravel deposits. Accurately describing the mode of formation of surficial deposits is important as the physical characteristics of the deposit may differ significantly. This is particularly important as they often control important hydraulic properties of the surficial sediments. As an example, the physical and hydraulic properties of a basal till versus an ablation till often differ significantly.

Pg 7-1 7.0 Travel Time Analysis

JRL's Response: Per the direction of the DEP during the pre-hearing conference held on February 10, 2016, all documents that are part of the project record must be submitted in an unalterable form so Excel worksheets has not been included. However, the Excel worksheets will be made available for DEP review at the SME office in Cumberland, where they can be reviewed with the appropriate SME staff. Time of travel schematics are provided in Attachment SME-3, which illustrate the components of subsurface travel-time used in the analysis (e.g., vertically downward through the till, horizontally through bedrock, and for surface water receptors vertically upward through the till) for the various locations where the time of travel analysis were completed.

MEDEP Follow-on Response

We have discussed JRL's concerns about the submission of the Excel spreadsheets with Cindy Bertocci who, in turn, has discussed the matter with Ms. Sauer and Ms. Green. They are in agreement that neither the Board's procedural order nor statements at the conference regarding filings with the board or responses to agency review comments prevents JRL from providing data in whatever form is useful, that staff need to review the application.

I appreciate JRL's concerns about providing the spreadsheets to the Department. Further I understand SME would like to review the spreadsheets with the Department before providing the Department with a copy of spreadsheets. Therefore, I will plan to schedule an appointment to review the worksheets and accompanying calculations with SME.

As requested, JRL has created the schematics I recommended. In my view, the schematics provide a very useful means for a reviewer to visualize each of the time of transport scenarios included in the analysis.

Appendix U Pg 25 <u>5.0 Pump Test Proof of Bedrock Interconnectivity</u>

<u>JRL's Response</u>: The manual water level measurements have been tabulated and were included in Appendix M of Volume II following the transducer drawdown plots.

MEDEP Follow-on Response

My original comment included a request for figures to illustrate the observed drawdowns in monitoring wells screened in the till. JRL's response did not include the requested figures. I continue to assert that a graphic depiction of locations where the till is hydraulically connected to the underlying bedrock is important and may assist in locating wells for long term monitoring and extraction wells in the unlikely event a significant leachate release were to occur.

Pg 6-1 <u>6.1 Expansion Water Quality Monitoring Locations</u>

<u>JRL's Response</u>: SME has discussed this comment in detail with Mr. Behr and has included as Attachment SME-2 a work plan that outlines the scope and schedule for a program to supplement the understanding of groundwater flow in the underlying bedrock, as presented in the Application, and refine the future placement of monitoring wells, also as presented in the Application.

MEDEP Follow-on Response

Based on the comments outlined my January 15, 2016 review memorandum and subsequent technical discussions with JRL and its consultant, JRL submitted a draft work plan (MEDEP - Attachment A) to address my concerns. I carefully reviewed the draft work plan and prepared a review memorandum[2] (MEDEP - Attachment B) with the understanding that the work plan would be presented for formal review through this submittal. The revised work plan, included as an attachment to JRL's responses, has satisfactorily addressed my comments.

Pg 6-2 <u>6.1.1 Leachate Monitoring for the Expansion</u>

[2] Technical Review Memorandum from Richard S. Behr to Kathy Tarbuck, February 25, 2016, Draft Work Plan for Refining Locations of Monitoring Wells at the Juniper Ridge Landfill Expansion Old Town, Maine – Prepared for Bureau of General Services and NEWSME Landfill Operations, LLC – Prepared by Sevee & Maher Engineers, Inc. February 2016.

JRL's Response: Because the existing site leachate sampling location is at the onsite leachate storage tank, which receives leachate from all the JRL cells, we agree that collecting a discrete sample of the leachate from the first expansion cell (i.e., Cell 11) would be useful to determine if a difference exists between the Cell 11 leachate and the combined JRL leachate collected in the tank. We propose to sample the Cell 11 leachate three times during the first year of operations in a manner consistent with the proposed sampling of leak detection and underdrain monitoring locations described in Section 3-3 of the proposed Environmental Monitoring Plan found in Appendix I of Volume IV of the Application to evaluate if the leachate within the new landfill cell is substantially different from the combined site leachate. At the end of the first year an evaluation of the difference between the two leachates would be completed as part of the Annual Report and recommendations made as to any modification to the site monitoring program. These recommendations would be reviewed with the DEP and only implemented upon the DEP's approval.

MEDEP Follow-on Response

JRL has agreed with the Department's request to characterize the leachate generated by Cell 11 during the first year of operation. The resulting data from Cell 11 will be compared to the leachate generated by the existing facility. Depending on the outcome of the comparison, the Department may ask JRL to continue to characterize both leachate streams for an extended period.

Pg 7-8 7.4 Calculated Travel Time to Site Identified Sensitive Receptors

JRL's Response: We agree. One additional minor correction is needed to the offset credits presented in the Application: Cell 11 Southern End to the Southern Sandy Zone. Two years was used, where three years should have been used, due to the presence of the augmented liner at that location. The calculated travel time continues to exceed that required by the DEP Rules. Revised Tables 7-3 and 7-4 of Volume II, along with the updated Volume II, Appendix X printouts are included in Attachment SME-4.

MEDEP Follow-on Response

In addition to making the correction I pointed out in my comment, JRL identified another minor error in Tables 7-3 and 7-4. It is related to the offset credit for Cell 11 Southern End to the Southern Sandy Zone. The revised Tables now include the corrected Offset Credits for the two landfill nodes (Cell 11 Southern End & Cell 13 Leachate Sump), but the totals in the column for the Total Travel Times were not corrected. JRL should make these final revisions.

Pg 7-12 <u>7.5 Sensitivity Analysis</u>

<u>JRL's Response</u>: It is not common practice to vary two parameters simultaneously in a sensitivity analysis, since the purpose of a sensitivity analysis is to assess the effect that varying each assumption over some reasonable range has on the result. To vary two parameters simultaneously is more a means of looking at two unlikely situations occurring simultaneously, which in our view is not a valid assumption. We have, however, prepared the requested evaluation. Attachment SME-3 includes the results of the evaluations when varying two parameters.

Individual, complete printouts for the sensitivity analysis were not included in the Application for brevity, the results, however are included in Attachment SME-4. We have added notes to the printouts to improve the explanation and documentation of the format and values contained on the printouts.

MEDEP Follow-on Response

I understand JRL's reluctance to perform the additional sensitivity analyses I outlined. Their reluctance relates to completing sensitivity runs while varying two parameters at the same time and inserting conservative input values that are unlikely to occur simultaneously. I do however appreciate their willingness to conduct the additional analysis. The additional sensitivity runs calculated travel times in both the till and bedrock using the upper confidence limits for hydraulic conductivity and lower confidence limits for porosity. The resulting total travel times are summarized in Appendix SME-3. As expected, the shortest travel times are produced when using a combination of the lowest estimates of porosity along with the highest estimates of hydraulic conductivity. Despite the use of the presumed conservative input values, the majority of the calculated travel times continue to exceed the six year time of travel to sensitive receptors. These results provide additional data demonstrating the suitability of the proposed expansion.

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VOLUME II, SITE ASSESSMENT REPORT – APPENDICES A-X

<u>Appendix H – Field-Scale Bedrock Tracer Test Results</u>

JRL's Response: SME's interpretation of the pumping test is consistent with Mr. Behr's, as documented in Appendix H of Volume II. The principal direction of the relatively-dense bromide tracer was downward and that is how we modeled the tracer plume in the Application. The primary tracer flow direction was rotated downward by adjusting the relative position of the observation wells to simulate the density driven flow component. The observation wells intercepted the edge of the plume and provided useful data against which to calibrate the analytical model to estimate dispersion and groundwater velocity. The spreading of the tracer in all observation wells over an arc of at least 90 degrees downgradient of the injection well demonstrates the well-interconnected nature of the bedrock fractures. Had the fracture system not been well interconnected we would not have recorded the tracer or we may have only recorded it in one observation well.

The pumping test that was done on the well also demonstrates a well-interconnected fracture system in the vicinity of the test. This is evident from the fact that water level drawdowns were observed in all observation wells over a spread of around 100 degrees from the pumping well. In a poorly interconnected fracture system maybe only one or two observation wells would have recorded drawdowns. This integration of fractures is consistent with the tracer test in that five of the six observation wells, spread over an angle of about 90 degrees all intercepted the bromide plume. As discussed in our response to DEP's comments on Section 3.2.7 above, the test provides useful qualitative information about the interconnection of fractures that have practical applications for locating monitoring wells in the bedrock with confidence for detecting the unlikely event of a landfill liner leak.

The need for nested wells will be considered based on the findings of the Work Plan described in Attachment SME-2.

DEP Follow-on Response

My primary concern regarding JRL's response relates to the last sentence in their response about the need for nested wells. The additional evaluation outlined in the work plan will undoubtedly increase our understanding of groundwater flow at this site. However, in my view no further justification for multilevel monitoring wells is necessary. A robust and defensible groundwater monitoring program for the expansion must include multilevel monitoring wells.

Appendix I – Helium-Tritium Groundwater Age Dating Results

JRL's Response: SME responded to DEP's questions on test protocol and methodologies above when we addressed questions on Section 3.2.8. The chain-of-custody forms are not available; however, the Monitoring Well Sample Purging Forms are attached in Attachment SME-3.

The comment about the terrragenic helium in the sample from P-04-06A was a cautionary statement by Poreda since he did not know where the sample came from. However, in comparing the initial tritium content of the sample with the historical precipitation tritium for the Ottawa, Canada monitoring station, the sample is consistent with the precipitation tritium for the estimated sample age. The initial tritium content is the sum of the measured tritium and the tritiogenic helium-3. Helium-3 is the by-product of tritium decay. This implies the sample is not mixed with older groundwater. The data from P-04-07B and P-04-06A is consistent with the estimated ages if one examines the initial tritium in the samples. The initial tritium is a sum of the sample tritium plus the tritiogenic helium-3 and is the tritium content of the precipitation. The initial tritium of the older sample (P-04-07B) is about 26 TUs. The younger sample is 15 TUs. This is consistent with the decay of tritium in the atmosphere resulting in less tritium in precipitation over time. Thus, the data is internally consistent.

MEDEP Follow-on comment

JRL states the chain of custody forms are not available for the helium-tritium sampling. Did JRL contact the University of Rochester's Noble Gas Laboratory or only review SME's records? The validity of laboratory analyses is in large part dependent on proper documentation including the applicable chain of custody records.

Appendix J - MW-06-02 Groundwater Pumping Test Results

Pg 4 4.0 Analysis of Results

JRL's Response: The reason SME describes the water level response after 400 minutes as a decrease in drawdown is that the pump rate is decreasing. The drawdowns are responding to lowering of the pump rate in the later part of the test as we began to shut it down. This drawdown recovery due to the lessening pump rate is the significant part of the water level response, not the precipitation. There is likely some water level change due to the precipitation event, but is overwhelmed by the declining pump rate in the later stages of the test. As stated in our response to DEP comment on Page 3-29, precipitation events will cause an immediate rise in groundwater levels due to the weight of the precipitation in the ground. The barometric efficiency of the specific portion of the groundwater system affected can be used to correct for this effect if significant.

The lag in water level response has to do with the pump rate, storage coefficient, and transmissivity of the formation, not necessarily the degree of interconnection of pore spaces. For instance, in a fine grained soil the pore spaces are intimately connected but it takes some time for the drawdowns to expand away from the well. The degree of interconnectedness is demonstrated here by the fact that all observation wells over an *arc of at least 100 degrees around the pumping well had measurable drawdowns. If the fractures were poorly interconnected some wells would drawdown and others would not.*

A direct comparison of drawdowns observed during the MW-06-02 pump test and the large-diameter wells is inappropriate. MW-06-02 was pumped at a time-weighted average rate of about 0.2 gallons per minute over an 8 hour period. Total volume of water removed from the bedrock was about 94 gallons. Drawdown in the pumping well averaged about 12 to 13 feet. By comparison, the approximately two-hundred-foot deep, large diameter wells that were positioned in the bedrock fracture zones (PW-08-01, PW-08-02, and PW-09-04) were pumped at between 32 and 96 gallons per minute for 24 to 50 hours with pumping well drawdowns of about 59 to 77 feet. Between approximately 52,000 and 276,000 gallons of water was withdrawn from each of these wells, compared to the 94 gallons withdrawn from MW-06-02. The longer pumping periods allowed for the cone-of-drawdown to extend further from the pumping well than at MW-06-02, which is what was being sought. The MW-06-02 pump test was considered a local test to examine rock that was known to be well fractured based on the downhole geophysics results. It is interesting to note that the hydraulic conductivities and orientation of the principal directions of hydraulic conductivities calculated for MW-06-02 and PW-08-01 were similar. In addition, the tracer test in the bedrock showed the tracer to be entering the downgradient observation wells over an arc of at least 90 degrees. If the fractures were poorly interconnected, we would have expected to see no tracer at all or maybe one random observation well detecting the tracer. We continue to conclude that the fractures surrounding MW-06-02 were well interconnected and this is qualitatively supported by all the available data.

MEDEP - Follow-on Response

In response to the first part of my comment about water level recovering in OW-06-08, JRL states, in part, drawdowns decreased in response to the reduction in pumping rates. This isn't correct as the pumping rates actually increased between 200 and 300 minutes (SME - Attachment B, Semi-Log Time vs. Pump Rate). Therefore, while pumping rates remained stable or increased, drawdowns measured in OW-06-08 were decreasing (SME - Attachment C, Semi-Log Time vs. Drawdowns). A similar recovery in water levels occurred in OW-06-09 during this time frame. I therefore ask JRL to reexamine the data and provide plausible explanations for the observed water levels.

<u>Appendix M – Hydraulic Analysis of Data from Long-Term Bedrock Pump Test at PW-08-01</u>

<u>Pg 3, 3.0 Pump Test Analysis</u>

<u>JRL's Response</u>: As requested, we have summarized the till observation wells where drawdowns were observed. The range of drawdowns for each well during each pump test is shown on Figures U-14 and U-15 in Appendix U of Volume II of the Application.

MEDEP - Follow-on Response

The referenced figures were included in the original application but they do not differentiate the till wells from the bedrock wells. I continue to believe JRL should produce figures that depict the till wells where drawdowns were observed during the long-term pumping tests. These figures may help in the evaluation of long term monitoring well locations.

<u>Appendix U – Bedrock Fracture Interconnectivity</u>

<u>Pg 25 Figures U-14 and U-15</u>

<u>JRL's Response</u>: The manual water level measurements have been tabulated and were included in Appendix M of Volume II following the transducer drawdown plots.

MEDEP - Follow-on Response

JRL's response to my comments about Figures U-14 and U-15 do not adequately address my comments. Additional figures are needed to properly illustrate the data collected during each of the five pumping tests. To further enhance the results of the pumping test data, it is necessary to include all of the drawdown data obtained during each test. Again, I contend it is important to differentiate between bedrock and till wells. As an example, the figure (Figure U-14) illustrating the 26.5 hour pumping test performed on PW-08-04, uses graduated symbols to depict the range of observed drawdowns for only 20 of the 53 wells where water levels were observed. There are also apparent inaccuracies on the existing figures. The text on page 26 states six wells (5 bedrock and 1 till) experienced between 0.1 and 1.0 foot of drawdown although Figure U-14 only depicts three wells in this range. The figure (Figure U-15) depicting the drawdowns observed during the long-term pumping tests at PW-08-01 and PW-08-02 also requires revisions as only a fraction of the drawdown data is depicted on this figure. Although JRL collected drawdown data for 53 wells during the tests, Figure U-15 only depicts data for 21 wells.

To address these comments, I recommend JRL display all of the drawdown data for each pumping test on appropriately scaled figures. I also ask JRL to augment the drawdown data included in Appendix M with a table summarizing the total drawdown observed in all wells during each of the pumping tests. This table would include those wells instrumented with pressure tranducers and those where manual water levels were made. I am certain JRL has previously compiled this data to complete the pumping tests analyses. I also request that JRL also provide the Department with an electronic copy of the spreadsheet.

Pg 30, 6.0 Theoretical Confirmation of Bedrock Fracture Interconnectivity

JRL's Response: SME did not base its conclusion only on outcrop OC-AG. The conclusion is based on all the outcrop mapping for the Site, all the downhole geophysical fracture mapping, all the bedrock cores, the photolineament mapping, and MGS regional mapping. The data collectively indicate there are numerous fractures at relatively close spacing of a few feet or less that occur in fractures sets that intersect one another and the fracture lengths are greater than the fracture spacing. Therefore, on the scale of the Expansion, with fractures intersecting at distances of less than a foot, it is reasonable to conclude there is significant fracture interconnectivity. The pump tests performed confirm this interconnectivity from a hydraulic perspective by demonstrating drawdown in all directions away from the pumping well for distances of up to a couple thousand feet. The bedrock tracer test results are consistent with well interconnected fractures as stated above and are inconsistent with limited or no interconnection due to the observed tracer spreading. The data collectively are the basis for our conclusion that bedrock fractures on the scale of the Expansion are well interconnected (see Appendix U).

MEDEP - Follow-on Response

JRL has provided a thorough explanation about the degree to which the bedrock fracture network is interconnected. Their explanation does include a misleading statement regarding drawdowns. While collectively the five pumping tests produced a population of drawdowns that encompassed all azimuths, results from an individual pumping test did not yield drawdowns in all directions as the text implies. In fact, Appendix U (Page 28) explicitly states that monitoring wells were not available in all radial directions from any one pumping well.

Appendix V – Groundwater Simulation Juniper Ridge Landfill Expansion Old Town, Maine July 2015

JRL's Response: The partial sentence quoted at the outset of this comment is poorly worded. It is intended to mean that if one examines the simulated groundwater flow directions and compares them to the equipotential contours, they are not exactly *perpendicular like they would be in an isotropic medium; in an anisotropic medium they are not perpendicular.*

Regarding DEP's recommendation to include pre- and post-equipotential head data and the estimated groundwater flow directions (relative to recharge cutoff changes), Section 5.0 of the Model Simulation includes: (1) Figure V-5, which illustrates the groundwater head equipotential contours for model layer 2 (i.e., near the phreatic surface) based on approximate recharge cutoff conditions for the period selected for calibration (i.e., April 2009); and (2) Figure V-6, which illustrates groundwater particle pathways away from the existing landfill and expansion area with recharge cutoff over both the existing landfill and expansion area.

Based on DEP's recommendation, two supplemental figures are provided in Attachment SME-3. Figure V-5S supplements Figure V-5 and includes groundwater particle pathways away from the existing landfill and Expansion area with approximate recharge cutoff conditions for the period selected for calibration (i.e., April 2009). Figure V-6S supplements Figure V-6 and includes groundwater phreatic surface contours in the area of the existing landfill and Expansion with recharge cutoff over both the existing landfill and expansion area.

Based on a comparison of Figures V-5 and V-6S, the phreatic surface elevations decrease in the area of the existing landfill and Expansion as a result of the simulated recharge cutoff. Groundwater heads were compared at 29 locations at equal spacing within the expansion area for pre- (i.e., April 2009 conditions) and post-expansion development in the model. Post-expansion development recharge cutoff results in an average decrease in head of 23 feet at those locations in the model, with a maximum decrease of 33 feet in the interior of the expansion and a minimum decrease of 8 feet along the northern perimeter of the expansion.

Figures V-5S and V-6 illustrate that the divide of the groundwater particle pathway flow directions (i.e., the groundwater divide) shifts to the east as a result of the recharge cutoff.

SME further discretized the model in the area of the existing landfill and expansion by refining the cell spacing from 100 feet by 100 feet to 25 feet by 25 feet. The changes in simulated groundwater particle pathways and groundwater heads were negligible.

MEDEP - Follow-on Response

JRL has responded to my request to model the pre and post equipotential heads and groundwater flow directions. The resulting post development modelled head data indicate the average head will decrease 23 feet. More importantly, post development modelling indicates groundwater flow directions are expected to change significantly once recharge is reduced to zero over the developed landfill area. For example, modeled results for the pre-expansion conditions (April 2009) depict groundwater flow in a northerly direction along the northern boundary of the proposed expansion (Figure V-5). Importantly, the modelled results are consistent with the interpreted phreatic surface data included in the application (Figure 5-1). In contrast, once recharge is reduced to zero, the groundwater high now present within the proposed expansion will move northward (see Figure V6S). As a result, projected future flow directions will be in a southerly direction. This represents a complete reversal in groundwater flow directions in the vicinity of the northern boundary of the proposed expansion. These results demonstrate the usefulness of modelling to estimate future conditions. The expected altered groundwater flow directions are particularly important in regard to the development of the facility's long term groundwater monitoring program.

In recognition that groundwater flow directions are anticipated to change significantly with landfill buildout, JRL should revise the facility's Environmental Monitoring Plan/Operations Manual to include a section providing for the periodic analysis of groundwater flow directions.

Recommended monitoring alternatives for evaluation

DEP Recommendation #1

<u>JRL's Response</u>: We understand that both BGS and NEWSME would not be opposed to discussing alternate sampling programs such as you described independent of the Expansion's permitting process.

MEDEP Follow-on Response

I understand and concur with JRL's desire to discuss the potential for an alternative monitoring program independent of the expansion application. In view of JRL's response I would like to arrange a meeting with JRL and its consultant to discuss potential modifications to the current monitoring program. I am particularly interested to have JRL characterize the tritium activity of the existing leachate.

DEP Recommendation #3

<u>JRL's Response</u>: We agree that based on the proposed expansion design the site monitoring wells are not the "initial" means of monitoring landfill liner performance. The proposed secondary liner and leak detection system provides both a means to monitor the performance of the Expansion's primary liner (i.e., the system that provides for the containment and collection of landfill leachate) and the initial means to detect and implement corrective actions due to a liner failure. The early warning afforded by the monitoring of the leak detection layer allows for a response action to be implemented before the groundwater monitoring network would detect such a leak. The approach used to monitor and respond to results from the leak detection monitoring is described in Volume IV, Appendix P of the Application.

MEDEP Follow-on Response

I have further discussed JRL's proposed liner leakage action plan with Steve Farrar, the department's project engineer. We concur that JRL's proposal for incorporating both flow and specific conductance data appears to create an overly complicated trigger for evaluating liner performance. Further discussion is necessary.

<u>Appendix B of Review Memorandum</u>
January 14, 2016 Memorandum from Gail Lipfert Re: Juniper Ridge Landfill Pumping and Tracer Test Evaluation.

Gail Lipfert has reviewed JRL's response to her comments and has prepared the attached memorandum (MEDEP - Attachment C). I concur with Gail's follow-on comments and expect JRL to respond appropriately.

Attachments

Email: Richard Heath
Steve Farrar
Victoria Eleftheriou

MEDEP – ATTACHMENT A

WORK PLAN FOR
REFINING LOCATION OF MONITORING WELLS
AT THE
JUNIPER RIDGE LANDFILL EXPANSION
OLD TOWN, MAINE

Prepared for

BUREAU OF GENERAL SERVICES
AND
NEWSME LANDFILL OPERATIONS, LLC

February 2016

SME
Sevee & Maher Engineers, Inc.

ENVIRONMENTAL • CIVIL • GEOTECHNICAL • WATER • COMPLIANCE

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WORK PLAN
FOR
REFINING LOCATION OF MONITORING WELLS AT THE
JUNIPER RIDGE LANDFILL EXPANSION
OLD TOWN, MAINE

1.0 PURPOSE

The purpose of this Work Plan is to present an approach for refining/finalizing the locations for new groundwater monitoring wells around the perimeter of the JRL Expansion for operational and long-term monitoring of the landfill. An Environmental Monitoring Plan, which includes establishment of a total of 45 monitoring locations consisting of: (1) background and downgradient piezometers and wells; (2) additional surface water and pore water sampling points; and, (3) leak detection and underdrain monitoring points. The proposed monitoring locations associated with the Expansion are as shown on Figure 6-1 of Volume II of the Application. Since the Expansion will be developed in a series of cells beginning in 2018, and continuing for a period of about 12 years, the installation of the monitoring wells included in the monitoring program can be phased as landfill development proceeds as proposed in the Application. However, in discussions with MEDEP, we agreed that a work plan outlining an approach to refine the locations for the proposed monitoring wells should be provided as part of the Expansion application, to obtain MEDEP approval prior to beginning field work.

During the development of this work plan, and in discussion with MEDEP we agreed, however, that there would be an advantage to gathering additional data now to confirm geologic features identified during the site assessment that will be relevant to siting the individual wells. This would be, therefore, a refinement of the information already submitted with the Application.

Thus, we have prepared a staged approach to gather this data as described in this work plan, with some additional data being collected in the near-term (i.e., winter/spring 2016), and with the approval of MEDEP, to help plan for what data may be necessary for final siting of the monitoring wells. This approach will help to fine-tune the geologic data that already exists for the Expansion site, which will, in turn, help to guide the eventual siting process for the monitoring wells needed prior to operation of the Expansion.

2.0 APPROACH

The investigations conducted as part of the Expansion Application were documented in Volume II - Site Assessment Report show that the bedrock at the site consists of fractured metasediments, which are typical of this area of Maine. The investigations found that the bedrock fracturing is on the scale of inches to a few feet. The borehole and surficial geophysical surveys completed onsite demonstrated that there are also localized, more densely fractured zones within the bedrock.

Information to be collected during execution of this Work Plan will supplement the available geologic data and be used to inform placement of the proposed observations and monitoring wells outside the perimeter of the Expansion. In part, this work will help to ensure more densely fractured zones have not been overlooked in siting the observation and monitoring wells. The data will be used to establish the final well locations and the screen depths within the bedrock. This Work Plan utilizes the same methodologies utilized during the previously completed site investigations, which has demonstrated that the site meets the requirements contained in 06-096 CMR 401 for landfill siting, design and operations.

Supplemental geophysical survey work is included in this Work Plan, as is installation of boreholes into the bedrock to confirm the geophysical and photolineament studies already completed. Each new borehole, as well as two existing boreholes (i.e., the water supply wells for the office and scale house) within the footprint of the Expansion, will be examined using geophysical borehole logging methods to establish fracture depths and possible fracture continuity between boreholes using surficial geophysical methods. Boreholes will be drilled within the Expansion footprint and along the Expansion's perimeter. Boreholes that do not become part of the groundwater monitoring plan will be decommissioned and sealed with grout. The outcome of this supplemental data gathering program will be the basis to refine the Expansion's groundwater monitoring system.

The work plan has been subdivided into two parts: (1) an early phase - Phase 1- which would be done now, and (2) a later phase - Phase 2- that would be done at least one year before operation of the Expansion begins. The Work Plan is designed to be completed in close cooperation with MEDEP, to streamline decision-making.

3.0 SCOPE OF WORK

3.1 Phase 1-Background Information for Planning and Confirmation

The purpose of Phase 1 is to collect data for planning and confirmation.

Task 1-Downhole Geophysical Survey of Existing Water Supply Wells. Task 1 of Phase 1 includes conducting downhole geophysical surveys of two existing water supply wells within the footprint of the Expansion. The pumps will be removed from the existing two water supply wells (i.e., the scale house and office) at least one day before the geophysical survey begins. Each well will be logged with a suite of downhole geophysical instruments to examine bedrock fracture locations, sizes, orientations and fracture water yield. The geophysical logging parameters are listed in Table 1, along with a brief explanation of the logging objective relative to identification of bedrock fractures.

Borehole diameter and fracture width data from caliper logs will be used to make preliminary estimates of fracture depths with the potential for water flow. Fluid resistivity and temperature are often useful in identifying zones where groundwater is seeping into the borehole. Vertical flow measurements between transmissive fractures can be evaluated with a heat-pulse flowmeter. Ambient and induced groundwater flows from fractures will also be measured using the downhole flowmeter. The acoustic and optical televiewer data will be used to identify planar features (e.g., fractures, joints, bedding, and foliation) that intercept the borehole wall and measure their strikes and dips. Results from the downhole geophysical logging will be plotted as stereo nets, rose diagrams and an image of the borehole wall. The strike and dip data along with fracture width will provide a qualitative sense of hydraulic conductivity anisotropy in the bedrock. The borehole fracture orientations will be compared with those previously measured at bedrock outcrops, bedrock cores, and existing downhole geophysical studies performed for the Expansion application. The geophysical survey will be conducted by Northeast Geophysical Services (NGS) of Bangor, Maine.

TABLE 1

BOREHOLE GEOPHYSICAL PARAMETERS

Instrument/Parameter	Objective
Caliper (Borehole Diameter)	Fractures are often indicated by widenings along the borehole wall.
Fluid Temperature	Changes in fluid temperature can indicate water entering a borehole through fractures.
Fluid Resistivity	Changes in fluid resistivity can indicate water entering the borehole through transmissive fractures.
Single Point Resistance	Electrical resistance between instrument and a surface electrode. Water-filled fractures often are characterized by low resistance.
Spontaneous Potential (SP)	Electrical voltage between the instrument and a surface electrode. SP sources can include lithologic changes and water movement in or out of a borehole through fractures.
Gamma	Provides lithologic/formation information. Clay-filled fractures can be characterized by gamma spikes.
Acoustic Televiewer	Oriented acoustical image of the borehole wall, including identification of strike and dip directions of planar features such as fractures and foliation.
Optical Televiewer	Oriented optical image of the borehole wall, including identification of strike and dip directions of planar features.
Heat-Pulse Flowmeter	Measures the vertical flow of water in the borehole, under ambient and pumping (stressed) conditions. Vertical flow indicates two or more transmissive fractures intersecting the borehole, at hydraulic disequilibrium.

Task 2-Borehole Drilling Within Expansion Footprint. Task 2 is to conduct additional borehole drilling within the footprint of the Expansion site. There are several geologic features along the east side of the Expansion that may be appropriate locations for monitoring wells. Three new boreholes (B16-101 through B16-103) within the Expansion footprint would be useful in finalizing the later elements of this work plan. Therefore, the three boreholes would be drilled at the approximate locations shown on the attached Figure 1 within the eastern side of the Expansion footprint. Two of these locations (B16-101 and B16-102) have been proposed along the alignments of previously identified photolineaments and should help resolve their importance for monitoring. Prior to drilling, the locations of existing photolineaments and denser fracture zones in the bedrock will be located in the field from the existing mapping. The intention is to drill along these features (accounting for the interpreted dip of the bedrock structures). A third borehole (B16-103) will be drilled within the footprint in an area not aligned with a photolineament to provide a point to compare the bedrock structure to that investigated with the other two boreholes. The approximate locations of these boreholes are shown on the attached Figure 1.

All three of the boreholes in Task 2 will extend at least 200 feet below the bedrock surface and will be drilled using air-rotary methodology. The soil overburden will be cased during advancement of the borehole into the bedrock. Soil and rock cuttings will be spread around each borehole. SME will observe the drilling and will classify rock chip samples obtained from the boreholes. Soil and rock cuttings will be spread around each borehole.

Each borehole will be developed by pumping and/or surging techniques to remove fine-grained sediments after the completion of drilling. The recovery rate of water levels will be recorded to estimate the borehole water yield. Static water levels in each boring will be recorded after levels have stabilized.

Task 3-Downhole Geophysical Survey of New Boreholes. Task 3 of Phase 1 is to conduct downhole geophysical surveys of each of the new boreholes. Each of the three boreholes described in Task 2 will be logged with the same downhole equipment and methodologies as described in Task 1 to examine structure locations, sizes, orientations and fracture water yield.

Task 4-Data Compilation and Review. Task 4 will be data compilation and review of the information gathered in Tasks 1 through 3. MEDEP will be notified of the specific schedule for the various work elements of Phase 1 and will be kept abreast of the results of the investigations. The data compiled from the investigations will be reviewed with MEDEP and it is anticipated at least one meeting with MEDEP will be held to review the results of the Phase 1 investigations. The results of the investigations will be reviewed in terms of (1) the voluminous existing data; (2) the understanding of both the bedrock depth and structural features, as they relate to locating, both horizontally and vertically, zones to be screened for the Expansion's monitoring wells; and (3) the interpretation of the groundwater flow paths beneath the Expansion footprint. These findings will be presented in a written report to supplement the information contained in the Expansion application. The report will include borehole logs; the geophysical report; survey data, a map showing the locations of the Phase 1 boreholes; and a summary of the supplemental field investigation work. Any appropriate refinements to the Phase 2 program, discussed below, will also be included. The schedule for completing Phase 1 is discussed in Section 4.0 of this Plan, below.

3.2 Phase 2-Locating Monitoring Wells

The objective of the Phase 2 program is to optimally locate the Expansion's observation and monitoring wells.

Task 5-Electrical Earth Resistivity. Task 5 involves performing earth resistivity transects as part of Phase 2 of this Plan. Electrical earth resistivity (resistivity) transects will be completed in areas along the perimeter of the Expansion to supplement existing resistivity transects, as shown on Figure 1. This will include running one transect (Line S-1, on Figure 1) along the north boundary of the Expansion and a second along the west boundary of the Expansion (Line S-2). A third transect will parallel the east side of the Expansion and pass through the boreholes installed and tested in Phase 1 (Line S-3). A fourth transect will pass through the Expansion area, in a north-south orientation (Line S-4). The purpose of the resistivity transects are to further refine information from previous investigations on fracture zones in the bedrock, which will provide information necessary for optimally locating new Expansion observation and monitoring wells. The earth resistivity results will also provide additional data on the soil overburden thickness. The earth resistivity transects will be "calibrated" by passing them over existing site borings that extend beneath the bedrock surface. The preliminary locations of these transects are shown in Figure 1 pending MEDEP review. This resistivity work will be done in close coordination with MEDEP. The earth resistivity survey will be conducted by NGS

Task 6-Additional Borehole Drilling. Task 6 of the Plan requires additional borehole drilling. Based on the results of the geophysical surveys and preliminary boreholes described in Phase 1, the six proposed monitoring boreholes (OW-602A, OW-605A, OW-606 A&B, OW-608A&B, MW-507 and OW-611A) will be drilled using the air-rotary hammer technique. The boreholes will be located outside of and along the northern (one), eastern (three) and western (two) boundaries of the Expansion. The approximate locations of these boreholes are as presented in the Expansion application, and are shown on Figure 1. The locations and depths of these wells will be finalized after the Phase 1 data has been analyzed. One of the boreholes will be intentionally located on a bedrock zone that indicates a relatively lower fracture density to aid in confirming and calibrating the earth resistivity survey data. Furthermore, prior to the beginning of drilling, SME and MEDEP will finalize the borehole locations and depths.

The new boreholes will allow access for downhole geophysical logging tools to the presence of fractures or fracture zones identified by the earth resistivity transects and photolineaments. The boreholes will be nominally six inches in diameter and drilled a minimum of 200 feet deep into bedrock. The soil overburden will be cased during advancement of the borehole through the bedrock. Soil and rock cuttings will be spread around each borehole. Rock chips will be visually logged.

Each borehole will be developed after the completion of drilling. The recovery rate of water levels will be recorded to estimate the borehole water yield. Static water levels in each boring will be recorded after levels have stabilized.

Site preparation for drilling will include clearing of brush and trees, and construction of access roads sufficient for a three-axle, water-well-style drill rig, support trucks, and equipment. Erosion control at these drilling locations will include installation of silt fencing between work areas and surface water streams (if any).

<u>Task 7-Downhole Geophysical Survey</u>. Task 7 will involve a downhole geophysical survey. Each of the six boreholes drilled in Task 6 will be logged with the same downhole logging probes utilized in Task 1 to examine fracture locations, sizes, orientations and fracture water yield.

<u>Task 8-Location Survey</u>. Task 8 of the Plan is to conduct a location survey. Once the boreholes and geophysical transects are completed, their horizontal and vertical locations will be measured by survey. Horizontal locations will be measured to the nearest one-foot and vertical locations measured to the nearest 0.1 foot.

<u>Task 9-Data Review and Monitoring Well Identification</u>. Task 9 will involve final data review and monitoring well identification. Once the Phase 2 field work is complete, the results of Tasks 1 through 8 will be provided to MEDEP in a summary report documenting what was done, how it was done, and the purpose of each Task performed. The collected information will be used to finalize the overall depth, location, and screen length for the Expansion’s observation and

monitoring wells, in cooperation with MEDEP. Available mapping provided in the Site Assessment Report will be updated to show the new boreholes and geophysical transects. The submittal will include the NGS report and logs for the boreholes. Groundwater elevations will be measured at the new boreholes and compared to those of existing surrounding wells and piezometers. Bedrock depth and fracture patterns will be compared with existing data. The report will include a description of the field work and an interpretation of the findings. The information gathered will be used to support SME's recommendations for final monitoring and observation well placement, design and construction. Well placement will focus on transmissive zones in the bedrock that can conduct groundwater from beneath the Expansion to its perimeter. MEDEP will approve each well location and screened interval, prior to installation.

Once the locations and designs of the monitoring wells are complete, they will be installed at least one year before the construction of the individual Expansion cells are adjacent to the well location is complete. Once the wells are installed and have a chance to equilibrate with the adjacent formation, they will be sampled for at least four rounds to establish pre-Expansion water quality. Boreholes, piezometers, and wells within the Expansion footprint will be grouted to eliminate open holes through the glacial till into the bedrock.

4.0 SCHEDULE

Scheduling of a qualified driller and NGS will be initiated before MEDEP approval of the Work Plan. The downhole geophysical logging of the existing two water supply wells, drilling of the two preliminary boreholes and the downhole geophysics in Phase 1 will commence once this Work Plan is approved by MEDEP. It is expected to take up to two months in order to coordinate access, water pump removal and replacement, drill the boreholes, and get the data report from NGS. It is expected that our report to MEDEP will be submitted in May 2016. Weather and driller availability will affect this schedule.

For Phase 2, the resistivity survey will require about one week to clear the transects and up to two weeks to complete the field work. This work is scheduled for the summer of 2017, after the Expansion application is approved. Once started, the results should be available in near real-time for review with MEDEP. The borehole drilling will take about two to three days per location once access is provided (up to 9 individual Expansion monitoring wells and 16 individual Expansion observation wells are anticipated). Access may take some time to complete since most of the boreholes are away from existing roads in heavily wooded areas and habitat will be considered. Clearing and road building for the drilling may take a few weeks but could be on-going during the earth resistivity field work and the start of drilling. Downhole geophysics can be scheduled for as soon as the wells have had a chance to rest for one or two weeks. It is not uncommon to complete the downhole work at a rate of two boreholes per day. Phase 2 may require up to four to six months to complete.

MEDEP – ATTACHMENT B

STATE OF MAINE

DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF REMEDIATION AND WASTE MANAGEMENT

M E M O R A N D U M

TO: Kathy Tarbuck, P.E., Senior Environmental Engineer
Division of Technical Services
Bureau of Remediation and Waste Management

FROM: Richard S. Behr, Environmental Hydrogeology Specialist RSB
Certified Geologist GE#342
Division of Technical Services
Bureau of Remediation and Waste Management

DATE: February 25, 2016

RE: Draft Work Plan for Refining Location of Monitoring Wells at the Juniper Ridge Landfill Expansion Old Town, Maine - Prepared for Bureau of General Services and NEWSME Landfill Operations, LLC - Prepared by Sevee & Maher Engineers, Inc. February 2016

****

I have reviewed the referenced draft work plan. Sevee & Maher Engineers, Inc. prepared this work plan for its client, NEWSME Landfill Operations, LLC (JRL) to address concerns outlined in my January 15, 2016 memorandum. Specifically, my comments detailed the need to complete additional bedrock explorations to further refine the proposed number and location of groundwater monitoring wells around the perimeter of the proposed expansion.

This memorandum contains a brief summary of the proposed work followed by several specific comments. All of the specific comments are preceded by the applicable section and page number. If you have any questions about the content of this memorandum, please contact me.

Summary

With a few minor exceptions, the proposed work plan satisfactorily addresses the additional bedrock evaluation required to improve the Environmental Monitoring Program (EMP) for the proposed expansion.

The scope of work includes two phases. Phase I will include downhole borehole geophysical surveys of two existing water supply wells (i.e., Office Well and Scale House Well) and the completion of three new bedrock boreholes (DEP - Figure 1). JRL will evaluate the three new boreholes using the standard suite of borehole geophysical tools. JRL proposes to complete the Phase I evaluation in 2016. The results and analysis of the data collected during Phase I will be reported to the Department in May 2016.

Phase II as outlined in the work plan will consist of four additional electrical resistivity lines, six additional bedrock explorations, borehole geophysical surveys of the six wells, a location survey and a subsequent data review and analysis. The data review and analysis will provide the Department with an opportunity to comment and suggest recommended revisions to the placement of the monitoring wells that will be used to monitor groundwater quality downgradient of the proposed expansion.

Specific Comments

Pg 3-4 <u>3.2 Phase 2 - Locating Monitoring Wells</u>

<u>Task 5 - Electrical Earth Resistivity</u> To help locate the bedrock explorations completed in support of the proposed expansion, JRL previously completed ten earth resistivity lines. In recognition of the utility of the method, the current work plan includes four additional geophysical lines (SME - Figure 1). To significantly improve the current proposal, I recommend one additional geophysical line. Line S-5 should be positioned roughly parallel with Line S-1 and about 250 feet due south such that it passes through two of the proposed bedrock explorations (B16-101 and B16-102). The approximate location of the proposed additional line is shown on DEP-Figure 1.

The text states Line S-3 will be located along the east side of the expansion and pass through Phase I borings. The location as depicted on SME - Figure 1 does not pass through any of the three proposed bedrock borings. SME provided the attached clarification to this discrepancy (Attachment A). The fourth line (Line S-4) will be located within the proposed expansion and according to the location depicted on SME Figure 1 its oriented northwest-southeast not north-south as described in the text. This discrepancy requires clarification.

As shown on SME Figure 1, Line S-4 will pass through the Scale House Well and the Office Supply Well. Will the existence of the steel well casings produce anomalous 2-D resistivity results?

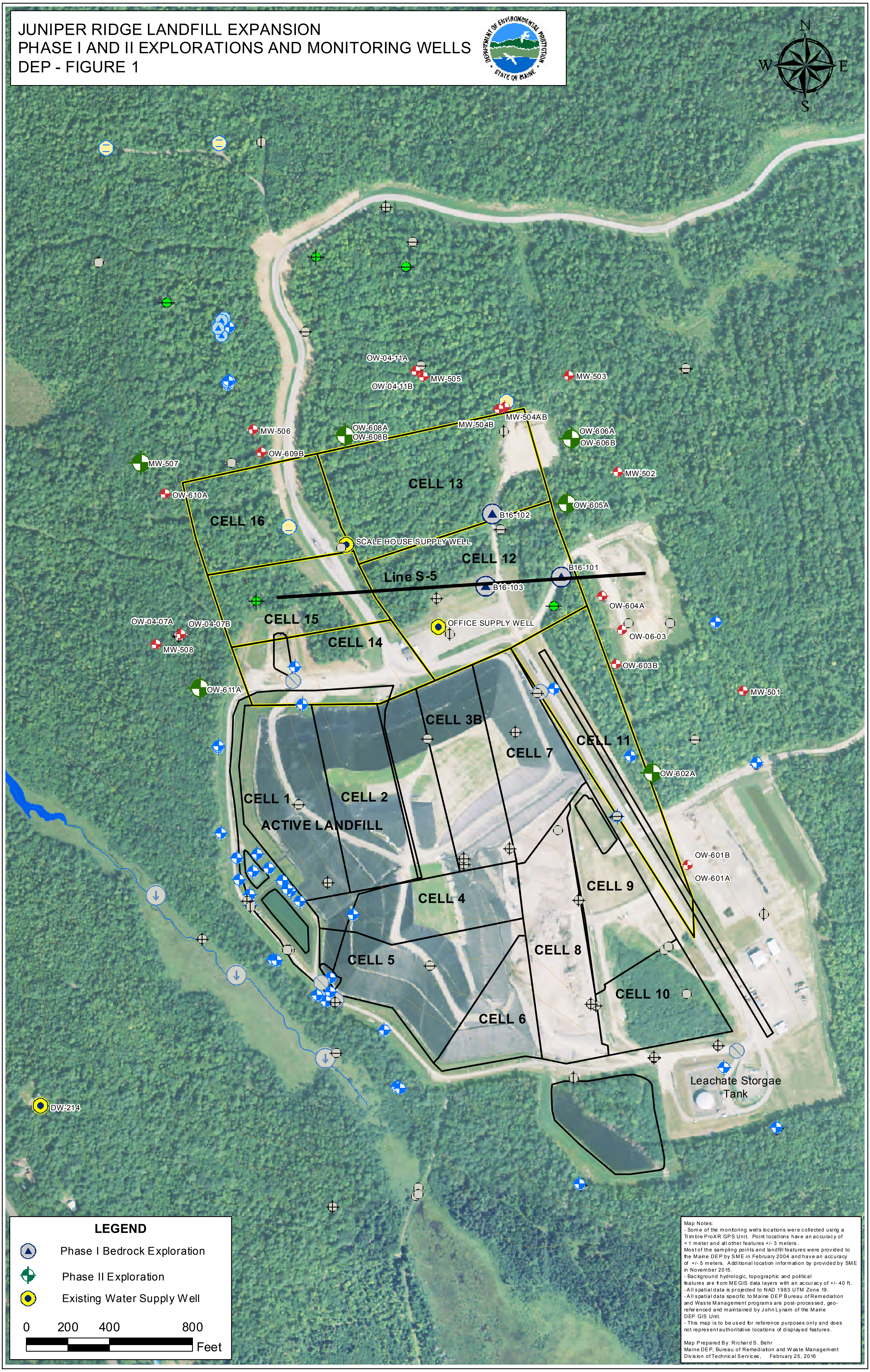
Task 6 - Additional Borehole Drilling The additional monitoring and observation wells included in Phase II (i.e., OW-602A, OW-605A, OW-606A&B, OW-608A&B, MW-507 and OW-611A) represent a subset of the additional wells depicted on Figure 3-1 and Table 3-1 of the proposed EMP found in Volume IV, Appendix I of the expansion application. I recommend JRL revise this work plan to clarify the schedule for installing all of the wells included in Table 3-1 of the expansion application.

Pg 4-1 4.0 Schedule I believe this section mistakenly states "two" preliminary boreholes rather than "three" as described in previous sections of the work plan.

The second paragraph of this section states, "….up to 9 individual monitoring wells and 16 individual expansion observation wells are anticipated." I have been unable to reconcile this description with the number of monitoring and observation wells depicted on SME Figure 1. I understand the Environmental Monitoring Plan for the proposed expansion includes a combination of wells designated with the prefix "MW" for monitoring wells and "OW" for observation wells. The inconsistency may arise, in part, from the nomenclature and symbology used on SME Figure 1.

Attachments

Email: Richard Heath
Steve Farrar
Victoria Eleftheriou


JUNIPER RIDGE LANDFILL EXPANSION
PHASE I AND II EXPLORATIONS AND MONITORING WELLS
DEP - FIGURE 1
DEPARTMENT OF ENVIRONMENTAL PROTECTION
STATE OF MAINE
N
W
E
S
OW-04-11A
MW-505
OW-04-11B
MW-503
MW-504A'B
MW-504B
MW-506
OW-608A
OW-608B
OW-606A
OW-606B
OW-609B
MW-507
MW-502
OW-610A
CELL 13
CELL 16
B16-102
OW-605A
SCALE HOUSE SUPPLY WELL
CELL 12
B16-101
Line S-5
B16-103
OW-604A
CELL 15
OFFICE SUPPLY WELL
OW-04-07A
OW-04-07B
OW-06-03
CELL 14
MW-508
OW-603B
OW-611A
MW-501
CELL 3B
CELL 11
CELL 7
OW-602A
CELL 1
CELL 2
ACTIVE LANDFILL
OW-601B
OW-601A
CELL 9
CELL 4
CELL 8
CELL 5
CELL 10
CELL 6
Leachate Storgae Tank
DW-214
LEGEND
Phase I Bedrock Exploration
Phase II Exploration
Existing Water Supply Well
0
200
400
800
Feet
Map Notes:
- Some of the monitoring wells locations were collected using a Trimble ProXR GPS Unit. Point locations have an accuracy of < 1 meter and all other features +/- 3 meters.
Most of the sampling points and landfill features were provided to the Maine DEP by SME in February 2004 and have an accuracy of +/- 5 meters. Additional location information by provided by SME in November 2015.
- Background hydrologic, topographic and political features are from MEGIS data layers with an accuracy of +/- 40 ft.
- All spatial data is projected to NAD 1983 UTM Zone 19.
- All spatial data specific to Maine DEP Bureau of Remediation and Waste Management programs are post-processed, geo-referenced and maintained by John Lynam of the Maine DEP GIS Unit.
- This map is to be used for reference purposes only and does not represent authoritative locations of displayed features.
Map Prepared By: Richard S. Behr
Maine DEP, Bureau of Remediation and Waste Management
Division of Technical Services, February 25, 2016

Attachment A

Behr, Richard S

From: John Sevee <jsevee@smemaine.com>
Sent: Monday, February 22, 2016 9:28 AM
To: Behr, Richard S; Tarbuck, Kathy; Mike Booth; Don Meagher; Tom and jade Doyle
Subject: Re: Proposed JRL Expansion-- draft work plan transmittal

Hello Dick, Good catch. The sentence should read " Line S-3 will pass generally through the approximate proposed locations of the wells outside of the east boundary of the Expansion." Our intention is, pending your approval, to offset the resistivity line from the existing resistivity Line 6 and use the information to locate the new wells outside the east boundary of the expansion. By offsetting the new resistivity line from Line 6, we should be able to confirm the bedrock anomalies observed in Line 6 and get a sense of their azimuths.

regards, John

From: Behr, Richard S <Richard.S.Behr@maine.gov>
Sent: Monday, February 22, 2016 8:31 AM
To: John Sevee; Tarbuck, Kathy; Mike Booth; Don Meagher; Tom and jade Doyle
Subject: RE: Proposed JRL Expansion-- draft work plan transmittal

Hi John,

I have initiated my review of the draft work plan and have a quick question for you. Task 5 (Page 3-4) describes the proposed electrical resistivity survey. The text states that Line S-3 will pass through the boreholes installed and tested in Phase I. I assumed this referred to Phase I borings B16-102 and B16-103. The location of S-3 as shown on Figure 1 is east of the proposed expansion boundary and does not pass through the proposed Phase I borings. Please clarify.

Regards,

Richard S. Behr
Environmental Hydrogeology Specialist
Maine Certified Geologist, #GE343
Maine Department of Environmental Protection
Augusta, Maine 04333

richard.s.behr@maine.gov

207-441-2847

From: John Sevee [mailto:jsevee@smemaine.com]
Sent: Friday, February 19, 2016 10:13 AM
To: Tarbuck, Kathy; Behr, Richard S; Mike Booth; Don Meagher; Tom and jade Doyle
Subject: Proposed JRL Expansion-- draft work plan transmittal

Kathy, please find attached a draft work plan related to an approach to finalize monitoring well locations. Please contact Mike Booth or Don Meagher if you have any questions or you have trouble opening the attachments. We look forward to your comments.

John Sevee

MEDEP – ATTACHMENT C

STATE OF MAINE

DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF REMEDIATION AND WASTE MANAGEMENT
DIVISION OF TECHNICAL SERVICES

M E M O R A N D U M

TO: Dick Behr, Hydrogeologist

FROM: Gail Lipfert, PhD, C.G. # GE506, Certified Environmental Hydrogeologist

DATE: March 28, 2016

RE: Juniper Ridge Landfill Pumping and Tracer Test Evaluation

CC: Rob Peale, C.G., Senior Geologist

****

Comment 2 a. Groundwater elevations were recorded every 5 minutes, whereas it is recommended that pumping tests within fractured bedrock be monitored more frequently at the very beginning to see the effects of fracture control on drawdown, then monitored less frequently later on.

Response: Our interest was getting the semi-log straight-line drawdown data, which we did starting around 100 minutes.

Follow-on comment: Please consult the following papers on aquifer test analysis of fractured rock to better understand the methods I am referring to:

Gernand, J.D. & J.P. Heidtman, 1994 Detailed bedrock pumping test to determin anisotropy of a fractured aquifer, Proceedings of the 1994 FOCUS Conference on Eastern Regional Ground Water Issues, Burlington VT, p. 171-183.

Gernand, J.D. & J.P. Heidtman, 1997, Detailed pumping test to characterize a fractured bedrock aquifer, Ground Water v. 35, n.4, p-632-637.

Gringarten, A.C. 1982, Flow-test evaluation of fractured reservoirs, Recent Trends in Hydrogeology, T.N Narasimhan, GSA special Paper 189, p. 237-263.

Sen, Z., 1986, Aquifer test analysis in fractured rock, Ground Water v. 24, n. 1, p. 72-78.

Jenkins, D.N. & J.K Prentice, 1982, Theory for aquifer test analysis in fractured rocks under linear (nonradial) flow conditions, Ground Water v. 20, n. 1, p. 12-21.

Comment 2 e. They started monitoring one minute after pumping started instead of monitoring for a day or two before the test to establish any background water level changes and trends.

Response: This test was intended to last long enough to collect the semi-log, straight-line drawdowns (maybe up to 8 hours), which it did, and long-term trend data was not necessary. The straight-line portion of the drawdown curves lasted about five hours and would have been unaffected by typical long-term water table trends.

We respectively disagree; prior water elevation data is always necessary. If water levels are decreasing at one well and not the others, it would appear that there was a response at that well even if it wasn't responding to the pumping well. For example, in the third paragraph in Section 4.0, there is uncertainty about the drawdown at OW-06-06; "The maximum drawdown reading during the pump test was approximately 0.16 feet. This may merely be natural fluctuation in the groundwater elevation as there is no apparent

recovery from the pump test." If you had monitored water elevations prior to the pumping test, this may have helped assess the response at this well.

Comment 2 f. They conducted the test during a thunder storm. The responses at OW-06-08, OW-06-09 and OW-06-10 to the rain storm at 200 minutes are abrupt and almost instantaneous, which indicates poorly-constructed wells.

Response: As stated elsewhere, the changes in drawdowns at around 200 minutes are due to decreasing pump rates, not the precipitation. Furthermore, the monitoring wells have 20 feet or more of bentonite chips effectively sealing them from the ground surface.

Follow-on comment: In the second paragraph of Section 3.0, it states: "It should be noted that at approximately 200 to 300 minutes into the pump test, a significant thunder shower passed over the pump test site… … The effects are particularly evident at OW-06-08, OW-06-09, and OW-06-10." There is no mention of this being due to lower pump rates. Another explanation other than poorly-constructed wells for causing short-circuiting at those wells, could be fractures that are allowing for a direct connection between the well and shallow groundwater.

Comment 4. Appendix H, 4.0, second paragraph. OW-06-10 and OW-06-07 are aligned with the two dominant fracture orientations, but these wells have later arrival times (3 and 3.6 days, respectively) than OW-06-09 and OW-06-08, which received tracer after 0.8 and 1 days, respectively. SME interpret these results along with the fact that the wells with the steepest groundwater gradients have the longest travel times, to indicate that the predominant fractures had more influence on tracer velocity than groundwater gradients. I don't see that the predominant fracture orientations have much influence at all. I would say that it appears that there are fractures outside the predominant orientations that are hydraulically connected between MW-06-02 and OW-06-08 and OW-06-09.

Response: In examining the tracer test results, the average direction of the groundwater flow gradient, based on Figure H-1, is to the east, even though horizontal seepage gradients are not uniform downgradient of the injection well. The strike direction of maximum fracture frequency is to the north-northeast/south-southwest. This is along the foliation pattern of the bedrock. Combining the gradient and fracture strike suggest to SME that the horizontal plume migration direction is more or less west-southwest from the injection well, if conditions were ideal and uniform (the tracer cannot move northeast or east since those directions are upgradient). Therefore, to observe the tracer first in the southwest quadrant is not surprising and might be expected if conditions were uniform. Movement of the tracer plume in other directions would be delayed. This is essentially what is observed and the reason for our conclusions as stated in Section 4.

Follow-on comment: But the document states: "OW-06-07 is best aligned with the secondary northeast/southwest striking fracture set" and "This secondary fracture set aligns with the steeper gradients". According to Figure H-1, the groundwater flow pattern is rather convoluted, but we judge the average flow direction to also be to the northwest, not the east. This means that OW-06-07 is aligned with a predominant flow direction, the steepest groundwater gradient, *and* one of the two predominant fracture orientation, but the arrival time is longer than other orientations. The evidence just does not support your assertion that the measured predominant fracture sets are controlling plume direction at this well.

Comment 6. Overall conclusions. One of the major assumptions in this analysis is that there are two principal transmissivities along two axes of an ellipse, but examination of the drawdowns at 200 minutes (before recharge affected the drawdowns) shows that the pattern of drawdowns is very irregular and cannot be described as an ellipse of anisotropy. The drawdowns also clearly indicate that the site is heterogeneous, which negates an underlying assumption for Papadopoulos's method. In general, it appears that the interconnectivity of the observation wells to the pumping well is quite variable and cannot be explained by the predominant fracture orientations or principal hydraulic conductivity orientations.

> *Response: The bedrock in the vicinity of MW-06-02 contains fractures in various orientations. When pumping on this well, drawdowns are observed in all radial directions where observation wells are located. This shows that all the fractures within about fifty feet of the pumping well are integrated with the pumping well and interconnected with other fractures. This was our objective for the test. These observations suggest to us that the bedrock fractures are well integrated and interconnected. The test, therefore, corroborates the interpretation that this should be the case based on the vast amount of bedrock data collected around the Expansion Site and existing landfill.*
>
> **Follow-on comment: We agree that drawdowns were observed at all the observation wells, but our point was that they were very irregular and their pattern does not match the dominant fracture orientations. Your response did not address our comment.**