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Deep Bedrock Investigation Final Report
Text and Tables
Coakley Landfill
Breakfast Hill Road
North Hampton, NH 03801

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26 September 2022

wood.

September 16, 2022

Mr. Richard Hull
US Environmental Protection Agency, Region I 5 Post
Office Square, Suite 100
Boston, Massachusetts 02109-3912

Re: Deep Bedrock Investigation Final Report
Coakley Landfill Superfund Site – Greenland and North Hampton, New Hampshire

Dear Mr. Hull:

On behalf of the Coakley Landfill Group (CLG), Wood Environment and Infrastructure Solutions, Inc. (Wood) is hereby submitting the Deep Bedrock Investigation Final Report (Final Report).

The Final Report was prepared by Wood and Sanborn Head Associates and presents our updated Conceptual Site Model (CSM) for the Coakley Landfill Superfund Site based on a detailed review and analysis of data collected during deep bedrock investigation activities executed between Spring 2017 and Spring 2022.

Following review of the Final Report by USEPA and New Hampshire Department Environmental Services, we look forward to discussing our recommendations.

Please feel free to contact Peter Britz of the CLG or the undersigned if you have questions concerning this report.

Sincerely,

Christopher Buckman, P.G., L.G.
Senior Project Geologist

CC: Andrew Hoffman, New Hampshire Department of Environmental Services
Peter Britz, The Coakley Landfill Group

September 16, 2022

Richard Hull
US Environmental Protection Agency, Region I
5 Post Office Square, Suite 100
Boston, Massachusetts 02109-3912

**Re: Response to Comments on Draft Deep Bedrock Investigation Final Report
Coakley Landfill – North Hampton and Greenland, New Hampshire**

Dear Mr. Hull:

On behalf of the Coakley Landfill Group (CLG), Wood Environment & Infrastructure Solutions, Inc. (Wood) has prepared the following response to comments made by the United States Environmental Protection Agency (USEPA) on the Draft Deep Bedrock Investigation Final Report (Draft Report). The Draft Report was submitted to the USEPA and New Hampshire Department of Environmental Services (NHDES) on December 21, 2021 and was developed in response to a request from the USEPA in its review of the Deep Bedrock Investigation Interim Report (Interim Report) submitted to the Agencies on November 25, 2019. It is important to note that USEPA comments included below reference specific sections and subsections of the Draft Report and these sections may be revised in the Final Report such that the original reference is no longer valid. Efforts have been made to address these changes in the CLG response.

Executive Summary

USEPA

1. **The discussion of the remedy for Operable Unit 1 (OU1) documented in the Record of Decision (ROD) should include reference to the groundwater extraction and treatment component of the selected remedy. This component was later dropped from the remedy for OU1 by an Explanation of Significant Differences (ESD) issued on September 29, 1999.**

CLG Response

The Final Report has been revised to include reference to the groundwater extraction and treatment component of the selected remedy for OU-1 as listed in the 1990 Record of Decision and later removed from the remedy as detailed in the September 29, 1999 ESD.

USEPA

2. **The discussion of the initiation of sampling for PFOA and PFOS at the Site indicates that the EPA health advisory (HA) of 70 parts per trillion (ppt) was exceeded "within the landfill boundary." Samples collected in May 2016 showed results that exceeded the EPA HA in both OU1 and OU2 wells, outside of the landfill boundary.**

CLG Response

The Final Report text has been updated to include reference to the Results of Perfluorinated Chemical Groundwater Sampling for Selected Wells within OU-1 and OU-2 at the Coakley Landfill – North Hampton, New Hampshire memorandum and included details of the sampling that occurred.

USEPA

3. **Page ii indicates that the fourth Five-Year Review (FYR) determined that the remedy at OU2 "was protective of human health and the environment". The fourth FYR issued in 2016 concluded that a protectiveness determination for OU2 could not be made (deferred) without obtaining further information. Accordingly, the site-wide protectiveness determination was deferred. The subsequent addendum to the fourth FYR issued in 2017 determined, based on information collected since the issuance of the fourth FYR, that the remedy for OU2, and for the Site overall, was protective in the short- term.**

CLG Response

The text of the Final Report has been revised for clarity as to the protectiveness determinations made between the fourth FYR and addendum to the fourth FYR.

USEPA

4. **With respect to the timeline for the submission of the draft and final Work Plan Addendum and EPA's subsequent conditional approval described on page iii, the Coakley Landfill Group (CLG) submitted a draft Work Plan Addendum on April 30, 2020, EPA issued comments on June 17, 2020, CLG submitted a response to comments and final Work Plan Addendum on July 17, 2020, and EPA issued a conditional approval on August 4, 2020.**

CLG Response

The Final Report has been revised to include the correct dates of submittal and USEPA comments on Work Plan Addendum submittals.

USEPA

5. **The last paragraph of the *Introduction and Site History* section states that "initial data collected from routine sampling of private water supply wells completed in deep bedrock indicate that little to no significant migration in the deep bedrock has occurred." EPA strongly disagrees with this statement. Routine sampling of water supply wells R3 and 339BHR has shown exceedances of the NHDES Ambient Groundwater Quality Standards (AGQS) for 1,4-dioxane and PFAS compounds demonstrating that the migration of contamination has occurred in the deep bedrock.**

CLG Response

This section of text has been removed from the Executive Summary as detections within these wells do support the migration of contaminants. However, individual lines of evidence have been provided within the revised report in support of the CSM to differentiate between migration to deep bedrock and migration within deep bedrock.

USEPA

6. **The *Completed Investigation Activities* section states that "both a variable rate pumping test and a constant rate pumping test [were conducted] at MW-6 to confirm that identified transmissive fractures in bedrock monitoring wells were not hydraulically connected to nearby private supply wells and did not provide potential pathways for off- site migration of Site contaminants to potential receptors." The actual objective of the pumping test as stated in the approved Deep Bedrock Investigation Pumping Test Work Plan dated November 20, 2020, was to assess bedrock fracture connectivity and further evaluate the southern migration pathway in bedrock, and to assist with 1) refining the Conceptual Site Model (CSM) and further the understanding of deep bedrock hydrogeology; 2) determining (along with other lines of evidence) whether transmissive fractures in bedrock monitoring wells provide likely migration pathways contaminants to potential receptors; and 3) evaluating inter- fracture groundwater flow and its relationship with overburden and shallow bedrock. A single pumping test that utilizes a well outside of the landfill footprint and has only very low contaminant concentrations would not be sufficient, on its own (single line of evidence), to support a conclusion about off-site migration to specific receptors.**

CLG Response

The objectives of the pumping test have been updated in the Final Report to be consistent with the Pumping Test Work Plan.

USEPA

7. **The *Geology and Hydrology* section cites MW-21D as an example of where overburden thickness is less than one foot but does not cite a well as an example of where overburden is 85-feet west-northwest of landfill. Additionally, MW-21D is located west-northwest of the landfill so there is some contradiction here.**

CLG Response

The Final Report has been revised to correct the references of overburden thickness relative to the landfill and direction referencing FPC-5A as an overburden well with thickness of 85 feet.

USEPA

8. **The *Geology and Hydrology* section indicates that the top of bedrock is shallower beneath the landfill because it is a topographic high point. That statement is incorrect and inconsistent with the cross-section shown in Figure 4.5 that shows the bedrock is located beneath nearly 50-feet of fill and overburden. Figure 3.4 provides a contour map of the bedrock surface that shows the high point for the bedrock is in the vicinity of the Bethany Church (120-foot elevation), while the elevation of the bedrock beneath the landfill is shown as 75-feet. Therefore, the bedrock surface near the landfill is neither shallow nor high in elevation compared to other locations in the study area.**

CLG Response

The revised report has been corrected for clarity relative to the lateral distribution and thickness of individual overburden units and elevations of bedrock units within the study area (i.e., updated bedrock topography map). In addition, figures have been revised to include updated information on the absence/presence of individual units and bedrock formations.

USEPA

9. **The *Geology and Hydrology* section lists the various factors that influence groundwater flow patterns in the vicinity of the Site, but the influence of sheeting fractures is not mentioned at all, nor is the highly variable distribution and thickness of the various overburden layers (outwash, marine silt and clay, till). Groundwater flow in crystalline bedrock is determined by the orientation of the various fracture sets (three fractures sets have been identified at this Site) and the local or regional hydraulic head field (distribution of groundwater elevations). This should be more clearly explained. The paragraph concludes that "…shallow and deep groundwater at the Site are discharging to the wetland complex and/or the Little River/Berrys Brook." While it is likely that overburden and shallow bedrock groundwater discharge to surface water in these drainage basins, it has not been conclusively shown that the deep bedrock groundwater discharges to surface water. Deep bedrock groundwater can follow longer flow paths that transcend smaller drainage basins, discharging to more distant regional or subregional drainages, or the Atlantic Ocean.**

<u>*CLG Response*</u>

With respect to the role sheeting fractures have in bedrock groundwater flow, the discussion in the revised Final Report has been expanded to demonstrate that fractures with dips of 20 degrees or less are rare and generally not associated with transmissive zones identified in the borehole geophysics. The three other fracture populations are also analyzed in detail regarding their role in groundwater flow. Vertical cross sections have been revised and now include vertical flow nets illustrating deep and shallow bedrock groundwater flow, showing upward gradients directing flow from the bedrock to the overburden, which in turn discharges to surface water. The revised report includes a discussion of these flow patterns.

USEPA

10. **The *Geology and Hydrology* section summarizes the trend analyses performed for various parameters and monitoring locations at the Site and concludes that "groundwater concentrations demonstrate primarily statistically significant decreasing concentrations of contaminants or no trend." No mention is made of the wells that show increasing trends and many of the interpretations of decreasing trends are incorrect. The lack of exceedances in water supply wells near the landfill is not necessarily an indication of plume stability or reduction. The text notes the exception of 339BHR and R3, but these are notable exceptions and document migration of contaminants from the landfill over large distances along preferential pathways in deep bedrock.**

<u>*CLG Response*</u>

For the revised report, MATLAB – MathWorks with Statistics Toolbox software was used to review groundwater data and re-analyze statistical metrics to address EPA's concerns regarding inclusiveness of data and conclusions regarding contaminant trends. Contaminants of concern (COC) selected for this evaluation include 1,4-dioxane, PFOA, PFOS, PFNA, PFHxS, arsenic, and manganese. These COCs were prioritized based on prevalence at the site, presence at concentrations above standards, and mobility.

Mann-Kendall trend analysis was used to evaluate concentration trends at individual wells. The Mann-Kendall test is a non-parametric statistical procedure that is well suited for analyzing trends in data over time. The Mann-Kendall test is designed for analyzing a single groundwater constituent at a single well, does not require any assumptions as to the statistical distribution of the data (e.g., normal, log-normal, etc.), and can be used with data sets which include irregular sampling intervals, non-detect results, and missing data.

The revised report provides summary tables of Mann-Kendall Trend Analyses for all wells with a statistically significant trend (increasing or decreasing), as well as a detailed description of methodology and conclusions. Appendix H has been prepared that includes Mann Kendall data for all wells in the sampling network regardless of trend.

USEPA

11. **Paragraph 1.d. of the *Conceptual Site Model* section concludes that the relatively small head differentials measured in nested wells indicates "relatively good hydraulic communication between fractures" and that this is consistent with short flow paths in a small watershed. However, extensive fracture measurements have shown that the area is characterized by relatively steeply dipping fractures, which would also tend to produce small vertical head variations. It is more likely that the small vertical head variations measured at the Site are indicative of near horizontal flow conditions along strike, as is common in New Hampshire.**

<u>*CLG Response*</u>

The Final Report has been revised to remove reference to why minor head differentials are indicative of short flow pathways with flow nets provided to illustrate flow paths. Additional reference to the Mack report has been included to provide context to the conceptual site model, which shows similar localized effects to bedrock flow pathways due to the presence of surface water drainages. Paragraph 1.d. of the Draft Report coincides with Paragraph 1.e. of the Final Report.

USEPA

12. **Paragraph 2.a. of the *Conceptual Site Model* section concludes that contaminant migration and the interconnectedness of fractures in deep bedrock are limited based on the lack of observed drawdown during the pumping test. However, the monitoring well used for the pumping test (MW-6) is not significantly impacted by contaminants from the landfill, suggesting that well is not well connected to the contaminant migration pathways. The well is located south of the landfill and not within the mapped zone of E- W lineaments. Hydraulic reaction to pumping at MW-6 was dominated by the primary fracture set (NE-SW) and the bedrock trough. Water level data from transducers placed in nearby monitoring wells during the drilling of MW-25 recorded measurable drawdown both east and west, confirming the importance of the E-W lineaments and cross-set fractures for contaminant migration from the landfill.**

<u>*CLG Response*</u>

To address contaminant migration and interconnectedness of fractures in deep bedrock, the Final Report has been revised to include a more detailed discussion of the observations made during background water level monitoring, influences during the installation of MW-25, and water levels observed in MW-25S during the pumping test. For example, the hydraulic connection between shallow bedrock wells proximal to deep bedrock well MW-25 that exhibited fluctuations in water level during drilling of MW-25 is due in part to the presence of the till above the bedrock surface. This till layer is in hydraulic communication with shallow bedrock fractures (i.e., sheeting fractures) and is more laterally continuous than shallow bedrock fractures. Based on the distribution of contaminants within this unit, the mapped lateral extents, and hydraulic influences observed, fluctuations are due in large part to the communication within this layer more so than the more laterally discontinuous E-W trending fracture set.

USEPA

13. **Paragraph 2.d. of the *Conceptual Site Model* section states that "Low to non-detect COC concentrations in this highly transmissive zone indicates low or no COC migration to this area." This statement is inaccurate. Concentrations of 1,4-dioxane and PFAS were found in all 12 fracture zones tested at MW-25. The presence of these compounds confirms contaminant migration to this area. The fact that they are found in a highly transmissive fracture at concentrations exceeding the Site cleanup levels (CLs) is indicative of a large mass of contamination that is contributing to that fracture, such that it is able to maintain these high concentrations.**

<u>*CLG Response*</u>

The Final Report has been updated to include a more detailed discussion of contaminant fate and transport mechanisms with the intent to more fully explain the concentrations present in MW-25 and nearby shallow bedrock well GZ-105. For example, the presence of contamination, though present in all three overburden units (outwash, marine deposits, and till), correlates to the lateral distribution of till overlying bedrock. Multiple lines of evidence are provided in the revised report that this migration pathway is in hydraulic communication with shallow bedrock fractures (i.e., sheeting fractures) and facilitates migration to deeper zones within bedrock. Groundwater flow pathways through the till allows for lateral migration of site contaminants while hydraulic head distributions in the overburden and bedrock aquifers allows for vertical migration within bedrock.

USEPA

14. **Paragraph 2.h. of the *Conceptual Site Model* section indicates that wells at the west and southwest toe of the landfill slope are influenced by stormwater contribution, but no evidence is presented to prove this conclusion. The correlation between the contaminant loading from stormwater runoff and contaminant level in groundwater should be developed and presented.**

<u>*CLG Response*</u>

The Final Report has been revised to reference PFAS concentrations at MW-9 and MW-10 (located west of the landfill) and the 2019 Stormwater Investigation Report. The Stormwater Investigation Report has also been included as Appendix B to the Final Report. Revised loading calculations will be completed in support of the June 25, 2020 Surface Water Evaluation Work Plan. This is addressed in Paragraph 2.i. of the Final Report.

USEPA

15. ***Recommendations*** **section concludes that there is little potential for groundwater to migrate beyond the Little River valley to receptors south of North Road. This conclusion needs to be supported with more detail and data. The bedrock trough pathway to the north and south is well established, and there is no data that would discount this as a significant pathway.**

CLG Response

This statement has been revised and a reference to the 2022 Bedrock Monitoring Well Installation Work Plan has been provided. The installation of a bedrock well in the southern extent of the survey area will serve to provide additional information on this flowpath, including extent to the south. The Draft Work Plan was submitted to the USEPA and NHDES on July 1, 2022 with comments received from the USEPA on July 11, 2022. A Revised Bedrock Well Installation Work Plan is under development at the time of this Report.

USEPA

16. **Recommendations section concludes that samples from private water supply wells located east of 339 BHR (golf course) and north of the landfill do not show Site COCs. This is not the case given that private wells on Stone Meadow Way, Berry Farm Lane, and now 399 BHR, east of 339 BHR and north of the landfill, consistently show detections of PFAS compounds**

CLG Response

This statement has been revised for clarity as the private water supply wells have reported some detections of PFAS below the NH AGQS.

USEPA

17. **Recommendations section indicates that the southern extent of contaminant migration from the landfill is in the vicinity of FPC-3A/B and FPC-4A/B. These wells are located along the eastern and western boundaries of the bedrock trough, which is the predominant groundwater flowpath to the north and south. GZ-105 and MW-25 are located near the center of the trough and have significantly higher contaminant concentrations. It is likely that the core of the plume is located near the centerline of the bedrock trough and that it extends some distance south of FPC-3A/B and FPC-4A/B. Again, no data currently exists that would discount this as a significant pathway for contaminated groundwater to impact receptors to the south. The northern extent of the plume extends beyond 339BHR which is located more than 3,200 feet north of the landfill. It has yet to be shown that the southern extent of the plume is not of a similar magnitude.**

CLG Response

This statement has been revised and a reference to the 2022 Deep Bedrock Monitoring Well Installation Work Plan included. The recommendations section has been updated to include the installation of a bedrock monitoring well to examine the southern flow pathway, at a location to be determined through a geophysical survey to complete evaluation of the potential southern flow pathway.

USEPA

18. **Recommendations section proposes to install a multilevel monitoring well in existing deep bedrock borehole MW-23 (Chinburg Well) that will serve as a long-term monitoring point for the northern extent of the plume. Results of the packer sampling and transducer monitoring programs for that well have shown that MW-23 is not connected to, or influenced by, the bedrock trough which is the primary pathway for contaminant migration to the north. Therefore, MW-23 is not located in a suitable spot to monitor contaminant migration to the north.**

CLG Response

The CLG recognizes the position of the USEPA on MW-23 and its disposition as a long-term monitoring location. The CLG is currently reevaluating this recommendation and the viability of this well as a long-term monitoring location.

<u>Section 1: Introduction</u>

USEPA

19. **To clarify, the remedial action objectives (RAOs) for OU2, as specified in the 1994 ROD, are to prevent ingestions of contaminated groundwater, to restore the aquifer to drinking water standards, and to facilitate wetland restoration.**

<u>CLG Response</u>

The stated objectives of the RAOs for OU-2 have been clarified to include those as listed in the 1994 ROD.

USEPA

20. **Section 1.1 states that the objective of the pumping test at MW-6 was to "…confirm that identified transmissive fractures in bedrock monitoring wells were not hydraulically connected to nearby private supply wells and did not provide potential pathways for off- site migration of Site contaminants to potential receptors." The objective of the pumping test is detailed in a previous comment. To reiterate, a single pumping test would not be able to meet the objective stated, and in any event, the detection of 1,4-dioxane and PFAS in off- site private supply wells R3, 178A, and 339BHR conclusively show that off-site migration of contaminants to potential receptors has occurred.**

<u>CLG Response</u>

The stated objectives of the pumping test at MW-6 have been revised to be consistent with those stated in the Pumping Test Work Plan. See also response to USEPA Comment No. 6.

USEPA

21. **Section 1.2, *Investigation* Approach, states that "Initial data collected from routine sampling of private water supply wells completed in deep bedrock indicate that little to no significant migration in the deep bedrock has occurred." This statement is incorrect. The original RI and follow up investigations and monitoring conducted in the 1980s and 1990s identified Site contaminants in residential wells along Lafayette Road and North Road, requiring the installation of a municipal water line to those areas to provide alternative drinking water. Section 1.2 also does not account for the impacts at the Site from 1,4-dioxane which has prompted the further assessment of groundwater quality in deep bedrock.**

<u>CLG Response</u>

The Final Report text has been revised to correct inaccuracies outlined by the USEPA above with references provided for the Fourth Five Year Review and August 4, 2015 ESD.

USEPA

22. **Section 1.2, *Investigation* Approach, mistakenly identifies Direct Push Technology (DPT) as "Deep Push Technology".**

<u>CLG Response</u>

The Final Report text has been revised to correct the definition of DPT to Direct Push Technology.

Section 2: Site History

USEPA

23. **Section 2 should discuss the water line extensions performed in the area around the Site between 1982-1986, including on Lafayette Road and the eastern end of North Road, and that the water lines were extended due to impacts from the Site. The development of the Seavey Way 10-lot subdivision and the associated water line extension should also be described.**

CLG Response

Section 2.2 of the Final Report includes references to water line installation activities completed from 1982 to 1986 with additional detail provided on the installation of water services to the Sewall Meadow subdivision on Breakfast Hill Road.

USEPA

24. **Section 2.1, *Site Mining and Landfill* Operations, indicates that sand and gravel operations were conducted between 1965 and 1972, but no mention is made of bedrock mining or blasting that is known to have occurred. Additional detail on the sand and gravel mining should be included, such as the depth to which the mining occurred and whether bedrock or groundwater were encountered (refer to Section 1.2.2 of the 1988 Remedial Investigation), and the bedrock mining and blasting operations should be summarized here. Bedrock mining plays an important role in the site history because blasting would have exacerbated shallow fractures in the rock what would act as contaminant transport mechanisms once the pit began accepting wastes in 1972. Maps and historical aerial photographs should be included to document the location and types of mining and landfilling activities as well as the timeframes.**

CLG Response

Section 2.1 has been expanded to include a more detailed discussion of historic mining, quarrying, and landfilling operations at the site. Due to time constraints associated with the completion of the revised Final Report, historic aerial photo imagery used by the USEPA could not be obtained to provide an independent analysis of results summarized in the RI (Weston, 1988).

USEPA

25. **Section 2.5, *Institutional Controls,* indicates that the Groundwater Management Zone (GMZ) restricts property owners from extracting groundwater for potable use. The GMZ, as established by the Groundwater Management Permit (GMP), has no inherent restrictive element. However, the GMP does have provisions for implementing institutional controls (ICs) above and beyond the recording of deed notices on properties within the GMZ. The CLG currently only records deed notices on properties within the GMZ and thus far has not established any further ICs.**

CLG Response

The Final Report has been updated to include clarifications regarding the GMZ, with specific reference to New Hampshire Code of Administrative Rules (CAR) Env-Or 608. This CAR outlines the provisions for implementation of institutional controls above and beyond those currently employed.

USEPA

26. **Section 2.5, *Institutional Controls*, should describe all supply wells that are within the GMZ, including the private well at 65 North Road. Permission to sample this well has not been granted by the property owner, therefore, the water quality of this well is unknown. At the least, a summary of the history of this well and attempts to access the well or apply institutional controls should be provided.**

CLG Response

Section 2.5 has been updated to include a discussion of the well at 65 North Road and the well at 67 North Road. The well at 67 North Road is currently sampled as part of the biannual sampling events. No institutional controls have been implemented at 65 North Road because permission to sample this well have been denied by the property owner. It is the CLG's understanding, based on anecdotal information provided by the USEPA, that the well at 65 North Road has treatment installed by the property owner and is sampled by the property owner. No confirmation of this was provided by the owner.

<u>Section 3: Completed Investigation Activities</u>

USEPA

27. **Section 3 should discuss the extensive surface geophysics that have been performed at the Site, including those that were conducted for locating monitoring wells MW-20, MW- 21, MW-22, and MW-25. These geophysics investigations were conducted to identify potential bedrock pathways west and north of the landfill and generated critical data that should be used to inform interpretations of bedrock topography and potential pathways<u>. The surface geophysics reports should be appended to the final report.</u>**

<u>CLG Response</u>

Sections 3.1.2 and 3.1.6 of the Final Report have been expanded to include a more detailed discussion of the borehole and surface geophysics completed in support of the deep bedrock investigation. See also response to Comment No. 30. The 2018 and 2020 surface geophysical results have been included as Appendix D of the Final Report.

USEPA

28. **Section 3.1.1, *Chinburg Well/MW-23 Investigation,* indicates that the conclusions presented are based on packer interval sampling results from MW-23, however interpretations of the migration pathway to receptors north of MW-23 and the bounding of the GMZ are interpreted, seemingly based only on this data. These interpretations are premature here and are not supported by this single line of evidence. This subsection should focus only on the work conducted at MW-23 and conclusions specific to that investigation, including geologic characteristics, fracture patterns and water quality.**

<u>CLG Response</u>

Section 3.1.1 has been updated to include the comprehensive discussion of the work completed in MW-23 as provided in the November 25, 2019 Deep Bedrock Investigation Interim Report. The well construction log and borehole geophysics have been included with the Final Report. The presentation of additional lines of evidence in support of the CSM throughout the revised report are designed to address the conclusions made on packer sampling results in MW-23 and in other wells investigated during the deep bedrock investigation (i.e., reconnaissance wells).

USEPA

29. **Section 3.1.2, *MW-20/MW-21/MW-22 Series Wells*, states that the location of MW-21 "…was selected to provide a sentinel monitoring location near the northern boundary of the GMZ and in the interpreted downgradient groundwater flow direction from the Site." This implies that there is only one downgradient flow direction. The groundwater/surface water divide west of the Site bifurcates the plume to the north and to the south, which should be considered here.**

<u>CLG Response</u>

Based on the text of the Draft Report, the CLG assumes that reference to MW-20 was intended rather than MW-21 as indicated by the USEPA. Section 3.1.2 of the Final Report has been updated to include specifics on the northern "downgradient" flow direction observed and mapped within overburden, shallow, and deep bedrock at MW-20. New groundwater potentiometric surface maps have been generated and are discussed in greater detail within individual groundwater flow sections of the Final Report.

USEPA

30. **Section 3.1.2, *MW-20/MW-21/MW-22 Series Wells,* should describe the data and criteria used for selecting the packer sampling intervals for MW-20, MW-21, and MW-22, as well as the intervals screened for completion.**

CLG Response

The data and criteria used for selecting the packer sampling intervals for MW-20, MW-21, and MW-22 have been included as well as the intervals screened for completion. Results of interval packer sampling for these wells have been included in Appendix C of the Final Report.

USEPA

31. **Historic wells that were discovered or suspected to be destroyed (GZ-127, GZ-128), as described in Section 3.1.3, *Reconnaissance Bedrock Wells*, should be represented on figures.**

CLG Response

Reconnaissance wells GZ-127 (overburden) and GZ-128 (bedrock) are suspected to have been destroyed. The owner has denied access to confirm and these wells have been included on Site figures with symbology denoting their status.

USEPA

32. **Section 3.1.5, *BP-4*, states that "…the lithologic contact at 50 feet is dipping at a shallow angle to the east." It should also be noted here, and cited in the CSM, that this contact is located within one of two transmissive zones within BP-4 and is an important line of evidence supporting a component of eastern groundwater flow in bedrock.**

CLG Response

Further evaluation of the geophysical log indicates that the change in rock type reflects an approximately five-foot thick pegmatitic unit rather than the significant lithologic contact. Additional context has also been added to describe the nature of the lithologic contact identified at BP-4. A discussion of the eastern groundwater flowpath is provided in Section 4.3.2.

USEPA

33. **Section 3.1.6, *New Well Installation: MW-25*, cites the NH AGQS for arsenic as 10 µg/L. References to the NH AGQS for arsenic should be changed to 5 µg/L, which is the new standard adopted on July 1, 2021.**

CLG Response

The AGQS for arsenic has been corrected to reflect the July 1, 2021 change in standard.

USEPA

34. **Section 3.1.7.1, *Initial Installation Summary*, indicates that the recorded water level fluctuations were less than 0.25 feet and "reflect residual barometric influences (i.e., tidal) in the data". Note that tidal (or associated earth tides) are not a barometric phenomenon but are cyclical and are caused by the gravitational influence of the moon and to a lesser extent the sun. Barometric responses are related to changes in atmospheric pressure associated with weather patterns.**

CLG Response

Clarification of the influences observed in the transducer hydrographs and the corrections made to correct for these effects have been included.

USEPA

35. **Section 3.1.7.3, *Vertical Hydraulic Gradient Assessment*, discusses the Spring 2020 data set, but vertical gradients from other monitoring events are listed in Table 3.2. A value of 0.1 feet in vertical gradient is used in the assessment to determine whether flow was vertical or neutral, but no explanation or reference for this particular value was provided. When evaluating gradients, the ratio of the vertical gradient to the local horizontal gradient should be considered, not just the magnitude of the vertical gradient. This assessment is often done using a gradient of hundredths of a foot, not 0.1 feet. Groundwater flow is a vector quantity and to properly evaluate the direction of groundwater movement in 3 dimensions, the magnitude of the vertical gradient in comparison to the horizontal gradient should beconsidered. The local horizontal groundwater gradient in the vicinity of each of the wells listed in Table 3.2 should be provided to facilitate this comparison.**

CLG Response

Text from Section 3.1.7.3 was moved to Section 4.3.2 where bedrock groundwater flow is discussed since most well couplets are in bedrock. The categorization of vertical gradients was changed based upon whether the gradient was positive or negative, with a gradient between 0.001 and -0.001 considered neutral. The local horizontal gradient has been included with the vertical gradient table.

USEPA

36. **Section 3.1.7.3, *Vertical Hydraulic Gradient Assessment,* discusses results from the spring 2021 round and notes changes from previous rounds, but it is not clear whether the comparison is with the spring 2020 or fall 2020 data set, or some other data set. Further evaluation is postponed until the 2021 Annual Groundwater Quality Report. <u>The variation of vertical gradients noted on the eastern side of the Site (GZ-109/117 and FPC9A/B) should be evaluated against precipitation records and measured groundwater elevation.</u> Vertical gradients can be sensitive to longer-term climatic variations such as droughts or unusually wet periods. The conclusion that vertical gradients in the wetland complex west of the landfill do not appear to have a discernible pattern does not support the CSM that groundwater from the landfill discharges to surface water in this area. Lastly, while it is true that the small magnitude of vertical gradients between bedrock and overburden may suggest good hydraulic communication, it could also simply mean that flow in both units is near-horizontal, as would be expected in bedrock where the flow is along strike and the predominant fractures are moderate to steeply dipping.**

<u>*CLG Response*</u>

Evaluation of the vertical gradients with respect to seasonality did not show any variation in trends. The predominant gradient identified (upward or downward) was found to be generally consistent across seasons and reversals of vertical gradients were not common. As stated elsewhere, vertical gradients are common across the Site and are generally of higher magnitude than the corresponding horizontal gradient. For 11 of 16 well clusters with identified horizontal and vertical gradients, the average vertical gradient was greater than the horizontal gradient, often by orders of magnitude. The direct influence of the shallow and deep bedrock aquifers to precipitation was observed during background monitoring during the pumping test, detailed in Figure F1 included in Appendix F.

With regards to the measurement and evaluation of surface water and shallow groundwater trends, a recommendation has been added in the Final Report, to supplement the measurement of water levels in overburden and bedrock wells with continuous measurements using pressure transducers since reliance on monthly measurements can result in conclusions based on incomplete data. Response of shallow groundwater levels (monitored by piezometers) to precipitation events is likely short in duration and not captured by singular monthly measurements.

USEPA

37. **Section 3.2, *Bedrock Outcrop Mapping*, should also mention the outcrops located around the Bethany Church parking lot as an area of interest. This section lists the three major types of fractures but should be corrected to include "primary foliation parallel (FPF), cross set, and sheeting fractures. 'Primary' is listed twice, and clarification should be added that the primary fracture set are parallel to regional foliation of the rock. In discussing the results of the outcrop mapping, only the orientation of the primary FPF fractures is mentioned. No discussion is provided about the frequency of the other fractures encountered (cross sets and sheeting fractures), nor is there any discussion about other key aspects of the outcrops such as rock type, fracture length, spacing, appearance (open, closed, staining, etc.). These observations are also not shown in Table 3.3 where the outcrop data are summarized. Along with the primary fracture data collected, other key information obtained from outcrop mapping is the frequency and relationship of the cross-set and sheeting fractures, along with the rock type.**

<u>*CLG Response*</u>

The Final Report has been updated to clarify the three types of fractures. Section 3.2 now references all locations where bedrock outcrop measurements were collected. All four fracture populations identified on the Site (primary, two foliation perpendicular, and sheeting) are discussed with respect to the field measurements. Data collected in the field were fracture and foliation measurements with some information on bedrock Formation (i.e., Rye) and rock type/lithology.

USEPA

38. **Section 3.3.1.1, *Well Redevelopment and Borehole Geophysics*, concludes that "the hydraulic influence in MW-5S/-5D (and minor influence in MW-2) observed during the redevelopment of MW-6 indicates these wells are located along the primary north-south preferential bedrock structure identified in the CSM" and appears to be based on this single line of evidence and is premature to state here without providing further evidence.**

<u>*CLG Response*</u>

The text has been updated to reflect that this single line of evidence does not definitively prove the preferential bedrock structure and defers interpretation to the constant rate pumping test analysis. There are now multiple lines of evidence to support the north to south trending primary bedrock fracture network, including borehole geophysics, outcrop mapping, and the lineament analysis completed for the original RI, that MW-5S and MW-5D lie to the north of MW-6 parallel to that trend, and there was a hydraulic response observed in MW-5S and MW-5D from the redevelopment of MW-6.

USEPA

39. **Section 3.3.1.1, *Well Redevelopment and Borehole Geophysics*, summarizes the analytical testing of redevelopment water but does not provide the actual analytical results. The results should be specified or provided in a table.**

<u>*CLG Response*</u>

The text has been updated to include a discussion of the analytical results from water containerized during redevelopment of MW-6.

USEPA

40. **The interval packer sampling results for MW-6 should be provided in Section 3.3.1.2, Interval Packer Sampling, or provided in a table.**

<u>*CLG Response*</u>

The text has been updated to include a discussion of the intervals selected for sampling within MW-6 with the MW-6 Interval Packer Sampling Results and Pumping Test Viability memorandum included as Appendix F of the Final Report. Attachment 2 of the Viability Memo have been included in Appendix C of the Final Report to reduce redundancy in supporting information.

USEPA

41. **Section 3.3.2.3, *Results,* states that "…the pumping rate to be used for the constant rate test was determined to be approximately 12.7 gpm. This rate was determined in order to stress the aquifer more than actual residential pumping influences." The pumping rate of 12.7 gpm was selected because it was the estimated yield of MW-6 based on the variable rate test.**

<u>*CLG Response*</u>

The text has been corrected to state that the pumping rate of 12.7, as determined during the variable rate pumping test, was the estimated yield of MW-6.

USEPA

42. **More explanation for the table and figure inserted in section 3.3.2.3, *Results,* should be provided.**

CLG Response

The table has been updated to reflect the achieved pumping rate and associated stabilized drawdown for each pumping rate with the included plot replaced with a discharge drawdown plot illustrating the logarithmic increase in drawdown with increased pumping rate. The text was updated to provide the methods used to determine the desired drawdown that would reflect the estimated yield and the plots were updated to illustrate how the maximum yield was met during the variable rate test.

USEPA

43. **Section 3.3.3.3, *Results*, should include a figure that shows the locations of the wells monitored during the pumping test, with the observed drawdown plotted and contoured to show the extent and shape of the cone of depression. The map should be used to estimate the anisotropy to see if it is consistent with the Mack (2012) estimate of 5:1.**

CLG Response

A figure has been generated to illustrate the wells monitored during the pumping test with the resultant contoured cone of depression consistent with the anisotropy estimated by Mack (5:1). This cone of depression is elongated in the north south direction and parallel to the primary foliation parallel fracture set observed at the site. The wells included in the pumping test monitoring network that was provided and approved in the October 21, 2020 Deep Bedrock Pumping Test Work Plan, is included in Appendix F.

USEPA

44. **Section 3.3.3.3, *Results,* indicates that the hydraulic influence observed in wells FPC-2B, MW- 2, MW-5S/5D and MW-11 during the constant rate pumping test agrees with the observations made during the redevelopment of MW-6 and the variable rate test. The discussion of the hydraulic influence observed during redevelopment of MW-6 indicates that only MW-5S/-5D and MW-2 showed an influence, and that no drawdown was observed in FPC-2A/-2B or MW-11. Similarly, the discussion of the variable rate test indicates that a drawdown was observed in MW-5S/5D only. The representation that the drawdowns from the constant rate test "agree" with the results from the redevelopment of MW-6 and the variable rate test needs clarification.**

CLG Response

The analysis of the pumping test data has been reexamined and updated results are included in the pumping test results and analysis appendix (Appendix F). The text of the report has been updated to reflect these results and further explanation of the observations of the redevelopment, variable rate test, and constant rate pumping test are included in the results and discussion sections regarding the pumping test. It is noted that during the constant rate test, the observed drawdown in FPC-2B and MW-11 was smaller in magnitude than what was observed at MW-5S/5D and MW-2 and was not immediately apparent from the start of the constant rate test. The lack of observed drawdown from the redevelopment and variable rate test, both of which involved pumping at lower rates for shorter periods of time, is consistent with the constant rate test. These observations also support that the constant rate test was effective at defining the extent of the interconnected fractures connected to the deep bedrock at MW-6, which was not readily apparent with a shorter period of pumping, at a lower rate.

USEPA

45. **The conclusions provided in the last two paragraphs of Section 3.3.3.3, *Results,* are not correct. Several statements mention the high or low bias of the results based on whether the wells were located north-south or east-west of the pumping well. These variations represent the anisotropy of the bedrock and the difference between Kx and Ky. Hydraulic conductivity parallel to the predominant fracture set (Kx) will be 5 to 10 times higher than the hydraulic conductivity in the transverse direction (Ky). The discussion should be revised to remove reference to data 'bias' and add a discussion of anisotropy and the variation of Kx and Ky.**

CLG Response

The analysis of the pumping test data has been reexamined and updated results are included in the pumping test results and analysis appendix (Appendix F). ***Section 3.3.3.3*** *of the Final Report have been updated to reflect the conclusions that can be made from the pumping test, including confirmation of the aquifer properties in the deep bedrock (transmissivity, storativity, and anisotropy) of the Central Silicic Complex. References to bias in the data have been removed and replaced with a more complete interpretation of the data, supported by analytical and graphical representations of the results.*

USEPA

46. **Section 3.3.3.3, *Results,* concludes that "the pumping test has confirmed that identified transmissive fractures in bedrock monitoring wells are not hydraulically connected to nearby private supply wells and do not provide potential pathways for off-site migration of Site contaminants to potential receptors." As mentioned in the comments for the Executive Summary, a single pumping test cannot 'confirm' this condition, especially at a site this large. Also, the detection of 1,4-dioxane at concentrations exceeding the AGQS at R3 and 339BHR confirms that transmissive fractures in bedrock are a pathway for contaminant migration.**

CLG Response

The analysis of the pumping test data has been reexamined and updated results are included in the pumping test results and analysis appendix (Appendix F). The conclusions in the report have been updated to reflect the conclusions that can be definitively made from the pumping test, including confirmation of the aquifer properties in the deep bedrock (transmissivity, storativity, and anisotropy) of the Central Silicic Complex. These results have been incorporated into the conceptual site model which incorporates multiple lines of evidence to determine potential implications for off-site receptors and transport pathways that may explain the detections in private wells.

USEPA

47. **Section 3.3.4, *Groundwater Sampling,* presents the results of groundwater sampling collected during the pumping test and indicates that concentrations of 1,4-dioxane and PFAS in the pumped groundwater steadily increased as pumping progressed, and that this may "suggest an eventual contribution of shallow fracture groundwater with higher concentrations…". Given the maximum observed drawdown in MW-5D, which has much higher PFAS and 1,4-dioxane concentrations than MW-6, it is more reasonable to conclude that pumping at MW-6 drew in groundwater from the vicinity of MW-5D via the deep bedrock fractures. As noted in the Report, the shallow fractures in MW-6 were sealed off with a Jaswell insert to target flow in the deeper fractures.**

<u>*CLG Response*</u>

The text of Section 3.3.4 has been revised to more accurately reflect the likely contributions of PFAS and 1,4-dioxane from the area near MW-5S/5D. Measured drawdown during the pumping test confirms the elongated anisotropic cone of depression in deep bedrock along the predominant north-south trending fracture set aligned between MW-6 and the MW-5S/5D wells. Additional analysis has been completed regarding the details of the timing of drawdown in MW-5S/5D and the timing of the dewatering of a large fracture in MW-6 around 75-76 feet AMSL. It is likely that a fracture identified through the geophysics provides a direct hydraulic connection between these wells. The gradual increase in concentrations observed in MW-6 during the constant rate test is likely due to the averaging of contributions from this fracture, which likely extends horizontally to higher concentration impacts in groundwater towards the landfill, with groundwater from other fractures which exhibits lower concentrations of site contaminants.

USEPA

48. **Section 3.4.2, *2021 Surface Water Elevations*, fails to provide the length of the screens used for the drive point piezometers. Both sections 3.4.1 and 3.4.2 conclude that "surface water and shallow groundwater elevations are similar in some areas" but no examples or comparisons are provided. Specific surface water gauging points and comparable monitoring wells should be cited as examples, along with a table showing the comparison.**

<u>*CLG Response*</u>

The Final Report has been updated with details on piezometer construction and examples on relationships between surface water and groundwater elevations (see also Section 4.4.3). In addition, reference to piezometer construction diagrams has been included to supplement discussion.

USEPA

49. **Section 3.5, *Investigation and Impacts West of MW-21S*, references surface geophysics that was conducted to inform the placement of MW-21, and specifically to a shallow zone of low resistivity, but the results are not provided. As mentioned previously, the surface geophysics reports should be appended to the final report.**

<u>*CLG Response*</u>

The 2018 and 2020 geophysical results have been included as Appendix D to the Final Report. The 2018 surface geophysical results were provided via email correspondence on June 25, 2018 with results from 2020 included in the Surface Geophysical Results and MW-25 Well Locating Memorandum dated October 7, 2020.

USEPA

50. **Section 3.5.1, *DPT Investigation and Temporary Well Installation*, indicates that the sediments in the area of the DPT investigation and MW-21S thinned to the west. However, overburden thickness along the northern DPT transect (DPT-1 thru DPT-5) increased to the west, going from a low of 4.5 feet at DPT-2 to 22.5 feet at DPT-5. This section also indicates that DPT-1 had the thinnest overburden at 4.5 feet, but the boring logs in Appendix A indicate refusal at 8.5 feet in DPT-1 and 4.5 feet in DPT-2. The boring logs indicate that the overburden only thins to the west along the southern DPT transect. <u>A table should be added that summarizes and interprets the lithology and depth to refusal for all the DPT points, along with a site-specific cross-section presenting the interpretation of the lithology.</u> And, based on the findings of the DPT investigation, the CLG had recommended the installation of a permanent well in the vicinity of DPT-11 to bound the GMZ, but this recommendation is not included in the Report.**

<u>CLG Response</u>

An interpretation of the lithology for existing wells and DPT locations is included with the report and the results have also been incorporated into the figures illustrating surficial material thicknesses, top of rock contours, and overburden groundwater flow pathways. Additionally, a cross section has been created which illustrates the interpreted lithology for the area under investigation during the DPT study. The recommendation to install a permanent overburden monitoring well in the vicinity of DPT-11 has been included in the report based on analytical collected in 2021 and preliminary/unvalidated data for TMW-11S/11D collected during Spring 2022.

USEPA

51. **Section 3.5.2.1, *Water Levels and Flow Directions*, presents the water elevation data from the DPT well points and discusses groundwater flow patterns. The text states that groundwater flow is "consistent with Site topography, LiDAR data, and monitoring data" and "generally mimic topography and support the flow and subsequent discharge of groundwater to the wetland complex". However, groundwater elevation data plotted on Figure 3.5 suggest that a westward component of groundwater flow is present along a portion of the northern DPT transect, suggesting that shallow groundwater flow patterns in this area are complex. The groundwater data should be contoured to illustrate groundwater flow patterns in this important area of the Site.**

<u>CLG Response</u>

The reported groundwater elevations for the DPT wells have been incorporated into the Spring 2021 overburden groundwater contour map. The figure illustrates flow towards the wetland complex to the east. The updated recommendations to include the installation of a permanent overburden monitoring well in this vicinity will allow for long-term monitoring of overburden groundwater quality in this area with the long-term retention of temporary monitoring wells installed during the DPT investigation being considered by the CLG to monitor water levels.

USEPA

52. **Section 3.5.2.2, *Temporary Monitoring Well Sampling*, should include an explanation for which temporary wells were selected for sampling. Most notably, TMW-11S and -11D were not sampled even though this location is most proximate to the GMZ boundary and would represent groundwater quality near the edge of the GMZ. The CLG shall sample TMW-11S and -11D as soon as possible. The CLG shall also establish one or more permanent monitoring well(s) for monitoring the GMZ boundary in this area. The statement that the "existing westward delineation of the GMZ is appropriate" based on the DPT analytical results is premature, pending results from the sampling of TMW-11S and -11D and establishment and sampling of a permanent monitoring well(s).**

CLG Response

TMW-11S and TMW-11D were sampled in Spring 2022 and results are included in the current version of the Deep Bedrock Investigation Report. The recommendations have been updated to include installation of a permanent overburden monitoring well to provide additional delineation of the westward extent of the GMZ boundary and to incorporate into the current monitoring program.

USEPA

53. **One of the intended outcomes of the investigation of water supply well records (Section 3.6) was to provide as much private well information as possible, including construction information, well type, well depth, well yield, and any other information that would be available. This section indicates that some well records exist, but no summary is provided, and the well logs that do exist are not appended to the report. Table 3.1 and 3.6 comments are provided separately.**

CLG Response

The well records table has been updated and additional residential well records have been identified, which have been included in Appendix A of the report. These well records vary in level of details included, but those records available through NHDES OneStop have been provided

Section 4: Geology and Hydrology

USEPA

54. **Section 4.1.1, *Description and Extent of Units,* references Figure 4.1 which shows the extent of the till unit at the Site. Review of Figure 4.1 suggests that it is based largely on data from the original RI and does not include till observations from the recent work including the DPT investigation along the western boundary of the GMZ or from monitoring wells at MW- 20, MW-21, MW-22, and MW-25. The interpreted extent of the till in Figure 4.1 does not align with the bedrock surface map presented in Figure 3.4, and the table in the figure indicates depth to till while the legend defines the contours as till thickness. The text states that the till follows the bedrock surface, but this is not evident based on a comparison of Figures 3.4 and 4.1. The large trough in the bedrock located north of the landfill (between the landfill and the Bethany Church) is not reflected on the till map.**

CLG Response

All figures detailing surficial material thickness and extent have been regenerated. These maps incorporate the boring logs, outcrop locations, DPT wells, geophysics, and LiDAR data to confirm or interpret surficial material thickness across the site. The thickness and extent of these units is detailed in a table that describes the extent of lithologies present in overburden and bedrock.

USEPA

55. **Section 4.1.1, *Description and Extent of Units,* Similar to the interpretation of glacial till deposits in this section, the map for the marine deposits (Figure 4.2) does not appear to include data from the DPT borings and does not appear to align with the bedrock surface map (Figure 3.4). The table in Figure 4.2 also indicates depth to marine deposit while the legend defines the contours as marine deposit thickness and shows the marine deposits extending beneath the landfill. Examination of the cross-sections in Figures 4.4 and 4.5 does not show marine deposits present in that area. Figures 4.1 and 4.2 should be redrawn to provide accurate interpretations and to be consistent with the other interpretations and figures.**

CLG Response

All figures detailing surficial material thickness and extent have been regenerated. These maps incorporate the boring logs, outcrop locations, DPT wells, geophysics, and LiDAR data to confirm or interpret surficial material thickness across the site. The thickness and extent of these units is detailed in a table that describes the extent of lithologies present in overburden and bedrock.

USEPA

56. **Section 4.1.1, *Description and Extent of Units*, references Figure 4.3 as an interpretation of the extent of the glacial outwash deposits. Again, the figure appears to be based largely on the original RI and does not incorporate the DPT borings or new wells. The text states that glacial outwash was encountered in all 70 borings at the site, so a map outlining the study area is not needed. A more useful figure would be one showing the mapped thickness of the outwash. As drawn, Figure 4.3 suggests that the outwash deposits do not extend beyond the study area and shows the outwash deposits being exposed at the surface within the landfill footprint, which is inaccurate.**

<u>CLG Response</u>

All figures detailing surficial material thickness and extent have been regenerated. These maps incorporate the boring logs, outcrop locations, DPT wells, geophysics, and LiDAR data to confirm or interpret surficial material thickness across the site. The thickness and extent of these units is detailed in a table describing the extent of lithologies present in overburden and bedrock.

USEPA

57. **The cross-sections (Figures 4.4 through 4.6) presented in support of Section 4.1, *Surficial Geology,* appear to be the same as provided in the Interim Bedrock Investigation Report, except that MW-25 was added to B-B'. The Agencies provided comments on the cross-sections presented in the Interim Report (see EPA letter to Peter Britz dated February 6, 2020) which do not appear to have been addressed here. Specifically, bedrock elevations presented on Figure 3.4 (bedrock surface contour map) do not match up with elevations on the cross-sections. Also, Figure 4.4 shows MW-5S/D screened in the Rye Formation, but Figure 4.5 shows them both screened in the Breakfast Hill Granite (BHG). Well BP-4 is similarly shown as screened in different geologic units on different cross-sections. Groundwater elevations should be plotted on the cross-sections and contours and flow arrows added to illustrate the vertical flow patterns.**

<u>CLG Response</u>

All cross sections have been regenerated based on the updated lithological interpretations made for the current version of the Deep Bedrock Investigation Report. Inconsistencies between cross sections and surficial material maps identified by USEPA and the current group working on the report have been addressed. Additionally, flow lines have been added in the cross section to illustrate vertical flow patterns.

USEPA

58. **Section 4.2, *Bedrock Geology*, references mapping performed by Mack, Lyons, and Escamilla-Casas. Copies of these geologic maps should be included to allow for direct comparison of geologic interpretations. The interpreted extent of the BHG as shown on Figure 3.4 appears much more limited than previous studies and does not seem to consider LiDAR imagery and topographic relief, which are often indicative of variations in bedrock composition resulting from differential weathering.**

<u>CLG Response</u>

The referenced maps have been included with the report including a newly referenced map (Hussey et al, 2008). Based on these maps, reexamination of boring logs, and comparisons with LiDAR, the extent of the Breakfast Hill Granite, also referred to as the Central Silicic Complex, has been revised.

USEPA

59. **Section 4.2.1.2, *Local, Breakfast Hill Granite*, provides a list of 1988 RI test borings where the BHG was confirmed, but these locations are not identified on Figure 3.4. The current understanding of the bedrock geology in the area should combine historic data with more recent data, detailing where data from this investigation has confirmed or contradicted the historic interpretations for the existence and extent of the BHG.**

<u>*CLG Response*</u>

The confirmed and inferred extent of the Breakfast Hill Granite has been reexamined based on a review of boring logs, downhole geophysical logging, and outcrop mapping and is updated on an updated Figure 3.4 as well as within the cross sections. There are several historical wells which have been abandoned or destroyed where the location is not known. A review of the original RI documents was completed, and the location of wells referenced in Section 4.2.1.2 (GZ-101A, GZ-106, GZ-107A, GZ-112, and GZ-113) have been approximated based on site features and scaled distances from common fixed points of reference.

USEPA

60. **Section 4.2.3.1, *Regional Structures*, describes two major faults that are mapped in the vicinity of the Site. These faults should be shown on a map and added to existing Figure 3.4.**

<u>*CLG Response*</u>

*The Portsmouth Fault and the Great Common fault, as mapped by Novotney, 1969 and later by Hussey 2008, are included in the report as inset maps to the text. The faults were not added to existing **Figure 3.4** due to the lack of evidence that either of these fault zones lie within the investigation area.*

USEPA

61. **Section 4.2.3.2, *Local Structures*, indicates that there is saddle in the bedrock valley (trough) west of the landfill in the vicinity of GZ-105, and references multiple interpretations from the RI, RI/FS, GMZ Report and this investigation. Because the bedrock valley and saddle are identified by multiple data points and represented in multiple cross-sections, other wells that are within the vicinity of the trough should be identified (GZ-105, FPC-5B, etc.).**

<u>*CLG Response*</u>

The discussion of local structures in this section has been updated, corresponding to the new bedrock contour map that was generated. The text describes the shape and extent of the saddle in the bedrock trough to the west of the landfill and includes all the wells in the vicinity of the trough utilized to justify the interpreted geometry of this structure.

USEPA

62. **Section 4.2.3.2, *Local Structures*, mentions the photo-lineament and fracture trace analysis data from the RI, but the presentation is confusing. For example, reference is made to east-west trending photolinears that may reflect a fracture system coincident with the bedrock valley (trough) which trends north-south. Clarification and discussion of other sets of photo-lineaments (north of Breakfast Hill Road, south of the landfill) should be provided.**

CLG Response

Three lineament trends, including the trends north of Breakfast Hill Road and south of the landfill are identified and discussed in the revised text.

USEPA

63. **Section 4.2.3.2, *Local Structures*, states that "a discussion of lithologies and fracture patterns interpreted from borehole geophysical data collected from the nine bedrock reconnaissance wells is included in Section 3.1.4." Section 3.1.4 discusses the evaluation of MW-6 for use in the pump test. Section 3.1.3 provides a summary list of the reconnaissance bedrock wells and their individual status and access but does not discuss lithology and fracture patterns interpreted from borehole geophysical data.**

CLG Response

Section 4.2.3.2 has been rewritten following the evaluation of surficial and bedrock lithologies present at the site. The lithology and fracture trends from the borehole geophysical data are discussed and illustrated in Section 4.2.4.3.

USEPA

64. **Section 4.2.4, *Statistical Analysis of Fracture Data,* indicates that outcrop data were excluded from the DAISY analysis of fracture groups by bedrock type. The rationale for why this large dataset was excluded from that evaluation should be provided. The description of the DAISY analysis does not explain the difference between the two Gaussian evaluations presented for each well in Appendix D. A more detailed explanation of the process used is needed.**

CLG Response

Outcrop data was excluded from the DAISY analysis due to a lack of detail provided with the outcrop data. No aperture was measured in the outcrop data and limited lithologic interpretation was provided by Haley Ward, so comparisons between the two datasets proved difficult and inconsistent with the accuracy of measurements obtained through the borehole geophysics. Additional data (i.e., fracture aperture from borehole geophysics) has been used to assist in determining the potential to transmit groundwater and a key component of interpreting the implications for the transport of groundwater through bedrock fractures. The two Gaussian evaluations were based on the two groups of data that includes fracture azimuth and fracture plunge/dip.

USEPA

65. **Section 4.2.4.2, *Fracture Families Identified by Individual Boreholes*, references Figure 4.7. Based on review of the downhole geophysics' logs and comparison of Figure 4.7 to the associated figures in the 2019 *Deep Bedrock Investigation Interim Report*, there are several errors in identification of the rock type in specific boreholes. The upper section of MW-20D is schist but is shown as basalt. The upper section of GZ-130 should be phyllite, not quartzite. The upper section of GZ-109 should be schist, not basalt. The upper section of GZ-110 should be phyllite, not quartzite. More explanation should be provided for how the difference between phyllite, schist, and gneiss was determined based on the optical televiewer (OTV) logs.**

<u>*CLG Response*</u>

Bedrock lithologies were defined based on a combination of boring logs and borehole geophysics completed at each location. A reevaluation of lithologies was performed by Wood by reviewing boring logs, an updated geologic map for the site, borehole geophysics (specifically optical and acoustic televiewers), and understanding of the local geologic structure based on these sources of data.

USEPA

66. **Section 4.2.4.3, *Fracture Families Identified by Rock Type*, presents the results of a statistical analysis of fractures by rock type for five different rock types: phyllite, schist, basalt, quartzite, and gneiss. However, the BHG represents a major bedrock formation at the Site and was observed in several monitoring wells (GZ-110, GZ-119, and GZ-125). The gneiss, schist, phyllite, and quartzite are all components of the Rye Formation and would therefore be expected to have the same fracture orientation since they were all exposed to the same regional forces and stresses during formation. The basalt and BHG are of different ages and may have different fracture patterns. The fracture analysis based on rock type should include the granite. Note that this same recommendation was included in EPA's February 6, 2020, comment letter on the Interim Bedrock Investigation Report.**

<u>*CLG Response*</u>

The description of the "Breakfast Hill Granite" has been updated to reflect the somewhat conflicting designations provided through historic geologic interpretations for the site and mapping of the unit. At this location, the Breakfast Hill Granite has been associated with a highly foliated, felsic gneiss when more detailed NQ coring techniques have been used and through downhole televiewer logging of bedrock wells. Meanwhile "Granite" is logged in boreholes advanced through air hammer drilling which does not provide the same detail. This is consistent with the designation of this unit during the original RI, which designated the unit as the "Central Silicic Complex" since Weston solutions properly identified that despite being a mapped, geologic unit the Breakfast Hill Granite did not match the descriptions of what was found through drilling. For the purpose of this analysis, the Breakfast Hill Granite is defined as a foliated and felsic gneiss associated with igneous intrusives such as pegmatites.

USEPA

67. **Section 4.2.4.6, *Lineament Identification and Fracture Correlation*, provides bulleted conclusions from the statistical analysis of the various fracture datasets.**
    - **As expected, the dominant fracture strike is NNE, parallel to the regional foliation. However, 2 to 3 other (less frequent) fracture families were also identified in 14 of 16 locations and also in the outcrop dataset. This confirms the presence of these other fracture families, whose importance should not be discounted because they can represent primary pathways for groundwater migration when the head distribution does not align with the primary fracture orientation.**

    - **The steep median dip angle strongly favors groundwater migration along strike, rather than down-dip.**

    - **orientation in the BHG. The large difference in fracture orientation noted in MW-24 relative to the other rock types evaluated may also hold true for the granite, which is of similar age/foliation as the basalt.**

    - **Numerous statistical evaluations have been conducted in an attempt to correlate well depth with yield in New England. No such correlation has been clearly identified. Hansen and Simcox (USGS WRI Report 93-4115) conclude that "The common assumptions that fractured crystalline rocks generally yield only small quantities of water to wells and that the fractures pinch out or are closed because of lithostatic pressure at depths greater than 300 to 400 feet may be in error."**

    - **Photo-lineaments are also shown on Figure 3.2. Examination of Figure 3.2 shows two clear groupings of lineaments: those parallel to the regional foliation (the majority) and a smaller number that are roughly perpendicular to the foliation. The distribution of the lineaments mirrors that of the fractures, as would be expected. <u>It is unclear why the statistical analysis did not identify the secondary set of cross- lineaments, as they are clearly visible on Figure 3.2.</u> The bedrock surface contours shown on Figure 4.8 are vastly different than those on Figure 3.4 and show the landfill on the west side of a bedrock high point. <u>References to the lineament figure in this section should be changed to Figure 3.2.</u>**

<u>*CLG Response*</u>

A discussion of photolineaments has been moved to the bedrock structure section 4.2.3.2, since they are a regional feature. Furthermore, because the identification of photolineaments is subjective, the discussion has been modified to be qualitative with respect to regional trends rather than statistical. This approach is supported by some lineaments appearing to reflect surficial deposits and several overlying Lafayette Road. The three trends do generally correlate with the Site fracture patterns. In addition, the analysis of Site fracture populations has been expanded to address all Site populations and their role in groundwater flow and clarifies that the "gneiss" measurements are actually the Breakfast Hill Granite (now labeled the Breakfast Hill Granite/Central Silicic Complex to more accurately describe its lithology).

USEPA

68. **Section 4.3, *Groundwater*, concludes that groundwater from the landfill discharges into a wetland on the west side, consistent with the overall principals outlined in the USGS paper (Mack, 2012). However, applying the principals of the USGS paper, the landfill is located at the top of a bedrock high point, so some groundwater is also expected to migrate to the east and discharge to the Bailey Brook and/or North Brook watersheds.**

<u>*CLG Response*</u>

Vertical flow nets have been added to the cross-section figures to detail groundwater flow on the east side of the landfill. The flow nets illustrate wells installed in bedrock and overburden east of the landfill have higher groundwater elevations than overburden and bedrock water levels adjacent to the landfill and to the west towards the wetland complex. Mack 2012 details that generally "ground water flows toward water bodies from topographic highs to lows" and that "ground water in the bedrock aquifer system may follow a short or long flow path because of factors such as position in the flow system and local stresses". This and other lines of evidence support that the wetland complex and associated streams provide a discharge source from groundwater, to locally affect groundwater flow.

In this case, it is plausible that there could be a groundwater divide that is not reflected on the cross sections or groundwater contour maps at some point east of bedrock well GZ-109 and its associated overburden well GZ-117. If so, there would be some aspect of eastern flow draining towards the North Brook or Baileys Brook watersheds. However, these wells, or upgradient wells closer to the landfill, consistently show no impacts from site COCs and significant eastward migration of site contaminants are not expected to be transported against the identified hydraulic gradient as shown in the flow nets and groundwater contour maps.

USEPA

69. **Section 4.3.1, *Occurrence and Flow in Overburden*, references the groundwater contour map in Figure 4.9. The groundwater flow patterns depicted on Figure 4.9 are inconsistent with the principals described in Mack 2012. Specifically, there is no eastward component of flow shown away from the topographic high point located along the eastern boundary of the landfill. This suggests that groundwater flow patterns in the vicinity of the Site are more complex than the simplistic, generalized description developed by Mack. There is no discussion of the screened interval or lithology screened by the various monitoring wells used to develop the groundwater contours on Figure 4.9. Lithology information for the overburden wells is not provided on Table 3.1. It is possible that many of the wells are screened in different lithologies and may not be representative of water table conditions. The last paragraph on Page 60 acknowledges that variations in overburden lithology are likely to have a significant effect on localized flow patterns, but no attempt is made to evaluate those affects, incorporate them into the interpretation of groundwater flow, or to elaborate on what they might be.**

CLG Response

*The screened interval and monitored stratum in overburden have been added to **Table 3.1**. Additionally, vertical flow pathways have been added to the cross sections to illustrate the complexity of groundwater flow at the site east of the landfill.*

Additional discussion has been included in the report which identifies the effects of overburden lithology on groundwater flow and transport pathways on the east side of the landfill. The USEPA is correct to identify that flow east of the landfill is complex and how lithology plays a role in these flow pathways. It is apparent from the well cluster at FPC-9A/B/C, the well screened across the till (FPC-9A), has the lowest hydraulic head, indicating a slight gradient thereby driving groundwater from the outwash and bedrock units into the till. As shown on the cross sections overburden lithology maps, unlike that shown in the wetland complex, the till unit east of the landfill is limited in extent and pinches out to the east away from the landfill. With this identified vertical gradient, water levels in FPC-9A are at a higher elevation than wells identified to the west, indicating there is still an overall gradient to the west even if local flow pathways may follow a circuitous route dictated by lithology.

USEPA

70. **Section 4.3.1, *Occurrence and Flow in Overburden*, concludes that groundwater elevation data at overburden well GZ-117 indicates a slight eastward flow component. However, the groundwater elevation at GZ-117 is 98.48, which represents one of the highest elevations in the study area and does not suggest eastward flow. The discussion neglects to mention the large head variation between MW-4 and the cluster of wells to the east and south, suggesting a much more robust component of groundwater flow to the east and south, which would be consistent with Mack 2012 as previously mentioned.**

CLG Response

The groundwater flow on the eastern side of the landfill has been reevaluated and does not show an eastward aspect of flow at GZ-117. Instead, the flow nets and lithology interpretation have been updated to show the complexities of flow, dictated by lithology in the area directly east of the landfill, between MW-4 and the well clusters to the southeast to northeast of MW-4 at FPC-11A/B/C and FPC-9A/B/C, elaborated within Section 4.3.1 and Section 4.3.2.

USEPA

71. **Section 4.3.1.1, *Overburden Groundwater Quality*, indicates that the discussion of overburden groundwater quality will be "focused on the presence and distribution of 1,4-dioxane and PFAS" and references figures showing the distribution of those compounds. However, a discussion of the distribution of arsenic and manganese, which are important contaminants in groundwater, is included later in this section. Figures should be added to illustrate the extent of arsenic and manganese in overburden groundwater, similar to 1,4-dioxane and PFAS.**

CLG Response

Figures to illustrate the extent of arsenic and manganese in overburden and groundwater have been generated and are included in the Final Report.

USEPA

72. **Section 4.3.1.1, *Overburden Groundwater Quality*, states that "…glacial till overlies bedrock in most locations and glacial outwash in all locations", which is inconsistent with the Surficial Geology Section where it is shown that, when present, glacial till directly overlies bedrock. Glacial till does not overly the outwash at any location.**

<u>*CLG Response*</u>

The Final Report has been revised to correct this inaccuracy. Additionally, new surficial material maps have been generated that illustrate the thickness and extent of overburden material including glacial till, marine deposits, and glacial outwash, with the elevations of the top and bottom of these units reported in Table 3.1.

USEPA

73. **Section 4.3.1.1, *Overburden Groundwater Quality*, states that "…overburden groundwater discharges to the wetland complex west of the landfill" and "…moves northward towards the headwaters of Berrys Brook where the marine deposit thins or becomes discontinuous allowing more direct discharge to Berrys Brook." The locations where marine deposits are thin or discontinuous allowing for the impacted groundwater to flow upward into Berrys Brook need to be identified, mapped, and targeted for long- term monitoring because they represent a critical point in the contaminant migration pathway.**

<u>*CLG Response*</u>

The Final Report has been updated to include a more complete figure illustrating the extent of marine deposits at the site. This isopach figure illustrates areas where the marine deposits thin along margins of the bedrock trough and along the eastern edge of the landfill. These areas contain multiple wells targeting both the till and outwash deposits, underlying and overlying the marine deposits, respectively. The locations where the marine deposits thin and could allow for a pathway for groundwater to discharge from the underlying till and shallow bedrock are discussed in the Final Report and will be incorporated into the Surface Water Evaluation currently in progress by the CLG.

USEPA

74. **Section 4.3.1.1, *Overburden Groundwater Quality*, presents the DPT water quality results. As commented previously, temporary wells TMW-11S and TMW-11D shall be sampled and CLG shall install a permanent well (or wells) to bound the GMZ in this area and to confirm that contaminant migration west of the landfill is within the deeper till and outwash deposits below the marine clay. If the CSM is correct, no exceedances of water quality criteria should be found in TMW-11S, but 1,4-dioxane and PFAS may be present in TMW-11D.**

<u>*CLG Response*</u>

Temporary monitoring wells TMW-11S and TMW-11D have been sampled and results have been added to Figure 3.5. Additionally, cross sections for the DPT borings will be generated which applies the CSM to explain the presence and or absence of site COCs from the temporary monitoring wells. The installation of a permanent overburden monitoring well to delineate and monitor the westward extent of site COCs, in the vicinity of the DPT wells, is included as a recommendation of the Final Report. Recommendations for well installation were initially provided by Haley Ward in its May 11, 2021 DPT Investigation Results memorandum. However, the Final Report includes a revised recommended location that incorporates results from TMW-11S/-11D sampled in Spring 2023.

USEPA

75. **Section 4.3.2, *Occurrence and Flow in Bedrock*, references Figure 4.15, a groundwater contour map for bedrock that includes data from several deep bedrock boreholes that have multiple well screens that are representative of shallower and deeper groundwater heads. In cases where the variation in head between the two wells impact the groundwater contours, such as at MW-21D1 and -21D2, the data from the shallower well screen should be used because substantially more of the bedrock monitoring wells at the site are screened in shallow bedrock. Accordingly, the 72-foot contour should be moved west of MW-21D to honor the groundwater elevation at MW-21D1 and a note should be added to indicate that the depth from the shallower well screens is used to develop the contours. In addition, the contour should be dashed through this area because there is no control to the west.**

CLG Response

Two bedrock groundwater potentiometric surface contour maps have been generated that represent groundwater flow pathways in Shallow Bedrock and Deep Bedrock. Bedrock wells classified as those representative of shallow bedrock are either open borehole or screened less than 75 feet below grade, while Deep Bedrock wells are those which are either open borehole or screened greater than 75 feet below grade. Section 4.3.2 has been revised to reflect the understanding of flow pathways shown by these new contour maps. Additionally, several of the current open borehole bedrock monitoring wells, including GZ-109, MW-23, MW-24, and GZ-130 have been proposed to be constructed as permanent bedrock monitoring wells across discrete intervals. Details of well construction for these locations were included in the Deep Bedrock Investigation Work Plan Addendum (Haley Ward, 2020). These wells will allow more discrete monitoring of the shallow (<75 ft bgs) and deep (>75 ft bgs) bedrock intervals.

USEPA

76. **Section 4.3.2.1, *Analysis of Transducer Water Level Data*, is incomplete. Transducer data from R-3 is cited even though this is a private well. Section 3.1.7 lists numerous data logger monitoring events that have been performed during this investigation, but Section 4.3.2.1 does not describe any of the events or discuss the findings relative to the objective of each specific event. The only conclusion presented was that earth tides were observed in most deep bedrock wells and that some bedrock wells close to MW-6 showed drawdown during the pumping test. This section needs to be expanded to provide a detailed analysis of the data logging results and present graphs of the data that support the conclusions, taking into consideration the effect of precipitation events, barometric pressure, and residential pumping on the bedrock aquifer.**

CLG Response

The revised Final Report has been updated to reflect a more complete analysis of transducer data and hydrographs of these monitoring events are now included in the appendices of the report.

USEPA

77. **Section 4.3.2.2, *Summary of Conceptual Flow System*, references Burton et al., 2002, but this is not listed in the Reference section.**

CLG Response

This paper has been added to the reference section in the Final Report.

USEPA

78. **Section 4.3.2.2, *Summary of Conceptual Flow System,* is confusing and does not discuss groundwater migration other than westward flow. Figures 4.16 through 4.18 are not referenced in this section and seem out of order. The previous section references Figure 4.15 and the following section references Figure 4.19. The cross-sections presented in Figures 4.16 through 4.18 include the results of the ambient heat pulse flow meter (HPFM) logging, with many of the logs stating "no flow". The intent appears to be to suggest there is no flow to the east of the landfill. This is misleading and should be corrected. The HPFM logging will identify vertical groundwater flow within a borehole but cannot measure horizontal flow through a borehole. The steeply dipping nature of the fractures at this Site tends to favor horizontal flow along strike and not vertical flow down dip, which would produce measurable vertical gradients within boreholes. The lack of ambient flow detected by the HPFM is indicative of horizontal flow, not a lack of groundwater flow altogether. Also, the Legend and Notes on the three figures reference sections or appendices that are incorrect or are blank (denoted with "XX"). The figures also reference the 'FLASH' analysis that was conducted as part of the Interim Report but is not presented in the Final Report. References to FLASH should be removed, along with the Day-Lewis references in Section 8.**

<u>*CLG Response*</u>

The Final Report has been revised for clarity. A new section of the report has been added which discusses the horizontal groundwater flow in bedrock, supported by the updated cross sections including flow nets and new updated groundwater contour maps for shallow and deep bedrock as Section 4.3.2.1. Horizontal gradients at bedrock wells where vertical gradients have been determined, have been calculated, are provided in the appendices of the report, and incorporated into the Conceptual Flow System in bedrock. The references to figures have been updated and the citation of the "FLASH" analysis has been removed along with the citation in the references section of the Final Report.

USEPA

79. **Section 4.3.2.2, *Summary of Conceptual Flow System:* As mentioned above, this section does not provide a clear description of groundwater flow in the bedrock aquifer. Based on EPA's analysis of the data, groundwater flow in bedrock is controlled by the bedrock fabric (fracture network and bedrock topography) and the head distribution. Topographic relief, variations in recharge, and the presence of streams (groundwater discharge points) will control the head distribution. The bedrock fabric is characterized by 1) a steeply- dipping predominant fracture set with strike parallel to the regional foliation (NNE-SSW); 2) less frequent steeply-dipping cross-set fractures striking roughly perpendicular to the foliation; and 3) near horizontal sheeting fractures. Unlike groundwater flow in porous media (overburden), bedrock groundwater cannot typically flow in a straight line from the recharge areas to the discharge areas and must move through the available fractures. Groundwater can more easily move along strike of the predominant fracture set (parallel to the regional foliation) because those fractures are more frequent but will move through cross-set or sheeting fractures (east or west) to reach groundwater discharge points (streams), resulting in a tortuous flow pattern from groundwater recharge areas on topographic and bedrock high points to groundwater discharge points.**

<u>*CLG Response*</u>

Section 4.3.2.2 has been revised and is now Section 4.3.2.5. The revised discussion of the Conceptual Flow System has been updated to reflect the additional analysis of horizontal gradients and has incorporated the additional understanding of bedrock flow gained through the generation of flow nets and updated groundwater contour maps. The fracture populations are discussed in greater detail, where sheeting fractures have been demonstrated to be limited in extent and are generally not found to be transmissive.

USEPA

80. **Section 4.3.2.3, *Bedrock Groundwater Quality*, indicates that the majority of the bedrock monitoring wells at the Site are shallow (50-75 ft) but that the private wells in the area are deeper (up to 300 ft). This suggests that the existing monitoring well network at the Site is insufficient to adequately monitor potential impacts to the receptors.**

<u>*CLG Response*</u>

Section 4.3.2.3 - Bedrock Groundwater Quality has been changed to Section 4.3.2.6 in the Final Report. An updated analysis of the monitoring network has shown that roughly half of the bedrock monitoring well network consists of wells less than 75 ft below grade while the remaining are greater than 75 ft below grade, including bedrock wells screened across discrete intervals and open boreholes. The distribution of these wells are included in the Shallow and Deep Bedrock Groundwater Potentiometric Contour Maps, Figures 4.15A and 4.15B. Notably on the northern end of the monitoring network, closest to the potential receptors in the subdivisions off Breakfast Hill Road, bedrock wells MW-20D2 (screened 224-234 ft bgs), MW-23 (open borehole to 280 ft bgs), and GZ-110 (open borehole to 188 ft bgs), are all installed to the deep bedrock interval, typical of residential wells. Downhole geophysical surveys and packer sampling have been completed on the transmissive fractures identified in these three wells. A review of the residential logs available indicates the majority of those wells are less than 300 ft deep.

It is acknowledged that there is a data gap to potential receptors to the southwest of the landfill, in the Little River Watershed, and the Final Report includes recommendations to install a bedrock well to delineate the southern extent of impacts. The installation of this bedrock well has been provided to the USEPA in the July 1, 2022 Bedrock Well Installation Work Plan (Wood, 2022) with comments received from the USEPA on July 11, 2022. A Revised Bedrock Well Installation Work Plan is under development at the time of reporting.

USEPA

81. **Section 4.3.2.3, *Bedrock Groundwater Quality,* indicates that there are eight open borehole bedrock wells that supplement the existing bedrock groundwater quality monitoring network, but 10 are listed.**

<u>*CLG Response*</u>

The Final Report has been updated from 8 to 10 as the open bedrock wells included reconnaissance wells.

USEPA

82. **Section 4.3.2.3, *Bedrock Groundwater Quality,* references Figure 4.21 which shows the distribution of PFOA in bedrock groundwater. Monitoring well FPC-11B located east of the landfill had a concentration of PFOA of 13.3 ppt, so the 12 ppt contour should extend around this well.**

<u>*CLG Response*</u>

This figure has been updated for the Final Report and is now Figure 4.25..

USEPA

83. **Section 4.3.2.3, *Bedrock Groundwater Quality,* finds that "The elongated distribution of 1,4-dioxane and PFAS north and south of the wetland complex is consistent with regional geologic structure, lineament analysis, and fracture orientation observed in most downhole geophysical surveys. However, the decline in concentrations to the north and south are also consistent with interpreted discharge of groundwater to Berrys Brook and Little River, which are also oriented in a north-south direction." This finding suggests that the extent of 1,4-dioxane and PFAS contamination to the south should be similar to that observed to the north of the landfill. Concentrations of these compounds at GZ-105 and MW-25 (south of the landfill) are substantially higher than in similarly placed wells north of the landfill (such as FPC-5B). It is known that contaminant along the northern pathway extend over 3,200 feet to Breakfast Hill Road (R-3 and BHR339). It is reasonable to suggest that the contaminant plume extends to the south a significant distance, beyond the extent of the current monitoring network.**

<u>*CLG Response*</u>

To further define the limits of the southern plume extents and evaluate groundwater quality in this area, the CLG will be installing a new deep bedrock well to the south. The installation of this bedrock well was provided to the USEPA in the July 1, 2022 Bedrock Well Installation Work Plan (Wood, 2022) with comments received from the USEPA on July 11, 2022.

USEPA

84. **Section 4.3.2.3, *Bedrock Groundwater Quality,* references Figures 4.22 and 4.23 which depict the distribution of PFNA and PFHxS in bedrock groundwater, respectively. These figures only contain one contour representing the NHDES AGQS. Additional contours should be added to show variations and distribution of the higher concentrations, similar to the figures for PFOA and PFOS.**

<u>*CLG Response*</u>

These figures have been revised to include isoconcentration contours representing the NHDES AGQS as well as a contour representing 70 ppt.

USEPA

85. **Section 4.3.2.3, *Bedrock Groundwater Quality,* includes findings related to packer sampling of the GZ-series reconnaissance wells, but the specific data from the packer sampling are not included here or represented in a figure. Because findings related to the packer sampling results are presented, the specific results of the sampling should be presented along with the other bedrock groundwater data.**

<u>*CLG Response*</u>

Appendix C for the Final Report has been updated to include the GZ-series reconnaissance well packer sampling results, MW-6, MW-20/-21/-22, and MW-25. Results have been included on the composite geophysical logs for each zone where interval packer sampling was completed.

USEPA

86. **Section 4.3.2.3, *Bedrock Groundwater Quality,* discusses the 1,4-dioxane detection at MW-24 and its relation to nearby wells BP-4 and GZ-109. Examination of the data on Figure 4.19, supplemented with the packer sampling results for the reconnaissance wells, suggests a consistent concentration gradient from BP-4 (6.9 ppb) to FPC-9B (3.9 ppb) to MW-24 (1.2 ppb) to AE-1B (1.1 ppb) to FPC-11B (0.57 ppb) to 178A LR (0.37 ppb). This may suggest a groundwater flow pathway to the south along the eastern contact between the Breakfast Hill Granite and the Rye Formation, or possibly impacts from the Great Common Fault.**

CLG Response

Building on the identified flow pathways from the flow nets included in the latest cross sections and the importance of the glacial till unit as the likely transport pathway from overburden into bedrock is used to explain the concentrations of 1,4-dioxane found in bedrock to the east of the landfill. A gradient pushing groundwater from the overlying outwash into the till unit is shown in cross sections included with the report. While the clusters at FPC-11 and FPC-9 indicate a slight upward vertical gradient from bedrock into the till, there may be locations where groundwater in the till is infiltrating into bedrock. A revised vertical gradient table has been included with the Final Report. Historically, mounding of groundwater at the landfill identified in the 1988 RI would have increased the hydraulic gradient to the east, driving site impacts east of the landfill. Based on the Mann-Kendall analysis performed for the site, the only bedrock well east of the landfill showing a statistically significant trend for 1,4- dioxane was BP-4 and this was a downward trend in concentration.

USEPA

87. **Section 4.3.2.3, *Bedrock Groundwater Quality,* refers to the "stayed AGQS" for PFAS while discussing the MW-6 interval packer sampling results. Note that the NH AGQS for four PFAS compounds have been adopted.**

CLG Response

The term "stayed" has been removed from the text.

USEPA

88. **Section 4.3.3, *Water Quality Trend Analysis*, presents the results of the water quality trend analysis performed using a Mann-Kendall test. A summary table of the Mann- Kendall results by well should be included in the Report and the output files should be included in Appendix F along with the time-series plots. A figure that shows the trend (increasing, decreasing, or stable) at each well should also be developed to allow for a visual representation of plume stability across the Site, which is a presented as a key conclusion of the investigation.**

CLG Response

MATLAB – MathWorks with Statistics Toolbox software was used to review groundwater data and re-analyze statistical metrics to address EPA's concerns regarding inclusiveness of data and conclusions regarding contaminant trends. Contaminants of concern (COC) selected for this evaluation were 1,4-Dioxane, PFOA, PFOS, PFNA, PFHxS, arsenic, and manganese. These COCs were prioritized based on prevalence at the site and mobility.

Mann-Kendall trend analysis was used to evaluate concentration trends at individual wells. The Mann-Kendall test is a non-parametric statistical procedure that is well suited for analyzing trends in data over time (discussed above).

Appendix H of the Final Report provides summary tables of Mann-Kendall Trend Analyses, organized by parameter and well type, for all wells with a statistically significant trend (increasing or decreasing), as well as a detailed description of methodology and conclusions. Appendix H of the Final Report will include Mann Kendall data for all wells in the sampling network regardless of trend.

Isoconcentration figures have been revised to include increasing or decreasing trend symbology to indicate wells where the Mann Kendall analysis resulted in a statistically significant trend exists. These figures allow for the data to be visualized and analyzed spatially across the site.

USEPA

89. **EPA does not concur with the interpretation of the time-series plots for 1,4-dioxane presented in Section 4.3.3, *Water Quality Trend Analysis*. For example, the Mann-Kendall analysis for FPC-11A indicated a decreasing trend, but evaluation of the time-series plot shows that while concentrations decreased between 2016-2019, they increased in 2020 and returned to previous levels. Taken as a whole, the trend analysis seems to suggest that wells with higher concentrations closer to the landfill are more likely to exhibit a decreasing trend, but wells with lower concentrations that are more distant from the landfill tend to show no trend. The wells with increasing Mann-Kendall trends are clustered near the northwest corner of the landfill (where discharge of stormwater runoff from the landfill is concentrated) and southeast of the landfill along the flow path mentioned in the previous section.**

CLG Response

Mann-Kendall trend analysis was used to re-evaluate concentration trends at all groundwater monitoring wells in the monitoring network (discussed above). Appendix H will include Mann Kendall data for all wells in the sampling network regardless of trend.

Conclusions regarding trends at individual wells will be based on statistical metrics rather than relying solely on visual analysis of Time vs. Concentration plots. Figures are included with the revised report that illustrate the trend (increasing or decreasing) at all wells where the Mann Kendall analysis indicated a statistically significant trend exists. These figures will allow the data to be visualized and analyzed spatially across the assessment area.

Visual analysis of Time vs. Concentration plots for 1,4-Dioxane at well FPC-11A indicated a decreasing trend. For the revised report, the data was re-evaluated using Mann-Kendall analysis and found no significant trend for the data from this well.

USEPA

90. **EPA does not concur with the interpretation of the time-series plots for PFOA/PFOS presented in Section 4.3.3, *Water Quality Trend Analysis*. For example, MW-10 was listed in the text as having a decreasing trend for both PFOS and PFNA, but examination of the time-series plot shows that concentrations of both compounds increased dramatically in that well from 2016 through 2020 (with PFOS going from less than 100 ppt to over 800 ppt) but decreased (to about 150 ppt) in the fall 2020 round. A single low data point does not constitute a trend or take precedence over a consistent trend measured over a 4-year period consisting of 8 data points. In general, increasing PFAS concentrations are found along the western edge of the landfill and southward in the bedrock trough, as well as on the eastern side along the same possible flow path mentioned above, where 1,4-dioxane concentrations are increasing.**

CLG Response

Mann-Kendall trend analysis was used to re-evaluate concentration trends at all groundwater monitoring wells in the monitoring network.

Regarding the specific example in USEPA's comments, "MW-10 was listed in the text as having a decreasing trend for both PFOS and PFNA", the data were re-evaluated using Mann-Kendall analysis which found a statistically significant increasing trend for PFOS and no statistically significant trend for PFNA.

USEPA

91. **Section 4.3.3, *Water Quality Trend Analysis*, should list the wells that were interpreted to be having increasing trends for PFOS.**

CLG Response

Mann-Kendall trend analysis was used to re-evaluate concentration trends at all groundwater monitoring wells in the monitoring network.

Conclusions regarding trends at individual wells are based on statistical metrics rather than relying solely on visual analysis of Time vs. Concentration plots. Isoconcentration figures have been revised to include increasing or decreasing trend symbology to indicate wells where the Mann Kendall analysis resulted in a statistically significant trend exists. These figures will allow the data to be visualized and analyzed spatially across the assessment area.

USEPA

92. **The radar plots included in Appendix H and referenced in Section 4.3.3.2, *PFAS Compositional Analysis,* should be included on a Site map, similar to the presentation of the fracture orientation rose diagrams in Figure 3.1, to present the spatial relationships in the PFAS composition.**

CLG Response

Based on the scale of map required to clearly post these results, it has not been included in this report. Compositional analysis as it relates to impacts evaluated during the Surface Water Evaluation (i.e., patterns in stormwater and surrounding landfill wells) may be presented visually as the USEPA recommends but in the Surface Water Evaluation Report. The reporting was included as Section 4 of the June 25, 2020 Surface Water Evaluation Work Plan.

USEPA

93. **The stormwater investigation radar plots in Appendix H seem to have a consistent pattern that matches the pattern for MW-9 and MW-10 from fall 2018. However, plots are also included for MW-9 and MW-10 using data from spring 2020 that shows a much different signature. This suggests that there may be a seasonal variation in PFAS composition at the Site that should be explored. Radar plots should be prepared for select monitoring wells and surface water locations over time to evaluate seasonal or longer-term trends in PFAS composition. Seasonal trend variations may be indicative of impacts from surface water runoff from the landfill.**

CLG Response

Seasonal trends are more pertinent to the annual reports on groundwater quality for the site and outside the scope of the Deep Bedrock Investigation. Considerations will be made to include temporal variations in PFAS composition in the evaluation of data during the completion of the Surface Water Evaluation currently being performed by the CLG.

USEPA

94. **Section 4.3.3.3, *Contaminants of Concern and Emerging Contaminants in Groundwater* does not address any contaminants other than 1,4-dioxane and PFAS compounds (emerging contaminants). Arsenic and manganese are the contaminants of concern at the Site that remain widespread near and downgradient of the landfill. A discussion of arsenic and manganese should be included, or the title of this section adjusted to more accurately reflect the discussion provided.**

CLG Response

The Final Report has been updated to include a discussion of arsenic, and manganese.

USEPA

95. **Section 4.4, *Surface Water*, states that "groundwater….primarily flows towards, and discharges into, a wetland complex west of the landfill" and that "the majority of surface water runoff from Site discharges towards the Little River and Berrys Brook". These conclusions do not consider the portion of groundwater and surface water runoff that discharges east of the Site into the Bailey Brook watershed. While it is reasonable to focus much of the discussion on the west side of the landfill, conditions and impacts on the east side should also be presented and discussed relative to the Berrys Brook, Little River and Baily Brook watersheds depicted in Figure 2.2. Also, the results of surface water sampling conducted in Bailey Brook in 2016 by Conservation Law Foundation for low-level 1,4- dioxane and PFOA/PFOS (all non-detect) should be cited as evidence that this water body has not been impacted by the landfill.**

CLG Response

The Final Report has been revised to include a discussion of additional stormwater shed from the landfill to the east and references the sampling results performed by the Conservation Law Foundation. In addition, watershed boundaries included with site figures have been updated to be consistent with those provided in the Deep Bedrock Investigation Interim Report (Haley Ward, 2019).

USEPA

96. **Section 4.4.2.1, *Surface Water Quality Monitoring Locations*, should clarify the location of SW-BB3, which is shown on the east side of the railroad easement but was relocated west of the railroad easement in 2020. In addition, the description of the beaver dam removal should indicate that the removal of the beaver dam lowered the overall water level in the wetland located to the east of the railroad easement and not the west.**

CLG Response

The Final Report has been revised to include a discussion of the culvert blockage removal and the location of SW-BB3. Figures illustrating the location of SW-BB3 have been updated to include the current location west of the easement

USEPA

97. **Section 4.4.2.2, *Surface Water Quality Monitoring Results*, appears to only present sampling results from 2020. A discussion of historical results and trends should be included. Location L-1 (seep) is a critical location and should be added to this discussion. Also, the results for 1,4-dioxane and PFAS should be plotted on a figure with arrows showing surface water drainage pathways which are critical to understanding the movement of surface water away from the landfill. The leachate seeps noted during the site inspection conducted in 2021 should also be discussed as further evidence of the extent of groundwater discharge to surface water. Arsenic and manganese data should also be discussed here as an indicator of the impact of groundwater on surface water.**

CLG Response

The Final Report has been updated to include a discussion of results at L-1 and expand on trends/historical results. Arrows have been added to Figure 2.2 to illustrate surface water flow from the landfill and within the different watersheds covered by the investigation area.

USEPA

98. **Section 4.4.3.1, *2019 Surface Water Quality Monitoring Results*: The title of this section is incorrect and should be changed to reflect the actual content of this section, which is surface water elevations.**

CLG Response

The title of this section has been revised to reflect the elevation information discussed.

USEPA

99. **Section 4.4.3.1, *2019 Surface Water Quality Monitoring Results*, indicates that the surface water elevation monitoring locations, including locations SB-1 and SB-2, are identified on Figure 2.2, but SB-1 and SB-2 are not shown on the figure. In addition, SB-1 and SB-2 are identified as being located in Stormwater Pond NW. SB-1 is located in the northeast basin and SB-2 is located in the northwest basin.**

CLG Response

Figure 2.2 has been updated to include the locations for SB-1 and SB-2 with text of the Final Report revised to correctly describe the location of these surface water monitoring locations

USEPA

100. **Section 4.4.3.1, *2019 Surface Water Quality Monitoring Results*, states that the surface water elevations listed "indicates that surface water flows from the Stormwater Pond towards the wetland complex, Berrys Brook, and Little River." As mapped in Figure 2.2, both stormwater basins are within the Berry Brook drainage basin, such that water from the basins would flow into Berrys Brook and not Little River, as presented in the bullet that follows. Although the northeast stormwater basin is within the Berrys Brook drainage basin, it is not clear if the discharge from the basin is fully within the watershed. That basin discharges to groundwater, as previously concluded by the investigation of stormwater, or overflows to the wetland area located directly north and is separated from Berrys Brook by the access road from Bethany Church to the landfill. Examination of LiDAR imagery from this area shows a large depression located directly east that could represent a surface water drainage pathway to the east from the northeast stormwater basin. This surface water flow condition should be evaluated further.**

<u>*CLG Response*</u>

Further description of localized surface water flow in this area has been included in the revised report. Preliminary elevations of the surface water as determined from available online imagery (i.e., Google Earth) has the surface water elevation within this area at approximately 98 feet AMSL. The surface water elevation in the northeast basin generally mimics the shallow groundwater elevation gauged in PZ-1. Surface water elevations in the northeast pond tend to vary between 92 and 96 feet AMSL, indicating a general flow of water to the north from the stormwater pond and west from this adjacent depression. However, additional effort to verify the elevation of this feature will be considered under the ongoing Surface Water Evaluation to confirm the flow of surface water through the system.

USEPA

101. **Section 4.4.3.1, *2019 Surface Water Quality Monitoring Results*, indicates that water elevations in the two stormwater basins are similar to groundwater elevations measured in piezometers and references the data in Table 3.4. Review of the water elevations presented in Table 3.4 suggest that the elevations between PZ-2 and SB-2 differ by several feet, which is substantial given the limited depth of the piezometer screens below the bottom of the basins. The significance of the variation in water level between PZ-2 and SB-2 should be discussed (basins are perched and water is infiltrating through the bottom into the underlying groundwater).**

<u>*CLG Response*</u>

Surface water and shallow groundwater elevations for the stormwater control ponds calculated for 2019 used a staff gauge for surface water and PZ-2 for shallow groundwater. More recent data (since March 2022) gauged inside PZ-2 (shallow groundwater) and outside PZ-2 (surface water) are more accurate and consistent with expectations of a difference in elevations of 0.1 feet or less between groundwater and surface water. These measurements are considered more accurate as they are recorded from a singular fixed point of reference (PZ-2 measuring point) rather than the staff gauge where ice had removed it during winter. In addition, these small changes in head between surface water and shallow groundwater likely change during precipitation events where surface water elevations increase in the short term before nearing equilibration with shallow groundwater.

USEPA

102. **Section 4.4.3.2, *Surface Water Quality Monitoring Results*: The title of this section is incorrect and should be changed to reflect the actual content of this section, which is surface water elevations. The intent of the piezometer investigation described in this section was to assess groundwater and surface water hydraulic interaction. The shallow groundwater elevations should be compared to surface water elevations measured at each location to determine whether groundwater is discharging to surface water or whether surface water is perched and is recharging the groundwater. The depth to water should have been measured both inside (groundwater) and outside (surface water) of each piezometer and the data presented on Table 3.5 to allow a determination of recharge/discharge conditions at each location.**

CLG Response

The title of this section has been changed to reflect the information discussed (surface water elevations). With regards to the evaluation of surface water interaction with shallow groundwater, more recent data as gauged from inside (shallow groundwater) and outside (surface water) at installed piezometers from March to June 2022 was used. These short-term trends have been included in the Final Report with the evaluation of additional data (through October 222) to be presented in more detail in the reporting effort for the Surface Water Evaluation.

USEPA

103. **Section 4.4.4.3, *Stormwater Infiltration Modeling*, references the Stormwater Investigation Report prepared by Haley Ward in 2019, for which EPA provided extensive written comments in a letter dated November 22, 2019. Many of the comments pertained to how PFAS loading from groundwater was calculated. In the January 22, 2020, Response to Comments letter, CLG indicated that additional details would be provided in future discussions of the stormwater investigation. However, this section does not provide any additional detail as to how the PFAS loading calculations were revised in accordance with EPA's comments. The estimated annual mass discharge of PFAS in stormwater (0.62 lbs) and groundwater (0.24 lbs) exactly match the values presented in the Stormwater Investigation Report, suggesting that EPA's recommendations for modifying those calculations were not implemented. Further discussion is required to justify the loading estimates and to explain how earlier comments were or were not addressed.**

CLG Response

Revised calculations have not been performed because this will be more appropriately presented in the Surface Water Evaluation report. These loading calcs will be removed and need to be redone as part of the ongoing surface water investigation which will address the stormwater flowpath. This is referenced in the text of the Final Report.

Section 5 Conceptual Site Model

USEPA

104. The comments provided for the Executive Summary also apply to Section 5, *Conceptual Site* Model. Overall, the CSM is not well described, illustrated, or supported, and does not fully consider secondary flow paths to the east and south, focusing only on the western and northern pathways.

CLG Response

The CSM description has been reworked and supported by additional line of evidence. Due to the re-analysis of much of the data gathered for the Deep Bedrock Investigation, evaluation of identified lithologies, top of rock contours, extent and thickness of surficial material, borehole geophysics and fracture data, vertical and horizontal gradients across the site, and evaluation of the pumping test data, a fuller understanding of the conceptual model for the ultimate fate and transport of site COCs has been obtained which addresses the potential secondary flow paths to the south and the east of the landfill.

USEPA

105. Section 5.1, *Site History and Contamination Source*, should include a more detailed description of the waste sources and known releases, including the years that the wastes were placed, the source/composition of the wastes, and the mode of placement.

CLG Response

Additional review of the site history including a description of waste sources and known release areas has been included in the Final Report. This includes agreements made between Portsmouth, North Hampton, Newcastle, Newington, and Pease Air Force Base on the type of material that could be disposed as well as historic NH solid waste regulations and inspection reports completed by state regulators on landfilling practices and information from agency site inspections. In addition, more details have been included on the methods of waste placement with information from multiple sources used.

USEPA

106. Section 5.1, *Site History and Contamination Source*, indicates that the Site was mined previous to placement of waste, but no discussion is provided about the type of mining that was conducted or where it was located. The location and mode of bedrock mining is critical to understanding how the wastes could have entered the bedrock. Also, blasting (if conducted) would have increased the shallow fracturing in the bedrock, providing additional pathways for waste migration. The location and orientation of any remnant bedrock troughs or pits could influence groundwater migration within the bedrock. Historical aerial photographs, including (but not limited to) the Site Analysis Coakley Landfill dated March 1985, should be consulted to develop a chronology of the quarry and filling activities.

CLG Response

Additional detail is provided in the Final Report that describes the mining operations that are known to have occurred at the site. Limited information is available to confirm historic blasting of the rock now underlying the landfill but historic blasting has been confirmed to the north of the current landfill at the "Quarry" identified on site maps. Some information obtained during the RI (i.e., GZ-106 installation) was used to supplement information contained in the RI.

USEPA

107. Section 5.1, *Site History and Contamination Source*, states that "refuse was placed in areas that were mined to within a few feet of the groundwater table". However, it should be noted that during the mining activities, trenches were dug to drain groundwater westward into the wetland area, artificially lowering the groundwater table to allow the mining to extend deeper. As a result, groundwater elevations are likely higher currently than they were at the time the fill was placed. Further, this statement conflicts with information contained in the ROD and original RI reports. Specifically, the ROD states: "Sand and gravel operations were conducted from 1968 to 1972 during which time rock quarrying and landfill operations were also conducted. Much of the refuse disposed at the landfill was placed in open trenches created by the rock quarrying and sand and gravel operations. Direct leachate discharge to the bedrock may take place beneath parts of the landfill since the refuse is in direct contact with bedrock in areas where rock quarrying had previously occurred. Much of the refuse disposed of at the Coakley Landfill was placed in open (some liquid-filled) trenches created by rock quarrying sand and gravel mining." This is important because whether the waste is situated in groundwater will impact the migration and degradation of the contaminants.

CLG Response

The discussion of the site history and sources of contamination has been updated to provide more detail regarding historic site operations. It is noted that solid waste landfilling regulations at the time (1972 State of New Hampshire Laws and Regulations Relating to Solid Waste Disposal) prohibited the disposal of wastes in open, water filled trenches. Routine landfill inspections performed by state personnel noted deficiencies related to insufficient covering of wastes or inadequate thickness of cover but there is no indication made to improper drainage of surface water or waste placement in water filled trenches. Because such waste placement issues would have been in violation of state regulations, they would likely have been mentioned in site inspection records if they were occurring. There was no information in the RI Report (Weston, 1988) to indicate waste was actively place in water-filled trenches.

USEPA

108. Section 5.2, *Potential Receptors,* concludes that properties along Falls Way and September Drive are not receptors of contamination from the Coakley Site based on the fact that site-related compounds have not been detected in those wells over the last 5 years. While the agencies agree with this conclusion, citing the private well data alone is not sufficient. Additional lines of evidence beyond just the sampling results should be cited such as the understanding of the bedrock fabric and hydraulic head distribution, to fully characterize groundwater migration in bedrock.

CLG Response

Cross sections including vertical flow nets and groundwater contour maps detailing flow in shallow and deep bedrock have been updated and include interpretations of groundwater flow in bedrock to the west of the wetland complex. This is supported with the additional bedrock wells to the west of the wetland complex, clusters MW-20, 21, and 22 installed as part of this investigation. Additionally, the deep bedrock pumping test has illustrated the anisotropy coincident with the primary fracture zones present in the deep bedrock as predicted by Mack 2012. These lines of evidence support the influence of the bedrock fabric as well as the hydraulic influence of the bedrock trough and surface water drainages to bedrock groundwater flow pathways and hydrogeologic factors limiting the western migration of site contaminants. These additional lines of evidence and reported analytical data for private wells indicate little to no risk of exposure to private wells almost a mile to the west of the landfill, perpendicular to the predominant flow direction.

USEPA

109. **Section 5.2, *Potential Receptors*, discusses the eastern flowpath and seems to suggest that the Rye Landfill is a potential source of the PFAS and 1,4-dioxane at 178A LR. This is inconsistent with the hydrogeologic conceptual model. The Rye Landfill is located well north of the Coakley Landfill and 178A LR is located south of the Coakley Landfill across a topographic high point. All data indicates that the Rye Landfill is a source only for contamination found to the north and east of that site. Well 178A LR is located along a presumed flow path that extends east from the Coakley Landfill through the Breakfast Hill Granite and associated mafic intrusive rocks (MW-24) and then south along the predominant foliation-parallel fractures in the Rye formation.**

CLG Response

The text of the report has been revised to clarify the suggestion that the Rye Landfill is not a potential source for the 1,4-dioxane at 178A LR. The CSM for the Coakley Landfill has been updated to include information on the potential for shallow contamination to migrate through glacial till southeast of the landfill and into bedrock. It should also be noted that the CLG has offered to connect the residence at 178A Lafayette Road (178LR) to the public water line available along Lafayette Road (US Route 1.

USEPA

110. **Section 5.3, *Physical Characteristics of the Site*, mentions the predominant fracture set (foliation-parallel fractures striking roughly northeast-southwest) at the Site. EPA concurs with the assessment of the predominant fracture set, but the cross-set fractures striking roughly perpendicular to the foliation and near horizontal sheeting fractures should also be discussed. While not as frequent as the predominant fractures, these secondary fracture sets provide important connections between the predominant fractures and allow groundwater movement in directions other than along strike of the predominant fractures (northeast-southwest). At the Coakley Site, it is the cross-set and sheeting fractures that facilitate the westward flow from the landfill into the bedrock trough, where flow is then controlled by the predominant foliation-parallel fracture set**.

CLG Response

As initially noted under USEPA Comment No. 9 and included in the revised report, sheeting fractures have been demonstrated to be limited in extent and are generally not transmissive. Additionally, the deep bedrock pumping test has confirmed the 5:1 anisotropy of the bedrock aquifer, parallel to the predominant fracture set, which incorporates the secondary and tertiary fracture sets identified. Notably this includes a large aperture, moderately westward dipping (approximately 40-50 degree), water transmitting fracture, identified in Zone 4 as well as other smaller aperture, near horizontal fractures identified in likely transmissive Zone 3 and Zone 7. The combination of these shallow and moderately dipping fractures along with the more typical, steeply dipping north to south oriented fractures, results in the 5:1 expected anisotropy which results in only limited eastward or westward flow from the landfill and the bedrock trough.

USEPA

111. Section 5.3, *Physical Characteristics of the Site*, focuses exclusively on the western flow path and does not discuss the eastern or southern flow paths, and concludes that groundwater in deep bedrock is discharging to the wetland complex without any specific discussion of the flow mechanism.

CLG Response

Section 5.3 on Physical Characteristics of the site has been revised and includes a discussion of the eastern and southern flow paths. The section also provides more context into potential mechanisms for groundwater discharge to the wetland supported by the most recent analysis to determine flow pathways. The Final Report also includes a recommendation to continue to investigate groundwater-surface water interactions in continued execution of the Surface Water Evaluation Work Plan (Haley Ward, 2020), including more detailed monitoring of surface water, overburden groundwater, and bedrock groundwater using pressure transducers to discern changes in water levels during various hydrologic conditions, including seasonally, and during precipitation events.

USEPA

112. Section 5.4, *Fate of Site Contaminants*, concludes that there is generally a "stable" contaminant concentration trend in groundwater. EPA disagrees with this conclusion (see comments Section 4.3).

CLG Response

A reanalysis of contaminant trends has been completed for the Final Report. Additional discussion has been included to justify the analytical methods applied and the interpretations gained from those statistical analysis. Visual trends were not relied on to make conclusions as were completed for the Draft Report.

USEPA

113. Section 5.5, *Transport of Site Contaminants*, references Figures 5.1 and 5.2. Figure 5.1 incorrectly depicts the landfill waste above the water table. As noted above, the waste was placed directly into standing water within bedrock trenches excavated into the bedrock, and drains had been constructed to lower the water table to facilitate mining. Landfill waste is depicted within the water table in Figure 4.5. The supposition that capping of the landfill has lowered the water table below the bottom of the waste is not supported by data. A plan-view figure paired with Figure 5.1 is needed to illustrate the flow paths described in this section. The figures need to clearly show the interpreted flow paths from the landfill (groundwater from the waste, as well as stormwater runoff from the cap) and follow them through to the eventual discharge point into surface water.

CLG Response

A conceptual image and updated cross sections of the landfill waste placement, fractured bedrock, surface water, and stormwater flow, and overburden has been generated for the revised report. As discussed above regarding Comment 107, the assertion that waste was placed directly into standing water within bedrock or overburden trenches has been found not to be supported by historical evidence.

Historical records indicate that sand and gravel removal during mining operations lowered ground elevations to around 90 ft amsl, consistent with the top of rock identified on the southern end of the landfill. Updated groundwater flow contours indicate, for overburden as well as shallow and deep bedrock groundwater, that groundwater may now be in contact with the lower part of the waste in a portion of the eastern side of the landfill, with a hydraulic gradient to the west. Overburden groundwater contours indicate that up to 5 feet of the bottom of refuse may be saturated on the eastern side of the landfill. The bedrock surface encountered within RI boring GZ-106, located at the northwest portion of the landfill (Figure 2.2), was noted at an elevation of 97.4 feet AMSL with water encountered at an approximate elevation of 99.4 feet AMSL. Based on this information and the current potentiometric surface for overburden groundwater within the landfill, limited portions of the landfill refuse may be in direct contact with groundwater as discussed above, but not likely within trenches excavated below the water table during initial waste placement

USEPA

114. Section 5.5, *Transport of Site Contaminants*, indicates that stormwater runoff from the landfill cap contributes a significant amount of PFAS to the wetland complex. This conclusion has not been adequately supported and is subject to the same comments provided for Section 4.4.4.3.

CLG Response

The loading of site contaminants from stormwater runoff and discharge to the larger groundwater and surface water hydrologic system will be further evaluated in the Surface Water Evaluation. References to loading calculations for Site COC mass, initially presented in the Stormwater Investigation Report (Haley Ward, 2019), have been removed and such calculations will be reevaluated during analysis completed for the Surface Water Evaluation.

USEPA

115. Section 5.5, *Transport of Site Contaminants*, references Appendix H as containing the Stormwater Investigation Report (Haley Ward, 2019), however, Appendix H contains PFAS radial plots. The Stormwater Report is not appended to the report.

CLG Response

Appendix B of the Final Report includes the 2019 Stormwater Investigation Report. The radial plots are included are included as part of the Stormwater Investigation Report and will be included in the Deep Bedrock Investigation.

Section 6 Conclusions

USEPA

116. **Second Bullet: The mafic intrusive rocks (MW-24) are not mentioned, and there is no discussion of the two other fracture sets identified at the Site, which are all critical components of the CSM.**

CLG Response

Discussion of all fracture sets and rock types identified during site investigation activities are included in the Conclusions section in the Final Report.

USEPA

117. **Third Bullet: Does not explain how groundwater from the bedrock and till layers is able to discharge into surface water in those areas where a thick sequence of marine clay separates the bedrock/till groundwater from the surface water bodies west of the landfill.**

CLG Response

For the Final Report, updated vertical flow nets have been added to the cross-section figures (4.4- 4.6) to illustrate how groundwater, on a sitewide scale, is moving through the hydrologic system in the vicinity of the site. These figures include interpretations of flow pathways through deep and shallow bedrock as well as overburden. The surface water evaluation will take a more detailed look at the mechanisms of groundwater discharge to surface water; however, the Final Report does include a discussion of hydraulic head distribution, occurrence and flow within overburden (and subsequent discharge to surface water).

USEPA

118. **Fourth Bullet: No mention is made of sheeting fractures and their role in the bedrock system. The last sentence conflicts with the prior one, which recognizes a component of flow to the east. The fate of groundwater in the eastern flow path is not discussed.**

CLG Response

The conclusions of the report have been updated to reflect a re-evaluation of fracture sets. This includes sheeting fractures which, as noted initially under Comment 9 of this response to comments, have been demonstrated to be limited in extent and are generally not transmissive. Additionally, more context to the eastern flow component has been included in the report.

USEPA

119. **Fifth Bullet: The pumping test did not show that the bedrock trough is a hydraulic barrier to westward migration. Rather, the bedrock trough, and associated storage of groundwater in the overburden deposits contained within it, acts as a groundwater reservoir. The lack of drawdown observed to the west during the pumping test is a result of the bedrock anisotropy and the higher bulk hydraulic conductivity of the overburden deposits present in the bedrock trough. The lines of evidence that the landfill has not impacted the neighborhoods to the west are 1) the orientation of the fractures that limit migration in that direction; 2) the hydraulic head field (groundwater elevations and surface water divides); and 3) the data from the sampling of private wells.**

CLG Response

The data generated from the pumping test has been re-evaluated for the Final Report. As such, the conclusions of the report based on this line of evidence have been updated as well. The revised conclusions incorporate the identified fracture orientation, vertical and horizontal flow nets, and the sampling of the current monitoring well field and private wells.

USEPA

120. Sixth Bullet: Again, the presence and importance of sheeting fractures is not discussed. Also, there is not 'limited migration' along the predominant foliation-parallel fracture set. As shown by the pumping test and detection of 1,4-dioxane and PFAS at R3 and 339BHR, no restriction to groundwater flow along this fracture set has been identified.

CLG Response

As noted initially under response to USEPA Comment No. 9, sheeting fractures have been demonstrated to be limited in extent and are generally not transmissive. The pumping test was able to illustrate the 5:1 anisotropy in the bedrock, which limits migration perpendicular to the predominant, foliation-parallel fracture set. Offsite stressors, such as relatively large withdrawals associated with the Breakfast Hill Golf Club at 339 Breakfast Hill Road (339BHR) bedrock well used for commercial purposes in supplying water to the clubhouse, would be consistent with the anisotropic influence of the bedrock fabric on groundwater flow through the bedrock aquifer. This well is separate from the Golf Club irrigation well constructed in overburden and located within a separate watershed to the west of the bedrock well. The presence of low- level 1,4-dioxane and PFAS at R-3 (368 Breakfast Hill Road) and at 339 BHR is slightly to the northwest of the strike parallel fracture set. The presence of Site contaminants in these wells is consistent with the interpretation that there is limited migration perpendicular to the primary bedrock fabric.

USEPA

121. Seventh Bullet: No explanation is provided for how groundwater in till and bedrock is able to discharge to the wetlands complex west of the site when there is a thick sequence of marine clay separating the till/bedrock from the shallower outwash deposits and the associated surface water bodies. The eastern pathway should be broken out into a separate bullet and that pathway should be discussed in greater detail, including the ultimate fate of groundwater flowing to the east.

CLG Response

As noted in the response to Comment 117, updated vertical flow nets have been added to the cross-section figures (4.4-4.6) to illustrate how groundwater, on a sitewide scale, is moving through the hydrologic system in the vicinity of the site. These figures include interpretations of flow pathways through deep and shallow bedrock as well as overburden.

The cross sections illustrate that, along the edge of the wetland complex, glacial till is either in contact with the more permeable outwash or daylights at the ground surface. Therefore, the groundwater is not entirely constrained by the marine clays. The surface water evaluation will take a more detailed look at the mechanisms of groundwater discharge to surface water.

USEPA

122. **Eighth Bullet: No evidence is provided that the contamination rate and interconnectedness of the fractures is "limited". Site contaminants are found in water supply wells on Breakfast Hill Road, some 3,200 ft north of the site. This is proof that bedrock fractures are interconnected along the predominant strike and the bedrock trough and supports contaminant transport over large distances. Results of the pumping test also confirm that the predominant foliation-parallel fractures are well connected.**

<u>*CLG Response*</u>

The conclusions of the Final Report have been updated to reflect the updated definition of the interconnectedness of fractures as they relate to contaminant fate and transport gained from the reevaluation of the lines of evidence gathered during this investigation. Additionally, it is discussed that a predominant mechanism for contaminant fate and transport to the north of the site is through the relatively permissive glacial till and shallow bedrock underlying the trough, which are more laterally extensive than the interconnected foliation parallel fractures.

USEPA

123. **Ninth Bullet: The conclusion that the pumping of active private drinking water wells does not influence contaminant migration or groundwater gradients within the contaminant plume is not well supported. It has not been proven that contamination identified in R3 and 339 BHR was not drawn to the north along the bedrock trough by the combined pumping of these wells. Drawdown related to pumping of R3 is observed in monitoring well MW-20D.**

<u>*CLG Response*</u>

Based on multiple lines of evidence presented in the revised report, the report text has been revised to indicate the influence of pumping at private drinking water supply wells is limited rather than non-existent, as previously presented. The limited artificial hydraulic stress created by the pumping of private water supply wells would be greatest perpendicular to the primary northeast-southwest oriented flowpath. The migration of contaminants along this flowpath is greatest within the till overlying the fractured bedrock surface with contaminants drawn down vertically into bedrock through steeply dipping to vertical fractures.

USEPA

124. **Final Bullet: While there is likely contribution of PFAS to Berrys Brook as a result of stormwater runoff from the landfill cap, the comparative PFAS loading evaluation presented in the Stormwater Sampling Report was flawed and Agency comments on that document were not addressed.**

<u>*CLG Response*</u>

The CLG acknowledges the Agency comments regarding the inconsistencies in the PFAS loading calculations of stormwater to Berrys Brook provided in the Stormwater Investigation Report (Haley Ward, 2019). However, the collection of additional data in 2021 and 2022 that included porewater and stormwater will aid in the refinement of the PFAS loading calculations. These calculations will be presented in reporting efforts associated with the Surface Water Evaluation Work Plan (Haley Ward, 2020) including the discussion of potential temporal/seasonal changes in PFAS contributions as suggested by the Agencies (USEPA Comment No. 93).

Section 7 Recommendations

USEPA

125. EPA agrees that additional work is required to better understand and define how and where bedrock groundwater is discharging to the wetland complex and streams (Berrys Brook and Little River) west of the landfill. The ongoing surface water/groundwater interaction investigation should continue to be implemented. In addition to staff gauge locations, hydraulic monitoring of the piezometers installed in the wetland area should continue to be conducted to evaluate temporal variations in vertical gradients. Measurements should be made on a monthly basis over a period of one year to assess seasonal variations resulting from differential precipitation, evapotranspiration, and temperature.

CLG Response

The CLG concurs with this recommendation. Gauging of piezometers is ongoing through October 2022 to document seasonal fluctuations; however, it is additionally recommended that some piezometer and paired surface water locations (where both surface water and shallow groundwater are measured from the same piezometer) be outfitted with pressure transducers to better monitor the short-term variations in the interaction between surface water and shallow groundwater during and immediately following precipitation events. Measurement of head variations at closer spaced time intervals (i.e., 15 minutes versus monthly) would provide water level information that can be used to better define the period of time the hyporheic system requires to achieve equilibrium. These data would be integrated into the reporting on the surface water evaluation as outlined in the Surface Water Evaluation Work Plan (Haley Ward, 2020).

USEPA

126. Vertical gradients should be measured at all paired DPT locations. All temporary well locations in this area should be included in the sampling program for water quality, including TMW-11S and -11D.

CLG Response

The CLG concurs with the recommendation to measure vertical gradients at all paired DPT locations and will continue to gauge other TMW locations pending agreement from the property owner that these locations may remain installed long-term. However, any decision on the need to regularly sample temporary wells will depend on the results for the permanent well once it is installed.

USEPA

127. MW-25 is not the ideal location to monitor the southern extent of the plume west of the landfill. As previously mentioned, the hydrogeologic data indicates that the southern extent of the plume would likely be similar to the northern extent. In addition, monitoring wells FPC-3A/B and FPC-4A/B are located the edge of the bedrock trough, not near the center where the most robust flow would be expected. MW-25/GZ-105 are located near the centerline of the bedrock trough but are both impacted by PFAS and 1,4- dioxane at fairly high concentrations and therefore are not located near the leading edge of the plume. The CLG shall install a new monitoring well to determine the extent of the southern flowpath south of MW-25.

<u>*CLG Response*</u>

The CLG developed the Draft Bedrock Well Installation Work Plan as submitted to the USEPA and NHDES on July 1, 2022. The USEPA provided comments to the Draft Work Plan on July 11, 2022. The Work Plan includes the use of surface geophysics to locate features associated with a southern migration flowpath (i.e., fractures and bedrock trough) to target with drilling. The use of borehole geophysics and interval packer sampling was included. The bedrock well installation will also include the installation of a paired overburden well to provide monitoring of vertical gradients within the southern portions of the GMZ and supplement vertical gradients at GZ-129/GZ-130. A Revised Bedrock Well Installation Work Plan is under development at the time of reporting.

USEPA

128. Packer sampling and monitoring of groundwater elevations in MW-23 have shown that this well is not located within the plume migrating along the northern pathway. MW- 23 is located between the Stone Meadow Way development and R3/339 BHR, so there are no receptors downgradient of this location, providing limited usefulness as a long- term monitoring point. The data from MW-23 and the nature of the fracture network in this area should be discussed further in the context of the potential for impact to the receptors to the north of MW-23.

<u>*CLG Response*</u>

Based on the USEPA position regarding the usefulness of this well for long-term monitoring, this recommendation has been removed from the Final Report. With the exception of the Golf Club well at 339 Breakfast Hill Road (339BHR) and the private well at 368 Breakfast Hill Road (R3), the location at 21 Stone Meadow Way (21SMW) is located most proximal to the primary northeast-southwest flowpath. Based on preliminary results from Spring 2022 sampling, 21SMW remains below the reporting limit or non-detect for regulated PFAS compounds. The location at R-5 is an overburden dug well. The CLG plans to extend public water from the existing line servicing the Sewell Meadows 10-lot subdivision to the residence at R-5, which is currently unoccupied and undergoing renovation. Locations R-3 and 339BHR have been on POET systems since late fall 2018 due to exceedances of 1,4-dioxane.

USEPA

129. Optimization of the groundwater monitoring program should not be considered until the additional monitoring described above has been completed and confirmed to support the CSM as described.

<u>*CLG Response*</u>

Optimization of the groundwater monitoring program will be completed following the approval of the Final Report and additional monitoring proposed through the installation and completion of overburden and bedrock monitoring wells. These include but are not limited to the completion of existing deep bedrock borings as permanent monitoring wells, the installation of a new well west of MW-21S, and a new bedrock well to evaluate the southern migration pathway. The optimization is anticipated to include statistical and spatial analysis of the existing monitoring network to determine the level of redundancy, if any, that exists within the network. This optimization will also result in recommended revisions to the project SAP to ensure that all changes that have occurred since 2018 have been captured. This methodology is more robust and would be completed in accordance with a Monitoring and Remediation Optimization System (MAROS) approach.

USEPA

130. Radio dating can be conducted to evaluate the age of groundwater at various points to assess the length of flow paths. The Report makes the statement in several locations that the bedrock is characterized by short flow paths and that groundwater west of Berrys Brook is expected to be older than groundwater from the landfill.

<u>*CLG Response*</u>

The lines of evidence presented in the Final Report are sufficient and support the CSM such that radio dating is not necessary.

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131. Figures

Figure 2.2, 2.2A, & 2.2B:

- **Insignias and color coding of SW, SED, SG, PZ, & PW are not consistent from legend to figure; some sampling locations appear twice and as different colors (i.e., SG-1, SW-4, and SG-3 on Figure 2.2).**
  These figures have been revised for clarity and include the addition of destroyed or abandoned wells described in the Final Report.
- **GZ-127 and GZ-128 have been confirmed destroyed but do not appear on figures. They should be added to figures and shaded to indicate destroyed.**
  Figures have been revised to include the addition of destroyed or abandoned wells described in the Final Report.
- **A private well exists at 65 North Road (Fitzgerald property), and though it is not part of the private well monitoring network, it should be shown on Fig 2.2 & 2.2A because it is located in the GMZ and along the inferred southern flowpath.** *Figures have been revised to include the addition of this well with a note included that it is not sampled as part of the monitoring program.*
- **In Figure 2.2A, residential wells 178A LR and 27 BR, and in Figure 2.2B, 339 BHR, R-3 and 340 BHR, are highlighted in yellow as OU2 wells. They should not be represented as OU2 wells, and only as residential wells as they are in Figure 2.2.**
  Figure symbology has been revised to include these as residential wells and not wells associated with either OU-1 or OU-2.

Figure 3.3 should include the bedrock outcrop location name (i.e., 1A, 1B, etc.) as designated in Table 3.3.

This figure has been updated to include outcrop location IDs consistent with Table 3.3.

Figure 3.4 indicates that it is based on existing sampling locations, which limits the interpretation of the bedrock type and surface contour. All available bedrock lithological and elevation data should be considered for this figure, or another figure added that considers all available data. Figure 3.1: The fracture orientations on Figure 3.1 and lineaments (shown on Figure 3.2) do not appear to align. It should be confirmed that the rose diagrams have been corrected for magnetic declination and that both the base map and rose diagrams are referenced to the same north (magnetic or geographic).

Rose diagrams were corrected for magnetic declination by Northeast Geophysical Services with the rose plots oriented relative to geographic north. It should be noted that lineament accuracy is based on the digitizing of non-georeferenced base data and is subject to some level of error during the digitizing process. The process involved the "rubber sheeting" of the static RI lineament figure over current high resolution aerial imagery using fixed points of reference (i.e., road intersections). This allowed for the placement of lineaments spatially within the current coordinate New Hampshire State Plane system. This was necessary based on original map quality and use of non-referenced spatial information.

Figure 3.4: Note 5 indicates that contours were developed from boring logs, while the legend defines the bedrock surface contour, so that it is not clear if the contours represent depth to bedrock or bedrock elevation. The extent of the Breakfast Hill Granite appears to be limited and based strictly on interpretations of outcrops and boring logs. Similar to the comment for Figure 3.4, all available bedrock lithological and elevation data should be considered.

Available geologic information was used to refine the top of bedrock surface contour map. These sources of information include boring logs, surface geophysics, bedrock outcrops, etc. Elevations of RI borings and those installed since the RI were checked against the existing monitoring well database. This includes the use of borings that have been abandoned or destroyed (i.e., GZ-106, GZ-107A) where locations have been estimated based on historical aerial imagery and site features (i.e., landfill access roads).

Figure 3.4 identifies a "Possible Linear Fracture" which would suggest potential for flow to the E-SE from the NE corner of the landfill towards the Bailey Brook drainage basin. The downhole geophysics log for MW-24 suggests that well encountered the mafic intrusive rocks, yet these are not shown on the bedrock geologic map.

The revised bedrock topography map included with the Final Report incorporates a more robust interpretation of geologic information, including that within MW-24, and is consistent with revised overburden isopach contour maps generated as part of the reporting effort.

Figure 3.5: The NWI Wetland delineation appears different from the previous figures. For example, the DPT locations are shown to be outside of the NWI delineated area, while they appear inside the NWI delineated area in Figures 2.2, 2.2A and 2.2B. In addition, the "F" and "J" qualifiers in the table should be defined.

This inconsistency has been addressed in the revised figure.

Figure 4.1: The figure does not appear to include the observations of till from the DPT, MW-20, MW-21 or MW-22 borings and appears to be based only on data from the original RI. <u>All available lithological data should be considered for development of Figures 4.1, 4.2 and 4.3.</u> This figure should be enhanced with the most recent geologic data. The 40 ft contour near GZ-125 is not supported by any data and is likely plotted incorrectly. A smaller contour interval (5 or 10 feet) should be used to show more detail. <u>The interpreted extent of the till does not align with the bedrock surface map presented in Figure 3.4. The depths for GZ-123 and GZ-125 are flipped between the table and the figure.</u>

A revised isopach thickness map (Figure 4.1) has been generated for glacial till that incorporates all available lithologic data. Correlation between bedrock topography and overlying till, marine deposits, and glacial outwash were used in the development of revised figures.

The legend in Figure 4.1 defines the glacial till thickness contour, while the table in the figure and the indication at each well identify depth to till. For example, depth to till for FPC-9B is shown as 56 feet in the table but is plotted within the 40-foot thickness contour on the figure. Figure 4.5 also appears to show depth to till at FPC-9B as about 56 feet, but the thickness looks to be about 15 feet. This comment also applies to Figure 4.2 for marine deposits. Contouring the depth to a certain unit provides little meaning because the surface topography is highly variable. Rather, the elevation of the top of the unit should be contoured. This comment applies to Figures 4.1, 4.2 and 4.3.

A revised isopach thickness map has been generated for glacial till that incorporates available lithologic data. Correlation between bedrock topography and overlying till, marine deposits, and glacial outwash were used in the development of revised figures.

The titles of Figures 4.1 and 4.2 do not clearly define what the figures are showing. Consider changing the titles to "Contoured Depth to Glacial Till" and "Contoured Depth to Marine Deposits".

New figures were generated with a more clear depiction of overburden unit thicknesses.

Figure 4.4 shows FPC-5B, MW-5D, and MW-5S in the Rye Formation and Figure 4.5 shows FPC-9B in the Rye Formation, but Figure 4.6 shows them both in the BHG. The same comments were made in EPA's February 6, 2020, letter on the 2019 Interim Report.

Geologic cross sections have been updated to more accurately represent the bedrock formations and lithologies in which these wells have been depicted.

Fig. 4.5 shows GZ-109 and GZ-117 to be 571.7' and 540.65' off center of the B-B' line, respectively, but Figure 4.3 shows them to be very close to, if not on the line.

Updates to cross sections have been completed to be accurate with regards to their relationship to the alignments depicted on Figures 2.2, 2.2A, and 2.2B.

Figure 4.6 shows MW-24 as being in the BHG, which is not correct.

The geologic map illustrating the extent of the BHG has been updated and includes well MW-24 in the Rye Formation.

Figure 4.7 does not correlate with the lithological interpretations shown in the cross sections. All available data should be considered for this lithological interpretation.

*Figure 4.7 has been updated with the lithologic interpretations consistent across figures. Additionally, all lithologic interpretations have been detailed in **Table 3.6**.*

Figure 4.8: The bedrock surface contours are not consistent with those shown on Figure 3.4.

Bedrock surface contours have been updated based on existing and abandoned monitoring wells and borings and are reflected in the updated figures.

Numerous figures (4.7, 4.8. 4.16. 4.17, 4.18) all of which appear to have been prepared by Sanborn Head, reference Appendix XX, which is not included in the Report. These figures appear to have been only slightly modified from the Interim Report, if at all.

Updates to figures prepared by Sanborn Head have been prepared from those included in the interim report.

Figures 4.10 (1,4-dioxane) and 4.12 (PFOA) show the presence of contaminants to the east of the landfill that supports an eastern component of flow that is not adequately discussed in the Report.

The Final Report addresses the eastern flow pathway and the presence of site contaminants in monitoring wells east of the landfill.

Figures 4.16, 4.17 and 4.18: The data within the blue boxes should be defined in the legend.

This has been addressed in Final Report figures.

Figure 4.19: Concentration contours south of GZ-105 are unbound and should be dashed. Consider updating figure to reflect exceedances of 1,4-dioxane in 178A.

This has been addressed in Final Report figures.

Figure 4.21: Concentration contours south of GZ-105 are unbound and should be dashed. Consider updating figure to reflect exceedances of PFOA at 399 BHR (R-5).

This has been addressed in Final Report figures. It should be noted that R-5 is a dug overburden well and is therefore not included with the bedrock concentrations of PFAS. In addition, where possible, consistency in use of Spring/Fall 2020 data for the Final Report was observed with the exception of DPT analytical data at TMW-11S/11D.

Additional explanation is needed regarding the interactive 3-D Figure 5.2. It is not obvious what that figure is intended to illustrate. The vertical scale on Figure 5.2 is too small to allow inspection of the various overburden layers and their interaction with bedrock and in fact the overburden is not discretized into its components.

The 3D figure included with the Draft Report is not needed or included with the Final Report due to the limitations provided in visualizing the conceptual flow of groundwater and surface water in light of the CSM presented. A new conceptual drawing has been developed and is supported by additional hydrogeologic information (i.e., flowlines) presented on revised site cross sections.

132. Tables

- **Table 3.1 Inventory of Monitoring Locations: If well records exist, they should be appended and summarized in a separate table. 340 BHR is not in the GMZ, as noted.**

  Table 3.1 has been updated with the residential locations included as a separate table. These updates include the addition of more details on wells construction with the available well records, as available from NHDES OneStop included with Appendix A of the Final Report.

- **Table 3.6 Residential Well Record Review: The private wells that are part of the current monitoring network should be added to this inventory. If well records exist, they should be appended and summarized in a separate table. The existing table has several errors:**
  - **well R-3 is currently not located in the GMZ, as noted;**
  - **well R-1 is not located in the GMZ, as noted; and**
  - **65 North Road is located in the GMZ.**

  Table 3.6 has been updated to include available well records and corrections to their location relative to the GMZ (inside or abutting) included.

- **All of the Table 4.3 tables are labeled as manganese. USEPA screening levels should be included for PFOA and PFOS.**

  All of the site COC tables will be included with the correct headers.

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133. Appendices

- **The boring logs in Appendix A should be organized chronologically and breaker pages added between groups of logs to aid the reader in finding specific logs. The DPT logs prepared by Haley Ward in 2020 are sandwiched between Aries Engineering logs from 2003 and CDM logs from 1992.**

  This has been addressed with 2018 boring logs and 2019 well construction diagrams combined into single set for MW-20/-21/-22 and 2021 includes construction details for MW-25 completed in 2022. Residential logs that were available from NHDES OneStop have also been included and bookmarked appropriately.

- **Appendix D plot for BP-4 is mislabeled as PB-4.**

  The Well ID/Label for BP-4 has been corrected.

- **Note that Appendix B and E each have 180+ pages repeating the geophysical logs, with the difference being that E includes interval sampling data.**

  Appendices B and E have been combined into a single appendix (Appendix C) with packer sampling results included on all logs.

DEEP BEDROCK INVESTIGATION FINAL REPORT

Prepared for:

COAKLEY LANDFILL
NORTH HAMPTON, NEW HAMPSHIRE
NHDES SITE #198712001

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LIST OF ACRONYMS AND ABBREVIATIONS

AGQS	Ambient Groundwater Quality Standards
AMSL	above mean sea level
BHG	Breakfast Hill Granite
bgs	below ground surface
CL	Cleanup Level
CLG	Coakley Landfill Group
COCs	contaminants of concern
CSC	Central Silicic Complex
CSM	Conceptual Site Model
DPT	Direct Push Technology
DQO	Data Quality Objective
ESD	Explanation of Significant Differences
FYR	Five-Year Review
GAC	granular activated carbon
GIS	Geographic Information Systems
GMP	Groundwater Management Permit
GMZ	Groundwater Management Zone
gpm	gallons per minute
HA	Health Advisory
HPFM	heat-pulse flowmeter
ICL	Interim Cleanup Levels
LiDAR	Light Detection and Ranging
MCL	Maximum Contaminant Level
MSL	mean sea level
ng/L	nanograms per liter
NGS	Northeast Geophysical Services
NHDES	New Hampshire Department of Environmental Services
NPL	National Priorities List

ORP	oxidation reduction potential
OTV	optical televiewer
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbons
PFAS	per- and polyfluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SAP	Sampling and Analysis Plan
Site	The Coakley Landfill Superfund Site
SVOC	Semi-volatile organic compounds
ug/L	micrograms per liter
µS/cm	microSiemens per centimeter
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	volatile organic compounds

EXECUTIVE SUMMARY

Introduction and Site History

The Coakley Landfill Superfund Site (Site) includes approximately 92 acres in Greenland and North Hampton, New Hampshire. The Site was the location of a historical unlined landfill active between 1972 and 1985. Complaints related to leachate breakouts around the landfill in 1979 and concerns regarding groundwater quality in surrounding drinking water wells in 1983 led to confirmatory sampling of residential wells east and southeast of the Site. Based on results of this sampling and following completion of a water line extension along Lafayette Road (U.S. Route 1) as an alternate water source for properties using groundwater, the United States Environmental Protection Agency (USEPA) proposed listing the Site on the National Priorities List (NPL) and it was listed in 1986. Subsequently, a Remedial Investigation (RI) was completed for Operable Unit (OU)-1 (landfill site proper) in 1990 and OU-2 (surrounding area) in 1994. Both studies identified contaminated groundwater including volatile organic compounds (VOCs) underlying and outside the boundary of the landfill. In 1990, a Record of Decision (ROD) was issued for OU-1 to 1) prevent ingestion of groundwater containing contamination in excess of Federal and State drinking water standards; 2) prevent the public from direct contact with contaminated soils, sediments, and solid waste; and 3) eliminate or minimize the migration of contaminants from soil to groundwater through consolidation of waste and capping of the landfill. Waste consolidation and capping were completed in 1998. The groundwater treatment identified in the ROD for OU-1 included the pumping and treatment of groundwater using chemical precipitation and air stripping for the removal of metals and VOCs, respectively. Following the capping of the landfill and subsequent groundwater monitoring, the chemical and hydrologic conditions at the landfill had changed to the extent that the groundwater treatment system was no longer required (USEPA, 1999). The ROD for OU-2 calls for;1) prevention of ingestion of groundwater containing contamination in excess of drinking water standards; 2) facilitation of the restoration of groundwater aquifer to drinking water standards; 3) ensuring that the remedy does not negatively impact the wetlands over a period of 30 years while contamination naturally attenuates; and 4) the elimination of potential threats posed by the future ingestion of contaminated groundwater by implementing institutional controls restricting the use of the groundwater. Since 1998, post-remedial water quality monitoring has been ongoing at the Site.

USEPA routinely conducts a Five-Year Review (FYR) of the Site to evaluate the implementation and performance of the Site remedy and to determine if the selected remedy remains protective of human health and the environment. The USEPA has conducted five FYRs since the issuance of the RODs for the Site and construction of the selected remedy. FYRs for the Site have been published in 2001 (USEPA, September 2001), 2006 (USEPA, September 2006), 2011(USEPA, September 2011), 2016 (USEPA, September 2016), and 2021 (USEPA, September 2021).

As part of institutional controls for the Site, the New Hampshire Department of Environmental Services (NHDES) issued a Groundwater Management Permit (GMP; GWP-198712001-N-001) for the Site for a five-year term on June 19, 2008. This GMP was subsequently renewed January 7, 2014, with an application submitted for renewal in October 2018 and Groundwater Management Zone (GMZ) expansion memorandum submitted in December 2018. The GMP included requirements for long-term environmental monitoring activities and created a GMZ that requires recording notice of the permit on all deeds within the GMZ. The GMZ was expanded in 2014 due to detections of 1,4-dioxane above cleanup goals along the northwestern portion of the Site, as indicated in the fifth FYR.

Interim Cleanup Levels (ICLs) for COCs were established in the ROD for groundwater and subsequently modified in several Explanations of Significant Differences (ESDs). The Fifth ESD issued in August 2015 formally changed the ICLs to Cleanup Levels (CLs) and established a CL for 1,4-dioxane. In 2016, USEPA and NHDES identified polyfluoroalkyl substances (PFAS) as an emerging environmental contaminant group that may be present in Site waste and requested that the CLG sample for PFAS in groundwater. In May 2016, the CLG initiated sampling for PFAS at a select group of seven monitoring wells within OU-1 and confirmed the presence of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) within the landfill boundary above USEPA's lifetime health advisory (HA) for exposure to these substances. Results from OU-1 led to the identification and sampling for PFAS of 20 wells within OU-2 and 18 private water supply wells. Results from these sampling efforts were provided in a September 2, 2016, memorandum *Results of Perfluorinated Chemical Groundwater Sampling for Selected Wells within OU-1 and OU-2 at the Coakley Landfill – North Hampton, New Hampshire*. Since 2016, PFAS have been included in the ongoing monitoring at the Site in all Site monitoring locations.

In September 2016, the USEPA completed the fourth FYR of the conditions at the Site and concluded that:

- The remedy at OU-1 was protective of human health and the environment.
- The remedy at OU-2 was protective of human health and the environment, with the exception of uncertainty related to the potential for human exposures in the southern area of the GMZ.
- A determination of Site-wide protectiveness needed to be deferred until additional data regarding OU-2 could be obtained and evaluated.

Following the fourth FYR conclusions, CLG obtained and provided to the USEPA additional data regarding OU-2. On September 28, 2017, the USEPA issued an addendum to the fourth FYR report (USEPA, September 2017) that updated the Site-wide protectiveness determination to indicate that, based on available data, current conditions were protective of human health and the environment in the short-term because data indicated no human exposures to COCs at levels exceeding either state or federal standards. However, the addendum to the fourth FYR report also concluded that "long-term uncertainty remained with respect to potential migration of contaminants in deeper portions of bedrock at the Site."

To address the concern expressed in the addendum to the fourth FYR report regarding uncertainty about migration in deeper bedrock, USEPA and the NHDES requested that the CLG undertake additional investigations to evaluate the potential migration of contaminants in deep bedrock at the Site. These additional investigation activities were outlined in the Deep Bedrock Investigation Work Plan (Work Plan; Haley Ward, May 2018) conditionally approved by the USEPA on July 17, 2018. The Work Plan presented a phased approach to collect and analyze additional Site data and perform additional investigations, as deemed necessary in consultation with the USEPA and the NHDES. Information collected during the execution of the Work Plan was summarized in the Deep Bedrock Investigation Interim Report (Interim Report; Haley Ward, November 2019) submitted to the USEPA and NHDES on November 25, 2019.

On February 6, 2020, the USEPA requested an addendum to the Work Plan to address additional informational requirements. The *Draft Deep Bedrock Investigation Work Plan Addendum* (Haley Ward, July 2020) was submitted to the USEPA on April 30, 2020. USEPA comments to the Draft Work Plan Addendum were received on June 17, 2020, with the *Final Deep Bedrock Investigation Work Plan Addendum* submitted on July 17, 2020. The Final Work Plan Addendum was conditionally approved by USEPA on August 4, 2020. The CLG has executed the Work Plan and Work Plan Addendum in cooperation and consultation with the USEPA and the NHDES (collectively referred to as the Agencies) to refine the understanding of Site conditions. The execution of the Work Plan and Work Plan Addendum included the completion of a Pumping Test Work Plan at the request of the USEPA.

Completed Investigation Activities

The deep bedrock investigation was based on a comprehensive scope of work including the following items presented in the 2019 Interim Report:

- Chinburg Well/MW-23 Investigation (2017): This effort included a borehole geophysical survey, pressure transducer data collection, and interval packer sampling (see Section 3.1.1).
- Location, installation, and construction of shallow and deep bedrock wells MW-20 S/-20D1/-D2, MW-21S/-21D1/-D2, and MW-22S/-22D1/-D2 on the western edge of the Site (2018; see Section 3.1.2).
- Reconnaissance bedrock well assessment of open bedrock monitoring wells (2018; designated as reconnaissance wells and/or open borehole bedrock wells in this report) installed as part of the original RI. These open borehole wells were identified as GZ-103, GZ-108, GZ-109, GZ-110, GZ-116, GZ-119, GZ-122, GZ-125, GZ-128, GZ-130, and GZ-131. MW-24 was also assessed. The assessment included well redevelopment, borehole geophysical surveying, and interval packer sampling (see Section 3.1.3).
- Installation of pressure transducers to measure water level fluctuations over time ahead of an irrigation well yield test at the Breakfast Hill Golf Club (2017), within MW-20D/-21D/-22D following well completion (2019), and in several reconnaissance bedrock boreholes (2019; see Section 3.1.7).
- Bedrock outcrop mapping at the Site and in the surrounding area to provide additional data on locations and orientation of fractures in the vicinity of the Site (2018 and 2019; see Section 3.2).
- A surface water evaluation to better understand the hydraulic connection between groundwater and surface water (2019 to present; see Section 3.4 and Section 4.4).

The following activities have been completed since the 2019 Interim Report:

- Well redevelopment, borehole geophysical data collection, and interval packer sampling at MW-6 to determine the well's viability for use as the pumping test well (2020; see Section 3.1.4).
- Borehole geophysical data collection at BP-4 to identify geologic structure and lithology penetrated by BP-4 (2021; see Section 3.1.5).
- The locating and installation of a new deep bedrock boring at MW-25. MW-25 was located using surface geophysical methods with borehole geophysical data collection and interval packer sampling completed in the borehole to better understand the interconnection of fractures within bedrock west-southwest of the landfill and to address a data gap associated with the potential for a southern migration pathway within deep bedrock (see Section 3.1.6).
- Installation of pressure transducers to monitor water level fluctuations over time during the installation of MW-25 (early 2021) and before, during, and after the pumping tests (mid-2021; see Section 3.1.7).
- Additional bedrock outcrop mapping throughout the Site and surrounding areas (2021; see Section 3.2).
- Both a variable rate and constant rate pumping tests were completed at MW-6 to assess bedrock fracture connectivity and further evaluate the southern migration pathway in bedrock and to assist with 1) refining the Conceptual Site Model (CSM) and further the understanding of deep bedrock hydrogeology, 2) determining whether transmissive fractures intersected by bedrock monitoring wells provide likely contaminant migration pathways to potential receptors; and 3) evaluating the flow of groundwater within deep bedrock fractures and its relationship with overburden and shallow bedrock (2021; see Section 3.3).
- A surface water evaluation to better understand the hydraulic connection between groundwater and surface water (2019 to present; see Section 3.4 and Section 4.4).
- Direct Push Technology (DPT) Investigation of impacts west of MW-21S to allow for definition of the extent of contaminant impacts in overburden near the western boundary of the GMZ (2020 to 2021; see Section 3.5).
- A residential water supply well records investigation to determine potential additional wells for monitoring and/or sampling (2021; see Section 3.6).

Geology and Hydrology

Data and results collected since the Site investigation began with the RI indicate that the geology and hydrogeology of the Site are consistent with typical conditions in this area of New Hampshire. Observed stratigraphy consists of discontinuous glacial outwash overlying discontinuous marine deposits, overlying till, and overlying fractured bedrock. Overburden thickness ranges from less than one foot in upland areas west of the wetland complex (e.g., MW-21D) to up to 85 feet in the wetland complex west-northwest of the landfill (FPC-5A). Bedrock outcrops are predominantly in areas north and northwest of the landfill; however, outcrops have been mapped in areas west of the wetland complex and in areas south of the landfill adjacent to the former railroad easement. Bedrock directly underlies the landfill, as the landfill sits on a bedrock topographical high that was quarried from approximately 1973 to 1981 to a base level of approximately 90 feet above mean sea level (AMSL); however, some areas of bedrock underlying the landfill remain at higher elevations of approximately 96 feet AMSL based on borings completed during the original RI.

According to the RI, the Assessment of Ground-Water Resources in the Seacoast Region of New Hampshire report published by the United States Geological Survey (USGS; Mack, 2012), and scientific publications written by Escamilla-Casas (2003) and Lyons et. al. (1997), the lithologies underlying the study area are composed of the Rye Complex, a major geologic unit comprised of the Rye Formation (schist/gneiss) and the Breakfast Hill Granite. Based on borehole geophysics statistical analysis and analysis of bedrock outcrop fracture orientation measurements, the primary fracture orientation is northeast-southwest with a median dip of 64° to the west-northwest (WNW).

The topography of the Site is controlled by the lithology of bedrock and overburden material. A ridge of bedrock underlying the landfill extends to the south along Lafayette Road and to the north beyond Breakfast Hill Road is largely composed of what has been referred to as the Breakfast Hill Granite, consisting of intrusive igneous rocks including pegmatites and highly foliated felsic gneiss. These lithologies are grouped together in the original RI and in this report as the Central Silicic Complex (CSC). Overburden thickness increases to the east and west, away from the ridge of the CSC, where the uppermost rock is the more easily erodible Rye Formation identified at lower elevations. The Rye formation is characterized by phyllite and quartzite with micaceous schist identified in boreholes proximal to the contact with the Breakfast Hill Granite/CSC. To the east of the CSC, a thick package of marine clays is overlain by glacial outwash that allows for ground surface elevation to remain flat, consistent with elevations of the bedrock ridge. To the west of the landfill, a northeast to southwest trending bedrock trough filled with glacial till, marine clays, and glacial outwash has been mapped, coincident with the local topographic low. This bedrock trough underlies a large wetland complex that serves as the headwaters of both Berrys Brook and the Little River watersheds. West of the wetland complex, ground surface elevation rises and outcrops of the Rye Formation have been identified during field investigations and through LiDAR imaging, indicating the thickness and extent of surficial material deposits is limited.

Groundwater flow at, as well as to the north and south of the capped landfill, has been shown to be primarily westward in overburden until it reaches the wetland complex in the topographic low west of the landfill. Once groundwater approaches the wetland complex, the gradient decreases and the flow bifurcates to the northeast and to southwest around a local high, or "saddle", in the bedrock identified through geophysical surveys and drilling operations at MW-25 and GZ-105. Groundwater levels measured to the west of the wetland complex also show groundwater flow pathways to have a shallow gradient to the east, towards the wetland complex.

East of the landfill, overburden groundwater flow is controlled by the stratigraphy of overburden and hydraulic gradients. Water levels in the outwash, glacial till, and underlying bedrock east of the landfill are higher than water levels to the west of the landfill; however, the presence of the CSC ridge acts as a barrier to westward flow through overburden. In outwash, groundwater is shown to flow to the north, west, and south, radially away from the high at GZ-117. Based on topography and the expression of surface water, there must be an eastward component of groundwater flow to the east of GZ-117 outside of the extent of site related impacts to groundwater. In glacial till, there is northern, eastern, and southern component of flow, emanating from the local high at MW-4, at the southeast corner of the landfill. The extent of glacial till underlying marine clays east of the landfill is limited in extent, pinching to less than five feet in thickness towards the north, south, and east, and is not identified in wells installed east of Lafayette Road. The marine clays, while not transmissive for groundwater flow, acts as a confining unit for groundwater in the underlying glacial till.

Groundwater flow in fractured bedrock is controlled by local and regional hydraulic head distributions as well as lithologic controls on the magnitude and orientation of fractures. For the Seacoast region, the primary fracture orientation trends to the northeast-southwest with a steep dip, consistent with the results of downhole geophysical surveys and outcrop mapping completed for this investigation and the lineament analysis completed for the original RI. In addition to these primary fractures, there are secondary steeply dipping fractures striking generally perpendicular to the primary orientation. In addition to these primary and secondary steeply dipping fractures, there are horizontal or shallowly dipping “sheeting” fractures along the Seacoast and mapped locally to the project area. Mack 2012 predicts a 5:1 anisotropy parallel to the primary fracture network in bedrock in this region, meaning the ability of the bedrock aquifer to transmit groundwater along the primary fracture network north to south is five times greater than the ability of the bedrock aquifer to transmit water to the east and west.

At this Site, consistent with the regional bedrock geology, there are three flow paths within fractured bedrock: 1) parallel with the primary fracture orientation identified by Site data and regional studies which is coincident with the northerly to southerly trending bedrock trough underlying the wetland complex west of the landfill, 2) westerly/easterly downdip via secondary steeply dipping fractures orthogonal to the primary network and, 3) laterally along shallow dipping “sheeting fractures” from the landfill and relative bedrock elevation high at the Site towards the wetland complex that forms the headwaters for the Little River and Berrys Brook. Results from the Deep Bedrock pumping test indicate there is a roughly 5:1 anisotropy in bedrock groundwater flow along the primary orientation of these fractures to the northeast and southwest in the CSC, consistent with Mack 2012 predictions. At the site, sheeting fractures are found to be fewer than the primary foliation parallel and crosscutting fractures and generally not associated with transmissive zones identified through borehole geophysics.

Vertical gradients identified in shallow and deep bedrock wells located in the bedrock trough and to the east and west are indicative of flow pathways to the trough and into the more permissive overburden units that ultimately allow for discharge to surface water. Hydraulic gradients in deep bedrock wells appear to be locally affected by the presence of the trough that provides a discharge point allowing deep bedrock groundwater to be pulled vertically. Both shallow and deep bedrock have been shown to exhibit a similar flow pattern as overburden groundwater, with converging flow patterns from the east and west of the bedrock trough, which bifurcates to the northeast and southwest when it reaches the bedrock trough.

Based on regional topography, there must be a deep bedrock groundwater divide east of bedrock well GZ-109. As such, there must be deep bedrock groundwater draining towards the North Brook or Baileys Brook watersheds. However, GZ-109 and upgradient bedrock wells closer to the landfill, consistently show no impacts from site COCs. In shallow bedrock it is expected that groundwater flow pathways are consistent with bedrock topography, allowing some aspect of eastern flow away from the CSC. However, the bedrock is identified underly a thick sequence of marine clays which would inhibit discharge of shallow bedrock groundwater to shallow groundwater and ultimately surface water. Eastward migration of site contaminants in bedrock is not expected against the identified hydraulic gradients driving bedrock groundwater to the west as shown in the flow nets and groundwater contour maps discussed in Section 4.

These Site characteristics generally agree with Mack's (2012) steady state modeling of the Seacoast region that shows a hydraulic high, coincident with the local topographic high, in the general vicinity of the watershed divide of the Little River and Berrys Brook. This hydraulic high is driving groundwater at a regional scale to the south/southeast along the Little River Watershed, northeast along the Berrys Brook watershed, and to the northwest, towards the Great Bay Estuary. It appears that locally, the regional flow pattern to the northwest is obscured by the influence of local topography and lithology, following a path through the more permeable overburden material such (i.e., glacial till or outwash) to the drainages in the local topographic low.

The OU-1 and OU-2 RIs identified impacted groundwater beneath and outside the boundary of the landfill. VOCs detected at the Site included benzene, ethyl benzene, chloroethane, chlorobenzene, and xylene. Semi-volatile organic compounds (SVOCs) detected at the Site included predominantly polycyclic aromatic hydrocarbons (PAHs) and dichlorinated benzenes. Inorganic compounds detected in groundwater and sediment samples included arsenic, barium, iron, lead, manganese, nickel, beryllium, selenium, and vanadium.

Source control activities were completed as part of the OU-1 remedial actions to address groundwater impacts and potential for leaching of soil contaminants to groundwater. Beginning in 1996, the waste from along the perimeter of the landfill was relocated to the top of the landfill as part of the OU-1 remedial action. Impacted wetland sediments were also removed from adjacent to the landfill and placed on the landfill during 1997 and 1998. Capping of the landfill consisted of both a synthetic liner and an underlying clay layer. Following completion of the landfill cap, the plume of VOC- and chlorinated VOC-contaminated groundwater stabilized and began attenuating based on sampling results in the late 1990s and early 2000s.

1,4-dioxane and PFAS were added to the monitoring program in 2009 and 2016, respectively, as emerging contaminants being examined in New Hampshire and nationally. They were identified in groundwater at the Site and found to be migrating from the Site into groundwater. Additional changes in the sampling program have included the alignment of the VOC analyte list with NHDES requirements.

Today, primary remaining dissolved phase contaminants at the Site include 1,4-dioxane and PFAS, although contaminants typical of landfill leachate and or reducing conditions in groundwater are also present, including iron, manganese, and arsenic. PFAS, 1,4-dioxane, arsenic, and manganese continue to be detected at concentrations above ambient groundwater quality standards (AGQS) in several monitoring wells at the Site. 1,4-dioxane and PFAS are present in many consumer products and industrial wastes and are therefore commonly detected in groundwater at landfills. In addition, the layer of topsoil that was placed on the landfill cap was augmented with compost and sand to promote growth of vegetation. PFAS is associated with certain compost and the augmented landfill cap was constructed according to common practice at the time, before PFAS were identified as emerging contaminants.

Concentrations for most site contaminants in most wells demonstrate statistically significant decreasing concentrations of contaminants or no trend as determined through Mann-Kendall analysis. A limited number of wells do show statistically significant increasing trends for certain contaminants. The distribution of increasing compared to decreasing or stable trends is provided in this report as well as figures, with implications for plume stability incorporated into the conceptual site model.

Conceptual Site Model

The extensive studies conducted historically and through the bedrock investigation have allowed development of a robust CSM and understanding of the deep bedrock environment at the Site.

Three migration pathways exist in deep bedrock:

1. The predominant pathway for migration through bedrock is along the northeast-southwest primary fracture network, coincident with the identified bedrock trough;
2. Secondary/limited migration East-Southeast – West-Northwest along cross-cutting fractures parallel to the secondary set of lineaments; and
3. Limited migration laterally through sheeting fractures that have horizontal to very shallow dips.

The distribution of contaminants (including 1,4-dioxane, PFAS, arsenic, manganese, and historical distribution of VOCs) aligns with these three pathways, predominantly the north-south primary fracture network as further supported below. Concentrations along these pathways decrease with distance, with the highest concentrations of contaminants immediately west of the landfill footprint. In addition to deep bedrock transport pathways, landfill cap soil materials contribute PFAS to surface water and shallow groundwater, as confirmed by recent stormwater, surface water, and landfill cap material sampling. While not a deep bedrock pathway, this source is important to overall Site understanding and is discussed in more detail throughout the report.

These conclusions are supported by the following:

1. PFAS and 1,4-dioxane are migrating westward from the landfill through bedrock and overburden sediments consistent with principal groundwater flow direction based on observed hydraulic gradients. Groundwater is subsequently discharging to, and surface water is collecting in, a wetland complex located west of the landfill. Surface water flow from this

wetland complex is both south towards North Road and north towards Breakfast Hill Road, consistent with dominant fracture strike (and a bedrock valley or trough). To a lesser extent, PFAS and 1,4-dioxane are identified to the east of the bedrock topographic high located east of the Site boundary. The conclusions in this paragraph are supported by the following:

a. The presence of a bedrock trough running north-south and underlying the wetland complex, Little River, and Berrys Brook and the dominant fracture strike orientation of nominally NE-SW.

b. Bedrock fracture orientation data showing dominant dip angle of WNW and moderately to steeply dipping (median of 64 degrees).

c. Bedrock topography slopes west towards the wetland complex and east from the eastern boundary of the Site. The westward slope is consistent with the observed decrease in water levels in overburden and bedrock groundwater contours.

d. Groundwater flow in overburden east of the CSC and the landfill is controlled by overburden lithology and hydraulic gradients. Hydraulic gradients in the outwash units illustrate radial flow, to the west, north and south from a local high in the vicinity of GZ-109. In glacial till, radial flow to the north, south, and east from the local groundwater high at MW-4 is constrained by the extent of the till unit underlying the marine clays. Historically, hydraulic gradients reported in the original RI identified stronger eastward flow from the landfill, prior to the installation of the current cap and stormwater management system. Mounding due to infiltration of stormwater into the refuse pile increased the local water table, creating a more significant gradient (and ability of the aquifer to transmit contaminant mass) to the east.

e. Vertical gradient data from monitoring well couplets and heat-pulse flowmeter results from the geophysical testing in open boreholes generally show hydraulic head values at higher elevations in the deeper bedrock fractures compared to the shallow bedrock fractures. These relationships illustrate that at discrete locations vertical gradients can drive groundwater flow from deep to shallow bedrock. On a site wide scale, groundwater flow nets have been constructed which illustrate the vertical and horizontal flow pathways that drive groundwater and site contaminants generally east to west, from Lafayette Road, across the landfill and into the wetland complex located west of the landfill. To the west of the wetland complex there is a lower gradient in deep bedrock. However, hydraulic head values indicate similar flow patterns, where deep and shallow bedrock is flowing toward the trough and ultimately the outlet provided by the surface water drainages. These conditions are consistent with the work completed by Mack (2012) which conceptualizes the localized effects of surface water drainage on regional flow pathways through bedrock in the Seacoast region.

f. Contaminant distribution shows the highest concentrations of 1,4-dioxane and PFAS are present in monitoring wells located closest to the landfill, with detectable concentrations coincident with the Berrys Brook valley. Relationships between concentrations of 1-4-dioxane and PFAS in the context of their spatial relationships to the landfill illustrate that there are two sources of site contaminants. One source of PFAS is from stormwater runoff that originates from interaction with the landfill cap into the engineered retention ponds north of the landfill and directly to the ground surface through underdrain discharge and a second source for PFAS, and identified source for 1,4-dioxane, is from groundwater interaction with refuse below the landfill. No 1,4-dioxane has been detected in stormwater that originates with the landfill cap.

g. Contaminant impacts to the surface water features (wetland complex, Berrys Brook, and Little River) indicate discharge of groundwater to surface water. Overburden lithology as illustrated in cross sections and isopach thickness maps developed for this report illustrate the pathways for groundwater travelling west from the landfill discharge to surface water.

2. Established flow paths of contaminant migration are well understood. Hydraulic gradients are driving contaminant migration from the landfill, determined largely by overburden and bedrock lithology as well as regional bedrock fracture networks:

   a. Of the 36 instrumented wells/intervals monitored during the constant rate pumping test, only five wells (FPC-2B, MW-2, MW-5S, MW-5D, and MW-11) exhibited drawdown resulting from the pump test after a duration of 98 hours and 40 minutes at a consistent drawdown of roughly 135 feet below the static water level and a withdrawal rate ranging between 11.4 and 11.8 gallons per minute (gpm). This hydraulic influence observed in wells FPC-2B (785 feet southwest of MW-6), MW-2 (288 feet north of MW-6), MW-5S (359 feet north/northeast of MW-6), MW-5D (370 feet north/northeast), and MW-11 (588 feet north of MW-6) during the constant rate pumping test is consistent with observations made during the redevelopment of MW-6 and the variable rate pumping test. It is noted that the variable rate test and redevelopment of MW-6 did not illustrate observable drawdown in wells MW-11 or FPC-2B, however those efforts involved pumping at lower rates for a shorter duration, and the response during the constant rate pumping test in those wells was not immediately apparent. The pumping test confirmed, through pumping at a rate and duration that reflected the maximum yield of MW-6, that transmissive fractures in deep bedrock exhibit a roughly 5:1 anisotropy along the predominant north to south trending fracture network.

   b. Transmissivity (T), Hydraulic Conductivity (K), and Storage Coefficient (S) of the aquifer were estimated from water level drawdown data in wells MW-5S and MW-5D which illustrated aquifer properties along the primary fracture network identified in the bedrock fabric to the northeast to southwest:

      i. Transmissivity was estimated to be 108.4 feet^2/day along the primary fracture network

      ii. Hydraulic Conductivity (K) values were estimated to be roughly 0.62 feet/day along the primary fracture network

   iii. Storage Coefficient (unitless) values were estimated to be 4.316×10^{-5} along the primary fracture network

c. A contour map illustrating the magnitude of drawdown was generated which supports the 5:1 anisotropy along the primary fracture network predicted by Mack 2012, allowing for the estimation of Transmissivity and Conductivity values orthogonal to the primary fracture network

   i. Transmissivity values were estimated to be roughly 20 feet^2/day orthogonal to the primary fracture network.

   ii. Hydraulic Conductivity (K) values were calculated to be roughly 0.12 feet/day orthogonal to the primary fracture network.

d. A review of aquifer properties calculated and reported by Golder Associates from a Pre-Design pumping test completed as part of the Coakley Landfill Feasibility Study in 1994 showed a range of T values from 92 to 368 feet^2/d, K values from 0.99 to 3.69 feet/day, and S values from 5.4 x 10-4 to 0.42. The USGS (Mack 2012) assumed hydraulic conductivity values between 0.5 and 1.0 feet/day for the Rye Complex, the formation underlying much of the Site.

e. During the drilling of the boring at MW-25 into deep bedrock, shallow bedrock wells proximal to MW-25 exhibited drawdown, illustrating a hydraulic connection. This is likely due to 1) east-west trending lineaments being outside the influence of MW-6 during the pumping test or 2) these shallow bedrock wells are in hydraulic communication with the laterally extensive, relatively coarse grained and poorly sorted angular glacial till underlying the wetland complex.

   i. The hydraulic connection between the shallow to deep bedrock aquifer underlying the wetland complex and overburden groundwater is supported by the analysis of background water levels prior to the initiation of the constant rate pumping test. Bedrock wells located in or adjacent to the trough exhibited immediate responses to precipitation while bedrock wells to the north, south, and east of the landfill exhibited little to no response to precipitation. These findings indicate that the bedrock aquifer outside the wetland complex is isolated from fluctuations in overburden groundwater while the bedrock aquifer underlying the wetland complex exhibits a hydraulic connection to the overburden aquifer system. This hydraulic connection could not occur solely through east-west lineaments in the deep bedrock and must occur through the overburden sediments underlying the wetland complex, which are directly connected to the steeply dipping, northeast to southwest trending primary fracture network.

   ii. The highest concentrations of COCs in MW-25 detected during packer sampling were from the shallowest interval (Zone 1: 40 to 57 feet below ground surface (bgs); 23.1 ug/L 1,4-dioxane and 365 ng/L PFOA+PFOS). Detections in Zone 3 through Zone

7 for 1,4-dioxane were also above the NHDES AGQS (0.32 ug/L) and USEPA CL (3 ug/L) with concentrations ranging from 5.42 ug/L to 8.84 ug/L. PFOA was detected above the NHDES AGQS of 12 ng/L in Zone 3 through Zone 7 with concentrations ranging from 18.7 ng/L to 29.70 ng/L. PFOS was detected in Zone 5 at a concentration of 15.30 ng/L, slightly above the NHDES AGQS of 15 ng/L. Zone 7 (169 to 183 feet bgs) is highly transmissive (649.65 feet/day) and is one of the few high-yielding fractures found throughout the deep bedrock investigation. Concentrations of 1,4-dioxane and PFAS in this highly transmissive zone indicates limited migration to this area has occurred.

f. Contaminant distribution described above and shown in contaminant distribution figures for 1,4-dioxane and PFAS in overburden and bedrock groundwater, respectively, shows concentrations decrease with increased distance from the landfill and are consistent with groundwater flow directions established using groundwater potentiometric surface elevations at wells and well couplets.

g. Concentration with distance plots coincident with the generalized north-south and east-west flow paths for 1,4-dioxane, PFOA+PFOS, arsenic, and manganese, which show decreasing concentrations away from the landfill.

h. Concentration trend plots demonstrate that the plume is stable to attenuating as 1,4-dioxane trends in monitoring wells are decreasing (26 of 53 wells analyzed) or show no trend (26 of 53 wells analyzed) based Mann-Kendall trend analysis. One overburden well (MW-10) indicated evidence of a statistically increasing trend by the Mann Kendall trend analysis. MW-10 monitors overburden immediately northwest of the landfill. The increasing trend is consistent with the identified interaction of shallow groundwater traveling to the wetland complex with landfill refuse being the source of 1,4-dioxane. Further west of MW-10, concentrations of 1,4-dioxane in overburden and bedrock are stable or decreasing.

i. Wells with apparent increasing PFOA/PFOS trends are generally located northwest of the landfill near the toe of the landfill slope and to a lesser extent to the west of the landfill. These are locations where the highest PFOA and PFOS concentrations have been reported and where the greatest fluctuation in concentrations has historically been observed. This area is influenced by stormwater contribution of contaminants as demonstrated by the composition of PFAS in overburden monitoring wells MW-9 and MW-10. These wells contain PFOA, PFOS, and PFHpA in relative concentrations similar to those observed in landfill stormwater as measured at stormwater discharge and collection locations. See the September 24, 2019 *Stormwater Investigation Report* (Haley Ward, 2019).

3. Artificial hydraulic stressors created by the pumping of active private water supply wells may not be sufficient to accelerate migration along the primary northeast-southwest trending flow path. However, short-term hydraulic gradients generated by pumping are likely orthogonal to this flow path (e.g., R-3, 339BHR) and may be sufficient to facilitate lateral migration within bedrock from individual fractures in hydraulic connection with those located along and within the primary flow path.

    a. Transducer data for wells located closest to active pumping wells (R-3, 339 BHR) only show minor influence at one monitoring well (MW-20D1/-D2) located approximately 100 feet from the R-3 well. MW-20D1/-D2 is along the primary flow path (north-south trough), as is R-3 (see 2a. above).

    b. The cone of influence developed during the constant rate pumping test extends roughly 1,500 feet along the primary north to south fracture network and roughly 300 feet to the east and west. This finding is consistent with predictions made by the USGS (Mack, 2012), which stated that a 5:1 anisotropy (parallel vs. perpendicular to regional fracture orientation) was utilized in water supply modelling efforts in the seacoast of New Hampshire.

4. Elevated concentrations of PFAS in Berrys Brook and the wetland complex, as compared to overburden groundwater concentrations, are the result of discharge of the shallow groundwater to the surface water and include a significant contribution from landfill surface water runoff. This is supported by the following:

    a. Surface water concentrations of select PFAS in Berrys Brook (PFOA, PFOS, and PFNA) are similar to or higher than the highest PFAS concentrations in groundwater detected in wells near to the landfill. A total of six surface water sampling locations in proximity to the landfill exceed the most stringent USEPA Site-specific surface water screening levels established for the Site (Child Recreator – 120 days) and provided to the CLG on September 1, 2022. It should be noted that though surface water data evaluated for this report were from samples collected in 2020, the current site-specific screening levels have been used for comparison.

    b. PFAS compositional analysis indicates that surface water samples have a different composition than most overburden and bedrock monitoring wells except for those located along the western edge of the landfill, which are likely also influenced by infiltrating stormwater run-off from the landfill (Section 4.4.4).

    c. PFAS were detected at elevated concentrations in some landfill stormwater runoff samples (including samples from outfalls discharging to the wetland complex). These samples did not contain other Site contaminants (i.e., 1,4-dioxane).

    d. Most of the landfill stormwater is discharged to ponds that allow for direct infiltration to overburden groundwater through unlined stormwater basins.

The CSM is well supported by historical geologic and hydrogeologic data for overburden and shallow bedrock, and newly collected data are consistent with the CSM. Contaminant distribution and migration are well understood in these units and ongoing groundwater monitoring continues to evaluate the progress of the natural attenuation remedy selected for the Site.

Analysis of data collected from surface geophysical surveys, bedrock outcrop mapping, photolineament analysis, review of regional bedrock data from the USGS, deep bedrock monitoring locations, reconnaissance wells, private wells, monitoring of 24 residential supply wells, the MW-6 pumping test, new bedrock borehole data (BP-4, MW-6, and MW-25), and long-term water level monitoring via data loggers has resulted in an improved understanding of deeper bedrock groundwater flow and water quality. These data have been used to refine the interpretation of Site conditions and have strengthened the CSM.

Recommendations

The work done during the deep bedrock investigation has provided defendable explanations using multiple lines of evidence to address the concern expressed in the addendum to the fourth FYR report that "long-term uncertainty remained with respect to potential migration of contaminants in ground water within deeper portions of bedrock at the Site." Even so, continued data collection and monitoring is recommended to augment the long-term monitoring program. These recommendations are as follows:

Surface Water Gauging to Confirm Groundwater/Surface Water Interaction West of the Site

Overburden and bedrock groundwater flowing west from the landfill area discharges into the wetland complex and/or the streams emanating from the wetland complex. Additional surface water gauging is recommended to confirm this groundwater/surface water interaction west of the Site. The surface water gauging locations are based on:

- Surface and bedrock topography;
- Watershed boundaries;
- Short flow paths in bedrock identified in the HPFM analysis;
- Prominence of upward/neutral vertical gradients and ambient upward flow;
- Groundwater elevations in new wells on the west side of the wetland complex; and,
- Contaminant concentrations in surface water.

Surface water gauging locations were added to select locations within the wetland complex, Berrys Brook, and Little River during deep bedrock investigation activities completed in 2018. Based on the evaluation of surface water elevations within the project area relative to overburden groundwater and surface water interactions, additional gauging locations were installed west of the wetland complex in 2021 in accordance with the January 22, 2020 *Surface Water Evaluation Work Plan* (Haley Ward. 2020). These gauging locations also serve as porewater and surface water sampling locations, which will be utilized to further assess surface water and groundwater hydraulic interaction related to the wetland complex.

Synoptic water levels were proposed for collection from these locations over a period of six months (November 2021 to October 2022) and are ongoing at the time of preparation of this report. Analytical samples were collected in November 2021 and again in Spring 2022 and provided additional information on overburden groundwater and surface water quality at the Site. Based on evaluation of the shallow groundwater and surface water interaction information in support of the Deep Bedrock Investigation, it is recommended that pressure transducers be installed at select piezometer locations. Transducers will be installed within the piezometer and within standing water outside the piezometer (where standing water present) to provide more comprehensive measurements of change in hydraulic head during and immediately following precipitation events. These short duration changes in head may not be accurately captured during single monthly gauging events.`

Monitoring of DPT TMWs to Confirm Westward Delineation

As discussed above, there is a primary groundwater flow path from the Site to the west with discharge to the wetland complex and then to headwaters of Little River (south) and Berrys Brook (north). This is supported by groundwater elevations, contaminant distribution, local topography, watershed boundary positions for the two streams, and the primary westward dipping orientation of most fractures assessed as part of the deep bedrock investigation.

Additional investigation of saturated overburden and its westward extent near MW-21S was conducted as the Direct Push Technology (DPT) Investigation (see Section 3.5.1). Results for the seven locations sampled during January 2021 and subsequent sampling of all 9 locations during Spring 2022, based on location within the western portion of the GMZ and position relative to FPC-6A and MW-21S, indicate western migration within overburden is limited and that only minor detections of PFAS, 1,4-dioxane, arsenic, and manganese occur outside the current GMZ. Results at DPT/TMW-1 were similar to known concentrations in overburden at MW-21S and FPC-6A. Concentrations of PFOA and PFOS exceeded the New Hampshire AGQS at TMW-1; however, locations sampled immediately west of the current GMZ (DPT/TMW-3 and DPT/TMW-9) were either non-detect (ND) or below the AGQS for analyzed constituents. Though detections were reported for some constituents in locations west of DPT/TMW-3 and DPT/TMW-9, most were estimated concentrations at or below respective reporting limits. These included DPT/TMW-5S/-5D, DPT/TMW-6, and DPT/TMW-7 (Figure 3.5). Preliminary results available at the time of reporting (Spring 2022) indicate exceedances of the AGQS and CL for 1,4-dioxane at TMW-11S and TMW-11D, located within and immediately adjacent to the western extent of the current GMZ.

A new overburden groundwater monitoring well will be installed in the area west of MW-21S based on the results obtained in 2021 and 2022 and proposed at TMW-3 with the revised GMZ boundary proposed in the area immediately west of this location. This location will be installed in accordance with the *Deep Bedrock Investigation Work Plan Addendum* (Haley Ward, 2020) with the location and construction details reviewed by the Agencies prior to installation. The temporary monitoring wells installed as part of the DPT effort will also be gauged with existing overburden and bedrock monitoring wells as part of regular sampling events. This is expected to provide sufficient information on overburden groundwater and surface water interaction west of the Site.

Monitoring Well Completion and Sampling to Confirm of Delineation of Southward Migration of Site Contaminants

Properties south and east of the landfill between North Road and the Site are served by a municipal water supply with the exception of a well at property designated as 178A Lafayette Road (178A LR). 178A LR is included in the long-term monitoring network. The CLG has offered to connect this property to a public water supply, but the property owner has not provided consent. 1,4-dioxane has been detected in this well at concentrations near the AGQS. The viability of this well to be included with routine groundwater sampling events following potential connection to the municipal supply is currently being assessed by the CLG.

Based on analytical data available for wells located south and west of the landfill, the southern extent of landfill COC migration is bounded to the east and west by FPC-3A/B and FPC-4A/B. There is also a general lack of receptors to the south and east of the Site since most locations are or will be served by a public water supply or are located more than 4,500 feet south of the landfill.

To supplement the monitoring of the southern extent of COC migration within deep bedrock fractures located west-southwest of the landfill, the construction of two intervals within MW-25 was completed in accordance with the *Deep Bedrock Well and Interval Packer Sampling Results and Well Construction Recommendations: MW-25 Memorandum* dated January 6, 2022. This memorandum incorporated USEPA comments to draft recommendations provided by the CLG on November 7, 2021. The two proposed sampling intervals in MW-25 will be added to the regular sampling events with the first samples collected during the Spring 2022 sampling event.

Private water supply wells serve properties south of North Road, located over 4,500 feet south of the landfill. Several supply wells on Wood Knoll Drive and Birch Road are included in the long-term monitoring network. Samples from these wells have not shown 1,4-dioxane detections but have shown PFAS at concentrations well below the AGQS. The PFAS detected at these wells are of a slightly different composition than those typically detected closer to the landfill as wells located closer to the Site tend to have more influence from PFAS detected in stormwater. Detections at these wells may be a background condition unrelated to the landfill. These properties are separated from the Site by the Little River and associated valley. The Little River valley serves as a groundwater discharge location with the potential for groundwater to migrate beyond the river valley to water supply wells located beyond the river in process of being evaluated. This evaluation is being completed in part, through the installation of a paired overburden and deep bedrock monitoring well couplet designed to investigate and monitor the southern extent of possible bedrock groundwater migration from the Site. These wells will aid in the measurement of vertical gradients between overburden and bedrock. Details of well locating, installation, geophysical surveying, and interval packer sampling are included in the *Draft Bedrock Well Installation Work Plan* provided to the USEPA and NHDES on July 1, 2022. Comments were received by the CLG on July 11, 2022, and will be addressed in the *Revised Bedrock Well Installation Work Plan* under development at the time of this report.

Optimization of Long-Term Groundwater Monitoring Plan

Eight additional deep bedrock wells have been installed since 2018 (MW-20D1/-20D2, MW-21D1/-21D2, MW-22D1/-22D2, and MW-25D1/-25D2) with at least 6 more proposed in the *Deep Bedrock Investigation Work Plan Addendum* (Haley Ward, 2020) through completion of existing open bedrock boreholes at MW-24, GZ-109, and GZ-130. As discussed in Recommendation Nos. 2 and 3, two additional bedrock wells (nested pair along southern migration pathway) and two overburden wells (one west of MW-21S and one paired with new southern pathway bedrock wells) are proposed that will allow for completion of a long-term monitoring network at the Site. Following installation and initial round of analytical results for these wells, a spatial and statistical analysis of the monitoring network will be performed to identify redundancy and optimize long-term monitoring efforts completed at the Site. This analysis will address sampling frequency, analyte list, and sampling locations and at a minimum include those locations with sufficient data to facilitate statistical analysis.

1.0 INTRODUCTION

The Coakley Landfill Superfund Site (Site) includes approximately 92 acres in Greenland and North Hampton, New Hampshire. The Site was the location of a historical unlined landfill active between 1972 and 1985. The Site is separated into two areas, or Operable Units.

- Operable Unit (OU) 1 includes the area in the immediate vicinity of the landfill where source control actions were completed to reduce impacts to surface water and groundwater quality and to eliminate potential threats posed by direct contact with, or ingestion of, contaminated media at the Site. The perimeter of the landfill and scope of monitoring wells associated with OU-1 are identified on Figure 2.2.
- Operable Unit (OU) 2 includes the area beyond the landfill where the objectives are to prevent the ingestion of contaminated groundwater in excess of drinking water standards, to restore the aquifer to drinking water standards, and to ensure that the remedy does not negatively impact the wetlands. The scope of monitoring wells associated with OU-2 is identified on Figure 2.2.

Every five years, the United States Environmental Protection Agency (USEPA) conducts a Five-Year Review (FYR) of the Site to evaluate the implementation and performance of the Site Remedy and to determine if the selected remedy remains protective of human health and the environment. The USEPA has conducted five FYRs since the issuance of the Records of Decision (RODs) for the Site in June 1990 for OU-1 and in September 1994 for OU-2 (see Section 2.4). FYRs for the Site have been published in 2001 (USEPA, September 2001), 2006 (USEPA, September 2006), 2011(USEPA, September 2011), 2016 (USEPA, September 2016), and 2021 (USEPA, September 2021).

As part of institutional controls for the Site, New Hampshire Department of Environmental Services (NHDES) issued a Groundwater Management Permit (GMP; GWP-198712001-N-001) for the Site for a five-year term beginning on June 19, 2008 (subsequently renewed January 2014 and an application was submitted for renewal to NHDES in October 2018). The GMP included requirements for long-term environmental monitoring activities and created a Groundwater Management Zone (GMZ) that requires recording notice of the permit on all deeds within the GMZ. The GMZ was expanded upon renewal in 2014 due to detections of 1,4-dioxane above cleanup goals along the northwestern portion of the Site, as indicated in the fifth FYR.

Interim Cleanup Levels (ICLs) for contaminants of concern (COCs) were established in the ROD for groundwater and subsequently modified in several Explanations of Significant Differences (ESDs). The Fifth ESD issued in August 2015 formally changed the ICLs to Cleanup Levels (CLs) and established a CL for 1,4-dioxane. In 2016, USEPA and NHDES identified polyfluoroalkyl substances (PFAS) as an emerging environmental contaminant group that may be present in the Site waste and requested that the Coakley Landfill Group (CLG) sample for PFAS in groundwater. In May 2016, the CLG initiated sampling for PFAS at a select group of monitoring wells within OU-1 and confirmed the presence of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) above USEPA's health advisory for lifetime exposure to these substances. Since 2016, PFAS have been included in the ongoing monitoring at the Site in all Site monitoring locations.

In 2016, the USEPA completed the fourth FYR of the conditions at the Site and issued the FYR on September 26, 2016. The fourth FYR concluded that:

- The remedy at OU-1 was protective of human health and the environment.
- The remedy at OU-2 was protective of human health and the environment, with the exception of uncertainty related to the potential for human exposures in the southern area of the GMZ.
- A determination of Site-wide protectiveness needed to be deferred until additional data regarding OU-2 could be obtained and evaluated.

Following the fourth FYR conclusions, the CLG obtained and provided to the USEPA additional data regarding OU-2. On September 28, 2017, the USEPA issued an addendum to the fourth FYR report (USEPA, September 2017) that updated the Site-wide protectiveness determination to indicate that, based on available data, current conditions were protective of human health and the environment in the short-term because data indicated no human exposures to COCs at concentrations exceeding either state or federal standards. However, the addendum to the fourth FYR report also concluded that "long-term uncertainty remained with respect to potential migration of contaminants in ground water within deeper portions of bedrock at the Site."

To address the concern expressed in the addendum to the fourth FYR report regarding uncertainty about migration in deeper bedrock, USEPA and the NHDES requested that the CLG undertake additional investigations to evaluate the potential migration of COCs in deep bedrock groundwater at the Site. These additional investigation activities were outlined in the Deep Bedrock Investigation Work Plan (Work Plan; Haley Ward, May 2018), which was conditionally approved by the USEPA on July 17, 2018. The Work Plan presented a phased approach to collect and analyze additional Site data and perform additional investigations, as deemed necessary in consultation with the USEPA and the NHDES (collectively referred to as the Agencies). Information collected during the execution of the Work Plan was summarized in the Deep Bedrock Investigation Interim Report (Interim Report; Haley Ward, November 2019) submitted to the USEPA and NHDES on November 25, 2019.

On February 6, 2020, the USEPA requested an addendum to the Work Plan to address additional informational requirements. The Work Plan Addendum (Haley Ward, July 2020) was subsequently provided to the USEPA and conditionally approved on July 17, 2020. The CLG has executed the Work Plan and Work Plan Addendum in cooperation and consultation with the Agencies to refine the understanding of Site conditions.[4]

The fifth FYR Report was issued by the USEPA on September 24, 2021. This FYR concluded that the remedy being implemented at the Site is protective of human health and the environment because remediation has addressed the contaminant source and institutional controls and access controls are in place that prevent exposure to Site sources and downgradient groundwater. However, the fifth FYR reiterated the USEPA's recommendation to complete the deep bedrock investigation to delineate the extent of contamination in deep bedrock groundwater, as well as the fate and transport of PFAS and 1,4-dioxane in deep bedrock groundwater.[5]

This Deep Bedrock Investigation Final Report was prepared to present the results of the investigation and to address USEPA comments in the fourth FYR, the addendum to the fourth FYR, and the fifth FYR, as described above.

1.1 Data Quality Objective

The overall Data Quality Objective (DQO) for this investigation was to develop sufficient data to characterize deep bedrock hydrogeology, contaminant distribution, migration pathways, and risk to receptors (groundwater users). The systematic approach used to accomplish this DQO included:

- Review of existing available data to refine the Conceptual Site Model (CSM) for the Site.
- Focused collection of sufficient data to address data gaps and support interpretations related to contaminant distribution and potential deep bedrock migration pathways.

Data utilized in individual tasks supporting the deep bedrock investigation DQO were obtained from a variety of sources including field analyses, laboratory analyses, existing property records, and existing literature including reevaluation of data from the Remedial Investigation (RI). The following source activities were presented in the 2019 Interim Report:

- Chinburg Well/MW-23 Investigation (2017): This effort included a borehole geophysical survey, pressure transducer data collection, and interval packer sampling (see Section 3.1.1).
- Location and installation of shallow and deep bedrock wells MW-20 S/D, MW-21 S/D, and MW-22 S/D on the western edge of the Site (2018; see Section 3.1.2).
- Reconnaissance bedrock well assessment of 11 open bedrock monitoring wells (2018; designated as reconnaissance wells and/or open borehole bedrock wells in this report) that were installed as part of the original RI. These open borehole wells were identified as GZ-103, GZ-108, GZ-109, GZ-110, GZ-116, GZ-119, GZ-122, GZ-125, GZ-128, GZ-130, and GZ-131. MW-24 was also assessed. The assessment included geophysical surveys and interval packer sampling (see Section 3.1.3).6F
- Installation of pressure transducers to measure water level fluctuations with time ahead of an irrigation well yield test at the Breakfast Hill Golf Club (early 2017), within MW-20D/-21D/-22D following their completion (late 2019), and in several bedrock boreholes (early 2019; see Section 3.1.7).
- Bedrock outcrop mapping at the Site and in the surrounding area to provide additional data on locations and orientation of fractures in the vicinity of the Site (2018 and 2019; see Section 3.2).
- A surface water evaluation to better understand the hydraulic connection between groundwater and surface water (2019 to present; see Section 3.4 and Section 4.4).

The following activities have been completed since the 2019 Interim Report:

- Well redevelopment, borehole geophysical data collection, and interval packer sampling at MW-6 to determine the well's suitability for use as the pumping test well (2020; see Section 3.1.4). MW-6 was selected as the pumping test well with agency concurrence.
- Borehole geophysical data collection at BP-4 to identify geologic structures in the vicinity of BP-4 (2021; see Section 3.1.5).
- Installation of the boring at MW-25 (2021), as well as completion of borehole geophysical data collection and interval packer sampling in the borehole to better understand the interconnection of fractures within bedrock west-southwest of the landfill and to address a data gap associated with the southern migration pathway within deep bedrock (see Section 3.1.6).
- Installation of pressure transducers to measure water level fluctuations with time during the installation of MW-25 (early 2021) and before, during, and after the pumping tests (mid-2021; see Section 3.1.7).
- Additional bedrock outcrop mapping throughout the Site and surrounding areas (2021; see Section 3.2).
- Variable rate and constant rate pumping tests were completed at MW-6 to assess bedrock fracture connectivity and further evaluate the southern migration pathway in bedrock and to assist with 1) refining the Conceptual Site Model (CSM) and further the understanding of deep bedrock hydrogeology, 2) determining whether transmissive fractures intersected by bedrock monitoring wells provide likely contaminant migration pathways to potential receptors; and 3) evaluating the flow of groundwater within fractures and its relationship with overburden and shallow bedrock (2021; see Section 3.3).
- A surface water evaluation to better understand the hydraulic connection between groundwater and surface water (2019 to present; see Section 3.4 and Section 4.4).
- Investigation of impacts west of MW-21S to allow for definition of the extent of contaminant impacts in overburden near the western boundary of the GMZ (2020 to 2021; see Section 3.5).
- A residential water supply well records investigation to determine potential additional wells for monitoring and/or sampling (2021; see Section 3.6).
- Completion of MW-25 as a deep bedrock couplet as MW-25D1 and MW-25D2 (Appendix A) in March 2022.

Investigation activities completed to date have been performed in accordance with the USEPA conditionally approved Work Plan, Work Plan Addendum, Quality Assurance Project Plan (QAPP; Haley Ward, 2017), Sampling and Analysis Plan (SAP; Haley Ward, 2018c), and Health and Safety Plan (Haley Ward, 2014).

1.2 Investigation Approach

Developing a CSM is an iterative process that uses various tiers of information and evidence to characterize and refine characterization of the hydrogeologic conditions of a site. In general, a site-specific CSM is initially developed using existing site information such as site location, topographic setting, existing data sources, surficial hydrology, lineament analysis, identification of potential receptors, and observation of site features. A site-specific CSM is then refined using additional information from site-specific explorations and investigations such as borings, monitoring well installations, multi-media sampling and monitoring programs, and geophysical surveys (surficial and downhole).

This approach was implemented during the RI of the Site by GZA/Weston in the late 1980s and early 1990s. The CSM developed during the initial RI ultimately resulted in the remedy that was selected for OU-1 for source control: consolidating waste, grading the Site, installing an engineered cover system, and conducting long-term monitoring of the natural attenuation of contaminants identified in soils, groundwater, surface water, and sediment (Section 2.4). The CSM was further refined and continues to be refined based on the results of long-term groundwater quality monitoring data from 1998 through present.

The original RI and subsequent groundwater quality monitoring focused on the migration and distribution of contaminants in overburden and shallow bedrock aquifers. Initial data collected during the original Site RI and from subsequent routine sampling of private water supply wells completed in deep bedrock indicated that limited migration in the deep bedrock occurred. Based on concentrations observed in private water supply wells. Evidence for this migration was primarily based on detections of 1,4-dioxane in two residential wells located adjacent to the northern extent of the GMZ. The 1,4-dioxane concentrations have been stable.

PFAS were later detected in one of three wells sampled by the NHDES southwest of the landfill; however, 1,4-dioxane was not detected in two of these three wells analyzed for 1,4-dioxane. This monitoring led to the establishment of a Cleanup Level for 1,4-dioxane in 2015 and it being added to the list of Site COCs in the August 4, 2015, ESD, the third ESD for OU-2.

The fourth FYR indicated concern regarding the potential for future contaminant migration in bedrock at possible pathway depths similar to residential water supply wells, including those areas located south of the landfill within the Little River watershed south of GZ-105, as this posed a data gap in the CSM with respect to long-term protectiveness of the selected Site remedy. This monitoring and the establishment of a NHDES Cleanup Level for 1,4-dioxane in 2015 led to it being added to the list of Site COCs in the August 4, 2015, ESD, the third ESD for OU-2.

This resulted in numerous consultations with USEPA and NHDES regarding a scope of work to address the data gap and ultimately led to the scope of work presented in the Work Plan and Work Plan Addendum (Section 1.1).

The investigation approach has also been impacted by identification of emerging contaminants and changes in ambient groundwater quality standards (AGQS) levels. As previously mentioned, the USEPA identified two PFAS substances, PFOA and PFOS, as emerging contaminants in 2016. As a result, multiple PFAS were added to the analyte list for subsequent semiannual sampling events at the Site. Since 2016, PFAS groundwater samples have been collected at the Site and from a number of residential water supply wells beyond the GMZ boundary to assess potential risks to receptors near the Site and provide further opportunity to refine the CSM. Since 2016, both the AGQS for 1,4-dioxane and PFAS have been lowered and portions of the investigative approach (e.g., Direct Push Technology (DPT) investigation) have also been developed and implemented, in part, to address these lowered AGQS.

Investigation activities completed as part of the deep bedrock investigation are detailed in Section 3. Geology and hydrogeology information is presented in Section 4. The CSM is described in Section 5. A summary of conclusions is presented in Section 6. Recommendations are presented in Section 7.

2.0 SITE HISTORY

The Site consists of approximately 92 acres, of which the landfill covers approximately 27 acres. The Site is located 800 feet west of Lafayette Road (U.S. Route 1), approximately 3,000 feet south of Breakfast Hill Road, and 2.5 miles northeast of the North Hampton town center. The Site borders undeveloped woodlands and wetlands to the north and west and commercial and residential properties to the east and south.

A location map is included as Figure 2.1 with a Site Plan included as Figure 2.2. A Site History Summary Table is included as Table 2.1.

2.1 Site Mining and Landfill Operations

Based on information provided in the Site RI (Weston, 1988), sand and gravel operations occurred at the Site beginning in approximately 1965. Mining activities began within the northern portion of the Site, west of the west access road, east of the east access road, and within two excavations located in the southern portions of the Site. This information was provided by land alterations visible from the analysis of historical aerial photographs performed by Weston. and documented in the RI Report. Sand and gravel operations continued to the northeast and by 1971 material was reported by the United States Department of Agriculture (USDA) Soil Conservation Service to have been mined within a few feet of the groundwater table. The Town of North Hampton began operations of the permitted landfill in 1972, with the southern portion of the Site used for waste disposal concurrent with sand and gravel mining. By 1973, quarrying operations were underway within the northwest portions of the Site with additional quarrying having expanded to a second location in the central portion of the Site by December 1974. By this time, most of the surrounding area, including the area occupied by quarrying, had been lowered to an approximate elevation of 90 feet above mean sea level (AMSL) with some areas of bedrock within the northern portion of the landfill remaining as high as approximately 96 feet based on the boring log for GZ-106 (Appendix A). Quarrying operations expanded significantly between 1974 and 1977 at both locations (central and northwest) with landfilling activities having expanded northward from the southern portions of the Site where landfilling began in 1972.

By 1981, landfilling operations had expanded such that most of the previously established sand and gravel and quarrying operations had been covered with only a small portion of the northernmost quarry remaining. According to the RI, aerial photographs from this period also revealed several new trenches in the southeastern portion of the Site and two new sand and gravel pits in the north and central portions. (Weston, 1988). It is not known whether the trenches were for the removal of sand and gravel, placement of waste, or to facilitate surface drainage within the Site., or some combination of two or more activities. These excavations are in addition to a swale constructed to drain the remaining open portion of the northern quarry into the wetland area located west of the landfill.

Excavations and surface water management operations were completed in accordance with Regulation No. 17 of the 1972 State of New Hampshire *Laws and Regulations Relating to Solid Waste Disposal* (State of New Hampshire, 1972). The regulation required the landfill operator to provide a drainage system to minimize surface water runoff onto and into the fill, prevent erosion of the fill, to drain off water falling on the fill, and prevent the collection of standing water. It is unclear when the sand and gravel operations ceased at the Site, but it is likely that these activities were completed prior to final closure of the landfill in 1985. Quarrying operations may have been completed by 1981; however, it is unknown based on available information whether the remaining quarry pits were actively removing rock or were drained to facilitate waste placement.

The landfill accepted municipal and industrial wastes from the Portsmouth area during the period between 1972 and July 1982. Landfilling began in the southern portions within existing sand and gravel operations and proceeded north as these areas were filled. The mode by which refuse was placed in the landfill may have affected the migration and degradation of contamination. Based on conclusions drawn from information provided in the 1988 RI report, waste was likely placed in open trenches excavated specifically for waste placement or directly within depleted sand and gravel pits. Though observations were made that some trenches were water filled at the time of aerial photography, the presence of purpose-built drainage swales during active site operations and specific solid waste disposal regulations requiring site drainage to prevent the collection of standing water would indicate that trenches and pits were likely dewatered prior to waste placement in accordance with Regulation No. 17, as referenced above. In addition, as the quarries were gravity drained through the use of swales, it is understood that the base level of quarrying likely did not extend below the level of groundwater and water present within these operations was likely perched or confined by topography or changes in overburden lithology. As provided in the RI, quarrying operations advanced to a level coincident with the elevation of the sand and gravel mining with the expansion of quarrying being generally areal in extent rather than vertical.

Based on the boring log provided for GZ-106 (Appendix A), waste was placed directly onto exposed bedrock surfaces within areas occupied by quarrying operations and in trenches and borrow areas where the depth to bedrock may have been greater. Exposed bedrock surfaces within quarried areas may have been subject to increased shallow fracturing as a result of blasting; however, the depth of this fracturing cannot be quantified. In March 1983, the New Hampshire Bureau of Solid Waste Management ordered the landfill to be closed to all waste, except for combustion residue (ash) from the Incineration Recovery Plant located at Pease Air Force Base. Landfill operations ceased in July 1985.

2.2 Superfund Designation

In 1979, the New Hampshire Waste Management Division received a complaint concerning leachate breakouts around the landfill. A second complaint received in 1983 by the New Hampshire Water Supply and Pollution Control Commission concerned water quality from a nearby domestic drinking water supply well. Subsequent confirmatory sampling detected volatile organic compounds (VOCs) in groundwater samples to the south, southeast, and northeast of the Site. Accordingly, the Towns of North Hampton and Rye completed a water main extension to commercial and residential users to the east and south of the Site along Lafayette Road (U.S. Route 1) in 1983 and onto Birch Road and North Road in 1986. Additional water services were provided to the 10-unit Sewall Meadow subdivision located along Breakfast Hill Road between the former railroad easement and Lafayette Road (US Route 1).

In December 1983, the USEPA proposed listing the Site on the National Priorities List (NPL). The Site was listed in 1986.

2.3 Remedial Investigation

The USEPA completed a Remedial Investigation/Feasibility Study (RI/FS) for OU-1 (source control) in 1990 and an RI/FS for OU-2 (management of migration) in 1994. Both studies identified impacted groundwater beneath and outside the boundary of the landfill. VOCs detected at the Site included benzene, ethyl benzene, chloroethane, chlorobenzene, and xylene. Semi-volatile organic compounds (SVOCs) detected at the Site included predominantly polycyclic aromatic hydrocarbons (PAHs) and dichlorinated benzenes. Inorganic compounds detected in groundwater and sediment samples included arsenic, barium, iron, lead, manganese, nickel, beryllium, selenium, and vanadium.

2.4 Site Remedy and Construction

On June 28, 1990, the USEPA issued a ROD for OU-1. The objective of the OU-1 ROD was to protect the drinking water aquifer by reducing further migration of contaminants to the groundwater and surface water and to eliminate threats posed by direct contact with, or ingestion of, contaminated soils and wastes at the Site.

OU-1 is a distinct area in which the remedy is a source control action intended to isolate the contaminant sources. The ROD for OU-1 (USEPA, June 1990) initially included consolidating contaminated sediments from the abutting wetland on the landfill, consolidating refuse material within the landfill footprint, constructing a multi-layered landfill cap over the landfill, treating groundwater and landfill gases, and long-term monitoring.

The CLG formed in February 1992 to represent the potentially responsible parties for the Site.[1] The CLG began pre-design studies for the OU-1 remedy in the summer of 1992 and the USEPA approved the design on January 25, 1996. Construction began on September 24, 1996, with the relocation of waste from along the perimeter of the landfill to the top of the landfill. Wetland sediments were removed from adjacent to the landfill and placed on the landfill during 1997. The landfill cover, passive landfill gas venting system, and wetland construction/restoration activities were completed in Fall 1998. The layer of topsoil that was placed on the landfill cap was augmented with compost and sand to promote the growth of vegetation. The compost material that was used has been identified as a likely source of PFAS (Section 4.4) with details of landfill cap construction and analytical results from construction material included in the September 24, 2019 *Stormwater Investigation Report* (Haley Ward, 2019), included as Appendix B. The augmented cap was constructed using common practices at the time, well before PFAS were identified as emerging contaminants.

Due to limited information concerning off-site contamination of wetlands and groundwater, a ROD for a second OU (OU-2) was established that required further investigation of Site conditions beyond the landfill footprint to determine the most appropriate response action. On September 30, 1994, USEPA issued a ROD for OU-2. The OU-2 Consent Decree was lodged on November 3, 1998. The objective of the OU-2 ROD is to manage the migration of contaminated groundwater outside the landfill boundaries. Investigations at the Site identified ingestion of groundwater as the primary threat to human health. The

[1] Potentially responsible parties for the Site are a group of municipalities, waste generators, and waste haulers who had contributed to the Coakley Landfill before it was closed.

OU-2 ROD identified natural attenuation of groundwater, which had migrated from beneath the landfill to off-Site areas, together with long-term environmental monitoring and institutional controls, as the selected remedy. The Consent Decree for the implementation of the management of migration remedy became effective on January 11, 1999. The ROD for OU-2 called for groundwater monitoring over the subsequent 30 years while contamination naturally attenuates, and for the elimination of potential risks posed by the future migration of contaminated groundwater by implementing institutional controls restricting the use of the groundwater.

Following completion of the landfill cap, the downgradient extent of VOC-contaminated groundwater stabilized, and concentrations of VOCs began to decline. Consequently, the USEPA issued an ESD on September 29, 1999, stating that "[a]n evaluation of the data ha[d] resulted in USEPA's determination that the groundwater extraction and treatment portion of the source control remedy specified in the [OU-1] ROD should be eliminated since the effect of the waste relocation and cap is sufficient to allow the cleanup of the aquifer and achievement of applicable or relevant and appropriate Federal and State requirements without the construction of the extraction and treatment system."

The long-term monitoring program that began in 1998 has been modified on several occasions in response to observed Site conditions. Most recently, 1,4-dioxane and PFAS were added to the monitoring program in 2009 and 2016, respectively, because they were identified to be present in groundwater at the Site above the AGQS and found to be migrating from the Site into groundwater. Additional changes in the sampling program have included the alignment of the VOC analyte list with NHDES requirements and the addition of several new surface water, sediment, and residential well locations in the vicinity of the landfill. In 2017, the sampling frequency was increased from annual to semiannual. Semiannual monitoring of groundwater, surface water, and sediments conducted in 2018, 2019, 2020, 2021, and data assessment reports have been provided to the USEPA and NHDES.

2.5 Institutional Controls

As part of institutional controls for the Site, NHDES issued a GMP (GWP-198712001-N-001) for the Site for a five-year term on June 19, 2008. The GMP included requirements for long-term environmental monitoring activities and created a GMZ. Although the GMP established for the Site does not specifically restrict property owners from extracting groundwater for potable use within the GMZ, New Hampshire Code of Administrative Rules Env-Or 608 allows implementation of an Activity and Use Restriction (AUR). The NHDES GMP requires that the GMZ be monitored, and results compared to NHDES AGQS with the CLG currently recording deed notices on properties located within the GMZ.

The June 19, 2008, GMP expired in 2013. As part of the GMP renewal application process, a GMZ boundary evaluation was prepared, which summarized trends in groundwater quality, the progress of the selected Site remedy of monitored natural attenuation for OU-2, and the appropriateness of the GMZ (Summit 2013a). The report concluded that long-term monitoring results for monitoring events prior to August 2013 indicate stable water quality was present at the majority of groundwater monitoring points. However, 1,4-dioxane concentrations at the northwestern boundary of the GMZ exceeded the AGQS and a GMZ expansion in this area was determined to be warranted.

To support the delineation of an appropriate expanded GMZ boundary in the northwestern portion of the Site, 11 private water supply wells located in Greenland, New Hampshire along Breakfast Hill Road were sampled and analyzed for the presence of 1,4-dioxane using Method 8260B SIM, a low-level detection limit methodology (Summit 2013b, 2013c). Following receipt of these data and subsequent discussions with the USEPA/NHDES, the boundary of the GMZ expansion area was delineated and a GMP Renewal Application was submitted on October 4, 2013. NHDES issued a new GMP on January 7, 2014 (GWP-198712001-N-002), effective for a five-year term. The new GMP included an expanded GMZ and a requirement to install two additional overburden/bedrock monitoring well couplets in the GMZ expansion area.[2] The boundary of the GMZ is shown on Figure 2.2.

There are currently two private water supply wells (65 North Road and 67 North Road) located within the southwestern portion of the GMZ (Figure 2.2). However, only 67 North Road (67NR) is sampled as part of regular sampling events performed in accordance with the SAP. Offers to sample the private well at 65 North Road by the CLG have been declined by the owner.

A GMP renewal application was filed with the NHDES on October 9, 2018, with a proposed expansion of the GMZ described in a December 21, 2018, memorandum. The expansion was in response to the lowering of the AGQS for 1,4-dioxane in September 2018 from 3 micrograms per liter (ug/L) to 0.32 ug/L. The lowering of the AGQS resulted in exceedances of the 1,4-dioxane standard at residential sampling locations R-3 (368 Breakfast Hill Road) and the Breakfast Hill Golf Club (339 Breakfast Hill Road) where Point of Entry Treatment (POET) was provided by the CLG in November/December 2018 in accordance with the GMP.[3]

[2] This resulted in the installation of well triplets at MW-20, MW-21, and MW-22, and was the basis for the *Work Plan*.
[3] Compliance was obtained via the installation of point-of-entry treatment systems.

3.0 COMPLETED INVESTIGATION ACTIVITIES

In accordance with the deep bedrock investigation approach as outlined in Section 1.2 of the *Work Plan* and *Section 2.0* of *Work Plan Addendum*, the following activities were undertaken to provide a systematic approach to characterizing deep bedrock hydrogeology and contaminant migration pathways. These tasks were designed to supplement existing Site data, revise the CSM, and address any data gaps. Each of the activities and data collection efforts was coordinated with USEPA and NHDES via deliverables, meetings, correspondence, review comments, and/or conference calls.

Analytical data generated for the Site is subject to a validation process. This process is an important part of verifying analytical data and ensuring its accuracy. Analytical data that is presented in this report was generally collected during 2020, as this represents the most recently available validated set of analytical data for the Site. It is important to note that, where 2020 data is presented in this report, it has been compared against preliminary 2021 data to confirm that trends are similar. Reconnaissance-based data generated for the Site for 2021 has been confirmed; thus, this data was used for some parts of the report. The report indicates, as appropriate, which investigation activities and/or evaluations are based on 2020 versus 2021 information.

3.1 Monitoring Wells

Monitoring well construction diagrams for all of the wells discussed in Section 3.1 are included as Appendix A. Available geophysical logs for the wells discussed in Section 3.1 are included as Appendix C. Refer to Figure 2.2 for the locations of the wells discussed and Figure 3.1 for available rose diagrams summarizing fracture orientation interpreted from borehole geophysics. Refer to Table 3.1 for an inventory of the monitoring wells associated with the Site.

3.1.1 Chinburg Well/MW-23 Investigation

Investigation activities at the Chinburg Well/MW-23 were initiated in 2017 by obtaining access to an existing high yield deep bedrock well originally designed to supply a 10-Lot residential subdivision near the northern boundary of the Site's GMZ. This well was designated as the Chinburg Well but has since been referred to as MW-23. The well is a six-inch diameter open bedrock boring approximately 282 feet in depth with bedrock encountered at approximately 30 feet below ground surface (bgs) with competent rock noted at 34 feet bgs. The well was completed with 48 feet of steel casing on July 15, 2013 and is located on Lot No. 10 of Greenland Tax Map No. R-2. Well yield information on the well completion report (Appendix A) states that approximately three gallons per minute (gpm) of yield was estimated within the uppermost 125 feet of the well (77 feet of open borehole). Based on information obtained during the installation of recent deep bedrock wells in support of the Deep Bedrock Investigation, the shallow portions of the bedrock surface at MW-23 would likely be weathered, fractured, and in hydraulic connection with the overburden. As a result, the installation of steel casing through 18 feet of shallow bedrock may have restricted flow often observed in the first 10-15 feet of bedrock. Estimated yield was noted to increase to 10 gpm at 229 feet below ground surface, though there were no transmissive fractures identified from the borehole geophysical data. Well yield estimates by the driller indicate that water-producing fractures within this interval are likely contributing to the aggregate water yield.

Yield estimated at 255 feet was noted to increase to 37 gpm, but it is not clear if this yield is associated with deeper fractures, although it is likely an aggregate yield that included the fractures from 256 to 259 feet below top of casing. Total well yield on the driller's log is estimated at 50 gpm for the entire borehole and would have been an aggregate yield for the entire borehole indicating that a large component of flow is coming from the deeper fractures near the bottom of the borehole. Yield values should be considered with caution as they represent a short-term "air lift" completed by the driller and do not represent sustained yields or yields that may occur when the well is fully developed.

The well is not being utilized for water supply, as municipal water service has been extended to the 10-Lot subdivision. Several investigative efforts were completed in MW-23 during execution of the Deep Bedrock Investigation to include transducer-enabled water level monitoring, borehole geophysical surveying, and interval packer sampling.

3.1.1.1 Water Level Monitoring

Access to MW-23 in 2017 allowed for water level monitoring to be completed during an irrigation well yield test at the Breakfast Hill Golf Club to assess, in part, an existing data gap related to the hydraulic interconnection of bedrock fractures near the northern end of the GMZ.

In advance of an additional irrigation well yield test at the Breakfast Hill Golf Club, pressure transducers were installed in bedrock monitoring wells MW-8, FPC-7B, AE-4B, AE-3B, AE-2B, FPC-6B, and MW-23 (Figure 2.2) on April 26, 2017. Construction details for the wells monitored during this test are included on Table 3.1 with boring logs and available monitoring well construction diagrams included as Appendix A. Transducers were set to record a pressure reading every 10 minutes for the duration of the approximate 72-hour monitoring event. Manual depth to water measurements were collected with an electronic water level meter from each monitoring well prior to transducer installation and following removal to allow for conversion of water levels to an elevation relative to mean sea level (msl). In addition to the water level transducers, an In-Situ Rugged BaroTROLL barometric pressure transducer was installed in MW-8 to record atmospheric pressure for data processing as transducers were not fitted with vented cables.

The purpose(s) of the long-term continuous monitoring included:

- Assessment of potential bedrock aquifer response to a pumping test being conducted at a Breakfast Hill Golf Club irrigation well between April 29, 2017 and May 2, 2017. It should be noted that the irrigation well used at the Golf Club is completed in a glacial outwash deposit located west of the Berrys Brook watershed boundary.
- To evaluate potential pressure (water level) responses to routine use of residential water supply wells located north/northeast of MW-23.

Significant water level fluctuations indicative of an aquifer response to a pumping stress were not observed in the instrumented wells during the monitoring period. Fluctuations were typically about 0.25 feet or less and reflect residual effects of the expansion and contraction of the bedrock fractures resulting from gravitational effects of the sun and moon, recharge from precipitation events, longer-term trends in seasonal water levels, or a combination of these factors.

The yield testing was coordinated between the NHDES and Golf Club personnel with the well yield evaluation completed by Epping Well & Pump Company, Inc. (Epping Well). The results of the irrigation well evaluation as provided by Epping Well were provided in Appendix A of the *Deep Bedrock Investigation Interim Report* and include water level hydrographs. Water level elevation data from the monitored wells did not show a consistent or significant downward trend for the period of the well yield test. The water level at MW-23 did not change significantly over the same period, though static water levels did fluctuate slightly throughout the testing period. Given that the groundwater withdrawal from the irrigation well was from an outwash deposit separated from the instrumented wells by a watershed divide, the lack of response in the instrumented bedrock wells is expected.

Small but distinct peaks were observed in water levels from FPC-7B, AE-3B, and FPC-6B on May 5, 2017 and May 14, 2017. A third peak was observed at AE-3B at the time the pressure transducers were removed from the well on May 27, 2017. Corresponding drops in water level were measured in wells AE-4B and AE-2B during the same time period. It should be noted that FPC-7B, AE-3B, and FPC-6B are located in the Berrys Brook watershed, while wells AE-2B and AE-4B are located in the Little River watershed. Several peaks and troughs on the associated hydrographs correspond to similar events on the barometric pressure plot suggesting that all barometric effects may not have been accounted for when the data was collected and processed. In addition, these peaks correspond to significant rain events as shown on the graphs suggesting rainfall (recharge) may have affected the water levels in the monitoring wells, although recharge effects would typically lag behind the actual rain event. However, if bedrock is exposed at the surface or interconnected bedrock fractures are exposed near these well locations, a rapid response to precipitation is possible. This is supported by precipitation effects observed during the constant rate pumping test performed in MW-6 (Figure 3.7).

3.1.1.2 Borehole Geophysics

Borehole geophysical surveying was completed in MW-23 on May 31, 2017. This survey was completed to obtain information on local bedrock conditions and characteristics (e.g., aperture and structural orientation) of bedrock fractures, fluid temperature and conductivity, flow regimes, and flow rates within open bedrock portions of the well. The borehole geophysical information was transmitted in a separate memorandum (*Chinburg Well – Downhole Geophysics and Water Level Data*) on June 29, 2017.

Northeast Geophysical Services, Inc. (NGS) was contracted to complete geophysical logging of the well and utilized the following borehole geophysical instruments to evaluate in-situ conditions.

- Caliper
- Temperature
- Fluid Conductivity
- Electrical Resistance
- Natural Gamma

- Heat Pulse Flowmeter (ambient/static and under pumping stress)
- Acoustic Televiewer
- Optical Televiewer

Following the completion of borehole geophysical surveying, data were processed to include structural information of interpreted fractures and classification of open aperture features as "likely" or "possible" transmissive fractures. The transmissive potential is based on measured aperture (in millimeters), borehole diameter, and flow measurements from heat pulse flowmeter records. Some fractures are in very close proximity to one another and may be considered one "fracture zone". Information generated as a result of the borehole geophysical investigation within MW-23 is presented in Appendix C with feature numbers referenced below provided in a table of identified fractures within the well. Based on the interpretation of data from borehole geophysical efforts, the following findings were made:

- A total of 79 fractures were noted within open bedrock portions of the borehole. The predominant strike direction is northeast (N30E to N50E) and is consistent with regional geologic structure as discussed in *Bedrock Geology of the Seacoast Region of New Hampshire (Casas, 2003)*.
- The predominant dip of interpreted fractures ranges from 60 to 70 degrees (i.e., high-angle) to the northwest.
- Seven fractures were considered "likely transmissive" and five fractures were considered "possibly transmissive", meaning that flow meter testing suggested some flow entering or exiting the borehole from these fractures.
- Groundwater flow within the borehole was upward under both ambient and pumping conditions. Flow rates varied between no measurable flow (NF) and 0.16 gallons per minute (gpm) under ambient conditions with rates between NF and 0.47 gpm while pumping at approximately 0.35 gpm to stress the bedrock aquifer.
- The largest and most transmissive fractures occurred near the bottom of the boring at approximately 260 feet (Feature Nos. 72-73) and 275 feet (Feature Nos. 78-79) below top of casing. Other "likely transmissive" fractures were identified at 62 feet (Feature Nos. 8-9) and 120 feet (Feature No. 39) below top of casing.
- "Likely Transmissive" features had strikes between N4E and N49E with all but two of these features being between N29E and N49E and dipping to the northwest. The remaining two features (Nos. 8-9) had a strike to the north and an easterly high angle dip of 65 degrees.
- "Possibly transmissive" fractures were identified at 72 feet (Feature Nos. 15-17) and 113 feet (Feature No. 37) below top of casing.

Fractures identified in the downhole logging are grouped in shallow bedrock interval between 59 and 122 feet below top of casing and in a second interval between 258 and 275 feet below top of casing.

No "possible or likely transmissive" fractures were identified between 122 feet and 255 feet below top of casing.

3.1.1.3 Interval Packer Sampling

Following completion of borehole geophysical surveying, interpreted bedrock fractures were selected for interval packer sampling and summarized in the June 29, 2017 results memorandum. A total of eight intervals were selected based on recommendations provided by the USEPA on October 19, 2017 with selected intervals and results included in Appendix C. Packer sampling activities were completed from December 6-8, 2017 with results detailed in a Haley Ward memorandum to the CLG dated February 9, 2018. It is important to note that packer sampling interval depths are in feet below top of casing with depths from the well completion report provided in feet below ground surface.

Interval packer sampling was completed in accordance with procedures outlined in a December 1, 2017 *Chinburg Well – Packer Testing Memorandum* prepared by Haley Ward and a follow-up e-mail from Andrew Hoffman with NHDES dated December 4, 2017. The sampling procedure started with the collection of quality assurance/quality control (QA/QC) samples from non-dedicated sampling equipment. Equipment rinsate blanks for the Grundfos pump, water level meter, and packers were collected and submitted for analysis. A duplicate, matrix spike, and matrix spike duplicate were collected from Zone 7 (254.5 feet to 260.5 feet) for QA purposes.

Interval packer sampling began by lowering the packer string assembly to the deepest interval and inflating the packers until seated against the borehole wall. Following inflation, a Grundfos submersible pump was lowered in the riser to just above the test interval and groundwater purging was initiated to obtain water from the target interval between the inflated packers. Water levels were monitored both inside and outside of the packers to assess whether leakage was occurring around the packers. Leakage was observed at Zone 3 (109 feet to 115 feet), Zone 4 (117 feet to 123 feet), and Zone 7 (254.5 feet to 260.5 feet). Prior to deflation and reseating, the geophysical logs were referenced, and the packers were adjusted by 0.5 to 1 foot up or down within the borehole depending on the absence/presence of interpreted fractures to gain a better seal. Following adjustment, pumping was resumed and monitoring for leakage continued. Final packer sampling intervals are summarized in Appendix C with Zone 3 and Zone 4 adjusted from those originally proposed due to reseating of the packers.

The volume of water within the packer string piping and the test interval was calculated and a minimum of one complete well volume plus two volumes of the isolated interval were removed prior to sampling. Field indicator parameters were monitored in accordance with the SAP for the Site. Once a sufficient volume of water had been purged and field parameters had stabilized, groundwater samples were collected directly from the pump discharge into pre-preserved, laboratory-supplied containers, and chilled to approximately 4°C for delivery to the analytical laboratory. Samples were analyzed for 1,4-dioxane (low detection limit analysis) using EPA Method 8260 SIM, PFAS using EPA Method 537, and arsenic and manganese by EPA Method 200.8 in accordance with the project SAP.

Interval Packer Sampling Results

Arsenic was not detected above the laboratory detection limit (0.001 milligrams per liter [mg/L]) in any of the intervals sampled (Appendix C). Manganese concentrations ranged from 0.006 mg/L to 0.14 mg/L. None of the detected concentrations of manganese exceeded the USEPA cleanup level (CL) (0.3 mg/L) or NHDES Ambient Groundwater Quality Standard (AGQS) (0.84 mg/L) for the Site. Manganese concentrations were generally higher in shallow test intervals with lower concentrations reported at depth.

1,4-dioxane was not detected above the laboratory detection limit 0.25 micrograms per liter (ug/L) in any of the intervals sampled.

PFAS analyses included a total of 26 compounds including perfluorooctansulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), the two compounds regulated by the USEPA and NHDES at the time of the investigation. The NHDES revised the AGQS on October 1, 2019. The AGQS included lower limits for PFOS (15 ng/L) and PFOA (12 ng/L) and the addition of perfluorononanoic acid (PFNA) and perfluorohexanesulfonic acid (PFHxS) at concentrations of 11 ng/L and 18 ng/L, respectively. PFAS were not detected above the laboratory detection limit in any intervals sampled except for PFHxS, reported at a concentration of 4.46 ng/L from Zone 5 (170 to 176 feet), below the current AGQS.

1,4-dioxane, arsenic, manganese, and PFAS were not detected above the laboratory detection limit in the field and equipment blanks submitted for analysis indicating that analytical data was not adversely affected by non-dedicated materials used during the sampling event or via cross-contamination due to sampling procedures.

3.1.2 MW-20/MW-21/MW-22 Series Wells

The 2018 *Work Plan* outlined completion of surface geophysical surveys to assist in identifying locations for proposed deep bedrock monitoring well couplets near the northern extent of the GMZ. Two deep bedrock well couplets were proposed in the March 21, 2018, *Draft Work Plan* with a third couplet recommended by the USEPA in its May 1, 2018, letter to the CLG and subsequently included in the final *Work Plan* dated May 31, 2018. Documents that discuss work related to this effort include:

- The May 1, 2018, Haley Ward memorandum *Summary of Previously Performed Geophysical Investigations on the Western Portion of the GMZ for the Coakley Landfill and Proposed Surface Geophysical Investigation for Deep Bedrock Well Siting*;
- The May 16, 2018 memorandum *Coakley Landfill Geophysical Investigation Status Update*;
- The June 13, 2018 *Coakley Landfill Well Couplet Locating and Surface Geophysics Update* memorandum;
- The June 22, 2018 email correspondence to USEPA "RE: Revised Geophysical Figures and Interpretations" (Appendix D);
- The August 27, 2018, memorandum *Deep Bedrock Downhole Geophysics and Packer Sampling Intervals: MW-20/MW-21/MW-22*; and,

- The November 25, 2019, *Deep Bedrock Investigation Interim Report - Section 3.*

Surface geophysical surveying was designed to locate the proposed well couplets in the northern and northwestern portion of the GMZ and to investigate lineaments identified west of the Site to provide a better understanding of the nature, extent, and orientation of bedrock fractures in this area. Completed surface geophysical transects were aligned to provide coverage relative to the interpreted lineament analysis completed as part of the RI with profiles included with Appendix D. It should be noted that two deep bedrock well couplets were proposed in the initial March 21, 2018 Draft Work Plan with a third couplet recommended by the USEPA in its May 1, 2018 letter to the CLG. This third well was subsequently included in the final Work Plan dated May 31, 2018.

The geophysical investigation began with a review of previously completed geophysical survey results (Weston, 1988) and the development of a surface geophysics work plan. This review and initial surface geophysics work plan were submitted on May 1, 2018 in the memorandum *Summary of Previously Performed Geophysical Investigations on the Western Portion of the GMZ for the Coakley Landfill and Proposed Surface Geophysical Investigation for Deep Bedrock Well Siting (Haley Ward, 2018).*

Completed electrical resistivity profile locations were modified from those originally proposed in the May 1, 2018 memorandum in accordance with comments received by the NHDES on May 4, 2018 and the USEPA on May 8, 2018. Results from electrical resistivity profiling were discussed in the Haley Ward memorandum *Coakley Landfill Geophysical Investigation Status Update,* dated May 16, 2018. These results were used in the identification of bedrock fractures and to aid in placement of seismic refraction and ground-penetrating radar (GPR) profiles.

Line 1

Line 1 was positioned immediately south of and adjacent to the property at 368 Breakfast Hill Road (R-3) (Appendix D) and approximately 800 feet in length. This location served to limit potential interference from overhead power lines within the southern Breakfast Hill Road right-of-way (ROW) and be positioned in closer proximity to the proposed MW-20 well couplet. Coincident electrical resistivity and seismic refraction profile data were collected along Line 1 with interpreted geophysical profile results illustrated in Appendix D.

Line 2

Line 2 was positioned north of and adjacent to Breakfast Hill Road, between the entrance to Breakfast Hill Golf Club and Berrys Brook, and approximately 500 feet in length (Appendix D). The profile was placed within the northern ROW between the golf course and roadway and extended east over Berrys Brook. Only electrical resistivity profile information was collected along Line 2 with interpreted results provided in Appendix D.

Line 3

Line 3 was positioned immediately west of and roughly parallel to the groundwater management zone (GMZ) boundary. The transect was approximately 2,950 feet in length and oriented approximately northeast/southwest. Electrical resistivity profile information was collected along the entire transect with seismic refraction data collected from Station 05+00 to 20+00 and from Station 23+00 to 28+00 to coincide with interpreted electrical resistivity anomalies A through D. Low frequency GPR data were collected coincident with seismic refraction profiles. Interpreted electrical resistivity, seismic refraction, and GPR profile information for Line 3 is illustrated in Appendix D.

Line 4

Line 4 was positioned immediately west of and parallel to Line 3 and approximately 2,950 feet in length. The placement of Line 4, adjacent and parallel to Line 3, allowed for the potential correlation of interpreted bedrock features (e.g., fractures) between lines. Similar to Line 3, electrical resistivity profile information was collected along the entire transect; however, seismic refraction and GPR profile data were collected from Stations 10+00 to 29+50 along the profile to coincide with interpreted electrical resistivity anomalies. Interpreted electrical resistivity, seismic refraction, and GPR profile information for Line 4 is illustrated in Appendix D.

Well couplet locations were selected based on surficial geophysical surveys discussed above and documented in a *Coakley Landfill Well Couplet Locating and Surface Geophysics Update* memorandum issued by Haley Ward on June 13, 2018. The locations of the surficial geophysical studies, the methodologies employed, and the selection of the drilling locations were made with input and concurrence provided by the USEPA and NHDES. Drilling locations were additionally verified and confirmed during site visits performed between Haley Ward and NHDES on June 19, 2018 for the placement of MW-20 and between Haley Ward and USEPA on June 26, 2018 for MW-21 and MW-22. These site visits were performed to verify the final drilling locations relative to interpreted surface geophysical information.

Deep bedrock borings were completed in July of 2018 for MW-20, MW-21, and MW-22 following in-field concurrence of locations with the USEPA.

MW-20 was sited along the northern extent of the current GMZ and immediately south of residential water supply location R-3 (Figure 2.2). This location was selected to provide a sentinel monitoring location near the northern boundary of the GMZ and in the interpreted northern downgradient groundwater flow direction from the Site. It should be noted that this northern component to groundwater flow is one of several mapped “downgradient” groundwater flow directions from the site (i.e., south, west, and east). These downgradient flow directions are included in overburden, shallow bedrock, and deep bedrock groundwater potentiometric surface maps included herein and discussed in greater detail below. The drilling location was sited to correlate with regional geologic structure and a north-south trending bedrock feature underlying Berrys Brook. A total of three intervals were sampled in MW-20 during interval packer sampling based on concurrence and input from the USEPA in its September 18, 2018 review of intervals as proposed by the CLG on August 27, 2018.

- Zone 1 – 66 to 77 feet. This interval was selected to span this interval and isolate the “likely” transmissive zones (Feature Nos. 20, 24, and 26 through 28) as indicated on the borehole geophysical logs (Appendix C). This interval represents fractures where the estimated well yield increased from approximately 10 to 25 gallons per minute (gpm) during drilling

(Appendix A). This interval is also within an area where measured flow from the heat pulse flow meter log transitioned from no measurable flow (NF) to ambient (non-pumping) downflow, indicating a net contribution of groundwater to the well. Optical televiewer images for this interval appear to indicate some areas of iron oxide staining that may be the result of water movement within this zone and several pieces of fractured rock contained within the opening of the fracture at 73.2 feet bgs (Feature No. 26).

- Zone 2 – 196 to 202 feet. This interval contained an area of anomalously low electrical resistivity (Appendix C) and was interpreted to represent an isolated interval of smaller "microfractures" with likely flow contribution to the well. This interval correlates to recorded downflow under ambient conditions and measured upflow within the borehole under stressed (pumping) conditions.
- Zone 3 – 225 to 231 feet. Packers were placed to span this zone and isolate the "likely" transmissive zone (Feature No. 43) as indicated on the borehole geophysical logs (Appendix D). This interval represents a fracture with an aperture of 19 mm at 228.2 feet where the measured flow within the well transitioned from ambient downflow to no measurable flow under both ambient and pumping conditions. This is indicative of an area of possible increased transmissivity where water may be exiting the borehole.

Concentrations of 1,4-dioxane were slightly above the NHDES AGQS of 0.32 ug/L for each of the sampled depth intervals and were below the CL of 3.0 ug/L, consistent with detections of 1,4-dioxane at the R-3 residential well located approximately 175 feet north and downgradient from MW-20. PFOA was detected in Zone 2 (196-202 feet below ground surface (bgs)) at a concentration of 4.62 nanograms per liter (ng/L), below the AGQS, consistent with R-3 results.

MW-21 was placed west-northwest of the landfill based on the interpretation of electrical resistivity profiles completed during the surface geophysical investigation in May and June 2018 (Appendix D). Electrical resistivity profiles indicated the likely presence of westerly trending subsurface geologic structures that had the potential to provide a deep bedrock contaminant migration pathway towards residential water supply wells located approximately one mile northwest of the landfill. A total of seven intervals were sampled in MW-21 during interval packer sampling based on the following criteria.

- Zone 1 – 20 to 26 feet. Though no measurable static flow was recorded within this interval, borehole caliper results and fluid conductivity trends observed immediately above and below, identified this as a zone to target for sampling. Borehole caliper instrumentation recorded an increase in borehole diameter from 3.8 to approximately 3.95 inches that may be related to an area of localized bedrock fracturing. This fracturing may have been an area of water inflow to the borehole as suggested by an increase in fluid conductivity to 350 uS/cm versus interpreted background fluid conductivity values of 320 uS/cm. Analytical data from this interval may allow for direct comparison with future groundwater analytical data from the adjacent overburden well (MW-21S) and provide information to substantiate a hydraulic connection between overburden and shallow fractured bedrock groundwater, as has been concluded in past studies.

- Zone 2 – 91.5 to 97.5 feet. Packers were placed to span this interval and isolate the "likely" transmissive zone (Feature No. 36) as indicated on the borehole geophysical logs (Appendix C). This interval represents a fracture with an interpreted aperture of 8 mm where the measured flow within the well transitioned from ambient upflow to no measurable flow under ambient conditions. This is indicative of an area where water may be exiting the borehole. In addition, optical televiewer images for this interval appear to indicate some areas of iron oxide staining that may be the result of water movement within this zone.
- Zone 3 – 125 to 136 feet. This interval represents the merging of Zone 4 and Zone 5 from the proposed interval packer sampling memo issued on August 27, 2018. Packers separated by 11 feet were placed to span this interval and isolate the "possible" transmissive zones (Feature Nos. 46 and 49 through 51) as indicated on the borehole geophysical logs (Appendix C). These features are associated with several large fractures located at 126.5, 130.8, 133.1, and 133.7 feet bgs respectively. The fracture of interest (130.8 feet bgs) is interpreted to have a large aperture (approximately 4 inches), though there is no visual evidence of staining based on the optical televiewer log.
- Zone 4 – 166 to 172 feet. This interval was interpreted to be moderately fractured and contained an area of anomalously low electrical resistivity (Appendix C). Though smaller in comparison to other identified fractures in the boring, this area may contribute flow into or out of the well.
- Zone 5 – 182 to 188 feet. This interval was interpreted to be associated with a fracture located at 184 feet in depth (Feature No. 70), as illustrated on the geophysical logs provided as Appendix C and correlates with a recorded change in flowmeter results from 0.72 to 0.47 gpm. This change in recorded flow under stressed conditions is indicative of a hydraulically active fracture.
- Zone 6 – 228 to 234 feet. Packers were used to isolate the interpreted fracture located at a depth of 232.5 feet (Feature No. 86). This fracture has an aperture of approximately 0.5 inches and corresponded with measurable upward flow within the borehole under both ambient and stressed conditions.
- Zone 7 – 301 to 307 feet. Packers were used to span this interval and isolate the "likely" transmissive zone as indicated on the borehole geophysical logs. Though this interval was not interpreted to be a large communicative fracture based on flowmeters results under ambient or stressed conditions, it did represent an area of anomalous resistivity and fluid conductivity response.

1,4-dioxane was only detected at the shallowest interval (Zone 1 - 20 to 26 feet bgs) at a concentration of 0.55 ug/L. These results within shallow fractured bedrock are consistent with observed concentrations of 1,4-dioxane within shallow fractured bedrock west and north of the landfill, as well as the interpreted attenuation of 1,4-dioxane concentrations downgradient (north) of the landfill. Zone 1 was additionally the only interval with a detection of PFAS.

MW-22 was located approximately 1,400 feet west of the landfill following review of photolineament analysis completed during the original 1988 RI, as well as the interpretation of electrical resistivity anomalies similar to those used in the placement of MW-21 (Figure 2.2). As with the selection of MW-21, the electrical resistivity anomalies indicated possible westerly trending bedrock features that had the potential to represent preferential pathways for groundwater towards residential supply wells located approximately 0.8 miles west of the landfill. A total of seven intervals were sampled in MW-22 during interval packer sampling and were based on the following criteria.

- Zone 1 – 21 to 27 feet. This interval represents a "likely" transmissive zone with closely spaced fractures (Feature Nos. 2 and 3) where measured flow within the boring transitioned from no measurable flow to downflow under ambient conditions (Appendix C). Analytical data from this interval may allow for direct comparison with groundwater analytical data from the adjacent overburden well (MW-22S) and provide information to substantiate the previous conclusion that a hydraulic connection exists between overburden and the uppermost fractured bedrock groundwater. The fracture of interest within this zone (23 feet bgs) appears to be orthogonal to bedding as observed in the acoustic and optical televiewer logs.
- Zone 2 – 77 to 83 feet. This "likely transmissive zone" contains a thin (<1 foot) interval of fracturing (Appendix C) that represents an area of a more than twofold increase in downward ambient flow within the boring. This increase in downward flow may be representative of a fracture where groundwater is entering the borehole. This interval also represents an area where there is a measurable increase in fluid conductivity and an observed response in travel time from the acoustic televiewer log. Additionally, acoustic and optical televiewer images depict a feature (Feature No. 15) that may be representative of a fracture with potential flow contribution to the well.
- Zone 3 – 86 to 97 feet. This interval represents the merging of Zone 3 and Zone 4 from the proposed interval packer sampling memo issued on August 27, 2018. Packers separated by 11 feet were placed to span this interval and isolate the zone of increased borehole diameter and increased fracture density as indicated on the borehole geophysical logs. Fracture aperture within this interval ranged from less than 1 mm to approximately 9 mm.
- Zone 4 – 130 to 136 feet. This interval is minimally to moderately fractured and contains an area of anomalously low electrical resistivity. Though smaller in comparison to larger identified fractures in the boring, based on observed signal travel time and both acoustic and optical televiewer response, represented a fracture interval with potential flow contribution to the well.
- Zone 5 – 184 to 190 feet. Packers were placed to span this interval and isolate the "possible" transmissive zone (Feature No. 47) as indicated on the borehole geophysical logs. Though not as large in comparison to other fractures within MW-22, this fracture appears to represent a transition in downward ambient flow rate. In addition, optical televiewer images for this interval appear to indicate iron oxide staining likely the result of water movement within this zone.

- Zone 6 – 211 to 217 feet. Packers spanned this zone and isolated the "likely" transmissive zone (Feature Nos. 55 and 57) as indicated on the borehole geophysical logs. This interval represents a fracture where the measured flow within the well transitioned from ambient downflow to no measurable flow under both ambient and pumping conditions and is indicative of an area where water may be exiting the borehole. This fracture also correlates to an increase in fluid conductivity from 112 microSiemens per centimeter (uS/cm) to greater than 140 uS/cm. Optical televiewer images for this interval appear to indicate isolated areas of staining that may be the result of water movement within this zone.
- Zone 7 – 251 to 257 feet. This interval contains a fracture at 252.9 feet (Feature No. 61) as illustrated in Appendix C.

PFAS and 1,4-dioxane were not detected above the laboratory detection limits in any of the seven intervals sampled in MW-22.

Pursuant to comments provided by the USEPA in a letter dated March 27, 2019, subsequent discussions at a May 15, 2019, meeting with USEPA and NHDES, and email correspondence from the USEPA on May 23, 2019, regarding the construction of monitoring wells in Deep Bedrock Boreholes MW-20, MW-21 and MW-22, the CLG proceeded with the completion of the deep bedrock open boreholes as permanent monitoring wells. Revised well construction recommendations were outlined in a letter to the USEPA dated July 24, 2019 and were finalized based on comments made by the USEPA in a letter provided on August 13, 2019. Well construction details for the completed wells at MW-20, MW-21, and MW-22 have been included with Appendix A.

The borehole at MW-20 was completed as two nested small diameter monitoring wells utilizing 10-foot well screens. Screened intervals were completed at Zone 1 (66-76 feet (feet) below ground surface (bgs)) as MW-20D1 and at Zone 3 (224-234 feet bgs) as MW-20D2.

MW-21 was completed as a nested pair of small diameter monitoring wells utilizing 10-foot well screens within two bedrock zones consistent with information provided in the packer sampling results and comments provided by the USEPA in their March 27, 2019, and August 13, 2019 letters. These intervals include Zone 1 (20 to 30 feet bgs) completed as MW-21D1 and Zone 7 (297 to 307 feet) as MW-21D2.

MW-22 was completed as a nested pair of small diameter monitoring wells utilizing 10-foot well screens within two bedrock zones consistent with information provided in the packer sampling results and comments provided by the USEPA in their March 27th and August 13th letters. These intervals include Zone 2 (75 to 85 feet bgs) completed as MW-22D1 and Zone 6 (210 to 220 feet) as MW-22D2.

Nested wells required grouting of open bedrock portions of the boring depending on the depth of selected screened intervals. The volume of grout was based on the borehole diameter obtained from borehole geophysical logs and length of borehole requiring a grout seal. Grout was placed using a tremie pipe lowered to the bottom of the interval and slowly withdrawn as grout was added to the borehole. A sample of grout was placed in a glass jar with water to monitor curing and used to ensure adequate time had elapsed prior to beginning well screen placement. Primary filter sand material was placed adjacent to the well screen in the screened interval and extended a minimum of two feet above the screen at each location, followed by 2-feet of time release bentonite pellets. The annular space between two screened intervals was grouted to within 10 feet of the next screened interval with the remaining open bedrock portion sealed using time-release bentonite pellets. The second (shallower bedrock) monitoring well was constructed utilizing similar techniques as those described above. All wells were installed by a New Hampshire-licensed well driller with completion logs included in Appendix A.

Following the analysis and review of analytical results from interval packer sampling, well construction recommendations were provided to the USEPA in the November 27, 2018, *Deep Bedrock Well Interval Packer Sampling Results and Well Construction Recommendations: MW-20/MW-21/MW-22* memorandum (Haley Ward, 2018). Comments to the proposed well construction recommendations were provided by the NHDES on January 4, 2019, with final well construction recommendations provided by Haley Ward on February 4, 2019, in the *Revised Deep Bedrock Well Interval Packer Sampling Results and Well Construction Recommendations: MW-20/MW-21/MW-22* memorandum.

3.1.3 Reconnaissance Bedrock Wells

In accordance with the *Work Plan*, open bedrock monitoring wells that were installed as part of the original RI were investigated to provide additional information on the potential for deep bedrock contaminant migration. These open borehole wells were identified as GZ-103, GZ-108, GZ-109, GZ-110, GZ-116, GZ-119, GZ-122, GZ-125, GZ-128, GZ-130, and GZ-131 and are generally referred to as "Reconnaissance Wells."

On May 2-3, 2018, Haley Ward personnel conducted Site reconnaissance to locate and perform well evaluations of the 11 open borehole bedrock wells and MW-24. The following determinations were made:

- GZ-108, GZ-109, and GZ-125 were accessible and viable for testing without limitation.
- GZ-110 and GZ-122 were accessible and viable for testing pending access and approval from property owners.
- GZ-116 required repair of the 6-inch diameter steel riser.
- GZ-119 had a blockage at 22.6 feet below top of casing. The blockage was further investigated on January 16, 2019, using a remote fiber optic camera and found to be a mass of nylon rope. The rope was removed and the well conditions verified in advance of obtaining property access.
- GZ-130 is located on private property (Drum Center of Portsmouth – 144 Lafayette Rd., North Hampton) and it was determined that the well was used for lawn irrigation. The downhole pump was removed and the line servicing the irrigation system has been capped to prevent further use.
- GZ-128 is considered to be destroyed.
- Haley Ward personnel were unable to locate wells GZ-103 and GZ-131 in the field.

- MW-24 does not have any pump fixtures (i.e., pitless adaptor) that would indicate prior use. Temporary access to the well for completion of the reconnaissance well investigation was verbally granted by the property owner.

Northeast Geophysical Services (NGS) performed borehole geophysics during three mobilizations to the Site based on landowner access to well locations and completion of well redevelopment activities. Based on data generated from the downhole logging efforts and RI information available for each well, a brief summary of conditions at each well was provided in *Section 3.7.3* of the *Interim Report*.

Following completion of borehole geophysics work, interval packer sampling was conducted in nine of the borehole bedrock wells (GZ-108, GZ-109, GZ-110, GZ-116, GZ-119, GZ-122, GZ-125, GZ-130, and MW-24). A total of 49 intervals were sampled among the nine deep bedrock borings. *Section 3.7.3* of the *Interim Report* further outlines the results of this effort with analytical results included in Appendix C.

3.1.4 MW-6

In accordance with the *Work Plan Addendum*, well redevelopment and borehole geophysical data collection were completed in MW-6. This work was completed to determine MW-6's suitability for use as the pumping well during the pumping test as proposed to the Agencies by the CLG and to better understand the interconnection of fractures between MW-5S/5D (located 325 feet north of MW-6 and on the southern edge of the landfill). Results of this well redevelopment and borehole geophysical investigation were documented in the memorandum Revised *Deep Bedrock Downhole Geophysics and Packer Sampling Interval Recommendations: MW-6* dated June 29, 2020.

An evaluation of the recommendations contained in the June 11, 2020, memorandum was performed by the USEPA and comments on the sampling recommendations were provided via email correspondence on June 18, 2020. Comments from the USEPA were incorporated into the packer sampling program and provided in the memorandum *Revised Deep Bedrock Downhole Geophysics and Packer Sampling Interval Recommendations: MW-6* dated June 29, 2020. The completion of investigation activities at MW-6 was included in the *Deep Bedrock Investigation Work Plan Addendum and Response to Comments* dated July 17, 2020, and conditionally approved by the USEPA on August 4, 2020.

An August 18, 2020, *MW-6 Interval Packer Sampling Results and Pumping Test Viability* memorandum concluded that, based on information provided through the redevelopment, borehole geophysical surveying, and interval packer sampling within MW-6, the well represented a viable well for the completion of the variable rate and constant rate pumping tests. As a result, the *Work Plan* was prepared utilizing MW-6 to complete the pumping test. Further details on the pumping test are included in Section 3.3.

3.1.5 BP-4

NGS performed borehole geophysics in bedrock monitoring well BP-4 on January 27, 2021 to record additional lithologic and structural information. BP-4 is located within OU-1 on the east side of the landfill, is completed to 100 feet below top of casing (Appendix A) and is sampled as part of routine biannual sampling events. BP-4 is the closest open bedrock well to the landfill and is located proximal to the contact between the Breakfast Hill Granite and Rye Formation (Figure 3.4). Due to the degree of metamorphism noted for these units, this contact is likely ductile in nature. This is supported by the boring logs, which indicate a gradual transition from a felsic granite or gneiss, with various igneous intrusions including diabase and pegmatites, to a "gneissic schist" interfingered with micaceous schist with more felsic units, to a consistent micaceous schist unit at the bottom of the boring. The following geophysical logging suites were completed:

- Borehole Caliper
- Fluid Temperature
- Fluid Conductivity
- Natural Gamma
- Single Point Resistance
- Heat-pulse Flowmeter (static and pumping)
- Acoustic Televiewer
- Optical Televiewer

During borehole geophysics work, only two zones in BP-4 were identified as likely transmissive zones based on heat pulse flowmeter, resistivity, caliper, and optical televiewer data. These intervals included 49 to 51 feet below top of casing and 55 to 57 feet below top of casing. These zones are close together, in the uppermost half of the well, and are located near a change in lithology, likely a pegmatite intrusion, at 50 feet below top of casing. There was no measurable flow (NF) below 55 feet with the measurable flow at the transmissive zones being upward at approximately 0.03 gallons per minute. Measurable flow above the two transmissive intervals averaged 0.43 gallons per minute.

BP-4 is dominated by north-south oriented fractures steeply dipping to the west; however, the identified pegmatite intrusion is dipping at a shallow angle to the east. Fracture flow is predominantly along strike, with a minor component of flow interpreted down dip. The delineation of these fractures, or lack of fractures through this contact zone, is supportive of the ductile nature of the contact between the more felsic Breakfast Hill Granite with the Rye Formation. The borehole geophysical results for BP-4 are included in Appendix C; however, interval packer sampling was not proposed for this well.

In addition to heat pulse flowmeter measurements completed during the January 27, 2021 geophysical logging effort, additional measurements were recorded during the constant rate pumping test and are detailed further in Section 3.3.

3.1.6 New Well Installation: MW-25

As part of work requested by USEPA in support of the *Work Plan Addendum* and *Pumping Test Work Plan*, the installation of the boring at MW-25, completion of borehole geophysics, and interval packer sampling was completed prior to the initiation of the pumping test.

The location of MW-25 was selected based on the results of surface geophysical surveying completed in accordance with the *Work Plan Addendum*[4] and installed to 1) better understand the interconnection of fractures within bedrock west/southwest of the landfill and 2) address a data gap associated with the southern migration pathway within deep bedrock This data gap was identified, in part, by reported concentrations of PFAS and 1,4-dioxane in shallow bedrock monitoring well GZ-105 located approximately 55 feet west of MW-25.

The survey results were documented in the *Surface Geophysical Results and MW-25 Well Locating Memorandum* dated October 7, 2020, and included in Appendix D. The concurrence of the final well location was performed with the USEPA and NHDES during an on-site meeting held on October 14, 2020. The completion of the boring at MW-25 was performed January 18 to January 22, 2021, with a subsequent remobilization to clear a blockage from the well on February 17, 2021.

The processed electrical resistivity profiles are included as Appendix D. The depth of exploration averaged 280 feet below ground surface (bgs) and correlated with the anticipated depth of the MW-25 well couplet. This is based on MW-25 being advanced 250 feet into bedrock with 30 feet of overburden material as per the boring log for GZ-105. Existing Site features and boundaries (i.e., monitoring wells, GMZ, and parcel) are labeled accordingly in Appendix D.

Several anomalous features identified from the electrical resistivity profiles correlate with information provided from boring logs at MW-6 and GZ-105 along Line 5 and FPC-8A/-8B along Line 6. The shallow depth to bedrock at MW-6 (located 140 feet south of Line 5) correlated with a section of higher resistivity material often characteristic of dry overburden materials and/or shallow bedrock. The depth to bedrock at GZ-105 (approximately 30 feet bgs) correlated with an area along Line 5 (980 feet along profile) where there is an interpreted boundary between more conductive overburden materials and resistive bedrock. Similar responses were observed at FPC-8A/-8B along Line 6 with regards to depth to bedrock/overburden thickness. The intersection of Line 6 with Line 3 (Appendix D), completed during the 2018 surface geophysical investigation and detailed in the Deep Bedrock Investigation Interim Report (Haley Ward, 2019), correlates well with regards to electrical resistivity response and depth to an interval of higher resistivity at 60 feet bgs.

Additional similarities in geophysical response and resulting anomaly locations, depths, and orientation were apparent between Line 5 and Line 6. For example, the location of low resistivity Anomaly A (Appendix D) along these two profiles were similar in electrical response (light blue to blue shading), were bordered by more resistive features to the east and west (light green to green shading) and extended west at a similar depth (approximately 130 feet bgs). These low resistivity features were characteristic of those typically associated with fluid filled fractures as electrical current is more readily transmitted through water in open fractures than through the electrically more resistive bedrock. The location of Anomaly A along each profile has been provided in Appendix D. The extension of a line between these two anomalies resulted in a trend parallel to the predominant fracture trend/strike for the Site. Due to the correlation of the geophysical results with existing Site geologic information,

[4] Surface geophysical surveying included electrical resistivity profiling to identify areas of anomalous electrical resistivity characteristic of bedrock fractures and variations in bedrock topography.

proximity to GZ-105, and access within parcel 21-40, the MW-25 well couplet was placed approximately 50 feet east of GZ-105.

MW-25 was installed with a total depth of 283 feet bgs with 6-inch casing set from 30 to 40 feet bgs.

In accordance with the conditional approval of the *Pumping Test Work Plan (Haley Ward, 2020),* water levels were monitored in nearby bedrock monitoring wells GZ-105, MW-2, MW-5S, MW-5D, MW-6, FPC-2B, FPC-3B, and FPC-8B during installation of MW-25. This was performed to monitor the effects, if any, that drilling may have on surrounding wells through the interconnection of bedrock fractures. Pressure transducers were deployed prior to drilling and monitored from January 16, 2021, through January 22, 2021. The observation wells exhibited variable responses to the drilling activities and environmental conditions (e.g., precipitation). The largest response was observed in the closest well, GZ-105, located 55 feet to the west, while wells located further away exhibited smaller or delayed responses to drilling.

A *Draft Downhole Geophysics and Packer Sampling Interval Recommendations: MW-25* was submitted to the USEPA and NHDES on March 16, 2021, and revised on March 24, 2021, per comments received from USEPA on March 22, 2021, detailing the work described above. Interval packer sampling results for MW-25 have been included in Appendix C.

Interval packer sampling was performed from March 24- 26, 2021 in accordance with the project SAP and adhered to *SOP-14 Straddle Packer Testing*. The shallowest interval (Zone 1: 40 to 57 feet bgs) detected 1,4-dioxane at a concentration of 23.1 ug/L, which was the highest detection within MW-25. Detections in Zones 3 through 7 were also above the NHDES AGQS (0.32 ug/L) and USEPA CL (3 ug/L) with concentrations ranging from 5.42 ug/L to 8.84 ug/L. In Zones 2, and 8 through 12, concentrations are above the NHDES AGQS (0.32 ug/L), ranging from 1.14 ug/L to 2.38 ug/L.

Similarly, Zone 1 and Zones 3 through 7 were the intervals with the highest PFAS detections. Within Zone 1, PFHxS was detected at a concentration of 34.5 ng/L, PFOA at 246 ng/L, PFNA at 31.7 ng/L, and PFOS at 119 ng/L, all above their respective USEPA CL and/or NHDES AGQS. PFOA was detected above the NHDES AGQS of 12 ng/L in Zones 3 through 7 with concentrations ranging from 18.7 ng/L to 29.70 ng/L. PFOS was also detected in Zone 5 at a concentration of 15.30 ng/L, above the NHDES AGQS of 15 ng/L.

Within Zone 1, total arsenic was also detected above the USEPA CL (0.01 mg/L) and NHDES AGQS (0.005 mg/L). The AGQS for arsenic was lowered from 0.01 mg/L to 0.005 mg/L on July 1, 2021. Although the AGQS was lowered following the collection of these samples, comparisons to the current AGQS for arsenic will be completed herein. Based on the information gathered, a *Deep Bedrock Well Interval Packer Sampling Results and Well Construction Recommendations: MW-25* Memo was submitted to the USEPA and NHDES on November 7, 2021.

3.1.7 Monitoring Well Transducer Data

Pressure transducers have been installed in various wells at the Site since 2017. Installation and data assessment for this effort is provided in the following sections.

3.1.7.1 Initial Installation Summary

In advance of an irrigation well yield test at the Breakfast Hill Golf Club, pressure transducers were installed in bedrock monitoring wells MW-8, FPC-7B, AE-4B, AE-3B, AE-2B, FPC-6B, and MW-23 on April 26, 2017. Transducers were set to record a pressure reading every 10 minutes for the duration of the approximate 72-hour monitoring event. Manual depth to water measurements were collected with an electronic water level meter from each monitoring well prior to transducer installation and following removal to allow for conversion of water levels to an elevation relative to mean sea level (MSL). In addition to the water level transducers, an In-Situ Rugged BaroTROLL barometric pressure transducer was installed in MW-8 to record atmospheric pressure for data processing. These corrections were required as the deployed transducers were not outfitted with vented cables. Significant water level fluctuations indicative of an aquifer response to a pumping stress were not observed in the instrumented wells during the monitoring period. Fluctuations were typically on the order of 0.25 feet or less and reflect earth tides, recharge from precipitation events, longer-term trends in seasonal water levels, or a combination of these factors. Specific to earth tide influences, these effects result from expansion and contraction of lithologic matrices under gravitational influences of the moon and sun and are commonly found during monitoring of crystalline, fractured bedrock wells given the measurements are collected at an adequate frequency. For well MW-8, no changes in water level were observed, as the transducer reportedly slipped through the carabiner holding the transducer in the well, and it remained on the bottom of the well, likely in sediment, for the duration of monitoring. Transducers in wells AE-2B and AE-4B were installed immediately after the spring sampling event, so their plots illustrate the return to static water levels after sampling. The hydrographs generated following the data collection, are included in Appendix E.

Following completion of the deep bedrock monitoring wells MW-20D/-21D/-22D in July 2018, water level dataloggers were installed in each of the three borings to record water levels in January 2019. The purpose of the data collection was to assess if there was evidence of water level change in response to pumping associated with nearby residential water supply wells. Transducers are removed during spring and fall groundwater sampling events and other wells instrumented as access and site investigation activities allowed (e.g., MW-23 and GZ-110). Bedrock well couplets (MW-20D1/D2, MW-21D1/D2, and MW-22D1/D2) were completed in August 2019 with transducers removed from the open bedrock borings prior to well construction. Transducers were reinstalled in November 2019, following the fall biannual sampling event.

Several bedrock boreholes, including MW-20D, MW-21D, MW-22D, and MW-23, were instrumented with pressure transducer dataloggers for a period of several weeks (January to May 2019) and recorded data provides a continuous record of groundwater levels in those boreholes.

Notably, monitoring well MW-20D illustrated periodic responses related to the pumping cycle of nearby residential well R-3. These cycles reflect the regeneration of existing water treatment system in the home. Other, less pronounced changes are thought to be related to typical household water usage (i.e., showering, dishwashing, or clothes washing). MW-20D is located 150 feet south of R-3 and is along strike of the primary fracture network. MW-20S did not show a response to pumping but did illustrate a rise in water levels, likely due to recharge through precipitation. This increase in water levels is also observed in MW-20D which exhibited a rise of less than one foot compared to MW-20S. MW-20S illustrated a rise of almost two feet on January 24, 2019. MW-23 did not show a similar response to pumping at R-3. MW-23 is east of R-3/MW-20D, orthogonal to the primary fracture network, and is on the east side of Berrys Brook. MW-21D and MW-22D did not exhibit responses to residential pumping; however, did illustrate cyclical rise and falls associated with earth tides and limited responses to the recharge event that increased water levels in MW-20S/D on January 24, 2019. The hydrographs generated following the data collection, is included in Appendix E.

3.1.7.2 2020/2021 Installations

Water levels were monitored in nearby bedrock monitoring wells GZ-105, MW-2, MW-5S, MW-5D, MW-6, FPC-2B, FPC-3B, and FPC-8B during the installation of MW-25 from January 16, 2021 through January 22, 2021 to monitor the effects, if any, that the drilling of MW-25 may have on surrounding bedrock wells. The observation wells exhibited a variety of responses to the drilling activities and environmental conditions (e.g., precipitation). Details of the timing of well installation activities and distance and direction of monitoring wells from MW-25 are listed below.

The largest response was observed in the closest well, GZ-105, located 55 feet to the west, which exhibited up to seven feet of drawdown during drilling. A gradual return to static water levels was observed overnight after the end of drilling. Additional wells that exhibited drawdown include FPC-8B and FPC-3B which exhibited a drawdown of up to 1.2 feet and 1.1 feet respectively on January 20, 2021 with smaller responses on January 21 and January 22, 2021. For GZ-105 and FPC-3B, the recovery of the well was almost immediate after the end or during a pause in drilling while the recovery FPC-8B was delayed by roughly 3 hours after drilling ended on January 20 and roughly an hour and a half on January 21, 2021. None of the wells exhibited drawdown as a result of drilling until air hammer drilling began to advance through bedrock, when the air pressure injected to clean out cuttings from the drill bit produced water out of the borehole. Of the wells that did not exhibit an obvious response to drilling, MW-6, MW-5S, MW-5D, MW-2, all exhibited a rise in water levels at the start of monitoring, associated with a precipitation event on January 16, 2021, followed by a gradual decline in water levels. MW-6, MW-5S, and MW-5D exhibited fluctuations attributed to earth tides, while MW-2 did not.

Table 3.1.7.2 A

Date/Time	Drilling Notes
1/18/2021 13:15	Begin Drilling, Sonic through overburden
1/18/2021 15:00	Stop Drilling
1/19/2021 8:15	Begin Drilling, Sonic through overburden
1/19/2021 13:10	Casing to 40 feet finished grouting
1/19/2021 12:30 -15:30	Field personnel checks transducers
1/20/2021 8:20	Start Air Hammer at 40 feet bgs
1/20/2021 12:00	Pause Drilling at 173 feet bgs
1/20/2021 13:10	Resume Drilling
1/20/2021 16:15	Finish Drilling to 233 feet bgs
1/21/2021 7:45	Start Air Hammer at 233 feet bgs
1/21/2021 10:25	Drill to 253 feet bgs pull rods to change bit
1/22/2021 7:50	Start Air Hammer at 253 feet bgs
1/22/2021 10:45	Finish hole to 283 feet bgs, air hammer off

*Note times are approximate.

Table 3.1.7.2 B

Monitoring Well	**Distance/Direction**
GZ-105	55 feet W
FPC-8B	380 feet NE
MW-2	800 feet E
FPC-3B	850 feet S
MW-6	900 feet S
MW-5S	925 feet E
MW-5D	930 feet E
FPC-2B	1,000 feet E

Water levels also were monitored prior to and following the pumping test as described in Section 3.3 below. The water level monitoring was completed to evaluate water levels during the test, to evaluate antecedent conditions in order to make corrections to drawdown data, and to monitor recovery of the aquifer system following the end of the pumping test. These results are provided in Appendix F.

3.2 Bedrock Outcrop Mapping

According to Mack (2012), outcrop areas make up less than one percent of the Seacoast region; however, several outcrops were identified in the areas surrounding the Site. Following the completion of bedrock outcrop mapping efforts in the western portion of the GMZ in May 2018 and within the utility corridor and accessible areas of the Breakfast Hill Golf Club in March 2019, additional areas of interest were identified north of the Site as follows with details provided in subsequent sections:

- Within an abandoned quarry west of the landfill access road,
- North of Breakfast Hill Road in a small subdivision,
- Along the former railroad corridor,
- Within accessible areas of the Breakfast Hill Golf Club,
- In the areas located around the Bethany Church (i.e., south and southwest perimeters of the parking lot), and
- Along a power line corridor southwest of Breakfast Hill Road.

The mapping consisted of recording lithology and the strike and dip of bedrock at multiple points along each surface exposure. Measurements were made using a Brunton Compass (2018, 2019, and 2021) and a smartphone application (FieldMOVE Clino Pro 2.5.19; 2021). Measurements included the foliation, primary fractures parallel to foliation, two sets of cross-foliation fractures, and a limited number of sheeting factures, as well as general rock type. Other information such as fracture length or mineralization were not collected. Refer to Figure 2.2 for an overall site plan and locations of the areas discussed, Figure 3.2 for bedrock lineament data collected by BCI Geonetics in support of the 1988 RI, Figure 3.3 for strike and dip data of outcrop mapping, and Figure 3.4 for a generalized bedrock geologic map of the area. A table summarizing the field measurements is provided as Table 3.3.

3.2.1 2018 and 2019 Mapping

On May 1, 2018, a letter from the USEPA recommended the mapping of bedrock outcrops west/northwest of the Site. The intended purpose of the mapping was to identify fracture orientations and bedrock lithology in the area between the landfill and residential developments northwest of the Site. On April 11, 2018, a Haley Ward representative who was a New Hampshire Licensed Professional Geologist visited the western portion of the GMZ to identify bedrock outcrops in this area and document the location and fracture orientations at exposed bedrock outcrops.

Three substantial bedrock outcrops (Figure 3.3) were observed during the 2018 Site visit and were noted to have a fine-grained texture and foliation/bedding features characteristic of metasedimentary rock. All three exposed outcrops were interpreted to belong to the Rye Formation and were weathered with fractures generally along foliation planes. Haley Ward measured strike and dip angles of relatively un-weathered foliation planes from each outcrop using a Brunton compass. Two measurements were collected from Outcrop 1, while a single measurement was collected from Outcrop 2 and Outcrop 3 each. All foliations/fractures were measured as having a strike between 117 and 33 degrees east of north (N17E to N33E) and a dip between 55 and 66 degrees to the northwest. These measurements are generally consistent with published geologic reports and other fracture orientation data collected at the Site.

In accordance with the *Work Plan* and subsequent to the outcrop mapping completed in Spring 2018, additional bedrock outcrop mapping was completed at the Breakfast Hill Golf Club and power transmission corridor located north/northwest of the GMZ boundary in February of 2019. This mapping effort was completed with field assistance from the USEPA. Eighteen outcrop locations were mapped in 2019 with one to four measurements collected at each location.

3.2.2 2021 Mapping

In accordance with the *Work Plan Addendum*, additional bedrock outcrop mapping occurred on October 13 and October 29, 2021, at multiple locations near the Site. The locations included areas along the railroad easement both north and south of the Site, at the abandoned quarry north of the Site, behind the church north of the Site, in the vicinity of Stone Meadow Way and Red Oak Drive north of the Site, at the Breakfast Hill Golf Club north of the Site, in the vicinity of the power transmission line running parallel to Breakfast Hill Road, in the wooded area near the intersection of Berry Farm Lane and Breakfast

Hill Road, and in the power transmission corridor located north/northwest of the Site (see Figure 3.3). This mapping effort was completed with field assistance from the USEPA. Seventeen outcrop locations, as well as six locations within the quarry, were mapped in 2021 with five to 48 measurements collected at each location.

3.2.3 Summary of Outcrop Fracture Measurements

Foliation measurements were predominated by north-northeast strikes and steep westerly dips. The primary fracture population also exhibited this orientation. The frequency of these measurements is consistent with published geologic reports, the fracture analysis in Section 4.2.4, and borehole geophysical logging conducted (Appendix C). Several other less common fracture trends were also evident with northeast or northwest strikes and with easterly dips. Sheeting fractures, defined for this report as being those fractures with dips less than 20 degrees, were rare but this is likely due to the exposure of the outcrops that in general did not provide vertical faces for measurement. In summary, all four fracture trends are consistent with the fracture orientation and frequency from the borehole geophysics described in Section 4.2.4.

3.3 Pumping Test

The pumping test, as detailed in the *Deep Bedrock Investigation Pumping Test Work Plan* originally submitted to the USEPA and NHDES on October 21, 2020, subsequently revised/submitted in November 2020, and conditionally approved on December 15, 2020, was completed between May and July 2021. The pumping test was completed to assess bedrock fracture connectivity and to further evaluate the southern migration pathway in bedrock as detailed in the data gap analysis of the *Interim Report*. In addition to investigating this migration pathway, the pumping test assisted in:

- Refining the CSM and furthering the understanding of the deep bedrock hydrogeology as it relates to anisotropy created by multiple bedrock fracture trends.
- Determining (along with other lines of evidence) whether transmissive fractures in bedrock exist that provide likely migration pathways for off-Site migration of Site contaminants to potential receptors.
- Evaluating inter-fracture groundwater flow and its relationship with overburden and shallow bedrock.

The pumping test was completed in existing deep bedrock monitoring well MW-6 as the pumping well (following detailed discussions and concurrence from the Agencies) based on well construction details and observations made during well installation (Appendix A), distance from landfill, location of available wells relative to mapped bedrock fracture and lineament data (Figure 3.1 and Figure 3.2), borehole geophysics and packer sampling (Appendix C), and analytical data available for wells within the monitoring network.

Supporting documentation for the justification and results of the pumping test, including an abbreviated MW-6 Pumping Test Viability Memo (reduced to eliminate duplicates of boring logs and downhole geophysical results found elsewhere in the appendices), the monitoring network as proposed in the pumping test work plan, hydrographs detailing the elevations of water levels of instrumented wells, a table detailing water levels in wells that were measured manually, water quality from groundwater samples and field parameters measured at MW-6, corrections made for monitoring wells which exhibited drawdown, the output of the aquifer property analysis completed using groundwater modeling software, and a figure detailing hydraulic responses correlated to precipitation, can be found in Appendix F.

3.3.1 Background Activities

The following background activities were completed in preparation and support of the pumping test completed at MW-6. Results of activities discussed below, where noted, have been additionally included in interim deliverables provided to the Agencies.

3.3.1.1 Well Redevelopment and Borehole Geophysics

As outlined in the Revised *Deep Bedrock Downhole Geophysics and Packer Sampling Interval Recommendations: MW*-6 (Haley Ward, June 2020), prior to initiation of the pumping test, MW-6 was redeveloped to prepare the well for the completion of borehole geophysical logging. MW-6 is a 6-inch diameter deep bedrock monitoring well located within the GMZ, approximately 350 feet south of the landfill boundary and roughly at the north end of Granite Drive. According to the boring log for the well, it was drilled to a total depth of 184 feet (June 19, 1985), with bedrock encountered at approximately 5 feet bgs and steel casing installed to a depth of 24 feet bgs. It should be noted that the boring log referenced the depth below ground surface while the borehole geophysical results reference depths below top of steel casing (2 feet above ground surface).

MW-6 was redeveloped in an effort to remove sediment and debris from within the borehole, promote the flow of fresh formation water into the borehole, and improve overall water clarity. These factors aided in obtaining representative measurements from the borehole geophysical instrumentation. In addition, well redevelopment provided an opportunity to monitor water level drawdown within the well during pumping and provide information that was used in the design of the variable rate pumping test. Results of well redevelopment, monitoring of water levels during redevelopment, borehole geophysics, and interval packer sampling were provided in the *MW-6 Interval Packer Sampling Results and Pumping Test Viability* memorandum dated August 18, 2020 and included in Appendix F. It should be noted that to reduce duplicity in supporting information provided in this report, Attachment 1 (MW-6 Boring Log) and Attachment 2 (MW-6 Interval Packer Sampling Results) of the MW-6 viability memorandum (Appendix F) have been removed as the boring log and interval packer sampling results have been included with Appendix A and Appendix C of this report, respectively.

Well Redevelopment

The well was first agitated using a water jetting tool attached to a 4-inch diameter submersible pump lowered into the well. Following submersion below the static water table, the pump was energized and pressurized water (jetting) was used to loosen sediment on the borehole walls and agitate the water column. The pump and jetting fixture were lowered to the bottom of the well and retrieved with agitation occurring in both directions (lowering and raising of the pump). Immediately following retrieval, the jetting fixture was removed, and a hose was attached to the pump discharge and lowered to approximately 50 feet below the static water table. Pumping was initiated at an average rate of 7 gallons per minute (gpm) and continued until water ran clear (<50 nephelometric turbidity units). Discharged water was containerized and transported to the landfill for storage in two 1,000-gallon tanks for later characterization and disposal. Water samples were collected of the containerized water and analysis completed for 1,4-dioxane, VOCs, PFAS, and the Resource Conservation and Recovery Act (RCRA) 8 metals. Manganese was the only compound that exceeded the NH AGQS (300 ug/L) with a concentration of 4,140 ug/L. There were detections of PFOA (10.3 ng/L), PFOS (5.91 ng/L), barium (15 ug/L), and carbon tetrachloride (0.94 ug/L), below their respective AGQS. Remaining VOCs, PFAS, and metals were below their respective reporting limits. The laboratory analytical report has been included with Appendix F. A temporary discharge permit was filed with and approved by NHDES. A total of approximately 1,300 gallons of water was removed during redevelopment and discharged to the NW stormwater control basin associated with the landfill in accordance with the temporary discharge permit.

During redevelopment, water levels in MW-5S/-5D, FPC-2A/-2B, MW-2, and MW-11 were monitored for drawdown to determine the effects, if any, that pumping in MW-6 may have on surrounding wells. It was determined that MW-5S/-5D, located roughly 400 feet northeast of MW-6 parallel to the primary fracture network, showed a significant hydraulic connection with MW-6 based on a total drawdown of 1.1 feet in MW-5D and approximately 0.61 feet in MW-5S. MW-2, located roughly 280 feet to the north of MW-6, slightly offset from the primary fracture network, had a total drawdown of approximately 0.28 feet over the duration of the redevelopment. No drawdown was observed in MW-11 or in FPC-2A/-2B. The open bedrock interval within MW-6 is coincident with bedrock intervals in MW-2, MW-11, FPC-2B, MW-5S, and MW-5D. The drawdown observed in MW-5S/-5D and minor influence in MW-2 observed during the redevelopment of MW-6 indicates these wells have a hydraulic connection. The hydraulic response was shown to be along strike of the primary fracture network, oriented northeast to southwest as shown in the lineament analysis in the original RI and supported by borehole geophysics and bedrock outcrop mapping. Due to the relatively short duration of the redevelopment and the pumping rate there remained several possibilities to explain the lack of response in wells FPC-2A, FPC-2B, and MW-11. These wells are located approximately 800 feet southwest (FPC-2A/-2B) and 560 feet north (MW-11) from MW-6 and the short relative duration (approximately 4 hours) and rate of pumping (average 7 gpm) during redevelopment may have been insufficient to result in observable drawdown in these wells. Further discussion of the hydraulic connectivity of the deep fractured bedrock is included in the analysis of the deep bedrock pumping test completed on MW-6 following redevelopment.

Borehole Geophysics

NGS performed borehole geophysics at MW-6 during a single mobilization to the Site on May 22, 2020. The following geophysical logging suites were completed:

- Borehole Caliper
- Fluid Temperature
- Fluid Conductivity

- Natural Gamma
- Single Point Resistance
- Heat-pulse Flowmeter (static and pumping)
- Acoustic Televiewer
- Optical Televiewer

The pumping rates recorded during flowmeter testing were estimated using a graduated five-gallon bucket and stopwatch and are considered representative of an *average* rate. It should be noted that pumping rates may have fluctuated due to variations in pump efficiency (resulting from changes in drawdown) and battery voltage.

Based on a review of provided borehole geophysical data, the following results were obtained:

1. Nine features are interpreted to be a "likely transmissive zone" (Feature Nos. 2, 37 and 43) or "possible transmissive zone" (Feature Nos. 8-12, 22, 40, 48-50, 59, and 68-69), meaning that flow meter testing suggested some flow entering or exiting the borehole from fractures identified by the downhole logging.
2. Heat-pulse flowmeter (HPFM) data indicate downward ambient (natural) flow within the boring at an interval located between 30 feet and 105 feet below top of casing ranging from 0.03 to 0.05 gpm. No measurable flow was detected above 30 feet or below 105 feet under ambient flow conditions. HPFM data under pumping conditions (0.85 gpm pumping rate) was upward at rates between 0.02 and 0.45 gpm.
3. A majority of fractures are located 35 to 120 feet below top of casing.
4. Fluid conductivity within this well averaged 320 µS/cm, consistent with the average fluid conductivity observed within most deep bedrock wells surveyed as part of the deep bedrock investigation.
5. Based on optical televiewer data (OTV), the rock type appears highly foliated and is visually consistent with rock types observed in GZ-125 and GZ-130 located south of MW-6.
6. Structural information (strike/dip) obtained from interpreted optical and acoustic televiewer data show a predominant SSW-NNE orientation of fractures and westerly high-angle (60-70 degrees) dip direction, generally consistent with deep bedrock wells located south of MW-6 (GZ-125 and GZ-130).

3.3.1.2 Interval Packer Sampling

Following the completion of borehole geophysical logging, interval packer sampling was performed in accordance with the recommendations outlined in the *Revised Deep Bedrock Downhole Geophysics and Packer Sampling Interval Recommendations: MW*-6 memorandum dated June 29, 2020 (Haley Ward, 2020) and incorporated comments provided by USEPA via email correspondence on June 18, 2020. Analytical results obtained during the interval packer sampling were presented in the *MW-6 Interval*

Packer Sampling Results and Pumping Test Viability memorandum included in Appendix F. A total of eight intervals were completed for sampling within MW-6 with interval midpoints, from 28 feet to 166.5 feet below ground surface (bgs).

- Zone 1 – Single packer set at 28 feet below top of casing.
- Zone 2 – 31 to 42 feet below top of casing.
- Zone 3 – 65.5 to 71.5 feet below top of casing.
- Zone 4 – 85 to 96 feet below top of casing.
- Zone 5 – 101 to 107 feet below top of casing.
- Zone 6 – 112.5 to 118.5 feet below top of casing.
- Zone 7 – 142.5 to 148.5 feet below top of casing.
- Zone 8 – 163.5 to 169.5 feet below top of casing.

One interval (Zone 1) was unable to be sampled due to insufficient recharge following purging. This interval was designed to evaluate the integrity of the well casing seal and determine if overburden groundwater was entering the well via seal bypass. It was determined that the casing seal was not leaking and water was not entering the borehole directly from overburden. In addition to analytical sampling, fluid transmissivity for each packer interval was calculated based on the estimated specific capacity as determined from the pumping rate and observed drawdown within the packer string during purging. This was estimated using the method for a fractured bedrock aquifer utilizing specific capacity was developed experimentally by Huntley and Steffey (1992).

Based on the information observed in the field and the analytical results from the seven intervals sampled, the following findings were noted:

- Arsenic concentrations did not exceed the CL or AGQS in any of the seven intervals sampled.
- Manganese concentrations exceeded the AGQS (300 ug/L) in all intervals sampled.
- 1,4-dioxane was detected in only four of seven intervals and at low concentrations below the AGQS of 0.32 ug/L.
- PFAS concentrations did not exceed the current HA or AGQS in any samples collected.
- No VOCs were detected in sampled intervals.

A summary of analytical results completed during the interval packer sampling of MW-6 have been included as Appendix F.

Specific to the evaluation criteria provided by the USEPA in its June 17, 2020, letter, MW-6 displayed characteristics that made it a suitable well for the completion of the deep bedrock investigation pumping test (see Section 3.3.1.3). Based on water level monitoring performed during the redevelopment of MW-6 (June 11, 2020, memorandum), total drawdown during the period of redevelopment at a pumping rate of 7 gpm resulted in an approximate specific capacity for the well of 0.212 gpm/foot. Using the relationship between specific capacity and transmissivity in fractured bedrock aquifers developed by Huntley and Steffey, results in an approximate transmissivity of 6.24 feet^2/day.

Analytical results for redevelopment water from MW-6 were used in the completion of a NHDES Temporary Groundwater Discharge Permit Application (NHDES-W-03-154) to facilitate the completion of the variable rate and constant rate pumping test described below.

3.3.1.3 Pumping Test Work Plan

Following approval of use of MW-6 as the pumping test well by USEPA via email on August 26, 2020, Haley Ward authored the *Revised Deep Bedrock Investigation Pumping Test Work Plan*, dated November 2020. The *Pumping Test Work Plan* outlined pumping test activities including background water level monitoring, the variable rate pumping test, the constant rate pumping test, groundwater influent and effluent sampling, and investigation derived waste management. The revised work plan included revisions based on comments by USEPA and NHDES made in a November 6, 2020, letter on the *Draft Deep Bedrock Investigation Pumping Test Work Plan*.

3.3.1.4 Background Water Level Monitoring

For a minimum of two weeks prior to commencing the pumping tests, background groundwater levels were monitored to assess ambient groundwater levels that may affect the interpretation of data prior to and following the variable rate and constant rate pumping tests. To complete the background water level monitoring, vented pressure transducers were placed in monitoring wells considered to represent background conditions, as identified in the current monitoring well network on Figure 2.2, to monitor pressure and temperature. Transducers were installed in monitoring wells AE-2B, AE-3B, BP-4, FPC-2A, FPC-2B, FPC-3B, FPC-5B, FPC-7B, FPC-8A, FPC-8B, FPC-9B, FPC-11B, GZ-105, GZ-108, GZ-109, GZ-110, GZ-116, GZ-125, GZ-130, MW-2, MW-4, MW-5S, MW-5D, MW-8, MW-11, MW-20D1/D2, MW-21D1/D2, MW-22D1/D2, MW-24, MW-25S, and MW-25D. The D1 series of wells were instrumented for the first time during this background monitoring. The installation of these wells fulfilled the instrumentation task of the 2018 work plan.

Specific to MW-25, a packer was installed prior to background water level monitoring and the pumping test. A packer was placed between Zone 2 and Zone 3 (approximately 103 to 106 feet bgs) so that two separate intervals could be monitored in MW-25 during the pumping test. The uppermost interval included the open hole section from the bottom of the casing (42 feet bgs) to roughly the location of the packer. The lower interval included the section from below the packer (103 to 106 feet bgs) to the bottom of the borehole (283 feet bgs). The rationale used to determine the placement of the packer included:

- Isolation of the shallow fractures within Zone 1 was needed due to the hydraulic connection with the overburden observed during the installation of MW-25. It was theorized that the influence of the shallow interval would dampen what was likely to be smaller scale influence from pumping at MW-6 in deeper bedrock intervals in MW-25.

- The location of the packer created a similar isolated interval to that in MW-6 (the uppermost 50 feet of bedrock was isolated in both wells). This isolated the contribution from the more productive shallow bedrock fractures (weathered zones, sheeting fractures, etc.), as referenced above.
- To monitor the east-west trending fractures within this location, several Zones were isolated during the packer sampling (Zone 6, Zone 8, Zone 10, and Zone 11), which have generally east-west trending fractures with shallow dips (less than 45 degrees). This was done to isolate these Zones from the shallow fractures in order to identify the anisotropy within the east-west and north-south fracture sets within bedrock.

Pressure transducers were synchronized to reflect the current time of day prior to installation and were set to record groundwater elevations (pressure) on a linear time scale at a rate of 5- to 15-minute intervals, depending on distance from the pumping well. Additionally, the day prior to the variable rate pumping test, groundwater levels in surrounding monitoring wells were recorded and used for static aquifer conditions. Pressure transducers were left in the wells indicated at the beginning of this section throughout the duration of the pumping tests to measure effects of pumping on water levels.

3.3.2 Variable Rate Pumping Test

3.3.2.1 Design

A variable rate pumping test (step drawdown test) was performed on MW-6 to evaluate the well's performance under controlled variable pumping conditions, assess aquifer characteristics, and determine the long-term constant pumping test rate. The specific capacity and transmissivity for the pumping well, estimated from groundwater drawdown measurements recorded during well redevelopment and packer testing, were used to estimate pumping rates. Four varying flow rates were used during the step drawdown pumping test. Each pumping rate was maintained until drawdown stabilized to less than 10% change in hydraulic head for at least one-half hour. The variable rate step drawdown test was performed in advance of the constant rate pumping test.

The *Pumping Test Work Plan Section 2.2* outlined the rationale and calculations behind determination of a pumping rate for the variable rate pumping test. The proposed pumping rates were 5, 10, 15 and 20 gpm/foot based on the preliminary data from well redevelopment and transmissivity estimates from packer testing. It was expected that the drawdown at any discrete pumping rate would increase with the upper, more transmissive fractures being isolated.

Prior considerations were also made to determine the maximum drawdown that would reflect the maximum well yield. MW-6 has a total depth of 184 feet bgs, necessitating that the pump should be set at approximately 179 feet below grade, with the pressure transducer to collect readings set at 170 feet below grade, or 159 feet below static water level. With a 15% factor of safety to ensure that the transducer remained submerged and readings could be collected throughout the entirety of the constant rate pumping test, the maximum yield would allow for roughly 135 feet of drawdown.

3.3.2.2 Execution

Prior to the initiation of the variable rate pumping test, MW-6 was redeveloped and a temporary double k-packer seal separated by approximately five feet was installed in MW-6 to isolate shallow bedrock fractures from those located at depth to better evaluate response to pumping within the deeper bedrock interval. The flexible rubber seal was approximately 12 inches in height and designed to isolate specific sections of the borehole. The seal was affixed to a 4-inch diameter PVC pipe and pushed into the borehole to the interval requiring isolation. This allowed for the pump, water level monitoring instrumentation, and pump discharge piping to be placed through the 4-inch diameter piping while maintaining the seal at the desired depth. The seal was removed following the completion of post constant rate pumping test water level monitoring.

Based on the well log, downhole borehole geophysics, interval packer sampling, and USEPA recommendations, the seal was placed from 58 to 62 feet below top of casing (56 to 60 feet bgs). This placement isolated shallow fractures that may be influenced by overburden groundwater (likely transmissive interval) within Zone 2 (31-42 feet below top of casing) from the deeper zones targeted for the tests and maintained isolation of the deeper bedrock fractures intercepted by the well. Following seal installation, water levels were monitored above and below the seal for stabilization prior to initiating the variable rate test and monitored using pressure transducers as noted below. This was completed prior to the background water level monitoring described in Section 3.3.1.4.

Setting the seal focused the pumping stress from the fractures located in the lowermost section of the borehole (Zone 3 [65.5 feet to 71.5 feet] through Zone 8 [163.6 feet to 169.5 feet]). The deepest fractures located in Zone 8 have an estimated transmissivity of 0.04 feet^2/day while the estimated transmissivities for Zone 6 (112.5 feet to 118.5 feet) and Zone 7 (142.5 feet to 148.5 feet) are 0.30 feet^2/day and 0.39 feet^2/day, respectively. Shallower fracture Zone 3 and Zone 4 (85 feet to 96 feet) have estimated transmissivities of 4.18 and 4.43 feet^2/day, respectively. The estimated transmissivities illustrate how the most transmissive fractures are generally shallow. Meanwhile, static water levels of the deeper fractures identified during packer sampling, between Zone 6 and Zone 8, indicate that the potential volume of water produced through these fractures would be limited by the relatively low magnitude of their transmissivities.

The variable rate pumping test was performed using a 4-inch submersible well pump placed near the bottom of the open hole section of MW-6, at roughly 179 feet below grade. The pump discharge was controlled using a gate valve with the discharge rate monitored using a totalizing in-line flowmeter calibrated for the flow rates anticipated during the test. A graduated measuring device and stopwatch were used to manually confirm the pumping rates reported on the flow meter. A vented pressure transducer was installed at 171.5 feet below top of casing. Manual water level measurements were collected above and below the sealed interval to ensure the seal was effective at isolating the shallow bedrock fractures from those targeted at depth. The pumping rate and water quality field parameters (pH, temperature, turbidity, oxidation reduction potential [ORP], and conductivity) were recorded at 5-minute intervals for the first 15 minutes of the test; then at 15-minute intervals for the first hour, and every half hour thereafter at each pumping rate. Parameters were monitored in accordance with the pumping test work plan.

Water levels were monitored with transducers and manually once per day in the following wells located nearest to MW-6: AE-2B, AE-3B, BP-4, FPC-2A, FPC-2B, FPC-3B, FPC-4B, FPC-5B, FPC-7B, FPC-8A, FPC-8B, FPC-9B, FPC-11B, GZ-105, GZ-108, GZ-109, GZ-110, GZ-116, GZ-125, GZ-130, MW-2, MW-4, MW-5S, MW-5D, MW-8, MW-11, MW-20D1/D2, MW-21D1/D2, MW-22D1/D2, MW-24, MW-25S, and MW-25D.

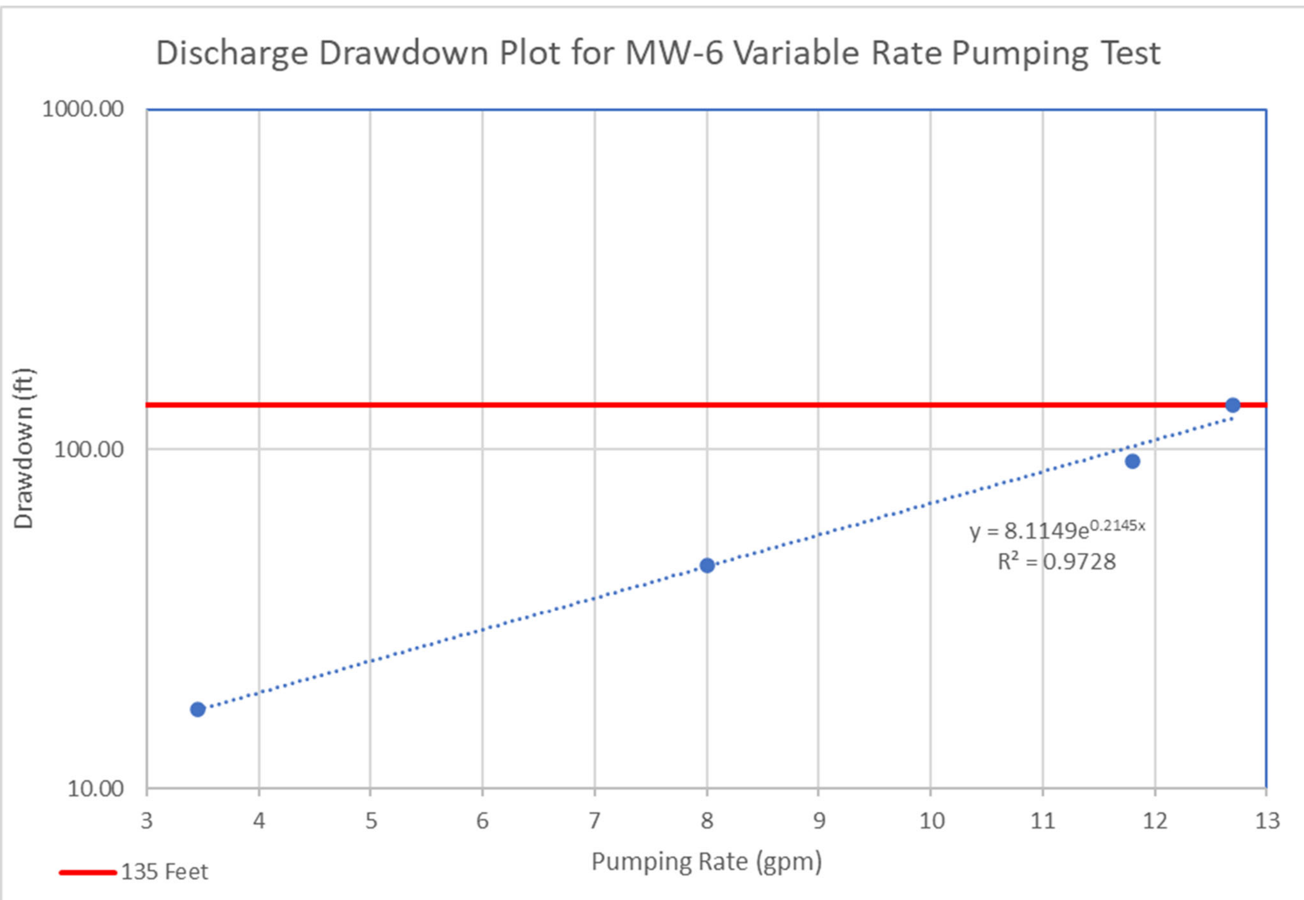
3.3.2.3 Results

Of the 35 instrumented wells/intervals during the variable rate test, wells MW-5S (shallow bedrock) and MW-5D (deep bedrock) exhibited drawdown during the variable rate pump test. MW-5S exhibited a drawdown of approximately 4.5 feet and MW-5D exhibited a drawdown of approximately 4 feet. These two wells are located directly northeast of the pumping well (MW-6) along the northeast/southwest trending bedrock strike with the screened portion of the wells located at the top (MW-5S) and bottom (MW-5D) of the open hole portion of MW-6. In general, this hydraulic influence in MW-5S/-5D observed during the variable rate pumping test agrees with observations made during the redevelopment of MW-6 and is consistent with the conclusion from the CSM that these wells are located along the primary north-south pathway parallel to the primary trend of fracture strike observed in this study.

The final results are based on measurements recorded in the field (flow rate) and stabilized drawdown within MW-6 from the deployed transducer. The water level in the borehole above the k-packer seal installed to isolate shallow bedrock fractures from the deeper pumping interval, stabilized at approximately 22 feet below the top of casing, or a drawdown of 11 feet below the static water level. This indicates that the packer installation depth was effective in isolating the contribution of the shallow fractures between 60 feet below top of casing and the bottom of casing at 26 feet.

The results from the variable rate pumping test were then used to make determinations for the constant rate pumping test. As per the information viewed in the field by representatives of the USEPA and NHDES and following in-field discussions on June 15, 2021, and those during the conference call of June 17, 2021, the pumping rate to be used for the constant rate test was determined to be approximately 12.7 gpm with a stabilized drawdown of 135 feet. This rate was determined to be the estimated yield of MW-6 based on the variable rate pumping test performed. A table detailing the pumping rates and associated stabilized drawdown values for MW-6 during the variable rate pumping test are provided below. As expected, there is a logarithmic increase in drawdown associated with increased pumping rates.

Stabilized Drawdown (feet)	Pumping Rate (gpm)
17.1	3.5
45.4	8
92	12
135.3	12.7



3.3.3 Constant Rate Pumping Test

3.3.3.1 Design

Following completion of the variable rate pumping test at MW-6, and once groundwater had returned to static conditions as determined by background water level monitoring, the constant rate pumping test was performed to determine boundary effects, aquifer parameters, and interconnectedness of bedrock fractures. The constant rate test included installation of a pump capable of pumping groundwater at a controlled rate based on the results of the variable rate pumping test. The pumping rate was selected to achieve the greatest stress on the bedrock aquifer while accounting for the anticipated 96-hour pumping test duration. A rate of 12.7 gpm was selected and approved by USEPA via email on June 17, 2021.

3.3.3.2 Execution

The constant rate pumping test began on Monday June 21, 2021, and continued for 98 hours, 40 minutes (until Friday, June 25). The pump was placed at a depth of approximately 179 feet bgs (five feet from the bottom of the well). To obtain accurate monitoring data during the groundwater recovery period after the pump test was complete, a check valve was installed at the base of the discharge pipe to reduce backflow of water into the well. Once the submersible pump was installed, a 1-inch diameter PVC stilling tube was installed near the top of the pump to allow for monitoring groundwater levels while reducing the effects of pumping turbulence on measurements. Pumping rates and volumetric totals were monitored using a digital totalizer/flowmeter, allowing for accurate measurement of flow rates and discharge volumes.

The pump discharge was connected to piping plumbed to a polyethylene storage tank staged near the well. The tank was used as a flow equalization tank to buffer flow prior to treatment and discharge to the Site via spray irrigation following treatment.

Pressure transducers were used to monitor groundwater levels within existing monitoring wells to record the influence of pumping. Transducers installed in each well recorded data, including pressure and temperature, during the constant rate test. Wells instrumented during the constant rate test included: AE-2A, AE-2B, AE-3B, BP-4, FPC-2A, FPC-2B, FPC-3B, FPC-4B, FPC-5B, FPC-7B, FPC-8A, FPC-8B, FPC-9B, FPC-11B, GZ-105, GZ-108, GZ-109, GZ-110, GZ-116, GZ-125, GZ-130, MW-2, MW-4, MW-5S, MW-5D, MW-8, MW-11, MW-20D1/2, MW-21D1/2, MW-22D1/2, MW-24, MW-25S, and MW-25D. Vented pressure transducers were used on a series of wells, including MW-6, MW-5S, MW-5D, MW-2, AE-2B, while non-vented pressure transducers were used for the rest of the instrumented wells. Barometric readings to correct the readings from the non-vented pressure transducers were collected throughout the pumping test as well as during the background and recovery monitoring. See Table 3.1 for additional detail on these wells.

The pumping rate, total volume pumped (in gallons), and water quality field parameters (pH, temperature, turbidity, ORP, and conductivity) were recorded at MW-6 for 5-minute intervals for the first 15 minutes of the test; then at 15-minute intervals for the first hour, and hourly thereafter. The pumping rate of 12.7 gpm was maintained for the first eight hours of the test, achieving the expected drawdown of 135 feet below static. As the test continued, the drawdown remained stable around 135 feet below static; however, the pumping rate began to slowly decrease. Ultimately the pumping rate stabilized between 11.4 and 11.8 gpm by the morning of June 23, 2021, two days after the start of the test, which was maintained until the test was complete.

Prior to the conclusion of the pumping test, real time HPFM data was collected from bedrock wells GZ-108, GZ-125, GZ-130, MW-24, and BP-4 to measure variations in ambient flow rate within the borehole resulting from pumping. These wells were selected from those previously investigated during the reconnaissance well investigation and based in part on the drawdown observed during the constant rate test.

At the conclusion of the constant rate pumping test, deployed transducers continued to collect readings, capturing the recovery period of the groundwater aquifer. The recovery test continued for approximately two weeks following the pumping test. The pump remained in the test well until the aquifer recovery monitoring was complete. Groundwater level measurements were also collected from transducers during the recovery period from monitoring wells considered to represent background conditions, to assess potential natural ambient water level fluctuations, and for use in correlation with pre-test water level measurements. Manual synoptic rounds of water levels were completed prior to the startup of the pumping test, daily during the test, and prior to shutdown of the event, in addition to the water levels collected by the transducers. Water levels data from both the transducers and manual readings are presented in Appendix F.

3.3.3.3 Results

Background monitoring of the pumping well and observation wells for a two-week period prior to commencing the test indicated a general downward trend in water levels in all monitoring wells. This downward, linear trend is consistent with the long term, seasonal decline in water levels of the overburden and bedrock aquifers. Daily fluctuations in water levels in the bedrock wells are attributed to earth tides, a common phenomenon observed in crystalline, fractured bedrock wells. During this background monitoring period, intermittent rain events (reported from the nearest weather station at the Portsmouth International Airport at Pease Station) occurred with up to 0.3 inches of precipitation over a 24-hour period. As shown in Figure F1 of Appendix F this precipitation was reflected in some bedrock wells, but not others. There was a direct and immediate response to precipitation (increase in water levels) observed in bedrock wells on the western side of the landfill. This effect was observed particularly within those wells installed in the Rye Formation underlying glacial till and located in the bedrock trough, illustrating the connection of bedrock groundwater with surface water and shallow groundwater in the wetland complex. Conversely, bedrock wells on the eastern side of the landfill or those installed into the CSC, showed a steady decrease in water levels with no impact from precipitation.

HPFM data collected from bedrock wells GZ-108 (6/24/2021), GZ-125 (6/23/2021), MW-24 (6/23/2021), GZ-130 (6/24/2021), and BP-4 (6/24/2021) during the pumping test indicated no measurable flow at all depths. GZ-130 is the only well that exhibited any response, indicating upward flow at a rate of 0.02 to 0.03 gpm from 82.5 feet below top of casing to 144.5 feet below top of casing.

Hydrographs produced from the pumping test were analyzed and several wells were found to have exhibited drawdown attributed to the pumping from MW-6. A portion of wells onsite were monitored using vented pressure transducers, which account for barometric pressure. For wells without vented cables, barometric pressure was measured using an in-situ barotroll data logger. The reported barometric pressure was subtracted from the raw data reported from the pressure transducers, which outputs a pressure measurement that is the sum of barometric pressure plus pressure exerted on the probe from the water column. From there, depth below water was calculated for the non-vented cables. Using either the raw (for vented cables) or corrected data from the pressure transducers accounting for barometric pressure, water levels were correlated to manually measured water levels. Using the manual measurements to constrain the reported or calculated depth below water, confirmed water level elevations throughout the test for each monitored well were calculated.

The pressure transducer in one well, FPC-4B malfunctioned during the test and reported results from that transducer are not valid. Due to distance from the pumping well, where FPC-4B represents shallow bedrock west of the wetland complex, and lack of response observed in wells closer to the pumping well. The transducer in AE-2A was used to replace a malfunctioning transducer in AE-2B, so data was not collected for the entirety of the test at AE-2A. At MW-4 the transducer was removed from the well at the end of the test to ensure recovery readings were collected from MW-6 after a malfunction of that transducer. The missing data from these three wells do not impact the evaluation of the pumping test.

For wells that exhibited drawdown, the water level measurements were corrected to account for the background decline in water levels. A linear trend was projected from the background monitoring, so more accurate drawdown measurements attributable to pumping were determined. Additional corrections to account for earth tides and short-term rainfall increases were not incorporated into these calculations of drawdown. Corrections to account for earth tides do not to have a significant impact on the calculated drawdowns. Impacts on water level from local precipitation vary significantly between wells and cannot be fully accounted for without significant prior knowledge regarding response to rainfall. To account for precipitation as best as possible with the dataset available, a linear trend was developed from the preceding three and a half days prior to the start of the test, following the end of the variable rate test. Corrected water levels accounting for the projected decline in water levels were calculated by subtracting the projected water levels from the calculated drawdown values (which account for barometric pressure).

For monitoring wells MW-5S/5D, MW-2, and FPC-2B the corrections made were consistent with the long term, linear trend in background water levels gradually dropping. Well MW-11 exhibited more influence from precipitation events prior to the start of the test, which made the corrections more subjective. However, roughly 1,000 minutes prior to the start of the test, the water levels diverge from the projected water levels, ultimately resulting in a drop of 0.2′ below the projected values at around 4,000 minutes after the start of the test. The slight rise in water levels in MW-11 after 4,000 minutes is consistent with a precipitation event during that time and with other wells that exhibit hydraulic responses to precipitation, ie GZ-105, FPC-7B, and MW-8.

During the pumping test the following 5 monitoring wells showed a response (water level drawdown in the well) to pumping at MW-6:

- MW-2, located approximately 288 feet north, with a total drawdown of 0.7 feet;
- MW-5S, located approximately 359 feet north/northeast, with a total drawdown of 8.0 feet;
- MW-5D, located approximately 370 feet north/northeast, with a total drawdown of 8.7 feet;
- MW-11, located approximately 588 feet north, with a total drawdown of 0.2 feet; and,
- FPC-2B, located approximately 785 feet southwest, with a total drawdown of 0.1 feet.

The five wells that exhibited drawdown are the closest five wells to the pumping well (MW-6) along the orientation (north/northeast to south/southwest) of fractures identified in downhole geophysical surveys (Appendix C), outcrop mapping (Figure 3.3), and lineament analysis (Figure 3.2). The remaining 28 wells instrumented during the pumping test did not show a response to pumping over the 98-hour test. As shown in Figure 3.6, which details the corrected drawdown measurements and includes drawdown contours, the magnitude and spatial distribution of the observed hydraulic influence is consistent with the 5:1 anisotropy parallel to the primary fracture network predicted by Mack 2012. This means drawdown was found to be five times greater parallel to the primary fracture network (NNE-SSW) than perpendicular to the primary fracture network (NNW-SSE). This result indicates the capacity of the bedrock aquifer to transmit groundwater is much greater along this primary fracture network in the CSC.

It is noted that for wells FPC-2B and MW-11, the observed drawdown was smaller in magnitude than what was observed at MW-5S, MW-5D, and MW-2, and the observed drawdown was not immediately obvious during the first few hours of the constant rate pumping test. This indicates the constant rate test was effective in stressing the deep bedrock aquifer in the vicinity of MW-6 to better define the extent of the interconnected fracture network in deep bedrock, which shorter periods of pumping at lower pumping rates.

Aquifer properties, well construction details, and pumping rates from MW-6, and drawdown readings and well construction details for wells MW-5S/5D were input into the Aquifer Test Analysis Software, AQTESOLV (AQTESOLV 2007) and solved for transmissivity and storativity using the Theis Solution. The Theis solution assumes an isotropic and homogenous aquifer material, it is known that neither of those assumptions are valid in the deep bedrock at this site, so the calculated values should be considered estimates of the reported aquifer properties. Conductivity was estimated from the transmissivity value assuming an aquifer thickness of 173 feet, which is the depth of MW-6, 184 feet, minus the static water level of 11 feet bgs. The output from the AQTESOLV analysis of aquifer properties to the north of MW-6 along the strike of the primary fracture network in the deep bedrock of the CSC is included in Appendix F.

The Theis solution matches well to the drawdown curve for MW-5S/5D but underpredicts the recovery of the monitoring wells. This means the Theis solution predicts a faster recovery of water levels in the bedrock monitoring wells than was observed. This is consistent with the identified isolation of the deep bedrock in the CSC from an aquifer hosted in an isotropic and homogeneous unconsolidated sediment, which the Theis solution would be better able to predict the response to pumping from.

Aquifer properties parallel to the primary north/south strike direction were estimated to be:

- Transmissivity (T): 108.4 $feet^2$/day
- Storativity (S): $4.316x10^{-5}$
- Conductivity (K): 0.62 feet/day

These values are generally consistent with past estimates. Aquifer properties calculated and reported by Golder Associates from a Pre-Design pumping test completed as part of the Coakley Landfill Feasibility Study in 1994 showed a range of T values from 92 to 368 $feet^2$/day, K values from 0.99 to 3.69 feet/day, and S values from 5.4 x 10^{-4} to 0.42. The USGS (Mack 2012) assumed hydraulic conductivity values between 0.5 and 1.0 feet/day for the Rye Complex, the formation underlying much of the Site. Aquifer properties in the direction of the primary strike direction calculated from the pumping test overlap many of the values calculated or assumed by others for the geologic units underlying the Site.

Calculations for aquifer properties in the wells offset from the primary strike direction, MW-2, MW-11, and FPC-2B, using the Theis Solution would be inherently flawed due to the assumptions of the solution, which assumes isotropic and homogenous aquifer conditions that have been shown to not be valid for the deep bedrock aquifer at the Site. Instead, the anisotropic conditions identified in the drawdown contour map (Figure 3.6) illustrate the aquifer properties perpendicular to the primary fracture network, supporting the 5:1 anisotropy expected by Mack 2012. The confirmation of this anisotropy to the Site allows for the estimate of transmissivity and conductivity perpendicular to the primary strike direction, as one fifth of the transmissivity of the aquifer parallel to the primary fracture network, to the east/west as roughly 22 $feet^2$/day for transmissivity and 0.12 feet/day for conductivity.

The results of the pumping test confirm aquifer characteristics present in the deep bedrock aquifer in the vicinity of MW-6, which represents a portion of the CSC the landfill is built on. The Constant Rate Test has allowed for the generation of a drawdown contour map to illustrate the extent and orientation of the interconnected fracture network at MW-6, supports the interpretation of anisotropy predicted by Mack 2012, allows for the estimation of aquifer properties including conductivity, transmissivity, and storativity, and provides a baseline to understand contaminant fate and transport in the deep bedrock underlying the landfill. It has shown that the interconnected fracture network is primarily along the primary northeast/southwest strike direction, and a deep bedrock pumping well utilized at its maximum well yield for five consecutive days can draw from fractures extending roughly 1,500 feet along the primary north to south fracture network and roughly 300 feet to the east and west.

The stress and distance of influence created by this pumping is significantly greater than what would be expected from a typical residential well (or group of wells) which are generally pumped for shorter periods to supply the needs of a home. In New Hampshire the average domestic water use from self-supplied domestic wells per person per day is 75 gallons (USGS 2010). A family of four would withdraw roughly 300 gallons per day. The pumping test completed here produced more water in less than one half hour, than would supply an average family in New Hampshire for one day.

3.3.4 Groundwater Sampling

In addition to water quality parameters monitored during the completion of both the variable rate and constant rate pumping tests, samples of untreated groundwater effluent from MW-6 were collected to assess for changes in groundwater quality as a result of artificial aquifer stress induced by pumping. The samples were collected from a sample port located on the pump discharge line, prior to the equalization tank in accordance with water sampling procedures outlined in the project SAP. Groundwater samples were collected for analysis of VOCs, PFAS, 1,4-dioxane, arsenic, manganese, and general landfill parameters (ammonia, chemical oxygen demand, chloride, hardness, and nitrate). Samples were collected during the constant rate test approximately every 18 hours.

Analytical results from the constant rate test at MW-6 showed an increasing trend of 1,4-dioxane, PFHpA, PFHxA, PFOA, and PFOS concentrations over time, while all other constituents remained relatively stable. This suggests the contribution of bedrock groundwater with higher concentrations of PFAS and 1,4-dioxane originating nearer the landfill to the effluent over the course of the pumping test. This is supported by the measured drawdown during the pumping test with an elongated anisotropic cone of depression in deep bedrock along the prmary northeast-southwest trending fracture set aligned between MW-6 and the MW-5S/5D wells. The likely presence of multiple interconnected steeply dipping parallel and cross cutting fractures within this cone of depression allows for the potential contribution of PFAS and 1,4-dioxane from an area rather than a singular set of deep fractures.

Additionally, an analysis of the timing of drawdown observed in MW-6 and MW-5S/-5D indicate that drawdown in MW-5S/-5D coincided with the dewatering of a fracture in MW-6, identified in the downhole geophysical logging in Zone 4, between 85 feet and 95 feet bgs, with a dip to the northwest of 37 to 40 degrees. Prior to the dewatering of this fracture, no drawdown was observed in either MW-5S or MW-5D, following dewatering, water levels began to drop in both wells. It is likely that this fracture represents a direct conduit between MW-6 and MW-5S/-5D and that dewatering the fracture allowed for the mobilization of the groundwater with higher concentrations of COCs proximal to the landfill to be transported to MW-6. Both MW-5S/-5D are hydraulically connected to this fracture either directly or through the more steeply dipping vertical fractures found in downhole geophysical logging results.

Analytical results associated with the pumping test, along with a graphical representation of water levels in MW-5S, MW-5D, and MW-6 during the dewatering of the fracture in Zone 4 of MW-6, can be found in Appendix F.

3.3.5 Investigation Derived Waste Management

Water generated during the variable rate and constant rate pumping tests was treated using a mobile treatment system that included inline duplex particulate filtration and granular activated carbon (GAC) vessels. The GAC filtration units were sized to allow for adequate empty bed contact time for removal of PFAS and other site contaminants to levels that are below the AGQS and applicable Maximum

Contaminant Levels (MCLs). The system included two sets of particulate pre-filtration and two GAC vessels. Each vessel contained 1,000 pounds of virgin coal-based GAC.

Prior to discharge of water generated during the variable rate test, a sample of treated effluent was collected and submitted for analysis. An additional sample of effluent was collected prior to completion of the constant rate pumping test to evaluate the system effectiveness of contaminant removal. Monitoring was performed in accordance with the temporary discharge permit requirements, as outlined in the *Pumping Test Work Plan*, and as outlined in USEPA/NHDES comments on the *Pumping Test Work Plan*. Results from these two effluent samples indicate that the treatment system was effective in removing PFAS and some 1,4 dioxane from the water generated and contained during the pumping test. Analytical results associated with the pumping test can be found in Appendix F.

Treated effluent water was pumped into a 10,000-gallon steel frac-tank for temporary storage, then pumped to two 1,000-gallon polyethylene storage tanks located on the adjacent landfill, then discharged via a high-capacity irrigation spray nozzle onto the landfill cap. Approximately 70,550 gallons of treated effluent water was sprayed onto the landfill cap. The application area was changed throughout the duration of the pumping tests to minimize the amount of water applied to a single area of the cap. System outfalls (e.g., underdrain pipe and perimeter ditches) were monitored during the test for discharge, but none were observed.

3.4 Surface Water Elevations

Surface water in the vicinity of the Site consists of precipitation runoff and surface expressions of groundwater. Surface water elevations have been measured to inform interactions between overburden groundwater and surface water and improve understanding of the upward movement of contaminants found in groundwater within the project area (Section 5). Surface water measurements will continue to be measured at the Site in accordance with Section 7.

Surface water elevations were collected at multiple gauging locations in the vicinity of the Site (Figure 2.2) in 2019 and 2021. Gauging locations consisted of historical locations (i.e., established long-term monitoring locations; Haley Ward, 2018c) and surface water gauging locations that were added within the wetland complex, Berrys Brook, and Little River to support the surface water evaluation/ stormwater investigation (Haley Ward, January 2020) and the deep bedrock investigation (Haley Ward, Inc./CES, Inc., 2020) activities completed in 2018 and 2019. The additional surface water gauging locations were constructed with steel pins or staff gauges based on an estimated mean seasonal water level, as observed during previous surface water sampling efforts. Piezometers that also serve as additional gauging locations include PZ-6 to the northeast, PZ-7 to the north, PZ-5, PZ-103, etc. to the northwest, and PZ-4 to the west of the landfill.

Gauging locations added are summarized below:

- SW-5, SW-103, SW-BB1, SW-BB2, SW-110, and SG-1 through SG-4 installed to understand the interaction of overburden groundwater and surface water west of the Site.

- SG-5 through SG-7 installed to understand the interaction of overburden groundwater and surface water north of the Site.
- PZ-1, PZ-2, and PZ-3 installed to support surface water evaluation efforts[5] and serve as additional surface water gauging locations where the northeast stormwater basin (SB-1) drains to the wetland north of the landfill and the northwest stormwater basin (SB-2) drains to the wetland north of the landfill and eventually to Berrys Brook.

To facilitate the evaluation of the interaction of overburden groundwater and surface water, overburden monitoring wells MW-20S and MW-21S were installed immediately adjacent to existing wetland areas and MW-22S was installed further inland from the complex. In addition, the installation of temporary monitoring wells (TMWs) during the DPT investigation supplemented shallow groundwater elevation data within the western extents of the wetland complex, near MW-21S.

Gauging locations installed were used to supplement information obtained through the delineation of westward extent of impacts near MW-21S (Section 3.5).

3.4.1 2019 Surface Water Elevations

Surface water elevations were measured at SB-1, SB-2, the L-1 Seep, SW-5, SW-103, SW-110, BB-1, BB-2, and the Little River Bridge over five events in 2019 (Haley Ward, January 2020). The events in April, May, July, August, and September of 2019 account for seasonal variations in elevations. Measurement locations are identified on Figure 2.2. Results are presented on Table 3.4 and discussed in Section 4.4. Generally, results indicate that surface water flows from the Site towards the wetland complex, Berrys Brook, and the Little River, and that surface water and shallow groundwater elevations are similar in some areas.

3.4.2 2021 Through 2022 Surface Water Elevations

Eight piezometers were installed in October 2021 to supplement 2019 monitoring locations. Piezometers were installed at existing surface water sampling locations BB-2, SW-4, SW-103, and SW-110; as well as in areas immediately north of the landfill boundary and west of the railroad easement between BB-1 and BB-2 (Figure 2.2). Locations were selected based on temperature profiling of the water column and sediment below to identify areas where groundwater discharge to surface water may have been occurring. Locations were verified in the field by USEPA and NHDES.

Piezometers were constructed using 1.25-inch diameter stainless steel drive point well screens 2.5 feet in length with galvanized steel risers completed to between 2.25 feet and 3.5 feet above grade (Appendix A). Piezometer locations were determined based on temperature profiling conducted in the field to determine areas of potential groundwater discharge (lower temperatures than surrounding water temperatures). Installation locations were approved by USEPA and NHDES in the field. Each piezometer screen was advanced at least one foot below grade at each location.

[5] PZ-1 was installed in the northeast stormwater retention basin (SB-1), PZ-2 was installed in the northwest basin (SB-2), and PZ-3 was installed in the vicinity of the L-1 seep sampling point to establish a discrete sampling location representative of shallow groundwater discharging to the wetlands in the area downgradient from the outfall discharge from stormwater retention basin SB-2.

Surface water and piezometer elevations were measured in 2021 following installation. These measurement locations are identified on Figure 2.2. Results are presented on Table 3.4 and discussed in Section 4.4 with monthly readings completed since installation at the request of the USEPA. Measurements through June 2022 have been provided in Table 3.4. Measurements have been collected at piezometer locations inside and outside the steel riser to be representative of shallow groundwater and surface water, respectively since March of 2022.

3.4.3 Additional Surface Water Elevation Measurements

As discussed in Section 3.4, surface water gauging locations were added to select locations within the wetland complex, Berrys Brook, and Little River during deep bedrock investigation activities completed in 2018. Based on the evaluation of surface water elevations within the project area relative to overburden groundwater and surface water interactions, additional gauging locations were installed west of the wetland complex in 2021. These gauging locations serve as porewater and surface water sampling locations and will be utilized to further assess surface water and groundwater hydraulic interaction related to the wetland complex. Synoptic water levels will be collected from these locations over a period of six months (November 2021 to October 2022) but recommendations are included in Section 7 related to continued monitoring of water levels. Samples were collected in November 2021 and during Spring 2022. These data are expected to provide additional information on overburden groundwater and surface water interaction at the Site.

3.5 Investigation of Impacts West of MW-21S

Light Detection and Ranging (LiDAR) elevation data has allowed for the identification of subtle low-lying areas immediately west of overburden and deep bedrock well couplet MW-21. These areas see fluctuations in shallow groundwater due to surface water levels within the wetland complex located east of and immediately adjacent to MW-21S. Concern was expressed by the Agencies that overburden groundwater may be migrating west of MW-21S and that could result in the potential migration of contaminants within overburden outside the current GMZ boundary. Additional investigation in this area was deemed warranted to better understand if overburden migration of contaminants might be occurring in this area.

Based on surface geophysical mapping performed in May/June 2018 (Appendix D) to position deep bedrock well couplet drilling locations, electrical resistivity data illustrated a shallow zone of low resistivity in the area immediately south and west of the MW-21 well couplet. These localized anomalies are characteristic of those typically associated with more electrically conductive overburden sediments deposited within the more electrically resistive bedrock topographic lows. These low resistivity anomalies are coincident between parallel north-south resistivity profiles and correlate with interpreted low-lying wetland topography interpreted from LiDAR data. The overburden sediments appear to thin to the west as the channel broadens, with the interpreted thickness ranging from approximately 14 to 16 feet to approximately 8 to 10 feet. This interpretation is supported, in part, by the absence of overburden observed during drilling at the MW-21D deep bedrock boring location. The location of MW-21S (130 feet south of MW-21D1/-D2) was selected based on in-field interpretation of surface topography, location relative to the MW-21D boring, and drilling rig access. Topographic ridges in the area surrounding MW-21S/-21D, based on field observations at the time of well installation, are comprised of bedrock with overburden sediments being thin to absent. These observations are consistent with interpreted LiDAR data and surface geophysical results (ground-penetrating radar and electrical resistivity). Similarities in topography between the area near MW-21S/-21D and areas west suggest that overburden sediments would thin to the west, which was confirmed with the DPT investigation, summarized in Section 3.5.1.

Analytical results for MW-21S sampled in October 2020 reported concentrations of 1,4-dioxane at 29.0 ug/L, with concentrations reported as Not Detected (ND) in both the shallow (MW-21D2) and deep (MW-21D1) bedrock intervals, indicating that 1,4-dioxane is present only in overburden but not deep bedrock at this location. The potential for migration within the overburden groundwater west of MW-21 was investigated to assess the relationship of contaminant distribution near MW-21S/D and the GMZ boundary. The additional overburden groundwater elevation data are also usable to help confirm the CSM relative to bedrock groundwater flow paths.

3.5.1 DPT Investigation and Temporary Well Installation

A total of 11 DPT borings were advanced to refusal in areas west of MW-21S from November 30, 2020, to December 7, 2020 (Haley Ward, May 2021b; Figure 3.5). Borings were completed at locations as proposed in the *Work Plan Addendum* (Haley Ward, July 2020); however, several locations (DPT-1, DPT-2, DPT-5S/D, DPT-6, and DPT-7) were adjusted in the field by representatives of the USEPA and NHDES based on field conditions observed at the time of installation. Of the 11 DPT locations completed, temporary monitoring wells were installed at eight locations based on lithology encountered and are identified accordingly on Figure 3.5 with a TMW (temporary monitoring well) prefix. Cross sections of DPT lithology encountered during the investigation have been included as Figure 3.5A and 3.5B with location included on Figure 3.5.

DPT locations were positioned approximately 150 feet apart within low-lying areas identified by analysis of surface geophysical data collected in 2018 (Appendix D), lithology and analytical information provided at MW-21S and MW-21D1/-D2, and high-resolution LiDAR data for the area. The locations were arranged along two intersecting transects oriented roughly east-west (DPT-1, DPT-2, DPT-3, DPT-4, DPT-5, and DPT-7) and southeast-northwest (DPT-11, DPT-10, DPT-9, DPT-8, and DPT-6). The east-west oriented transect (B-B') was located north of the southeast-northwest transect (A-A') as illustrated on Figure 3.5. Depths to refusal ranged from 4.5 feet bgs at DPT-2 to 24 feet bgs at DPT-11. It is important to note that depths noted are refusal depths of the DPT sampler and may not be a true depth terminated at the bedrock surface. Though not a continuous lateral thinning of overburden sediments progressing west, depths to refusal appear consistent with the locations of DPT borings to areas of topographic relief as illustrated on LiDAR imagery. These areas of topographic relief, based on field observations at the time of DPT advancement and during the surveying of DPT measuring points, are most often related to shallow and/or exposed bedrock. For example, locations DPT-9 through DPT-11 and DPT-5 are located more central to the axis of the low-lying areas targeted with the investigation while DPT locations DPT-1 through DPT-3 are the shallowest of the DPT locations and are positioned more proximal to the edges of areas in topographic relief. Intermediate locations (DPT-4, DPT-6, and DPT-7) are positioned nearer valley midpoints or between DPT locations with greater depths to refusal and areas of interpreted shallow and/or exposed bedrock. Shallower than expected refusal was encountered at DPT-8 based on refusal depths encountered at DPT-5 and DPT-9. It is also to be expected that the bedrock surface to the edge of the bedrock trough (i.e., west of MW-21S) will be irregular and may contain a weak or fractured surface resulting from the formation of the trough and formation of localized smaller scale sheeting fractures.

Lithology encountered during installation consisted primarily of fine to medium-grained sand overlying clay (Haley Ward, May 2021b); however, several locations had sand/fine gravel units directly overlying the bedrock surface/underlying the clay. These lithologies are consistent with overburden at the Site with the marine deposits (clay) being covered with and underlain by glacial till units, respectively, as illustrated in Figure 3.5A and 3.5B. The composition of till deposits overlying bedrock were consistent with those observed during the drilling of MW-25. Based on thicknesses of individual units within each DPT boring, variations in bedrock topography resulted in changes in the thicknesses of till more so than marine deposits. For example, along the northern transect (B-B'), till was encountered in DPT-1 but not in DPT-2 where bedrock shallows before deepening at DPT-3 where till reappears above the bedrock surface and thickens to the west towards DPT-4 through DPT-6. Boring logs from the DPT investigation are included in Appendix A.

Well construction consisted of 1-inch diameter PVC materials with screen lengths varying between 3 and 5 feet and were positioned based on the lithology encountered and depth to refusal. The screen length varied depending on the mapped thickness of overburden units and was installed based on conditions observed in the field. For example, if till was encountered directly overlying the point of DPT refusal (assumed bedrock surface), the screened interval was placed closest to the inferred bedrock surface. Conversely, if a single lithology was observed extending from ground surface to DPT refusal, a screened interval was placed at the base of refusal and another at the uppermost section of saturated overburden. This construction was designed to allow for the lateral delineation of 1,4-dioxane within overburden west of MW-21S and to provide information relative to the interaction between groundwater at the bedrock/overburden interface.

Wells were constructed within the DPT borings with silica sand filter material placed around the annulus of the well screen from the base of the well to approximately 2 feet above the well screen with bentonite chips placed from the top of the filter sand to ground surface to seal the screened interval. Wells were developed within 24 hours of installation using a stainless-steel check valve and dedicated high density polyethylene tubing. This method effectively removed any accumulated silt from within the well and introduced fresh formation water to the temporary monitoring well prior to sampling. Temporary monitoring well construction diagrams are included in Appendix A.

Most locations were screened within the lowermost sand and gravel units (till) due to the presence of water at the time of boring advancement. A total of three locations (DPT-5/-6/-11) had paired shallow and deep wells installed. Overlying clay (marine deposits) were less transmissive and showed limited evidence of water at the time of advancement. Glacial outwash, where present overlying the marine deposits, was generally thin such that temporary monitoring wells could not be installed. The marine deposits encountered during the DPT investigation were highly plastic with the overlying glacial outwash and underlying glacial till, where present, containing trace silt and gravel.

3.5.2 Groundwater Investigation West of MW-21S

3.5.2.1 Water Levels and Flow Directions

Static water level information within each temporary well was recorded at the time of sampling, with measuring point elevations surveyed relative to previously surveyed wells MW-21S and MW-21D1/-D2. A synoptic water level round of installed temporary monitoring wells was completed on January 14, 2021. These groundwater elevations have been included on the boring logs and well construction diagrams in Appendix A, with calculated elevations from the January 2021 gauging event included on Figure 3.5. In general, overburden water levels were consistent with those typically recorded in the area of the wetland complex (FPC-5A) and east of the GMZ boundary (MW-21S and FPC-6A). Water level elevations typically average between 71 and 73 feet above mean sea level (AMSL) between the wetland complex and the western GMZ boundary with elevations recorded in the DPT borings ranging from approximately 71 to 76 feet AMSL.

Overburden groundwater flow in the area of MW-21S and to the west of MW-21S is primarily towards the wetland complex where discharge to surface water occurs (refer to CSM in Section 5). This is consistent with Site topography, LiDAR data, and monitoring data. These overburden groundwater elevations generally mimic topography and support the flow and subsequent discharge of groundwater to the wetland complex. Specific to DPT locations, there is a slight southeastern component of flow towards the wetland complex based on the January 2021 groundwater elevations.

As discussed in the 2020 Annual Summary Report for the Site (Haley Ward, 2021a), the vertical groundwater gradients between overburden and bedrock (MW-21S and MW-21D1) and within bedrock (MW-21D1/-D2) are upward and indicate that some bedrock groundwater discharges to overburden and subsequently to surface water within the wetland complex. The understanding of water movement within and between overburden and bedrock and within bedrock units is important to conceptualizing groundwater flow and contaminant transport for the Site.

3.5.2.2 Temporary Monitoring Well Sampling

In December 2020/January 2021, groundwater samples were collected from six DPT locations and consisted of seven total samples due to the sampling of both shallow and deep temporary wells (TMW-5S/-5D) at DPT-5. These results were provided in the May 11, 2021 *Direct Push Technology Investigation Results* memorandum (Haley Ward, 2021b). Samples were not collected from TMW-11S/-11D during this initial event due to frozen water within the PVC riser; however, these locations were sampled during the Spring 2022 biannual sampling event with results included on Figure 3.5. Samples were analyzed for PFAS and 1,4-dioxane with arsenic and manganese results included from initial sampling completed in January 2021. PFAS and 1,4-dioxane were target contaminants for the area of investigation due to exceedances of the current AGQS at MW-21S, with samples also analyzed for arsenic and manganese based on historical concentrations of these metals at MW-21S and FPC-6A at or slightly above the AGQS and/or USEPA CL.

3.5.2.3 Analytical Results

Results for the seven locations sampled, based on location within the western portion of the GMZ and position relative to FPC-6A and MW-21S, indicate western migration within overburden was limited and that only minor detections of PFAS, 1,4-dioxane, arsenic, and manganese were reported outside the current GMZ. Results at DPT/TMW-1 (Figure 3.5) were similar to known concentrations in overburden at MW-21S and FPC-6A. Concentrations of PFOA and PFOS exceeded the New Hampshire AGQS at TMW-1; however, locations sampled immediately west of the current GMZ (DPT/TMW-3 and DPT/TMW-9) were either non-detect (ND) or below the AGQS for analyzed constituents. Detections of PFAS were reported at TMW-11S and TMW-11D, but below the AGQS. Though detections were reported for some constituents in locations west of DPT/TMW-3 and DPT/TMW-9, most were estimated concentrations at or below respective reporting limits. These included DPT/TMW-5S/-5D, DPT/TMW-6, and DPT/TMW-7 (Figure 3.5).

Analytical data indicates that the AGQS were not exceeded at TMWs at or west of the existing GMZ.

3.6 Residential Water Supply Well Records Investigation

A private water supply well records investigation was performed to support the pumping test described in Section 3.3 and to identify options for monitoring bedrock groundwater to the south and east of the GMZ. The residential water supply well records investigation included a review of wells identified in the RI and Knowles Field Source Water Investigation. The evaluation included a review of currently available well records, comparison of property ownership information between RI records and the current GMZ abutters list, and review of water supply records from the public water supply utility.

The desktop evaluation did not identify additional private water supply wells for analysis and monitoring during the pumping test. This is because some wells were unable to be located, did not have records or records of sufficient quality, or were not sufficiently proximate to the pumping test location. This section summarizes the results of the residential water supply well records investigation with available water well records included in Appendix A.

3.6.1 Knowles Field Assessment

Refer to Table 3.5 for a list of wells that were reviewed as part of the desktop evaluation. This table lists wells that were identified during the Knowles Field Assessment (Aquarion Water Company of New Hampshire, 2010) and cross-referenced against current publicly available well information (i.e., tax assessor and public well records). The results of this portion of the investigation are summarized below:

- Seven bedrock wells were identified at locations along North Road, Birch Road, and Shepherds Lane. Well records were identified for these wells.
- North Road wells are in the vicinity of GZ-129/GZ-130 and Little River.
- Birch Road wells are southwest of GZ-129/GZ-130.
- Shepherd’s Lane wells are southwest of Birch Road and GZ-129/GZ-130.
- One shallow well was identified on Birch Road. Well records were identified for this well.

- A test well was located on Lafayette Road, south of GZ-129/GZ-130. Well records were identified for this well.

3.6.2 Original RI Residential Locations

Table 3.5 lists wells that were identified in the RI (Weston, 1988) and cross-referenced against current publicly available well information (i.e., tax assessor and well records). The results of this portion of the investigation are summarized below:

- R-1, R-3, R-5, R-6, R-34, R-66, R-72, R-98, and R-99 are currently sampled.
- Remaining wells are not currently sampled.
- Locational information is not available for R-7, R-8, R-13, R-17, R-20, R-25 through R-29, R-31, R-32, R-38, R-46, and R-100.
- Well type information is not available for R-9, R-19, R-20, R-31, R-47 through R-51, R-54, R-59, R-60, R-63, R-65, R-67, R-68, R-69, R-71 through R-80, R-92, and R-95 through R-97.
- Well record information is available for R-45, R-47, R-58, R-69, R-73, R-74, R-77, and R-94.
- R-45, R-58, R-76, R-88, and R-94 are the only wells not currently sampled that were identified to have locational, well type, and well record information. R-45 is located between GZ-120/GZ-122 and GZ-129/GZ-130, R-76 is located west and south of GZ-129/GZ-130, R-88 is located southwest of GZ-129/GZ-130, R-58 is located south of GZ-120/GZ-122, and R-94 is located west of GZ-129/GZ-130 and Little River.

Potential monitoring at any off-site location is contingent upon obtaining the permission of the property owner.

4.0 GEOLOGY AND HYDROLOGY

The following subsections present a summary of the geology, hydrogeology, groundwater quality, surface water quality, and concentration trends for the Coakley Landfill Site.

Conclusions on water quality data presented herein are generally informed by data collected during 2020, as these data were used for development of the Draft Report. However, validated 2021 data were used for evaluation of statistical trends with Spring 2022 TMW data used for evaluation of the DPT investigation because it included information for TMW-11S and TMW-11D. The report indicates, as appropriate, which data were used in provided evaluations.

4.1 Surficial Geology

Overburden encountered in the vicinity of the Site consists of glacial deposits and recent wetland and alluvial deposits. These glacial deposits can be separated into glacial till, glaciomarine (marine), and glacial outwash sediments, as further described below.

4.1.1 Description and Extent of Units

Glacial Till Deposits

Glacial till is typically observed to be deposited directly onto the bedrock surface. The till appears to be either absent or less than 5 foot in thickness overlying the Breakfast Hill Granite.

Till described overlying the Rye formation, particularly underlying the wetland complex and east of the CSC is described as coarse, mixed sand and gravel with silt and clay described as minor components, including angular or rounded cobbles to boulders and is often described as saturated. This is in contrast with the descriptions of glacial till in much of New England, which is often described as having much higher proportions of fine material mixed with sand and gravel, and therefore have lower capacity to transmit water. The glacial till within the bedrock trough is interpreted to form two lobes with thinning of the unit coincident with the saddle of bedrock between the Berrys Brook and Little River watersheds. East of the CSC, overlying the Rye formation, the till was described at the southeast corner of the landfill at MW-4, as dense, sandy gravel up to 23 feet thick, which is shown to pinch out to less than five feet thick towards well clusters GZ-109/117 and GZ-120/122. A third lobe of glacial till is mapped to the north of the landfill, based on the boring logs for GZ-115, however it is noted that conflicting lithologies are noted at GZ-116 where weathered bedrock is noted much shallower than at GZ-115. This portion of the site may have been associated with reworked material associated with the historic sand and gravel mining, so the overburden material may be highly variable.

According to the RI, slug tests were completed on wells screened across the glacial till, GZ-112, GZ-115, and GZ-127 with hydraulic conductivity values of 0.08 feet/day in GZ-112, 0.06 feet/day and 0.13 feet/day for GZ-115, and 1.6 feet/day in GZ-127. GZ-112 and GZ-115 are screened in the till unit overlying the Rye Formation north of the landfill, west of the CSC, while GZ-127 overlies the Rye on the southern end of the wetland complex. A figure illustrating the thickness and extent of glacial till is included as Figure 4.1.

Marine Deposits

Marine deposits encountered in the study area were observed to be deposited overlying glacial till, or directly onto bedrock where the till unit was not present. Descriptions of the marine unit varied from stiff to soft fine sand to silty, grey clay. Marine deposits to the west of the landfill are thickest over the area coincident with thinner glacial till where two lobes of till within the trough have been mapped as described above. The unit has been identified to be discontinuous and was largely absent between along the CSC and where thick units of glacial outwash have been mapped. Hydraulic conductivity was not measured for the marine unit during the RI, as it was assumed to be very low with minimal groundwater movement within this unit. A figure illustrating the thickness and extent of marine deposits is included as Figure 4.2.

Glacial Outwash Deposits

Glacial outwash deposits generally overlie the marine sediment, but directly overlie bedrock or till in areas where marine deposits are absent and represent the surficial unit across much of the Site except where it was removed during the mining of sand and gravel or where bedrock outcrops are present. Outwash deposits range in thickness from less than 5 to over 40 feet and are typically described as fine to coarse sand with varying amounts of silt and rounded gravel. Deposits were thinnest north of the landfill where sand and gravel mining was known to have occurred, over the CSC where surficial material of all lithology is thin and overlying the bedrock saddle in the wetland complex. Thicker areas of outwash are present to the east of the Site overlying the previously described marine clay and overlying the lobes of the bedrock trough in the wetland complex to the west of the Site. A thick package of outwash is also present to the north of the site, identified in the logs for GZ-112 and 110 which may represent the thickness of outwash that was present between Breakfast Hill Road and the landfill, before mining occurred. A figure illustrating the thickness and extent of glacial outwash deposits is included as Figure 4.3.

According to the RI, hydraulic conductivity in the outwash unit was determined to be 2.1 feet/day and 2.5 feet/day at GZ-133, and 510 feet/day at GZ-101.

Geologic cross sections illustrating the interpreted extent of overburden units overlying bedrock in the study area are included as Figures 4.4 through 4.6 and Figures 4.16 through 4.18. display the locations of these cross sections.

4.2 Bedrock Geology

According to the 1988 RI, the *Assessment of Ground-Water Resources in the Seacoast Region of New Hampshire* report published by the USGS (Mack, 2012), and scientific publications written by Escamilla-Casas (2003) and Lyons et. Al. (1997), the lithologies underlying the study area are composed of the Rye Complex, a major geologic unit comprised of the Rye Formation and the Breakfast Hill Granite. Further detail on the lithologies, both regionally and locally, is provided below.

4.2.1 Description of Formations

4.2.1.1 Regional

Breakfast Hill Granite

The Breakfast Hill Granite is interpreted to be an intrusive body into the Rye Formation, described as a blastomylonitic quartz-feldspar granitic gneiss (Novotny, 1964; Lyons et.al. 1997). It is a variably foliated two-mica granite gneiss, to coarse pegmatite, to a per-aluminous, highly foliated pluton with massive, foliated pegmatite intruding the Rye Formation prior to deformation. Foliations have been described by Escamilla-Casas & Schulz (2015) as trending 200-215° (N20E to N35E). Based on lead/uranium dating described by Bothner et. Al., the age of the Breakfast Hill Granite is approximately 403 million years old.

Rye Formation

The Rye Formation is described by Escamilla-Casas as a major lithotectonic sequence and interpreted as the oldest of the metasedimentary units exposed in the Seacoast region. The Rye Formation is further described by Bothner et. Al., and Hussey et. Al. as a package of highly tectonized pelitic and nonpelitic schists and gneisses. Protoliths include aluminous shale, limey mudstone, and mafic volcanic rock. Minor mappable units within the Rye Formation are amphibolites, marble and rusty, weathering sulfide graphitic phyllonite. The Rye Formation was subdivided into separate metavolcanic and metasedimentary members by Billings, but this distinction has since been removed. According to Bothner et. Al., rocks from the Rye Formation potentially formed as far back 530 million years ago.

4.2.1.2 Local

Basalt Dikes

The Remedial Investigation identified mafic dikes being present at the Site and described them as amygdaloidal aphanitic basalt. Their orientation is north-northeast but due to their scale the dikes were not mapped. This rock type is encountered sporadically across the Site. Based on geophysical logs, the basalt appears to be the predominant rock type in MW-24 as well as making up minor components of GZ-109, GZ-116, MW-23, MW-25, MW-20D, and MW-22D.

Breakfast Hill Granite/Central Silicic Complex (CSC)

Based on subsurface data collected during the RI, the Breakfast Hill Granite at this locality occurs as a felsic gneiss with some mylonite textures. The RI (Weston, 1988) referred to this unit as the Central Silicic Complex (CSC), likely due to the conflicting descriptions of this unit regarding the distinction between granite and gneiss. It is often associated with other igneous intrusive rock types, such as diabase or pegmatites. Rock types described by previous consultants as a granite (using inconclusive methods such as air hammer drilling) have been shown by downhole borehole imaging to have a clear foliation, indicating metamorphism and gneissic texture. It is likely that the parent rock of this felsic gneiss was a granite that intruded the parent rocks of the Rye Formation but was metamorphosed during subsequent deformation of the sequence. A current understanding of the extent of the Breakfast Hill Granite/CSC in the area is presented as Figure 3.4 while the cross sections (Figure 4.4 through Figure 4.6) illustrate the extent in the subsurface. Rocks indicative of the Breakfast Hill Granite/CSC were confirmed in test borings for MW-4, MW-5S/5D, MW-6, MW-8, BP-4, GZ-101A, GZ-107A, GZ-106, GZ-108, and GZ-113. A high degree of foliation was observed in rock cores from these borings. The eastern contact has been mapped as a thrust fault that transitions from partially brittle to ductile from south to north (Hussey et al, 2008). This interpretation has not been confirmed by this investigation although the ductile deformation of the Breakfast Hill Granite may not be easily recognized from the geophysical logs. Well locations drilled through the interpreted contact between the CSC and the Rye Formation (i.e., BP-4 or GZ-125) are described as the felsic granite or gneiss, including igneous intrusions, either interfingered (BP-4) or gradually grading (GZ-125) to micaceous schists. Downhole borehole logs do not indicate extensive fracturing that would be consistent with a brittle fault zone at these contacts but the presence of a ductile fracture zone in this area is inconclusive with existing data.

Note that this unit is described more generically in most of the following fracture analyses as "gneiss".

<u>Rye Formation</u>

Based on subsurface data collected during the RI, the NHDES Data Mapper, Lyons et. Al., Hussey et. Al., and Novotny and Escamilla-Casas, the Rye Formation is the major lithologic unit underlying the remainder of the Site, described by Lyons, et. Al. as light-colored gray schists and gneisses, quartzites and amphibolites, variably migmatized and mylonized.

During the RI, metamorphic rock cores of the Rye Formation were observed to consist of phyllite, metagraywacke, quartzite, and feldspathic amphibolite. Proximal to the CSC, on the inferred fringe of the felsic intrusion, coarser grained, micaceous schists are described. Bedding in these cores was observed to range from less than one inch to approximately two inches (1 to 5 centimeters) in thickness. Bedrock borings were advanced during the RI using air rotary techniques so rock identification was primarily based on subsequent borehole geophysics.

4.2.2 Extent/Relationship of Formations

<u>4.2.2.1 Regional</u>

As stated above, both the Breakfast Hill Granite and Rye Formation belong to a sequence of rocks known as the Rye Complex, described by Escamilla-Casas as a southwest-trending lithotectonic unit approximately 4.5 miles long and four miles wide.

The origin and age of the rocks comprising the Rye Complex has been in dispute, but through a variety of available techniques, the rocks have been dated to between 245 to 530 million years old. Using the geologic law of cross-cutting relationships, the basalt dikes are younger than the Breakfast Hill Granite, which in turn is younger than the surrounding rocks of the Rye Formation.

<u>4.2.2.2 Local</u>

While much of the area has been interpreted by others (e.g., Novotny and Lyons) as Breakfast Hill Granite, the Breakfast Hill Granite/CSC has been metamorphosed to an extent that mafic, pegmatite, and quartzite layers generated by the deformation and metamorphism have altered the contact between the granite gneiss and the Rye formation and Breakfast Hill Granite/CSC. The irregular contact with the surrounding Rye Formation, perhaps reflecting the original igneous contacts that have since been deformed. A current interpretation of extent and relationship of the formations at the Site is presented on Figure 3.4 while the identified and inferred extent in the subsurface is included in the cross section, Figure 4.4 through Figure 4.6.

4.2.3 Structure/Fracturing

4.2.3.1 Regional Structures

The bedrock underlying the study area is widely recognized as being foliated in a distinctly northeast/southwest direction. The foliation orientation is supported by various scientific publications, including the Mack 2012 USGS Report, which describes foliations as trending approximately north 22 degrees east.

The closest mapped fault to the Site is the Great Common Fault. The Great Common Fault is mapped by the Data Mapper, Hussey, Novotny, and others as trending north-northeast at the Site and more northeasterly to the north. According to Escamilla-Casas & Shultz and Hussey et. Al, the Great Common Fault occupies a 300- to 600-foot wide, northeast-trending shear zone characterized by early ductile and later brittle fault fabrics. Displacement along the fault zone is described as dextral strike slip, which is typically represented by nearly horizontal offset via nearly vertical faults. The fault separates less migmatized lithologies of the Rye Complex on the southeast from more migmatized lithologies on the northwest. The most recent motion along this fault system is estimated to be from the Mesozoic Era (252 to 65 million years ago).

The Portsmouth Fault is located approximately one mile to the west of the site and comprises a 100- to 300-meter wide north to northeast-trending zone. According to Bothner et. Al., slip sense suggests a steep, west-dipping normal fault, west side down. The most recent motion along this fault system is estimated to be from the Mesozoic Era (252 to 65 million years ago).

According to Ferguson et. Al. (1997A and 1997B), mapped lineaments within and surrounding the study area are oriented in a general northeast/southwest direction. The majority of these lineaments were observed by the use of low-altitude aerial photography having an approximate scale of 1:20,000. These lineaments are generally coincident with bedrock foliation and the orientation of regional structures, but lineaments identified using conventional photography are subjective in nature.

4.2.3.2 Local Structures and Photolineaments

Bedrock topography under and around the Site has been mapped with a north-northeast trending ridge with two high points, one partially under the landfill and another to the northeast near the Lafayette Road (U.S. Route 1) and Breakfast Hill Road intersection (See Figure 3.4, Bedrock Surface Map). A bedrock valley with a maximum depth of approximately 60 feet is located to the west of this ridge also trending north-northeast. This valley is bisected by a bedrock saddle just southwest of the landfill near GZ-105 and MW-25D1/D2 (Figure 3.4), with the southern part of the valley approximately 40 feet deep. This saddle is defined by bedrock depths encountered in AE-4B, FPC-4B and MW-22D1/D2 to the west and AE-2B, FPC-3B and FPC-8B to the east. A small bedrock saddle is present just northeast of the landfill with approximately 30 feet of relief and trending northwest. This saddle may correspond with the secondary fracture population discussed in Section 4.2.4.

Various cross sections presented in the RI (Weston, 1988) and RI/FS (CDM, 1994) and in the 2013 GMZ report (Figures 3 and 4, Summit, 2013), as well as in the bedrock topographic mapping (Figures 3.4, 4.4, 4.5, and 4.6) show these local bedrock structures. The cross sections also illustrate the bedrock valley overlain by glacial till that was filled by glaciomarine deposits and outwash.

The RI contained a photolineament and fracture trace analysis for the area in the vicinity of the Site; these data have been transferred to a LiDAR basemap for correlation with topography, bedrock relief, and local cultural features (Figure 3.2). Three populations of photolineaments were identified and are listed from most to least frequent: north-northeast, west to northwest, and northeast. A statistical analysis was not considered appropriate since photolineament identification is a subjective process and as noted below, can reflect non-bedrock features. However, these trends generally correspond with the three fracture populations discussed below in Section 4.2.4. The primary north-northeast trending photolineament group is concentrated in the valley west of the landfill, correlates with the bedrock valley described above, and is parallel to the primary foliation. Two smaller populations are present north of Breakfast Hill Road. The secondary west to northwest-trending photolineaments group is more varied in their orientation and are most common west of the landfill. The tertiary set of northeast-trending photolineaments are rare near the Site but a group are present south of the landfill, to the east of the intersection of North Road and Lafayette Road. Overlaying the tertiary set of northeast trending lineaments south of the landfill, to the east of Lafayette Road shows these lineaments may be representative of the linear edge of glacial outwash deposits as opposed to bedrock features. It is significant to note that no photolineaments were shown intersecting the landfill.

Seismic refraction completed as part of the RI support some photolinears being characteristic of fractured bedrock. Lower relative bedrock velocities observed on seismic refraction transects across or perpendicular to photolineaments may have been indicative of less competent bedrock. Other geophysical techniques employed during the RI (e.g., electromagnetics) were used primarily to map potentially impacted groundwater and did not indicate major water bearing fractures. A review of the surface geophysics completed during the RI was submitted on May 1, 2018, in the Haley Ward memorandum *Summary of Previously Performed Geophysical Investigations on the Western Portion of the GMZ for the Coakley Landfill and Proposed Surface Geophysical Investigation for Deep Bedrock Well Siting*.

As described in more detail below, borehole geophysics was performed in bedrock borings where fracture populations and potentially transmissive zones were identified.

4.2.4 Analysis of Fracture Data

Fracture data from multiple locations in the vicinity of the Site have been obtained from bedrock boreholes using downhole geophysical tools and from surface bedrock outcrops by making hand measurements on observed fracture planes. As described in the USGS report by Degnan and Clark (2002), fracture populations (principal trends of fractures) have been defined for the bedrock boreholes and outcrop features by plotting normalized azimuth-frequency (rose) diagrams using software (DAISY) by Salvini (2000). A Gaussian curve-fitting routine is used in DAISY for determining peaks in directional data (Salvini et al, 1999) that first was described for lineament analysis by Wise and others (1985). Peaks and the standard deviation for each peak were calculated with DAISY. Peaks with normalized heights greater than 50 percent of the highest peak have been considered by other studies to be representative of principal trends (Walsh and Clark, 2000) and this same principal is applied to the data in this report.

The fracture dataset has been analyzed using multiple groups to assess if the occurrence or attributes of the fractures are influenced by location, depth, rock type, and potential to transmit groundwater. The results of the statistical analysis of the fracture data for each of these groups is discussed in the following subsections.

4.2.4.1 Fracture Populations Identified for the Entire Fracture Dataset

In total, approximately 1,600 fracture/joint data points were obtained in the vicinity of the Site, with 1,262 fractures recorded from the borehole geophysics conducted at: Chinburg Well (MW-23), GZ-108, GZ-109, GZ-110, GZ-116, GZ-119, GZ-122, GZ-125, GZ-130, MW-6, MW-20D, MW-21D, MW-22D, MW-24D, MW-25, and PB-4; and 310 joint features recorded from outcrop measurements conducted at multiple locations in the vicinity of the Site. In addition, 184 foliation features were also measured and recorded at the outcrop locations. As shown in Exhibit 1 below, analysis of the entire fracture dataset (borehole fractures and outcrop joints) shows the following (All references to strike and dip are based on the right-hand rule).

- The primary fracture azimuth (i.e., dip direction) is about 283 degrees with a strike of 193 degrees;
- The secondary fracture set with a fracture dip azimuth of 43 degrees and a strike of 49 degrees; and,
- The tertiary set with an azimuth dip of 139 degrees and a strike of 313 degrees.

All locations
Azimuth
Frequency Gaussians
Tot.Data: 1573 h-max: 77 h-min: 2 h-mean: 17.478 Mean: -78.888 SD: 6.620 Mode: 288.000

RMS = 1.68187548022752

GAUSSIAN PARAMETERS					
#	%	Nor. H.	Max H.	Azimuth	sd
1	77.95	100.00	54.16	282.9°	15.04°
2	15.13	21.65	11.73	42.58°	13.49°
3	38.57	19.13	10.36	139.4°	38.9°

Base Line Value = 5.839907

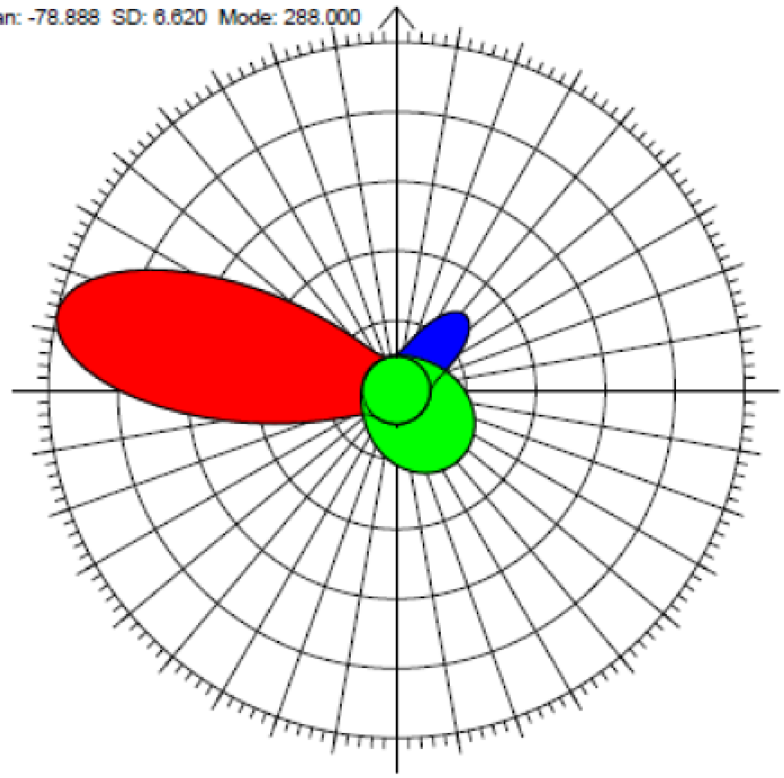
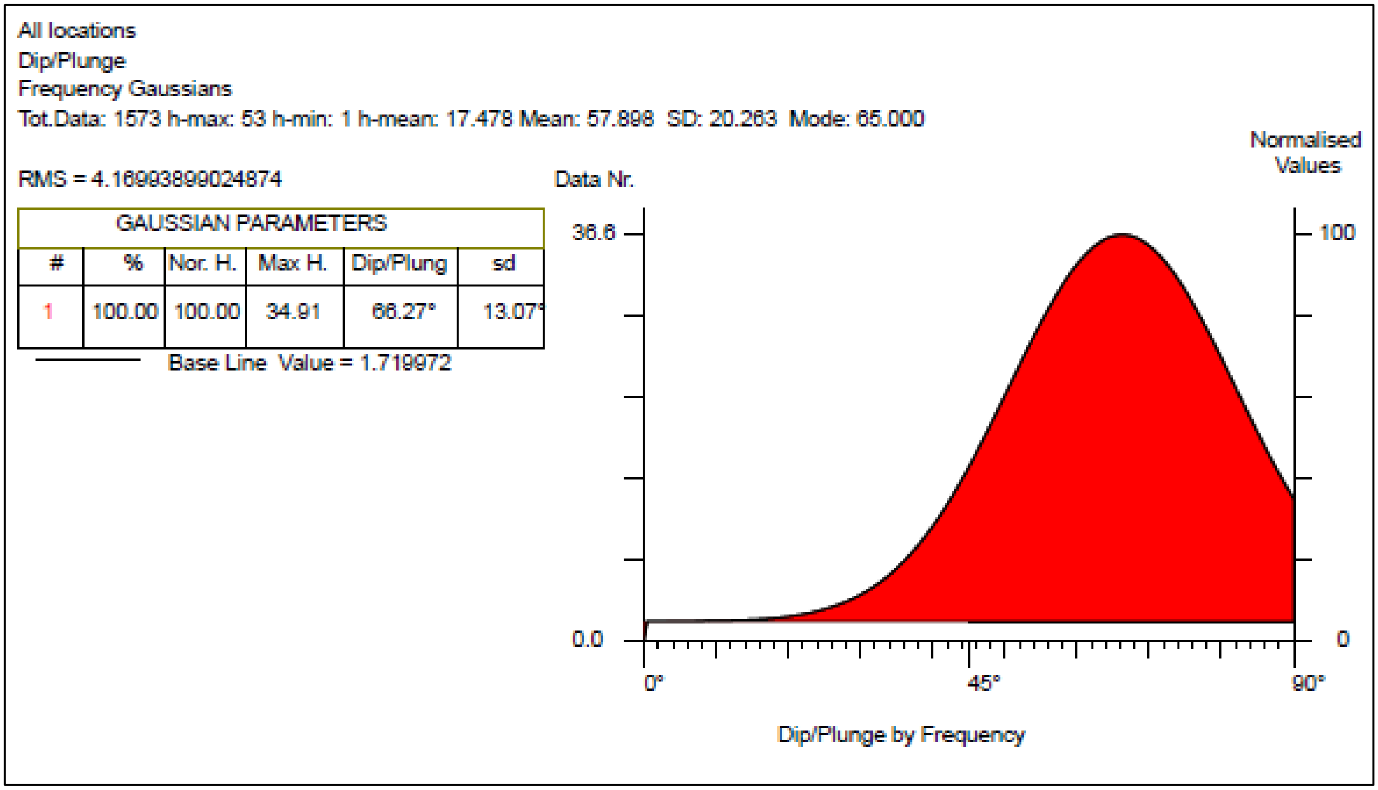


Exhibit 1: Graphical summary of the statistical analysis for the entire fracture dataset showing a predominant fracture family with an azimuth (i.e., dip direction) of about 283 degrees or approximately west-northwest (WNW).

The primary fracture population clearly corresponds with the primary Site-wide bedrock foliation, as well as regional groundwater flow. For the same dataset, the statistical analysis, which is summarized in Exhibit 2 below, shows that the primary fracture population has a mean dip/plunge of approximately 66 degrees (i.e., moderately to steeply dipping fractures). As discussed under Section 4.3, the secondary and tertiary fracture populations also play a role in bedrock groundwater. The statistical summaries of strike and dip as well and Gaussian azimuth analysis for each borehole, and the Gaussian azimuth analysis for other subsets of bedrock data discussed below for the entire dataset, are provided in Appendix G.

Exhibit 2: Graphical summary of the statistical analysis for the entire fracture dataset showing a single predominant fracture family with a dip/plunge of approximately 66 degrees.



4.2.4.2 Fracture Populations Identified by Rock Type

The fracture data has also been assessed by grouping the data by rock type present in each borehole. Rock type has been interpreted using the borehole geophysics OTV images. which are presented in Figure 4.8 along with the associated interpretation of rock type. The OTV images were separated into five bedrock types including: phyllite (660 fractures); schist (265 fractures); basalt (174 fractures); quartzite (128 fractures); and Breakfast Hill Granite referred to here as a gneiss (36 fractures). Azimuth-frequency rose diagrams and dip frequency charts of normalized values are presented in Appendix G for each of the five identified rock types.

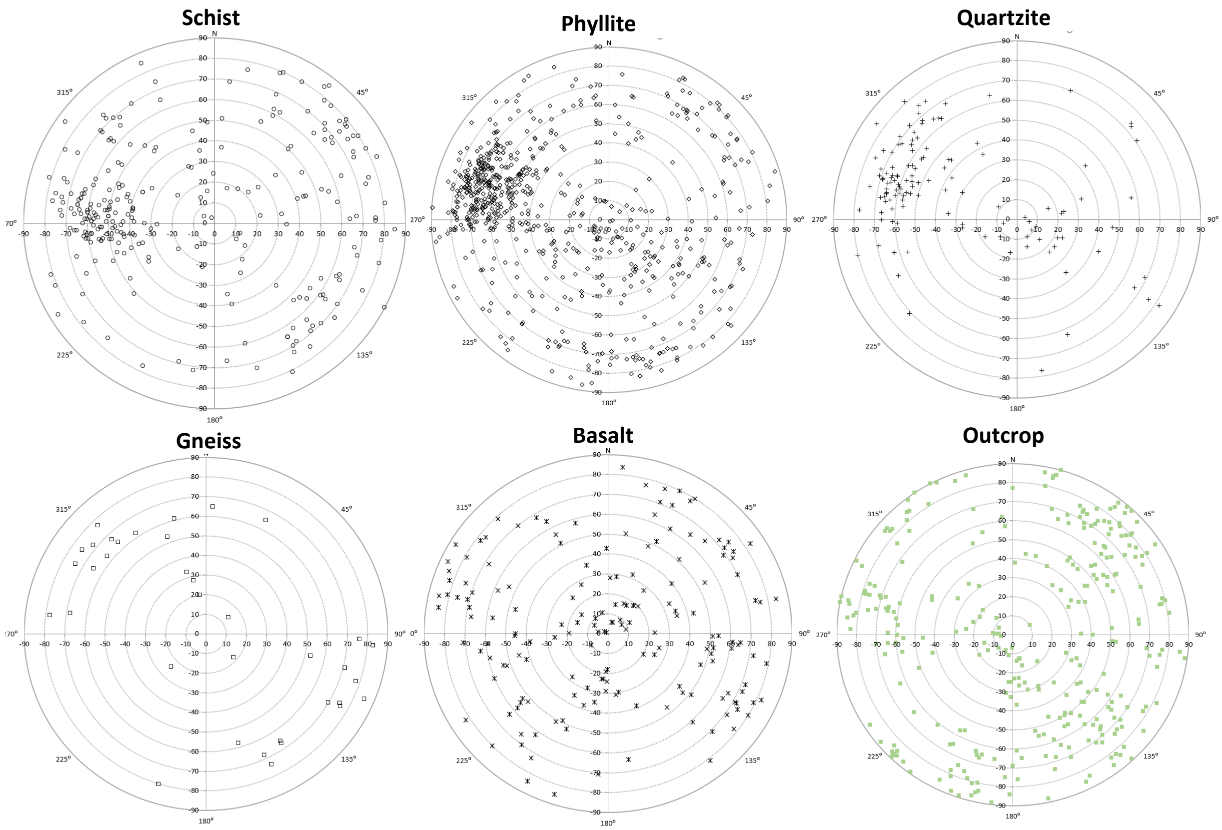


Exhibit 3: Rose scatter plots of fracture data by bedrock type and for measured bedrock outcrops. Points are plotted as a combination of dip direction (0-360 degrees with north equal to zero) and dip angle [points at the center have zero-degree dip (horizontal) and at the outer circle 90-degree dip (vertical)].

Review of Exhibit 3 above shows that schist, phyllite, and quartzite bedrock types with the highest density of data points are between west and northwest azimuths with moderate to steep dip angles. The Granite Hill Gneiss has a limited data set with the dip azimuths approximately equally distributed in the northwest and southeast quadrants. Only the basalt rock type shows an apparent lack of dominant orientation both in terms of dip azimuth and dip/plunge angle. This lack of dominant orientation is a result of the lack of foliation in the basalt, and the younger rock age compared to the older metamorphic rocks, which have been subject to previous periods of regional stressing.

Exhibit 4 illustrates the number and orientation of fractures by rock type.

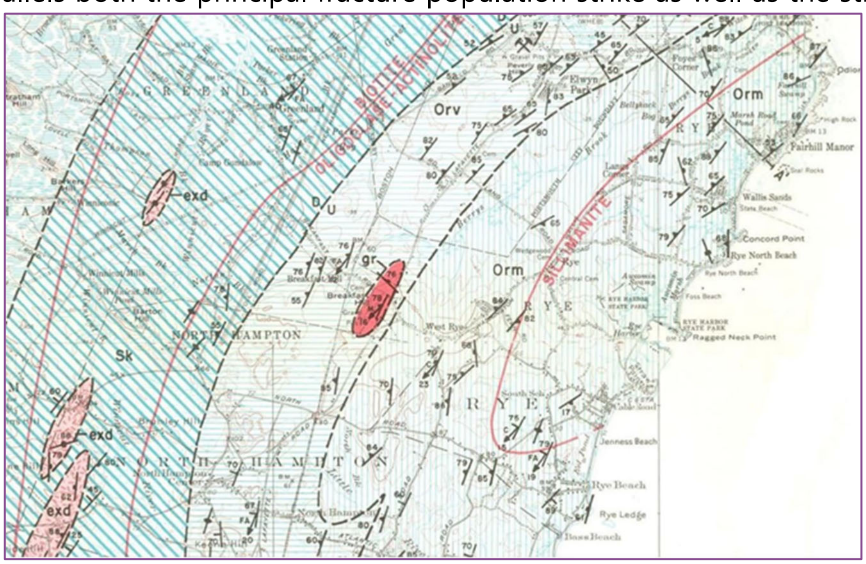
Rock Type	Total Fracture Count	Total Length	Proportion of Total Length	Azimuth/(Std. Dev.) of Principal Fracture Family	Dip angle/(Std. Dev.) of Principal Fracture Family	Average Fracture Spacing
		(feet)	%	(degrees)	(degrees)	(feet)
Basalt	174	310	11%	284.2/(20.78)	72.49/(8.06)	1.8
Gneiss	36	80	3%	306.4/(14.26)	67.5/(6.28)	2.2
Phyllite	660	1070	39%	287.7/(13.60)	69.74/(6.64)	1.6
Quartzite	128	320	12%	290.9/(17.08)	65.01/(6.04)	2.5
Schist	265	970	35%	272.6/(14.35)	63.66/(11.79)	3.7

Exhibit 4 Tabular summary of principal fracture families by bedrock type.

As shown on the bedrock map (Novotny, 1969; Exhibit 5), the foliation of Rye Formation bedrock measured at outcrops throughout the region have a north-northeast to northeast strike and a dip between about 55 and 85 degrees.

Exhibit 5: Bedrock map and bedrock structure (Novotny 1969).

This strike parallels both the principal fracture population strike as well as the strike of the larger fault



structures that have a similar northeasterly orientation (Hussey et al, 2008), Exhibit 6).

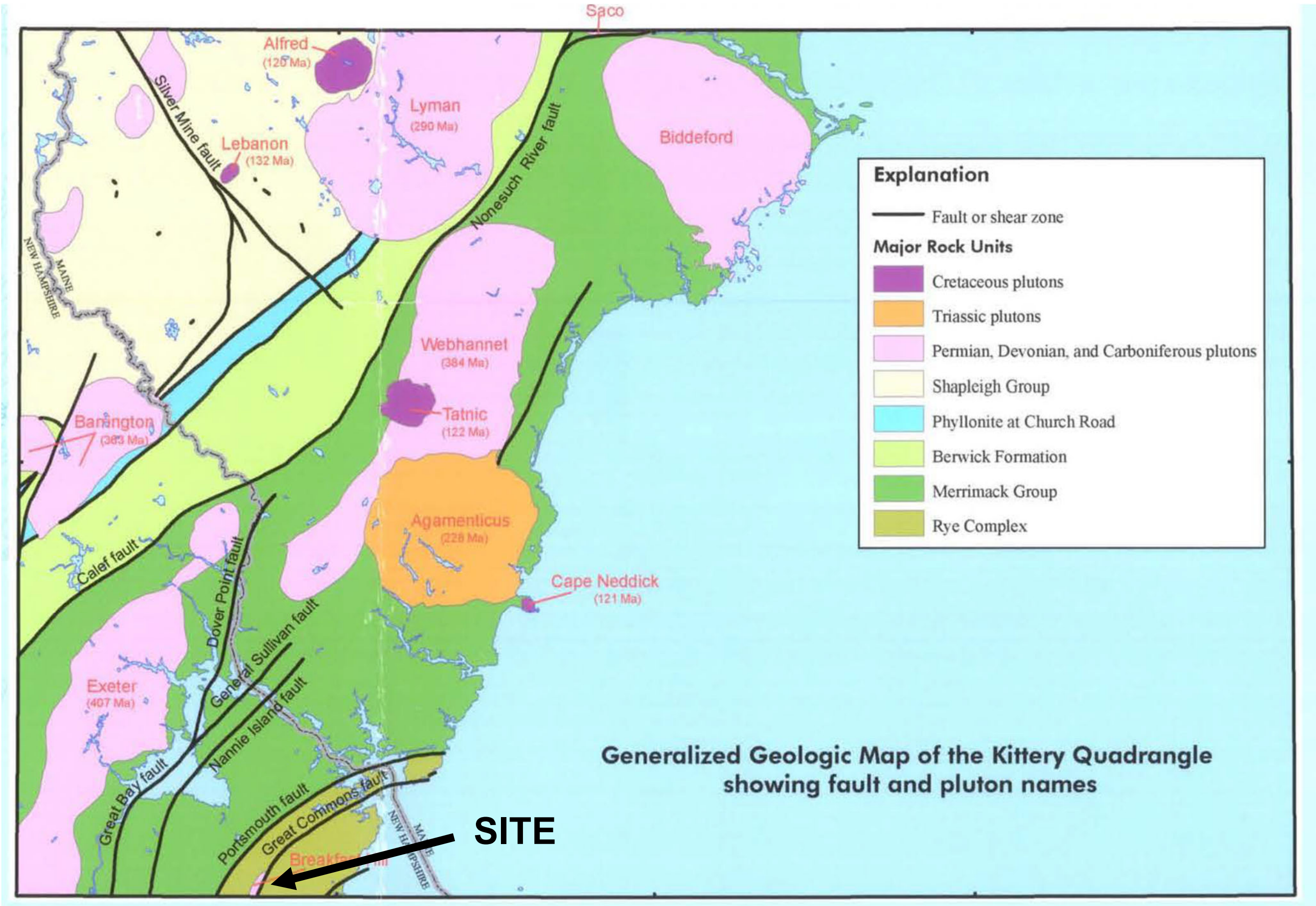


Exhibit 6: Regional bedrock structure (Hussey et al 2008).

4.2.4.3 Fracture Populations and Spacing at Individual Boreholes

Considering each borehole fracture dataset independently, the same approximate structure present in the full dataset is also apparent within individual boreholes. The predominant fracture dip direction is generally between west-southwest and northwest. The single exception to this fracture family orientation is observed in borehole MW-24, where the dominant fracture dip direction is towards the north northeast/northeast. The apparent reason for this departure from the typical trend in this area is the occurrence of a thick intrusion of basalt rock at the MW-24 location, which is different from the rock types that are dominant in the other group of boreholes where schist, phyllite, and quartzite are typically observed. The frequency and Gaussian statistical parameters for each main family and sub-families of fractures provided in Appendix G.

In addition to reviewing the fracture populations by borehole, the assessment of fracture spacing within each borehole was completed. As a total dataset, the 1,262 fractures recorded in the bedrock boreholes were measured over a total open hole length of approximately 2,750 feet, resulting in an average fracture spacing of one fracture every 2.2 feet of borehole. The fracture count, open borehole length, and resulting calculation of average fracture spacing is summarized in Exhibit 7, below. The average fracture spacing ranges from 0.9 feet to 6.1 feet, and in general fracture spacing is relatively dense with a median spacing of 1.8 feet and average of 2.2 feet. Figure 3.1 provides a map with rose diagrams for each logged boring.

Borehole Location	Fracture Count	Total Borehole Depth (feet)	Casing Depth (feet)	Open hole length (feet)	Average Fracture Spacing (feet)
MW-20D	48	308	15	293	**6.1**
MW-21D	102	308	13	296	2.9
MW-22D	65	309	18	292	4.5
MW-23 (Chinburg)	79	282	48	234	3.0
MW-24	48	143	80	62	**1.3**
GZ-108	53	157	17	140	2.6
GZ-109	86	253	103	150	1.7
GZ-110	80	188	58	130	1.6
GZ-116	62	158	23	135	2.2
GZ-119	74	183	46	138	1.9
GZ-122	95	191	54	137	1.4
GZ-125	79	202	59	143	1.8
GZ-130	80	178	41	137	1.7
MW-6	69	184	27	157	2.3
MW-25	169	284	43	241	1.4
BP-4	74	100	35	65	0.9
Total Dataset	1263			2751	**2.2**

Exhibit 7: Tabular summary of average fracture spacing for each borehole location.

4.2.4.4 Analysis of Fracture Data by Depth

Exhibit 8 provides a summary of fracture count per 10-foot interval for each borehole location. Visually it is apparent that there is no strong linear trend with depth. We note that in these data an apparent trend, if any, may be influenced by bedrock type and the spatial location of the boreholes. However, it is consistent with the idea that with increasing depth there may be fewer open fractures as a result of increasing overburden pressure, as well as the concept that there are likely to be a higher number of fractures nearer to the bedrock surface because of reduced overburden pressure in erosional areas (i.e., valley bottoms).

Depth	BP-4	Chinburg	GZ-108	GZ-109	GZ-110	GZ-116	GZ-119	GZ-122	GZ-125	GZ-130	MW-6	MW-20D	MW-21D	MW-22D	MW-24	MW-25
10	11	7	3	6	9	11	5	18	12	4	9	10	5	3	8	6
20	8	7	7	3	8	10	5	10	10	5	8	4	5	2	8	5
30	16	4	1	5	8	6	6	7	5	9	2	2	11	3	10	9
40	13	3	3	7	4	4	4	4	5	8	5	3	7	3	7	9
50	7	6	2	4	9	3	1	7	6	6	8	1	4	1	8	9
60	14	8	2	5	4	2	6	3	7	4	5	9	3	2	6	5
70	5	4	1	6	2	1	3	6	5	6	4	1	2	5		11
80		3	5	8	5	1	9	6	7	6	4	1	1	4		9
90		4	1	4	8	5	8	7	4	3	5	1	6	4		11
100		2	1	5	5	5	4	9	3	5	2	1	7	4		9
110		4	8	7	9	7	6	7	3	7	6	1	2	4		7
120		1	13	6	4	3	6	6	3	11	2	2	4	1		12
130		3	6	10	5	4	8	3	4	4	5	2	1	1		6
140		3		10			3	2	5	2	4	1	9	1		7
150		1										1	2	3		4
160		2										1	3	3		7
170		2										1	3	4		5
180		1										1	1	3		5
190		3										1	4	1		5
200		1										1	6	5		3
210		4										1	5	1		4
220		3										1	3	1		4
230		3										1	2	1		5
240													3	1		
250													1	1		
260													1	1		
270													1	1		
280													1	1		

Exhibit 8: Summary of fracture count by depth (10-foot intervals) for each borehole.

4.2.4.5 Water-Bearing Potential of Fracture Populations

This evaluation was based on the 1,262 fracture measurements identified from the geophysical data in 15 wells across the Site (see Section 4.2.4.1). These data are provided in Appendix C. These fractures were assigned by the geophysical contractor one of four categories related to their likely ability to transmit groundwater. More specifically, the logs list four categories of fractures:

- Category 100 = planar feature (possible fracture, joint, foliation, bedding, etc.) aperture < 1 mm
- Category 101 = planar feature (possible fracture, joint, foliation, bedding, etc.) aperture > 1 mm
- Category 108 = Possible water bearing fracture
- Category 107 = Likely water bearing feature

The three fracture populations cited earlier in Section 4.2.4.1, and sheeting fractures, were evaluated with respect to their water-bearing potential using data from the borehole geophysical logs. (Sheeting fractures are fractures that are generally parallel to the ground surface and exhibit low angle dips, with most forming from extensional forces that include the glacial unloading. For this evaluation, sheeting fractures were defined as those fractures whose dip is 20 degrees or less.)

Section 4.2.4.1 defined the three fracture populations from primary to tertiary as having strikes of 193, 49, and 313 degrees, respectively, following the right-hand rule. To assess the frequency and viability of these fractures for transmitting groundwater, these fractures populations were assigned the compass quadrant that include their mean strike (see Exhibit 9). This approach was taken to account for the variability in strikes for each population compared to their mean (i.e., see standard deviation values in Exhibit 1 above).

Fracture Population	Mean Strike (degrees)	Quadrant (degrees)
Primary	193	180 to 270
Secondary	49	0 to 90
Tertiary	313	270 to 360

Exhibit 9: Assignment of quadrants for the three fracture populations.

For example, for the primary fracture population, the entire data set was first sorted to show only those fractures whose strike was between 180 and 270 degrees. This subset was then sorted to show only those fractures assigned Categories 108 and 107. For the sheeting fractures, the data set was sorted by dips less than or equal to 20 degrees, and then again sorted for Categories 108 and 107. The results are summarized below and in Exhibit 10.

Total Fracture Measurements from Geophysical Logs =	1262	
Total Primary Fractures (strike between 180 and 270)	515	41%
Primary fractures in Categories 108 and 107	70	14%
Total Secondary Fractures (strike between 0 and 90 degrees)	262	21%
Secondary fractures in Categories 108 and 107	52	20%
Total Tertiary Fractures (strike between 270 and 360 degrees)	175	14%
Tertiary fractures in Categories 108 and 107	22	13%
Total Sheeting Fractures (dip 20 degrees or less)	94	7%
Sheeting Fractures in Categories 108 and 107	17	18%

Note: the percentage for fractures in Categories 108 and 107 is based on total fractures for that population.

Exhibit 10: Fracture populations with respect to water-bearing potential.

Primary Fracture Population: The analysis shows that 41% of all fractures are part of the primary fracture population (i.e., generally parallel to foliation). Of these fractures, 14% are classified as being a possible or likely water-bearing fracture.

Secondary Fracture Population: The analysis shows that 21% percent of all fractures were identified as part of the secondary population, with 20% classified as being a possible or likely water-bearing fracture.

Tertiary Fracture Population: The analysis shows that 14% of all fractures were identified as part of the tertiary population, with 13% classified as being a possible or likely water-bearing fracture.

Sheeting Fracture Population: The analysis shows that 7% of all fractures were identified as part of the sheeting fracture population, with 18% classified as being a possible or likely water-bearing fracture.

These four fracture populations account for 83% of the total fractures, with the remaining 17% within the 90-to-180-degree quadrant. In this population, strikes between 170 and 180 have the greatest frequency and therefore may represent the primary fracture population since its mean strike is 193 degrees. The exclusion of this quadrant of fractures is not considered significant for this analysis. See Section 4.3.2 for a discussion of bedrock groundwater flow in the context of these fracture systems.

4.2.4.6 Water-Bearing Fractures at Individual Wells

The geophysical logs were also used to determine the frequency of fractures categorized as a possible water-bearing (Category 108) and likely water-bearing fractures (Category 107) per well. Exhibit 11 ranks the borings from the most to least fractures with respect to the potential transmission of groundwater. See the following section for discussion.

Well	Total Depth (ft)	# of Possible Water-Bearing Fracture	# of Likely Water Bearing Fracture	Total
GZ-110	188	14	8	22
MW-25	285	7	12	19
GZ-130	178	8	9	17
GZ-122	190	9	4	13
GZ-116	163	10	2	12
MW-23	282	5	7	12
MW-24	145	8	4	12
MW-6	184	9	2	11
GZ-119	183	6	4	10
GZ-125	200	3	5	8
GZ-108	155	5	1	6
MW-20D	234	3	3	6
MW-22D	220	2	4	6
GZ-109	252	2	3	5
MW-21D	307	3	2	5
BP-4	100	2	1	3

Exhibit 11: Number of water-bearing fractures by well.

With the exception of MW-25, the top four borings by number of potentially transmissive fractures are not currently contaminated.

4.2.4.6 Lineament Identification and Fracture Correlation

Straight-line lineaments are assumed to be formed by steeply dipping features (Degnan and Clark, 2002). Lineaments identified during the RI and shown on Figure 4.7 have been compared to the strike of the principal fracture families discussed in prior sections. Because most of the principal fracture families contain steeply dipping features (i.e., greater than 45 degrees), it is reasonable to assess the potential correlation of the lineament orientation with the strike of dominant fractures.

As summarized in Appendix G, the principal strike of the lineament dataset is 56.5/236.5 degrees with a standard deviation of 10.5 degrees, while the strike of the full fracture dataset is approximately 13/193 degrees with a standard deviation of 15 degrees. Reviewing the strike of the dominant fracture family in each borehole reveals that only MW-23 has a strike orientation for the principal fracture family that is close to that of the lineament dataset. Figure 4.7 shows the location of identified photo-lineaments as well as the azimuth-frequency diagrams for each borehole. It is apparent that MW-23 is the borehole most closely aligned with the strike of the dominant set of lineaments. Review of the LiDAR data, bedrock elevation contours, and geologic mapping of the Breakfast Hill Granite intrusive suggest an erosional bedrock type aligned along the contact of the Breakfast Hill intrusive and the surrounding Rye Formation, which is potentially responsible for the identification of many of the photo-lineaments in this area.

In summary, comprehensive statistical analysis of a dataset of 1,263 fractures measured in boreholes and 310 joints measured in outcrop demonstrates the following:

- The dominant fracture azimuth (i.e., dip direction) is approximately 283 degrees or approximately west-northwest (WNW) and is observed in all but one of the boreholes assessed (as the dominant fracture orientation) and the outcrop measurements. Eleven of the 16 boreholes assessed demonstrate this dominant fracture orientation.
- The median dip angle from the data sets is 66° and indicates moderately to steeply dipping fractures are dominant.
- Analysis of different rock types indicates that the schist, phyllite, gneiss, and quartzite groups are consistent with the total fracture results with only the basalt showing a different dominant orientation. This difference is primarily observed in well MW-24 where basalt is the dominant rock type.
- Analysis of fractures that are potentially transmissive is also consistent with the dip angle, fracture azimuth for the larger fracture data set. Review of the fracture dataset suggests that fractures decrease in frequency with depth, which is consistent with regional information indicating water-bearing fractures are more predominant in the upper fractured zones of crystalline bedrock in New England.
- Outcrop joint measurements are generally consistent with borehole geophysical results and indicate moderately to steeply dipping features with azimuth that are similar to that of the potentially water-bearing fractures identified by borehole geophysics.
- Photo-lineaments shown on Figure 4.7 are generally correlated with strike of bedrock foliation and appear to be related to the contact between the Breakfast Hill intrusive and the Rye Formation, implying that the bedrock in this relatively narrow zone may have been

structurally deformed in such a way as to increase weathering and perhaps increase permeability of the bedrock.

Therefore, analysis of these data is consistent with the CSM as it demonstrates that the dominant fracture orientation is dipping to the WNW and is steeply dipping. This is consistent with two of three primary flow paths identified in the CSM: westerly along predominant dip direction and north/south along predominant strike of fractures (also coincident with a bedrock trough west of the landfill).

4.3 Groundwater

Assessment of Ground-Water Resources in the Seacoast Region of New Hampshire (Mack, 2012) evaluates the behavior of groundwater resources in the Seacoast region of coastal southeastern New Hampshire, where the Site is located. This document indicates that in the Seacoast region:

- “Ground water flows toward water bodies from topographic highs to lows”
- “The water table in the study area is generally 10 to 20 feet below the land surface, following the topography, except in wetlands and water bodies, where the water table is at the land surface."
- “The ground-water system is recharged by precipitation at the land surface and discharges to streams or to tidal water bodies.”
- “Ground water in the bedrock aquifer system may follow a short or long flow path because of factors such as position in the flow system and local stresses”

Overall, the Site and the Site CSM, as it relates to groundwater, agree with these general statements on characteristics of the Seacoast region. Groundwater flow in overburden and bedrock primarily flow towards, and discharges into, a wetland complex located west of the landfill, the Little River located southwest of the landfill, and Berrys Brook located northeast of the landfill. Where the generalities of from the Mack 2021 paper allow for questions regarding the details of flow patterns, (i.e., groundwater flows from high elevation to low), one goal of this section is to define the position of the landfill in the flow system and local stresses that determine the more complex flow regimes in deep bedrock and between lithologic units.

4.3.1 Occurrence and Flow in Overburden

As discussed in Section 4.1, overburden at the Site consists of glacial till, marine deposits, and glacial outwash. Groundwater flow in the overburden is interpreted to be influenced by surface topography, lithology, surface water discharge locations, and the top of bedrock. Given the low hydraulic conductivity of marine clay, little groundwater flow is occurring in the marine deposits. In many locations, the marine clay forms an aquitard that limits communication between the uppermost outwash deposits and the underlying till and or bedrock units. However, in areas where the marine unit is thin or absent, hydraulic communication likely exists between outwash deposits and underlying glacial till.

Hydraulic conductivity values presented in the original RI indicate hydraulic conductivity of the glacial till ranged from 0.06 feet/day at GZ-115 to 1.6 feet/day at GZ-127, with an outlier of 510 feet/day at GZ-

101. Hydraulic conductivity in the outwash unit ranged from 2.1 feet/day at GZ-133 to 28 feet/day at GZ-112. Groundwater flow velocities calculated for the overburden aquifer during the 1994 CDM RI ranged from 5.71 feet/year to 1,482 feet/year. Overburden average linear groundwater velocities were calculated to be fastest between the landfill and the wetlands to the west (296 to 1,482 feet/year); slowest beneath the Little River wetlands (5.71 to 28.5 feet/year); and intermediate for flow from the landfill to the east (64.1 to 320 feet/year) and Lafayette Terrace to the south and southwest (80.1 to 400 feet/year).

Interpretation of horizontal groundwater flow patterns in the RI identified a western and southern component of flow, with an inferred eastern component, coincident with the bedrock topographic high underlying the landfill. Mounding of groundwater evidenced by the now abandoned GZ-106 was shown to be a driver of this eastern flow component. Additional delineation through the installation of overburden and bedrock monitoring wells since the initial RI has allowed for current understanding of overburden flow pathways as described below

Infiltrating of precipitation during landfill operations in the 1970s and 1980s, as well as during the post-closure period prior to capping, likely caused a mounding effect within the footprint of the landfill resulting in a higher magnitude gradient driving the radial flow component east of the landfill that allowed migration of impacted groundwater to the east. However, this gradient present in outwash was eliminated by the capping of the landfill and the eastern gradient in glacial till was greatly reduced following the completion of the landfill cap system in 1998. Water quality data in monitoring wells east and south of the landfill indicate landfill-related impacts are present, albeit lower concentrations compared to water quality data from monitoring wells located west of the landfill.

During construction of the cover system, landfill refuse was consolidated into the current landfill footprint. Refuse located near the topographic high was pulled westward into the current landfill footprint and refuse that was intermingled with wetlands along the northwest corner of the landfill was removed and placed within the current landfill footprint.

As part of the cover system construction, perimeter ditches were installed to convey stormwater runoff from the cover system to stormwater basins (ponds) located northeast and northwest of the landfill. As a result of these construction activities, infiltration of precipitation into or through landfill waste has been minimized or eliminated. Interpretation of groundwater elevation data following installation of the cover system indicates that overburden groundwater under the footprint of the landfill flows in a westerly direction.

Overburden groundwater flowing westward from the Site discharges into a large wetland complex that serves as the headwaters for Berrys Brook and Little River. The wetland complex occurs in a broad topographic saddle to the west of the landfill. Distinct channelized flow representing Berrys Brook becomes evident on aerial images near the north end of the wetland complex approximately 2,000 feet north of the Site. Similarly, channelized flow representing Little River becomes evident approximately 1,500 to 2,000 feet south of the Site.

Overburden groundwater contour maps are presented in Annual Groundwater Monitoring reports that have been submitted to USEPA and NHDES. A groundwater contour map utilizing water level gauging data collected in May 2021 is included as Figure 4.9. Based on water level elevations and consistent with the discussion above, overburden groundwater flows primarily westward from the landfill and topographic high towards the wetland complex where it bifurcates to the north and south within the thicker overburden deposits in the bedrock trough.

Lesser northern and southern flow components are present within the overburden east of the landfill, emanating from the local groundwater high at GZ-117, AE-1A and MW-4. Southern groundwater flow components east of the landfill originate in the area of MW-4/FPC-11A/AE-1A area and flow south/southwest. Northern groundwater flow components drive groundwater from GZ-117 towards the FPC-9A/-9B/-9C series wells.

There are localized eastern flow components which are not large enough to be evident at the scale of the shallow groundwater contour map. For example, there are gradients that range from 0.0006 feet/foot to 0.001 feet/foot between MW-4/AE-1A and MW-4/FPC-11C well pairs and coincide with isolated thicker glacial till deposits as illustrated on Figure 4.1. These wells are located within an area of deepening overburden deposits within a bedrock valley extending east of the north-south oriented groundwater divide. No localized trends or patterns in the groundwater potentiometric surface related to lithology are apparent with an even spatial distribution of wells in the network screened in either outwash or glacial till. A thick sequence of marine clays overlies this glacial till and constrains further groundwater flow to the east.

The wetland complex and associated Little River and Berrys Brook valleys are interpreted to be the discharge location for overburden groundwater. However, the variation in thickness and extent of overburden beneath the wetland complex (e.g., presence/absence of marine deposits) has a significant effect on localized flow patterns as groundwater discharges to the wetlands and eventually Berrys Brook and/or Little River. There is good spatial correlation between the more transmissive glacial till deposits (Figure 4.1) underlying the less transmissive marine deposits (Figure 4.2) and the location of an overburden groundwater divide within the wetland complex. Marine deposits within the wetland complex are oriented parallel to the long axis of the bedrock trough (NNE-SSW) and thin in all directions; however, the extent of these deposits to the south in the Little River watershed is uncertain. Glacial outwash deposits are thin or absent in the central portion of the wetland complex (Figure 4.3) with deposits thickening to the north and south. Overburden deposits are constrained by bedrock topography with localized thicker deposits of outwash having been targeted by historic sand and gravel mining operations at the site and areas located south of North Road. As discussed in Section 4.4, groundwater discharge provides a large component of base flow for both the Little River and Berrys Brook.

Based on boring logs and LiDAR to the west of the wetland complex, overburden thins and pinches out along numerous bedrock outcrops. Overburden monitoring wells MW-21S and MW-22S encountered only several feet of saturated overburden above bedrock; however, a boring approximately 100 feet west of MW-21S (MW-21D) did not encounter saturated overburden deposits. High resolution ground topography information obtained through the analysis of LiDAR data identifies the presence of a relatively narrow low-lying area extending from the wetland complex to the west of MW-21S, which aligns with the general delineation of wetlands by the National Wetland (Figure 2.2). This information and DPT data presented in Section 3.5.1 support the conclusion in the CSM (Section 5) that overburden groundwater flows towards the wetland complex where it bifurcates to the north and south within these deposits as described above.

4.3.1.1 Overburden Groundwater Quality

Overburden groundwater quality has been monitored on an annual basis beginning in 1998 following cover system construction. Sampling frequency was increased to semiannual sampling in 2017 in order to establish a more robust database for PFAS, which was added to the analyte list in 2016. The analyte list includes contaminants of concern for the Site that are included in the ROD and ESD, plus PFAS. A detailed discussion of analytical results for all analytes is included in Annual Groundwater Monitoring reports submitted to USEPA and NHDES.

The distribution of arsenic, manganese, 1,4-dioxane, and PFAS largely mimic groundwater flow in overburden, with the highest concentrations near the landfill. Though arsenic and manganese are naturally occurring within the bedrock at the Site and regionally, reducing conditions associated with the landfill can result in increased concentrations of these metals. The lateral distribution of arsenic and manganese in overburden groundwater are included as Figure 4.10 and 4.12, respectively. The distribution of arsenic correlates well to the distribution of glacial till with lobes of arsenic present to the northwest and southwest coincident with the bedrock trough and thickening glacial till deposits (Figure 4.1) and separated by the bedrock saddle within the trough (Figure 3.4). Arsenic is also present in the till deposits that thicken to the southeast of the landfill. Manganese follows a similar trend within till to the northwest and southeast as that observed with arsenic with lesser extents observed to the southwest.

PFAS and 1,4-dioxane are more mobile and persistent in the environment than COCs addressed by the original OU-1 and OU-2 remedies (i.e., VOCs) and may be more vertically and laterally extensive. The distribution and interpreted lateral extent of 1,4-dioxane in overburden groundwater, based on analytical data from the Fall 2020 sampling event[6], is presented in Figure 4.12. With the regulation of four PFAS compounds as of October 1, 2019, the distribution and interpreted lateral extent of PFOS, PFOA, PFNA, and PFHxS have been included and are illustrated in Figures 4.13 through 4.16.

As expected, the distribution of 1,4-dioxane and PFAS largely mimic groundwater flow in overburden, with the highest concentrations near the landfill and decreasing with increased distance from the landfill. With the exception of concentrations detected within shallower outwash wells nearest the landfill (i.e., OP-2, OP-5, MW-9, and MW-10), the distribution of these contaminants is greatest within glacial till units. Two lobes PFOA and 1,4-dioxane are present to the east of the landfill and detected in wells screened in glacial till. Concentrations of arsenic and manganese decrease as one moves to the north and east away from the landfill. Monitoring wells screened in glacial till exhibit the highest concentration

[6] Data from fall of 2020 was used, as this is the latest set of validated and confirmed data. A general comparison of fall 2020 data to 2021 data exhibits similar trends.

of both 1,4-dioxane and PFAS. Monitoring wells exhibiting the highest concentrations of arsenic and manganese were screened in various geologic units (glacial till, glacial outwash, and bedrock). As discussed in the surficial geology section, glacial till overlies bedrock in most locations with the thickness based in part on bedrock topography. Given that the landfill was developed overlying a bedrock topographic high as evidenced by shallow depth to bedrock in monitoring wells near the landfill and exposed bedrock in a former small quarry to the north of the Site, contaminants migrating from the landfill would have migrated to and through glacial till and outwash, and shallow weathered bedrock. As noted in the discussion concerning vertical gradients, it appears that relatively good hydraulic communication exists between glacial till and outwash and weathered shallow bedrock.

Although data show that overburden groundwater moves westward from the landfill and ultimately discharges to the wetland complex, an extensive marine clay deposit underlying the wetland likely confines groundwater discharge to areas where the marine clay is thin or absent. As a result, it is interpreted that a broad area of glacial till beneath the marine clay contains elevated concentrations of 1,4-dioxane and PFAS. MW-21S is installed in this area and has shown concentrations of 1,4-dioxane slightly higher, but similar to, those reported in nearby well FPC-5A and concentrations of PFAS lower than those reported at nearby well FPC-5A. The lateral distribution of 1,4-dioxane, PFAS, arsenic, and manganese from the landfill is predominantly to the northwest, towards a northern lobe of thicker glacial till within the bedrock trough, with the distribution of manganese and PFHxS illustrating the greatest trend of compounds evaluated. A smaller trend to the southwest towards a southern lobe of glacial till within the trough is observed in the distribution of 1,4-dioxane and manganese. In addition, the distribution of PFOA, PFNA, and 1,4-dioxane to the southeast of the landfill trends towards a lobe of thicker glacial till near the FPC-11 series wells.

To the west of MW-21S, overburden extent is generally limited by bedrock outcrops, although a narrow extension of the wetland complex is present a few hundred feet south of MW-21S that is likely to represent saturated overburden with a limited westward extent in that area. Analytical data generated during the DPT investigation (Figure 3.5) supports a limited westward extent of groundwater impact, as AGQSs were not exceeded at TMWs at or west of the existing GMZ (Section 3.5). It should be noted that property west of MW-21S is undeveloped woodland extending westward to the Berrys Brook watershed boundary.

As discussed in the RI and subsequent Annual Groundwater Monitoring reports, overburden groundwater discharges to the wetland complex west of the landfill and subsequently is interpreted to follow the north-south trending valleys of Little River (to the south) and Berrys Brook (to the north). Groundwater beneath the wetland complex moves northward towards the headwaters of Berrys Brook where the marine deposit thins or becomes discontinuous allowing more direct discharge to Berrys Brook. Coincident with movement of groundwater to the north under the wetland complex, additional attenuation of 1,4-dioxane concentrations occurs as unimpacted groundwater from the east and west of Berrys Brook (north of the landfill) moves towards Berrys Brook. As a result, concentrations of 1,4-dioxane decline significantly north of the wetland complex, with analytical results from samples at MW-20S located near Breakfast Hill Road being reported as ND (<0.20 ug/L; with the exception of private water supply wells 339BHR and R-3) for several biannual sampling events. PFAS is also reported as ND in MW-20S and generally shows a decreasing trend in the westward direction (Figures 4.11 through 4.14).

Concentrations of arsenic,1,4-dioxane, and PFAS to the southwest of the landfill in the wetland complex and Little River valley show a similar (but lower concentration) pattern to concentrations in the northern portion of the wetland complex and Berrys Brook valley. This distribution pattern, as discussed above, trends towards the distribution of glacial till underlying the marine clay west of the landfill. Concentrations are higher in glacial till and shallow bedrock as discussed in Section 4.3.2 with the distribution these contaminants coincident with the shape and distribution of till. The westward extent of 1,4-dioxane and PFAS in this area is demonstrated by ND results at both AE-4A and MW-22S. The marine clay is relatively thin to the south, as shown on boring logs and may be less of a confining layer as compared to the northern end of the wetland complex.

To the east of the landfill, distribution of 1,4-dioxane is highest in monitoring wells completed in glacial till, although overburden thickness increases to the east and concentrations decline rapidly away from the landfill compared to concentrations observed west of the landfill. Concentrations are bounded on the northeast with a 0.79 ug/L at OP-2, to the east by an ND at GZ-117, and a concentration of 0.96 ug/L at FPC-11A (Figure 4.10). PFAS concentrations follow a similar pattern to the east, with the distribution and interpreted lateral extent of PFOS, PFOA, PFNA, and PFHxS contained within the GMZ (Figures 4.11 through 4.14).

DPT Water Quality Results

Water samples were collected from six DPT locations and consisted of seven total samples due to the installation of both shallow and deep temporary wells (TMW-5S/-5D) at DPT-5. Although PFAS and 1,4-dioxane were target contaminants for the area of investigation due to exceedances of the current New Hampshire AGQS at MW-21S, samples were also analyzed for arsenic and manganese based on historical concentrations of these metals at MW-21S and FPC-6A at or slightly above the AGQS and/or USEPA CL. Field parameters (dissolved oxygen [DO], ORP, pH, specific conductance, temperature, and turbidity) were also monitored during sampling activities in accordance with the SAP. Analytical results are provided on Figure 3.5.

Results for the seven locations sampled, based on location within the western portion of the GMZ and position relative to FPC-6A and MW-21S, were consistent with expectations. Western migration within overburden was limited and only minor detections of PFAS, 1,4-dioxane, arsenic, and manganese were reported outside the current GMZ. Results at DPT/TMW-1 (Figure 3.5) were similar to known concentrations in overburden at MW-21S and FPC-6A. Concentrations of PFOA and PFOS exceeded the New Hampshire AGQS at TMW-1 (Figure 3.5); however, locations sampled immediately west of the current GMZ (DPT/TMW-3 and DPT/TMW-9) were either non-detect (ND) or below the AGQS for analyzed constituents. Though detections were reported for some constituents in locations west of DPT/TMW-3 and DPT/TMW-9, most were estimated concentrations at or below respective reporting limits. These included DPT/TMW-5S/-5D, DPT/TMW-6, and DPT/TMW-7 (Figure 3.5). Sampling at TMW-11S and 11D were completed during the Spring 2022 sampling event. Results were evaluated and will be used in the locating and installation of a permanent overburden monitoring well to monitor the western extents of the GMZ as described in Section 7.

4.3.2 Occurrence and Flow in Bedrock

Groundwater flow in Site bedrock is controlled by the following components:

- Natural and imposed (i.e., pumping wells) hydraulic gradients;
- Fracture frequency, orientation, and connectivity; and
- Bedrock and surface topography.

Four fracture populations (including sheeting fractures) were identified at the Site and characterized in a variety of ways in Section 4.2.4.2.

The primary fracture population is parallel to the regional foliation (north-northeast to south-southwest) and represents 41% of the fractures identified in the geophysical boring logs. Evidence for groundwater flow along this flow pathway includes the high number of fractures and lineaments with this orientation, higher likelihood to transmit groundwater based on geophysical logs, and contaminant distribution maps (see Section 4.3.2.3). However, as discussed below, the secondary and tertiary fracture populations do have an influence on groundwater flow.

4.3.2.1 Horizontal Bedrock Groundwater Flow

Figures 4.17A and 4.17B depict shallow (depths less than 75 feet) and deep (depths greater than 75 feet) horizontal groundwater flow contours, respectively. These intervals were selected based on an approximately equal number of wells in each category as fracture orientation and frequency did not correlate with depth. Both maps show a strong westerly component of flow until the bedrock valley is reached, at which point flow diverges southerly and northerly where an approximately east-west bedrock groundwater divide is located. In deep bedrock, there is a southern component of flow, towards the Little River watershed identified south of the landfill. The two resulting flow paths are consistent with the primary fracture population. With respect to the origin of the westerly flow component, the secondary fracture population is generally oriented northeast and represents 21% of the fractures identified in the geophysical logs. Combined with the northwest-oriented tertiary fracture population, which represents 14% of the fractures, this flow path is likely attributed to these two fracture sets with the groundwater flowing in a “zig-zag” pattern toward the west between the primary fractures.

Interpretation of horizontal groundwater flow patterns in the RI identified a western, southern, and eastern component of flow, with the divide coincident with the bedrock topographic high to the north of the landfill in the vicinity of former GZ-131 by the Bethany Church. The axis of this bedrock groundwater divides trends to the southwest, from the Bethany Church, towards GZ-109 and widens substantially south of the landfill.

Sheeting fractures made up only 7% of the total identified in the geophysical logs as indicated earlier. As illustrated in below, the sheeting fractures are most common between depths of 50 and 200 feet, so it is possible that when present, these fractures may promote flow between the more high-angle fractures in the deeper bedrock.

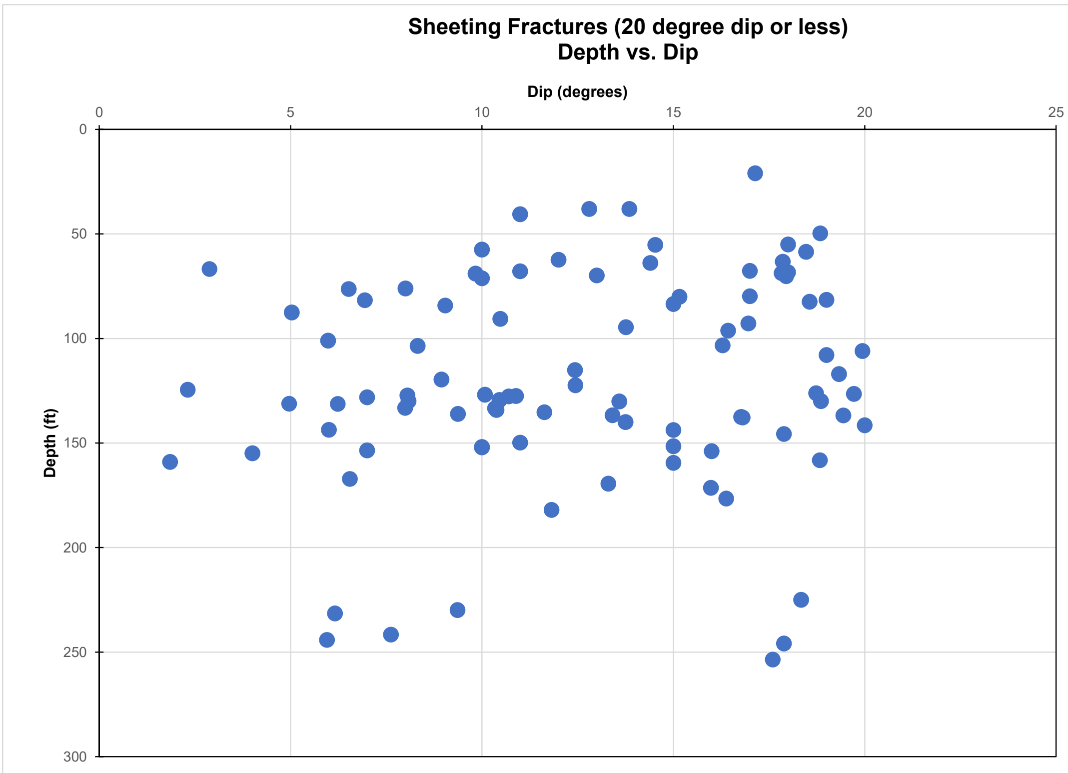


Exhibit 12: Depth of sheeting fractures in bedrock.

<u>4.3.2.2 Vertical Bedrock Groundwater Flow</u>

Figures 4.4, 4.5, and 4.6 depict vertical flow paths based on the geologic cross-sections presented in 4.2.3.2. Figure 4.4 is a south to north cross section within the bedrock valley and shows two important features. First, a bedrock ridge is present in the vicinity of MW-6 that is coincident with the horizontal bedrock groundwater divide referenced above. This divide is also visible in the vertical flow net with a distinct upward gradient on both sides of the divide. Bedrock groundwater flows up into the overburden deposits and ultimately to Berrys Brook and the Little River.

Figure 4.5 is a west to east cross section that includes the landfill. Flow is from east to west as depicted in the horizontal contour map with a slightly upward gradient in the bedrock. This gradient increases significantly at the bedrock-overburden interface before groundwater discharges to the adjacent overburden valley.

Vertical flow to the far east at well group FPC-9 is unique in that the flow at FPC-9C is downward to well FPC-9A but is upward from FPC-9B to PPC-9A. In other words, shallow overburden flow and shallow bedrock flow is converging in the till layer at this location. This phenomenon is not visible in the overburden or bedrock contour maps since the till layer is below the water table but above the bedrock.

Figure 4.6 is another west to east section that includes the landfill with a similar pattern as Figure 4B. (Note: well MW-21D is interpreted to be in a deeper flow regime based on its water level and lack of contamination). A converging flow pattern as present at the FPC-9 is also evident below the wetland complex just west of the landfill, where till is receiving groundwater from above and below before it discharges to the surface.

In light of the foregoing, one explanation for bedrock contamination east of the landfill is that flow through the till in this area, which is capped by clay, may be toward the east even though the bedrock groundwater contour map shows flow to the west. In addition, the vertical gradient just southeast of the landfill is downward from the till into the bedrock at well couplets FPC-1 and FPC-11 (see Section 4.3.2.3). In summary, contaminated groundwater within the till may flow to the east and then move downward into the bedrock.

4.3.2.3 Vertical Gradients in Bedrock

Vertical groundwater gradients were calculated at 18 well pairs (e.g., AE-1A/-1B) or triplets (e.g., FPC-3A/-3B/-3C) based on synoptic water level gauging measurements completed during the 2019 and 2020. A summary of water level measurements and corresponding calculation of vertical gradients is included in Table 3.2. For the purpose of categorizing locations as showing an upward or downward gradient, positive gradients are upward and negative gradients are downward; paired wells with a gradient between 0.001 and -0.001 are considered neutral. While seasonal variations have occurred, most of the well pairs show a predominant gradient direction, so the primary gradient direction was selected for each well couplet based on gradient direction for the majority of measurements. The average gradient based on the primary direction is also provided in Table 3.2.

The following observations can be made:

- Two out of the three well pairs that are both within overburden have a neutral vertical gradient. Thus, flow is considered fully horizontal at those locations and depths.
- As shown below in Exhibit 13 below, the magnitude of the upward gradients is higher overall than the downward gradients. This pattern is likely due to the upward gradients being derived from head generated by the adjacent higher topography, rather than simply gravity and the overlying head that drives downward gradients.
- As included with vertical gradients on Table 3.2, bedrock valleys are influencing the distribution of vertical gradients: a) upward gradients are common and of greater magnitude in the primary southerly to northerly bedrock valley and in the northwest-trending bedrock valley just east of the landfill, b) the lowest upward and downward vertical gradients are generally distant from the primary valley.

- Exceptions to the trends described above include FPC-2 and FPC-3, which exhibit some of the strongest gradients in the upward and downward direction, respectively, even though both are in close proximity. Neither well is contaminated.

Monitoring Well	Primary Vertical Gradient	Average Gradient	Monitoring Well	Primary Vertical Gradient	Average Gradient
AE-1A	Down	-0.001	**MW-21D**	Up	0.001
MW-20D	Down	-0.002	**AE-4A**	Up	0.005
MW-22D	Down	-0.002	**GZ-117**	Up	0.006
MW-20S	Down	-0.004	**GZ-123**	Up	0.014
MW-22S	Down	-0.006	**MW-21S**	Up	0.016
MW-5S	Down	-0.007	**AE-2A**	Up	0.016
FPC-8A	Down	-0.007	**AE-3A**	Up	0.027
FPC-3A	Down	-0.011	**FPC-5A**	Up	0.027
FPC-6A	Down	-0.032	**FPC-9A**	Up	0.047
FPC-7A	Down	-0.047	**FPC-2A**	Up	0.071

Exhibit 13. Vertical gradients sorted by direction and magnitude.

4.3.2.4 Analysis of Transducer Water Level Data

Previous transducer data from MW-20D, R-3, and MW-23 presented in the *Interim Report* was interpreted to represent daily fluctuations caused by earth-tides[7]. In addition, it was noted that lateral permeability between principal fractures, which are interpreted to be aligned with the foliation planes, is likely to be much lower than the permeability downdip/along strike of the fractures. Therefore, the bedrock structure may also limit observed drawdown in wells that are laterally close, if those wells are drilled in separate parallel fracture systems that are infrequently connected by fractures families with a different orientation to the principal fracture system.

Monitoring wells instrumented during the constant rate pumping test included: AE-2A, AE-2B, AE-3B, BP-4, FPC-2A, FPC-2B, FPC-3B, FPC-4B, FPC-5B, FPC-7B, FPC-8A, FPC-8B, FPC-9B, FPC-11B, GZ-105, GZ-108, GZ-109, GZ-110, GZ-116, GZ-125, GZ-130, MW-2, MW-4, MW-5S, MW-5D, MW-8, MW-11, MW-20D1/2, MW-21D1/2, MW-22D1/2, MW-24, MW-25S, and MW-25D. All of these instrumented wells exhibited daily fluctuations caused by earth-tides. The pumping test overcame these habitual fluctuations in wells MW-2, MW-5S, and MW-5D, which all showed a flattening of their respective water level curves during periods of pumping. This elimination of earth-tide influence is a further line of evidence that these wells (MW-2, MW-5S, and MW-5D) are part of several wells that are hydraulically connected to the pumping well, MW-6.

[7] Earth-tides are caused by the gravitational forces exerted on the Earth by the Moon and the Sun, which can cause diurnal fluctuations in groundwater head.

4.3.2.5 Summary of Conceptual Flow System

As previously summarized in Section 4.2.4, the primary bedrock fracture population is moderately to steeply dipping to the WNW with a 193-degree strike. These fractures occur coincident with the bedrock foliation. In addition, secondary, tertiary, and sheeting fractures are likely to result in a cross-connection with the primary fractures, resulting in a complex flow path on the local scale.

Bedrock groundwater flow through this fracture system is controlled by the hydraulic gradient which in turn reflects larger scale surface and bedrock topography. As previously discussed in Section 4.2.4, fewer fractures are inferred to occur at depth within the bedrock and closure of fractures at greater depth may occur because of overburden pressure. Therefore, in the bedrock setting with layered dipping fracture sets, flow will occur downdip and then many be forced to follow the strike along the foliation plane until it enters a discharge zone such as a stream. If a stream is aligned with strike, as is the case for the wetland complex and surface water to the west of the Site, then groundwater head on the down-dip side of the stream is in general higher, and its age in general older, than on the up-dip side, resulting in asymmetry in groundwater residence time on the opposite sides of a stream aligned with strike (Burton et al., 2002). However, it is also noted that dominance of topography over structure and fracturing may occur where there is a high degree of weathering and/or stress-relief fracturing in the upper shallow bedrock. Where this zone is present, the majority of flow through the bedrock may occur in this layer, as opposed to migrating through deeper bedrock, as a result of the relatively higher number of pathways, and hence higher permeability, so that flow is more strongly driven by topography than structure in the deeper bedrock.

4.3.2.6 Bedrock Groundwater Quality

Groundwater quality is monitored in six bedrock monitoring wells in OU-1 and 15 bedrock monitoring wells in OU-2 as part of routine long-term water quality monitoring at the Site. These monitoring locations have been supplemented by 24 private water supply wells located outside of the GMZ, six monitoring wells installed in accordance with the 2018 work plan (MW-20D1/-20D2, MW-21D1/-21D2, and MW-22D1/-22D2), ten open borehole bedrock wells (GZ-108, GZ-109, GZ-110, GZ-116, GZ-119, GZ-122, GZ-125, GZ-130, BP-4, and MW-6), and two private wells (MW-23 and MW-24). Locations of these wells are shown on Figure 2.2.

Roughly half of bedrock monitoring wells in OU-1 and OU-2 are screened less than 75 feet below grade, while many open borehole private water supply wells are installed up to 300 feet below grade. The distribution of shallow (75 feet bgs) and deep (>75 feet bgs) bedrock groundwater are included in Table 3.1 and shown in the shallow and deep bedrock groundwater potentiometric contour maps, included as Figures 4.15A and 4.15B, respectively. Information on deep bedrock groundwater quality and the monitoring of impacts to potential receptors is supported currently by interval packer sampling results for reconnaissance wells inside the GMZ (GZ-108 and GZ-116) and outside (GZ-109, GZ-110, and GZ-122). These results were provided to USEPA and NHDES in the *Reconnaissance Well Interval Packer Testing Technical Memorandum* dated September 10, 2019, with analytical results additionally provided in Appendix C. Deep bedrock water quality outside of those wells currently included with routine sampling will be supported with the completion of MW-24, GZ-109, and GZ-130 as permanent nested bedrock monitoring wells in accordance with the Work Plan Addendum (Haley Ward, 2020). In addition, a new deep bedrock monitoring well installed to monitor the southern migration pathway is proposed for installation in accordance with the *Draft Bedrock Well Installation Work Plan* provided to the Agencies on July 1, 2022 (Wood, 2022).

Detailed discussions of water quality results for OU-1, OU-2, and water supply wells outside of the GMZ are presented in Annual Groundwater Monitoring reports provided to USEPA and NHDES and in the results of intervals packer sampling at open bedrock monitoring wells included with Appendix C.

A summary of fall 2020 bedrock groundwater sampling results is provided as Table 4.1A, while results from interval packer sampling at MW-20D, MW-21D, MW-22D, and open borehole bedrock wells are provided in Appendix C.

The distribution and interpreted lateral extent of Site COCs in bedrock groundwater, specifically arsenic, manganese, and 1,4-dioxane, based on analytical data from the Fall 2020 sampling event, is presented in Figure 4.21 through Figure 4.23. With the regulation of four PFAS compounds as of the date of this report, the distribution and interpreted lateral extent of PFOS, PFOA, PFNA, and PFHxS are illustrated in Figure 4.24 through Figure 4.27, respectively.

Findings based on a review of 2020 data are as follows:

- The highest concentrations of arsenic, manganese, 1,4-dioxane, and PFAS were detected in monitoring wells closest to the landfill. Concentrations decrease with increased distance from the landfill.
- The distribution of these compounds is consistent with groundwater flow patterns interpreted from potentiometric head data collected for the Site.
- The elongated distribution of arsenic, manganese, 1,4-dioxane, and PFAS north and south of the wetland complex (Figure 4.21 through Figure 4.27) is consistent with regional geologic structure, lineament analysis, and fracture orientation observed in most downhole geophysical surveys. However, the decline in concentrations to the north and south are also consistent with interpreted discharge of groundwater to Berrys Brook and Little River, which are also oriented in a north-south direction. It should be noted that at the time of reporting, the *Draft Bedrock Monitoring Well Installation Work Plan* (Wood, 2022) to monitor bedrock groundwater quality to the south and outside of the current groundwater monitoring network was submitted on July 1, 2022 with comments to the work plan provided by the USEPA on July 11, 2022. A *Revised Bedrock Well Installation Work Plan* is under development at the time of reporting.
- 1,4-dioxane was not detected in 21 of the 24 private water supply wells sampled in 2020. Concentrations detected at R-3 (368 Breakfast Hill Road) during the fall 2020 event were 0.5 ug/L and 0.48 ug/L for the original and duplicate samples, respectively. The concentration detected in well 339 BHR (Breakfast Hill Golf Club) was 0.57 ug/L. A detection of 1,4-dioxane was also reported for 178ALR at a concentration of 0.21 ug/L, below the CL and AGQS.

Concentrations of 1,4-dioxane continue to be stable and below the CL in these wells. Although 1,4-dioxane was detected above the AGQS at R-3 and 339 BHR, these two locations have Point of Entry (POE) treatment systems installed by and currently maintained by CLG contractors to prevent any exposure to users of these wells.

- Though very low concentrations of PFOA, PFOS, PFNA, PFHxS, and/or PFOA/PFOS combined were detected in one or more residences in 2020, with the exception of PFOA at R-3 and 339 BHR, there were no exceedances of the AGQS/HA for PFOA, PFOS, PFNA, PFHXS, or PFOA/PFOS combined in any of the private water supply wells sampled in 2020. Exceedances of PFOA in drinking water at R-3 and 339 are treated by the POET systems installed by the CLG in 2018.
- With the exception of 1,4-dioxane and PFOA in two private water supply wells (339BHR and R-3, Fall 2020 only), concentrations of COCs and PFAS do not exceed CLs, HAs, or AGQS in private water supply wells.
- Of the 26 bedrock groundwater wells sampled in 2020, 15 did not contain 1,4-dioxane at concentrations above the CL while 11 of the 26 wells sampled did not contain 1,4-dioxane at concentrations above the AGQS. There were no first-time exceedances of the CL for 1,4-dioxane in 2020. The absence of 1,4-dioxane and PFAS in bedrock monitoring wells MW-22D1, MW-22D2, AE-4B, MW-21D1, and MW-21D2 demonstrates that landfill related contaminants are not migrating in deeper bedrock to the west beyond the GMZ boundary and are not impacting private wells in the subdivision west of the Site.

Findings based on a review of reconnaissance well interval packer sampling are as follows:

- GZ-119 is located immediately downgradient of the closed Rye Breakfast Hill Landfill and within the GMZ for that Site. Results from GZ-119 are consistent with historic monitoring conducted for that location; PFOS and PFOA were reported in all five intervals ranging from 11.8 ng/L to 13.2 ng/L and 0.925 ng/L to 3.28 ng/L, respectively. Based on the location of GZ-119 within the Rye Landfill GMZ and hydraulically downgradient of the Rye landfill, these impacts are not likely to be attributable to the Site. Based on analytical data provided in the Groundwater Management Permit Renewal Application for the Rye Landfill dated July 13, 2018, the concentrations of PFOS and PFOA within Rye Landfill monitoring wells MW-4A and MW-10 are similar to those reported during interval packer sampling results within GZ-119 (Appendix C). Additionally, the absence of data to support landfill impacts in bedrock wells GZ-109, GZ-110, and GZ-116 suggests that impacts reported in GZ-119 are attributed to the Rye Landfill.
- 1,4-dioxane detected at MW-24 is interpreted to be associated with the Site. Concentrations exceed the AGQS for 1,4-dioxane but are consistent with concentrations reported in bedrock monitoring well BP-4, located approximately 600 feet to the west. A bedrock well downgradient of MW-24 (GZ-109) did not detect 1,4-dioxane above the laboratory detection limit of 0.2 ug/L. Together with groundwater quality parameter information collected during

interval packer sampling, this information suggests that water within GZ-109 does not exhibit impacts from the Site. MW-24 is a private well located approximately 600 feet east of the landfill, initially constructed as an irrigation well for a local garden center. Observations of the well location, construction, and condition suggest that it is not currently in use; however, past use is unknown based on information provided by the current property owner. The property is serviced by a municipal water supply.

- Concentrations of PFOS, PFNA and PFHxS did not exceed the AGQS in any of the 49 open borehole bedrock well samples.
- Concentrations of PFOA did not exceed the AGQS in 40 of the 49 open borehole bedrock well samples. Exceedances of the AGQS (12 ng/L) were detected in the 10 primary samples collected at GZ-119 and GZ-130, with the highest concentration detected in samples from well GZ-119. PFOA was detected at 11.8 ng/L in the duplicate sample collected from Zone 2 in GZ-130.
- Concentrations of PFOA in six interval samples from well GZ-130 ranged from 11.8 to 13.2 ng/L, with five of the six samples slightly exceeding the AGQS of 12.0 ng/L. The similarity of results from the six intervals suggests that groundwater within the sampled intervals was well mixed prior to sampling. Discussions with the property owner indicate that the well had been used for landscape irrigation purposes in the past, although volumes and duration of use are unknown. The well pump that was present in this well has been removed.
- Analytical results from the nine wells sampled as part of the Reconnaissance Wells sampling program are consistent with the interpreted distribution of contaminants based on the results of long-term sampling at monitoring wells associated with OU-1 and OU-2 at the Coakley site and do not indicate the presence of significant, previously undefined contaminant migration pathways from the Coakley landfill.
- A total of 12 intervals or zones were sampled within MW-25 in March of 2021 to supplement data collected in other open borehole bedrock wells. All twelve intervals had detections of 1,4-dioxane above the laboratory detection limit of 0.2 ug/L. The shallowest interval (Zone 1: 40 to 57 feet bgs) detected 1,4-dioxane at a concentration of 23.1 ug/L. This was the highest detection within MW-25 during packer testing. Detections in Zones 3 through 7 were also above the USEPA CL (3 ug/L) with concentrations ranging from 5.42 ug/L to 8.84 ug/L. In Zones 2, and 8 through 12, concentrations are above the NHDES AGQS (0.32 ug/L), ranging from 1.14 ug/L to 2.38 ug/L. Zone 1 and Zones 3 through 7 were also the intervals with the highest PFAS detections. Within Zone 1, PFHxS was detected at a concentration of 34.5 ng/L, PFOA at 246 ng/L, PFNA at 31.7 ng/L, and PFOS at 119 ng/L, all above their respective USEPA CL and/or NHDES AGQS. PFOA was detected above the NHDES AGQS of 12 ng/L in Zones 3 through 7 with concentrations ranging from 18.7 ng/L to 29.70 ng/L. PFOS was also detected in Zone 5 at a concentration of 15.30 ng/L, above the NHDES AGQS of 15 ng/L. Within Zone 1, total arsenic was also detected above the USEPA CL and NHDES AGQS of 0.01 mg/L.

- MW-6 interval packer sampling results indicate that arsenic concentrations did not exceed the CL or AGQS in any of the seven intervals sampled, manganese concentrations exceeded the AGQS (840 ug/L) in all intervals sampled, 1,4-dioxane was detected in only four of seven intervals and at low concentrations below the AGQS of 0.32 ug/L, PFAS concentrations did not exceed the current CL or AGQS in any samples collected, and no VOCs were detected in sampled intervals.

4.3.3 Water Quality Trend Analysis

A water quality trend analysis was provided in the Deep Bedrock Investigation Interim Report (Haley Ward, 2019). The general conclusion from the trend analysis indicates there is a "stable contaminant concentration trend in groundwater". Based on USEPA comments provided in its March 16, 2022 comments on the Draft Deep Bedrock Investigation Final Report, additional data were requested to support these conclusions. The data has been re-evaluated to refine the discussion and conclusions reached in this analysis.

4.3.3.1 Water Quality Trend Analysis Methodology

The data set evaluated consisted of groundwater samples collected from 59 wells screened within the till (T), overburden (OB), shallow bedrock (SB), or deep bedrock (DB). Residential wells completed in bedrock are designated as water supply wells (WS). The number of sample events for each statistical analysis varied by parameter. Sample counts for 1,4-dioxane, arsenic, and manganese ranged from eight to 32 sampling events, while sample counts for PFAS ranged from 10 to 11 sampling events. The number of wells, number of sampling events, and minimum data per well is sufficient to insure a meaningful comparison of groundwater concentrations over time and space.

The data set was "cleaned" prior to statistical analysis. Values consisting of not analyzed (NA), not sampled (NS), below detection limit with no lab qualifiers (BDL), and multiple samples collected on the same day (i.e., interval samples) were replaced with a large negative value (-999). For laboratory results reported with values and laboratory qualifiers, the numerical value was retained.

Non-detects commonly reported in groundwater monitoring are statistically known as "left censored" measurements, because the concentration of any non-detect either cannot be estimated or is not reported directly. The concentration is known or assumed only to fall within a certain range of concentration values (*e.g.*, between zero and the *quantitation limit* [QL]). Groundwater non-detect data are censored on the low or left end of a sample concentration range.

The substitution method is a method for handling non-detects (ND) in a data set, where the ND is replaced by a defined value such as 0, detection limit (DL)/2 or DL prior to statistical calculations or graphical analyses. For this analysis non-detects were replaced with the DL. For datasets with greater than 30% non-detects, substitution can introduce 'invasive' patterns or artifacts (Helsel, 2005), making proper interpretation of the data more difficult. The bias introduced by applying the substitution method cannot be quantified with any certainty.

Statisticians have noted that *outliers* — extreme, unexpected measurements — are a regular occurrence with groundwater data (Helsel and Hirsch, 2002; Gibbons and Coleman, 2001). Sometimes an outlier results from nothing more than a typographical error, an incorrectly calibrated measuring device, or a piece of equipment that was not properly decontaminated. An unusual measurement might also reflect the sampling of a temporary, local 'hot spot' of higher concentration. In each of these situations, outliers in a statistical context represent values that are inconsistent with the distribution of the remaining measurements. Tests for outliers thus attempt to infer whether the suspected outlier could have reasonably been drawn from the same population as the other measurements, based on the sample data observed up to that point (USEPA, 2009).

Outliers can have strong influences on statistical outcomes. The inclusion of outliers in the computation of various decision statistics tends to yield inflated values, which can lead to poor decisions. The data set was visually screened for potential outliers, but no formal tests were applied for identifying statistical outliers, and no suspect values were removed from the data set prior to analysis.

A statistical distribution is an organized summary of a set of data values, sorted into the relative frequencies of occurrence of different measurement levels. Most statistical tests are based on an assumption of *normally distributed* or *normal* data. However, groundwater quality data generally have non-normal distributions. Rapidly changing concentrations, both increasing and decreasing, often result in log-normally distributed datasets. Nonparametric tests such as the Mann-Kendall test for trend does not require any assumptions as to the statistical distribution of the data (e.g., normal, lognormal, etc.) and can be used with data sets that do not follow a normal distribution. Therefore, statistical test for data distribution or normality were not performed.

MATLAB – MathWorks with Statistics Toolbox software was used to review groundwater data and analyze trends and statistical metrics, confirming that the groundwater database is sufficient to document changes within a plume over time. Contaminants of concern (COC) selected for this evaluation include 1,4-dioxane, PFOA, PFOS, PFNA, PFHxS, arsenic and manganese. These COCs were prioritized based on toxicity, prevalence at the site, and mobility. Top COCs by toxicity were determined by examining a representative concentration for each compound over the entire site. The compound representative concentrations were then compared with the chosen preliminary remediation goal (PRG) for that compound, with the percentage exceedance from the PRG determining the compound's toxicity. (Note that PRGs are equivalent to NHDES AGQS and USEPA Health Advisory values).

For a delineated plume, a stable or shrinking condition can be identified by a stable or decreasing concentration trend over time. For this analysis, an overall plume condition was determined for each COC based on a statistical trend analysis of concentrations at each well.

Mann-Kendall trend analysis was used to evaluate concentration trends at individual wells. The Mann-Kendall test was implemented as described in *U.S. Environmental Protection Agency, July 2000, Guidance for Data Quality Assessment, EPA/600/R-96/084, Office of Environmental Information, p. 4-16*. Specifically, data has been evaluated as described in Section 4.3.4.1, One Observation per Time Period for One Sample Location. The Mann-Kendall test is a non-parametric statistical procedure that is well suited for analyzing trends in data over time. The Mann-Kendall test is designed for analyzing a single groundwater constituent at a time, does not require any assumptions as to the statistical distribution of the data (e.g., normal, lognormal, etc.), and can be used with data sets which include irregular sampling intervals and missing data.

Mann-Kendall test is a statistical method for assessing the probability that a trend exists in a given data set. The test evaluates each data point relative to previous data points to calculate the number of positive and negative differences between constituent concentrations. Based on the number of data points and the sum of the negative and positive differences between adjacent data points, the probability that a statistically significant trend exists is calculated at the confidence limit selected (95% confidence).

The MK test tests whether to reject the null hypothesis (H_0) and accept the alternative hypothesis (Ha), where:

H_0: No trend is present

H_a: Trend is present

The initial assumption of the MK test is that the H_0 is true and that the data must be convincing beyond a reasonable level of certainty (95% confidence) before H_0 is rejected and Ha is accepted.

The Mann Kendall p-value is a probability that measures the evidence against the null hypothesis. Lower p-values provide stronger evidence against the null hypothesis (i.e., no trend) or alternatively, greater confidence that there is a trend. The p-value is used to determine whether to reject or fail to reject the null hypothesis.

The Coefficient of Variation (COV) is a statistical measure of how the individual data points vary about the mean value. Values less than or near 1.00 indicate that the data form a relatively close group about the mean value. Values larger than 1.00 indicate that the data show a greater degree of scatter about the mean. The standard variation (σ) is a measure of how dispersed the data is in relation to the arithmetic mean of the data.

The Kendall Tau (τ), or Kendall rank correlation coefficient, measures the monotony of the slope (i.e., changes in one variable are always associated with a change in the same direction in another variable). Kendall's Tau varies between -1 and 1; it is positive when the trend increases and negative when the trend decreases. The Sen's slope (MK sen) measures the magnitude of the trend.

The value of Z (absolute) is compared to the standard normal cumulative distribution to determine if there is a trend or not at the selected significance level. A positive value of Z indicates an upward trend, and a negative value of Z indicates a downward trend.

4.3.3.2 Water Quality Trend Analysis Results

A summary of time series plots as well as statistically significant trends identified in the Mann-Kendall Statistics for wells in the monitoring network are shown in Table H1 in Appendix H. The time series plots illustrate concentrations of site COCs at wells with exceedances of the NHDES AGQS for those compounds.

Of the 59 wells in the monitoring network used in this evaluation, sampling and analysis data from 47 of the wells, or about 80 percent, show a statistically significant upward or downward trend for one or more parameters. Summaries of the trends (increasing/decreasing) by parameter and location are shown on Figures 4.10 through 4.16 and Figures 4.21 through 4.27.

Results for site contaminants are listed below:

PFAS and 1, 4-Dioxane

The summary table shows a statistically significant trend for PFAS (PFOA, PFOS, PFNA, PFHxS) analysis in samples collected from 10 of the 59 wells (16.9%). Increasing concentration trends were calculated for 9 of the 10 wells (90%) that showed a trend, while 1 of the wells (10%) showed a decreasing trend. As indicated above, substituting the detection limit for the large number of non-detects in the dataset for PFAS may introduce artifacts, and may account for the large number of “no trend” determinations in this evaluation. A no trend determination does not mean a trend is not possible or present, just not within the prescribed confidence limits. However, for wells in which all or nearly all the measured results are non-detect values, concentrations in that well can effectively be designated as being “stable”.

For PFOA, only two wells had statistically significant trends, both in OU-1. MW-4 had a decreasing trend in till in the southeast corner of the landfill with MW-11 having an increasing trend in shallow bedrock to the southwest of the landfill. A total of three wells had statistically significant trends for PFOS, all located northwest of the landfill. These included increasing trends in overburden at AE-3A and MW-10 and a decreasing trend in bedrock at FPC-5B, located in the center of the bedrock trough. For PFNA, no statistically significant trends were observed in overburden with increasing trends noted only in shallow bedrock at MW-5S, MW-8, and MW-11, all within OU-1. A total of three statistically significant trends were identified for PFHxS, all located in wells screened in overburden. These wells include OP-2, AE-4A, and FPC-3C, located to the north, west, and south of the landfill with no clear spatial distribution trend as with other PFAS compounds.

Statistically significant trends for 1,4-dioxane were calculated for samples collected from 27 of the 59 wells, or 46% of the total. Decreasing trends were calculated for 26 of the wells (96%), while only one well (MW-10) in the overburden near the northwest corner of the landfill showing an increasing trend. Downward trends were noted for wells screened in the overburden (till and outwash), shallow and deep bedrock wells, and residential wells.

Scatter plots were prepared for PFAS and 1,4-dioxane on a select number of wells. A scatter plot is a graphical tool for analyzing the relationship between two or more variables. Based on these plots there is some correlation between PFAS and 1,4-dioxane concentrations in groundwater samples from wells across the project area. Figure HA in Appendix H shows a general positive linear trend for 1,4-dioxane vs. PFAS (PFOS and PFOA) when plotted on a log scale. In other words, as concentrations of PFAS or 1,4-dioxane increase or decrease, there generally appears to be corresponding increase or decrease in the concentration of the other parameter. Figure HB is the same data plot with error bars showing the variability in data about the mean. Figure HC shows a similar trend for all four PFAS constituents. However, there is an apparent spatial element to the correlation. As shown on the linear plot of 1,4-

dioxane vs. PFAS (Figure HD), the highest 1,4-dioxane levels (MW-5D, MW-8) do not necessarily have high PFAS concentrations, especially for PFOS and PFNA. There are also a set of wells (AE-2A, AE-2B, MW-4, MW-5S, MW-9, MW-10, MW-11) with higher PFOA but with lower levels of 1,4-dioxane. This suggests a PFOA-rich area that emanates from an area of lower 1,4-dioxane, and 1,4-dioxane area (near MW-5D, MW-8) that contains lower PFAS. These wells are either in OU-1 or within OU-2 closest to the landfill and with the exception of MW-4 and MW-5S, are located west of the landfill. The higher PFOA concentrations with lower 1,4-dioxane coincide with those with the greatest likely influence from stormwater where 1,4-dioxane is absent and PFAS (PFOA and PFOS) predominate. Other wells seem to have more steadily increasing PFOA or PFOS with increasing 1,4-dioxane. This is easier to observe with a log-log plot. It should be noted that data are limited for high concentrations of 1,4-dioxane and PFAS.

Figure HE shows mean PFOA concentrations vs. mean PFHxS, PFOS, and PFNA concentrations. When tracking PFOA vs. 1,4-dioxane, you can see that PFOA shows up at the low end of the concentration range, with most of the other PFAS at non-detect. For higher concentrations of PFOA, PFOS and PFHxS have a positive correlation, although greater variation is shown in PFNA concentrations.

Arsenic and Manganese

Statistical trends for naturally occurring metals arsenic and manganese in groundwater were also evaluated using the Mann-Kendall test. Statistically significant trends for arsenic concentrations were found in groundwater data from 15 of the 59 wells (25%) of those with sample data. Of these 15 wells, 12 were found to have a decreasing trend, while 3 of the wells showed an increasing trend. Two of the three wells exhibiting an increasing trend are in overburden (FPC-5A and FPC-6A) and located at the interpreted leading edge of the mapped northern arsenic concentrations within till while the remaining well is AE-1B, a shallow bedrock well located at the eastern edge of the arsenic plume mapped to the recently lowered NH AGQS (0.005 mg/L). Decreasing trends were found in wells screened in till, overburden and shallow bedrock with most wells located to the west or north of the landfill.

A slightly higher number of trends were found for manganese. Statistically significant trends for manganese concentrations were found in groundwater data from 22 of the 59 wells (37%), of the wells sampled. Of these 22 wells, 15 were found to have a decreasing trend, while 7 of the wells showed an increasing trend. Decreasing trends were found in wells screened in till, overburden, shallow bedrock, and deep bedrock. Of those trends determined for bedrock, 9 of 10 were decreasing and located west and north of the landfill. The only increasing trend for manganese in bedrock was at MW-6, a bedrock well south of the landfill. Increasing trends in manganese concentrations were found in wells screened in till (AE-1A, AE-3A, and FP-6A), overburden (OP-2 and FPC-3C), deep bedrock (MW-6), and one water supply well (R-3). In overburden, the increasing trends were observed in AE-1A, AE-3A, FP-6A, OP-2, and FPC-3C, located at the perimeter of the plume mapped to the AGQS (0.3 mg/L). These locations correlate with those located in the plume leg trending to the northwest, southwest, and to the eastern plume edge.

Variations in water quality reflect differences in mineralogy and type of bedrock and can be expected within a given aquifer. Water in an aquifer may have been derived from different environments and may vary in quality accordingly. Groundwater may also be derived directly from precipitation, from adjacent rocks or unconsolidated deposits, or from surface water at different places within an aquifer.

According to the USGS report, *USGS, Quality of Water in the Fractured Bedrock Aquifer of New Hampshire, Scientific Investigations Report 2004-5093,* groundwater from the bedrock aquifers in New Hampshire generally has high concentrations of iron, manganese, and arsenic. Bedrock aquifers tend to have higher pH, and much higher concentrations of arsenic than stratified drift aquifers, and similar concentrations of manganese.

However, various geochemical properties have a significant effect on the concentrations of metals in groundwater. Aerobic conditions in the aquifer tend to control the solubility of arsenic and other metals. Highly aerobic conditions tend to decrease the solubility and mobility of metals, which result in lower dissolved concentrations of metals in groundwater. Conversely, anerobic conditions (low oxygen), such as those found in wetlands, tend to increase the solubility and mobility of metals which generally results in higher dissolved concentrations of metals in groundwater. Different geochemical regimes upgradient, downgradient, and near the landfill could account for some of the variations in metal concentrations noted in the project area.

4.3.3.3 Concentration with Distance

In addition to concentration trends with time, concentration trends with distance were analyzed in the *Interim Report* and are carried forward into this report along generalized flow paths for 1,4-dioxane, and PFOA + PFOS. Results for open bedrock wells MW-23, GZ-109, GZ-125, and GZ-130 are based on maximum concentrations reported from packer sampling efforts. It is important to note that with the exception of GZ-109, packer sampling results represent a singular event and long-term trends in concentration cannot be evaluated. Results for all intervals completed within open bedrock wells are additionally provided in Appendix C. Plots for the north-south oriented and east-west oriented concentration plots are provided in Appendix I. These plots illustrate the following:

Arsenic

Arsenic concentrations generally decrease with increased distance from the landfill. This coincides with statistically significant decreasing trends or no trends (stable) noted for arsenic in bedrock groundwater for most wells as discussed in Section 4.3.3.2.

Manganese

Manganese exhibits decreasing trends in concentration with increasing distance with most wells having statistically significant decreasing trends or no trends in bedrock groundwater.

1,4-Dioxane

Concentrations of 1.4-dioxane are highest in wells adjacent to the landfill (i.e., AE-2B, MW-11, MW-5S/-5D) and decrease with increased distance from the landfill. 1,4-dioxane concentrations decrease toward GZ-130 to the south, MW-23 to the north, GZ-109 to the east, and MW-21 to the west.

PFOA and PFOS

Concentrations of PFOA and PFOS are highest in wells adjacent to the landfill and decrease with increased distance from the landfill. One item to note is that PFOA and PFOS show a slight increase towards well GZ-130, the southernmost well within the survey area. This is contrary to the behavior exhibited by 1,4-dioxane near GZ-130.

4.3.3.4 PFAS Composition Analysis

Radial plots were prepared in the *Interim Report* and are carried forward into this report for several monitoring wells and packer sampling intervals for PFAS, comparing the relative amount of individual PFAS compounds. These plots are provided in Appendix J. Based on a review of these data; a few patterns are apparent:

- Total PFAS composition for shallow bedrock monitoring wells and packer sampling intervals are primarily dominated by PFOA with significant amounts of PFOS and PFHpA.
- Total PFAS composition for surface water samples is dominated by PFOS with significant amounts of PFOA, PFNA, and PFBS. Surface water samples also include approximately similar amounts of PFOS and PFOA compared to samples from Berrys Brook, located north of the landfill (BB1, BB2, SW-110, SW-111).
- Total PFAS composition for till and outwash overburden wells are primarily dominated by PFOA and are similar to compositions observed for shallow bedrock, indicating a hydraulic connection between these units.

Exceptions to the general observations above occur in overburden and shallow bedrock wells immediately west of the landfill where the highest PFAS concentrations have been observed historically: AE-2A, AE-2B, MW-9, MW-10. For these wells, PFOS and PFOA appear to be similar in percentages of the total PFAS composition.

4.3.3.5 Contaminants of Concern and Emerging Contaminants in Groundwater

COCs for the Site are discussed below based on analytical data provided in the 2020 Annual Water Quality Summary Report (Haley Ward, 2021). Though not listed specifically as COCs for the Site, PFAS are contaminants that have been reported at concentrations exceeding the New Hampshire AGQS in some overburden and bedrock monitoring wells. The status of these contaminants in groundwater, as summarized in the 2020 annual monitoring report, is discussed below.

Antimony

Antimony is rarely detected in groundwater. The last exceedance was an isolated detection/exceedance identified at AE-4A in 2006.

Arsenic/Manganese

Arsenic and manganese are identified above cleanup criteria (CL/AGQS) at many wells located in close proximity to or downgradient of the landfill. Arsenic and/or manganese exceedances were or have been identified at several monitoring wells (FPC-9A, FPC-11A/11B, AE-1A/1B, and AE-4A/4B, and historically at GZ-123, GZ-125 and FPC-2A) located hydraulically upgradient or cross-gradient of the impacted groundwater area. Arsenic and manganese are both naturally occurring in groundwater at varying concentrations based on geology. Concentrations reported in upgradient or cross-gradient wells may be attributed to naturally occurring concentrations or from sources apart from Coakley Landfill.

Beryllium

Beryllium is rarely detected in groundwater. The last exceedance was an isolated detection/exceedance identified at MW-6, AE-1A, and FPC-11A in 2005.

Chromium/Lead/Nickel

Chromium, lead, and/or nickel exceedances were identified at several wells (MW-4 in 2005 through 2008; AE-4B in 2003; FPB-7B in 2004; FPC-11B in 2005; and BP-4 in 2005). However, only trace concentrations well below the clean-up criteria have been identified since 2008. Chromium was identified above the CL (0.05 mg/L) in MW-20D2 but below the AGQS (0.1 mg/L) in 2020. Well MW-20D2 was sampled for metals for the first time in 2020 as part of the biannual sampling program.

Vanadium

Trace concentrations have been identified at selected monitoring wells. No exceedances have been identified since 2005.

Benzene

Trace concentrations below the CL/AGQS continue to be identified in seven monitoring wells located in close proximity to or downgradient of the landfill. Concentrations of benzene in monitoring wells have not exceeded the CL or AGQS since August 2012.

Chlorobenzene

Trace concentrations continue to be identified in eight monitoring wells located in close proximity to or downgradient of the landfill. The last exceedance of a CL or AGQS was identified at MW-9 in 2002.

Tetrachloroethylene

No detections have been identified since the start of the long-term monitoring plan in 1999.

Tetrahydrofuran (THF)

In the last five years, detections have been identified at six monitoring wells located in close proximity to or downgradient of the landfill. MW-8 slightly exceeded the CL (160J ug/L) for tetrahydrofuran during 2016. However, it was identified below the CL in 2017 (110 and 120 ug/L, Spring and Fall), 2018 (110J+ and 130 ug/L, Spring and Fall), 2019 (91 ug/L), and 2020 (88 ug/L). Prior to that, the last identified exceedance of a CL or AGQS was in 2010 (MW-8).

1,2-dichloropropane

No detections have been identified since the start of the long-term monitoring plan in 1999.

2-butanone

In 1998 and 1999, trace concentrations were identified at MW-11. No detections have been identified since 1999.

Trans-1,2-dichloroethene

No detections have been identified since the start of the long-term monitoring plan in 1999.1,4-Dioxane

Since August 2009, samples from select monitoring wells have been analyzed for 1,4-dioxane with a low-level detection limit methodology (EPA Method 8260B SIM). Since 2017, all monitoring wells have been analyzed for 1,4-dioxane using low-level detection methods.

1,4-dioxane concentrations exceeded the AGQS in 29 of the 49 groundwater monitoring wells sampled in 2020. Concentrations exceeded the USEPA CL in 19 of the 49 wells sampled. A visually apparent increasing trend occurred in five groundwater monitoring wells sampled in 2020 with a visually apparent decreasing trend in 16 of the 49 groundwater monitoring wells sampled in 2020. 2020 groundwater monitoring well results were consistent with historical concentrations.

1,4-dioxane was detected in private water supply wells R-3 (368 Breakfast Hill Road), 339 Breakfast Hill Road (339BHR), and 178A Lafayette Road (178ALR) during 2020 with results included in Table 4.1B. It continues to be stable at concentrations well below the USEPA CL of 3 micrograms per liter (ug/L) but slightly above the NHDES AGQS of 0.32 ug/L as established for the Site for R-3 and 339BHR; these locations are equipped with effective treatment systems to prevent exposure to well users. Concentrations at all three locations ranged from 0.21 micrograms per liter (ug/L) at 178ALR to 0.57 ug/L at 339BHR. Concentrations of 1,4-dioxane at 178ALR remain detectable, but below the AGQS, and stable.

PFOA

PFOA was identified above the AGQS (12 ng/L) in ten OU-1 wells and 18 OU-2 wells in 2020. The wells exceeding the AGQS are generally close to, downgradient of, or along the western edge of the landfill.

PFOS

PFOS was identified above the AGQS (15 ng/L) in seven OU-1 wells and 10 OU-2 wells in 2020. Wells exceeding the AGQS are generally close to, downgradient of, or along the western edge of the landfill.

PFNA

PFNA was identified above the AGQS (11 ng/L) in six OU-1 wells and seven OU-2 wells in 2020. The wells exceeding the AGQS are generally close to, downgradient of, or along the western edge of the landfill.

PFHxS

PFHxS was identified above the AGQS (18 ng/L) in five OU-1 wells and seven OU-2 wells in 2020. The wells exceeding the AGQS are generally close to, downgradient of, or along the western edge of the landfill.

4.4 Surface Water

Surface water generally consists of discharges of groundwater to surface water, and stormwater runoff. The CLG has completed literature reviews of regional and Site-specific surface water resources, surface water monitoring, and a Site stormwater investigation to affirm its understanding of this aspect of the CSM (Section 5). The results of each of these activities are summarized below and are detailed in Section 4.4.1, Section 4.4.2, and Section 4.4.3.

- Large wetlands in the Seacoast region often represent a surface expression of the regional water table. Stream baseflows in the Seacoast region typically originate from groundwater, and contributions of both surface runoff and groundwater to streamflow generally mimic surface topography and watershed boundaries as described in Mack, 2012 as well as the *New Hampshire Water Resources Primer* (NHDES, 2008)).
- Groundwater in overburden and bedrock at the Site primarily flows towards, and discharges into, a wetland complex located west of the landfill. This wetland complex serves at the headwaters for the Little River located southwest of the landfill, and Berrys Brook located to the northwest of the landfill (Section 4.4.1). The discharge of groundwater to surface water is supported by the presence of contaminant impacts to these surface water features and vertical hydraulic gradients identified in the groundwater system (Section 4.4.2).
- The majority of surface water runoff from the Site discharges towards the Little River and Berrys Brook with remaining surface water draining along the east side of the landfill into the Bailey's Brook watershed. Much of the surface water runoff from the landfill infiltrates into the groundwater system of these two watersheds, prior to discharge to surface water. The water shed along the east side of the landfill drains north and enters a low-lying area adjacent to the northeast stormwater control basin and into the eastern margins of the Berrys Brook watershed. This is supported by the presence of similar or higher contaminant impacts in stormwater runoff at the Site within the Berrys Brook and Little River watersheds as documented in annual water quality reports for the Site and in the *Summary of Surface Water Testing Results for the Coakley Landfill Superfund Site* (Weston, 2022). Results for sampling completed in Bailey's Brook by the Conservation Law Foundation in November 2016 were non detect for PFOA, PFOS, and 1,4-dioxane.

Efforts to understand surface water and groundwater interactions near the wetland complex are planned to continue in accordance with Section 7. The results of the continued monitoring activities are expected to support the Site CSM, as presented in Section 5.

4.4.1 Watershed Evaluation

The Coakley landfill is located adjacent to Berrys Brook and the Little River (Figure 2.2). A large wetland complex located west of the Site, and situated on a topographical high, serves as the headwaters for both Berrys Brook and the Little River. In the vicinity of the Site, these surface water features are understood to consist of precipitation runoff and groundwater discharges to the wetland complex, Berrys Brook, and the Little River.

4.4.1.1 Literature Review

The CLG reviewed published water and groundwater investigation reports to inform regional trends in surface water composition. Investigation reports reviewed and discussed in this Section include *Assessment of Ground-Water Resources in the Seacoast Region of New Hampshire* (Mack, 2012) published by USGS and the *New Hampshire Water Resources Primer* (NHDES, 2008) published by the NHDES. Information in these investigation reports supports the conclusion in the Site CSM (Section 5) that precipitation runoff discharges to the wetland complex, Berrys Brook, and the Little River and that groundwater discharges to the wetland complex, Berrys Brook, and the Little River.

Assessment of Ground-Water Resources in the Seacoast Region of New Hampshire (Mack, 2012) evaluates the behavior of groundwater resources in the Seacoast region of coastal southeastern New Hampshire, where the Site is located. This document indicates that in the Seacoast region:

- Groundwater and surface water systems are generally connected.
- Wetlands represent a surface expression of the regional water table.
- Groundwater predominantly discharges to streams or other waterbodies.
- Stream baseflows typically originate from groundwater.

The *New Hampshire Water Resources Primer* (NHDES, 2008) synthesizes State-wide water resource information in an overview of the information necessary to understand and make informed policy decisions about New Hampshire's water resources. This document indicates that in New Hampshire:

- Groundwater replenishes and is closely connected to surface waters.[8]
- Most surface water bodies receive much of their water from other surface waters, e.g., wetlands or other streams; however, some depend significantly on groundwater.
- Many surface waters (e.g., streams, rivers, etc.) generally depend on groundwater for baseflow during dry-weather periods.
- Contributions of groundwater and surface water to streamflow mimic surface topography and watershed boundaries.
- Precipitation runoff can pick up pollutants and discharge them into surface waters.

4.4.1.2 Watershed Descriptions

The Coakley Landfill is adjacent to two named surface water bodies: Berrys Brook and the Little River. A large wetland complex west of the Site serves as the headwaters for these two water bodies. Site topography indicates that:

[8] Groundwater moves from areas of higher pressure to areas of lower pressure. As it moves through overburden and rock fractures, it can interact with surface waters.

- The drainage divide between the Berrys Brook Watershed and the Little River Watershed bisects the wetland complex directly west of the Landfill (Figure 2.2).[9]
- The majority of surface water runoff from the Coakley Landfill flows westerly into the wetland complex.

In accordance with the *New Hampshire Water Resources Primer* (NHDES, 2008), when surface water runoff comes into contact with pollutants, it can pick up and carry those pollutants as it runs off or infiltrates into the ground. This means that PFAS present in the landfill cap material (Section 4.4.4) has the potential to be picked up by stormwater that falls on the Site, and flow into the wetland complex and, derivatively, Berrys Brook and the Little River.[10]

In accordance with the *New Hampshire Water Resources Primer* (NHDES, 2008) and *Assessment of Ground-Water Resources in the Seacoast Region of New Hampshire* (Mack, 2012), it is expected that the wetland complex west of the Site is a surface expression of the regional water table and is recharged by groundwater. This is supported by hydraulic gradients identified in the groundwater system, described in Section 4.3.

This Section describes the Berrys Brook and Little River watersheds and estimates the potential maximum contribution of groundwater to surface water for these waterbodies.18F[11]

<u>*Berrys Brook Watershed*</u>

According to the *Berry's Brook Watershed Management Plan* (Appledore Engineering, 1993), the Berrys Brook Watershed is approximately 5.9 square miles,[12] tends to be gently sloping with elevations ranging from approximately 151 feet at its headwaters near the Site to sea level, consists predominantly of a coastal ecosystem, and has been impacted by substantial commercial and residential development over time. Berrys Brook is approximately 6.2 miles long and is associated with freshwater wetlands, an estuary, and a tidal marsh.

According to the USGS's National Water Information System Web Interface Tool, the closest Berrys Brook stream gauge data to the Site exists at the intersection between Berrys Brook and the Sagamore

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[9] The drainage divide was approximated using LIDAR Data from the USGS's 3D Elevation Program. The drainage divide runs from, approximately, the location of MW-4 westward toward the locations of MW-22S/D and FPC-4A/4B.

[10] Stormwater that falls on the Site is transported via direct surface runoff and infiltration through the cover soil to underdrain collection piping that subsequently discharges to the wetland complex west and north of the landfill and to the ground surface at a rip rap swale northwest of the landfill (**Section 4.4.4**).

[11] The estimate of maximum groundwater to surface water composition for each watershed assumes that groundwater predominantly discharges to surface waters. This is consistent with the *New Hampshire Water Resources Primer* (NHDES, 2008) and *Assessment of Ground-Water Resources in the Seacoast Region of New Hampshire* (Mack, 2012).

[12] Approximately 55% of the Berrys Brook Watershed is in the Town of Rye and approximately 40% is in the City of Portsmouth. Berrys Brook headwaters in the Town of Greenland comprise approximately 5% of the watershed. A very small portion of Berrys Brook headwaters is located in the Town of North Hampton. Open water, urban land, and the Site comprise approximately 13% of the watershed.

Road overpass, approximately four miles downstream of the Site. According to USGS stream gauge data, stream flows at this point average approximately 25,781,000 cubic feet per month.

A web-based Geographic Information Systems (GIS) StreamStats report from the USGS website was generated for the section of the Berrys Brook watershed between the source area of the watershed and the stream gauge located on Sagamore Road. This report indicated that the area of the watershed that drains to this point (i.e., subwatershed area) is approximately 3,450 acres. The report also indicated that the mean annual groundwater recharge for the Berrys Brook Watershed is 22.3 inches, or 1.9 inches per month.

The maximum average groundwater contribution to Berrys Brook at the stream gauge was calculated by multiplying an average of 1.9 inches of groundwater recharge per month by the subwatershed area of 3,450 acres.[13] Accordingly, the maximum average groundwater contribution to Berrys Brook at the stream gauge was determined to be approximately 23,794,700 cubic feet per month. This represents approximately 92% of the average monthly stream flow at the stream gauge (25,781,000 cubic feet); suggesting that groundwater discharge contributes significantly to Berrys Brook.

Little River Watershed

According to the *Little River Watershed Based Plan* (FB Environmental Associates, 2011) the Little River Watershed is approximately 7.7 square miles and is primarily located in North Hampton, New Hampshire. The Little River flows into and impounds in Mill Pond, outflows, and then continues towards the Atlantic Ocean.

According to the USGS's National Water Information System Web Interface Tool, the closest Little River stream gauge data to the Site exists at the intersection between the Little River and Woodland Road, approximately 2.5 miles from the Site. According to USGS stream gauge data, stream flows at this point average approximately 31,062,994 cubic feet per month.

A web-based GIS StreamStats report from the USGS website was generated for the section of the Little River watershed between the source area of the watershed and the stream gauge located on Woodland Road. This report indicated that the subwatershed for this point is approximately 3,917 acres. The report also indicated that the mean annual groundwater recharge for the Little River Watershed is 21.4 inches, or 1.8 inches per month.

The maximum average groundwater contribution to the Little River at the stream gauge was calculated by multiplying an average of 1.8 inches of groundwater recharge per month by the subwatershed area of 3,917 acres.[14] Accordingly, the maximum average groundwater contribution to the Little River at the stream gauge was determined to be approximately 25,593,600 cubic feet per month. This represents

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[13] The estimate of maximum groundwater to surface water composition assumes that groundwater predominantly discharges to surface waters (NHDES, 2008; Mack, 2012).

[14] The estimate of maximum ground water to surface water composition assumes that groundwater predominantly discharges to surface waters (NHDES, 2008; Mack, 2012).

approximately 82% of the average monthly stream flow at the stream gauge (31,062,994 cubic feet); suggesting that groundwater discharge also contributes significantly to the Little River.

4.4.2 Surface Water Quality Monitoring

The CLG routinely collects surface water quality samples at various locations west (wetland complex); southwest (Little River headwaters); and northwest, north, and northeast (Berrys Brook) of the Site (Figure 2.2).

As supported by information presented in Section 4.4.1, the surface water that is monitored consists of a combination of groundwater discharge and surface water flow from precipitation runoff. Precipitation runoff (including snowmelt) generally includes stormwater that runs off of the landfill surface[15] and stormwater that infiltrates through the cover system and is captured by and discharged to the surface via a network of underdrains.[16]

This Section identifies surface water quality monitoring locations and presents and discusses surface water quality monitoring results.

4.4.2.1 Surface Water Quality Monitoring Locations

Surface water monitoring locations are described below. Each description identifies the location of the monitoring point relative to the Site – i.e., whether the location is west (wetland complex); southwest (Little River headwaters); or northwest, north, and northeast (Berrys Brook) of the Site. Surface water monitoring locations are also shown on Figure 2.2.

SW-4

SW-4 is located approximately 500 feet west of the railroad and approximately 600 feet from the southwestern boundary of the Landfill in a broad and flat pit-and-mound forested wetland Samples are collected in an area of shallow ponded water with no current evidence of channelization or deposition of mineral sediment.

Surface water at this location is a combination of precipitation (including snowmelt) originating from topographically high areas to the west, with contribution from the wetland complex to the east during wet and high-water periods.[17] The soils at this location are composed predominately of leaf litter and twigs over poorly decomposed organic soil/sediment. Leaf litter is removed prior to sampling to expose the underlying organic soils.

SW-5

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[15] Stormwater runoff from the Landfill is routed via perimeter ditches to two stormwater retention ponds that discharge to areas north and northwest of the Landfill.

[16] A network of underdrains in the landfill cover system sand drainage layer discharges to a retention pond (located in the northeast corner of the landfill) or a rip rap-lined outlet structure in the northwest corner of the landfill.

[17] Water in the wetland complex consists of groundwater discharge to surface water at the wetland complex and surface water runoff from the Site (**Section 4.4.1**).

SW-5 is located approximately 250 feet from the northwestern boundary of the Landfill, roughly between seep L-1 and the railroad right-of-way. The area between the landfill and the railroad is a large wetland area with dense phragmites and wetland plants. The ground surface in the area of SW-5 is covered by a thick layer of partially decomposed phragmites with an area of ponded water located along the margins.

Surface water at this location is a combination of precipitation (including snowmelt) originating from topographically high areas to the south and contribution from areas north-northeast of this location during wet and high-water periods. Additional sources of contribution to surface water at SW-5 include surface/overland flow and stormwater retention basin discharge originating at the landfill located southeast of SW-5 and shallow groundwater discharge to surface water during seasonal low precipitation or baseflow periods. Leaf litter is removed from the edge of the ponded water where three to five inches of organic material has been observed overlying gray clay. There is no current visual evidence of mineral sediment deposition at this location.

SW-103

SW-103 is located approximately 450 feet from the northwestern boundary of the landfill and 200 feet downstream of SW-5 in a dense phragmites stand where no evidence of channelization or deposition of mineral sediment was observed. Samples are collected from ponded water in the vicinity of SW-103 (when present).

Surface water at this location is a combination of precipitation (including snowmelt) originating from topographically high areas to the southwest and contribution from areas north-northeast of this location during wet and high-water periods. Additional sources of contribution to surface water at SW-5 include surface/overland flow and stormwater retention basin discharge originating at the landfill located southeast of SW-103 and shallow groundwater discharge to surface water during seasonal low precipitation or baseflow conditions.

SW-110

SW-110 is located approximately 3,200 feet from the northwestern boundary of the landfill and 400 feet downstream from SW-BB1 at the culvert where Berrys Brook runs under Breakfast Hill Road. Surface water samples are collected from a ponded area immediately to the south of the culvert.

Surface water at this location is from the Berrys Brook watershed and is a combination of precipitation (including snowmelt) and water exiting the wetland complex to the south. Additional contribution to surface water at SW-110 would be from shallow groundwater discharge to surface water during periods of low precipitation and base flow conditions. The soils at this location are composed predominately of leaf litter and twigs over gray clay.

SW-111

SW-111 is located over a mile from the northeastern landfill boundary at the culvert where Berrys Brook crosses Lafayette Road (U.S. Route 1). Surface water in the sample collection area is approximately four feet deep.

Surface water at this location is from within the Berrys Brook watershed and includes contribution from shallow groundwater discharge to surface water during periods of low precipitation and base flow conditions. Soils consist of decomposed organic sediments.

SW-LR

SW-LR is located at the culvert where the Little River crosses North Road, approximately 3,600 feet south of the southwestern boundary of the landfill. The area upstream of the sampling point is channelized; however, water ponds in front of the culvert where samples are collected.

Surface water at this location is from within the Little River watershed with the headwaters originating within the wetland complex north of the SW-LR location. Additional contribution to surface water at SW-LR would be from shallow groundwater discharge to surface water during periods of low precipitation and base flow conditions. The soils in this location consist of decomposed organic sediments over gray clay.

SW-BB1

SW-BB1 is located in a channel to the east of the railroad right-of-way and approximately 2,700 feet from the northwestern boundary of the landfill. The sampling location is approximately 400 feet upstream from SW-110 and 1,000 feet downstream from SW-BB2. The stream is channelized and surface water samples are collected from the channel.

Surface water at this location is from within the Berrys Brook watershed and is comprised primarily of precipitation and surface flow from areas south and east of BB-1. The underlying sediments consist of leaf litter and cobbles (railroad ballast) over sandy organic sediments.

SW-BB2

SW-BB2 is located approximately 1,800 feet north from the northwestern boundary of the landfill and 1,200 feet downstream from SW-103. It is in a broad and flat wetland approximately 20 feet east of the railroad bed. No evidence of channelization or the deposition of mineral sediment has been observed in the vicinity of SW-BB2. Surface water samples are collected from ponded water in this area.

Surface water at this location is from within the Berrys Brook watershed and is comprised primarily precipitation and surface flow from areas south and east of SW-BB2. The soils at this location are composed predominately of leaf litter and twigs over poorly decomposed organic sediments.

SW-BB3

In October 2020, a culvert blockage was removed in an area along the railroad easement located between SW-BB1 and SW-BB2. The removal of this blockage restored flow between wetlands located either side of the easement and lowered the overall water level in the wetland located east of the railroad easement. The water level at SW-BB1 was lowered as a result. Therefore, SW-BB1 was removed from the monitoring program after routine fall monitoring activities and replaced with SW-BB3. The location of SW-BB3 west of the railroad easement is more representative of surface water conditions that exist to the north of the Site and is established at a culvert equidistant from SW-BB2 and SW-110.

4.4.2.2 Surface Water Quality Monitoring Results

The results of surface water monitoring activities are provided in annual monitoring reports that are submitted to USEPA and NHDES.[18] Analytical results for surface water quality samples collected during Spring 2020 and Fall 2020 sampling events are presented below and in Table 4.2. These analytical results are presented in this report because they are the most current validated surface water analytical results.

- 1,4-dioxane levels were highest at SW-5 near the Landfill (1.8 ug/L); detectable at SW-103 (0.86 ug/L) and SW-4 (0.2 ug/L), and not detectable at other locations sampled (Section 4.4.2.2). This is consistent with historic results and consistent with the observation that there is a decreasing concentration with increased distance from the landfill.
- Surface water samples are analyzed for twenty-six PFAS compounds. The highest concentrations of PFAS were detected at SW-5 (1,060 ng/L) and SW-103 (1,080 ng/L), the two locations nearest to the landfill boundary. Of the twenty-six compounds analyzed, PFOA and PFOS were reported at the highest concentrations. This is consistent with historic results.

Regulatory standards for 1,4-dioxane and PFAS in surface water have not been established. However, in a September 1, 2022 letter to the CLG, USEPA presented lowered site-specific surface water screening levels (SSSLs) for PFOA, PFOS, and PFBS with new SSSLs established for PFNA and PFHxS in Berrys Brook. As part of the 2021 Five-Year Review for the Site, USEPA performed a screening and risk evaluation for PFOA and PFOS in surface water at the Site. The screening and risk evaluation used analytical results from 2018, 2019 and 2020, to evaluate site- specific risk to humans, assuming a recreational exposure and incidental ingestion of surface water. The maximum concentrations of PFOA and PFOS in surface water were used to calculate acceptable risk levels for these contaminants in surface water. The screening and risk evaluation concluded that though SSSLs had been exceeded, there was no unacceptable risk to a child or adult recreator from exposure to surface water. It is important to note that an exceedance of a screening level does not necessarily mean that there is an unacceptable risk at the Site.

Comparison to the newly lowered SSSLs for these five PFAS compounds for the Child Recreator (exposure factor equal to 120 days) was completed. PFOA exceeded the lowered SSSLs (110 ng/L) at the six locations closest to the landfill and included SW-4 (114 ng/L), SW-5 (719 ng/L), SW-103 (594 ng/L), SW-110 (160 ng/L), SW-BB1 (118 ng/L), and SW-BB2 (280 ng/L). PFOS exceeded the SSSL (76 ng/L) at five locations that included SW-5 (1,060 ng/L), SW-103 (1,080 ng/L), SW-110 (149 ng/L), SW-BB1 (91.1 ng/L), and SW-BB2 (300 ng/L). PFNA exceeded the SSSL of 96 ng/L at three locations that included SW-5 (427 ng/L), SW-103 (399 ng/L), and SW-BB2 (162 ng/L). There were no exceedances for the new SSSLs established for the Child Recreator with an exposure factor of 120 days for PFHxS (654 ng/L) and PFBS (11,300 ng/L).

[18] Surface water samples were collected at SW-4, SW-5, SW-103, SW-110, SW-111, SW-LR, SW-BB1, and SW-BB2 during the spring and/or fall 2020 sampling events (**Figure 2.2**; SW-BB3 replaced SW-BB1 in 2021). Samples were not collected at locations SW-4, SW-5, SW-103, SW-110, SW-BB1, or SW-BB2 during the fall of 2020 as insufficient water was present to facilitate sampling as a result of drought conditions experienced in 2020.

In addition to the surface water sampling performed during biannual events, sampling of the seep at L-1 has been performed since 2001 for chemical oxygen demand (COD), ammonia (as NH_3), metals and VOCs with low level detection of 1,4-dioxane and PFAS analysis added beginning in 2017. Sampling is targeted during a period when contribution from surface water or stormwater is not observed. It is important to note that the landfill does not have a leachate collection system and field observations have indicated that samples collected at L-1 appear representative of shallow overburden groundwater discharging via seepage from the adjacent embankment to the impounded wetland area located near the northwest margin of the landfill. Based on these observations, historical analytical results, and measurements of shallow groundwater and surface water in this area, water present at L-1 is more likely from the comingling of leachate and shallow groundwater. Results for metals, ammonia, and 1,4-dioxane appear more characteristic of landfill leachate associated with the landfill. The presence and concentration of PFAS is, on the other hand, more representative of stormwater which has been shown to impact shallow groundwater in the northwest portions of the landfill (Appendix B). Arsenic and manganese concentrations in surface water (Table 4.3) are highest at the landfill (SW-5) with concentrations generally decreasing with increased distance from the landfill. These constituents are also elevated at SW-BB1; however, this location was abandoned in 2021 and replaced with a new location more representative of surface water conditions (SW-BB3; Figure 2.2). Surface water sampling location SW-5 is located closest to L-1.

During Spring 2021, representatives of the USEPA and the CLG performed field reconnaissance of a shallow groundwater seep located approximately 1,500 feet north of Breakfast Hill Road and 4,500 feet north of the Coakley Landfill. Preliminary results of sampling completed during Spring 2022 for 1,4-dioxane, PFAS, alkalinity, chloride, and ammonia (as NH_3) indicate 1,4-dioxane was not detected and minimal detections of PFAS, alkalinity, chloride, and ammonia. These results do not appear to be associated with the Coakley Landfill or typical of landfill discharge in general.

A Stormwater Investigation performed by the CLG and summarized in Section 4.4.4, indicates that materials in the landfill cover system contribute PFAS compounds to surface waters adjacent to the Site. These compounds dissolve in stormwater that falls on the Site and are transported via direct surface runoff and infiltration through the cover soil to underdrain collection piping. Surface flow is collected in rip rap-lined channels where it subsequently discharges to one of two unlined stormwater basins where it infiltrates to the overburden. Water that infiltrates through the cap and is collected by the stormwater management system is discharged to surface to either the northeast basin or directly to the surface at a separate outfall location in the northwest corner of the landfill. These locations and concentrations reported at sampled locations are illustrated and detailed further in the *Stormwater Investigation Report* included as Appendix B (Haley Ward, 2019). It should also be noted that the ongoing collection of data in support of the Surface Water Evaluation by the CLG is designed to supplement the understanding of the surface water flow regime in the vicinity of the site and provide additional information on contaminant fate and transport.

4.4.3 Surface Water Elevation Summary

As discussed in Section 3.4, the CLG measured surface water elevations at multiple gauging locations in the project area (Figure 2.2) in 2019 and in 2021. This data was collected to improve understanding of interactions between overburden groundwater and surface water (Section 5). Efforts to understand surface water and groundwater interactions near the wetland complex are planned to continue into 2022 (Section 7).

Surface water gauging locations have consisted of some historical locations (i.e., established long-term monitoring locations; Haley Ward, 2018c) and surface water gauging locations that were added within the wetland complex, Berrys Brook, and Little River in fall of 2021 to support Stormwater Investigation (Haley Ward, January 2020) and Deep Bedrock Investigation (Haley Ward, Inc./CES, Inc., 2020) activities completed in 2018 and 2019. Refer to Section 3.4 for a description of surface water gauging locations.

4.4.3.1 2019 Surface Water Elevations

Surface water elevations were measured at two locations at the Stormwater Pond (SB-1 and SB-2), the L-1 Seep, SW-5, SW-103, SW-110, BB-1, BB-2, and the Little River Bridge over five events in 2019 (Haley Ward, January 2020). The events occurred in April, May, July, August, and September[19] with measurement locations identified on Figure 2.2. Surface water elevations ranged from approximately 96 feet at SB-1 (Stormwater Pond NW) and 81 feet at SB-2 (Stormwater Pond NW) to approximately 64 feet at Little River Bridge (Little River), 68 feet at SW-110 (Berrys Brook), and 73 feet at SW-103 (wetland complex). Results are presented on Table 3.4 and are summarized below:

- Recorded elevations indicate that surface water flows from the Stormwater Ponds towards the wetland complex and Berrys Brook. Most water flows within the Berrys Brook watershed as the divide between the Berrys Brook and Little River watersheds is located well south of the stormwater ponds and surrounding wetlands. Some surface water may enter the western margin of the adjacent Bailey's Brook watershed; however, no impacts to Bailey's Brook have been reported to date with the most recent sampling completed in 2016 by the Conservation Law Foundation (non-detect for PFOS and PFOA).
- Based on field observations made during a precipitation event in Spring 2021, the flow of surface water from the wetland area located north of the northeast stormwater pond and east of the access road flows under the access road through culverts (approx. 170 feet north of landfill gate) to the wetland area located west of the access road. This area is heavily vegetated and details of the conveyance construction could not be determined.

[19] Shallow groundwater elevations were also measured at each event at PZ-1, PZ-2, and PZ-3. Refer to **Section 3.4**.

- A localized surface depression is located east of the northeast stormwater pond (SB-1) appears to be at an elevation similar to that of the wetland areas north of the stormwater basin. However, this depression may serve as part of the catchment area that drains north and ultimately west towards Berrys Brook. Preliminary elevations of the surface water as determined from available online imagery (i.e., Google Earth) has the surface water elevation within this area at approximately 98 feet AMSL. The surface water elevation in the northeast basin generally mimics the shallow groundwater elevation gauged in PZ-1. As a result, surface water elevations in the northeast pond vary between 92 and 96 feet AMSL indicating a general flow of water to the north from the stormwater pond and west from this adjacent depression.
- Surface water elevations varied seasonally; however, gradient trends generally remained consistent between individual monitoring/gauging locations.
- The distribution of surface water elevations supports a flow path from SB-1 and SB-2 and towards the wetland complex and Berrys Brook.
- The elevation of surface water in the northeast stormwater pond (SB-1) and northwest stormwater pond (SB-1) is generally the same as that observed for shallow groundwater as measured in PZ-1 and PZ-2, respectively. More recent data (since March 2022) gauged inside (shallow groundwater) and outside (surface water) of the piezometer riser exhibit a difference in elevation of 0.1 feet or less. These more recent data have been included in Table 3.4.

Shallow groundwater elevations were also measured at each event at PZ-1, PZ-2, and PZ-3 (Section 3.4). These measurements indicate that the surface water elevation and shallow groundwater elevation in the vicinity of the stormwater ponds (SB-1 and SB-2) were similar (Table 3.4).

<u>4.4.3.2 2021 and 2022 Surface Water Elevations</u>

Surface water elevations were measured at SG-1 through SG-7 located in the wetland complex and shallow groundwater elevations were measured at PZ-1 through PZ-9, PZ-103, and PZ-110 beginning in Fall 2021.[20] For the following discussion of results, measurements recorded from March 29, 2022 to June 6, 2022 were used as water levels inside and outside of individual piezometers were not recorded prior to this period. Based on measurements recorded during each gauging event, elevations of surface water (outside measurement) and shallow groundwater (inside measurement) are more representative of head variations present at each location than those recorded by separate staff gauge and piezometer locations where standing water is present. Measurement locations are identified on Figure 2.2. Refer to Section 3.4 for additional information regarding 2021 piezometer installation.

Results are presented on Table 3.4 and are summarized below:

- Water levels indicate surface water flows from the Site north towards Berrys Brook and that surface water and shallow groundwater elevations are either at equilibrium or have slight

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[20] In accordance with **Section 3.4**, piezometers were installed at existing surface water sampling locations BB-2, SW-4, SW-5, SW-103, and SW-110; as well as in areas immediately north of the landfill boundary and west of the railroad easement between BB-1 and BB-2.

vertical gradients supporting either infiltration of surface water to groundwater or groundwater discharge to surface water

- Surface water elevations near the watershed divide between Berrys Brook and Little River as gauged at PZ-4 and SG-1 (70.39 to 70.87 feet AMSL: November 2021), supporting northern flow towards SW-110 (68.45 ft AMSL) and southern flow towards Little River Bridge (64.85 feet AMSL).
- Surface water and shallow groundwater elevations east of the railroad easement and more proximal to the landfill, specifically PZ-3, PZ-6, PZ-7, PZ-5/SG-SW-5, are higher than shallow groundwater and surface water levels in the wetland complex
- While surface gages SG-1 through SG-4 are located upstream of SG-5, water levels in SG-5 are consistently higher than those upstream gages. Downstream of SG-5, water surface water levels decrease gradually towards BB-2, SG-7, and SW-110.
- Vertical gradients driving flow of overburden groundwater toward the wetland complex is identified through comparisons of groundwater levels and surface water levels measured in May of 2022, at locations FPC-8A/SG-1, AE-2A/SG-2, MW-21S/SG-4, and FPC-6A/SG-3.
- Vertical gradients based on the difference between water levels measured inside vs outside piezometers supporting groundwater discharge to surface water or equilibrium between shallow groundwater and surface water at discrete locations since March 2022, were recorded consistently at PZ-6, PZ-8, and PZ-110
- Vertical gradients based on the difference between water levels measured inside vs outside piezometers supporting surface water infiltration to groundwater or equilibrium between shallow groundwater and surface water at discrete locations since March 2022, were recorded consistently at PZ-1, PZ-5, and PZ-7
- Vertical gradients based on the difference between water levels measured inside vs outside piezometers that switch between either infiltration of surface water or discharge of groundwater at discrete locations since March 2022 include PZ-2, PZ-4, PZ-9, and PZ-103.

Additional surface water elevations will be collected in accordance with Section 7 to further assess surface water and groundwater hydraulic interaction related to the wetland complex. These data are expected to provide additional information on overburden groundwater and surface water interaction at the Site.

4.4.4 Stormwater Investigation

A Stormwater Investigation was completed in 2018 and 2019 in accordance with the Stormwater Investigation Work Plan (Haley Ward, 2018). The purpose of this investigation was to better understand the chemical composition of stormwater, landfill runoff, and groundwater within and near the landfill cap; the relationship between stormwater discharge, shallow groundwater quality, and landfill seep discharge from monitoring location L-1; and the design and function of the stormwater collection system installed at the landfill during landfill cap construction. The results of the investigation were provided to USEPA and NHDES in a Stormwater Investigation Report (Haley Ward, 2019).

The investigation was comprised of the following tasks: verification of the stormwater system (Section 4.4.1.1); groundwater and surface water sampling/monitoring (Section 4.4.1.2); and a stormwater infiltration analysis (Section 4.4.1.4). The stormwater infiltration analysis included calculating an estimate of the mass-discharge of PFAS in stormwater, groundwater, and Berrys Brook.

The investigation results indicate that materials in the landfill cover system contribute PFAS to surface waters adjacent to the Site. These compounds dissolve in precipitation that falls on the Site which infiltrates through the cover soil to underdrain collection piping that subsequently discharges to the wetland complex west and north of the landfill and to the ground surface at a rip rap swale northwest of the landfill.

4.4.4.1 Stormwater Management System

The CLG completed a comprehensive review of stormwater routing and conveyance system components to differentiate surficial stormwater runoff, drainage layer discharge, and other discrete points of contribution to the stormwater retention basins (SB-1/SB-2). This verification involved desktop evaluation of the Final 100% Remedial Design Report (Design Report) developed by Golder Associates (Golder, 1996), as-built drawings, and a field inspection of system components. To aid in this process, a New Hampshire-licensed land surveyor was used to survey and record invert elevations for portions of the stormwater system (e.g., outfall piping), the location and elevation of surface water and seep sampling locations, verification of top of riser elevations for groundwater monitoring wells included as part of the investigation, and piezometers installed in accordance with the Stormwater Investigation Work Plan (Section 4.4.1.2; Haley Ward, 2018).

- The desktop evaluation for the stormwater retention system resulted in the conclusion that precipitation falling on the landfill cover system and subsequent stormwater runoff does not come into direct contact with landfill refuse.

A review of the project documentation was performed to identify materials used in the construction of the Coakley Landfill cover system and stormwater collection system. These materials included the flexible membrane liner, geotextile, underdrain conveyance piping, cover soil, sand and gravel drainage layers, and topsoil materials. Landfill cap and stormwater system construction materials determined to have direct contact with stormwater were sampled and analyzed for PFAS (Haley Ward, 2018).

- The highest concentration of PFAS in cover system materials was detected in the topsoil/vegetation layer. The topsoil sample from the northwest portion of the landfill had the highest reported concentrations of PFOA and PFOS at 0.00425 mg/kg and 0.0396 mg/kg, respectively.
- Lower concentrations of PFAS were detected in underlying common borrow soil.
- PFAS was not detected in the sand drainage layer.

4.4.4.2 Stormwater and Piezometer Monitoring

Stormwater sampling locations were selected based on the stormwater management system design. Stormwater samples were collected from the Northeast Stormwater Retention Basin, Northeast Basin Outfall Pipe, Northeast Perimeter Ditch, Northeast Underdrain Piping, Landfill Seep (L-1), Northwest Stormwater Retention Basin, Northwest Basin Outfall Pipe, Northwest Perimeter Ditch, and Northwest Underdrain Piping (Haley Ward, 2019). It is important to note that dry weather periods during the stormwater investigation affected sampling activities at some locations. Refer to the *Stormwater Investigation Report* (Haley Ward, 2019).

Three piezometers (PZ-1, PZ-2, PZ-3) were installed and sampled as part of the Stormwater Investigation (Haley Ward, 2019). PZ-1 and PZ-2 were installed in the northeast and northwest stormwater retention basins (SB-1 and SB-2), respectively, and designed to monitor infiltration of stormwater through the unlined basins and interaction with shallow groundwater. A third piezometer (PZ-3) was installed in the vicinity of the L-1 sampling location to establish a discrete sampling location representative of groundwater discharging to the wetlands in the area. The depth of installed piezometers was based on conditions encountered in the field during installation and included depth of soil/fill material, depth to water, and spatial relationship to stormwater system components as determined from design drawings and observed field conditions at the time of installation (Haley Ward, 2019). Construction diagrams for these piezometers have been included with Appendix A.

Samples were collected from stormwater sampling locations and piezometer sampling locations in fall 2018 and spring 2019 in accordance with the Stormwater Investigation Work Plan (Haley Ward, 2018).[21] The findings of sampling and investigation activities are summarized below (Haley Ward, 2019):

- PFAS were detected in all stormwater samples, with samples from underdrain piping exhibiting higher PFAS concentrations compared to other direct discharge stormwater samples. Discharge from the underdrain system is the result of water (precipitation) infiltrating through cover and subsurface materials (topsoil and common borrow cover soil) that is subsequently collected in perforated piping and discharged to SB-1 at the northeast corner of the landfill or to the rip rap letdown structure near the northwest toe of the landfill, approximately 60 feet southwest of SB-2 (Figure 2.2). Water infiltrating through cover material will have a longer contact time with cover materials containing PFAS as compared to direct overland surface runoff.
- 1,4-dioxane was not detected in stormwater samples. 1,4-dioxane is typically present in groundwater samples and is interpreted to be the result of contact or interaction with landfill

[21] Surface water sampling locations that are part of the routine monitoring program (SW-4, SW-110, SW-111, Little River, BB-1, and BB-2) continued to be monitored during regularly scheduled biannual sampling events separate from stormwater sampling. However, efforts were made to schedule stormwater sampling in conjunction with routine sampling events to allow for more direct correlation of analytical results. Stormwater sampling events were dependent on the occurrence of precipitation events that generated both surficial and underdrain discharge.

waste. These data indicate that the source of PFAS in stormwater samples is not due to interaction of stormwater with landfill waste.

- PFAS were detected in PZ-1, PZ-2, and PZ-3. PFAS concentrations were highest in PZ-1.
- 1,4-dioxane was not detected in samples connected from PZ-1 during the fall 2018 or spring 2019 sampling events. However, samples collected in spring 2019 from PZ-2 and PZ-3 had detections of 1,4-dioxane.
- The absence of a 1,4-dioxane detection in PZ-2 during the fall 2018 event and a detection of 5.7 ug/L during spring 2019 is interpreted to be a result of shallow groundwater beyond the landfill boundary interacting with discharges from the northwest outfall pipe during periods of high overburden groundwater levels.

Refer to the *Stormwater Investigation Report* (Appendix B) for further detail. Plots of PFAS results (i.e., compositional makeup) for stormwater samples collected in 2019 are included in Appendix J.

4.4.4.3 Stormwater Infiltration Modeling

The mass discharge of PFAS in stormwater and groundwater from the Site was estimated to understand an approximate relative contribution of stormwater runoff and groundwater to the wetland complex and Berrys Brook (Haley Ward, 2019).[22] These values were based on limited data available at the time of evaluation. The installation of additional surface water gauging locations and piezometers and the sampling of surface water, piezometers, and porewater are being completed in support of an ongoing surface water evaluation at the Site. These data will be used to provide more constraint to the modelling of PFAS contribution and in the calculation of mass flux through the system. The reevaluation of mass flux is included as Task 3.6 of the *Surface Water Evaluation Work Plan* (Haley Ward, 2020). The additionally installed monitoring locations will provide information necessary to better understand the hydrology of the hyporheic zone and the movement of contaminants through the system.

An estimate of the potential contribution of PFAS in stormwater was calculated using an annual volume of stormwater runoff and underdrain discharge for the Site, and average PFAS concentrations from the Fall 2018 and Spring 2019 stormwater analytical results (Section 4.4.1.1).[23] The annual volume of stormwater runoff was estimated using precipitation data from the National Oceanic and Atmospheric Administration and the Hydrologic Evaluation of Landfill Performance (HELP) program. The HELP program was used to estimate the direct stormwater runoff from the cover system and quantity of water that enters the stormwater system via underdrains. Values used in the model were subject to the information available on landfill cover design and construction and assumptions made on the lateral homogeneity of the cover material.

[22] The estimated stormwater and groundwater mass discharges that were calculated were compared against a watershed-based mass discharge approximation. Refer to the Stormwater Investigation Report (Haley Ward, 2019) for further detail.

[23] The average PFAS concentration used was the calculated sum of PFOA, PFOS, PFNA, and PFHxS.

- The total mass of PFAS discharged from the landfill surface via stormwater runoff, direct discharge to the surface from the underdrain system, and infiltration through the unlined stormwater ponds resulting from precipitation events was estimated to be on the order of 0.62 pounds annually. However, the collection of additional information during the ongoing surface water evaluation (e.g., analytical data) will be used to refine these estimates and are not included herein.

Estimating potential contribution of PFAS via groundwater discharge[24] was calculated using an assumed annual volume of groundwater discharge to the wetland complex and average PFAS concentrations from the Site. The annual volume of groundwater discharge was estimated based on average annual precipitation and groundwater recharge information for the Berrys Brook Watershed from the USGS, and an assumed discharge area of impacted water to the wetland complex of approximately 40 acres. Average PFAS concentrations at several overburden monitoring wells west of the landfill (MW-9, MW-10, and AE-2) were assumed to be representative of water quality discharge to the wetland complex. As mentioned, the installation of additional monitoring locations and collection of supplemental analytical data on PFAS concentrations within the wetland complex will be used in later efforts to more accurately model and report on these findings.

- The total magnitude of PFAS discharged from groundwater was estimated to be 0.24 pounds but will be recalculated pending the collection and analysis of additional data on shallow groundwater, stormwater, and surface water.

These estimates suggest that both stormwater and groundwater contribute significantly to the wetland complex and ultimately Berrys Brook. Refer to the Stormwater Investigation Report (Haley Ward, 2019) for further detail with information detailing ongoing efforts to monitor the surface water system included in the *Surface Water Evaluation Scope of Work* for the Site dated January 22, 2020.

4.4.4.4 Stormwater Investigation Conclusions

Materials in the landfill cover system, primarily the topsoil/vegetative layer, contain PFAS that is dissolved in stormwater and transported via direct surface runoff of precipitation and via infiltration of stormwater through the cover soil to underdrain collection piping that subsequently discharges to the wetland complex west and north of the landfill and to the ground surface at a rip rap swale northwest of the landfill. Compositional plots of PFAS analytical results indicate a similarity between shallow groundwater (MW-9 and MW-10) and stormwater in the vicinity of the swale, indicating a likelihood of mixing between stormwater and groundwater in this area (Haley Ward, 2019). This conclusion is supported by the identified increasing trend in concentrations of PFOS and 1,4-dioxane at MW-10, the only overburden well with a statistically significant increasing trend in 1,4-dioxane and one of only two overburden wells (MW-10 and AE-3A) with the same trend for PFOS. Both MW-10 and AE-3A are located in the northwest corner of the landfill where most stormwater is discharged or infiltrates to the overburden.

[24] Prior to the implementation of the remedy for OU-1, contaminants at the Site had the potential to come into contact with groundwater.

Estimates of PFAS mass discharge indicate that stormwater and groundwater contribute significant amounts of PFAS to the wetland complex. This noted, analytical results from surface water sampling at various locations inside and outside of the GMZ show that concentrations of PFAS in surface water exceed the new SSSLs established for the Site on September 1, 2022. The USEPA lowered site-specific surface water screening levels (SSSLs) for PFOA, PFOS, and PFBS with new SSSLs established for PFNA and PFHxS. A total of six locations exceeded the SSSLs for PFOA, five for PFOS, and three for PFNA. These locations and concentrations as reported for results in 2020 are provided in greater detail in Section 4.4.2.2. Locations that exceeded the new SSSLs are proximal to the landfill, and with the exception of SW-BB1 and SW-110, are within the GMZ.

5.0 CONCEPTUAL SITE MODEL

5.1 Site History and Contamination Source

The Coakley Landfill Superfund Site (Site) includes approximately 92 acres in Greenland and North Hampton, New Hampshire with the actual landfill footprint covering approximately 27 acres. The Site was the location of a historical unlined landfill active between 1972 through 1985 that began as a site for sand and gravel mining and quarrying operations in 1965. In 1979, the New Hampshire Waste Management Division received a complaint concerning leachate breakouts around the landfill. Following subsequent complaints and investigation, the Site was listed in 1986 on the NPL by the USEPA.

Based on information provided in the Site RI (Weston, 1988), mining activities began within the northern portion of the Site, west of the west access road, east of the east access road, and within two excavations located in the southern portions of the Site. This information was based on land alterations visible from the analysis of historical aerial photographs performed by Weston. and documented in the RI Report. Sand and gravel operations continued to the northeast and by 1971 material was reported by the United States Department of Agriculture (USDA) Soil Conservation Service to have been mined within a few feet of the groundwater table. The Town of North Hampton began operations of the permitted landfill in 1972, with the southern portion of the Site used for waste disposal concurrent with sand and gravel mining. By 1973, quarrying operations were underway within the northwest portions of the Site with additional quarrying having expanded to a second location in the central portion of the Site by December 1974. By this time, most of the surrounding area, including the area occupied by quarrying, had been lowered to an approximate elevation of 90 feet above mean sea level (AMSL). However, these bedrock elevations likely varied across the site as some borings completed within or adjacent to the landfill (i.e., GZ-106) noted competent bedrock at an elevation of approximately 96 feet AMSL. Quarrying operations expanded significantly between 1974 and 1977 at both locations (central and northwest) with landfilling activities having expanded northward from the southern portions of the Site where landfilling began in 1972.

By 1981, landfilling operations had expanded such that most of the previously established sand and gravel and quarrying operations had been covered with only a small portion of the northernmost quarry remaining. Aerial photographs from this period also revealed several new trenches in the southeastern portion of the Site and two new sand and gravel pits in the north and central portions. (Weston, 1988). It is not known whether the trenches were for the removal of sand and gravel, placement of waste, to facilitate surface drainage within the Site, or a combination of two or more activities. These excavations are in addition to a swale constructed to drain the remaining open portion of the northern quarry into the wetland area located west of the landfill.

Excavations and surface water management operations were completed in accordance with Regulation No. 17 of the 1972 State of New Hampshire *Laws and Regulations Relating to Solid Waste Disposal.* The regulation required the landfill operator to provide a drainage system to minimize surface water runoff onto and into the fill, prevent erosion of the fill, drain off water falling on the fill, and prevent the collection of standing water. It is unclear when the sand and gravel operations ceased at the Site, but it is likely that these activities were completed prior to final closure of the landfill in 1985. Quarrying operations may have been completed by 1981; however, it is unknown based on available information whether the remaining quarry pits were actively removing rock or were drained to facilitate waste placement.

The landfill accepted municipal and industrial waste from the Portsmouth area during the period between 1972 and July 1982. Landfilling began in the southern portions within existing sand and gravel operations and proceeded north as these areas were filled. The mode by which refuse was placed in the landfill may have affected the migration and degradation of contamination with information provided from aerial photography suggesting the trench and area methods were used. Based on conclusions drawn from operations information provided in the RI, waste was likely placed in open trenches excavated specifically for waste placement or directly within depleted sand and gravel pits as would be common in use of the trench and area methods, respectively. Though observations were made from aerial photographs that some trenches were water filled, the presence of purpose-built drainage swales during active site operations and specific solid waste disposal regulations requiring site drainage to prevent the collection of standing water would indicate that trenches and pits were likely dewatered prior to waste placement. in accordance with Regulation No. 17 as referenced above. In addition, as the quarries were gravity drained through the use of swales, it is understood that the base level of quarrying likely did not extend below the level of groundwater and water present within these operations was likely perched or confined by topography or changes in overburden lithology. As provided in the RI, quarrying operations advanced to a level coincident with the elevation of the sand and gravel mining with the expansion of quarrying being generally areal in extent rather than vertical.

It is likely that waste was placed directly onto exposed bedrock surfaces within areas occupied by quarrying operations and in trenches and borrow areas where the depth to bedrock may have been greater. Exposed bedrock surfaces within quarried areas may also have been subject to increased shallow fracturing as a result of blasting; however, the depth of this fracturing cannot be quantified. As the cover placed over the waste material would not have been impermeable, precipitation would have percolated through waste before coming in contact with groundwater below sand and gravel excavations or with the blasted bedrock surface within the quarried areas of the Site. Water was encountered at GZ-106 at an elevation of approximately 99.5 feet AMSL, indicating that some refuse was submerged at the time of drilling.

The source of groundwater contamination is historical waste disposal at the Site that began in 1972 with the accepting of municipal waste from Portsmouth, North Hampton, Newcastle, Newington, and Pease Air Force Base. An agreement between the Town of North Hampton, City of Portsmouth, and Coakley Landfill, Inc., restricted the landfilling of shop and ordnance wastes from Pease AFB, construction and demolition debris (CDD), automobiles, machinery, and large trees and stumps. Anecdotal information referenced in the 1988 RI suggested that prior to 1975, liquid wastes and drums may have been disposed of at the landfill site; however, confirmatory information on the validity of these reports was not available. Oil-soaked debris was landfilled at the north end of the landfill in early 1978 and late 1979 with residual fuel oil waste spread along the access road and landfill, presumably for dust mitigation, in summer 1978. In August 1981, the Town of North Hampton was granted permission by the State of New Hampshire to dispose of pesticide waste at the site with landfilling of municipal wastes largely ceasing by July 1982 when the incinerator facility at Pease AFB began operation. The landfill continued to accept waste in the form of incinerator residue until closure in 1985.

Routine landfill inspections completed by the NHDES Waste Management Division resulted in the documentation of operational deficiencies related primarily to insufficient covering of wastes or inadequate thickness cover. Those reports had no comments suggesting improper drainage of surface water or waste placement within water-filled trenches as would be in violation of the Solid Waste Regulations.

To address Site contamination and as part of the Site's listing on the NPL, the Site was separated into two areas, or Operable Units. Operable Unit 1 (OU-1) includes the area in the immediate vicinity of the landfill where source control actions were completed to reduce impacts to surface water and groundwater quality and to eliminate potential threats posed by direct contact with, or ingestion of, contaminated media at the Site. The approved ROD remedy for OU-1 included consolidation of waste with the stated objective of removing waste from wetland areas adjacent to the landfill and consolidating waste into a single unit under an engineered cover system (cap). Waste consolidation and capping was completed in 1998. This effectively controlled the contaminant source by reducing migration of contaminants to groundwater via infiltration of water (rain/snow) through the originally placed waste.[25] Capping of the landfill altered the hydrogeology of the Site, changing groundwater levels, flow, and recharge to both the overburden and bedrock groundwater under the landfill by preventing direct percolation through the landfill. Operable Unit 2 (OU-2) generally includes the area beyond the landfill boundary with some wells located immediately outside the landfill perimeter included within OU-1. The 1994 ROD for OU-2 calls for groundwater monitoring over a period of 30 years while contamination naturally attenuates, and the elimination of potential threats posed by the future ingestion of contaminated groundwater by implementing institutional controls restricting the use of the groundwater. Since 1998, post-remedial water quality monitoring has been ongoing at the Site.

Following completion of the landfill cap, the plume of VOC- and chlorinated VOC-contaminated groundwater stabilized and began attenuating based on sampling results in the late 1990s and early 2000s. 1,4-dioxane and PFAS were added to the monitoring program in 2009 and 2016, respectively, as emerging contaminants being examined in New Hampshire and nationally. They were identified to be present in groundwater at the Site and found to be migrating from the Site into groundwater. Additional changes in the sampling program have included the alignment of the VOC analyte list with NHDES requirements.

Landfill stormwater sampling and sampling of the landfill cap construction materials have identified the presence of PFAS and a general lack of other contaminants typically associated with landfills (i.e., VOCs, 1,4-dioxane). In addition, the layer of topsoil that was placed on the landfill cap was augmented with compost and sand to promote growth of vegetation. PFAS is associated with certain compost and the

[25] The OU-1 remedy originally also called for the collection and treatment of contaminated groundwater at the edge of the landfill. USEPA documented in the 1999 ESD that the landfill cap was effective in reducing leachate generation such that the collection and treatment of contaminated groundwater at the edge of the landfill was no longer necessary.

augmented landfill cap was constructed according to common practice at the time, before PFAS were identified as emerging contaminants.

For this study, the water quality trend analysis, Section 4.3.3, groundwater contour maps, Figures 4.9, 4.17A, and 4.17B, and isoconcentration maps illustrating contaminant distribution, figures 4.10 through 4.17 and 4.21 through 4.27, confirm two separate sources of site contaminants. First, the landfill refuse, with contaminants being transported through the interaction of groundwater with refuse, and secondly, the discharge of stormwater runoff that has infiltrated through cap material and is subsequently discharged and allowed to infiltrate into the local groundwater. The water quality trend analysis identifies two divergent water quality trends among wells. One trend indicates higher 1,4-dioxane and lower PFAS concentrations in wells proximal to the overall landfill footprint. The other trend identifies higher PFAS and lower 1,4-dioxane in certain wells which are typically proximal to the stormwater management system. Further from these sources the divergence in concentrations between these compounds is not as pronounced, illustrating how the plumes are mixing as concentrations decrease further from their respective sources. Bedrock and overburden groundwater flow illustrates water levels underlying the landfill at up to 95 feet amsl, slightly above the reported depth of excavation of 90 feet amsl. Isopach concentration maps illustrate the distribution of these contaminants support the findings of the water quality trend analysis.

5.2 Physical Characteristics of the Site

To understand the fate and transport of contaminants at the Site, an understanding of the Site's physical characteristics is required. Data and results collected since Site investigation began with the RI indicate that the geology and hydrogeology of the Site are consistent with previously mapped and studied conditions in this area of New Hampshire.

Observed stratigraphy consists of discontinuous glacial outwash often overlying discontinuous marine deposits or overlying glacial till and overlying fractured bedrock. Overburden thickness ranges from less than one foot in upland areas (e.g., MW-21D) to up to nominally 85 feet west-northwest of the landfill. Bedrock outcrops are predominantly in areas north and northwest of the landfill and west of the wetland complex. The top of bedrock is shallower underlying the landfill, as the landfill sits on a bedrock topographical high. According to the original RI, the *Assessment of Ground-Water Resources in the Seacoast Region of New Hampshire* report published by the USGS (Mack, 2012), and scientific publications written by Escamilla-Casas (2003) and Lyons et. al. (1997), the lithologies underlying the study area are composed of the Rye Complex, a major geologic unit comprised of the Rye Formation and the Breakfast Hill Granite.

Based on borehole geophysics statistical analysis and analysis of bedrock outcrop fracture orientation measurements, the primary fracture orientation in bedrock (strike) is northeast-southwest with a median dip of 64° to the west-northwest. Secondary and tertiary fracture networks are identified in bedrock at the Site which have the potential to facilitate eastward or westward migration through bedrock. The deep bedrock pumping test supports a roughly 5:1 anisotropy in the bedrock aquifer, parallel to the predominant fracture set present in the CSC/BHG immediately south of the landfill. The pumping well, MW-6, incorporates the primary, secondary, and tertiary fracture sets including a large aperture, moderately dipping (approximately 40-50 degree), water transmitting fracture, as well as other smaller aperture, near horizontal fractures identified in likely transmissive zones (Appendix C). The combination of these shallow and moderately dipping fractures along with the primary, steeply dipping north to south oriented fractures identified in MW-6, results in the 5:1 anisotropy predicted by Mack 2012. This anisotropy limits eastward or westward flow from the landfill through bedrock. Considering that the typical household usage for a family of four in New Hampshire is approximately 300 gallons per day, the stress on the bedrock aquifer imposed by this pumping test is much greater than would be asserted by an individual well or even a series of residential wells. During the test, over 70,000 gallons of water was pumped out of and treated for site contaminants from the aquifer, producing enough water to supply over 45 families of four for that time period.

With eastern/western migration flow of groundwater through bedrock inhibited by the local bedrock fracture network, additional transport pathways are considered to understand groundwater flow west of the landfill. Identification of the direct hydraulic connection between overburden and bedrock in the bedrock trough/wetland complex to the west of the landfill during rain events captured in the antecedent monitoring from the pumping test illustrates the groundwater flow pathway to deep bedrock underlying the trough is not solely through secondary or tertiary fracture networks in deep bedrock. Recent drilling and review of historical records illustrate that the glacial till in the bedrock trough is often described as a relatively coarse material (capable of transmitting groundwater) and directly overlies highly fractured, bedrock. Hydraulic gradients illustrated in the cross sections (Figure 4.4 through Figure 4.6), indicate that overburden and shallow bedrock groundwater underlying the bedrock ridge of the CSC/BHG is driving groundwater flow to the west into the trough. Once groundwater reaches the trough, vertical gradients identified in well clusters allow for shallow and deep bedrock groundwater to rise vertically, and discharge to the surface water. Hydraulic gradients in bedrock and overburden on the western side of the wetland complex illustrate eastern flow, towards the wetland. Wells installed into outwash or till on the eastern side of the wetland complex, proximal to the landfill exhibit higher hydraulic heads than overburden wells on the western side of the wetland complex, with the lowest hydraulic heads identified in the center of the wetland complex. While the marine clays present in the center of the trough act as a barrier to flow, groundwater flow along the glacial till and shallow bedrock interface allows for discharge of groundwater, sourced from the landfill to the wetland complex, west and north of the extent of the marine clays.

In the bedrock trough to the southwest of the landfill, a saddle in the bedrock in the vicinity of GZ-105 and MW-25, is coincident with the surface water drainage divide between Berrys Brook and the Little River. This surface water drainage divide is reflected in groundwater flow through overburden, shallow, and deep bedrock. To either side of this saddle are depressions in bedrock, filled with thick sequences of overburden consisting of glacial till underlying discontinuous marine clays underlying discontinuous glacial outwash. To the north, this overburden thins, the marine clays pinch out, and bedrock elevation has been shown to rise gradually towards outcrops identified at Breakfast Hill Road. To the south, the extent of this overburden material has not been completely delineated. As shown on the groundwater potentiometric surface contour maps (Figures 4.9, 4.17A, and 4.17B), there is an aspect of northern flow, north of the saddle and southern flow, south of the saddle. This bifurcation of flow allows groundwater to flow parallel to the primary bedrock fracture network through overburden and bedrock underlying the wetland complex.

The designed cap and engineered stormwater system at the site directs the majority of stormwater runoff from the landfill cap to the stormwater retention ponds to the north of the landfill. The drainage pathways then direct this runoff to either infiltrate through the unlined stormwater ponds or to a lesser extent, as runoff into the Berrys Brook watershed. The overburden and surface water elevations in this portion of the Site drives the transport of the majority of stormwater impacted groundwater to the Berrys Brook watershed.

The original RI illustrated a groundwater flow pathway to the east, driven by mounding of groundwater from the landfill itself. This condition would have allowed groundwater that had infiltrated through landfill material to flow to the east for decades before the installation of the engineered landfill cap and stormwater management system expanding the plume of landfill related site contaminants. The presence of fine-grained deposits in the marine clays could act as a storage reservoir for contaminants transported through this flow pathway, gradually releasing lower and lower concentrations of the residues of historic landfill management over time.

5.3 Transport of Site Contaminants

Based on review of data collected, three migration pathways exist in *deep bedrock:*

1. The predominant pathway for migration through bedrock is along the northeast-southwest primary fracture network, coincident with the identified bedrock trough
2. Secondary/limited migration East-Southeast – West-Northwest along cross-cutting fractures parallel to the secondary set of lineaments, and,
3. Limited migration laterally through sheeting fractures that have horizontal to very shallow dips.

Additionally, a more predominant transport pathway for site contaminants has been identified through the glacial till and shallow bedrock interface, particularly in the bedrock trough. Landfill cap soil materials contribute PFAS to shallow groundwater through the infiltration of stormwater, confirmed by recent stormwater, surface water, and landfill cap material sampling. To a lesser extent, shallow groundwater interacts with landfill material as it is flowing to the west. Historic management of landfill waste material allowed for the mounding of groundwater at the landfill, driving site contaminants to the east. With the change in groundwater flow regimes post-capping, that eastern flow of contamination has been gradually attenuating.

These conclusions are supported by the following:

1. Groundwater potentiometric surface contour maps for overburden and for both shallow and deep bedrock, and flow nets illustrate the westward hydraulic gradients driving the transport and discharge of site contaminants to overburden groundwater and ultimately surface water downgradient in the bedrock trough. These gradients are further illustrated in hydrologic flow nets included on cross sections for A-A′ (Figure 4.4), B-B′ (Figure 4.5), and C-C′ (Figure 4.6).
   a. The wetland complex and surface water drainages are coincident with the north-south bedrock trough and the predominant NE-SW fracture strike orientation.
   b. Bedrock topography slopes west towards the wetland complex from the landfill. Water level gauging data from the DPT investigation temporary monitoring wells and from permanent monitoring wells to the west of the wetland complex are consistent with this interpretation. In this area, overburden groundwater flows east.
   c. Vertical gradients calculated from monitoring well couplets and HPFM results from borehole geophysical logging indicate upward gradients in most bedrock monitoring wells.
   d. Contaminant distribution shows the highest concentrations of 1,4-dioxane and PFAS in monitoring wells located closest to the landfill, with detectable concentrations coincident with the Berrys Brook valley.
   e. Contaminant impacts to the wetland complex, Berrys Brook, and Little River indicate discharge of groundwater to surface water. Additionally, estimates of PFAS mass discharge indicate that stormwater contributes a significant amount of PFAS to the wetland complex (Section 4.4.4).
2. Surface water flow from the wetland complex is both south towards North Road and north towards Breakfast Hill Road, consistent with dominant fracture strike with a groundwater divide coincident with bedrock topography.
   a. Two lobes of deeper bedrock filled with surficial material have been identified in the trough, which are coincident with the watershed divides of these two streams which are reflected in groundwater flow pathways through overburden and bedrock.
   b. Surface water levels above the bedrock saddle, proximal to the identified watershed divide of Berrys Brook and the Little River and are higher than water levels downstream at North Road and Breakfast Hill Road.
3. Impacts to groundwater decrease with distance from the landfill and concentrations of most site contaminants appear to be stable or decreasing with the exception of PFAS in wells northwest and west of the landfill
   a. This is supported through the statistical analysis completed, illustrated in the isoconcentration plots (Figures 4.10 through 4.17 and 4.21 through 4.27) and described in Appendix H.

   b. Wells with increasing PFOA/PFOS trends are located west and northwest of the landfill near the toe of the landfill slope. These are the locations where the highest PFOA and PFOS results have been reported and where the greatest fluctuation in concentrations has historically been observed. This area is influenced by stormwater contribution of contaminants.

4. Statistical analysis illustrates the divergent sources identified in groundwater results. One source is landfill refuse, with wells proximal to the landfill having higher proportions of 1,4-dioxane, while other wells appear to be influenced by stormwater discharge in the northwest corner of the landfill having higher concentrations of PFAS.
   a. Landfill material has been reported to have been placed at an elevation of roughly 90 feet amsl. The groundwater contour maps illustrate groundwater contours flowing west, between 90 to 95 feet amsl on the eastern side of the landfill for bedrock and overburden groundwater.
   b. Stormwater that has infiltrated through the cap is either discharged to the surface (northwest underdrain pipe) or routed to stormwater retention ponds located to the north and northwest of the landfill. Water diverted to these ponds is allowed to infiltrate through these unlined ponds to overburden groundwater. Groundwater impacted by the stormwater runoff subsequently discharges to surface water in the wetland complex. Impacts to surface water are not solely attributed to surface runoff from the landfill cap directed to surface water drainages.
5. The presence of site contaminants east of the landfill is explained from mounding of groundwater caused by historic refuse management prior to the installation of the current cap.
   a. A thin, laterally constrained layer of glacial till underlying the outwash and marine clays and directly above bedrock extends to the identified extent of impacts identified from the landfill.
   b. A substantial thickness of fine grained, marine clays could act as a reservoir for site contaminants such as PFOA and 1,4-dioxane that were transported to the east though mounding or unpermitted withdrawals.
   c. The storage of site contaminants in fine grained material would result in the gradual release of decreasing concentrations of these compounds to the concentrations now observed
   d. A statistically significant decrease or stable trends in contaminant concentrations to the east of the landfill in both overburden and bedrock illustrate that continued transport of site contaminants has not been identified and that attenuation of site contaminants to the east is occurring.

e. The sampling of Baileys Brook completed by the Conservation Law Foundation in 2016 for PFAS compounds illustrate that groundwater impacted by the landfill are not discharging to the surface water in the watershed directly east of the landfill

6. Glacial till proximal to the bedrock interface in the bedrock trough has been described as relatively coarse-grained sediment as shown recently in the drilling of MW-25 and the DPT investigation. Shallow fractures in bedrock have been identified to be extensive and transmissive, as evidenced through drilling and subsequent downhole borehole geophysics at MW-25. A preferential pathway along the glacial till/shallow bedrock interface explains the lateral distribution of site contaminants in the wetland complex.

   a. During drilling of MW-25 the lateral extent of hydraulic influence exhibited orthogonal to the primary fracture network was greater than was observed during the pumping test at MW-6, where deep bedrock fractures were isolated from shallow bedrock and overburden groundwater

   b. The installation of casing 10 feet into bedrock during drilling of MW-25 allowed for the transmission of shallow bedrock groundwater, in direct communication with overburden groundwater, to be incorporated into the discharge from air hammer drilling.

7. Groundwater in the deep bedrock below the trough west of the landfill must be hydraulically connected with the overburden groundwater through steeply dipping fractures as evidenced by the immediate response of deep bedrock wells to precipitation events during water level monitoring.

   a. Sheeting or shallowly dipping fractures connected to deep bedrock underlying the landfill, isolated from overburden cannot explain the hydraulic connection between precipitation and groundwater levels in the deep bedrock in the trough.

8. Along established flow paths the interconnectedness of fractures in deep bedrock is limited, where pathways through deep bedrock allow transport of site contaminants parallel to the primary fracture network (north to south). However, groundwater transport orthogonal to the primary fracture network (east to west) is limited.

   a. Of the 36 instrumented wells/intervals during the constant rate pumping test, only five wells (FPC-2B, MW-2, MW-5S, MW-5D, and MW-11) exhibited drawdown after a duration of 96 hours at a constant withdrawal rate of approximately 11.4-11.8 gallons per minute (gpm). This hydraulic influence observed in wells FPC-2B (785 feet southwest of MW-6), MW-2 (288 feet north of MW-6), MW-5S (359 feet north/northeast of MW-6), MW-5D (370 feet north/northeast), and MW-11 (588 feet north of MW-6) during the constant rate pumping test are consistent with observations made during the redevelopment of MW-6 and the variable rate pumping test.

b. The pumping test supports, through pumping at a rate and duration reflecting the maximum yield of the deep bedrock for MW-6, that transmissive fractures in deep bedrock monitoring wells demonstrate a 5:1 anisotropy predicted by Mack 2012.

c. The identified elongate plumes of site contaminants along the north/south fracture network in the bedrock trough without identified impacts to bedrock or overburden groundwater, west of the trough

d. Aquifer properties parallel to the primary north/south strike direction were estimated to be:

   i. Transmissivity (T): 108.4 feet^2/day

   ii. Storativity (S): 4.316x10^{-5}

   iii. Conductivity (K): 0.62 feet/day

e. Transmissivity and conductivity in the orthogonal direction should be roughly 1/5 of those values calculated in the primary fracture network

f. The aquifer properties estimated here are consistent with previously published values calculated for the site and predicted in Mack 2012.

9. The highest concentrations of COCs in MW-25 detected during packer sampling were from the shallowest interval (Zone 1: 40 to 57 feet bgs; 23.1 ug/L 1,4-dioxane and 365 ng/L PFOA+PFOS). Detections in Zones 3 through 7 for 1,4-dioxane were also above the NHDES AGQS (0.32 ug/L) and USEPA CL (3 ug/L) with concentrations ranging from 5.42 ug/L to 8.84 ug/L. PFOA was detected above the NHDES AGQS of 12 ng/L in Zones 3 through 7 with concentrations ranging from 18.7 ng/L to 29.70 ng/L. PFOS was also detected in Zone 5 at a concentration of 15.30 ng/L, above the NHDES AGQS of 15 ng/L. Zone 7 (169 to 183 feet bgs) is highly transmissive (649.65 feet/day) and is one of the few high-yielding fractures found throughout the deep bedrock investigation. Lower and in some cases a lack of COC detections in this highly transmissive zone indicates limited COC migration to the deep bedrock underlying the trough.

   a. The groundwater flow net at MW-25, as included on Figure 4.5 illustrates how hydraulic gradients in deep bedrock underlying the landfill are traveling westward, to MW-25 before being captured by the vertical gradients created by the presence of the bedrock trough. Vertical gradients from overburden impacted by landfill stormwater runoff may also travel downdip through steep fractures in this portion of the wetland complex.

   b. Transport of site contaminants west of MW-25 is not expected due to the increase in hydraulic head identified in bedrock wells west of the trough. This convergence of flow around surface water discharge points is consistent with the Mack 2012 predictions regarding surface water drainage influence on bedrock groundwater systems.

10. Contaminant distribution described above and shown in figures for 1,4-dioxane (Figures 4.10 and 4.19) and PFAS (Figures 4.11-4.14 and Figures 4.20-4.23) in overburden and bedrock groundwater, respectively, shows concentrations decrease with increased distance from the landfill (Appendix I), and are consistent with groundwater flow directions established using groundwater potentiometric surface elevations at wells and well couplets.
    a. Concentrations of site COCs west of the landfill reflect the bifurcating groundwater flow pathways identified in the groundwater contour maps
11. Artificial hydraulic stressors created by the pumping of active private water supply wells do not appear to be sufficient to accelerate migration along the primary northeast-southwest trending flow path to pull contaminants that have infiltrated into bedrock underlying the landfill. However, short-term hydraulic gradients generated by pumping orthogonal to this flow path (e.g., R-3, 339BHR) may be sufficient to facilitate lateral migration within bedrock from individual fractures in hydraulic connection with overburden and bedrock at the north end of the bedrock trough.
    a. Transducer data for wells located closest to active pumping wells (R-3, 339 BHR) only show minor influence at one monitoring well (MW-20D1/-D2) located approximately 100 feet from the R-3 well. MW-20D1/-D2 is along the primary flow path (north-south trough), as is R-3 (see 2a. above).
    b. The influence observed during the pumping test extended roughly 300 feet orthogonal to the primary fracture network. Over time, the cumulative impacts of withdrawals from residential wells, could have a similar impact to the transport of contaminants orthogonal to the primary fracture network
12. Elevated concentrations of PFAS in Berrys Brook and the wetland complex compared to overburden groundwater concentrations are the result of discharge of the shallow groundwater plume to the surface water and includes a significant contribution from landfill surface water runoff. This is supported by the following:
    a. PFAS surface water concentrations in Berrys Brook are similar to or higher than the highest PFAS concentrations in groundwater detected in wells near to the landfill. However, the SSSLs for surface water were lowered on September 1, 2022. The lowering of these screening levels for the Child Recreator (exposure factor equal to 120 days) resulted in the exceedance for PFOA at six locations, PFOS at five locations, and PFNA at three locations. SSSLs were not exceeded for PFHxS or PFBS at any location.
    b. PFAS compositional analysis indicates that surface water samples have a different composition than most overburden and bedrock monitoring wells except for those located along the western edge of the landfill, which are influenced from direct stormwater discharge to surface water or infiltrating stormwater run-off from the landfill (Appendix B; *Stormwater Investigation Report* (Haley Ward, 2019)).

c. PFAS were detected at elevated concentrations in landfill stormwater runoff (including samples from outfalls discharging to the wetland complex) and did not contain other Site contaminants (namely 1.4-dioxane).

d. The majority of landfill stormwater is discharged to infiltration basin that direct runoff to infiltrate into overburden groundwater.

e. Water levels in piezometers and surface water gaging stations support infiltration of groundwater from surface water proximal to the landfill, particularly the stormwater discharge basins, and discharge of groundwater further from the landfill in the wetland complex

The Site CSM will continue to be refined based on additional studies being conducted in the Seacoast area by the USGS, NHDES, and others, as week as continued collection of data from the Site.

5.4 Fate of Site Contaminants

The USEPA completed an RI for OU-1 (source control) in 1990 and an RI for OU-2 (management of migration) in 1994. Both studies identified impacted groundwater beneath and outside the boundary of the landfill. VOCs detected at the Site included benzene, ethyl benzene, chloroethane, chlorobenzene, and xylene. Semi-volatile organic compounds (SVOCs) detected at the Site included predominantly PAHs and dichlorinated benzenes. Inorganic compounds detected in groundwater and sediment samples included arsenic, barium, iron, lead, manganese, nickel, beryllium, selenium, and vanadium.

Beginning in 1996, the waste from along the perimeter of the landfill was relocated to the top of the landfill. Wetland sediments were removed from adjacent to the landfill and placed on the landfill during 1997 and 1998 and the engineered cover system was installed on the landfill in 1998. The layer of topsoil that was placed on the landfill cap was augmented with compost and sand. The augmented cap was constructed before PFAS were identified as emerging contaminants. Following completion of the landfill cap, the plume of VOC- and chlorinated VOC-contaminated groundwater stabilized and began attenuating based on sampling results in the late 1990s and early 2000s.

1,4-dioxane and PFAS were added to the monitoring program in 2009 and 2016, respectively, because they were identified to be present in groundwater at the Site and found to be migrating from the Site into groundwater. Additional changes in the sampling program have included the alignment of the VOC analyte list with NHDES requirements.

Today, primary remaining dissolved phase contaminants at the Site include 1,4-dioxane and PFAS, although contaminants typical of landfill leachate are also present, including iron, manganese, and arsenic. PFAS, 1,4-dioxane, arsenic, and manganese continue to be detected at concentrations above AGQS in several monitoring wells at the Site. Groundwater trends demonstrate primarily statistically significant decreasing or no trends. Although a number of wells have sufficient variance in the data such that a statistically significant trend cannot be determined (i.e., no trend), most wells show a decreasing trend in site contaminant concentrations.

5.5 Potential Receptors

Potential receptors for contaminants of concern were identified in the vicinity of the Site. Residents utilizing water supply wells north of the Site along Breakfast Hill Road (BHR) from Berry Farm Lane (BFL) to the east and 346 BHR to the west, including Stone Meadow Way and Red Oak Drive along with the Breakfast Hill Golf Club (339 BHR), are considered potential receptors because these properties are in close proximity to an interpreted groundwater flow pathway from the Site. The CLG has conducted semiannual sampling in that area since 2017 to assess the nature and extent of impacts, if any, in existing supply wells. Low concentrations of 1,4-dioxane have been detected at two locations: the Breakfast Hill Golf Club clubhouse well at 339 Breakfast Hill Road (339BHR) and a residential well designated R-3 located at 368 Breakfast Hill Road (368 BHR) located south of the golf course clubhouse on the south side of Breakfast Hill Road. PFOA has additionally been detected at low concentrations in 339 BHR. Water supplies at 339 BHR and R-3 (368 BHR) have been provided with point of entry treatment (POET) systems by CLG since December 2018 to address 1,4-dioxane exceedances resulting from the lowering of the AGQS for 1,4-dioxane in 2018 from 3.0 ug/L to 0.32 ug/L. The water quality in these wells is largely the same as it has been historically, and it is only the lowering of the AGQS for 1,4-dioxane and PFAS that has resulted in exceedances.

Properties in the Falls Way and September Drive subdivision areas west of the Site have also been evaluated as potential receptors by sampling private wells. Cross sections including vertical flow nets (Figures 4.4-4.6) and groundwater potentiometric surface contour maps (Figures 4.9, 4.15A and 4.15B) detailing flow in shallow and deep bedrock, have been generated and include interpretations of groundwater flow in bedrock to the west of the wetland complex. These interpretations are supported by gauging and analytical data measured at additional deep bedrock wells installed at MW-20D1/D2, MW-21D1/D2, and MW-22D1/D2. Additionally, the deep bedrock pumping test has illustrated the 5:1 anisotropy coincident with the primary fracture zones present in the deep bedrock underlying the landfill as modeled by Mack 2012 and demonstrating limited migration for contaminants within the secondary fracture flow path (orthogonal to primary north-south oriented fracture network). These lines of evidence support the influence of the bedrock fabric as well as the hydraulic influence of the bedrock trough and surface water drainages to bedrock groundwater flow pathways and resistance to western migration of site contaminants. These lines of evidence, along with the absence of landfill COCs detected in these wells since sampling began in 2017, indicate these neighborhoods are not within the groundwater flow pathways identified at the Site and contamination from the landfill is not migrating to these neighborhoods.

Most properties east and southeast of the Site are served by public water supplies; however, 178A Lafayette Road (178A LR) has a private well still in use. The well at 178A LR is located approximately 1,500 feet southeast of the landfill along Lafayette Road (U.S. Route 1) and has been offered by the CLG for connection to the municipal water supply managed by Aquarion, but the property owner has not provided consent at the time of reporting.

Impacts to the south of the landfill extends approximately 800 feet along an interpreted north-south flow path in bedrock coincident with the bedrock trough underlying Little River to the south and Berrys

Brook to the north. Development present between the landfill and North Road, approximately 4,000 feet south of the landfill, is predominantly on public water supply. Much of this area is part of the wetland complex located west of the Site. Several private wells are located along North Road, including a cluster of wells associated with Wood Knoll Drive and Birch Road south of North Road. This cluster of wells is separated from the Site by the Little River and is greater than 5,000 feet from the landfill. There is additionally a private well (67NR) located approximately 900 feet north of North Road, which is within the Site GMZ. Despite efforts to obtain approval from the property owner to monitor this well, access has been denied.

Based on the defined flow path toward the south, these private wells have also been evaluated as potential receptors. Sampling results for these wells do not show detections of 1,4-dioxane that is typically present in landfill-impacted groundwater. There have been detections of PFAS in these wells at low concentrations (near laboratory detection limits) below the applicable AGQS. These detections do not appear to be attributable to the Coakley Landfill. Data collected by NHDES across New Hampshire show that "PFAS are present in a wide variety of environmental media and consumer products, with an ever-growing number of potential sources (NHDES, 2019)." These sources may include septic systems, land application of biosolids, wastewater discharge from treatment plants, atmospheric deposition and precipitation, and PFAS producing/using industries.

To further assess receptor potential and monitor migration along the interpreted southern flow path, additional subsurface investigation to the south of the landfill is proposed. The investigation will further refine the conceptual model of groundwater flow through overburden and bedrock south of the landfill (and south of GZ-105/MW-25D1/D2) and determine if these residences are potential receptors of landfill impacts. This investigation was provided to the Agencies on July 1, 2022, in the *Bedrock Well Installation Work Plan* (Wood, 2022) with Agency comments received on July 11, 2022. Further details on the investigation have been included in Section 7.

6.0 CONCLUSIONS

The following is a summary of conclusions presented throughout this report:

- Observed stratigraphy consists of discontinuous glacial outwash overlying discontinuous marine deposits, overlying till, and overlying fractured bedrock. Overburden thickness ranges from less than one foot in upland areas (e.g., MW-21D) to up to nominally 85 feet west-northwest of the landfill. Bedrock outcrops are largely in areas north and northwest of the landfill. The landfill sits on a bedrock topographical high.
- Lithologies underlying the study area are composed of the Rye Complex, a major geologic unit comprised of the Rye Formation (phyllite, quartzite, schist, and volcanics) and the Breakfast Hill Granite (also referred to as the Central Silicic Complex, composed of a felsic gneiss and igneous intrusive rocks). Based on borehole geophysics statistical analysis and analysis of bedrock outcrop fracture orientation measurements, the primary fracture orientation is northeast-southwest with a median dip of 64° to the west-northwest (WNW). Secondary, steeply dipping fracture sets are generally orthogonal to the primary network. Shallow dipping sheeting fractures were found to be uncommon and often, not transmissive for groundwater.
- Groundwater occurs in glacial till, marine clays, glacial outwash, and within permeable fractures in the bedrock underlying the Site.
    - Groundwater flow from the capped landfill area is primarily to the west where local hydraulic gradients are dictated by the lithologic changes associated with the bedrock trough and overburden stratigraphy. Vertical flow nets included in the cross sections illustrate how marine clays in the trough may confine groundwater flow along the glacial till, shallow groundwater interface while hydraulic gradients drive the transmission of groundwater proximal to the landfill, downgradient and outside of the extent of the marine clays to discharge to surface water. Along the edge of the wetland complex, the till either daylights at the surface or is in direct contact with outwash deposits that are capable of transmitting groundwater to the surface. The surficial material thickness maps and cross sections, figures 4.2 and 4.4 through 4.6 illustrate the extent of this marine clay. Once in the trough, the bifurcation of flow is driven by bedrock topography, where overburden and bedrock groundwater north of the identified saddle, discharges to the Berrys Brook watershed and groundwater south of the saddle discharges to the Little River watershed. The upcoming surface water evaluation will take a closer look into the mechanisms of groundwater and surface water communication.
    - To the east of the Site, the flow regime is also dictated by lithology and hydraulic head gradients. As shown on the vertical flow nets, just east of the Site, there is a westward flow component in the glacial outwash and in deep bedrock. However, there is a slight eastward component of flow through glacial till and shallow bedrock that is constrained by the overlying marine clay. Based on interpretations of topographic changes and understanding of regional flow patterns, a groundwater divide, driving groundwater flow

in the glacial outwash and deep bedrock flow to the east, must exist outside the extent of identified site impacts. Mounding of overburden groundwater due to the presence of the landfill identified in the RI, prior to the installation of the current landfill cap, is identified as a historic transport pathway to the east. Installation of the cap has eliminated this mounding, resulting in the current flow regime through overburden.

- Groundwater flow and migration pathways through fractured bedrock is controlled by the regional hydrogeology and the fracture orientation of the system, which is interconnected and interrelated.
    - The predominant pathway for migration through bedrock is along the northeast-southwest primary fracture network, coincident with the identified bedrock trough
    - Secondary/limited migration East-Southeast – West-Northwest along cross-cutting fractures parallel to the secondary set of lineaments,
    - Limited migration laterally through sheeting fractures that have horizontal to very shallow dips.
    - The bedrock trough immediately west of the Site influences groundwater flow within the fractured bedrock aquifer underlying the Site, acting as an outlet for groundwater discharge. This discharge of surface water drives local hydraulic gradients, pulling groundwater along vertical gradients proximal to the site.
    - Deep bedrock in the trough is in direct hydraulic communication with the overburden groundwater and surface water, as evidenced by the immediate response in water levels to precipitation.
    - To the east of the landfill, vertical flow nets indicate that the hydraulic draw of the Berrys Brook and Little River surface water outlets is ultimately pulling deep groundwater east of the landfill, towards the wetland complex. South of the landfill, there is a southern component of flow in deep bedrock towards the Little River watershed. This identification of bedrock groundwater flow is consistent with the Mack 2012 conceptualization of the influence of surface water drainages on bedrock groundwater flow.
- The results of the pumping test allow for estimates of aquifer characteristics present in the deep bedrock aquifer in the CSC over which the landfill is built. The drawdown contours generated from the test support the 5:1 anisotropy predicted by Mack 2012. These contours illustrate the interconnected fracture network is primarily along the predominant northeast/southwest strike direction.
    - The duration and rate of pumping on the fractured bedrock well MW-6 would provide a significantly greater quantity of water than would be expected from residential private well. Being utilized at its maximum well yield for five consecutive days, well MW-6 exhibited a cone of depression extending roughly 1,500 feet along the primary north to south fracture network and roughly 300 feet to the east and west.

- Aquifer properties parallel to the primary north/south strike direction were estimated to be:
  - Transmissivity (T): 108.4 feet^2/day
  - Storativity (S): 4.316×10^{-5}
  - Conductivity (K): 0.62 feet/day
- Transmissivity and conductivity in the orthogonal direction should be roughly 1/5 of those values.

- PFAS and 1,4-dioxane are migrating westward from the landfill through bedrock and overburden sediments consistent with principal groundwater flow direction based on observed hydraulic gradients.
  - Groundwater is subsequently discharging to, and surface water is collecting in, a wetland complex located west of the landfill. Surface water flow from this wetland complex is both south towards North Road and north towards Breakfast Hill Road, consistent with dominant fracture strike (and a bedrock valley or trough).
  - To a lesser extent, PFAS and 1,4-dioxane are also present east away from a bedrock topographic high located east of the landfill footprint. However, the presence of these compounds is constrained by the distribution of glacial till directly overlying bedrock and the presence of the marine clay which inhibits further migration.
  - Along established flow paths, the capacity for contaminant migration and stability of the plume is well understood. Contaminant migration is driven by the combination of overburden and bedrock lithology and hydraulic gradients. Plume stability has been confirmed with statistical evaluation of groundwater and surface water analytical results.
- Artificial hydraulic stressors created by the pumping of active private water supply wells do not appear to be sufficient to accelerate migration along the primary northeast-southwest trending flow path. However, short-term hydraulic gradients generated by pumping are likely orthogonal to this flow path (e.g., R-3, 339BHR) and may be sufficient to facilitate lateral migration within bedrock from individual fractures in hydraulic connection with those located along and within the primary flow path.
- Elevated concentrations of PFAS in Berrys Brook and the wetland complex compared to overburden groundwater concentrations are the result of discharge of groundwater and surface water runoff from the landfill. Further evaluation of the dynamics of overburden groundwater, surface water, and stormwater conditions will further refine the understanding of these systems and better quantify the mass flux of contaminants from the landfill.

7.0 RECOMMENDATIONS

Support for the CSM has been provided throughout this report, tying together multiple lines of evidence to provide context to groundwater flow and contaminant fate and transport. This includes the review of historic mining and landfilling activities, evaluation of historic geologic and hydrogeologic data for overburden and bedrock, evaluation of regional geologic and hydrogeologic characteristics, additional bedrock monitoring well installations, monitoring of residential supply wells, geophysical surveys, downhole geophysics at individual boreholes, bedrock outcrop mapping, evaluation of fracture characteristics, the constant rate pumping test to determine aquifer properties, long term monitoring of water levels at monitoring wells, and continued monitoring of groundwater and surface water quality and hydraulic gradients. This has established a more detailed understanding of the CSM and allowed for the identification of further work necessary to identify gaps in knowledge outside of the scope of the Deep Bedrock Investigation. Contaminant distribution and migration are well understood in the deep and shallow Bedrock; and ongoing groundwater monitoring continues to evaluate plume stability of site contaminants.

The work done during the deep bedrock investigation has provided defendable explanations using multiple lines of evidence to address the concern expressed in the addendum to the fourth FYR report that "long-term uncertainty remained with respect to potential migration of contaminants in ground water within deeper portions of bedrock at the Site." Even so, continued data collection and monitoring is recommended to augment the long-term monitoring program. These recommendations are as follows:

1. Surface Water Gauging to Confirm Groundwater/Surface Water Interaction West of the Site

Overburden and bedrock groundwater flowing west from the landfill area discharges into the wetland complex and/or the streams emanating from the wetland complex. Additional surface water gauging is recommended to confirm this groundwater/surface water interaction west of the Site. The surface water gauging locations are based on:

- Surface and bedrock topography;
- Distribution of overburden lithologies, specifically glacial till and marine clay
- Watershed boundaries;
- Prominence of upward/neutral vertical gradients and ambient upward flow;
- Groundwater elevations in new wells on the west side of the wetland complex; and
- Contaminant concentrations in surface water.

Surface water gauging locations were added to select locations within the wetland complex, Berrys Brook, and Little River during deep bedrock investigation activities completed in 2018. Based on the evaluation of surface water elevations within the project area relative to overburden groundwater and surface water interactions, additional gauging locations were installed west of the wetland complex in 2021. These gauging locations also serve as porewater and surface water sampling locations, which will be utilized to further assess surface water and groundwater hydraulic interaction related to the wetland complex. Synoptic water levels have been collected from these locations since Fall 2021. Samples were collected in November 2021 and were proposed for collection during Spring 2022. These data are expected to provide additional information on overburden groundwater and surface water interaction at the Site.

To supplement the Surface Water Evaluation, as outlined in the June 25, 2020 *Revised Surface Water Evaluation Work Plan* (Haley Ward, 2020), the CLG proposes the installation of paired transducers at select piezometer locations to monitor surface water levels outside the piezometer (for those in standing water) and shallow groundwater levels inside the piezometer. Due to the catchment area and role that surface water head variations play in the migration of contaminants within the investigation area, monthly measurements are believed to be insufficient to capture the short-term variations in head during and immediately following a precipitation event. The addition of supplemental water level information in these two units will be used to better understand the relationship and movement of water between them. The deployment of these transducers will occur during Fall 2022, with a list of piezometers and monitoring locations provided to the Agencies following installation. Locations will be identified where sufficient standing water is present to ensure the transducers remain submerged. Transducers placed in surface water adjacent to existing piezometers will be within PVC stilling tubes affixed to piezometer risers.

2. Monitoring Well Installation West of MW-21S

As discussed above, there is a primary groundwater flow path from the Site to the west with discharge to the wetland complex and then to headwaters of Little River (south) and Berrys Brook (north). This is supported by groundwater and surface water elevations, contaminant distribution, overburden lithology, local topography, and watershed boundary positions for the two streams.

Additional investigation of the saturated overburden and its westward extent near MW-21S was conducted as through the DPT Investigation (see Section 3.5.1). Results for the eight locations sampled during Spring 2022, based on location within the western portion of the GMZ and position relative to FPC-6A and MW-21S, indicate western migration within overburden is limited and that only minor detections of PFAS, 1,4-dioxane, arsenic, and manganese occur outside the current GMZ boundary. Results at TMW-1 were similar to those at TMW-11S and TMW-11D (Figure 3.5), with no exceedances of PFAS at any of the TMW locations sampled. Exceedances of 1,4-dioxane were reported at TMW-1 (0.93 ug/L), TMW-11S (2 ug/L), and TMW-11D (1.7 ug/L). Though detections were reported for some PFAS in locations west of the current GMZ (TMW-3, TMW-6S), most were estimated concentrations at or below respective reporting limits.

Based on these data, a permanent overburden monitoring well is proposed west of the current GMZ at TMW-3 to serve as the monitoring location for the GMZ boundary. The well will be screened within the same interval as at TMW-3 (Appendix A) with the well to be constructed of 2-inch diameter PVC, silica sand filter pack, and bentonite seal. The GMZ boundary will be moved west of the new monitoring well location. The well will be sampled as part of ongoing sampling performed at the site. The temporary monitoring wells installed as part of the DPT effort will be gauged with existing overburden and bedrock monitoring wells as part of regular sampling events but not sampled. The gauging will assist in the monitoring of localized overburden groundwater gradients in the western portion of the GMZ. Details on the final well placement and proposed GMZ boundary expansion will be included as part of the pending GMP renewal between the CLG and NHDES and be located west of the final well placement.

3. Monitoring Well Completion and Sampling to Confirm of Delineation of Southward Migration of Site Contaminants

Properties south and east of the landfill between North Road and the Site are served by a municipal water supply, with the exception of a well at property designated as 178A Lafayette Road (LR). The well in this location has been approved for connection to a municipal supply at the time of reporting, though consent has not yet been obtained from the owner. The bedrock well at 178A LR may continue to be included in the long-term monitoring network if the property is connected to public water. However, an evaluation of well integrity would be required to ensure casing seal. 1,4-dioxane has been detected historically in this well. Concentrations have been below the AGQS but were slightly above the AGQS during the Spring 2022 groundwater sampling event.

Private water supply wells serve properties south of North Road, which are over 4,500 feet south of the landfill. Several supply wells on Wood Knoll Drive and Birch Road are included in the long-term monitoring network. Samples from these wells have not shown 1,4-dioxane detections but have detected PFAS at concentrations below the AGQS. The PFAS detected at these wells are of a slightly different composition than those typically detected closer to the landfill. Detections at these wells are likely a background condition from sources unrelated to the landfill as these properties are separated from the Site by the Little River. The Little River valley is a groundwater discharge location that reduces the potential for groundwater to migrate beyond the river valley to water supply wells beyond the river.

To supplement the long-term monitoring of the southern extent of COC migration in deep bedrock, MW-25 has been completed as a permanent bedrock groundwater monitoring location in accordance with the *Draft Deep Bedrock Well Interval Packer Sampling Results and Well Construction Recommendations: MW-25* memorandum. This was submitted to the USEPA and NHDES on November 7, 2021 and incorporated comments provided by the USEPA in its January 27, 2022 letter to the CLG. Well construction details for MW-25D1/25D2 are included in Appendix A. These two wells have been added to the regular sampling events.

The southern extent of landfill COC migration is bounded to the east and west by FPC-3A/B and FPC-4A/B, respectively, as indicated on Figures 4.10 through 4.16 and 4.21 through 4.27. There is also a general lack of receptors to the south and east of the Site since most locations are served by municipal water supply, are proposed for connection to a municipal water supply (i.e., 178A LR), or are located more than 4,500 feet south of the landfill. However, the currently mapped southern extent of contamination, as observed at GZ-105 and more recently MW-25D1/-25D2, indicates there is potential for the presence of contamination located south of these locations Based on available analytical data and understanding of the transport mechanisms present at the Site, a new deep bedrock well has been proposed for the Site in the area located south of GZ-105 ad north of North Road. Details on the locating and installation of this well are included in the *Draft Bedrock Well Installation Work Plan* (Wood, 2022).

The *Draft Bedrock Well Installation Work Plan* was submitted to the USEPA on July 1, 2022. USEPA provided comments on July 11, 2022. A *Revised Bedrock Well Installation Work Plan* incorporating Agency comments is under development at the time of this report.

To guide locating where the new bedrock well will be installed and further refine the CSM, electrical resistivity profiling is proposed to identify areas of anomalous electrical resistivity characteristic of bedrock fractures and variations in bedrock topography anticipated within the northeast-southwest oriented bedrock trough west of the Coakley Landfill. For data collection in the area south of the GMZ (and north of North Road), the potential for electrical interference may be present from underground utilities and infrastructure. Management of this potential will be evaluated based on site conditions with seismic refraction profiling proposed to address interference while meeting data quality objectives. Following the collection and interpretation of electrical resistivity data, results will be provided to the USEPA and NHDES for review. Recommendations for a well location will be provided by the CLG and finalized through collaboration with the Agencies.

Following concurrence on its location, a 4-inch diameter bedrock boring will be installed at least 250 feet into bedrock using air rotary, water rotary, or sonic drilling techniques. The final well depth and location will be based on the results of the surface geophysical surveying. However, based on previous bedrock borings completed in support of the Deep Bedrock Investigation (e.g., MW-20/-21/-22/-25), it is anticipated that the boring will be advanced approximately 250 feet into bedrock. Following installation and development, borehole geophysics will be performed with intervals selected for interval packer sampling. The geophysical results will be used with analytical data to design permanent well construction details. It is anticipated that up to two bedrock wells will be installed and be paired with an overburden well to monitor vertical gradients.

4. Optimization of Long-Term Groundwater Monitoring Plan

Environmental monitoring results for the 2021 sampling events and trends in groundwater quality parameters are generally consistent with the CSM and overall trends in groundwater quality noted in previous years. Compounds and locations that exceeded regulatory thresholds during recent long-term monitoring events were similar to historical monitoring events reported for the Site. This deep bedrock investigation has provided data on groundwater quality, bedrock stratigraphy and structure, and contaminant distribution to further support and refine the CSM.

Eight additional deep bedrock wells have been installed since 2018 with at least 6 more proposed in the *Deep Bedrock Investigation Work Plan Addendum* (Haley Ward, 2020) through completion of existing open bedrock boreholes at MW-24, GZ-109, and GZ-130. As discussed in Recommendation Nos. 2 and 3, two additional bedrock wells (nested pair along southern migration pathway) and two overburden wells (one west of MW-21S and one paired with new southern pathway bedrock wells) are proposed that will allow for completion of a long-term monitoring network at the Site. Following installation and initial round of analytical results for these wells, a spatial and statistical analysis of the monitoring network will be performed to identify redundancy and optimize long-term monitoring efforts completed at the Site. This analysis will address sampling frequency, analyte list, and sampling locations and at a minimum include those locations with sufficient data to facilitate statistical analysis.

It is anticipated that a revised long-term monitoring plan will be submitted to USEPA to incorporate deep bedrock monitoring with overburden and shallow bedrock monitoring to assess Site conditions going forward from this deep bedrock investigation.

8.0 REFERENCES

Appledore Engineering, 1993, Berry's Brook Watershed Management Plan.

Billings, M.P. (1956). The geology of New Hampshire; Part II, Bedrock Geology: New Hampshire State Planning and Development Commission.

Bothner Wallace A, Kane Patrick, Stoesz Erin, Sorota Kristin, Laird Jo, Hussey Art, Dorais Mike, Wintsch Bob, Hepburn Chris, Kunk Mick, 2015, Ages of the Rye Complex, Coastal NH: a Deformational History Slowly Revealed.

Burton, W. C., L. N. Plummer, E. Busenberg, B. D. Lindsey, and W. J. Gburek (2002), Influence of Fracture Anisotropy on Groundwater Ages and Chemistry, Valley and Ridge Province, Pennsylvania, *Ground Water*, 40 (3), 242–257.

CDM Federal Programs Corp. (May 1, 1994). Remedial Investigation/Feasibility Study Report. Coakley Landfill.

Degnan, J.R., and Clark, S.F., Jr., 2002, Fracture Correlated Lineaments at Great Bay, Southeastern New Hampshire: U.S. Geological Survey Open-File Report 02-13.

Duffield, G.M., 2007. *AQTESOLV for Windows Version 4.5 User's Guide*, HydroSOLVE, Inc., Reston, VA.

Escamilla-Casas José Cruz, 2003, Bedrock Geology of the Seacoast Region of New Hampshire, U.S.A.

Escamilla-Casas José Cruz, Schulz Jeffrey E., 2015, Tectonic Interpretation of Topographic Lineaments in the Seacoast Region of New Hampshire.

Fan, Y., L. Toran, and R. W. Schlische (2007), Groundwater flow and groundwater-stream interaction in fractured and dipping sedimentary rocks: Insights from numerical models, Water Resource. Res., 43, W01409, doi:10.1029/2006WR004864.

FB Environmental, 2011, Little River Watershed Based Plan.

Ferguson Eric W, Clark Jr. Stewart F, Moore Richard Bridge, 1997A, Lineament Map of Area 1 of the New Hampshire Bedrock Aquifer Assessment, Eastern New Hampshire.

Ferguson Eric W, Clark Jr. Stewart F, Picard M. Zoe, Moore Richard Bridge, 1997B, Lineament Map of Area 3 of the New Hampshire Bedrock Aquifer Assessment, Eastern New Hampshire.

Golder Associates, Inc. (1996), Final (100%) Design Report, Coakley Landfill, North Hampton, New Hampshire (May 1996).

Haley Ward, Inc./CES, Inc. (2014). Health and Safety Plan. Coakley Landfill Superfund Site, North Hampton and Greenland, New Hampshire.

Haley Ward, Inc./CES, Inc. (October 2017). Quality Assurance Project Plan. Coakley Landfill Superfund Site, North Hampton and Greenland, New Hampshire.

Haley Ward, Inc./CES, Inc. (June 2017). Chinburg Well Report – Downhole Geophysics and Water Well Data.

Haley Ward, Inc./CES, Inc. (December 2017). Chinburg Well – Packer Testing Procedure Memo.

Haley Ward, Inc./CES, Inc. (2018a), 2017 Draft Annual Report, Coakley Landfill, Greenland, New Hampshire (January 2018). Prepared by CES, Inc. for The Coakley Landfill Group.

Haley Ward, Inc./CES, Inc. (2018b), Bedrock Investigation - Results of Packer Testing at the Chinburg Well, Coakley Landfill, Greenland, New Hampshire (February 2018). Prepared by CES, Inc. for The Coakley Landfill Group.

Haley Ward, Inc./CES, Inc. (2018c), Sampling and Analysis Plan, Coakley Landfill Superfund Site, North Hampton and Greenland, New Hampshire.

Haley Ward, Inc./CES, Inc. (May 2018a). Summary of Previously Performed Geophysical Investigations in the Western Portion of the GMZ for Coakley Landfill and Proposed Surface Geophysical Investigation for Deep Bedrock Well Siting.

Haley Ward, Inc./CES, Inc. (May 2018b). Memo - Coakley Landfill Geophysical Investigation Status Update.

Haley Ward, Inc./CES, Inc. (May 2018). Revised Draft – Deep Bedrock Investigation Work Plan for Coakley Landfill Superfund Site, North Hampton and Greenland, New Hampshire.

Haley Ward, Inc./CES, Inc. (June 2018). Memo – Coakley Landfill Well Couplet Locating and Surface Geophysics Update.

Haley Ward, Inc./CES, Inc. (August 2018). Deep Bedrock Downhole Geophysics and Packer Sampling Intervals MW-20/21/22, Coakley Landfill Superfund Site.

Haley Ward, Inc./CES, Inc. (October 2018). Stormwater Investigation Work Plan.

Haley Ward, Inc./CES, Inc. (November 2018). Memo – Deep Bedrock Well Interval Packer Sampling Results and Well Construction Recommendations MW-20/21/22.

Haley Ward, Inc./CES, Inc. (February 4, 2019). Deep Bedrock Boreholes – Well Construction Recommendations.

Haley Ward, Inc./CES, Inc. (April 1, 2019). Deep Bedrock Downhole Geophysics and Packer Sampling Interval Recommendations: GZ-108, GZ-109, GZ-116, GZ-119, GZ_122, GZ-125, MW-24.

Haley Ward, Inc./CES, Inc. (April 2020). Deep Bedrock Investigation Work Plan Addendum to Complete Bedrock Investigation.

Haley Ward, Inc./CES, Inc. (July 17, 2019). Revised Deep Bedrock Downhole Geophysics and Packer Sampling Interval Recommendations: GZ-110 and GZ-130.

Haley Ward, Inc./CES, Inc. (July 24, 2019). Deep Bedrock Well Couplet – Final Well Construction Recommendations MW-20, MW-21, and MW-22.

Haley Ward, Inc./CES, Inc. (September 10, 2019). Draft Deep Bedrock Reconnaissance Well Interval Packer Sampling Results.

Haley Ward, Inc./CES, Inc. (November 25, 2019). Deep Bedrock Investigation Interim Report for Coakley Landfill Superfund Site.

Haley Ward, Inc./CES, Inc. (June 2020). Revised Surface Water Evaluation Scope of Work.

Haley Ward, Inc./CES, Inc. (June 2020). Revised Deep Bedrock Geophysics and Packer Sampling Interval Recommendations: MW-6.

Haley Ward, Inc./CES, Inc. (July 2020). Deep Bedrock Investigation Work Plan Addendum, Coakley Landfill Superfund Site.

Haley Ward, Inc./CES, Inc. (August 18, 2020). MW-6 Interval Packer Sampling Results and Pumping Test Viability.

Haley Ward, Inc./CES, Inc. (October 2020). Surface Geophysical Results and MW-25 Well Locating Memorandum.

Haley Ward, Inc./CES, Inc. (October 21, 2020). Draft Deep Bedrock Investigation Pumping Test Work Plan.

Haley Ward, Inc./CES, Inc. (November 20, 2020). Revised Deep Bedrock Investigation Pumping Test Work Plan.

Haley Ward, Inc. (March 16, 2021). Draft Downhole Geophysics and Packer Sampling Interval Recommendations: MW-25.

Haley Ward, Inc. (May 2021a), Draft 2020 Annual Summary Report, Coakley Landfill, Breakfast Hill Road, North Hampton, New Hampshire.

Haley Ward, Inc. (May 2021b), Direct-Push Investigation Report, Coakley Landfill Superfund Site.

Haley Ward, Inc. (November 2021). Memo – Deep Bedrock Well Interval Packer Sampling Results and well Construction Recommendations: MW-25.

Hussey Arthur M., Bothner Wallace A., Thompson Peter J., 2016A, Bedrock Geology of the Kittery 1:100,000 Quadrangle Maine and New Hampshire.

Geofísica Internacional (2016) 55-1: Original paper Tectonic Interpretation of Topographic Lineaments in the Seacoast Region of New Hampshire, U. S. A. José Cruz Escamilla-Casas * and Jeffrey E.

Lyons J.B., Bothner W.A., Moench R.H., Thompson J.B. Jr., 1997, Bedrock Geologic Map of New Hampshire: U.S. Geological Survey State Map Series, scale 1:250,000.

Mack, Thomas J., 2012, Assessment of Ground-Water Resources in the Seacoast Region of New Hampshire, United States Geological Survey Scientific Investigations Report 2008-5222.

Massachusetts Audubon Society, 1993, Getting up to Speed: New England's Ground Water Resources.

New Hampshire Department of Environmental Services OneStop Data Mapper.

New Hampshire Department of Environmental Services, 2008, New Hampshire Water Resources Primer.

New Hampshire Department of Environmental Services, 2019, Technical Background Report for the June 2019 Proposed Maximum Contaminant Levels (MCLs) and Ambient Groundwater Quality Standards (AGQSs) for Perfluorooctane sulfonic Acid (PFOS), Perfluorooctanoic Acid (PFOA), Perfluorononanoic Acid (PFNA), and Perfluorohexane sulfonic Acid (PFHxS).

Novotny Robert F., 1969, The Geology of the Seacoast Region New Hampshire, published by New Hampshire Department of Resources and Economic Development.

Roy F. Weston, Inc. and Goldberg-Zoino and Associates, Inc., October 1988, Remedial Investigation, Coakley Landfill, North Hampton, New Hampshire.

Salvini, F., 2000, The structural data integrated system analyzer software (DAISY 2.19): Rome, Italy, Dipartimento di Scienze Geologiche, Universita degli Studi di "Roma Tre."

Salvini, F., Billi, A., and Wise, D.U., 1999, Strike-slip fault propagation cleavage in carbonate rocks: the Mattinata Fault Zone, Southern Apennines, Italy: Journal of Structural Geology, v. 21, p. 1,731-1,749.

Summit Environmental Consultants, Inc. (2013a), Groundwater Management Zone Evaluation (Final Version), Coakley Landfill, North Hampton, New Hampshire (April 2013)

Summit Environmental Consultants, Inc (2013b), Well R-3 Water Quality Sampling Results, 368 Breakfast Hill Road, Greenland, New Hampshire, Coakley Landfill, New Hampshire (April 2013).

Summit Environmental Consultants, Inc (2013c), Results of Well Sampling for Properties in Greenland, New Hampshire, Coakley Landfill, New Hampshire (May 2013).

United States Environmental Protection Agency (USEPA), June 1990, Superfund Record of Decision: Coakley Landfill, New Hampshire. EPA/ROD/R01-90-47.

USEPA. (September 1994). Record of Decision, Coakley Landfill Site, Operable Unit 2, Management of Mitigation.

USEPA, September 2001, Initial Five-Year Review Report for Coakley Landfill Superfund Site, Towns of North Hampton and Greenland, Rockingham County, New Hampshire.

USEPA, September 2006, Second Five-Year Review Report for Coakley Landfill Superfund Site, Towns of North Hampton and Greenland, Rockingham County, New Hampshire.

US Environmental Protection Agency, March 2009, Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance, EPA 530/R-09-007.

USEPA, September 2011, Third Five-Year Review Report for Coakley Landfill Superfund Site, Towns of North Hampton and Greenland, Rockingham County, New Hampshire.

USEPA, September 2016, Fourth Five-Year Review Report for Coakley Landfill Superfund Site, Towns of North Hampton and Greenland, Rockingham County, New Hampshire.

USEPA, December 2016, Letter Regarding Additional Data Needs, Coakley Landfill.

USEPA, September 2017, Addendum to Fourth Five-Year Review Report dated September 23, 2016 for Coakley Landfill Superfund Site, Towns of North Hampton and Greenland, Rockingham County, New Hampshire.

USEPA, January 18, 2018, Coakley Landfill Superfund Site, Request for Bedrock Investigation.

USEPA. (September 2018). Comments. Coakley Landfill Superfund Site, August 27, 2018 Deep Bedrock Downhole Geophysics and Packer Sampling Intervals MW-20/21/22, Coakley Landfill Superfund Site.

USEPA. (January 4, 2019). Comments – November 2018 Memo – Deep Bedrock Well Interval Packer Sampling Results and Well Construction Recommendations MW-20/21/22.

USEPA. (March 2019). Comments – February 4, 2019 Deep Bedrock Boreholes – Well Construction Recommendations.

USEPA. (May 1, 2018). Comments – March 21, 2018 Draft Deep Bedrock Investigation Work Plan.

USEPA. (May 10, 2019). Comments – April 1, 2019 Deep Bedrock Downhole Geophysics and Packer Sampling Interval Recommendations: GZ-108, GZ-109, GZ-116, GZ-119, GZ_122, GZ-125, MW-24.

USEPA. (June 18, 2019). Comments – June 18, 2019 Deep Bedrock Downhole Geophysics and Packer Sampling Interval Recommendations: GZ-110 and GZ-130.

USEPA. (August 13, 2019). Comments – July 24, 2019 Deep Bedrock Well Couplet – Final Well Construction Recommendations MW-20, MW-21, and MW-22.

USEPA. (October 29, 2019). Comments – September 10, 2019 Draft Deep Bedrock Reconnaissance Well Interval Packer Sampling Results.

USEPA. (February 6, 2020). Coakley Landfill Superfund Site, Comments, November 25, 2019, Deep Bedrock Interim Report.

USEPA. (June 17, 2020). Comments – April 2020 Deep Bedrock Investigation Work Plan Addendum to Complete Bedrock Investigation.

USEPA. (August 4, 2020). Comments – July 17, 2020 Deep Bedrock Investigation Response to Comments on Draft Bedrock Investigation Work Plan Addendum.

USEPA. (October 21, 2020). Comments – Deep Bedrock Investigation Work Plan Addendum.

USEPA. (November 6, 2020). Comments – October 21, 2020 Draft Deep Bedrock Investigation Pumping Test Work Plan.

USEPA. (December 15, 2020). Comments – November 20, 2020 Response to Comments Draft Deep Bedrock Investigation Pumping Test Work Plan.

USEPA. (March 22, 2021). Comments – March 16, 2021 Draft Downhole Geophysics and Packer Sampling Interval Recommendations: MW-25.

USEPA. (July 1, 2021). Comments – May 11, 2021 Direct Push Technology Investigation Results.

USEPA, September 2021, Fifth Five-Year Review Report for Coakley Landfill Superfund Site, Towns of North Hampton and Greenland, Rockingham County, New Hampshire.

USEPA and New Hampshire Department of Environmental Services (NHDES), March 1991, Declaration for the Explanation of Significant Differences (ESD) – Operable Unit 1.

USEPA and NHDES, May 1996, ESD Operable Unit 1, Coakley Landfill Superfund Site, North Hampton and Greenland, NH.

USEPA and NHDES, September 1999, ESD Coakley Landfill Superfund Site, North Hampton and Greenland, NH.

USEPA and NHDES, July 2007, Fourth ESD, Coakley Landfill Superfund Site, EPA ID: NHD064424153, OU 01, North Hampton and Greenland, New Hampshire.

USEPA and NHDES, September 2009, Second ESD, Coakley Landfill Superfund Site, Operable Unit 2, North Hampton and Greenland, New Hampshire.

USEPA and NHDES, July 2009, Addendum to Second Five-Year Review Report, Coakley Landfill Superfund Site.

USEPA and NHDES, July 2009, Fourth ESD (re-issued), Coakley Landfill Superfund Site, EPA ID: NHD064424153, OU 01, North Hampton and Greenland, New Hampshire.

USEPA and NHDES, August 2015, Fifth ESD for OU-1 and Third ESD for OU-2, Coakley Landfill Superfund Site, EPA ID: NHD064424153, North Hampton and Greenland, New Hampshire.

USGS - Maupin, M.A., Kenny, J.F., Hutson, S.S., Lovelace, J.K., Barber, N.L., and Linsey, K.S., 2014, Estimated use of water in the United States in 2010: U.S. Geological Survey Circular 1405, 56 p., http://dx.doi.org/10.3133/cir1405.

United States Geological Survey, 3D Elevation Program.

United States Geological Survey, National Water Information System Web Interface Tool.

United States Geological Survey, StreamStats Online Reports.

Weston Solutions, Inc. (May 2020). Summary of Bedrock Groundwater Flow Conditions, Coakley Landfill Superfund Site.

Weston Solutions, Inc. (1988). Remedial Investigation Coakley Landfill. North Hampton, New Hampshire.

Walsh, G.J., and Clark, S.F., Jr., 2000, Contrasting methods of fracture trend characterization in crystalline metamorphic and igneous rocks of the Windham quadrangle, New Hampshire: Northeastern Geology and Environmental Sciences, v. 22, no. 2, p. 109-120.

Wise, D.U., Funiciello, Renato, Parotto, Maurizo, and Salvini, Francesco, 1985, Topographic lineament swarms: clues to their origin from domain analysis of Italy: Geological Society of America Bulletin, v. 96, p. 952-967.

Wood Environment and Infrastructure Solutions, Inc. (Wood), (July 2022) Draft Bedrock Well Installation Work Plan – Coakley Landfill Superfund Site.

TABLES

Table 2.1
Site History Summary Table

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

DATE	COAKLEY SITE MILESTONES
1965	Sand and gravel operations begin at the Site.
1972	Permitted landfill operations begin at the Site. The southern portion of the Site is used for refuse from the municipalities of Portsmouth, North Hampton, Newington, and New Castle, along with Pease Air Force Base.
1973	Rock quarrying operations begin at the Site.
1977	Rock quarrying operations end at the Site.
1978 – 1979	Unknown quantity of oily debris is placed in Oily Debris Area at Landfill from local accidents.
1979	The State of New Hampshire (State) receives a complaint regarding leachate breakouts around the Site.
1981	The State granted permission to dispose of pesticides at the Landfill.
1982	The Site begins accepting incinerator residue (ash) from a nearby incinerator at Pease Air Force Base.
1982	The towns of North Hampton and Rye complete water main extensions to commercial and residential users to the east and south of the Site along Lafayette Road.
July 1982	The Landfill stops accepting municipal and industrial waste from the Portsmouth area.
1983	The State receives a complaint regarding the water quality from a nearby domestic drinking water supply well. Subsequent confirmatory sampling detects the presence of Site-related contaminants in groundwater samples to the south, southeast, and northeast of the Site.
1983	The Town of North Hampton completes a water main extension to Lafayette Terrace. The Town of Rye completes a water main extension along Washington Road and along Dow Lane.
March 1983	The State orders the Landfill to be closed to all waste except for incinerator residue (ash) from a nearby incinerator at Pease Air Force Base.
December 1983	The USEPA proposed listing the Site on the National Priorities List (NPL).
July 1985	Landfill operations cease; incinerator residue is no longer accepted.
June 1986	The USEPA lists the Site on the NPL.
August 1985	The USEPA signs a cooperative agreement with the State to conduct a remedial investigation and feasibility study (RI/FS).
1986	The Town of North Hampton completes a water main extension to Birch Road and North Road.
March 1990	The State completes the RI/FS for OU-1.

Table 2.1
Site History Summary Table

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

DATE	COAKLEY SITE MILESTONES
June 1990	The USEPA issues a Record of Decision (ROD) for OU-1. *Remedial action includes excavating and consolidating wetland sediment and solid waste and depositing into Landfill prior to capping, collecting and treating landfill gasses; pumping and treating groundwater and treatment byproducts; implementing site access restrictions; and long-term monitoring.*
September 1990	The USEPA begins a RI/FS for OU-2.
March 1991	The USEPA issues an Explanation of Significant Differences (ESD). *The ESD modifies the remedy for OU-1. Cap construction and emission treatment specifications are amended.*
February 1992	Coakley Landfill Group is formed.
May 1992	Consent decree for Site becomes effective.
June 1992	Remedy design for OU-1 begins.
September 1994	The USEPA completes the RI/FS for OU-2.
September 1994	The USEPA completes a human health and ecological risk assessment for OU-2.
September 1994	The USEPA issues the ROD for OU-2. *Remedial action includes the implementation of institutional controls, natural attenuation for the contaminated groundwater plume, and groundwater monitoring.*
August 1995	Consent decree for OU-1 becomes effective.
January 1996	The OU-1 remedy design is completed by CLG and approved by the USEPA.
May 1996	The USEPA issues an ESD for OU-1. *The ESD modifies the remedy for OU-1. The landfill gas management component of the remedy is modified to allow passive landfill gas collection and venting.*
September 1996	Construction of the OU-1 remedy begins.
1997	Wetland sediments were removed from adjacent to the landfill and placed on the landfill.
Fall 1998	Modifications to the remedy (i.e., Landfill cover, passive Landfill gas venting system, and wetland construction/restoration activities) are completed (ESD, 1996). The layer of topsoil that is placed on the Landfill cap is augmented with compost and sand. Remedial design for OU-2 began.
January 1999	OU-1 remedial design is completed, and remedial action began. The OU-2 Consent Decree for the implementation of the management of migration remedy becomes effective.
March 1999	OU-2 remedial design is completed, and remedial action began.

Table 2.1
Site History Summary Table

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

DATE	COAKLEY SITE MILESTONES
September 1999	Remedy construction for OU-2 is completed. The USEPA issues an ESD for OU-1. *Due to the efficacy of the Site remedy, the USEPA eliminates the requirement to extract and treat groundwater.*
September 1999	The State issues a Declaration of Concurrence with the USEPA ESD.
March 2000	Remedial actions for OU-1 and OU-2 are completed.
August 2001	USEPA approves the Institutional Control Plan for the Site. *This plan requires the Site to obtain deed restrictions prohibiting groundwater use on the properties without public water that overlie the contaminated groundwater. The restrictions are required to be in place by February 1, 2002.*
September 2001	First Five-Year Review (FYR) Report is issued. *The FYR concludes that the remedy remains protective of human health and the environment. The Report concludes that off-site gas levels must be brought into compliance with State regulations for methane and that the arsenic cleanup level requires review to determine whether the remedy (monitored natural attenuation) remains protective in light of any revised cleanup levels.*
September 2006	Second FYR Report is issued. *The FYR concludes that a protectiveness determination cannot be made until further information is obtained. The USEPA indicates that a protectiveness determination will be made after additional data has been collected and changes to arsenic and manganese requirements have been evaluated.*
September 2007	The USEPA issues an ESD for OU-1. *The ESD adds tetrahydrofuran as a contaminant of concern (COC) and documents changes in the standards for arsenic and manganese at the Site.*
September 2007	The USEPA issues an ESD for OU-2. *The ESD documents changes in the standards for arsenic and manganese at Site.*
June 2008	Groundwater Management Permit #GWP-198712001-N-001 is issued.
July 2009	The USEPA reissues an ESD for OU-1. *The ESD revises the September 2007 ESD to correct the MCL for arsenic.*
July 2009	The USEPA reissues an ESD for OU-2. *The ESD revises the September 2007 ESD to correct the MCL for arsenic.*

Table 2.1
Site History Summary Table

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

DATE	COAKLEY SITE MILESTONES
July 2009	Addendum to second FYR Report is issued. *The addendum modified the Second FYR Report to indicate that the Landfill gas monitoring program, a reduced surface water and sediment monitoring effort, and groundwater monitoring in OU-2 would remain/occur. The addendum indicates that the remedy at OU-1 is protective of human health and the environment in the short-term, long-term protectiveness is achieved in OU-1, and long-term protectiveness will be achieved in OU-2 when interim cleanup levels for contaminants of concern are met and use restrictions are removed. 1,4-dioxane added to monitoring program.*
May 2010	EPA approves CLG's updated OU-2 project operation plan.
March 2011	EPA determines that Site is ready for reuse and redevelopment.
September 2011	Third FYR Report is issued. *The FYR concludes that the remedy is protective of human health and the environment in the short-term, long-term protectiveness is achieved in OU-1, and long-term protectiveness will be achieved in OU-2 when interim cleanup levels for contaminants of concern are met and use restrictions can be removed.*
January 2014	Groundwater Management Permit #GWP-198712001-N-002 is issued.
August 2015	The USEPA issues an ESD for OU-1 and an ESD for OU-2. *This ESD adds 1,4-dioxane as a Site COC, expands the groundwater monitoring zone (GMZ), and identifies land use restrictions or other institutional controls for the Site.*
May 2016	CLG sampled a select group of OU-1 wells and confirmed presences of PFOA and PFOS above regulatory standards.
September 2016	The USEPA issues the Fourth FYR Report. *The FYR concludes that the remedy for OU-1 is protective of human health and the environment in the short- and long-term and that a protectiveness determination for OU-2 cannot be made until further information is obtained.*
December 2016	The USEPA issues to the CLG a Letter summarizing the additional data required to update the Fourth FYR. *The USEPA requests that all monitoring wells be sampled twice a year for two years for COC and hexavalent chromium. Surface water, sediment, and leachate samples will be collected in the Spring and Fall of 2017. Well FPC-5A will be decommissioned and replaced. Two additional monitoring well couplets will be installed, developed, and sampled in the area of the GMZ extension. A background study for arsenic and manganese will be designed and implemented. Although not formally requested, it is highly recommended that PFOA and PFOS be added to the sampling list.*
August 2017	CLG installs warning signs along Berrys Brook due to PFAS concentrations in surface water exceeding site-specific screening levels.

Table 2.1
Site History Summary Table

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

DATE	COAKLEY SITE MILESTONES
September 2017	The USEPA issues an addendum to the fourth FYR Report. *This addendum updates the Site-wide protectiveness determination in the fourth FYR Report to indicate that, based on available data, current conditions are protective of human health and the environment in the short-term because data indicated no human exposures to COCs at levels exceeding either state or federal standards. The addendum also concludes that long-term uncertainty remains with respect to potential migration of contaminants in deeper portions of bedrock at the Site.*
September 2018	AGQS for 1,4-dioxane lowered from 3 ug/L to 0.32 ug/L.
October 2018	GMP renewal application filed with a proposed expansion to the GMZ.
November 2018	CLG installs treatment system at two private wells.
December 2018	CLG submits proposal to expand GMZ.
September 2019	CLG completes a Stormwater Investigation Report confirming that PFAS in shallow groundwater and the adjacent complex is from stormwater runoff and stormwater discharge from the landfill cover system.
November 2019	CLG completes a Deep Bedrock Investigation *Interim Report.*
2020	AGQS for PFOA, PFOS, PFNA, and PFHxS are lowered.
September 2021	The USEPA issues the fifth FYR Report. *This Report concludes that the remedies at OU-1 and OU-2 are protective of human health and the environment and recommends completion of the deep-bedrock investigations to delineate the extent of contamination in bedrock groundwater and fate/transport of PFAS and COCs in groundwater. Report requests the design and implementation of a background study to determine whether concentrations of arsenic and manganese are reflective of background conditions or landfill contamination.*
September 2022	CLG completes the Deep Bedrock Investigation *Final Report.*

Table 3.1
Inventory of Monitoring Locations

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

BEDROCK WELLS										
Well	OU No.	Installation Date	Sampled	Monitored Stratum	Well Dia	Measuring Point	MP Elevation	Well Depth Below Grade	Screened Interval Below Grade	Bedrock Penetration
AE-1B	2	3/25/1999	Yes	Bedrock - Shallow	2" PVC	Top of PVC	126.80	85.5	75.5-85.5	20.5
AE-2B	2	7/27/1999	Yes	Bedrock - Shallow	2" PVC	Top of PVC	79.50	50.0	40-50	28.0
AE-3B	2	3/23/1999	Yes	Bedrock - Shallow	2" PVC	Top of PVC	86.20	40.0	30-40	23.0
AE-4B	2	9/16/2003	Yes	Bedrock - Shallow	2" PVC	Top of PVC	76.71	44.0	34-44	29.0
BP-4	1	5/17/1993	Yes	Bedrock - Deep	6" Open	Top of Casing	107.40	132.9	35.7-132.9	97.2
FPC-2B	2	4/3/1992	No	Bedrock - Shallow	2" PVC	Top of PVC	77.98	37.8	22.5-37.8	21.8
FPC-3B	2	4/27/1992	Yes	Bedrock - Shallow	1.5" PVC	Top of PVC	72.22	95.5	80.5-95.5	25.5
FPC-4B	2	6/3/1992	Yes	Bedrock - Shallow	2" PVC	Top of PVC	75.83	33.5	18-33	19.5
FPC-5B	2	5/14/1992	Yes	Bedrock - Shallow	2" PVC	Top of PVC	74.00	110.3	95-110	20.8
FPC-6B	2	3/24/1992	Yes	Bedrock - Shallow	2" PVC	Top of PVC	76.11	28.5	13-28	22.5
FPC-7B	2	5/8/1992	Yes	Bedrock - Shallow	2" PVC	Top of PVC	85.30	45.0	29.8-44.8	22.0
FPC-8B	2	4/8/1992	Yes	Bedrock - Shallow	2" PVC	Top of PVC	73.60	55.7	40-55	22.7
FPC-9B	2	5/26/1992	Yes	Bedrock - Shallow	2" PVC	Top of PVC	116.00	87.0	72-87	25.0
FPC-11B	2	6/19/1992	Yes	Bedrock - Shallow	2" PVC	Top of PVC	117.90	73.0	58-73	24.0
GZ-105	2	5/7/1987	Yes	Bedrock - Shallow	1.5" PVC	Top of PVC	73.60	50.0	35-50	18.0
GZ-108	2	3/18/1987	No	Bedrock - Deep	6" Open	Top of Casing	119.80	155.0	15-155	153.0
GZ-109	2	4/8/1987	Yes	Bedrock - Deep	6" Open	Top of Casing	119.36	252.0	103-252	161.0
GZ-110	2	3/24/1987	No	Bedrock - Deep	6" Open	Top of Casing	91.26	188.0	57-188	150.0
GZ-116	2	3/31/1987	No	Bedrock - Deep	6" Open	Top of Casing	89.50	163.0	21-163	158.0
GZ-119	2	3/30/1987	No	Bedrock - Deep	6" Open	Top of Casing	119.59	183.0	44-183	152.0
GZ-122	2	4/22/1987	No	Bedrock - Deep	6" Open	Top of Casing	87.06	190.0	50-190	153.0
GZ-125	2	4/13/1987	No	Bedrock - Deep	6" Open	Top of Casing	87.99	200.0	57-200	153.0
GZ-128 (Destroyed)	2	4/23/1987	No	Bedrock - Deep	6" Open	Top of Casing		184.0	46.5-184	149.0
GZ-130	2	3/17/1987	No	Bedrock - Deep	6" Open	Top of Casing	82.72	178.0	39-178	156.0
MW-2	1	6/10/1985	No	Bedrock - Shallow	1" PVC	Top of PVC	94.54	20.0	10-20	16.0
MW-5D	1	6/22/1993	Yes	Bedrock - Deep	2" PVC	Top of PVC	99.72	163.5	139-159	151.5
MW-5S	1	8/9/1993	Yes	Bedrock - Deep	2" PVC	Top of PVC	101.96	78.0	48-78	66.0
MW-6	1	6/19/1985	Yes	Bedrock - Deep	6" Open	Top of Casing	101.15	184.0	24-184	178.0
MW-8	1	4/25/1996	Yes	Bedrock - Shallow	2" PVC	Top of PVC	85.02	65.0	44-65	44.0
MW-11	1	4/26/1996	Yes	Bedrock - Shallow	2" PVC	Top of PVC	92.70	52.0	30-52	30.0
MW-20D1	2	8/28/2019	Yes	Bedrock - Deep	1.25" PVC	Top of PVC	75.51	75.0	65-75	65.0
MW-20D2	2	8/19/2019	Yes	Bedrock - Deep	1.5"PVC	Top of PVC	75.49	234.0	224-234	224.0
MW-21D1	2	8/28/2019	Yes	Bedrock - Shallow	1.25" PVC	Top of PVC	78.66	30.0	20-30	20.0
MW-21D2	2	8/19/2019	Yes	Bedrock - Deep	1.5"PVC	Top of PVC	78.71	307.0	297-307	297.0
MW-22D1	2	8/28/2019	Yes	Bedrock - Deep	1.25" PVC	Top of PVC	76.75	85.0	75-85	69.0
MW-22D2	2	8/19/2019	Yes	Bedrock - Deep	1.5"PVC	Top of PVC	76.78	220.0	210-220	204.0
MW-23	2	7/1/2013	No	Bedrock - Deep	6" Open	Top of Casing	80.69	282.0	48-280	280.0
MW-24	2	Unknown	No	Bedrock - Deep	6" Open	Top of Casing	118.70	142.6	80-142.6	UNKNOWN
MW-25D1	2	2/28/2022	Yes	Bedrock - Deep	1.5" PVC	Top of PVC	73.76	162.0	147-162	127.0
MW-25D2	2	3/2/2022	Yes	Bedrock - Deep	1.5" PVC	Top of PVC	73.69	219.0	214-219	184.0

Table 3.1
Inventory of Monitoring Locations

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

OVERBURDEN WELLS										
Well	Colocated Well	OU No.	Installation_Date	Sampled	Monitored Stratum	Well Dia	Measuring Point	MP Elevation	Well Depth Below Grade	Screened Interval Below Grade
AE-1A	AE-1B	2	3/26/1999	Yes	Glacial Till	2" PVC	Top of PVC	127.00	65.0	55-65
AE-2A	AE-2B	2	7/27/1999	Yes	Glacial Till	2" PVC	Top of PVC	79.60	20.0	10-20
AE-3A	AE-3B	2	3/24/1999	Yes	Glacial Till and Marine	2" PVC	Top of PVC	85.00	17.8	?? - 17.8
AE-4A	AE-4B	2	9/15/2003	Yes	Glacial Outwash	2" PVC	Top of PVC	76.45	15.0	5-15
FPC-2A	FPC-4B	2	4/3/1992	No	Glacial Outwash	2" PVC	Top of PVC	78.40	16.0	6-16
FPC-3A	FPC-3B	2	5/4/1992	Yes	Glacial Till	2" PVC	Top of PVC	73.17	73.0	63-73
FPC-3C		2	5/5/1992	Yes	Glacial Till and Outwash	2" PVC	Top of PVC	72.36	28.5	18.5-28.5
FPC-4A	FPC4B	2	6/4/1992	No	Glacial Till	2" PVC	Top of PVC	75.42	13.0	?? - 13
FPC-5A	FPC-5B	2	3/17/1992	No	Glacial Till	2" PVC	Top of PVC	73.80	70.0	60-70
FPC-6A	FPC-6B	2	8/1/2003	Yes	Glacial Till	1.5" PVC	Top of Casing	79.20	4.5	3.5-4.5
FPC-7A	FPC-7B	2	5/11/1992	Yes	Glacial Till	2" PVC	Top of PVC	87.60	22.0	12-22
FPC-8A	FPC-8B	2	4/9/1992	Yes	Glacial Till	2" PVC	Top of PVC	73.80	33.0	23-33
FPC-9A	FPC-9B	2	5/28/1992	Yes	Glacial Till	2" PVC	Top of PVC	114.10	68.0	58-68
FPC-9C		2	5/27/1992	No	Glacial Outwash	2" PVC	Top of PVC	114.60	25.0	15-25
FPC-11A	FPC-11B	2	6/23/1992	Yes	Glacial Till	2" PVC	Top of PVC	117.95	52.0	46.6 - 51.6
FPC-11C		2	6/24/1992	No	Glacial Outwash	2" PVC	Top of PVC	117.86	33.0	17.7 - 32.7
GZ-111 (Destroyed)		2	4/21/1987	No	Glacial Outwash	2" PVC	Ground	73.80	9.0	4-9
GZ-112	GZ-110	2	1/22/1987	No	Glacial Till	2" PVC	Ground	92.00	38.0	31-38
GZ-114	GZ-116	2	1/13/1987	No	Glacial Outwash	2" PVC	Ground	90.76	13.0	3-13
GZ-115		2	1/13/1987	No	Glacial Till	2" PVC	Ground	88.87	38.0	18-38
GZ-117	GZ-109	2	2/3/1987	Yes	Glacial Outwash	2" PVC	Top of PVC	118.10	40.5	30.5-40.5
GZ-120	GZ-122	2	2/4/0987	No	Glacial Outwash	2" PVC	Ground	87.16	20.2	10.5-20.2
GZ-123	GZ-125	2	2/25/1987	No	Glacial Outwash	2" PVC	Top of PVC	86.60	16.5	11.5-16.5
GZ-127 (Destroyed)	GZ-128	2	2/11/1987	No	Glacial Till	2" PVC	Ground	67.30	33.0	23-33
GZ-129	GZ-130	2	2/20/1987	No	Glacial Outwash	2" PVC	Ground	81.67	26.0	16-26
MW-1		1	6/5/1985	No	Glacial Outwash and Marine	2" PVC	Top of PVC	116.90	18.0	8-18
MW-3D (Destroyed)		1	6/7/1985	No	Glacial Till	1" PVC	Top of PVC		34.5	29.5-34.5
MW-3S (Destroyed)		1	6/7/1985	No	Glacial Outwash	1" PVC	Top of PVC		23.0	13-23
MW-4		1	6/14/1985	Yes	Glacial Till	2" PVC	Top of PVC	129.12	38.0	28-38
MW-9		1	4/15/1996	Yes	Glacial Outwash	2" PVC	Top of PVC	81.70	10.0	5-10
MW-10		1	4/15/1996	Yes	Glacial Outwash	2" PVC	Top of PVC	79.10	10.0	5-10
MW-20S	MW-20D1/D2	2	7/13/2018	Yes	Glacial Outwash	2" PVC	Top of PVC	75.09	10.0	5-10
MW-21S	MW-21D1/D2	2	7/13/2018	Yes	Marine Clay	2" PVC	Top of PVC	73.57	14.0	6-14
MW-22S	MW-22D1/D2	2	7/30/2018	Yes	Glacial Outwash	2" PVC	Top of PVC	76.51	14.0	6-14
OP-2		1	5/7/1993	Yes	Glacial Outwash and Marine	1.25" PVC	Top of PVC	100.00	12.0	7-12
OP-5		1	6/11/1993	Yes	Glacial Outwash	1.25" PVC	Top of PVC	108.40	23.0	13-23

Table 3.1
Inventory of Monitoring Locations

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Surface Water Locations					
ID	Colocated with	Measuring Point	Sampled	ELEVATION	Notes
PZ-1	SG-NE Pond	Top of Steel	Yes	99.5; 97.7	
PZ-2	SG-NW Pond	Top of Steel	Yes	84.50	
PZ-3		Top of Steel	Yes	81.58	
PZ-4	SW-4, SG-1	Top of Steel	Yes	71.60	
PZ-5	SW-5, SG-SW-5	Top of Steel	Yes	75.40	
PZ-6		Top of Steel	Yes	94.60	
PZ-7		Top of Steel	Yes	78.60	
PZ-8	SW-BB2, SG-BB-2, Sed-BB2	Top of Steel	Yes	73.6; 71.90	
PZ-9		Top of Steel	Yes	72.00	
PW-1		Top of Pin	Yes	*	Estimated
PW-2		Top of Pin	Yes	*	Estimated
PW-3	SG-3	Top of Pin	Yes	71.20	
PW-4	PZ-103, SW-103	Top of Pin	Yes	PZ: 72.5; SW: 75.5	
PW-5	SG-5	Top of Pin	Yes	72.60	
PW-6	SG-6	Top of Pin	Yes	73.60	
PW-7	SG-7	Top of Pin	Yes	*	
PW-8		Top of Pin	Yes	*	
PW-9		Top of Pin	Yes	*	
SW-110	SED-110, PZ-110	Top of Pin	Yes	68.90	Ground Elevation
SW-111	SED-111	None	Yes	38.73	Estimated
SW-4	SG-1, SED-4	Top of Pin	Yes	70.34; 71.30	Estimated
SW-5	SED-5	Staff Gauge	Yes	72.40	Ground Elevation
SW-LR	SED-LR	Top of Culvert	Yes	68.90	Top of Concrete Headwall
SW-BB1	SED-BB1	Top of Pin	No - P&A'ed	70.00	Estimated
SW-BB3	SED-BB3	Top of Pin	Yes		Estimated
SG-2		Top of Pin	Yes	71.30	
SG-4		Top of Pin	Yes	71.50	

Sediment Locations				
ID	Colocated with	Sampled	ELEVATION	Notes
SED-4	SW-4	Yes	70.34	SW-4 (Estimated)
SED-5	SW-5	Yes	72.40	GROUND
SED-110	SW-110	Yes	67.10	GROUND
SED-111	SW-111	Yes	38.73	SW-111 (Estimated)
SED-LR	SW-LR	Yes	68.90	TOP CONC HEADWALL
SED-BB1	SW-BB1	No - P&A'ed	70.00	GROUND
SED-BB2	SW-BB2	Yes	71.90	GROUND
SED-BB3	SW-BB3	Yes		

Leachate Locations					
ID	Colocated with	Measuring Point	Sampled	ELEVATION	Notes
L-1	PZ-3	Staff Gauge (L-1)	Yes	78.50	L1 STAKE

NOTES:
SG = Staff Gauge
* = no elevation data
Shallow bedrock <75 ft below grade
Deep Bedrock > 75 ft below grade

Table 3.1A
Details of Sampled Residential Wells

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

RESIDENTIAL WELLS												
Well	**Contact/Owner/Business Name**	**Town**	**Address**	**Sampled**	**Well Type**	**In GMZ?**	**Well Record Available?**	**Well Depth (ft bgs)**	**Depth To Bedrock (ft bgs)**	**Casing Depth (ft bgs)**	**Well Diameter**	**Notes**
339BHR	Breakfast Hill Golf Club LLC	Greenland	339 Breakfast Hill Rd	Yes	Bedrock	Yes	No	Not Available	Not Available	Not Available	Not Available	
340BHR	Sewall Elmer M Rev Trust	Greenland	340 Breakfast Hill Rd	Yes	Bedrock	No	Yes	200	30	44	6"	
346BHR	Stephen A & Mary Ann Sewall	Greenland	346 Breakfast Hill Rd	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	
R-3(368BHR)	Patrick J & Melisa A St John	Greenland	368 Breakfast Hill Rd	Yes	Bedrock	Yes	No	Not Available	Not Available	Not Available	Not Available	
415BHR	Breakfast Hill Trust I+II+III	Greenland	415 Breakfast Hill Rd	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	
463BHR	Seacoast Mental Health	Greenland	463 Breakfast Hill Rd	Yes	Bedrock	No	Yes	300	30	30	6"	"Broken Ledge" at 20 ft bgs
4SMW	Trevor B & Maria S Emory	Greenland	4 Stone Meadow Way	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	
9SMW	Thomas E & Brooke A Conlin	Greenland	9 Stone Meadow Way	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	
10SMW	David H & Liza B McGuckin Trustees	Greenland	10 Stone Meadow Way	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	
16SMW	Dan Lynch	Greenland	16 Stone Meadow Way	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	
19SMW	Timothy J & Aimee C Miller	Greenland	19 Stone Meadow Way	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	
21SMW	D.B. Farrell & C.M. Vermette	Greenland	21 Stone Meadow Way	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	
4ROD	Theresa A Sorenson Revocable Trust	Greenland	4 Red Oak Dr	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	
10ROD	Arthur D & Sharon M Hoffman	Greenland	10 Red Oak Dr	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	
25FW	Dan White	Greenland	25 Falls Way	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	
5BFL	Heidi Nigro	Greenland	5 Berry Farm Ln	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	
9BFL	Ellie Eckhoff	Greenland	9 Berry Farm Ln	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	
15BFL	Pamela L Gove	Greenland	15 Berry Farm Ln	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	
7WKD	Jeanne Brown	Greenland	7 Woodknoll Dr	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	
8WKD	Janet Knowles	North Hampton	8 Woodknoll Dr	Yes	Bedrock	No	Yes	220	84	101	6"	
27BR	James & Susan Buchanan	North Hampton	27 Birch Rd	Yes		No	No	Not Available	Not Available	Not Available	Not Available	Irrigation well
178ALR	Dean N E & Cora A Stevens Trustees	North Hampton	172-178 Lafayette Rd	Yes	Shallow	No	No	Not Available	Not Available	Not Available	Not Available	
67NR	Walter Nordstrom	North Hampton	67 North Rd	Yes	Shallow	Yes	No	Not Available	Not Available	Not Available	Not Available	
14PWC	JENNA SWEET	Greenland	14 Pinewood Circle	Yes	Bedrock	No	No	Not Available	Not Available	Not Available	Not Available	

Table 3.2
Vertical and Horizontal Hydraulic Gradients - Select Well Couplets

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Monitoring Well	Geologic Unit	Primary Vertical Gradient	Ground Elevation	Screened Depth (ft bgs)	Bottom of Screen Elevation	GW Elevation January 2019	GW Elevation May 2019	GW Elevation July 2019	GW Elevation September 2019	GW Elevation May 2020	GW Elevation October 2020	Vertical Gradient January 2019	Vertical Gradient May 2019	Vertical Gradient July 2019	Vertical Gradient September 2019	Vertical Gradient May 2020	Vertical Gradient October 2020	Average of Primary Vertical Gradient	Overburden Horizontal Gradient
MW-5S	SBR	Down	99.30	48-78	21.30	91.15	91.08	90.21	87.90	91.09	87.13	0.007	-0.006	-0.007	-0.008	-0.005	-0.007	-0.007	0.003
MW-5D	DBR		97.58	139-159	-61.42	91.72	90.60	89.64	87.25	90.70	86.52								
AE-1A	Till	Down	125.00	55-65	60.00	98.60	98.48	97.73	96.28	98.73	95.65	0.000	-0.001	-0.001	-0.001	-0.001	-0.002	-0.001	NA
AE-1B	SBR		125.00	75-85	40.00	98.59	98.47	97.72	96.27	98.72	95.62								
AE-2A	Till	Up	76.97	10-20	56.97	75.88	75.83	75.18	72.70	75.82	71.65	0.019	0.019	0.014	0.014	0.018	0.013	0.016	0.0075
AE-2B	SBR		77.04	40-50	27.04	76.44	76.40	75.60	73.13	76.36	72.05								
AE-3A	Till	Up	82.80	7.8-17.8	65.00	76.87	76.83	76.37	75.45	76.67	75.07	0.032	0.033	0.026	0.019	0.031	0.019	0.027	0.0125
AE-3B	SBR		82.80	28-40	42.80	77.57	77.56	76.95	75.87	77.35	75.49								
AE-4A	Outwash	Up	74.20	5-15	59.20	72.94	72.93	72.34	69.43	72.80	67.33	0.006	0.006	-0.002	-0.003	0.004	0.004	0.005	0.002
AE-4B	SBR		74.01	34-44	30.01	73.11	73.10	72.29	69.33	72.92	67.45								
FPC-2A	Outwash	Up	75.60	6-16	59.60	Frozen	75.68	75.39	74.67	75.64	74.31	NC	0.079	0.076	0.065	0.075	0.061	0.071	0.015
FPC-2B	SBR		75.40	22.8-37.8	37.60	Frozen	77.42	77.06	76.11	77.28	75.65								
FPC-3A	Till	Down	70.57	63-73	-2.43	Frozen	70.51	70.72	68.95	71.02	67.94	NC	-0.002	-0.021	-0.001	-0.021	0.000	-0.011	0.005
FPC-3B	SBR		70.57	80.5-95.5	-24.93	70.50	70.47	70.25	68.93	70.55	67.95								
FPC-3C	Outwash	Neutral	69.68	18.5-28.5	41.18	Frozen	71.13	70.77	68.95	71.04	67.94	NC	-0.014	-0.001	0.000	0.000	0.000	NA	0.005
FPC-3A	Till		70.57	63-73	-2.43	Frozen	70.51	70.72	68.95	71.02	67.94								
FPC-5A	Till	Up	73.80	60-70	2.06				70.88	71.7	70.52	NC	NC	NC	0.021	0.042	0.018	0.027	0.0075
FPC-5B	SBR		74.00	95.3-110.3	-37.68				71.70	73.35	71.23								
FPC-6A	Till	Down	73.66	1.8-2.8	70.86	72.79	72.75	72.03	72.14	72.57	69.67	-0.020	-0.021	-0.016	-0.099	-0.017	-0.022	-0.032	0.001
FPC-6B	SBR		73.62	13.5-28.5	45.12	72.28	72.22	71.63	69.58	72.14	69.11								
FPC-7A	Till	Down	85.52	17-22	63.52	Frozen	81.66	81.05	79.46	86.95	84.93	NC	-0.009	-0.009	-0.008	-0.104	-0.106	-0.047	0.019
FPC-7B	SBR		82.87	30-45	37.87	Frozen	81.42	80.81	79.26	84.28	82.20								
FPC-8A	Till	Down	71.70	23-33	38.70	Frozen	73.19	72.64	70.44	73.13	68.95	NC	-0.007	-0.005	-0.005	-0.008	-0.009	-0.007	0.019
FPC-8B	SBR		71.36	40.7-55.7	15.66	Frozen	73.03	72.52	70.32	72.95	68.74								
FPC-9A	Till	Up	111.73	58-68	43.73	98.32	98.26	97.41	95.92	95.01	91.83	0.001	0.003	0.000	0.000	0.090	0.095	0.047	NA
FPC-9B	SBR		113.53	72-87	26.53	98.34	98.31	97.41	95.92	96.55	93.46								
FPC-9C	Outwash	Down	112.22	15-25	87.22	98.66	98.57	97.87	96.51	95.55	92.75	-0.008	-0.007	-0.011	-0.014	-0.012	-0.021	-0.012	NA
FPC-9A	Till		111.73	58-68	43.73	98.32	98.26	97.41	95.92	95.01	91.83								
FPC-11A	Till	Down	118.36	47-52	66.36	Frozen	98.31	97.50	95.88	98.47	95.43	NC	-0.001	-0.002	0.002	-0.003	-0.001	-0.002	NA
FPC-11B	SBR		118.45	58-73	45.45	Frozen	98.29	97.46	95.93	98.40	95.40								
FPC-11C	Outwash	Neutral	118.18	18-33	85.18	Frozen	98.21	97.55	Paved Over	Paved Over	Unable to reach water	NC	0.005	-0.003	NC	NC	NC	NA	NA
FPC-11A	Till		118.36	47-52	66.36	Frozen	98.31	97.50	95.88	98.47	95.43								
GZ-117	Till	Up	118.10	30.5-40.5	77.60	96.89	96.85	96.35	95.06	96.90	94.53	0.007	0.007	0.005	0.004	0.007	0.004	0.006	NA
GZ-109	Open BR		117.74	103-252	-134.26	98.46	98.35	97.40	95.86	98.41	95.33								
GZ-123	Outwash	Up	85.21	11.5-16.5	68.71	78.52	77.88	76.90	75.89	78.08	75.67	0.007	0.011	0.014	0.016	0.018	0.016	0.014	0.015
GZ-125	Open BR		85.72	57-200	-114.28	79.88	79.84	79.39	78.87	81.35	78.57								
MW-20S	Outwash	Down	72.59	5-10	62.59				68.46	71.17	67.31	NC	NC	NC	-0.008	-0.002	-0.001	-0.004	NA
MW-20D1	DBR		72.79	65-75	-2.21				67.95	71.02	67.23								
MW-20D1	DBR	Down	72.79	65-75	-2.21				67.95	71.02	67.23	NC	NC	NC	-0.001	-0.003	-0.001	-0.002	NA
MW-20D2	DBR		72.79	224-234	-161.21				67.80	70.56	67.11								
MW-21S	MSC	Up	71.18	6-14	57.18				69.67	72.10	69.13	NC	NC	NC	0.002	0.029	-0.011	0.016	0.0008
MW-21D1	DBR		74.06	20-30	44.06				69.70	72.48	68.98								
MW-21D1	DBR	Up	74.06	20-30	44.06				69.70	72.48	68.98	NC	NC	NC	0.001	0.003	0.001	0.001	0.0008
MW-21D2	DBR		74.06	297-307	-232.94				69.85	73.28	69.14								
MW-22S	Outwash	Down	74.26	6-14	60.26				69.80	73.58	67.50	NC	NC	NC	-0.007	-0.010	-0.001	-0.006	0.0025
MW-22D1	DBR		74.94	75-85	-0.06				69.36	72.96	67.45								
MW-22D1	DBR	Down	74.94	75-85	-0.06				69.36	72.96	67.45	NC	NC	NC	-0.001	-0.003	0.000	-0.002	0.0025
MW-22D2	DBR		74.94	210-220	-145.06				69.20	72.58	67.43								

Notes:
FT BGS = Feet Below Ground Surface
Frozen = Unable to measure due to frozen well
NC = Not Calculated
NA = Not applicable due to lack of horizontal gradient contro
Horizontal gradient from 4/21/21
Open BR = Open Borehole
SBR = Shallow Bedrock
DBR = Deep Bedrock
MSC = Marine silt and clay.
= Neutral vertical gradient (between -0.001 and 0.001)
= Upward Vertical Gradient
= Downward vertical gradient
= Data not collected

Table 3.3
Bedrock Outcrop Mapping Information

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Location Name	dataId	Plane Type	Strike	Dip	Dip (Azimuth)	unitId	Date Collected
1A	1A_01	Fracture	136	10	226	Rye Formation (OZrz)	Oct-21
	1A_02	Foliation	214	67	304	Rye Formation (OZrz)	
	1A_03	Fracture	95	25	185	Rye Formation (OZrz)	
	1A_04	Fracture	92	7	182	Rye Formation (OZrz)	
	1A_05	Fracture	73	17	163	Rye Formation (OZrz)	
	1A_06	Foliation	205	69	295	Rye Formation (OZrz)	
	1A_07	Foliation	204	60	294	Rye Formation (OZrz)	
	1A_08	Foliation	204	66	294	Rye Formation (OZrz)	
	1A_09	Foliation	208	51	298	Rye Formation (OZrz)	
	1A_10	Fracture	316	66	46	Rye Formation (OZrz)	
	1A_11	Fracture	320	63	50	Rye Formation (OZrz)	
	1A_12	Fracture	311	64	41	Rye Formation (OZrz)	
	1A_13	Fracture	315	66	45	Rye Formation (OZrz)	
	1A_14	Foliation	201	70	291	Rye Formation (OZrz)	
	1A_15	Foliation	213	88	303	Rye Formation (OZrz)	
	1A_16	Foliation	206	86	296	Rye Formation (OZrz)	
	1A_17	Foliation	327	58	57	Rye Formation (OZrz)	
	1A_18	Foliation	325	52	55	Rye Formation (OZrz)	
	1A_19	Foliation	318	54	48	Rye Formation (OZrz)	
	1A_20	Foliation	319	57	49	Rye Formation (OZrz)	
	1A_21	Foliation	209	53	299	Rye Formation (OZrz)	
	1A_22	Foliation	208	66	298	Rye Formation (OZrz)	
	1A_23	Foliation	212	70	302	Rye Formation (OZrz)	
		Foliation	N19E	76°W	76°W	Rye Formation (OZrz)	
		Foliation	N23E	67°W	67°W	Rye Formation (OZrz)	
		Fracture	N43W	67°NE	67°NE	Rye Formation (OZrz)	
		AVE Foliation	**208**	**68**	**298**		
		AVE Fracture_1	**99**	**15**	**189**		
		AVE Fracture_2	**316**	**65**	**46**		
1B	1B_01	Foliation	215	55	305	Rye Formation (OZrz)	Oct-21
	1B_02	Foliation	205	72	295	Rye Formation (OZrz)	
	1B_03	Foliation	199	69	289	Rye Formation (OZrz)	
	1B_04	Foliation	221	81	311	Rye Formation (OZrz)	
	1B_05	Foliation	215	70	305	Rye Formation (OZrz)	
	1B_06	Foliation	229	63	319	Rye Formation (OZrz)	
		AVE Foliation	**214**	**68**	**304**		
1C	1C_01	Fracture	65	32	155	Rye Formation (OZrz)	Oct-21
	1C_02	Fracture	323	52	53	Rye Formation (OZrz)	
	1C_03	Fracture	317	62	47	Rye Formation (OZrz)	
	1C_04	Fracture	49	42	139	Rye Formation (OZrz)	
	1C_05	Fracture	50	33	140	Rye Formation (OZrz)	
	1C_06	Fracture	319	56	49	Rye Formation (OZrz)	
	1C_07	Foliation	210	69	300	Rye Formation (OZrz)	
		AVE Foliation	**210**	**69**	**300**		
		AVE Fracture_1	**54**	**36**	**144**		
		AVE Fracture_2	**320**	**57**	**50**		

Table 3.3
Bedrock Outcrop Mapping Information

Coakley Landfill Superfund Site
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Location Name	dataId	Plane Type	Strike	Dip	Dip (Azimuth)	unitId	Date Collected
1D	1D_01	Foliation	328	42	58	Rye Formation (OZrz)	Oct-21
	1D_02	Foliation	348	51	78	Rye Formation (OZrz)	
	1D_03	Foliation	352	50	82	Rye Formation (OZrz)	
	1D_04	Foliation	336	40	66	Rye Formation (OZrz)	
	1D_05	Foliation	325	74	55	Rye Formation (OZrz)	
	1D_06	Foliation	126	74	216	Rye Formation (OZrz)	
	1D_07	Foliation	114	79	204	Rye Formation (OZrz)	
	1D_08	Foliation	121	75	211	Rye Formation (OZrz)	
	1D_09	Foliation	200	62	290	Rye Formation (OZrz)	
	1D_10	Foliation	202	64	292	Rye Formation (OZrz)	
	1D_11	Foliation	202	58	292	Rye Formation (OZrz)	
	1D_12	Foliation	205	61	295	Rye Formation (OZrz)	
	1D_13	Foliation	209	62	299	Rye Formation (OZrz)	
		AVE Foliation	**236**	**61**	**188**		
1E	1E_01	Fracture	107	64	197	Rye Formation (OZrz)	Oct-21
	1E_02	Fracture	98	66	188	Rye Formation (OZrz)	
	1E_03	Fracture	104	65	194	Rye Formation (OZrz)	
	1E_04	Fracture	105	67	195	Rye Formation (OZrz)	
	1E_05	Fracture	348	78	78	Rye Formation (OZrz)	
	1E_06	Fracture	328	57	58	Rye Formation (OZrz)	
	1E_07	Fracture	329	62	59	Rye Formation (OZrz)	
	1E_08	Foliation	209	54	299	Rye Formation (OZrz)	
	1E_09	Foliation	197	59	287	Rye Formation (OZrz)	
	1E_10	Foliation	325	58	55	Rye Formation (OZrz)	
	1E_11	Foliation	200	70	290	Rye Formation (OZrz)	
	1E_12	Foliation	180	59	270	Rye Formation (OZrz)	
	1E_13	Foliation	196	65	286	Rye Formation (OZrz)	
	1E_14	Fracture	147	15	237	Rye Formation (OZrz)	
	1E_15	Fracture	183	29	273	Rye Formation (OZrz)	
	1E_16	Fracture	76	13	166	Rye Formation (OZrz)	
	1E_17	Fracture	88	23	178	Rye Formation (OZrz)	
	1E_18	Fracture	45	50	135	Rye Formation (OZrz)	
	1E_19	Fracture	76	26	166	Rye Formation (OZrz)	
	1E_20	Foliation	192	70	282	Rye Formation (OZrz)	
	1E_21	Foliation	194	71	284	Rye Formation (OZrz)	
	1E_22	Foliation	198	71	288	Rye Formation (OZrz)	
	1E_23	Foliation	189	73	279	Rye Formation (OZrz)	
	1E_24	Foliation	191	71	281	Rye Formation (OZrz)	
		Foliation	N18E	69	69°W	Rye Formation (OZrz)	
		Fracture	N53W	81	81°W	Rye Formation (OZrz)	
		Fracture	N32W	48	48°N	Rye Formation (OZrz)	
		Fracture	N63W	80	80°S	Rye Formation (OZrz)	
		AVE Foliation	**195**	**66**	**285**		
		AVE Fracture_1	**94**	**46**	**184**		
		AVE Fracture_2	**165**	**22**	**255**		
		AVE Fracture_3	**335**	**66**	**65**		

Table 3.3
Bedrock Outcrop Mapping Information

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Location Name	dataId	Plane Type	Strike	Dip	Dip (Azimuth)	unitId	Date Collected
1F	1F_01	Fracture	82	14	172	Rye Formation (OZrz)	Oct-21
	1F_02	Fracture	92	25	182	Rye Formation (OZrz)	
	1F_03	Fracture	112	74	202	Rye Formation (OZrz)	
	1F_04	Fracture	109	76	199	Rye Formation (OZrz)	
	1F_05	Fracture	21	35	111	Rye Formation (OZrz)	
	1F_06	Fracture	25	38	115	Rye Formation (OZrz)	
	1F_07	Foliation	198	63	288	Rye Formation (OZrz)	
	1F_08	Foliation	195	60	285	Rye Formation (OZrz)	
	1F_09	Foliation	192	57	282	Rye Formation (OZrz)	
		AVE Foliation	**195**	**60**	**285**		
		AVE Fracture_1	**23**	**37**	**113**		
		AVE Fracture_2	**99**	**47**	**189**		
3	3_01	Foliation	167	88	257	Rye Formation (OZrz)	Oct-21
	3_02	Foliation	148	88	238	Rye Formation (OZrz)	
	3_03	Fracture	113	9	203	Rye Formation (OZrz)	
	3_04	Fracture	74	13	164	Rye Formation (OZrz)	
	3_05	Fracture	48	19	138	Rye Formation (OZrz)	
	3_06	Fracture	266	57	356	Rye Formation (OZrz)	
	3_07	Fracture	291	65	21	Rye Formation (OZrz)	
	3_08	Fracture	265	62	355	Rye Formation (OZrz)	
	3_09	Foliation	180	79	270	Rye Formation (OZrz)	
	3_10	Foliation	173	85	263	Rye Formation (OZrz)	
	3_11	Foliation	182	82	272	Rye Formation (OZrz)	
	3_12	Foliation	180	83	270	Rye Formation (OZrz)	
	3_13	Fracture	254	56	344	Rye Formation (OZrz)	
	3_14	Fracture	247	52	337	Rye Formation (OZrz)	
	3_15	Fracture	197	79	287	Rye Formation (OZrz)	
	3_16	Fracture	244	89	334	Rye Formation (OZrz)	
	3_17	Fracture	250	86	340	Rye Formation (OZrz)	
	3_18	Fracture	220	85	310	Rye Formation (OZrz)	
	3_19	Fracture	196	79	286	Rye Formation (OZrz)	
	3_20	Fracture	233	89	323	Rye Formation (OZrz)	
	3_21	Fracture	231	84	321	Rye Formation (OZrz)	
	3_22	Foliation	173	73	263	Rye Formation (OZrz)	
	3_23	Foliation	171	78	261	Rye Formation (OZrz)	
	3_24	Foliation	168	78	258	Rye Formation (OZrz)	
		AVE Foliation	**171**	**82**	**261**		
		AVE Fracture_1	**78**	**14**	**168**		
		AVE Fracture_2	**241**	**74**	**301**		

Table 3.3
Bedrock Outcrop Mapping Information

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Location Name	dataId	Plane Type	Strike	Dip	Dip (Azimuth)	unitId	Date Collected
4	4_01	Foliation	189	35	279	Rye Formation (OZrz)	Oct-21
	4_02	Foliation	179	52	269	Rye Formation (OZrz)	
	4_03	Fracture	6	69	96	Rye Formation (OZrz)	
	4_04	Fracture	9	71	99	Rye Formation (OZrz)	
	4_05	Fracture	13	76	103	Rye Formation (OZrz)	
	4_06	Foliation	203	69	293	Rye Formation (OZrz)	
	4_07	Foliation	212	62	302	Rye Formation (OZrz)	
	4_08	Fracture	31	78	121	Rye Formation (OZrz)	
	4_09	Fracture	297	76	27	Rye Formation (OZrz)	
	4_10	Fracture	37	84	127	Rye Formation (OZrz)	
	4_11	Foliation	202	45	292	Rye Formation (OZrz)	
	4_12	Foliation	186	37	276	Rye Formation (OZrz)	
	4_13	Foliation	202	58	292	Rye Formation (OZrz)	
	4_14	Foliation	175	55	265	Rye Formation (OZrz)	
		Fracture	N40E	82	82°S	Rye Formation (OZrz)	
		Fracture	N43E	78	78°S	Rye Formation (OZrz)	
		AVE Foliation	**193**	**52**	**283**		
		AVE Fracture_1	**19**	**76**	**109**		
		AVE Fracture_2	**297**	**76**	**27**		
5A	5A_01	Fracture	299	74	29	Rye Formation (OZrz)	Oct-21
	5A_02	Fracture	325	45	55	Rye Formation (OZrz)	
	5A_03	Fracture	49	70	139	Rye Formation (OZrz)	
	5A_04	Fracture	147	87	237	Rye Formation (OZrz)	
	5A_05	Fracture	48	67	138	Rye Formation (OZrz)	
	5A_06	Fracture	64	66	154	Rye Formation (OZrz)	
	5A_07	Fracture	317	34	47	Rye Formation (OZrz)	
	5A_08	Foliation	188	55	278	Rye Formation (OZrz)	
	5A_09	Foliation	181	61	271	Rye Formation (OZrz)	
	5A_10	Foliation	164	52	254	Rye Formation (OZrz)	
	5A_11	Fracture	326	52	56	Rye Formation (OZrz)	
	5A_12	Fracture	336	56	66	Rye Formation (OZrz)	
	5A_13	Fracture	332	55	62	Rye Formation (OZrz)	
	5A_14	Fracture	64	86	154	Rye Formation (OZrz)	
	5A_15	Fracture	62	84	152	Rye Formation (OZrz)	
	5A_16	Foliation	175	56	265	Rye Formation (OZrz)	
	5A_17	Foliation	178	45	268	Rye Formation (OZrz)	
	5A_18	Foliation	180	57	270	Rye Formation (OZrz)	
	5A_19	Foliation	170	55	260	Rye Formation (OZrz)	
	5A_20	Foliation	182	50	272	Rye Formation (OZrz)	
	5A_21	Foliation	180	57	270	Rye Formation (OZrz)	
		Folation	N15E	76	76°W	Rye Formation (OZrz)	
		AVE Foliation	**178**	**54**	**268**		
		AVE Fracture_1	**58**	**75**	**148**		
		AVE Fracture_2	**322**	**53**	**52**		

Table 3.3
Bedrock Outcrop Mapping Information

Coakley Landfill Superfund Site
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Location Name	dataId	Plane Type	Strike	Dip	Dip (Azimuth)	unitId	Date Collected
5B	5B_01	Fracture	49	63	139	Rye Formation (OZrz)	Oct-21
	5B_02	Fracture	108	89	198	Rye Formation (OZrz)	
	5B_03	Fracture	284	86	14	Rye Formation (OZrz)	
	5B_04	Fracture	270	77	0	Rye Formation (OZrz)	
	5B_05	Fracture	88	61	178	Rye Formation (OZrz)	
	5B_06	Fracture	238	81	328	Rye Formation (OZrz)	
	5B_07	Fracture	58	50	148	Rye Formation (OZrz)	
	5B_08	Fracture	38	62	128	Rye Formation (OZrz)	
	5B_09	Fracture	33	70	123	Rye Formation (OZrz)	
	5B_10	Fracture	51	73	141	Rye Formation (OZrz)	
	5B_11	Fracture	35	62	125	Rye Formation (OZrz)	
	5B_12	Fracture	228	81	318	Rye Formation (OZrz)	
	5B_13	Fracture	41	74	131	Rye Formation (OZrz)	
	5B_14	Fracture	61	55	151	Rye Formation (OZrz)	
	5B_15	Foliation	159	72	249	Rye Formation (OZrz)	
	5B_16	Foliation	164	73	254	Rye Formation (OZrz)	
	5B_17	Foliation	159	75	249	Rye Formation (OZrz)	
	5B_18	Foliation	159	77	249	Rye Formation (OZrz)	
		Foliation	N18W	76	76°W		
		Fracture	N55E	83	83°N		
		Fracture	N55E	85	85°N		
		AVE Foliation	**160**	**74**	**250**		
		AVE Fracture_1	**56**	**66**	**146**		
		AVE Fracture_2	**255**	**81**	**165**		
6A	6A_01	vein	179	55	269	Rye Formation (OZrz)	Oct-21
	6A_02	Foliation	216	64	306	Rye Formation (OZrz)	
	6A_03	Foliation	178	55	268	Rye Formation (OZrz)	
	6A_04	Foliation	179	60	269	Rye Formation (OZrz)	
			N10W	63	63°W		
		AVE Foliation	**191**	**60**	**281**		
		AVE Vein	**179**	**55**	**269**		

Table 3.3
Bedrock Outcrop Mapping Information

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Location Name	dataId	Plane Type	Strike	Dip	Dip (Azimuth)	unitId	Date Collected
6B	6B_01	Fracture	73	55	163	Rye Formation (OZrz)	Oct-21
	6B_02	Fracture	45	74	135	Rye Formation (OZrz)	
	6B_03	Fracture	77	52	167	Rye Formation (OZrz)	
	6B_04	Fracture	53	71	143	Rye Formation (OZrz)	
	6B_05	Foliation	186	58	276	Rye Formation (OZrz)	
	6B_06	Fracture	200	75	290	Rye Formation (OZrz)	
	6B_07	Fracture	197	71	287	Rye Formation (OZrz)	
	6B_08	Fracture	185	59	275	Rye Formation (OZrz)	
	6B_09	Fracture	359	35	89	Rye Formation (OZrz)	
	6B_10	Fracture	0	41	90	Rye Formation (OZrz)	
	6B_11	Fracture	214	68	304	Rye Formation (OZrz)	
	6B_12	Fracture	355	65	85	Rye Formation (OZrz)	
	6B_13	Fracture	67	47	157	Rye Formation (OZrz)	
	6B_14	Fracture	54	51	144	Rye Formation (OZrz)	
	6B_15	Fracture	61	50	151	Rye Formation (OZrz)	
	6B_16	Foliation	209	67	299	Rye Formation (OZrz)	
	6B_17	Foliation	198	64	288	Rye Formation (OZrz)	
	6B_18	Foliation	213	60	303	Rye Formation (OZrz)	
	6B_19	Foliation	208	63	298	Rye Formation (OZrz)	
	6B_20	Foliation	190	83	280	Rye Formation (OZrz)	
		Foliation	N5W	42	42°E		
		Fracture	N5E	57	57°W		
		AVE Foliation	**200**	**66**	**290**		
		AVE Fracture_1	**54**	**55**	**144**		
		AVE Fracture_2	**199**	**68**	**289**		
		AVE Fracture_3	**357**	**50**	**87**		

Table 3.3
Bedrock Outcrop Mapping Information

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Location Name	dataId	Plane Type	Strike	Dip	Dip (Azimuth)	unitId	Date Collected
6C	6C_01	Fracture	65	71	155	Rye Formation (OZrz)	Oct-21
	6C_02	Fracture	6	77	96	Rye Formation (OZrz)	
	6C_03	Fracture	318	54	48	Rye Formation (OZrz)	
	6C_04	Fracture	101	11	191	Rye Formation (OZrz)	
	6C_05	Fracture	329	35	59	Rye Formation (OZrz)	
	6C_06	Fracture	308	88	38	Rye Formation (OZrz)	
	6C_07	Fracture	47	89	137	Rye Formation (OZrz)	
	6C_08	Foliation	213	56	303	Rye Formation (OZrz)	
	6C_09	Foliation	216	59	306	Rye Formation (OZrz)	
	6C_10	Foliation	215	53	305	Rye Formation (OZrz)	
	6C_11	Fracture	111	88	201	Rye Formation (OZrz)	
	6C_12	Fracture	346	79	76	Rye Formation (OZrz)	
	6C_13	Fracture	8	89	98	Rye Formation (OZrz)	
	6C_14	Fracture	103	85	193	Rye Formation (OZrz)	
	6C_15	Fracture	352	81	82	Rye Formation (OZrz)	
	6C_16	Foliation	201	60	291	Rye Formation (OZrz)	
	6C_17	Foliation	198	52	288	Rye Formation (OZrz)	
	6C_18	Fracture	107	79	197	Rye Formation (OZrz)	
	6C_19	Fracture	219	76	309	Rye Formation (OZrz)	
	6C_20	Fracture	347	80	77	Rye Formation (OZrz)	
	6C_21	Fracture	97	89	187	Rye Formation (OZrz)	
	6C_22	Fracture	236	31	326	Rye Formation (OZrz)	
	6C_23	Fracture	222	83	312	Rye Formation (OZrz)	
	6C_24	Fracture	188	81	278	Rye Formation (OZrz)	
	6C_25	Fracture	6	86	96	Rye Formation (OZrz)	
	6C_26	Foliation	223	61	313	Rye Formation (OZrz)	
	6C_27	Foliation	180	60	270	Rye Formation (OZrz)	
	6C_28	Foliation	198	60	288	Rye Formation (OZrz)	
		Fracture	N39E	85	85°N		
		Fracture	N60W	90	90°		
		AVE Foliation	**206**	**57**	**296**		
		AVE Fracture_1	**104**	**70**	**194**		
		AVE Fracture_2	**216**	**68**	**306**		
		AVE Fracture_3	**333**	**70**	**63**		

Table 3.3
Bedrock Outcrop Mapping Information

Coakley Landfill Superfund Site
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Location Name	dataId	Plane Type	Strike	Dip	Dip (Azimuth)	unitId	Date Collected
7	7_01	Foliation	32	81	122	Rye Formation (OZrz)	Oct-21
	7_02	Foliation	32	86	122	Rye Formation (OZrz)	
	7_03	Foliation	212	89	302	Rye Formation (OZrz)	
	7_04	Foliation	211	71	301	Rye Formation (OZrz)	
	7_05	Foliation	35	81	125	Rye Formation (OZrz)	
	7_06	Fracture	24	51	114	Rye Formation (OZrz)	
	7_07	Fracture	4	51	94	Rye Formation (OZrz)	
	7_08	Fracture	64	30	154	Rye Formation (OZrz)	
	7_09	Fracture	167	42	257	Rye Formation (OZrz)	
	7_10	Foliation	196	50	286	Rye Formation (OZrz)	
	7_11	Foliation	196	70	286	Rye Formation (OZrz)	
	7_12	Foliation	219	52	309	Rye Formation (OZrz)	
	7_13	Foliation	215	52	305	Rye Formation (OZrz)	
	7_14	Foliation	212	63	302	Rye Formation (OZrz)	
	7_15	Fracture	348	77	78	Rye Formation (OZrz)	
	7_16	Fracture	104	87	194	Rye Formation (OZrz)	
	7_17	Fracture	114	78	204	Rye Formation (OZrz)	
	7_18	Fracture	106	66	196	Rye Formation (OZrz)	
	7_19	Fracture	118	57	208	Rye Formation (OZrz)	
			N48E	34	34°W		
			N73W	75	75°S		
			N30E	78	78°W		
		AVE Foliation	**209**	**64**	**299**		
		AVE Fracture_1	**31**	**44**	**121**		
		AVE Fracture_2	**122**	**66**	**212**		
8A	8A_01	Fracture	279	43	9	Breakfast Hill Gneiss	Oct-21
	8A_02	Fracture	272	38	2	Breakfast Hill Gneiss	
	8A_03	Fracture	306	50	36	Breakfast Hill Gneiss	
	8A_04	Fracture	287	69	17	Breakfast Hill Gneiss	
	8A_05	Fracture	294	69	24	Breakfast Hill Gneiss	
	8A_06	Fracture	92	33	182	Breakfast Hill Gneiss	
	8A_07	Fracture	87	37	177	Breakfast Hill Gneiss	
	8A_08	Fracture	75	30	165	Breakfast Hill Gneiss	
	8A_09	Fracture	82	23	172	Breakfast Hill Gneiss	
	8A_10	Fracture	83	27	173	Breakfast Hill Gneiss	
	8A_11	Foliation	200	85	290	Breakfast Hill Gneiss	
	8A_12	Foliation	198	89	288	Breakfast Hill Gneiss	
	8A_13	Foliation	22	87	112	Breakfast Hill Gneiss	
	8A_14	Foliation	188	85	278	Breakfast Hill Gneiss	
	8A_15	Foliation	13	88	103	Breakfast Hill Gneiss	
	8A_16	Foliation	24	86	114	Breakfast Hill Gneiss	
		Foliation	N20E	88	88°S	Breakfast Hill Gneiss	
		AVE Foliation	**20**	**87**	**110**		
		AVE Fracture_1	**84**	**30**	**174**		
		AVE Fracture2	**288**	**54**	**18**		

Table 3.3
Bedrock Outcrop Mapping Information

Coakley Landfill Superfund Site
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Location Name	dataId	Plane Type	Strike	Dip	Dip (Azimuth)	unitId	Date Collected
8B	8B_01	Fracture	78	88	168	Breakfast Hill Gneiss	Oct-21
	8B_02	Fracture	73	74	163	Breakfast Hill Gneiss	
	8B_03	Fracture	19	29	109	Breakfast Hill Gneiss	
	8B_04	Fracture	69	59	159	Breakfast Hill Gneiss	
	8B_05	Fracture	71	68	161	Breakfast Hill Gneiss	
	8B_06	Fracture	75	66	165	Breakfast Hill Gneiss	
	8B_07	Foliation	200	69	290	Breakfast Hill Gneiss	
	8B_08	Foliation	200	71	290	Breakfast Hill Gneiss	
	8B_09	Foliation	200	47	290	Breakfast Hill Gneiss	
	8B_10	Foliation	193	49	283	Breakfast Hill Gneiss	
	8B_11	Foliation	182	59	272	Breakfast Hill Gneiss	
	8B_12	Foliation	194	65	284	Breakfast Hill Gneiss	
		Foliation	N5E	55	55°W	Breakfast Hill Gneiss	
		Fracture	N60E	62	62°S	Breakfast Hill Gneiss	
		AVE Foliation	**195**	**60**	**285**		
		AVE Fracture_1	**64**	**64**	**154**		
8C	8C_01	Foliation	188	53	278	Breakfast Hill Gneiss	Oct-21
	8C_02	Fracture	285	87	15	Breakfast Hill Gneiss	
	8C_03	Fracture	38	42	128	Breakfast Hill Gneiss	
	8C_04	Fracture	59	55	149	Breakfast Hill Gneiss	
	8C_05	Fracture	308	33	38	Breakfast Hill Gneiss	
	8C_06	Fracture	335	41	65	Breakfast Hill Gneiss	
	8C_07	Fracture	333	38	63	Breakfast Hill Gneiss	
	8C_08	Fracture	333	32	63	Breakfast Hill Gneiss	
	8C_09	Foliation	41	84	131	Breakfast Hill Gneiss	
	8C_10	Foliation	220	75	310	Breakfast Hill Gneiss	
	8C_11	Foliation	195	57	285	Breakfast Hill Gneiss	
	8C_12	Foliation	219	81	309	Breakfast Hill Gneiss	
		Foliation	N29E	70	70°W	Breakfast Hill Gneiss	
		Foliation	N25E	61	61°W	Breakfast Hill Gneiss	
		Fracture	N18E	53	53°S	Breakfast Hill Gneiss	
		AVE Foliation	**193**	**54**	**283**		
		AVE Fracture_1	**51**	**83**	**141**		
		AVE Fracture_2	**210**	**72**	**300**		

Table 3.3
Bedrock Outcrop Mapping Information

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Location Name	dataId	Plane Type	Strike	Dip	Dip (Azimuth)	unitId	Date Collected
8C-2	8C_2_01	Fracture	197	68	287	Breakfast Hill Gneiss	Oct-21
	8C_2_02	Fracture	53	86	143	Breakfast Hill Gneiss	
	8C_2_03	Fracture	254	87	344	Breakfast Hill Gneiss	
	8C_2_04	Fracture	52	82	142	Breakfast Hill Gneiss	
	8C_2_05	Fracture	49	84	139	Breakfast Hill Gneiss	
	8C_2_06	Fracture	50	82	140	Breakfast Hill Gneiss	
	8C_2_07	Fracture	230	84	320	Breakfast Hill Gneiss	
	8C_2_08	Fracture	160	51	250	Breakfast Hill Gneiss	
	8C_2_09	Foliation	226	59	316	Breakfast Hill Gneiss	
	8C_2_10	Foliation	204	68	294	Breakfast Hill Gneiss	
	8C_2_11	Foliation	149	36	239	Breakfast Hill Gneiss	
		Fracture	N25E	90	90°	Breakfast Hill Gneiss	
		Fracture	N70E	90	90°		
		AVE Foliation	**193**	**54**	**283**		
		AVE Fracture_1	**51**	**83**	**141**		
		AVE Fracture_2	**210**	**72**	**300**		
10	10_01	foliation	190	74	280	Breakfast Hill Gneiss	Oct-21
	10_02	foliation	196	64	286	Breakfast Hill Gneiss	
	10_03	foliation	199	70	289	Breakfast Hill Gneiss	
	10_04	foliation	191	71	281	Breakfast Hill Gneiss	
	10_05	Fracture	253	69	343	Breakfast Hill Gneiss	
	10_06	Fracture	230	35	320	Breakfast Hill Gneiss	
	10_07	Fracture	307	83	37	Breakfast Hill Gneiss	
	10_08	foliation	206	66	296	Breakfast Hill Gneiss	
	10_09	foliation	222	59	312	Breakfast Hill Gneiss	
	10_10	foliation	207	71	297	Breakfast Hill Gneiss	
	10_11	foliation	204	70	294	Breakfast Hill Gneiss	
	10_12	foliation	217	72	307	Breakfast Hill Gneiss	
	10_13	foliation	221	74	311	Breakfast Hill Gneiss	
	10_14	foliation	234	72	324	Breakfast Hill Gneiss	
	10_15	foliation	227	61	317	Breakfast Hill Gneiss	
	10_16	foliation	232	69	322	Breakfast Hill Gneiss	
	10_17	Fracture	220	20	310	Breakfast Hill Gneiss	
	10_18	Fracture	209	19	299	Breakfast Hill Gneiss	
	10_19	Fracture	313	80	43	Breakfast Hill Gneiss	
	10_20	Fracture	314	79	44	Breakfast Hill Gneiss	
	10_21	Fracture	208	8	298	Breakfast Hill Gneiss	
	10_22	Fracture	184	10	274	Breakfast Hill Gneiss	
	10_23	Fracture	140	88	230	Breakfast Hill Gneiss	
	10_24	Fracture	319	81	49	Breakfast Hill Gneiss	
	10_25	Fracture	328	81	58	Breakfast Hill Gneiss	
	10_26	Fracture	327	75	57	Breakfast Hill Gneiss	
	10_27	Fracture	324	71	54	Breakfast Hill Gneiss	
	10_28	Fracture	313	89	43	Breakfast Hill Gneiss	
		AVE Foliation	**211**	**69**	**301**		
		AVE Fracture_1	**206**	**36**	**296**		
		AVE Fracture_2	**318**	**80**	**48**		

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Coakley Landfill Superfund Site
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Location Name	dataId	Plane Type	Strike	Dip	Dip (Azimuth)	unitId	Date Collected
Church	Church_01	Fracture	185	7	275	Rye Formation (OZrz)	Oct-21
	Church_02	Fracture	116	56	206	Breakfast Hill Gneiss	
	Church_03	Fracture	129	61	219	Breakfast Hill Gneiss	
	Church_04	Fracture	184	9	274	Breakfast Hill Gneiss	
	Church_05	Fracture	299	75	29	Breakfast Hill Gneiss	
	Church_06	Fracture	38	49	128	Breakfast Hill Gneiss	
	Church_07	Fracture	172	6	262	Breakfast Hill Gneiss	
	Church_08	Fracture	118	65	208	Breakfast Hill Gneiss	
	Church_09	Fracture	312	75	42	Breakfast Hill Gneiss	
	Church_10	Fracture	36	43	126	Breakfast Hill Gneiss	
	Church_11	Fracture	119	66	209	Breakfast Hill Gneiss	
	Church_12	Fracture	308	85	38	Breakfast Hill Gneiss	
	Church_13	Fracture	318	78	48	Breakfast Hill Gneiss	
	Church_14	Fracture	46	82	136	Breakfast Hill Gneiss	
	Church_15	Fracture	57	49	147	Breakfast Hill Gneiss	
	Church_16	Fracture	310	77	40	Breakfast Hill Gneiss	
	Church_17	Fracture	302	69	32	Breakfast Hill Gneiss	
	Church_18	Fracture	329	61	59	Breakfast Hill Gneiss	
	Church_19	Fracture	148	20	238	Breakfast Hill Gneiss	
	Church_20	Fracture	306	72	36	Breakfast Hill Gneiss	
	Church_21	Fracture	96	31	186	Breakfast Hill Gneiss	
	Church_22	Fracture	163	15	253	Breakfast Hill Gneiss	
	Church_23	Fracture	301	74	31	Breakfast Hill Gneiss	
	Church_24	Fracture	330	10	60	Breakfast Hill Gneiss	
	Church_25	Fracture	105	81	195	Breakfast Hill Gneiss	
	Church_26	Fracture	299	75	29	Breakfast Hill Gneiss	
	Church_27	Fracture	308	76	38	Breakfast Hill Gneiss	
	Church_28	Fracture	299	71	29	Breakfast Hill Gneiss	
	Church_29	Fracture	303	79	33	Breakfast Hill Gneiss	
	Church_30	Fracture	226	12	316	Breakfast Hill Gneiss	
	Church_31	Fracture	322	76	52	Breakfast Hill Gneiss	
	Church_32	Fracture	313	72	43	Breakfast Hill Gneiss	
	Church_33	Fracture	198	21	288	Breakfast Hill Gneiss	
	Church_34	Fracture	91	84	181	Breakfast Hill Gneiss	
	Church_35	Fracture	187	24	277	Breakfast Hill Gneiss	
	Church_36	Fracture	88	76	178	Breakfast Hill Gneiss	
	Church_37	Fracture	90	69	180	Breakfast Hill Gneiss	
	Church_38	foliation	197	75	287	Breakfast Hill Gneiss	
	Church_39	foliation	199	72	289	Breakfast Hill Gneiss	
	Church_40	foliation	202	81	292	Breakfast Hill Gneiss	
	Church_41	foliation	187	60	277	Breakfast Hill Gneiss	
	Church_42	foliation	210	84	300	Breakfast Hill Gneiss	
	Church_43	foliation	201	73	291	Breakfast Hill Gneiss	
	Church_44	foliation	210	73	300	Breakfast Hill Gneiss	
	Church_45	foliation	209	60	299	Breakfast Hill Gneiss	
	Church_46	foliation	194	62	284	Breakfast Hill Gneiss	
	Church_47	foliation	204	61	294	Breakfast Hill Gneiss	
	Church_48	foliation	209	66	299	Breakfast Hill Gneiss	
		AVE Foliation	**202**	**70**	**292**		
		AVE Fracture_1	**44**	**56**	**134**		
		AVE Fracture_2	**142**	**41**	**232**		
		AVE Fracture_3	**310**	**70**	**40**		

Table 3.3
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Location Name	dataId	Plane Type	Strike	Dip	Dip (Azimuth)	unitId	Date Collected
Outcrop 1	Outcrop_01_01	Foliation	N20E	57	57°NW	Rye Formation (OZrz)	Apr-18
	Outcrop_01_01	Foliation	N21E	55	55°NW	Rye Formation (OZrz)	
	Outcrop_01_02	Fracture	305	70	35	Rye Formation (OZrz)	Oct-21
	Outcrop_01_03	Fracture	306	74	36	Rye Formation (OZrz)	
	Outcrop_01_04	Fracture	356	51	86	Rye Formation (OZrz)	
	Outcrop_01_05	Fracture	281	87	11	Rye Formation (OZrz)	
	Outcrop_01_06	Fracture	39	71	129	Rye Formation (OZrz)	
	Outcrop_01_07	Fracture	51	55	141	Rye Formation (OZrz)	
	Outcrop_01_08	Fracture	324	78	54	Rye Formation (OZrz)	
	Outcrop_01_09	Fracture	327	87	57	Rye Formation (OZrz)	
	Outcrop_01_10	Fracture	328	78	58	Rye Formation (OZrz)	
	Outcrop_01_11	Fracture	331	76	61	Rye Formation (OZrz)	
	Outcrop_01_12	Fracture	44	51	134	Rye Formation (OZrz)	
	Outcrop_01_13	Fracture	126	89	216	Rye Formation (OZrz)	
	Outcrop_01_14	Fracture	136	84	226	Rye Formation (OZrz)	
	Outcrop_01_15	Fracture	312	86	42	Rye Formation (OZrz)	
	Outcrop_01_16	foliation	195	50	285	Rye Formation (OZrz)	
	Outcrop_01_17	foliation	195	45	285	Rye Formation (OZrz)	
	Outcrop_01_18	foliation	175	40	265	Rye Formation (OZrz)	
	Outcrop_01_19	foliation	176	48	266	Rye Formation (OZrz)	
	Outcrop_01_20	foliation	179	44	269	Rye Formation (OZrz)	
		AVE Foliation	**184**	**45**	**274**		
		AVE Fracture_1	**45**	**59**	**135**		
		AVE Fracture_2	**131**	**86**	**221**		
		AVE Fracture_3	**319**	**76**	**49**		

Table 3.3
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Location Name	dataId	Plane Type	Strike	Dip	Dip (Azimuth)	unitId	Date Collected
Outcrop 2	Outcrop_02_01	Foliation	N17E	66	66°NW	Rye Formation (OZrz)	Apr-18
	Outcrop_02_02	foliation	205	59	295	Rye Formation (OZrz)	Oct-21
	Outcrop_02_03	foliation	201	45	291	Rye Formation (OZrz)	
	Outcrop_02_04	foliation	203	44	293	Rye Formation (OZrz)	
	Outcrop_02_05	foliation	204	57	294	Rye Formation (OZrz)	
	Outcrop_02_06	Fracture	30	64	120	Rye Formation (OZrz)	
	Outcrop_02_07	Fracture	38	64	128	Rye Formation (OZrz)	
	Outcrop_02_08	Fracture	55	68	145	Rye Formation (OZrz)	
	Outcrop_02_09	Fracture	317	87	47	Rye Formation (OZrz)	
	Outcrop_02_10	Fracture	135	87	225	Rye Formation (OZrz)	
	Outcrop_02_11	Fracture	52	60	142	Rye Formation (OZrz)	
	Outcrop_02_12	Fracture	33	58	123	Rye Formation (OZrz)	
	Outcrop_02_13	Fracture	40	68	130	Rye Formation (OZrz)	
	Outcrop_02_14	Fracture	34	52	124	Rye Formation (OZrz)	
	Outcrop_02_15	Fracture	134	88	224	Rye Formation (OZrz)	
	Outcrop_02_16	Fracture	311	89	41	Rye Formation (OZrz)	
	Outcrop_02_17	Fracture	47	66	137	Rye Formation (OZrz)	
	Outcrop_02_18	Fracture	43	73	133	Rye Formation (OZrz)	
	Outcrop_02_19	Fracture	134	89	224	Rye Formation (OZrz)	
	Outcrop_02_20	Fracture	134	87	224	Rye Formation (OZrz)	
	Outcrop_02_21	Fracture	24	33	114	Rye Formation (OZrz)	
	Outcrop_02_22	Fracture	130	87	220	Rye Formation (OZrz)	
	Outcrop_02_23	Fracture	134	85	224	Rye Formation (OZrz)	
	Outcrop_02_24	Fracture	133	87	223	Rye Formation (OZrz)	
	Outcrop_02_25	foliation	202	59	292	Rye Formation (OZrz)	
	Outcrop_02_26	foliation	211	66	301	Rye Formation (OZrz)	
	Outcrop_02_27	foliation	200	73	290	Rye Formation (OZrz)	
	Outcrop_02_28	foliation	201	78	291	Rye Formation (OZrz)	
		AVE Foliation	**204**	**60**	**294**		
		AVE Fracture_1	**40**	**61**	**130**		
		AVE Fracture_2	**133**	**87**	**223**		
		AVE Fracture_3	**314**	**88**	**44**		
Outcrop 3	Outcrop_3_01	Foliation	N33E	65	65°NW	Rye Formation (OZrz)	Apr-18
	Outcrop_3_02	foliation	207	72	297	Rye Formation (OZrz)	Oct-21
	Outcrop_3_03	foliation	199	67	289	Rye Formation (OZrz)	
	Outcrop_3_04	foliation	193	56	283	Rye Formation (OZrz)	
	Outcrop_3_05	foliation	189	54	279	Rye Formation (OZrz)	
	Outcrop_3_06	foliation	189	60	279	Rye Formation (OZrz)	
	Outcrop_3_07	foliation	191	72	281	Rye Formation (OZrz)	
	Outcrop_3_08	Fracture	284	85	14	Rye Formation (OZrz)	
	Outcrop_3_09	Fracture	67	63	157	Rye Formation (OZrz)	
	Outcrop_3_10	Fracture	317	76	47	Rye Formation (OZrz)	
	Outcrop_3_11	Fracture	102	84	192	Rye Formation (OZrz)	
	Outcrop_3_12	Fracture	310	48	40	Rye Formation (OZrz)	
	Outcrop_3_13	Fracture	306	48	36	Rye Formation (OZrz)	
	Outcrop_3_14	Fracture	319	80	49	Rye Formation (OZrz)	
	Outcrop_3_15	Fracture	339	70	69	Rye Formation (OZrz)	
	Outcrop_3_16	Fracture	353	65	83	Rye Formation (OZrz)	
		AVE Foliation	**195**	**64**	**285**		
		AVE Fracture_1	**84**	**73**	**174**		
		AVE Fracture_2	**318**	**67**	**48**		

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Location Name	dataId	Plane Type	Strike	Dip	Dip (Azimuth)	unitId	Date Collected
BR1-1	NA	NA	N30E	78W	NA	Rye Formation (OZrz)	Feb-19
BR1-2	NA	NA	N40E	89W	NA	Rye Formation (OZrz)	
BR1-3	NA	NA	N24E	75W	NA	Rye Formation (OZrz)	
BR2-1	NA	NA	N16E	83W	NA	Rye Formation (OZrz)	
BR2-2	NA	NA	N10E	70W	NA	Rye Formation (OZrz)	
BR3-1	NA	NA	N20E	85W	NA	Rye Formation (OZrz)	
BR3-2	NA	NA	N27E	65W	NA	Rye Formation (OZrz)	
BR4-1	NA	NA	N26E	86W	NA	Rye Formation (OZrz)	
BR4-2	NA	NA	N30E	70W	NA	Rye Formation (OZrz)	
BR4-3	NA	NA	N50W	65NE	NA	Rye Formation (OZrz)	
BR4-4	NA	NA	N64W	80NE	NA	Rye Formation (OZrz)	
BR5-1	NA	NA	N10E	60W	NA	Rye Formation (OZrz)	
BR5-2	NA	NA	N15E	64W	NA	Rye Formation (OZrz)	
BR5-3	NA	NA	N90E	55S	NA	Rye Formation (OZrz)	
BR5-4	NA	NA	N50W	85S	NA	Rye Formation (OZrz)	
BR6-1	NA	NA	N25E	62W	NA	Rye Formation (OZrz)	
BR6-2	NA	NA	N14E	59W	NA	Rye Formation (OZrz)	
BR6-3	NA	NA	N80W	65S	NA	Rye Formation (OZrz)	
BR6-4	NA	NA	N25W	65SW	NA	Rye Formation (OZrz)	
BR7-1	NA	NA	N27E	90W	NA	Rye Formation (OZrz)	
BR7-2	NA	NA	N12E	56W	NA	Rye Formation (OZrz)	
BR7-3	NA	NA	N10E	64W	NA	Rye Formation (OZrz)	
BR8-1	NA	NA	N21E	82W	NA	Rye Formation (OZrz)	
BR8-2	NA	NA	N25E	71W	NA	Rye Formation (OZrz)	
BR9-1	NA	NA	N12E	46W	NA	Rye Formation (OZrz)	
BR9-2	NA	NA	N50W	40NE	NA	Rye Formation (OZrz)	
BR10-1	NA	NA	N38E	45W	NA	Rye Formation (OZrz)	
BR10-2	NA	NA	N60W	43N	NA	Rye Formation (OZrz)	
BR11-1	NA	NA	N40E	46W	NA	Rye Formation (OZrz)	
BR11-2	NA	NA	N22E	60W	NA	Rye Formation (OZrz)	
BR12-1	NA	NA	N34E	78W	NA	Rye Formation (OZrz)	
BR13-1	NA	NA	N30E	60W	NA	Rye Formation (OZrz)	
BR13-2	NA	NA	N25W	65E	NA	Rye Formation (OZrz)	
BR13-3	NA	NA	N30E	76W	NA	Rye Formation (OZrz)	
BR15-1	NA	NA	N25E	85W	NA	Breakfast Hill Gneiss	
BR15-2	NA	NA	N25E	65W	NA	Breakfast Hill Gneiss	
BR15-3	NA	NA	N76E	90NW	NA	Breakfast Hill Gneiss	
BR16-1	NA	NA	N5E	66W	NA	Breakfast Hill Gneiss	
BR17-1	NA	NA	N60E	76W	NA	Breakfast Hill Gneiss	
BR17-2	NA	NA	N20W	56E	NA	Breakfast Hill Gneiss	
BR18-1	NA	NA	N20W	46E	NA	Breakfast Hill Gneiss	
BR18-2	NA	NA	N22E	76SE	NA	Breakfast Hill Gneiss	

Notes:
1. Right-hand rule measurements from FieldMove Clino App Data. Others from Brunton compass.
2. NA = not applicable or not available.

TABLE 3.4
Surface Water Elevation Summary

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Location	Type of Measuring Point	Easting	Northing	MP Elevation	Staff Gauge Elevation (bottom)	10/28/2018		4/17/2019		5/6/2019	
		NH State Plane	NH State Plane			Measured WL	Elevation	Measured WL	Elevation	Measured WL	Elevation
SURFACE WATER											
Stormwater Pond (SB-1)	Staff Gauge	1212178.05	184101.54	97.70	95.64	1.56	97.20	0.75	96.39	1.26	96.90
Stormwater Pond (SB-2)	Staff Gauge	1211326.74	184074.27	84.00	80.14	1.60	81.74	0.92	81.06	1.09	81.23
L-1 Seep	Staff Gauge	1211281.31	184153.70	78.50	76.44	-	-	NM	-	0.56	77.00
SW-5	Staff Gauge	1211286.92	184845.04	75.00	72.94	1.10	74.04	0.86	73.80	0.8	73.74
SW-103	Staff Gauge	1211367.44	185228.27	74.80	72.74	0.78	73.52	1.09	73.83	1.09	73.83
		1211874.68	187243.98	68.70							
*SW-110	Steel Pin	1211870.4	187239.53	69.80		1.49	67.21	0.56	68.14	1.55	67.15
+BB-1	Steel Pin	1211763.51	186949.74	72.00		1.74	70.26	1.08	70.92	1.06	70.94
		1211500.44	185818.19	73.50							
*BB-2	Steel Pin	1211523.17	185807.25	73.60		0.91	72.59	0.69	72.81	0.44	73.06
Little River Bridge	Top of Culvert	1208971.20	179648.17	68.90		3.58	65.32	NM	-	4.21	64.69
SG-1	Steel Pin	1210400.470	183299.400	71.60		-	-	-	-	-	-
SG-2	Steel Pin	183770.810	1210587.560	71.30		-	-	-	-	-	-
SG-3	Steel Pin	185007.170	1210971.530	71.20		-	-	-	-	-	-
SG-4	Steel Pin	184684.870	1210718.840	71.50		-	-	-	-	-	-
SG-5	Steel Pin	185719.650	1211197.860	75.40		-	-	-	-	-	-
SG-6	Steel Pin	185683.430	1211830.650	73.60		-	-	-	-	-	-
SG-7	Steel Pin	186271.264	1211501.821	72.30		-	-	-	-	-	-
PIEZOMETERS											
PZ-1	Piezometer	1212179.59	184101.08	99.50		4.25	95.25	3.02	96.48	3.09	96.41
PZ-2	Piezometer	1211347.26	184095.08	84.50		2.12	82.38	0.94	83.56	0.89	83.61
PZ-3	Piezometer	1211250.12	184157.76	81.58		-	-	NM	-	2.86	78.72
PZ-4	Piezometer	183301.870	1210400.310	71.60		-	-	-	-	-	-
PZ-5	Piezometer	184841.890	1211288.080	75.40		-	-	-	-	-	-
PZ-6	Piezometer	184262.980	1212265.660	94.60		-	-	-	-	-	-
PZ-7	Piezometer	184521.000	1211693.760	78.60		-	-	-	-	-	-
PZ-8	Piezometer	185806.650	1211522.590	71.90		-	-	-	-	-	-
PZ-9	Piezometer	186489.890	1211506.110	72.00		-	-	-	-	-	-
PZ-103	Piezometer	1211363.32	185229.00	72.50		-	-	-	-	-	-
PZ-110	Piezometer	1211870.400	187239.530	68.90		-	-	-	-	-	-
Monitoring Wells											
MW-9	Monitoring Well	1211047.000	183778.000	81.70		5.15	76.55	-	-	5.37	76.33
MW-10	Monitoring Well	1211132.540	184167.680	79.10		5.64	73.46	-	-	5.48	73.62
OP-2	Monitoring Well	1211936.000	184139.000	100.00		5.65	94.35	-	-	5.11	94.89
OP-5	Monitoring Well	1212016.540	183457.150	108.40		15.01	93.39	-	-	14.11	94.29
AE-3A	Monitoring Well	1211380.240	184301.830	85.00		7.82	77.18	-	-	8.17	76.83
FPC-5A	Monitoring Well	1210979.690	184509.920	73.80		0.34	73.46	-	-	1.82	71.98
FPC-6A	Monitoring Well	1210817.000	185095.000	79.20		5.76	73.44	-	-	3.86	75.34
FPC-7A	Monitoring Well	1211925.710	185037.990	87.60		0.33	87.27	-	-	0.42	87.18
FPC-9A	Monitoring Well	1212479.830	183576.850	114.10		20.25	93.85	-	-	19.31	94.79

TABLE 3.4
Surface Water Elevation Summary

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Location	Type of Measuring Point	Easting	Northing	MP Elevation	Staff Gauge Elevation (bottom)	7/3/2019		8/9/2019		9/30/2019	
		NH State Plane	NH State Plane			Measured WL	Elevation	Measured WL	Elevation	Measured WL	Elevation
Stormwater Pond (SB-1)	Staff Gauge	1212178.05	184101.54	97.70	95.64	0.1	95.74	dry	-	Dry	-
Stormwater Pond (SB-2)	Staff Gauge	1211326.74	184074.27	84.00	80.14	0.67	80.81	0.9	81.04	Dry	-
L-1 Seep	Staff Gauge	1211281.31	184153.70	78.50	76.44	Dry	-	0.55	76.99	0.49	76.93
SW-5	Staff Gauge	1211286.92	184845.04	75.00	72.94	0.68	73.62	0.71	73.65	Dry	-
SW-103	Staff Gauge	1211367.44	185228.27	74.80	72.74	0.91	73.65	0.98	73.72	0.26	73.72
		1211874.68	187243.98	68.70							
*SW-110	Steel Pin	1211870.4	187239.53	69.80		Dry	-	1.35	67.35	Dry	-
+BB-1	Steel Pin	1211763.51	186949.74	72.00		1.12	70.88	1.17	70.83	Dry	-
		1211500.44	185818.19	73.50							
*BB-2	Steel Pin	1211523.17	185807.25	73.60		0.57	72.93	0.79	72.71	Dry	-
Little River Bridge	Top of Culvert	1208971.20	179648.17	68.90		4.24	64.66	4.25	64.65	4.63	64.65
SG-1	Steel Pin	1210400.470	183299.400	71.60		-	-	-	-	-	-
SG-2	Steel Pin	183770.810	1210587.560	71.30		-	-	-	-	-	-
SG-3	Steel Pin	185007.170	1210971.530	71.20		-	-	-	-	-	-
SG-4	Steel Pin	184684.870	1210718.840	71.50		-	-	-	-	-	-
SG-5	Steel Pin	185719.650	1211197.860	75.40		-	-	-	-	-	-
SG-6	Steel Pin	185683.430	1211830.650	73.60		-	-	-	-	-	-
SG-7	Steel Pin	186271.264	1211501.821	72.30		-	-	-	-	-	-
PZ-1	Piezometer	1212179.59	184101.08	99.50		4.29	95.21	5.24	94.26	Dry	-
PZ-2	Piezometer	1211347.26	184095.08	84.50		1.46	83.04	1.81	82.69	2.64	81.86
PZ-3	Piezometer	1211250.12	184157.76	81.58		2.83	78.75	2.83	78.75	4.99	76.59
PZ-4	Piezometer	183301.870	1210400.310	71.60		-	-	-	-	-	-
PZ-5	Piezometer	184841.890	1211288.080	75.40		-	-	-	-	-	-
PZ-6	Piezometer	184262.980	1212265.660	94.60		-	-	-	-	-	-
PZ-7	Piezometer	184521.000	1211693.760	78.60		-	-	-	-	-	-
PZ-8	Piezometer	185806.650	1211522.590	71.90		-	-	-	-	-	-
PZ-9	Piezometer	186489.890	1211506.110	72.00		-	-	-	-	-	-
PZ-103	Piezometer	1211363.32	185229.00	72.50		-	-	-	-	-	-
PZ-110	Piezometer	1211870.400	187239.530	68.90		-	-	-	-	-	-
MW-9	Monitoring Well	1211047.000	183778.000	81.70		7.6	74.10	-	-	-	-
MW-10	Monitoring Well	1211132.540	184167.680	79.10		5.72	73.38	-	-	-	-
OP-2	Monitoring Well	1211936.000	184139.000	100.00		5.88	94.12	-	-	-	-
OP-5	Monitoring Well	1212016.540	183457.150	108.40		14.82	93.58	-	-	-	-
AE-3A	Monitoring Well	1211380.240	184301.830	85.00		9.25	75.75	-	-	-	-
FPC-5A	Monitoring Well	1210979.690	184509.920	73.80		2.06	71.74	-	-	-	-
FPC-6A	Monitoring Well	1210817.000	185095.000	79.20		7.17	72.03	-	-	-	-
FPC-7A	Monitoring Well	1211925.710	185037.990	87.60		1.03	86.57	-	-	-	-
FPC-9A	Monitoring Well	1212479.830	183576.850	114.10		20.16	93.94	-	-	-	-

TABLE 3.4
Surface Water Elevation Summary

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Location	Type of Measuring Point	Easting	Northing	MP Elevation	Staff Gauge Elevation (bottom)	5/11/2020		10/5/2020		5/12/2021	
		NH State Plane	NH State Plane			Measured WL	Elevation	Measured WL	Elevation	Measured WL	Elevation
Stormwater Pond (SB-1)	Staff Gauge	1212178.05	184101.54	97.70	95.64	0.88	96.52	DRY	-	0.85	96.49
Stormwater Pond (SB-2)	Staff Gauge	1211326.74	184074.27	84.00	80.14	0.96	81.10	DRY	-	-	-
L-1 Seep	Staff Gauge	1211281.31	184153.70	78.50	76.44	0.42	76.86	DRY	-	0.65	77.09
SW-5	Staff Gauge	1211286.92	184845.04	75.00	72.94	0.78	73.72	DRY	-	-	-
SW-103	Staff Gauge	1211367.44	185228.27	74.80	72.74	1.27	74.01	DRY	-	-	-
		1211874.68	187243.98	68.70							
*SW-110	Steel Pin	1211870.4	187239.53	69.80		DRY	-	DRY	-	-	-
+BB-1	Steel Pin	1211763.51	186949.74	72.00		0.76	71.24	DRY	-		
		1211500.44	185818.19	73.50							
*BB-2	Steel Pin	1211523.17	185807.25	73.60		1.15	72.35	DRY	-	-	-
Little River Bridge	Top of Culvert	1208971.20	179648.17	68.90		4.29	64.61	4.6	64.30	-	-
SG-1	Steel Pin	1210400.470	183299.400	71.60		-	-	-	-	-	-
SG-2	Steel Pin	183770.810	1210587.560	71.30		-	-	-	-	-	-
SG-3	Steel Pin	185007.170	1210971.530	71.20		-	-	-	-	-	-
SG-4	Steel Pin	184684.870	1210718.840	71.50		-	-	-	-	-	-
SG-5	Steel Pin	185719.650	1211197.860	75.40		-	-	-	-	-	-
SG-6	Steel Pin	185683.430	1211830.650	73.60		-	-	-	-	-	-
SG-7	Steel Pin	186271.264	1211501.821	72.30		-	-	-	-	-	-
PZ-1	Piezometer	1212179.59	184101.08	99.50		3.34	96.16	DRY	-	3.25	96.25
PZ-2	Piezometer	1211347.26	184095.08	84.50		1.02	83.48	DRY	-	-	-
PZ-3	Piezometer	1211250.12	184157.76	81.58		2.89	78.69	3.56	78.02	1.18	80.40
PZ-4	Piezometer	183301.870	1210400.310	71.60		-	-	-	-	-	-
PZ-5	Piezometer	184841.890	1211288.080	75.40		-	-	-	-	-	-
PZ-6	Piezometer	184262.980	1212265.660	94.60		-	-	-	-	-	-
PZ-7	Piezometer	184521.000	1211693.760	78.60		-	-	-	-	-	-
PZ-8	Piezometer	185806.650	1211522.590	71.90		-	-	-	-	-	-
PZ-9	Piezometer	186489.890	1211506.110	72.00		-	-	-	-	-	-
PZ-103	Piezometer	1211363.32	185229.00	72.50		-	-	-	-	-	-
PZ-110	Piezometer	1211870.400	187239.530	68.90		-	-	-	-	-	-
MW-9	Monitoring Well	1211047.000	183778.000	81.70		5.86	75.84	9.87	71.83	6.22	75.48
MW-10	Monitoring Well	1211132.540	184167.680	79.10		5.50	73.60	8.05	71.05	5.58	73.52
OP-2	Monitoring Well	1211936.000	184139.000	100.00		5.00	95.00	8.3	91.70	5.47	94.53
OP-5	Monitoring Well	1212016.540	183457.150	108.40		13.87	94.53	16.92	91.48	14.57	93.83
AE-3A	Monitoring Well	1211380.240	184301.830	85.00		8.33	76.67	9.93	75.07	8.45	76.55
FPC-5A	Monitoring Well	1210979.690	184509.920	73.80		2.10	71.70	3.28	70.52	2.25	71.55
FPC-6A	Monitoring Well	1210817.000	185095.000	79.20		6.63	72.57	9.53	69.67	6.75	72.45
FPC-7A	Monitoring Well	1211925.710	185037.990	87.60		0.50	87.10	2.67	84.93	0.75	86.85
FPC-9A	Monitoring Well	1212479.830	183576.850	114.10		19.09	95.01	22.27	91.83	19.9	94.20

TABLE 3.4
Surface Water Elevation Summary

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Location	Type of Measuring Point	Easting	Northing	MP Elevation	Staff Gauge Elevation (bottom)	7/13/2021		10/1/2021		11/16/2021	
		NH State Plane	NH State Plane			Measured WL	Elevation	Measured WL	Elevation	Measured WL	Elevation
Stormwater Pond (SB-1)	Staff Gauge	1212178.05	184101.54	97.70	95.64	1.44	97.08	DRY	-	1.26	96.90
Stormwater Pond (SB-2)	Staff Gauge	1211326.74	184074.27	84.00	80.14	-	-	0.63	80.77	-	-
L-1 Seep	Staff Gauge	1211281.31	184153.70	78.50	76.44	0.69	79.19	0.53	76.97	0.43	76.87
SW-5	Staff Gauge	1211286.92	184845.04	75.00	72.94	-	-	0.84	73.78	0.98	73.92
SW-103	Staff Gauge	1211367.44	185228.27	74.80	72.74	-	-	1.36	74.10	1.50	74.24
*SW-110	Steel Pin	1211874.68	187243.98	68.70		-	-	1.6	68.20	1.30	67.40
		1211870.4	187239.53	69.80							
+BB-1	Steel Pin	1211763.51	186949.74	72.00							
*BB-2	Steel Pin	1211500.44	185818.19	73.50		-	-	2.23	71.37	1.79	71.81
		1211523.17	185807.25	73.60							
Little River Bridge	Top of Culvert	1208971.20	179648.17	68.90		-	-	4.13	64.77	4.05	64.85
SG-1	Steel Pin	1210400.470	183299.400	71.60		-	-	0.9	70.70	0.73	70.87
SG-2	Steel Pin	183770.810	1210587.560	71.30		-	-	0.72	70.58	0.56	70.74
SG-3	Steel Pin	185007.170	1210971.530	71.20		-	-	0.65	70.55	0.49	70.71
SG-4	Steel Pin	184684.870	1210718.840	71.50		-	-	0.84	70.66	0.68	70.82
SG-5	Steel Pin	185719.650	1211197.860	75.40		-	-	2.02	73.38	1.93	73.47
SG-6	Steel Pin	185683.430	1211830.650	73.60		-	-	0.76	72.84	0.72	72.88
SG-7	Steel Pin	186271.264	1211501.821	72.30		-	-	1.93	70.37	1.79	70.51
PZ-1	Piezometer	1212179.59	184101.08	99.50		2.79	96.71	6.67	92.83	2.93	96.57
PZ-2	Piezometer	1211347.26	184095.08	84.50		1.36	83.14	1.7	82.80	0.98	83.52
PZ-3	Piezometer	1211250.12	184157.76	81.58		2.54	79.04	2.86	78.72	0.72	80.86
PZ-4	Piezometer	183301.870	1210400.310	71.60		-	-	1.39	70.21	1.21	70.39
PZ-5	Piezometer	184841.890	1211288.080	75.40		-	-	1.52	73.88	1.40	74.00
PZ-6	Piezometer	184262.980	1212265.660	94.60		-	-	2.6	92.00	2.42	92.18
PZ-7	Piezometer	184521.000	1211693.760	78.60		-	-	2.6	76.00	2.63	75.97
PZ-8	Piezometer	185806.650	1211522.590	71.90		-	-	2.18	69.72	2.38	69.52
PZ-9	Piezometer	186489.890	1211506.110	72.00		-	-	2.23	69.77	1.91	70.09
PZ-103	Piezometer	1211363.32	185229.00	72.50		-	-	1.59	70.91	1.47	71.03
PZ-110	Piezometer	1211870.400	187239.530	68.90		-	-	2.24	66.66	1.83	67.07
MW-9	Monitoring Well	1211047.000	183778.000	81.70		5.07	76.52	7.89	73.81	5.28	76.42
MW-10	Monitoring Well	1211132.540	184167.680	79.10		5.18	73.58	5.69	73.41	5.36	73.74
OP-2	Monitoring Well	1211936.000	184139.000	100.00		5.52	85.51	6.48	93.52	5.26	94.74
OP-5	Monitoring Well	1212016.540	183457.150	108.40		14.49	93.91	15.23	93.17	14.00	94.40
AE-3A	Monitoring Well	1211380.240	184301.830	85.00		7.62	77.38	8.63	76.37	7.94	77.06
FPC-5A	Monitoring Well	1210979.690	184509.920	73.80		2.13	71.67	2.4	71.40	2.15	71.65
FPC-6A	Monitoring Well	1210817.000	185095.000	79.20		6.54	72.66	7.17	72.03	6.48	72.72
FPC-7A	Monitoring Well	1211925.710	185037.990	87.60		0.42	87.18	1.05	86.55	0.58	87.02
FPC-9A	Monitoring Well	1212479.830	183576.850	114.10		19.64	94.46	20.54	93.56	19.27	94.83

TABLE 3.4
Surface Water Elevation Summary

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Location	Type of Measuring Point	Easting	Northing	MP Elevation	Staff Gauge Elevation (bottom)	12/16/2021		1/24/2022	
		NH State Plane	NH State Plane			Measured WL	Elevation	Measured WL	Elevation
Stormwater Pond (SB-1)	Staff Gauge	1212178.05	184101.54	97.70	95.64	1.20	96.84	FROZEN	---
Stormwater Pond (SB-2)	Staff Gauge	1211326.74	184074.27	84.00	80.14	-	-	FROZEN	---
L-1 Seep	Staff Gauge	1211281.31	184153.70	78.50	76.44	0.51	76.95	0.50	76.94
SW-5	Staff Gauge	1211286.92	184845.04	75.00	72.94	0.94	73.88	FROZEN	---
SW-103	Staff Gauge	1211367.44	185228.27	74.80	72.74	FROZEN	-	1.58	74.32
		1211874.68	187243.98	68.70					
*SW-110	Steel Pin	1211870.4	187239.53	69.80		1.35	68.45	FROZEN	---
+BB-1	Steel Pin	1211763.51	186949.74	72.00					
		1211500.44	185818.19	73.50					
*BB-2	Steel Pin	1211523.17	185807.25	73.60		1.82	71.78	FROZEN	---
Little River Bridge	Top of Culvert	1208971.20	179648.17	68.90		4.25	64.65	FROZEN	---
SG-1	Steel Pin	1210400.470	183299.400	71.60		0.72	70.88	FROZEN	---
SG-2	Steel Pin	183770.810	1210587.560	71.30		0.64	70.66	FROZEN	---
SG-3	Steel Pin	185007.170	1210971.530	71.20		0.62	70.58	FROZEN	---
SG-4	Steel Pin	184684.870	1210718.840	71.50		0.68	70.82	FROZEN	---
SG-5	Steel Pin	185719.650	1211197.860	75.40		1.98	73.42	FROZEN	---
SG-6	Steel Pin	185683.430	1211830.650	73.60		0.70	72.90	FROZEN	---
SG-7	Steel Pin	186271.264	1211501.821	72.30		1.84	70.46	FROZEN	---
PZ-1	Piezometer	1212179.59	184101.08	99.50		2.95	96.55	FROZEN	---
PZ-2	Piezometer	1211347.26	184095.08	84.50		1.14	83.36	FROZEN	---
PZ-3	Piezometer	1211250.12	184157.76	81.58		2.78	78.80	FROZEN	---
PZ-4	Piezometer	183301.870	1210400.310	71.60		1.23	70.37	FROZEN	---
PZ-5	Piezometer	184841.890	1211288.080	75.40		1.36	74.04	FROZEN	---
PZ-6	Piezometer	184262.980	1212265.660	94.60		2.42	92.18	FROZEN	---
PZ-7	Piezometer	184521.000	1211693.760	78.60		2.60	76.00	FROZEN	---
PZ-8	Piezometer	185806.650	1211522.590	71.90		1.75	70.15	FROZEN	---
PZ-9	Piezometer	186489.890	1211506.110	72.00		1.98	70.02	FROZEN	---
PZ-103	Piezometer	1211363.32	185229.00	72.50		1.44	71.06	FROZEN	---
PZ-110	Piezometer	1211870.400	187239.530	68.90		1.98	66.92	FROZEN	---
MW-9	Monitoring Well	1211047.000	183778.000	81.70		5.43	76.27	6.72	74.98
MW-10	Monitoring Well	1211132.540	184167.680	79.10		5.40	73.70	5.40	73.70
OP-2	Monitoring Well	1211936.000	184139.000	100.00		5.45	94.55	5.51	94.49
OP-5	Monitoring Well	1212016.540	183457.150	108.40		14.67	93.73	14.60	93.80
AE-3A	Monitoring Well	1211380.240	184301.830	85.00		8.13	76.87	8.11	76.89
FPC-5A	Monitoring Well	1210979.690	184509.920	73.80		2.19	71.61	2.15	71.65
FPC-6A	Monitoring Well	1210817.000	185095.000	79.20		6.49	72.71	3.98	75.22
FPC-7A	Monitoring Well	1211925.710	185037.990	87.60		0.73	86.87	FROZEN	---
FPC-9A	Monitoring Well	1212479.830	183576.850	114.10		19.89	94.21	19.88	94.22

TABLE 3.4
Surface Water Elevation Summary

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Location	Type of Measuring Point	Easting	Northing	MP Elevation	Staff Gauge Elevation (bottom)	3/29/2022			
		NH State Plane	NH State Plane			Measured WL		Elevation	
						Inside	Outside	Inside	Outside
Stormwater Pond (SB-1)	Staff Gauge	1212178.05	184101.54	97.70	95.64	1.21	-	96.85	-
Stormwater Pond (SB-2)	Staff Gauge	1211326.74	184074.27	84.00	80.14	-	-	-	-
L-1 Seep	Staff Gauge	1211281.31	184153.70	78.50	76.44	0.60	-	77.04	-
SW-5	Staff Gauge	1211286.92	184845.04	75.00	72.94	1.00	-	73.94	-
SW-103	Staff Gauge	1211367.44	185228.27	74.80	72.74	1.52	-	74.26	-
		1211874.68	187243.98	68.70					
*SW-110	Steel Pin	1211870.4	187239.53	69.80		1.52	-	68.28	-
+BB-1	Steel Pin	1211763.51	186949.74	72.00					
		1211500.44	185818.19	73.50					
*BB-2	Steel Pin	1211523.17	185807.25	73.60		1.83	-	71.77	-
Little River Bridge	Top of Culvert	1208971.20	179648.17	68.90		2.80	-	66.10	-
SG-1	Steel Pin	1210400.470	183299.400	71.60		0.80	-	70.80	-
SG-2	Steel Pin	183770.810	1210587.560	71.30		0.59	-	70.71	-
SG-3	Steel Pin	185007.170	1210971.530	71.20		0.54	-	70.66	-
SG-4	Steel Pin	184684.870	1210718.840	71.50		0.70	-	70.80	-
SG-5	Steel Pin	185719.650	1211197.860	75.40		2.01	-	73.39	-
SG-6	Steel Pin	185683.430	1211830.650	73.60		0.79	-	72.81	-
SG-7	Steel Pin	186271.264	1211501.821	72.30		NM	-	-	-
PZ-1	Piezometer	1212179.59	184101.08	99.50		3.01	2.98	96.49	96.52
PZ-2	Piezometer	1211347.26	184095.08	84.50		0.93	0.93	83.57	83.57
PZ-3	Piezometer	1211250.12	184157.76	81.58		3.01	Dry	78.57	-
PZ-4	Piezometer	183301.870	1210400.310	71.60		1.38	1.24	70.22	70.36
PZ-5	Piezometer	184841.890	1211288.080	75.40		1.36	1.36	74.04	74.04
PZ-6	Piezometer	184262.980	1212265.660	94.60		2.46	2.71	92.14	91.89
PZ-7	Piezometer	184521.000	1211693.760	78.60		2.62	2.65	75.98	75.95
PZ-8	Piezometer	185806.650	1211522.590	71.90		1.71	1.82	70.19	70.08
PZ-9	Piezometer	186489.890	1211506.110	72.00		2.00	2.11	70.00	69.89
PZ-103	Piezometer	1211363.32	185229.00	72.50		1.44	1.41	71.06	71.09
PZ-110	Piezometer	1211870.400	187239.530	68.90		2.24	2.41	66.66	66.49
MW-9	Monitoring Well	1211047.000	183778.000	81.70		5.38	-	76.32	-
MW-10	Monitoring Well	1211132.540	184167.680	79.10		5.35	-	73.75	-
OP-2	Monitoring Well	1211936.000	184139.000	100.00		5.16	-	94.84	-
OP-5	Monitoring Well	1212016.540	183457.150	108.40		14.11	-	94.29	-
AE-3A	Monitoring Well	1211380.240	184301.830	85.00		8.24	-	76.76	-
FPC-5A	Monitoring Well	1210979.690	184509.920	73.80		2.18	-	71.62	-
FPC-6A	Monitoring Well	1210817.000	185095.000	79.20		6.50	-	72.70	-
FPC-7A	Monitoring Well	1211925.710	185037.990	87.60		0.49	-	87.11	-
FPC-9A	Monitoring Well	1212479.830	183576.850	114.10		19.26	-	94.84	-

TABLE 3.4
Surface Water Elevation Summary

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Location	Type of Measuring Point	Easting	Northing	MP Elevation	Staff Gauge Elevation (bottom)	4/14/2022			
		NH State Plane	NH State Plane			Measured WL		Elevation	
						Inside	Outside	Inside	Outside
Stormwater Pond (SB-1)	Staff Gauge	1212178.05	184101.54	97.70	95.64	1.25	-	96.89	-
Stormwater Pond (SB-2)	Staff Gauge	1211326.74	184074.27	84.00	80.14	- (1.28)	-	-	-
L-1 Seep	Staff Gauge	1211281.31	184153.70	78.50	76.44	0.66	-	77.10	-
SW-5	Staff Gauge	1211286.92	184845.04	75.00	72.94	1.03	-	73.97	-
SW-103	Staff Gauge	1211367.44	185228.27	74.80	72.74	1.55	-	74.29	-
*SW-110	Steel Pin	1211874.68	187243.98	68.70		1.45	-	68.35	-
		1211870.4	187239.53	69.80					
+BB-1	Steel Pin	1211763.51	186949.74	72.00					
*BB-2	Steel Pin	1211500.44	185818.19	73.50		1.82	-	71.78	-
		1211523.17	185807.25	73.60					
Little River Bridge	Top of Culvert	1208971.20	179648.17	68.90		2.49	-	66.41	-
SG-1	Steel Pin	1210400.470	183299.400	71.60		0.59	-	71.01	-
SG-2	Steel Pin	183770.810	1210587.560	71.30		0.59	-	70.71	-
SG-3	Steel Pin	185007.170	1210971.530	71.20		0.49	-	70.71	-
SG-4	Steel Pin	184684.870	1210718.840	71.50		0.70	-	70.80	-
SG-5	Steel Pin	185719.650	1211197.860	75.40		1.99	-	73.41	-
SG-6	Steel Pin	185683.430	1211830.650	73.60		1.75	-	71.85	-
SG-7	Steel Pin	186271.264	1211501.821	72.30		1.85	-	70.45	-
PZ-1	Piezometer	1212179.59	184101.08	99.50		3.00	2.90	96.50	96.60
PZ-2	Piezometer	1211347.26	184095.08	84.50		0.87	0.94	83.63	83.56
PZ-3	Piezometer	1211250.12	184157.76	81.58		3.83	Dry	77.75	-
PZ-4	Piezometer	183301.870	1210400.310	71.60		1.23	1.27	70.37	70.33
PZ-5	Piezometer	184841.890	1211288.080	75.40		1.34	1.34	74.06	74.06
PZ-6	Piezometer	184262.980	1212265.660	94.60		2.49	2.58	92.11	92.02
PZ-7	Piezometer	184521.000	1211693.760	78.60		2.66	2.66	75.94	75.94
PZ-8	Piezometer	185806.650	1211522.590	71.90		1.66	1.74	70.24	70.16
PZ-9	Piezometer	186489.890	1211506.110	72.00		1.95	2.08	70.05	69.92
PZ-103	Piezometer	1211363.32	185229.00	72.50		1.44	1.39	71.06	71.11
PZ-110	Piezometer	1211870.400	187239.530	68.90		2.02	2.30	66.88	66.60
MW-9	Monitoring Well	1211047.000	183778.000	81.70		5.29	-	76.41	-
MW-10	Monitoring Well	1211132.540	184167.680	79.10		5.38	-	73.72	-
OP-2	Monitoring Well	1211936.000	184139.000	100.00		5.08	-	94.92	-
OP-5	Monitoring Well	1212016.540	183457.150	108.40		14.18	-	94.22	-
AE-3A	Monitoring Well	1211380.240	184301.830	85.00		8.19	-	76.81	-
FPC-5A	Monitoring Well	1210979.690	184509.920	73.80		2.15	-	71.65	-
FPC-6A	Monitoring Well	1210817.000	185095.000	79.20		6.48	-	72.72	-
FPC-7A	Monitoring Well	1211925.710	185037.990	87.60		0.39	-	87.21	-
FPC-9A	Monitoring Well	1212479.830	183576.850	114.10		19.38	-	94.72	-

TABLE 3.4
Surface Water Elevation Summary

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Location	Type of Measuring Point	Easting	Northing	MP Elevation	Staff Gauge Elevation (bottom)	5/9/2022			
		NH State Plane	NH State Plane			Measured WL		Elevation	
						Inside	Outside	Inside	Outside
Stormwater Pond (SB-1)	Staff Gauge	1212178.05	184101.54	97.70	95.64	0.48	-	96.12	-
Stormwater Pond (SB-2)	Staff Gauge	1211326.74	184074.27	84.00	80.14	- (1.52)	-	-	-
L-1 Seep	Staff Gauge	1211281.31	184153.70	78.50	76.44	0.79	-	77.23	-
SW-5	Staff Gauge	1211286.92	184845.04	75.00	72.94	0.94	-	73.88	-
SW-103	Staff Gauge	1211367.44	185228.27	74.80	72.74	1.46	-	74.20	-
		1211874.68	187243.98	68.70					
*SW-110	Steel Pin	1211870.4	187239.53	69.80		1.53	-	68.27	-
+BB-1	Steel Pin	1211763.51	186949.74	72.00					
		1211500.44	185818.19	73.50					
*BB-2	Steel Pin	1211523.17	185807.25	73.60		1.80	-	71.80	-
Little River Bridge	Top of Culvert	1208971.20	179648.17	68.90		2.70	-	66.20	-
SG-1	Steel Pin	1210400.470	183299.400	71.60		0.80	-	70.80	-
SG-2	Steel Pin	183770.810	1210587.560	71.30		0.65	-	70.65	-
SG-3	Steel Pin	185007.170	1210971.530	71.20		0.59	-	70.61	-
SG-4	Steel Pin	184684.870	1210718.840	71.50		0.78	-	70.72	-
SG-5	Steel Pin	185719.650	1211197.860	75.40		2.07	-	73.33	-
SG-6	Steel Pin	185683.430	1211830.650	73.60		0.75	-	72.85	-
SG-7	Steel Pin	186271.264	1211501.821	72.30		1.89	-	70.41	-
PZ-1	Piezometer	1212179.59	184101.08	99.50		3.77	3.71	95.73	95.79
PZ-2	Piezometer	1211347.26	184095.08	84.50		1.15	1.20	83.35	83.30
PZ-3	Piezometer	1211250.12	184157.76	81.58		3.00	Dry	78.58	-
PZ-4	Piezometer	183301.870	1210400.310	71.60		1.30	1.25	70.30	70.35
PZ-5	Piezometer	184841.890	1211288.080	75.40		1.45	1.40	73.95	74.00
PZ-6	Piezometer	184262.980	1212265.660	94.60		2.42	2.50	92.18	92.10
PZ-7	Piezometer	184521.000	1211693.760	78.60		2.60	2.58	76.00	76.02
PZ-8	Piezometer	185806.650	1211522.590	71.90		1.75	1.75	70.15	70.15
PZ-9	Piezometer	186489.890	1211506.110	72.00		2.20	2.20	69.80	69.80
PZ-103	Piezometer	1211363.32	185229.00	72.50		1.45	1.45	71.05	71.05
PZ-110	Piezometer	1211870.400	187239.530	68.90		2.08	2.38	66.82	66.52
MW-9	Monitoring Well	1211047.000	183778.000	81.70		6.85	-	74.85	-
MW-10	Monitoring Well	1211132.540	184167.680	79.10		5.50	-	73.60	-
OP-2	Monitoring Well	1211936.000	184139.000	100.00		5.51	-	94.49	-
OP-5	Monitoring Well	1212016.540	183457.150	108.40		14.38	-	94.02	-
AE-3A	Monitoring Well	1211380.240	184301.830	85.00		8.60	-	76.40	-
FPC-5A	Monitoring Well	1210979.690	184509.920	73.80		2.20	-	71.60	-
FPC-6A	Monitoring Well	1210817.000	185095.000	79.20		6.68	-	72.52	-
FPC-7A	Monitoring Well	1211925.710	185037.990	87.60		0.55	-	87.05	-
FPC-9A	Monitoring Well	1212479.830	183576.850	114.10		19.65	-	94.45	-

TABLE 3.4
Surface Water Elevation Summary

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Location	Type of Measuring Point	Easting	Northing	MP Elevation	Staff Gauge Elevation (bottom)	6/6/2022			
		NH State Plane	NH State Plane			Measured WL		Elevation	
						Inside	Outside	Inside	Outside
Stormwater Pond (SB-1)	Staff Gauge	1212178.05	184101.54	97.70	95.64	Dry	-	-	-
Stormwater Pond (SB-2)	Staff Gauge	1211326.74	184074.27	84.00	80.14	0.43	-	-	-
L-1 Seep	Staff Gauge	1211281.31	184153.70	78.50	76.44	0.64	-	77.08	-
SW-5	Staff Gauge	1211286.92	184845.04	75.00	72.94	0.92	-	73.86	-
SW-103	Staff Gauge	1211367.44	185228.27	74.80	72.74	1.43	-	74.17	-
		1211874.68	187243.98	68.70					
*SW-110	Steel Pin	1211870.4	187239.53	69.80		1.71	-	68.09	-
+BB-1	Steel Pin	1211763.51	186949.74	72.00		0.60	-	-	-
		1211500.44	185818.19	73.50					
*BB-2	Steel Pin	1211523.17	185807.25	73.60		1.88	-	71.72	-
Little River Bridge	Top of Culvert	1208971.20	179648.17	68.90		2.99	-	65.91	-
SG-1	Steel Pin	1210400.470	183299.400	71.60		0.93	-	70.67	-
SG-2	Steel Pin	183770.810	1210587.560	71.30		0.75	-	70.55	-
SG-3	Steel Pin	185007.170	1210971.530	71.20		0.67	-	70.53	-
SG-4	Steel Pin	184684.870	1210718.840	71.50		0.83	-	70.67	-
SG-5	Steel Pin	185719.650	1211197.860	75.40		2.15	-	73.25	-
SG-6	Steel Pin	185683.430	1211830.650	73.60		0.90	-	72.70	-
SG-7	Steel Pin	186271.264	1211501.821	72.30		1.98	-	70.32	-
PZ-1	Piezometer	1212179.59	184101.08	99.50		6.51	Dry	92.99	-
PZ-2	Piezometer	1211347.26	184095.08	84.50		1.84	1.78	82.66	82.72
PZ-3	Piezometer	1211250.12	184157.76	81.58		3.01	Dry	78.57	-
PZ-4	Piezometer	183301.870	1210400.310	71.60		1.37	1.32	70.23	70.28
PZ-5	Piezometer	184841.890	1211288.080	75.40		1.47	1.45	73.93	73.95
PZ-6	Piezometer	184262.980	1212265.660	94.60		2.61	Dry	91.99	-
PZ-7	Piezometer	184521.000	1211693.760	78.60		2.63	2.63	75.97	75.97
PZ-8	Piezometer	185806.650	1211522.590	71.90		1.73	1.77	70.17	70.13
PZ-9	Piezometer	186489.890	1211506.110	72.00		2.35	2.32	69.65	69.68
PZ-103	Piezometer	1211363.32	185229.00	72.50		1.49	1.54	71.01	70.96
PZ-110	Piezometer	1211870.400	187239.530	68.90		2.28	Dry	66.62	-
MW-9	Monitoring Well	1211047.000	183778.000	81.70		8.02	-	73.68	-
MW-10	Monitoring Well	1211132.540	184167.680	79.10		5.65	-	73.45	-
OP-2	Monitoring Well	1211936.000	184139.000	100.00		6.38	-	93.62	-
OP-5	Monitoring Well	1212016.540	183457.150	108.40		15.10	-	93.30	-
AE-3A	Monitoring Well	1211380.240	184301.830	85.00		8.72	-	76.28	-
FPC-5A	Monitoring Well	1210979.690	184509.920	73.80		2.15	-	71.65	-
FPC-6A	Monitoring Well	1210817.000	185095.000	79.20		7.00	-	72.20	-
FPC-7A	Monitoring Well	1211925.710	185037.990	87.60		0.90	-	86.70	-
FPC-9A	Monitoring Well	1212479.830	183576.850	114.10		20.34	-	93.76	-

TABLE 3.4
Surface Water Elevation Summary

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Notes:
Dry = Surface water not present at time of measurement
NM = Not measured
- = No value
All elevations in Feet Above Mean Sea Level
* = Measuring point moved and re-surveyed in Fall 2021 due to lack of water from beaver dam removals.
+ = Surface water monitoring location BB-1 was replaced with BB-3 in Spring 2021. BB-3 was repaired in May 2022 and fitted with a staff gauge ruler that hasn't been surveyed yet.
~ = Surface water monitoring location SB-2 was measured from the top of the steel pin in April and May 2022. A new staff gauge ruler was installed at the end of May 2022, and readings following May 2022 are from the new staff gauge ruler which hasn't been surveyed yet.

Table 3.5
Residential Well Record Review

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

WELLS IDENTIFIED IN REMEDIAL INVESTIGATION (RI)												
Well No. (RI)		Contact/Owner (RI)	Business Name (RI)	Address	Town	Map/Lot	Current Owner	On well? (Assessor)	Well Type	Currently Sampled?	Well Record Available?	In GMZ?
R-	1	SEWALL, DR. ELMER AND BARBARA	RED HOUSE	340 BREAKFAST HILL ROAD	GREENLAND	R1/13	BARBARA E SEWALL REVOCABLE TRUST 1996	UNKNOWN	BEDROCK	YES	YES	NO
R-	2	CORORON, NORMAN	SEWALL RENTAL	351 BREAKFAST HILL ROAD	GREENLAND	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	NO
R-	3	HYATT, CAROL	N/A	368 BREAKFAST HILL ROAD	GREENLAND	R1/12	PATRICK ST. JOHN	UNKNOWN	BEDROCK	YES	NO	NO
R-	4	HYATT, CAROL	N/A	368 BREAKFAST HILL ROAD	GREENLAND	R1/12	PATRICK ST. JOHN	UNKNOWN	SHALLOW	NO	NO	YES
R-	5	SEWALL, DAVID AND BARBARA	N/A	399 BREAKFAST HILL ROAD	GREENLAND	R1/2	BREAKFAST HILL TRUST I+II+III	UNKNOWN	BEDROCK	NO	NO	NO
R-	6	JUDD, MONA P.	N/A	463 BREAKFAST HILL ROAD	GREENLAND	R1/4	SEACOAST MENTAL HEALTH	UNKNOWN	BEDROCK	YES	YES	NO
R-	7	SEROWICK, PHIL	THERMAL HOMES	BREAKFAST HILL	GREENLAND	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	UNKNOWN
R-	8	CASWELL, MIKE	DRIVERS SEAT	LAFAYETTE ROAD	GREENLAND	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	UNKNOWN
R-	9	KULAK, ROBERT	RYE CENTER	150 RYE PLACE	RYE	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	NO	NO	NO
R-	10	CARPENTER, BILL	HOME CENTER	1247 WASHINGTON ROAD	RYE	10/19	MULTIPLE (OFFICE CONDOS)	UNKNOWN	BEDROCK	NO	NO	NO
R-	11	CORBETT, CATHY	B.H. PROFESSIONAL BUILDING	270 LAFAYETTE ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	NO
R-	12	SHERWIN, RICHARD	N/A	1220 WASHINGTON ROAD	RYE	10/81	JAMES MULVEY	NO	BEDROCK	NO	NO	NO
R-	13	UNKNOWN	SLEEPY HOLLOW HOTEL	LAFAYETTE ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	UNKNOWN
R-	14	BALFE, MICHAEL	C.G.C	300 LAFAYETTE ROAD	RYE	10/85	ALLEGIANT MANAGEMENT CORPORATION	UNKNOWN	BEDROCK	NO	NO	NO
R-	15	FOWHAN, RICHARD	N/A	1210 WASHINGTON ROAD	RYE	10/80	JOSHUA AND KAILEY GOULD	UNKNOWN	BEDROCK	NO	NO	NO
R-	16	BURNETT	N/A	1152 WASHINGTON ROAD	RYE	10/55	SAMUEL AND KATHERINE BIDDLE	UNKNOWN	SHALLOW	NO	NO	NO
R-	17	UNKNOWN	HECTORS COUNTRY KITCHEN	LAFAYETTE ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	UNKNOWN
R-	18	UNKNOWN	WAYNE'S GARDEN CENTER	56 DOW LANE	RYE	10/68	CONNECTING POINT REALTY, LLC	UNKNOWN	BEDROCK	NO	NO	NO
R-	19	BERRY, LILA	TUDOR HOUSE	220 LAFAYETTE ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	NO	NO	UNKNOWN
R-	20	HARGRAVES, GLEN	GLEN'S M.H.P.	203 LAFAYETTE ROAD	NORTH HAMPTON	21/7	CROWN PROPERTIES/JOSEPH ROY REALTY	NO	BEDROCK	NO	NO	NO
R-	20	UNKNOWN	JAMESON PLUMBING	LAFAYETTE ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	NO	NO	UNKNOWN
R-	21	KOSGROVE, KEVIN	ABECROMBIE AND FITCH	219 LAFAYETTE ROAD	NORTH HAMPTON	21/2	PRIME STORAGE NORTH HAMPTON, LLC	UNKNOWN	BEDROCK	NO	NO	NO
R-	22	TUCKER, JIM	DEXTER SHOE STORE	217 LAFAYETTE ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	NO
R-	23	ROBINSON, TED	ARCWAY WELDING	203 LAFAYETTE ROAD	NORTH HAMPTON	21/7	CROWN PROPERTIES AND HOME SALES	NO	SHALLOW	NO	NO	NO
R-	24	HARGRAVES, GLEN	GLEN'S M.H.P.	203 LAFAYETTE ROAD	NORTH HAMPTON	21/7	JOSEPH ROY REALTY	NO	SHALLOW	NO	NO	NO
R-	25	LAMBERT	N/A	LAFAYETTE ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	UNKNOWN
R-	26	BUDDE, SHEILA	N/A	LAFAYETTE ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	UNKNOWN
R-	27	GREENLEAF	GREENLEY	LAFAYETTE ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	UNKNOWN
R-	28	UNKNOWN	LAFAYETTE TERRACE	LAFAYETTE ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	UNKNOWN
R-	29	TRAVIS, PAULA	KENDA MOTEL	LAFAYETTE ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	UNKNOWN
R-	31	UNKNOWN	DRIVE-IN THEATRE	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	NO	NO	UNKNOWN
R-	32	UNKNOWN	DRIVE-IN/MINI MART	LAFAYETTE ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	SHALLOW	NO	NO	UNKNOWN
R-	33	TUCKER, PHIL	TILTON EQUIPMENT	189 LAFAYETTE ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	UNKNOWN
R-	34	STEVENS, DEAN	ELLIOT (RENTER)	178A LAFAYETTE ROAD	NORTH HAMPTON	17/84-1	E. DEAN AND CORA A STEVENS TRUSTS	YES	SHALLOW	YES	NO	NO
R-	35	UNKNOWN	PHILBRICKS	181 LAFAYETTE ROAD	NORTH HAMPTON	17/96	ONE SEVENTY NINE LAFAYETTE REALTY LLC	NO	BEDROCK	NO	NO	NO
R-	36	SILVA, EDMUND	E. SILVA MOTEL	178 LAFAYETTE ROAD	NORTH HAMPTON	17/84-1	E. DEAN AND CORA A STEVENS TRUSTS	NO	BEDROCK	NO	NO	NO
R-	37	WILHELM, WALTER	PINE HAVEN MOTEL	183 LAFAYETTE ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	UNKNOWN
R-	38	LUCK, EDWARD	BETTY'S KITCHEN	LAFAYETTE ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	UNKNOWN
R-	39	LUCK, EDWARD	MERRY MAIDS	160 LAFAYETTE ROAD	NORTH HAMPTON	17/82	GRANITE POSTE GREEN MHC	NO	BEDROCK	NO	NO	YES
R-	40	GREITZER, MARTIN	N/A	49 NORTH ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	NO
R-	41	GREENE, D.R.	N/A	43 NORTH ROAD	NORTH HAMPTON	17/79	SUSAN SHAPIRO	NO	BEDROCK	NO	NO	NO
R-	42	CAFARELLA, JOHN	N/A	41 NORTH ROAD	NORTH HAMPTON	17/77	JOHN CAFARELLA, LACEY TEDDY TRUST	NO	SHALLOW	NO	NO	NO
R-	43	DRAKE, JOSHUA	N/A	148 LAFAYETTE ROAD	NORTH HAMPTON	17/80	PETER RHOADES	NO	SHALLOW	NO	NO	NO
R-	44	HALE, WALLACE AND MARY	N/A	165 LAFAYETTE ROAD	NORTH HAMPTON	17/99	SEACOAST BIRTH AND FAMILY CONNECTION, LLC	NO	BEDROCK	NO	NO	NO
R-	45	KITENDAUGH, E.C.	N/A	155 LAFAYETTE ROAD	NORTH HAMPTON	17/39	GEORGETOWN ANS AND GRAVEL COMPANY, INC.	NO	BEDROCK	NO	YES	NO
R-	46	UNKNOWN	PANTELAKES RESTAURANT	LAFAYETTE ROAD	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	NO	NO	UNKNOWN
R-	47	ADAMS MOBILE HOME PARK	N/A	1 ADAMS PARK	RYE	10/13-1	ADAMS MOBILE HOME PARK INC	UNKNOWN	UNKNOWN	NO	YES	NO
R-	48	OILER, MIKE	N/A	41 BIRCH ROAD	NORTH HAMPTON	17/20	OILER FAMILY REVOCABLE TRUST	NO	SHALLOW	NO	NO	NO
R-	49	NELSON, RICHARD	N/A	39 BIRCH ROAD	NORTH HAMPTON	17/19	KEVIN BELLAVANCE	NO	UNKNOWN	NO	NO	NO
R-	50	WALSH, PAUL	N/A	11 NORTH ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	NO	NO	NO
R-	51	EDWARDS, JAMES P.	FORMERLY CRUIKSHANK	15 NORTH ROAD	NORTH HAMPTON	17/102	KRISTOHPER SMITH	NO	UNKNOWN	NO	NO	NO
R-	52	RYAN, RON	N/A	9 NORTH ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	SHALLOW	NO	NO	NO
R-	53	BYRNE, JOHN	N/A	7 NORTH ROAD	NORTH HAMPTON	17/104	JOHN AND DENIS BYRNE	NO	BEDROCK	NO	NO	NO
R-	54	KRATT, RON	N/A	5 NORTH ROAD	NORTH HAMPTON	17/1052	CHRISTOPHER AND DONNA BROWN	NO	UNKNOWN	NO	NO	NO
R-	55	DUNN, JOE AND PHYL	N/A	6 NORTH ROAD	NORTH HAMPTON	17/107-3	LAURIE KELLEHER	NO	BEDROCK	NO	NO	NO
R-	56	NIGRELLI, TOM AND JOYCE	N/A	1 PARK CIRCLE	NORTH HAMPTON	17/107-8	ROBERT FERNALD	NO	BEDROCK	NO	NO	NO
R-	57	BEVERIDGE, DAN AND NANCY	N/A	2 PARK CIRCLE	NORTH HAMPTON	17/107-9	AARON GLENNEY	NO	BEDROCK	NO	NO	NO
R-	58	LINDLEY, S. EUGENE	N/A	4 NORTH ROAD	NORTH HAMPTON	17/107	HPM INVESTMENT, LLC	NO	BEDROCK	NO	YES	NO
R-	59	MACARTHUR, DAVE AND DEB	N/A	2 NORTH ROAD	NORTH HAMPTON	17/107-4	DAVID AND AMY MACARTHUR	NO	UNKNOWN	NO	NO	NO
R-	60	WYATT, STEVE	N/A	7 PARK CIRCLE	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	NO	NO	NO
R-	61	FORTI, A.J.	N/A	184 MILL ROAD	NORTH HAMPTON	12/58	SUSAN MOREHOUSE	NO	BEDROCK	NO	NO	NO
R-	62	SHEHOUSE	N/A	182 MILL ROAD	NORTH HAMPTON	12/57	SHEROUSE FAMILY TRUST	NO	UNKNOWN	NO	NO	NO
R-	63	BUCKLIN, KATHY	N/A	3 NORTH ROAD	NORTH HAMPTON	17/106	ALAN BUCKLIN	NO	BEDROCK	NO	NO	NO
R-	64	LINDLEY, S. EUGENE	N/A	4 NORTH ROAD	NORTH HAMPTON	17/107	HPM INVESTMENT, LLC	NO	SHALLOW	NO	NO	NO
R-	65	GOULIS, JOSEPH	N/A	197 MILL ROAD	NORTH HAMPTON	12/43	PHYLLIS GOULIS	YES	UNKNOWN	NO	NO	NO
R-	66	NORDSTROM, JODY	N/A	67 NORTH ROAD	NORTH HAMPTON	17/72	MARK SMITH AND COLEEN WEEKS	NO	SHALLOW	YES	NO	YES
R-	67	LAMATE, SANDY	N/A	1190 WASHINGTON ROAD	RYE	10/77	PE AND KH GOLDMAN TRUSTS	UNKNOWN	UNKNOWN	NO	NO	NO
R-	68	CHIARELLO	N/A	21 DOW LANE	RYE	10/74	MICHAEL C BURNETT LIVING TRUST	UNKNOWN	UNKNOWN	NO	NO	NO
R-	69	SAMPTON, CARL AND LINDA	TAYLOR SHOP	113 LAFAYETTE ROAD	RYE	10/8	LINDA SAMPSON	UNKNOWN	UNKNOWN	NO	YES	NO
R-	70	BURNETT, GLORIA	N/A	12 DOW LANE	RYE	10/58	CHARLES AND VALERIE PRESCOTT	UNKNOWN	BEDROCK	NO	NO	NO

Table 3.5
Residential Well Record Review

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Well No. (RI)		Contact/Owner (RI)	Business Name (RI)	Address	Town	Map/Lot	Current Owner	On well? (Assessor)	Well Type	Currently Sampled?	Well Record Available?	In GMZ?
WELLS IDENTIFIED IN REMEDIAL INVESTIGATION (RI)												
R-	71	OSBORN, MRS. JOHN	N/A	112 MILL ROAD	NORTH HAMPTON	6/147-2	F.S. 123 NOMINEE TRUST	NO	UNKNOWN	NO	YES	NO
R-	72	KNOWLES, RICHARD	N/A	8 WOODKNOLL DRIVE	NORTH HAMPTON	17/43-1	JANET S. KNOWLES REVOCABLE TRUST	NO	UNKNOWN	YES	YES	NO
R-	73	KNOWLES, JEFFREY	N/A	16A WOODKNOLL DRIVE	NORTH HAMPTON	18/11-1	JEFFREY AND KATHLEEN KNOWLES	NO	UNKNOWN	NO	YES	NO
R-	74	KNOWLES, STANLEY	N/A	3 CHERRY ROAD	NORTH HAMPTON	18/11	KNOWLES FAMILY REVOCABLE TRUST	NO	UNKNOWN	NO	YES	NO
R-	75	GRAVELS, MALCOMB	N/A	22 WOODKNOLL DRIVE	NORTH HAMPTON	17/55	DAVID AND ASHLEY HASS	NO	UNKNOWN	NO	NO	NO
R-	76	RUSTIGAN, ALISON	N/A	19 WOODKNOLL DRIVE	NORTH HAMPTON	17/57	MARCIA MURPHY, TRUSTEE	NO	UNKNOWN	NO	NO	NO
R-	77	O'CONNOR, LILLIAN	N/A	14 BIRCH ROAD	NORTH HAMPTON	17/42	PAUL AND BONNIE HEYWOOD	NO	UNKNOWN	NO	YES	NO
R-	78	FERDETTE, CHARLES	N/A	2 CHERRY ROAD	NORTH HAMPTON	18/23	CHARLES AND TERESA FREDETTE	UNKNOWN	UNKNOWN	NO	NO	NO
R-	79	BEDARD, CATHY	N/A	1090 WASHINGTON ROAD	RYE	6/28	INDEPENDENCE FARM, LLC	UNKNOWN	UNKNOWN	NO	NO	NO
R-	80	ECCARD	N/A	142 MILL ROAD	NORTH HAMPTON	12/47	RICHARD SKOWRONSKI	NO	UNKNOWN	NO	NO	NO
R-	81	LUFF, PETER	SAGAMORE GOLF COURSE	97 NORTH ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	SHALLOW	NO	NO	NO
R-	84	SANBORN, JANET	N/A	29 WOODKNOLL DRIVE	NORTH HAMPTON	17/62	JOHN AND ASHLEY BALL	NO	SHALLOW	NO	NO	NO
R-	85	KOSTANDIN, NICHOLAS	N/A	1156 WASHTINGON ROAD	RYE	10/56	MARCIA ROACH	UNKNOWN	BEDROCK	NO	NO	NO
R-	86	BLAKE, CHRISTINE	N/A	79 NORTH ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	NO
R-	87	BLANEY, ALDELBERT	N/A	176 MILL ROAD	NORTH HAMPTON	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	NO
R-	88	BRAYTON, VIRGINIA	N/A	2 BIRCH ROAD	NORTH HAMPTON	13/14	JUAN AND LORI GARCES	NO	SHALLOW	NO	YES	NO
R-	89	CARLINO, DAVID JR.	N/A	264 POST ROAD	GREENLAND	22/17	CARLINO FAMILY REVOCABLE TRUST	UNKNOWN	BEDROCK	NO	NO	NO
R-	90	CARLINO, DAVID SR.	N/A	266 POST ROAD	NORTH HAMPTON	22/16-2	DAVID W. CARLINO	NO	BEDROCK	NO	NO	NO
R-	91	CRAIG, ROBERT	N/A	120 POST ROAD	NORTH HAMPTON	14/143	ANDREW AND PATRICIA VORKINK	YES	BEDROCK	NO	NO	NO
R-	92	DUNHAM, MARY	N/A	15 CHERRY ROAD	NORTH HAMPTON	18/13	JANIS L FIESSELER REVOCABLE TRUST OF 2017	UNKNOWN	UNKNOWN	NO	NO	NO
R-	93	HENSON	N/A	14 BLUEBERRY LANE	RYE	11/44	ETHELANN HENSON	UNKNOWN	BEDROCK	NO	NO	NO
R-	94	LUFF, PETER	SAGAMORE GOLF COURSE	101 NORTH ROAD	NORTH HAMPTON	18/35	SAGAMORE HAMPTON GOLF CLUB INC	UNKNOWN	BEDROCK	NO	YES	NO
R-	95	SANBORN	N/A	73 NORTH ROAD	NORTH HAMPTON	17/70	KATHLEEN CORBETT	NO	UNKNOWN	NO	NO	NO
R-	96	YOUNG, BEN	N/A	75 NORTH ROAD	NORTH HAMPTON	17/69-1	CAMDEN AND FRANCES MITCHELL	NO	UNKNOWN	NO	NO	NO
R-	97	FULLER	N/A	84 NORTH ROAD	NORTH HAMPTON	18/15	JOHN AND TAMARA SULLIVAN	NO	UNKNOWN	NO	NO	NO
R-	98	TOWNHOUSE #1	THERMO HOMES	BREAKFAST HILL	GREENLAND	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	YES	YES	NO
R-	99	STEINBERG, W.	N/A	5 BERRY FARM LANE	GREENLAND	R1/4D	HEIDI NIGRO	UNKNOWN	BEDROCK	YES	NO	NO
R-	100	LONGSTREET CONSTRUCTION	N/A	LAFAYETTE ROAD	RYE	UNKNOWN	UNKNOWN	UNKNOWN	BEDROCK	NO	NO	NO
		BREAKFAST HILL GOLF CLUB, LLC	BREAKFAST HILL GOLF CLUB	339 BREAKFAST HILL ROAD	GREENLAND	UNKNOWN	BREAKFAST HILL GOLF CLUB, LLC	YES	BEDROCK	YES	YES	YES
		STEPHEN A & MARY ANN SEWALL	NA	346 BREAKFAST HILL ROAD	GREENLAND	UNKNOWN	STEPHEN A & MARY ANN SEWALL	YES	BEDROCK	YES	NO	NO
		BREAKFAST HILL TRUST I+II+III	NA	415 BREAKFAST HILL ROAD	GREENLAND	UNKNOWN	BREAKFAST HILL TRUST I+II+III	YES	BEDROCK	YES	NO	NO
		TREVOR B & MARIA S EMORY	NA	4 STONE MEADOW WAY	GREENLAND	UNKNOWN	TREVOR B & MARIA S EMORY	YES	BEDROCK	YES	NO	NO
		THOMAS E & BROOKE A CONLIN	NA	9 STONE MEADOW WAY	GREENLAND	UNKNOWN	THOMAS E & BROOKE A CONLIN	YES	BEDROCK	YES	NO	NO
		DAVID H & LIZA B MCGUCKIN TRUSTEES	NA	10 STONE MEADOW WAY	GREENLAND	UNKNOWN	DAVID H & LIZA B MCGUCKIN TRUSTEES	YES	BEDROCK	YES	NO	NO
		DAN LYNCH	NA	16 STONE MEADOW WAY	GREENLAND	UNKNOWN	DAN LYNCH	YES	BEDROCK	YES	NO	NO
		TIMOTHY J & AIMEE C MILLER	NA	19 STONE MEADOW WAY	GREENLAND	UNKNOWN	TIMOTHY J & AIMEE C MILLER	YES	BEDROCK	YES	NO	NO
		D.B. FARRELL & .M. VERMETTE	NA	21 STONE MEADOW WAY	GREENLAND	UNKNOWN	D.B. FARRELL & .M. VERMETTE	YES	BEDROCK	YES	NO	NO
		THERESA A SORENSON REVOCABLE TRUST	NA	4 RED OAK DRIVE	GREENLAND	UNKNOWN	THERESA A SORENSON REVOCABLE TRUST	YES	BEDROCK	YES	NO	NO
		ARTHUR D & SHARON M HOFFMAN	NA	10 RED OAK DRIVE	GREENLAND	UNKNOWN	ARTHUR D & SHARON M HOFFMAN	YES	BEDROCK	YES	NO	NO
		DAN WHITE	NA	25 FALLS WAY	GREENLAND	UNKNOWN	DAN WHITE	YES	BEDROCK	YES	NO	NO
		ELLIE ECKHOFF	NA	9 BERRY FARM LANE	GREENLAND	UNKNOWN	ELLIE ECKHOFF	YES	BEDROCK	YES	NO	NO
		PAMELA L GOVE	NA	15 BERRY FARM LANE	GREENLAND	UNKNOWN	PAMELA L GOVE	YES	BEDROCK	YES	NO	NO
		JEANNE BROWN	NA	7 WOODKNOLL DRIVE	GREENLAND	UNKNOWN	JEANNE BROWN	YES	BEDROCK	YES	NO	NO
		JAMES & SUSAN BUCHANAN	NA	27 BIRCH ROAD	NORTH HAMPTON	UNKNOWN	JAMES & SUSAN BUCHANAN	YES	BEDROCK	YES	NO	NO
		JENNA SWEET	NA	14 PINEWOOD CIRCLE	GREENLAND	UNKNOWN	JENNA SWEET	YES	BEDROCK	YES	NO	NO
		FORMER LOCATION - REPLACED BY 14 PWC	NA	67 RIDGECREST DRIVE	GREENLAND	UNKNOWN	FORMER LOCATION - REPLACED BY 14 PWC	NO	BEDROCK	NO	NO	NO
ADDITIONAL WELLS IDENTIFIED IN KNOWLES FIELD ASSESSMENT												
				Address	**Town**	**Map/Lot**	**Current Owner**	**On well? (Assessor)**	**Well Type**	**Currently Sampled?**	**Well Record Available?**	**In GMZ?**
				65 NORTH ROAD	NORTH HAMPTON	17/73	FITZGERALD, JOSEPH AND YOLANDA	NO	BEDROCK	NO	YES	YES
				96 NORTH ROAD	NORTH HAMPTON	18/30	JOHNSON, EUGENE AND CHRISTINE	NO	NA	NO	YES	NO
				149 POST ROAD	NORTH HAMPTON	18/8	KUTT, JENNIFER	NO	NA	NO	NO	NO
				BIRCH ROAD	NORTH HAMPTON	14/101	NORTH HAMPTON YOUTH ASSOCIATION	NO WATER SOURCE LISTED	BEDROCK	NO	NO	NO
				10 BIRCH ROAD	NORTH HAMPTON	17/43-2	LEONARDI, MARK AND SUSAN	NO	SHALLOW	NO	YES	NO
				137 LAFAYETTE ROAD	NORTH HAMPTON	17/41-1	DMO NORTH HAMPTON REALTY, LLC	NO	TEST	NO	YES	NO
				4 SHEPHERDS LANE	NORTH HAMPTON	14/91-2	MACHAIN, GEORGE AND DEBORAH	NO	BEDROCK	NO	YES	NO
				3 SHEPHERDS LANE	NORTH HAMPTON	14/91-6	BROPHY, MARK AND LESLIE	YES	BEDROCK	NO	YES	NO
				6 SHEPHERDS LANE	NORTH HAMPTON	14/91-3	NAULT, MICHAEL AND SHARYN	NO	BEDROCK	NO	YES	NO
				10 SHEPHERDS LANE	NORTH HAMPTON	14/91-5	DONAHUE, DANIEL	NO	BEDROCK	NO	YES	NO
				1 SHEPHERDS LANE	NORTH HAMPTON	14/91-1	FECTEAU, JUSTIN AND LANGMAID, SARAH	NO	BEDROCK	NO	YES	NO

RI	Remedial Investigation
N/A	Not Applicable
(grey)	Wells Currently Sampled
(green)	Wells that have available locational, well type, and well record information

Table 3.6:
Interpretation of Subsurface Lithology

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

OVERBURDEN WELLS															
Monitoring Well ID	Fill (ft bgs)		Fill Elevation (ft AMSL)		Fill Thickness (ft)	Outwash (ft bgs)		Outwash Elevation (ft amsl)		Outwash Thickness (ft)	Marine Deposits (ft bgs)		Marine Elevation (ft amsl)		Marine Deposits Thickness (ft)
Overburden Wells	Top	Drilled To	Top	Drilled To		Top	Drilled To	Top	Drilled To		Top	Drilled To	Top	Drilled To	
AE-1A	-	-	-	-	-	0	40	123.78	83.78	40.00	40	60	83.78	63.78	20.00
AE-2A	-	-	-	-	-	0	10	76.78	66.78	10.00	-	-	-	-	-
AE-3A	0	10	79.96	69.96	10	-	-	-	-	-	10	15	69.96	64.96	5.00
AE-4A	-	-	-	-	-	0	15	73.45	58.45	15.00	-	-	-	-	-
FPC-11A	-	-	-	-	-	0	38	117.17	79.17	38.00	38	44	79.17	73.17	6.00
FPC-11C	-	-	-	-	-	0	35	117.17	82.17	35.00	-	-	-	-	-
FPC-2A	-	-	-	-	-	0	16	75.22	59.22	16.00	-	-	-	-	-
FPC-3A	-	-	-	-	-	0	20	70.72	50.72	20.00	-	-	-	-	-
FPC-3C	-	-	-	-	-	0	20	70.75	50.75	20.00	-	-	-	-	-
FPC-4A	-	-	-	-	-	0	6	74.75	68.75	6.00	-	-	-	-	-
FPC-5A	-	-	-	-	-	0	22	72.06	50.06	22.00	22	47	50.06	25.06	25.00
FPC-6A	-	-	-	-	-	0	6	73.85	67.85	6.00	-	-	-	-	-
FPC-7A	-	-	-	-	-	0	4	78.64	74.64	4.00	-	-	-	-	-
FPC-8A	-	-	-	-	-	0	3	71.65	68.65	3.00	3	26	68.65	45.65	23.00
FPC-9A	-	-	-	-	-	0	38	113.76	75.76	38.00	38	56	75.76	57.76	18.00
FPC-9C	-	-	-	-	-	0	25	113.70	88.70	25.00	-	-	-	-	-
GZ-111	-	-	-	-	-	0	9	72.43	63.43	9.00	-	-	-	-	-
GZ-112	-	-	-	-	-	0	31.5	90.55	59.05	31.50	-	-	-	-	-
GZ-113	-	-	-	-	-	0	4	85.84	81.84	4.00	-	-	-	-	-
GZ-114	-	-	-	-	-	0	13	85.54	72.54	13.00	-	-	-	-	-
GZ-115	-	-	-	-	-	0	13	116.68	103.68	13.00	-	-	-	-	-
GZ-117	-	-	-	-	-	0	41	90.80	49.80	41.00	41	91.5	49.80	-0.70	50.50
GZ-120	-	-	-	-	-	0	17	81.26	64.26	17.00	17	37	64.26	44.26	20.00
GZ-123	0	7.5	69.36	61.86	7.5	7.5	18	61.86	51.36	10.50	18	46	51.36	23.36	28.00
GZ-127	-	-	-	-	-	0	5	69.61	64.61	5.00	5	16	64.61	53.61	11.00
GZ-129	-	-	-	-	-	0	26	79.97	53.97	26.00	-	-	-	-	-
MW-10	-	-	-	-	-	0	10.4	77.09	66.69	10.40	-	-	-	-	-
MW-1	-	-	-	-	-	0	15	114.58	99.58	15.00	15	18.5	99.58	96.08	3.50
MW-4	0	6	127.55	121.55	6	6	15	121.55	112.55	9.00	-	-	-	-	-
MW-9	-	-	-	-	-	0	10.4	86.55	76.15	10.40	10.4	12	76.15	74.55	1.60
OP-2	-	-	-	-	-	0	9	97.65	88.65	9.00	9	12.5	88.65	85.15	3.50
OP-5	-	-	-	-	-	0	21.2	111.93	90.73	21.20	21.2	23.2	90.73	88.73	2.00
MW-20S	-	-	-	-	-	0	10	72.97	62.97	10.00	-	-	-	-	-
MW-21S	-	-	-	-	-	-	-	-	-	-	0	14	73.02	59.02	14.00
MW-22S*	-	-	-	-	-	0	15	74.99	59.99	15.00	-	-	-	-	-

NOTES:
Outwash - Typical Description: moderately to well sorted sand to gravel, rounded gravels, finer grained outwash intermitent in trough, lies above marine clays or till
Marine Deposits: Typical Description - grey to green silty clay, plastic, sometimes has minor clasts
Basal Till: Fine to coarse sand to gravel with silt to clay, rounded to angular gravel to boulders, poorly sorted lies directly above bedrock
MW-22D1/-22D2 and MW-22S logged 0-15 feet as "Overburden" nearby wells AE-4A/-4B interpreted as Glacial Outwash
Feet above mean sea level: (ft amsl)
Feet Below Ground Surface: (ft bgs)

Table 3.6:
Interpretation of Subsurface Lithology

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

OVERBURDEN WELLS							
Monitoring Well ID	Basal Till (ft bgs)		Basal Till Elevation (ft amsl)		Till Thickness (ft)	Bedrock Depth Below Grade (ft)	Lidar Elevation (ft AMSL)
Overburden Wells	Top	Drilled To	Top	Drilled To			
AE-1A	60	66	63.78	57.78	6.00	66	123.78
AE-2A	10	20	66.78	56.78	10.00	20	76.78
AE-3A	15	17.5	64.96	62.46	2.50	17.5	79.96
AE-4A	-	-	-	-	-	-	73.45
FPC-11A	44	53	73.17	64.17	9.00	53	117.17
FPC-11C	-	-	-	-	-	-	117.17
FPC-2A	16	17	59.22	58.22	1.00	17	75.22
FPC-3A	20	70	50.72	0.72	50.00	75	70.72
FPC-3C	20	70	50.75	0.75	50.00	75	70.75
FPC-4A	6	12	68.75	62.75	6.00	14	74.75
FPC-5A	47	90	25.06	-17.94	43.00	90	72.06
FPC-6A	6	8	67.85	65.85	2.00	8	73.85
FPC-7A	4	24	74.64	54.64	20.00	24	78.64
FPC-8A	26	33	45.65	38.65	7.00	35	71.65
FPC-9A	56	66	57.76	47.76	10.00	-	113.76
FPC-9C	-	-	-	-	-	-	113.70
GZ-111	-	-	-	-	-	9	72.43
GZ-112	31.5	38	59.05	52.55	6.50	38	90.55
GZ-113	-	-	-	-	-	4.3	85.84
GZ-114	13	37.7	72.54	47.84	24.70	NA	85.54
GZ-115	13	39	103.68	77.68	26.00	39	116.68
GZ-117	-	-	-	-	-	-	90.80
GZ-120	37	42	44.26	39.26	5.00	42	81.26
GZ-123	46	47	23.36	22.36	1.00	47	69.36
GZ-127	16	38.5	53.61	31.11	22.50	38.5	69.61
GZ-129	-	-	-	-	-	26	79.97
MW-10	-	-	-	-	-	-	77.09
MW-1	-	-	-	-	-	18.5	114.58
MW-4	15	38	112.55	89.55	23.00	38	127.55
MW-9	-	-	-	-	-	-	86.55
OP-2	-	-	-	-	-	-	97.65
OP-5	-	-	-	-	-	-	111.93
MW-20S	-	-	-	-	-	-	72.97
MW-21S	-	-	-	-	-	-	73.02
MW-22S*	-	-	-	-	-	-	74.99

NOTES:
Outwash - Typical Description: moderately to well sorted sand to gravel, rounded gravels, finer grained outwash intermitent in trough, lies above marine clays or till
Marine Deposits: Typical Description - grey to green silty clay, plastic, sometimes has minor clasts

Basal Till: Fine to coarse sand to gravel with silt to clay, rounded to angular gravel to boulders, poorly sorted lies directly above bedrock
MW-22D1/D2 and MW-22S logged 0-15 as "Overburden" nearby wells AE-4A/B interpretted as Glacial Outwash
Feet above mean sea level: (ft amsl)
Feet Below Ground Surface: (ft bgs)

Table 3.6:
Interpretation of Subsurface Lithhology

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

BEDROCK WELLS															
Monitoring Well ID	Fill (ft bgs)		Fill Elevation (ft amsl)		Fill Thickness (ft)	Outwash (ft bgs)		Outwash Elevation (ft amsl)		Outwash Thickness (ft)	Marine Deposits (ft bgs)		Marine Elevation (ft amsl)		Marine Deposits Thickness (ft)
Bedrock	Top	Drilled To	Top	Drilled To		Top	Bottom	Top	Drilled To		Top	Bottom	Top	Drilled To	
AE-1B	-	-	-	-	-	0	40	123.59	83.59	40.00	40	60	83.59	63.59	20.00
AE-2B	-	-	-	-	-	0	10	76.63	66.63	10.00	-	-	-	-	-
AE-3B	0	10	80.09	70.09	10	-	-	-	-	-	10	15	70.09	65.09	5.00
AE-4B	-	-	-	-	-	0	15	73.53	58.53	15.00	-	-	-	-	-
BP-4	-	-	-	-	-	0	33	115.19	82.19	33.00	-	-	-	-	-
FPC-11B	-	-	-	-	-	0	38	117.17	79.17	38.00	38	44	79.17	73.17	6.00
FPC-2B	-	-	-	-	-	0	16	75.14	59.14	16.00	-	-	-	-	-
FPC-3B	-	-	-	-	-	0	20	70.74	50.74	20.00	-	-	-	-	-
FPC-4B	-	-	-	-	-	0	6	74.60	68.60	6.00	-	-	-	-	-
FPC-5B	-	-	-	-	-	0	22	72.62	50.62	22.00	22	47	50.62	25.62	25.00
FPC-6B	-	-	-	-	-	0	6	73.72	67.72	6.00	-	-	-	-	-
FPC-7B	-	-	-	-	-	0	4	78.47	74.47	4.00	-	-	-	-	-
FPC-8B	-	-	-	-	-	0	3	71.38	68.38	3.00	3	26	68.38	45.38	23.00
FPC-9B	-	-	-	-	-	0	38	113.52	75.52	38.00	38	56	75.52	57.52	18.00
GZ-105	-	-	-	-	-	0	5	69.94	64.94	5.00	5	16.5	64.94	53.44	11.50
GZ-108	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GZ-109	-	-	-	-	-	0	41	116.69	75.69	41.00	41	91	75.69	25.69	50.00
GZ-110	-	-	-	-	-	0	32	91.18	59.18	32.00	-	-	-	-	-
GZ-116	-	-	-	-	-	0	5	86.93	81.93	5.00	-	-	-	-	-
GZ-119	-	-	-	-	-	0	33	118.29	85.29	33.00	-	-	-	-	-
GZ-122	-	-	-	-	-	0	15	91.70	76.70	15.00	15	37	76.70	54.70	22.00
GZ-125	0	9	81.83	72.83	9	9	18	72.83	63.83	9.00	18	47	63.83	34.83	29.00
GZ-128	-	-	-	-	-	0	5	80.72	75.72	5.00	5	16	75.72	64.72	11.00
GZ-130	-	-	-	-	-	0	22	92.86	70.86	22.00	-	-	-	-	-
GZ-131	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW-11	-	-	-	-	-	0	10	118.92	108.92	10.00	-	-	-	-	-
MW-2*	-	-	-	-	-	0	5	116.64	111.64	5.00	-	-	-	-	-
MW-5D	-	-	-	-	-	0	12	101.42	89.42	12.00	-	-	-	-	-
MW-5S	-	-	-	-	-	0	12	100.63	88.63	12.00	-	-	-	-	-
MW-6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW-8	-	-	-	-	-	0	12	86.90	74.90	12.00	-	-	-	-	-
MW-20D1	-	-	-	-	-	0	10	72.79	62.79	10.00	-	-	-	-	-
MW-20D2	-	-	-	-	-	0	10	72.79	62.79	10.00	-	-	-	-	-
MW-21D1	-	-	-	-	-	-	-	-	-	-	0	14	74.06	60.06	14.00
MW-21D2	-	-	-	-	-	-	-	-	-	-	0	14	74.06	60.06	14.00
MW-22D1	-	-	-	-	-	0	15	74.94	59.94	15.00	-	-	-	-	-
MW-22D2	-	-	-	-	-	0	15	74.94	59.94		-	-	-	-	-
MW-23	-	-	-	-	-	0	30	77.87	47.87	30.00	-	-	-	-	-
MW-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW-25	-	-	-	-	-	-	-	-	-	-	0	24.5	69.94	45.44	24.50

NOTES:

Outwash - Typical Description: moderately to well sorted sand to gravel, rounded gravels, finer grained outwash intermitent in trough, lies above marine clays or till
Marine Deposits: Typical Description - grey to green silty clay, plastic, sometimes has minor clasts
Basal Till: Fine to coarse sand to gravel with silt to clay, rounded to angular gravel to
boulders, porrly sorted lies directly above bedrock
Feet above mean sea level: (ft amsl)
Feet Below Ground Surface: (ft bgs)

Table 3.6:
Interpretation of Subsurface Lithhology

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

BEDROCK WELLS							
Monitoring Well ID	Basal Till (ft bgs)		Basal Till Elevation (ft amsl)		Till Thickness (ft)	Bedrock Depth Below Grade (ft)	Lidar Elevation (ft AMSL)
Bedrock	Top	Bottom	Top	Drilled To			
AE-1B	60	66	63.59	57.59	6.00	66	123.59
AE-2B	10	20	66.63	56.63	10.00	20	76.63
AE-3B	15	17.5	65.09	62.59	2.50	17.5	80.09
AE-4B	-	-	-	-	-	15	73.53
BP-4	33	35.7	82.19	79.49	2.70	35.7	115.19
FPC-11B	44	53	73.17	64.17	9.00	53	117.17
FPC-2B	16	17	59.14	58.14	1.00	17	75.14
FPC-3B	20	70	50.74	0.74	50.00	75	70.74
FPC-4B	6	12	68.60	62.60	6.00	12	74.60
FPC-5B	47	90	25.62	-17.38	43.00	90	72.62
FPC-6B	6	8	67.72	65.72	2.00	8	73.72
FPC-7B	4	24	74.47	54.47	20.00	24	78.47
FPC-8B	26	33	45.38	38.38	7.00	33	71.38
FPC-9B	56	66	57.52	47.52	10.00	66	113.52
GZ-105	16.5	26	53.44	43.94	9.50	26	69.94
GZ-108	0	2	115.44	113.44	2.00	2	115.44
GZ-109	-	-	-	-	-	91	116.69
GZ-110	32	38	59.18	53.18	6.00	38	91.18
GZ-116	13	16	73.93	70.93	3.00	16	86.93
GZ-119	-	-	-	-	-	33	118.29
GZ-122	37	40	54.70	51.70	3.00	40	91.70
GZ-125	-	-	-	-	-	47	81.83
GZ-128	16	38.5	64.72	42.22	22.50	38.5	80.72
GZ-130	-	-	-	-	-	22	92.86
GZ-131	0	2	89.44	87.44	2.00	2	89.44
MW-11	10	22	108.92	96.92	12.00	22	118.92
MW-2*	-	-	-	-	-	5	116.64
MW-5D	-	-	-	-	-	12	101.42
MW-5S	-	-	-	-	-	12	100.63
MW-6	0	5	96.79	91.79	5.00	5	96.79
MW-8	12	21	74.90	65.90	9.00	21	86.90
MW-20D1	-	-	-	-	-	10	72.79
MW-20D2	-	-	-	-	-	10	72.79
MW-21D1	-	-	-	-	-	14	74.06
MW-21D2	-	-	-	-	-	14	74.06
MW-22D1	-	-	-	-	-	15	74.94
MW-22D2	-	-	-	-	-	15	74.94
MW-23	30	34	47.87	43.87	4.00	34	77.87
MW-24	-	-	-	-	-		117.08
MW-25	24.5	30.5	45.44	39.44	6.00	30.5	69.94

NOTES:

Outwash - Typical Description: moderately to well sorted sand to gravel, rounded gravels, finer grained outwash intermitent in trough, lies above marine clays or till

Marine Deposits: Typical Description - grey to green silty clay, plastic, sometimes has minor clasts

Basal Till: Fine to coarse sand to gravel with silt to clay, rounded to angular gravel to boulders,
porrly sorted lies directly above bedrock

Feet above mean sea level: (ft amsl)

Feet Below Ground Surface: (ft bgs)

Table 3.6:
Interpretation of Subsurface Lithhology

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

DPT BORINGS												
Monitoring Well ID	**Marine Deposits (ft bgs)**		**Marine Elevation (ft amsl)**		**Marine Deposits Thickness (ft)**	**Basal Till (ft bgs)**		**Basal Till Elevation (ft amsl)**		**Till Thickness (ft)**	**Refusal Depth Below Grade (ft)**	**Lidar Elevation (ft amsl)**
Temporary Wells	**Top**	**Bottom**				**Top**	**Bottom**					
DPT 1	0	8.5	73.71	65.21	8.5	-	-	-	-	-	8.5	73.71
DPT 2	0	4.5	74.28	69.78	4.5	-	-	-	-	-	4.5	74.28
DPT 3	0	5	76.57	71.57	5	5	9.5	71.57	67.07	4.5	9.5	76.57
DPT 4	0	2.3	75.36	73.06	2.3	2.3	11.2	73.06	64.16	8.9	11.2	75.36
DPT 5	0	15	74.31	59.31	15	15	22.5	59.31	51.81	7.5	22.5	74.31
DPT 6	0	3	77.07	74.07	3	3	15.7	74.07	61.37	12.7	15.7	77.07
DPT 7	0	12	76.4	64.4	12	12	13	64.4	63.4	1	13	76.4
DPT 8	0	12.5	74.48	61.98	12.5	12.5	14	61.98	60.48	1.5	14	74.48
DPT 9	0	10	73.8	63.8	10	10	21.5	63.8	52.3	11.5	21.5	73.8
DPT 10	0	5	72.81	67.81	5	15	17	57.81	55.81	2	17	72.81
DPT 11	0	23	72.41	49.41	23	23	24	49.41	48.41	1	24	72.41

NOTES:
Outwash - Typical Description: moderately to well sorted sand to gravel, rounded gravels, finer grained outwash intermitent in trough, lies above marine clays or till
Marine Deposits: Typical Description - grey to green silty clay, plastic, sometimes has minor clasts
Basal Till: Fine to coarse sand to gravel with silt to clay, rounded to angular gravel to boulders, porrly sorted lies directly above bedrock
*Outwash deposits not identified in substantial thickness (<1 ft) in DPT borings, coarse material at bottom of DPT boring is consistent with basal till identified elsewhere overlying the Rye Formation in bedrock trough
Feet above mean sea level: (ft amsl)
Feet Below Ground Surface: (ft bgs)

Table 3.6:
Interpretation of Subsurface Lithhology

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Bedrock Lithology										
Monitoring Well ID	Depth to Rye Formation (ft bgs)		Elevation of Rye Formation (ft AMSL)		Depth to Breakfast Hill Granite (ft bgs)		Elevation of Breakfast Hill Granite (ft AMSL)		Lidar Elevation (ft amsl)
OVERBURDEN	Top	Drilled To	Top	Drilled To	Top	Drilled To	Top	Drilled To	
GZ-112	38	46.3	34.43	26.13	-	-	-	-	72.43
GZ-113	-	-	-	-	4.3	9.3	86.25	81.25	90.55
GZ-115	39	45	46.54	40.54		-	-	-	85.54
GZ-117	96	101	20.68	15.68	-	-	-	-	116.68
GZ-118	33	38	57.80	52.80	-	-	-	-	90.80
GZ-120	43	48	38.26	33.26	-	-	-	-	81.26
GZ-123	47	52	22.36	17.36	-	-	-	-	69.36
GZ-127	38.5	43.5	31.11	26.11	-	-	-	-	69.61
GZ-129	26	32	53.97	47.97	-	-	-	-	79.97
MW-4	-	-	-	-	38	40.5	89.55	87.05	127.55
BEDROCK									
AE-1B	66	85.5	57.59	38.09	-	-	-	-	123.59
AE-2B	20	50	56.63	26.63	-	-	-	-	76.63
AE-3B	17	32	63.09	48.09	32	40	48.09	40.09	80.09
AE-4B	15	44	58.53	29.53	-	-	-	-	73.53
BP-4	110	132	5.19	-16.81	35	110	80.19	5.19	115.19
FPC-11B	53	73	64.17	44.17	-	-	-	-	117.17
FPC-2B	17	37.8	58.14	37.34	-	-	-	-	75.14
FPC-3B	70	95.5	0.74	-24.76	-	-	-	-	70.74
FPC-4B	14	33.5	60.60	41.10	-	-	-	-	74.60
FPC-5B	90.3	110.3	-17.68	-37.68	-	-	-	-	72.62
FPC-6B	8	28.5	65.72	45.22	-	-	-	-	73.72
FPC-7B	24	45	54.47	33.47	-	-	-	-	78.47
FPC-8B	35	55.7	36.38	15.68	-	-	-	-	71.38
FPC-9B	67	87	46.52	26.52	-	-	-	-	113.52
GZ-105	26	50	43.94	19.94	-	-	-	-	69.94
GZ-108	-	-	-	-	2	155	113.44	-39.56	115.44
GZ-109	91	252	25.69	-135.31	-	-	-	-	116.69
GZ-110	38	188	53.18	-96.82	-	-	-	-	91.18
GZ-116	16	163	70.93	-76.07	-	-	-	-	86.93
GZ-119	33	185	85.29	-66.71	-	-	-	-	118.29
GZ-122	50	190	41.70	-98.30	-	-	-	-	91.70
GZ-125	47	186	34.83	-104.17	186	200	-104.17	-118.17	81.83
GZ-128	46	184	69.30	-68.70	-	-	-	-	115.30
GZ-130	22	178	58.72	-97.28	-	-	-	-	80.72
MW-11	-	-	-	-	22	52	70.86	40.86	92.86
MW-2*	-	-	-	-	5	20	84.44	69.44	89.44
MW-5D	-	-	-	-	12	150	89.42	-48.58	101.42
MW-5S	-	-	-	-	12	150	88.63	-49.37	100.63
MW-6	-	-	-	-	3	184	93.79	-87.21	96.79
MW-8	-	-	-	-	21	65	65.90	21.90	86.90
MW-20D1-MW-20D2	15	310	57.79	-237.21	-	-	-	-	72.79
MW-21D1-MW-21D2	14	310	60.06	-235.94	-	-	-	-	74.06
MW-22D1-MW-22D2	18	315	56.94	-240.06	-	-	-	-	74.94
MW-23	34	280	43.87	-202.13	-	-	-	-	77.87
MW-24	-	-	-	-	-	-	-	-	117.08
MW-25	30.5	283	39.44	-213.06	-	-	-	-	69.94

Notes:
Rye Formation: Predominantly schist, phyllite, quartzite, minor basalt
Breakfast Hill Granite: Also reported as the Central Silicic Complex: Felsic foliated Gneiss with igneous intrusives including pegmatites and diabase
*Interpretation of bedrock lithology from boring logs and downhole geophysical logs for select wells

Table 4.1A
Summary of 2020 Groundwater Analytical Data

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

OPERABLE UNIT 1 (OU-1)																												
Sampling Point ID	USEPA	NHDES	MW-4[7]	MW-4-DUP[7]	MW-4	MW-4-DUP	MW-5D	MW-5D	MW-5S	MW-5S	MW-6	MW-6	MW-8[7]	MW-8	MW-9	MW-9	MW-10	MW-10	MW-11	MW-11	OP-2	OP-2	OP-5	OP-5	BP-4	BP-4	# of Exceedances	
Date of Sample Collection	CL	AGQS	5/19/20	5/19/20	10/13/20	10/13/20	5/15/20	10/12/20	5/15/20	10/12/20	5/22/20	10/8/20	5/20/20	10/12/20	5/22/20	10/12/20	5/22/20	10/12/20	5/18/20	10/12/20	5/14/20	10/8/20	5/18/20	10/9/20	5/18/20	10/12/20	CL	AGQS
VOLATILE ORGANIC COMPOUNDS BY 8260C - (ug/L)																												
1,2,4-Trimethylbenzene	---	330	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	---	0
1,2-Dichloropropane	5	5	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0
1,4-Dichlorobenzene	---	75	N/A	N/A	N/A	N/A	1.1	N/A	1	N/A	1 U	N/A	1.6	N/A	N/A	N/A	N/A	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	---	0
2-Butanone(MEK)	200	4,000	N/A	N/A	N/A	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	N/A	N/A	N/A	N/A	10 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0
Acetone	---	6,000	N/A	N/A	N/A	N/A	10 U	N/A	10 U	N/A	10 U	N/A	12	N/A	N/A	N/A	N/A	N/A	10 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	---	0
Benzene	5	5	N/A	N/A	N/A	N/A	2	N/A	1.9	N/A	1 U	N/A	3	N/A	N/A	N/A	N/A	N/A	1.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0
Carbon disulfide	---	70	N/A	N/A	N/A	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	N/A	N/A	N/A	N/A	2 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	---	0
Chlorobenzene	100	100	N/A	N/A	N/A	N/A	1.8	N/A	1	N/A	1 U	N/A	5.6	N/A	N/A	N/A	N/A	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0
Chloroethane	---	---	N/A	N/A	N/A	N/A	35	N/A	3.7	N/A	2 U	N/A	11	N/A	N/A	N/A	N/A	N/A	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A	---	---
Chloroform	80	---	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	---
Diethyl Ether	---	1,400	N/A	N/A	N/A	N/A	100	N/A	23	N/A	2 U	N/A	59	N/A	N/A	N/A	N/A	N/A	11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	---	0
IsoPropylbenzene	---	800	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1.5	N/A	N/A	N/A	N/A	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	---	0
Methyl-t-butyl ether(MTBE)	---	13	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	---	0
m&p-Xylene	---	10,000^	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	---	0
o-Xylene	---	10,000^	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	---	0
tert-Butyl Alcohol (TBA)	---	40	N/A	N/A	N/A	N/A	55	N/A	30 U	N/A	30 U	N/A	46	N/A	N/A	N/A	N/A	N/A	30 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	---	2
Tetrachloroethene	3.5	5	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0
Tetrahydrofuran(THF)	154	600	N/A	N/A	N/A	N/A	89	N/A	11	N/A	10 U	N/A	88	N/A	N/A	N/A	N/A	N/A	10 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0
trans-1,2-Dichloroethene	100	100	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0
1,4-DIOXANE BY 8260B SIM - (ug/L)																												
1,4-Dioxane	3	0.32	**4.3**	**4.2**	**3.5**	**3.6**	**140**	**120**	**36**	**27**	0.2 U	0.2 U	**100 J+**	**130**	0.2 U	N/A	1.3	**10**	**26**	**31**	0.43	0.79	0.2 U	0.2 U	**5.7**	**6.9**	7	8
DISSOLVED METALS BY 200.8 - (mg/L)																												
Dissolved Antimony	0.006	0.006	0.001 U	0.001 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0	0
Dissolved Arsenic	0.01	0.005	**0.048**	**0.05**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0047	N/A	0.0063	N/A	N/A	N/A	**0.15**	N/A	**0.032**	N/A	N/A	N/A	3	4
Dissolved Barium	---	2	0.065	0.066	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.02	N/A	0.019	N/A	N/A	N/A	0.0098	N/A	0.012	N/A	N/A	N/A	---	0
Dissolved Beryllium	0.004	0.004	0.001 U	0.001 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0	0
Dissolved Calcium	---	---	73 J+	73 J+	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	35 J+	N/A	25 J+	N/A	N/A	N/A	37 J+	N/A	10 J+	N/A	N/A	N/A	---	---
Dissolved Chromium	0.05	0.1	0.001 U	0.001 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0	0
Dissolved Iron	---	---	29 J+	30 J+	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.9 J+	N/A	13 J+	N/A	N/A	N/A	52 J+	N/A	14 J+	N/A	N/A	N/A	---	---
Dissolved Lead	0.015	0.015	0.001 U	0.001 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0	0
Dissolved Magnesium	---	---	20	21	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.8	N/A	6	N/A	N/A	N/A	7.2	N/A	2.4	N/A	N/A	N/A	---	---
Dissolved Manganese	0.3	0.84	**1.2**	**1.3**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**0.65**	N/A	**1.2**	N/A	N/A	N/A	**2.1**	N/A	**2.5**	N/A	N/A	N/A	5	4
Dissolved Nickel	0.1	0.1	0.0092	0.012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0048	N/A	0.0018	N/A	N/A	N/A	0.0098	N/A	0.015	N/A	N/A	N/A	0	0
Dissolved Potassium	---	160	35	35	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.1	N/A	4.7	N/A	N/A	N/A	9.1	N/A	2	N/A	N/A	N/A	---	---
Dissolved Sodium	---	---	32	33	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.5	N/A	17	N/A	N/A	N/A	1.3	N/A	6.2	N/A	N/A	N/A	---	---
Dissolved Vanadium	0.26	---	0.005 U	0.005 U	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.005 U	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	0.005 U	N/A	N/A	N/A	0	---
TOTAL METALS BY 200.8																												
Total Antimony	0.006	0.006	N/A	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	0	0
Total Arsenic	0.01	0.01	N/A	N/A	N/A	N/A	0.0052	N/A	**0.018**	N/A	0.001 U	N/A	0.0018	N/A	N/A	N/A	N/A	N/A	**0.014**	N/A	N/A	N/A	N/A	N/A	**0.04**	N/A	3	3
Total Barium	---	2	N/A	N/A	N/A	N/A	0.11	N/A	0.12	N/A	0.012	N/A	0.15	N/A	N/A	N/A	N/A	N/A	0.059	N/A	N/A	N/A	N/A	N/A	0.038	N/A	---	0
Total Beryllium	0.004	0.004	N/A	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	0	0
Total Calcium	---	---	N/A	N/A	N/A	N/A	38 J+	N/A	38 J+	N/A	29 J+	N/A	29 J+	N/A	N/A	N/A	N/A	N/A	19 J+	N/A	N/A	N/A	N/A	N/A	54 J+	N/A	---	---
Total Chromium	0.05	0.1	N/A	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	0.0011	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	0	0
Total Iron	---	---	N/A	N/A	N/A	N/A	17 J+	N/A	13 J+	N/A	15 J+	N/A	2.6 J+	N/A	N/A	N/A	N/A	N/A	14 J+	N/A	N/A	N/A	N/A	N/A	16 J+	N/A	---	---
Total Lead	0.015	0.015	N/A	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	0	0
Total Magnesium	---	---	N/A	N/A	N/A	N/A	34	N/A	18	N/A	13	N/A	36	N/A	N/A	N/A	N/A	N/A	16	N/A	N/A	N/A	N/A	N/A	21	N/A	---	---
Total Manganese	0.3	0.84	N/A	N/A	N/A	N/A	**1**	N/A	**3.3**	N/A	**4**	N/A	**1.5**	N/A	N/A	N/A	N/A	N/A	**0.49**	N/A	N/A	N/A	N/A	N/A	**1.6**	N/A	6	5
Total Nickel	0.1	0.1	N/A	N/A	N/A	N/A	0.0095	N/A	0.0076	N/A	0.0082	N/A	0.026	N/A	N/A	N/A	N/A	N/A	0.0064	N/A	N/A	N/A	N/A	N/A	0.0086	N/A	0	0
Total Potassium	---	160	N/A	N/A	N/A	N/A	23	N/A	18	N/A	2.9	N/A	11	N/A	N/A	N/A	N/A	N/A	9.3	N/A	N/A	N/A	N/A	N/A	16	N/A	---	---
Total Sodium	---	---	N/A	N/A	N/A	N/A	120	N/A	70	N/A	28	N/A	150	N/A	N/A	N/A	N/A	N/A	65	N/A	N/A	N/A	N/A	N/A	50	N/A	---	---
Total Vanadium	0.26	---	N/A	N/A	N/A	N/A	0.005 U	N/A	0.005 U	N/A	0.005 U	N/A	0.005 U	N/A	N/A	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	N/A	N/A	0.005 U	N/A	0	---
PER- & POLY-FLUORINATED ALKYL SUBSTANCES BY MODIFIED 537 - (ng/L)																												
Perfluorobutanoic Acid (PFBA)	---	---	59.6	55.1	46.9	47.5	28.4	22.9	43.1	48.7	1.63 J	3.18 J	43.8	4.43 U	36.7 J	N/A	72.8	40.4	49.5	49.1	9.55	9.03	4.41 U	4.36 U	7.43	6.35	---	---
Perfluoropentanoic acid (PFpEA)	---	---	106	100	87.3	84.6	37.9	46.9	91	112	3.21 J	3.48 J	226 J	79.7	69.7	N/A	146	72.3	105	109	15	12	4.41 U	4.36 U	10.9	9.72	---	---
Perfluorobutanesulfonic acid (PFBS)	---	---	4.34 J	4.21 J	5.21	4.05 J	28.7	25.1	9.09	8.04	3.26 J	4.38 U	24.2	27.2	2.59 J	N/A	3.40 J	4.69	9.95	13.3	2.2 J	4.49 U	4.41 U	4.36 U	2.6 J	2.54 J	---	---
Perfluorohexanoix Acid (PFHxA)	---	---	193	190	138	153	89.8	95.7	185	193	3.81 J	5.06	173	186	92.4	N/A	210	98.1	204	230	25.2	20.4	4.41 U	4.36 U	18.1	21.1	---	---

Table 4.1A
Summary of 2020 Groundwater Analytical Data

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

OPERABLE UNIT 1 (OU-1)																												
Sampling Point ID	USEPA	NHDES	MW-4[7]	MW-4-DUP[7]	MW-4	MW-4-DUP	MW-5D	MW-5D	MW-5S	MW-5S	MW-6	MW-6	MW-8[7]	MW-8	MW-9	MW-9	MW-10	MW-10	MW-11	MW-11	OP-2	OP-2	OP-5	OP-5	BP-4	BP-4	# of Exceedances	
Date of Sample Collection	CL	AGQS	5/19/20	5/19/20	10/13/20	10/13/20	5/15/20	10/12/20	5/15/20	10/12/20	5/22/20	10/8/20	5/20/20	10/12/20	5/22/20	10/12/20	5/22/20	10/12/20	5/18/20	10/12/20	5/14/20	10/8/20	5/18/20	10/9/20	5/18/20	10/12/20	CL	AGQS
Perfluoroheptanoic acid (PFHpA)	---	---	397	388	294	314	51.6	54.9	406	428	4.40 U	7.19	214	237	190	N/A	422	174	412	452	41.5	40	4.41 U	4.36 U	28	25.5	---	---
Perfluorohexanesulfonic acid (PFHxS)	---	18[2]	30	26.7	37.1	35.1	50.7	43.8	60.9	50.6	4.40 U	1.37 J	98.5	89.2	13	N/A	11.7	17.1	58.9	64.2	8.13	7.12	4.41 U	4.36 U	11	9.62	---	5
1H, 1H, 2H, 2H-Perfluorooctanesulfonic Acid (6:2FTS)	---	---	4.54 U	4.47 U	4.30 U	4.23 U	4.45 U	4.35 U	4.56 U	4.27 U	4.40 U	4.38 U	4.71 U	4.43 U	4.49 U	N/A	4.66 U	4.40 U	4.52 U	4.39 U	4.45 U	4.49 U	4.41 U	4.36 U	4.37 U	4.34 U	---	---
Perfluorooctanoic acid (PFOA)	70	12[2]	**815**	**818**	**695**	**712**	**86.2**	**104**	**577**	**770**	8.99	16.1	**425**	**422**	**553**	N/A	**914**	**416**	**812**	**899**	**96.1**	**76.1**	2.76 J	4.98	64.4	69.6	8	10
Perfluoroheptanesulfonic Acid (PFHpS)	---	---	4.62	2.89 J	2.54 J	2.35 J	4.45 U	4.35 U	7.49	7.29	4.40 U	4.38 U	5.75	7.31	3.34 J	N/A	11.7	3.84 J	10.5	11.7	4.45 U	4.49 U	4.41 U	4.36 U	4.37 U	4.34 U	---	---
Perfluorononanoic acid (PFNA)	---	11[2]	39.1	38	35.4	27.6	4.45 U	4.35 U	76	68.7	4.40 U	4.38 U	32.9	14.2	175	N/A	392	107	109	110	10	5.87	4.41 U	4.36 U	1.83 J	2.69 J	---	6
Perfluorooctanesulfonamide (PFOSA)	---	---	2.02 J	3.13 J	2.78 J	4.16 J	4.59	3.63 J	16	26.5	8.19	64.6	18.6	5.21	5.25	N/A	23.3	25.9	15	39.8	6.5	13.1	7.14	13.4	7.97	17.5	---	---
Perfluorooctanesulfonic (PFOS)	70	15[2]	34.8	38.9	33.6	24.6	16.7	17	**108**	68.2	2.26 J	2.49 J	**223 J**	**199**	**404**	N/A	**819**	**156**	**395**	**350**	10.5	12.5	4.41 U	4.36 U	6.98	10.7	5	7
Perfluorodecanoic Acid (PFDA)	---	---	4.54 U	4.47U	4.30 U	4.23 U	4.45 U	4.35 U	4.56 U	4.27 U	4.40 U	4.38 U	4.71 U	4.43 U	19	N/A	81.2	13.8	5.77	5.52	4.45 U	4.49 U	4.41 U	4.36 U	4.37 U	4.34 U	---	---
1H, 1H, 2H, 2H-Perfluorodecanesulfonic Acid (8:2FTS)	---	---	4.54 U	4.47U	4.30 U	4.23 U	4.45 U	4.35 U	4.56 U	4.27 U	4.40 U	4.38 U	4.71 U	4.43 U	4.49 U	N/A	4.66 U	4.40 U	4.52 U	4.39 U	4.45 U	4.49 U	4.41 U	4.36 U	4.37 U	4.34 U	---	---
N-Methyl Perfluorooctanesulfonamidoacetic Acid (MeFOSAA)	---	---	4.54 U	4.47U	4.30 U	4.23 U	4.45 U	4.35 U	4.56 U	4.27 U	4.40 U	4.38 U	4.71 U	4.43 U	4.49 U	N/A	4.66 U	4.40 U	4.52 U	4.39 U	4.45 U	4.49 U	4.41 U	4.36 U	4.37 U	4.34 U	---	---
N-Ethyl Perfluorooctanesulfonamidoacetic (EtFOSAA)	---	---	1.76 J	4.47U	4.30 U	4.23 U	4.45 U	4.35 U	4.56 U	4.27 U	4.40 U	4.38 U	4.71 U	4.43 U	4.49 U	N/A	4.66 U	4.40 U	4.52 U	4.39 U	4.45 U	4.49 U	4.41 U	4.36 U	4.37 U	4.34 U	---	---
Perfluoroundecanoic Acid (PFUnA)	---	---	4.54 U	4.47U	4.30 U	4.23 U	4.45 U	4.35 U	4.56 U	4.27 U	4.40 U	4.38 U	4.71 U	4.43 U	4.49 U	N/A	4.66 U	4.40 U	4.52 U	4.39 U	4.45 U	4.49 U	4.41 U	4.36 U	4.37 U	4.34 U	---	---
Perfluorodecanesulfonic Acid (PFDS)	---	---	4.54 U	4.47U	4.30 U	4.23 U	4.45 U	4.35 U	4.56 U	4.27 U	4.40 U	4.38 U	4.71 U	4.43 U	4.49 U	N/A	4.66 U	4.40 U	4.52 U	4.39 U	4.45 U	4.49 U	4.41 U	4.36 U	4.37 U	4.34 U	---	---
Perfluorododecanoic Acid (PFDoA)	---	---	4.54 U	4.47U	4.30 U	4.23 U	4.45 U	4.35 U	4.56 U	4.27 U	4.40 U	4.38 U	4.71 U	4.43 U	4.49 U	N/A	4.66 U	4.40 U	4.52 U	4.39 U	4.45 U	4.49 U	4.41 U	4.36 U	4.37 U	4.34 U	---	---
N-Methyl Perfluorooctane Sulfonamide (MeFOSA)	---	---	22.7 U	22.3 U	21.5 U	21.2 U	22.2 U	21.8 U	22.8 U	21.4 U	22.0 U	21.9 U	22.4 UJ	22.2 U	22.5 U	N/A	23.3 U	22.0 U	22.6 U	22.0 U	22.2 U	22.5 U	22.0 U	22.5 U	21.8 U	21.7 U	---	---
Perfluorotrodecanoic Acid (PFTrDA)	---	---	4.54 U	4.47U	4.30 U	4.23 U	4.45 U	4.35 U	4.56 U	4.27 U	4.40 U	4.38 U	4.71 U	4.43 U	4.49 U	N/A	4.66 U	4.40 U	4.52 U	4.39 U	4.45 U	4.49 U	4.41 U	4.36 U	4.37 U	4.34 U	---	---
Perfluorotetradecanoic Acid (PFTeDa)	---	---	4.54 U	4.47U	4.30 U	4.23 U	4.45 U	4.35 U	4.56 U	4.27 U	4.40 U	4.38 U	4.71 U	4.43 U	4.49 U	N/A	4.66 U	4.40 U	4.52 U	4.39 U	4.45 U	4.49 U	4.41 U	4.36 U	4.37 U	4.34 U	---	---
N-Ethyl Perfluorooctane Sulfonamide (EtFOSA)	---	---	22.7 U	22.3 U	21.5 U	21.2 U	22.2 U	21.8 U	22.8 U	21.4 U	22.0 U	21.9 U	22.4 UJ	22.2 U	22.5 U	N/A	23.3 U	22.0 U	22.6 U	22.0 U	22.2 U	22.5 U	22.0 U	22.5 U	21.8 U	21.7 U	---	---
Perfluorogexadecanoic Acid (PFHxDA)	---	---	4.54 U	4.47U	4.30 U	4.23 U	4.45 U	4.35 U	4.56 U	4.27 U	4.40 U	4.38 U	4.71 U	4.43 U	4.49 U	N/A	4.66 U	4.40 U	4.52 U	4.39 U	4.45 U	4.49 U	4.41 U	4.36 U	4.37 U	4.34 U	---	---
N-Methyl Perfluorooctanesulfonamido Ethanol (MeFOSE)	---	---	22.7 U	22.3 U	21.5 U	21.2 U	22.2 U	21.8 U	22.8 U	21.4 U	22.0 U	21.9 U	23.5 U	22.2 U	22.5 U	N/A	23.3 U	22.0 U	22.6 U	22.0 U	22.2 U	22.5 U	22.0 U	22.5 U	21.8 U	21.7 U	---	---
N-Ethyl Perfluorooctanesulfonamido Ethanol (EtFOSE)	---	---	22.7 U	22.3 U	21.5 U	21.2 U	22.2 U	21.8 U	22.8 U	21.4 U	22.0 U	21.9 U	2.35 U	22.2 U	22.5 U	N/A	23.3 U	22.0 U	22.6 U	22.0 U	22.2 U	22.5 U	22.0 U	22.5 U	21.8 U	21.7 U	---	---
Combination of PFOA and PFOS	70	---	**849.8**	**856.9**	**728.6**	**736.6**	**102.9**	**121**	**685**	**838.2**	11.25 J	18.59 J	**648 J**	**621**	**957**	N/A	**1,733**	**572**	**1,207**	**1,249**	**106.6**	**88.6**	2.76 J	4.98	**71.38**	**80.3**	9	---
FIELD PARAMETERS																												
Dissolved Oxygen (mg/l)	---	---	N/A	N/A	N/A	N/A	1.6	3.4	1.9	3	0.7	1	1.5	1.3	1.3	N/A	0.9	2.1	1.4	2.3	1.4	2	0.7	0.8	1	2.9	---	---
Oxidation Reduction Potential (mV)	---	---	N/A	N/A	N/A	N/A	-128	-154	-116	-136	57	86	-141	-173	51	N/A	-69	-64	-125	-136	-45	-79	-1	-28	-108	-115	---	---
pH (standard units)	---	---	N/A	N/A	N/A	N/A	7.1	7	6.9	6.9	6	6.1	7.5	7.5	5.9	N/A	6.4	6.5	7	6.9	6	6.6	5.9	6.2	6.8	6.7	---	---
Specific Conductance (us/cm)	---	---	N/A	N/A	N/A	N/A	1,523	1,458	838	795	439	554	1,207	1,244	252	N/A	301	757	611	609	525	707	179	251	858	801	---	---
Temperature (degrees Celcius)	---	---	N/A	N/A	N/A	N/A	12	13	12	12	10	12	12	13	14	N/A	13	13	12	13	12	16	9	11	11	12	---	---
Turbidity (NTU)	---	---	N/A	N/A	N/A	N/A	< 5	<5	< 5	<5	97	7	< 5	<5	< 5	N/A	< 5	<5	< 5	<5	< 5	<5	< 5	<5	< 5	<5	---	---

Notes on Last Page of Table

Table 4.1A
Summary of 2020 Groundwater Analytical Data

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

OPERABLE UNIT 2 (OU-2)																										
Sampling Point ID	USEPA	NHDES	AE-1A	AE-1A	AE-1B	AE-1B	AE-2A[1]	AE-2A	AE-2B[1]	AE-2B	AE-3A[1]	AE-3A-DUP[1]	AE-3A	AE-3A DUP	AE-3B[1]	AE-3B	AE-4A	AE-4A	AE-4B	AE-4B	FPC-2A[1]	FPC-2A	FPC-2B[1]	FPC-2B	# of Exceedances	
Date of Sample Collection	CL	AGQS	5/15/20	10/13/20	5/15/20	10/13/20	5/21/20	10/12/20	5/21/20	10/12/20	5/20/20	5/20/20	10/7/20	10/7/20	5/20/20	10/7/20	5/12/20	10/6/20	5/12/20	10/6/20	5/19/20	10/8/20	5/19/20	10/8/20	CL	AGQS
VOLATILE ORGANIC COMPOUNDS BY 8260C - (ug/L)																										
1,2,4-Trimethylbenzene	---	330	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	---	0
1,2-Dichloropropane	5	5	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	0	0
1,4-Dichlorobenzene	---	75	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	---	0
2-Butanone(MEK)	200	4,000	N/A	N/A	N/A	N/A	10 U	N/A	10 U	N/A	10 U	10 U	N/A	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	0	0
Acetone	---	6,000	N/A	N/A	N/A	N/A	10 U	N/A	10 U	N/A	13	10 U	N/A	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	---	0
Benzene	5	5	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1.3	1.3	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	0	0
Carbon disulfide	---	70	N/A	N/A	N/A	N/A	2 U	N/A	2 U	N/A	2 U	2 U	N/A	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	---	0
Chlorobenzene	100	100	N/A	N/A	N/A	N/A	1.6	N/A	1 U	N/A	4.8	4.9	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	0	0
Chloroethane	---	---	N/A	N/A	N/A	N/A	2 U	N/A	2 U	N/A	4.5	4.5	N/A	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	---	---
Chloroform	80	---	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	0	---
Diethyl Ether	---	1,400	N/A	N/A	N/A	N/A	2.1	N/A	11	N/A	10	11	N/A	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	---	0
IsoPropylbenzene	---	800	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	---	0
Methyl-t-butyl ether(MTBE)	---	13	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	---	0
m&p-Xylene	---	10,000^	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	---	0
o-Xylene	---	10,000^	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	---	0
tert-Butyl Alcohol (TBA)	---	40	N/A	N/A	N/A	N/A	30 U	N/A	30 U	N/A	30 U	30 U	N/A	N/A	30 U	N/A	30 U	N/A	30 U	N/A	30 U	N/A	30 U	N/A	---	0
Tetrachloroethene	3.5	5	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	0	0
Tetrahydrofuran(THF)	154	600	N/A	N/A	N/A	N/A	10 U	N/A	12	N/A	10 U	10 U	N/A	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	0	0
trans-1,2-Dichloroethene	100	100	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	0	0
1,4-DIOXANE BY 8260B SIM - (ug/L)																										
1,4-Dioxane	3	0.32	0.97	0.96	1.2	1.1	**7**	**5.5**	**48**	**45**	**9.7**	**13**	**16**	**17**	**11**	**18**	0.2 U	0.2 U	0.2 U	0.2 U	0.21	0.2 U	0.2 U	0.2 U	4	6
DISSOLVED METALS BY 200.8 - (mg/L)																										
Dissolved Antimony	0.006	0.006	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	0.001 U	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0	0
Dissolved Arsenic	0.01	0.005	**0.018**	N/A	N/A	N/A	**0.14**	N/A	N/A	N/A	**0.1**	**0.11**	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	3	4
Dissolved Barium	---	2	0.019	N/A	N/A	N/A	0.019	N/A	N/A	N/A	0.059	0.058	N/A	N/A	N/A	N/A	0.0038	N/A	N/A	N/A	0.019	N/A	N/A	N/A	---	0
Dissolved Beryllium	0.004	0.004	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	0.001 U	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0	0
Dissolved Calcium	---	---	40 J+	N/A	N/A	N/A	27 J+	N/A	N/A	N/A	44 J+	46 J+	N/A	N/A	N/A	N/A	7.2 J+	N/A	N/A	N/A	28 J+	N/A	N/A	N/A	---	---
Dissolved Chromium	0.05	0.1	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	0.001 U	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0	0
Dissolved Iron	---	---	0.42 J+	N/A	N/A	N/A	21 J+	N/A	N/A	N/A	30 J+	30 J+	N/A	N/A	N/A	N/A	0.05 U	N/A	N/A	N/A	5.6 J+	N/A	N/A	N/A	---	---
Dissolved Lead	0.015	0.015	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	0.001 U	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0	0
Dissolved Magnesium	---	---	14	N/A	N/A	N/A	7.9	N/A	N/A	N/A	18	18	N/A	N/A	N/A	N/A	5.8	N/A	N/A	N/A	15	N/A	N/A	N/A	---	---
Dissolved Manganese	0.3	0.84	**0.6**	N/A	N/A	N/A	**1.1**	N/A	N/A	N/A	**1.9**	**2**	N/A	N/A	N/A	N/A	0.012	N/A	N/A	N/A	**1.2**	N/A	N/A	N/A	4	3
Dissolved Nickel	0.1	0.1	0.001 U	N/A	N/A	N/A	0.0071	N/A	N/A	N/A	0.0073	0.0074	N/A	N/A	N/A	N/A	0.001U	N/A	N/A	N/A	0.0012	N/A	N/A	N/A	0	0
Dissolved Potassium	---	160	4.1	N/A	N/A	N/A	13	N/A	N/A	N/A	16	17	N/A	N/A	N/A	N/A	2.4	N/A	N/A	N/A	4.9	N/A	N/A	N/A	---	0
Dissolved Sodium	---	---	21	N/A	N/A	N/A	25	N/A	N/A	N/A	56	59	N/A	N/A	N/A	N/A	7.7	N/A	N/A	N/A	15	N/A	N/A	N/A	---	---
Dissolved Vanadium	0.26	---	0.005 U	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	0.005 U	N/A	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0	---
TOTAL METALS BY 200.8																										
Total Antimony	0.006	0.006	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	0	0
Total Arsenic	0.01	0.01	N/A	N/A	0.0082	N/A	N/A	N/A	0.0051	N/A	N/A	N/A	N/A	N/A	**0.052**	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.0021	N/A	1	1
Total Barium	---	2	N/A	N/A	0.036	N/A	N/A	N/A	0.075	N/A	N/A	N/A	N/A	N/A	0.11	N/A	N/A	N/A	0.0077	N/A	N/A	N/A	0.012	N/A	---	0
Total Beryllium	0.004	0.004	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	0	0
Total Calcium	---	---	N/A	N/A	35 J+	N/A	N/A	N/A	39 J+	N/A	N/A	N/A	N/A	N/A	48 J+	N/A	N/A	N/A	7.9 J+	N/A	N/A	N/A	9.9 J+	N/A	---	---
Total Chromium	0.05	0.1	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	0	0
Total Iron	---	---	N/A	N/A	2.4 J+	N/A	N/A	N/A	2.2 J+	N/A	N/A	N/A	N/A	N/A	9.6 J+	N/A	N/A	N/A	0.05 U	N/A	N/A	N/A	0.057 J+	N/A	---	---
Total Lead	0.015	0.015	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	0	0
Total Magnesium	---	---	N/A	N/A	16	N/A	N/A	N/A	28	N/A	N/A	N/A	N/A	N/A	22	N/A	N/A	N/A	6.5	N/A	N/A	N/A	1.2	N/A	---	---
Total Manganese	0.3	0.84	N/A	N/A	**0.59**	N/A	N/A	N/A	**1.2**	N/A	N/A	N/A	N/A	N/A	**1.2**	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	3	2
Total Nickel	0.1	0.1	N/A	N/A	0.001 U	N/A	N/A	N/A	0.0085	N/A	N/A	N/A	N/A	N/A	0.0082	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	0	0
Total Potassium	---	160	N/A	N/A	5.9	N/A	N/A	N/A	11	N/A	N/A	N/A	N/A	N/A	18	N/A	N/A	N/A	3.7	N/A	N/A	N/A	4.5	N/A	---	0
Total Sodium	---	---	N/A	N/A	26	N/A	N/A	N/A	140	N/A	N/A	N/A	N/A	N/A	76	N/A	N/A	N/A	14	N/A	N/A	N/A	37	N/A	---	---
Total Vanadium	0.26	---	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	0	---
PER- & POLY-FLUORINATED ALKYL SUBSTANCES BY MODIFIED 537 - (ng/L)																										
Perfluorobutanoic Acid (PFBA)	---	---	1.5 J	0.91 J	2.01 J	0.846 J	24.8	24.9	47.1	49.8	20.2	20.2	14.6	18.6	19.6	14.3	4.42 U	4.46 U	4.14 U	4.47 U	1.46 J	1.70 J	3.11 J	4.03 J	---	---
Perfluoropentanoic acid (PFpEA)	---	---	2.02 J	2.01 J	4.54 U	2.12 J	50.2	50.9	106	103	43.1	40.5	30.2	31.4	37.4	28.9	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	5.51	4.54	---	---
Perfluorobutanesulfonic acid (PFBS)	---	---	4.27 U	4.32 U	4.54 U	4.38 U	4.77	4.34	14	13.2	6.55	5.94	5.92	4.97	4.09 J	5.73	4.42 U	4.46 U	4.14 U	4.47 U	3.59 J	4.88	4.57 U	4.36 U	---	---
Perfluorohexanoix Acid (PFHxA)	---	---	2.64 J	3.36 J	2.8 J	3.9 J	109	98.3	206	183	68.5	64.1	53	55.4	67.1	50.5	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	4.57 U	4.36 U	---	---
Perfluoroheptanoic acid (PFHpA)	---	---	4.27 U	0.947 J	4.54 U	1.1 J	244	205	383	338	103	105	70.4	92.4	96.8	64.9	4.42 U	4.46 U	4.14 U	4.47 U	2.81 J	2.08 J	1.42 J	1.30 J	---	---
Perfluorohexanesulfonic acid (PFHxS)	---	18[2]	1.8 J	1.87 J	1.88 J	2.52 J	22.8	23.9	89.4	74.4	20.1	19.4	16	9.84	13.4	16.7	4.42 U	4.46 U	4.14 U	4.47 U	1.48 J	4.44 U	4.57 U	4.36 U	---	3

Table 4.1A
Summary of 2020 Groundwater Analytical Data

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

OPERABLE UNIT 2 (OU-2)																										
Sampling Point ID	**USEPA**	**NHDES**	**AE-1A**	**AE-1A**	**AE-1B**	**AE-1B**	**AE-2A[1]**	**AE-2A**	**AE-2B[1]**	**AE-2B**	**AE-3A[1]**	**AE-3A-DUP[1]**	**AE-3A**	**AE-3A DUP**	**AE-3B[1]**	**AE-3B**	**AE-4A**	**AE-4A**	**AE-4B**	**AE-4B**	**FPC-2A[1]**	**FPC-2A**	**FPC-2B[1]**	**FPC-2B**	**# of Exceedances**	
Date of Sample Collection	**CL**	**AGQS**	5/15/20	10/13/20	5/15/20	10/13/20	5/21/20	10/12/20	5/21/20	10/12/20	5/20/20	5/20/20	10/7/20	10/7/20	5/20/20	10/7/20	5/12/20	10/6/20	5/12/20	10/6/20	5/19/20	10/8/20	5/19/20	10/8/20	**CL**	**AGQS**
1H, 1H, 2H, 2H-Perfluorooctanesulfonic Acid (6:2FTS)	---	---	4.27 U	4.32 U	4.54 U	4.38 U	4.62 U	4.34 U	2.11 U	4.30 U	4.59 U	4.59 U	4.47 U	4.31 U	4.55 U	4.40 U	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	4.57 U	4.36 U	---	---
Perfluorooctanoic acid (PFOA)	70	12[2]	4.47	5.52	5.61	6.67	**558**	**483**	**766**	**733**	**302**	**288**	**180**	**212**	**261**	**164**	4.42 U	1.50 J	4.14 U	4.47 U	7.18	6.13	0.902 J	3.43 J	4	4
Perfluoroheptanesulfonic Acid (PFHpS)	---	---	4.27 U	4.32 U	4.54 U	4.38 U	6.69	4.94	13.6	13.8	1.23 J	4.59 U	4.47 U	1.45 J	1.91 J	4.40 U	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	4.57 U	4.36 U	---	---
Perfluorononanoic acid (PFNA)	---	11[2]	4.27 U	4.32 U	4.54 U	4.38 U	142	116	120	110	55.6	49.3	29.1	36.9	43.4	28.1	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	4.57 U	4.36 U	---	4
Perfluorooctanesulfonamide (PFOSA)	---	---	4.27 U	4.32 U	4.54 U	2.19 J	13.1	19.3	**7.83**	18.2	19.7 J	31.4 J	26.6	13.7	11.3	27.6	4.42 U	7.00	4.14 U	4.47 U	5.24	63.6	4.57 U	5.01	---	---
Perfluorooctanesulfonic (PFOS)	70	15[2]	4.27 U	4.32 U	4.54 U	1.32 J	**413**	**280**	**445**	**526**	**104 J**	**100**	**74.6**	**93.1**	**92.7**	**71.5**	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	1.47 J	1.90 J	4	4
Perfluorodecanoic Acid (PFDA)	---	---	4.27 U	4.32 U	4.54 U	4.38 U	18.5	20	9.01	8.91	7.86	7.57	5.8	8.15	7.68	5.33	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	4.57 U	4.36 U	---	---
1H, 1H, 2H, 2H-Perfluorodecanesulfonic Acid (8:2FTS)	---	---	4.27 U	4.32 U	4.54 U	4.38 U	4.62 U	4.34 U	2.11 U	4.30 U	4.59 U	4.59 U	4.47 U	4.31 U	4.55 U	4.40 U	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	4.57 U	4.36 U	---	---
N-Methyl Perfluorooctanesulfonamidoacetic Acid (MeFOSAA)	---	---	4.27 U	4.32 U	4.54 U	4.38 U	4.62 U	4.34 U	2.11 U	4.30 U	4.59 U	4.59 U	4.47 U	4.31 U	4.55 U	4.40 U	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	4.57 U	4.36 U	---	---
N-Ethyl Perfluorooctanesulfonamidoacetic (EtFOSAA)	---	---	4.27 U	4.32 U	4.54 U	4.38 U	4.62 U	4.34 U	2.11 U	4.30 U	2.74 J	2.81 J	4.47 U	3.65 J	3.12 J	4.40 U	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	4.57 U	4.36 U	---	---
Perfluoroundecanoic Acid (PFUnA)	---	---	4.27 U	4.32 U	4.54 U	4.38 U	4.62 U	4.34 U	2.11 U	4.30 U	4.59 U	4.59 U	4.47 U	4.31 U	4.55 U	4.40 U	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	4.57 U	4.36 U	---	---
Perfluorodecanesulfonic Acid (PFDS)	---	---	4.27 U	4.32 U	4.54 U	4.38 U	4.62 U	4.34 U	2.11 U	4.30 U	4.59 U	4.59 U	4.47 U	4.31 U	4.55 U	4.40 U	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	4.57 U	4.36 U	---	---
Perfluorododecanoic Acid (PFDoA)	---	---	4.27 U	4.32 U	4.54 U	4.38 U	4.62 U	4.34 U	2.11 U	4.30 U	4.59 U	4.59 U	4.47 U	4.31 U	4.55 U	4.40 U	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	4.57 U	4.36 U	---	---
N-Methyl Perfluorooctane Sulfonamide (MeFOSA)	---	---	21.6 UJ	21.6 U	22.2 UJ	21.9 U	23.1 U	21.7 U	10.5 U	21.5 U	22.9 U	22.9 U	22.4 U	21.5 U	22.7 U	22.0 U	22.1 U	22.3 U	20.7 U	22.3 U	23.1 U	22.2 U	21.0 UJ	21.8 U	---	---
Perfluorotrodecanoic Acid (PFTrDA)	---	---	4.27 U	4.32 U	4.54 U	4.38 U	4.62 U	4.34 U	2.11 U	4.30 U	4.59 U	4.59 U	4.47 U	4.31 U	4.55 U	4.40 U	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	4.57 U	4.36 U	---	---
Perfluorotetradecanoic Acid (PFTeDa)	---	---	4.27 U	4.32 U	4.54 U	4.38 U	4.62 U	4.34 U	2.11 U	4.30 U	4.59 U	4.59 U	4.47 U	4.31 U	4.55 U	4.40 U	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	4.57 U	4.36 U	---	---
N-Ethyl Perfluorooctane Sulfonamide (EtFOSA)	---	---	21.6 UJ	21.6 U	22.2 UJ	21.9 U	23.1 U	21.7 U	10.5 U	21.5 U	22.9 U	22.9 U	22.4 U	21.5 U	22.7 U	22.0 U	22.1 U	22.3 U	20.7 R	22.3 U	23.1 U	22.2 U	21.0 UJ	21.8 U	---	---
Perfluorogexadecanoic Acid (PFHxDA)	---	---	4.27 U	4.32 U	4.54 U	4.38 U	4.62 U	4.34 U	2.11 U	4.30 U	4.59 U	4.59 U	4.47 U	4.31 U	4.55 U	4.40 U	4.42 U	4.46 U	4.14 U	4.47 U	4.61 U	4.44 U	4.57 U	4.36 U	---	---
N-Methyl Perfluorooctanesulfonamido Ethanol (MeFOSE)	---	---	21.3 U	21.6 U	22.7 U	21.9 U	23.1 U	21.7 U	10.5 U	21.5 U	22.9 U	22.9 U	22.4 U	21.5 U	22.7 U	22.0 U	22.1 U	22.3 U	20.7 U	22.3 U	23.1 U	22.2 U	22.8 U	21.8 U	---	---
N-Ethyl Perfluorooctanesulfonamido Ethanol (EtFOSE)	---	---	21.3 U	21.6 U	22.7 U	21.9 U	23.1 U	21.7 U	10.5 U	21.5 U	22.9 U	22.9 U	22.4 U	21.5 U	22.7 U	22.0 U	22.1 U	22.3 U	20.7 U	22.3 U	23.1 U	22.2 U	22.8 U	21.8 U	---	---
Combination of PFOA and PFOS	70	---	4.47	5.52	5.61	7.99 J	**971**	**763**	**1,211**	**1,259**	**406 J**	**388**	**254.6**	**305.1**	**353.7**	**235.5**	ND	1.50 J	ND	ND	7.18	6.13	2.372 J	5.33 J	4	---
FIELD PARAMETERS																										
Dissolved Oxygen (mg/l)	---	---	N/A	N/A	N/A	N/A	1.3	1.9	1.3	1.9	1.3	N/A	2	N/A	1.4	2.3	2.7	3.1	6	2.2	1	1.7	1.6	2.4	---	---
Oxidation Reduction Potential (mV)	---	---	N/A	N/A	N/A	N/A	-96	-95	-113	-130	-106	N/A	-105	N/A	107	-99	150	15	173	145	-68	-27	-15	-140	---	---
pH (standard units)	---	---	N/A	N/A	N/A	N/A	6.7	6.8	7.3	7.3	6.5	N/A	6.4	N/A	6.9	6.1	6.6	6.6	7.0	7.1	6.8	6.7	8.1	8.2	---	---
Specific Conductance (us/cm)	---	---	N/A	N/A	N/A	N/A	491	458	1,010	979	830	N/A	983	N/A	804	1,002	132	137	169	178	395	417	233	238	---	---
Temperature (degrees Celcius)	---	---	N/A	N/A	N/A	N/A	12	12	12	12	12	N/A	14	N/A	13	14	10	14	10	14	10	13	12	13	---	---
Turbidity (NTU)	---	---	N/A	N/A	N/A	N/A	< 5	<5	< 5	<5	< 5	N/A	<5	N/A	< 5	<5	< 5	<5	< 5	<5	61	7	< 5	<5	---	---

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Table 4.1A
Summary of 2020 Groundwater Analytical Data

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

OPERABLE UNIT 2 (OU-2)																																						
Sampling Point ID	USEPA	NHDES	FPC-3A[1]	FPC-3A	FPC-3B[1]	FPC-3B	FPC-3C[1]	FPC-3C	FPC-4B	FPC-4B	FPC-5A	FPC-5A	FPC-5B	FPC-5B	FPC-6A	FPC-6A	FPC-6B	FPC-6B	FPC-7A[1]	FPC-7A	FPC-7B[1]	FPC-7B	FPC-8A[1]	FPC-8A	FPC-8B[1]	FPC-8B	FPC-9A	FPC-9A	FPC-9B[1]	FPC-9B	FPC-11A	FPC-11A[1]	FPC-11A	FPC-11B	FPC-11B	# of Exceedances	
Date of Sample Collection	CL	AGQS	5/19/20	10/8/20	5/19/20	10/8/20	5/19/20	10/8/20	5/12/20	10/6/20	5/22/20	10/12/20	5/22/20	10/12/20	5/13/20	10/7/20	5/13/20	10/7/20	5/20/20	10/12/20	5/20/20	10/12/20	5/21/20	10/9/20	5/21/20	10/9/20	5/14/20	10/8/20	5/21/20	10/8/20	5/14/20		10/9/20	5/14/20	10/9/20	CL	AGQS
VOLATILE ORGANIC COMPOUNDS BY 8260C - (ug/L)																																					
1,2,4-Trimethylbenzene	---	330	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	---	0
1,2-Dichloropropane	5	5	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	0	0
1,4-Dichlorobenzene	---	75	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	---	0
2-Butanone(MEK)	200	4,000	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	N/A	N/A	N/A	N/A	10 U	N/A	10 U	N/A	N/A	N/A	N/A	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	N/A	N/A	N/A	N/A	N/A	0	0
Acetone	---	6,000	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	N/A	N/A	N/A	N/A	10 U	N/A	10 U	N/A	N/A	N/A	N/A	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	N/A	N/A	N/A	N/A	N/A	---	0
Benzene	5	5	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	0	0
Carbon disulfide	---	70	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	N/A	N/A	N/A	N/A	2 U	N/A	2 U	N/A	N/A	N/A	N/A	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2U	N/A	N/A	N/A	N/A	N/A	N/A	---	0
Chlorobenzene	100	100	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	0	0
Chloroethane	---	---	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	N/A	N/A	N/A	N/A	2 U	N/A	2 U	N/A	N/A	N/A	N/A	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	N/A	N/A	N/A	N/A	N/A	---	---
Chloroform	80	---	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	0	---
Diethyl Ether	---	1,400	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	N/A	N/A	N/A	N/A	4.3	N/A	2 U	N/A	N/A	N/A	N/A	N/A	2 U	N/A	2 U	N/A	2 U	N/A	6.6	N/A	N/A	N/A	N/A	N/A	N/A	---	0
IsoPropylbenzene	---	800	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	---	0
Methyl-t-butyl ether(MTBE)	---	13	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	---	0
m&p-Xylene	---	10,000^	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	---	0
o-Xylene	---	10,000^	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	---	0
tert-Butyl Alcohol (TBA)	---	40	30 U	N/A	30 U	N/A	30 U	N/A	30 U	N/A	N/A	N/A	N/A	N/A	30 U	N/A	30 U	N/A	N/A	N/A	N/A	N/A	30 U	N/A	30 U	N/A	30 U	N/A	30 U	N/A	N/A	N/A	N/A	N/A	N/A	---	0
Tetrachloroethene	3.5	5	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	N/A	0	0
Tetrahydrofuran(THF)	154	600	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	N/A	N/A	N/A	N/A	10 U	N/A	10 U	N/A	N/A	N/A	N/A	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	N/A	N/A	N/A	N/A	N/A	0	0
trans-1,2-Dichloroethene	100	100	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	N/A	N/A	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	2 U	N/A	N/A	N/A	N/A	N/A	N/A	0	0
1,4-DIOXANE BY 8260B SIM - (ug/L)																																					
1,4-Dioxane	3	0.32	0.2 U	0.2 U	0.2 U	0.2 U	0.25	0.32	0.2 U	0.2 U	**21**	**21**	**37**	**37**	**7.1**	N/A	**3.4**	**12**	0.2 U	0.2 U	0.2 U	0.21	0.41	0.5	0.38	0.41	**13**	**10**	**3.7**	**3.9**	0.84		0.96	0.27	0.57	6	11
DISSOLVED METALS BY 200.8 - (mg/L)																																					
Dissolved Antimony	0.006	0.006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	0	0
Dissolved Arsenic	0.01	0.005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**0.038**	N/A	N/A	N/A	**0.014**	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	**0.049**	N/A	N/A	N/A	0.0061	N/A	N/A	N/A	N/A	3	4
Dissolved Barium	---	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.07	N/A	N/A	N/A	0.015	N/A	N/A	N/A	0.0085	N/A	N/A	N/A	0.0078	N/A	N/A	N/A	0.072	N/A	N/A	N/A	0.023	N/A	N/A	N/A	N/A	---	0
Dissolved Beryllium	0.004	0.004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	0	0
Dissolved Calcium	---	---	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	55 J+	N/A	N/A	N/A	16 J+	N/A	N/A	N/A	35 J+	N/A	N/A	N/A	27 J+	N/A	N/A	N/A	46 J+	N/A	N/A	N/A	36 J+	N/A	N/A	N/A	N/A	---	---
Dissolved Chromium	0.05	0.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	0	0
Dissolved Iron	---	---	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6 J+	N/A	N/A	N/A	1.1 J+	N/A	N/A	N/A	0.05 U	N/A	N/A	N/A	0.05 U	N/A	N/A	N/A	6.1 J+	N/A	N/A	N/A	0.36 J+	N/A	N/A	N/A	N/A	---	---
Dissolved Lead	0.015	0.015	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	0	0
Dissolved Magnesium	---	---	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26	N/A	N/A	N/A	6.8	N/A	N/A	N/A	11	N/A	N/A	N/A	5.4	N/A	N/A	N/A	23	N/A	N/A	N/A	12	N/A	N/A	N/A	N/A	---	---
Dissolved Manganese	0.3	0.84	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.28	N/A	N/A	N/A	**1.4**	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.17	N/A	N/A	N/A	**0.35**	N/A	N/A	N/A	N/A	2	1
Dissolved Nickel	0.1	0.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0081	N/A	N/A	N/A	0.0036	N/A	N/A	N/A	0.011	N/A	N/A	N/A	0.0011	N/A	N/A	N/A	0.0037	N/A	N/A	N/A	0.025	N/A	N/A	N/A	N/A	0	0
Dissolved Potassium	---	160	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	21	N/A	N/A	N/A	4.4	N/A	N/A	N/A	3.2	N/A	N/A	N/A	2.4	N/A	N/A	N/A	9.1	N/A	N/A	N/A	4.3	N/A	N/A	N/A	N/A	---	0
Dissolved Sodium	---	---	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	110	N/A	N/A	N/A	37	N/A	N/A	N/A	15	N/A	N/A	N/A	17	N/A	N/A	N/A	76	N/A	N/A	N/A	150	N/A	N/A	N/A	N/A	---	---
Dissolved Vanadium	0.26	---	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	N/A	0	---
TOTAL METALS BY 200.8																																					
Total Antimony	0.006	0.006	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	0.001 U	N/A	0	0
Total Arsenic	0.01	0.01	0.0068	N/A	0.0028	N/A	**0.013**	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.0013	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.0069	N/A	N/A	N/A	0.0019	N/A	N/A	N/A	N/A	0.0039	N/A	1	1
Total Barium	---	2	0.0025	N/A	0.005	N/A	0.0066	N/A	0.0034	N/A	N/A	N/A	0.03	N/A	N/A	N/A	0.015	N/A	N/A	N/A	0.0059	N/A	N/A	N/A	0.0068	N/A	N/A	N/A	0.054	N/A	N/A	N/A	N/A	0.18	N/A	---	0
Total Beryllium	0.004	0.004	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	0.001 U	N/A	0	0
Total Calcium	---	---	4.6 J+	N/A	2.1 J+	N/A	28 J+	N/A	3.9 J+	N/A	N/A	N/A	4.8 J+	N/A	N/A	N/A	5.2 J+	N/A	N/A	N/A	36 J+	N/A	N/A	N/A	24 J+	N/A	N/A	N/A	25 J+	N/A	N/A	N/A	N/A	61 J+	N/A	---	---
Total Chromium	0.05	0.1	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	0.001 U	N/A	0	0
Total Iron	---	---	0.089 J+	N/A	0.05 U	N/A	0.05 U	N/A	0.05 U	N/A	N/A	N/A	0.22 J+	N/A	N/A	N/A	1.2 J+	N/A	N/A	N/A	0.05 U	N/A	N/A	N/A	0.11 J+	N/A	N/A	N/A	0.77 J+	N/A	N/A	N/A	N/A	15 J+	N/A	---	---
Total Lead	0.015	0.015	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	0.001 U	N/A	0	0
Total Magnesium	---	---	0.58	N/A	0.98	N/A	7.8	N/A	2.6	N/A	N/A	N/A	3	N/A	N/A	N/A	2.9	N/A	N/A	N/A	11	N/A	N/A	N/A	5.2	N/A	N/A	N/A	19	N/A	N/A	N/A	N/A	21	N/A	---	---
Total Manganese	0.3	0.84	0.0094	N/A	0.017	N/A	0.14	N/A	0.005 U	N/A	N/A	N/A	0.054	N/A	N/A	N/A	**0.55**	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.024	N/A	N/A	N/A	0.18	N/A	N/A	N/A	N/A	**2.1**	N/A	2	1
Total Nickel	0.1	0.1	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0.0061	N/A	N/A	N/A	0.0012	N/A	N/A	N/A	0.0029	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	0.001 U	N/A	0	0
Total Potassium	---	160	4.1	N/A	2.4	N/A	2.9	N/A	1.5	N/A	N/A	N/A	6.3	N/A	N/A	N/A	3.5	N/A	N/A	N/A	2.9	N/A	N/A	N/A	3	N/A	N/A	N/A	7.1	N/A	N/A	N/A	N/A	15	N/A	---	0
Total Sodium	---	---	62	N/A	70	N/A	13	N/A	5.2	N/A	N/A	N/A	230	N/A	N/A	N/A	42	N/A	N/A	N/A	16	N/A	N/A	N/A	18	N/A	N/A	N/A	37	N/A	N/A	N/A	N/A	800	N/A	---	---
Total Vanadium	0.26	---	0.005 U	N/A	0.005 U	N/A	0.005 U	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	N/A	0.005 U	N/A	0	---

Table 4.1A
Summary of 2020 Groundwater Analytical Data

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

OPERABLE UNIT 2 (OU-2)

Sampling Point ID / Date of Sample Collection	USEPA CL	NHDES AGQS	FPC-3A[1] 5/19/20	FPC-3A 10/8/20	FPC-3B[1] 5/19/20	FPC-3B 10/8/20	FPC-3C[1] 5/19/20	FPC-3C 10/8/20	FPC-4B 5/12/20	FPC-4B 10/6/20	FPC-5A 5/22/20	FPC-5A 10/12/20	FPC-5B 5/22/20	FPC-5B 10/12/20	FPC-6A 5/13/20	FPC-6A 10/7/20
PER- & POLY-FLUORINATED ALKYL SUBSTANCES BY MODIFIED 537 - (ng/L)																
Perfluorobutanoic Acid (PFBA)	---	---	4.63 UJ	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	21.6 J	22.5	23.4	19.7	3.7 J	N/A
Perfluoropentanoic acid (PFpEA)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	46.6	42.2	36.7	33.5	7.74	N/A
Perfluorobutanesulfonic acid (PFBS)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	6.7	8.16	13.2	11.6	2.69 J	N/A
Perfluorohexanoix Acid (PFHxA)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	73.9	67	57.5	54.5	15.3	N/A
Perfluoroheptanoic acid (PFHpA)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	105	100	28.4	29.5	16.4	N/A
Perfluorohexanesulfonic acid (PFHxS)	---	18[2]	4.63 U	4.48 U	4.41 U	4.39 U	1.55 J	4.37 U	4.36 U	4.46 U	23.3	18.6	39.1	32.4	9.04	N/A
1H, 1H, 2H, 2H-Perfluorooctanesulfonic Acid (6:2FTS)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	4.64 U	4.33 U	4.49 U	4.29 U	4.43 U	N/A
Perfluorooctanoic acid (PFOA)	70	12[2]	1.07 J	1.48 J	0.854 J	4.39 U	2.64 J	3.59 J	4.36 U	4.46 U	**310**	**284**	**152**	**149**	52.4	N/A
Perfluoroheptanesulfonic Acid (PFHpS)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	1.75 J	2.75 J	1.20 J	4.29 U	4.43 U	N/A
Perfluorononanoic acid (PFNA)	---	11[2]	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	35.2	32.3	4.49 U	1.52 J	3.65 J	N/A
Perfluorooctanesulfonamide (PFOSA)	---	---	7.01	4.57	3.88 J	4.59	4.48 U	4.37 U	10.3	6.03	9.89	24.6	4.49 U	3.68 J	5.85	N/A
Perfluorooctanesulfonic (PFOS)	70	15[2]	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	58.4	64.1	17.1	18.7	11.5	N/A
Perfluorodecanoic Acid (PFDA)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	3.07 J	3.14 J	4.49 U	4.29 U	4.43 U	N/A
1H, 1H, 2H, 2H-Perfluorodecanesulfonic Acid (8:2FTS)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	4.64 U	4.33 U	4.49 U	4.29 U	4.43 U	N/A
N-Methyl Perfluorooctanesulfonamidoacetic Acid (MeFOSAA)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	4.64 U	4.33 U	4.49 U	4.29 U	4.43 U	N/A
N-Ethyl Perfluorooctanesulfonamidoacetic (EtFOSAA)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	4.85	3.89 J	4.49 U	4.29 U	4.43 U	N/A
Perfluoroundecanoic Acid (PFUnA)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	4.64 U	4.33 U	4.49 U	4.29 U	4.43 U	N/A
Perfluorodecanesulfonic Acid (PFDS)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	4.64 U	4.33 U	4.49 U	4.29 U	4.43 U	N/A
Perfluorododecanoic Acid (PFDoA)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	4.64 U	4.33 U	4.49 U	4.29 U	4.43 U	N/A
N-Methyl Perfluorooctane Sulfonamide (MeFOSA)	---	---	23.2 U	22.4 U	22.0 U	21.9 U	22.4 U	21.9 U	21.8 R	22.3 U	23.2 U	21.6 U	22.4 U	21.4 U	22.1 U	N/A
Perfluorotrodecanoic Acid (PFTrDA)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	4.64 U	4.33 U	4.49 U	4.29 U	4.43 U	N/A
Perfluorotetradecanoic Acid (PFTeDa)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	4.64 U	4.33 U	4.49 U	4.29 U	4.43 U	N/A
N-Ethyl Perfluorooctane Sulfonamide (EtFOSA)	---	---	23.2 U	22.4 U	22.0 U	21.9 U	22.4 U	21.9 U	21.8 R	22.3 U	23.2 U	21.6 U	22.4 U	21.4 U	22.1 U	N/A
Perfluorogexadecanoic Acid (PFHxDA)	---	---	4.63 U	4.48 U	4.41 U	4.39 U	4.48 U	4.37 U	4.36 U	4.46 U	4.64 U	4.33 U	4.49 UJ	4.29 U	4.43 U	N/A
N-Methyl Perfluorooctanesulfonamido Ethanol (MeFOSE)	---	---	23.2 U	22.4 U	22.0 U	21.9 U	22.4 U	21.9 U	21.8 U	22.3 U	23.2 U	21.6 U	22.4 U	21.4 U	22.1 U	N/A
N-Ethyl Perfluorooctanesulfonamido Ethanol (EtFOSE)	---	---	23.2 U	22.4 U	22.0 U	21.9 U	22.4 U	21.9 U	21.8 U	22.3 U	23.2 U	21.6 U	22.4 U	21.4 U	22.1 U	N/A
Combination of PFOA and PFOS	70	---	1.07 J	1.48 J	0.854 J	ND	2.64 J	3.59 J	ND	ND	**368.4**	**348.1**	**169.1**	**167.7**	63.9	N/A
FIELD PARAMETERS																
Dissolved Oxygen (mg/l)	---	---	1	2.1	0.7	1.4	0.6	1.4	6.4	1.3	1.5	1.9	1.6	1.2	1.1	N/A
Oxidation Reduction Potential (mV)	---	---	-118	-163	-127	-116	-52	32	134	152	-134	-120	-146	-165	-42	N/A
pH (standard units)	---	---	9.1	8.7	8.7	8.3	8.2	7.7	6.1	6.4	7.2	7.1	8.1	8	7.0	N/A
Specific Conductance (us/cm)	---	---	295	302	325	322	256	259	74	97	1,108	1,050	1,093	1,034	353	N/A
Temperature (degrees Celcius)	---	---	10	12	10	13	9	12	8	11	14	10	16	12	10	N/A
Turbidity (NTU)	---	---	< 5	<5	< 5	<5	< 5	<5	< 5	<5	< 5	<5	< 5	<5	< 5	N/A

Sampling Point ID / Date of Sample Collection	FPC-6B 5/13/20	FPC-6B 10/7/20	FPC-7A[1] 5/20/20	FPC-7A 10/12/20	FPC-7B[1] 5/20/20	FPC-7B 10/12/20	FPC-8A[1] 5/21/20	FPC-8A 10/9/20	FPC-8B[1] 5/21/20	FPC-8B 10/9/20	FPC-9A 5/14/20	FPC-9A 10/8/20	FPC-9B[1] 5/21/20	FPC-9B 10/8/20	FPC-11A 5/14/20	FPC-11A[1]	FPC-11A 10/9/20	FPC-11B 5/14/20	FPC-11B 10/9/20	# of Exceedances CL	# of Exceedances AGQS
PER- & POLY-FLUORINATED ALKYL SUBSTANCES BY MODIFIED 537 - (ng/L)																					
Perfluorobutanoic Acid (PFBA)	0.964 J	6.46	10 J	12.1	9.31	10.7	3.00 J	3.92 J	1.76 J	1.93 J	6	5.37	3.00 J	3.28 J	1.93 J		2.12 J	4.5 U	4.45 U	---	---
Perfluoropentanoic acid (PFpEA)	3.47 J	13.1	31	36.4	24.9	28.8	1.45 J	2.90 J	4.66 U	4.18 U	9.65	7.71	5.53	5.89	5.88		8.12	4.5 U	4.45 U	---	---
Perfluorobutanesulfonic acid (PFBS)	4.45 U	3.65 J	6	5.68	4.56	5.32	3.34 J	2.89 J	4.66 U	4.18 U	4.57	4.83	3.19 J	4.15 J	4.43 U		4.55 U	4.5 U	4.45 U	---	---
Perfluorohexanoix Acid (PFHxA)	5.5	23.5	28	26.7	21.5	23.7	4.97	5.11	3.24 J	4.18 U	25.6	22	13.8	11.9	8.83		11.8	4.5 U	6.32	---	---
Perfluoroheptanoic acid (PFHpA)	6.04	28.1	5.4	4.62	5.8	4.29 J	4.11 J	6.61	4.66 U	0.749 J	20	18.4	8.02	8.18	4.43 U		4.85	4.5 U	1.08 J	---	---
Perfluorohexanesulfonic acid (PFHxS)	3.84 J	12	2.08 J	1.43 J	1.36 J	1.91 J	2.62 J	2.92 J	1.57 J	4.18 U	14.3	10.4	8.00	7.48	2.87 J		3.84 J	4.5 U	2.32 J	---	2
1H, 1H, 2H, 2H-Perfluorooctanesulfonic Acid (6:2FTS)	4.45 U	4.32 U	4.50 U	4.18 U	4.25 U	4.35 U	4.46 U	4.48 U	4.66 U	4.18 U	4.26 U	4.34 U	4.44 U	4.45 U	4.43 U		4.55 U	4.5 U	4.45 U	---	---
Perfluorooctanoic acid (PFOA)	20.8	**84.4**	11.8	10.6	12.6	11.5	11.5	20.7	4.42 J	2.02 J	67.8	58	39.2	36.3	18.1		22.3	2.59 J	13.3	3	10
Perfluoroheptanesulfonic Acid (PFHpS)	4.45 U	4.32 U	4.50 U	4.18 U	4.25 U	4.35 U	4.46 U	4.48 U	4.66 U	4.18 U	4.26 U	4.34 U	4.44 U	4.45 U	4.43 U		4.55 U	4.5 U	4.45 U	---	---
Perfluorononanoic acid (PFNA)	4.45 U	4.61	4.50 U	4.18 U	1.14 J	4.35 U	1.39 J	1.04 J	4.66 U	4.18 U	4.26 U	4.34 U	4.44 U	4.45 U	4.43 U		4.55 U	4.5 U	4.45 U	---	1
Perfluorooctanesulfonamide (PFOSA)	6.99	21.1	3.89 J	3.13 J	3.15 J	4.35 U	4.46 U	4.48 U	7.89	2.11 J	9.94	9.76	3.11 J	3.40 J	17.7		4.19 J	4.5 U	9.3	---	---
Perfluorooctanesulfonic (PFOS)	2.67 J	17	4.50 U	4.18 U	2.41 J	1.43 J	1.17 J	3.80 J	4.66 U	1.42 J	15.4	12.2	5.04	6.22	2.53 J		5.64	4.5 U	2.19 J	0	4
Perfluorodecanoic Acid (PFDA)	4.45 U	4.32 U	4.50 U	4.18 U	4.25 U	4.35 U	4.46 U	4.48 U	4.66 U	4.18 U	4.26 U	4.34 U	4.44 U	4.45 U	4.43 U		4.55 U	4.5 U	4.45 U	---	---
1H, 1H, 2H, 2H-Perfluorodecanesulfonic Acid (8:2FTS)	4.45 U	4.32 U	4.50 U	4.18 U	4.25 U	4.35 U	4.46 U	4.48 U	4.66 U	4.18 U	4.26 U	4.34 U	4.44 U	4.45 U	4.43 U		4.55 U	4.5 U	4.45 U	---	---
N-Methyl Perfluorooctanesulfonamidoacetic Acid (MeFOSAA)	4.45 U	4.32 U	4.50 U	4.18 U	4.25 U	4.35 U	4.46 U	4.48 U	4.66 U	4.18 U	4.26 U	4.34 U	4.44 U	4.45 U	4.43 U		4.55 U	4.5 U	4.45 U	---	---
N-Ethyl Perfluorooctanesulfonamidoacetic (EtFOSAA)	4.45 U	4.32 U	4.50 U	4.18 U	4.25 U	4.35 U	4.46 U	4.48 U	4.66 U	4.18 U	4.26 U	4.34 U	4.44 U	4.45 U	4.43 U		4.55 U	4.5 U	4.45 U	---	---
Perfluoroundecanoic Acid (PFUnA)	4.45 U	4.32 U	4.50 U	4.18 U	4.25 U	4.35 U	4.46 U	4.48 U	4.66 U	4.18 U	4.26 U	4.34 U	4.44 U	4.45 U	4.43 U		4.55 U	4.5 U	4.45 U	---	---
Perfluorodecanesulfonic Acid (PFDS)	4.45 U	4.32 U	4.50 U	4.18 U	4.25 U	4.35 U	4.46 U	4.48 U	4.66 U	4.18 U	4.26 U	4.34 U	4.44 U	4.45 U	4.43 U		4.55 U	4.5 U	4.45 U	---	---
Perfluorododecanoic Acid (PFDoA)	4.45 U	4.32 U	4.50 U	4.18 U	4.25 U	4.35 U	4.46 U	4.48 U	4.66 U	4.18 U	4.26 U	4.34 U	4.44 U	4.45 U	4.43 U		4.55 U	4.5 U	4.45 U	---	---
N-Methyl Perfluorooctane Sulfonamide (MeFOSA)	22.3 U	21.6 U	22.3 UJ	20.9 U	21.4 UJ	21.7 U	22.3 U	22.4 U	23.3 U	20.9 U	21.3 U	21.7 U	22.2 U	22.3 U	22.2 U		22.8 U	22.5 UJ	22.2 U	---	---
Perfluorotrodecanoic Acid (PFTrDA)	4.45 U	4.32 U	4.50 U	4.18 U	4.25 U	4.35 U	4.46 U	4.48 U	4.66 U	4.18 U	4.26 U	4.34 U	4.44 U	4.45 U	4.43 U		4.55 U	4.5 U	4.45 U	---	---
Perfluorotetradecanoic Acid (PFTeDa)	4.45 U	4.32 U	4.50 U	4.18 U	4.25 U	4.35 U	4.46 U	4.48 U	4.66 U	4.18 U	4.26 U	4.34 U	4.44 U	4.45 U	4.43 U		4.55 U	4.5 U	4.45 U	---	---
N-Ethyl Perfluorooctane Sulfonamide (EtFOSA)	22.3 U	21.6 U	22.3 UJ	20.9 U	21.4 UJ	21.7 U	22.3 R	22.4 U	23.3 U	20.9 U	21.3 U	21.7 U	22.2 U	22.3 U	22.2 U		22.8 U	22.5 UJ	22.2 U	---	---
Perfluorogexadecanoic Acid (PFHxDA)	4.45 U	4.32 U	4.50 R	4.18 U	4.25 U	4.35 U	4.46 U	4.48 U	4.66 UJ	4.18 U	4.26 U	4.34 U	4.44 U	4.45 U	4.43 U		4.55 U	4.5 U	4.45 U	---	---
N-Methyl Perfluorooctanesulfonamido Ethanol (MeFOSE)	22.3 U	21.6 U	22.5 U	20.9 U	21.2 U	21.7 U	22.3 U	22.4 U	22.3 U	20.9 U	21.3 U	21.7 U	22.2 U	22.3 U	22.2 U		22.8 U	22.5 U	22.2 U	---	---
N-Ethyl Perfluorooctanesulfonamido Ethanol (EtFOSE)	22.3 U	21.6 U	22.5 U	20.9 U	21.2 U	21.7 U	22.3 U	22.4 U	22.3 U	20.9 U	21.3 U	21.7 U	22.2 U	22.3 U	22.2 U		22.8 U	22.5 U	22.2 U	---	---
Combination of PFOA and PFOS	23.47 J	**101.4**	11.8	10.6	15.01 J	12.93 J	12.67 J	24.5 J	4.42 J	3.44 J	**83.2**	**70.2**	44.24	42.52	20.63 J		27.94	2.59 J	15.49 J	4	---
FIELD PARAMETERS																					
Dissolved Oxygen (mg/l)	1	1	4.5	5.3	4.1	4.5	2.2	0.9	1.1	1.2	0.7	0.7	1	1.4	1.4		1.2	1.8	1.8	---	---
Oxidation Reduction Potential (mV)	-57	-107	197	176	153	150	125	182	-131	-113	-126	-135	-153	-129	-16		-142	-89	-96	---	---
pH (standard units)	7.1	6.8	6.1	6.1	6.2	6.3	6.5	6.5	8.1	9.0	7.1	7.4	7.6	7.9	7		7.4	6.9	7.0	---	---
Specific Conductance (us/cm)	248	532	395	435	393	430	291	358	245	233	847	827	456	437	1,120		1,140	5,271	2,142	---	---
Temperature (degrees Celcius)	10	13	10	11	12	12	11	11	11	12	11	10	12	11	14		13	14	15	---	---
Turbidity (NTU)	< 5	<5	< 5	<5	< 5	<5	< 5	<5	< 5	<5	< 5	<5	< 5	<5	< 5		<5	< 5	<5	---	---

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Table 4.1A
Summary of 2020 Groundwater Analytical Data

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

OPERABLE UNIT 2 (OU-2)														
Sampling Point ID	USEPA	NHDES	GZ-105[1]	GZ-105-DUP[1]	GZ-105	GZ-105-DUP	GZ-109	GZ-109	GZ-117	GZ-117	MW-20S	MW-20S	MW-20D1	MW-20D1 DUP
Date of Sample Collection	CL	AGQS	5/21/20	5/21/20	10/12/20	10/12/20	5/14/20	10/8/20	5/14/20	10/8/20	5/18/20	10/8/20	5/18/20	5/18/20
VOLATILE ORGANIC COMPOUNDS BY 8260C - (ug/L)														
1,2,4-Trimethylbenzene	---	330	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	1 U
1,2-Dichloropropane	5	5	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	1 U
1,4-Dichlorobenzene	---	75	1.7	1.8	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	1 U
2-Butanone(MEK)	200	4,000	10 U	10 U	N/A	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	10 U
Acetone	---	6,000	10 U	10 U	N/A	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	10 U
Benzene	5	5	2.5	2.7	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	1 U
Carbon disulfide	---	70	2 U	2 U	N/A	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	2 U
Chlorobenzene	100	100	4.2	4.4	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	1 U
Chloroethane	---	---	3.1	3.1	N/A	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	2 U
Chloroform	80	---	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	1 U
Diethyl Ether	---	1400	25	26	N/A	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	2 U
IsoPropylbenzene	---	800	1 U	1	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	1 U
Methyl-t-butyl ether(MTBE)	---	13	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	1 U
m&p-Xylene	---	10,000^	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	1 U
o-Xylene	---	10,000^	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	1 U
tert-Butyl Alcohol (TBA)	---	40	30 U	30 U	N/A	N/A	30 U	N/A	30 U	N/A	30 U	N/A	30 U	30 U
Tetrachloroethene	3.5	5	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	1 U
Tetrahydrofuran(THF)	154	600	17	18	N/A	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	10 U
trans-1,2-Dichloroethene	100	100	1 U	1 U	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	1 U
1,4-DIOXANE BY 8260B SIM - (ug/L)														
1,4-Dioxane	3	0.32	**31**	**35**	**45**	**42**	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.26	0.2 U
DISSOLVED METALS BY 200.8 - (mg/L)														
Dissolved Antimony	0.006	0.006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A
Dissolved Arsenic	0.01	0.005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A
Dissolved Barium	---	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0038	N/A	N/A	N/A
Dissolved Beryllium	0.004	0.004	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A
Dissolved Calcium	---	---	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8.1 J+	N/A	N/A	N/A
Dissolved Chromium	0.05	0.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A
Dissolved Iron	---	---	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05 U	N/A	N/A	N/A
Dissolved Lead	0.015	0.015	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A
Dissolved Magnesium	---	---	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.5	N/A	N/A	N/A
Dissolved Manganese	0.3	0.84	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0079	N/A	N/A	N/A
Dissolved Nickel	0.1	0.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0013	N/A	N/A	N/A
Dissolved Potassium	---	160	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.2	N/A	N/A	N/A
Dissolved Sodium	---	---	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	N/A	N/A	N/A
Dissolved Vanadium	0.26	---	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A
TOTAL METALS BY 200.8														
Total Antimony	0.006	0.006	0.001 U	0.001 U	N/A	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	0.001 U
Total Arsenic	0.01	0.01	**0.01**	0.0097	N/A	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0.0011	0.0012
Total Barium	---	2	0.039	0.038	N/A	N/A	0.0023	N/A	0.046	N/A	N/A	N/A	0.032	0.031
Total Beryllium	0.004	0.004	0.001 U	0.001 U	N/A	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	0.001 U
Total Calcium	---	---	45 J+	43 J+	N/A	N/A	0.42 J+	N/A	90 J+	N/A	N/A	N/A	35 J+	35 J+
Total Chromium	0.05	0.1	0.001 U	0.001 U	N/A	N/A	0.001U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	0.001
Total Iron	---	---	3.2 J+	3 J+	N/A	N/A	0.069 J+	N/A	0.24 J+	N/A	N/A	N/A	0.05 UJ	0.91 J+
Total Lead	0.015	0.015	0.001 U	0.001 U	N/A	N/A	0.001U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	0.001 U
Total Magnesium	---	---	18	18	N/A	N/A	0.24	N/A	12	N/A	N/A	N/A	0.37	0.39
Total Manganese	0.3	0.84	**0.41**	**0.4**	N/A	N/A	0.014	N/A	0.005 U	N/A	N/A	N/A	0.005 U	0.006
Total Nickel	0.1	0.1	0.0064	0.0062	N/A	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	0.001 U
Total Potassium	---	160	6.3	6.1	N/A	N/A	1.8	N/A	4.8	N/A	N/A	N/A	4.8	4.7
Total Sodium	---	---	120	120	N/A	N/A	68	N/A	280	N/A	N/A	N/A	71	68
Total Vanadium	0.26	---	0.005 U	0.005 U	N/A	N/A	0.005 U	N/A	0.005 U	N/A	N/A	N/A	0.005 U	0.005 U

Sampling Point ID	MW-20D1	MW-20D1 DUP	MW-20D2	MW-20D2	MW-21S	MW-21S	MW-21D1	MW-21D1	MW-21D2	MW-21D2	MW-22S	MW-22S	MW-22D1	MW-22D1	MW-22D2	MW-22D2	# of Exceedances	
Date of Sample Collection	10/7/20	10/7/20	5/18/20	10/7/20	5/13/20	10/7/20	5/13/20	10/7/20	5/13/20	10/7/20	5/12/20	10/6/20	5/12/20	10/6/20	5/12/20	10/6/20	CL	AGQS
VOLATILE ORGANIC COMPOUNDS BY 8260C - (ug/L)																		
1,2,4-Trimethylbenzene	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	---	0
1,2-Dichloropropane	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	0	0
1,4-Dichlorobenzene	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	---	0
2-Butanone(MEK)	N/A	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	0	0
Acetone	N/A	N/A	26	N/A	10 U	N/A	24	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	---	0
Benzene	N/A	N/A	1 U	N/A	1.6	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	0	0
Carbon disulfide	N/A	N/A	7.3	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	---	0
Chlorobenzene	N/A	N/A	1 U	N/A	3.6	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	0	0
Chloroethane	N/A	N/A	2 U	N/A	4.7	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	---	---
Chloroform	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1.9	N/A	1 U	N/A	1 U	N/A	0	---
Diethyl Ether	N/A	N/A	2 U	N/A	24	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	2 U	N/A	---	0
IsoPropylbenzene	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	---	0
Methyl-t-butyl ether(MTBE)	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	---	0
m&p-Xylene	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	---	0
o-Xylene	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	---	0
tert-Butyl Alcohol (TBA)	N/A	N/A	30 U	N/A	30 U	N/A	30 U	N/A	30 U	N/A	30 U	N/A	30 U	N/A	30 U	N/A	---	0
Tetrachloroethene	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	0	0
Tetrahydrofuran(THF)	N/A	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	10 U	N/A	0	0
trans-1,2-Dichloroethene	N/A	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	1 U	N/A	0	0
1,4-DIOXANE BY 8260B SIM - (ug/L)																		
1,4-Dioxane	0.54	0.58	0.64	0.74	**28**	**29**	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2	4
DISSOLVED METALS BY 200.8 - (mg/L)																		
Dissolved Antimony	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0	0
Dissolved Arsenic	N/A	N/A	N/A	N/A	0.0087	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0	1
Dissolved Barium	N/A	N/A	N/A	N/A	0.026	N/A	N/A	N/A	N/A	N/A	0.0023	N/A	N/A	N/A	N/A	N/A	---	0
Dissolved Beryllium	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0	0
Dissolved Calcium	N/A	N/A	N/A	N/A	59 J+	N/A	N/A	N/A	N/A	N/A	5.8 J+	N/A	N/A	N/A	N/A	N/A	---	---
Dissolved Chromium	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0	0
Dissolved Iron	N/A	N/A	N/A	N/A	3.1 J+	N/A	N/A	N/A	N/A	N/A	0.05 U	N/A	N/A	N/A	N/A	N/A	---	---
Dissolved Lead	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0	0
Dissolved Magnesium	N/A	N/A	N/A	N/A	19	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	N/A	N/A	N/A	---	---
Dissolved Manganese	N/A	N/A	N/A	N/A	**0.34**	N/A	N/A	N/A	N/A	N/A	0.0082	N/A	N/A	N/A	N/A	N/A	1	0
Dissolved Nickel	N/A	N/A	N/A	N/A	0.0064	N/A	N/A	N/A	N/A	N/A	0.001 U	N/A	N/A	N/A	N/A	N/A	0	0
Dissolved Potassium	N/A	N/A	N/A	N/A	8.5	N/A	N/A	N/A	N/A	N/A	2.1	N/A	N/A	N/A	N/A	N/A	---	0
Dissolved Sodium	N/A	N/A	N/A	N/A	110	N/A	N/A	N/A	N/A	N/A	6.8	N/A	N/A	N/A	N/A	N/A	---	---
Dissolved Vanadium	N/A	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	N/A	N/A	0.005 U	N/A	N/A	N/A	N/A	N/A	0	---
TOTAL METALS BY 200.8																		
Total Antimony	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	0	0
Total Arsenic	N/A	N/A	0.0011	N/A	N/A	N/A	**0.024**	N/A	0.001 U	N/A	N/A	N/A	0.0032	N/A	0.001 U	N/A	2	2
Total Barium	N/A	N/A	0.043	N/A	N/A	N/A	0.0061	N/A	0.0011	N/A	N/A	N/A	0.017	N/A	0.13	N/A	---	0
Total Beryllium	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	0	0
Total Calcium	N/A	N/A	27 J+	N/A	N/A	N/A	7.3 J+	N/A	2.3 J+	N/A	N/A	N/A	12 J+	N/A	240 J+	N/A	---	---
Total Chromium	N/A	N/A	**0.085**	N/A	N/A	N/A	0.01	N/A	0.0019	N/A	N/A	N/A	0.001 U	N/A	0.028	N/A	1	0
Total Iron	N/A	N/A	0.15 J+	N/A	N/A	N/A	0.49 J+	N/A	0.051 J+	N/A	N/A	N/A	0.05 U	N/A	0.1 J+	N/A	---	---
Total Lead	N/A	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	N/A	N/A	0.001 U	N/A	0.001 U	N/A	0	0
Total Magnesium	N/A	N/A	0.05 U	N/A	N/A	N/A	0.2	N/A	0.26	N/A	N/A	N/A	3.1	N/A	0.056	N/A	---	---
Total Manganese	N/A	N/A	0.005 U	N/A	N/A	N/A	0.0065	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	0.005 U	N/A	1	0
Total Nickel	N/A	N/A	0.001 U	N/A	N/A	N/A	0.0011	N/A	0.001	N/A	N/A	N/A	0.001 U	N/A	0.0027	N/A	0	0
Total Potassium	N/A	N/A	51	N/A	N/A	N/A	9.1	N/A	5.3	N/A	N/A	N/A	4.9	N/A	52	N/A	---	0
Total Sodium	N/A	N/A	130	N/A	N/A	N/A	82	N/A	89	N/A	N/A	N/A	34	N/A	95	N/A	---	---
Total Vanadium	N/A	N/A	0.011	N/A	N/A	N/A	0.015	N/A	0.005 U	N/A	N/A	N/A	0.005 U	N/A	0.005 U	N/A	0	---

Table 4.1A
Summary of 2020 Groundwater Analytical Data

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

OPERABLE UNIT 2 (OU-2) Sampling Point ID / Date of Sample Collection	USEPA CL	NHDES AGQS	GZ-105[1] 5/21/20	GZ-105-DUP[1] 5/21/20	GZ-105 10/12/20	GZ-105-DUP 10/12/20	GZ-109 5/14/20	GZ-109 10/8/20	GZ-117 5/14/20	GZ-117 10/8/20	MW-20S 5/18/20	MW-20S 10/8/20	MW-20D1 5/18/20	MW-20D1 DUP 5/18/20
PER- & POLY-FLUORINATED ALKYL SUBSTANCES BY MODIFIED 537 - (ng/L)														
Perfluorobutanoic Acid (PFBA)	---	---	31.5	27	26	24.7	4.39 U	4.64 U	1.68 J	1.64 J	4.42 U	4.51 U	4.36 R	4.37 R
Perfluoropentanoic acid (PFpEA)	---	---	61.6	52.7	50.5	47.1	4.39 U	4.64 U	1.96 J	4.41 U	4.42 U	4.51 U	4.36 UJ	4.37 UJ
Perfluorobutanesulfonic acid (PFBS)	---	---	17	13.2	10.5	13	4.39 U	4.64 U	4.16 U	2.10 J	4.42 U	4.51 U	4.36 U	4.37 U
Perfluorohexanoix Acid (PFHxA)	---	---	101	97.9	85	87.3	4.39 U	4.64 U	4.16 U	4.41 U	4.42 U	4.51 U	4.36 U	4.37 U
Perfluoroheptanoic acid (PFHpA)	---	---	138	132	122	123	4.39 U	4.64 U	0.925 J	4.41 U	4.42 U	4.51 U	1.29 J	0.944 J
Perfluorohexanesulfonic acid (PFHxS)	---	18[2]	68.3	64.9	54.9	41	4.39 U	4.64 U	4.16 U	4.41 U	4.42 U	4.51 U	4.36 U	4.37 U
1H, 1H, 2H, 2H-Perfluorooctanesulfonic Acid (6:2FTS)	---	---	4.6 U	4.71 U	4.28 U	4.26 U	4.39 U	4.64 U	4.16 U	4.41 U	4.42 U	4.51 U	4.36 U	4.37 U
Perfluorooctanoic acid (PFOA)	70	12[2]	**324**	**279**	**277**	**266**	4.39 U	4.64 U	5.06	3.71 J	4.42 U	4.51 U	2.6 J	2.32 J
Perfluoroheptanesulfonic Acid (PFHpS)	---	---	5.58	4.28 J	4.22 J	6.14	4.39 U	4.64 U	4.16 U	4.41 U	4.42 U	4.51 U	4.36 U	4.37 U
Perfluorononanoic acid (PFNA)	---	11[2]	30.8	29.9	29.5	23	4.39 U	4.64 U	4.16 U	4.41 U	4.42 U	4.51 U	4.36 U	4.37 U
Perfluorooctanesulfonamide (PFOSA)	---	---	10.2	7.73	8.32	10	4.39 U	2.86 J	4.16 U	2.23 J	4.42 U	4.51 U	4.49	2.72 J
Perfluorooctanesulfonic (PFOS)	70	15[2]	**168**	**146**	**147**	**137**	4.39 U	4.64 U	11.4	8.31	4.42 U	2.04 J	4.36 U	4.37 U
Perfluorodecanoic Acid (PFDA)	---	---	2.40 J	2.43 J	1.95 J	1.81 J	4.39 U	4.64 U	4.16 U	4.41 U	4.42 U	4.51 U	4.36 U	4.37 U
1H, 1H, 2H, 2H-Perfluorodecanesulfonic Acid (8:2FTS)	---	---	4.6 U	4.71 U	4.28 U	4.26 U	4.39 U	4.64 U	4.16 U	4.41 U	4.42 U	4.51 U	4.36 U	4.37 U
N-Methyl Perfluorooctanesulfonamidoacetic Acid (MeFOSAA)	---	---	4.6 U	4.71 U	4.28 U	4.26 U	4.39 U	4.64 U	4.16 U	4.41 U	4.42 U	4.51 U	4.36 U	4.37 U
N-Ethyl Perfluorooctanesulfonamidoacetic (EtFOSAA)	---	---	4.6 U	4.71 U	4.28 U	4.26 U	4.39 U	4.64 U	4.16 U	4.41 U	4.42 U	4.51 U	4.36 U	4.37 U
Perfluoroundecanoic Acid (PFUnA)	---	---	4.6 U	4.71 U	4.28 U	4.26 U	4.39 U	4.64 U	4.16 U	4.41 U	4.42 U	4.51 U	4.36 U	4.37 U
Perfluorodecanesulfonic Acid (PFDS)	---	---	4.6 U	4.71 U	4.28 U	4.26 U	4.39 U	4.64 U	4.16 U	4.41 U	4.42 U	4.51 U	4.36 U	4.37 U
Perfluorododecanoic Acid (PFDoA)	---	---	4.6 U	4.71 U	4.28 U	4.26 U	4.39 U	4.64 U	4.16 U	4.41 U	4.42 U	4.51 U	4.36 U	4.37 U
N-Methyl Perfluorooctane Sulfonamide (MeFOSA)	---	---	22.5 UJ	23.6 U	21.4 U	21.3 U	22.0 U	23.2 U	20.8 U	22.0 U	22.1 U	22.5 U	21.8 UJ	21.7 UJ
Perfluorotrodecanoic Acid (PFTrDA)	---	---	4.6 U	4.71 U	4.28 U	4.26 U	4.39 U	4.64 U	4.16 U	4.41 U	4.42 U	4.51 U	4.36 U	4.37 U
Perfluorotetradecanoic Acid (PFTeDa)	---	---	4.6 U	4.71 U	4.28 U	4.26 U	4.39 U	4.64 U	4.16 U	4.41 U	4.42 U	4.51 U	4.36 U	4.37 U
N-Ethyl Perfluorooctane Sulfonamide (EtFOSA)	---	---	22.5 UJ	23.6 U	21.4 U	21.3 U	22.0 U	23.2 U	20.8 U	22.0 U	22.1 U	22.5 U	21.8 UJ	21.7 UJ
Perfluorogexadecanoic Acid (PFHxDA)	---	---	4.6 U	4.71 U	4.28 U	4.26 U	4.39 U	4.64 U	4.16 U	4.41 U	4.42 U	4.51 U	4.36 U	4.37 U
N-Methyl Perfluorooctanesulfonamido Ethanol (MeFOSE)	---	---	23.0 U	23.6 U	21.4 U	21.3 U	22.0 U	23.2 U	20.8 U	22.0 U	22.1 U	22.5 U	21.8 U	21.8 U
N-Ethyl Perfluorooctanesulfonamido Ethanol (EtFOSE)	---	---	23.0 U	23.6 U	21.4 U	21.3 U	22.0 U	23.2 U	20.8 U	22.0 U	22.1 U	22.5 U	21.8 U	21.8 U
Combination of PFOA and PFOS	70	---	**492**	**425**	**424**	**403**	ND	ND	16.46	12.02 J	ND	2.04 J	2.6 J	2.32 J
FIELD PARAMETERS														
Dissolved Oxygen (mg/l)	---	---	0.9	N/A	1.1	N/A	0.6	0.8	6.1	4.5	8.7	5.6	0.6	N/A
Oxidation Reduction Potential (mV)	---	---	-147	N/A	-162	N/A	-171	-180	117	86	199	203	-170	N/A
pH (standard units)	---	---	7.5	N/A	7.5	N/A	8.4	8.8	6.6	7	6.3	6.1	11.6	N/A
Specific Conductance (us/cm)	---	---	829	N/A	851	N/A	338	335	2,019	2,001	215	292	730	N/A
Temperature (degrees Celcius)	---	---	10	N/A	10	N/A	13	13	13	15	8	12	9	N/A
Turbidity (NTU)	---	---	<5	N/A	<5	N/A	< 5	<5	< 5	<5	< 5	<5	< 5	N/A

Sampling Point ID / Date of Sample Collection	MW-20D1 10/7/20	MW-20D1 DUP 10/7/20	MW-20D2 5/18/20	MW-20D2 10/7/20	MW-21S 5/13/20	MW-21S 10/7/20	MW-21D1 5/13/20	MW-21D1 10/7/20	MW-21D2 5/13/20	MW-21D2 10/7/20	MW-22S 5/12/20	MW-22S 10/6/20	MW-22D1 5/12/20	MW-22D1 10/6/20	MW-22D2 5/12/20	MW-22D2 10/6/20	# of Exceedances CL	# of Exceedances AGQS
PER- & POLY-FLUORINATED ALKYL SUBSTANCES BY MODIFIED 537 - (ng/L)																		
Perfluorobutanoic Acid (PFBA)	4.30 U	4.40 U	4.33 R	4.35 U	18	13.5	4.39 UJ	4.30 U	4.54 R	4.26 U	4.25 U	4.26 U	4.37 UJ	4.38 U	4.24 R	4.21 U	---	---
Perfluoropentanoic acid (PFpEA)	4.30 U	4.40 U	2.94 J	2.14 J	29.7	24.9	4.39 UJ	4.30 U	4.54 UJ	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 UJ	4.21 U	---	---
Perfluorobutanesulfonic acid (PFBS)	4.30 U	4.40 U	4.33 U	4.35 U	7.85	4.86	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 UJ	4.21 U	---	---
Perfluorohexanoix Acid (PFHxA)	4.30 U	4.40 U	3.15 J	3.2 J	55.3	47.8	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 UJ	4.21 U	---	---
Perfluoroheptanoic acid (PFHpA)	2.96 J	2.99 J	3.19 J	2.58 J	61.5	48.7	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	4.21 U	---	---
Perfluorohexanesulfonic acid (PFHxS)	1.55 J	4.40 U	2.48 J	1.38 J	27.4	20.4	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	4.21 U	---	2
1H, 1H, 2H, 2H-Perfluorooctanesulfonic Acid (6:2FTS)	4.30 U	4.40 U	4.33 U	4.35 U	4.3 U	4.33 U	4.39 U	4.30 U	3.0 J	2.97 J	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	4.21 U	---	---
Perfluorooctanoic acid (PFOA)	10.1	13.8	11.2	13.4	**192**	**155**	4.39 U	1.15 J	4.54 U	9.36	4.25 U	4.26 U	4.37 U	5.42	4.24 U	1.98 J	2	4
Perfluoroheptanesulfonic Acid (PFHpS)	4.30 U	4.40 U	4.33 U	4.35 U	4.3 U	4.33 U	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	4.21 U	---	---
Perfluorononanoic acid (PFNA)	4.30 U	4.40 U	4.33 U	4.35 U	13.4	10.8	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	4.21 U	---	2
Perfluorooctanesulfonamide (PFOSA)	4.30 U	3.69 J	4.33 U	4.35 U	16	10.6	4.39 U	4.30 U	4.54 U	3.92 J	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	2.97 J	---	---
Perfluorooctanesulfonic (PFOS)	4.30 U	4.40 U	4.33 U	4.35 U	29	28.1	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	1.04 J	1	2
Perfluorodecanoic Acid (PFDA)	4.30 U	4.40 U	4.33 U	4.35 U	4.3 U	4.33 U	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	4.21 U	---	---
1H, 1H, 2H, 2H-Perfluorodecanesulfonic Acid (8:2FTS)	4.30 U	4.40 U	4.33 U	4.35 U	4.3 U	4.33 U	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	4.21 U	---	---
N-Methyl Perfluorooctanesulfonamidoacetic Acid (MeFOSAA)	4.30 U	4.40 U	4.33 U	4.35 U	4.3 U	4.33 U	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	4.21 U	---	---
N-Ethyl Perfluorooctanesulfonamidoacetic (EtFOSAA)	4.30 U	4.40 U	4.33 U	4.35 U	4.3 U	4.33 U	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	4.21 U	---	---
Perfluoroundecanoic Acid (PFUnA)	4.30 U	4.40 U	4.33 U	4.35 U	4.3 U	4.33 U	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	4.21 U	---	---
Perfluorodecanesulfonic Acid (PFDS)	4.30 U	4.40 U	4.33 U	4.35 U	4.3 U	4.33 U	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	4.21 U	---	---
Perfluorododecanoic Acid (PFDoA)	4.30 U	4.40 U	4.33 U	4.35 U	4.3 U	4.33 U	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	4.21 U	---	---
N-Methyl Perfluorooctane Sulfonamide (MeFOSA)	21.5 U	22.0 U	21.7 U	21.8 U	21.5 U	21.6 U	21.9 U	21.5 U	22.7 U	21.3 U	21.2 U	21.3 U	21.9 U	21.9 U	21.2 U	21.1 U	---	---
Perfluorotrodecanoic Acid (PFTrDA)	4.30 U	4.40 U	4.33 U	4.35 U	4.3 U	4.33 U	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	4.21 U	---	---
Perfluorotetradecanoic Acid (PFTeDa)	4.30 U	4.40 U	4.33 U	4.35 U	4.3 U	4.33 U	4.39 U	4.30 U	4.54 U	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	4.21 U	---	---
N-Ethyl Perfluorooctane Sulfonamide (EtFOSA)	21.5 U	22.0 U	21.7 U	21.8 U	21.5 U	21.6 U	21.9 U	21.5 U	22.7 U	21.3 U	21.2 U	21.3 U	21.9 U	21.9 U	21.2 U	21.1 U	---	---
Perfluorogexadecanoic Acid (PFHxDA)	4.30 U	4.40 U	4.33 U	4.35 U	4.3 U	4.33 U	4.39 U	4.30 U	4.54 UJ	4.26 U	4.25 U	4.26 U	4.37 U	4.38 U	4.24 U	4.21 U	---	---
N-Methyl Perfluorooctanesulfonamido Ethanol (MeFOSE)	21.5 U	22.0 U	21.7 U	21.8 U	21.5 U	21.6 U	21.9 U	21.5 U	22.7 U	21.3 U	21.2 U	21.3 U	21.9 U	21.9 U	21.2 U	21.1 U	---	---
N-Ethyl Perfluorooctanesulfonamido Ethanol (EtFOSE)	21.5 U	22.0 U	21.7 U	21.8 U	21.5 U	21.6 U	21.9 U	21.5 U	22.7 U	21.3 U	21.2 U	21.3 U	21.9 U	21.9 U	21.2 U	21.1 U	---	---
Combination of PFOA and PFOS	10.1	13.8	11.2	13.4	**221**	**183.1**	ND	1.15 J	ND	9.36	ND	ND	ND	5.42	ND	3.02 J	2	---
FIELD PARAMETERS																		
Dissolved Oxygen (mg/l)	0.7	N/A	1.1	1.5	1.5	1.5	1.7	0.9	3.0	1.6	5.3	1.9	0.6	1.9	1.4	1.7	---	---
Oxidation Reduction Potential (mV)	-163	N/A	-121	-133	-103	-133	-68	73	-22	87	146	149	-71	-72	-87	-149	---	---
pH (standard units)	12.1	N/A	11.9	12.2	7.5	7.4	10.5	10.2	10.5	10.6	6.3	6.4	9.8	10.6	12.7	12.7	---	---
Specific Conductance (us/cm)	717	N/A	1,373	1,295	941	985	467	432	443	463	98	122	239	252	5,267	3,537	---	---
Temperature (degrees Celcius)	12	N/A	10	14	11	16	10	13	8	13	9	13	9	13	10	13	---	---
Turbidity (NTU)	<5	N/A	< 5	<5	< 5	<5	< 5	11	< 5	<5	9	65	< 5	<5	<5	<5	---	---

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Table 4.1A
Summary of 2020 Groundwater Analytical Data

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

NOTES

1.	**Bolded values** denote concentration exceeding the USEPA Cleanup Level (CL).
2.	Shaded values denote concentration exceeding the NHDES Ambient Groundwater Quality Standard (AGQS).
3.	The list of volatile organic compounds (VOCs) provided includes analytes detected in OU-1 or OU-2 since 2006, and all VOCs that have ICLs. ICLs were established for 1,2-dichloropropane and tetrachloroethylene (PCE), however, no detections have been reported at groundwater sampling points included in the long-term monitoring events since 1998. An ICL was established for trans-1,2-dichloroethene, however, no detections have been reported at groundwater sampling points included in the long-term monitoring events since 1999.
4.	An ICL was established for the semi-volatile organic compounds (SVOCs) diethyl phthalate and phenol. However, in May 1998 and April 1999, groundwater samples were submitted for analysis of SVOCs and no exceedances were reported; therefore, SVOCs were removed from the long-term monitoring plan.
5.	Result for groundwater primary/duplicate samples are provided in this table: MW-4/MW-4-DUP, AE-3A/AE-3A-DUP, GZ-105/GZ-105-DUP, and MW-20D1/MW-20D1-DUP.
6.	The NHDES AGQS was lowered to 0.005 mg/L on July 1, 2021. Exceedances have been highlighted retroactive to this date.

ABBREVIATIONS

N/A	Sample was not analyzed/measured for indicated parameter
J	Estimated concentration
J+	Estimated high
J-	Estimated low
R	Data rejected
#.## U	Not Detected at the reporting detection limit indicated
UJ	Undetected estimated
NHDES AGQS	NH Department of Environmental Services Ambient Groundwater Quality Standard (Env-Or-600, Table 600-1)
USEPA CL	US Environmental Protection Agency Cleanup Level established in 2015 Fifth Explanation of Significant Difference. Cleanup
uS/cm	microsiemens per centimeter
ug/L	micrograms per liter, parts per billion
mg/L	milligram per liter, parts per million
ng/L	nanograms per liter, parts per trillion
NTU	nephelometric turbidity unit
mV	millivolt
*	Field parameter result qualified due to failed QA/QC or suspected issues with measurements, as noted on field forms and
^	The AGQS for xylenes is for total xylene or the sum of all isomers, including: m&p-Xylene and o-Xylene.
<#	Less than # indicated.
1	Monitoring well resampled for PFAS on June 9 through 11, 2020 due to the initial sample arriving at the lab outside of the required
2	NHDES Ambient Groundwater Quality Standards effective July 1, 2021.

Table 4.1B
1,4-Dioxane (Low Level Method) in Private Water Supply Wells

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Well ID / Appox. Date Sampled	May-16	May-17	Sep-17	Apr-18	Sep-18	May-19	Oct-19	May-20	Oct-20	May-21	Oct-21	Fall 2021 Resample
Private Water Supply Wells												
339 BHR	0.51	0.35	0.54	0.25 U	0.56	0.39	0.385 J-	0.28	0.57	0.41	0.35	---
346 BHR	0.25 U	0.25 U	0.25 U	0.25 U	0.2 U	0.2 U	0.144 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
415 BHR	0.25 U	0.25 U	0.25 U	0.25 U	0.2 U	0.2 U	0.142 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
R-3	0.3/0.34	0.33/0.34	0.28/0.32	0.25 U/0.25 U	0.39/0.35	0.24/0.25	0.267 J-/0.377 J-	0.26/0.21	0.5/0.48	0.33/0.35	0.42 J/0.42	---
R-5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.2 U	---
67 RCD	0.25 U	0.25 U	0.25 U	0.25 U	0.2 U	NS	NS	NS	NS	NS	NS	---
4 SMW	0.25 U	0.25 U	0.25 U	0.25 U	0.2 U	0.2 U	0.144 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
9 SMW	0.25 U	0.25 U	0.25 U	0.25 U	0.2 U	0.2 U	0.147 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
10 SMW	0.25 U	0.25 U	0.25 U	0.25 U	0.2 U	0.2 U	0.139 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
16 SMW	0.25 U	0.25 U	0.25 U	0.25 U	0.2 U	0.2 U	0.139 UR	NS	NS	0.2 U	0.2 U	---
19 SMW	0.25 U	0.25 U	0.25 U	0.25 U	0.2 U	0.2 U	0.136 UR	0.2 U	0.2 U	0.2 U	0.2 UJ	---
21 SMW	0.25 U	0.25 U	0.25 U	0.25 U	0.2 U	0.2 U	0.136 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
4 ROD	0.25 U	0.25 U	0.25 U	0.25 U	0.2 U	0.2 U	0.132 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
10 ROD	0.25 U	0.25 U	0.25 U	0.25 U	0.2 U	0.2 U	0.136 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
25 FW	0.25 U	0.25 U	0.25 U	0.25 U	0.2 U	0.2 U	0.144 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
5 BFL	NS	NS	0.25 U	0.25 U	0.2 U	0.2 U	0.147 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
9 BFL	NS	0.25 U	0.25 U	0.25 U	0.2 U	0.2 U	0.132 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
15 BFL	NS	0.25 U	0.25 U	0.25 U	0.2 U	0.2 U	0.139 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
340 BHR	NS	0.25 U	0.25 U	0.25 U	0.2 U	0.2 U	0.129 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
463 BHR	NS	0.25 U	0.25 U	0.25 U	0.2 U	0.2 U	0.136 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
7 WKD	NS	NS	0.25 U	0.25 U	0.2 U	0.2 U	0.147 UR	NS	0.2 U	0.2 U	0.2 U	---
8 WKD	NS	NS	0.25 U	0.25 U	0.2 U	0.2 U	0.132 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
27 BR	NS	NS	0.25 U	0.25 U	0.2 U	NS	NS	0.2 U	0.2 U	0.2 U	NS	---
178A LR	NS	NS	0.29	0.25 U	0.21	0	0.182 J-	0.2 U	0.21	0.2 U	0.37	0.28
67 NR	NS	NS	NS	NS	0.2 U	0.22	0.153 UR	0.2 U	0.2 U	0.2 U	0.2 U	---
14 PWC	NS	NS	NS	NS	NS	NS	0.136 UR	0.2 U	0.2 U	NS	0.2 UJ	---

Table Notes:

1. All data in micrograms per liter (ug/L), parts per billion - Analysis by Method 8260B SIM (a low level detection limit methodology
2. NHDES Ambient Groundwater Quality Standard (AGQS) for 1,4-dioxane is 0.32 ug/L. Exceedances are identified with GRAY shading
3. USEPA Cleanup Level (CL) for 1,4-dioxane is 3 ug/L.
4. Cells highlighted in yellow exceed one or more regulatory limit.

Abbreviations:

NS = Not Sampled; < ## = reported concentration is less than the detection limit (##)

J = estimated, J- = estimated low, J+ = estimated high, R = rejected, U = Undetected

Table 4.1B
PFOA in Private Water Supply Wells

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Well ID / Appox. Date Sampled	May-16	May-17	Sep-17	Apr-18	Sep-18	May-19	Oct-19	Dec-19	May-20	Oct-20	May-21	Oct-21	Fall 2021 Resample
Private Water Supply Wells													
339 BHR	25	17.8	13.5 J	23 J	20.7	14.2	15 J	NS	16.3	19.6	19.5	20.8	---
346 BHR	8 U	8 U	1.16 U	1.21 U	1.46 J	0.79 J	1.84 UJ	NS	1.56 J	0.984 J	4.23 U	1.47 J	---
415 BHR	8 U	8 U	1.2 U	1.62 J	2.15 J-	1.37 J	2.07 J	2.27	3.15 J	3.43 J	4.67 J	2.43	---
R-3	8 U	8 U	2.03 J/1.22 U	2.57 J/3.14 J	4.55/4.03 J	2.98 J/2.61 J	6.92 J/7.5 J	NS	4.32/4.58	9.04 J/12.3 J	5.20/6.23	7.3/7.3	---
R-5	NS	8 U	NS	NS	NS	NS	NS	NS	NS	NS	NS	30.3	15.7
67 RCD	NS	8 U	2.03 J/1.22 U	1.15 U	0.67 U	NS	NS	NS	NS	NS	NS	NS	---
4 SMW	8 U	8 U	4.57 J	2.29 J	2.08 J	3.51 J	4.16 J	3.74	5.87	2.84 J	3.23 J	3.83	---
9 SMW	8 U	8 U	1.29 U	2.39 J	2.32 J	0.90 J	2.56 J	NS	4.87	3.65 J	3.27 J	1.91	---
10 SMW	8 U	8 U	2.81 J	1.15 U	0.64 U	0.70 U	2.17 J	2.37	1.36 J	2.43 J	4.14 UJ	1.98	---
16 SMW	NS	8 U	1.17 U	2.92 J	1.52 J	0.76 U	1.84 UR	2.02 U	NS	2.14 J	4.20 UJ	1.13 J	---
19 SMW	8 U	8 U	1.77 J	1.17 U	0.65 U	0.68 U	1.23 J	NS	4.12 J	4.27 J	4.11 UJ	1.25 J	---
21 SMW	8 U	8 U	2.21 J/1.19 U	1.22 U/1.17 U	0.68 U/0.66 U	0.74 /0.7 U	1.54 UR/1.44 J	1.76 U/1.38 U	1.71J/1.54J	1.57 J/0.938 J	2.40 J/4.32 UJ	1.82 J/1.85	---
4 ROD	8 U	8 U	1.15 U	1.18 J	0.74 J	1.55 J	2.16	NS	4.13 J	8.1	4.45	2.39	---
10 ROD	8 U	8 U	2.34 J	2.3 J	0.68 U/0.66 U	0.95 J	1.86 J	NS	3.59 J	2.28 J	3.13 J	1.43 J	---
25 FW	8 U	8 U	3.06 J	2.11 J	1.06 J	1.72 J	2.57	NS	3.34 J	6.16	2.53 J	2.15	---
5 BFL	NS	8 U	1.2 U	1.15 U	NS	0.79 J	2.29 UJ	NS	1.86 J	1.01 J	4.26 UJ	1.65 J	---
9 BFL	NS	8 U	1.22 U	1.71 J	0.72 J	0.71 U	1.78	NS	4.09 J	2.04 J	4.44 UJ	1.62 J	---
15 BFL	8 U	8 U	1.18 U	1.15 U	0.66 U	0.77 U	0.534 J	NS	5.93	4.22 U	4.16 UJ	0.390 J	---
340 BHR	8 U	8 U	1.22 U	1.13 U	0.87 J	0.87 J	1.76 UJ	NS	2.70 J	1.36 J	4.23 U	0.388 J	---
463 BHR	8 U	8 U	1.18 U	1.21 J	2.15 J-	2.88 J	4.54 J	NS	6.46	7.1	4.01 J	3.29	---
7 WKD	NS	NS	6.06 J	9.68 J	9.01	6.34	7.34	NS	NS	10.8	10.8 J	8.7	---
8 WKD	NS	NS	1.21 U	1.16 U	0.90 J	0.87 J	1.84	NS	1.94 J	2.84 J	4.33 U	2.05	---
27 BR	NS	NS	2.75 J	4.54 J	7.9	NS	NS	NS	6.11	6.49	6.25	NS	---
178A LR	NS	NS	3.72 J	7.49 J	7.23	5.31	6.36 J	8.17	7.66	8.37	8.28	5.18	---
67 NR	NS	NS	NS	NS	0.66 U	0.69 U	0.69 J	NS	1.27 J	1.69 J	2.63 J	0.318 J	---
14 PWC	NS	NS	NS	NS	NS	NS	0.371 J	NS	3.06 J	2.56 J	NS	0.432 J	---

Table Notes:

1. All data in nanograms per liter (ng/L), parts per trillion - Analysis by Method 537 Modified
2. NHDES Ambient Groundwater Quality Standard (AGQS) for PFOA is 12 ng/L. Exceedances are identified with GRAY shading.
3. A USEPA Health Advisory (HA) for PFOA is 70 ng/L.
4. Residential results for July 2016 are reported in the May 2016 column and January 2017 results are reported in the May 2017 column. Method detection limits for the laboratory were 8 to 16 ng/L for the May 2016 and January 2017 sampling events while detection limits ranged from less than 1 to 5 ng/L during subsequent sampling events.
5. Cells highlighted in yellow exceed one or more regulatory limit.
6. USEPA has not designated PFOA as a Contaminant of Concern, however, data has been included on this table for informational purposes.

Abbreviations:

NS = Not Sampled; < ## = reported concentration is less than the detection limit (##)
J = estimated, J- = estimated low, J+ = estimated high, R = rejected, U = Undetected

Table 4.1B
PFHxS in Private Water Supply Wells

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Well ID / Appox. Date Sampled	May-16	May-17	Sep-17	Apr-18	Sep-18	May-19	Oct-19	Dec-19	May-20	Oct-20	May-21	Oct-21	Fall 2021 Resample
Private Water Supply Wells													
339 BHR	8 U	8 U	1.28 U	1.85 J	3.22 J	1.00 U	2.33 J	NS	1.53 J	2.57J	4.37 U	2.00	---
346 BHR	8 U	8 U	1.18 U	1.24 U	0.98 U	1.00 U	0.469 J	NS	4.28 U	4.42 U	4.23 U	0.453 J	---
415 BHR	8 U	8 U	1.66 J	3.14 J	4.03 J-	2.58 J	3.57 J	3.16	2.19J	3.01J	3.39J	3.18	---
R-3	8 U	8 U/8 U	1.23 U/1.24 U	1.21 U/1.17 U	1.62J/1.48J	1.31J/0.98 U	1.86J/2.31J	NS	4.32 U/4.37 U	1.71J/1.79J	4.22 U/4.28 U	1.78/1.77 J	---
R-5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	3.02	2.51
67 RCD	NS	8 U	1.23 U	1.17 U	0.97 U	NS	NS	NS	NS	NS	NS	NS	---
4 SMW	8 U	8 U	2.52 J	1.17 U	0.94 U	1.1 J	1.84 UR	0.915 J	1.40 J	1.95 J	2.42 J	0.802 J	---
9 SMW	8 U	8 U	1.31 U	3.58 J	3.97 J	2.95 J	3.59 J	NS	2.71 J	3.93 J	2.30 J	2.69	---
10 SMW	8 U	8 U	1.99 J	1.17 U	0.93 U	1.01 U	2.46 J	2.66	1.54 J	1.80 J	2.36 J	2.33	---
16 SMW	NS	8 U	1.19 U	1.18 U	0.98 U	1.10 U	1.84 UR	2.02 U	NS	<4.28	4.20 UJ	1.96 U	---
19 SMW	8 U	8 U	1.18 U	1.19 U	1.41 J	<0.99	1.14 J	NS	<4.46	1.20 J	4.11 UJ	1.44 J	---
21 SMW	8 U	8 U	1.20 U/1.21 U	1.24 U/1.19 U	1.33J/1.01J	1.07 U/1.02 U	0.938J/1.10J	1.02J/0.936J	4.37 U/4.33 UJ	4.32 U/4.20 U	4.22 UJ/4.32 UJ	1.09 J/1.24 J	---
4 ROD	8 U	8 U	1.68 J	2.56 J	0.98 U	1.95 J	1.79 J	NS	2.15 J	1.33 J	4.18 U	1.74 J	---
10 ROD	8 U	8 U	2.59 J	2.0 J	1.09 J	0.99 U	1.71 J	NS	1.46 J	1.38 J	4.29 UJ	1.45 J	---
25 FW	8 U	8 U	8 U	1.26 U	1.16 U	0.99 U	1.13 U	1.83 U	4.37 U/4.33 UJ	4.47 U	4.35 U	0.400 J	---
5 BFL	8 U	NS	1.23 U	1.17 U	NS	0.98 U	0.0986J	NS	4.41 U	4.5 U	4.26 UJ	1.09 J	---
9 BFL	NS	8 U	1.40 J	1.19 U	0.98 UJ	1.49 J	2.35	NS	1.76 J	4.61	4.44 UJ	2.27	---
15 BFL	8 U	8 U	1.20 U/1.21 U	1.24 J	2.23 J	1.12 U	1.98	NS	4.34 U	2.81J	4.16 UJ	1.58 J	---
340 BHR	8 U	8 U	1.24 U	1.15 U	0.98 J	0.98 J	1.76 UJ	NS	4.39 U	<4.18	4.23 U	1.85 U	---
463 BHR	11	8 U	7.17 J	7.8 J	7.15	4.79	7.78 J	NS	6.97	6.7	5.64 J	6.32	---
7 WKD	NS	NS	4.24 J	5.07 J	3.02 J	3.57 J	3.34	NS	NS	5.6	4.42 J	3.3	---
8 WKD	NS	NS	2.50 J	2.68 J	2.01 J	1.83 J	2.01	NS	1.16 J	1.80 J	2.58 JQ	2.34	---
27 BR	NS	NS	1.24 U	1.17 U	1.48 J	NS	NS	NS	4.28 U	1.14 J	4.33 U	NS	---
178A LR	NS	NS	1.21 U	2.2 J	2.21 J	1.69 J	1.64 J	1.63 J	4.46 UJ	4.47 U	4.27 U	1.53 J	---
67 NR	NS	NS	NS	NS	0.96 U	1.01 U	1.82 U	NS	4.33 U	4.27 U	4.28 U	1.80 U	---
14 PWC	NS	NS	NS	NS	NS	NS	1.78 UJ	NS	4.37 U	4.24 U	NS	1.83 U	---

Table Notes:

1. All data in nanograms per liter (ng/L), parts per trillion - Analysis by Method 537 Modified
2. NHDES Ambient Groundwater Quality Standard (AGQS) for PFHxS is 18 ng/L.
3. Residential results for July 2016 are reported in the May 2016 column and January 2017 results are reported in the May 2017 column. Method detection limits for the laboratory were 8 to 16 ng/L for the May 2016 and January 2017 sampling events while detection limits ranged from less than 1 to 5 ng/L during subsequent sampling events.
4. USEPA has not designated PFHxS as a Contaminant of Concern, however, data has been included on this table for informational purposes.

Abbreviations:

NS = Not Sampled; < ## = reported concentration is less than the detection limit (##)

J = estimated, J- = estimated low, J+ = estimated high, R = rejected, U = Undetected

Q = The ion transition ratio is outside the acceptable limits.

Table 4.1B
PFNA in Private Water Supply Wells

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Well ID / Appox. Date Sampled	May-16	May-17	Sep-17	Apr-18	Sep-18	May-19	Oct-19	Dec-19	May-20	Oct-20	May-21	Oct-21	Fall 2021 Resample
Private Water Supply Wells													
339 BHR	16 U	8 U	2.30 U	2.33 U	1.86 J	1.10 J	1.43 J	NS	4.47 U	1.08J	1.69 JQ	2.4	---
346 BHR	8 U	8 U	2.11 U	2.21 U	0.84 U	0.86 U	1.84 U	NS	4.28 U	4.42 U	4.23 U	1.87 U	---
415 BHR	8 U	8 U	2.19 U	2.1 U	0.84 UJ	0.85 U	1.80 UR	1.77 U	4.31 U	4.32 U	4.16 UJ	1.87 U	---
R-3	8 U	8 U/8 U	2.20 U/2.21 U	2.16 U/2.1 U	0.83U/0.81U	0.86U/0.84U	1.85UJ/1.80UJ	NS	4.32U/4.37U	4.33U/4.40U	4.22U/4.28U	1.78U/1.87U	---
R-5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	5.7	3.84
67 RCD	NS	8 U	2.19 U	2.09 U	0.83 U	NS	NS	NS	NS	NS	NS	NS	---
4 SMW	8 U	8 U	2.22 U	2.09 U	0.81 U	0.87 U	0.434 J	0.572 J	4.31 U	4.36 U	4.18 UJ	0.714 J	---
9 SMW	8 U	8 U	2.35 U	2.08 U	0.88 U	0.86 U	1.83 UJ	NS	4.22 U	4.37 U	4.13 U	1.85 U	---
10 SMW	8 U	8 U	2.16 U	2.1 U	0.80 U	0.87 U	1.81 UR	1.78 U	4.41 U	4.28 U	4.14 UJ	1.85 U	---
16 SMW	NS	8 U	2.13 U	2.11 U	0.84 U	0.94 U	1.84 UR	2.02 U	NS	4.28 U	4.20 UJ	1.96 U	---
19 SMW	8 U	8 U	2.10 U	2.12 U	0.81 U	0.85 U	1.82 UJ	NS	4.46 U	4.49 U	4.11 UJ	1.87 U	---
21 SMW	8 U	8 U	2.14U/2.16 U	2.2U2/2.13U	0.84U/0.83U	0.91U/0.88U	1.82UR/1.86UR	1.72U/1.99U	4.37U/4.33U	4.32U/4.20U	4.22 UJ/4.32 UJ	1.84U/1.83U	---
4 ROD	8 U	8 U	2.09 U	2.11 U	0.84 U	0.88 U	1.83 U	NS	4.18 U	4.34 U	U4.18	1.87 U	---
10 ROD	8 U	8 U	2.20 U/2.21 U	2.11 U	0.85 U	0.84 U	1.89 UJ	NS	4.57 U	4.48 U	4.29 UJ	1.82 U	---
25 FW	8 U	8 U	8 U	2.25 U	2.07 U	0.84 U	0.97 U	1.83 U	4.37 U	4.47 U	4.35 U	1.82 U	---
5 BFL	16 U	NS	2.19 U	2.09 U	NS	0.84 U	2.29 UJ	NS	4.41 U	4.50 U	4.26 UJ	1.77 U	---
9 BFL	NS	8 U	2.22 U	2.13 U	0.81 U	0.89 U	1.73 U	NS	4.36 U	4.25 U	4.44 UJ	1.83 U	---
15 BFL	16 U	8 U	2.14 U	2.1 U	0.82 U	0.96 U	1.78 U	NS	4.34 U	4.22 U	4.16 UJ	1.78 U	---
340 BHR	16 U	8 U	2.22 U	2.06 U	0.83 U	0.83 U	1.76 UJ	NS	4.39 U	4.18 U	4.23 U	1.85 U	---
463 BHR	16 U	8 U	2.15 U	2.15 U	0.81 U	0.85 U	1.78 UJ	NS	4.30 U	4.16 U	4.11 UJ	1.83 U	---
7 WKD	NS	NS	2.17 U	2.09 U	0.84 U	0.84 U	1.77 U	NS	NS	4.37 U	4.28 UJ	0.601 J	---
8 WKD	NS	NS	2.19 U	2.12 U	0.84 U	0.88 U	1.80 U	NS	4.56 U	4.37 U	4.33 U	1.78 U	---
27 BR	NS	NS	2.21 U	2.09 U	0.85 J	NS	NS	NS	4.28 U	4.47 U	4.33 U	NS	---
178A LR	NS	NS	2.16 U	2.12 U	0.79 U	0.82 U	0.507 J	0.467 J	4.46 U	4.47 U	4.27 U	1.84 U	---
67 NR	NS	NS	NS	NS	0.82 U	0.86 U	1.82 U	NS	4.33 U	4.27 U	4.28 U	1.80 U	---
14 PWC	NS	NS	NS	NS	NS	NS	1.78 UJ	NS	4.37 U	4.24 U	NS	1.83 U	---

Table Notes:

1. All data in nanograms per liter (ng/L), parts per trillion - Analysis by Method 537 Modified
2. NHDES Ambient Groundwater Quality Standard (AGQS) for PFNA is 11 ng/L.
3. Residential results for July 2016 are reported in the May 2016 column and January 2017 results are reported in the May 2017 column. Method detection limits for the laboratory were 8 to 16 ng/L for the May 2016 and January 2017 sampling events while detection limits ranged from less than 1 to 5 ng/L during subsequent sampling events.
4. USEPA has not designated PFNA as a Contaminant of Concern, however, data has been included on this table for informational purposes.

Abbreviations:

NS = Not Sampled; < ## = reported concentration is less than the detection limit (##)

J = estimated, J- = estimated low, J+ = estimated high, R = rejected, U = Undetected

Q = The ion transition ratio is outside the acceptable limits

Table 4.1B
PFOS in Private Water Supply Wells

Coakley Landfill Superfund Site
North Hampton and Greenland, New Hampshire

Well ID / Appox. Date Sampled	May-16	May-17	Sep-17	Apr-18	Sep-18	May-19	Oct-19	Dec-19	May-20	Oct-20	May-21	Oct-21	Fall 2021 Resample
Private Water Supply Wells													
339 BHR	8 U	8 U	1.15 U	3.58 J	1.90 J	0.86 U	1.57 J	NS	1.01 J	1.23 J	4.37 U	1.82 U	---
346 BHR	16 U	8 U	1.05 J	1.1 U	1.88 J	1.68 J	1.50 J	NS	1.04 J	1.97 J	4.23 U	1.70 U	---
415 BHR	16 U	8 U	1.09 U	1.05 U	0.84 UJ	0.85 U	1.80 UR	1.77 U	4.31 U	4.32 U	4.16 UJ	.87 U	---
R-3	16 U	8 U	1.1U/1.11U	1.08U/1.05U	0.94/0.83U	0.85U/1.11 J	1.56 J/1.75 J	NS	4.32U/4.37U	1.92 J/1.3 J	4.22U/4.28U	1.96 JB/1.96 JB	---
R-5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	6.58	4.10
67 RCD	NS	8 U	1.1 U	1.04 U	0.83 U	NS	NS	NS	NS	NS	NS	NS	---
4 SMW	16 U	8 U	1.87 J	1.21 J	0.8 U	0.87 U	0.665 J	1.84 U	4.31 U	4.36 U	4.18 UJ	0.478 U	---
9 SMW	16 U	8 U	1.17 U	1.04 U	0.88 U	0.85 U	1.83 UJ	NS	4.22 U	1.01 J	4.13 U	1.85 U	---
10 SMW	16 U	8 U	1.08 U	1.05 U	0.8 U	0.86 U	1.81 UR	1.78 U	4.41 U	4.28 U	4.14 UJ	1.14 U	---
16 SMW	NS	8 U	1.06 U	1.05 U	0.83 U	0.94 U	1.84 UR	2.02 U	NS	4.28 U	4.20 UJ	1.96 U	---
19 SMW	16 U	8 U	1.05 U	1.06 U	0.81 U	0.84 U	1.82 UJ	NS	4.46 U	4.49 U	4.11 UJ	1.87 U	---
21 SMW	16 U	8 U	1.07U/1.08U	1.11U/1.07U	0.84U/0.82U	0.91U/0.87U	1.82 UR/1.86 UR	1.72U/1.99U	4.37UJ/4.33J	4.32U/4.2U	4.22 UJ/4.32 UJ	1.84U/1.83U	---
4 ROD	16 U	8 U	1.05 U	1.05 U	0.83 U	0.87 U	1.33 J	NS	4.18 U	2.16 J	2.42 JQ	1.42 U	---
10 ROD	16 U	8 U	2.50 J	1.6 J	0.85 U	0.84 U	0.841 J	NS	4.57 U	4.48 U	4.29 UJ	0.818 U	---
25 FW	16 U	8 UJ	1.12 U	1.04 U	0.84 UJ	0.97 U	1.83 U	NS	4.37 U	8.08	4.35 U	1.82 U	---
5 BFL	NS	8 U	1.37 J	5.3 J	NS	4.43	4.12 J	NS	4.42	4.76	6.17 J	6.12	---
9 BFL	NS	8 U	4.69 J	1.06 U	1.76 J	3.88 J	7.64	NS	4.98	6.47	4.44 UJ	5.30	---
15 BFL	8 U	8 U	1.07 U	2.34 J	1.31 J	0.95 U	2.27	NS	0.895 J	1.09 J	4.16 UJ	1.89 JB	---
340 BHR	8 U	8 U	1.11 U	1.03 U	0.83 U	0.84 U	0.496 J	NS	4.39U	4.18 U	4.23 U	0.706 U	---
463 BHR	8.1	8 U	4.66 J	9.46 J	3.22	4.86	7.73 J	NS	6.17	5.92	6.33 J	6.01	---
7 WKD	NS	NS	3.62 J	6.9 J	5.73	5.8	4.96	NS	NS	6.13	6.13 J	5.81	---
8 WKD	NS	NS	1.1 U	1.06 U	0.83 U	0.88 U	0.996 J	NS	4.56 U	1.05 J	4.33 U	0.886 U	---
27 BR	NS	NS	6.11 J	5.17 J	1.09	NS	NS	NS	5.36	6.55	5.54 Q	NS	---
178A LR	NS	NS	1.14 J	5.19 J	3.46 J	1.63 J	2.86 U	2.51 U	2.31 J	3.76 J	2.42 J	2.13 JB	---
67 NR	NS	NS	NS	NS	0.82 U	0.86 U	0.766 J	NS	4.33 U	4.27 U	4.28 U	1.80U	---
14 PWC	NS	NS	NS	NS	NS	NS	0.650 J	NS	4.37 U	0.921 J	NS	1.83 U	---

Table Notes:

1. All data in nanograms per liter (ng/L), parts per trillion - Analysis by Method 537 Modified
2. NHDES Ambient Groundwater Quality Standard (AGQS) for PFOS is 15 ng/L.
3. A USEPA Health Advisory (70) for PFOS is 70 ng/L.
4. Residential results for July 2016 are reported in the May 2016 column and January 2017 results are reported in the May 2017 column. Method detection limits for the laboratory were 8 to 16 ng/L for the May 2016 and January 2017 sampling events while detection limits ranged from less than 1 to 5 ng/L during subsequent sampling events.
5. USEPA has not designated PFOS as a Contaminant of Concern, however, data has been included on this table for informational purposes.

Abbreviations:

NS = Not Sampled; < ## = reported concentration is less than the detection limit (##)

J = estimated, J- = estimated low, J+ = estimated high, R = rejected, U = Undetected

F= The ratio of quantifer response to qualifer ion response falls outside of the laboratory criteria. Results are considered to be an estimated maximum concentration.

Q = The ion transition ratio is outside the acceptable limits.

Table 4.2
Summary of Surface Water Analytical Data for 2020

Coakley Landfill Superfund Site
North Hampton Greenland, New Hampshire

SAMPLE IDENTIFICATION	NHDES Surface Water Standard		SW-4	SW-5	SW-5Dup	SW-103	SW-110	SW-111	SW-111	SW-LR	SW-LR	SW-LR Dup	SW-BB1	SW-BB2
DATE SAMPLED	Acute	Chronic	5/14/2020	5/14/2020	5/14/2020	5/14/2020	5/14/2020	5/15/2020	10/8/2020	5/14/2020	10/9/2020	10/9/2020	5/14/2020	5/15/2020
VOLATILE ORGANIC COMPOUNDS BY 8260B (ug/L)														
Acetone	---	---	10 U	10 R	10 U	10 U	10 U	10 U	Not analyzed	10 U	Not analyzed	Not analyzed	10 U	10 U
METALS BY 200.8 (mg/L)														
TOTAL OR DISSOLVED (METALS ONLY)			Dissolved	Dissolved	Dissolved	Dissolved	Dissolved	Dissolved	Dissolved	Dissolved	Dissolved	Dissolved	Dissolved	Dissolved
Aluminum	0.75	0.087	0.061	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.058	0.15	0.05 U	0.05 U	0.05 U	0.05 U
Antimony	9	1.6	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Arsenic*	0.34	0.15	0.001 U	0.0043	0.0046	0.001 U	0.001 U	0.001 U	0.0017	0.001 U	0.001 U	0.001 U	0.0017	0.001 U
Barium	---	---	0.0043	0.024	0.027	0.0077	0.0048	0.0066	0.022	0.0073	0.015	0.016	0.0094	0.0065
Beryllium	0.13	0.0053	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Cadmium*	0.00039	0.00021	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Calcium	---	---	9.9 J+	25 J+	29 J+	25 J+	15 J+	11 J+	25	14 J+	34	35	14 J+	21 J+
Chromium (Cr+3 + Cr+6)*	0.152 (Cr+3) 0.016 (Cr+6)	0.0198 (Cr+3) 0.011 (Cr+6)	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Cobalt	---	---	0.001 U	0.0017	0.002	0.001 U	0.001 U	0.001 U	0.0011	0.001 U	0.001 U	0.001 U	0.0015	0.001 U
Copper*	0.0029	0.0023	**0.013**	0.001 U	0.001 U	0.0011	0.001 U	0.0015	0.0021	0.001 U	0.001 U	0.001 U	0.001 U	0.0016
Iron	---	1	0.15	3.8	4.6	0.15	0.32	0.36	0.76	0.34	0.32	0.30	1.2	0.21
Lead*	0.0105	0.00041	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0014	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Magnesium	---	---	2.9	5.9	6.5	6.1	3.6	3.0	5.4	3.6	7.5	7.6	3.5	5.1
Manganese	---	---	0.061	0.93	1.1	0.019	0.13	0.14	0.95	0.079	0.20	0.21	0.40	0.068
Mercury*	0.0014	0.00077	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U
Nickel*	0.12	0.0133	0.0011	0.0029	0.003	0.0023	0.0014	0.0021	0.0016	0.0015	0.001 U	0.001 U	0.0015	0.0044
Potassium	---	---	1.5	6.8	6.7	6.8	2.1	1.8	8.3	1.4	4.0	4.2	2.2	2.8
Selenium	---	0.005	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Silver*	0.0002	---	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Sodium	---	---	9	19	18	16	19	26	130	23	42	42	20	21
Thallium	1.4	0.04	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Vanadium	---	---	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Zinc*	0.03	0.03	0.0095	0.005 U	0.005 U	0.005 U	0.0057	0.0067	0.0066	0.005 U	0.005 U	0.005 U	0.005 U	0.0072
1,4-Dioxane by 8260B SIM ug/L														
1,4-Dioxane	---	---	0.2	1.7	1.8	0.86	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
GENERAL CHEMISTRY														
Ammonia** (mg/L)	pH Dependent		0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
FIELD PARAMETERS														
Temperature (degrees C)	---	---	14	14	NA	13	10	14	13	12	12	NA	12	13
pH (Standard Units)	---	---	6.4	6.9	NA	6.9	6.8	6.6	6.8	7	6.9	NA	6.4	6.6
Specific Conductance (us/cm)	---	---	102	337	NA	249	204	220	971	242	532	NA	179	268
Dissolved Oxygen (mg/L)	---	---	6.7	<0.5	NA	1.2	7.5	6.8	3.3	10.4	3.6	NA	7	3.7
Turbidity (NTU)	---	---	< 5	30	NA	5	< 5	5	33	9	6	NA	6	<5
Oxidation Reduction Potential (mV)	---	---	176	-106	NA	110	46	92	98	77	137	NA	113	12

Table 4.2
Summary of Surface Water Analytical Data for 2020

Coakley Landfill Superfund Site
North Hampton Greenland, New Hampshire

SAMPLE IDENTIFICATION	USEPA Screening Levels		USEPA Screening Levels		SW-4	SW-5	SW-5Dup	SW-103	SW-110	SW-111	SW-111	SW-LR	SW-LR	SW-LR Dup	SW-BB1	SW-BB2
DATE SAMPLED	Adult Recreator	Child Recreator	Adult Recreator	Child Recreator	5/14/2020	5/14/2020	5/14/2020	5/14/2020	5/14/2020	5/15/2020	10/8/2020	5/14/2020	10/9/2020	10/9/2020	5/14/2020	5/15/2020
	EF = 45 Days		EF = 120 Days													
PERFLUORINATED CHEMICALS BY MODIFIED 537 - (ng/L)																
Perfluorobutanoic Acid (PFBA)	---	---	---	---	5.4	45.4	49.2	32.9	10.3	5.9	4.30 U	3.49 J	3.22 J	3.01 J	8.82	19
Perfluoropentanoic acid (PFpEA)	---	---	---	---	8.28	91.7	92.2	77.5	22.9	7.64	7.16	4.02 J	4.18 J	4.41	16.7	39.2
Perfluorobutanesulfonic acid (PFBS)	173,000	30,200	65,000	11,300	4.28 U	4.33	3.37 J	3.27 J	2.20 J	4.53 U	2.24 J	4.42 U	4.32	3.09 J	4.48 U	2.99 J
Perfluorohexanoix Acid (PFHxA)	---	---	---	---	19.5	155	135	108	28.4	11.7	6.34	4.92	4.95	4.63	24.5	51.5
Perfluoroheptanoic acid (PFHpA)	---	---	---	---	41.7	276 J	282	219	67.6	23.6	11.9	6.27	2.97 J	2.89 J	54.1	111
Perfluorohexanesulfonic acid (PFHxS)	7,640	1,750	2,860	654	7.23	10.6 J	14.9 J	11.2	5.64	1.57 J	4.30 U	1.20 J	1.70 J	2.41 J	5.66	8.78
1H, 1H, 2H, 2H-Perfluorooctanesulfonic Acid (6:2FTS)	---	---	---	---	4.28 U	4.63 U	4.52 U	4.67 U	4.74 U	4.53 U	4.30 U	4.42 U	4.20 U	4.29 U	4.48 U	4.46 U
Perfluorooctanoic acid (PFOA)	1,800	304	664	110	114	709 J	719	594	160	50.1	22.2 J	13.6	9.05 J	9.18 J	118	280
Perfluoroheptanesulfonic Acid (PFHpS)	---	---	---	---	1.67 J	6.94	8.14	7.53	2.11 J	4.53 U	4.30 U	4.42 U	4.20 U	4.29 U	1.90 J	2.47 J
Perfluorononanoic acid (PFNA)	1,080	260	406	96	39.6	424 J	427	399	81	21	8.36	3.21 J	1.76 J	1.48 J	69.2	162
Perfluorooctanesulfonamide (PFOSA)	---	---	---	---	8.76	4.63 U	7.86	4.67 U	24.2	15.6	10.3	17.4	32.8 J+	31.2	3.59 J	17.2
Perfluorooctanesulfonic (PFOS)	1,200	200	442	76	35.6	1,060 J	1,060	1,080	149	43.7	20.6	3.45 J	13.5	13.2	91.1	300
Perfluorodecanoic Acid (PFDA)	---	---	---	---	4.28 U	259 J	186 J	291	19.9	4.76	2.94 J	4.42 U	4.20 U	4.29 U	10.4	62.6
1H, 1H, 2H, 2H-Perfluorodecanesulfonic Acid (8:2FTS)	---	---	---	---	4.28 U	4.63 U	4.52 U	4.67 U	4.74 U	4.53 U	4.30 U	4.42 U	4.20 U	4.29 U	4.48 U	4.46 U
N-Methyl Perfluorooctanesulfonamidoacetic Acid (MeFOSAA)	---	---	---	---	4.28 U	4.63 U	4.52 U	4.67 U	4.74 U	4.53 U	4.30 U	4.42 U	4.20 U	4.29 U	4.48 U	4.46 U
N-Ethyl Perfluorooctanesulfonamidoacetic (EtFOSAA)	---	---	---	---	4.28 U	4.63 U	4.52 U	4.67 U	4.74 U	4.53 U	4.30 U	4.42 U	4.20 U	4.29 U	4.48 U	4.46 U
Perfluoroundecanoic Acid (PFUnA)	---	---	---	---	4.28 U	20.1 J	7.94 J	26.7	4.74 U	4.53 U	4.30 U	4.42 U	4.20 U	4.29 U	4.48 U	4.46 U
Perfluorodecanesulfonic Acid (PFDS)	---	---	---	---	4.28 U	4.63 U	4.52 U	4.67 U	4.74 U	4.53 U	4.30 U	4.42 U	4.20 U	4.29 U	4.48 U	4.46 U
Perfluorododecanoic Acid (PFDoA)	---	---	---	---	4.28 U	4.63 U	4.52 U	4.67 U	4.74 U	4.53 U	4.30 U	4.42 U	4.20 U	4.29 U	4.48 U	4.46 U
N-Methyl Perfluorooctane Sulfonamide (MeFOSA)	---	---	---	---	21.4 R	23.1 U	22.6 UJ	23.3 U	23.7 U	22.1 UJ	21.5 U	19.6 UJ	21.0 U	21.4 U	22.4 U	22.3 U
Perfluorotrodecanoic Acid (PFTrDA)	---	---	---	---	4.28 U	4.63 U	4.52 U	4.67 U	4.74 U	4.53 U	4.30 U	4.42 U	4.20 U	4.29 U	4.48 U	4.46 U
Perfluorotetradecanoic Acid (PFTeDa)	---	---	---	---	4.28 U	4.63 U	4.52 U	4.67 U	4.74 U	4.53 U	4.30 U	4.42 U	4.20 U	4.29 U	4.48 U	4.46 U
N-Ethyl Perfluorooctane Sulfonamide (EtFOSA)	---	---	---	---	21.4 R	23.1 U	22.6 U	23.3 U	23.7 U	22.1 UJ	21.5 U	19.6 UJ	21.0 U	21.4 U	22.4 U	22.3 U
Perfluorogexadecanoic Acid (PFHxDA)	---	---	---	---	4.28 U	4.63 U	4.52 U	4.67 U	4.74 U	4.53 U	4.30 U	4.42 U	4.20 U	4.29 U	4.48 U	4.46 U
N-Methyl Perfluorooctanesulfonamido Ethanol (MeFOSE)	---	---	---	---	21.4 U	23.1 U	22.6 U	23.3 U	23.7 U	22.7 U	21.5 U	22.1 U	21.0 U	21.4 U	22.4 U	22.3 U
N-Ethyl Perfluorooctanesulfonamido Ethanol (EtFOSE)	---	---	---	---	28.6	23.1 U	22.6 U	23.3 U	23.7 U	22.7 U	21.5 U	22.1 U	21.0 U	21.4 U	22.4 U	22.3 U
Combination of PFOA and PFOS	---	---	---	---	149.6	1,769 J	1,779	1,674	309	93.8	42.8	17.05 J	22.55	22.38	209.1	580

NOTES:

1.	VOCs list is limited to analytes detected in samples
2.	--- no standard has been established for the indicated parameter.
3.	NHDES Surface Water Standards are listed in Env Wq 1700, Table 1703.1
4.	There are no ROD ICLs established for surface water.
5.	Highlighting: Bold values denote NHDES Acute Surface Water Criteria Exceedances; Gray shaded values denote NHDES Chronic Criteria Exceedances. Blue shaded values denote USEPA Screening Level Child Recreator Exceedances, EF = 120 days based on September 1, 2022 site-specific SLs.
6.	The reporting detection limit (RDL) for zinc, silver and lead are consistent with RDLs specified in the SAP; however, they exceed the "default" (see footnote *) acute and/or chronic standards.
7.	Perfluorinated chemicals were re-extracted beyond the 14-day holding time limit (27 days) due to method blank contamination. The results from the reextracted sample (SW-110) was used in the decision making.
*	Acute and chronic standards based on "default" values listed in Env Wq 1700, Table 1703.1. Actual standards may vary based
**	The freshwater and saltwater aquatic life criteria for ammonia are pH dependent. Refer to Env-Wq 1703.25 through Env-Wq 1703.31.
J	Concentration detected is below the reporting limit/LOQ.
R	Data rejected
#.## U	Not detetced at the reporting limit.
UJ	Undetcted estimated
uS/cm	microsiemens per centimeter
ug/L	micrograms per liter, parts per billion
mg/L	milligram per liter, parts per million
ng/L	nanograms per liter, parts per trillion
NTU	nephelometric turbidity unit
mV	millivolt
EF	Effective Days
< #	Less than number indicated

Table 4.3
Surface Water Quality Results by Contaminant
Manganese

Coakley Landfill Superfund Site.
North Hampton and Greenland, New Hampshire

Manganese Analytical																				
Location / Appox. Date	8/26/2004	8/25/2005	8/1/2006	8/30/2006	11/1/2007	11/15/2007	8/14/2008	8/19/2009	8/19/2011	10/14/2014	9/16/2015	6/1/2016	4/1/2017	9/21/2017	4/27/2018	9/27/2018	5/10/2019	10/9/2019	5/1/2020	10/2/2020
Surface Water Samples																				
Total or Dissolved	Total	Total	Total	Dissolved	Total	Dissolved	Total	Total	Total	Dissolved	Dissolved	Dissolved	Dissolved	Dissolved	Dissolved	Dissolved	Dissolved	Dissolved	Dissolved	Dissolved
SW-4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.054	0.82	0.012	0.14	0.24	NS	0.061	NS
SW-5	200	6	3	2.6	1	2	1	2	2.1	0.35	0.26	0.68/0.71	0.22/0.22	3.0/3.0	0.32/0.32	0.36/0.36	0.59/0.56	NS	0.93/1.1	NS
SW-103	NS	NS	NS	1.6	1.4	1.6	0.59	3.3	0.4	NS	0.6	0.7	0.022	4.6	0.027	0.61	0.009	0.21	0.019	NS
SW-110	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.048	0.57	0.075	0.43	0.13	0.19/0.19	0.13	NS
SW-111	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.04	2	0.56	0.029	0.099	0.84	0.14	0.95
SW-LR	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.03	0.085	0.04	0.06	0.053	0.17	0.079	0.2/0.21
SW-BB1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.23	1.3	0.35	1	0.51	NS	0.4	NS
SW-BB2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.029	0.64	0.039	0.19	0.11	NS	0.068	NS

Table Notes:
1. All data in milligrams per liter (mg/L), parts per million - Analyzed by Method 200.8

Abbreviations:
NA = Not Analyzed; NS = Not Sampled; INT = Interval Sampled; < ## = reported concentration is less than the detection limit (##)

Table 4.3
Surface Water Quality Results by Contaminant 1,4-Dioxane (Low Level Method)

Coakley Landfill Superfund Site.
North Hampton and Greenland, New Hampshire

1,4-Dioxane Analytical								
Location / Appox. Date Sampled	5/17/2017	9/21/2017	4/27/2018	9/27/2018	5/10/2019	10/9/2019	5/1/2020	10/2/2020
Surface Water Samples								
SW-4	0.25 U	0.25 U	0.25	0.2 U	0.92	NS	0.2	NS
SW-5	0.59	2	1.1	0.81	0.87	NS	1.7/1.8	NS
SW-103	1.3	1.3	0.71	0.38	1.2	0.144 UJ	0.86	NS
SW-110	0.25 U	0.25 U	0.25 UJ	0.2 U	0.28	0.144 UJ	0.2 U	NS
SW-111	0.25 U	0.25 U	0.25 UJ	0.2 U	0.2 U	0.142 UJ	0.2 U	0.2U
SW-LR	0.25 U	0.25 U	0.25 UJ	0.2 U	0.2 U	0.144 UJ	0.2 U	0.2U
SW-BB1	0.25 U	0.25 U	0.25 UJ	0.2 U	0.2 U	NS	0.2 U	NS
SW-BB2	0.25 U	0.25 U	0.25 UJ	0.22	0.28	NS	0.2 U	NS

Table Notes:
1. All data in micrograms per liter (ug/L), parts per billion - Analysis by Method 8260B SIM (a low level detection limit methodology)

Abbreviations:

NA = Not Analyzed; NS = Not Sampled; INT = Interval Sampled; < ## = reported concentration is less than the detection limit (##)

Table 4.3
Surface Water Quality Results by Contaminant
PFOA

Coakley Landfill Superfund Site.
North Hampton and Greenland, New Hampshire

Perfluorooctanoic acid (PFOA) Analytical								
Location / Appox. Date Sampled	5/1/2017	9/21/2017	4/27/2018	9/27/2018	5/10/2019	10/9/2019	5/1/2020	10/2/2020
Surface Water Samples								
SW-4	129	145	282	176	146	NS	114	NS
SW-5	794 J	648	786 J-	945	611 J	NS	709	NS
SW-103	763 J-	675	654	740	558	217	594	NS
SW-110	198 J-	88.6	87.9	76.4	112	102 J	160	NS
SW-111	57	26.6	24	23.1	44.9	2.51	50.1	22.2J
SW-LR	11.4 J	18.1 J	21.2 J	25	18.5	10.1	13.6	9.05J
SW-BB1	178	108	103	77.3	63.2	NS	118	NS
SW-BB2	293	213	335	221	226	NS	280	NS

Table Notes:
All data in nanograms per liter (ng/L), parts per trillion - Analysis by Method 537 Modified
USEPA Screening Level - Child Recreator 120 Days EF for PFOS is 76 ng/L (September 1, 2022 Site-Secific Screening Levels).
Exceedances are identified with grey shading.
Abbreviations:
NA = Not Analyzed; NS = Not Sampled; INT = Interval Sampled; < ## = reported concentration is less than the detection limit (##)

Table 4.3
Surface Water Quality Results by Contaminant
PFOS

Coakley Landfill Superfund Site.
North Hampton and Greenland, New Hampshire

Perfluorooctanesulfonic (PFOS) Analytical								
Location / Appox. Date Sampled	5/1/2017	9/21/2017	4/27/2018	9/27/2018	5/10/2019	10/9/2019	5/1/2020	10/2/2020
Surface Water Samples								
SW-4	36.2	42.1	50.8	50.7	80.5	NS	35.6	NS
SW-5	391 DJ	1120	654 J	870	815	NS	1060 J	NS
SW-103	758	993	577	701	967	407	1080	NS
SW-110	77.1	68.2	61.6	60.9	108	91.9 J	149	NS
SW-111	25.5	23.9	12.1 J	7.77	36.7	20.7	43.7	20.6
SW-LR	5.57 J	9.79 J	5.41 J	5.92	3.63 J	8.32	3.45 J	13.5
SW-BB1	88.1	80.1	87.2	69.7	56.7	NS	91.1	NS
SW-BB2	176	205	270	162	223	NS	300	NS

Table Notes:
All data in nanograms per liter (ng/L), parts per trillion - Analysis by Method 537 Modified

USEPA Screening Level - Child Recreator 120 Days EF for PFOS is 76 ng/L (September 1, 2022 Site-Secific Screening Levels).
Exceedances are identified with grey shading.

Abbreviations:

NA = Not Analyzed; NS = Not Sampled; INT = Interval Sampled; < ## = reported concentration is less than the detection limit (##)

Table 4.3
Surface Water Quality Results by Contaminant
PFOA and PFOS Combined

Coakley Landfill Superfund Site.
North Hampton and Greenland, New Hampshire

PFOA and PFOS Combined								
Location / Appox. Date Sampled	May-17	Sep-17	Apr-18	Sep-18	May-19	Oct-19	May-20	Oct-20
Surface Water Samples								
SW-4	165.2	187.1	332.8	226.7	226.5	NS	149.6	NS
SW-5	1185 DJ	1768	1440 JJ-	1815	1426 J	NS	1769 J	NS
SW-103	1521	1668	1231	1441	1525	624	1674	NS
SW-110	275.1	156.8	149.5	137.3	220 J	193.9 J	309	NS
SW-111	82.5	50.5	36.1 J	30.87	81.6	90	93.8	42.8
SW-LR	16.97	27.89	26.61 J	30.92	22.13 J	18.42	17.05 J	22.55
SW-BB1	266.1	188.1	190.2	147	119.9	NS	209.1	NS
SW-BB2	469	418	605	383	449	NS	580	NS

Table Notes:
1. All data in nanograms per liter (ng/L), parts per trillion - Analysis by Method 537 Modified

Abbreviations:

NA = Not Analyzed; NS = Not Sampled; INT = Interval Sampled; < ## = reported concentration is less than the detection limit (##)

J = estimated, D = diluted, J- = estimated low