SENSIBLE SOLUTIONS

CES INC

STORMWATER INVESTIGATION REPORT
COAKLEY LANDFILL SUPERFUND SITE
NORTH HAMPTON
AND GREENLAND, NEW HAMPSHIRE

FOR

COAKLEY LANDFILL GROUP

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Portsmouth, New Hampshire

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1.0 | INTRODUCTION

On behalf the Coakley Landfill Group (CLG), CES, Inc. (CES) has prepared this Stormwater Investigation Report to document the collection and analysis of samples from stormwater management structures at the Coakley Landfill Superfund Site (Site). In addition to stormwater, landfill seep, and groundwater sampling, landfill cover system materials were also sampled to assess the presence of contaminants in these materials. The intent of this investigation is to better understand: (1) the chemical composition of stormwater, landfill runoff, and groundwater within and near the landfill cap system; (2) the relationship between stormwater discharge, shallow groundwater quality, and landfill seep discharge from monitoring location L-1; and (3) the design and function of the stormwater collection system installed at the landfill during landfill cap construction.

Initial stormwater system sampling was proactively completed by the CLG in Spring 2018 with the sampling of stormwater at select stormwater system locations. This sampling was initiated by CLG voluntarily to further investigate reasons for variations in surface water and seep concentrations near the northwest corner of the landfill previously observed during relatively wet versus dry seasonal events. Sampling results were presented in an August 14, 2018 letter report by CES and initiated a request by the United States Environmental Protection Agency (USEPA) and the New Hampshire Department of Environmental Services (NHDES) to complete a more comprehensive stormwater investigation as outlined in a letter from the USEPA to the CLG dated August 17, 2018. Following this request, a *Draft Stormwater Investigation Work Plan* was issued on September 10, 2018 and conditionally approved by the USEPA on September 26, 2018. A revised *Stormwater Investigation Work Plan* (Work Plan) was issued by the CLG on October 24, 2018 and included recommendations made by the USEPA in its September 26, 2018 conditional approval letter.

2.0 | PROJECT BACKGROUND AND DESCRIPTION

As part of Site remedy design and construction activities implemented in the mid and late 1990s, stormwater runoff from the landfill surface is conveyed to two unlined stormwater retention basins, one near the northeast corner of the landfill (designated as SB-1) and one near the northwest corner of the landfill (designated as SB-2), via a series of perimeter drainage ditches and rip-rap let-down structures on the landfill (**Figure 1**). Stormwater retained in the basins is subsequently discharged to adjacent wetland areas through infiltration and via an outlet structure in each basin and associated corrugated metal piping.

In addition to direct overland stormwater runoff, precipitation that infiltrates through the landfill's vegetative layer and cover soil is collected in a geonet or sand/gravel layer placed above the geomembrane liner of the cap system. Based on an initial review of the 100% Design drawings (Golder, 1996) and a field visit performed by CES on September 4, 2018 in advance of Work Plan development, water in the drainage layer/geonet along the east side of the landfill is conveyed via gravity to underground perforated piping to stormwater retention basin SB-1, while water along the west side of the landfill is conveyed via similar perforated piping to a rip rap lined discharge swale located west of SB-2 (**Figure 1)**.

Following remedy construction, a seepage area was noted on an embankment adjacent to the northwest stormwater retention basin (SB-2) outfall pipe discharge. This seepage is interpreted to be shallow groundwater discharging to the ground surface at or near the head of a wetland complex west-northwest of the landfill. The seepage location became a sampling point in the Site monitoring network and is designated as location L-1 on site plans and in annual monitoring reports. It has also previously been referred to as a leachate seep in site-related correspondence but has been more appropriately referred to as simply a “seep” in recent correspondence and it is now considered to be representative of shallow groundwater discharge. Analytical results for samples collected at L-1 have been reported in monitoring reports since 2000.

During a review of 2017 analytical data for the L-1 seep location, it was noted that concentrations of per- and polyfluoroalkyl substances (PFAS) in the L-1 sample were significantly higher in the Spring event during relatively wet conditions when discharge was observed from the SB-2 outfall pipe, as compared to the drier Fall event when little or no discharge was observed in the northwest stormwater retention basin (SB-2) outfall pipe. These results seemed contrary to the previously held assumption that concentrations in the groundwater seep at L-1 would be lower following a storm due to dilution, since the landfill cap has no direct contact with landfill waste.

To verify the physical relationship between the L-1 seep location and stormwater retention basin outfall piping, a Site visit was conducted by CES on December 7, 2017 to observe Site conditions. During the Site visit, iron-stained soil was observed on the embankment adjacent to the corrugated steel outfall pipe from SB-2. Soil staining appeared to extend to (or above) the bottom elevation of the stormwater outfall pipe, although the inside of the stormwater outfall pipe did not show evidence of iron staining or iron precipitate indicative of impacted groundwater entering the outfall piping. The heaviest staining and water seepage were observed to be in a ponded area downslope of the outfall pipe and 1-3 feet lower in elevation than the invert of the outfall pipe. This ponded area is a result of a rip rap check dam placed downstream of the outfall pipe, approximately 20 feet from the L-1 seep location (**Figure 1**).

Water samples were collected from select stormwater management system components and L-1 on April 26, 2018 during the Spring 2018 biannual sampling event to further investigate stormwater quality for comparison to historic seep sample results. Results for these samples were documented in the August 13, 2018 letter report to the CLG, which detailed the additional sampling performed at the northwest perimeter ditch, northwest stormwater basin outfall pipe, and northwest underdrain piping discharge location west of SB-2.

A Site visit was completed on September 4, 2018 by the CLG, CES, USEPA, and NHDES to observe previously sampled stormwater control system components and identify additional sampling locations for inclusion into the investigation detailed below.

2.1 Study Objectives

The goal of this investigation was to better understand the chemical composition of stormwater and the relationships between stormwater discharge, shallow groundwater quality, and landfill seep discharge from monitoring location L-1. This information serves to aid in a more thorough understanding of the design and function of the stormwater collection system installed at the landfill during landfill cap construction. It also allows examination of the relative contributions of PFAS in stormwater and groundwater to the wetland complex and ultimately Berry's Brook.

3.0 | SAMPLING AND INVESTIGATION ACTIVITIES

To better understand the interaction between stormwater and groundwater at L-1, the investigation was comprised of several tasks. These tasks, as outlined below, were designed to assist in interpreting the presence, source and migration of PFAS within the stormwater collection system and its components and to provide information necessary to make informed decisions on subsequent investigation activities.

3.1 Verification of Stormwater System

CES 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 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 (SW-5, SW-103, and L-1), verification of top of riser elevations for groundwater monitoring wells included as part of the investigation, and piezometers installed in accordance with the Work Plan. The survey included the installation and elevation control of staff gauges at the L-1 seep and surface water sampling locations. Recorded elevation information provided verification of "100% Design" conditions of the stormwater system and aided in the interpretation of hydrologic relationships between surface water, stormwater, and groundwater. Survey information for sampling point locations, monitoring wells, piezometers, and stormwater system components are listed in **Table 1**. Review of the Design Report for the stormwater retention system resulted in the conclusion that precipitation falling on the landfill cover system and subsequent stormwater runoff does not come in direct contact with landfill refuse.

The stormwater management system has been divided into four separate components based on stormwater conveyance and/or discharge location. These components include the landfill cap, stormwater retention basins, perimeter drains, and toe drains. Precipitation that is collected and conveyed via these components can be divided into direct runoff (overland/sheet flow) of water via perimeter ditches to retention basins and precipitation that infiltrates the landfill cap with flow characteristics typical of groundwater (e.g. flow within interstitial pore spaces via gravity and capillary action) and is subsequently discharged to the surface at underdrain discharge locations as illustrated on **Figure 1**. While overland flow and subsurface infiltration are both sourced from precipitation, their composition varies as a result of the degree of interaction with landfill cover materials.

Landfill Cap

From top to bottom, the landfill cap consists of a vegetated topsoil (TS) layer underlain by a common borrow cover soil (CS) frost protection layer as illustrated in **Figure 2** and detailed in Drawing 5-5 of the Design Report. These soil materials overlie a plastic drainage netting (geonet) with bonded geotextile fabric on top and a textured flexible membrane liner (FML) located below the geonet. The geonet provides an interstitial space between the geotextile and FML for water that has infiltrated through the cap materials to drain via gravity to collection piping located along landfill benches. The geonet and FML also act as a separation layer between the topsoil and cover soil of the landfill cap cover system from underlying grading fill and sand layers used in the collection and venting of landfill gas. Landfill refuse is present beneath the grading layer and landfill gas collection sand layer (**Figure 2**).

Water infiltrating through the landfill cap cover system moves through the geonet layer to a series of gravel-bedded perforated high density polyethylene (HDPE) pipes that are routed through downchutes and collection pipes to either the northeast stormwater collection basin (SB-1) or to a rip rap lined discharge channel west of the northwest stormwater retention basin (SB-2) as detailed in Drawing 5-13 (**Appendix A**) of the Design Report.

The landfill cap is divided, based on specifications within the Design Report, into Areas 1 through 3 (**Appendix A**: Drawing 5-5). These areas are based on slope and cap construction.

- Area 1 is identified as the “Refuse Consolidation Area” (approximately 35 percent of landfill cap surface) and is comprised of gentle slopes of less than 5% and containing one of two landfill cap types (Type 1 or Type 2). These cap types are similar in construction but differ in the presence (Type 1) or absence (Type 2) of a gravel drainage layer below the cover soil which facilitates drainage of the cover soils in lieu of a geonet layer.
- Area 2 is comprised of moderate slopes (5 to 20%) and includes approximately 60 percent of the landfill cover system. Area 2 is comprised of a Type 4 cap construction (**Appendix A:** Drawing 5-5).
- Area 3 consists of the outermost portions of the landfill cap where slopes are the greatest (20 to 33%) and represents the smallest percentage of total landfill cover (approximately 5 percent). Area 2 is comprised of a Type 3 cap construction (**Appendix A:** Drawing 5-5).

Water infiltrating within Areas 1 and 2 is collected by the underdrain piping system while water infiltrating in Area 3 enters a gravel-filled toe drain system.

Although the cover system functions are generally the same over the landfill surface, minor variations in the cover system construction discussed above are present on some portions of the landfill based on the steepness of constructed slopes. Specific construction details are shown on the design drawings included in **Appendix A**.

Stormwater Retention Basins

The stormwater management system includes two unlined stormwater retention basins. These basins are located in the northeast (SB-1) and northwest (SB-2) corners of the landfill (**Figure 1**). SB-1 collects stormwater from direct precipitation and input from perimeter ditches and underdrain piping (**Appendix A:** Drawing 5-15) on the east side of the landfill cover system while SB-2 collects water from direct precipitation and a perimeter drain (Drawing 5-16) on the western portion of the cover system. Water exits each basin through infiltration between precipitation events or via outfall piping during events of sufficient precipitation to result in flow to the outlet structure in the retention basin (Drawing 5-18). The outfall pipe discharges to outfall points located northwest of each basin structure. Water draining from the basins through infiltration mixes with shallow groundwater while outfall piping discharge directly enters the wetland complex west and northwest of the landfill.

Perimeter Ditches

Precipitation that does not infiltrate into the landfill cap is collected as surface flow by a series of perimeter drains. For the purposes of consistency with design drawings and Design Report text, the term perimeter ditches will be used. The perimeter ditches are responsible for the collection of surface flow on the majority of the landfill surface. However, surface water on the lowermost portion of the landfill slope is discharged as sheet flow to surrounding areas due to surface slopes. The perimeter ditches are either grass or rip rap lined and are constructed to allow for either conveyance of water to the stormwater retention basins or to allow for infiltration into the subsurface through the cover soil for collection by the underdrain system.

Toe Drains

The toe drains are designed to allow for water that has infiltrated within the lowermost portion of the landfill slope to exit the landfill cap system through a gravel layer at the toe of the landfill. Water exits the toe drains primarily as surface flow; however, based on Drawing 5-7 of the Design Report (**Appendix A**), water can infiltrate into grading fill located below the toe drains and enter the shallow subsurface.

3.1.1 Source Material Investigation

A review of 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 FML, geotextile, underdrain conveyance piping, cover soil, sand and gravel drainage layers, and topsoil materials. A list of landfill cap and stormwater system construction materials determined to have direct contact with stormwater was generated for sample collection and analysis. Samples of these materials were collected and analyzed for PFAS compounds using an extraction and analysis technique as determined by media type (e.g. soil, geotextile, etc.). Samples were submitted to Vista Analytical Laboratory (Vista) via subcontract from Eastern Analytical, Inc. (EAI) in accordance with sample preparation, handling, and chain of custody procedures as outlined in the project sampling and analysis plan (SAP). Results of these analyses are presented in **Section 4.0**, below.

Topsoil

Topsoil was placed over the areal extent of the landfill cap and served to provide a media onto which vegetation (grass) could be planted for erosion control, slope stability, control of stormwater runoff, and to provide insulation to underlying cap materials. Topsoil was processed on Site by mixing virgin topsoil, compost, and sand. The topsoil was then spread over common borrow cover soil. Topsoil was supplied from an off-site source in Exeter, New Hampshire with sand supplied from a sand and gravel pit in Rochester, New Hampshire. Compost was supplied from compost sources in Maine, Massachusetts, and New Hampshire.

Cover Soil

The primary function of the cover soil is to provide frost protection for the geomembrane. Cover soil was placed in a minimum 18-24-inch thick layer as shown in design documents. A source for topsoil material could not be verified through review of cap construction documentation.

Sand/Gravel Drainage Material

Drainage sand was used as a protective cover layer for the geomembrane in portions of the cap system. The sand was brought from an off-site source in Rochester, New Hampshire and placed in minimum one-foot thick layer over the geomembrane liner. Gravel was comprised of crushed stone and used primarily as drainage stone in the underdrains and toe drains and was placed around the 6-inch diameter underdrain collection pipes. The gravel was supplied by a source located in Rochester, New Hampshire.

Geomembrane

The geomembrane serves as a component of the impermeable layer and prevents infiltrating water from contacting landfill refuse. Water on top of the geomembrane is conveyed to the toe drain and underdrain systems of the landfill cap. Geomembrane material was provided by Polyflex Inc. of Grand Prairie, Texas.

Geocomposite

Geocomposite materials included those comprised of one or more types of geotextile or geomembrane material. The two types of geocomposite used during the Coakley Landfill cap construction were single-sided and double-sided geocomposite. These geocomposites were designed to act as an interstitial space through which water infiltrating through the cap materials could drain via gravity to perforated collection piping. Single-sided geocomposite (JDRAIN 200 FN) is constructed of HDPE geonet with woven geotextile bonded to the top. Double-sided geocomposite (JDRAIN 200FNF) is constructed of internal HDPE geonet with woven geotextile bonded to both sides of the geonet. Geocomposite was provided by JDR Enterprises Inc. of Alpharetta, Georgia.

Geotextile

The landfill cap used geotextile fabric in several applications, including geomembrane cushion layer, soil and rip rap separator, and toe drain wrap. The design specified 10-ounce geotextile as a separator material to keep cover soil fines from infiltrating into the drainage sand layer. Geotextile material was provided by TNS Mills, Inc. of Greer, South Carolina.

3.2 Piezometer Installation

Three piezometers (PZ-1, -2, -3) were installed and sampled as part of the Investigation. 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. PZ-3 was installed in response to USEPA requests made via email correspondence on March 7th, 2019. 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.

Piezometers installed in the stormwater basins (**Figure 1**) were constructed by manually driving a 30-inch stainless steel drive point well screen below the bottom of the unlined basin. A 5-foot section of 1.25-inch diameter galvanized steel pipe was connected to each well screen to provide an extension above the static water level within the pond as noted during rain events. PZ-3 was installed using 1-inch diameter PVC materials with a 5-foot well screen placed within a sand layer downgradient from the L-1 seep. A hand auger was used to advance a boring and overburden materials were recorded to ensure screen placement within a saturated zone. Silica sand filter material was placed adjacent to the screen interval with a bentonite seal above the sand pack extending to ground surface. Construction diagrams for each piezometer are included as **Appendix B**.

3.3 Groundwater and Surface Water Elevation Monitoring

Depth-to-groundwater measurements from overburden monitoring wells (MW-9, MW-10, FPC-5A, FPC-6A, AE-3A, FPC-7A, FPC-9A, OP-2, and OP-5) was obtained to monitor the overburden piezometric surface in the vicinity of the stormwater basins and stormwater discharge locations. Supplemental gauging locations included piezometers installed within stormwater retention basins and downgradient from L-1 as described in **Section 3.1**. Overburden piezometric groundwater surface elevations recorded during the Fall 2018 and Spring 2019 stormwater sampling events are included on **Table 1**.

Surface water elevations are recorded during regularly scheduled semiannual monitoring events with the elevations of surface water determined from staff gauges and gauging pins installed as part of the stormwater investigation. Surface water locations SW-5 and SW-103, that are part of the routine surface water sampling network, are locations in closest proximity to the stormwater control system discharges in the northwest portion of the landfill and are approximately 75-ft and 300-ft north of L-1, respectively. Surface water elevations, based on the gauging of locations performed during the Fall 2018 and Spring 2019 stormwater sampling events, are included on **Table 1**.

3.4 Stormwater Management System and Surface Water Sampling

Based on a review of the stormwater routing and conveyance system components, as shown on design documents, CES identified locations for stormwater sample collection, including those previously sampled during the April 26, 2018 sampling event.

Cover system components that included topsoil, common borrow, sand, and geomembranes as discussed above, were identified and sampled for analysis based on information obtained through the review and field verification of the Design Report.

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 outlined below. 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.

3.4.1 Cover System Component Sampling

Four landfill cap types were defined in the Design Report (**Appendix A**), with Type 4 selected for sampling. All landfill cap types utilized the same materials with variations in the thickness of the cover soil and absence/presence of a sand or gravel collection layers. A Type 4 landfill cap area was selected for sampling as it represented approximately 65% of the total landfill surface area.

Landfill cover system materials were sampled on December 4th and 20th, 2018 and analyzed for the presence of PFAS. The designation "STM" was used for samples collected as part of this investigation. The following materials in the cover system were sampled, listed in order from top down:

- Vegetated topsoil (STM-SO-TS-01) composite sample on northeast portion of the landfill,
- Vegetated topsoil (STM-SO-TS-02) composite sample on northwest portion of the landfill,
- Cover Soil common borrow (STM-SO-CM-01) composite sample on northeast portion of the landfill,
- Cover Soil common borrow (STM-SO-CM-02) composite sample on northwest portion of the landfill,

- Geotextile fabric (construction material) bonded to expanded plastic geonet (STM-CM-DL-01) and placed over Flexible Membrane Liner,
- High Density Polyethylene (HDPE) Underdrain Pipe (STM-CM-UDP) that conveys water collected in the underdrain system,
- Grading fill/landfill gas collection sand Drainage Layer (STM-SO-DL-01) composite sample on northeast portion of the landfill, and
- Grading fill/landfill gas collection sand Drainage Layer (STM-SO-DL-02) composite sample on northwest portion of the landfill.

Cover system sampling locations are shown on **Figure 1**. Samples consisting of a soil matrix were composited based on a four-point composite methodology, with construction material (e.g., filter fabric) samples comprised of a two-point composite.

3.4.2 Stormwater Sampling

Two stormwater sampling events were completed as part of this investigation. The first sampling event was completed in the Fall of 2018 with a second completed in the Spring of 2019. Stormwater sampling events were scheduled based on the occurrence of a rainfall event of sufficient duration and measurable amount as to “charge” the landfill cap with water. This “charging” allows for enough water to infiltrate the cover system and generate flow to the underdrain system. Flow to perimeter ditch outfalls; however, is a function of precipitation rate, with higher rates of precipitation resulting in increased surface flow and collection by the perimeter ditch system and conveyance to the stormwater retention basins. Precipitation at lower rates is collected by perimeter ditches, infiltrates into the landfill cap, and is subsequently collected by the underdrain system and discharged to either SB-1 or the northwest underdrain discharge location west of SB-2. Discharge to outfall pipes is based on both duration and quantity of precipitation. Contribution to the northeast stormwater basin (SB-1) is from perimeter ditches and underdrain piping with contribution to the northwest stormwater basin (SB-2) being from perimeter ditches only. Underdrain piping in the northwest corner of the landfill is routed to the rip rap-lined discharge channel.

Samples related to the Northeast Stormwater Basin have a designation suffix of 1 while samples related to the Northwest Stormwater Basin had a designation suffix of 2. Stormwater samples were collected from a total of 9 locations as illustrated in **Figure 1** and included:

- Northeast Stormwater Retention Basin (STM-SB-1)
- Northeast Basin Outfall Pipe (STM-OFP-1)
- Northeast Perimeter Ditch (STM-PD-1)
- Northeast Underdrain Piping (STM-UP-1)
- Landfill Seep (L-1)
- Northwest Stormwater Retention Basin (STM-SB-2)
- Northwest Basin Outfall Pipe (STM-OFP-2) (noted as “STM-Outfall Pipe” during May 2018 sampling)

- Northwest Perimeter Ditch (STM-PD-2) (noted as “STM-Perimeter Ditches” during May 2018 sampling)
- Northwest Underdrain Piping (STM-UP-2) (noted as “STM-Subsurface Piping” during May 2018 sampling)

[Note that locations L-1, STM-OFP-2, STM-PD-2, and STM-UP-2 were previously sampled during the April 26, 2018 sampling event; however, different sample designations were used at that time.]

PZ-1 and PZ-2 were sampled during the Fall 2018 and Spring 2019 sampling events while PZ-3 was only sampled in Spring 2019 following its installation.

3.5 Laboratory Analysis

Collected stormwater (STM-SB-1, STM-OFP-1, STM-PD-1, STM-UP-1, STM-TD-1, STM-SB-2, STM-OFP-2, STM-PD-2, STM-UP-2, and STM-TD-2), landfill seep (L-1), and piezometer (PZ-1 and PZ-2) samples (**Figure 1**) were submitted to the analytical laboratory for analysis of PFAS and 1,4 dioxane during the Fall 2018 sampling event.

Sampling at location PZ-3 was added to the Spring 2019 sampling event following the USEPA request to install PZ-3 made in a March 7th, 2019 email correspondence. Landfill general chemistry parameters were added to the analyses completed during the Spring 2019 sampling event and included alkalinity, ammonia, iron, and nitrate. The addition of these parameters was requested in the USEPA March 7th, 2019 email correspondence. Analysis of PFAS compounds included an expanded list of analytes (a total of 26) from those compounds contained in the Quality Assurance Project Plan (QAPP) (CES, 2017), as approved by the USEPA and NHDES, and analyzed in previously completed sampling events at the Site. A list of these compounds is included in **Appendix C**.

4.0 | SAMPLING AND INVESTIGATION ACTIVITY RESULTS

Analytical results for samples collected during the Fall 2018 and Spring 2019 sampling events are presented below with comparisons made, where applicable (e.g. L-1), to historical results.

4.1 Cover System Sampling Results

Analytical results for landfill cover system samples are presented on **Table 2**. Sample results are presented in milligrams per kilogram (mg/kg), or parts per million.

Of the cover system materials sampled, topsoil samples (TS-01/TS-02) had the highest concentrations and greatest number of PFAS compounds. The topsoil sample from the northwest portion of the landfill (TS-02) had the highest reported concentrations of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) at 0.00425 mg/kg and 0.0396 mg/kg, respectively. Common borrow cover soil samples (CM-01/CM-02) ranged from 0.000497 mg/kg to 0.000755 mg/kg for PFOA and from 0.00648 mg/kg to 0.012 mg/kg for PFOS, with the composite sample collected in the northwest section of the landfill containing the highest concentrations. PFOA and PFOS were not detected in the grading fill/sand landfill gas collection layer samples (SO-DL-01/SO-DL-02).

PFOA and PFOS were not detected in the sample of HDPE underdrain discharge pipe material (CM-UDP); however, detections of PFOA and PFOS were reported for the geotextile/FML sample (CM-DL-01) at concentrations of 0.000386 mg/kg and 0.00317 mg/kg, respectively.

4.2 Stormwater Sampling Results

Samples were collected from stormwater sampling locations in accordance with the Work Plan. However, samples from L-1 could not be collected during conditions when there was no observed discharge from the adjacent SB-2 outfall pipe (STM-OFP-2) as some discharge was observed during repeated visits to the L-1/OFP-2 location. Consistency in sampling location was maintained from previous sampling events and was not visibly influenced by any other monitored stormwater discharge or surface water. Though potential exists for some locations (e.g. STM-OFP-1 and STM-OFP-2) to be dry during sampling events, based on the absence or presence of water within the stormwater basins, these conditions were not encountered during sampling. Toe drain samples (TD-1 and TD-2) were also planned but were not collected during the Fall 2018 or Spring 2019 events because there was no stormwater discharge from these locations at the time of sample collection.

Analytical results for stormwater samples were compared to site-specific USEPA Screening Levels (SLs) for a Child Recreator (45 and 120 days) with groundwater samples from L-1, PZ-1, -2, and -3, compared to revised New Hampshire Ambient Groundwater Quality Standards (AGQS) effective October 1, 2019. The revised AGQS for PFAS compounds include lower standards for PFOS (15 ng/L) and PFOA (12 ng/L) with the addition of PFNA (11 ng/L) and PFHxS (18 ng/L).

4.2.1 Fall 2018

There were no detections of 1,4-dioxane in stormwater samples collected during the Fall 2018 stormwater investigation sampling efforts (**Table 3)**. Historic results for the L-1 seep are discussed in greater detail in the 2018 Annual Groundwater Monitoring Report.

PFAS was detected in each of the stormwater samples and in the L-1 seep sample during the Fall 2018 sampling event. Of the 26 PFAS compounds analyzed, PFOA and PFOS were detected at the highest concentrations at each location (**Table 3**). Concentrations of PFNA ranged from 405 ng/L (SB-2) to 1,060 ng/L at UP-2 and OFP-1 with PFHxS concentrations ranging from not detected (ND) to 35.6 ng/L (UP-2). Samples from stormwater sampling locations (SB-1/-2, PD-1/-2, OFP-1/-2, UP-1/-2) exceeded the USEPA SLs for a Child Recreator at 120 days (760 ng/L) for PFOS and PFOA with samples from UP-1 and UP-2 also exceeding the 45 day SL of 2,030 ng/L. The sample from OFP-1 exceeded the 45-day SL for PFOS only. In general, reported concentrations of PFAS in stormwater retention basin samples (SB-1/SB-2) are similar to those reported in their respective perimeter ditch samples (PD-1/PD-2). Reported PFAS concentrations at L-1 also exceed the revised AGQS for PFOS, PFOA, and PFNA (**Table 4**).

4.2.2 Spring 2019

There were no detections of 1,4-dioxane in stormwater samples collected during the Spring 2019 sampling efforts (**Table 3).** However, 1,4-dioxane was reported in the sample collected from the L-1 seep location at a concentration of 12 micrograms per liter (ug/L).

PFAS were detected in each stormwater sample and in the L-1 seep sample during the Spring 2019 sampling event. Of the 26 PFAS compounds analyzed, PFOA, PFOS, and PFNA were detected at the highest concentrations at each location (**Table 3**). Concentrations of these three compounds were reported at lower concentrations during the Spring 2019 event as opposed to those reported from the Fall 2018 sampling event at all locations, with the exception of PFOS at UP-1. At UP-1, PFOS was reported at only a slightly higher concentration during Spring 2019 (2,180 B ng/L) versus Fall 2018 (2,110 ng/L). Samples from stormwater sampling locations SB-1, UP-1, and PD-2 exceeded the USEPA SLs for a Child Recreator at 120 days (760 ng/L) for PFOS with UP-2 also exceeding the 45-day SL (2,030 ng/L). Samples collected from UP-1 and UP-2 exceeded both the 120-day and 45-day SL for PFOS. Reported concentrations of PFOS, PFOA, PFNA, and PFHxS at L-1 exceeded the NHDES AGQS (**Table 4**)**.**

Additionally, stormwater samples were analyzed for alkalinity, iron, ammonia, and nitrate during the Spring 2019 sampling event as per USEPA request in their March 7th, 2019 correspondence. Nitrate was not detected in any stormwater samples collected. Nitrate is typically not present or elevated in landfill leachate as it is a more oxidized form of nitrogen with leachate being a reducing environment and oxygen deficient. Ammonia is the more typical nitrogen-based compound in landfill leachate. Concentrations of alkalinity ranged from 14 mg/L (SB-2) to 91 mg/L (UP-2). Ammonia concentrations ranged from ND to 0.12 mg/L (OFP-1 Duplicate). The relatively low alkalinity and ammonia results indicate there is no significant leachate component of impacted groundwater in the stormwater-based samples as leachate is typically elevated for these parameters. Iron concentrations ranged from 0.26 mg/L (PD-2) to 3 mg/L (OFP-1 Duplicate).

4.3 Piezometer Sampling Results

There were no detections of 1,4-dioxane in samples collected 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 at 5.7 ug/L and 11 ug/L, respectively, exceeding the AGQS of 0.32 ug/L.

Reported PFAS concentrations in PZ-1 were similar between the two sampling events with concentrations reported during the Spring 2019 sampling event being generally lower than those reported during the Fall 2018, with the exception of PFNA. Concentrations ranged from 1,030 to 1,280 ng/L (PFOS), 979 to 1,390 ng/L (PFOA), 556 to 596 ng/L (PFNA), and 13.9 to 16.8 ng/L (PFHxS). Conversely, PFAS concentrations reported from the sample collected from PZ-2 during Spring 2019 were approximately half of those reported during the Fall 2018 event (**Table 3**). PZ-3 was only sampled during the Spring 2019 sampling event due to the date of installation but had similar reported PFAS concentrations to those in samples from PZ-2 and L-1. Samples collected from piezometers during the Fall 2018 and Spring 2019 sampling events exceeded the AGQS for PFOS, PFOA, and PFNA with no exceedances of PFHxS reported (**Table 3**).

Alkalinity, iron, and ammonia concentrations were elevated at all three piezometer locations during the Spring 2019 sampling event. Alkalinity ranged from 110 mg/L (PZ-1) to 370 mg/L (PZ-3) with iron concentrations ranging from 4.6 mg/L (PZ-1) to 49 mg/L (PZ-3). Ammonia concentrations ranged from 0.4 mg/L (PZ-1) to 18 mg/L (PZ-3), indicative of a component of impacted groundwater in samples collected from piezometers.

5.0 | STORMWATER SYSTEM INFILTRATION, DISCHARGE, AND GROUNDWATER INTERACTION

5.1 Stormwater System Infiltration Evaluation

Based on stormwater system design drawings, piezometer installations and elevation data for groundwater and surface water, an evaluation was performed to assess potential interaction between stormwater and groundwater.

Design documents indicate that stormwater basin elevations were selected to maintain a separation between shallow groundwater and the bottom of the stormwater basin. According to the Design Report, a separation distance of 2.3-feet and 2.7-feet were used in the design of the northeast basin (SB-1) and northwest basin (SB-2, respectively). During summer months, the stormwater basins are often dry, indicating that groundwater levels remain below the elevation of the bottom of the basins.

Historically, limited intermittent discharge has been observed from basin outfall pipes northeast and northwest of the landfill (OFP-1 and OFP-2) at times when the elevation of surface water in the stormwater basins (SB-1 and SB-2) is below the top of the outfall pipe inlet. This indicates some infiltration of shallow groundwater may be entering the annular space between the corrugated steel piping of the outfall system and surrounding bedding material during periods when shallow groundwater levels are high. OFP-1 and OFP-2 discharge to wetland areas north and northwest of the landfill, respectively, and these wetland areas appear to be supported by shallow groundwater discharge based on shallow overburden groundwater elevations and surface water elevations in the wetlands.

When discharge was not observed from the northeast stormwater retention basin outfall location (OFP-1) and the surface water elevation within the basin (SB-1) was below the inlet location for the outfall, minor seepage (<0.25 gallons per minute) was observed from the OFP-2 location concurrent with seepage observed at L-1. The presence of elevated iron concentrations in stormwater samples varies with the greatest concentrations reported in samples collected in OFP-1 and OFP-2. The presence of elevated iron concentrations in those samples may be indicative of some shallow groundwater infiltration into the outfall pipe locations; however, this infiltration is likely based on shallow groundwater elevation relative to potential pipe seepage locations with residence time of seepage short-lived due to water movement within the outfall pipe. Alkalinity and ammonia were also reported in outfall pipe samples collected during the Spring sampling event but could not be compared to historical concentrations, if any, due to these parameters having only been added for inclusion during the Spring 2019 sampling event. Elevated concentrations of iron, alkalinity, and ammonia in samples from L-1, PZ-1, PZ-2, and PZ-3 may also be indicative of periodic interaction between stormwater and shallow impacted groundwater.

5.2 Stormwater Infiltration Modeling

To estimate direct stormwater runoff from the cover system and quantity of water entering the underdrain collection system, numerical modeling and visual monitoring were employed. Modeling included use of the Hydrologic Evaluation of Landfill Performance (HELP) program developed for the USEPA by the U.S. Army Corps of Engineers Waterways Experiment Station. This model was developed to support the RCRA and Superfund programs. It applies to open, partially closed, and fully closed sites. Landfill systems that can be modeled include various combinations of vegetation, cover soils, lateral drain layers, low permeability barrier soils, and synthetic geomembrane liners. The model calculates daily, monthly, annual, and average annual estimates and provides estimates of runoff, evapotranspiration, drainage, infiltration, and liner leakage. The HELP program was the same one used in the design of the landfill cap.

Stormwater modeling was completed for multiple “watershed areas” of the landfill surface contributing to the underdrain (UDP) or perimeter ditch (PD) systems as defined in the Surface Water Management System Layout (Drawing 5-13) of the Design Report. Several watershed areas outside of defined landfill boundaries were not modeled due to insufficient information on defined lateral extents or construction information

Modeling was performed using an average annual precipitation of 59.55 inches, based on reported precipitation received during 2018 with data downloaded from available National Oceanic and Atmospheric Administration (NOAA) sources. Precipitation data from 2018 was selected to provide a year-long data set to coincide with analytical data collected in 2018], Using an average annual precipitation value falling over 24.18 acres (area of modeled landfill surface) results in a total of approximately 39 million gallons of water (**Table 5**) falling on the landfill annually. Of this total precipitation volume, the model showed approximately 24 percent (9 million gallons) results in surface runoff with 36 percent (14 million gallons) infiltrating the landfill cap. Another 40 percent (16 million) of the total precipitation returns to the atmosphere through evapotranspiration based on the presence of an established vegetative layer.

Assuming a long-term steady state condition, water that infiltrates the landfill cap (approximately 14 million gallons) would eventually enter the underdrain system. It should be noted that the HELP model utilizes an assigned value for leakage through small perforations in the FML or imperfections in FML seams. These imperfections are modelled based on a number of perforations per unit surface area of liner. In total, the default amount of water that is modeled to penetrate the landfill cap FML is 0.22 percent (approximately 88,000 gallons) per year.

It should be noted that 2018 precipitation data is higher than long-term average precipitation data by approximately 20%. In an effort to use comparable long-term average data, the mass loading estimates described below utilize an adjusted average annual precipitation of 46 inches compared to the 59 inches recorded in 2018.

5.2.1 PFAS Mass Discharge in Stormwater

Based on the calculated volumes of stormwater runoff and underdrain discharge and using an average PFAS concentration from the Fall 2018 and Spring 2019 stormwater analytical results, an annual mass of contaminants being discharged in stormwater can be calculated. For the purposes of this investigation, the average PFAS concentration is the sum of PFOA, PFOS, PFNA, and PFHxS. Where appropriate, surface water and stormwater analytical results will be compared to the USEPA's Site specific SLs while groundwater analytical results would be compared to proposed NHDES AGQS.

The average combined concentration of these compounds in underdrain water samples (UP-1 and UP-2) during the Fall 2018 and Spring 2019 sampling events is approximately 5,100 ng/L. The volume of water estimated to discharge to the underdrain system annually is approximately 11.2 million gallons (42 million liters). As a result, approximately 0.48 pounds (216 grams) of PFAS is estimated to be discharged annually from the underdrain system.

The average combined concentration of these compounds in direct surface runoff was based on samples from the perimeter ditch (PD-1, PD-2) and northwest stormwater basin (SB-2) water samples during the Fall 2018 and Spring 2019 sampling events and is approximately 2,400 ng/L. [Note that SB-1 is not included due to mixing of underdrain discharges with basin water.] The volume of water estimated to discharge as surface runoff annually is approximately 7.2 million gallons (27 million liters). As a result, approximately 0.14 pounds (65 grams) of PFAS is estimated to be discharged annually via direct surface runoff.

Total mass of PFAS being discharged from the 24-acre landfill surface as a result of storm events is estimated to be on the order of 0.62 pounds or 281 grams or annually.

5.2.2 PFAS Mass Discharge via Groundwater

Estimating potential contribution of PFAS via ground water discharge is significantly more complex due to spatial variability of groundwater quality monitoring data and partitioning groundwater discharges in outwash, glacial till and marine deposits that are present along the groundwater pathway from the landfill to the wetland complex. However, using the following simplifying assumptions allows one to make an order of magnitude estimate.

- Water quality in overburden monitoring wells west of the landfill (MW-9, MW-10, and AE-2) is representative of water quality discharging to the wetland complex.

and that direct bedrock discharge to the wetlands or Berry's Brook is not occurring. It should be noted that PFAS concentrations in bedrock wells near the western boundary of the landfill are less than those reported in samples from overburden wells.

- The discharge area of impacted groundwater to the wetland complex and/or Berry's Brook is conservatively estimated to be approximately 40 acres in size. This area encompasses the wetland complex directly west of the landfill and extends north past FPC-5A and MW-21S (**Figure 3**).
- An average concentration of PFAS (4 compounds) is approximately 1,200 ng/L within overburden groundwater.
- The presence of 1,4-dioxane in groundwater quality monitoring samples indicates a groundwater migration pathway from (or interacting with) landfill waste. The presence of PFAS in groundwater samples containing 1,4-dioxane may indicate a PFAS source separate from stormwater runoff, where 1,4-dioxane has not been detected.

A web-based Geographic Information Systems (GIS) StreamStats report from the USGS website was generated for the section of the Berry's Brook watershed from the source area of the watershed to a stream gauge located on Sagamore Road. This report provided information pertaining to this section of watershed including mean annual precipitation (45.9 inches) and mean annual groundwater recharge (22.3 inches).

Using a flux of groundwater equal to 22.3 inches of recharge over the 40 acres, results in a volume of approximately 24 million gallons (91 million liters). Assuming an average PFAS concentration of 1,200 ng/L in overburden groundwater, the mass of PFAS discharging to the wetland complex annually via groundwater is calculated to be 109 grams (0.24 pounds).

5.2.3 PFAS Mass Discharge – Berry's Brook

Using an annual recharge of 22.3 inches as the base flow contribution from groundwater to Berry's Brook, and calculating the watershed area above an established surface water sampling point (SW-110) at a culvert under Breakfast Hill Road, an estimate of PFAS mass being contributed from the upstream watershed can be made.

The watershed area of Berry's Brook above Breakfast Hill Road is estimated to be 312 acres, not including the 24-acre landfill footprint discussed above (i.e., little if any groundwater recharge is occurring beneath the landfill cover system). An annual recharge of 22.3 inches results in a total recharge volume of 189 million gallons (715 million liters) within the 312 acres. Semiannual sampling completed at surface water location SW-110 in 2018 and Spring of 2019 detected an average of 207 ng/L for the 4 PFAS compounds discussed in **Section 5.2.1**. The resulting mass of PFAS is 0.32 pounds (143 grams).

The estimated average annual contributions of PFAS from stormwater (281 grams) plus groundwater discharge (109 grams), exceeds the mass estimate of PFAS calculated in

Berry's Brook (143 grams) by a factor of 2.5. The discrepancy is likely due to one or more of the following:

- The "average" PFAS concentration in stormwater samples is based on two sampling events and is biased high. The range of concentrations in stormwater samples varied significantly and the calculated average may not be representative of long-term steady state conditions.
- The tendency for PFAS compounds to bind with organic matter may result in PFAS being retained in the wetland complex with only a portion of the total PFAS entering the complex leaving through surface water flow in Berry's Brook.
- A portion of stormwater discharged via the northwest underdrain (UP-2) may mix with shallow groundwater near the western and northwestern edge of the landfill where the highest overburden groundwater concentrations have been detected (i.e., MW-9 and MW-10). UP-2 discharges to the ground surface at a rip rap swale approximately 150 feet from these monitoring wells. Groundwater is on the order of 3 feet below ground surface in this area and a portion of stormwater discharged at UP-2 may infiltrate through shallow overburden to the water table prior to discharging to the wetland. As a result, a portion of the PFAS mass assumed to discharge in stormwater may be "double counted" if it also contributes to the groundwater PFAS mass.
- General variability of data spatially and temporally in natural systems may result in a bias when assigning "average" values to multiple inputs resulting in a wider range of output values.

5.3 Discharge Monitoring

Discharge monitoring was completed at the request of the USEPA in their March 7th, 2019 email correspondence. Specifically, the USEPA and NHDES suggested that correlation between duration and intensity of rainfall events to the duration and intensity of discharge within the stormwater management system (basin outfalls and underdrain piping) may assist in understanding stormwater retention times in the landfill cover system. The monitoring was used to record precipitation event start and stop times and record duration of discharge from the underdrain and outfall piping. The photo-documentation also served to provide images that could be used in the estimation of discharge rates from the underdrain piping. Monitoring included the deployment of a camera to record a visual record of underdrain and outfall pipe discharge locations. Precipitation events (duration and measurable precipitation amounts) were downloaded from publicly available online resources and correlated with the photographic record. This information aided in the evaluation of lag time between precipitation and discharge from stormwater system components (UDP-1/-2 and OFP-1/-2), quantify discharge estimates from system components, and evaluate discharge duration from monitored locations.

The northwest underdrain system, based on measured lengths of piping from Drawing 5-13 of the Design Report (**Appendix A**), is comprised of approximately 6,300 feet of collection and conveyance piping, more than twice that of the northeast system. This additional amount of drainage area resulted in the modification of original design drawings to allow for the discharge of UDP-2 to be separated from SB-2 and be constructed as a separate discharge location. The additional length of collection piping results in a greater amount and duration of flow from UDP-2 than that of UDP-1 based on flow rates observed at the time of sample collection and camera footage of pipe discharge discussed below.

The northwest underdrain (UDP-2) was monitored from April 17, 2019 to June 3, 2019 and recorded precipitation during five separate events. The amount of precipitation recorded during these events varied from 0.05 to 1.81 inches and occurred over periods ranging from 8 to 72 hours (**Figure 4**). On average, the lag time between the start of a precipitation event and the beginning of observed discharge from UDP-2 was between 6 to 10 hours. The lag time would be expected to vary based on the amount of residual water present in the cap soils (soil moisture), time between successive precipitation events, and rate of precipitation. Heavier rates of precipitation and greater periods of time between events result in a greater percentage of water being diverted as direct surface runoff. Lower precipitation rates over extended periods of time result in a shorter lag time. The same relationship was observed for the length of time discharge occurs from the underdrain system following initial water flow. Longer durations of precipitation appear to lead to extended periods of underdrain discharge due to a greater percentage of water infiltrating through the landfill cap to the underdrain system.

For example, the precipitation event on April 26th, 2019 was recorded as 1.81 inches and occurred over a period of 26 hours. This event was preceded by an event of 0.63 inches over a 20-hour period on April 22nd, 2019. The landfill cap is believed to have had a higher initial soil moisture content prior to the onset of the April 26th event, though not saturated (three days between events), with a longer period of peak discharge and higher rate of gravity drainage versus that observed from the April 22nd event. Minimal measurable precipitation (<0.05 inches) occurred approximately 24 hours prior to the April 22nd event, resulting in a lower initial soil moisture content prior to the onset of the April 22nd event.

The peak discharge is illustrated as the rise in discharge and typically short duration plateau before tapering to a more consistent flow for an extended period of time following a precipitation event. This discharge rate then reduces further before ending completely.

The event of May 13th was recorded as 0.9 inches and occurred over an approximately 34-hour period. The peak discharge was shorter in duration (approx. 4 hours) compared to precipitation events on 4/22 and 4/26 but had a longer period of reduced flow. This is believed to be a result of a lower overall rate of precipitation allowing for a more complete saturation of landfill cap soils allowing for the extended period of observed underdrain discharge. The event of May 2nd, 2019 received approximately half (0.55 inches) the amount of precipitation of the May 13th event but occurred over a period twice that of the same event. There was little to no observed peak discharge with most being that of a rate similar to that of the interpreted gravity drainage (<0.02 cubic ft/sec). It is interpreted that the lower overall rate of precipitation resulted in the landfill cap allowing for a more controlled passage of precipitation through the cap soils and into the underdrain system. The period of time between the May 2nd and May 13th event allowed sufficient time for the cap material to drain and accept the 0.9 inches from the May13th event, resulting in a short but observable change in discharge rate. UDP-2 discharge was monitored again from July 3rd, 2019 to July 19th, 2019 with no observable discharge from the underdrain despite recorded precipitation events on July 7th and 12th of 0.10 and 0.48 inches, respectively. This likely indicates that most precipitation was absorbed by the landfill cap due to only 0.05 inches of recorded precipitation since June 20th, 2019.

The northeast underdrain (UDP-1) was monitored from June 3rd, 2019 to July 3rd, 2019 and recorded precipitation during five separate events. The amount of precipitation recorded during these events varied from 0.05 to 1.44 inches and durations being between 6 and 26 hours (**Figure 4**). The lag time between the start of a precipitation event and discharge from the underdrain ranged from 4 (6/12/19) to 12 hours (6/19/19). Longer lag times, when compared to that of UDP-2, are interpreted to be related to less collection area and fewer contributions from areas of lower slope (e.g. Area 3) where more precipitation is infiltrated. A greater percentage of UDP-1 collection piping is in areas of higher slope where more precipitation results in increased surface runoff to the perimeter ditches. In general, the discharge rates from UDP-1 are lower than those estimated from UDP-2 and are related to collection area and available contribution. Though similar changes in flow rate are observed between UDP-1 and UDP-2, peak discharge rates were shorter in duration.

Outfall pipe discharge was monitored at the OFP-2 discharge location from July 17th to August 9th, 2019. Monitoring was not completed at the OFP-1 location due to an increased likelihood for discharge to occur at OFP-2 during the monitoring period based on amount of water received in the northwest stormwater retention basin. Approximately 1.89 inches of precipitation was received from July 22nd to July 25th, 2019, with the greatest amount (1.76 inches) received on July 23rd. Discharge from OFP-2 began approximately 6 hours following the start of precipitation (exact onset of precipitation not recorded) and continued approximately one day following the end of the precipitation event until July 26th, 2019. Discharge from OFP-2 may have been limited due to the stormwater retention basin being dry at the onset of precipitation with the basin showing no measurable water at the start of recording on July 17th, 2019. Monitoring was ongoing at the time of this report to capture precipitation events sufficient enough to result in discharge from the outfall pipe.

6.0 | FINDINGS AND CONCLUSIONS

The stormwater investigation discussed in this report was completed in accordance with the *Draft Stormwater Investigation Work Plan* issued on September 10, 2018 and conditionally approved by the USEPA on September 26, 2018. In addition to the scope of work presented in the Work Plan, additional tasks were added to the scope of work based on subsequent requests and suggestions made by the USEPA and NHDES in email correspondence as the investigation proceeded.

6.1 Findings

Based on the activities completed as part of the stormwater investigation, the following findings have been made:

- PFAS was detected in all stormwater samples, with samples from underdrain piping (UP-1 and UP-2) 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. 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 waste. These data indicate that the source of PFAS in stormwater samples is not due to interaction of stormwater with landfill waste.
- 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, along with elevated iron detected in samples collected from OFP-1, L-1, PZ-1, PZ-2, and PZ-3 indicates that shallow groundwater beyond the landfill boundary interacts with discharges from the northwest outfall pipe (OFP-2) during periods of high overburden groundwater levels.
- Concentrations of PFAS in underdrain samples were higher in samples collected during the Fall 2018 compared to those collected during Spring 2019. This may be due to the effects of evapotranspiration during summer months which limits the amount of water infiltrating through cover soil. Residual soil moisture may have extended contact time throughout the summer and as evapotranspiration effects decline in the Fall, discharges may reflect flushing of the soil moisture having longer contact time with soil.
- The highest concentration of PFAS in cover system materials was detected in the topsoil/vegetation layer with lower concentrations in underlying common borrow soil. PFAS was not detected in the sand drainage layer. The topsoil used at the Site was a combination of locally sourced topsoil, compost from multiple sources and sand from a local source.
- Although a number of variables influence calculations of PFAS mass being discharged in stormwater and groundwater, those estimates suggest that both stormwater and groundwater contribute PFAS to the wetland complex and ultimately Berry's Brook.
- Plots of PFAS results (i.e., compositional makeup) show similarity between stormwater samples and shallow overburden groundwater in the vicinity of MW-9 and 10, located near the northwest underdrain discharge (UP-2) swale (**Figure 1**).

6.2 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 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 where UP - 2 discharges to the ground surface, indicating a likelihood of mixing between stormwater and groundwater in this area.

Estimates of PFAS mass discharge indicates that stormwater and groundwater contribute significant percentages of PFAS to the wetland complex. However, analytical results from surface water sampling at various locations inside and outside of the Groundwater Management Zone (GMZ) show that concentrations of PFAS in surface water are well below USEPA's site-specific SLs at the GMZ boundary. Only 2 locations in close proximity (< 300 feet) to the landfill detected PFAS concentrations above the Screening Levels.

7.0 | REFERENCES

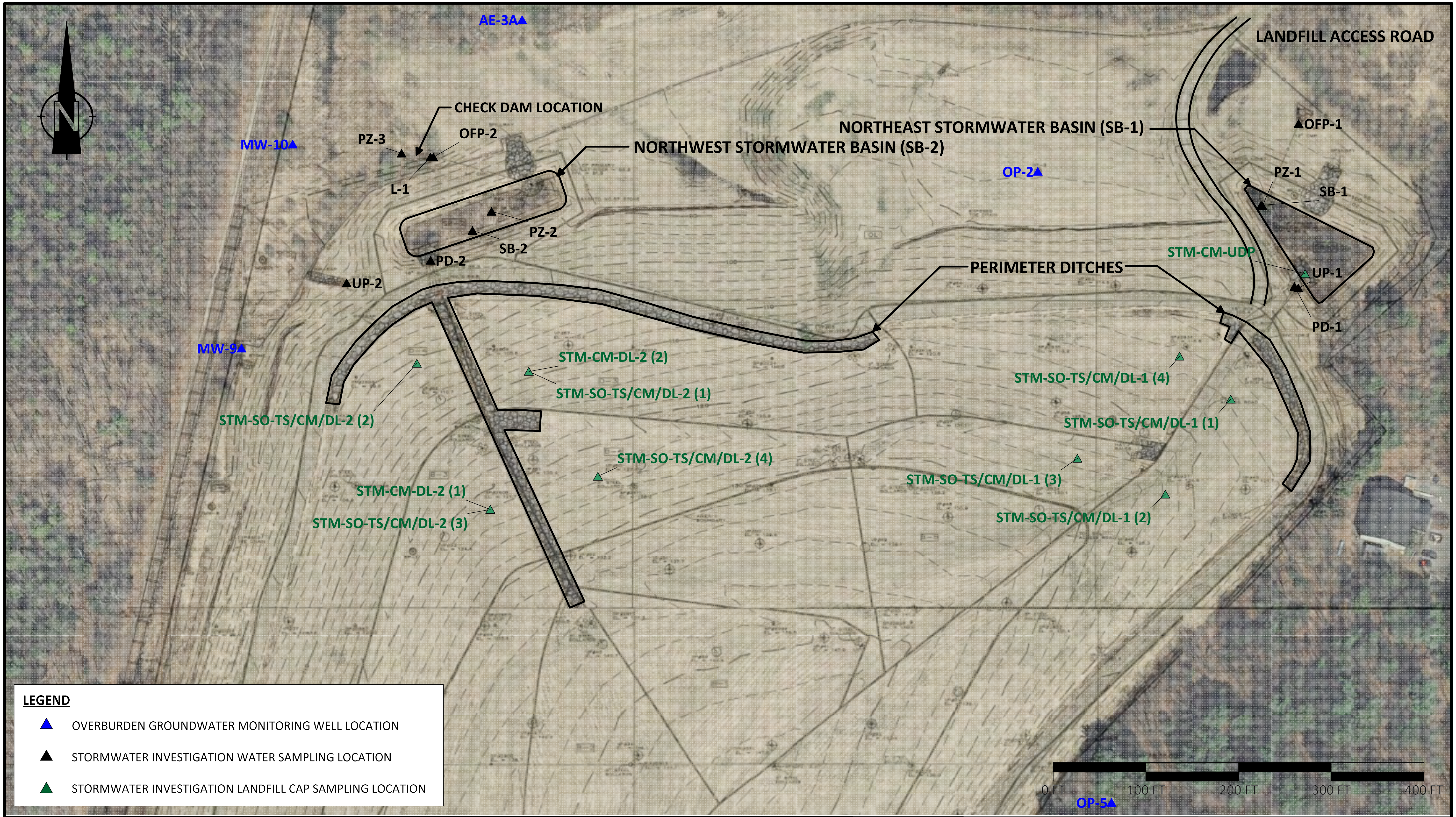
CES, Inc. (2017), Quality Assurance Project Plan (Revision 1), Coakley Landfill Superfund Site, North Hampton and Greenland, New Hampshire (September 2017). Prepared by CES, Inc. for The Coakley Landfill Group

CES, Inc. (2018), Sampling and Analysis Plan, Coakley Landfill Superfund Site, North Hampton and Greenland, New Hampshire (July 2018). Prepared by CES, Inc. for The Coakley Landfill Group

Golder Associates, Inc. (1996), Final (100%) Design Report, Coakley Landfill, North Hampton, New Hampshire (May 1996). Prepared by Golder Associates, Inc. for The Coakley Landfill Group

Golder Associates, Inc. (1998), Remedial Cap Construction Report, Coakley Landfill Superfund Site, North Hampton, New Hampshire (October 1998). Prepared by Golder Associates, Inc. for The Coakley Landfill Group

FIGURES



PROJECT TITLE:

COAKLEY LANDFILL SUPERFUND SITE
NORTH HAMPTON & GREENLAND, NEW HAMPSHIRE

SHEET TITLE

STORMWATER SAMPLING AND GAUGING LOCATIONS

DWG
FIGURE 1

JN: 10424.020

SCALE AS SHOWN

BY: CFB

DATE 2019-09-24

APPROVED BY MAD

CHECKED BY CFB

REV:

REV DATE

ISSUE

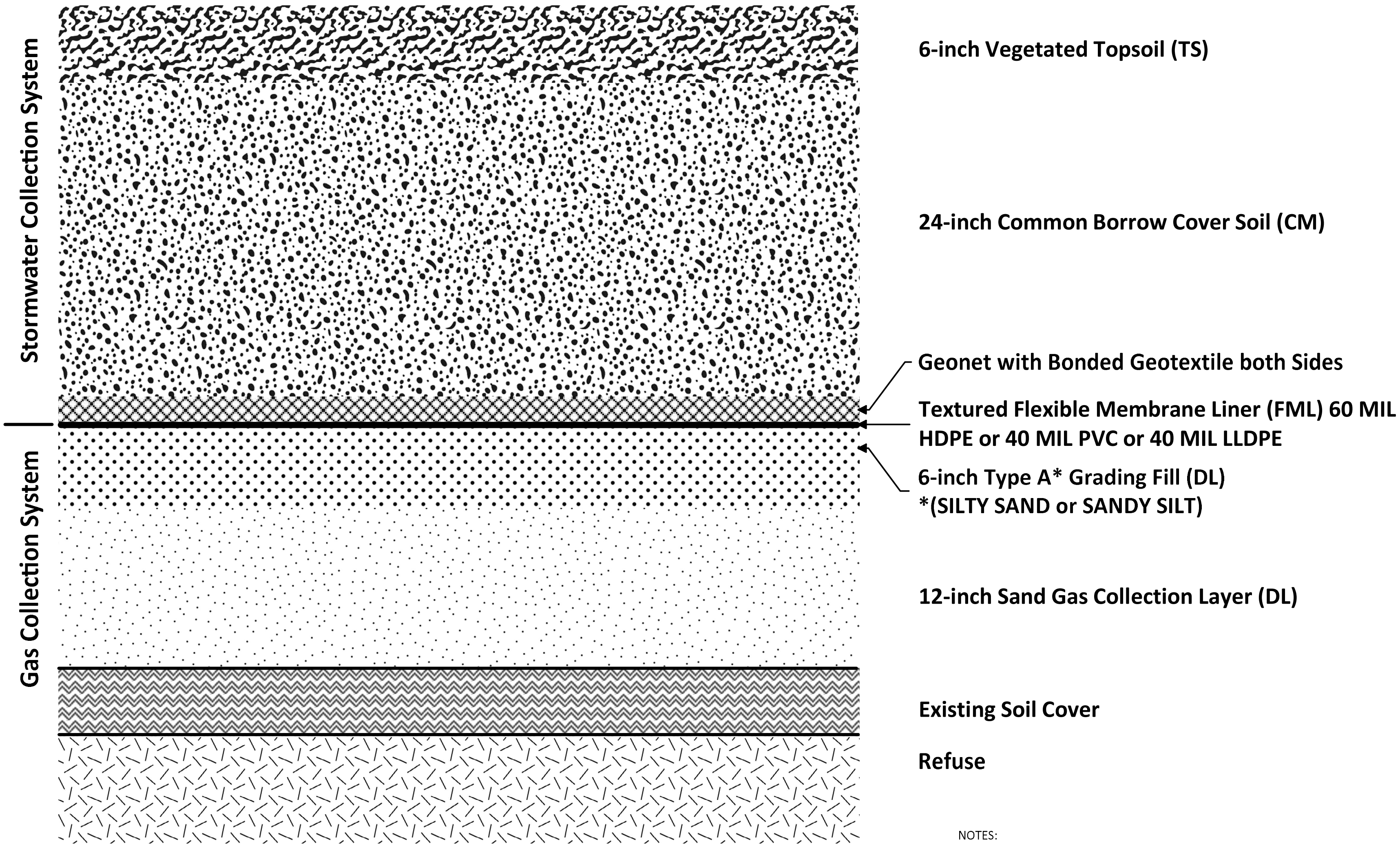
ISSUE DATE

NOTE

EXISTING CONDITIONS BASEMAP FROM PLAN TITLED "AS-BUILT SURVEY OF THE COAKLEY LANDFILL, BREAKFAST HILL ROAD, NORTH HAMPTON, N.H." PREPARED BY RICHARD D. BARTLETT & ASSOCIATES, INC. DATED SEPT. 23, 1998.

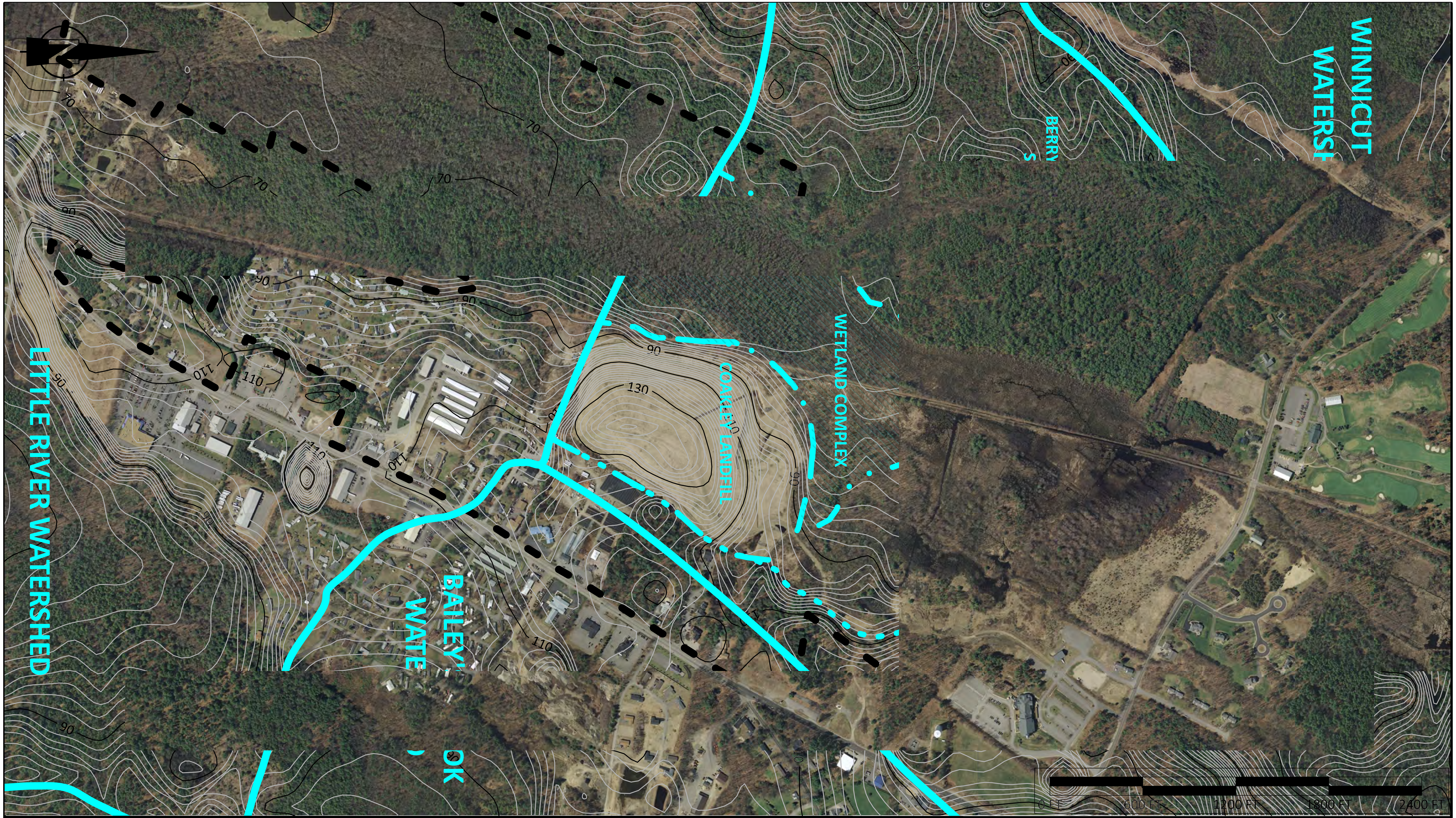
COVER MATERIAL SAMPLE IDENTIFICATION NOMENCLATURE IS BASED ON SAMPLE MATERIAL AND LOCATION. STM-STORMWATER, SO-SOIL, SB-STORMWATER BASIN, UP-UNDERDRAIN PIPE, PD-PERIMETER DITCH, OFP-OUTFALL PIPE, TS-TOPSOIL, CM-CONSTRUCTION MATERIAL, DL- DRAINAGE LAYER, (1)-COMPOSITE SAMPLE NUMBER.

CES INC
Engineers • Environmental Scientists • Surveyors



NOTES:
1 - Landfill cap materials sampled as part of Stormwater Investigation Work Plan dated October 24, 2018 were completed within landfill side slopes with Type 4 cap details within Area 2 portions of the landfill having >5% to >20% slopes.
2 - Details referenced from Coakley Landfill 100% Remedial Design Report - Drawing 5-5 "Cap Layout and Cap Sections".

PROJECT TITLE: COAKLEY LANDFILL SUPERFUND SITE NORTH HAMPTON & GREENLAND, NEW HAMPSHIRE	DWG: FIGURE 2	BY: CFB DATE: 2019-09-16	CES INC Engineers • Environmental Scientists • Surveyors
SHEET TITLE: LANDFILL SIDE SLOPE CAP DETAILS - TYPE 4 CAP TYPE	JN: 10424.020 SCALE: AS SHOWN	REV: REV DATE:	



PROJECT TITLE:
COAKLEY LANDFILL SUPERFUND SITE
NORTH HAMPTON & GREENLAND, NEW HAMPSHIRE

SHEET TITLE
COAKLEY LANDFILL WATERSHED BOUNDARY LOCATIONS

DWG
FIGURE 3

JN: 10424.020

SCALE AS SHOWN

BY: CFB

DATE 2019-09-18

APPROVED BY MAD

CHECKED BY CFB

REV:

REV DATE

ISSUE

ISSUE DATE

NOTE
1. GMZ BOUNDARY IS BASED UPON "GMZ BOUNDARY PLAN" DATED MAY 9, 2008 INCLUDED IN THE 2008 GMP APPLICATION PREPARED BY HANCOCK ASSOCIATES AND 2013 GMZ EXPANSION AREA ESTABLISHED BY THE 2013 GMP DATED JANUARY 7, 2014.
2. GIS DATA COURTESY OF NEW HAPSHIRE ONLINE GRANIT DATABASE.
3. MAP IS PROJECTED USING THE NEW HAMPSHIRE STATE PLANE PROJECTION, US FEET AND REFERENCES THE NORTH AMERICAN VERTICAL DATUM OF 1983.

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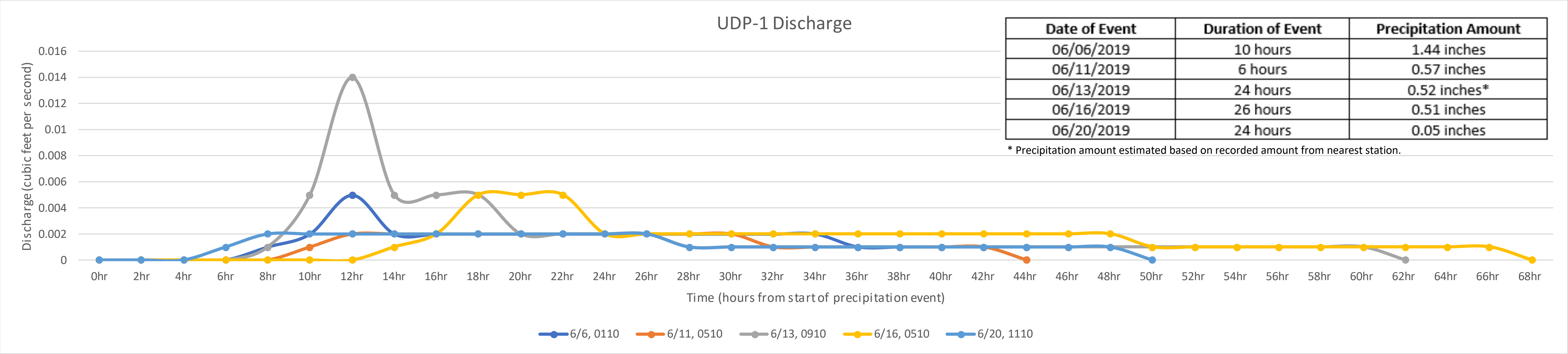
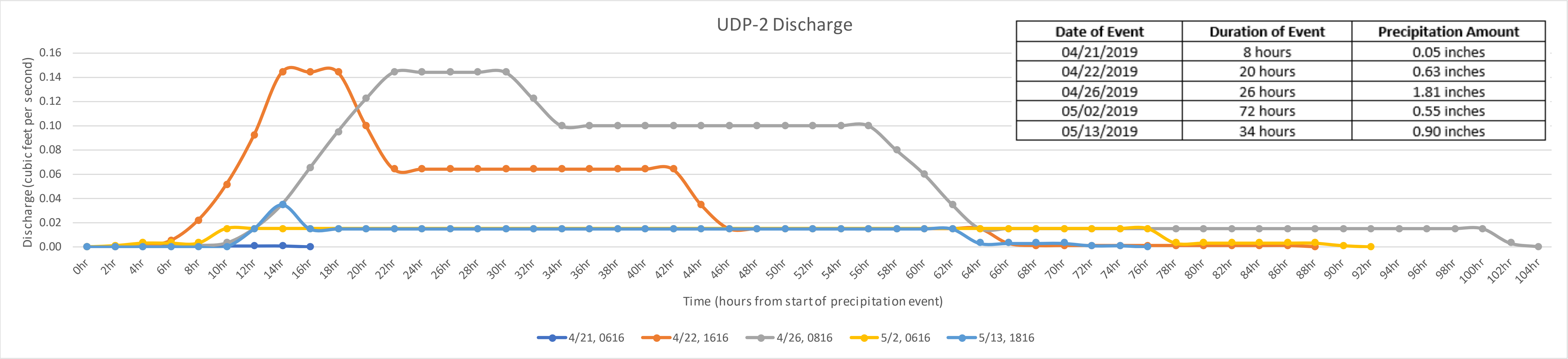


Date of Event	Duration of Event	Precipitation Amount
06/06/2019	10 hours	1.44 inches
06/11/2019	6 hours	0.57 inches
06/13/2019	24 hours	0.52 inches*
06/16/2019	26 hours	0.51 inches
06/20/2019	24 hours	0.05 inches

* Precipitation amount estimated based on recorded amount from nearest station.



Date of Event	Duration of Event	Precipitation Amount
04/21/2019	8 hours	0.05 inches
04/22/2019	20 hours	0.63 inches
04/26/2019	26 hours	1.81 inches
05/02/2019	72 hours	0.55 inches
05/13/2019	34 hours	0.90 inches

PROJECT TITLE:
COAKLEY LANDFILL SUPERFUND SITE
NORTH HAMPTON & GREENLAND, NEW HAMPSHIRE

SHEET TITLE:
LANDFILL CAP UNDERDRAIN DISCHARGE
RATES AND DURATION

DWG: **FIGURE 4**
JN: 10424.020
SCALE: AS SHOWN

BY: CFB
DATE: 09.16.2019
APPROVED BY: CFB
CHECKED BY: MAD

REV:
REV DATE:
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NOTE:

CES INC
Engineers • Environmental Scientists • Surveyors

TABLES

TABLE 1

Summary of Groundwater and Surface Water Elevation Data
Stormwater Investigation Report
Coakley Landfull Superfund Site
North Hampton and Greenland, New Hampshire

	Easting NH State Plane NAD 1983 Feet	Northing NH State Plane NAD 1983 Feet	Ref. Pt Elev. (FT. NGVD)	Fall 2018 GW. EL. FT.	Spring 2019 GW. EL. FT.	Comments
Operable Unit 1						
MW-9	1211077.36	183947.41	81.70	76.55	76.33	Top of Riser
MW-10	1211132.54	184167.68	79.10	73.46	73.62	Top of Riser
OP-2	1211936.99	184138.16	99.00	93.35	93.89	Top of Riser
OP-5	1212016.54	183457.15	108.40	93.39	94.29	Top of Riser
Operable Unit 2						
AE-3A	1211380.24	184301.83	85.00	77.18	76.83	Top of Riser
FPC-5A	1210979.69	184509.92	73.80	73.46	71.98	Top of Riser
FPC-6A	1210835.64	185063.10	78.19	72.43	74.33	Top of Riser
FPC-7A	1211925.71	185037.99	87.60	87.27	87.18	Top of Riser
FPC-9A	1212479.83	183576.85	114.10	93.85	94.28	Top of Riser
Stormwater						
PZ-1	1212179.59	184101.08	99.50	95.25	96.41	Top of Riser
PZ-2	1211347.26	184095.08	84.50	82.38	83.04	Top of Riser
PZ-3	1211250.12	184157.76	81.58	NA	78.60	Top of Riser
L-1	1211281.31	184153.70	78.50	77.19	77.94	Top of Staff Gauge
OFP-1	1212218.65	184189.78	93.20	NA	NA	Invert Elevation of Pipe
OFP-2	1211190.95	184018.72	76.90	NA	NA	Invert Elevation of Pipe
PD-1	1212214.11	184013.95	101.80	NA	NA	Invert Elevation of Pipe
PD-2	1211281.47	184042.12	87.10	NA	NA	Invert Elevation of Pipe
UP-1	1212218.32	184012.51	100.30	NA	NA	Invert Elevation of Pipe
UP-2	1211190.93	184017.80	83.20	NA	NA	Invert Elevation of Pipe
SB-1	1212178.05	184101.54	97.70	97.20	96.44	Top of Staff Gauge
SB-2	1211326.74	184074.27	84.00	81.74	80.93	Top of Staff Gauge
Surface Water						
SW-5	1211286.92	184845.04	75.00	74.04	74.20	Top of Staff Gauge
SW-103	1211367.44	185228.27	74.80	73.52	73.71	Top of Staff Gauge
SW-110	1211874.68	187243.98	68.70	67.21	67.15	Top of Staff Gauge
BB-1	1211763.51	186949.74	72.00	71.74	71.56	Top of Steel Pin
BB-2	1211500.44	185818.19	73.50	72.59	72.44	Top of Steel Pin
LRB - Little River	1208971.20	179648.17	68.90	65.32	64.69	Top of Concrtete Headwall

NOTES:

Elevations and Locations of refernce points were surveyed by TF Moran on 11/16/18 and 3/25/19.

TABLE 2
Landfill Cover Material Analytical Results
Stormwater Investigation Report
Coakley Landfill Superfund Site - North Hampton and Greenland, New Hampshire

SAMPLE IDENTIFICATION	SOILS						CONSTRUCTION MATERIALS	
	STM SO-CM 01	STM SO-CM 02	STM SO-TS 01	STM SO-TS 02	STM SO-DL-01	STM SO-DL-02	STM CM DL 01	STM CM UDP
MATERIAL TYPE	**Cover Soil**	**Cover Soil**	**Topsoil**	**Topsoil**	**Grading Fill/Sand**	**Grading Fill/Sand**	**Geotextile**	**HDPE Pipe**
DATE SAMPLED	**12/4/2018**	**12/4/2018**	**12/4/2018**	**12/4/2018**	**12/20/2018**	**12/20/2018**	**12/20/2018**	**12/4/2018**
PERFLUORINATED CHEMICALS BY MODIFIED 537 - (mg/kg)								
Perfluorobutanoic Acid (PFBA)	0.000139 U	0.000137 U	0.000416 J	0.000671 J	0.000134 U	0.000138 U	0.000131 U	0.000106 U
Perfluoropentanoic Acid (PFPeA)	0.000200 U	0.000198 U	0.000748 J	0.001090 J	0.000194 U	0.000199 U	0.000189 U	0.000153 U
Perfluorohexanoic Acid (PFHxA)	0.000201 U	0.000199 U	0.000639 J	0.000717 J	0.000194 U	0.000200 U	0.000190 U	0.000154 U
Perfluoroheptanoic Acid (PFHpA)	0.000203 U	0.000200 U	0.000994 J	0.001150 J	0.000196 U	0.000202 U	0.000192 U	0.000156 U
Perfluorohexane Sulfonate (PFHxS)	0.000307 U	0.000303 U	0.000455 J	0.000497 J	0.000297 U	0.000306 U	0.000290 U	0.000235 U
6:2 Fluorotelomer Sulfonic Acid (6:2 FTS)	0.000227 U	0.000224 U	0.000226 U	0.000229 U	0.000219 U	0.000226 U	0.000214 U	0.000174 U
Perfluoroheptane Sulfonic Acid (PFHpS)	0.000168 U	0.000166 U	0.000168 U	0.000170 U	0.000163 U	0.000168 U	0.000159 U	0.000129 U
Perfluorononanoic Acid (PFNA)	0.000579 J	0.001510 J	0.00332	0.00408	0.000171 U	0.000176 U	0.000313 J	0.000135 U
Perfluorooctane Sulfonamide (PFOSA)	0.000225 U	0.000222 U	0.00388	0.00425	0.000217 U	0.000390 J	0.000212 U	0.000172 U
Perfluorodecanoic Acid (PFDA)	0.00275	0.00369	0.0115	0.0137	0.000245 U	0.000253 U	0.000724 J	0.000194 U
8:2 Fluorotelomer Sulfonate (8:2 FTS)	0.000282 U	0.000279 U	0.0024	0.00297	0.000273 U	0.000281 U	0.000266 U	0.000216 U
N-Methyl Perfluorooctane Sulfonamidoacetic Acid (MeFOSAA)	0.000299 U	0.000295 U	0.000882 J	0.000739 J	0.000289 U	0.000298 U	0.000282 U	0.000229 U
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (EtFOSAA)	0.000318 U	0.000314 U	0.00593	0.00682	0.000308 U	0.000317 U	0.000300 U	0.000244 U
Perfluoroundecanoic Acid (PFUnA)	0.000928 J	0.000979 J	0.0106	0.0107	0.000339 U	0.000349 U	0.000528 J	0.000269 U
Perfluorodecane Sulfonate (PFDS)	0.000533 J	0.000524 J	0.00592	0.00506	0.000193 U	0.000198 U	0.000188 U	0.000153 U
Perfluorododecanoic Acid (PFDoA)	0.000314 J	0.000270 U	0.00543	0.00588	0.000264 U	0.000272 U	0.000315 J	0.000210 U
N-Methyl Perfluorooctane Sulfonamide (MeFOSA)	0.000934 U	0.000922 U	0.000931 U	0.000945 U	0.000903 U	0.000931 U	0.000881 U	0.000716 U
Perfluorotridecanoate (PFTrDA)	0.000121 U	0.000119 U	0.001060 J	0.001210 J	0.000117 U	0.000120 U	0.000114 U	0.0000926 U
Perfluorotetradecanoic Acid (PFTeDA)	0.000196 U	0.000194 U	0.001080 J	0.001000 J	0.000190 U	0.000195 U	0.000185 U	0.000150 U
N-Ethyl Perfluorooctane Sulfonamide (EtFOSA)	0.000133 U	0.001310 U	0.001320 U	0.001340 U	0.001280 U	0.001320 U	0.001250 U	0.001020 U
Perfluorohexadecanoic Acid (PFHxDA)	0.0000346 U	0.0000341 U	0.000148 J	0.000145 J	0.0000334 U	0.0000344 U	0.0000326 U	0.0000265 U
N-Methyl Perfluorooctane Sulfonamidoethanol (MeFOSE)	0.001930 U	0.001910 U	0.006210 J	0.006210 J	0.001870 U	0.001920 U	0.001820 U	0.001480 U
N-Ethyl Perfluorooctane Sulfonamidoethanol (EtFOSE)	0.001000 U	0.000988 U	0.001200 J	0.001040 J	0.000968 U	0.000997 U	0.000944 U	0.000767 U
Perfluorobutane Sulfonic Acid (PFBS)	0.000359 U	0.000355 U	0.000359 U	0.000364 U	0.000348 U	0.000358 U	0.000339 U	0.000276 U
Perfluorooctanoic Acid (PFOA)	0.000497 J	0.000755 J	0.00365	0.00425	0.000226 U	0.000233 U	0.000386 J	0.000179 U
Perfluorooctane Sulfonate (PFOS)	0.00648	0.012	0.0279	0.0396	0.000809 U	0.000834 U	0.00317	0.000642 U

NOTES:

1. J = Estimated concentration below the reporting limit.
2. Q = Ion ratio outside of the 70 - 130 % standard ratio.
3. U = Not detected above the reporting limit
4. ND = Not detected
5. STM-SO-CM =- Cover Soil Common Borrow (frost protection) Layer Soil Sample
6. STM-SO-TS - Top Soil (vegetative layer) Sample
7. STM-SO-DL = Grading Fill/Sand Drainage Layer Sample
8. STM-CM-UDP = Construction Material Under Drain Pipe (HDPE) Sample
9. STM-CM-DL = Construction Material Geotextile Fabric over Sand Drainage Layer
10. **Bold** denotes concentrations reported above the applicable reporting limit/Limit of Quantitation

TABLE 3
Summary of Stormwater Analytical Data
Stormwater Investigation Report
Coakley Landfill Superfund Site - North Hampton and Greenland, New Hampshire

	Northeast Stormwater Basin									Northeast Underdrain		NHDES AGQS	USEPA Screening Levels		USEPA Screening Levels	
SAMPLE IDENTIFICATION	**SB 1**	**SB 1**	**PD 1**	**PD 1**	**OFP 1**	**OFP 1**	**OFP 1 (Duplicate)**	**PZ-1**	**PZ-1**	**UP 1**	**UP 1**					
DATE SAMPLED	**10/28/2018**	**6/6/2019**	**10/28/2018**	**6/6/2019**	**10/28/2018**	**6/6/2019**	**6/6/2019**	**11/15/2018**	**6/6/2019**	**10/28/2018**	**6/6/2019**					
1,4-Dioxane by 8260B SIM ug/L													**Adult Recreator**	**Child Recreator**	**Adult Recreator**	**Child Recreator**
1,4-Dioxane	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	0.2 U	0.32				
Other Parameters mg/L																
Alkalinity Total (CaCO3)	NA	**29**	NA	**15**	NA	**68**	**71**	NA	**110**	NA	**75**					
Ammonia-N	NA	**0.099**	NA	0.05 U	NA	**0.099**	**0.12**	NA	**0.4**	NA	0.05 U					
Iron	NA	**0.36**	NA	**1.4**	NA	**2.5**	**3**	NA	**4.6**	NA	**0.51**					
Nitrate-N	NA	0.5 U	NA	0.5 U	NA	0.5 U	0.5 U	NA	0.5 U	NA	0.5 U					
PERFLUORINATED CHEMICALS BY MODIFIED 537 - (ng/L)													**EF = 45 Days**		**EF = 120 Days**	
Perfluorobutanoic Acid (PFBA)	**66.7**	**25.3**	**50.2**	**13.4**	**60.8**	**37**	**37.1**	**86.1**	**71.3**	**147**	**59.4**	---	---	---	---	---
Perfluoropentanoic Acid (PFPeA)	**135**	**46.2**	**107**	**27.9**	**124**	**73**	**72.6**	**183**	**154**	**310**	**123**	---	---	---	---	---
Perfluorohexanoic Acid (PFHxA)	**304**	**63.9**	**312**	**67.4**	**288**	**112**	**119**	**346**	**226**	**635**	**203**	---	---	---	---	---
Perfluoroheptanoic Acid (PFHpA)	**676**	**119**	**832**	**156**	**646**	**223**	**226**	**787**	**453**	**1,290**	**464**	---	---	---	---	---
Perfluorohexane Sulfonate (PFHxS)	**16.5**	**5.68**	**15.2**	**7.34**	**17.2**	**14.9**	**14.6**	**16.8**	**13.9**	**29.7**	**20.9**	18	---	---	---	---
6:2 Fluorotelomer Sulfonic Acid (6:2 FTS)	2.30 U	2.08 U	2.26 U	2.2 U	2.25 U	2.14 U	2.21 U	4.56 U	2.13 U	2.08 U	2.13 U	---	---	---	---	---
Perfluoroheptane Sulfonic Acid (PFHpS)	**10.3**	**4.76**	**6.67**	**3.8 J**	**18.7**	**9.3**	**6.58**	**10.7**	**8.29**	**20.2**	**16.9**	---	---	---	---	---
Perfluorononanoic Acid (PFNA)	**536**	**244**	**531**	**247**	**1,060**	**222**	**238**	**556**	**596**	**921**	**933**	11	---	---	---	---
Perfluorooctane Sulfonamide (PFOSA)	**8.59**	**2.36 J**	**9.96**	**2.91 J**	**16.8**	**3.41 J**	**6.14**	4.56 U	**1.95 J**	**5.25**	**3.2 J**	---	---	---	---	---
Perfluorodecanoic Acid (PFDA)	**408**	**268**	**427**	**230**	**876**	**184**	**175**	**269**	**211**	**596**	**728**	---	---	---	---	---
8:2 Fluorotelomer Sulfonate (8:2 FTS)	**4.65**	**2.93 J**	**6.49**	2.27 U	**10.7**	2.2 U	**2.36 J**	4.56 U	**3 J**	**17.7**	**12.7**	---	---	---	---	---
N-Methyl Perfluorooctane Sulfonamidoacetic Acid (MeFOSAA)	1.90 U	1.72 U	1.86 U	1.82 U	1.85 U	1.77 U	1.82 U	4.56 U	1.76 U	1.72 U	1.76 U	---	---	---	---	---
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (EtFOSAA)	**13.7**	**2.74 J**	**18.5**	**4.28 J**	**30.6**	1.47 U	1.51 U	4.56 U	1.46 U	7.41	9.07	---	---	---	---	---
Perfluoroundecanoic Acid (PFUnA)	**51.9**	**79.1**	**61.7**	**41.7**	**107**	**43.1**	**38.7**	**28.6**	**22**	**48.1**	**53.2**	---	---	---	---	---
Perfluorodecane Sulfonate (PFDS)	**5.07**	**7.29**	**3.48 J**	**2.85 J**	**9.71**	**4.09 J**	**3.71 J**	4.56 U	**2.86 J**	**3.00 J**	**3.95 J**	---	---	---	---	---
Perfluorododecanoic Acid (PFDoA)	**2.86 J**	**7.2**	**3.06 J**	**3.3 J**	**5.19**	**4.54**	**4.08 J**	4.56 U	**1.79 J**	**1.33 J**	**1.89 J**	---	---	---	---	---
N-Methyl Perfluorooctane Sulfonamide (MeFOSA)	4.41 U	3.99 U	4.32 U	4.22 u	4.30 U	4.1 U	4.23 U	22.8 U	4.08 U	3.98 U	4.08 U	---	---	---	---	---
Perfluorotridecanoate (PFTrDA)	0.568 U	**0.817 J**	0.558 U	0.544 U	0.555 U	**0.667 J**	**0.61 J**	4.56 U	0.526 U	0.514 U	0.527 U	---	---	---	---	---
Perfluorotetradecanoic Acid (PFTeDA)	0.869 U	0.786 U	0.852 U	0.832 U	0.848 U	0.808 U	0.833 U	4.56 U	0.803 U	0.785 U	0.805 U	---	---	---	---	---
N-Ethyl Perfluorooctane Sulfonamide (EtFOSA)	5.88 U	5.32 U	5.77 U	5.63 U	5.74 U	5.47 U	5.64 U	22.8 U	5.44 U	5.31 U	5.45 U	---	---	---	---	---
Perfluorohexadecanoic Acid (PFHxDA)	0.338 U	0.306 U	0.332 U	0.324 U	0.330 U	0.315 U	0.324 U	4.56 U	0.313 U	0.306 U	0.314 U	---	---	---	---	---
N-Methyl Perfluorooctane Sulfonamidoethanol (MsFOSE)	6.99 U	6.32 U	6.85 U	6.69 U	6.82 U	6.5 U	6.7 U	22.8 U	6.46 U	6.31 U	6.47 U	---	---	---	---	---
N-Ethyl Perfluorooctane Sulfonamidoethanol (EtFOSE)	10.9 U	9.83 U	10.7 U	10.4 U	10.6 U	10.1 U	10.4 U	22.8 U	10 U	9.81 U	10.1 U	---	---	---	---	---
Perfluorobutane Sulfonic Acid (PFBS)	**2.99 J**	1.86 U	**2.60 J**	1.97 U	**2.66 J**	**2.89 J**	**2.90 J**	4.56 U	**2.56 J**	**5.67**	1.91 U	---	18,300,000	2,030,000	6,850,000	760,000
Perfluorooctanoic Acid (PFOA)	**1,290**	**289**	**1,460**	**386**	**1,650**	**622**	**620**	**1,390**	**979**	**2,230**	**1,230**	12	18,300	2,030	6,850	760
Perfluorooctane Sulfonate (PFOS)	**1,420 B**	**761**	**1,200 B**	**694**	**3,190 B**	**664**	**602**	**1,030**	**1,280**	**2,110 B**	**2180**	15	18,300	2,030	6,850	760

NOTES:

1. J = Estimated concentrations below the reporting limit.
2. B = Compound detected in the method blank
3. U = Not detected above the reporting limit
4. D = Dilution
5. NA = Not analyzed
6. Shaded values denote EPA Screening Level Child Recreator Exceedances, EF = 120 days (Site Specific)
7. Shaded values denote EPA Screening Level Child Recreator Exceedances, EF = 45 days (Site Specific)
8. **Bold** denotes concentration reported above applicable reporting limit/Limit of Quantitation.
9. NHDES AGQS for PFOS, PFOA, PFNA, and PFHxS are proposed standards to become effective October 1, 2019.

SB - Stormwater Basin
PD - Perimeter Ditch
OFP - Outfall Pipe
PZ - Piezometer
UP - Underdrain Pipe

TABLE 3
Summary of Stormwater Analytical Data
Stormwater Investigation Report
Coakley Landfill Superfund Site - North Hampton and Greenland, New Hampshire

	Northwest Stormwater Basin											**Northwest Underdrain**				**NHDES AGQS**	**USEPA Screening Levels**		**USEPA Screening Levels**	
SAMPLE IDENTIFICATION	**SB-2**	**SB-2**	**PD-2**	**PD-2**	**PD-2**	**OFP-2**	**OFP-2 (Duplicate)**	**OFP-2**	**OFP-2**	**PZ-2**	**PZ-2**	**UP-2**	**UP-2**	**UP-2**	**PZ-3**		**Adult Recreator**	**Child Recreator**	**Adult Recreator**	**Child Recreator**
DATE SAMPLED	**10/28/18**	**6/6/19**	**4/26/2018**	**10/28/18**	**6/6/19**	**4/26/2018**	**4/26/2018**	**10/28/2018**	**6/6/2019**	**11/15/2018**	**6/28/2019**	**4/26/2018**	**10/28/2018**	**6/6/2019**	**6/6/2019**		**EF = 45 Days**		**EF = 120 Days**	
1,4-Dioxane by 8260B SIM ug/L																				
1,4-Dioxane	0.2 U	0.2 U	0.25 U	0.2 U	0.2 U	0.25 U	0.25 U	0.2 U	0.2 U	0.2 U	**5.7**	0.25 U	0.2 U	0.2 U	**11**	0.32				
Other Parameters mg/L																				
Alkalinity Total (CaCO3)	NA	**14**	NA	NA	**22**	NA	NA	NA	**21**	NA	**240**	NA	NA	**91**	**370**					
Ammonia-N	NA	0.05 U	NA	NA	0.05 U	NA	NA	NA	**0.069**	NA	**10**	NA	NA	0.05 U	**18**					
Iron	NA	**0.72**	NA	NA	**0.26**	NA	NA	NA	**1.6**	NA	**47**	NA	NA	**0.98**	**49**					
Nitrate-N	NA	0.5 U	NA	NA	0.5 U	NA	NA	NA	0.5 U	NA	0.5 U	NA	NA	0.5 U	0.5 U					
PERFLUORINATED CHEMICALS BY MODIFIED 537 - (ng/L)																				
Perfluorobutanoic Acid (PFBA)	**44.3**	**19.6**	NA	**40.6**	**30.9**	NA	NA	**50**	**22.4**	**41.7**	**24.4**	NA	**97.7**	**50.5**	**29.4**	---	---	---	---	---
Perfluoropentanoic Acid (PFPeA)	**89.3**	**33.9**	NA	**87.9**	**58.4**	NA	NA	**97**	**37.1**	**77**	**45.5**	NA	**200**	**104**	**60.4**	---	---	---	---	---
Perfluorohexanoic Acid (PFHxA)	**226**	**58.5**	NA	**274**	**117**	NA	NA	**227**	**53.2**	**138**	**60.6**	NA	**495**	**205**	**88.4**	---	---	---	---	---
Perfluoroheptanoic Acid (PFHpA)	**561**	**107**	**217**	**696**	**205**	**223**	**223**	**529**	**115**	**293**	**104**	**531**	**1,040**	**435**	**147**	---	---	---	---	---
Perfluorohexane Sulfonate (PFHxS)	**14**	**3.62 J**	6.68 U	**16.6**	**10.5**	**7.77 J**	**8.22 J**	**15.7**	**4.43**	**5.71**	**10.4**	**19.6 J**	**35.6**	**18.9**	**17.5**	18	---	---	---	---
6:2 Fluorotelomer Sulfonic Acid (6:2 FTS)	2.18 U	2.2 U	NA	2.30 U	2.21 U	NA	NA	2.09 U	2.13 U	4.5 U	2.18 U	NA	2.08 U	2.12 U	2.2 U	---	---	---	---	---
Perfluoroheptane Sulfonic Acid (PFHpS)	**10.4**	**2.98 J**	NA	**10.2**	**4.81**	NA	NA	**10.7**	**3.48 J**	**4.92**	1.02 U	NA	**31.5**	**23.6**	**3.66 J**	---	---	---	---	---
Perfluorononanoic Acid (PFNA)	**405**	**157**	**268**	**523**	**278**	**307**	**299**	**491**	**228**	**285**	**110**	**770**	**1060**	**901**	**119**	11	---	---	---	---
Perfluorooctane Sulfonamide (PFOSA)	**17.6**	1.94 U	NA	**17.4**	**6.57**	NA	NA	**17.3**	1.88 U	4.5 U	1.93 U	NA	**14.3**	**14.2**	**2.68 J**	---	---	---	---	---
Perfluorodecanoic Acid (PFDA)	**342**	**156**	NA	**427**	**289**	NA	NA	**444**	**266**	**205**	**94.3**	NA	**569**	**507**	**22.5**	---	---	---	---	---
8:2 Fluorotelomer Sulfonate (8:2 FTS)	2.24 U	2.26 U	NA	2.37 U	**2.91 J**	NA	NA	2.16 U	2.19 U	4.5 U	**2.37 J**	NA	**8.17**	**7.47**	**2.35 J**	---	---	---	---	---
N-Methyl Perfluorooctane Sulfonamidoacetic Acid (MeFOSAA)	1.79 U	1.81 U	NA	1.90 U	1.82 U	NA	NA	1.73 U	1.76 U	4.5 U	1.79 U	NA	1.72 U	1.75 U	1.81 U	---	---	---	---	---
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (EtFOSAA)	**15.1**	1.51 U	NA	**15.8**	**5.97**	NA	NA	**19.6**	**2.25 J**	**9.92**	**10.7**	NA	**9.67**	**12.3**	**8.88**	---	---	---	---	---
Perfluoroundecanoic Acid (PFUnA)	**47.7**	**29.6**	NA	**57.3**	**48.9**	NA	NA	**63.5**	**68.5**	**27.6**	**12**	NA	**52.4**	**57.2**	**1.25 J**	---	---	---	---	---
Perfluorodecane Sulfonate (PFDS)	**5.94**	**2.39 J**	NA	**5.94**	1.36 U	NA	NA	**5.34**	**4.87**	4.5 U	1.34 U	NA	**9.84**	**6.65**	1.35 U	---	---	---	---	---
Perfluorododecanoic Acid (PFDoA)	**4.09 J**	**1.78 J**	NA	**3.49 J**	**4.23 J**	NA	NA	**4.48**	**5.55**	4.5 U	**0.983 J**	NA	**2.19 J**	**4.4**	0.871 U	---	---	---	---	---
N-Methyl Perfluorooctane Sulfonamide (MeFOSA)	4.17 U	4.21 U	NA	4.41 U	4.22 U	NA	NA	4.01 U	4.08 U	22.5 U	4.17 U	NA	3.99 U	4.05 U	4.21 U	---	---	---	---	---
Perfluorotridecanoate (PFTrDA)	**0.618 J**	0.543 U	NA	0.569 U	0.545 U	NA	NA	0.517 U	0.526 U	4.5 U	0.537 U	NA	0.514 U	0.523 U	0.543 U	---	---	---	---	---
Perfluorotetradecanoic Acid (PFTeDA)	0.821 U	0.830 U	NA	0.869 U	0.833 U	NA	NA	0.79 U	0.804 U	4.5 U	0.821 U	NA	0.786 U	0.799 U	0.830 U	---	---	---	---	---
N-Ethyl Perfluorooctane Sulfonamide (EtFOSA)	5.56 U	5.61 U	NA	5.88 U	5.64 U	NA	NA	5.35 U	5.44 U	22.5 U	5.56 U	NA	5.32 U	5.41 U	5.62 U	---	---	---	---	---
Perfluorohexadecanoic Acid (PFHxDA)	0.32 U	0.323 U	NA	0.338 U	0.324 U	NA	NA	0.308 U	0.313 U	4.5 U	**0.557 J**	NA	0.306 U	0.311 U	0.323 U	---	---	---	---	---
N-Methyl Perfluorooctane Sulfonamidoethanol (MsFOSE)	6.60 U	6.67 U	NA	6.99 U	6.69 U	NA	NA	6.35 U	6.46 U	22.5 U	6.6 U	NA	6.32 U	6.42 U	6.67 U	---	---	---	---	---
N-Ethyl Perfluorooctane Sulfonamidoethanol (EtFOSE)	10.3 U	10.4 U	NA	10.9 U	10.4 U	NA	NA	9.88 U	10.1 U	22.5 U	10.3 U	NA	9.83 U	9.99 U	10.4 U	---	---	---	---	---
Perfluorobutane Sulfonic Acid (PFBS)	**2.28 J**	1.97 U	2.58 U	**2.82 J**	1.97 U	2.29 U	2.19 U	**2.04 J**	1.91 U	4.5 U	**2.96 J**	**3.62 J**	**6.07**	**2.03 J**	**4.95**	---	18,300,000	2,030,000	6,850,000	760,000
Perfluorooctanoic Acid (PFOA)	**1,160**	**261**	**591 B**	**1,400**	**431**	**532 B**	**631 B**	**1,180**	**303**	**622**	**253**	**1,480 B**	**2,480**	**1,310**	**403**	12	18,300	2,030	6,850	760
Perfluorooctane Sulfonate (PFOS)	**1,460 B**	**586**	**1,240**	**1,790 B**	**1260**	**1,440**	**1,230**	**1,850 B**	**818**	**807**	**332**	**3,060 D**	**3,390 B**	**2710**	**172**	15	18,300	2,030	6,850	760

NOTES:
1. J = Estimated concentrations below the reporting limit.
2. B = Compound detected in the method blank
3. U = Not detected above the reporting limit
4. D = Dilution
5. NA = Not analyzed
6. Shaded values denote EPA Screening Level Child Recreator Exceedances, EF = 120 days (Site Specific)
7. Shaded values denote EPA Screening Level Child Recreator Exceedances, EF = 45 days (Site Specific)
8. **Bold** denotes concentration reported above applicable reporting limit/Limit of Quantitation.
9. NHDES AGQS for PFOS, PFOA, PFNA, and PFHxS are proposed standards to become effective October 1, 2019.

SB = Stormwater Basin
PD = Perimeter Ditches
OFP = Outfall Piping
PZ = Piezometer
UP = Underdrain Pipe Discharge

TABLE 4

Historical L-1 Seep Analytical Results
Stormwater Investigation Report
Coakley Landfill Superfund Site - North Hampton and Greenland, New Hampshire

SAMPLE IDENTIFICATION	NHDES SURFACE		L-1	L-1	L-1	L-1	L-1	L-1	L-1		L-1	L-1	L-1	L-1	L-1	L-1	L-1-DUP	L-1	L-1-DUP	L-1	L-1-DUP	L-1	L-1-DUP	L-1	L-1-DUP	L-1	L-1-DUP	L-1	L-1-DUP	L-1	L-1-DUP
DATE SAMPLED	WATER STANDARDS		16-Aug-01	7-Aug-02	27-Aug-03	25-Aug-04	25-Aug-05	30-Nov-06	13-Nov-07		12-Aug-08	19-Aug-09	17-Aug-10	19-Aug-11	30-Aug-12	14-Aug-13	14-Aug-13	17-Sep-15	17-Sep-15	1-Jun-16	1-Jun-16	28-Apr-17	28-Apr-17	21-Sep-17	21-Sep-17	30-Apr-18	30-Apr-18	28-Oct-18	28-Oct-18	15-May-19	15-May-19
COMMENTS	ACUTE	CHRONIC						ID 104240																							
PARAMETER ANALYZED																															
VOLATILE ORGANIC COMPOUNDS (ug/L)																															
Benzene	5300	NSE	3	2	2	2 U	2	2	3		1 U	1.9	2	2.0	2	2	2	2	2	1	1	1 U	1 U	1	1	<1	<1	<1	<1	1.5	1.4
Chlorobenzene	250	50	27	15	18	12	20	18	22		2 U	20	24	18	15	13	14	16	14	11	12	1 U	1 U	12	12	2.6	2.7	<1	<1	12	12
Chloroethane	NSE	NSE	8	6	6	3	6	2 U	6		5 U	4.4	5 U	4.1	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	<5	<5	<5	<5	<5	<5
1,4 Dichlorobenzene (See Note 4)	1120	763	<2	3	2	2 U	3	2	3		1 U	2.5	3	2.3	2	2	2	2	2	2 J	2 J	1 U	1 U	2	2	<1	<1	<1	<1	1.5	1.6
1,3-Dichlorobenzene (See Note 4)			<2	<2	<2	2 U	2 U	2 U	1 U		1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2 J	1 U,J	1 U	1 U	1 U	1 U	<1	<1	<1	<1	<1	<1
1,2 Dichlorobenzene (See Note 4)			<2	<2	<2	2 U	2 U	2 U	1		1 U	1.1	2	1.2	1	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	<1	<1	<1	<1	<1	<1
Isopropylbenzene	NSE	NSE	<2	<2	<2	2 U	2 U	2	2		1 U	1.5	2	1.6	1	1	1	1	BDL	1 U	1 U	1 U	1 U	1 U	1 U	<1	<1	<1	<1	<1	<1
Diethyl Ether	NSE	NSE	31	<10	<10	10 U	10 U	10 U	23		5 U	13	15	12	10	10	10	11	10	7	7	5 U	5 U	7	7	<5	<5	<5	<5	8.8	8.6
Naphthalene	2300	620	<10	<10	<10	10 U	10 U	10 U	<5	5 U	5 U	0.6	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	<5	<5	<5	<5	<5	<5
Tetrahydrofuran	NSE	NSE	32	<30	<30	30 U	30 U	30 U	20		10 U	12	10	10 U	10 U	10 U	10 U	10	10	10 U	10 U	10 U	10 U	10 U	10 U	<10	<10	<10	<10	<10	<10
Toluene	NSE	NSE	<2	<2	<2	2 U	2 U	2 U	1 U		1 U	1 U	1	1 U	1 U	1 U	1 U	1 U	2 J	1 U	1 U	1 U	1 U	1 U	1 U	<1	<1	<1	<1	<1	<1
LOW LEVEL 1,4-DIOXANE (ug/L)																															
1,4-Dioxane	NSE	NSE	NA	NA	NA	NA	NA	NA	NA		NA	26	20	25	28	22	24	NA	NA	NA	NA	1.5	1.3	17	18	4.9	4.1	<0.2	<0.2	12	12
METALS (ug/L)			**Total**	**Total**	**Total**	**Total**	**Total**		**Total**	**Dissolved**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
Aluminum	750	87	**3200**	**4100**	**9,500**	**29,000**	**18,000**	NA	50 U	50 U	170	50 U	50 U	50 U	50 U	50 U	80	50 U	50 U	50 U	50 U	80	70	100 U	100 U	100 U	100 U	140	140	100 U	100 U
Antimony	9,000	1,600	6	<2	<2	<4	<6	NA	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Arsenic	340	150	83	23	67	150	300	NA	7	6	4	4	7	6	4	5	7	6	6	3	3	2	2	5	5	1.1	1.2	2.3	2.3	2.1	2.1
Barium	NSE	NSE	1300	260	610	2,200	4,600	NA	97	99	11	100	100	97	87	92	110	100	96	74	73	11	10	75	78	25	25	6.2	6	71	70
Beryllium	130	5.3	3	<4	<4	3	<2	NA	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Cadmium	0.95	0.80	<2	<2	<2	<4	<6	NA	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Calcium	NSE	NSE	120,000	97,000	100,000	140,000	150,000	NA	50,000	62,000	20,000	64,000	71,000	63,000	79,000	56,000	57,000	67,000	67,000	52,000	52,000	17,000	16,000	57,000	57,000	28,000	29,000	10,000	10,000	64,000	58,000
Chromium	183	24	20	13	27	55	70	NA	1 U	1 U	1	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1	1 U	1 U	1 U	1 U	1.4	1.7	1 U	1 U
Cobalt	NSE	NSE	<2	3	6	11	10	NA	1 U	1	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Copper	3.6	2.7	<2	**5**	**13**	**36**	**40**	NA	1 U	1	**8**	1 U	1 U	1	1 U	1 U	1 U	1 U	1 U	1 U	1 U	**9**	**8**	1 U	1 U	**5.6 J+**	**6.4 J+**	**13**	**13**	1 U	1 U
Iron	NSE	1,000	350,000	130,000	330,000	1,000,000	1,100,000	NA	30,000	27,000	1,200	35,000	34,000	31,000	31,000	35,000	45,000	35,000	33,000	36,000	35,000	2,800	2,500	32,000	33,000	8,800	8,700	450	390	35,000	36,000
Lead	14	0.54	<2	2	8	**34**	<6	NA	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Magnesium	NSE	NSE	49,000	43,000	36,000	34,000	43,000	NA	20,000	25,000	2,500	25,000	21,000	21,000	20,000	16,000	16,000	17,000	17,000	18,000	18,000	3,400	3,100	18,000	19,000	7,200	7,300	1,300	1,200	19,000	18,000
Manganese	NSE	NSE	7,600	5,700	5,900	10,000	9,800	NA	2,700	3,200	98	3,200	2,900	2,700	3,300	2,500	2,500	2,400 J+	2,200 J+	2,700	2,700	400	370	2,800	2,900	1,200	1,200	29	23	2800	2900
Mercury	1.4	0.77	<0.2	<0.2	<0.2	<0.2	<0.2	NA	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.2 U	0.2 U	0.2 U	0.2 U	0.1 U	0.1 U	0.1 U	0.1 U
Nickel	144.9	16.1	22	18	28	32	40	NA	7	8	3	7	6	4	6	5	5	5	5	5 J	5 J	4	3	5	5	3.7	4.5	2.1	2.4	4.7	5
Potassium	NSE	NSE	66	55	46,000	38,000	50,000	NA	34,000	40	7,800	37,000	33,000	30,000	31,000	25,000	27,000	26,000	27,000	25,000	25,000	5,200	5,300	25,000	26,000	11,000	11,000	3,500	3,500	26,000	25,000
Selenium	NSE	5	7	8	4	3	<2	NA	1 U	1 U	1 U	1 U	2	2	5	5	5	5	5	3	3	4	3	4	4	1 U	1 U	1 U	1 U	1 U	1 U
Silver	0.32	NSE	<2	<2	**2**	<4	<6	NA	1 U	1 U	1 I	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U,J	1 U,J	1 U	1 U	1 U,J	1 U,J	1 U	1 U	1 U	1 U	1 U	1 U
Sodium	NSE	NSE	220,000	200,000	160,000	140,000	150,000	NA	130,000	150,000	10 U	100,000	110,000	91,000	100,000	78,000	76,000	90,000	90,000	61,000	62,000	8,000	8,000	65,000	71,000	23,000	24,000	5,000 U	5,000 U	71,000	70,000
Thallium	1,400	40	<2	<2	<2	<4	<6	NA	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Vanadium	NSE	NSE	46	13	36	89	220	NA	1	1	2	2	1	1 U	1 U	1 U	1 U	1 U	1 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Zinc	36.2	36.5	**45**	**51**	**140**	**390**	**690**	NA	5 U	**650**	**56**	12	6	5 U	5 U	5 U	10	5 U	5 U	5 U	5 U	**38**	34	5 U	5 U	34	**37**	19	19	9	14
PERFLUORINATED CHEMICALS BY MODIFIED 537 - (ng/L)																															
Perfluorobutanesulfonic acid (PFBS)	NSE	NSE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.09 U	2.13 U	4.85 J	5.50 J	2.72 J	2.99 J	4.2 U	4.13 U	6.47	6.27
Perfluoroheptanoic acid (PFHpA)	NSE	NSE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	175	170	111	109	208	196	523	483	133	134
Perfluorohexanesulfonic acid (PFHxS)	NHDES AGQS - 18 ng/L		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	9.12 J	9.39 J	**19.0 J**	**19.4 J**	12.0 J	11.6 J	10.8	9.77	**18.1**	**18.7**
Perfluorooctanoic acid (PFOA)	NHDES AGQS - 12 ng/L		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**656**	**736**	**319**	**310**	**532**	**492**	**1,040**	**948**	**369 J**	**369**
Perfluorononanoic acid (PFNA)	NHDES AGQS - 11 ng/L		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**308**	**310**	**70.3**	**75.6**	**207 J**	**193**	**366**	**339**	**83.6**	**80.5**
Perfluorooctanesulfonic (PFOS)	NHDES AGQS - 15 ng/L		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**1,930 D**	**1,560 J**	**164 J**	**150**	**567**	**571**	**1210**	**1,210**	**137 J**	**147**
GENERAL CHEMISTRY																															
Chemical Oxygen Demand (mg/l)	NSE	NSE	190	178	560	282	377	NA	70		50	50	54	40	44	52	68	32	43	19	18	28	33	55	48	20	19	46	44	18	25 J
Ammonia-N (mg/l)	36.1	5.91	**44**	**41**	**44.8**	**56.8**	**79**	NA	33		0.62	21	22	25	24	21	19	23	23	**110**	**100**	1.5	1.3	19	19	5.8	6.2	0.15	0.16	17	17 J+
FIELD PARAMETERS																															
Temperature (degrees Celcius)									12		18	14	16	15	16	15	NA	15	NA	11	NA	11	NA	15	NA	9	NA	7	NA	8	NA
pH (standard units)									6.2		6.6	6.4	6.6	5.1	6.6	6.3	NA	6.4	NA	6.6	NA	6.7	NA	6.3	NA	6.4	NA	6.8	NA	6.4	NA
Specific Conductivity (us/cm)									1,600		176	1,459	1,500	821	1,399	1,220	NA	1,283	NA	1,223	NA	189	NA	1,066	NA	550	NA	85	NA	1,044	NA
Dissolved Oxygen (mg/l)									2.2		4.9	1.3	0.6	3.4	2.3	2.3	NA	2.6	NA	0.8	NA	5.1	NA	<0.5	NA	5.6	NA	11.3	NA	<0.5	NA
Turbidity (NTU)									18		90	10	9	2	17	144	NA	6	NA	10	NA	16	NA	18	NA	10	NA	43	NA	<5	NA
Oxidation Reduction Potential (mV)									138		42	-38	-99	-73	-76	-102	NA	-111	NA	-60	NA	-25	NA	-36	NA	-23	NA	106	NA	-64	NA

NOTES:

1. BDL = Below Detection Limit; NA = Not Analyzed
2. NSE indicates no standard has been established for the indicated parameter.
3. NHDES Surface Water Standard are listed in Env Wq 1700
4. Acute and chronic standards based on total dichlorobenzenes
5. Ammonia-N standard is based on pH of 7.0 at 14 C, salinoids not present.
6. A **bold** entry indicates the parameter exceeded the acute surface water standard.
7. Shaded values indicate the parameter exceeded the chronic surface water standard.
8. **Bold** and shaded values indicate exceedances of both NHDES acute and chronic criteria.
9. Volatile organic compounds and metals results are in micrograms per liter (µg/l).
10. Only volatile organic compounds detected in one or more leachate sample during the period shown are listed.
11. Only volatile organic compounds detected in one or more leachate sample during the period shown are listed.
12. The laboratory detection limits (for 2013) were above the either the Acute or Chronic standard for the following parameters (detection limit in parantheses): Cadmium (1 ug/L), Lead (1 ug/L) and Silver (1 ug/L).
13. Listed NHDES AGQS for PFAS compounds are effective October 1, 2019.

LABORATORY ANALYTICAL METHODS *(Not Confirmed for Analyses Performed Prior to 2010)*

1. Volatile Organic Compounds (VOC) analyzed by EPA Method 8260B.
2. 1,4-dioxane (low level) analyzed by EPA Method 8260B SIM
3. Metals analyzed by EPA Method 200.8
4. Chemical Oxygen Demand analyzed by 4500-NH3
5. Ammonia-N analyzed by H8000

TABLE 5

Summary of HELP Model Precipitation Estimates

Stormwater Investigation Report

Coakley Landfill Superfund Site - North Hampton and Greenland, New Hampshire

	Landfill Cap Area*										Total (inches)	Total (cubic feet)	Total (gallons)	Percent
	B-1	B-2	B-3	B-4	B-5	D-1	D-2	D-3	D-4	D-5				
Area (acres)	1.01	1.35	3.52	1.65	1.13	5.26	1.16	1.42	4.54	3.14				
Precipitation (inches)	59.55	59.55	59.55	59.55	59.55	59.55	59.55	59.55	59.55	59.55	59.55	5,226,905.17	39,102,477.55	100
Surface Runoff (inches)	11.93	12.07	12.382	12.38	12.02	11.99	12.11	12.11	21.33	12.11	130.44	1,216,519.81	9,100,784.67	23
Evapotranspiration (inches)	23.60	23.92	23.97	23.97	23.94	23.95	23.95	23.95	24.08	23.95	239.27	2,103,146.34	15,733,637.80	40
Drainage Collected from Cap (inches)	24.03	23.57	23.20	23.20	23.58	23.61	23.48	23.48	14.13	23.48	225.78	1,907,126.15	14,267,210.72	36
Total Modelled Leakage (inches)	0.13	0.13	0.13	0.13	0.13	0.03	0.19	0.19	0.19	0.19	1.46	11,818.64	88,415.28	0

NOTES:

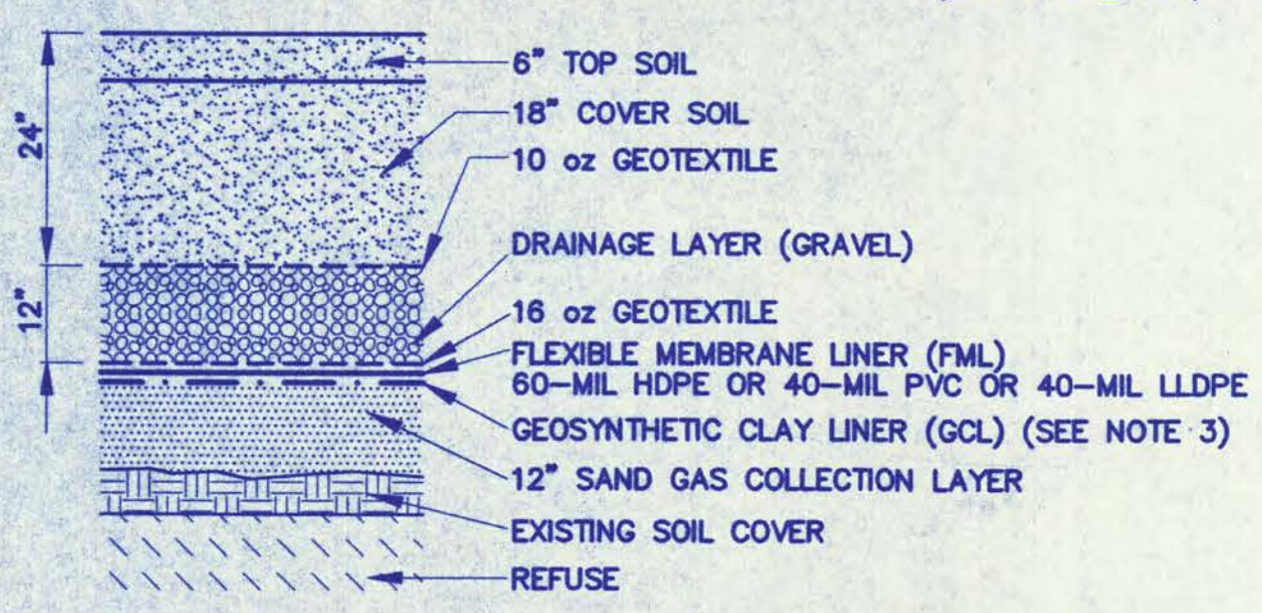
* - Landfill Cap Area references HELP model boundaries based on Drawing 5-13 of the 100% Design Report (Golder, 1996).

APPENDIX A

LANDFILL COVER SYSTEM DESIGN REPORT DRAWINGS

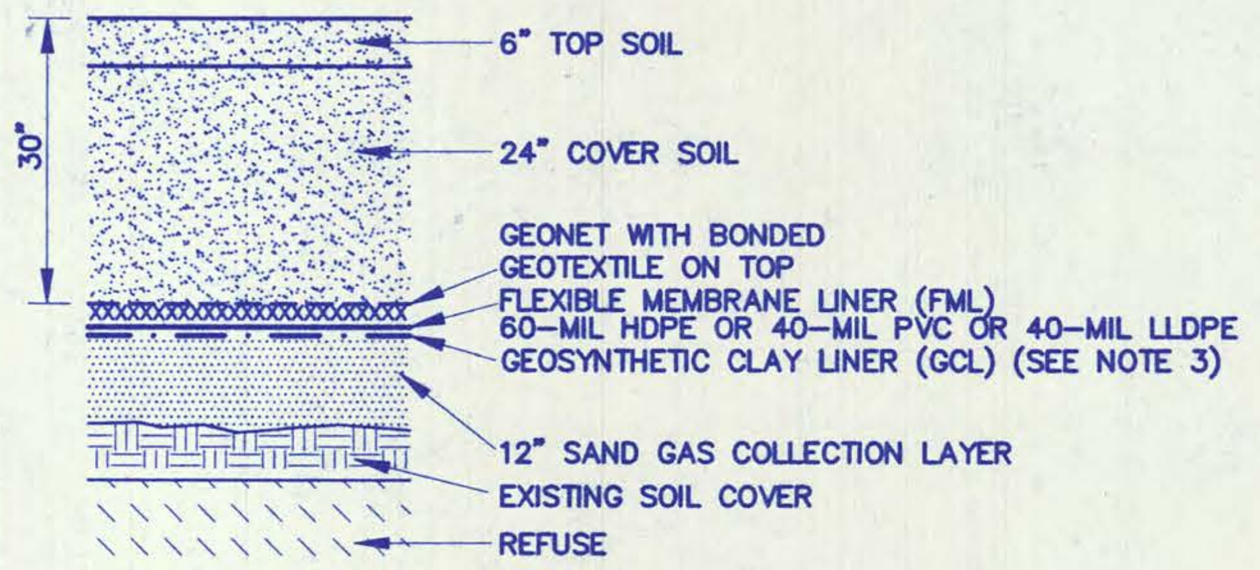
CAPS FOR SLOPES UP TO 5%

(3% < S ≤ 5%)



1 / 5-5 LANDFILL CAP TYPE 1

N.T.S.

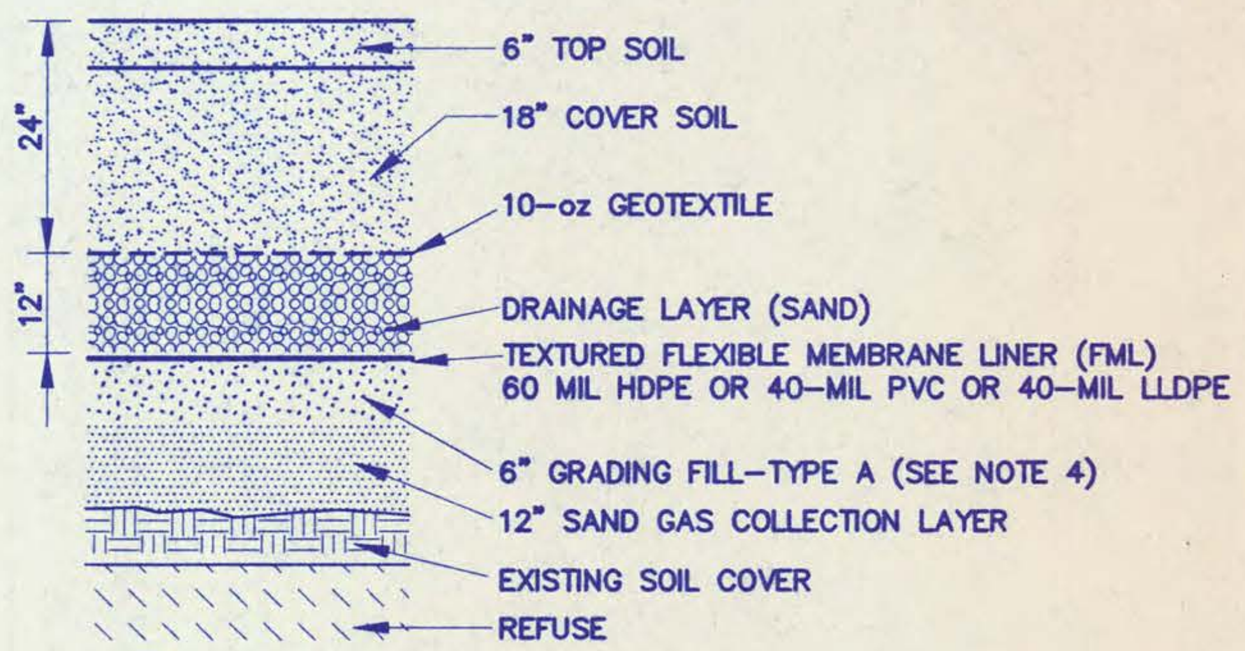


2 / 5-5 LANDFILL CAP TYPE 2

N.T.S.

CAPS FOR SIDE SLOPES

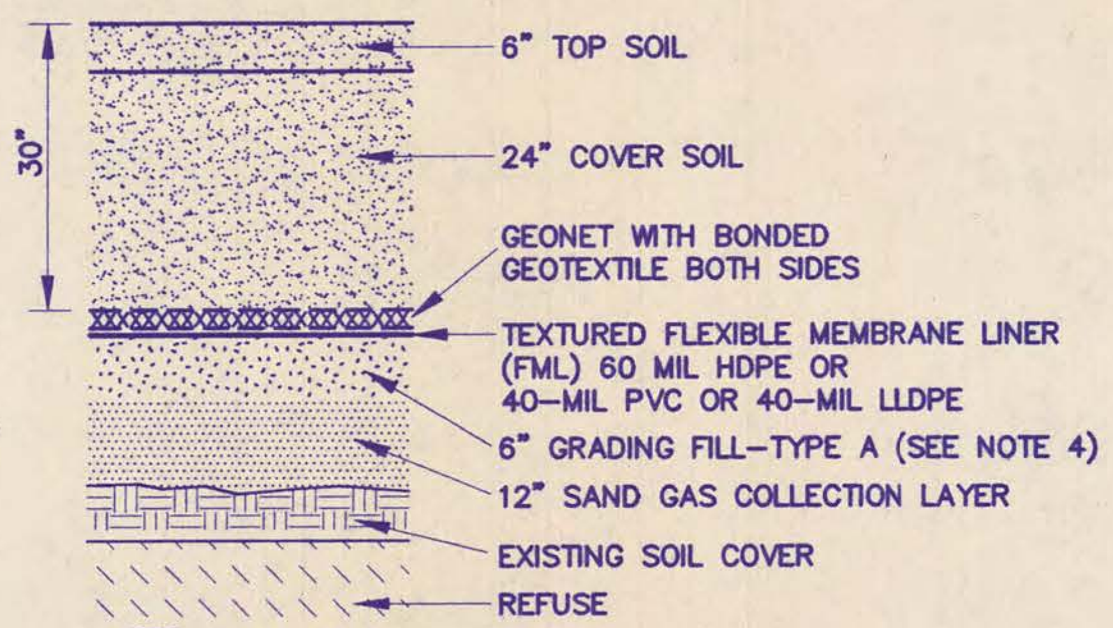
(20% < S ≤ 33%)



3 / 5-5 LANDFILL CAP TYPE 3

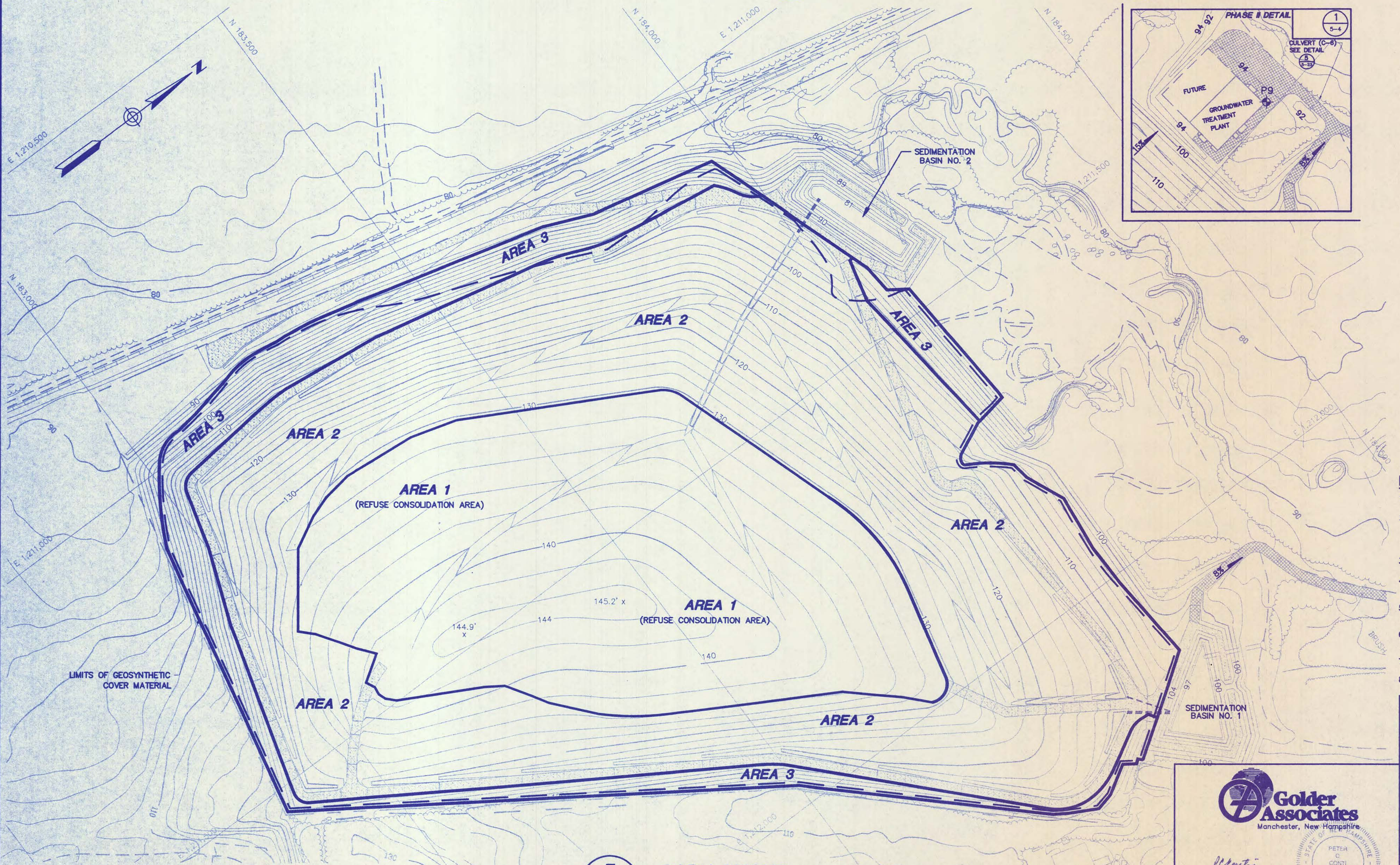
N.T.S.

(5% < S ≤ 20%)



4 / 5-5 LANDFILL CAP TYPE 4

N.T.S.



5 / 5-5 CAP LAYOUT

80 0 80 160
scale feet

CAP TYPE SCHEDULE

LOCATION	SLOPE	CAP TYPE	DETAIL
AREA 1	3% to ≤ 5%	TYPE 1 OR 2	SEE DETAIL 1/5-5 OR 2/5-5
AREA 2	>5% to ≤ 20%	TYPE 4	SEE DETAIL 4/5-5
AREA 3	>20% to ≤ 33%	TYPE 3	SEE DETAIL 3/5-5

LEGEND

A / 5-9	DETAIL OR CROSS SECTION DESIGNATION DRAWING No. WHERE DETAIL OR CROSS SECTION IS PRESENTED
━━━	LIMIT OF LINER SYSTEM
— — —	EXISTING EDGE OF REFUSE
— — —	NEW EDGE OF REFUSE
———	APPROXIMATE CAP BOUNDARIES
— — —	PROPERTY LINE
▨	PROPOSED GRAVEL ACCESS ROAD
▦	PROPOSED PAVED ACCESS ROAD
×123.7	SPOT ELEVATION
—130—	REGRADED FINAL CONTOUR
—90—	EXISTING 10 FT CONTOUR
~~	EXISTING 2 FT CONTOUR
═══	EXISTING PAVED ROAD
- - -	EXISTING UNPAVED ROAD
⌒⌒⌒	EXISTING TREELINE
⌒⌒⌒	EXISTING BRUSH LINE
—○—	EXISTING UTILITY POLE
┼┼┼	EXISTING RAILROAD
N 183,500 E 1,212,500	GRID SYSTEM

NOTES

1. SCREENED CONTOURS IN THE LANDFILL AREA REPRESENT THE FINAL GRADING.
2. CAP TYPE 2, 3 AND 4 ARE USED IN PREPARATION OF THIS DRAWING. IF CAP TYPE 1 IS USED INSTEAD OF CAP TYPE 2, ALL DRAWINGS AFFECTED INCLUDING THIS DRAWING SHALL BE REVISED BY CONTRACTOR FOR ENGINEER'S APPROVAL BASED ON CORRESPONDING CAP THICKNESS.
3. REFER TO DRAWINGS 5-6 AND 5-7 FOR DETAILS AT CAP BOUNDARIES.
4. SIDE SLOPE GRADING FILL SHALL BE SILTY SAND OR SANDY SILT (SM-ML UNIFIED SOIL CLASSIFICATION).
5. THE HYDRAULIC CONDUCTIVITY OF GRAVEL AND SAND OF THE DRAINAGE LAYER SHALL BE GREATER THAN 1.0 cm/sec AND $3x10^{-2}$ cm/sec, RESPECTEVLY.
6. AREA 1 / AREA 2 BOUNDARY MAY CHANGE DEPENDING ON THE VOLUME OF REFUSE EXCAVATED.
7. REFER TO SPECIFICATIONS FOR DESCRIPTIONS OF GRADING FILL TYPES.
8. THE HYDRAULIC CONDUCTIVITY OF SAND IN THE GAS COLLECTION LAYER SHALL BE GREATER THAN $5x10^{-3}$ cm/sec.

REFERENCE

ON AERIAL PHOTOGRAMMETRY BY EASTERN TOPOGRAPHIC SERVICES, DATED 05/03/92.
VERTICAL DATUM: 1929 NGVD; HORIZONTAL DATUM: N.H. STATE PLANE, 1983

Golder Associates
Manchester, New Hampshire

P.C.Conti
5/8/96
Date

PETER C. CONTI
No. 6485

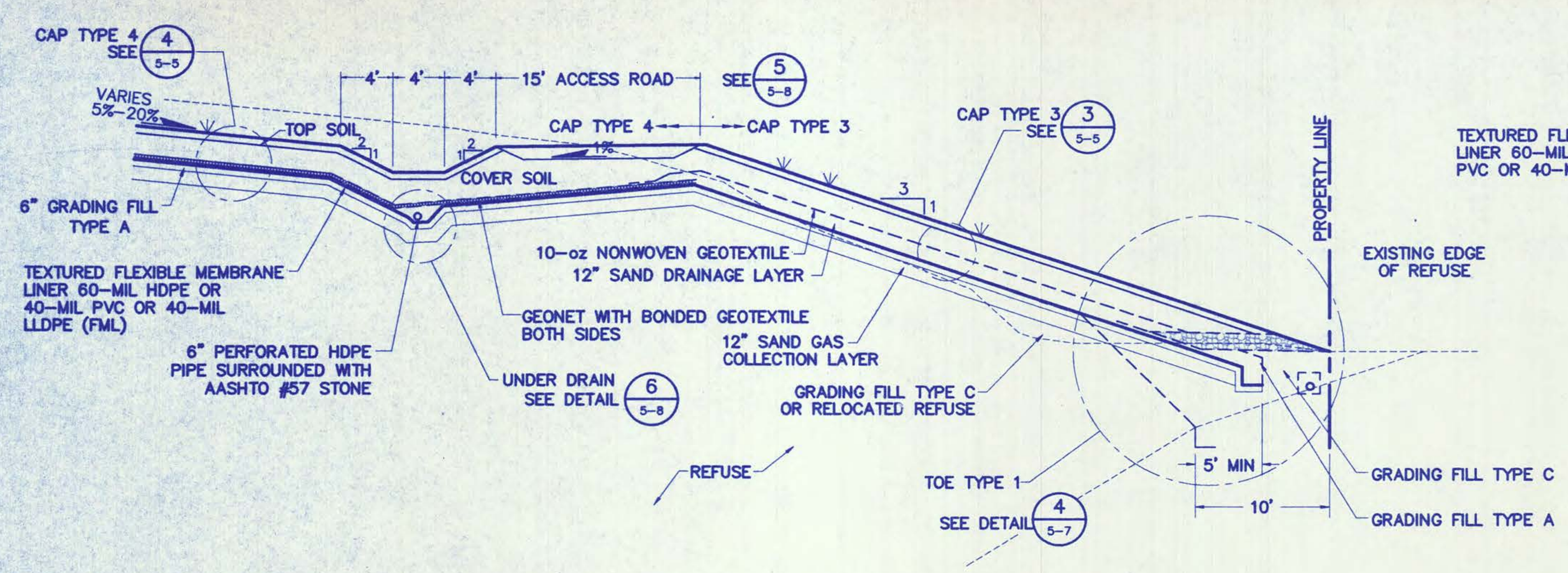
REV	DATE	DESCRIPTION	DR BY	CHK BY	RVW BY
0	5/10/96	RELEASED FOR BID	CDS	MRT	pcc

PROJECT:
THE COAKLEY LANDFILL GROUP
COAKLEY LANDFILL 100% REMEDIAL DESIGN REPORT
NORTH HAMPTON, NEW HAMPSHIRE

SHEET TITLE:
CAP LAYOUT AND CAP SECTIONS

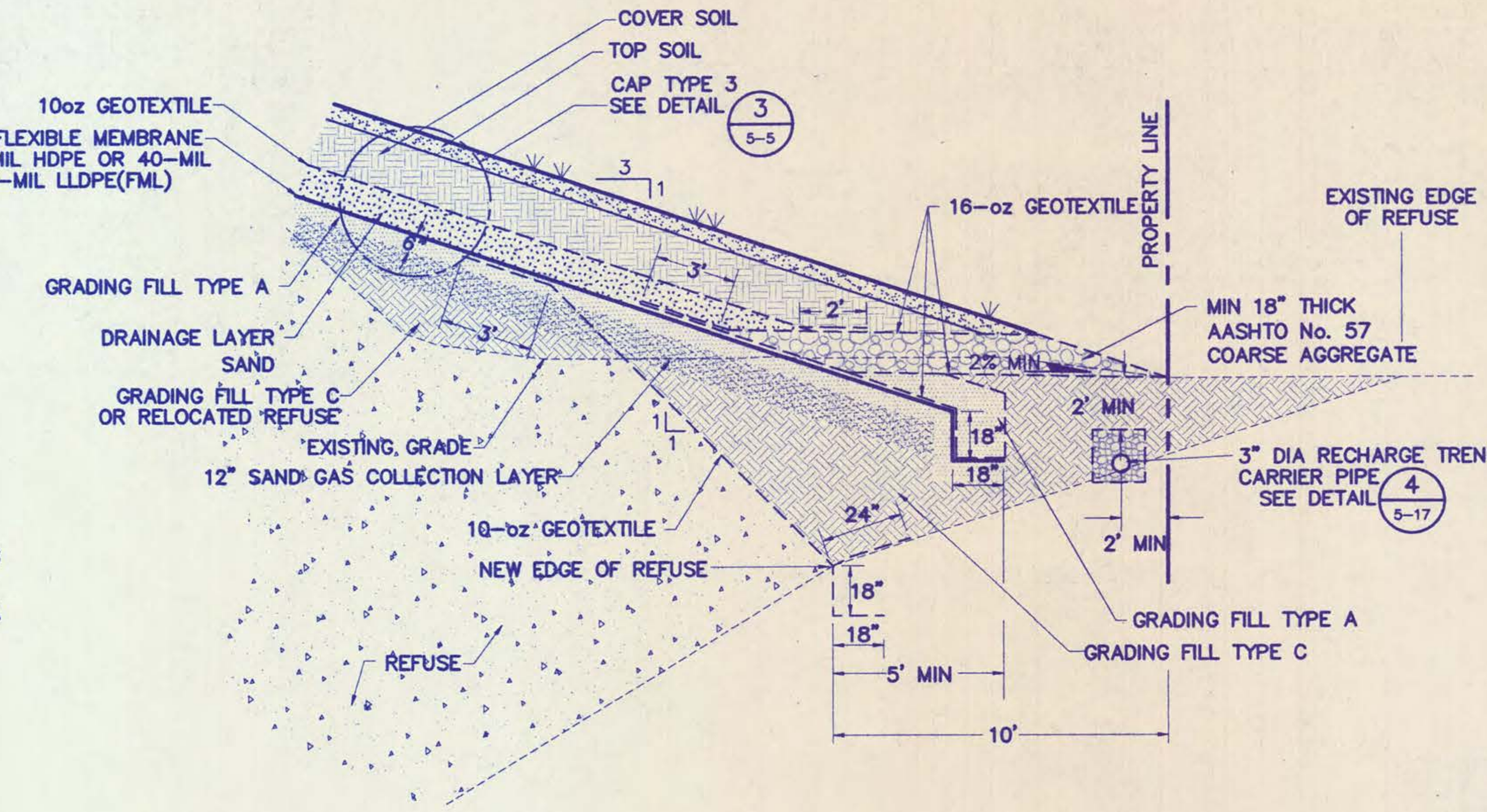
Golder Associates
Manchester, New Hampshire

PROJECT No.		923-6058	FILE No.:	NH11-440
CLIENT PROJ. No.			DRAFTING SUBTITLE:	23
DES BY	MRT	10/95	SCALE:	AS SHOWN
DR BY	CDS	11/95	DRAWING:	5-5
CHK BY	MRT	3/15/96		
RVW BY	pcc	3/15/96		



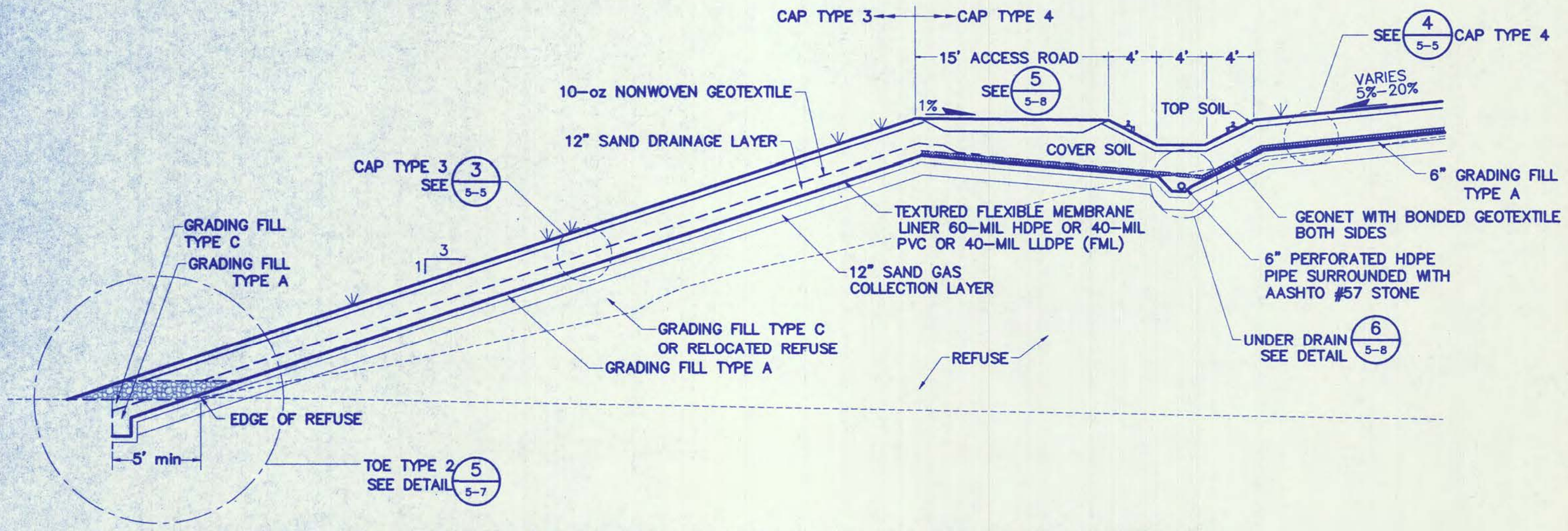
1 5-7 TYPICAL EDGE SECTION WITHOUT RECHARGE TRENCH (EXISTING EDGE OF REFUSE OUTSIDE THE PROPERTY LINE)

8 0 8 16
scale feet



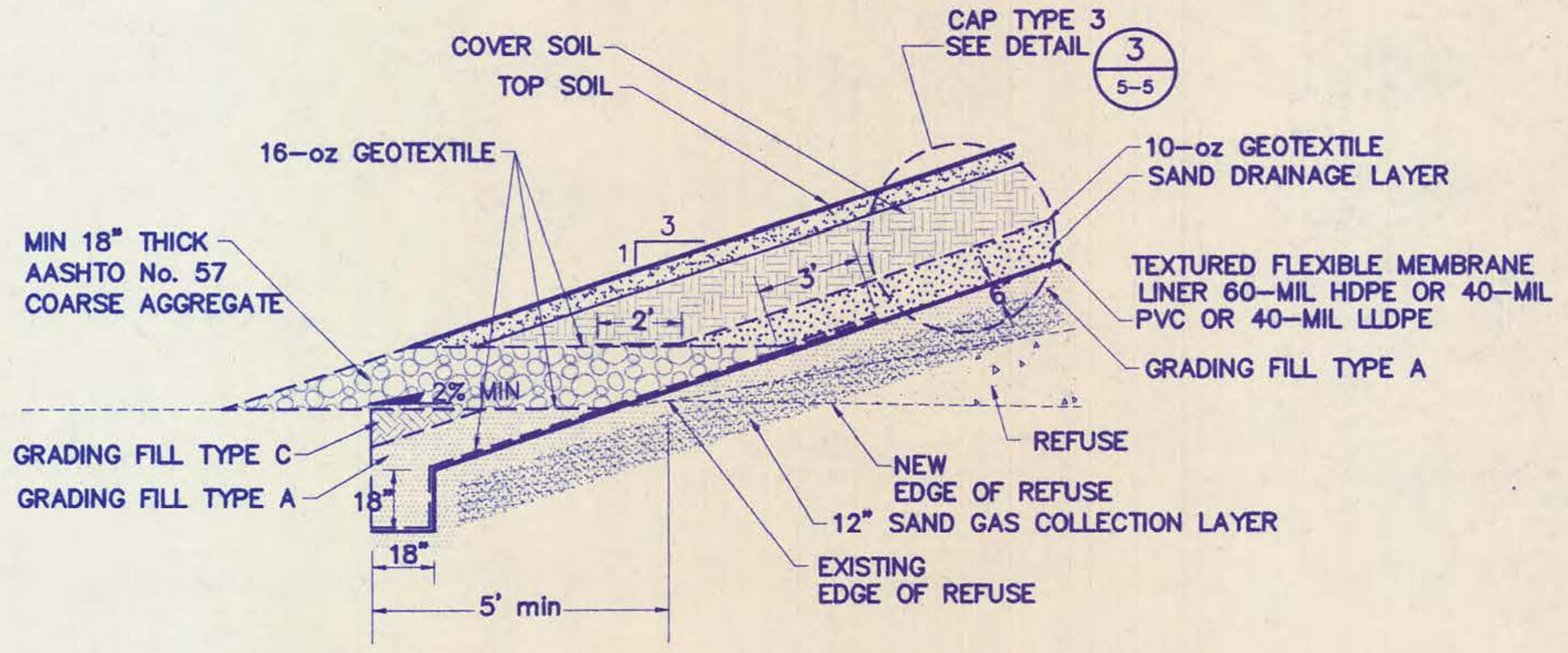
4 5-7 TOE TYPE 1

4 0 4 8
scale feet



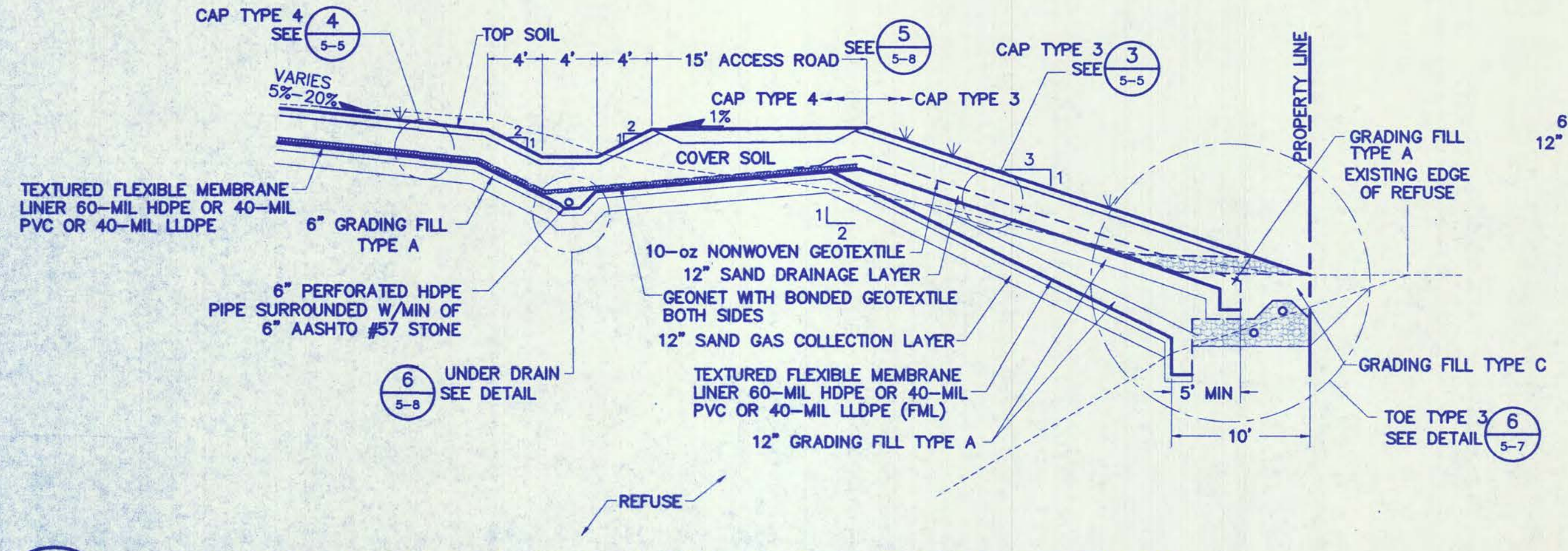
2 5-7 TYPICAL EDGE SECTION WITHOUT RECHARGE TRENCH (EXISTING EDGE OF REFUSE WITHIN THE PROPERTY LINE)

8 0 8 16
scale feet



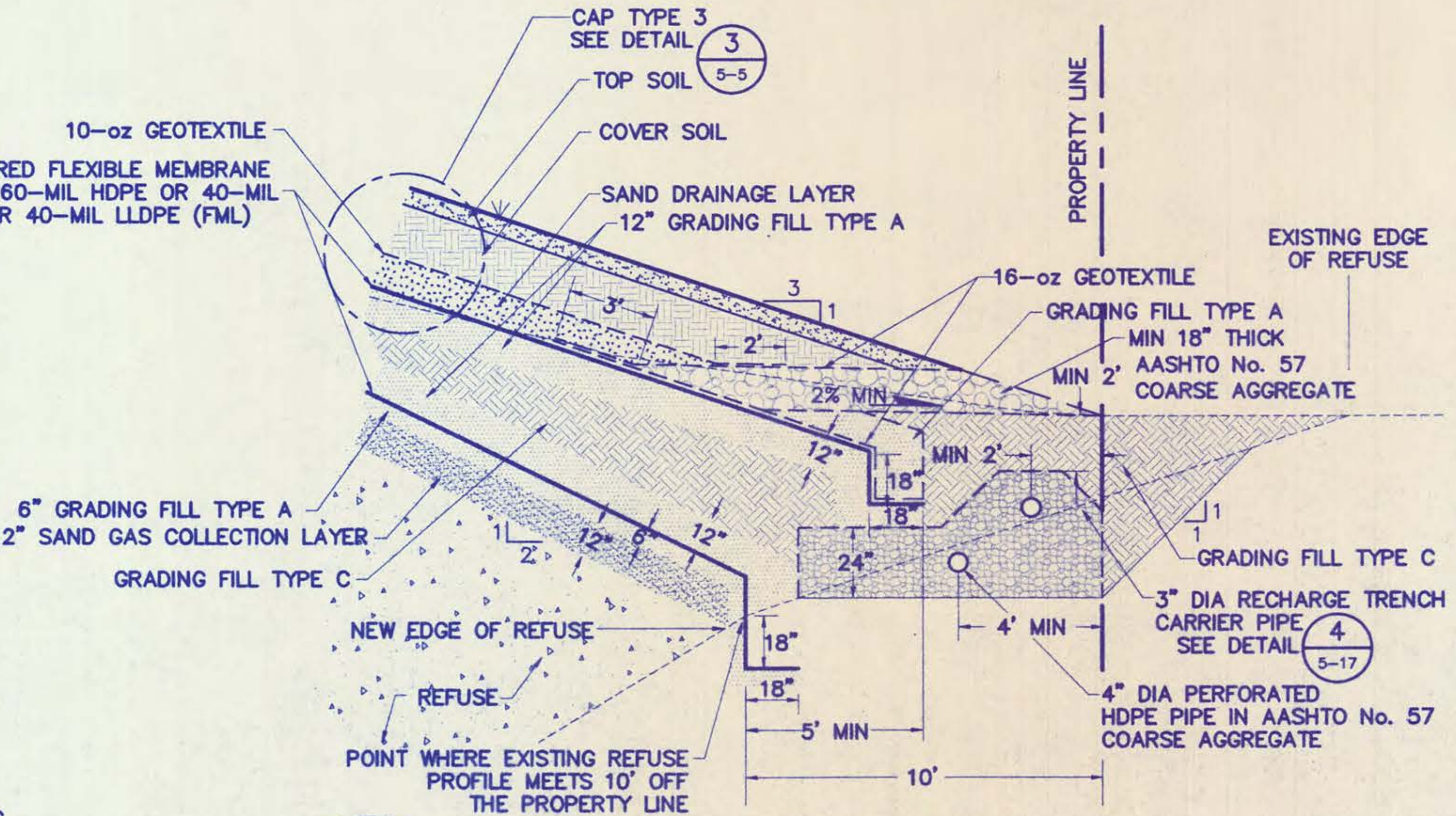
5 5-7 TOE TYPE 2

4 0 4 8
scale feet



3 5-7 TYPICAL EDGE SECTION WITH RECHARGE TRENCH

8 0 8 16
scale feet



6 5-7 TOE TYPE 3

4 0 4 8
scale feet

LEGEND

4 / 5-4	DETAIL OR CROSS SECTION DESIGNATION DRAWING No. WHERE DETAIL OR CROSS SECTION IS PRESENTED
▽ ▽	PROPOSED FINISHED SURFACE
— — —	GEOTEXTILES
- - - -	EXISTING GRADE / BOTTOM OF REFUSE
──	FLEXIBLE MEMBRANE LINER
5%	PROPOSED GRADES
▨	TOP SOIL
▨	COVER SOIL
▨	DRAINAGE LAYER
▨	GRADING FILL TYPE A
▨	GRADING FILL TYPE C
▨	SAND GAS COLLECTION LAYER
▨	DRAINAGE STONE (AASHTO No.57)
▨	REFUSE

NOTES

1.) REFER TO DRAWING 5-5 FOR CAP DETAILS

2.) THE GRADES LOWERED DUE TO EXCAVATION OF REFUSE OUTSIDE THE PROPERTY LINE SHALL BE BROUGHT BACK TO THE EXISTING ELEVATIONS WITH GRADING FILL TYPE C.

3.) FOR PERIMETER CHANNEL / PERIMETER ROAD DETAIL REFER TO DETAIL 5 / 5-8

4.) ALL HDPE PIPE SHALL BE TYPE SDR 11.

Golder Associates
Manchester, New Hampshire

PCConti
5/8/96
Date

PETER C. CONTI
No. 8485

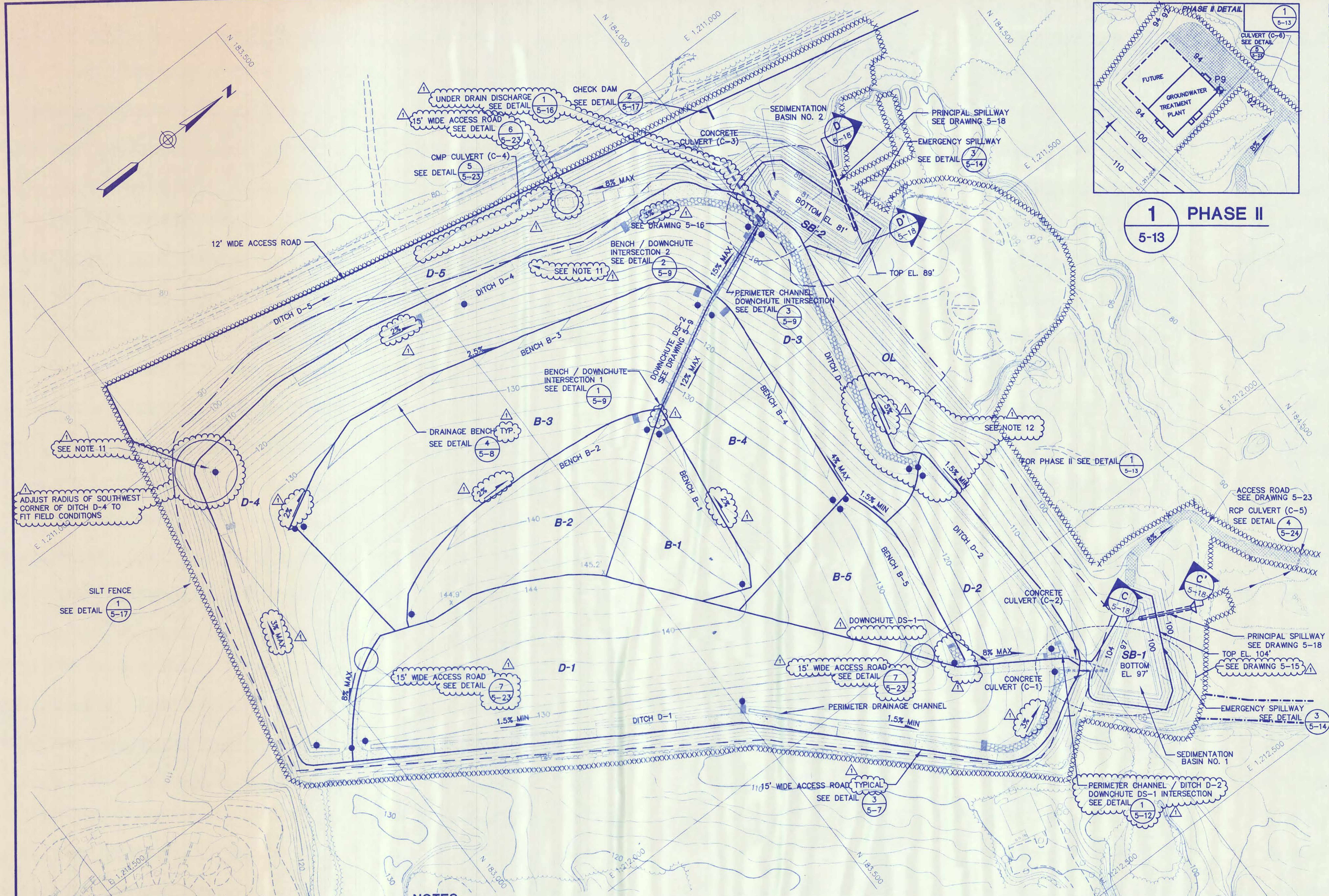
REV	DATE	DESCRIPTION	DR BY	CHK BY	RVW BY
0	5/10/96	RELEASED FOR BID	CDS	MRT	PCC

PROJECT:
THE COAKLEY LANDFILL GROUP
COAKLEY LANDFILL 100% REMEDIAL DESIGN REPORT
NORTH HAMPTON, NEW HAMPSHIRE

SHEET TITLE:
LINER DETAILS
SHEET 2 OF 7

Golder Associates
Manchester, New Hampshire

PROJECT No.		923-6058	FILE No.:	NH11-442
CLIENT PROJ. No.			DRAFTING SUBTITLE:	23
DES BY	MRT	02/96	SCALE:	AS SHOWN
DR BY	CDS	02/96	DRAWING:	5-7
CHK BY	MRT	3/15/96		
RVW BY	PCC	3/15/96		



LEGEND

— — — — — —	NEW EDGE OF REFUSE
— – — – — –	EXISTING EDGE OF REFUSE
—— – – ——	PROPERTY LINE
═══════	PROPOSED GRAVEL ACCESS ROAD
▨▨▨▨▨▨	PROPOSED PAVED ACCESS ROAD
▨▨▨▨▨▨	PROPOSED RIP RAP CHANNEL
———	DRAINAGE DIVIDE
▨	TEMPORARY HAYBALE, SEE DETAIL 3 5-17
B-1	WATER SHED
>==<	CULVERT
●	UNDERDRAIN CLEANOUTS
–·–·–·–·–	LIMIT OF CONSTRUCTION/ACCESS
XXXXXXXXXXXXXXXXXXXXXX	SILT FENCE AND LIMIT OF CONSTRUCTION / ACCESS
	SPOT ELEVATION
5%	DIRECTION OF RUN-OFF AND SLOPE %
—— 130 ——	REGRADED FINAL CONTOUR
—— 90 ——	EXISTING 10 FT CONTOUR
	EXISTING 2 FT CONTOUR
	EXISTING PAVED ROAD
	EXISTING UNPAVED ROAD
	EXISTING TREELINE
	EXISTING BRUSH LINE
	EXISTING UTILITY POLE
	EXISTING RAILROAD
●	HIGH POINT
A 5-9	DETAIL OR CROSS SECTION DESIGNATION DRAWING No. WHERE DETAIL OR CROSS SECTION IS PRESENTED

WATERSHED AREAS

WATERSHED ID	AREAS (acres)
B-1	1.01
B-2	1.35
B-3	3.52
B-4	1.65
B-5	1.13
D-1	5.26
D-2	1.16
D-3	1.42
D-4	4.54
D-5	3.14
ED	0.59
ER	1.02
SB-1	0.66
SB-2	0.44
OL	8.14

80 0 80 160
scale feet

NOTES

1. ELEVATION CONTOURS ARE FOR INFORMATION ONLY. CONTOURS SHOWN ARE BEFORE SETTLEMENT OF THE LANDFILL.
2. REFER TO DRAWING 5-18 FOR SEDIMENTATION BASIN DETAILS.
3. REFER TO DRAWING 5-14, 5-23, 5-24 FOR CULVERT AND CHANNEL SCHEDULE AND DETAILS.
4. FOR SEDIMENTATION BASIN INLET/OUTLET DETAILS REFER TO DRAWINGS 5-15, 5-16, 5-17 AND 5-18.
5. FOR PIPE BEDDING DETAIL REFER TO DETAIL 4 5-17
6. TEMPORARY SILT FENCE AND HAYBALES SHALL BE INSTALLED AND MAINTAINED BY THE CONTRACTOR THROUGHOUT THE CONSTRUCTION PERIOD AND UNTIL THE VEGETATION IS ESTABLISHED ON THE CAP AND DISTURBED AREAS.
7. IN ADDITION TO THE SILT FENCE SHOWN ON THIS DRAWING, CONTRACTOR SHALL PROVIDE AN EROSION AND SEDIMENT CONTROL PLAN INCLUDING TEMPORARY MEASURES SUCH AS HYDROMULCH, SILT FENCING, HAY BALES OR MULCHING AROUND WORK AREAS TO PREVENT SEDIMENT TRANSPORT. SUCH PLAN SHALL BE APPROVED BY PROJECT COORDINATOR IN CONJUNCTION WITH ENGINEER.
8. FOR LOCATING REFUSE FROM THE NORTH END OF THE LANDFILL TO CENTRAL AREA OF THE LANDFILL, CONTRACTOR SHALL SUBMIT AN EXCAVATION AND BACKFILL PLAN ALONG WITH NECESSARY EROSION AND SEDIMENT CONTROL MEASURES, INCLUDING TEMPORARY DITCHES, SILT FENCE ETC. FOR APPROVAL BY PROJECT COORDINATOR IN CONJUNCTION WITH ENGINEER PRIOR TO COMMENCEMENT OF EXCAVATION.
9. ALL UNDERDRAIN CLEANOUTS SHALL BE PROTECTED WITH 4 BOLLARDS INSTALLED AT 4' CENTER TO CENTER. FOR PROTECTIVE BOLLARDS REFER TO DETAIL 4 5-9
10. CHANNEL AND BENCH SLOPES MAY VARY ± 0.3% UNLESS NOTED MIN. OR MAX.
11. ADJUST LOCATION OF TRANSITION FROM 2% TO 3% FOR DITCH D-4 TO FIT FIELD CONDITIONS.
12. ALIGN ROAD AND DITCH D-2 SO THAT GAS VENT 65 FALLS 5' SOUTH OF THE ROAD AND 5' NORTH OF DITCH D-2. GRADE ROAD SHOULDER AT 3% TOWARD DITCH D-2.

REFERENCE

BASE DRAWING SUPPLIED BY TF MORAN, BEDFORD, N.H., DATED 09/15/92, BASED ON AERIAL PHOTOGRAMMETRY BY EASTERN TOPOGRAPHIC SERVICES, DATED 05/03/92.
VERTICAL DATUM: 1929 NGVD; HORIZONTAL DATUM: N.H. STATE PLANE, 1983

REV	DATE	DESCRIPTION	DR BY	CHK BY	RVW BY
1	6/11/97	CLARIFICATION / REQUEST FOR INFORMATION	CDS	MRT	PCC
0	5/10/96	RELEASED FOR BID	CDS	MRT	PCC

Golder Associates
Manchester, New Hampshire

PCConti
6/12/97
Date

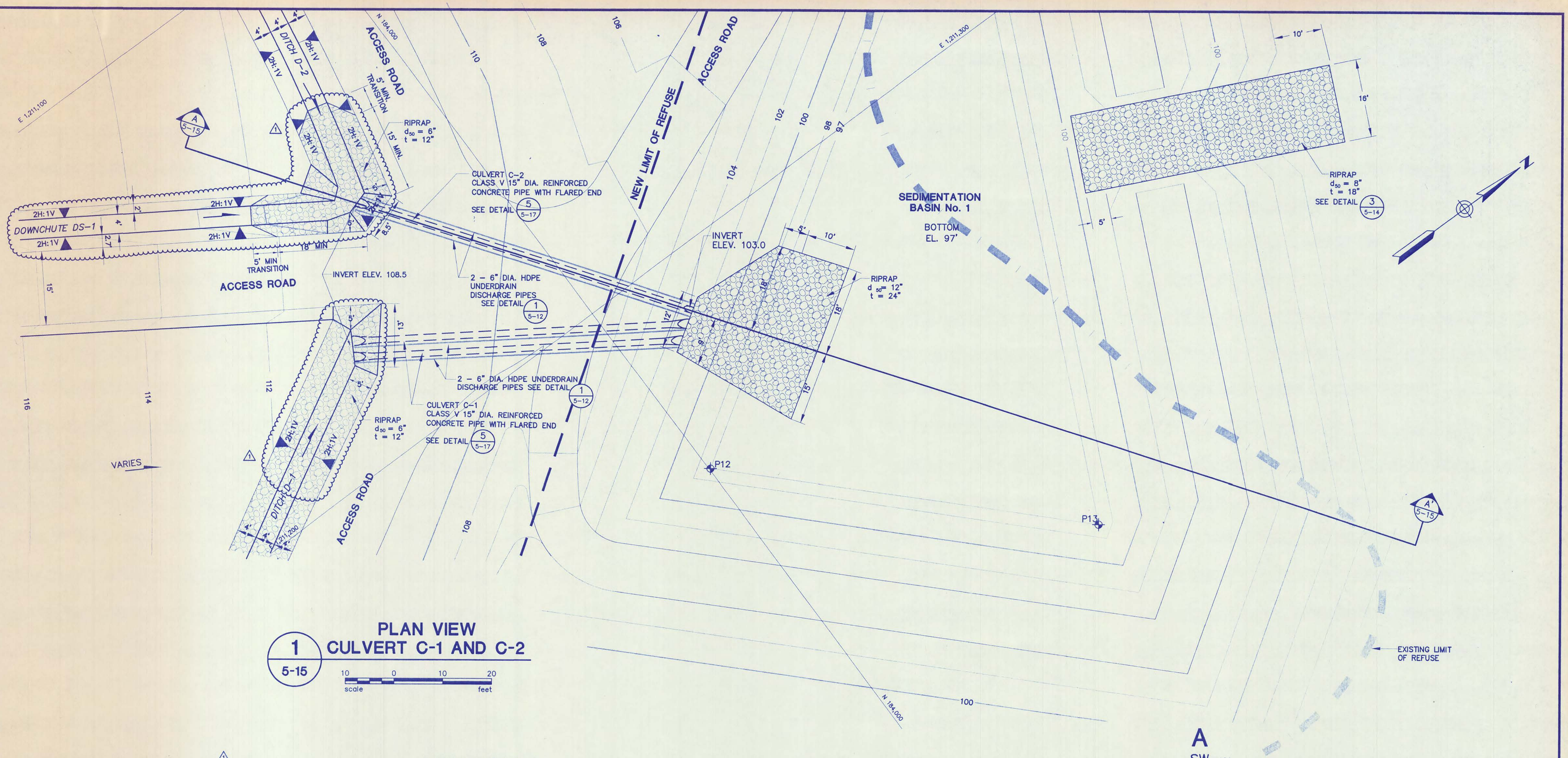
PETER C. CONTI
No. 6485

PROJECT:
THE COAKLEY LANDFILL GROUP
COAKLEY LANDFILL 100% REMEDIAL DESIGN REPORT
NORTH HAMPTON, NEW HAMPSHIRE

SHEET TITLE:
SURFACE WATER MANAGEMENT SYSTEM LAYOUT

Golder Associates
Manchester, New Hampshire

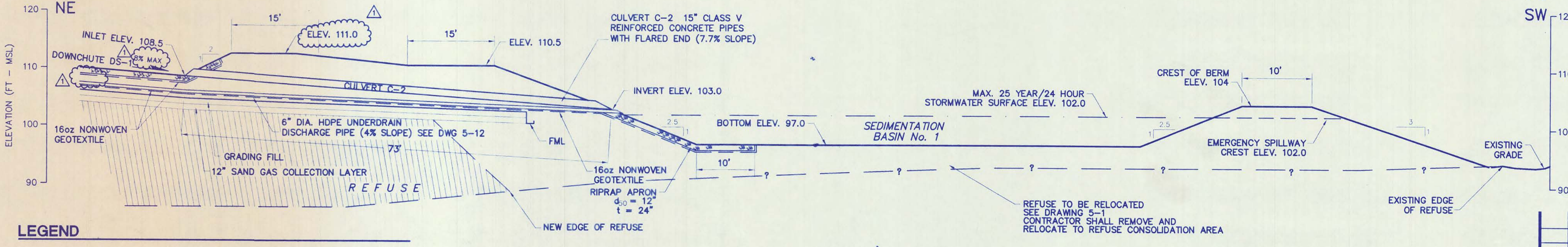
PROJECT No.		923-6058	FILE No.:	1NH11-448
CLIENT PROJ. No.			DRAFTING SUBTITLE:	20
DES BY	DC	02/96	SCALE:	AS SHOWN
DR BY	CDS	02/96	DRAWING:	5-13
CHK BY	MRT	03/15/96		
RVW BY	PCC	03/15/96		



PLAN VIEW
CULVERT C-1 AND C-2

1
5-15

10 0 10 20
scale feet



A SEDIMENTATION BASIN No. 1 INLET ARRANGEMENT

5-15

10 0 10 20
scale feet

LEGEND

A 22	DETAIL OR CROSS SECTION DESIGNATION DRAWING No. WHERE DETAIL OR CROSS SECTION IS PRESENTED
P13 ⌖	CONTROL COORDINATE POINT (SEE DRAWING 4-5)
— ? — ? —	ESTIMATED BOTTOM OF REFUSE

NOTES

1.) REFER TO DRAWING 5-12 FOR UNDERDRAIN DETAILS
2.) FOR SEDIMENTATION BASIN DETAILS REFER TO DRAWING 5-18
3.) FOR CHANNEL DETAILS REFER TO DRAWING 5-14
4.) REFER TO DETAIL 4 5-17 FOR PIPE TRENCH DETAIL.

Golder Associates
Manchester, New Hampshire

PCont
6/11/97
Date

STATE OF NEW HAMPSHIRE
PETER C. CONTI
No. 8485
LICENSED PROFESSIONAL ENGINEER

REV	DATE	DESCRIPTION	DR BY	CHK BY	RVW BY
1	6/11/97	CLARIFICATION / REQUEST FOR INFORMATION	CDS	MRT	PCC
0	5/10/96	RELEASED FOR BID	CDS	MRT	PCC

PROJECT:
THE COAKLEY LANDFILL GROUP
COAKLEY LANDFILL 100% REMEDIAL DESIGN REPORT
NORTH HAMPTON, NEW HAMPSHIRE

SHEET TITLE:
SURFACE WATER MANAGEMENT SYSTEM DETAILS
SHEET 2 OF 4

Golder Associates
Manchester, New Hampshire

PROJECT No.		923-6058	FILE No.:	1NH11-450
CLIENT PROJ. No.			DRAFTING SUBTITLE:	20
DES BY	DC	02/96	SCALE:	AS SHOWN
DR BY	CDS	02/96	DRAWING:	5-15
CHK BY	MRT	3/15/96		
RVW BY	PCC	3/15/96		

LEGEND

A	DETAIL OR CROSS SECTION DESIGNATION
22	DRAWING No. WHERE DETAIL OR CROSS SECTION IS PRESENTED
P14 ⌖	CONTROL COORDINATE POINT (SEE DRAWING 5-4)
—?—?—?—	ESTIMATED BOTTOM OF REFUSE

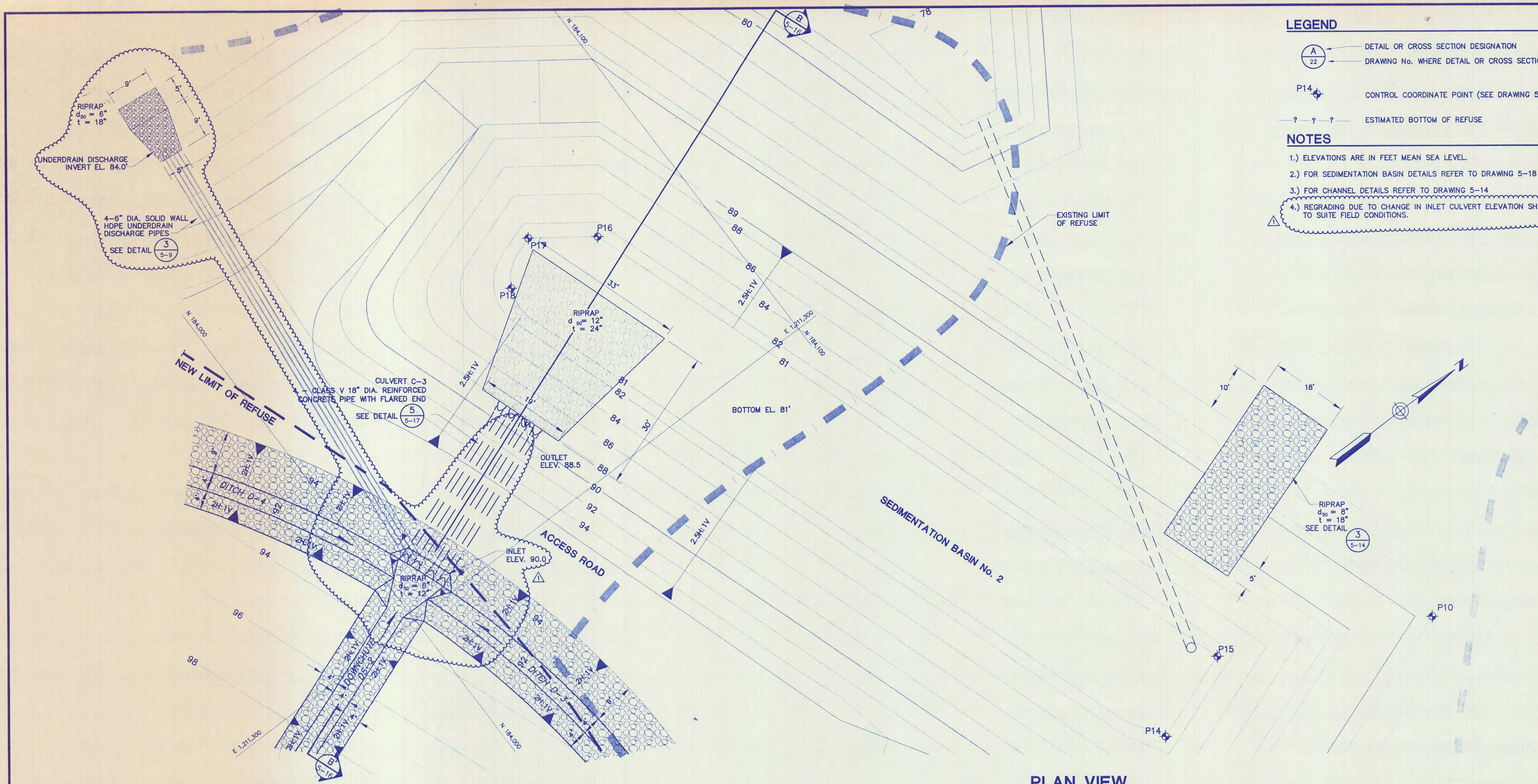
NOTES

1.) ELEVATIONS ARE IN FEET MEAN SEA LEVEL.

2.) FOR SEDIMENTATION BASIN DETAILS REFER TO DRAWING 5-18

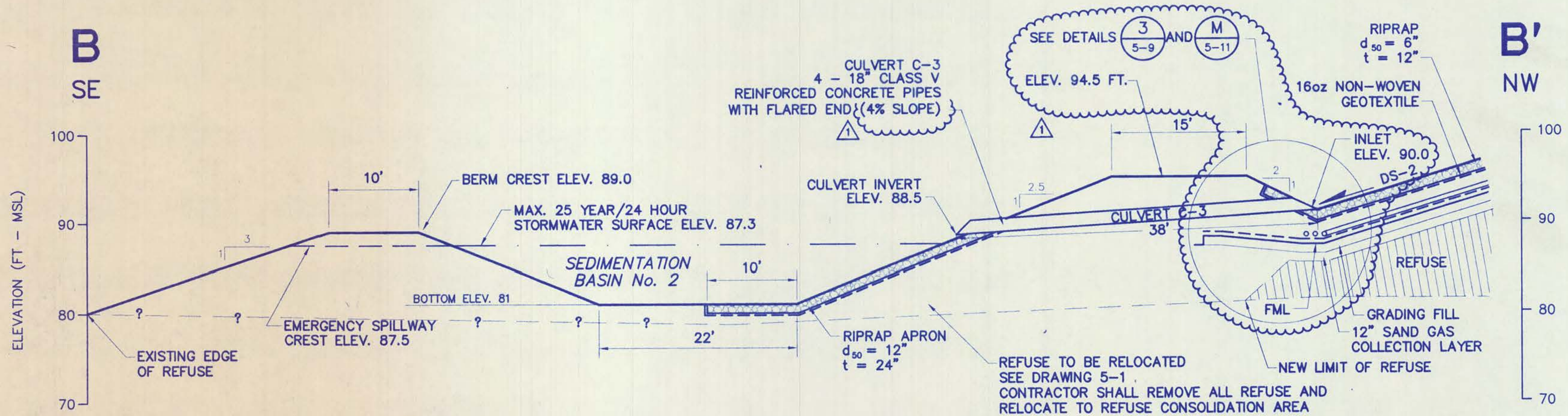
3.) FOR CHANNEL DETAILS REFER TO DRAWING 5-14

△1 4.) REGRADING DUE TO CHANGE IN INLET CULVERT ELEVATION SHALL BE MODIFIED TO SUITE FIELD CONDITIONS.



1/5-16 PLAN VIEW CULVERT C-3

10 0 10 20
scale feet



B/5-16 SEDIMENTATION BASIN No. 2 INLET ARRANGEMENT

10 0 10 20
scale feet

PConti
6/11/97
Date

PETER C. CONTI

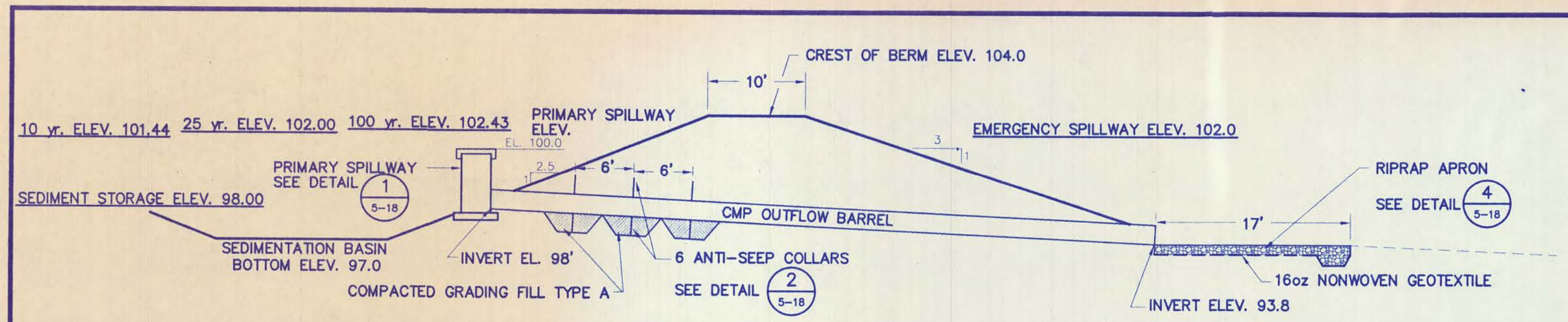
REV	DATE	DESCRIPTION	DR BY	CHK BY	RVW BY
1	6/11/97	CLARIFICATION / REQUEST FOR INFORMATION	CDS	MRT	PCC
0	5/10/96	RELEASED FOR BID	CDS	MRT	PCC

PROJECT:
THE COAKLEY LANDFILL GROUP
COAKLEY LANDFILL 100% REMEDIAL DESIGN REPORT
NORTH HAMPTON, NEW HAMPSHIRE

SHEET TITLE:
SURFACE WATER MANAGEMENT SYSTEM DETAILS
SHEET 3 OF 4

Golder Associates
Manchester, New Hampshire

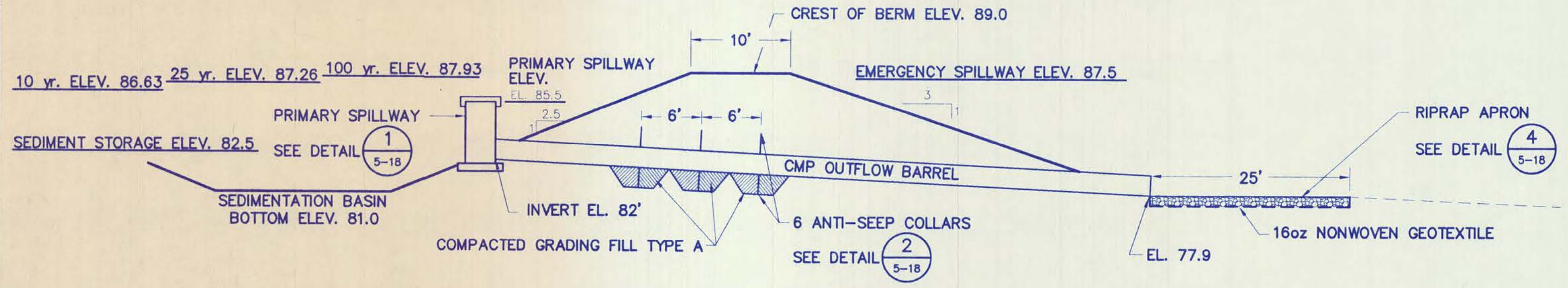
PROJECT No.	923-6058		FILE No.:	1NH11-451
CLIENT PROJ. No.			DRAFTING SUBTITLE:	20
DES BY	DC	02/96	SCALE:	AS SHOWN
DR BY	CDS	02/96	DRAWING:	5-16
CHK BY	MRT	3/15/96		
RVW BY	PCC	3/15/96		



C
5-18

SEDIMENTATION BASIN No. 1 DISCHARGE PROFILE

N.T.S.



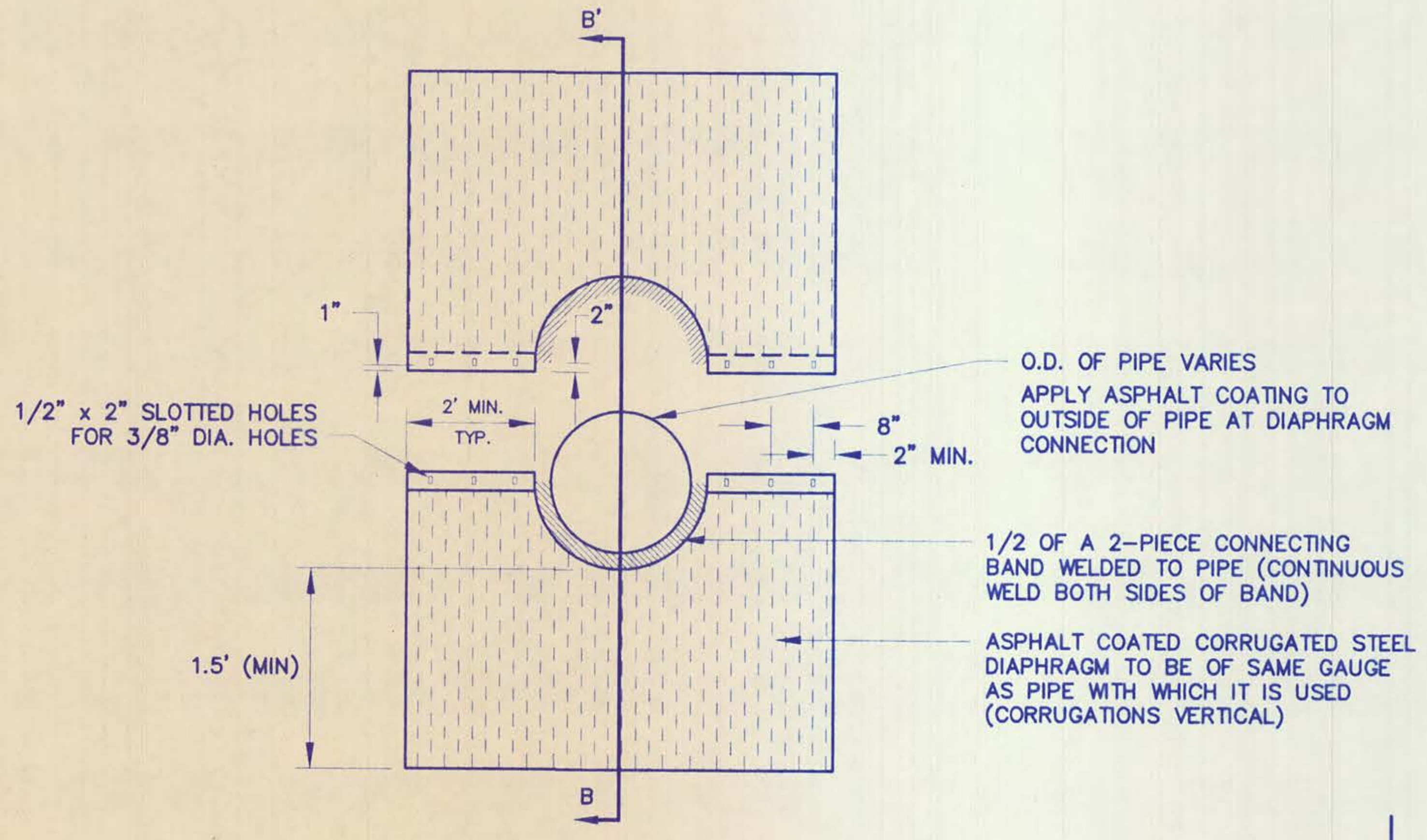
D
5-18

SEDIMENTATION BASIN No. 2 DISCHARGE PROFILE

N.T.S.

ANTI-SEEP COLLAR SCHEDULE

SEDIMENTATION BASIN	INTSIDE DIAMETER OF PIPE (INCHES)	DIMENSIONS OF ANTI-SEEP	NUMBER OF ANTI-SEEP COLLARS
1	12	5 x 5	3
2	24	5 x 5	3



2
5-18

ANTI-SEEP COLLAR DETAIL

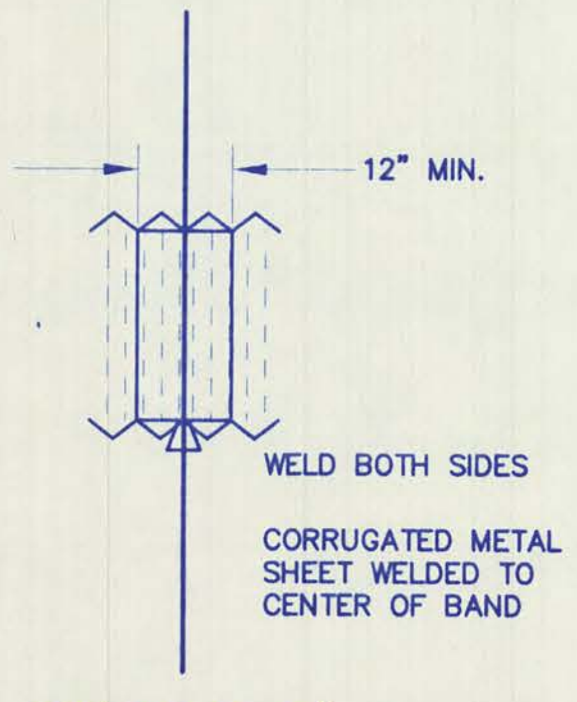
NOT TO SCALE

NOTES FOR COLLARS

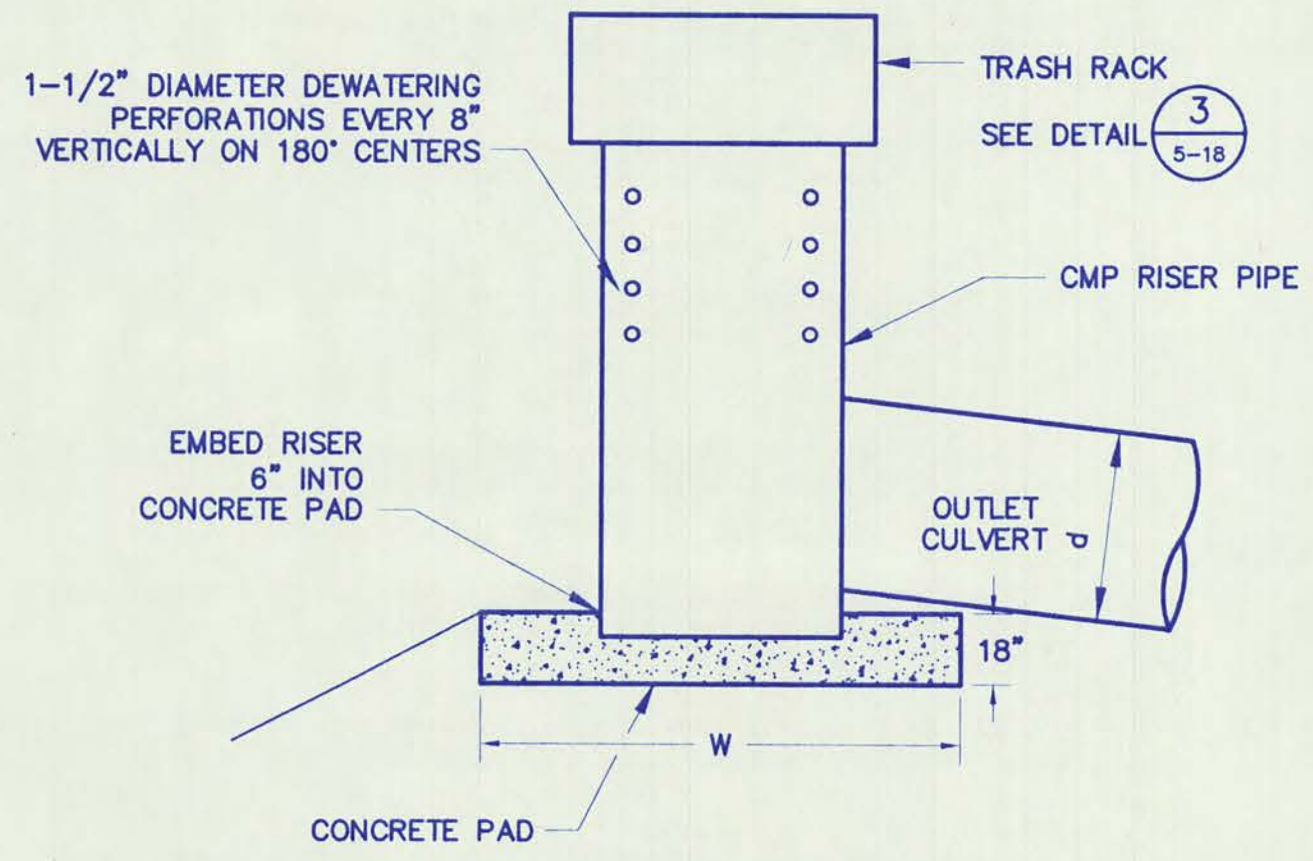
1.) UNASSEMBLED COLLARS SHALL BE MARKED BY PAINTING OR TAGGING TO IDENTIFY MATCHING PAIRS.

2.) THE LAP BETWEEN THE TWO HALF SECTIONS AND BETWEEN THE PIPE AND CONNECTING BAND SHALL BE CAULKED WITH ASPHALT MASTIC AT TIME OF INSTALLATION.

3.) EACH COLLAR SHALL BE FURNISHED WITH TWO 1/2" DIA. RODS WITH STANDARD TANK LUGS FOR CONNECTING COLLARS TO PIPE.



DETAIL B–B'



1
5-18

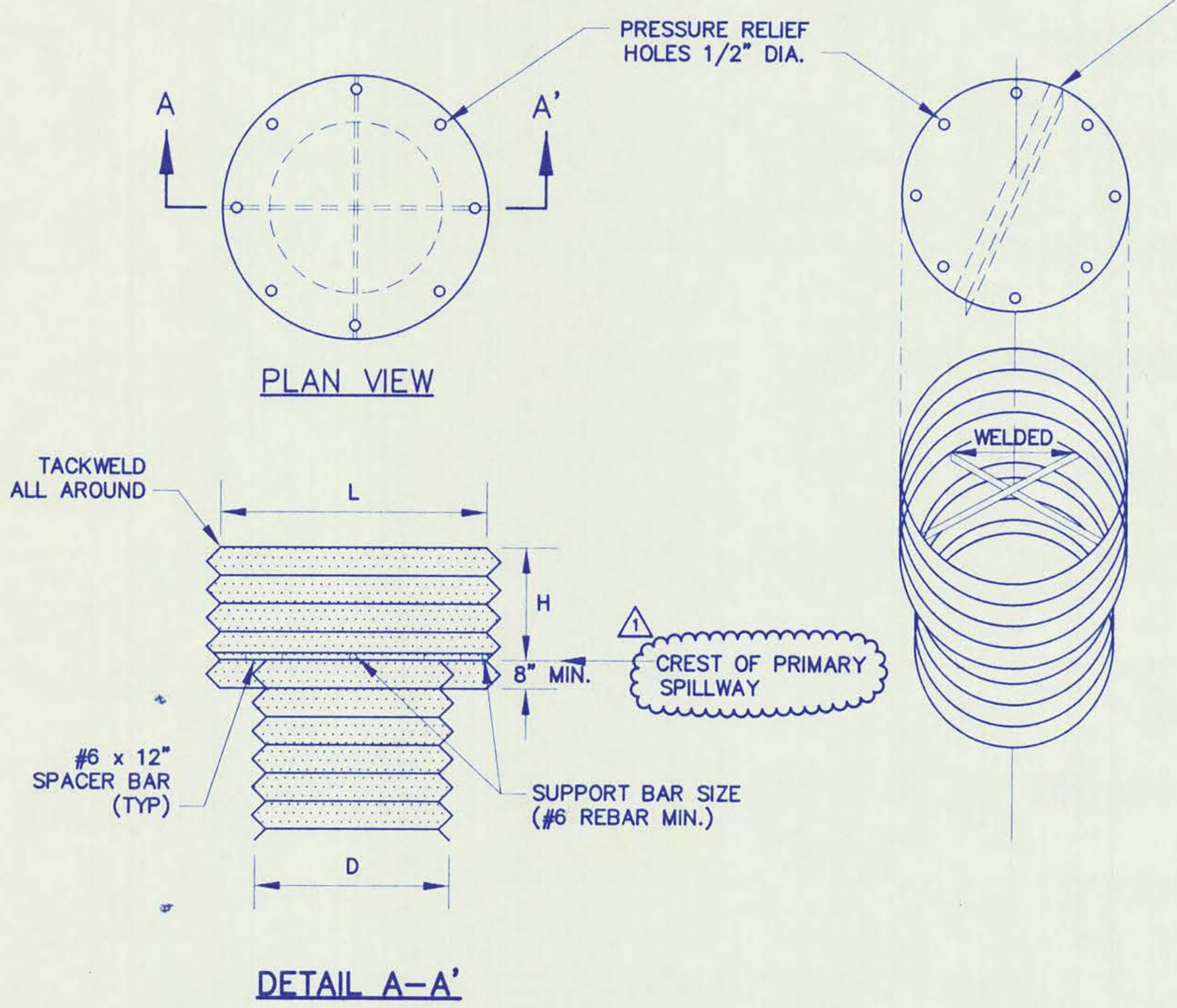
TYPICAL PRIMARY RISER DETAIL

N.T.S.

NOTE: CONCRETE PAD REINFORCEING SHALL BE No. 4 BARS AT 6" SPACING 2 1/2" FROM BOTTOM IN BOTH DIRECTIONS

PRIMARY SPILLWAY SCHEDULE

SEDIMENTATION BASIN	DIAMETER OF ANTI-VORTEX DEVICE (L) (in)	DIAMETER OF RISER PIPE (in) (D)	DIAMETER OF OUTFLOW PIPE (in) (d)	HEIGHT (in) (H)	BASE DIMENSIONS (W) (ft)
1	18	12	12	6	2 x 2
2	30	24 ⚠1	24	11	3.5 x 3.5



TOP STIFFENER (IF REQUIRED) IS 1 1/2 x 1 1/2 x 3/16 ANGLE WELDED TO TOP AND ORIENTED PERPENDICULAR TO CORRUGATIONS.

TOP IS 16 GAUGE CORRUGATED METAL OR 1/8" STEEL PLATE. PRESSURE RELIEF HOLES MAY BE OMITTED, IF ENDS OF CORRUGATIONS ARE LEFT FULLY OPEN WHEN THE TOP IS ATTACHED.

CYLINDER IS 16 GAUGE CORRUGATED METAL PIPE OR FABRICATED FROM 1/8" STEEL PLATE.

NOTES:

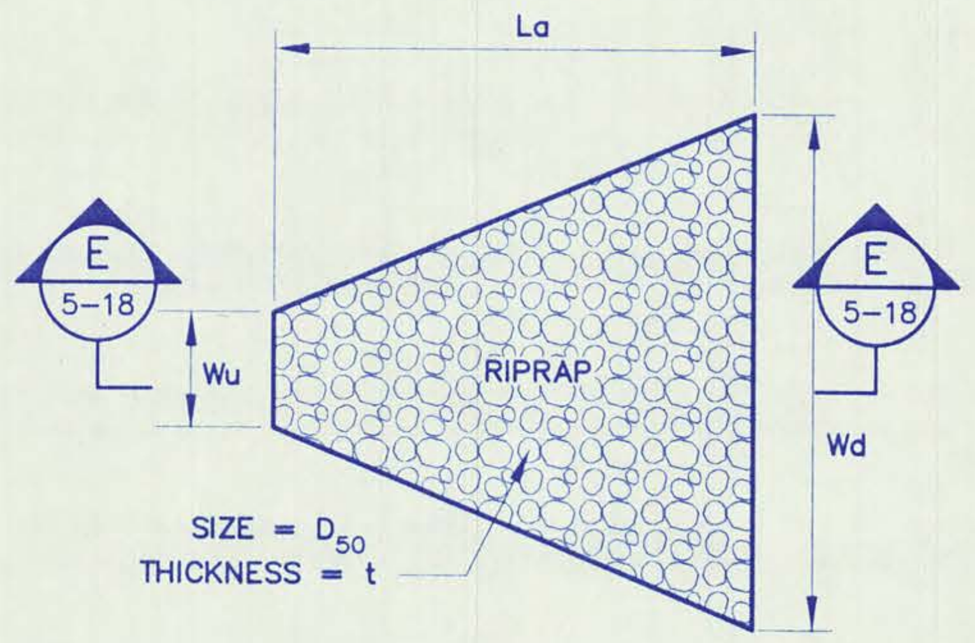
1). THE CYLINDER MUST BE FIRMLY FASTENED TO THE TOP OF THE RISER.

2). SUPPORT BARS ARE WELDED TO BOTH PIPES OR ATTACHED WITH STRAPS BOLTED TO TOP OF RISER.

3
5-18

TRASH RACK AND ANTI-VORTEX DEVICE

NOT TO SCALE



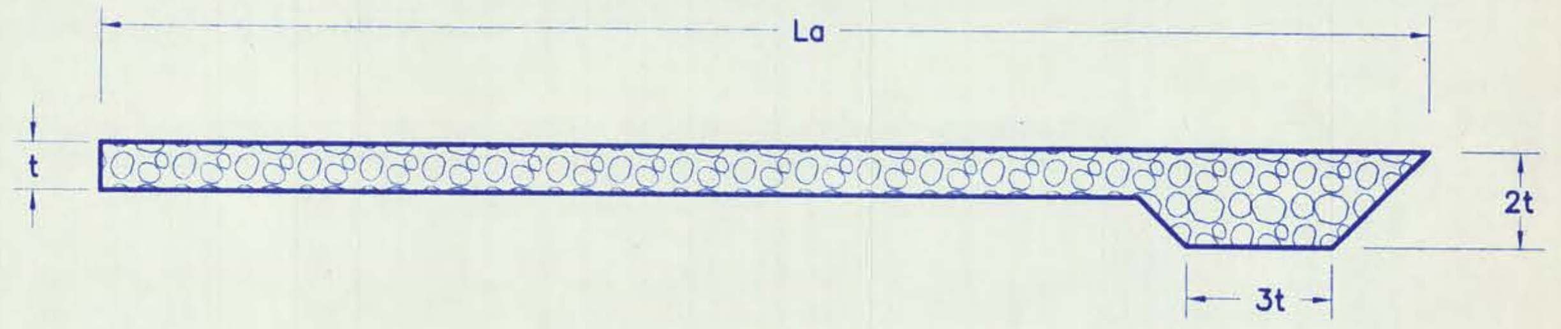
4
5-18

TYPICAL RIPRAP APRON DETAIL

NOT TO SCALE

SEDIMENTATION BASIN OUTLET APRON SCHEDULE

SEDIMENTATION BASIN	APRON LENGTH (ft) (La)	APRON UPSTREAM WIDTH (ft) (Wu)	APRON DOWNSTREAM WIDTH (ft) (Wd)	RIPRAP (in) D_{50}	RIPRAP THICKNESS (t) (in)
1	17	3	20	3	9
2	25	6	27	12	24



E
5-18

TYPICAL RIPRAP APRON SECTION DETAIL

NOT TO SCALE

LEGEND

A — DETAIL OR CROSS SECTION DESIGNATION

5-15 — DRAWING No. WHERE DETAIL OR CROSS SECTION IS PRESENTED

NOTES

1. REFER TO DRAWING 5-15 AND 5-16 FOR SEDIMENTATION BASIN INLET PIPE DETAILS

2. REFER TO DRAWING 5-14 FOR EMERGENCY SPILLWAY DETAILS.

REV	DATE	DESCRIPTION	DR BY	CHK BY	RVW BY
1	6/11/97	CLARIFICATION / REQUEST FOR INFORMATION	CDS	mrt	pcc
0	5/10/96	RELEASED FOR BID	CDS	MRT	PCC

Golder Associates
Manchester, New Hampshire

PCConti
6/11/97
Date

PETER C. CONTI

PROJECT:
THE COAKLEY LANDFILL GROUP
COAKLEY LANDFILL 100% REMEDIAL DESIGN REPORT
NORTH HAMPTON, NEW HAMPSHIRE

SHEET TITLE:
SEDIMENTATION BASIN DETAILS

Golder Associates
Manchester, New Hampshire

PROJECT No. 923-6058
CLIENT PROJ. No.
DES BY MRT 10/95
DR BY CDS 11/95
CHK BY MRT 11/22/95
RVW BY CDS 11/22/95
FILE No.: 1NH11-387
DRAFTING SUBTITLE: 20
SCALE: AS SHOWN
DRAWING: 5-18

APPENDIX B

PIEZOMETER CONSTRUCTION DIAGRAMS

CES INC
ENGINEERING • SURVEYING • PLANNING • SCIENCES

WELL COMPLETION LOG

Well: PZ-1

Project: Coakley Landfill
Location: Greenland/ North Hampton, NH

Project #: 10424.020
Sheet: 1
Chkd by: CFB

Drilling Co: CES, Inc.
Operator:
CES Geologist: WEH

Well Location: Coakley Landfill Northeast Stormwater Basin (SB-1)
Date started: 11/16/2018 Date Completed: 11/16/2018

2.25' Steel Stickup

Depth (ft.)	Stratum from Soil Boring Log
	Organic Sediment and Leaf Litter
1	
2	
3	
4	
5	Total Depth = 5.35 ft BGS
6	* Material inferred from stormwater pond construction diagrams.
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

REFERENCE ELEVATIONS
Surveyor: TF Moran
Reference (MSL or TBM): MSL
Top of Protective Casing: 99.5
Top of inner casing: N/A
Ground Surface: 97.02

GW ELEVATIONS Date	Elevation
12/11/2018	95.25
5/6/2019	96.41

WELL CONSTRUCTION DETAILS

PROTECTIVE CASING
Type (Standpipe or roadbox): NA
Diameter (in.): NA
Length (ft.): NA
Concrete Seal (ft.): NA

WELL CASING AND SCREEN

	Riser	Screen
Material:	G. Steel	S. Steel
Schedule:		
Diameter (in.):	1.25	1.25
Length (ft):	5.0	2.5
Interval below ground surface (ft):	0-2.85	2.85-5.35
Slot size (in.):	N/A	0.007

FILTER AND SEAL MATERIALS

	Filter	Seal
Type:	N/A	N/A
Size:	N/A	N/A
Quantity (bags):	N/A	N/A
Interval below ground surface (ft):	N/A	N/A

GROUT
Type (filter sand, bentonite, etc.): N/A
Quantity (gal. or lbs.): N/A
Interval below ground surface (ft.): N/A

WELL DEVELOPMENT DETAILS

Water level from measuring point (ft): 3.02
Depth of well from measuring point (ft): 7.67
Total feet of water: 4.65
Volume of water (gal): 0.30
Volume of water evacuated: 2.50
Method of development: Checkball/Peristaltic Pump

Explanation:
Sediment
Rip/Rap - Gravel Fill
Grading Fill
Stainless Steel Screen

CES INC
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WELL COMPLETION LOG

Well: PZ-2

Project:	Coakley Landfill	Project #:	10424.020
Location:	Greenland/ North Hampton, NH	Sheet:	1
		Chkd by:	CFB

Drilling Co: CES, Inc.
Operator:
CES Geologist: WEH

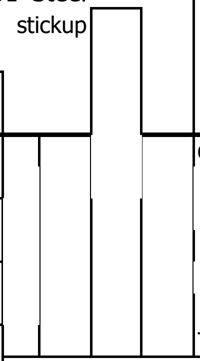
Well Location: Coakley Landfill
Northwest Stormwater Basin (SB-2)
Date started: 11/9/2018 Date Completed: 11/9/2018

REFERENCE ELEVATIONS
Surveyor: CES, Inc.
Reference (MSL or TBM): MSL
Top of Protective Casing: 84.5**
Top of inner casing: N/A
Ground Surface: 81.99

GW ELEVATIONS

Date	Elevation
12/11/2018	82.38
5/6/2019	83.04

2.51' Steel
stickup



Depth (ft.)

Stratum from Soil Boring Log

Organic Sediment and Leaf Litter

Fill*

Total Depth = 3.56 ft BGS

* Material inferred from stormwater pond construction diagrams.

1
2
3
4
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8
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14
15
16
17
18
19
20

WELL CONSTRUCTION DETAILS

PROTECTIVE CASING
Type (Standpipe or roadbox): N/A
Diameter (in.): N/A
Length (ft.): N/A
Concrete Seal (ft.): N/A

WELL CASING AND SCREEN

	Riser	Screen
Material:	G. Steel	S. Steel
Schedule:		
Diameter (in.):	1.25	1.25
Length (ft):	4.85	2.50
Interval below ground surface (ft):	0-1.06	1.06-3.56
Slot size (in.):	N/A	0.007

FILTER AND SEAL MATERIALS

	Filter	Seal
Type:	N/A	N/A
Size:	N/A	N/A
Quantity (bags):	N/A	N/A
Interval below ground surface (ft):	N/A	N/A

GROUT
Type (filter sand, bentonite, etc.): N/A
Quantity (gal. or lbs.): N/A
Interval below ground surface (ft.): N/A

WELL DEVELOPMENT DETAILS

Water level from measuring point (ft): 0.94
Depth of well from measuring point (ft): 6.07
Total feet of water: 5.13
Volume of water (gal): 0.34
Volume of water evacuated: 2.50
Method of development: Checkball/Peristaltic Pump

Explanation:
Sediment
Rip/Rap - Gravel Fill
Grading Fill
Stainless Steel Screen

** Elevation taken relative to fixed survey benchmark location.

CES INC
ENGINEERING • SURVEYING • PLANNING • SCIENCES

WELL COMPLETION LOG

Well: PZ-3

Project:	Coakley Landfill	Project #:	10424.020
Location:	Greenland/ North Hampton, NH	Sheet:	1
		Chkd by:	CFB

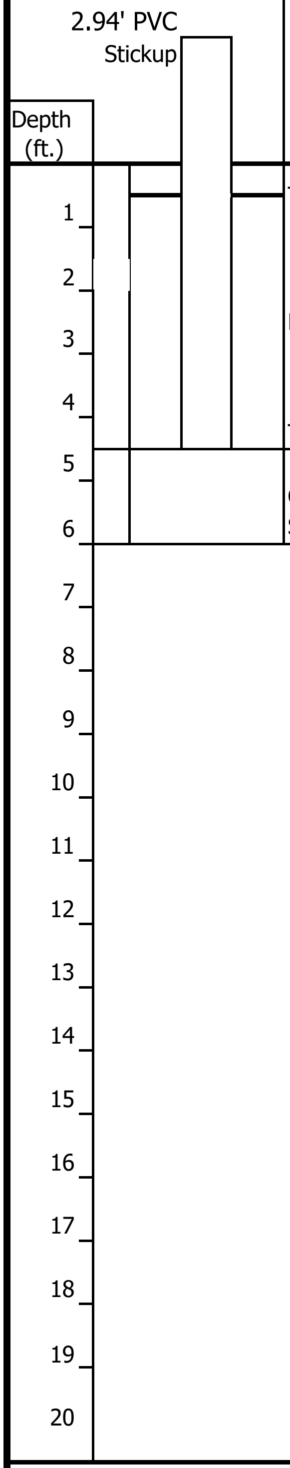
Drilling Co:	*CES, Inc.*
Operator:	
CES Geologist:	WEH
Well Location:	Coakley Landfill West of L-1 Seep
Date started:	4/17/2019
Date Completed:	4/17/2019

REFERENCE ELEVATIONS

Surveyor: C Buckman
Reference (MSL or TBM): MSL
Top of Protective Casing: 81.58
Top of inner casing: N/A
Ground Surface: 78.64

GW ELEVATIONS

Date	Elevation
5/6/2019	78.6



Stratum from soil boring log

Topsoil/FILL

Fine-grained SAND.

Total Depth = 4.24 ft BGS

CLAY. Highly Plastic.
Saturated.

WELL CONSTRUCTION DETAILS

PROTECTIVE CASING

Type (Standpipe or roadbox): N/A
Diameter (in.): N/A
Length (ft.): N/A
Concrete Seal (ft.): N/A

WELL CASING AND SCREEN

	Riser	Screen
Material:	PVC	PVC
Schedule:	40	40
Diameter (in.):	1.25	1.25
Length (ft):	1.75	2.50
Interval below ground surface (ft):	0-1.74	1.74-4.24
Slot size (in.):		0.007

FILTER AND SEAL MATERIALS

	Filter	Seal
Type:	Silica	Bentonite
Size:	#10	Granular
Quantity (bags):	N/A	N/A
Interval below ground surface (ft):	1.5-4.25	0-1.5

GROUT

Type (filter sand, bentonite, etc.): N/A
Quantity (gal. or lbs.): N/A
Interval below ground surface (ft.): N/A

WELL DEVELOPMENT DETAILS

Water level from measuring point (ft): 2.91
Depth of well from measuring point (ft): 7.18
Total feet of water: 4.27
Volume of water (gal): 0.17
Volume of water evacuated: 1.50
Method of development: Checkball/Peristaltic Pump

Explanation:

Topsoil/Organic Debris
Clay
Sand
PVC Screen

APPENDIX C

EXPANDED PFAS ANALYTE LIST

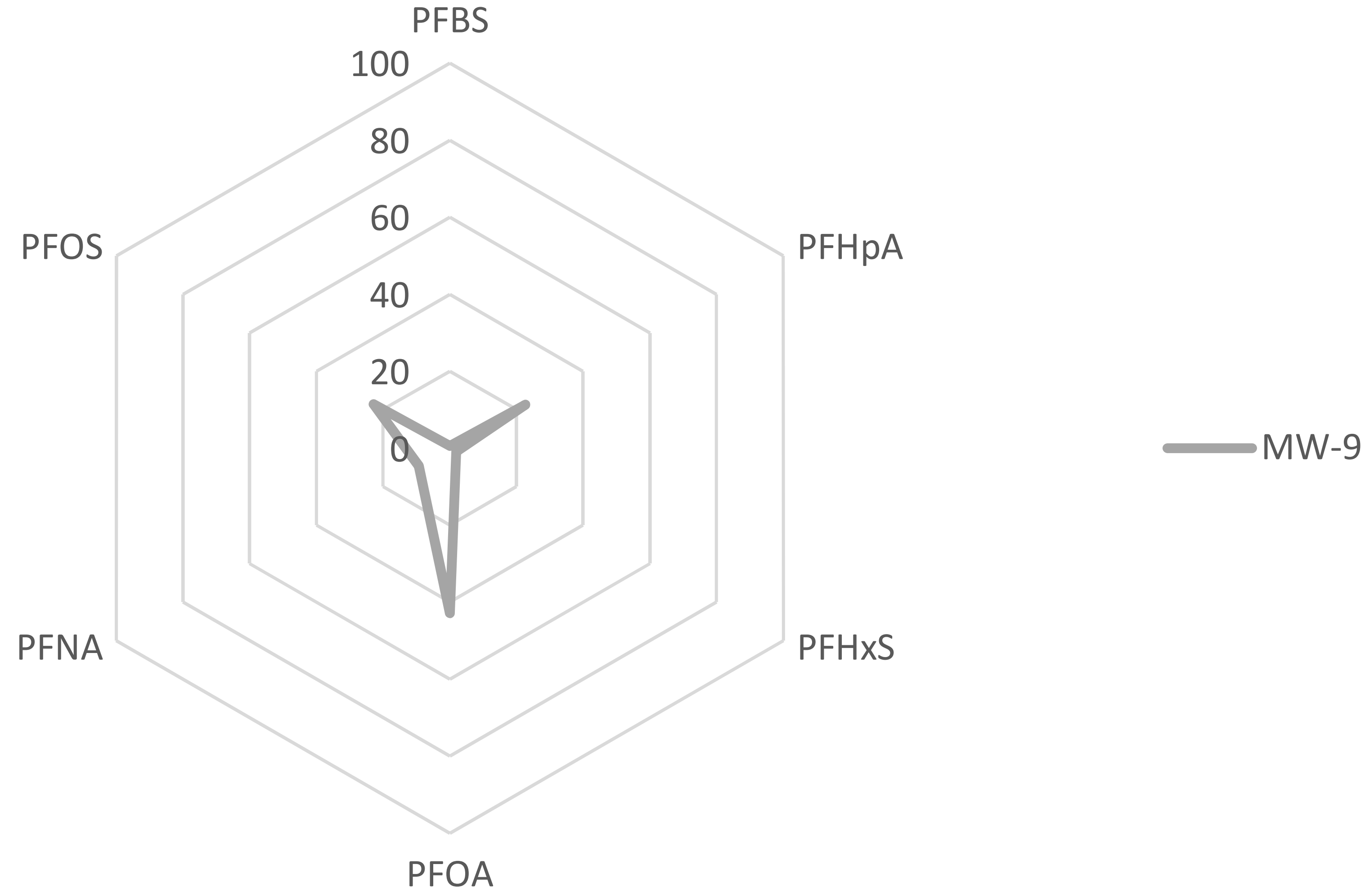
Appendix C
EXPANDED PFAS ANALYTE LIST

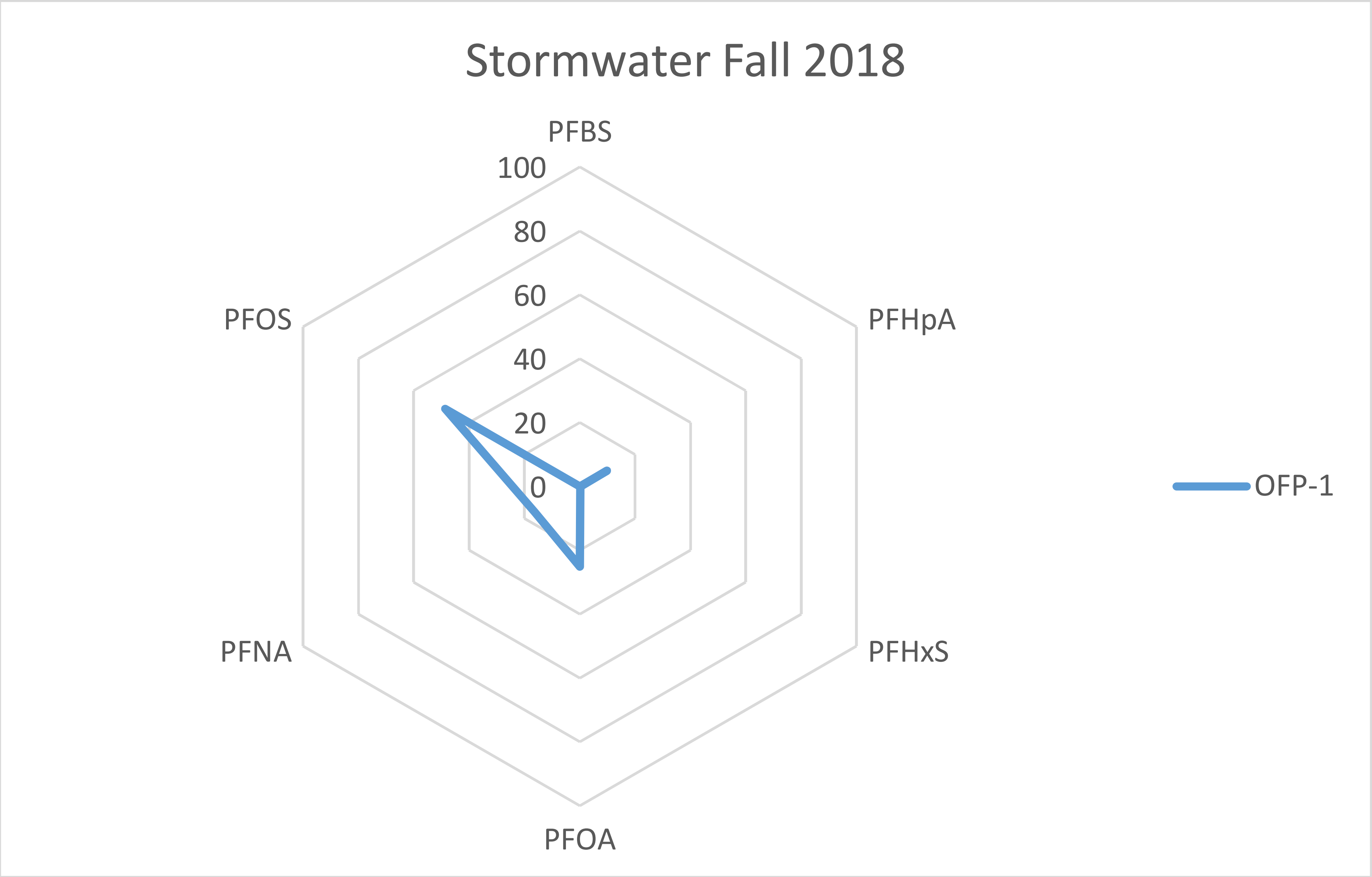
ANALYTE		CAS No.
PFPeA	Perfluoropentanoic Acid	2706903
PFBS	Perfluorobutane Sulfonic Acid	375735
PFBA	Perfluorobutanoic Acid	375224
PFUnA	Perfluoroundecanoic Acid	2058948
PFTrDA	Perfluorotridecanoate	862374876
PFTeDA	Perfluorotetradecanoic Acid	376067
PFOSA	Perfluorooctane Sulfonamide	754916
PFOS	Perfluorooctane Sulfonate	1763231
PFOA	Pentadecafluorooctanoic Acid	335671
PFNA	Perfluorononanoic Acid	375951
PFHxS	Perfluorohexane Sulfonate	355464
PFHxDA	Perfluorohexadecanoic Acid	67905195
PFHxA	Perfluorohexanoic Acid	307244
PFHpS	Perfluoroheptane Sulfonic Acid	375928
PFHpA	Perfluoroheptanoic Acid	375859
PFDS	Perfluorodecane Sulfonate	67906427
PFDoA	Perfluorododecanoic Acid	307551
PFDA	Perfluorodecanoic Acid	335762
MeFOSE	N-Methyl Perfluorooctane Sulfonamidoethanol	24448097
MeFOSAA	N-Methyl Perfluorooctane Sulfonamidoacetic Acid	2355319
MeFOSA	N-Methyl Perfluorooctane Sulfonamide	31506328
EtFOSE	N-Ethyl Perfluorooctane Sulfonamidoethanol	1691992
EtFOSAA	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid	2991506
EtFOSA	N-Ethyl Perfluorooctane Sulfonamide	4151502
8:2 FTS	8:2 Fluorotelomer Sulfonate	39108344
6:2 FTS	6:2 Fluorotelomer Sulfonic Acid	27619972

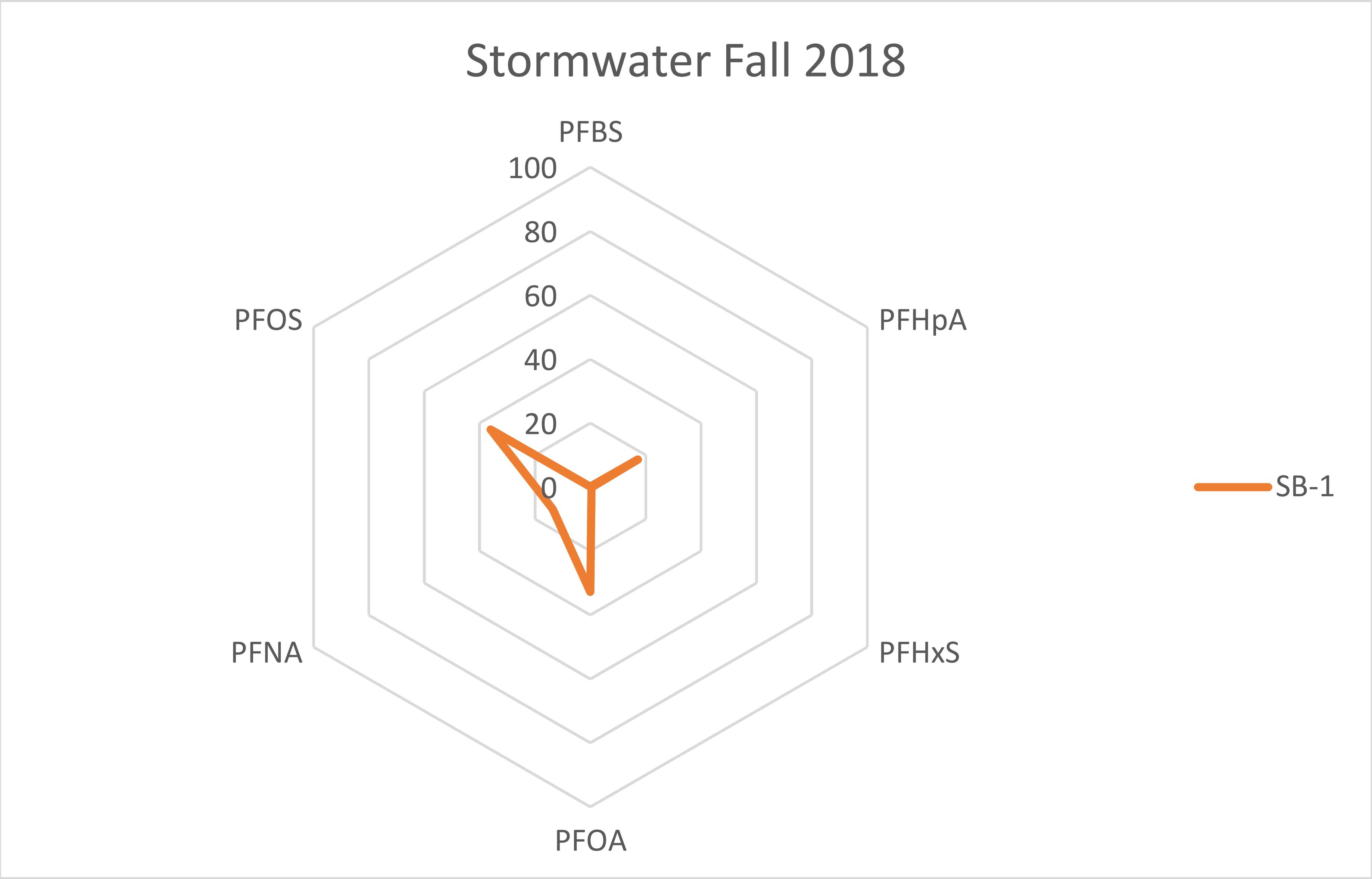
APPENDIX D

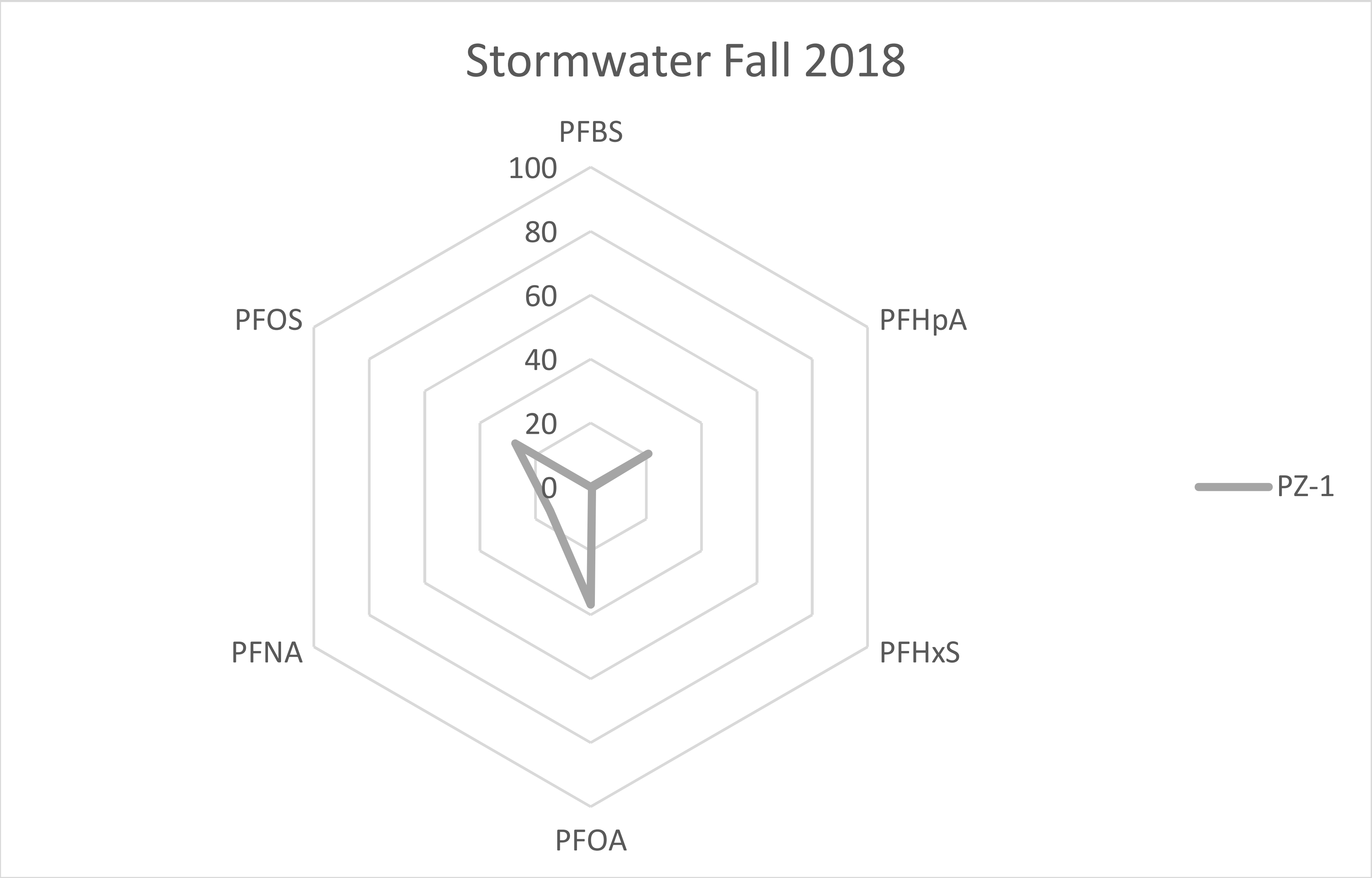
PFAS COMPOSITION PLOTS – SELECT LOCATIONS

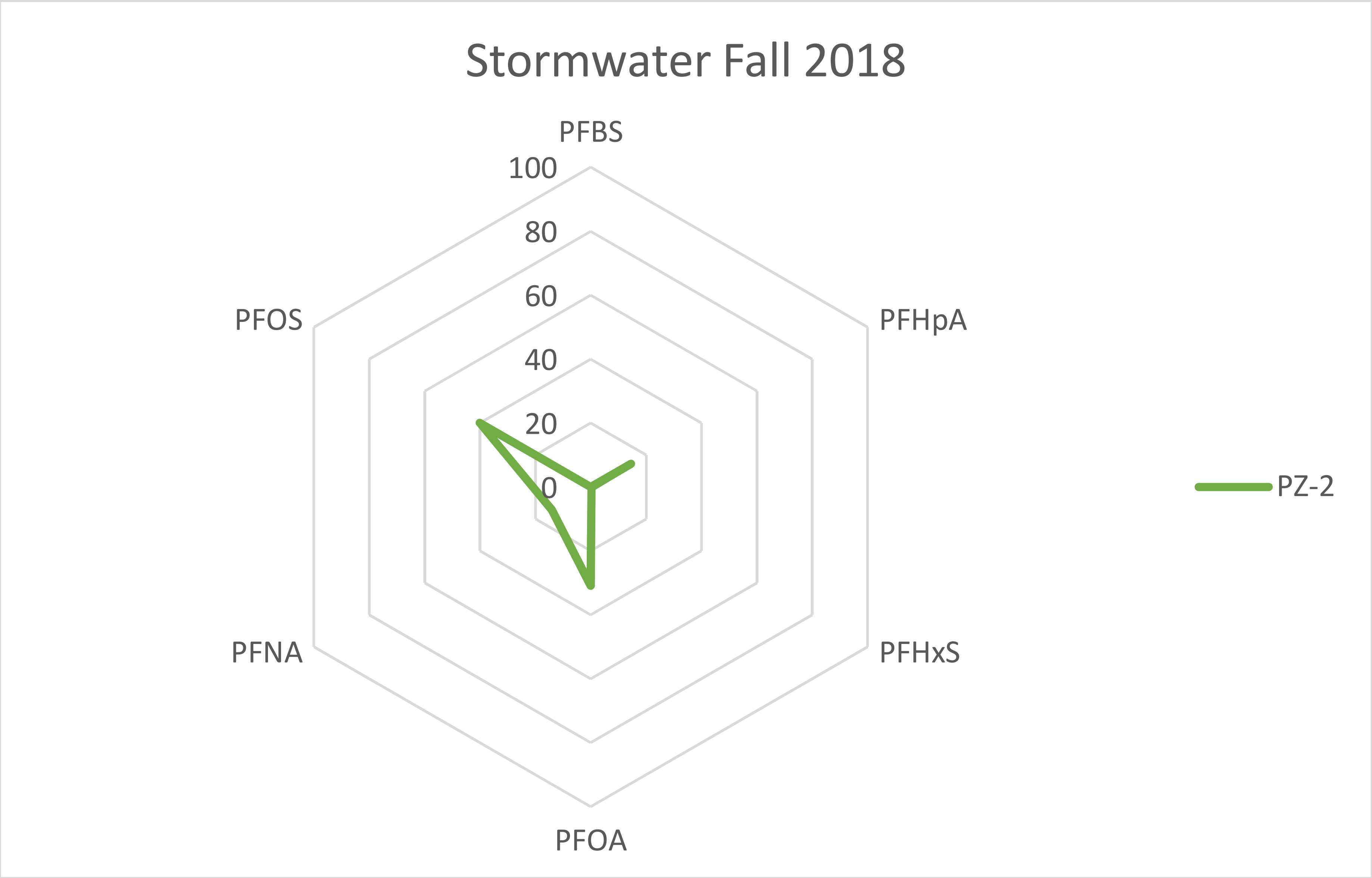
Overburden Fall 2018

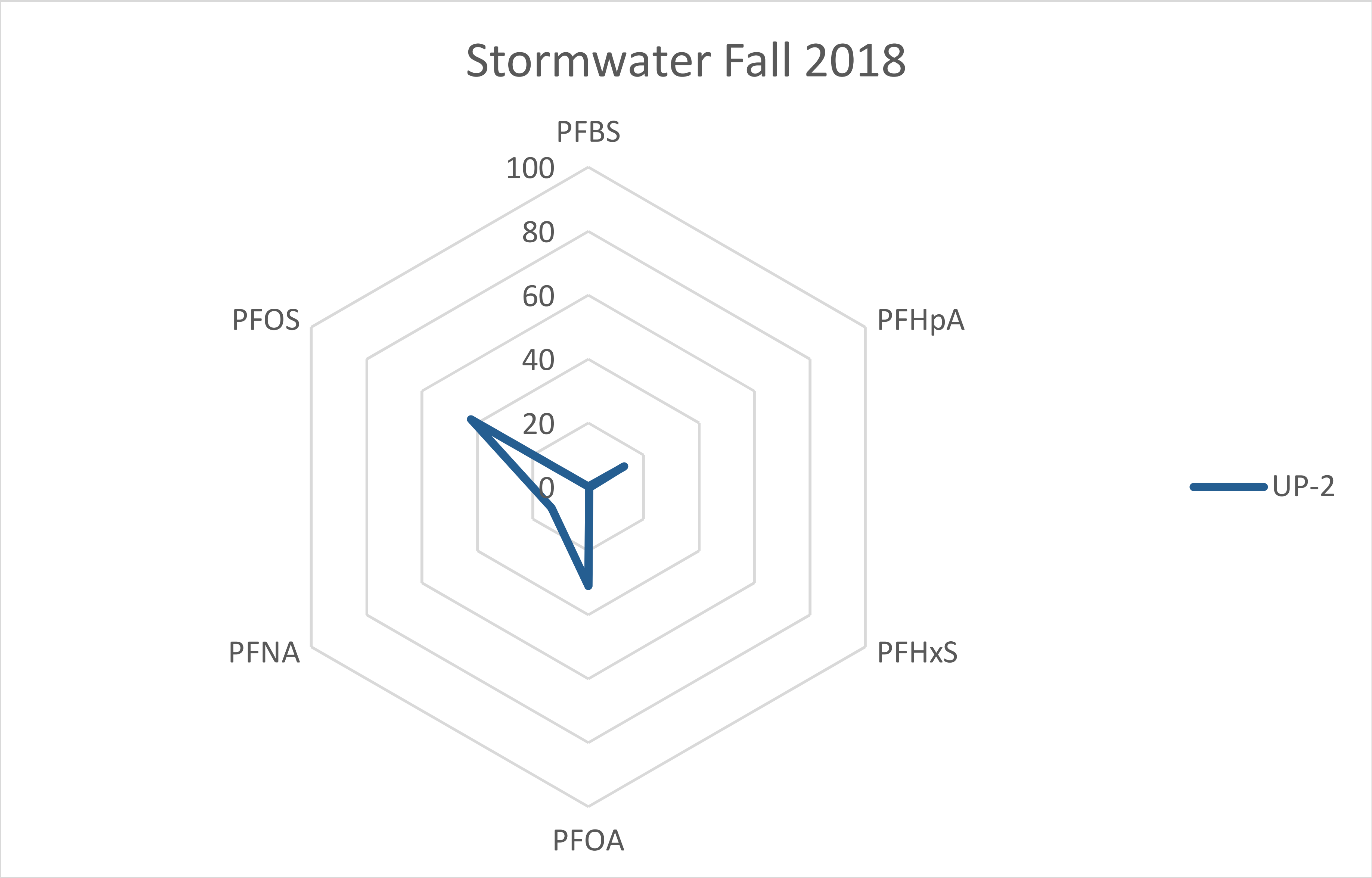


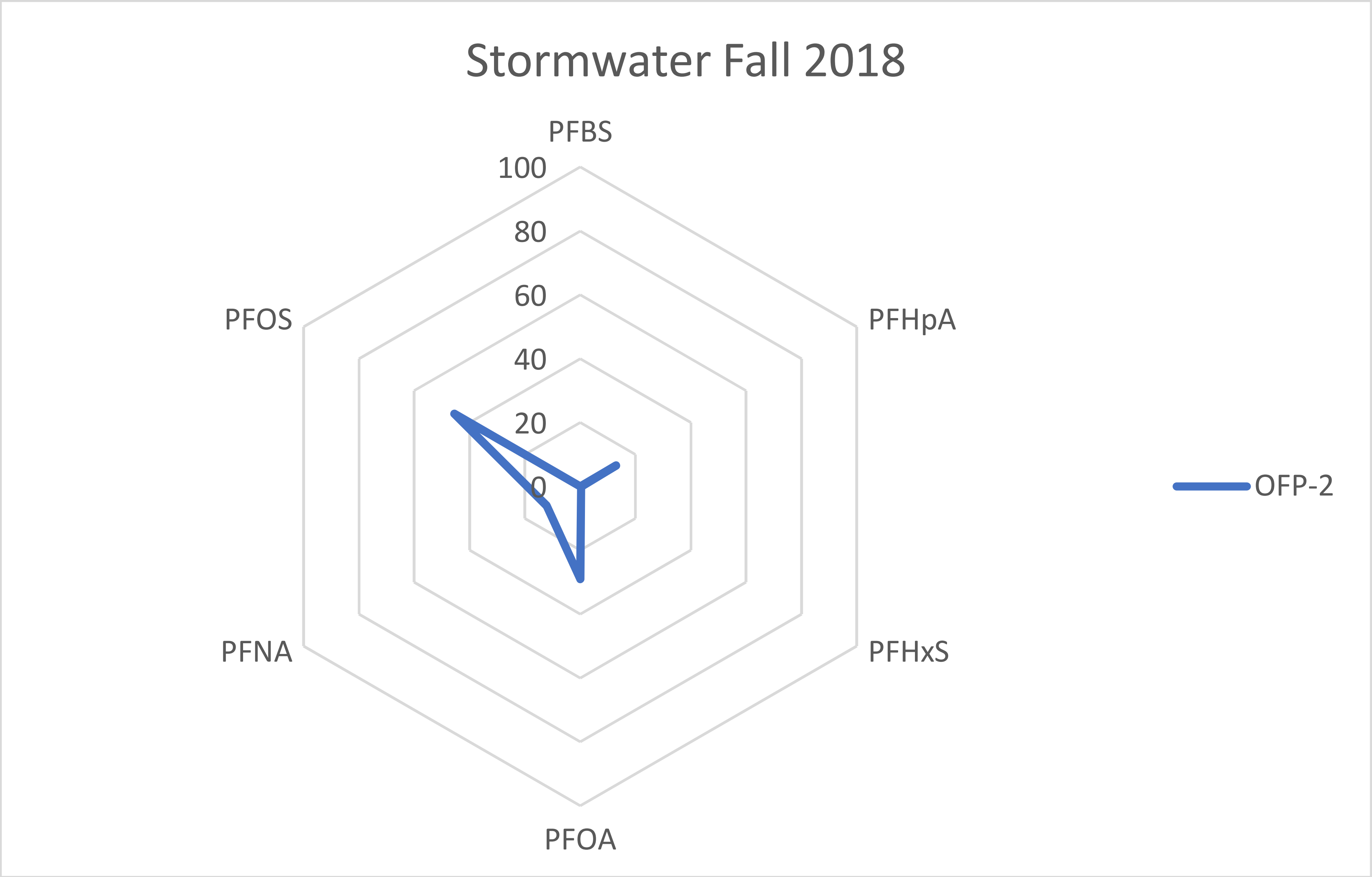

Stormwater Fall 2018
PFBS
100
80
60
40
20
0
PFHpA
PFHxS
PFOA
PFNA
PFOS
OFP-1

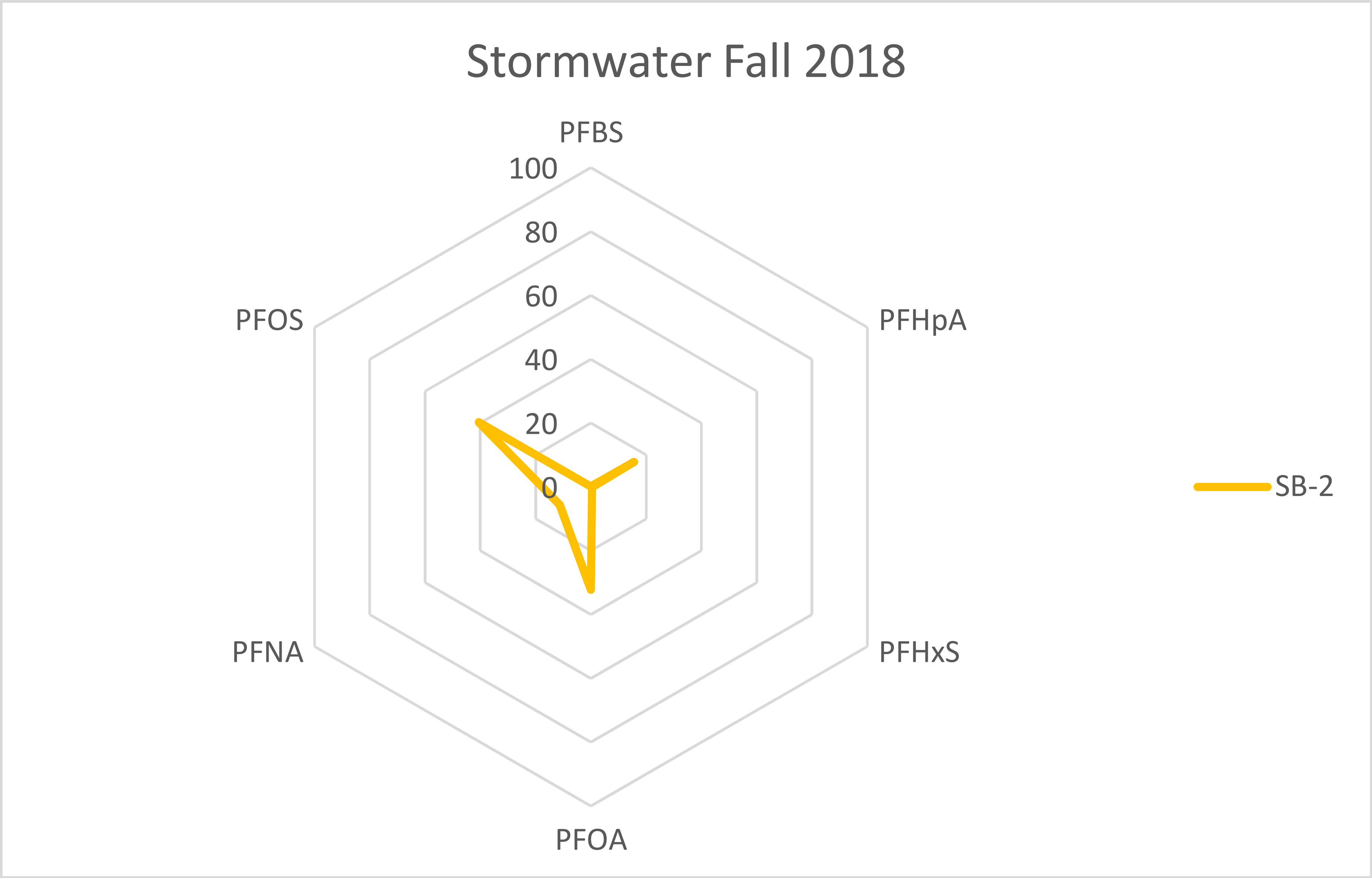

Stormwater Fall 2018
PFBS
PFHpA
PFHxS
PFOA
PFNA
PFOS
100
80
60
40
20
0
SB-1

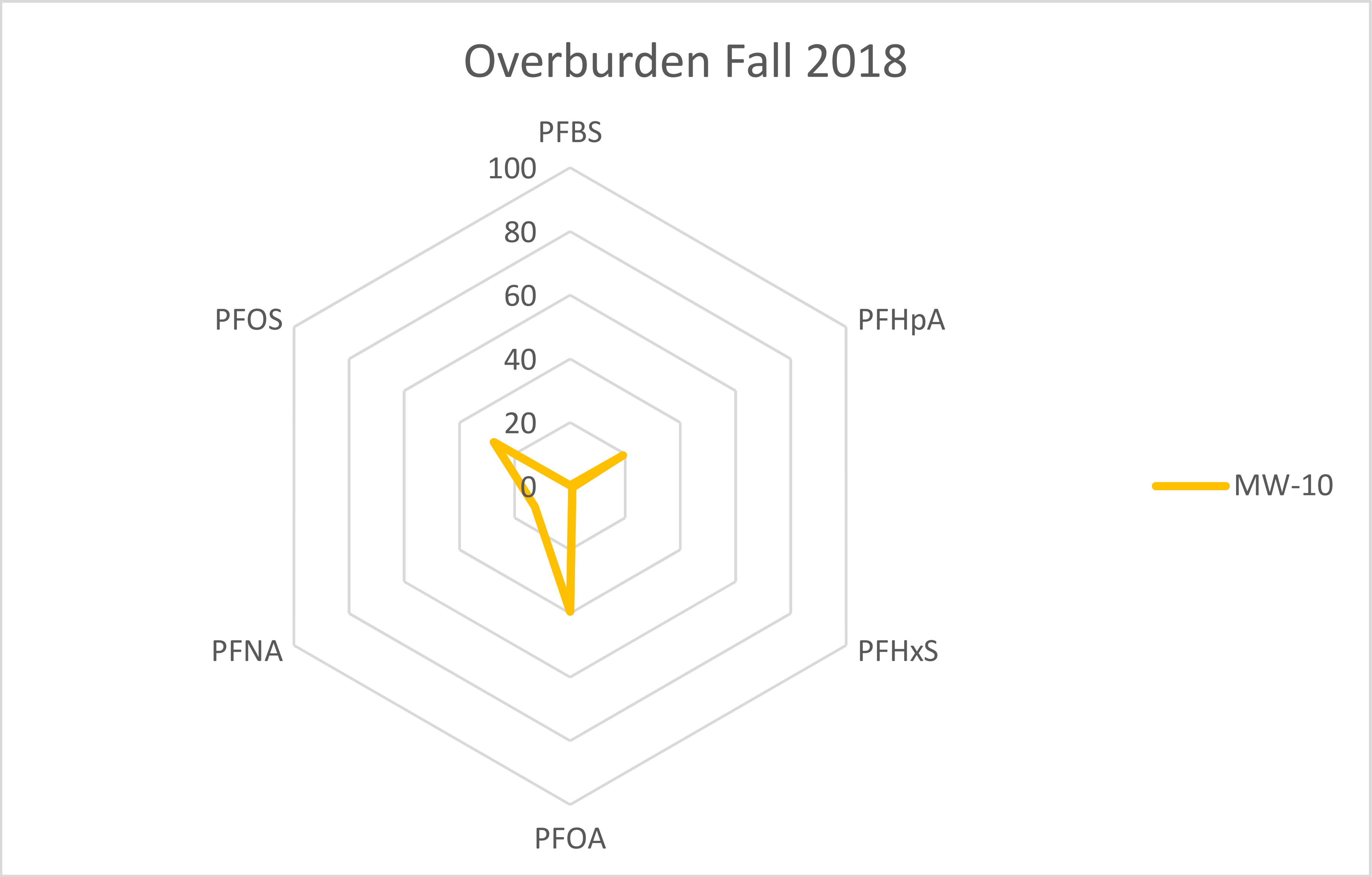

Stormwater Fall 2018
PFBS
PFHpA
PFHxS
PFOA
PFNA
PFOS
100
80
60
40
20
0
PZ-1


Stormwater Fall 2018
PFBS
100
80
60
40
20
0
PFHpA
PFHxS
PFOA
PFNA
PFOS
PZ-2


Stormwater Fall 2018
PFBS
PFHpA
PFHxS
PFOA
PFNA
PFOS
100
80
60
40
20
0
UP-2


Stormwater Fall 2018
PFBS
100
80
60
40
20
0
PFHpA
PFHxS
PFOA
PFNA
PFOS
OFP-2


Stormwater Fall 2018
PFBS
PFHpA
PFHxS
PFOA
PFNA
PFOS
100
80
60
40
20
0
SB-2


Overburden Fall 2018
PFBS
PFHpA
PFHxS
PFOA
PFNA
PFOS
100
80
60
40
20
0
MW-10