ASSESSMENT OF CORRECTIVE MEASURES REPORT

FEDERAL CCR RULE

WESTLAND ASH MANAGEMENT FACILITY
DICKERSON, MARYLAND

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1. INTRODUCTION

1.1 Purpose

Geosyntec Consultants, Inc. (Geosyntec) has prepared this Assessment of Corrective Measures (ACM) Report on behalf of GenOn MD Ash Management LLC (MD Ash) to recommend Corrective Measures for Cell B at the Westland Ash Management Facility (Site). Pursuant to the Federal Coal Combustion Residuals (CCR) Rule (40 Code of Federal Regulations [CFR] Part 257.96) (USEPA, 2015), this ACM was initiated on December 3, 2018 in response to detections of Federal CCR Rule Appendix IV constituents at statistically significant levels (SSLs) exceeding the groundwater protection standards (GWPS) defined under CCR Rule Part 257.95(h). Specifically, the remedial goals of the proposed corrective measures for Cell B include:

- Protect human health and the environment;
- Attain the GWPS at compliance monitoring wells;
- Control the source(s) of release so as to reduce or eliminate further release of Appendix IV constituents to the environment; and
- Comply with standards for management of wastes as specified in CCR Rule Part 257.98(d).

This ACM is specific to Cell B which is the only CCR management unit at the Site regulated by the Federal CCR Rule. A Corrective Measures Plan (CMP) has also been prepared pursuant to Paragraphs 61 through 68 of the Consent Decree (CD) which was entered into between MD Ash and the Maryland Department of Environment (MDE) on 30 April 2013. The CMP describes all the corrective measures that have been or are planned to be implemented at the Site to mitigate water pollution and identified adverse effects to biological communities and public health. The corrective measures discussed in this ACM for Cell B are also discussed in the CMP for the Site.

The scope of the CMP was described in the Scope of Work for a Nature and Extent of Contamination Study (NES), Revision 2, dated May 2015 (Work Plan; Geosyntec, 201a5) which was approved by the MDE in a letter dated May 2016. The original CMP and Nature and Extent of Contamination Study (NES) were submitted to MDE in June 2017 and were revised in July 2018 to address comments provided by MDE in a letter dated 12 February 2018. A second revision of the CMP will be submitted to MDE in Spring 2019 to address a recent decision to remove ash from the site for beneficial reuse rather than closing in place. In addition to the NES Work Plan, MDE has approved the Drinking Water Well Assessment Plan (Geosyntec, 2015b), Drinking Water Well Assessment Report (Geosyntec, 2016), and cap designs.

All of these actions were approved and completed in accordance with the CD including public comment by the following Plaintiff-Intervenors: Defenders of Wildlife, Sierra Club, Chesapeake Climate Action Network, and Amicus Potomac Riverkeeper, Inc. Copies of all plans and schedules prepared in accordance with the CD were and are provided to the Plaintiff-Intervenors.

1.2 Site Description

1.2.1 Site Description

The Site is located in Dickerson, Montgomery County, Maryland (**Figure 1-1**) and is operated by GenOn MD Ash Management LLC (MD Ash). The Site is a dry ash management operation and does not have CCR surface impoundments (SI) as defined in the CCR Rule. The Site encompasses 180 acres of which approximately 64.4 acres have been used to manage CCR at landfill Cell B. Cell C is located downgradient of Cell B. Cell C was inactive and closed prior to the effective date of the Federal CCR Rule and therefore not regulated by the Federal CCR Rule. The active area of Cell B was constructed with a geosynthetic bottom liner and associated leachate collection system that directs leachate to a zero valent iron (ZVI) waste water treatment system (WWTS) for treatment and then to Pond 003 prior to discharge. Pond 003 is lined with a geosynthetic liner and is located to the west of Cell B. In accordance with requirements outlined in the Consent Decree, Pond 002 was lined with a geosynthetic linear in 2015. The remaining portion of Cell B is not lined but does include a leachate collection layer constructed using bottom ash. Leachate collected from the unlined areas of Cell B is also directed to the WWTS and then to Pond 003. Non-contact storm water runoff is directed to Pond 002. Ponds 002 and 003, which are used to manage storm water and leachate (not wet ash), respectively, are also exempt from the Federal CCR Rule. Features of the Site and their locations are presented on **Figure 1-2**.

1.2.2 Regional Physiographic Setting

The Site is located in the Culpepper Basin portion of the Piedmont province of Maryland and was previously used for agricultural purposes. Fractured sandstones and siltstones of the Poolesville Member of the Manassas Sandstone (referred to as the New Oxford Formation by others), with interbedded shale layers, form the upper aquifer at the Site. The overlying saprolite soils are unsaturated. Bedrock bedding planes strike north-south and dip 10-20 degrees to the west.

The groundwater table in the upper aquifer generally follows topography and flows along bedding planes toward the west but is locally influenced by Big Stream to the south and flows along bedrock strike. The hydraulic conductivity of the more fractured interbedded thin shale layers is greater than that of the massive sandstones that comprise most of the bedrock stratigraphic sequence. Therefore, CCR constituent migration in groundwater is along the shale horizons. Groundwater monitoring wells are screened in the shale layers.

1.3 Groundwater Monitoring Network

This section describes the groundwater monitoring well network for the CCR Rule at Cell B. As described in the *Basis for Groundwater Monitoring Network* (Geosyntec, 2017a), the groundwater monitoring network around Cell B was designed to comply with 40 CFR 257.91.

Groundwater quality is monitored around Cell B through a network of ten monitoring wells. As shown on **Figure 1-2**, there are three upgradient monitoring wells (D-2, D-3 and D-4) that are used to measure background conditions and seven downgradient monitoring wells (MW-03, MW-09, MW-10S, MW-12, MW-13, D-6R, and Core-2S) that are used as compliance wells.

Federal CCR Rule compliance and background monitoring wells at the Site are designed to monitor the upper aquifer conditions. Monitoring well construction and soil boring logs were provided in Geosyntec (2017a).

1.4 Report Organization

The remainder of the report is organized as follows:

- Section 2 summarizes the existing engineered barrier systems at the Site;
- Section 3 summarizes the CCR Rule groundwater monitoring program;
- Section 4 presents the Remedial Action Objectives (RAOs);
- Section 5 screens potential Corrective Measures;
- Section 6 evaluates the Corrective Measures;
- Section 7 presents final recommendations; and
- Section 8 presents references.

Supporting information is provided in the tables, figures, and appendices.

2. EXISTING ENGINEERED BARRIER SYSTEMS

2.1 Cover Systems

Final closure capping of the inactive side-slopes of Cell B (25 acres) was completed in 2017. The design/closure report [AECOM, 2017] indicate that the cover system was prepared in accordance with COMAR 26.04.10.04.C(3). The closure cap includes a low permeability geomembrane cap, drainage layer, final two-foot earthen cover, and vegetated cover.

The inactive areas of Cell B (25 acres) that were not included in the 2017 side-slope capping have vegetated soil covers. Cell B-1 (14 acres) is active, lined with a geomembrane overlain by a leachate collection system, and currently uncovered.

2.2 Leachate and Storm Water Management Systems

The leachate management system for most of Cell B is comprised of compacted saprolite overlain by a bottom ash layer and vitrified clay pipe (VCP) drainage system, all below the CCB material stored in the cell. Two sub-cells (Cells B-1A and B-1B, collectively Cell B-1) in the eastern portion of Cell B were constructed with a geomembrane liner and leachate collection system in 2011. These systems have been designed to meet COMAR 26.04.10 requirements. The leachate collection systems in Cells B-1A and B-1B were installed over the geosynthetic liner system and are composed of bottom ash (Cell B-1A) or gravel (Cell B-1B) and high-density polyethylene (HDPE) leachate collection pipes.

Non-contact stormwater from Cell B is either captured and conveyed to Pond 002 for impoundment and discharge via Outfall 002 or discharged via two outlets south of Cell B and north of Pond 002. Outfall 002 flows to a ditch that runs north and west along Martinsburg Road to Dickerson Stream. The stormwater outfall from Cell B is on the southwest side of the cell. Non-contact stormwater flows from the discharge point via sheet flow to Big Stream on the southwestern border of the Site.

The NPDES permit for the Site was renewed in November 2016 and established more stringent discharge limits for several constituents including selenium, arsenic, and cadmium. These more stringent limits prompted MD Ash to upgrade the existing leachate treatment systems at the Site to achieve the new discharge limits. These upgrades included installing equipment and piping to intercept leachate main lines from Cells B. Intercepted leachate is conveyed into a 20,000-gallon frac tank. The water is pumped from the frac tank to a new NPDES treatment system, approximately 400 feet to the northeast, as shown on **Figure 1-2**.

The new NPDES treatment system was installed in 2017 and consists of a zero-valent iron (ZVI) treatment process, referred to herein as the wastewater treatment system (WWTS). The WWTS consists of reactive media that acts as an electron generator to chemically reduce select soluble metal cations and oxyanions in wastewater to insoluble forms that are removed by surface adsorption and chemical incorporation into the iron oxidation products. Treated effluent from the

WWTS is conveyed and stored in Pond 003 and batch discharged via NPDES Outfall 003 towards Big Stream. The locations of the ponds, outfalls, and stormwater outlets are shown on **Figure 1-2**.

Discharge of wastewater towards Big Stream via Outfall 003 is regulated by the NPDES permit with the Maryland State Discharge Permit number 00-DP-1680 and Federal permit number MD0057584. Big Stream and Dickerson Stream are classified as tributaries of the Potomac River (Use I-P) which are protected for water contact recreation, fishing, aquatic life, public water supply, and wildlife.

3. CCR RULE GROUNDWATER MONITORING

The Baseline Monitoring Program was completed in September 2017 and the Site transitioned to detection monitoring in October 2017. Assessment monitoring began in February 2018. Groundwater monitoring was conducted in accordance with the *Sampling and Analysis Plan* (SAP) provided in Geosyntec (2015a).

In October 2017, the first detection monitoring program samples were collected. In accordance with 40 CFR 257.94(a) of the CCR Rule, samples were analyzed for Appendix III list parameters only. Prior to sampling, a synoptic round of groundwater measurements was collected from the compliance and background monitoring wells. Groundwater elevation data and analytical results are presented in the *2017 Annual Groundwater Monitoring and Corrective Action Report* (Geosyntec, 2018).

An Assessment Monitoring Program was triggered at the Site in January 2018 when statistically significant increases (SSIs) above background concentrations were detected in the detection monitoring results from the October 2017 groundwater monitoring samples. In accordance with 40 CFR 257.95(a) of the CCR Rule, samples were collected in February 2018 for the full Appendix IV list of constituents for the first assessment monitoring program. Samples were analyzed for all Appendix IV list parameters. Resampling for Appendix III constituents and the Appendix IV constituents detected in the February 2018 assessment monitoring samples was conducted in May 2018. The second semi-annual assessment monitoring event was completed in August 2018. Prior to sampling, a synoptic round of groundwater measurements was collected from the compliance and background monitoring wells. The Site remains in assessment monitoring. Groundwater elevation data and analytical results are presented in the *2018 Annual Groundwater Monitoring and Corrective Action Report* (Geosyntec, 2019).

3.1 Statistically Significant Increases of Appendix III Constituents Above Background Concentrations

The baseline monitoring data collected from the three background wells (D-2, D-3, and D-4) between 2015 and 2017 were previously used to select statistical methods for calculating the range of background concentrations for Appendix III constituents. These data are discussed and presented in (Geosyntec, 2018). The resulting background concentrations are summarized in **Table 3-1** based upon upper prediction limit (UPL) methods.

In January 2018, the calculated background concentrations were compared to the results of the detection monitoring event in October 2017. The comparison of those data to the calculated background concentrations resulted in SSIs over background and triggered the initiation of an Assessment Monitoring Program. Comparison of Appendix III parameters in Cell B compliance wells continued for the May and August 2018 assessment monitoring events and is shown in **Table 3-2.**

3.2 Statistically Significant Levels of Appendix IV Constituents Above Ground Water Protection Standards

The baseline and assessment monitoring data collected from the background wells were used to calculate background concentration limits for detected Appendix IV constituents. The GWPS shown in **Table 3-3** were established for each detected Appendix IV constituent as the greater of background or the maximum contaminant level (MCL) (or the EPA Regional Screening Level for cobalt, lead, lithium, and molybdenum that do not have MCLs). The baseline and assessment monitoring data collected from the compliance wells between 2015 and 2018 were used to calculate the 95% lower confidence limit (LCL) of the mean concentration for each compliance well for each Appendix IV constituent that exceeded the GWPS in one or more samples. These data are discussed and presented in Geosyntec (2018 and 2019). Those LCL concentrations were then compared to the GWPS for each Appendix IV constituent. The comparison of those LCLs and the GWPS, provided in **Table 3-4**, resulted in the following statistically significant levels (SSLs) on September 4, 2018 and triggered this ACM:

- Lithium at compliance wells D-6R, MW-03, and MW-12;
- Molybdenum at compliance wells MW-03 and MW-12; and
- Selenium at compliance wells D-6R, MW-09, MW-10S, and MW-12.

4. REMEDIAL ACTION OBJECTIVES

4.1 Source Control

The Corrective Measures will reduce future generation of CCB leachate from Cell B and reduce or eliminate further release of Appendix IV constituents to groundwater.

4.2 Groundwater

The GWPS for Appendix IV constituents, provided in **Table 3-1**, will be attained at compliance monitoring wells. As specified in CCR Rule Part 257.98(d), this ACM considers the edge of waste as the point of compliance for groundwater.

5. DESCRIPTION OF CORRECTIVE MEASURES

5.1 Screening of Potential Corrective Measures

Potential remedial action technologies from the Federal Remediation Technologies Screening Matrix and Reference Guide (Federal Remediation Technologies Roundtable [FRTR], 2002) were screened based on their applicability to the physical setting and subsurface conditions described in **Section 1** and the ability of the technologies to address the RAOs defined in **Section 4**. Herein, a "technology" refers to:

- A component, such as geomembrane cap or leachate collection system; or
- An activity, such as environmental monitoring; or
- An institutional control, such as a property use restriction to control or eliminate a potential exposure pathway.

Remedial technologies from the FRTR document were identified that could address the RAOs for the Cell B based on: i) protection of human health and the environment, ii) site-specific implementability; and iii) qualitative cost. Remedial technologies were eliminated from consideration if they did not adequately address a RAO or their use is reasonably precluded by Site and/or CCB constituent characteristics. **Table 5-1** provides a summary of the remedial action technologies that were selected from the FRTR for further evaluation and how they compare to the screening criteria. Those technologies that were retained during the screening process have been (or will be) implemented as Corrective Measures for Cell B to address the RAOs.

It is anticipated that the Corrective Measures listed in **Table 5-2** will be sufficient to satisfy the RAOs for Cell B within a reasonable period of time. The effectiveness of each Corrective Measure will be periodically monitored to assess the need for additional Corrective Measures. The implementation diagram provided as **Figure 5-1** identifies trigger points that will be used to evaluate if the Corrective Measures are trending toward achieving the RAOs. The following sections present the Corrective Measures that have been, or will be, implemented as Corrective Measures.

5.2 Source Control

5.2.1 Source Containment

According to **Section 2**, seepage through the vegetated cover system on inactive/unlined portions of Cell B is the primary source of CCB constituents to groundwater at the Site. Prior to implementation of the source control improvements, existing hydraulic controls will mitigate migration of CCB constituents from source areas to surrounding media. According to the Sites' Operations and Maintenance Manual (URS, 2013), run on/run off (RORO) controls are in place at the Site that effectively keep off-site stormwater from entering the Site or on-site contact stormwater to migrate off-site without treatment.

Under the Corrective Measures, removal of CCB stored in Cell B, and Cell B-1, and lower-permeability cover systems (i.e., geomembrane and temporary cover) installed on the inactive areas of Cell B will reduce the amount of leachate loading to groundwater. In combination with the existing leachate collection systems at Cell B, these source removal and physical containment technologies will significantly reduce the mass of leachable CCB material present at the Site, as well as reduce migration of CCB constituents to groundwater.

As discussed in **Section 2**, geosynthetic liners and leachate collection systems were installed in Cell B1-A and Cell B1-B. These systems effectively mitigate the potential seepage of CCB constituents to groundwater in those areas. Geomembrane caps are planned for Cell B1-A and Cell B1-B after they reach final grades to reduce the volume of leachate generated by infiltrating precipitation if the CCB is not removed for beneficial reuse.

5.2.2 Source Removal

As discussed in **Section 2.1**, prior to 2015 the Cell B cover system consisted of a vegetative soil cover over CCB material. The soil cover was graded to promote runoff and mitigate infiltration of stormwater into the CCB. The water balance for Cell B, provided in **Appendix A** and summarized in **Table 5-3,** shows approximately 23,458 gallons per day (gpd) was either captured as leachate by the leachate collection system or was stored in the CCB. However, approximately 20,443 gpd of additional water migrated to shallow groundwater.

In 2016, MD Ash began implementing source control improvements at the Site to reduce future generation of CCB leachate and address the RAO for source control. The source control improvements include replacement of existing vegetated soil cover with a geosynthetic cap system over the inactive side-slopes of Cell B. The geosynthetic cap system over the inactive side-slopes of Cell B consisted of a geomembrane, overlain by a cover drainage layer, and vegetated soil cover. The cap is graded to promote runoff and mitigate infiltration of stormwater into CCB. The water balance scenario for 2017 site conditions, presented in **Appendix A** and summarized in **Tables 5-3** and **5-4**, indicate that these measures result in an approximate 58 percent reduction in leachate generation and loading to shallow groundwater at Cell B.

In 2018, GenOn initiated plans to remove the CCB from the Site for beneficial reuse in the manufacturing of cement. GenOn anticipates removing an average of 600,000 tons of CCB per year beginning in early 2019. Based on the approximate quantity of CCB in Cell B the estimated time to remove the CCB will be approximately five (5) years.

Most of the cover soil and geomembrane cover systems will be removed and properly disposed (cap material) or used (soils) by the cement manufacturers per the (anticipated) Deconstruction Plan. Following completion of source removal activities, GenOn's goal will be to clean close Cell B, and Cell B-1, in accordance with 40 CFR 257.102.(c). However, if a portion of the CCB materials in Cell B are not amendable to beneficial reuse, those materials could be managed in Cell B-1 and that cell would eventually be closed in-place. **Table 5-3** indicates that >99 percent of leachate is captured at Cell B-1 for treatment.

Per the Deconstruction Plan, areas being actively mined should not exceed seven (7) acres at one-time during source removal. At the end of each work day, 4 to 6 inches of cover soil will be compacted over areas of open ash. In preparation for storm events, Posi-shell (or equivalent) will be sprayed over areas of open ash to form a “hard” shell to provide additional erosion protection. The Posi-shell (or equivalent) will protect the ash from erosion by wind and rain.

Operations of the source removal activities, storm water management controls, and temporary covers will be detailed in a deconstruction plan that will be provided to MDE under a separate cover at a later date. **Figure 5-1** shows the maximum area of a geomembrane cap systems and/or temporary cover that are/or will be installed on Cell B.

5.3 Groundwater

The groundwater monitoring program will continue under the Assessment Monitoring Program to document changes to CCB constituent concentrations in groundwater at the Site as a result of implementation of the Corrective Measures. The RAO for groundwater will be achieved when the groundwater quality standards are consistently attained at established and approved compliance points for three consecutive years based upon the 95 percent upper confidence limit (UCL) of the mean concentrations of lithium, molybdenum, and selenium at compliance monitoring wells D-6R, MW-03, MW-09, MW-10S, and MW-12.

6. EVALUATION OF CORRECTIVE MEASURES

This section describes how the Corrective Measures were evaluated with respect to the applicable requirements in the Federal CCR Rule. First, the Corrective Measures were evaluated based on threshold criteria provided 40 CFR 257.97 to demonstrate that the approach meets basic requirements such as:

- Protect human health and the environment;
- Attain the GWPS at compliance monitoring wells;
- Control the source(s) of release so as to reduce or eliminate further release of Appendix IV constituents to the environment; and
- Comply with standards for management of wastes as specified in CCR Rule Part 257.98(d).

Next, the Corrective Measures were evaluated considering the following factors:

- Short-term and long-term effectiveness;
- Reduction in the toxicity, mobility, or volume of contaminant;
- Implementability;
- Reliability;
- Safety and cross-media impacts;
- Time to complete; and
- Regulatory and community acceptance.

Several remedial technologies have already been implemented and/or are ongoing at the Site (i.e., installation of geomembrane caps on the inactive side-slopes of Cell B, as well as installation of the new WWTS). Their effectiveness to date and their potential for enhancement were evaluated. The results of this evaluation were used in **Section 7** to recommend these Corrective Measures.

6.1 Threshold Criteria

6.1.1 Protection of Human Health and Environment

Removal of CCB material at the Site will eliminate potential future exposure to CCBs as well as leachate generation and hence the potential risk to human health for future site workers and off-site receptors using a groundwater supply well, as well as the potential risk of exposure to ecological receptors. Removal is a proven technology that also limits the potential for cross-media impacts. It is reliable because there are no remedial systems that require operation and maintenance.

Dissolved CCB constituents already in groundwater might be transported by groundwater advection to potential future downgradient groundwater supply wells or diffuse seeps. This would pose a potential short-term risk to human receptors, including on-site workers, visitors, residents, and off-site maintenance workers; and ecological receptors, including aquatic life, crops, and livestock that could be exposed to CCB constituents through the groundwater supply wells and streams. The remedy includes groundwater monitoring to evaluate and manage these potential risks, should they arise.

The existing vegetated cover system on the inactive side-slopes of Cell B were replaced with low-permeability geosynthetic cap system in 2016 and 2017. For the planned source removal operations, CCB will be removed from Cell B. Cell B-1A will be mined early to a depth of four feet above the leachate underdrain system in accordance with the *Dickerson, Westland Ash Cell B1A Ash Removal Plan*, which was approved by MDE on 12 February 2019. Cells B-1A and B1-B will remain as options for rejected CCB material from the cement manufacturers. If no CCB material remains, Cells B-1A and B-1B will be dismantled and clean closed. Implementing the source removal will greatly increase protection of human health and the environment by mitigating the risk of cross-media transfer of CCB constituents from leachate to groundwater and surface water, and subsequent transport by groundwater advection to potential exposure points, such as potential future shallow groundwater supply wells, diffuse seeps, and downgradient surface water.

The water balance for Cell B is presented in **Appendix A** and summarized in **Table 5-3.** It estimates that the loading of leachate from Cell B to groundwater following implementation of the geomembrane cap in 2017 reduced leachate generation by approximately 58 percent (from 20,443 gpd to 8,513 gpd). Following source removal, it is anticipated that total leachate loading to groundwater will be further reduced by over 99 percent (from 8,513 gpd to 13 gpd) with the potential leachate generation occurring in Cell B-1, if it is closed in place.

The Corrective Measures will provide additional protection to potential downgradient human and ecological receptors that might come into contact with CCB constituents in other media. These additional protections are now being provided by reducing CCB mass loading to the streams from groundwater seepage (arising from cap construction) and by diverting leachate that had been destined for Pond 003 to the WWTS prior to discharge through Outfall 003. MD Ash installed this treatment system to achieve new or more stringent discharge limits that became effective in the summer of 2017.

Groundwater and surface water monitoring results will be used to track progress and to evaluate how quickly protection standards are achieved.

6.1.2 Attainment of GWPS

The Federal CCR Rule indicates that the point of compliance is the edge of waste. Under existing conditions prior to the summer of 2016, CCB constituents in groundwater were likely to persist at statistically significant levels above the groundwater quality standards at the points of compliance into the future. However, source removal will cause the concentrations to decrease.

Groundwater travel times from the source area to the point of compliance were estimated by projecting the screened bedrock interval in select monitoring wells at the point of compliance back towards the source area (Cell B), where the screened interval suboutcrops beneath Cell B. The projected path was estimated using an average bedrock dip of 15º from the well screen and the travel time along the projected path was estimated with hydraulic conductivity data of the screened interval collected during packer testing.

Estimated travel times from source areas to selected monitoring wells are presented in **Table 6-1**. Groundwater travel times in the shallow and deep bedrock wells ranged from less than one (1) year at monitoring well MW-03 to 3.6 years at monitoring well MW-10S. These travel times are estimates of the time to flush one pore volume, and actual cleanup times will likely be longer. Concentration reductions should be detectable prior to these travel times because leachate loading between the compliance and the edge of waste will be reduced. Flushing of several pore volumes will likely be necessary to achieve cleanup goals at the point of compliance for some constituents.

The new WWTS supplements the old settling pond (BAT) to attain NPDES discharge compliance. Big Stream, toward which treated wastewater migrates over the ground surface, is protected for potable use, water contact recreation, fishing, aquatic life, and wildlife. As such, surface water quality limits for both aquatic life and human consumption are applicable.

6.1.3 Controlling the Source

Installation of a lower-permeability cap on the inactive side slopes of Cell B during source removal will increase source control of CCB constituents managed at the Site. The cap will help mitigate infiltration of precipitation into the CCB managed in the cells during the time required to complete removal. This will greatly reduce future releases of CCB to groundwater via leaching by reducing the volume of CCB available for precipitation infiltration and hence limit the potential for cross-media impacts. Similar to the existing vegetated soil cover systems, the lower-permeability caps will create little potential for exposure of CCB material at the ground surface. In the inactive areas of Cell B, where fugitive emissions might act as release mechanisms, current filling practices, and compliance with the Site dust control plan will mitigate fugitive emissions of CCB at the ground surface. Additionally, the Deconstruction Plan will have discussion on controlling dust emissions during source removal.

6.2 Detailed Evaluation Criteria

6.2.1 Short-Term and Long-Term Effectiveness

Source removal will be highly effective in reducing potential current and future risk to human health and ecological receptors by reducing the volume of leachable CCB material that could impact groundwater.

Additionally, source removal will be more effective than the pre-2015 vegetated soil cover in controlling CCB material in Cell B to mitigate future releases of CCB constituents to groundwater via leaching. **Table 5-3** shows that source removal will reduce infiltration of precipitation into the CCB in Cell B by over 99% (from 35,669 gpd to 0 gpd). If Cell B-1 is closed in place, this will reduce the total rate of leakage to groundwater from Cell B by over 99% (from the previous 20,443 gpd to 13 gpd).

The long-term reliability of the lower-permeability cover for Cell B-1 is determined by: (i) the level of quality assurance/quality control (QA/QC) during construction to document that the cap is built according to design standards; and (ii) the level of maintenance after construction to prolong the performance of the cap to prevent infiltration/seepage.

The WWTS provides immediate and effective treatment of leachate prior to discharge from Pond 003 going forward. As long as the system operates as designed, it is expected to provide compliance with the discharge requirements of the NPDES permit.

6.2.2 Reduction of Toxicity, Mobility, or Volume of Contaminant

The source control measures that will be implemented are expected to reduce the volume and mobility of CCB constituents in Cell B to the extent necessary to mitigate effects on downgradient groundwater. Restricting infiltration of precipitation into the cells through source removal and the lower-permeability cap will mitigate dissolution and subsequent transport of CCB constituents from CCB material managed in the cells. This will decrease the overall volume of leachate and reduce the volume of groundwater impacted by CCB constituents from Cell B, thus reducing potential toxicity in downgradient media.

The mass flux of sulfate and boron in groundwater will be used to assess performance vs. the interim milestones given on **Figure 5-1**. Sulfate and boron mass flux will be monitored as early indicators of remedy progress because these two constituents do not adsorb strongly to aquifer solids and therefore should have detectable concentration declines, and ultimately reach final cleanup goals, before other constituents that adsorb more strongly to aquifer solids and hence flush out of the system more slowly.

Due to the relatively short estimated groundwater travel times from Cell B to MW-03 (**Table 6-1)**, reductions in groundwater concentrations or mass flux could be detected in late 2026 (i.e. approximately two years after all the CCB has been removed from Cell B in late 2024. As shown in **Figure 5-1**, if such reductions in concentrations or mass flux are not detected by late 2027 (i.e. within five years of completion of source removal) at monitoring wells MW-03 or MW-12, and if statistically significant increasing trends are documented, if appropriate, then additional Corrective Measures may be considered.

Implementation of the new WWTS will reduce the levels of CCB constituents in the NPDES discharge, thereby reducing the mobility and toxicity of CCB constituents directed toward surface water via overland flow from the discharge point at Pond 003.

6.2.3 Implementability

The final geomembrane cap systems were previously installed on the inactive side-slopes of Cell B. The new WWTS went into service in May 2017 and is currently being used to treat contact stormwater and leachate prior to discharging to Pond 003 and then through Outfall 003.

Source removal of CCB material from the Site will be managed through the Deconstruction Plan. Over the expected removal period of five years, the plan will be updated to incorporate new information and operational experience. The Deconstruction Plan details will be provided to MDE under a separate cover at a later date. Implementation of those technologies will require the preparation of design specifications, mobilization of construction crews and equipment, and surveying. Environmental monitoring is ongoing at the Site. The plan will also include support plans to limit the potential for safety and cross-media impacts.

6.2.4 Regulatory and Community Acceptance

Source removal of CCB from the Site is the preferred closure technology and will reduce the overall volume of CCB managed at the Site that could pose a potential risk to future human health and ecological receptors. Source removal will be equally effective as capping at reducing risk to human and ecological receptors. Furthermore, the new WWTS will supplement the existing BAT at Pond 003 to meet the reduced discharge limits imposed in the 2016 NPDES permit. Collectively with existing systems, the lower-permeability cap, source removal of CCB, and new discharge treatment systems are expected to improve groundwater and surface water quality downgradient of Cell B to the extent necessary to attain regulatory compliance within a reasonable timeframe. Therefore, the Corrective Measures are likely to be acceptable to the State and the community as a final remedy for the Site.

On 30 January 2019, MD Ash submitted the *Dickerson, Westland Ash Cell B1A Ash Removal Plan* to MDE, which detailed the steps that will be taken to remove ash from Cell B1A to within 4 feet above the existing liner and leachate collection system within the cell. The ash removal plan was approved by MDE in a letter dated 12 February 2019. Prior to removing ash from the remaining areas of Cell B, MD Ash must obtain approval of a Deconstruction Plan and Erosion and Sediment Control Plan.

7. RECOMMENDATION

7.1 Recommended Corrective Measures

The Corrective Measures described in **Section 6** are recommended for the Westland Ash Management Facility to achieve the RAOs identified in **Section 4** pursuant to the Federal CCR Rule. The Corrective Measures consist of the following components:

- **Source Containment** – Replace the existing vegetated soil covers over the side-slopes of the inactive area of Cell B with geomembrane caps. The geomembrane caps significantly reduce migration of precipitation into the inactive side-slopes of Cell B and therefore limit cross-media impacts. Continue operation of the existing stormwater management systems under the Site's RORO plan and operation of the leachate collection systems installed at Cell B.

- **Source Removal** – Excavate and remove CCB from Cell B for beneficial reuse in the manufacturing of cement. Cell B-1A will be mined early to a depth of four feet above the leachate underdrain system. Cells B-1A and B-1B will remain as options for rejected CCB material from the cement manufacturers. If no CCB material remains, Cells B-1A and B-1B will be dismantled and clean closed.

- **Wastewater Discharge** – Install and operate the ZVI treatment system to treat comingled leachate and contact storm water prior to discharge via Outfall 003, monitor for NPDES limits and WET testing compliance.

- **Groundwater** – Monitor groundwater to document changes to CCB constituent concentrations in groundwater and mass flux of sulfate and boron in groundwater across transects at the downgradient well locations and assess interim milestones.

The Corrective Measures meet basic requirements consistent with the Federal CCR Rule, including protection of human health and the environment, attain GWPS at compliance monitoring wells, control the source(s) of release so as to reduce or eliminate further release of Appendix IV constituents to the environment, and comply with standards for management of wastes, as discussed in **Section 6**. Additional Corrective Measures may be evaluated and implemented at a later date, as shown in **Figures 5-1,** if it is determined that these Corrective Measures are not trending toward achieving the RAOs.

7.2 Basis for Recommendation

The analysis in **Section 6** indicates that the Corrective Measures should achieve the RAOs and satisfy the threshold and feasibility evaluation criteria. The containment technologies (i.e., geomembrane caps) that have been implemented are expected to significantly increase protection of human health and the environment, and limit cross-media impacts, by immediately and effectively reducing the average daily leakage rate of precipitation through the inactive areas of Cell B. Additionally, source removal of CCB from Cell B is expected to significantly increase protection of human health and the environment by reducing the overall volume of CCB material managed at the Site and reducing the volume of leachable CCB. These source containment and source removal controls are reliable technologies that are anticipated to significantly decrease the volume of leachate generated at the Site and mass loading to groundwater.

In addition, the WWTS is providing additional protection to downgradient human health and ecological receptors that could contact surface water downgradient of Outfall 003. Immediately following installation, and for as long as the system operates as designed, the treatment system is anticipated to mitigate CCB constituent concentrations in discharge from Pond 003 to meet the NPDES discharge limits.

With the geomembrane caps system in place on the inactive side-slopes of Cell B, **Table 6-1** shows seepage of CCB constituents to downgradient groundwater are expected to decline by over 58 percent in the short term. Seepage of CCB constituents to downgradient groundwater should be eliminated within approximately seven years with the CCB removal. The concentration of residual CCB constituents in downgradient groundwater are expected to decrease over time. The concentration of CCB constituents in surface water are also expected to decline in response to the groundwater declines (i.e. reduced seepage) and installation of the WWTS.

Groundwater and surface water monitoring programs are already in place and will be continued to evaluate the effectiveness of the new systems as well as natural processes in attaining the groundwater and surface water RAOs.

As of 2017, the geomembrane caps on the inactive side-slopes of Cell B has been installed. The recommended Corrective Measures approach is expected to be accepted by the State and the community because it will likely satisfy all of the RAOs set forth in the Federal CCR Rule by reducing the volume of CCB managed at the Site, mitigating leachate generation and migration, reducing the toxicity of discharge from the Site, and improving the quality of downgradient groundwater.

8. REFERENCES

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TABLES

TABLE 3-1
BACKGROUND CONCENTRATIONS FOR APPENDIX III CONSTITUENTS
Federal CCR Rule
Westland Ash Storage Facility - Cell B
Dickerson, Maryland

Appendix III Parameter	Unit	UPL [1]
Boron	µg/L	25
Calcium	mg/L	53.4
Chloride	mg/L	17.5
Fluoride	mg/L	[2]
pH	S.U.	7.02-8.45
Sulfate	mg/L	25.4
Total Dissolved Solids	mg/L	325

Notes:

UPL Upper Prediction Limit
µg/L micrograms per Liter
mg/L milligrams per Liter
S.U. Standard Units
[1] Subject to change as additional data are generated. Calculations provided in Statistical Analysis Calculations Package for Background Groundwater – Cell B, Westland Ash Storage Facility, Dickerson, MD (Geosyntec, 2017)

[2] The Double Quantification Rule (DQR) is used for background data sets with no detections.

TABLE 3-2
STATISTICALLY SIGNIFICANT INCREASES OF APPENDIX III CONSTITUENTS
Federal CCR Rule
Westland Ash Storage Facility - Cell B
Dickerson, Maryland

	Analyte:	Boron		Calcium	Chloride	Fluoride		pH	Sulfate	TDS
	UPL [1]	25		53.4	17.5	[2]		7.02 - 8.45	25.4	325
Well ID	**Sample Date**	µg/L		mg/L	mg/L	mg/L		S.U.	mg/L	mg/L
Core-2S	10/26/2017	317		199	181	<0.25	U	7.6	228	1,030
	2/14/2018	421		228	206	<0.25	U	7.6	232	1,040
	5/4/2018	371		234	195	<0.25	U	8.0	227	1,140
	8/8/2018	242		198	182	<0.25	U	7.9	202	728
D-6R	10/27/2017	5,180		676	338	<0.25		7.3	1,330	2,860
	2/6/2018	5,410		657	309	<0.25	U	7.4	1,330	2,280
	5/3/2018	5,650		648	288	<0.25	U	7.3	1,170	2,730
	8/10/2018	5,490		733	280	<0.25	U	7.6	1,250	2,230
MW-03	10/26/2017	10,700		494	362	<0.25	U	6.7	1,330	2,640
	2/13/2018	9,750		463	264	<0.25	U	7.1	1,301	2,700
	5/4/2018	9,980		460	209	<0.25	U	7.0	1,130	2,380
	8/13/2018	8,510		341	165	<0.25	U	7.6	980	1,460
MW-09	10/26/2017	2,580		276	95	<0.25	U	7.4	505	1,410
	2/14/2018	2,660		289	92.9	<0.25	U	7.5	244	1,220
	5/3/2018	2,760		292	85.5	<0.25	U	7.8	475	1,280
	8/9/2018	2,680		287	91.4	<0.25	U	7.6	498	1,050
MW-10S	10/26/2017	311		353	86.5	<0.25	U	7.3	608	1,290
	2/14/2018	331		351	81.4	<0.25	U	7.4	587	1,260
	5/3/2018 [3]	310		334	54.9	<0.25	U	7.7	409	1,190
	8/10/2018	305		327	66.9	<0.25	U	7.7	516	1,240
MW-12	10/26/2017	1,990		371	101	<0.25	U	6.7	991	1,990
	2/14/2018	8,050		378	107	<0.25	U	6.8	912	1,810
	5/4/2018	6,280		386	90.2	<0.25	U	7.0	885	1,850
	8/13/2018	5,450		323	67.3	<0.25	U	7.6	716	1,410
MW-13	10/30/2017	<10.1	U	44.5	11.0	<0.25	U	7.4	24.9	256
	2/13/2018	<10.1	U	49.6	12.6	<0.25	U	8.0	31.4	371
	5/4/2018	21.3	J	50.7	11.3	<0.25	U	8.1	30.8	225
	8/13/2018	<12	U	48.4	11.5	<0.25	U	8.2	27.9	221

Notes:

(highlighted) Concentration is a statistically significant increase (SSI) over the background concentration

UPL Upper prediction limit

µg/L micrograms per Liter

mg/L milligrams per Liter

S.U. Standard Units

J Constituent detected below reportable quantitation limit; result is an estimated value.

U Constituent not detected above method detection limit.

[1] Subject to change as additional data are generated. Calculations provided in Statistical Analysis Calculations Package for Background Groundwater – Cell B, Westland Ash Storage Facility, Dickerson, MD (Geosyntec, 2017).

[2] The Double Quantification Rule (DQR) is used for background data sets with no detections.

TABLE 3-3
GROUNDWATER PROTECTION STANDARDS FOR APPENDIX IV CONSTITUENTS
Federal CCR Rule
Westland Ash Storage Facility - Cell B
Dickerson, Maryland

Constituent [1]	Unit	MCL	RSL	Background Value [2]	Selected GWPS
Antimony	**µg/L**	**6**		**1.1**	**6**
Arsenic	**µg/L**	**10**		**2.0**	**10**
Barium	µg/L	2,000		429	2,000
Beryllium	µg/L	4		0.50	4
Cadmium	µg/L	5		0.50	5
Chromium	**µg/L**	**100**		**15.2**	**100**
Cobalt	**µg/L**		**6**	**5.0**	**6.0**
Fluoride	mg/L	4		0.50	4
Lead	**µg/L**		**15**	**20.5**	**20.5**
Lithium	**µg/L**		**40**	**14.0**	**40**
Mercury	µg/L	2		0.20	2
Molybdenum	**µg/L**		**100**	**8.8**	**100**
Radium 226, 228 Combined	**pCi/L**	**5**		**5.4 [3]**	**5.4**
Selenium	**µg/L**	**50**		**2.0**	**50**
Thallium	µg/L	2		0.50	2

Notes:

[1] Constituents detected during the February and May Assessment Monitoring Program events are shown. Thallium and Cobalt were not detected in any monitoring well in these events.

[2] The recommended background value is the tolerance limit (see Geosyntec, 2018).

[3] The standard for Radium 226 and 228 is a combined standard.

bold Constituent detected above the GWPS in at least one compliance well in one of the eight Baseline Monitoring Program events or the February or May Assessment Monitoring Program events.

GWPS Groundwater Protection Standard

MCL Maximum Contaminant Level

RSL Regional Screening Level, only applies if MCL not promulgated

µg/L micrograms per Liter

mg/L milligrams per Liter

pCi/L picocurie per Liter

TABLE 3-4
STATISTICALLY SIGNIFICANT LEVELS FOR APPENDIX IV CONSTITUENTS
Federal CCR Rule
Westland Ash Storage Facility - Cell B
Dickerson, Maryland

	Antimony		**Arsenic**		**Chromium**		**Lead**		**Lithium**		**Molyb-denum**		**Radium 226, 228 Combined**		**Selenium**	
	GWPS = 6 µg/L		GWPS = 10 µg/L		GWPS = 100 µg/L		GWPS = 15 µg/L		GWPS = 40 µg/L		GWPS = 100 µg/L		GWPS = 5 pCi/L		GWPS = 50 µg/L	
WELL ID	**LCL**	**Trend**	**LCL**	**Trend**	**LCL**	**Trend**	**LCL**	**Trend**	**LCL**	**Trend**	**LCL**	**Trend**	**LCL**	**Trend**	**LCL**	**Trend**
CORE-2S																
D-6R									●						●	
MW-03									●		●					
MW-09															●	
MW-10S															●	
MW-12									●		●				●	
MW-13																

Notes:

- (shaded) Not evaluated because no SSI for the constituent in this well.
- (blank) LCL does not exceed GWPS.
- ● LCL is greater than GWPS

µg/L micrograms per Liter
pCi/L picoCurie per Liter
SSL Statistically Significant Level
SSI Statistically Significant Increase
LCL Lower Confidence Limit
GWPS Groundwater Protection Standard
[1] Barium, beryllium, cadmium, fluoride, and mercury did not exceed their GWPS in any compliance well in any monitoring event; thus, the LCL was not calculated for these constituents.

TABLE 5-1
SCREENING OF REMEDIAL ACTION TECHNOLOGIES
Federal CCR Rule
Westland Ash Storage Facility - Cell B
Dickerson, Maryland

Target Media	General Response Actions	Remedial Action Technologies		Protectiveness of Human Health and the Environment	Implementability	Cost	Status
CCB	Source Removal	Beneficial Re-Use Harvesting	The existing geomembrane and vegetated soil cover system in place over the inactive portion of Cell B will be removed to allow for source removal of CCB material. The CCB material will be excavated and hauled off-site for beneficial reuse.	Above Average Source removal will significantly increase protectiveness of human and health and the environment by significantly reducing the mass of leachable CCB material present at the Site.	Difficult Implementation requires careful planning and sequencing. In addition, a Posi-shell (or equivalent) will be sprayed over areas of open ash to form a "hard" shell to provide additional erosion protection. The Posi-shell (or equivalent) will protect the ash from erosion by wind and rain.	None Costs of excavation of CCB material and installation of a Posi-shell (or equivalent) will be high. However, the excavated material will be sold for beneficial re-use at unit-value that will offset the excavation cost.	Removal partners are secured and under contract. Details regarding the excavation sequencing and Posi-shell (or equivalent) will be discussed during the design phases that will follow acceptance of these Corrective Measures.
	Source Containment	Vegetated Soil Cover System	Vegetated soil cover system is in place the inactive areas of Cell B. The system consisted of a vegetative soil layer over CCB. The soil cover was graded to promote runoff and limit infiltration of surface water into the CCB.	Average Graded surface somewhat effective for reducing infiltration of precipitation into the inactive areas of Cell B. HELP modeling indicates that about 76% of precipitation on Cells B is diverted as evapotranspiration or becomes stormwater runoff. Approximately 24% of precipitation on Cell B is either captured by the leachate management system (4%), discharged to groundwater (11%), or stored in CCB (9%) (due to changing moisture content). Therefore, this technology alone does not mitigate the risk of cross-media transfer of CCB constituents from leachate to groundwater and surface water, and subsequent transport to potential exposure points, to the extent necessary to protect human health and the environment.	Easy Existing system was placed over the inactive areas of Cell B prior to site-wide upgrades starting in 2016.	Low Prior system	In 2016-2017, the existing vegetated soil cover system was removed from the inactive areas of Cell B and replaced with a geomembrane cap system.
		Temporary Soil/Posi-Shell (or equivalent) Cover	Temporary soil/Posi-Shell cover over inactive area of Cell B not covered by a permanent geomembrane cap. Temporary cover designed to promote runoff and limit potential infiltration of surface water into the CCB.	Below Average Less effective than vegetated soil cover and geomembrane cover in reducing infiltration of precipitation into the inactive area of Cell B not covered by a permanent geomembrane cap. Soil/Posi-Shell cover is a temporary cover solution during mining activities. Soil or Posi-Shell will be placed over the uncovered CCB area daily.	Average In 2017, the existing vegetated soil cover system was removed from the inactive area of Cell B and the surface prepared for cover. Several temporary controls may be implemented during construction to manage traffic, stormwater, and dust.	Low Soil/Posi-Shell covers typically have low costs to design and construct, and low costs to maintain.	Under the current draft deconstruction plan, source removal will prioritize source removal in the uncapped areas of Cell B. The draft deconstruction plan discusses the use of temporary soil covers to cover the areas not actively being mined.
		Geomembrane Cap System	Low-permeability geomembrane cap system installed over the inactive side-slopes of Cell B in 2016-2017. The system consists of a geomembrane, overlain by a cover drainage layer, and vegetated soil cover. The soil cover is graded to promote runoff. Install an additional low-permeability geomembrane cap system over the remaining inactive portion of Cell B that is not already covered by a geomembrane cover.	Above Average Very effective for reducing infiltration of precipitation into the inactive side-slopes of Cell B, and thus effective for reducing the future volume of leachate generated. HELP modeling estimates that construction of the geomembrane caps over the inactive side-slopes of Cell B will reduce infiltration of precipitation into the CCB by approximately 58.395%. This will mitigate the risk of cross-media transfer of CCB constituents from leachate to groundwater and surface water. This is expected to improve existing downgradient groundwater quality and over time will be protective of human health and the environment.	Average In 2016-2017, existing vegetated soil cover system was removed from the inactive areas of Cell B. The cell was regraded, and covered with a geomembrane cap, cover drainage layer, and vegetated soil cover. Several temporary controls were implemented during construction to manage traffic, stormwater, and dust. Several temporary controls may be implemented during construction to manage traffic, stormwater, and dust.	High Geomembrane cap systems typically have average costs to design and construct, and low costs to maintain. The inactive side-slopes of Cell B cover a large area (approximately 25 acres); therefore, costs were high. To install a geomembrane cap system over the remaining inactive portion of Cell B (approximately 26.7 acres), costs would also be high.	In 2016-2017, the existing vegetated soil cover systems were removed from the inactive side-slopes of Cell B, and replaced with geomembrane cap systems. The geomembrane cap on the side-slopes was completed in 2017.

TABLE 5-1
SCREENING OF REMEDIAL ACTION TECHNOLOGIES
Federal CCR Rule
Westland Ash Storage Facility - Cell B
Dickerson, Maryland

Target Media	General Response Actions	Remedial Action Technologies		Protectiveness of Human Health and the Environment	Implementability	Cost	Status
Leachate and Contact Stormwater	Hydraulic Containment	Bottom Ash Leachate Collection System	Portions of Cell B have bottom ash drainage layers and vitrified clay pipe (VCP) drainage systems that are intended to capture leachate from CCB and convey it to the new WWTS.	Below Average Somewhat effective for reducing leachate migration to groundwater which provides protections for downgradient human health and environmental receptors. However, this technology alone does not provide sufficient protection to downgradient human health and environmental receptors. HELP modeling indicates 4% of precipitation at Cell B is captured as leachate in the drainage blanket in the inactive area of Cell B, while approximately 11% migrates through the cell to groundwater.	Easy Existing system in place at the Site.	Low Existing system in place at the Site.	Existing system that will remain at the Site and continue to operate.
		HDPE Leachate Collection System	Impermeable geosynthetic liner system and overlying high density polyethylene (HDPE) leachate collection system, meeting the requirement of COMAR 26.04.10, was installed below CCB contained in Cells B-1A and B-1B . The system is intended to capture leachate from CCB above the liner and convey it to the new WWTS.	Above Average Meets the requirements of COMAR 26.04.10; therefore, the system reduces seepage of leachate to groundwater to the extent necessary to provide sufficient protections to downgradient human health and environmental receptors. HELP modeling indicates that approximately 27% of precipitation is captured as leachate by the leachate collection system below Cells B-1A and B-1B, and only about 0.048% migrates through Cells B-1A and B-1B to groundwater.	Easy Existing system in place at the Site.	Low Existing system in place at the Site.	Existing system that will remain at the Site and continue to operate.
		Pond Liner Systems	Pond 003 was constructed with a liner system and Pond 002 was lined in 2015 as part of the capping project.	Average Effective for reducing seepage of pond water through the bottom of the pond into groundwater. The existing pond liner systems below Ponds 002 and 003 provide protections to downgradient human health and environmental receptors.	Easy Existing system in place at the Site.	Low Existing system in place at the Site.	Existing system that will remain at the Site and continue to operate.
		Geologic Barriers	No naturally occurring migration barriers such as an aquitard are present as a hydraulic barrier for vertical migration from the source areas. Groundwater flow is primarily controlled by bedding planes and other fractures in the bedrock. Hydraulic conductivity is low and when combined with moderate hydraulic gradient results in low groundwater flow velocity.	Low No naturally occurring migration barriers are present at the Site. However, the groundwater flow velocity is low which likely allows for some degree of MNA via adsorption to solids.	None Not naturally occurring at the Site.	None Not naturally occurring at the Site.	Not naturally occurring at the Site.
		Slurry Wall	Surround source area (cell) with a slurry wall of low permeability soil-bentonite that extends to bedrock to limit downgradient migration. Slurry walls are typically installed at depths of less than 50 feet in unconsolidated material. Can be used in funnel and gate configuration with PRB.	Highly dependent on location, existing infrastructure, depth, and permeability of underlying soil. Effective for containing impacted groundwater within a source area and/or diverting unimpacted groundwater around a source area if underlying low permeability material is present to key into. Saline water can increase permeability of bentonite in slurry wall. Laboratory and/or pilot tests could be necessary to assess the effectiveness and longevity of a slurry wall at the Site. The groundwater table is in bedrock; therefore, slurry wall would need to extend up to 150 feet into bedrock to key into a low permeability unit. However, even at that depth, the slurry wall would not likely intercept deep pathways in bedrock.	Difficult Implementability of slurry walls is highly dependent on existing infrastructure around the proposed location, and the proposed depth of the slurry wall. Since groundwater has been interpreted to flow in bedrock in a general south westerly direction beneath Cell B, a slurry wall would need to encompass a large portion of the Site. Depth to bedrock makes this potentially not feasible. In addition, construction would be challenging between landfills and streams.	High Costs are highly dependent on location, length, existing infrastructure and depth. Cost for construction of a slurry wall at the Site would be high because the slurry wall would need to encompass a large portion of the Site and extend to bedrock to intercept groundwater which flows general south westerly direction in bedrock beneath Cell B. Costs would also be high for treatment of associated groundwater extraction to maintain inward hydraulic gradient.	Technology eliminated from future consideration. The cost to construct a slurry wall at the Site would be too high because the wall would need to be installed up to 150 feet into bedrock and extend across a large area of the Site.
		Solidification / Stabilization	Solidification/stabilization material is injected into CCB at low elevations under Cell B below groundwater to mitigate seepage of leachate to groundwater.	Low No ash is present below the groundwater table.	Difficult Cell B encompass approximately 64.4 acres and contain CCB material up to 110 feet in thickness. Therefore, it would be very difficult to uniformly distribute solidification/stabilization materials to the low elevations of Cell B. This technology would require puncturing of the new geomembrane cap system in several locations over the side-slopes of Cell B in order to inject solidification/stabilization materials into the CCB.	High Existing ponds, roads, and utilities in the vicinity of Cell B would affect the installation and related cost. The new geomembrane cap system would need to be repaired after each injection.	Technology eliminated from further consideration because there is no ash present below the groundwater table.

TABLE 5-1
SCREENING OF REMEDIAL ACTION TECHNOLOGIES
Federal CCR Rule
Westland Ash Storage Facility - Cell B
Dickerson, Maryland

Target Media	General Response Actions	Remedial Action Technologies		Protectiveness of Human Health and the Environment	Implementability	Cost	Status
Non-Contact Stormwater	Hydraulic Containment	Existing Stormwater Management System Prior to 2015	Non-contact stormwater is captured and conveyed to Pond 002 for impoundment and discharge via Outfall 002, or discharged via an outlet south of Cell B. The existing stormwater management system was upgraded in 2015-2017.	Below Average In 2014, the Site has had one unintentional release of CCB from the active area of Cell B via stormwater erosion. CCB was recovered from the release to the satisfaction of the MDE. This Corrective Measure alone does not prevent additional potential releases and does not provide sufficient protections to downgradient human health and environmental receptors.	Easy Prior system in place at the Site.	Low Prior system in place at the Site.	In 2015-2017, the existing stormwater management system at the Site was upgraded.
		Upgraded Stormwater Management System	Beginning in 2015, the berm in Cell B-1B was upgraded, and down spouts and chimney drains were installed to divert contact stormwater to perimeter conveyance piping. During capping operations, the drainage ditches and conveyance piping on Cells B were modified. Non-contact stormwater continues to be captured and conveyed to Pond 002 for impoundment and discharge via Outfall 002, or discharged via an outlet south of Cell B.	Above Average Upgraded system is effective for managing noncontact stormwater. This Corrective Measure will provide additional protection to potential downgradient human and ecological receptors that might come into contact with surface water.	Easy Existing system in place at the Site as of 2017.	Low Existing system in place at the Site.	Construction of the upgraded stormwater management systems were completed in 2017.
Discharge from Ponds	Best Available Economically Achievable Technology (BAT)	Gravity Settling Pond	Prior to 2017, Pond 003 was used for impoundment and treatment of contact stormwater and leachate captured from the underdrain collection systems via gravity settling prior to discharge towards Big Stream. Facility personnel manually added soda ash to wastewater for softening and precipitation of metals operated in batch treatment/discharge manner.	Average Prior to 2017, the gravity settling ponds acted as the BAT to achieve compliance with the prior NPDES permit effluent limits at the point of discharge. The discharge limits in the 2016 NPDES permit are more stringent, and this technology does not provide sufficient treatment of comingled leachate, noncontact and contact stormwater from Pond 003 to meet NPDES effluent limits which are intended to be protective of human health and the environment.	Easy Existing technology at the Site prior to 2017.	Low Existing technology in place at the Site.	Existing technology at the Site. Gravity settling continues to be used to treat leachate and non-contact stormwater from Pond 003 prior to discharge towards Big Stream via Outfall 003. However, gravity is no longer used as the primary treatment for wastewater from Pond 003. Leachate and stormwater are treated by the WWTS before they are conveyed to Pond 003 for storage prior to discharge towards Big Stream via Outfall 003.
	Upgraded NPDES Treatment System	Wastewater Treatment System (WWTS)	As of 2017, wastewater including leachate, non-contact and contact stormwater from Cell B is routed to a physical/chemical zero-valent iron (ZVI) treatment process. The WWTS consists of reactive media that acts as an electron generator to chemically reduce soluble metal cations and oxyanions in wastewater to insoluble forms that are removed by surface adsorption and chemical incorporation into the iron oxidation products. Following treatment, the water is conveyed to Pond 003, and then discharged through Outfall 003 to a drainage trench that flows toward Big Stream.	Above Average The WWTS was selected by MD Ash to supplement the existing gravity settling ponds to achieve compliance with NPDES permit effluent limits at Outfall 003 which are intended to be protective of human health and the environment. This technology will provide additional protection to potential downgradient human and ecological receptors that might come into contact with surface water. These additional protections are being provided by reducing CCB mass loading to the streams. MD Ash installed this treatment system to achieve new or more stringent NPDES discharge limits that became effective in May of 2017.	Average Implementation required careful planning and sequencing, as well as an understanding of the water balance. System was constructed in an open area of the Site on the eastern berm of Pond 003.	High Construction of the WWTS was high. Operation and maintenance costs are moderate and reasonably understood and anticipated by MD Ash.	Construction of the WWTS was completed in 2017 to supplement existing gravity settling pond (Pond 003).
Groundwater	In Situ Treatment	Permeable Reactive Barrier (PRB)	Treats groundwater impacted by CCB as it flows through permeable, engineered subsurface reactive zones that are designed to treat the groundwater for specific constituents. PRB would be installed along the downgradient edge of Cell B or together with a slurry wall in a funnel and gate configuration.	Highly dependent on groundwater constituents, aquifer characteristics and groundwater characteristics. Multiple groundwater constituents require further evaluation to demonstrate they can be treated by one or more compatible reactive media/processes. Further evaluation would be needed to demonstrate suitability of a PRB in reducing groundwater concentrations to the extent necessary to achieve GWPS.	Difficult Permeable reactive media may be injected using temporary/permanent wells, or may be trenched/excavated. However, construction would be challenging between landfills and streams. It would also be very difficult to key a PRB into bedrock which is approximately 150 feet below ground surface. Permeable reactive media may require some frequency of reactivation/replacement.	High Existing ponds, roads, buildings and utilities would affect the installation and related cost. Costs usually vary with depth of installation. Costs are highly dependent on location, existing infrastructure, depth and geology. The required reactive media volume and/or flow-through thickness has a large influence on project cost.	Technology eliminated from further consideration. No single known PRB technology is able to reduce all CCB constituents to the extent needed to meet groundwater quality standards. The limited distance and steep slopes between the CCB management areas and the Site boundaries do not provide enough space/accessibility for sequential PRBs. It would not be feasible to install a PRB up to 150 feet below ground surface in order to key into bedrock.
		Bio-Reactive Zone	Intercepts groundwater impacted by CCB as it flows through permeable, engineered biologically reactive zones that are designed to treat the groundwater for specific constituents. Bio-reactive barrier would be installed along the downgradient edge of Cell B.	Highly dependent on groundwater constituents, aquifer characteristics and groundwater characteristics. Multiple CCB constituents require further evaluation to demonstrate they can be treated by one or more compatible biological processes. Further evaluation would be needed to demonstrate suitability of bio-reactive treatment to reduce groundwater concentrations to the extent necessary to achieve GWPS.	Difficult Reactive media may be injected using temporary/permanent wells, or may be trenched/excavated. However, construction would be challenging between landfills and streams. Bio-reactive materials may require some frequency of reactivation/replacement.	High Existing ponds, roads, buildings and utilities would affect the installation and related cost. Costs usually vary with depth of installation. For injection systems, numerous overlapping injections would be required to install a high-integrity system. The required reactive media volume and/or flow-through thickness has a large influence on project cost.	Technology retained as contingent additional corrective measure, although the limited distance and steep slopes between the CCB management areas and the Site boundaries would make construction challenging.

TABLE 5-1
SCREENING OF REMEDIAL ACTION TECHNOLOGIES
Federal CCR Rule
Westland Ash Storage Facility - Cell B
Dickerson, Maryland

Target Media	General Response Actions	Remedial Action Technologies		Protectiveness of Human Health and the Environment	Implementability	Cost	Status
Groundwater	In Situ Treatment	Constructed Wetlands	Engineered wetlands intercept and treat shallow groundwater prior to discharge via seepage into streams. Wetlands would be installed downgradient of CCB adjacent to the streams.	Below Average Engineered wetlands are not likely to reduce concentrations of all CCB constituents to the extent necessary to achieve GWPS. Further evaluation of wetland uptake rates for CCB constituents, aquifer characteristics and groundwater characteristics would be required prior to implementation.	Difficult Available space for construction upgradient of streams is limited in some areas of the Site and slopes are steep that could make implementation challenging. Bedrock outcrops in stream beds. Wetlands would require routine maintenance and monitoring.	Average Existing ponds, roads, buildings and utilities would affect the installation and related cost. Construction materials are moderate. The required maintenance and monitoring frequency has a large influence on project cost.	Technology eliminated from further consideration. Wetlands would not likely reduce all CCB constituents to the extent needed to meet surface water quality standards, and there is little room for construction.
		Soil Flushing	Clean water is injected into the soil under the middle of Cell B to accelerate removal of CCB constituents sorbed or precipitated onto aquifer solids beneath the cell toward the perimeter of the cell.	Below Average The saprolite underlying Cell B is thin, and injection of water beneath those cells would likely saturate the bottom of the CCB . This would reverse the benefit of the new geomembrane cap system by increasing seepage of CCB constituents to groundwater. Therefore, this technology would not likely reduce groundwater concentrations to the extent necessary to achieve GWPS.	Average Implementation would require understanding of the water balance and identification of an appropriate source of clean water for injection. In addition, geochemical modeling and/or feasibility testing would be conducted prior to implementation to assess the feasibility of this technology in accelerating removal of CCB constituents sorbed or precipitated onto aquifer solids. Additionally, implementation would require the new geomembrane cap systems to be punctured in several locations, and for a groundwater collection system to be installed at the downgradient edge of CCB	Moderate Existing ponds, roads, and utilities in the vicinity of Cell B would affect the installation and related cost. Costs usually increase with the depth/number of injection wells. New conveyance piping will be needed for injecting clean water.	Technology eliminated from further consideration because it would likely reverse the benefit of the new geomembrane cap system by raising the groundwater elevation thereby increasing seepage of CCB constituents to groundwater.
	Monitoring	Groundwater Monitoring	Implement a groundwater monitoring program to evaluate performance of source control measures in improving downgradient groundwater quality. Institute groundwater potable use restriction on Site to prevent exposure. If after two years of monitoring (by 2020), a reduction in groundwater concentrations has not been detected at monitoring wells MW-03 and MW-12, then continue monitoring, consider implementing additional Corrective Measures and consult with MDE.	The groundwater monitoring program will evaluate the progress and effectiveness of the other Corrective Measures in improving groundwater quality at the Site, as well as assess the need for additional Corrective Measures to increase protections to human health and environmental receptors. Shallow groundwater potable use restriction will protect those receptors in the interim.	Easy Groundwater monitoring is ongoing at the Site.	Medium Costs related to groundwater monitoring at the Site are reasonably understood and anticipated by MD Ash.	Implement as a Corrective Measure.

Notes:
- (orange shading) Not retained as a remedial action technology to address the RAOs for the Site.
- (green shading) Retained as a remedial action technology to address the RAOs for the Site.
- CCB Coal combustion by-products
- COMAR Code of Maryland Regulations
- GCL Geosynthetic clay liner
- HDPE High-density polyethylene
- ZVI Zero-valent iron
- MDE Maryland Department of Environment
- NPDES National Pollutant Discharge Elimination System [1]
- PRB Permeable Reactive Barrier
- WWTS Wastewater Treatment System

[1] Discharge of wastewater toward Big Stream and Dickerson Creek is regulated by the NPDES permit with the Maryland State Discharge Permit number 00-DP-1680 and Federal permit number MD0057584.

TABLE 5-2
CORRECTIVE MEASURES APPROACH
Federal CCR Rule
Westland Ash Storage Facility - Cell B
Dickerson, Maryland

Remedial Action Objectives (RAOs)	Target Media	General Response Actions	Remedial Action Technologies		Existing Conditions Prior to 2015	Corrective Measures Approach
Source Control: Reduce future generation of CCB leachate from Cell B in order reduce or eliminate further release of Appendix IV constituents to groundwater.	CCB	Source Containment	Vegetated Soil Cover System	Vegetated soil cover systems were in place over the inactive areas of Cell B. The systems consisted of a vegetative soil layer over CCB. The soil cover was graded to promote runoff and limit infiltration of surface water into the CCB.	O	
			Geomembrane Cap System	Low-permeability geomembrane cap systems were installed over the inactive side-slopes of Cell B in 2016-2017. The systems consists of a geomembrane, overlain by a cover drainage layer, and vegetated soil cover. The soil cover is graded to promote runoff.		O
			Temporary Soil Cover/Posi-Shell (or equivalent)	Temporary soil cover and/or posi-shell will be used during source removal in areas being mined and over inactive area of Cell B not covered by a permanent geomembrane cap. Temporary cover designed to promote runoff and limit potential infiltration of surface water into the CCB.		O
		Source Removal	Beneficial Re-Use Harvesting	The existing vegetated soil cover system and or geomembrane cover systems installed at the Site will be removed to allow for source removal of CCB material. The CCB material will be excavated and hauled off-site for beneficial reuse.		O
	Leachate	Hydraulic Containment	Bottom Ash Leachate Collection System	Portions of Cells B and C have bottom ash drainage layers and vitrified clay pipe (VCP) drainage systems that are intended to capture leachate from CCB and convey it to the new WWTS.	O	O
			HDPE Leachate Collection System	Impermeable geosynthetic liner system and overlying high density polyethylene (HDPE) leachate collection system, meeting the requirement of COMAR 26.04.10, was installed below CCB contained in Cells B-1A and B-1B . The system is intended to capture leachate from CCB above the liner and convey it to the new WWTS.	O	O
			Pond Liner Systems	Pond 003 was constructed with a liner system and Pond 002 was lined in 2015 as part of the capping project.	O	O
	Stormwater	Hydraulic Containment	Upgraded Stormwater and Leachate Management System	Beginning in 2015, the berm in Cell B-1B was upgraded, and down spouts and chimney drains were installed to divert contact stormwater to perimeter conveyance piping. During capping operations, the drainage ditches and conveyance piping on Cells B and C were modified. Non-contact stormwater continues to be captured and conveyed to Pond 002 for impoundment and discharge via Outfall 002, or discharged via two outlets south of Cell B and north of Cell C. In addition, contact stormwater continues to be captured and conveyed by the leachate collection system to the WWTS for treatment then to Pond 003 prior to discharge via Outfall 003.		O
	Discharge from Ponds	Best Available Economically Achievable Technology (BAT)	Gravity Settling Pond	Prior to 2017, Pond 003 was used for impoundment and treatment of contact stormwater and leachate captured from the underdrain collection systems via gravity settling prior to discharge towards Big Stream. Facility personnel manually added soda ash to wastewater for softening and precipitation of metals operated in batch treatment/discharge manner. Pond 002 continues to be used for impoundment of noncontact stormwater prior to discharge towards Dickerson Stream via Outfall 002.	O	O
		Upgraded NPDES Treatment System	Wastewater Treatment System (WWTS)	As of 2017, wastewater including leachate, non-contact and contact stormwater from Cells B and C is routed to a physical/chemical zero-valent iron (ZVI) treatment process. The WWTS consists of reactive media that acts as an electron generator to chemically reduce soluble metal cations and oxyanions in wastewater to insoluble forms that are removed by surface adsorption and chemical incorporation into the iron oxidation products. Following treatment, the water is conveyed to Pond 003, and then discharged through Outfall 003 to a drainage trench that flows toward Big Stream.		O
Groundwater: Attain GWPS for Appendix IV constituents [1] at established and approved compliance points.	Groundwater	Monitoring	Groundwater and Surface Water Monitoring	Implement groundwater and surface water monitoring programs to evaluate performance of source control measures in improving downgradient groundwater and surface water quality. Evaluate effectiveness of Corrective Measures in reducing groundwater concentrations and mass flux after 2, 5 and 30 years of groundwater monitoring.	O	O

Notes:

CCB Coal combustion by-products
COMAR Code of Maryland Regulations
GWPS Groundwater Protection Standards [1]
HDPE High-density polyethylene
MDE Maryland Department of Environment
RAO Remedial Action Objective
ZVI Zero-valent iron

[1] GWPS, defined under CCR Rule Part 257.95(h), were established for each detected Appendix IV constituent as the greater of background or the maximum contaminant level (MCL) (or the EPA Regional Screening Level for cobalt, lead, lithium, and molybdenum that do not have MCLs).

TABLE 5-3
WATER BALANCE SUMMARY
Federal CCR Rule
Westland Ash Storage Facility - Cell B
Dickerson, Maryland

Scenario	Cell	Cover/Liner System	Average Daily Rainfall [1]	Evapotranspiration		Stormwater Runoff		Cover Drainage Collected		Leachate Collected [2]		Discharge to Groundwater [3]		Stored in CCB (due to changing moisture content)	
			(gpd)	(gpd)	% of Average Daily Rainfall	(gpd)	% of Average Daily Rainfall	(gpd)	% of Average Daily Rainfall	(gpd)	% of Average Daily Rainfall	(gpd)	% of Average Daily Rainfall	(gpd)	% of Average Daily Rainfall
Prior Conditions [4]	B	Vegetated Soil Cover	152,000	110,800	73%	5,860	3.8%	0	0%	39.2	0.026%	20,430	13%	15,200	10%
	B1-A/B	Geomembrane Liner	27,800	16,830	61%	2,600	9.4%	0	0%	7,490	27%	13.2	0.048%	819	3.0%
		Total	**179,800**	**127,630**	**71%**	**8,460**	**4.7%**	**0**	**0%**	**7,529**	**4.2%**	**20,443**	**11%**	**16,019**	**8.9%**
2017 Conditions [5]	B	Geomembrane Cap (side-slopes only)	152,000	85,700	56%	5,000	3.3%	42,400	28%	15.5	0.010%	8,500	5.6%	10,700	7.0%
	B1-A/B	Geomembrane Liner	27,800	16,830	61%	2,600	9.4%	0	0.00%	7,490	27%	13.2	0.048%	819	3.0%
		Total	**179,800**	**102,530**	**57%**	**7,600**	**4.2%**	**42,400**	**24%**	**7,506**	**4.2%**	**8,513**	**4.7%**	**11,519**	**6.4%**
Proposed Corrective Measures [6]	B	Source Removal	152,000	N/A	N/A	N/A	N/A	0	0%	0	0.00%	0.00	0.00%	0	0.00%
	B1-A/B	Geomembrane Liner	27,800	16,830	61%	2,600	9.4%	0	0.00%	7,490	27%	13.2	0.048%	819	3.0%
		Total	**179,800**	**16,830**	**9%**	**2,600**	**1.4%**	**0**	**0%**	**7,490**	**4.2%**	**13**	**0%**	**819**	**0.5%**

Notes:

gpd gallons per day

% percent

CCB coal combustion byproducts

[1] Average daily rainfall is based on an assumed average yearly rainfall at the Site of 41.37 inches over 64.4 acres of CCB in Cell B.

[2] Predicted leachate collection by existing leachate collection systems. Most of the leachate is collected from Cell B-1.

[3] Most of the predicted leakage to groundwater occurs in the unlined inactive areas of Cell B.

[4] Existing conditions prior to the summer of 2016. This includes the vegetated soil covers on Cell B; leachate and stormwater management systems; and geosynthetic liners in Cell B1-A and Cell B1-B.

[5] The 2017 conditions are the same as the 2018 conditions and assume the existing soil cover on the side slopes of the inactive area of Cell B has been removed, and a geomembrane cap has been installed in its place. This scenario does not take into account that a soil/posi-shell (or equivalent) cover will be installed on the inactive areas of Cell B during source removal. This scenario assumes that the existing vegetated soil cover will remain intact in order to provide a conservative estimate of leakage to groundwater. This scenario also includes the leachate and stormwater management

[6] Proposed corrective measures are source removal of CCB stored in Cell B, and Cell B-1 and lower-permeability cover systems (i.e., geomembrane and Posi-Shell cover) installed on the inactive areas of Cell B not covered by a permanent geomembrane cap. The lower permeability cover system will allow for source control during CCB removal.

TABLE 5-4
ADDITIONAL REDUCTION OF LEACHATE LOADING TO GROUNDWATER
Federal CCR Rule
Westland Ash Storage Facility - Cell B
Dickerson, Maryland

Cell	Prior Conditions [1]	2017 Conditions [2]	Proposed Corrective Measures [3]
	% Reduction		
B	0%	58.395%	99.999%
B-1A/B	0%	0%	0%
Total	0%	58.357%	99.935%

Notes:

gpd gallons per day

% percent

[1] Existing conditions prior to the summer of 2015. This includes the vegetated soil covers on Cell B; leachate and stormwater management systems; and geosynthetic liners in Cell B1-A and Cell B1-B.

[2] Reduction compared to prior conditions. The 2017 conditions are the same as the 2018 conditions and assume the existing soil cover on the side slopes of the inactive area of Cell B has been removed, and a geomembrane cap has been installed in its place. This scenario does not take into account that a temporary soil/posi-shell (or equivalent) cover will be installed on the inactive areas of Cell B during source removal. This scenario assumes that the existing vegetated soil cover will remain intact in order to provide a conservative estimate of leakage to groundwater. This scenario also includes the leachate and stormwater management systems; and geosynthetic liners in Cell B1-A and Cell B1-B.

[3] Reduction compared to prior conditions. Proposed corrective measures are source removal of CCB stored in Cell B and Cell B-1.

TABLE 6-1
GROUNDWATER TRAVEL TIMES TO POINT OF COMPLIANCE FOR CELL B
Federal CCR Rule
Westland Ash Storage Facility - Cell B
Dickerson, Maryland

Downgradient Monitoring Wells	Groundwater Elevation (ft msl) [1]	Estimated Upgradient Groundwater Elevation (ft msl) [2]	Δ h (ft)	Δ l (ft)	Flow Path Length (ft) [3]	Average η of Flow Path [4]	Gradient Δ h/Δ l	Average Hydraulic Conductivity (K) (cm/sec) [5]	Linear Velocity (inches/month)	Particle Travel Time to Point of Compliance (months)	Particle Travel Time to Point of Compliance (years)
MW-03	305.62	310	4.38	223	232	0.01	0.020	1.44E-04	**2.93E+02**	**10**	**0.8**
MW-10S	242.10	250	7.90	179	186	0.01	0.044	1.12E-05	**5.11E+01**	**44**	**3.6**
MW-12	271.78	280	8.22	150	155	0.01	0.055	2.66E-05	**1.51E+02**	**12**	**1.0**

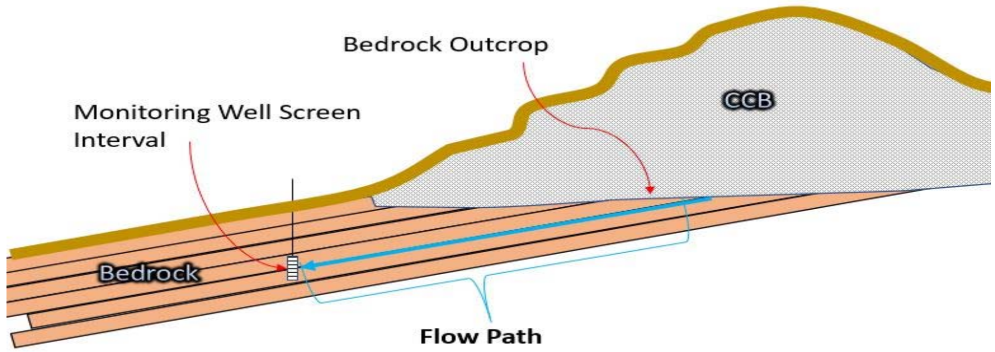
Notes:
cm/sec centimeter per second
ft feet
ft msl feet above mean sea level
[1] Groundwater elevations used are from the February 2016 groundwater monitoring event.
[2] Groundwater elevation are projected upgradient using a 15 degree bedrock dip.
[3] Figure to the right depicts how flow path lengths were estimated.
[4] Avergare η is the average porosity for siltstone.
[5] Average hydraulic conductivities are the average K for the screened interval. Average K were calculated using results from packer testing.
[6] Calculated velocity is idealized based on large-scale assumption of Darcy porous media equivalent flow. Actual velocities could be higher or lower than the calculated values.

Groundwater Velocity Equation:

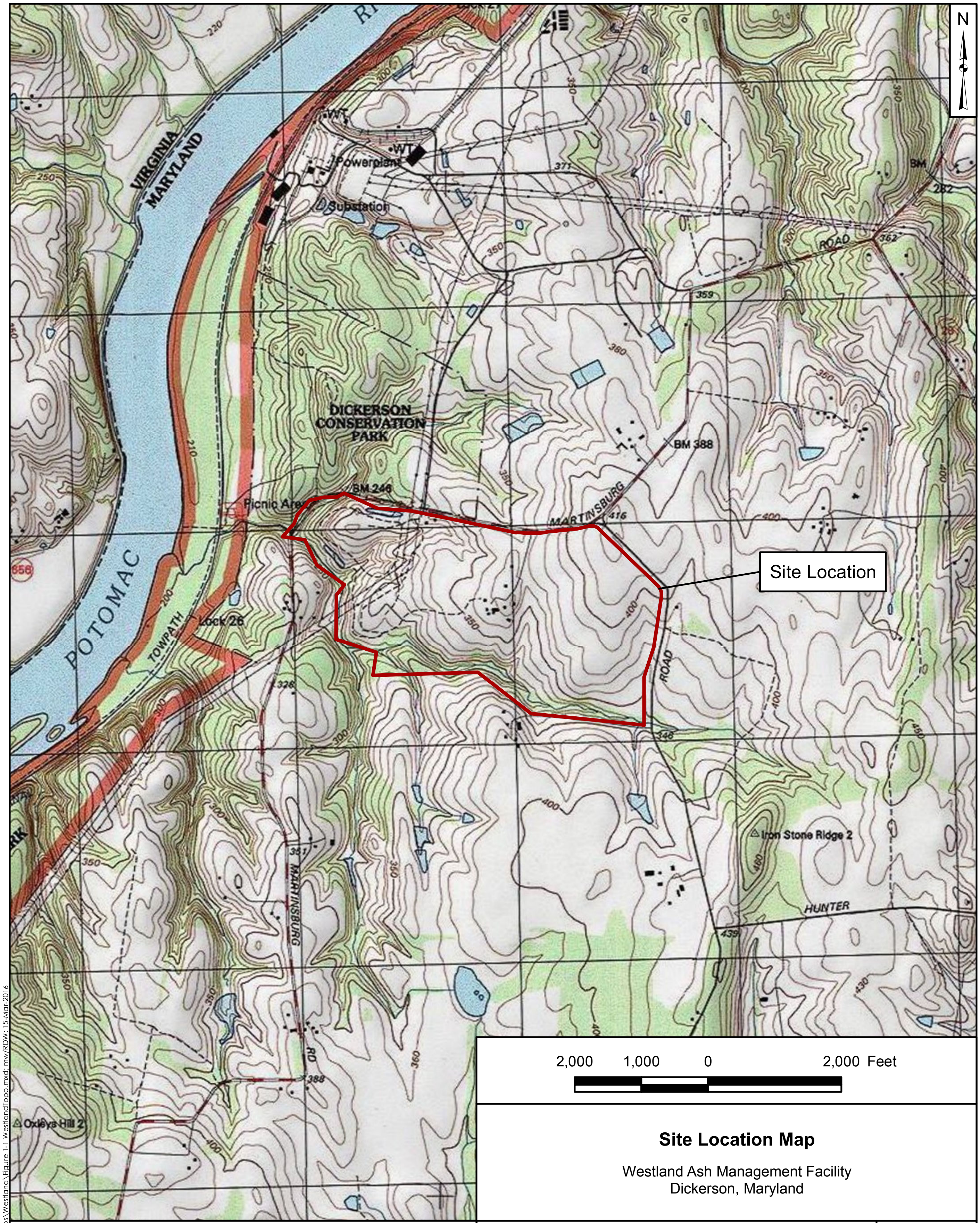
$$V_\eta = \frac{K}{\eta} \times \frac{\Delta h}{\Delta l}$$

V_η linear groundwater velocity
K hydraulic conductivity (cm/sec)
η effective porosity (unitless)
Δh change in head between wells (ft)
Δl distance between wells (ft)

Generalized Groundwater Flow Diagram



FIGURES



2,000 1,000 0 2,000 Feet

Site Location Map

Westland Ash Management Facility
Dickerson, Maryland

Source:
USGS Topographic Quadrangle - Dickerson, Maryland, provided by the National Geographic Society, i-cubed. © 2011 National Geographic Society, i-cubed

Geosyntec consultants

Columbia, Maryland

March 2019

Figure 1-1

Path: P:\GIS\NRG\GenOn\Maps\Westland\Figure 1-1 WestlandTopo.mxd; mw/RDW: 15-Mar-2016

NOTES:

1. EXISTING CONDITIONS COMPILED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHY DATED 28 DECEMBER 2013 EXCEPT AS FOLLOWS. EXISTING LEACHATE TRANSMISSION PIPES WITHIN CELLS B, B-1A, AND B-1B OBTAINED FROM FLORA SURVEYING ASSOCIATES, INC. BASED ON FIELD-RUN SURVEY DATED 2010; LOCATIONS OF OTHER LEACHATE TRANSMISSION LINES ARE APPROXIMATE.

2. HORIZONTAL CONTROL IS MARYLAND STATE PLAN COORDINATE SYSTEM, NAD27; VERTICAL CONTROL IS NGVD29.

REV	DATE	DESCRIPTION	DRN	APP

Geosyntec consultants
10211 WINCOPIN CIRCLE, 4TH FLOOR
COLUMBIA MARYLAND 21044 USA
PHONE: 410.381.4333

GenOn

TITLE: SITE FEATURES AND MONITORING LOCATIONS

PROJECT: ASSESSMENT OF CORRECTIVE MEASURES, FEDERAL CCR RULE

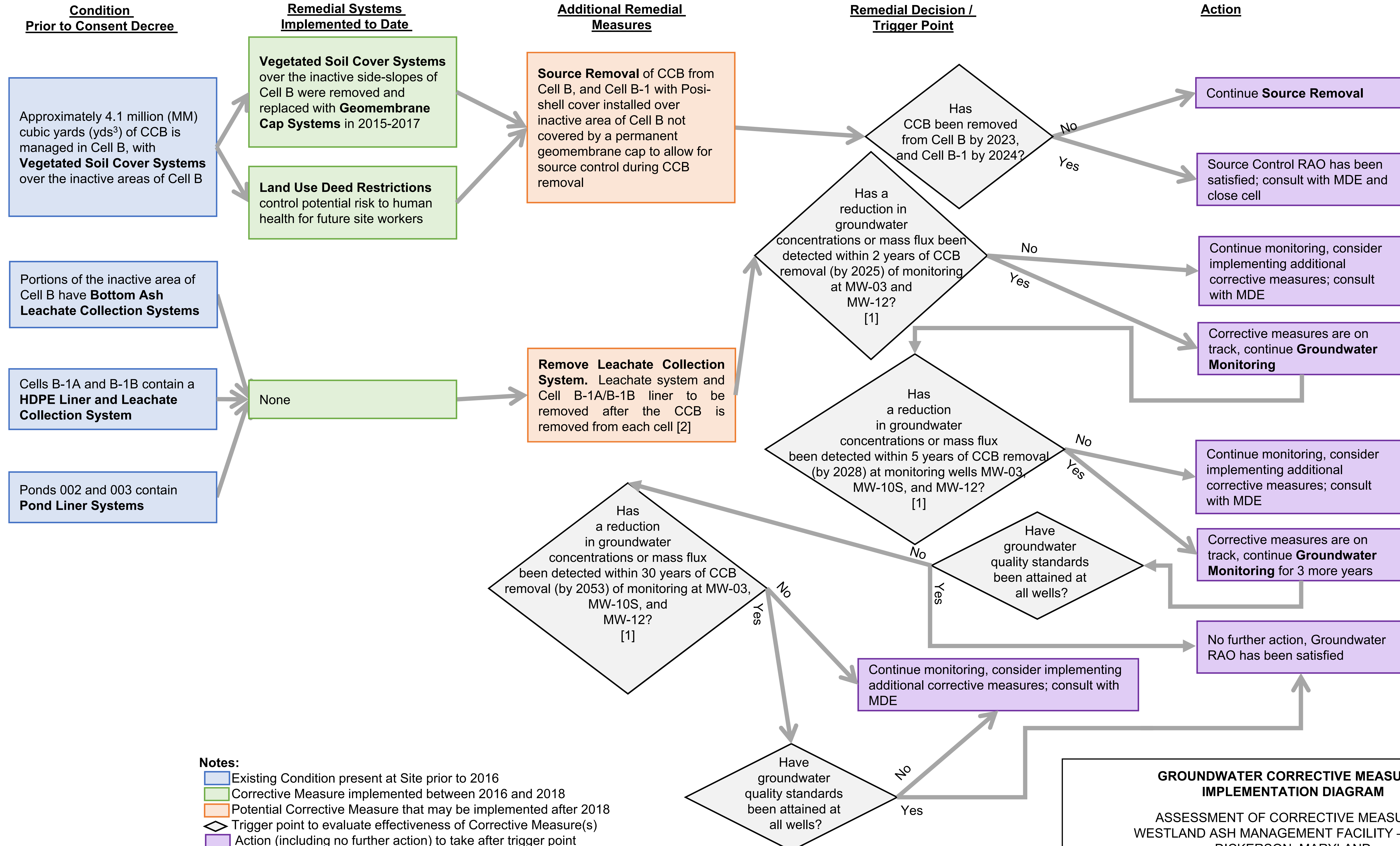
SITE: WESTLAND ASH MANAGEMENT FACILITY, CELL B DICKERSON, MARYLAND

NOT FOR CONSTRUCTION

SIGNATURE

DATE

DESIGN BY:	MB	DATE:	MARCH 2018
DRAWN BY:	JOC	PROJECT NO.:	MEM0823C
CHECKED BY:	MB	FILE:	FIG 2-1
REVIEWED BY:	RMG	FIGURE NO.:	2-1
APPROVED BY:	MAJ		



Notes:

- Existing Condition present at Site prior to 2016
- Corrective Measure implemented between 2016 and 2018
- Potential Corrective Measure that may be implemented after 2018
- Trigger point to evaluate effectiveness of Corrective Measure(s)
- Action (including no further action) to take after trigger point

O&M – Operation and maintenance
RAO – Remedial Action Objective

[1] Estimated particle travel times in screened bedrock intervals from Cell B to downgradient monitoring wells are provided in Table 6-1. Reductions in groundwater concentrations and mass flux at monitoring wells MW-03, and MW-12 are expected to be detected before other locations, and monitoring well MW-10S has are the longest travel time from Cell B.

[2] Once the CCB material in the surrounding portions of Cell B has been removed, Cell B-1A will remain as an option for rejected CCB material from the cement manufacturers. If no CCB material remains, Cells B-1A and B-1B will be dismantled and clean closed.

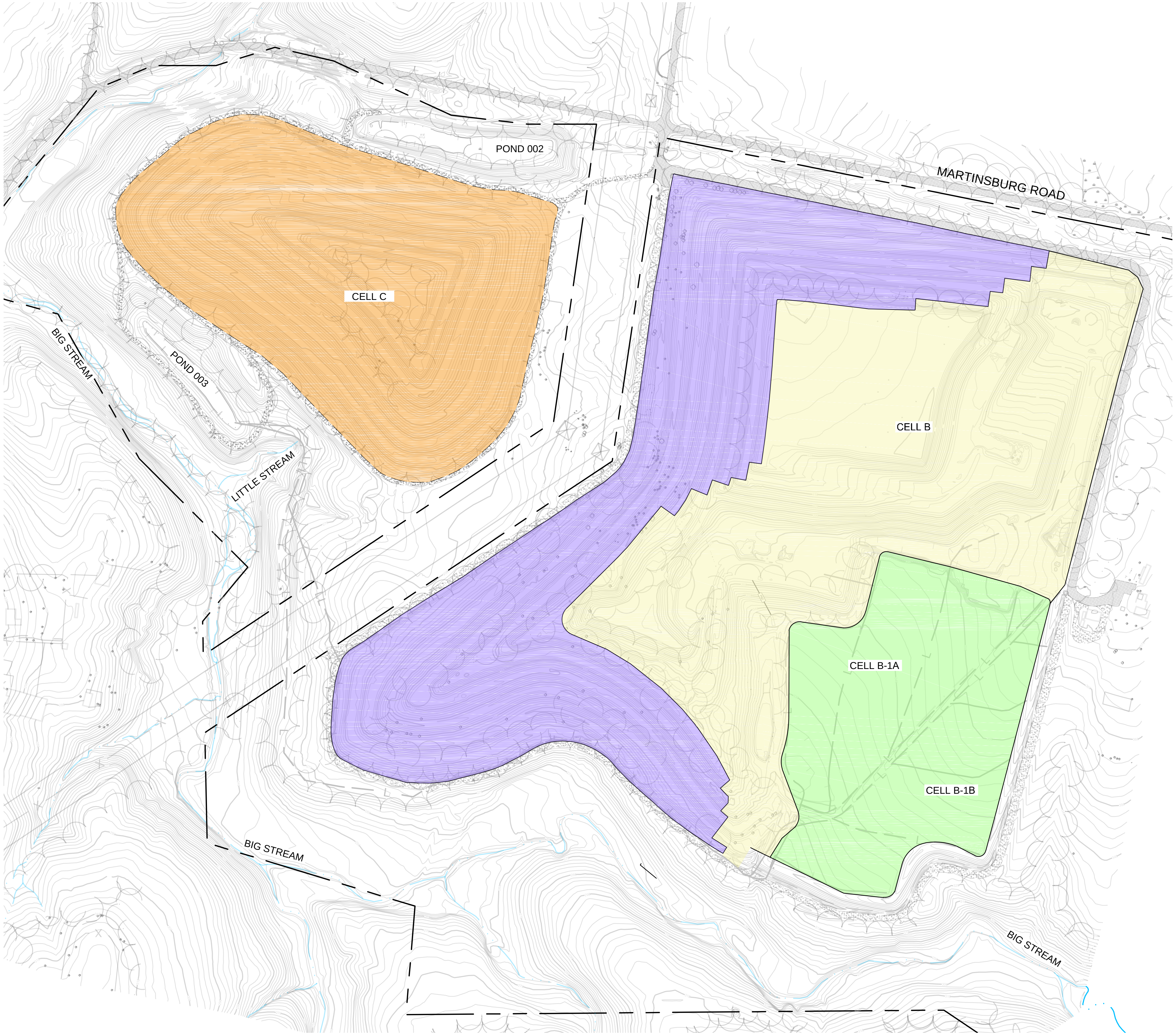
GROUNDWATER CORRECTIVE MEASURES IMPLEMENTATION DIAGRAM

ASSESSMENT OF CORRECTIVE MEASURES
WESTLAND ASH MANAGEMENT FACILITY – CELL B
DICKERSON, MARYLAND

Geosyntec consultants

Columbia, Maryland | March 2019

Figure 5-1



N

LEGEND

- PROPOSED TEMPORARY SOIL COVER AND POSI-SHELL. PRIORITY SOURCE REMOVAL AREA (26.7 AC).
- INACTIVE SIDE-SLOPES OF CELL B - GEOMEMBRANE CAP INSTALLED 2017 (23.0 AC)
- ACTIVE AREAS OF CELL B - LINED AND WILL BE CAPPED AFTER FILLED TO FINAL GRADES (11.9 AC)
- CCB MANAGEMENT UNIT NOT REGULATED UNDER THE CCR RULE

NOTE: CELL B IS THE ONLY CCB MANAGEMENT UNIT REGULATED BY THE CCR RULE.

0 300'
SCALE IN FEET

CONTROLS DURING SOURCE REMOVAL OF CELL B

Geosyntec consultants
COLUMBIA, MARYLAND

DATE:	MARCH 2019
PROJECT NO.	ME0823A
DOCUMENT NO.	
FILE NO.	f001
FIGURE NO.	5 - 2

P:\cadd\0westland-nrg\1106-westland\1106-300\f001.dwg, 4-1, 6/29/2018 3:47:37 PM, bferrick

APPENDIX A

Water Balance for Cell B at Westland Ash Management Facility

WATER BALANCE FOR CELL B AT WESTLAND ASH MANAGEMENT FACILITY

1. OBJECTIVE

The objective of this calculation package is to develop a water balance for Cell B at the Westland Ash Management Facility (the site) located near the town of Dickerson, Montgomery County, Maryland. The site is owned by MD Ash Management, LLC and operates as a disposal facility for Coal Combustion Byproducts (CCB) produced at Dickerson Generating Station. The water balance will be used to estimate the volumes of clean stormwater runoff and leachate collected from Cell B, as well as the volume of leachate that seeps through the unlined areas of Cell B and into the shallow groundwater. A schematic detailing the inputs and outputs of the water balance is shown in Figure 1.

2. BACKGROUND

The location of Cell B at the site is shown in Figure 2. Cell B consists of two unlined areas: (i) the inactive, unlined western, northern, and southwestern side slopes (Cell B side slopes); and (ii) the inactive, unlined central and northeastern portions of the cell. Both inactive areas had a 2-ft. soil cover from 2010 to 2017. The southeastern section of Cell B was lined in 2010 and was designated as Cell B-1. The Cell B side slopes were capped with a geomembrane between 2016 and 2017, the central and northeastern portion of Cell B remains inactive with vegetated soil cover, and the active portion of Cell B-1 (Cell B-1A) receives CCB. The inactive, lined portion of Cell B-1 (Cell B-1B) contains no CCB and all water collected within Cell B-1B is treated as non-contact stormwater and discharged to the local stream. For this reason, Cell B-1B is not considered in this analysis. Figure 2 shows the approximate location of active and inactive areas of Cell B.

The proposed corrective measure for Cell B is full source removal of CCBs from Cell B with waste material (e.g. material rejected for source removal) placed in Cell B-1A. This analysis develops a water balance for Cell B under three different scenarios. In the first scenario none of the areas have geomembrane caps, while in the second scenario the Cell B side slopes are capped with a geomembrane, the central and northeastern portion of Cell B remains inactive with vegetated soil cover, and Cell B-1A continues to receive CCBs. In the third scenario, CCBs from the unlined portions of Cell B are removed, and Cell B-1A contains CCB material rejected for source removal. This third scenario likely represents the future condition of Cell B when the full source removal is complete. Because the unlined portion of Cell B will be completely devoid of ash under the proposed corrective measure, they are not modeled in the third (future conditions) scenario.

3. METHOD

The Hydrologic Evaluation of Landfill Performance (HELP) Version 3.07 (USEPA, 1994) computer program was used to perform this analysis. HELP is a quasi-two-dimensional hydrologic model for the movement of water into, through, and out of landfills. Multiple HELP simulations were performed in order to capture the variations in stratigraphy, surface slope, liner conditions, and cover conditions assumed for the two conditions considered (soil cover vs. geomembrane cap on inactive areas). Several assumptions regarding weather data, stratigraphy of the disposal site, and the leachate collection system were made in order to perform the analysis. These assumptions are outlined in the following section.

4. INPUT DATA

4.1 Introduction

The input data in the HELP model is classified into site/design specific data such as the layering configuration and material properties, and location specific data such as climatic data. For both types of input data properties, HELP offers the option of using default values or user defined values. Each set of input data is described in the following sections.

4.2 Weather Data

The HELP model requires the following weather-related input data: (i) evapotranspiration, (ii) precipitation, (iii) temperature, and (iv) solar radiation data. The HELP model provides default values and synthetically generated weather data for specific cities in the United States. The closest city to the Westland site available in HELP, Baltimore, MD, was selected for weather data input. Weather data were synthetically generated for a 30-year period.

The HELP default values for evaporation zone depth and maximum leaf area index (LAI) were used. For the inactive areas of the site, an evaporative zone depth of 21 inches and a maximum LAI of 3.5 were chosen, corresponding to a site with a fair to good stand of grass. For active areas of the site, an evaporative zone depth of 9 inches and a maximum LAI of 0 were chosen, corresponding to a site with bare soil.

4.3 Soil, CCB and Geomembrane Material Data

Three basic configurations for the stratigraphy of the disposal site were modeled to represent the different conditions described in Section 2: (Type I) unlined/soil cover/inactive; (Type II) unlined/geomembrane cap/inactive; and (Type III) lined/uncapped/active. These three configurations are detailed below with layers listed from top to bottom.

Type I: Unlined/soil cover/inactive:

- 24-in. protective cover soil (intermediate soil cover);
- Fly ash (thickness varies);
- 24-in. bottom ash drainage layer;
- 36-in. compacted saprolite;

Type II: Unlined/geomembrane cap/inactive:

- 24-in. protective cover soil;
- 200-mil geocomposite drainage layer (cover geocomposite);
- 40-mil low density polyethylene (LDPE) geomembrane (cover geomembrane);
- Fly ash (thickness varies);
- 24-in bottom ash drainage layer;
- 36-in. compacted saprolite;

Type III: Lined/uncapped/active:

- 6-in protective cover soil (intermediate cover);
- Fly ash (thickness varies);
- 18-in. bottom ash drainage layer;
- 60-mil high density polyethylene (HDPE) geomembrane (liner geomembrane);
- 36-in. compacted saprolite;

A brief description of each of the material layers is presented below from the bottom to the top.

Compacted Saprolite

Drilling records and historical design records indicate that the CCB cells at the Westland site are built above a thin (average of 3 ft) layer of compacted saprolite. Records indicate that this saprolite layer can be classified as a silty sand to a clayey silt with properties very similar to those of the underlying parent bedrock (D'Appolonia 1978). Drilling records for monitoring well installation and Packer Testing performed by Geosyntec (2016) indicate that the bedrock underlying the saprolite layer has a highly variable hydraulic conductivity depending on location and depth at the Westland site (2.0×10^{-10} - 8.0×10^{-4} cm/s). To estimate the hydraulic conductivity of the saprolite, the hydraulic conductivities measured in the topmost layer of bedrock by Geosyntec (2016) were averaged on a log scale. Using this method, an average hydraulic conductivity of 5.38 x

10^{-6} cm/s was chosen. In HELP, this layer was modeled as a barrier soil layer with a default soil texture of 7, corresponding to a silty sand.

Bottom Ash Drainage Layer

Bottom ash, a CCB material, was placed on top of the compacted saprolite (unlined cells) or the geomembrane (lined cell B-1) to act as a drainage layer for leachate generated in the cells. In Cell B-1, gravel was used as the drainage layer in subcell B-1A, while bottom ash was used in subcell B-1B. However, as bottom ash is generally less permeable than gravel, bottom ash was conservatively assumed as the drainage material in the entirety of Cell B-1, including Cell B-1A. The layer was modeled as a horizontal drainage layer with a default soil texture number of 31, corresponding to coal-burning electric plant bottom ash in the HELP model. A hydraulic conductivity of 1.49 x 10^{-2} cm/s was chosen based on the value measured by D'Appolonia (1978) on bottom ash generated at the Dickerson Generating Station. The drainage slope was assumed to be the slope of the existing topography prior to construction of the unlined portions of CCB cell B. For Cell B, the slope was measured as approximately 8%. A topographic map showing the original and proposed grades of the site is shown in Figure 3. The maximum drainage length for the bottom ash layer in Cell B was assumed to be 300 ft based upon design drawings from D'Appolonia (1978). Figure 4 shows the locations of leachate collection pipes in Cell B. For Cell B-1A the drainage slope was assumed to be 5% with a drainage length of 150 feet from as-built drawings for the leachate collection system (URS 2011b).

Fly Ash

Fly ash, another CCB material, has been placed continuously in the cells since the 1980s. The fly ash layer in each of the models was represented as a vertical percolation layer with a default soil texture number of 30, corresponding to moderately compacted coal-burning electric plant fly ash. A hydraulic conductivity of 1.0 x 10^{-5} cm/s was assigned to the fly ash layer, based on values measured using a flexible wall permeameter on fly ash samples taken from the Westland site during monitoring well installation in 2015 (Geosyntec 2016). This value also agrees well with data from D'Appolonia (1978) for fly ash generated at the Dickerson Generating Station (1.6 x 10^{-5} cm/sec). The thickness of the modeled fly ash layer was dependent on the modeled location within each cell. Fly ash thicknesses were calculated by comparing topography of the site before and after CCB placement. It was assumed that the change in topography was the result of fly ash placement at the site. Fly ash thicknesses for various parts of the cell are shown in Table 1.

Protective Cover Soil

This 24-in. layer was modeled under soil cover and geomembrane cap conditions for the inactive portions of the site. This intermediate cover soil was placed on the inactive portions of the site (Cell B side slopes) once CCB placement was completed. With the recent addition of the final geomembrane cap system on the side slopes of Cell B, this protective cover soil was excavated and, following placement of the geomembrane and geocomposite drainage layers, replaced above the geomembrane. Testing by URS (2011a) indicates that this soil can be classified as a sandy silty clay, a silty gravel with sand, a sandy silt, or a silty sand with gravel depending on sampling location. URS (2011a) also indicates that hydraulic conductivity of this layer can vary from 5×10^{-7} to 5×10^{-4} cm/s depending on sampling location. For this analysis, the protective cover soil was modeled as a vertical percolation layer with a default soil texture number of 7, corresponding to a silty sand (SM) material. The material was assigned a saturated hydraulic conductivity of 1.4×10^{-4} cm/s.

Cap Geocomposite

The cap geocomposite layer was modeled as a horizontal drainage layer with default texture number of 20, corresponding to a drainage net with a saturated hydraulic conductivity of 10 cm/s. The drainage slope for the cap geocomposite was assigned based on the cap surface grades. The drainage slope was assumed to be 50% for the side slopes of Cell B. The drainage length for the cap geocomposite layer was assigned based on the measured drainage lengths for each portion of the cell (60 ft for side slopes), corresponding to slope lengths between benches.

Geomembrane

The 40-mil LDPE geomembrane used in the cap system was assigned a default texture number of 36, corresponding to LDPE. The 60-mil HDPE geomembrane used in the liner system of Cell B-1 was assigned a default texture number of 35, corresponding to HDPE. Both geosynthetics were assumed to have pinhole densities of one hole per acre with four holes per acre in installation defects, corresponding to a good placement quality.

4.4 <u>Surface Data</u>

HELP models the surface runoff using the Soil Conservation Service (SCS) curve number method. HELP uses the surface slopes, lengths, soil type, and vegetative cover to determine a runoff curve number, which is used for runoff calculations. The surface characteristics vary depending upon the cell condition. The topographic map showing existing cell conditions (Figure 2) was used to measure slopes and slope lengths. The assumed slope for each condition modeled can be found in Tables 1 and 2.

For soil cover, inactive conditions, it was assumed that runoff was possible over 100% of the surface area due to the presence of the continuous 2-ft cover soil layer on all inactive surfaces. For the active area of Cell B-1, it was assumed that runoff was possible over 50% of the surface area as the active nature of this area means that there is a higher likelihood for improper drainage. For fully capped conditions (i.e. with geomembrane cap), it was assumed that runoff was possible over 100% of the capped area.

4.5 HELP Model Analyses

In order to compare the three different scenarios (soil cover/inactive, geomembrane cap/inactive, and source removal), several models had to be prepared to represent each area shown in Figure 2. Eight different HELP analyses were modeled to represent each area under each scenario, using one of the four types of soil stratigraphy (Types I – IV) described in Section 3.3. For each model, a 1-acre area was considered. The inputs for the HELP models generated are detailed in Table 1, 2, and 3.

Table 1: HELP model inputs for Soil Cover Conditions (Pre-2016)

Capped/ Uncapped	Model Number	Area	Stratigraphy	Vegetation	Slope (%)	Slope Length (ft)	Fly Ash thickness (ft)
Soil Cover/ Inactive	1	Cell B side slopes (inactive)	Type I	Good stand of grass	50	60	42
	2	Northeast Cell B (inactive)	Type I	Good stand of grass	3	250	82
Uncapped/ Active	3	Cell B-1 (active)	Type III	Bare ground	3	250	20

Table 2: HELP model inputs for Geomembrane Cap/Inactive Conditions

Capped/ Uncapped	Model Number	Area	Stratigraphy	Vegetation	Slope (%)	Slope Length (ft)	Fly Ash thickness (ft)
Geomembrane Cap	4	Cell B side slopes (inactive)	Type II	Good stand of grass	50	60	42
Soil Cover/ Inactive	2	Northeast Cell B (inactive)	Type I	Good stand of grass	3	250	48
Uncapped/ Active	3	Cell B-1 (active)	Type III	Bare ground	3	250	20

Table 3: HELP model inputs for Source Removal Conditions

Capped/ Uncapped	Model Number	Area	Stratigraphy	Vegetation	Slope (%)	Slope Length (ft)	Fly Ash thickness (ft)
Uncapped/ Active	5	Cell B-1 (active)	Type III	Bare ground	3	250	20

The raw HELP simulation output for each model can be found in Attachment 1. For each model, daily flows for the thirty-year modeling period were calculated. To calculate the total for each condition, the output from each model was multiplied by the respective projected area (detailed in Figure 2) and then added.

5. HELP MODEL RESULTS

The output of the water balance for average daily flow are shown in Tables 4, 5, and 6 for the soil cover/inactive, geomembrane cap/inactive, and source removal scenarios respectively. Results show that average yearly rainfall at the Westland site totals 41.37 inches, corresponding to an average of 180,030 gallons per day (gpd) over Cells B and B-1. For the soil cover condition, approximately 8,460 gpd ends up as stormwater runoff, 7,529 gpd is collected as leachate, and 20,443 gpd leaks through the base of the cells to shallow groundwater. The remaining water is evapotranspired or stored in the CCB due to changing moisture content of the CCB material. Most of the leakage through the base of the facility occurs in the unlined areas of the site, while most of the leachate is collected from Cell B-1A. A more detailed accounting can be found in Table 4.

The yearly average for the geomembrane cap condition on the side slopes of Cell B shows that 7,606 gpd is collected as stormwater runoff, 42,400 gpd is collected with the cover drainage system which is also managed as stormwater, 7,506 gpd is collected as leachate, and 8,513 gpd leaks through the base of the facility to shallow groundwater. The remaining water is evapotranspired or stored in the facility. Most of the leakage occurs in the unlined, inactive portions of Cell B, while most of the collected leachate is from Cell B-1. A more detailed accounting can be found in Table 5. Figure 5 shows the drainage areas for Cell B.

The yearly average for the source removal condition shows that 2,600 gpd is collected as stormwater runoff, 7,490 is collected as leachate, and 13 gpd leaks through the base of the facility to shallow groundwater. Water at the remainder of the site (the unlined portion of Cell B) is non-contact water that either infiltrates, evapotranspires, or runs off the site as stormwater. As non-contact water, it is not considered in this analysis. A more detailed accounting can be found in Table 6.

To determine the amount of runoff to Pond 003, the drainage area was delineated. Runoff from the northern side slopes of Cell B is directed to Pond 002, while the remainder of the drainage outfalls to Big Stream on the southwest corner of the cell. Under soil cover conditions, Pond 003 receives approximately 6,200 gpd of precipitation in the Pond 003 drainage area. Pond 003 also accepts all the leachate from Cell B, adding an additional 7,529 gpd in leachate for the soil cover condition. In total, 13,729 gpd can be expected to drain to Pond 003 under soil cover conditions. Figure 5 shows the drainage areas for Cell B and Pond 003.

For the geomembrane cap condition on the side slopes of Cell B, Pond 003 receives 7,506 gpd in leachate from Cells B and B-1. Adding in the 6,200 gpd of direct precipitation, this would result in a total drainage to Pond 003 of 13,706 gpd for the capped condition.

For the source removal condition, Pond 003 is predicted to receive an average of 7,490 gpd in leachate from Cell B-1A. Adding in the 6,200 gpd of direct precipitation, this would result in a total drainage to Pond 003 of 13,690 gpd for the source removal condition.

6. REFERENCES

Schroeder, P. R., Aziz, N. M., Lloyd, C. M. and Zappi, P. A. (1994). "The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3," EPA/600/R-94/168a, September 1994, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.

Geosyntec Consultants, Inc. (2016). "Nature and Extent of Contamination Study, Status Report – Spring 2016. Westland Ash Management Facility Dickerson, MD." Geosyntec Consultants, Columbia, MD.

D'Appolonia Consulting Engineers, Inc. (1978). "Site Investigation and Design Ash Storage Area and Haul Road, Westland Tract, Dickerson Generating Station." D'Appolonia Consulting Engineers, Washington, D.C.

URS Corporation. (2011a). "Conceptual Ash Storage Facility Capping and Pond Lining Project Report." URS Corporation, Gaithersburg, MD.

URS Corporation (2011b). "Construction Certification Report, Westland Cell B-1. GenOn Westland Coal Ash Management Facility, Dickerson, MD." URS Corporation, Gaithersburg, MD.

Table 4: Average daily results from HELP analysis for Soil Cover Condition

Average Daily Totals for Each Cell – Soil Cover					
Cell	**Evapotranspiration (gpd)**	**Change in Soil Storage (gpd)**	**Runoff Stormwater (gpd)**	**Leachate Collected (gpd)**	**Discharge to Groundwater (gpd)**
B	110,800	15,200	5,860	39.2	20,430
B-1	16,830	819	2,600	7,490	13.2
Total	**127,630**	**16,019**	**8,460**	**7,529**	**20,443**

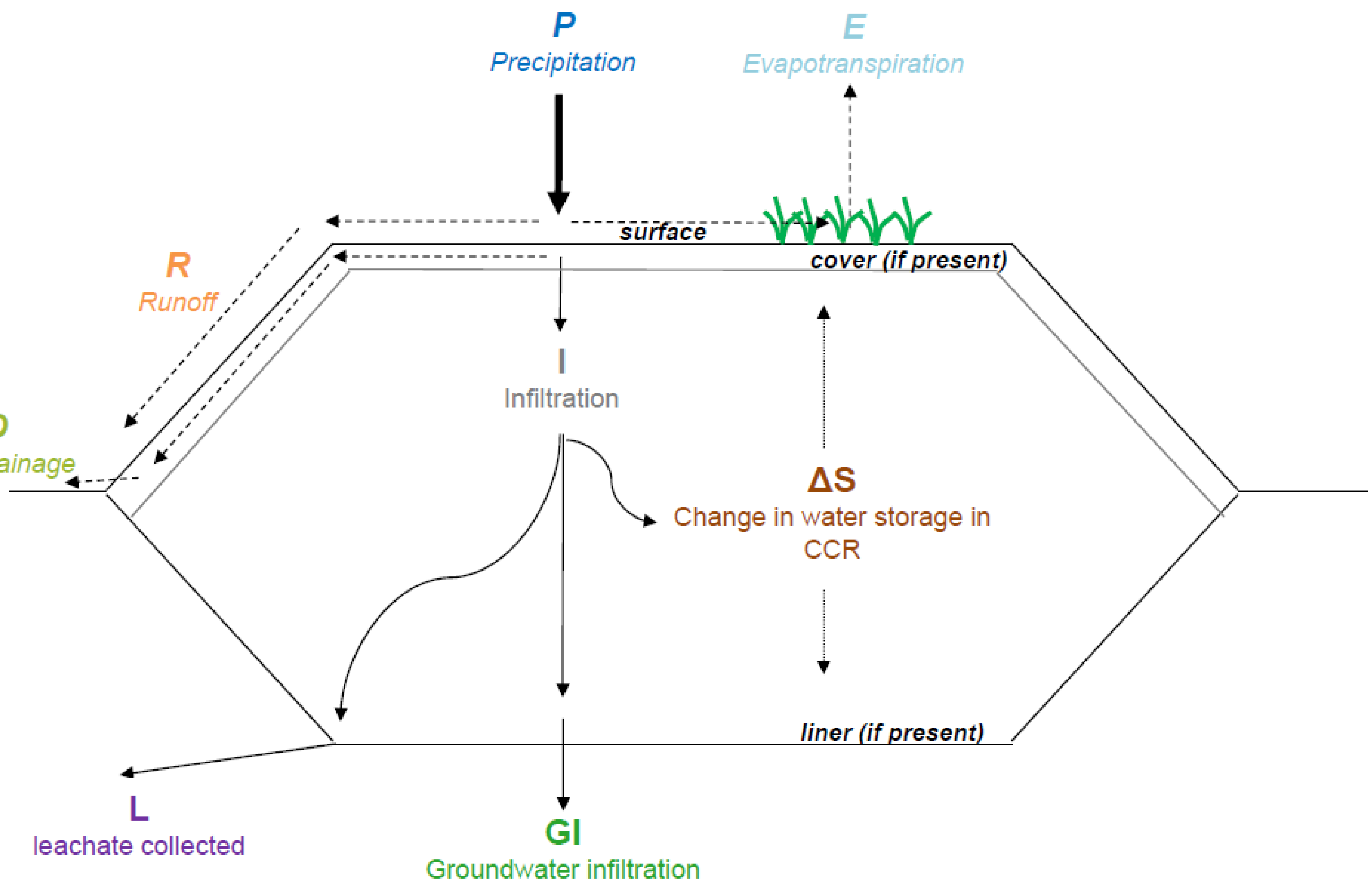
Table 5: Average daily results from HELP analysis for the Geomembrane Cap/Active Condition

Average Daily Totals for Each Cell – Geomembrane Cap						
Cell	**Evapotranspiration (gpd)**	**Change in Soil Storage (gpd)**	**Runoff Stormwater (gpd)**	**Cover Drainage Collected (gpd)**	**Leachate Collected (gpd)**	**Discharge to Groundwater (gpd)**
B	85,700	10,700	5,000	42,400	15.5	8,500
B-1	16,830	819	2,600	0	7,490	13.2
Total	**102,530**	**11,519**	**7,600**	**42,400**	**7,506**	**8,513**

Table 6: Average daily results from HELP analysis for the Source Removal Condition

Average Daily Totals for Each Cell – Source Removal						
Cell	**Evapotranspiration (gpd)**	**Change in Soil Storage (gpd)**	**Runoff Stormwater (gpd)**	**Cover Drainage Collected (gpd)**	**Leachate Collected (gpd)**	**Discharge to Groundwater (gpd)**
B	N/A	N/A	N/A	0	0	0
B-1	16,830	819	2,600	0	7,490	13.2
Total	**16,830**	**819**	**2,600**	**0**	**7,490**	**13.2**

FIGURES



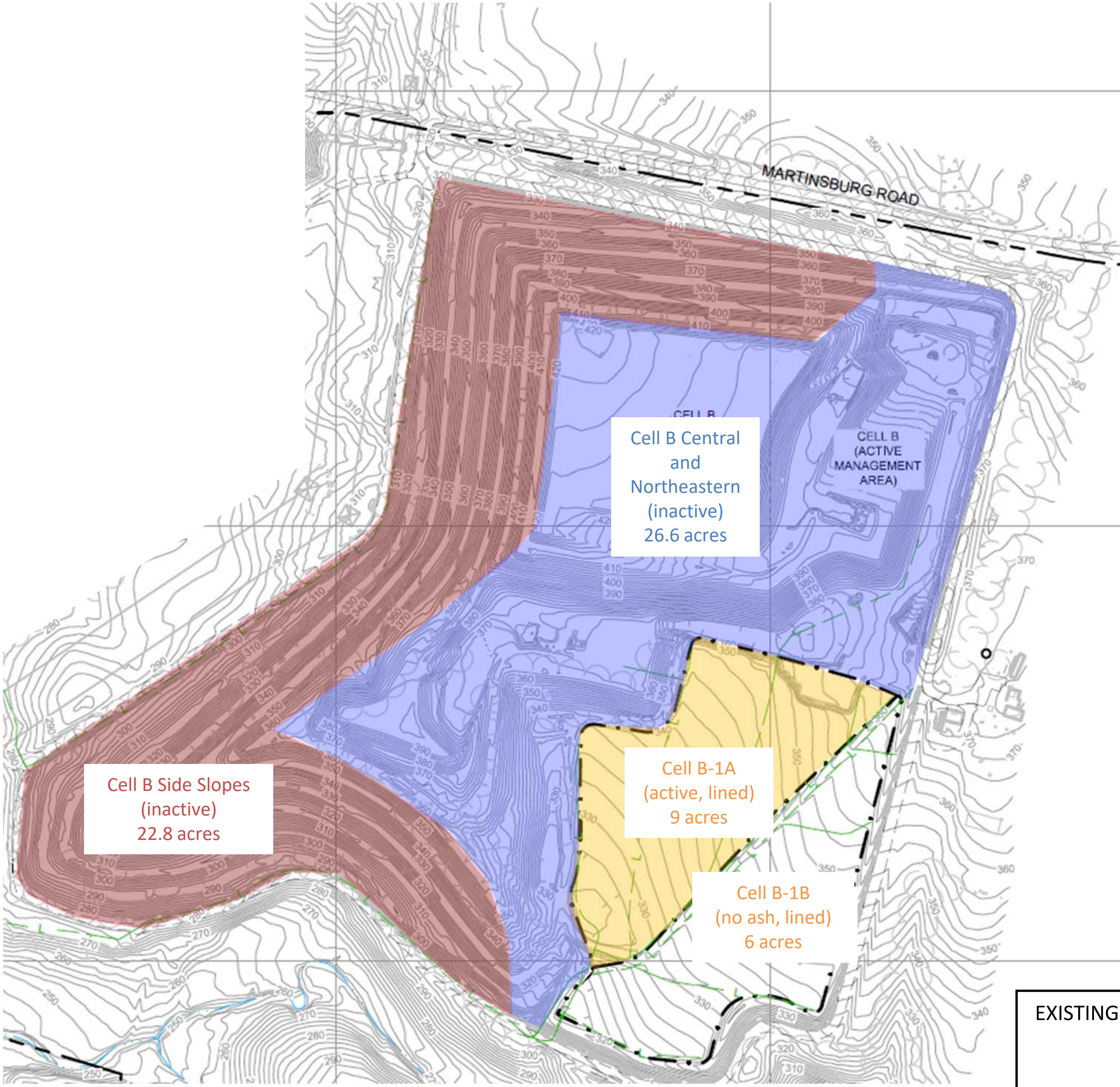
WATER BALANCE SCHEMATIC
WESTLAND ASH MANAGEMENT FACILITY

Dickerson, MD

Geosyntec consultants

Columbia, Maryland | January 2019

FIG 1



EXISTING CELL B TOPOGRAPHY WITH ACTIVE AND INACTIVE ZONES
WESTLAND ASH MANAGEMENT FACILITY

Dickerson, MD

Geosyntec consultants

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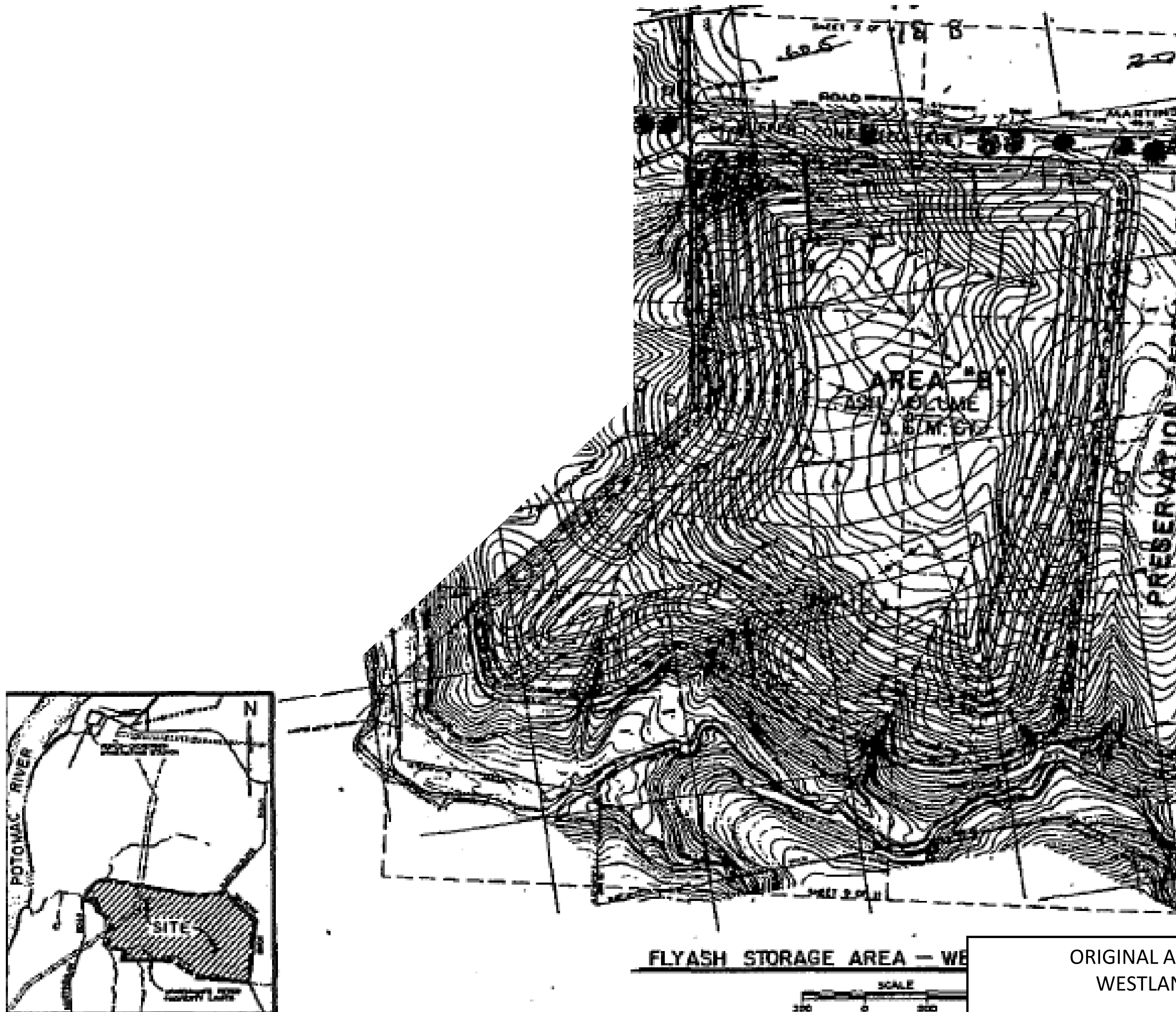
FIG 2



ORIGINAL AND PROPOSED GRADES FOR CELL B
WESTLAND ASH MANAGEMENT FACILITY

Dickerson, MD

Geosyntec consultants

FIG 3

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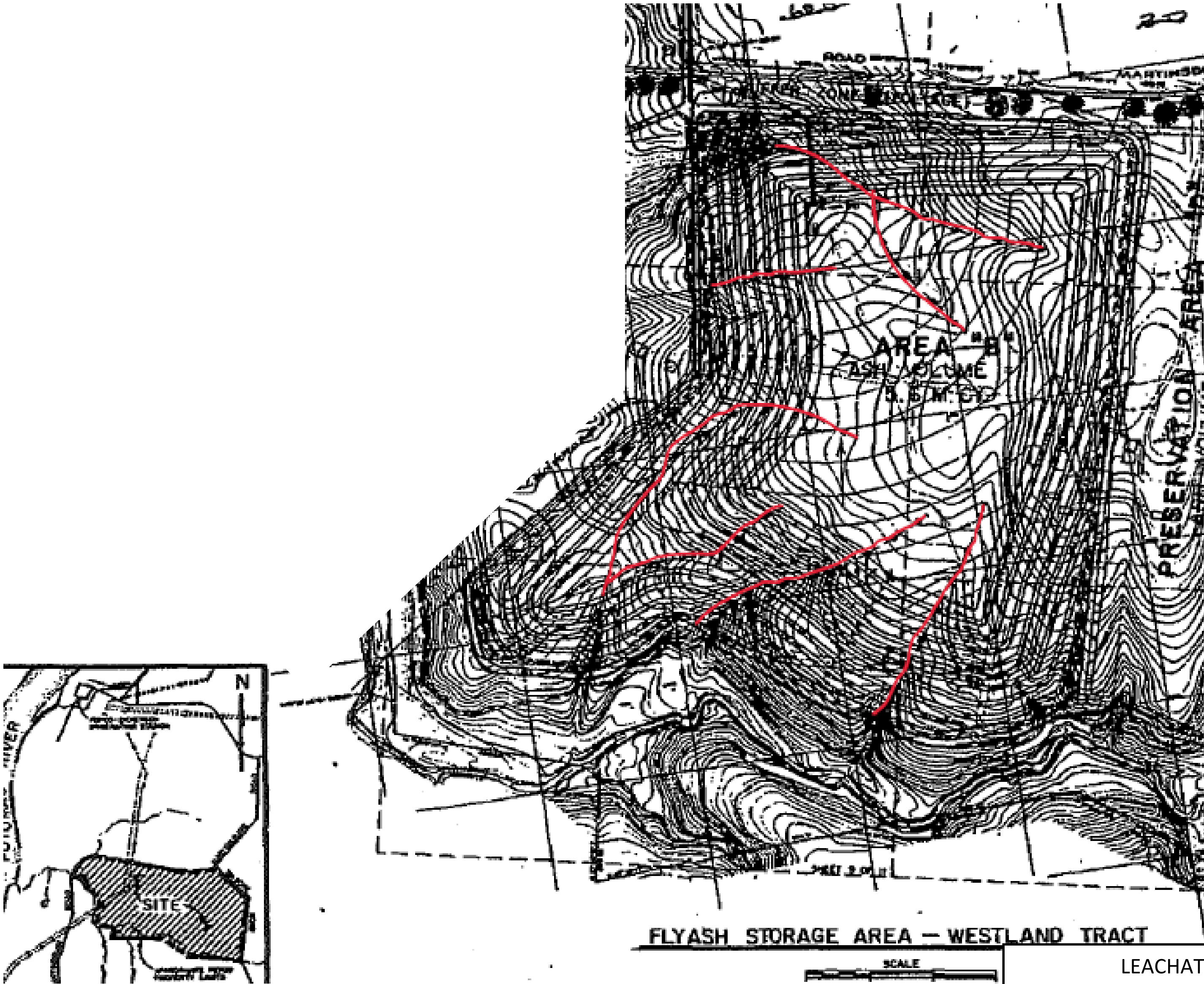
Reference:
D'Appolonia Consulting Engineers, Inc. Figure 7 - "Site Investigation and Design Ash Storage and Haul Road, Westland Tract, Dickerson Generating Station." Washington, D.C., 1978



Reference:
D'Appolonia Consulting Engineers, Inc. Figure 7 - "Site Investigation and Design Ash Storage and Haul Road, Westland Tract, Dickerson Generating Station." Washington, D.C., 1978

LEACHATE COLLECTION SYSTEM FOR CELL B
WESTLAND ASH MANAGEMENT FACILITY

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FIG 4

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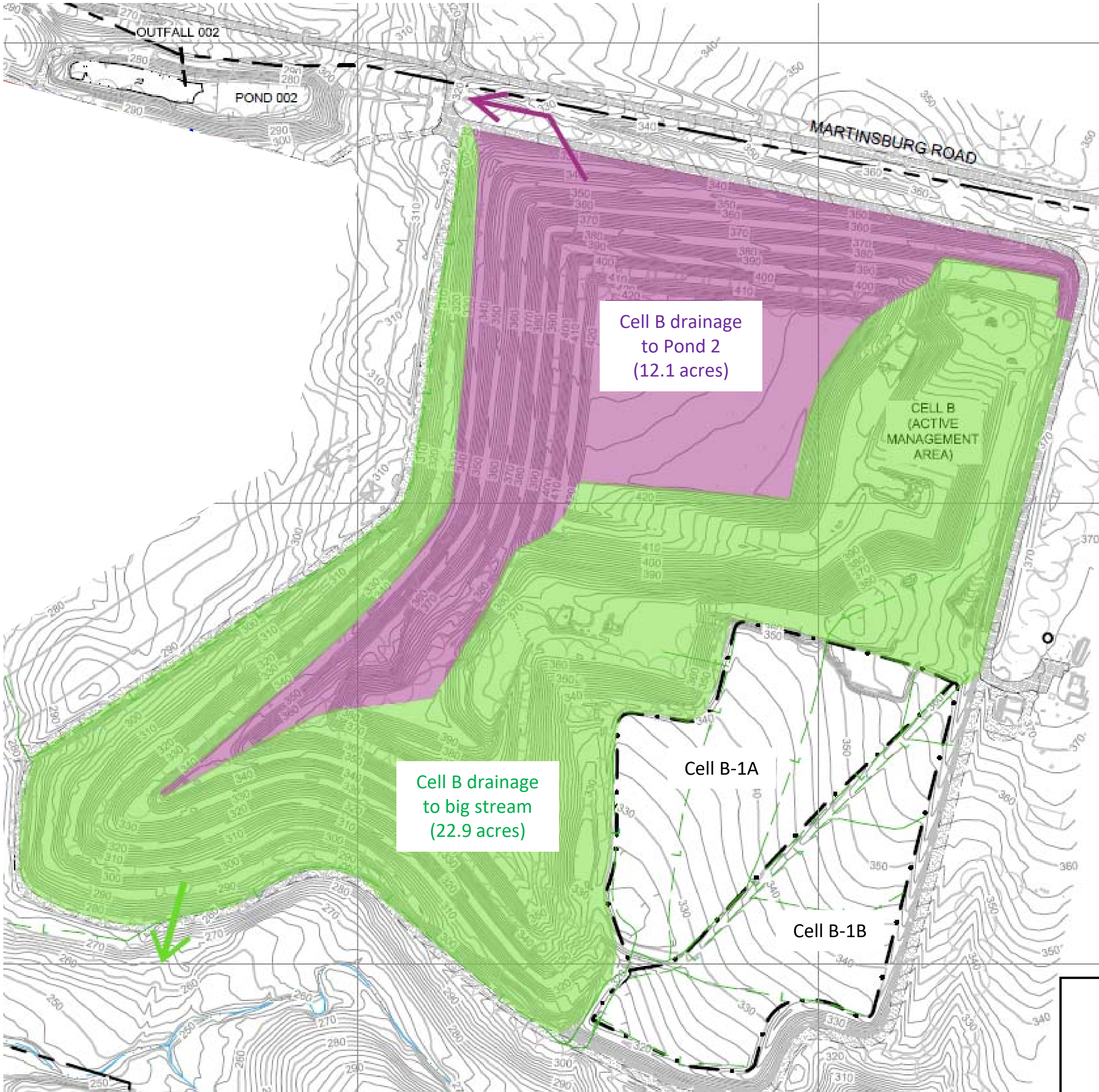

DRAINAGE AREAS FOR CELL B
WESTLAND ASH MANAGEMENT FACILITY

Dickerson, MD

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FIG

5

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ATTACHMENT 1

HELP MODEL OUTPUT

Attachment 1a

Cell B side slopes (inactive, uncovered)

```
****************************************************************************
****************************************************************************
**                                                                        **
**                                                                        **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE             **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)              **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                 **
**                    USAE WATERWAYS EXPERIMENT STATION                   **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY            **
**                                                                        **
**                                                                        **
****************************************************************************
****************************************************************************


PRECIPITATION DATA FILE:    C:\HELP3\BALT_P.D4
TEMPERATURE DATA FILE:      C:\HELP3\BALT_T.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\BALT_SR.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\BALT_ET.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\WBUC50.D10
OUTPUT DATA FILE:           C:\HELP3\WBUC50.OUT


TIME:  12: 5     DATE:  11/21/2016


****************************************************************************

     TITLE:  WESTLAND CELL B UNCOVERED UNLINED 50% SLOPE

****************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.4730 VOL/VOL
FIELD CAPACITY               =      0.2220 VOL/VOL
WILTING POINT                =      0.1040 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3104 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.140000004000E-03 CM/SEC


                        LAYER  2
                        --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    504.00   INCHES
POROSITY                     =      0.5410 VOL/VOL
FIELD CAPACITY               =      0.1870 VOL/VOL
WILTING POINT                =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2068 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-05 CM/SEC


                        LAYER  3
                        --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.5780 VOL/VOL
FIELD CAPACITY               =      0.0760 VOL/VOL
WILTING POINT                =      0.0250 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0764 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.148999998000E-01 CM/SEC
SLOPE                        =      8.00   PERCENT
DRAINAGE LENGTH              =    300.0    FEET


                        LAYER  4
                        --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER   0
```

```
THICKNESS                    =     36.00   INCHES
POROSITY                     =      0.4730 VOL/VOL
FIELD CAPACITY               =      0.2220 VOL/VOL
WILTING POINT                =      0.1040 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.4730 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.537999995000E-05 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

```
NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A
         GOOD STAND OF GRASS, A SURFACE SLOPE OF 50.%
         AND A SLOPE LENGTH OF   60. FEET.

SCS RUNOFF CURVE NUMBER             =     73.00
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =     21.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      6.430  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      9.933  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.184  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =    130.552  INCHES
TOTAL INITIAL WATER                 =    130.552  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

```
NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         BALTIMORE             MARYLAND

    STATION LATITUDE                         =  39.18 DEGREES
    MAXIMUM LEAF AREA INDEX                  =   3.50
    START OF GROWING SEASON (JULIAN DATE)    =    102
    END OF GROWING SEASON (JULIAN DATE)      =    300
    EVAPORATIVE ZONE DEPTH                   =  21.0  INCHES
    AVERAGE ANNUAL WIND SPEED                =   9.30 MPH
    AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  62.00 %
    AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  65.00 %
```

AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 71.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 68.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BALTIMORE MARYLAND

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.00	2.98	3.72	3.35	3.44	3.76
3.89	4.62	3.46	3.11	3.11	3.40

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BALTIMORE MARYLAND

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
32.70	34.70	43.30	54.00	63.40	72.20
76.80	75.60	68.90	56.90	46.30	36.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BALTIMORE MARYLAND
AND STATION LATITUDE = 39.18 DEGREES

HEAD #1: AVERAGE HEAD ON TOP OF LAYER 4
DRAIN #1: LATERAL DRAINAGE FROM LAYER 3 (RECIRCULATION AND COLLECTION)
LEAK #1: PERCOLATION OR LEAKAGE THROUGH LAYER 4

****

DAILY OUTPUT FOR YEAR 1

S

344		0.65	0.000	0.046	0.3375	0.0077	.5762E-04	.3073E-01
345	*	0.00	0.000	0.013	0.3365	0.0076	.5833E-04	.3123E-01
346		0.47	0.000	0.045	0.3516	0.0075	.5641E-04	.3060E-01
347		0.01	0.000	0.024	0.3393	0.0076	.5595E-04	.3030E-01
348		0.00	0.000	0.018	0.3316	0.0079	.6004E-04	.3127E-01
349		0.67	0.000	0.049	0.3509	0.0080	.6224E-04	.3185E-01
350		0.03	0.000	0.043	0.3436	0.0077	.5783E-04	.3073E-01
351		0.00	0.000	0.024	0.3328	0.0075	.5503E-04	.3000E-01
352		0.66	0.000	0.053	0.3510	0.0074	.5335E-04	.2956E-01
353		0.30	0.000	0.051	0.3566	0.0073	.5248E-04	.2932E-01
354		0.00	0.000	0.028	0.3433	0.0073	.5217E-04	.2925E-01
355		0.00	0.000	0.024	0.3294	0.0073	.5227E-04	.2928E-01
356		0.00	0.000	0.024	0.3191	0.0073	.5265E-04	.2939E-01
357		0.19	0.000	0.052	0.3191	0.0074	.5323E-04	.2955E-01
358		0.00	0.000	0.023	0.3125	0.0074	.5041E-04	.2781E-01
359		0.28	0.000	0.048	0.3200	0.0048	.2740E-04	.1937E-01
360		0.00	0.000	0.024	0.3143	0.0039	.2124E-04	.2034E-01
361		0.00	0.000	0.025	0.3102	0.0078	.5912E-04	.3109E-01
362		0.00	0.000	0.022	0.3053	0.0096	.9312E-04	.3949E-01
363	*	0.00	0.000	0.019	0.3026	0.0111	.1225E-03	.4502E-01
364		0.08	0.000	0.045	0.3036	0.0118	.1369E-03	.4744E-01
365		0.00	0.000	0.020	0.3010	0.0120	.1403E-03	.4792E-01

****

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.50	3.30	3.36	3.35	3.77	3.77
	3.77	5.57	3.38	2.65	2.96	3.00
STD. DEVIATIONS	1.25	1.51	1.27	1.69	1.70	2.29
	1.76	2.71	2.41	1.41	1.46	1.56
RUNOFF						
TOTALS	0.208	0.683	0.317	0.002	0.022	0.032
	0.093	0.093	0.077	0.030	0.012	0.131
STD. DEVIATIONS	0.464	0.937	0.807	0.008	0.118	0.082

```
                         0.327    0.243    0.167    0.087    0.034    0.549

  EVAPOTRANSPIRATION
  ------------------
    TOTALS               1.022    0.985    2.189    2.708    4.234    4.980
                         3.902    4.072    2.813    1.149    1.088    0.935

    STD. DEVIATIONS      0.292    0.374    0.416    0.771    0.607    1.583
                         1.816    1.516    0.810    0.257    0.258    0.190

  LATERAL DRAINAGE COLLECTED FROM LAYER  3
  ----------------------------------------
    TOTALS               0.0012   0.0007   0.0008   0.0004   0.0005   0.0010
                         0.0013   0.0016   0.0018   0.0017   0.0015   0.0016

    STD. DEVIATIONS      0.0013   0.0009   0.0010   0.0007   0.0009   0.0014
                         0.0015   0.0017   0.0016   0.0014   0.0012   0.0011

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  ------------------------------------
    TOTALS               0.6020   0.4205   0.4796   0.3469   0.3096   0.4978
                         0.6043   0.6984   0.7977   0.7851   0.7064   0.7716

    STD. DEVIATIONS      0.4455   0.3368   0.3722   0.2713   0.3346   0.4626
                         0.5345   0.5594   0.5125   0.4966   0.4502   0.4297


-------------------------------------------------------------------------------
             AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES             0.0048   0.0037   0.0038   0.0028   0.0024   0.0041
                         0.0048   0.0056   0.0066   0.0063   0.0058   0.0061

    STD. DEVIATIONS      0.0036   0.0029   0.0030   0.0022   0.0026   0.0038
                         0.0043   0.0045   0.0042   0.0039   0.0037   0.0034

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
```

	WBUC50 INCHES		CU. FEET	PERCENT
PRECIPITATION	41.37	(6.611)	150156.2	100.00
RUNOFF	1.701	(1.3551)	6175.89	4.113
EVAPOTRANSPIRATION	30.076	(3.9779)	109174.19	72.707
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.01399	(0.01103)	50.779	0.03382
PERCOLATION/LEAKAGE THROUGH LAYER 4	7.01994	(4.21034)	25482.375	16.97058
AVERAGE HEAD ON TOP OF LAYER 4	0.005	(0.003)		
CHANGE IN WATER STORAGE	2.555	(5.8194)	9272.93	6.176

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.68	20618.398
RUNOFF	2.118	7688.1782
DRAINAGE COLLECTED FROM LAYER 3	0.00039	1.41031
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.092363	335.27768
AVERAGE HEAD ON TOP OF LAYER 4	0.020	
MAXIMUM HEAD ON TOP OF LAYER 4	0.026	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	76.8 FEET	
SNOW WATER	3.90	14161.6172

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4020

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1040

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	7.2346	0.3014
2	179.9870	0.3571
3	2.9386	0.1224
4	17.0280	0.4730
SNOW WATER	0.000	

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Attachment 1b

Cell B crest (inactive, uncovered)

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******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\HELP3\BALT_P.D4
TEMPERATURE DATA FILE:      C:\HELP3\BALT_T.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\BALT_SR.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\BALT_ET.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\WBUC3C.D10
OUTPUT DATA FILE:           C:\HELP3\WBUC3C.OUT


TIME:  12: 5     DATE:  11/21/2016


******************************************************************************

     TITLE:  WESTLAND CELL B UNCOVERED UNLINED 3% SLOPE INACTIVE

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.4730 VOL/VOL
FIELD CAPACITY              =      0.2220 VOL/VOL
WILTING POINT               =      0.1040 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3099 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.140000004000E-03 CM/SEC


                         LAYER  2
                         --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    984.00   INCHES
POROSITY                    =      0.5410 VOL/VOL
FIELD CAPACITY              =      0.1870 VOL/VOL
WILTING POINT               =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1973 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC


                         LAYER  3
                         --------

              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.5780 VOL/VOL
FIELD CAPACITY              =      0.0760 VOL/VOL
WILTING POINT               =      0.0250 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0764 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.148999998000E-01 CM/SEC
SLOPE                       =      8.00   PERCENT
DRAINAGE LENGTH             =    300.0    FEET


                         LAYER  4
                         --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER   0
```

```
THICKNESS                    =     36.00   INCHES
POROSITY                     =      0.4730 VOL/VOL
FIELD CAPACITY               =      0.2220 VOL/VOL
WILTING POINT                =      0.1040 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.4730 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.537999995000E-05 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A GOOD STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 250. FEET.

```
SCS RUNOFF CURVE NUMBER              =     67.60
FRACTION OF AREA ALLOWING RUNOFF     =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
EVAPORATIVE ZONE DEPTH               =     21.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =      6.417  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      9.933  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      2.184  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =    220.435  INCHES
TOTAL INITIAL WATER                  =    220.435  INCHES
TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
BALTIMORE   MARYLAND

```
STATION LATITUDE                           =  39.18 DEGREES
MAXIMUM LEAF AREA INDEX                    =   3.50
START OF GROWING SEASON (JULIAN DATE)      =    102
END OF GROWING SEASON (JULIAN DATE)        =    300
EVAPORATIVE ZONE DEPTH                     =  21.0  INCHES
AVERAGE ANNUAL WIND SPEED                  =   9.30 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY      =  62.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY      =  65.00 %
```

AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 71.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 68.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BALTIMORE MARYLAND

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.00	2.98	3.72	3.35	3.44	3.76
3.89	4.62	3.46	3.11	3.11	3.40

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BALTIMORE MARYLAND

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
32.70	34.70	43.30	54.00	63.40	72.20
76.80	75.60	68.90	56.90	46.30	36.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BALTIMORE MARYLAND
AND STATION LATITUDE = 39.18 DEGREES

HEAD #1: AVERAGE HEAD ON TOP OF LAYER 4
DRAIN #1: LATERAL DRAINAGE FROM LAYER 3 (RECIRCULATION AND COLLECTION)
LEAK #1: PERCOLATION OR LEAKAGE THROUGH LAYER 4

****

DAILY OUTPUT FOR YEAR 1

S

344		0.65	0.000	0.046	0.3375	0.0089	.7739E-04	.3562E-01
345	*	0.00	0.000	0.013	0.3365	0.0089	.7820E-04	.3611E-01
346		0.47	0.000	0.045	0.3516	0.0088	.7588E-04	.3545E-01
347		0.01	0.000	0.024	0.3393	0.0088	.7552E-04	.3520E-01
348		0.00	0.000	0.018	0.3316	0.0091	.8026E-04	.3616E-01
349		0.67	0.000	0.049	0.3509	0.0092	.8247E-04	.3667E-01
350		0.03	0.000	0.043	0.3436	0.0089	.7709E-04	.3549E-01
351		0.00	0.000	0.024	0.3328	0.0087	.7394E-04	.3478E-01
352		0.66	0.000	0.053	0.3510	0.0086	.7228E-04	.3440E-01
353		0.30	0.000	0.051	0.3566	0.0086	.7163E-04	.3426E-01
354		0.00	0.000	0.028	0.3433	0.0086	.7169E-04	.3428E-01
355		0.00	0.000	0.024	0.3294	0.0086	.7221E-04	.3441E-01
356		0.00	0.000	0.024	0.3191	0.0086	.7304E-04	.3462E-01
357		0.19	0.000	0.052	0.3191	0.0087	.7406E-04	.3486E-01
358		0.00	0.000	0.023	0.3125	0.0088	.7090E-04	.3312E-01
359		0.28	0.000	0.048	0.3200	0.0067	.4430E-04	.2853E-01
360		0.00	0.000	0.024	0.3143	0.0032	.2767E-04	.2271E-01
361		0.00	0.000	0.025	0.3102	0.0099	.9365E-04	.3865E-01
362		0.00	0.000	0.022	0.3053	0.0117	.1372E-03	.4790E-01
363	*	0.00	0.000	0.019	0.3026	0.0133	.1758E-03	.5387E-01
364		0.08	0.000	0.045	0.3036	0.0139	.1900E-03	.5581E-01
365		0.00	0.000	0.020	0.3010	0.0139	.1884E-03	.5548E-01

****

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.50	3.30	3.36	3.35	3.77	3.77
	3.77	5.57	3.38	2.65	2.96	3.00
STD. DEVIATIONS	1.25	1.51	1.27	1.69	1.70	2.29
	1.76	2.71	2.41	1.41	1.46	1.56
RUNOFF						
TOTALS	0.197	0.678	0.298	0.000	0.015	0.014
	0.062	0.069	0.037	0.010	0.003	0.115
STD. DEVIATIONS	0.466	0.941	0.808	0.000	0.080	0.046

```
                          0.233    0.219    0.093    0.030    0.013    0.545

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                1.023    0.985    2.184    2.714    4.233    4.982
                          3.905    4.076    2.819    1.149    1.091    0.936

    STD. DEVIATIONS       0.293    0.375    0.420    0.767    0.608    1.585
                          1.810    1.519    0.807    0.259    0.259    0.191

  LATERAL DRAINAGE COLLECTED FROM LAYER  3
  ----------------------------------------
    TOTALS                0.0008   0.0004   0.0004   0.0003   0.0002   0.0005
                          0.0005   0.0008   0.0010   0.0010   0.0009   0.0009

    STD. DEVIATIONS       0.0012   0.0008   0.0007   0.0004   0.0004   0.0011
                          0.0010   0.0013   0.0013   0.0014   0.0012   0.0012

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  ------------------------------------
    TOTALS                0.4127   0.2699   0.2899   0.2348   0.2110   0.2944
                          0.3074   0.3913   0.4518   0.4976   0.4390   0.4892

    STD. DEVIATIONS       0.4537   0.3133   0.3077   0.2313   0.2377   0.4170
                          0.4192   0.5074   0.5142   0.5263   0.4874   0.4849


-------------------------------------------------------------------------------
             AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES              0.0033   0.0024   0.0023   0.0019   0.0017   0.0024
                          0.0024   0.0031   0.0037   0.0040   0.0036   0.0039

    STD. DEVIATIONS       0.0036   0.0028   0.0025   0.0018   0.0019   0.0034
                          0.0033   0.0040   0.0043   0.0042   0.0040   0.0038

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
```

WBUC3C

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.37 (6.611)	150156.2	100.00
RUNOFF	1.496 (1.3018)	5431.91	3.618
EVAPOTRANSPIRATION	30.096 (3.9813)	109249.79	72.757
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.00780 (0.01015)	28.298	0.01885
PERCOLATION/LEAKAGE THROUGH LAYER 4	4.28895 (4.30861)	15568.897	10.36847
AVERAGE HEAD ON TOP OF LAYER 4	0.003 (0.003)		
CHANGE IN WATER STORAGE	5.476 (5.9128)	19877.27	13.238

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.68	20618.398
RUNOFF	2.118	7688.0527
DRAINAGE COLLECTED FROM LAYER 3	0.00045	1.62742
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.083412	302.78391
AVERAGE HEAD ON TOP OF LAYER 4	0.022	
MAXIMUM HEAD ON TOP OF LAYER 4	0.039	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	8.2 FEET	
SNOW WATER	3.90	14161.6172

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4061

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1040

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	7.2346	0.3014
2	357.4755	0.3633
3	2.9713	0.1238
4	17.0280	0.4730
SNOW WATER	0.000	

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Attachment 1c

Cell B-1 (active, lined, uncovered)

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******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\HELP3\BALT_P.D4
TEMPERATURE DATA FILE:      C:\HELP3\BALT_T.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\BALT_SR.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\BALT_ETA.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\WBUCL5.D10
OUTPUT DATA FILE:           C:\HELP3\WBUCL5.OUT


TIME:  12: 6     DATE:  11/21/2016


******************************************************************************

     TITLE:  WESTLAND CELL B UNCOVERED LINED 3% SLOPE

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
```

MATERIAL TEXTURE NUMBER 0

```
THICKNESS                  =      6.00   INCHES
POROSITY                   =      0.4730 VOL/VOL
FIELD CAPACITY             =      0.2220 VOL/VOL
WILTING POINT              =      0.1040 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.2511 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.140000004000E-03 CM/SEC
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

```
THICKNESS                  =    240.00   INCHES
POROSITY                   =      0.5410 VOL/VOL
FIELD CAPACITY             =      0.1870 VOL/VOL
WILTING POINT              =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.2355 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.999999975000E-05 CM/SEC
```

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

```
THICKNESS                  =     18.00   INCHES
POROSITY                   =      0.5780 VOL/VOL
FIELD CAPACITY             =      0.0760 VOL/VOL
WILTING POINT              =      0.0250 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.0762 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.148999998000E-01 CM/SEC
SLOPE                      =      5.00   PERCENT
DRAINAGE LENGTH            =    150.0    FEET
```

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

```
THICKNESS                    =     0.06   INCHES
POROSITY                     =     0.0000 VOL/VOL
FIELD CAPACITY               =     0.0000 VOL/VOL
WILTING POINT                =     0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =     1.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =     4.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD
```

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

```
THICKNESS                    =    36.00   INCHES
POROSITY                     =     0.4730 VOL/VOL
FIELD CAPACITY               =     0.2220 VOL/VOL
WILTING POINT                =     0.1040 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.4730 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.537999995000E-05 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 250. FEET.

```
SCS RUNOFF CURVE NUMBER            =    88.50
FRACTION OF AREA ALLOWING RUNOFF   =    50.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     1.000  ACRES
EVAPORATIVE ZONE DEPTH             =     9.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =     2.776  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =     4.461  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =     0.765  INCHES
INITIAL SNOW WATER                 =     0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =    76.421  INCHES
TOTAL INITIAL WATER                =    76.421  INCHES
TOTAL SUBSURFACE INFLOW            =     0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
BALTIMORE MARYLAND

STATION LATITUDE	=	39.18 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	102
END OF GROWING SEASON (JULIAN DATE)	=	300
EVAPORATIVE ZONE DEPTH	=	9.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	9.30 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	62.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	65.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	68.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BALTIMORE MARYLAND

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.00	2.98	3.72	3.35	3.44	3.76
3.89	4.62	3.46	3.11	3.11	3.40

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BALTIMORE MARYLAND

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
32.70	34.70	43.30	54.00	63.40	72.20
76.80	75.60	68.90	56.90	46.30	36.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING

WBUCL5

COEFFICIENTS FOR BALTIMORE MARYLAND
AND STATION LATITUDE = 39.18 DEGREES

HEAD #1: AVERAGE HEAD ON TOP OF LAYER 4
DRAIN #1: LATERAL DRAINAGE FROM LAYER 3 (RECIRCULATION AND COLLECTION)
LEAK #1: PERCOLATION OR LEAKAGE THROUGH LAYER 5

****

DAILY OUTPUT FOR YEAR 1

DAY	AIR	SOIL	RAIN IN.	RUNOFF IN.	ET IN.	E. ZONE WATER IN./IN.	HEAD #1 IN.	DRAIN #1 IN.	LEAK #1 IN.
1			0.00	0.000	0.052	0.2931	0.0057	.1609E-03	.4896E-06
2	*		0.00	0.000	0.048	0.2807	0.0055	.1549E-03	.4732E-06
3	*		0.00	0.000	0.048	0.2704	0.0052	.1464E-03	.4501E-06
4	*		0.00	0.000	0.041	0.2618	0.0049	.1383E-03	.4281E-06
5	*		0.00	0.000	0.049	0.2529	0.0047	.1307E-03	.4072E-06
6			0.00	0.000	0.062	0.2428	0.0044	.1235E-03	.3873E-06
7			0.00	0.000	0.052	0.2345	0.0042	.1167E-03	.3685E-06
8			0.00	0.000	0.054	0.2262	0.0039	.1103E-03	.3505E-06
9			0.00	0.000	0.041	0.2195	0.0037	.1043E-03	.3335E-06
10	*		0.00	0.000	0.035	0.2137	0.0035	.9853E-04	.3173E-06
11			0.00	0.000	0.031	0.2085	0.0033	.9311E-04	.3019E-06
12	*		0.00	0.000	0.028	0.2038	0.0031	.8800E-04	.2872E-06
13	*		0.00	0.000	0.025	0.1993	0.0030	.8316E-04	.2733E-06
14	*		0.13	0.000	0.035	0.1998	0.0028	.7859E-04	.2601E-06
15	*		0.02	0.000	0.030	0.2005	0.0026	.7427E-04	.2475E-06
16	*		0.00	0.000	0.040	0.1998	0.0025	.7019E-04	.2356E-06
17	*		0.00	0.000	0.024	0.1960	0.0024	.6633E-04	.2242E-06
18			0.00	0.000	0.022	0.1924	0.0022	.6268E-04	.2135E-06
19			0.00	0.000	0.021	0.1889	0.0021	.5924E-04	.2032E-06
20			0.02	0.000	0.021	0.1879	0.0020	.5598E-04	.1935E-06
21			0.00	0.000	0.019	0.1848	0.0019	.5290E-04	.1842E-06
22			0.00	0.000	0.018	0.1819	0.0018	.4999E-04	.1754E-06
23			0.41	0.000	0.019	0.2245	0.0017	.4725E-04	.1670E-06
24			0.40	0.000	0.085	0.2589	0.0016	.4465E-04	.1591E-06
25			0.18	0.000	0.072	0.2702	0.0015	.4219E-04	.1515E-06

326		0.01	0.000	0.060	0.2763	1.6355	.4594E-01	.7890E-04
327		0.00	0.000	0.062	0.2658	1.6352	.4593E-01	.7888E-04
328		0.00	0.000	0.061	0.2559	1.6389	.4603E-01	.7904E-04
329		0.00	0.000	0.048	0.2476	1.6458	.4622E-01	.7934E-04
330		0.00	0.000	0.061	0.2386	1.6577	.4656E-01	.7986E-04
331		0.00	0.000	0.067	0.2289	1.6761	.4708E-01	.8066E-04
332		0.00	0.000	0.054	0.2209	1.6952	.4761E-01	.8150E-04
333		0.00	0.000	0.041	0.2143	1.7139	.4814E-01	.8231E-04
334	*	0.00	0.000	0.035	0.2087	1.7322	.4865E-01	.8310E-04
335	*	0.41	0.000	0.031	0.2091	1.7510	.4918E-01	.8392E-04
336	*	0.00	0.000	0.031	0.2095	1.7647	.4956E-01	.8451E-04
337		0.00	0.000	0.012	0.2408	1.7763	.4989E-01	.8502E-04
338		0.09	0.000	0.058	0.2429	1.7871	.5019E-01	.8548E-04
339		0.00	0.000	0.063	0.2345	1.7961	.5045E-01	.8587E-04
340	*	0.00	0.000	0.041	0.2285	1.8019	.5061E-01	.8612E-04
341		0.19	0.000	0.048	0.2430	1.8054	.5071E-01	.8628E-04
342		0.00	0.000	0.061	0.2351	1.8077	.5077E-01	.8637E-04
343		0.63	0.003	0.045	0.2987	1.8077	.5077E-01	.8638E-04
344		0.65	0.027	0.045	0.3616	1.8040	.5067E-01	.8622E-04
345	*	0.00	0.000	0.041	0.3570	1.8029	.5064E-01	.8617E-04
346		0.47	0.003	0.045	0.3936	1.7931	.5036E-01	.8575E-04
347		0.01	0.000	0.051	0.3644	1.7691	.4969E-01	.8471E-04
348		0.00	0.000	0.054	0.3378	1.7366	.4878E-01	.8330E-04
349		0.67	0.015	0.051	0.3927	1.7116	.4807E-01	.8221E-04
350		0.03	0.000	0.068	0.3665	1.7109	.4805E-01	.8218E-04
351		0.00	0.000	0.066	0.3338	1.6965	.4765E-01	.8155E-04
352		0.66	0.013	0.064	0.3859	1.6923	.4753E-01	.8137E-04
353		0.30	0.001	0.058	0.3923	1.7274	.4852E-01	.8290E-04
354		0.00	0.000	0.071	0.3518	1.7161	.4820E-01	.8240E-04
355		0.00	0.000	0.062	0.3297	1.7298	.4858E-01	.8300E-04
356		0.00	0.000	0.059	0.3150	1.7899	.5027E-01	.8561E-04
357		0.19	0.000	0.060	0.3218	1.8300	.5140E-01	.8734E-04
358		0.00	0.000	0.055	0.3096	1.8542	.5208E-01	.8839E-04
359		0.28	0.000	0.050	0.3306	1.8657	.5240E-01	.8888E-04
360		0.00	0.000	0.054	0.3209	1.8670	.5244E-01	.8894E-04
361		0.00	0.000	0.055	0.3098	1.8600	.5224E-01	.8864E-04
362		0.00	0.000	0.048	0.3013	1.8463	.5186E-01	.8805E-04
363	*	0.00	0.000	0.041	0.2955	1.8273	.5132E-01	.8722E-04
364		0.08	0.000	0.046	0.2976	1.8039	.5067E-01	.8621E-04
365		0.00	0.000	0.043	0.2905	1.7770	.4991E-01	.8505E-04

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.50	3.30	3.36	3.35	3.77	3.77
	3.77	5.57	3.38	2.65	2.96	3.00
STD. DEVIATIONS	1.25	1.51	1.27	1.69	1.70	2.29
	1.76	2.71	2.41	1.41	1.46	1.56
RUNOFF						
TOTALS	0.292	0.707	0.442	0.077	0.148	0.281
	0.374	0.598	0.445	0.185	0.118	0.208
STD. DEVIATIONS	0.440	0.836	0.750	0.119	0.323	0.415
	0.677	0.751	0.630	0.333	0.154	0.504
EVAPOTRANSPIRATION						
TOTALS	1.162	1.059	2.315	2.669	2.993	2.726
	2.646	3.101	2.024	1.588	1.639	1.168
STD. DEVIATIONS	0.406	0.430	0.466	0.847	0.834	1.110
	0.842	1.105	0.812	0.638	0.395	0.254
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.9369	0.8227	0.9553	0.7419	0.9276	1.0952
	1.0754	0.9901	0.8408	0.7904	0.9477	1.0362
STD. DEVIATIONS	0.4896	0.4413	0.4617	0.3989	0.5038	0.5450
	0.5114	0.4509	0.3544	0.3420	0.5102	0.5316
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	0.0016	0.0015	0.0017	0.0013	0.0016	0.0019
	0.0019	0.0017	0.0015	0.0014	0.0017	0.0018
STD. DEVIATIONS	0.0008	0.0007	0.0008	0.0007	0.0008	0.0009
	0.0008	0.0007	0.0006	0.0006	0.0008	0.0009

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	1.0760	1.0376	1.0972	0.8805	1.0653	1.2997
	1.2351	1.1371	0.9978	0.9078	1.1248	1.1901
STD. DEVIATIONS	0.5623	0.5568	0.5302	0.4734	0.5786	0.6468
	0.5873	0.5179	0.4206	0.3928	0.6055	0.6105

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.37 (6.611)	150156.2	100.00
RUNOFF	3.873 (1.9603)	14060.14	9.364
EVAPOTRANSPIRATION	25.089 (3.0701)	91072.80	60.652
LATERAL DRAINAGE COLLECTED FROM LAYER 3	11.16026 (4.14830)	40511.746	26.97974
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.01964 (0.00699)	71.284	0.04747
AVERAGE HEAD ON TOP OF LAYER 4	1.087 (0.404)		
CHANGE IN WATER STORAGE	1.223 (4.9519)	4440.23	2.957

****

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)

PRECIPITATION	5.68	20618.398
RUNOFF	2.793	10140.2295
DRAINAGE COLLECTED FROM LAYER 3	0.09363	339.86301
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000150	0.54623
AVERAGE HEAD ON TOP OF LAYER 4	3.333	
MAXIMUM HEAD ON TOP OF LAYER 4	5.740	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	20.5 FEET	
SNOW WATER	3.90	14161.6172

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4957

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1275

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	1.5070	0.2512
2	92.3311	0.3847
3	2.2509	0.1251

WBUCL5

4	0.0000	0.0000
5	17.0280	0.4730
SNOW WATER	0.000	

****
****

Attachment 1d

Cell B side slopes (inactive, covered)

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↑
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******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**              HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                  **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**              USAE WATERWAYS EXPERIMENT STATION                           **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************
```

```
PRECIPITATION DATA FILE:    C:\HELP3\BALT_P.D4
TEMPERATURE DATA FILE:      C:\HELP3\BALT_T.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\BALT_SR.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\BALT_ET.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\WBC50.D10
OUTPUT DATA FILE:           C:\HELP3\WBC50.OUT
```

TIME: 15:16   DATE: 11/ 7/2016

```
******************************************************************************

     TITLE:  WESTLAND CELL B COVERED 50% SLOPE

******************************************************************************
```

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER

```
                          WBC50
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.4730 VOL/VOL
FIELD CAPACITY               =      0.2220 VOL/VOL
WILTING POINT                =      0.1040 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2497 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.140000004000E-03 CM/SEC



                        LAYER  2
                        --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER  20
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.8500 VOL/VOL
FIELD CAPACITY               =      0.0100 VOL/VOL
WILTING POINT                =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0151 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   10.0000000000     CM/SEC
SLOPE                        =     50.00   PERCENT
DRAINAGE LENGTH              =     60.0    FEET



                        LAYER  3
                        --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  36
THICKNESS                    =      0.04   INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      4.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD



                        LAYER  4
                        --------
```

```
          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    504.00   INCHES
POROSITY                     =      0.5410 VOL/VOL
FIELD CAPACITY               =      0.1870 VOL/VOL
WILTING POINT                =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.1870 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-05 CM/SEC



                        LAYER  5
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.5780 VOL/VOL
FIELD CAPACITY               =      0.0760 VOL/VOL
WILTING POINT                =      0.0250 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0760 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.148999998000E-01 CM/SEC
SLOPE                        =      8.00   PERCENT
DRAINAGE LENGTH              =    300.0    FEET



                        LAYER  6
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     36.00   INCHES
POROSITY                     =      0.4730 VOL/VOL
FIELD CAPACITY               =      0.2220 VOL/VOL
WILTING POINT                =      0.1040 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.4730 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.537999995000E-05 CM/SEC



        GENERAL DESIGN AND EVAPORATIVE ZONE DATA
        ----------------------------------------
```

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A
GOOD STAND OF GRASS, A SURFACE SLOPE OF 50.%
AND A SLOPE LENGTH OF 60. FEET.

SCS RUNOFF CURVE NUMBER	=	73.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.976	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.933	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.184	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	119.095	INCHES
TOTAL INITIAL WATER	=	119.095	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
BALTIMORE MARYLAND

STATION LATITUDE	=	39.18	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50	
START OF GROWING SEASON (JULIAN DATE)	=	102	
END OF GROWING SEASON (JULIAN DATE)	=	300	
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.30	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	62.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	65.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	68.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BALTIMORE MARYLAND

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.00	2.98	3.72	3.35	3.44	3.76

```
         3.89         4.62         3.46         3.11         3.11         3.40


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    BALTIMORE           MARYLAND

               NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

         JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
         -------     -------     -------     -------     -------     -------
          32.70       34.70       43.30       54.00       63.40       72.20
          76.80       75.60       68.90       56.90       46.30       36.50


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    BALTIMORE           MARYLAND
                  AND STATION LATITUDE  =  39.18 DEGREES




       HEAD  #1:  AVERAGE HEAD ON TOP OF LAYER  3
       DRAIN #1:  LATERAL DRAINAGE FROM LAYER  2 (RECIRCULATION AND COLLECTION)
       LEAK  #1:  PERCOLATION OR LEAKAGE THROUGH LAYER  3
       HEAD  #2:  AVERAGE HEAD ON TOP OF LAYER  6
       DRAIN #2:  LATERAL DRAINAGE FROM LAYER  5 (RECIRCULATION AND COLLECTION)
       LEAK  #2:  PERCOLATION OR LEAKAGE THROUGH LAYER  6


***********************************************************************************
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                                       DAILY OUTPUT FOR YEAR    1

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          S
  DAY  A  O  RAIN  RUNOFF   ET   E. ZONE   HEAD      DRAIN     LEAK      HEAD
DRAIN     LEAK
      I  I                        WATER     #1        #1        #1        #2
#2        #2
      R  L   IN.    IN.    IN.  IN./IN.    IN.       IN.       IN.       IN.
IN.       IN.
```

```
  353          0.30  0.000  0.051  0.1112    0.0018 .3500     .1318E-06    0.0000
.8408E-15 .1218E-06
  354          0.00  0.000  0.000  0.1086    0.0010 .1904     .7958E-07    0.0000
.6171E-15 .9263E-07
  355          0.00  0.000  0.000  0.1081    0.0003 .6436E-01 .3327E-07    0.0000
.1705E-15 .4485E-07
  356          0.00  0.000  0.000  0.1078    0.0002 .3712E-01 .2137E-07    0.0000
.4158E-16 .2434E-07
  357          0.19  0.000  0.049  0.1108    0.0002 .2462E-01 .1401E-07    0.0000
.1749E-16 .1585E-07
  358          0.00  0.000  0.002  0.1086    0.0003 .5130E-01 .2976E-07    0.0000
.3630E-16 .2582E-07
  359          0.28  0.000  0.050  0.1111    0.0003 .4229E-01 .2150E-07    0.0000
.3731E-16 .2357E-07
  360          0.00  0.000  0.000  0.1086    0.0008 .1512     .6588E-07    0.0000
.1608E-15 .5478E-07
  361          0.00  0.000  0.000  0.1081    0.0003 .6214E-01 .3327E-07    0.0000
.1332E-15 .4142E-07
  362          0.00  0.000  0.000  0.1079    0.0002 .3650E-01 .2107E-07    0.0000
.4105E-16 .2412E-07
  363  *       0.00  0.000  0.000  0.1077    0.0001 .2551E-01 .1957E-07    0.0000
.2470E-16 .1994E-07
  364          0.08  0.000  0.040  0.1095    0.0001 .2014E-01 .1756E-07    0.0000
.2045E-16 .1806E-07
  365          0.00  0.000  0.000  0.1084    0.0001 .1181E-01 .9789E-08    0.0000
.1023E-16 .1173E-07


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          AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
 ------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
   PRECIPITATION
   -------------
     TOTALS                2.50     3.30     3.36     3.35     3.77     3.77
                           3.77     5.57     3.38     2.65     2.96     3.00

     STD. DEVIATIONS       1.25     1.51     1.27     1.69     1.70     2.29
                           1.76     2.71     2.41     1.41     1.46     1.56
```

RUNOFF

TOTALS	0.140	0.477	0.267	0.004	0.022	0.019
	0.058	0.048	0.035	0.017	0.006	0.118
STD. DEVIATIONS	0.317	0.699	0.777	0.010	0.115	0.064
	0.250	0.134	0.075	0.059	0.025	0.538

EVAPOTRANSPIRATION

TOTALS	0.609	0.689	1.174	1.808	3.007	2.436
	1.417	1.577	0.988	0.622	0.507	0.476
STD. DEVIATIONS	0.149	0.262	0.291	0.637	0.891	1.553
	1.056	1.195	0.691	0.363	0.216	0.160

LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	1.5864	1.2882	2.2051	1.5622	1.5530	2.3903
	2.4918	3.6853	2.2471	1.6689	2.2655	1.9957
STD. DEVIATIONS	1.4555	1.3027	1.0423	1.0324	0.9014	1.5343
	1.2204	1.8443	1.2739	1.0700	1.1570	1.1701

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

```
-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  3
  -------------------------------------
    AVERAGES              0.0003   0.0003   0.0004   0.0003   0.0003   0.0005
                          0.0005   0.0007   0.0004   0.0003   0.0004   0.0004

    STD. DEVIATIONS       0.0003   0.0003   0.0002   0.0002   0.0002   0.0003
                          0.0002   0.0004   0.0002   0.0002   0.0002   0.0002

  DAILY AVERAGE HEAD ON TOP OF LAYER  6
  -------------------------------------
    AVERAGES              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

*******************************************************************************


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     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                      INCHES           CU. FEET       PERCENT
                                -------------------  -------------   ---------
 PRECIPITATION                   41.37    (   6.611)     150156.2     100.00

 RUNOFF                           1.211   (  1.1432)       4395.98      2.928

 EVAPOTRANSPIRATION              15.311   (  3.7099)      55578.34     37.014

 LATERAL DRAINAGE COLLECTED      24.93933 (  5.00255)     90529.789   60.29042
   FROM LAYER  2

 PERCOLATION/LEAKAGE THROUGH      0.00001 (  0.00000)         0.042    0.00003
   LAYER  3

 AVERAGE HEAD ON TOP              0.000 (    0.000)
   OF LAYER  3

 LATERAL DRAINAGE COLLECTED       0.00000 (  0.00000)         0.000    0.00000
```

FROM LAYER 5

PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00001 (	0.00000)	0.042	0.00003
AVERAGE HEAD ON TOP OF LAYER 6	0.000 (	0.000)		
CHANGE IN WATER STORAGE	-0.096 (	1.6819)	-348.00	-0.232

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.68	20618.398
RUNOFF	2.093	7595.8530
DRAINAGE COLLECTED FROM LAYER 2	2.16779	7869.08936
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000001	0.00234
AVERAGE HEAD ON TOP OF LAYER 3	0.017	
MAXIMUM HEAD ON TOP OF LAYER 3	0.009	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 5	0.00000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000001	0.00234
AVERAGE HEAD ON TOP OF LAYER 6	0.000	
MAXIMUM HEAD ON TOP OF LAYER 6	0.000	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	3.90	14161.6172

MAXIMUM VEG. SOIL WATER (VOL/VOL)   0.3805

MINIMUM VEG. SOIL WATER (VOL/VOL)   0.1040

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	3.1171	0.1299
2	0.0021	0.0105
3	0.0000	0.0000
4	94.2480	0.1870
5	1.8240	0.0760
6	17.0280	0.4730
SNOW WATER	0.000	

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