Review of 2018 Bedrock Investigation Documents for the Coakley Landfill

Thomas P. Ballestero

6 June 2018

The following documents were reviewed to assess whether the EPA letter of May 1, 2018 requires something more by way of bedrock investigation in order to detect flow of contaminants from the Coakley Landfill going to the south or the east, than is being proposed by the Coakley Landfill Group's Expert (CES), and if EPA's letter does not require something more, an opinion is offered on why should EPA so require.

- 9 January 2018 EPA/NHDES Coakley Landfill Update
- 21 March 2018 CES DRAFT Deep Bedrock Investigation Workplan
- 30 March 2018 CLG Meeting Summary on the DRAFT Deep Bedrock Investigation Workplan
- 1 May 2018 EPA response letter to the Coakley Landfill Superfund Site Draft Deep Bedrock Investigation Work Plan.

In reviewing these documents, the initial opinions articulated in my 1 December 2017 report entitled, Town of Hampton Concerns Regarding Future efforts at the Coakley Landfill, remain largely unchanged. Found in Table 1 herein are excerpts from each of these documents along with some of my comments (in red). As a summary, CLG and its contractor (CES) believe that any landfill plume flow to the east and south are either miniscule and pose no risk (to the east, population served by potable water) or non-existent (to the south). The primary focus of the CLG deep bedrock investigation appears to be the Groundwater Management Zone (GMZ) to the north along Berry's Brook (Figure 8 of the Draft Deep Bedrock Investigation Plan).

The CES Draft Deep Bedrock Investigation Workplan reviews and presents much of the historic geologic data from the RI, FS, MOM, and subsequent documents. There does seem to be a dramatic difference in the overburden groundwater potentiometric map between the CES and RI documents (Figures 2 and 3 herein, respectively). The CES map (Figure 2) shows groundwater contours that line-up almost north south and decrease in elevation towards the west, whereas the RI contours show more circular contours indicating radial flow away from the landfill. Groundwater flows perpendicular to these contours. It is easy to see why CES then concludes that groundwater flows to the west, and although not specifically mentioned, their flow net implies that all groundwater discharges to either Berry's Brook or the Little River. Unfortunately the field data does not bear this out (Table 2 here), and therefore the overburden piezometric map is in error. Table 2 presents data from the DRAFT 2017 ANNUAL SUMMARY REPORT for COAKLEY LANDFILL. The three wells (FPC 3, 8, and 6) have multi-level completions from the surface to the bedrock. For well triplet FPC-3, the shallowest screen is FPC-3B, then FPC-3A, then FPC-3C in the bedrock. This well triplet water level data exhibits an upwards vertical hydraulic gradient, however, the shallowest well screen water level is below the ground surface, and therefore at this location groundwater is not discharging to surface water. The same is true for the FPC-6 wells but not the FPC-8 wells, however both of the FPC-8 well screens are completed below the hydraulically limiting marine deposits (Figure 5 of the Draft Deep Bedrock Investigation Plan). Given the recognized hydraulic limit of the marine deposits, it is most likely that any westward moving bedrock groundwater will turn south or north following the streams as well as along recognized bedrock fractures/strike. This in turn leads to misinterpretation of bedrock hydraulics as represented by the bedrock groundwater potentiometric map, Figure 4 here, found not in the Draft Deep Bedrock Investigation Workplan but rather the 2017 Annual Summary Report for Coakley Landfill. Specifically, there should be a saddle in the groundwater contours between the 75-ft and 72-ft contours of the bedrock groundwater potentiometric map, and this saddle would indicate southerly flow of the plume. Figure 5 here is a generic depiction of groundwater flow in the seacoast from the USGS modeling study. Local streams like the Little River and Berry's Brook may drain some of the groundwater flow, but not necessarily all of it, especially the deeper water that was driven into the system at local high spots, like the Coakley Landfill. Additionally for this same bedrock contour map, well BP-4 water level versus those water levels in wells to the east contradict the drawn groundwater contours: the data implies eastward flow from the landfill. The figure as drawn does not.

The 30 March 2018 meeting minutes basically reinforce the CLG intent to study north and west of the former landfill.

The EPA response letter indicates the need to better understand bedrock groundwater in general. EPA questioned the apparent CLG indifference of the eastward plume. However in neither of these two issues does EPA require new wells or investigation in the east or south directions.

Therefore the EPA is not at this time requiring further deep bedrock investigations east or south. They have questioned the interpretation of data and they have left the door open for such investigations should future data warrant it.

Figures 6 and 7 here, taken from the CES 2017 Annual Summary Report, succinctly illustrate the differences between overburden and shallow bedrock plumes for PFOA and PFOS, with the bedrock plume demonstrating that it moved west then turned south. I commented on this exact issue at the public meeting in North Hampton last November, especially the westward/southward plume movement.

Figure 8 presents the relative locations of the Coakley landfill to some domestic water wells. The CLG seems to have focused some attention on Falls Way, which according to their own conceptual hydrogeologic model, should be out of harm's way. However, given the broader concerns of public health and groundwater supply, concern for further bedrock groundwater investigations should be directed at both the Aquarion Water Company Winnicut well field to the west (shown in Figure 8 here) as well as the Woodknoll Drive subdivision in which PFOA and PFOS have been detected in homeowner wells. Given the: decades that have transpired, the bedrock plume trajectory, the intricate movement of groundwater through fractured rock systems, the very high water solubility for PFOA/PFOS, the limited degradation of PFOA/PFOS, and the regional conceptual hydrogeologic model… it is certainly plausible that the Woodknoll subdivision is a location where the Coakley plume has moved. Furthermore, when reflecting on Aquarion's wellhead protection area map (Figure 9 here) for its Mill Road well field in Hampton, the Woodknoll Drive subdivision is within this wellhead protection area.

By focusing this most recent emphasis to understand only groundwater movement to the northwest and only in the GMZ while ignoring the plume that has migrated well past it, the CLG will not be able to determine far field issues associated with the landfill.

Figure 7 here displays the bedrock groundwater PFOS/PFOA contours. The contours stop at 70 ng/L, but concentrations of concern are further eastward. If a 20 ng/L contour were to be drawn, it would give a much more realistic understanding of plume extent and movement.

The following data that has been made available demonstrates plume movement to the south and west: Well piezometric data, Well water quality results, and Geologic data. EPA has not required further investigations in these directions, but has left the door open. Instead of waiting for more private wells to the south to exhibit contamination as well as ignoring the contamination moving to the east, four multi-level well installations have been identified in Figure 1 here: orange stars to the south and green stars to the east. The water level and water quality information from these wells should be able to further clarify the conceptual hydrogeologic model. In addition, a streambed piezometer survey should be performed from the headwaters of the Little River southward to North Road to validate whether the presumed groundwater discharge in fact occurs.

Table 1. Excerpts of reviewed documents and documents (quotes) and comments (red)

Date	Title	Comment
21 March 2018	Draft Deep Bedrock Investigation Workplan	"…EPA stated long-term uncertainty remained with respect to potential migration of contaminants in deeper portions of bedrock at the Site." "Data collected during the RI (prior to remedy selection) identified significant water quality impacts to the west of the Site and lesser impacts to the east and south." "Groundwater elevation and water quality data collected as part of ongoing long-term monitoring indicate groundwater flow to the west from the landfill after the completion of waste

		consolidation and capping." "The RI also identified that the headwaters of Berry's Brook and Little River are sourced in a wetland complex immediately west of the landfill. The watershed boundary between Little River and Berry's Brook is underlain by a slight bedrock high with bedrock troughs located to the north and south coincident with the Little River and Berry's Brook valley." "These photolinears also have a similar orientation to segments of Berry's Brook and Little River that are present between North Road and Breakfast Hill Road." "Overall, the most prominent photolinear orientations observed around the site are northeast and southwest which correlates to the regional foliation patterns and fabric-controlled joints described in the BCI reports in the Weston RI Appendix (Weston, 1988) and the orientation of the bedrock valley west of the landfill observed during drilling and surface geophysics." "In general, horizontal groundwater flow at the Coakley Site follows the local topography where groundwater elevation highs and lows coincide with land surface highs and lows." Current groundwater elevation measurements support predominately westward flow away from the landfill toward a prominent northeast-southwest trending valley at the headwaters of Little River (to the south) and Berry's Brook (to the north). "The marine clay layer is expected to have a significantly lower permeability than other overburden units and, in many places, forms an aquitard that hydraulically isolates the uppermost outwash layers from the lower till unit,…" Would this not only prevent bedrock groundwater from discharging to the surface, but also allow the contamination in the bedrock below the landfill to then flow great distances until the marine unit no longer existed? "Water quality data in monitoring wells east of the landfill indicated landfill related impacts were present, albeit at relatively minor concentrations compared to water quality data from monitoring wells located west of the landfill." "Refuse located near the topographic high was pulled westward into the current landfill footprint and perimeter ditches were installed to convey stormwater runoff to stormwater basins (ponds) located west of the topographic high."

		"Water quality data collected from GZ-117 along with water quality data from other overburden monitoring wells east of the landfill show minor water quality impacts, well below regulatory standards and advisories." "Monitoring wells in and near groundwater discharge areas (FPC-2, -3, -5, -7, and -8) exhibit water levels at or above ground surface and where well couplets exist, an upward vertical gradient within overburden units." Many of these have the marine unit present. "Groundwater elevation contour maps have been prepared annually and included in Annual Monitoring reports for the Site." These need to be produced for inspection. "However, following capping of the landfill and routing of stormwater to the northwest of the landfill, bedrock groundwater elevations have shown a westward flow direction from immediately east of the landfill toward the bedrock valley under Berry's Brook and Little River." "• Groundwater elevations in bedrock wells support flow to the west from under the landfill. Groundwater flowing west of the landfill encounters a flow divide located in the broad topographic saddle to the west of the landfill, which results in the bifurcation of groundwater flow into two distinct flow pathways along a prominent northeast/southwest trending valley. • The northeastern flow pathway is situated within the watershed of Berry's Brook, which drains to the northeast across Breakfast Hill Road. • The southwestern flow pathway is situated within the watershed of the Little River, which drains to the south-southeast across North Road." So, there is a southern bedrock plume… "• Hydraulic gradients supporting a component of upward flow from bedrock into the till or outwash units are present in the bedrock valley northwest of the landfill that are associated with headwaters of Berry's Brook (couplets FPC-5, FPC-6). • However, there is only one hydraulic gradient measurement in the bedrock valley southeast of the landfill in the headwaters of Little River at FPC-4 couplets. The one reading was slightly downward. This would then imply that the bedrock groundwater contour map is in error, specifically 72-ft contour (Figure 4 here), and that there must be a southward moving bedrock plume.

		• Downward hydraulic gradients that may indicate a component of downward flow are generally restricted to the areas where the marine unit is absent or where it interfingers with the outwash deposits (i.e., couplets FPC-2, AE-4, AE-2). Note that, in these areas, the component of vertical flow likely varies seasonally, with a component of upward flow during wet periods and a component of downward flow during dry periods." This reinforces that there is a southward moving groundwater plume. "Remedial investigations identified the highest concentrations of constituents of concern (VOCs and metals) in shallow bedrock and till units." "As of the August 2017 sampling event, the concentration of TBA in groundwater only slightly exceeds the cleanup criteria (40 ug/L) at two bedrock wells located immediately west of the landfill (MW-5D [50ug/L, Spring 2017], MW-8 [50 ug/L, fall 2017]). TBA concentrations at these two wells have been reported sporadically at concentrations at or slightly above the CL since 2007." "1,4-dioxane was also reported at a trace concentration at water supply well 178A LR (located south of the landfill along Lafayette Road), which was sampled for the first time in 2017." "Arsenic and/or manganese exceedances were or have been reported at several monitoring wells (FPC-7, AE-1 and AE-4, and historically at GZ-123, GZ-125 and FPC-2) located hydraulically upgradient or cross-gradient of the impacted groundwater area." How are these last three wells considered UPGRADIENT or even cross gradient, when no other wells south of there are used to develop the flow net (Figure10). "Results for 2017 indicate that PFOA, PFOS, and combined PFOA/PFOS were reported above the Federal HA of 70 nanograms per liter (ng/L) in certain OU-1 and OU-2 wells. The wells exceeding the HA are generally in close proximity to or within 1,000 feet downgradient of the western edge of the landfill." "Results from the FPC-3 series monitoring wells to the southwest of the site for samples collected in December of 2016 have provided a better understanding of the extent of impacts south of the landfill. Results for PFAS and 1,4-dioxane at the FPC-series wells indicate that the extent of groundwater impacts

		in bedrock attributable to the landfill do not extend south of FPC-3. It should be noted that monitoring well GZ-105, located north of FPC-3, reported moderate concentrations of PFAS and 1,4-dioxane. GZ-105 is screened in shallow bedrock." How is this conclusion arrived at given the contamination at Woodknoll Drive wells? This is not conclusive as was pointed out earlier in the North Hampton public meeting. FPC3 and FPC4 wells could easily be acting as "goalposts", especially if contamination entered a transmissive bedrock fracture. "Bedrock monitoring wells FPC-4B and AE-4B are located on the west side of the bedrock valley and did not detect PFAS or 1,4-dioxane. Data from these wells also indicates that the bedrock valley and associated hydrologic conditions are serving as a barrier to westward movement of contaminants in bedrock." This assumes that the conceptual hydrogeologic model for bedrock groundwater is correct. As stated previously, there seems to be an error in this model because data indicates that all bedrock water does not discharge to surface waters. "Water quality testing at the Chinburg well located approximately 2,800 feet north of the landfill and on the eastern side of the bedrock valley did not detect PFOA, PFOS or 1,4 dioxane in any of the eight intervals sampled. The well is 280 feet deep and near the interpreted northern groundwater flow path associated with the landfill." Is it possible that this infers that the assumed groundwater flowpath is in error? "…(Little River near North Road) The combination of PFOA and PFOS was detected at a concentration of 10.8 ng/L in November 2016 and at a concentration of 16.97 ng/L (May) and 27.89 ng/L (September) in 2017." Increasing concentrations should be cause for concern and additional monitoring wells in this direction. "Properties in the Falls Way and September Drive subdivision areas northwest of the Site are also considered potential receptors, because the aggregate of water supply wells in those subdivisions could draw groundwater to those areas if a direct pathway in deep bedrock were present. CLG has been sampling in that area since 2017 to demonstrate protectiveness conditions. It should be noted that the closest property location is on the order of 4,000 feet from the Site and beyond a watershed divide separating Berry's Brook and the Winnicut River Watersheds." First, this seems contradictory to the conceptual hydrogeologic model. Second, it is counter to rock regional strike (NNE-SSW),

		third, given distance and propensity for plume to follow Little River, why is more effort not in southerly direction? "The extent of impacts to the south of the landfill have been interpreted to extend approximately 800 feet south of the landfill. Little development is present between the landfill and North Road, approximately 4,000 feet south from the landfill. Much of this area is wetland. The nearest cluster of residential wells is greater than 5,000 feet from the landfill. It is unlikely that a cluster of residential wells greater than 5,000 feet from the landfill will alter flow paths in the vicinity of the Site. As a result, properties south of North Road are not considered potential receptors." Then how does one explain Woodknoll Drive bedrock groundwater? North Road, southwest of the landfill, is in the Aquarion Wellhead protection Area. "The Site model is well supported by existing geologic and hydrogeologic data for overburden and shallow bedrock. Contaminant distribution and migration is well understood in these units and the ongoing groundwater monitoring program continues to evaluate the progress of the Natural Attenuation remedy selected for the Site." Not true for plume lobe shown in Draft 2017 Annual Summery Report along Little River and very possibly leading to Woodknoll Drive. "..direct observation of site specific conditions in deep bedrock is limited." "To date, data has supported the Site model, particularly with respect to fate and transport of Site related contaminants." This does not seem to be true for southerly moving contaminants. Taken at face value, data may support the site model, which demonstrates contaminants moving east and south, however efforts in these directions have been considered unnecessary by the CLG and its consultant. "In response to agency actions and requests the following deep bedrock investigations were initiated and/or completed as Phase I of the investigation: • Fifteen water supply wells located north and west of the landfill were added to semiannual sampling events in 2017 and 2018 to establish a database for PFAS and 1,4-dioxane concentrations adjacent to the GMZ. A review of available records indicates that the majority of these wells are drilled into bedrock at depths between 200 and 300 feet below ground surface and are

		considered to be completed in "deep bedrock". No effort is being made to look west and south where a large lobe of pollutants are suggested to be moving, and most likely moved there historically. Figure 4 of the DRAFT Deep Bedrock Investigation Workplan. Cross sections C-C' and D-D' are identified, but the cross section never shown. Figure 6 (cross section A-A') of the DRAFT Deep Bedrock Investigation Workplan implies that landfill closure knowingly allowed groundwater to flow through the buried refuse for time immemorial. Why? Figure 10 of the DRAFT Deep Bedrock Investigation Workplan …The overburden groundwater potentiometric map implies all groundwater discharges at contour 70, which is east of the Little River. Well data does not support this hypothesis. Streambed piezometer data needs to be provided to support. Figure 11 of the DRAFT Deep Bedrock Investigation Workplan: most of plume is in the Little River watershed. Why is there not more attention being paid to this plume?
30 March 2018	CLG Meeting Summary	"…preferential groundwater flow direction at the site is west and north…" "…is possible that there may be easterly flow from the site…" "…Berrys Brook and Little River are gaining streams…" Focus really only on GMZ "There appears to be inconsistencies in lining up the various historic and current maps/figures which contain GMZ boundaries, the expansion lines, town lines, wetland boundaries, lineament interpretations, and other features/information which have been overlaid on figures at different points since the original RI."
1 May 2018	EPA Response to CLG Bedrock Work Plan	"…The overall objective of this investigation will be to identify and characterize any hydro-geologic pathways in deep overburden and bedrock, along with groundwater conditions in the deep bedrock at the Site and adjacent areas…" "12. Along with the well couplets to be installed to characterize the expanded GMZ and near the western GMZ boundary just north of the Greenland/North Hampton town line, additional

		bedrock boreholes may be required to fully characterize the potential for contaminant migration in bedrock. USEPA and NHDES may specify the need for additional bedrock boreholes based on the data and information gathered as part of the initial phases of the bedrock investigation." "13. Section 3.3.1 of the Draft Work Plan cites horizontal velocities of 64.1 to 320 ft/yr to the east. However, the groundwater contour map in Figure 10 does not show any component of flow to the east, and the discussion throughout section 3.3.1 repeatedly states that there is no current flow to the east. A similar condition is cited for the south or southwest vector velocity given for the Layfette Terrace area, where there is no flow to the south shown on Figure 10. This interpretation should be reviewed and corrected as appropriate based on data collected as part of this investigation." "• Figure 10 – Based on the measured groundwater elevations in wells OP-5, FPC-9A, and GZ-117, there appears to be a small, but discernable, eastern component of groundwater flow. Understanding that the 5-foot contour intervals do not provide sufficient definition of groundwater contours to show eastern groundwater flow in this area, the data warrant further consideration of this flow component. • Figure 11 – How is it that the eastern boundary of the drainage divide correlates exactly with extent of landfill and Greenland/Rye town line? Updated LiDAR data shall be used to update surficial conditions and to develop surface topography mapping."

Table 2. Groundwater versus land elevations for selected overburden wells

Well	Land elevation (ft)	Groundwater elevation (ft)	Date
FPC-3A	70.57	70.58	Sep 2017
FPC-3B	70.57	70.23	Sep 2017
FPC-3C	69.98	70.61	Sep 2017
FPC-8A	71.70	72.3	Sep 2017
FPC-8B	71.36	72.15	Sep 2017
FPC-6A	73.66	71.81	Sep 2017
FPC-6B	74.61	72.17	Sep 2017

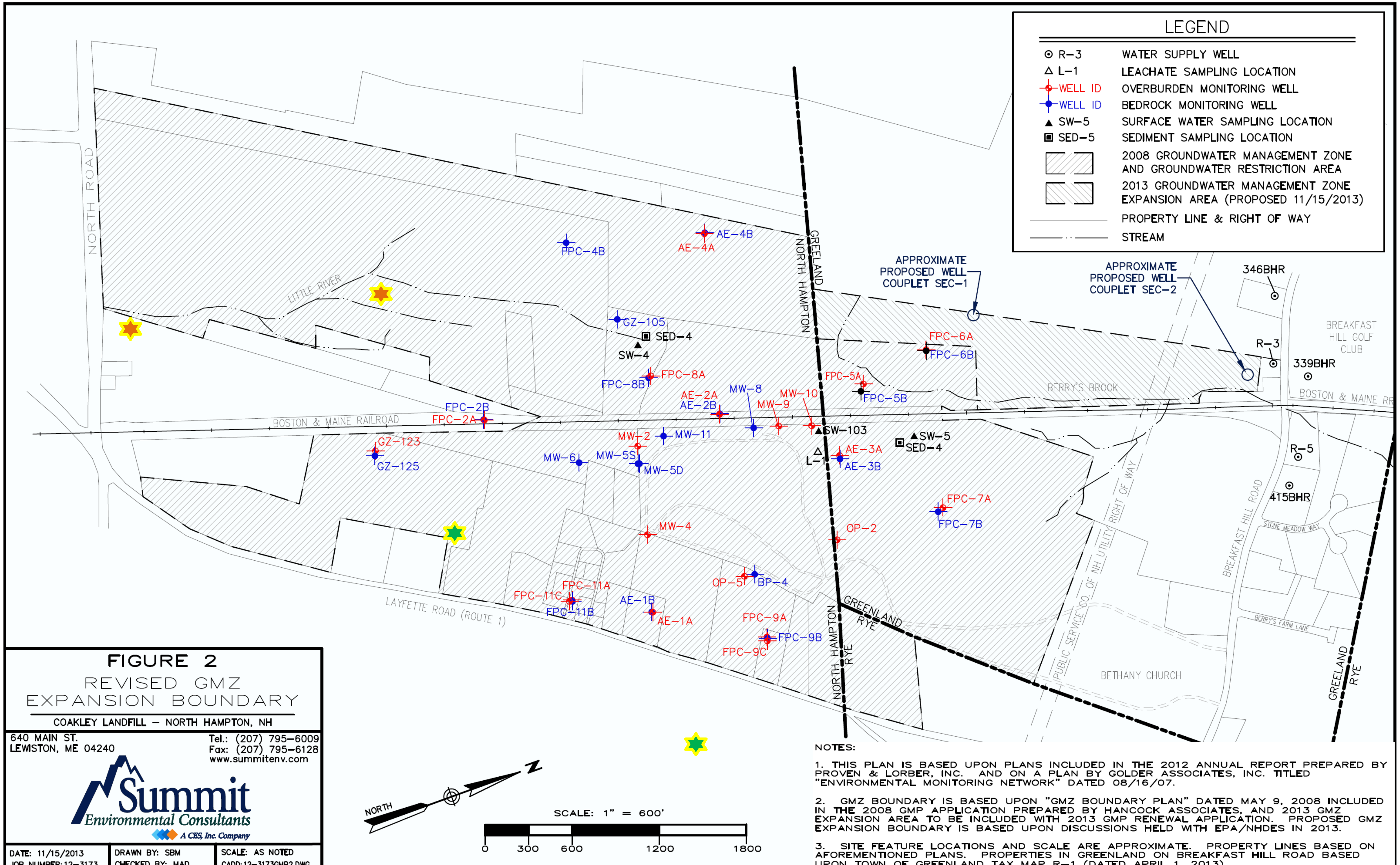

Figure 1. Coakley GMZ

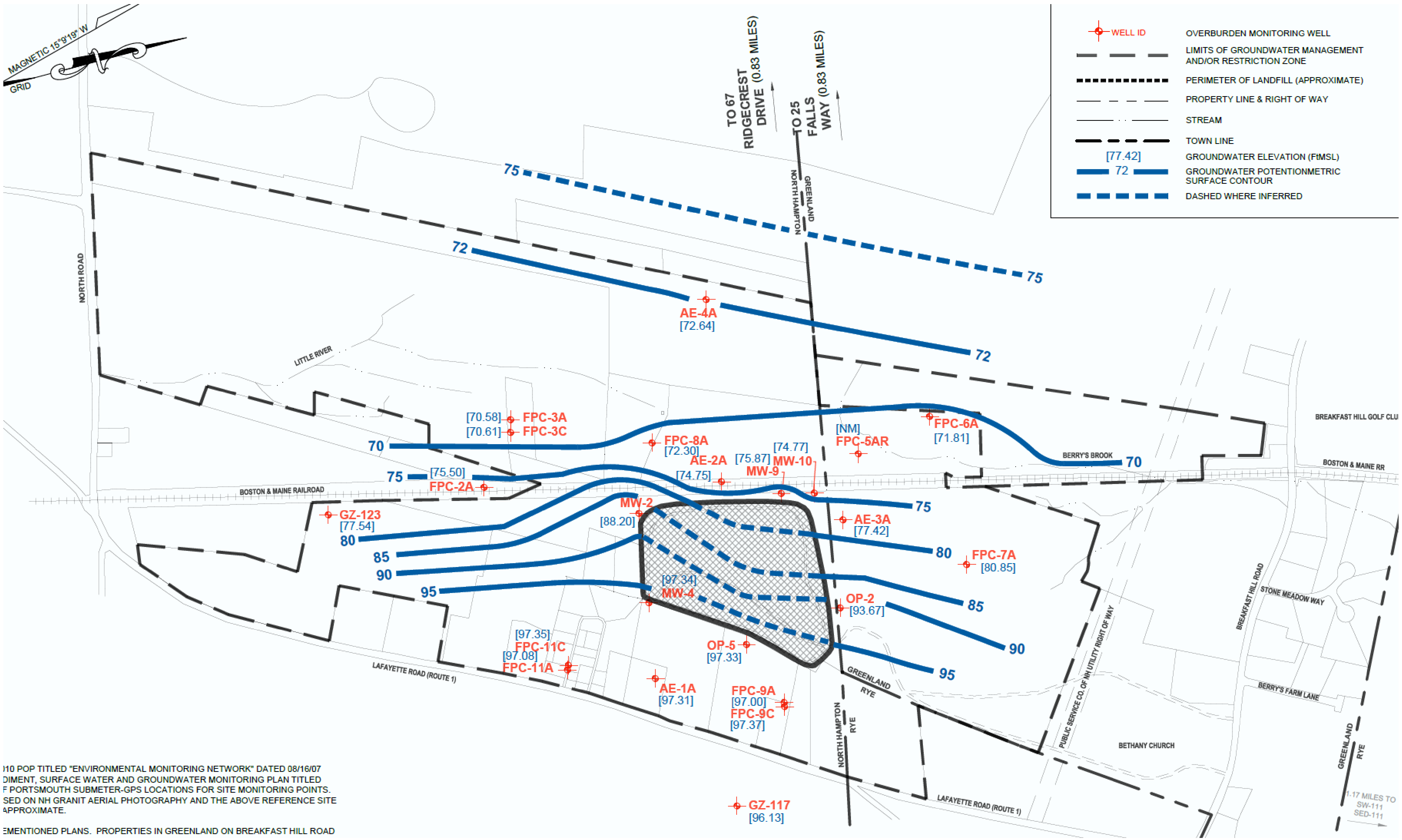

Figure 2. Overburden Groundwater Potentiometric Surface from the CES 2018 Draft Deep Bedrock Investigation Workplan

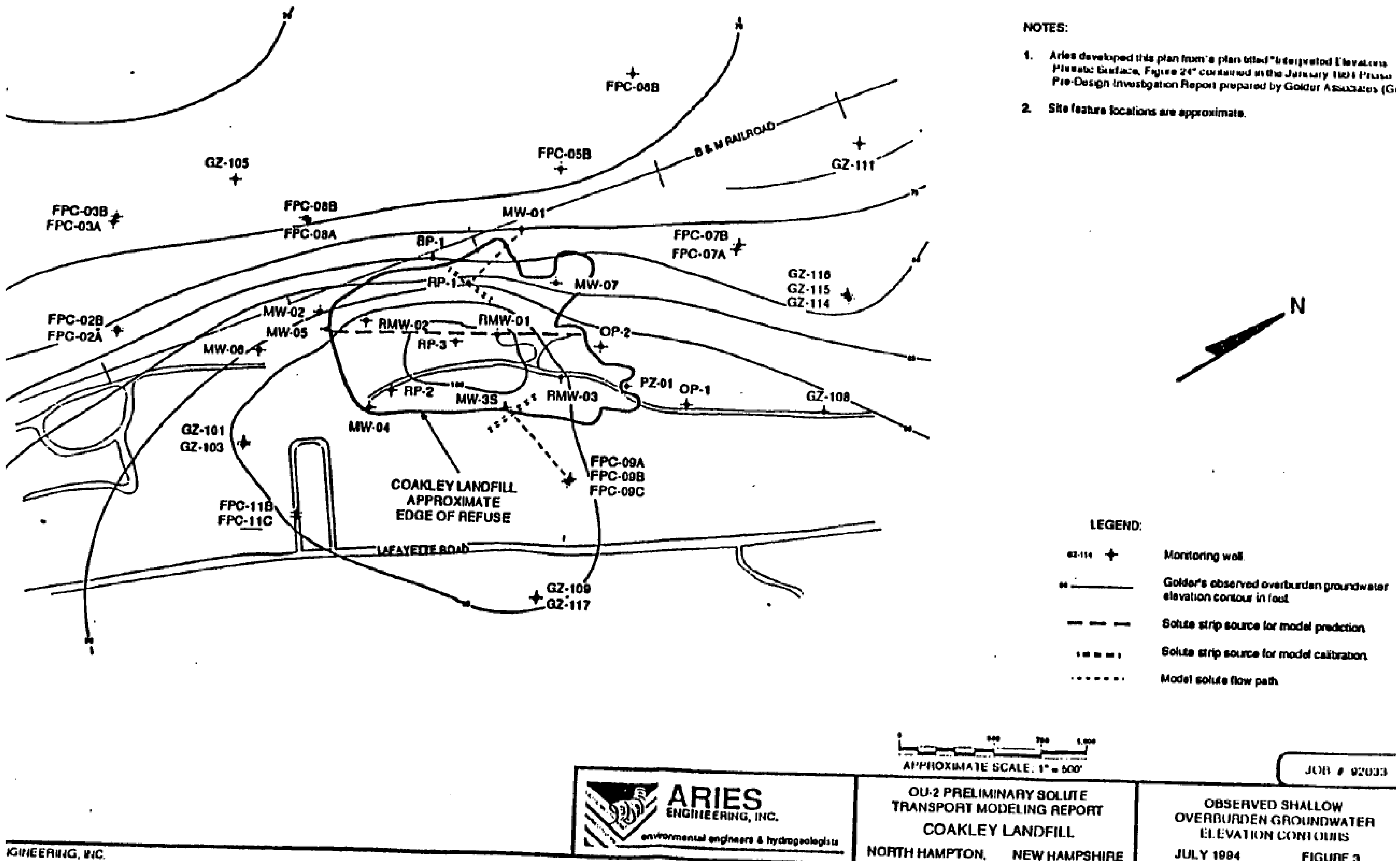

Figure 3. Overburden Piezometric Head Map. Coakley Landfill Management of Migration (O.U.2), NH, 30 Sep 1994

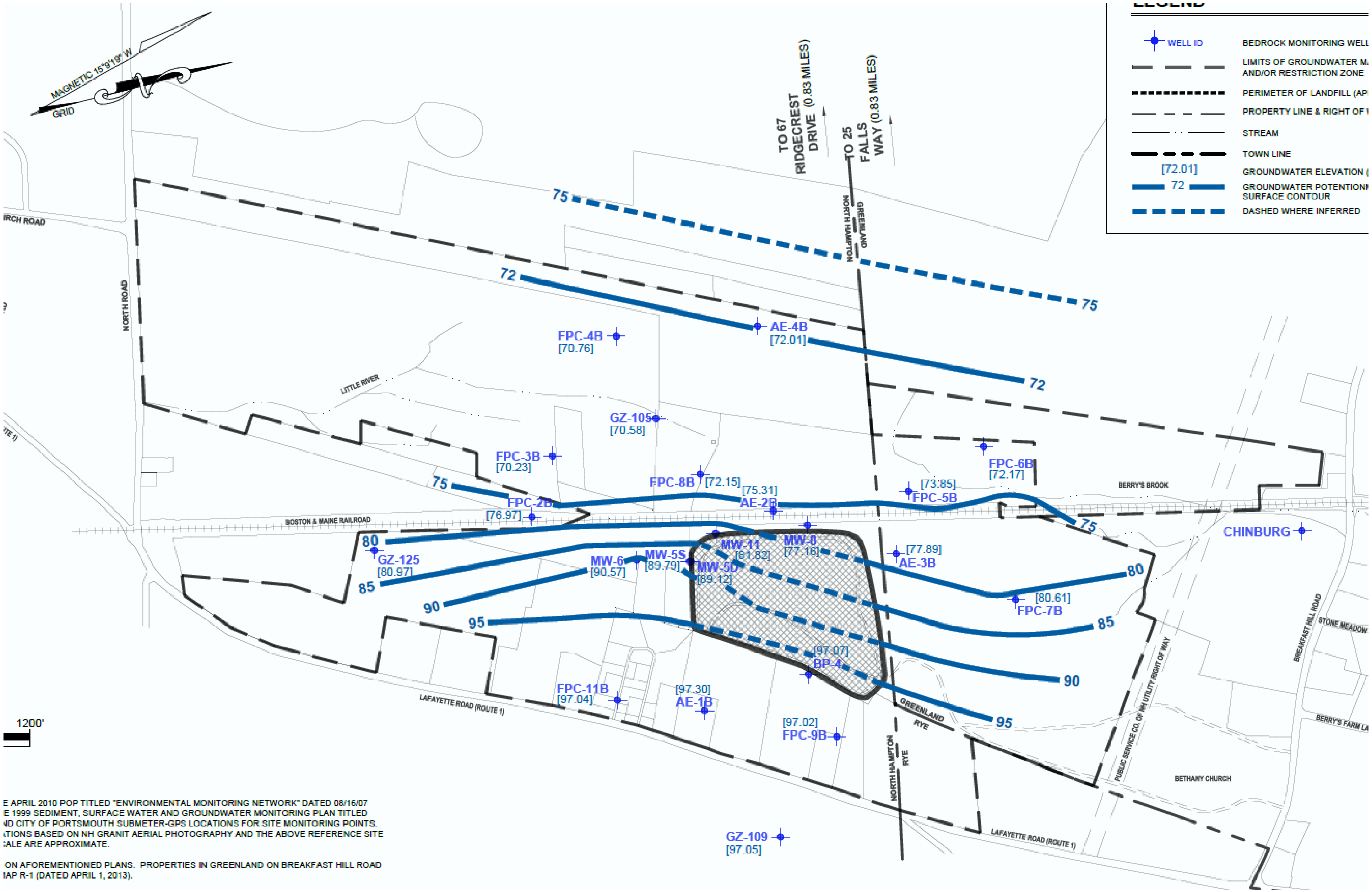

Figure 4. Bedrock groundwater potentiometric surface from the CES 2017 Annual Summary Report

28 Assessment of Ground-Water Resources in the Seacoast Region of New Hampshire

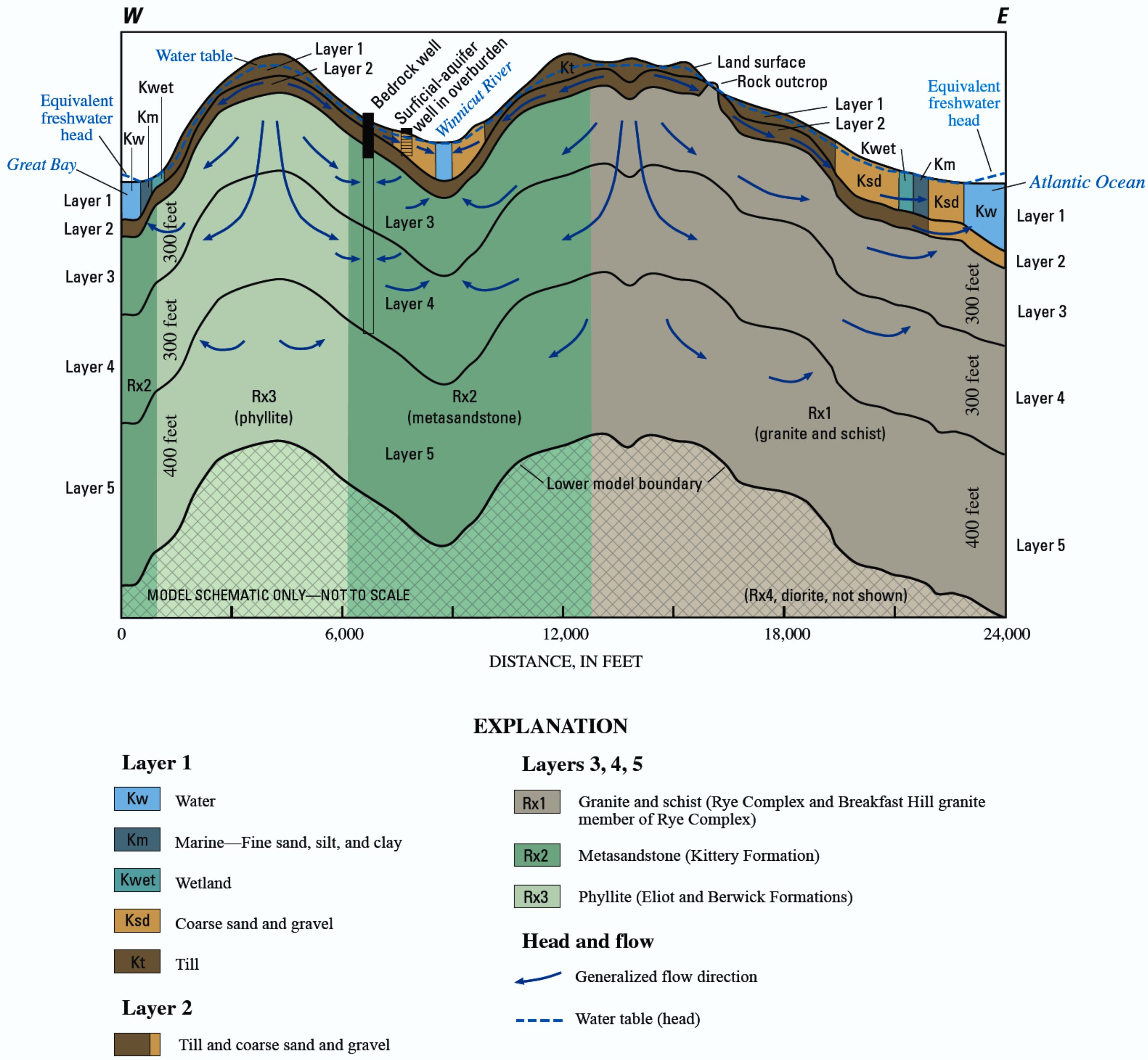

Figure 13. Schematic cross section of the ground-water-flow model for the Seacoast model area, southeastern New Hampshire.

Figure 5. General seacoast groundwater flow From USGS Mack Report

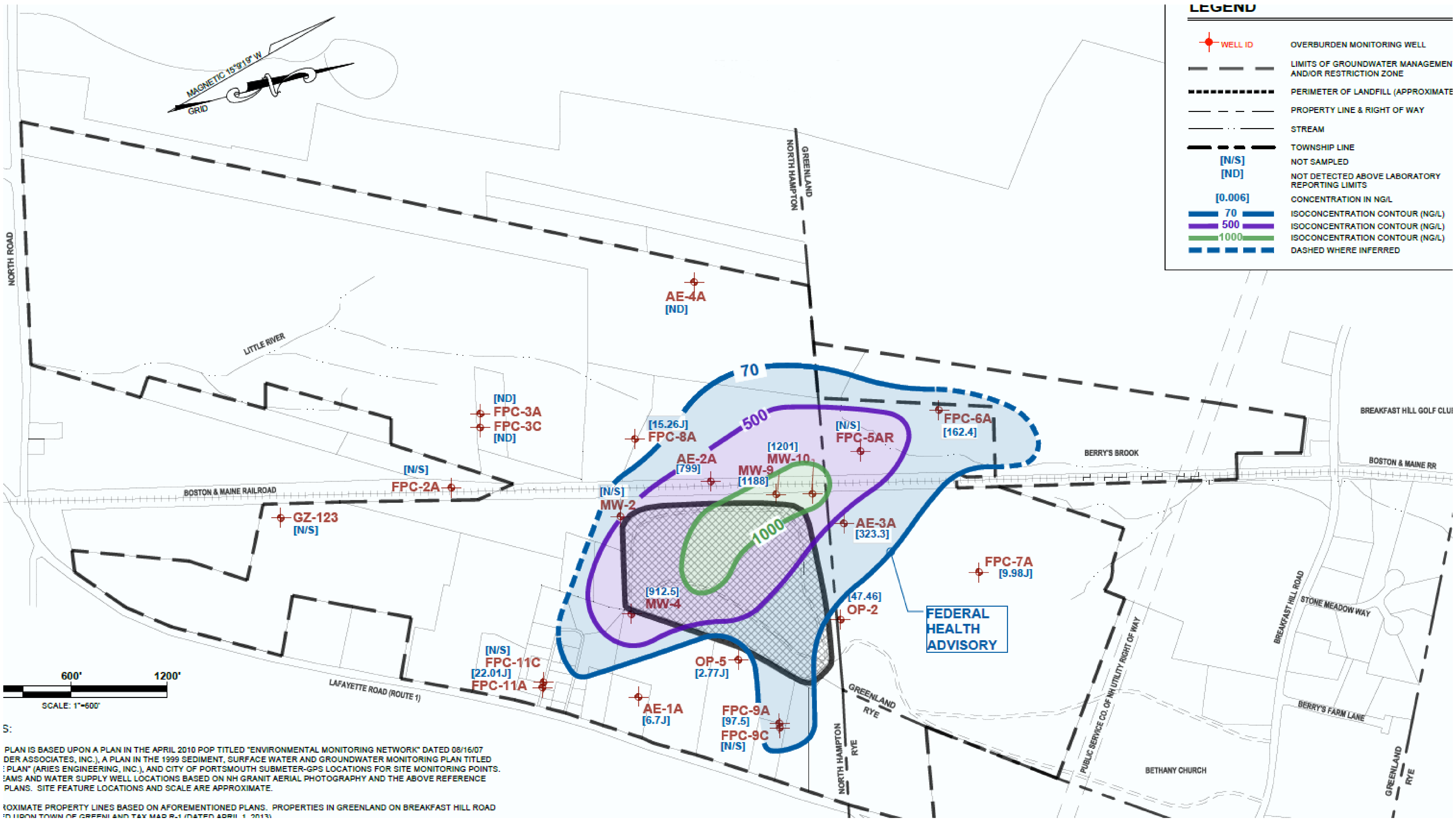

Figure 6. Lateral Distribution of PFOA and PFOS in Overburden from the CES 2017 Annual Summary Report

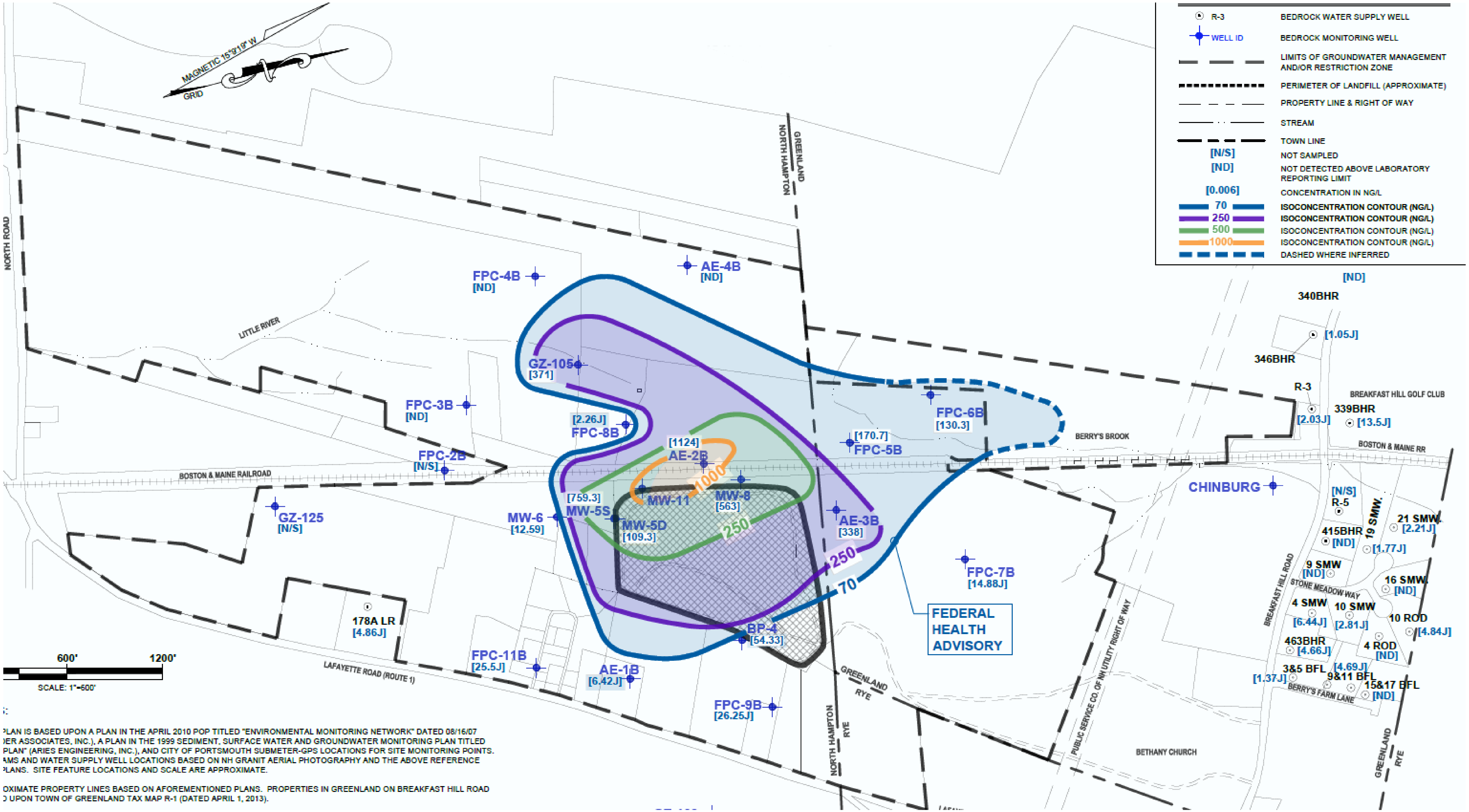

Figure 7. Lateral Distribution of PFOA and PFOS in Bedrock from the CES 2017 Annual Summary Report

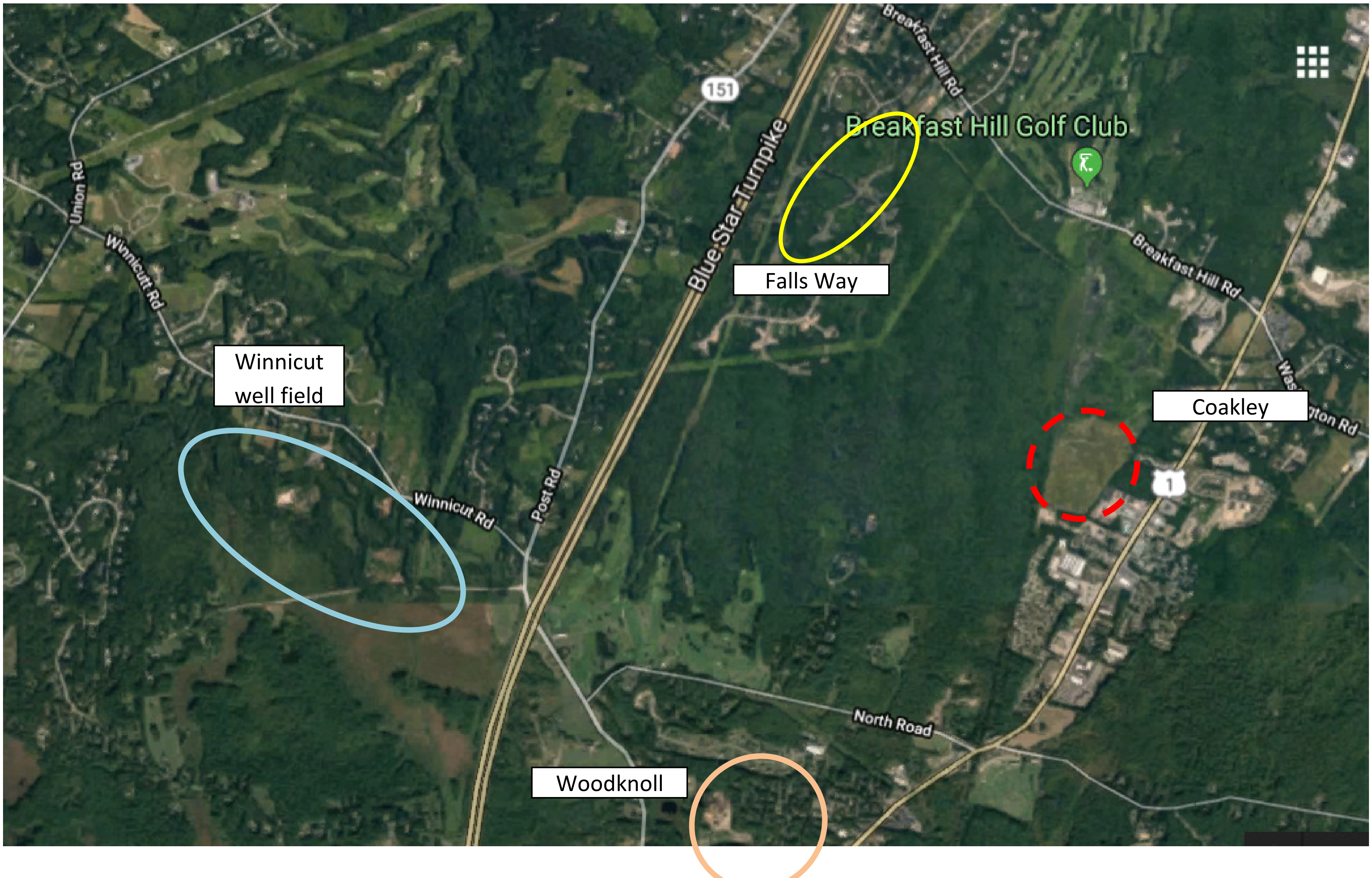

Figure 8. Relative locations of Coakley landfill to drinking water wells

Figure 9. Aquarion Water Company Wellhead Protection Area's