Geo-Logic
ASSOCIATES

July 17, 2024

Jacqueline M. Cooperider, P.E.
Permit Section Manager
Bureau of Land
Illinois Environmental Protection Agency
1021 North Grand Avenue East
Springfield, IL 62702

Re: 0978020002 – Lake County
Response to Draft Denial Comments Dated April 12, 2024 and Verbal Comments Provided by the IEPA in Virtual Meetings on March 28 and May 15, 2024
Permit No. 1995-343-LFM, Log No. 2022-254

Dear Ms. Cooperider,

On behalf of Zion Landfill, Inc., Geo-Logic Associates (GLA) is submitting this response to the Draft Denial Letter received from the Illinois Environmental Protection Agency (IEPA) on April 12, 2024 regarding the permit application to expand Zion Landfill. Each comment is listed below, followed by a response.

Draft Denial Letter Responses

IEPA Comment 1: *The applicant does not meet the requirements of 35 IAC 811.504(b). A sampling program shall be implemented as part of the Construction Quality Assurance (CQA) plan, for all construction activities. The sampling program shall be based upon statistical sampling techniques and shall establish and specify criteria for acceptance or rejection of materials and operations.*

- *Multiple revisions to sample testing frequency have been proposed without an explanation. Provide a narrative justifying the proposed changes in sampling frequency. All tests summarized in CQA plan Table 13 that have been revised require an explanation.*

Response: The testing frequencies for the low-permeability earth liner have been reduced from 1 test per 5,000 cubic yards to 1 test per 10,000 cubic yards for soil classification, proctor, nuclear density, grain size, and Atterberg limit tests. This was determined to be sufficient as the low permeability earth liner will be consist of the same clay soil present on site that has been used for the 48-year history of the site. Over the thousands of tests performed on this material, it has been demonstrated to be incredibly consistent.

Nuclear density testing on the final cover barrier soil was also reduced from 1 test per 5,000 cubic yards to 1 test per 10,000 cubic yards. Similarly to the Low-Permeability Earth Liner material to be used on site, the final cover barrier soil will be the same material that has been used throughout the history of the site. It has been demonstrated to be incredibly consistent.

Finally, proposed testing of the leachate collection pipe bedding has been changed from 1 test 3,000 cubic yards to 1 test per source per phase. This testing frequency was changed from a volumetric basis to a source and construction phase basis to ensure that new sources of material are tested, and that material is retested in each construction phase.

However, some specific changes to the proposed plan have been made as requested by the IEPA as addressed in the following comment responses. As such, a revised version of Appendix O (CQA Plan) has been provided in Attachment 1. A table outlining sampling frequencies which were modified from previous site CQA Plans, and explanations of the reasoning for those changes (as also described above) is provided in Attachment 2.

IEPA Comment 2: *As proposed, the Interface Sheer Testing specifications are not approvable and should be revised. The current proposal is to have the frequency of Interface Sheer Testing vary depending on the date last tested and or previous test in the same construction season.*

- *Revise the proposed Interface Sheer Testing specifications to a fixed testing frequency. Testing should occur routinely and independently of the last construction occurrence.*

Response: Appendix O (CQA Plan) has been revised to note that Interface Shear Testing will occur at a regular 18-month interval. Please refer to Section 8, 9, 10, 11, and 14 of the revised Appendix O provided as Attachment 1.

IEPA Comment 3: *Appendix O, Page 17, Section 7.0 Test Liner, references "Part 911.507(a)" regulation.*

- *No such regulation exists. This is believed to be a typo and should be revised.*

Response: This reference was erroneous and has now been corrected to refer to Part 811.507(a) *Requirements for a Test Liner*. The revised Appendix O has been provided as Attachment 1.

IEPA Comment 4: *Appendix O, Page 64, Section 15.2.2 Placement Requirements, states that air supply lines shall be pressure tested at 120 psi for 60 minutes. Table 13 states that pneumatic piping shall be pressurized to at least 150 psi for at least 60 minutes.*

- *Revise the proposed test pressure such that it is consistent throughout the CQA Plan.*

Response: The CQA plan has been revised to note that all pneumatic piping will be tested at a consistent pressure of 150 psi. The revised Appendix O has been provided as Attachment 1.

IEPA Comment 5: *Appendix O, Table 13, provides the units for the Nuclear Density test in cubic yards (yd^3) and square feet (ft^2)*

- *Is the unit square feet (ft^2) a typo?*

Response: The use of the units square feet (ft^2) was a typo. Table 13 of Appendix O has been corrected to note a Nuclear Density testing frequency of once per 10,000 cubic yards (yd^3) for low permeability earth liner. The revised Appendix O has been provided as Attachment 1.

IEPA Comment 6: *The revisions to the CQA plan should be submitted as a complete document and not individually revised pages.*

Response: The entire CQA Plan with the revisions noted throughout this letter has been provided as Attachment 1.

Verbal Comment Responses

In addition to the above comments concerning the CQA Plan, GLA has also received verbal comments from the IEPA concerning the spacing of temporary monitoring wells downgradient of each cell and with a request for additional information on how the presented Groundwater Impact Assessment (GIA) model is as conservative as a two-dimensional model. The substance of these comments has been generally paraphrased from notes taken during virtual meetings with the IEPA on March 28 and May 15, 2024 and they are numbered as IEPA Comments 7 and 8 below.

IEPA Comment 7: The IEPA has requested that modeling be conducted to inform the spacing of temporary monitoring wells downgradient of each cell.

Response: GLA has prepared PLUME models to represent flow conditions downgradient of each Cell (refer to Attachment 3) under very conservative modeling conditions. This modeling found plume widths to range from 59-198 feet at 50 feet from the interim waste boundary (refer to Figure 1 in Attachment 3).

As requested by the IEPA, this modeling was extremely conservative and ignored the significant environmental safeguards that are inherent in the landfill design and the conservative assumptions that have been used in the Groundwater Impact Assessment models. For example, the modeling assumes that a hypothetical plume has already moved through the in-situ clay and is in the aquifer starting on day 1. However, using the average thickness of the in-situ clay below the landfill cells (10.27 m) and the coefficient of hydrodynamic dispersion of 0.019 m2/yr (transport will be dominated by diffusion due to the low seepage rate), which will take approximately 540 years to occur. However, these wells will each be in service for an average of only approximately 6 years prior to abandonment for construction of the subsequent landfill cell.

As a result of this low conductivity cohesive soil surrounding the landfill, along with the high integrity of the landfill liner system in place, the applicant is proposing a more reasonable well spacing of 250 feet which will be adequate to detect any discharge of contaminants from any portion of the landfill. Figure 2.8-2 (Proposed Monitoring Network) and Drawing No. D12 (Proposed Groundwater Monitoring Plan) have been updated to reflect these additional temporary wells (refer to Attachment 3). Also included in Attachment 3 is a revised Section 2.8 with an updated Table 2.8-1 (Proposed Groundwater Monitoring Network Phasing). Note that while these changes have been made by GLA, the logos on revised Section 2.8-2 and Drawing No. D12 remain that of the original author of those documents (Aptim Environmental & Infrastructure, LLC). These logos were retained to provide consistency for the IEPA's files (e.g. so that Drawing D12 can be added to the IEPA's master drawing set without causing confusion in the future).

IEPA Comment 8: The IEPA has questioned whether the one-dimensional POLLUTE model presented with the application is more conservative than had a two-dimensional MIGRATE model been presented in previous permit applications approved for the existing facility.

While the baseline model conservatively generated a Groundwater Concentration Prediction Factor (GCPF) prior to the Zone of Attenuation (ZOA), there was a concern that the baseline model was not taking into account the landfill base length in the direction of groundwater flow in the uppermost aquifer.

Response: As described to the IEPA during a virtual meeting on May 15, 2024, the POLLUTE model was presented to provide simplicity. Using a one-dimensional model eliminated the complexities of the two-dimensional flow, while allowing for evaluation at the base of the Wadsworth Till, well before the Zone of Attenuation.

However, to address the IEPA's concerns, a MIGRATE sensitivity analysis was preformed to determine if adding the landfill base would generate a higher predicted GCPF in the uppermost aquifer at the ZOA (refer to Attachment 4 of this response).

This MIGRATE model included the following conservative assumptions, among others:

1. The landfill flow length was conservatively measured from southwest to northeast across the entire landfill at the longest southwest to northeast distance below the landfill.

2. The shortest distance from the landfill base to the waste boundary (occurring in the northeast corner of the facility) was used to evaluate the model results.

3. An impermeable bottom boundary condition was utilized. The impermeable bottom boundary is conservative as it does not allow any transmission of contaminant across this boundary. If the bottom boundary was not assumed to be impermeable, contaminants would actually diffuse across this boundary and move slowly into the Lower Till below the site (diluting concentrations).

4. The highest average horizontal gradient (to the north) was used to calculate the Darcy velocity used in the model.

5. A constant leachate concentration was used throughout the modeling period. The concentration of each constituent in leachate can be assumed to be constant or a specific mass can be assumed to be present. Assuming a specific mass results in a decreasing source concentration over time, which would most accurately represent the fact that leachate concentrations in landfills with leachate collection and removal systems will gradually decrease over time. However, a constant concentration was assumed as it results in conservative model results.

6. The landfill will have an inward gradient throughout the entire modeling period, with groundwater flowing into the landfill in the unlikely event that a puncture of the liner was to occur. Conservatively, the groundwater model assumed that the landfill will have an outward gradient with one (1) foot of leachate head acting on the liner. A one (1) foot leachate head was used in the calculation of the landfill vertical seepage rate, resulting in

higher predicted concentrations at the base of the Wadsworth Formation prior to reaching the Shallow Drift Aquifer (uppermost aquifer) and the Zone of Attenuation (ZOA).

7. Poor liner contact was assumed in the calculation of the landfill vertical seepage rate, resulting in a higher seepage rate. A more conservative model is created by using a higher seepage rate through the liner. Section 2.5 of this application discusses the Construction Quality Assurance Program, which details specifications for liner installation. Good contact between the 60 mil HDPE liner and recompacted soil liner is expected at the site, making the poor liner contact assumption conservative.

8. The maximum reported leachate concentration for each constituent was used in the development of the model prediction table. An average of the reported leachate concentrations would result in a less conservative evaluation of the landfill expansion. Therefore, the maximum reported concentrations were used in the model.

9. Adsorption was conservatively not applied to the baseline groundwater model. Adsorption can play a significant role in retarding the migration of numerous constituents in groundwater. Not using adsorption in the model results in a higher predicted concentration at the base of the Wadsworth Formation prior to reaching the Shallow Drift Aquifer (uppermost aquifer) and the ZOA.

10. Degradation was conservatively not used in the baseline groundwater model. Degradation can play a significant role in reducing the migration of numerous constituents in groundwater. Not using degradation in the model results in a higher predicted concentration at the base of the Wadsworth Formation prior to reaching the Shallow Drift Aquifer (uppermost aquifer) and the ZOA.

The MIGRATE sensitivity analysis predicted a maximum Groundwater Concentration Prediction Factor for the entire 147-year simulation period at the edge of the zone of attenuation in the Shallow Drift Aquifer (uppermost aquifer) of 8.19×10^{-10}.

As a result, even with numerous conservative assumptions, the two-dimensional MIGRATE modeling has resulted in a prediction limit that is roughly 700 times less than the limit determined using the one-dimensional POLLUTE model provided in the permit application (5.81×10^{-7}).

We are hopeful that the IEPA will find these responses to be sufficient to address its comments. If you have any questions, please do not hesitate to contact me at (847) 942-6765. Meanwhile, we look forward to receipt of a development permit for the facility.

Sincerely,
Geo-Logic Associates

Martin N. Fallon
Operations Manager

Attachment 1

Revised CQA Plan

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1.0 PURPOSE AND SCOPE

1.1 Purpose

The purpose of this Construction Quality Assurance Plan (CQA Plan) is to provide procedures to assure that landfill components of the Zion Landfill are constructed and documented in adherence to their design and regulatory requirements.

This CQA Plan has been prepared in accordance with the requirements of Title 35 Illinois Administrative Code Part 811 Subpart E and Appendix D to IEPA Landfill Permit Application Instructions Form No. LPC-PA2. This CQA Plan is intended to serve as a guide and can be modified upon IEPA approval to reflect current industry standards with regard to laboratory testing methods and requirements.

1.2 Scope

Construction components and facilities subject to this CQA Plan are as follows:

Construction Component	Applicable Sections*
Foundation and Subgrades	2.0 –5.0, 6.0, 8.0
Test Liner	2.0 –5.0, 6.0, 7.0, 8.0
Gradient Control Layer	2.0 –5.0, 14.0, 15.0
Compacted Low-Permeability Soil Liner	2.0 –5.0, 7.0, 8.0
Geomembrane Installation	2.0 –5.0, 11.0
Leachate Drainage and Collection System	2.0 –5.0, 10.0, 12.0, 13.0, 14.0, 15.0
Final Cover System	2.0 –5.0, 7.0, 8.0, 9.0, 11.0, 12.0, 13.0, 14.0, 15.0
Surface Water Control Facilities	2.0 –5.0, 12.0, 15.0, 16.0
Gas Control System	2.0 – 5.0, 17.0
Leachate Storage Tanks	2.0 –5.0, 19.0

* NOTE: Sections 2.0 through 5.0 are applicable to all landfill components.

Sections 2.0 through 5.0 discuss CQA requirements common to all the components of landfill construction. These common requirements include Roles, Responsibilities, and Qualifications (Section 2.0), Preconstruction Planning (Section 3.0), General Inspection and Documentation (Section 4.0), and the Construction Acceptance Report (Section 5.0).

Sections 6.0 through 19.0 discuss specific construction procedures, observation, sampling, testing, acceptance criteria, surveying and documentation requirements for each material utilized in construction of landfill components. Several sections will have to be referenced for landfill components constructed of multiple materials. For example, the final cover utilizes general fill (final protective layer), geocomposite, geomembrane, and low-permeability soil (low-permeability layer).

2.0 OPERATOR AND CQA ROLES, RESPONSIBILITIES, AND QUALIFICATION

2.1 Owner/Operator

For each component of landfill construction addressed by this CQA Plan, the Owner/Operator shall retain professional services of a third party other than the Owner/Operator or an employee of the Operator to fulfill the requirements of the CQA Officer.

2.2 CQA Officer

The CQA Officer shall supervise and be responsible for all inspections, testing, and related construction documentation as described in this CQA Plan. The CQA Officer will be responsible for preparation of the construction acceptance report to certify substantial compliance with the engineering design. The CQA Officer shall be an Illinois Registered Professional Engineer.

The CQA Officer may delegate daily inspection, testing, and sampling duties to a qualified technician with experience in the assigned aspect of construction who will serve as the CQA Officer-In-Absentia (COIA). Although these duties may be delegated, the CQA Officer will retain the responsibility for these activities.

When a COIA is designated, the CQA Officer shall visit the construction site periodically during active periods of construction to personally observe the construction and documentation procedures. Also, at a minimum, the CQA Officer shall personally observe, on at least one occasion, each of the following major elements of landfill construction:

- ❑ Compaction of the subgrade and foundation to design parameters;
- ❑ Installation of underdrain system;
- ❑ Installation/testing of the compacted low permeability soil liner;
- ❑ Installation/testing of the geomembrane;
- ❑ Installation/testing of the leachate drainage and collection system;
- ❑ Application/testing of the final cover;
- ❑ Installation/testing of gas control facilities; and
- ❑ Construction of the ponds, ditches, and berms.

The CQA Officer shall be readily available for consultation, as needed.

2.3 CQA Officer-In-Absentia (COIA)

In the event that the CQA Officer is unable to be present to perform the requirements of this CQA Plan, the CQA Officer will designate a person to fulfill the duties of the CQA Officer and exercise professional judgment in the role of CQA Officer-In-Absentia (COIA). The COIA will not necessarily be an Illinois Registered Professional Engineer. The Officer-in-Absentia form provided in Section 21, or its equivalent, shall be completed in its entirety when a COIA is designated, and shall be included in the construction acceptance report.

The COIA will carry out daily inspection, testing, and sampling duties under the direct supervision of the CQA Officer. The COIA shall be a qualified technician with experience in the assigned aspect of construction. The COIA will prepare daily summary and inspection reports and transmit these routinely to the CQA Officer. The COIA will immediately notify the CQA Officer of any problems or deviations from design plans and specifications. The COIA will not have authority to approve any design or specification changes without the consent of the CQA Officer.

2.4 Soils Testing Laboratory

The Soils Testing Laboratory shall have experience in testing soils in accordance with standards developed by the American Society of Testing and Materials (ASTM), American Association of State Highway and Transportation Officials (AASHTO), United States Army Corp of Engineers (USCOE), and other applicable test standards. A third-party laboratory, not owned by the Operator or the Manufacturer will be used. The selected laboratory will be required to be responsive to the project needs by providing test results within reasonable time frames. Final laboratory reports will be certified by the Soils Testing Laboratory and submitted to the CQA Officer.

2.5 Geosynthetic Testing Laboratory

The Geosynthetic Testing Laboratory will have experience in testing geosynthetics in accordance with standards developed by the American Society of Testing and Materials (ASTM), Geosynthetic Institute (GSI), International Standards Organization (ISO), and other applicable test standards. A third-party laboratory not owned by the Operator or the manufacturer will be used. The selected laboratory will be required to be responsive to the project needs by providing test results within reasonable time frames. Final laboratory reports will be certified by the Geosynthetic Testing Laboratory and submitted to the CQA officer.

2.6 Construction Contractor

The Construction Contractor will be responsible for performing and controlling earthwork, construction, and piping installation, and to provide overall construction responsibility. The Construction Contractor will be experienced in solid waste landfill construction or similar type projects, knowledgeable about clay liner construction techniques, and familiar with geosynthetic installations. Selection of a qualified Construction Contractor will be at the Owner’s discretion.

2.7 Geosynthetics Installation Contractor

The Geosynthetic Installation Contractor (Installer) will be responsible for providing the materials, equipment, and personnel to install the required geosynthetic components. The Geosynthetics Installation Contractor will be trained and qualified to install the various required geosynthetic components. The Geosynthetics Installation Contractor will be approved and/or licensed by the manufacturer. Selection of a qualified Geosynthetic Installation Contractor will be at the Owner’s discretion.

2.8 Manufacturer(s)

The Manufacturers are responsible for manufacturing and/or fabricating their respective components in accordance with the design criteria, drawings, and specifications to the satisfaction of the CQA Officer and Operator. The Manufacturers are required to implement the MQA and MQC programs described in the specifications. The Manufacturers may implement their own supplemental quality assurance/quality control program for purposes of monitoring the manufacture or fabrication of their respective components.

3.0 PRECONSTRUCTION MEETING

Prior to construction commencing at the landfill facility, a preconstruction meeting shall be held. This meeting will include the parties involved in the construction, including the CQA Officer, COIA, construction and/or installation contractor, and Operator.

The objectives of this meeting include construction planning and coordination of tasks; identification of potential problems that might cause difficulties and delays in construction; proper interpretation of design intent by contractor(s); and to present the CQA Plan to all the parties involved. It is very important that the rules regarding documentation, reporting, testing, repair, and acceptance be understood by each party to this CQA Plan.

Specific topics considered for this meeting include the following:

- ❑ Review the construction plans, construction specifications, and CQA Plan. Review all critical design details of the project.
- ❑ Review measures for surface and storm water control, including but not limited to storm water diversion, erosion control measures, pumping locations, storm water retention, and discharge requirements.
- ❑ Review pending and approved IEPA modifications to the CQA Plan and develop any project specific addenda.
- ❑ Review the responsibilities of each party.
- ❑ Review lines of authority and communication.
- ❑ Review methods for documenting, reporting, and distributing documents and reports.
- ❑ Review the testing requirements, locations, and frequency for the soil and geosynthetic components.
- ❑ Construction procedures for the compacted low-permeability soil layer, including compaction and water content requirement, precautions to be taken to maximize bonding between lifts of compacted low-permeability soil, method for splicing liner and cover, precautions to minimize desiccation cracking, surface preparation and approval prior to geomembrane placement.
- ❑ Establish rules for writing on the geomembrane (i.e., who is authorized to write, what can be written, and in which color). Outline procedures for packaging and storing archive samples.
- ❑ Review the time schedule for all operations and hours of operations.
- ❑ Establish procedures for deployment of materials over completed geosynthetics.
- ❑ Observe where the site survey benchmarks are located, and review methods for maintaining vertical and horizontal control.
- ❑ Review permit documentation requirements.
- ❑ Review the survey documentation tables and plans that identify the locations where survey documentation information is required.
- ❑ Conduct a site walk-around to review material storage locations and general conditions relative to construction.
- ❑ Review geomembrane panel and seam layout drawings and numbering systems.

- ❑ Establish procedures for use of the geomembrane welding apparatus, if applicable.
- ❑ Finalize field cutout sample sizes.
- ❑ Review repair procedures.
- ❑ Review procedures for working in areas containing waste.

Unless otherwise agreed upon, the meeting will be documented by the CQA Officer, and minutes will be distributed to all parties involved in the construction project.

4.0 GENERAL CONSTRUCTION OBSERVATION AND DOCUMENTATION

This section describes general documentation procedures to be implemented including use of forms, identification and resolution of problems or deficiencies, and photographic documentation.

4.1 Daily Reports

A daily construction report shall be prepared by the CQA Officer, or under direct supervision of the CQA Officer, for each day of activity. Each report shall contain the following information:

- ❑ Date, project name, location, and report preparer's name and signature. Names and signatures of all inspectors on-site performing CQA under the supervision of the CQA Officer.
- ❑ Time work starts and ends each construction work day. Also identify the duration and reason for any work stoppages (i.e., weather delay, equipment shortage, labor shortage, unanticipated conditions encountered, etc.).
- ❑ Data on weather conditions including temperature, humidity, wind speed and direction, cloud cover, and precipitation.
- ❑ Construction Contractor's work force, equipment in use, and materials delivered to or removed from job site.
- ❑ Chronological description of work in progress including locations and type of work performed.
- ❑ Summary of any meetings held and attendees.
- ❑ A description of all materials used and references or results of testing and documentation.
- ❑ Discussion of any problems/deficiencies identified and any corrective actions taken as described in Section 4.3 (Problem/Deficiency Identification and Corrective Action).
- ❑ Identification/list of laboratory samples collected, marked, and delivered to laboratories or clear reference to the document containing such information if samples were obtained.
- ❑ An accurate record of calibrations, recalibrations, or standardizations performed on field testing equipment, including any actions taken as a result of recalibrations. In addition, the results of other data recording such as geomembrane seaming temperatures shall be included or clearly referenced to the document containing such information, if applicable.
- ❑ Copies of each inspectors daily field data sheets.

Field data sheets shall be prepared daily by the COIA and contain the following information:

- ❑ Test or sample location and elevation
- ❑ Type of inspection
- ❑ The procedures used
- ❑ Test data
- ❑ Test results

- ❑ Personnel involved in the inspection and sampling activities
- ❑ Name of the COIA

4.2 Forms, Checklists, and Data Sheets

Additional forms may be developed during the course of the project to provide specific needs such as geomembrane inspections or simply to improve efficiency of data collection. Any new forms shall be approved by the CQA Officer prior to their use.

4.3 Problem/Deficiency Identification and Corrective Action

Problem and/or deficiency identification and corrective action will be documented in the Daily Summary Report when any construction material or activity is observed or tested that does not meet the requirements set forth in this CQA Plan. The Summary Report should clearly reference any other report, photograph, or form that contains data or observations leading to the determination of a problem or deficiency. Problem/deficiency identification and corrective action documentation may include the following information:

- ❑ A description of the problem or deficiency, including reference to any supplemental data or observations responsible for determining the problem or deficiency.
- ❑ Location of the problem or deficiency, including how and when the problem or deficiency was discovered. In addition, an estimate of how long the problem or deficiency has existed should be included.
- ❑ A recommended corrective action for resolving the problem or deficiency. If the corrective action has already been implemented, then the observations and documentation to show that the problem or deficiency has been resolved should be included. If the problem or deficiency has not been resolved by the end of the day upon which it was discovered, then the report will clearly state that it is an unresolved problem or deficiency.

The CQA Officer and the COIA will discuss the necessary corrective actions with the Owner and the Construction Contractor and implement actions, as necessary, to resolve the problem or deficiency as soon as possible. A description of such problems or deficiencies and corrective actions implemented will be provided in the Construction Documentation Report.

The CQA Officer, working with the Operator and Construction Contractor, will determine if the problem or deficiency is an indication of a situation that might require changes to the plans and specifications and/or the CQA Plan. Any revisions to the plans or specifications or the CQA Plan must be approved by the CQA Officer and the site Operator. CQA Plan modifications will be approved by the IEPA.

4.4 Photographic Documentation

Photographs shall be taken of each major element of the CQA process to document observations, problems, deficiencies, corrective actions, and work in progress. The following information should be documented in the daily report or a log book for each photograph:

- ❑ Date and time.
- ❑ Approximate location where photograph was taken, including information regarding the orientation of the photograph itself for proper viewing (i.e., looking south), if not

apparent from the content of the photograph.

- ❑ Description of the subject matter.
- ❑ Unique identifying number for reference in other reports.
- ❑ Name and signature of photographer.

4.5 Surveying

Documentation surveying requirements for each major landfill component are described in Sections 6.0 through 19.0. All required surveying will be performed under the direct supervision of the CQA Officer. All surveys will be based on survey control monuments to be established according to Part 811.104. The location of all field tests and samples will be recorded. Generally, these locations can be determined by reference to nearby construction stakes or markings; however, if such convenient reference is not readily available, the CQA Officer or the designated COIA is responsible to provide or request survey control.

5.0 CONSTRUCTION ACCEPTANCE REPORT

Following completion of construction of each major phase (or sub-phase), a Construction Acceptance Report will be prepared including certification by the CQA Officer that construction was completed in substantial conformance with the engineering design and applicable approvals. The report will be submitted to the IEPA, as required for operation approval.

The report will include the following information, at a minimum:

5.1 Narrative

A narrative description in chronological order for each of the major construction elements listed in Section 1.0. The narrative will include discussion of the following items:

- A physical description of the subject construction and a description of the construction procedures used.
- A comparison of testing requirements, as specified by the CQA Plan, to the testing actually performed.
- A comparison of acceptance criteria specified by the CQA Plan to the testing results actually achieved. Summaries of all test data (including sample and test locations) will be provided as well as copies of pertinent laboratory testing reports such as grain-size distribution curves, hydraulic conductivity test data, moisture- density curves, and geosynthetic test data.
- A comparison of surveying requirements specified by the CQA Plan to those performed, and an evaluation of conformance to specified thicknesses, lines, and grades. Survey data will be summarized and/or represented by drawings of record.
- Any deviation from the design plan or from the agency approval will be discussed including the reason and justification for the change.
- Any pertinent correspondence related to the construction will be referenced in the narrative and included in appendices.

5.2 Photographic Documentation

Photographic documentation will be included in an appendix. A sufficient number of photos will be included to provide a visual concept of each major component of landfill construction. Photographs may also depict testing and sampling procedures and construction procedures.

5.3 Summary Reports

Copies of all Daily Summary Reports will be provided in an appendix.

5.4 Drawings of Record

Drawings of Record for the construction may include the following Plan Sheets and contents, as applicable. When practical, each of these record drawings should show where samples are collected and/or tests were conducted, with a reference to test/ sample identification:

- ❑ Title Sheet - Project name, date, site location, preparer, Owner/Operator, certification, and drawing index.
- ❑ Subgrade Grades - Surveyed subgrade grade spot elevations, areas of over excavation, average depth of over excavation, locations of areas requiring placement of geosynthetics or crushed stone for dewatering, and locations of any areas requiring stabilization.
- ❑ Liner Grades - Surveyed top of liner grade spot elevations.
- ❑ Liner Geomembrane - Panel and seam locations, anchor trench locations, any pertinent testing locations, and penetration locations, including repairs.
- ❑ Leachate Drainage and Collection System - Surveyed top of drainage layer grade spot elevations, or measured thickness, location and slopes of leachate collection pipes, anti-seep collars, manholes, tanks, and loading facilities.
- ❑ Gas Control System – Surveyed locations of wells, laterals, and header piping with spot elevations as necessary, locations of air lines and condensate forcemain piping, locations of tanks, condensate collection points, and tie-in locations.
- ❑ Surface Water Drainage Facilities - Lines, grades, and spot elevations of surface water control facilities. Pipe locations, elevations, and any control devices will also be shown. If possible, this information may be incorporated into another Plan Sheet.
- ❑ Final Cover Low-Permeability Soil Layer - Surveyed top of low-permeability soil cover spot elevations.
- ❑ Final Cover Geomembrane - Panel and seam locations, any pertinent testing locations, and penetration locations, including repairs.
- ❑ Final Cover Drainage Layer - Surveyed top of granular layer, or limits of geocomposite if geosynthetic material is used.
- ❑ Final Cover Protective Layer - Top of protective layer grade spot elevations. Any surface water drainage or diversion facilities associated with the final cover.
- ❑ Details - Detail Plan Sheets will depict any necessary components, as necessary, to clearly document construction. Details may include, but may not be limited to: plan and profiles of manholes, tanks, piping and pump controls, liner penetrations, gas control system structures, and drainage structure controls.

6.0 SUBGRADE AND FOUNDATION

The liner subgrade will be established by excavating overburden soils to the designed subgrade grades.

6.1 Procedures and Observation

- In order to ensure a firm subgrade, the Contractor will proof-roll the subgrade if required by the CQA Officer. The COIA will observe the proof-rolling and note any areas that appear unacceptable or soft.
- Upon attainment of subgrade grades by excavation, the COIA will observe subgrade conditions and document unexpected conditions such as wet or unstable areas, permeable lenses, or standing or running water. The COIA will observe soil surfaces for joints, fractures, and depressions. These areas will be repaired as discussed below.
- Any unstable areas, permeable lenses, joints, or fractures encountered will be excavated at least 2 foot in depth and replaced with low-permeability soil. If required, dewatering, placement of geosynthetics, or placement of crushed stone to stabilize the subgrade undercut below 2 foot shall be at the direction of the CQA Officer.
- In the event that groundwater is encountered during excavation, the following procedures will be followed:
  - Excavating in the area will cease until the area can be assessed and mitigation measures implemented.
  - Zion Landfill will be notified by the contractor immediately.
  - The CQA Officer and an experienced geotechnical engineer will be notified immediately.
  - Based on recommendations by the geotechnical engineer, mitigation measures will be implemented (mitigation measures may include, but not be limited to perimeter dewatering, horizontal drains, and or drainage ditches). If groundwater is present in an amount that would impede construction of the liner, additional mitigation measures may be implemented to construct an underdrain system (see Section 6.2).
  - Upon stabilization of the uplift forces, subgrade grade excavation will be completed and the low-permeability soil liner will be placed.
  - Mitigation measures will be maintained during waste placement operations until sufficient overburden materials are in place in order to counteract hydrostatic uplift forces.
  - Any corrective actions taken under this section should be documented using the methods in Section 4.3.

6.2 Excavation

The following procedures will be followed prior to and during construction.

- All available geologic information, including boring logs and geologic cross sections, will be reviewed prior to excavation.
- Meetings will be scheduled on a regular basis between the Owner, contractor, and

CQA Officer to discuss elevations of the subgrade.

- Excavation depths will be monitored continuously to ensure subgrade grades are not over excavated.

In areas where groundwater is encountered which may be anticipated to impede construction of the liner, an underdrain system will be installed. The underdrain system is a 200-mil double-sided geocomposite, which consists of an HDPE Geonet with a 6 oz/yd^2 geotextile heat-bonded to both sides, and will be placed to intercept the encountered groundwater seepage. Groundwater will be transported via the geocomposite drainage layer to sumps which will be constructed similar to those constructed above the liner however, the sump will not be lined with a geomembrane liner. A geomembrane liner is not necessary due to the upward gradient and the fact that the groundwater will at no time come in contact with waste. The groundwater will be pumped up sideslope risers similar to those constructed above the liner and will discharge to the perimeter ditches.

Groundwater inflow may occur during periods of high water table. This inflow can be managed through the use of perimeter ditches and sumps. The sumps will be field located during construction. Sumps will be located in areas of groundwater seepage.

6.3 Sampling Requirements and Acceptance Criteria

- As discussed above, subgrade stability will be determined by visual observations of surface conditions under proof rolling with a loaded haul truck or scraper, with rutting less than four inches considered acceptable.
- Any subgrade areas requiring placement of compacted low-permeability soil for stabilization should follow the Quality Assurance requirements.
- One representative sample will be obtained from the subgrade/subbase soil areas and analyzed for each cell construction area.
  - The following laboratory analysis will be performed:
    - Shear Strength – ASTM D3080
  - The following represents the Acceptance Criteria:
    - Angle of Internal Friction and Cohesion shall be greater than or equal to the window of 24.1 degrees with 0 psf and 14.9 degrees with 45 psf. See Table 12 for a figure of the required window.

6.4 Surveying

Subgrade elevations will be surveyed on a 100-foot grid pattern at a minimum and any additional locations required to depict breaks in grade, toe, and top of sideslopes. In the alignment of undercuts for leachate collection lines, subgrade elevations will be surveyed at 50-foot intervals. The subgrade grades shall be equal to or lower in elevation than the design subgrade grades.

The limits of any subgrade stabilization or permeable lense removal and backfill will be surveyed and depicted on the Subgrade Grades record drawing plan sheet. The location of all field tests and samples will be recorded.

7.0 TEST LINER

A test liner has previously been constructed at the site and approved by the IEPA as meeting the requirements of 35 IAC Part 811.507. Additional test liner(s) will be constructed if the material properties of the borrow source substantively changes or there is a change in equipment or procedure. It should be noted that admixtures are not proposed at this time as part of the liner; however, a new test liner will be constructed if they are proposed in the future. If additional test liner(s) are required, they will be constructed and evaluated in accordance with the requirements of 35 IAC Part 811.507. The COIA will observe its construction and perform the required testing and sampling. The CQA Officer will inspect the construction and testing of the test liner to ensure that the requirements of Part 811.507(a) are met following the construction of the test liner. The CQA Officer will prepare a documentation report of the test liner construction and testing results for IEPA submittal prior to a full-scale low-permeability earth liner construction.

7.1 Test Liner Design

The test liner dimensions will be 100 feet in length by 50 feet in width and 5 feet thick. The liner will be constructed with a 2 percent slope across its width, and the final surface will be elevated approximately 0.5 foot above the existing ground surface to promote runoff. The widest piece of equipment to be used in liner construction is approximately 12 feet. The scraper, being the longest piece of equipment, is approximately 40 feet in length. The scraper will already be in motion when it approaches the test liner and operates at very low speeds when depositing soil; therefore, the testing area of the liner has been determined by establishing a buffer for edge effects equal to one half the length of a scraper and one half the width of equipment. This provides a testing area with dimensions of 38 feet by 60 feet.

7.2 Procedures and Observation

- ❑ A shallow excavation will be made to remove topsoil and simulate subgrade conditions. The subgrade will be proof-rolled and quantitatively evaluated for acceptance using the methods in Section 6.3.
- ❑ Low-permeability soil for construction of the test liner will be obtained from the same borrow source(s) or from excavation material, for the full-scale liner.
- ❑ The COIA will confirm the source and uniformity of the borrow source.
- ❑ The Construction Contractor will segregate and/or remove unsuitable soils as discussed in Subsection 8.1 (Low-Permeability Soils). Contractor methods will be evaluated for removal of stones which may cause damage to the liner or are greater than 2 inches in diameter within 6 inches of the final test liner surface.
- ❑ Low-permeability soil will be placed in loose lifts using scrapers or dozers. The effectiveness of scrapers performing this task will be evaluated by measuring loose lift thickness. The equipment will spread each lift to an approximate 9-inch thickness prior to compaction. Then, the compactor speed and number of passes required to achieve specified compaction will be evaluated. The test liner documentation report will discuss construction methods and propose a method for construction of the full scale liner.
- ❑ The test liner will be constructed to a minimum thickness of 5-feet.
- ❑ The final surface of the test liner will be compacted with a smooth drum roller. Then, the suitability of the surface relative to geomembrane placement will be evaluated.

- Moisture conditioning may be implemented at the direction of the CQA Officer to protect the completed test liner surface from desiccation, particularly if the in- field hydraulic conductivity testing has not been completed.
- The test liner will be abandoned following completion of all data collection upon notice by the CQA Officer.
- The low permeability soil material used for the construction of the test liner may be incorporated in the full-scale liner construction.

7.3 Sampling Requirements and Acceptance Criteria

Due to the relative size of the test liner, sampling frequencies are intensified solely for the purpose of demonstrating repeatability of results. The COIA will perform field tests and collect soil samples for laboratory analysis.

7.3.1 Field Testing

Parameter	Method
Moisture Content & Soil Density	ASTM D6938
Hydraulic conductivity	ASTM D6391-11

Field density and moisture content will be performed on each lift thickness of soil placed at the locations chosen by the CQA Officer. A properly calibrated nuclear density-moisture gauge will be used for field moisture and density determination. The COIA will select field density/moisture content test locations by random and judgmental processes. The testing frequency shall be no less than two tests per lift of earth liner placed.

In-field hydraulic conductivity testing will be performed on the final test liner surface at a minimum of three locations determined by the CQA Officer. Tests will be conducted in accordance with ASTM D6391-11. Extreme care will be used in conducting this testing as the procedure has inherent interferences that may adversely affect results and yield unrepresentative data. Such interference includes evaporation and inadequate seals between the permeameter and low-permeability soil. These factors will be closely monitored to verify test results.

The COIA shall record the approximate location of all field density and moisture content tests and hydraulic conductivity samples to a nominal accuracy of twenty-five (25) feet, referencing the project coordinate and elevation system, and depth according to the lift number.

7.3.2 Field Testing Acceptance Criteria

Acceptance criteria for density and moisture content will require soil compaction to a minimum of 95 percent of the Standard Proctor maximum dry density, or to a minimum of 90 percent of the Modified Proctor maximum dry density, at a moisture content equal to or greater than optimum. Field hydraulic conductivity will be required to be no greater than 1 x 10^{-7} cm/s.

7.3.3 Laboratory Testing

Undisturbed Sample Analysis

Samples for determining in-place properties will be collected by an appropriate method for obtaining intact, undisturbed samples. Two undisturbed samples per lift will be obtained. An undisturbed sample will be obtained on the final lift so each in-field hydraulic conductivity test can be compared to laboratory hydraulic conductivity results. The following laboratory analysis will be performed on each undisturbed sample:

Parameter	**Test Method**
Moisture Content and Dry Density	ASTM D2216
Atterberg limits	ASTM D4318
Grain Size Analysis*	ASTM D7928 (particle size smaller than no. 200 sieve)
	ASTM D6913 (particle size larger than no. 200 sieve)
Hydraulic conductivity	ASTM D5084 or SW846-EPA Method 9100

* The former grain size analysis standard (ASTM D422) was withdrawn by ASTM in 2016.

Representative Sample Analysis

A single representative (grab) sample will be obtained from the low-permeability soil borrow source and analyzed prior to construction. This will confirm soil characteristics and provide the maximum dry density value for compaction testing. A single sample will be adequate as only 740 cubic yards of in-place low-permeability soil will be required to construct the test liner.

The following laboratory analysis will be performed on the representative sample:

Parameter	**Test Method**
Moisture Density Relationship using Standard or Modified Proctor Compaction	ASTM D698 (or ASTM D1557)
Atterberg limits	ASTM D4318
Grain Size Analysis*	ASTM D7928 (particle size smaller than no. 200 sieve) ASTM D6913 (particle size larger than no. 200 sieve)
Soil Classification per USCS (Unified Soil Classification System)	ASTM D2487

Remolded Hydraulic Conductivity At 95 percent compaction and equal to or greater than optimum water content per Standard Proctor Method (ASTM D698) or 90 percent compaction and equal to or greater than optimum water content per Modified Proctor Method (ASTM D1557)	ASTM D5084 or SW846-EPA Method 9100

* The former grain size analysis standard (ASTM D422) was withdrawn by ASTM in 2016.

Laboratory Testing Acceptance Criteria

- ❑ Hydraulic conductivity shall be no greater than 1 x 10^{-7} cm/s (low-permeability soil liner only).
- ❑ Percent passing No. 200 sieve shall be at least 50%.
- ❑ Plasticity index shall be at least 4%, as long as hydraulic conductivity is no greater than 1 x 10^{-7} cm/s (low-permeability soil liner only).
- ❑ Atterberg Limits and Grain Size Analysis will be used to classify soils per the USCS. Low-permeability soils with USCS classification as CH, CL, or CL-ML are acceptable.

7.4 Surveying

Top and bottom of low-permeability soil liner elevations will be surveyed on a grid system with 25-foot intervals across the width of the test liner and 50-foot intervals across its length. The minimum acceptable liner thickness will be 5 feet. The location and elevation of all samples will be recorded.

8.0 LOW-PERMEABILITY SOILS

Low-permeability soil refers to the compacted low-permeability soil components of the composite liner (i.e., floor and sidewalls), the composite cover designs, compacted foundation fill, and low-permeability fill for containment berms, temporary and permanent berms, stormwater basin dikes, and fill embankments. The composite liner design consists of (from bottom to top) a 5-foot thick compacted low-permeability soil layer (low-permeability earth liner) overlain with a 60-mil HDPE geomembrane, cushion geotextile, 1-foot thick granular drainage layer, and filter geotextile. The composite cover design consists of (from bottom to top) a 2-foot-thick compacted low-permeability soil layer (final cover barrier soil), a 40-mil LLDPE geomembrane, a geocomposite drainage layer, and a 3-foot-thick vegetative protective layer.

8.1 Procedures and Observation

The COIA will observe all compacted low-permeability earth liner, final cover barrier soil, compacted foundation fill, low-permeability containment berm, temporary and permanent berm, and stormwater basin dike soil construction activities and document relevant observations to support certification of the following requirements:

- ❑ Compaction equipment similar to that used in the test fill shall be used in the actual, full-scale compacted low-permeability earth liner and final cover barrier soil.
- ❑ The same compaction procedures employed in the test fill shall be utilized for the actual low-permeability earth liner, compacted foundation fill, final cover barrier soil, and low-permeability berms and basins, such as the number of passes, speed, and uniformity of coverage.
- ❑ The COIA will confirm the source and uniformity of the low-permeability borrow soils. Soil excavation and placement will be monitored for segregation and removal of unsuitable material and for changes in soil type, color, texture, and moisture content. Additional characterization and testing will be completed if borrow soils for the conditions anticipated during design change from those used in the test pad.
- ❑ The Construction Contractor will segregate and/or remove unsuitable materials such as granular soils, silty or sandy clays not meeting acceptance criteria, boulders, cobbles, and organic material. Additionally, the Construction Contractor will remove any stones greater than 2 inches in diameter observed in the low-permeability earth liner and final cover barrier soil placed within 6 inches of the geomembrane liner. Prior to compaction of the final lift of low-permeability soil, the material will be checked for the presence of sharp objects and angular stones by visual inspection. Any stones or clods larger than 4-inches in least dimension will be removed prior to placing compacted foundation fill.

Following compaction of the final lift, the material will be checked again for the presence of sharp objects and angular stones by visual inspection. Any stones observed will be removed.

- ❑ The COIA will measure field densities and moisture contents, to document that the compacted low-permeability earth liner is in substantial conformance with the placement specifications and that soil placement has been conducted in a manner to achieve a uniform, homogeneous mass.
- ❑ Any areas of unacceptable compaction density or moisture content will be documented by the COIA. Corrective action will consist of moisture conditioning of

the soil and/or additional compactive effort as necessary. Following corrective actions, such areas will be retested. Rework and testing will continue until satisfactory conditions have been achieved.

- Loose lift thicknesses for low-permeability soil compaction will not exceed 9 inches, or the thickness of the compactor foot. If soil is deposited in thickness exceeding 9 inches, dozers will be used to spread the soil to a 9-inch thickness prior to compaction. This will assure adequate reduction of clod size and provide a thin enough layer to achieve required compaction throughout the lift.
- If necessary, surfaces of liner to receive successive lifts of low-permeability soil will be moisture conditioned either by scarification and addition of water where desiccated, or by discing and air drying where too wet to promote effective bonding of lifts. Water will be applied with a spray bar applicator by a tank truck or equivalent methods to achieve uniform distribution following scarification.
- Low-permeability soil compaction will be performed in a manner to achieve continuous and complete keying together of all segments of low-permeability soil construction. Stepped joints will be utilized to connect any lateral segments of low-permeability soil construction.
- Preconstruction planning will be done to sequence construction activities which minimizes the length of time any completed low-permeability soil surfaces are exposed prior to receiving protective cover. Protective cover will be provided by installation of the geomembrane. Surfaces will be maintained until protective cover is placed.
- Construction of the composite liner system, consisting of both the floor and sidewalls, will be done in accordance with the low permeability earth liner specifications and the minimum liner strength will be consistent for both the floor and sidewalls.
- Construction of the low-permeability soil layers or features will proceed only during favorable climatic conditions.
- No frozen soils will be used for low-permeability soil construction. Any frozen soils in the compaction work area will be removed.
- The final surface of the low-permeability earth liner and final cover barrier soil will be compacted with a smooth drum roller to provide a level surface for installation of the geomembrane liner. Preconstruction planning will be done to minimize the need for traffic over the completed liner surface. Heavy trucking of materials and cleated equipment will not be allowed directly on completed liner surfaces. If this is unavoidable, an evaluation will be made upon termination of the haul route to determine if the liner should be reconstructed or repaired in such areas. Floatation-type all-terrain vehicles will be used to assist in deployment of the geomembrane liner to avoid disruption of the completed low-permeability soil liner surface.
- When the completed compacted low-permeability soil is exposed prior to geomembrane deployment, moisture conditioning of the liner surface will be employed as necessary to prevent desiccation.

8.2 Sampling Requirements and Acceptance Criteria

Field and laboratory sampling frequencies are based on proportionate sampling of construction areas or volume of material placed. This section describes required analysis, methods, sample frequency, and acceptance limits. The COIA will perform field tests and collect soil samples for laboratory analysis.

8.2.1 Field Testing

The following field testing methods will be used by the COIA during construction of low-permeability soils:

Parameter	Method
Moisture Content & Soil Density	ASTM D6938

Field density and moisture content tests will be performed at a minimum frequency of 5 tests per acre per lift (6-inch) for the final cover barrier soil and for the low-permeability earth liner. Field density and moisture content tests will be performed at a minimum frequency of 1 test per 1,000 cubic yards for the compacted foundation fill, containment berms, temporary and permanent berms, stormwater basin dikes, and fill embankments. At a minimum, at least one field density/moisture content test will be conducted per lift and at least one test per day of compacted low-permeability soil construction. This sampling distribution will confirm that compaction is spatially uniform. A nuclear density-moisture gauge will be used for field moisture and density determination.

8.2.2 Field Testing Acceptance Criteria

Acceptance criteria for field density and moisture content of the compacted foundation fill and low-permeability earth liner will require soil compaction to a minimum of 95 percent of the Standard Proctor maximum dry density, or to a minimum of 90 percent of the Modified Proctor maximum dry density, at a moisture content equal to or greater than optimum. The acceptance criteria for field density and moisture content of the final cover barrier soil and the containment berms, temporary and permanent berms, stormwater basin dikes, and fill embankments will require soil compaction to a minimum of 90 percent of the Standard Proctor maximum dry density, or to a minimum of 85 percent of the Modified Proctor maximum dry density. Visual inspections will be performed to verify that the soil is free of organics (roots, leaves, grasses, etc.) and that the maximum size of the stones/clods in the soil is approximately 3 inches.

8.2.3 Laboratory Testing

Routine laboratory testing of the compacted low-permeability soils will be performed on samples from the low-permeability soil borrow area and in-place low- permeability soils collected by the COIA. Samples for determining in-place properties will be collected by an appropriate method for obtaining intact, undisturbed samples. Soil characteristics will be determined from representative samples.

Undisturbed Sample Analysis

Laboratory hydraulic conductivity of the in-place low-permeability earth liner will be completed:

Hydraulic conductivity	ASTM D5084 or SW 846-EPA Method 9100

The hydraulic conductivity testing frequency is based on the USEPA Technical Guidance Document, which states that if a test pad has demonstrated that the field-scale hydraulic conductivity is satisfactory, the QA program for the actual soil liner should focus on establishing that the actual liner is built of similar materials and to equal or better standards compared to the test pad, and that laboratory hydraulic conductivity testing is not necessary. This Section describes the procedures to be implemented to ensure that the actual liner is built of similar materials and to equal or better standards compared to the test pad. Given the historical consistency of the soils available on-site, an industry standard hydraulic conductivity testing frequency of 1 per 10,000 cubic yards of low-permeability soil placed is included in this CQA Plan as an added measure of liner performance. At the discretion of the CQA Officer, the hydraulic conductivity testing frequency may increase if borrow sources change.

The CQA Officer shall also have the discretion to forgo Internal Shear Strength Testing provided the test liner results satisfy the material requirements specified in Table 13.

Representative Sample Analysis

Representative (grab) samples will be obtained on the basis of three criteria. First, an initial sample will be obtained from the low-permeability soil borrow source and analyzed prior to construction. This will confirm soil characteristics and provide an initial maximum dry density value for compaction testing. The representative sample obtained for the test liner may be used to satisfy this initial sample requirement. Second, routine samples will be obtained for every 10,000 cubic yards placed. Third, in the event that changes in physical appearance or soil characteristics are observed, a sample will be obtained and analyzed. The maximum dry density value used for compaction testing may be adjusted during the course of liner construction based on the results of the above sampling.

The following laboratory analyses will be performed on all representative samples obtained:

Parameter	Test Method
Moisture-Density Relationship using Standard or Modified Proctor Compaction	ASTM D698 or ASTM D1557
Atterberg Limits	ASTM D4318
Grain-size Analysis*	ASTM D7928 (particle size smaller than no. 200 sieve) ASTM D6913 (particle size larger than no. 200 sieve)
Soil Classification per USCS (Unified Soil Classification System)	ASTM D2487

* The former grain size analysis standard (ASTM D422) was withdrawn by ASTM in 2016.

At a minimum, one representative sample per soil source per construction season shall be collected be analyzed for remolded hydraulic conductivity at 95% of the Standard Proctor density (or 90 of the Modified Standard Proctor density) for the low-permeability earth liner and compacted foundation fill, and 90% of the Standard Proctor density (or 85% of the Modified Proctor density) for the final cover barrier soil and detention basin sidewalls as follows:

Remolded Hydraulic Conductivity	ASTM D5084 or SW846-EPA Method 9100

Interface shear testing of the low-permeability earth liner and final cover barrier soil to the geosynthetics will also be completed per ASTM D5321. Testing shall be conducted at least once prior to use and upon change in materials (including soil type) comprising the interface, and at least once every 18 months. The CQA Officer shall determine if a change in soil type has occurred that warrant interface shear testing of materials that interface with that soil type. See Table 12 for the required specifications.

Laboratory Testing Acceptance Criteria

- Hydraulic conductivity shall be no greater than 1 x 10^{-7} cm/s for low-permeability earth liner and compacted foundation fill.
- Percent passing No. 200 sieve shall be at least 50% for the low-permeability earth liner.
- Hydraulic conductivity shall be not greater than 1 x 10^{-5} cm/s for final cover barrier soil and detention basin sidewalls, as required by stormwater detention basin design details.
- Percent passing No. 200 sieve shall be at least 20% for final cover barrier soil.
- Plasticity index shall be at least 4% for low-permeability liner, as long as hydraulic conductivity is no greater than 1 x 10^{-7} cm/s.
- Plasticity index shall be at least 4% for stormwater detention basin sidewalls, as long as hydraulic conductivity is no greater than 1 x 10^{-5} cm/s.
- Plasticity index shall be at least 4% for the final cover barrier soil. PI less than 4% may be acceptable, as long as hydraulic conductivity is no greater than 1 x 10^{-5} cm/s.
- Internal shear strength of the low-permeability soils must meet the shear strength window requirements in Table 13. The average of the samples shall be used to determine compliance with the project specifications, however no single test shall be less than 75% of the specified strength value.
- Atterberg Limits and Grain Size Analysis will be used to classify soils per the USCS. Clay soils with USCS classification as CH, CL, or CL-ML are acceptable for low-permeability earth liner material. Soils with USCS classification as CH, CL, CL-ML, ML, SC, or SM/SC are acceptable for the final cover barrier soil material and for the detention basin sidewall material, provided they meet the hydraulic conductivity specification.

8.3 Surveying

The top of low-permeability soil liner and final cover barrier soil will be surveyed on the same 100-foot grid pattern and other locations surveyed for subgrade grades. Other locations include breaks in grade, toe of slope, and top of sideslopes. In the alignment of undercuts for leachate collection lines, top of liner elevations will be surveyed at 50-foot intervals. Vertical survey tolerance will be 0.0 to +0.1 foot, and horizontal tolerance will be 0.5 foot. The low-permeability soil liner thickness will be determined at all surveyed locations and reported in table fashion. The minimum acceptable low-permeability earth liner thickness will be 5 feet perpendicular to the slope. The minimum acceptable final cover barrier soil thickness will be 2 feet perpendicular to the slope. The location and elevation of all samples will be recorded. Devices may be employed to document final cover barrier soil thickness.

9.0 GENERAL SOILS

General soils will be used for construction of the final cover protective cover soil layer, which consists of at least 36 inches of fill with the upper 6 inches capable for supporting vegetation. Stormwater berms are also to be constructed as protective cover soil. General soils may be any inorganic soil, except rock, and will be obtained from on-site stockpiles or directly from the subgrade excavation. Generally, these soils will consist of segregated excavation soils that do not meet the low-permeability soil liner soil specifications. For general soils used for construction of final cover protective cover soil layer, the first lift above the geosynthetics in the final cover will not contain stones greater than 2-inches diameter or other sharp objects that could damage the underlying geosynthetics, and the upper 6-inches will consist of natural, fertile top soil. Alternatively, the upper 12-inches of the cover will be amended with fertilizer or other approved material to ensure turf establishment. High odor potential materials will not be used to amend protective cover soils. Seeding, fertilizing, and mulching of general soils for establishment of vegetation is discussed in Section 18.0.

9.1 Procedures and Observation

The COIA will observe general soil placement activities and document relevant observations to support certification of the following requirements:

- ❑ The COIA will confirm the source and uniformity of general soils used. Soil excavation and placement will be monitored for segregation and removal of unsuitable material and for changes in soil type that may affect maximum dry density values used for determining percent compaction.
- ❑ The Construction Contractor will segregate and/or remove unsuitable materials such as boulders and organic material.
- ❑ General soils used for the final cover protective layer construction shall not be compacted; however, loose lift thickness shall not exceed 36 inches.
- ❑ Confirm that the soil over geosynthetic materials on the final cover sideslopes is placed from bottom of the slope upwards toward the top of the slope.
- ❑ No frozen soils will be used for general fill construction.
- ❑ Prior to seeding, the final protective layer will be worked to prepare a suitable seed bed.
- ❑ Fertilizing, seeding, and mulching will be performed in a timely manner.

9.2 Sampling Requirements and Acceptance Criteria

Field and laboratory sampling frequencies are based on proportionate sampling of construction areas or volume of material placed. This Section describes required analysis, methods, sample frequency, and acceptance limits. The COIA will perform field tests and collect soil samples for laboratory analysis. General soils placed for the final cover protective cover soil layer are not to be compacted, and thus field testing, sampling, and laboratory analysis will not be conducted.

9.2.1 Field Testing

No field testing will be required for the protective cover soils.

9.2.3 Laboratory Testing

Laboratory testing of the protective cover soil will be performed on representative samples from the general fill source and on representative samples of in-place fill collected by the COIA.

Representative Sample Analysis

Representative (grab) samples will be obtained for an initial sample will be obtained from the general fill source and analyzed prior to construction. In the event that changes in physical appearance or soil characteristics are observed, a sample will be obtained and analyzed.

Parameter	**Test Method**
Soil Classification per USCS	ASTM D2487(Unified Soil Classification System)

Additionally, interface shear testing of the protective cover soil to the geocomposite drainage layer in the final cover will be completed per ASTM D5321. Testing shall be conducted at least once prior to use and upon changes in material comprising the interface, and at least once every 18 months. See Table 12 for the required specifications and acceptable window.

9.3 Surveying

The top of the protective cover grades will be surveyed on the same 100-foot grid pattern and other locations surveyed for top of final cover barrier soil grades. Other locations include breaks in grade and toe, and top of sideslopes. Vertical survey tolerance will be 0.0 to +0.1 foot, and horizontal tolerance will be 0.5 foot. The protective cover thickness will be determined at all surveyed locations and reported in table fashion. The minimum acceptable protective cover thickness will be 3 feet normal to the slope. Devices may be employed to document protective cover thickness.

10.0 GRANULAR SOILS

Granular soils refer to materials to be used as the granular drainage layer on the landfill base overlying the geotextile and geomembrane or coarse aggregate to be used for transmission of leachate and structural support of leachate collection pipes. All granular soils should be rounded to sub-angular.

10.1 Procedures and Observation

The COIA will observe granular soil placement activities and document relevant observations to support certification of the following requirements:

- ❑ The COIA shall periodically observe loads of granular soils for general conformance to material specifications and may randomly sample questionable loads. The COIA will perform routine conformance sampling.
- ❑ No tracked or rubber-tired equipment will travel directly on the geomembrane. Only low-ground pressure equipment may operate over the geomembrane when there is a 12-inch minimum layer of granular drainage material in-place. Procedures for deployment of pipe, sand, coarse aggregate, and/or geotextiles overlying any placed geomembranes will be planned at the Pre-Construction Meeting. No equipment shall apply a ground pressure greater than 5 psi on the geomembrane. Any special requirements for geomembrane protection and equipment necessary to deploy materials must be approved by the CQA Officer.
- ❑ In the Site 2 North Expansion a 12 oz/yd^2 geotextile cushion will be placed between the geomembrane and granular drainage layer and coarse aggregate in leachate collection lines, and an 8 oz/yd^2 geotextile filter will be placed on top of the granular drainage layer and coarse aggregate to minimize the entry of fines into the leachate collection system.
- ❑ A minimum of 6 inches of stone shall be placed under leachate collection pipes prior to pipe placement, and a minimum of 6 inches of stone shall be placed over the top of leachate collection pipes.
- ❑ Verify that the granular drainage layer thickness is 1 foot nominal to the surface.
- ❑ If granular soils are stockpiled on-site prior to use, measures should be taken to minimize contamination by fines such as wind-blown particles and surface soils during loading operations.
- ❑ Verify that the coarse aggregate (pipe bedding material) directly abuts the leachate collection layer placed during a preceding phase of construction and that any previously placed rainflap has been removed.
- ❑ Verify that the granular drainage layer (drainage layer material) directly abuts the leachate drainage layer placed during a preceding phase of construction and that any previously placed rainflap has been removed.

10.2 Sampling Requirements and Acceptance Criteria

Field sampling and laboratory testing frequencies are based on proportionate sampling of construction areas or volume of material placed. This section describes the required analysis, methods, sampling frequency, and acceptance limits. The COIA will collect soil samples for laboratory analysis.

10.2.1 Field Testing

No field testing will be required for granular soils. However, as above, the COIA will perform visual inspection of granular soils for conformance to material specifications and may randomly sample questionable loads, per ASTM D4288.

10.2.2 Laboratory Testing

Representative (grab) samples will be obtained from the proposed granular soil source prior to the delivery of any material. The source sampling frequency will be dependent on the apparent uniformity of the source and must be approved by the CQA Officer.

Grab samples of granular soils placed will be collected and analyzed as follows:

Soil Type	Frequency	Parameter	Test Method
Drainage Layer Material	1 test per source per phase	Grain size* (particle size larger than No. 200 sieve)	ASTM D6913
Drainage Layer Material	1/5,000 CY	Hydraulic conductivity	ASTM D2434
Drainage Layer Material	1/5,000 CY	Soil Class. per USCS	ASTM D2487
Pipe Bedding Material	1 test per source per phase	Grain size* (particle size larger than No. 200 sieve)	ASTM D6913
Pipe Bedding Material	1 test per source per phase	Soil Class. per USCS	ASTM D2487

* The former grain size analysis standard (ASTM D422) was withdrawn by ASTM in 2016.

Additionally, interface shear testing of the granular drainage layer and the cushion geotextile will be completed. This will be completed per ASTM D5321. Testing shall be conducted at least once prior to use and upon change in materials comprising the interface, and at least once every 18 months. See Table 12 for the required specifications and acceptable windows.

Laboratory Testing Acceptance Criteria

For laboratory testing acceptance criteria of the granular drainage layer material, see Table 13.

10.3 Surveying/Thickness Determination

The finished elevation of the granular drainage layer will be documented by one of two methods to verify its thickness: survey on the same 100 foot grid as the final low-permeability soil liner surface, or physical measurement of the in-place thickness on a maximum 100 foot grid. The leachate collection pipe alignments shall be documented at locations of pipe fittings and intersections (e.g. wyes and tees). Stone placed along leachate collection pipe alignments will be surveyed for elevation prior to pipe placement and following pipe backfilling at 50-foot intervals to document the thickness of stone placed below pipe inverts and above the top of pipe.

11.0 GEOMEMBRANES

This section of the CQA Plan applies to the high density polyethylene (HDPE) geomembrane used in the composite liner and the linear low density polyethylene (LLDPE) geomembrane used in the final cover system.

The geomembrane will be supplied to the site in factory rolls. No factory seams will be used to prepare larger panels of geomembrane for delivery to the site. This CQA Plan, therefore, does not contain any QA/QC requirements for factory seaming.

This section is divided into four major subheadings which cover the QA requirements for the Pre-Installation (includes Resin Manufacturers and Geomembrane Manufacturers), Installation, Field Seaming, and Post-Installation (includes the final examination of the geomembranes prior to placing the appropriate material above the geomembrane). The terms Pre-Installation, Installation, Field Seaming, and Post-Installation are applicable only to the geomembrane installation and do not apply to the overall construction of the landfill facility.

11.1 Pre-Installation

This section describes the quality control measures that are applicable to the polyethylene (PE) Resin Manufacturers, Geomembrane Manufacturers, and finished geomembrane roll delivery to the site prior to installation.

The geomembranes must be fabricated from polyethylene resin, and the fabricated geomembrane must be classified as Type III Class C Category 4 or 5 as defined by ASTM D1248. (Note: these classifications are based on tests performed on the finished product, not the polyethylene resin used to fabricate the geomembrane.)

11.1.1 Manufacturing

Material Specifications

The following list specifies the required geomembrane materials for liner and final cover construction:

Composite liner on floor and sideslopes 3:1	60-mil Textured HDPE
Final cover on plateau and sideslopes 4:1	40-mil Double-Sided Textured LLDPE

The CQA Officer will confirm that the geomembrane utilized has adequate interface fiction properties based upon the actual materials/products that are used for construction.

Quality Control Requirements

Prior to the delivery of any geomembrane rolls to the site, the Geomembrane Manufacturer will provide the CQA Officer with the following information:

- ❑ The resin supplier, location of supplier's production plant(s), and resin brand name and lot number.

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- ❑ Any test results conducted by the Geomembrane Manufacturer and/or the Resin Manufacturer testing laboratories to document the quality of the resin used in fabricating the geomembrane.
- ❑ The Quality Control Plan that the Geomembrane Manufacturer will be using for the geomembrane being supplied.
- ❑ Every roll of geomembrane for delivery to the site must be manufactured and inspected by the Geomembrane Manufacturer according to the following requirements:
  - First quality polyethylene resin must be used.
  - The resin shall contain no more than 10% rework (which must originate from the same resin type as the parent material).
  - No post-consumer resin of any type shall be used.
  - Natural resin (without carbon black) shall meet the requirements for density, melt flow index, and oxidative induction time (OIT) as listed on Tables 1 and 3 for HDPE and LLDPE, respectively.
  - The geomembrane must contain no more than a maximum of 1 percent by weight of additives, fillers, or extenders, excluding carbon black.
  - The geomembrane must have no striations, roughness (except for where the textured geomembrane is specified), or bubbles on the surface.
  - The geomembrane must be free of holes, blisters, undispersed raw materials, or any other sign of contamination by foreign matter.

The Geomembrane Manufacturer will routinely perform specific gravity (ASTM D792) tests on the raw resin to document the quality of the resins used to manufacture the geomembrane rolls designated to this project. The results will be submitted to the CQA Officer.

Manufacturer's Certification

The Geomembrane Manufacturer will provide certification, based on tests performed in accordance with Tables 1 and 3 (see Section 20) by either the Geomembrane Manufacturer's laboratory or other outside laboratory contracted by the Geomembrane Manufacturer, that the geomembrane supplied under this CQA Plan will meet the specifications listed in Tables 1 and 3.

Additionally, the Manufacturer shall provide certification that the Manufacturer's Quality Control Plan was (or will be) fully implemented for the geomembrane material supplied under this CQA Plan. The Manufacturer shall provide documentation to verify results of the Manufacturer's Quality Control Plan implementation if requested by the CQA Officer.

11.1.2 Delivery, Handling, and Storage of Geomembrane Roles

The geomembrane will be protected during shipment from excessive heat or cold, puncture, cutting, or other damaging or deleterious conditions. The geomembrane rolls will be stored on-site in a designated area and will be protected from long-term ultraviolet exposure prior to actual installation.

Each geomembrane roll will be marked by the Geomembrane Manufacturer with the following information on a durable gummed label, or equivalent, on inside of core:

- ❑ Name of manufacturer
- ❑ Product type and identification number (if any)
- ❑ Batch lot number
- ❑ Nominal product thickness
- ❑ Date of manufacture
- ❑ Roll number
- ❑ Roll length and width

When cores are required for preparing geomembranes for shipment, the contractor shall require the Manufacturer to use cores with sufficient crushing strength to avoid collapse or other damage while in use.

The following practices should be used as a minimum in receiving and storing geomembrane rolls in the designated storage area at the job site:

- ❑ The Installer shall be responsible for unloading, handling and storing all materials, supplies, and equipment in accordance with the Manufacturer's recommendations.
- ❑ While unloading or transferring the geomembrane rolls from one location to another, prevent damage to the geomembrane itself. The preferred method involves use of a spreader-bar, straps, and a loader. Do not drag rolls.
- ❑ Store the geomembrane rolls to ensure that they are adequately protected from the following:
    - Equipment damage
    - Strong oxidizing chemicals, acids, or bases
    - Flames including welding sparks
    - Temperatures in excess of 160°F
    - Soiling

The COIA will observe and document, throughout the pre-installation, installation, and post-installation periods that the Installer provides adequate handling equipment for moving geomembrane rolls and that the equipment and the handling methods used do not pose unnecessary risk of damage. The Installer is responsible for means and methods to implement the work.

The Installer will be responsible for assuring that all materials installed meet specifications. The COIA will maintain a log of geomembrane roll deliveries. The following information, at a minimum, will be recorded on the log for each shipment received at the job-site:

- ❑ Date of receipt of delivery at job-site
- ❑ For each geomembrane roll the following information will be noted:
    - Roll number
    - Batch lot number

11.2 Installation

This section includes discussions of geomembrane roll testing requirements, earthwork required for geomembrane placement, placement of the geomembrane, defects and repairs of geomembranes, and requirements applicable to other materials in contact with the geomembranes.

All parties involved in the installation of the geomembrane should be familiar with geomembranes and should emphasize protection of the geomembrane from damage during construction activities.

11.2.1 Test Methods

Geomembrane roll samples will be collected by the COIA as per the testing frequency mentioned in Material Acceptance Specifications Tables included in Section 20 of this CQA Plan. At least one sample shall also be obtained for each geomembrane production batch in each shipment. The Installer shall not ship to, nor receive at the site, geomembrane from more than two production batches in any single shipment without the prior written approval of the CQA Officer.

Samples will be 3 feet long by the full width of the roll and will not include the first 3 feet of any roll. Since machine direction for geomembrane rolls is the direction that the material comes off the roll, machine direction for any sample will always be along the 3-foot-length dimension of the sample.

Tables 1 and 3 in Section 20 list the tests and the test methods to be performed on the HDPE and LLDPE geomembrane roll samples. Specifications and methods used in evaluating the results are discussed below under Procedures for Determining Geomembrane Roll Test Failures. Unless specified, preparation of sample specimens will be performed in accordance with the referenced test method. Results for tear resistance and each of the tensile property tests will be reported for both the machine and cross direction.

Interface Shear Testing

The Operator will coordinate with the Geomembrane Manufacturer to submit a representative sample of the geomembranes and other applicable materials (e.g. low-permeability earth liner/final cover barrier soil materials, granular drainage layer materials, and geocomposite drainage layer materials) to the Geosynthetic Testing Laboratory for shear testing.

The following interfaces will be interface direct shear tested prior to each phase of the Geomembrane installation:

- ❑ Double-sided Geocomposite Drainage Layer vs. Final Cover 40-mil Textured LLDPE Geomembrane.
- ❑ Final Cover 40-mil Textured LLDPE Geomembrane vs. Final Cover Barrier Soil.
- ❑ 60-mil Textured HDPE Geomembrane vs. Low-permeability Earth Liner.
- ❑ 60-mil Textured HDPE Geomembrane vs. 12 oz Cushion Geotextile.

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The Geomembrane interface shear testing combination shall be conducted based on the permitted design material at least once prior to first use and upon a change in materials comprising the interface (change in Manufacturer(s), material or manufacturing process).

Geomembrane-Earth Liner interface shear testing shall be conducted prior to each phase of Geomembrane installation, and at least once every 18 months. The interface shear testing frequency can be relaxed to once per 12 acres of additional installed liner for interfaces which have demonstrated compliance with the specified minimum interface adhesion and friction angle (or secant angle) criteria during each of the three most recent interface shear tests that were performed on different lots of geosynthetic materials. The relaxed testing frequency only applies when the materials comprising the interfaces have not changed, e.g. the earth materials have not changed appreciably and are from the same source as previously tested (i.e. the same borrow pit for imported material and the same geological unit for earth materials obtained onsite). The geosynthetic materials also must be of the same type and manufacturing process, and sourced from the same Manufacturer as materials which were previously tested.

Geomembrane-Cushion Geotextile interface shear testing shall be conducted at least once prior to first use and upon a change in materials comprising the interface (change in Manufacturer(s), materials or manufacturing process). Interface shear testing shall be conducted prior to each phase of installation along the landfill sideslopes, and at least once every 18 months. The interface shear testing frequency can be relaxed to once every 48 months for materials which have demonstrated compliance with the specified minimum interface adhesion and friction angle (or secant angle) criteria during each of the three most recent interface shear tests that were performed on different lots of geosynthetic materials. The relaxed testing frequency only applies when the materials comprising the interfaces have not changed, e.g. are from the same Manufacturer(s), and are of the same type and manufacturing process as materials which were previously tested.

Geomembrane-Final Cover Barrier Soil interface shear testing shall be conducted prior to each final cover construction event of Geomembrane installation on the 4:1 (horizontal to vertical) final cover slopes after the effective date of this CQA Plan, but need not be retested more than once per construction season.

Geomembrane-Geocomposite Drainage Layer interface shear testing shall be conducted at least once prior to first use and upon a change in materials comprising the interface (change in Manufacturer(s), materials or manufacturing process). Interface shear testing shall be conducted prior to each phase of installation along the landfill sideslopes, and at least once every 18 months. The interface shear testing frequency can be relaxed to once every 48 months for materials which have demonstrated compliance with the specified minimum interface adhesion and friction angle (or secant angle) criteria during each of the three most recent interface shear tests that were performed on different lots of geosynthetic materials. The relaxed testing frequency only applies when the materials comprising the interfaces have not changed, e.g. are from the same Manufacturer(s), and are of the same type and manufacturing process as materials which were previously tested.

All interface shear testing results shall meet the window requirements specified in Table 12.

Role of Testing Laboratory

The Geosynthetic Testing Laboratory will be responsible for performing the tests on samples submitted to them as described above under Test Methods. Results of tests performed will be reported to the CQA Officer and the COIA.

Retesting of geomembrane rolls for quality assurance purposes, because of failure to meet any or all of the acceptance specifications listed in Tables 1 and 3 (see Section 20), can only be authorized by the CQA Officer.

The Geomembrane Manufacturer and/or Installer may perform their own tests according to the methods and procedures defined in Tables 1 and 3; however, the results will only be applicable to their own quality control needs. These results will not be substituted for the quality assurance testing described herein.

Procedures for Determining Geomembrane Roll Test Failures

Tables 1 and 3 (see Section 20) list the acceptance specifications for the HDPE and LLDPE geomembranes. These tables apply to both textured and nontextured geomembranes. For tests where results are reported for both machine and cross direction, each result will be compared to listed specification to determine acceptance.

The values listed in the acceptance specifications of Table 1 are from GRI GM-13 Revision 16. The values listed in the acceptance specifications of Table 3 are from GRI GM-17 Revision 14. If the specifications in GM-13 and GM-17 are further revised in the future by GRI, the revised specifications will be used.

The following procedure will be used for interpreting results:

- If the test values meet the stated specifications in Tables 1 and 3 (see Section 20), then the roll and the lot will be accepted for use at the job-site. If the sample represents all rolls from an entire shipment, then the entire shipment will also be considered accepted.
- If the result does not meet the specifications, then the roll and the batch may be retested using specimens either from the original roll sample or from another sample collected by the COIA. For retesting, two additional tests will be performed for the failed test procedure. Each additional test will consist of multiple specimen tests if multiple specimens are called for in the test procedure. If both of the retests are acceptable, then the roll and batch will be considered to have passed this particular acceptance test; if either of the two additional tests fail, then the roll and batch will be considered unsuitable without further recourse. The CQA Officer may obtain samples from other rolls in the batch. On the basis of testing these samples, the CQA Officer may choose to accept a portion of the batch while rejecting the remainder.
- If retesting does not result in passing test results as defined in the preceding paragraph, or if there is any other nonconformity with the material specifications, then the Installer shall withdraw the rolls from use in the project at the Installer's sole risk, cost, and expense. The Installer shall be responsible at its sole risk, cost, and expense for removing this geomembrane from the site and replacing it with acceptable geomembrane.

11.2.2 Earthwork

The Construction Contractor will be responsible for preparing the supporting soil according to the CQA Plans and specifications. The Construction Contractor will remove any stones greater than 2-inch diameter from the uppermost 6 inches of recompacted low-permeability soil liner below the geomembrane. Abrupt changes will be removed in grade, including ridges one inch or more left from smooth drum rolling and cracking greater than 0.5-inches in either width or depth. For installation of any of the geomembranes, the Installer will certify in writing that the surface on which the geomembrane will be installed is acceptable. This certification of acceptance will be reported daily by the Installer prior to the start of geomembrane installation in the area under consideration. Unacceptable areas noted by the Installer will be immediately reported to the COIA.

The soil surface will also be examined daily by the COIA to ensure the surface on which the geomembrane will be installed, does not contain undesirable objects and to evaluate any areas softened by precipitation or cracked due to desiccation. The daily observation will be documented in the daily report. Areas determined to be unacceptable will be reworked until acceptable.

11.2.3 Placement

Location and Layout Drawing

A layout drawing for the geomembrane installation covered by this CQA Plan will be prepared by the Installer prior to installation and submitted to the CQA Officer, showing the location of geomembrane panels to be installed and anchorages to be installed. Panel layout drawings are not required for repairs.

Installation Techniques

Geomembrane panels will be installed using one of the techniques described below. The Installer will determine the method that best suits the conditions at the time of installation considering factors such as schedule and weather conditions.

- All geomembrane panels are placed prior to field seaming, in order to protect the underlying soil from rain, etc. Seams may be tack-welded or sand-bagged to prevent the geomembrane panels from shifting and to maintain proper overlap for eventual seaming.
- Geomembrane rolls are placed one at a time, and each panel is seamed immediately after placement.
- Any combination of the above two techniques.

If a decision is reached to place all panels prior to field seaming, care should be taken to facilitate drainage in the event of precipitation. Scheduling decisions must be made during placement in accordance with varying conditions. The COIA will evaluate every change in the schedule proposed by the Installer and will advise the CQA Officer on the acceptability of that change. The COIA will document that the condition of the supporting soil has not changed detrimentally during installation.

The COIA will record the roll number, location, and date of each geomembrane panel installed to document that the placement plan is followed. In addition, the COIA will document the following:

- Equipment used does not damage the geomembrane by handling, excessive heat, leakage of hydrocarbons, or by other means.
- Personnel working on the geomembrane do not smoke, wear damaging clothing, or engage in other activities that could damage the geomembrane.
- Method used to unroll the geomembrane does not cause scratches or crimps in the geomembrane and does not damage the supporting soil.
- Method used to place the rolls minimizes wrinkles and slack.
- Adequate temporary loading or anchoring (continuously placed, if necessary), which will not damage the geomembrane, will be placed to prevent uplift by the wind.
- Direct contact with the geomembrane will be minimized. The geomembrane will be protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected. No direct contact with the geomembrane by heavy equipment, automobiles, or all-terrain vehicles will be allowed.
- Method used to construct and backfill the anchor trench to prevent damage to the geomembrane.
- Ensure rub sheets are removed to the extent possible following liner installation.
- Confirm that the in-place geomembrane is adequately ballasted to prevent displacement.
- Observe anchor trench backfilling and compaction as specified.
- The geomembrane anchor trenches shall be constructed to the lines, grades, and minimum dimensions shown on the drawings and shall be free of loose or disturbed material, debris, and standing water upon geomembrane placement.
- Stones greater than 2 inches in diameter placed within 6 inches of the geomembrane liner will be removed.

The COIA will inform the CQA Officer and document if any of the above conditions are not fulfilled.

Weather Conditions

Geomembrane placement will not be performed in an area of ponded water, during precipitation events, in the presence of excessive winds, or if the ambient air temperature is less than 32°F or above 104°F (unless demonstrated by the Installer and approved by the CQA Officer). The COIA will document that this condition is fulfilled. The CQA Officer will cause to cease or postpone the geomembrane placement when conditions are unacceptable. With the approval of the CQA Officer, geomembrane placement may be performed in adverse weather conditions if all necessary steps are taken to provide an acceptable environment for geomembrane placement and welding.

Damages

The COIA will examine each panel for damage after placement and determine which panels, or panel portions, should be rejected, repaired, or accepted. Damaged panels or panel portions that have been rejected will be marked, and their removal from the site will be recorded by the COIA. Panel repairs will be made according to the procedures described below.

11.3 Defects and Repairs

This section applies to all defects and repairs resulting from examinations, tests, or visual observations performed on the geomembrane material itself and on the seams used in joining rolls in the field.

11.3.1 Identification

All seam and non-seam areas of the geomembranes will be examined and documented by the COIA for identification of defects, holes, blisters, undispersed raw materials, and any signs of contamination by any foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane will be clean at the time of examination. The geomembrane surface will be swept with a broom and/or washed by the Installer if the amount of dust or mud inhibits examination.

11.3.2 Evaluation

Each suspect area identified will be nondestructively tested using the vacuum box test method. Each location that fails the non-destructive tests will be marked (according to the marking procedures agreed upon during the preconstruction meeting) and repaired by the Installer.

11.3.3 Repair Procedures

Any portion of the geomembrane exhibiting a flaw or failing a destructive or nondestructive test will be repaired. Several procedures exist for the repair of these areas. The procedures available include the following:

- ❑ Patching—used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter.
- ❑ Grinding and rewelding—used to repair small sections of extruded seams.
- ❑ Spot welding or seaming–used to repair small tears, pinholes, or other minor, localized flaws.
- ❑ Capping—used to repair large lengths of failed seams.
- ❑ Removal and replacement—used to replace nonconforming or damaged panels or portions thereof.
- ❑ Others may be used at the recommendation of the Installer if agreed upon by the CQA Officer and the COIA.

The repair procedures, materials, and techniques will be approved in advance of the specific repair by the CQA Officer, COIA, and Installer. At a minimum, the following provisions will be satisfied:

- ❑ Patches or caps will extend at least 6 inches beyond the edge of the defect, and all corners of patches will be rounded with a radius of at least 3 inches.
- ❑ Geomembrane surfaces must be clean and dry at the time of repair.

11.3.4 Examination of Repairs

Each repair will be numbered and logged according to the repair procedures agreed upon during the preconstruction meeting. Each repair will be nondestructively tested using a vacuum box for extrusion welds and air-pressure testing for fusion welds. Repairs that pass the above testing will be considered to be adequately repaired, except that large caps may be of sufficient extent to require destructive seam sampling and testing, at the discretion of the COIA.
Failed tests indicate that the repair was inadequate and will be redone and retested until a passing result is obtained. The COIA will document that repairs have been subjected to nondestructive testing and will record the number of each repair, the date, and the test outcome.

11.3.5 Large Wrinkles

When seaming of the geomembrane is completed, the COIA will examine the geomembrane for wrinkles and determine which wrinkles should be cut and repaired by the Installer. Each repair will be numbered, logged and nondestructively tested to the procedures agreed upon during the preconstruction meeting.

11.4 Field Seaming

This section covers the quality assurance procedures on seams used to join the rolls of geomembrane into a continuous layer. The installation of each of the geomembranes at the landfill facility will include 100 percent nondestructive testing of all field seams to determine openings or gaps along the seams. In addition, destructive testing will be performed at a routine interval for determining the strength and mode of failure of field seams in both the shear and peel modes.

The allowable field seam methods, equipment, personnel qualifications, and destructive and nondestructive testing methods are described in this section.

11.4.1 Seam Layout

The Installer will provide the CQA Officer and the COIA with seam layout drawings for each geomembrane installation covered by this CQA Plan showing each expected seam. The CQA Officer will review the seam layout drawing and document that it is consistent with the accepted practice and the design plans and specifications. Any variations of consequence, such as a change in overall seam direction, shall be reviewed by the CQA Officer before proceeding with seaming of said variations of consequence.

In general, horizontal seams will not be allowed on slopes steeper than 10 percent. However, at the discretion of the CQA Officer this practice may be modified. In corners and at other odd-shaped geometric intersections, the number of seams should be minimized. A seam numbering system comparable and compatible with the geomembrane roll numbering system will be agreed upon at the Preconstruction Meeting.

11.4.2 Seaming Equipment

The approved process for production field seaming (roll to roll) are the dual track fusion- type welding seam method and the extrusion welding process. Specialty seams and repair seams (non-production) will be done by the extrusion welding process. No other processes can be used without prior written authorization from the CQA Officer and the COIA. Dual-track welding should be used on panel-to-panel seams whenever possible.

Dual Track Fusion Welding Process

The Installer will meet the following requirements regarding the use, availability, and cleaning of the equipment to be used at the job-site:

- ❑ An automated self-propelled type of apparatus will be used.
- ❑ The welding apparatus will be equipped to continuously monitor applicable temperatures.
- ❑ One spare operable seaming device will be maintained on site at all times.
- ❑ Equipment used for seaming should not damage the geomembrane.
- ❑ The geomembrane should be protected in areas of heavy traffic to prevent damage.
- ❑ For cross seams, the edge of the cross seams will be ground to a smooth incline (top and bottom) prior to welding.
- ❑ For seam intersections the intersecting dual track seams shall be patched.
- ❑ The electric generator for the equipment will be placed on a smooth base in such a way that no damage occurs to the geomembrane. Similarly, a smooth insulating plate or fabric will be placed beneath the hot equipment after usage.
- ❑ A small movable piece of geomembrane may be used directly below each geomembrane overlap that is to be seamed to prevent buildup of water and/or moisture between the geomembrane sheets. The geomembrane piece is slid along the overlap as the seaming progresses. This piece is removed when the seam is completed.

The COIA will perform the following tasks relative to the use of dual hot wedge seaming devices:

- ❑ Log apparatus, ambient air, and geomembrane surface temperatures, and apparatus-operating temperatures and speed at appropriate intervals.
- ❑ Document that the Installer maintains on site the number of spare operable seaming devices agreed upon at the Pre-Construction meeting.
- ❑ Document that equipment used for seaming is not likely to damage the geomembrane.
- ❑ Document that for cross seams, the intersecting dual hot wedge seam is patched using the extrusion fillet process described below.
- ❑ Document that the electric generator is placed on a smooth base such that no damage occurs to the geomembrane.

- ❑ Document that a smooth insulating plate or fabric is placed beneath the hot equipment after usage.
- ❑ Document if a small movable geomembrane layer is used directly below each geomembrane overlap that is to be seamed to prevent buildup of water and/or moisture between the geomembrane sheets.

Extrusion Welding Process

The Installer will meet the following requirements regarding the use, availability, and cleaning of extrusion welding equipment to be used at the job-site:

- ❑ The welding apparatus will be equipped to continuously monitor temperature at the nozzle.
- ❑ One spare operable seaming device will be maintained on site at all times.
- ❑ Equipment used for seaming should not damage the geomembrane.
- ❑ The geomembrane should be protected in areas of heavy traffic to prevent damage.
- ❑ The extruder will be cleaned and purged prior to beginning seaming, and at any time that seaming operations are stopped, until all heat-degraded extrudate has been removed from the barrel.
- ❑ The electric generator for the equipment will be placed on a smooth base in such a way that no damage occurs to the geomembrane. Similarly, a smooth insulating plate or fabric will be placed beneath the hot equipment after usage.
- ❑ Grinding geomembrane surfaces for welding preparation shall not be performed more than 1 hour prior to seaming.

The Installer and, if applicable, the Geomembrane Manufacturer will provide documentation to the CQA Officer regarding the quality of the extrudate used in the welding apparatus. At a minimum, the extrudate should be compatible with the geomembrane liner material and contain the same grade and quality of polyethylene resin as used in the base material.

The Installer and COIA will perform the following tasks relative to the use of extrusion welding devices:

- ❑ Log apparatus (machine number/ ID), extrudate, ambient air, and geomembrane surface temperatures at appropriate intervals.
- ❑ Document that the Installer maintains on site the number of spare operable seaming devices agreed upon at the Pre-Construction meeting.
- ❑ Document that equipment used for seaming is not likely to damage the geomembrane.
- ❑ Document that the extruder is purged prior to beginning a seam until all heat degraded extrudate has been removed from the barrel.
- ❑ Document that the electric generator is placed on a smooth base such that no damage occurs to the geomembrane.
- ❑ Document that grinding is completed no more than 1 hour prior to seaming.

- ❑ Document that a smooth insulating plate or fabric is placed beneath the hot equipment after usage.

11.4.3 Personnel Qualifications

All personnel performing seaming operations will be qualified by experience or by successfully passing seaming tests for the type of seaming equipment to be used. At least one seamer will have experience seaming a minimum of 2,000,000 ft^2 of polyethylene geomembrane using the same type of seaming apparatus to be used at the landfill facility. The most experienced seamer, the "master seamer," will have direct supervisory responsibility at the job-site over less experienced seamers. At least 90% of the seams shall be completed by seamers who have installed at least 100,000 ft^2 of geomembrane.

The Installer will provide a list of proposed seaming personnel and their experience records to the CQA Officer and the COIA for their review and approval.

11.4.4 Weather Conditions

The range of weather conditions under which geomembrane seaming can be performed are as follows:

- ❑ Unless otherwise authorized in writing by the CQA Officer, no seaming will be attempted or performed at an ambient temperature below 32°F or above 104°F.
- ❑ Geomembrane will be dry and protected from the wind.
- ❑ Seaming will not be performed during any precipitation event unless the Installer erects satisfactory shelter to protect the geomembrane areas for seaming from water and/or moisture.
- ❑ Seaming will not be performed in areas where ponded water has collected below the surface of the geomembrane.

If the Installer wishes to use methods that may allow seaming at ambient temperatures below 32°F or above 104°F, the Installer will demonstrate and certify that the methods and techniques used to perform the seaming produce seams that are entirely equivalent to seams produced at temperatures above 32°F and below 104°F, and that the overall quality of the geomembrane is not adversely affected.

The COIA will document the following items:

- ❑ Ambient temperature at which seaming is performed.
- ❑ Any precipitation events occurring at the site, including the time of such occurrences.

The COIA will inform the CQA Officer if any of the weather conditions are not being fulfilled. The CQA Officer will cause to cease or postpone the geomembrane seaming when weather conditions are unacceptable.

11.4.5 Overlapping and Temporary Bond

The Installer will be responsible for the following:

- ❑ Panels of geomembranes have a finished overlap of a minimum of 3 inches for extrusion welding and 4 inches for fusion welding; but, in any event, sufficient overlap will be provided to allow peel tests to be performed on the seam.

- No solvents or adhesives will be used on the geomembranes unless the product has been approved in writing by the CQA Officer. Approval can only be obtained by submitting samples and data sheets to the CQA Officer for testing and evaluation.
- Procedures used to temporarily bond adjacent geomembrane rolls does not damage the geomembrane; in particular, the temperature of the hot air at the nozzle of any spot welding apparatus is controlled such that the geomembrane is protected at all times against potential damage.

The COIA will log all appropriate data and information for the above requirements.

11.4.6 Trial Seams

Trial seams will be made on fragment pieces of geomembrane representative of actual material to be used to document that seaming conditions are adequate. Trial seams will be made at the beginning of each day of seaming period, and at least once every five hours thereafter, for each seaming apparatus used that day. Also, each seamer will make at least one trial seam each day. Trial seams will be made under the same conditions as actual seams. The trial seam samples will be at least 3 feet long by 1 foot wide after seaming, with the seam centered lengthwise. Seam overlap will be as indicated above under Overlapping and Temporary Bond.

The trial seams will be examined for squeeze-out, foot pressure applied by seaming equipment, and general appearance by the Installer. If the seam fails any of these examinations, it will be repeated until satisfactory seams are obtained.

The COIA will observe all trial seam procedures. A minimum of five specimens, each 1 inch wide, will be cut from opposite ends of the trial seam sample by the installer. The remainder of the sample shall be given to the COIA. The specimens will be subject to in field shear and peel tests conducted in accordance with the most recent edition of ASTM D6392. The weld visually must appear continuous and homogeneous and the test seam shall meet the current peel and shear strength criteria stipulated in the most current version of GRI-GM19a as noted in Tables 2 and 4 for HDPE and LLDPE, respectively.

If a specimen fails, a second trail seam shall be made, inspected, and tested. If the second test also fails, the seaming apparatus and seamer will not be accepted and will not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved.

The remainder of the trial seam sample will be identified and marked by the COIA as follows:

- The sample will be assigned a number and marked as to welding apparatus used and seamer name.
- The date, time, applicable welding equipment operating temperatures, and ambient temperature at the time of seaming.
- Whether the sample passes or fails.

The COIA will observe all trial seam procedures. The COIA may randomly select trial field samples for destructive testing by the Geosynthetic Testing Laboratory. Testing frequency will be at the discretion of the COIA.

If a trial seam sample fails a destructive test performed by the Geosynthetic Testing Laboratory, according to the acceptance criteria, then a destructive test seam sample(s) will be taken from each of the seams completed by the seamer during the shift related to the failed trial seam test. These samples will be forwarded by the COIA to the Geosynthetic Testing Laboratory and, if any of them fails the tests, the procedures described in Destructive Seam Testing will apply. The conditions of this paragraph will be considered met if a destructive seam test sample, collected and tested according to the provisions under Destructive Seam Testing has already been taken and passed.

11.4.7 Seam Preparation

The Installer will meet the following conditions for each of the geomembrane installations covered by this CQA Plan:

- ❑ Prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material.
- ❑ If seam overlap grinding is required, the grinding process will be completed according to the Geomembrane Manufacturer's instructions within 1 hour of the seaming operation, and in a way that will not damage the geomembrane or cause excessive striation of the geomembrane surface.
- ❑ Seams will be aligned so as to minimize the number of wrinkles and "fishmouths."

11.4.8 General Seaming Procedures

Unless otherwise specified, the general seaming procedures to be used by the Installer for each of the geomembrane installations covered by this CQA Plan, and observed by the COIA, will be as follows:

- ❑ As much as practical, field seaming shall start from the top of the slope down. Tack welds (if used) shall use heat only; no double sided tape, glue or other method will be permitted;
- ❑ The completed liner shall not exhibit any "bridging" or "trampolining" (i.e., lifting of geomembrane off the subgrade surface due to excessive tension on the geomembrane) at the time protective cover or other materials are being placed over the Geomembrane;
- ❑ Dual hot wedge fusion welding shall be used wherever possible;
- ❑ Fishmouths or wrinkles at the seam overlaps shall be "walked out" if possible or cut along the ridge of the wrinkle in order to achieve a flat overlap and the cut fishmouths or wrinkles seamed or patched;
- ❑ If seaming operations are to be conducted at night, adequate illumination shall be provided;
- ❑ Seaming shall be done under conditions which will eliminate overlap beads, beads on top of beads, and sharp creases on the bottom of seams;
- ❑ If an extrusion seam must be restarted, the end of the existing extrusion bead must be ground and the new seaming must start such that there is no less than a 2-inch overlap of the existing and new beads;

- ❑ Seaming shall extend to the outside edge of the geomembrane panels which shall be placed in the anchor trenches;
- ❑ Grinding shall be completed in accordance with Manufacturer recommendations; over-ground or improperly ground areas shall be replaced at no expense to Owner.

11.4.9 Nondestructive Testing

Each field seam will be nondestructively tested over its full length using one of the methods described in this section. The purpose of nondestructive testing is to determine the continuity of the seams. Nondestructive testing, at this stage of development, does not provide any information on the strength of seams. Seam strengths will be determined by destructive testing methods. Failure of any of the nondestructive or destructive tests will require the repair of the failed section.

Nondestructive testing as described in this section will be performed on seams for every geomembrane installation covered by this CQA Plan. The recommended test methods for conducting the nondestructive seam testing are the air pressure test for fusion welds and the vacuum box test for extrusion welds. These two nondestructive testing methods are described below.

The COIA will perform the following:

- ❑ Observe all nondestructive seam testing, and examine all seams for squeeze-out, foot pressure, and general appearance. Failure of these criteria will be considered as failure of the seam, and repair or reconstruction will be required.
- ❑ Document location, date, test unit number, name of tester, and outcome of all testing.
- ❑ Inform the Installer and CQA Officer of any required repairs.
- ❑ Confirm that appropriate repairs are made and that the repairs are retested nondestructively with passing results.

<u>Air Pressure Testing</u>

The following test procedures are applicable only to dual hot wedge fusion seams. The equipment for performing the test should meet the following minimum requirements:

- ❑ An air compressor or hand pump equipped with a pressure gauge and regulator capable of producing and sustaining a pressure of 50 psi and mounted on a cushion to protect the geomembrane surface.
- ❑ Fittings, rubber hose, valves, etc., to operate the equipment, and a sharp hollow needle or other approved pressure feed device.
- ❑ Air pressure monitoring device capable of indicating 150% of the minimum allowable testing pressure.

Air pressure testing will be performed according to the following procedure:

- ❑ Seal both ends of the seam to be tested.
- ❑ Insert needle or other approved pressure feed device into the air space at one end of the fusion welded seam.

- ❑ Energize the air compressor or hand pump and pressurize the air channel to a pressure of 25-30 psi. Close the valve and observe the pressure response in the seam air space. The pressure should soon stabilize, and then remain constant and without fluctuations.
- ❑ Record the initial test pressure in the seam. The results below must be met:

Geomembrane Thickness (mils)	Minimum Test Pressure (psi)	Maximum Test Pressure (psi)
40	25	30
60	25	30

- ❑ If pressure loss exceeds Maximum Permissible Pressure Differential or does not stabilize, locate faulty area, repair and retest seam.

  Maximum Permissible Pressure Differential

Geomembrane Thickness (mils)	Pressure Difference (psi)	Time Period (minutes)
40	4	2
60	3	5

- ❑ If pressure loss does not exceed the Maximum Permissible Pressure Differential over the time period outlined in the table above, then the seam is considered to have passed the nondestructive test.
- ❑ The Installer must verify that the air channel tested was not obstructed by noting a release of pressure at the end of the tested seam interval opposite the pressure gauge.

For any seam interval which fails the air pressure nondestructive test, additional nondestructive testing or visual inspection shall be used to identify, if possible, the faulty area of the seam. The faulty area shall be repaired and retested. If the faulty area cannot be identified, then the entire seam shall be repaired and retested.

<u>Vacuum Box Test</u>

Vacuum box testing is to be used on those seams made by the extrusion fillet process, to locate precisely the defects identified from air pressure testing, or to evaluate suspect seam and non-seam areas. Vacuum box testing shall be completed in accordance with ASTM D5641.

Vacuum box testing equipment must meet the following minimum standards:

- ❑ A five-sided vacuum box with an open bottom, a clear viewing panel on top, and a pliable gasket attached to the bottom.
- ❑ A vacuum assembly equipped with a pressure controller and pipe connections capable of achieving a vacuum of 10 psig.
- ❑ A vacuum gauge on the tank with a minimum operating range of 0 to 10 psig and a vacuum gauge on the vacuum box with a minimum operating range from 0 to 10 psig.

The following procedure will be used in performing the vacuum box test:

- ❑ Step 1: Seams to be tested should be clean and relatively free from soil or foreign objects that might prohibit a good seal from being formed between the vacuum chamber and the geomembrane.
- ❑ Step 2: Energize the vacuum pump and reduce the tank pressure to approximately 24 inches of water vacuum (or approximately 3 psig).
- ❑ Step 3: Wet a strip of geomembrane approximately twice the size of the vacuum box with the soapy solution.
- ❑ Step 4: Place and center the vacuum box with the gasket in contact with the geomembrane surface over the wetted area of the seam.
- ❑ Step 5: Applying a normal force to the top of the vacuum box, close the bleed valve and open the vacuum valve. Check to make certain that a tight seal is created between the geomembrane and the vacuum box. A minimum vacuum of 5 inches of water should be used for testing with the maximum allowable testing pressure never exceeding 10 inches of water vacuum.
- ❑ Step 6: With the vacuum drawn, use the viewing panel to examine the geomembrane seam for bubbles resulting from the flow of air through the seam. Continue this examination for not less than 10 seconds.
- ❑ Step 7: Remove the vacuum box by first closing the vacuum valve and opening the bleed valve. Proceed to Step 8 if bubbles appear in Step 6. If no bubbles appear in Step 6, then proceed directly to Step 9.
- ❑ Step 8: If bubbles appear through the geomembrane, the defective area should then be marked for repair. All repairs must be nondestructively tested with passing results.
- ❑ Step 9: Move the vacuum box along the seam to be tested, overlapping the previously tested area by no less than three inches.

11.4.10 Destructive Seam Testing

Destructive seam testing will be performed on the geomembrane seams covered by this CQA Plan. Destructive seam testing is performed to determine the strength of the seam in both shear and peel failure modes. Destructive seam testing should be performed within 48 hours of sampling either in an on-site laboratory by personnel under the direction of the CQA Officer or at the Geosynthetic Testing Laboratory. Samples will not be taken near high tensile stress areas.

<u>Location and Sampling Frequency</u>

The COIA will select locations where seam samples will be cut out for the destructive testing. Test locations will be determined during seaming at the COIA's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential causes of an imperfect seam. The Installer will not be informed in advance of any location where seam samples will be taken.

The minimum frequency of sample collection will be one test location per every 500 lineal feet of seam length per welder-seamer, per day unless otherwise approved by IEPA.

Sampling Procedure

Samples will be cut under the direction of the COIA as the seaming progresses. For each sample location, the following information will be documented:

- ❑ Assign a sample number and mark accordingly.
- ❑ Record sample location on layout drawing.
- ❑ By sample number, record the reason for collecting the sample (e.g., as part of statistical testing program, suspicious seam, etc.).
- ❑ Note on the sample, for the peel test, which geomembrane is the top and which is the bottom with respect to seams performed using dual hot wedge or fusion weld techniques.
- ❑ Record pertinent information including date, time, seaming unit number, seam number, and the name of the seamer.

Specimens for qualitative field and quantitative testing will be taken prior to removal of the laboratory sample. Samples for field tensiometer testing will be 1 inch wide by 12 inches long with the seam centered parallel to the width. The distance between the two samples should be 42 inches measured from inside edge to inside edge. If both samples pass the field tensiometer test described below under Field Test Methods, then the sample for laboratory testing will be taken according to the procedure described below.

The sample for laboratory testing will be located between the two samples used for field testing. Therefore, the laboratory sample will be 12 inches wide by 42 inches long with the seam centered lengthwise. The sample will be cut by the COIA into three parts and distributed as follows:

- ❑ A 12-inch-by-14-inch sample will be given to the Installer for testing if so desired.
- ❑ A 12-inch-by-14-inch sample will be given to the Owner for record storage.
- ❑ A 14-inch-by-18-inch sample will be transmitted to the Geosynthetic Testing Laboratory or on-site testing laboratory by the COIA.

The COIA will make periodic reports to the Installer detailing the locations of samples taken that must be repaired.

All holes cut into the geomembrane resulting from destructive seam sampling will be immediately repaired by the Installer in accordance with the repair procedures described in this Section. The repaired area will be nondestructively tested in accordance with the requirements of this Section.

Field Test Methods

The two 1-inch-wide samples for field tensiometer testing described above under Sampling Procedure will be qualitatively tested for both peel and shear. Quantitative test results shall be recorded and evaluated against the acceptance specifications listed in Tables 2 and 4 in Section 20. The seam will be considered as passing if the failure in both peel and shear does not occur within the seam. If the samples fail the field tensiometer test, then the seam reconstruction procedures for the repair of the defective seam must be implemented.

Laboratory Test Methods

Laboratory testing of the destructive seam samples will be performed by the Geosynthetic Testing Laboratory or on-site testing laboratory under the direction of the CQA Officer. All laboratory destructive seam tests, whether performed on trial seam samples or on samples cut out from production seams, will be performed in general accordance with the methodology of GRI-GM19a and ASTM D4437, which stipulates that at least five specimens should be tested in shear and five in peel. Samples will be cut in alternating order and should also be tested in the order of cutting, to determine if any trend in seam quality along the length of the sample exists. All specimens will be cut as 1-inch-wide strips.

The following tests will be performed on each seam sample submitted for laboratory testing:

- **Shear and peel maximum tension** is the maximum load per unit width of a 1-inch-wide specimen expressed in pounds per inch of width in both the shear and peel mode, according to ASTM D4437 as modified by GM-19a.
- **Shear elongation at break** is the extension at break expressed as a percentage of the initial distance between the edge of the fused track and the nearer grip. This distance should be the same on both sides of the seam and is usually 2 inches. No referenced ASTM test exists for this procedure as defined; however, the specimen will be elongated to a maximum of 100 percent with any failures of individual specimens noted. For specimens that fail below 100 percent elongation, the value that failure occurred at will be noted on the results.
- **Peel seam separation** estimates the area of seam interface separation expressed as a percentage of the original area.

Also, for both the seam shear and peel tension tests, an indication will be given for each specimen tested that defines the locus of the failure. The loci will be defined in accordance with GM-19a.

For seam shear tests, specimens should be inserted in the test machine with gauge lengths of 1 inch between each edge of the seam and the adjacent grip. The crosshead speed will be 2 inches per minute.

Parameters monitored during the test will be load and crosshead displacement. The test may be terminated when the crosshead has moved 2 inches.

For peel tests, specimens will be inserted in the tensile machine, so grips are no closer than 1 inch to the edge of the seam. The grips may be closer than 1 inch only if there is insufficient material to allow insertion at this setting. All seam peel specimens will be tested 2 inches per minute crosshead speed.

For shear tests, the following values will be reported for each specimen tested:

- Maximum tension in pounds per inch
- Elongation at break indicating at what percentage the specimen failed (up to a tested maximum of 100)

- ❑ The locus of failure using the above designations

For peel tests, the following values will be reported for each specimen tested:

- ❑ Maximum tension in pounds per inch
- ❑ Seam separation expressed as percent of original seam area
- ❑ Locus of failure

Role of Testing Laboratory

The Geosynthetic Testing Laboratory or on-site testing laboratory will be responsible for performing the tests on samples submitted to them as described above. Results of tests performed will be reported to the CQA Officer and the COIA. Retesting of seams, because of failure to meet any or all of the specifications listed below can only be authorized by the CQA Officer.

The Geomembrane Manufacturer and/or Installer may perform their own quality control testing in accordance with the methods and procedures defined above under Laboratory Test Methods; however, the results, if substantially different from those obtained by the Geosynthetic Testing Laboratory or on-site laboratory, may only be used to request a retesting by the Geosynthetic Testing Laboratory or on-site testing laboratory. All quality assurance test results from the Geosynthetic Testing Laboratory or on-site laboratory govern over any test results from the Geomembrane Manufacturer of Installer. Only the CQA Officer is authorized to approve a retesting request.

Procedures for Determining Destructive Seam Test Failures

The procedures described in this section apply to the destructive testing procedures defined above under Field Test Methods and Laboratory Test Methods. Procedures for repairing failed seams are given in this Section of this CQA Plan.

Results from the shear and peel tests for the HDPE and LLDPE geomembranes will be evaluated against the criteria in Tables 2 and 4.

All tabular criteria for each respective geomembrane type must be met for a given seam to be considered acceptable.

The Installer has the following two options in determining the repair boundary whenever a seam has failed either the field tensiometer testing or laboratory destructive testing:

- ❑ The seam can be reconstructed between any two previously tested and passed destructive seam test locations.
- ❑ The Installer can trace the welding path to an intermediate location (at a 10-foot minimum from the point of the failed test in each direction) and request that field tensiometer tests be performed at these intermediate locations. If the field tensiometer sample results are acceptable, then full laboratory samples are taken and tested. If the laboratory tests are acceptable, then the seam is reconstructed between these intermediate locations. If either sample fails, then the process is repeated until acceptable destructive seam tests have been performed in both directions away from the original failed sample location. All retesting of seams, according to this procedure, will use the sampling methodology described above

under Sampling Procedure.

For seams reconstructed due to a failing destructive seam sample, that are greater than 150 feet in length, an additional sample taken from the reconstructed zone must pass destructive seam testing.

The COIA will be responsible for documenting all actions, including test results submitted by the Geosynthetic Testing Laboratory, taken in conjunction with seam testing. The COIA will also be responsible for keeping the CQA Officer informed on seam testing results and seaming progress.

11.5 Post-Construction

Each geomembrane covered by this CQA Plan will be examined by the COIA. Any defects, whether due to failed seams, pinholes, or other penetrations, will be repaired. Deployment of the geotextile cushion and placement of the drainage layer material shall proceed as soon as practical following the COIAs testing and acceptance of completed geomembrane areas.

For pipe penetrations and appurtenances, the Installer and COIA shall verify that the following requirements are met:

- ❑ Seaming performed on and pipe penetrations, and other appurtenances will be non-destructively tested according to one of the following methods: (1) vacuum box method; (2) spark testing according to Manufacturer's recommended procedures; (3) factory testing, along with certification, of prefabricated seams (i.e., pipe boots).
- ❑ The geomembrane has not been visibly damaged while making connection to sumps and appurtenances; and
- ❑ Installation of the geomembrane in the area of the pipe penetrations and connections of the geomembrane to these structures and appurtenances have been made according to the approved engineering plans and shop drawings.

For soils placed above the geomembrane (or geotextile), the COIA shall document that the following general criteria is met:

- ❑ Do not place soils on the geomembrane at an ambient temperature below 32°F, nor above 104°F, unless otherwise specified.
- ❑ Do not drive equipment used for placing the soil directly on the geomembrane.
- ❑ A minimum thickness of 1 foot of soil is specified between a low ground pressure dozer (maximum contact pressure of 5 psi) and the geomembrane.
- ❑ A minimum thickness of 2 feet of soil is specified between tracked equipment (contact pressures exceeding 5 psi) and the geomembrane.
- ❑ A minimum thickness of 3 feet of soil is specified between rubber-tired vehicles and the geomembrane, including areas of heavy traffic.
- ❑ The geomembrane (geotextile) shall be covered within 30 days of completing geomembrane quality control and quality assurance testing.

11.6 Leak Location Survey

A leak location survey may be performed after completion of installation of geomembrane liner and/or drainage layer blanket, in accordance with ASTM D7007, Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials, or an equivalent method approved by the CQA Officer and Owner.

12.0 GEOTEXTILES

This section of the CQA Plan applies to non-woven geotextiles used in the final cover and leachate extraction system as cushion and filter geotextiles. A 12-ounce geotextile cushion will be placed over the geomembrane liner prior to placement of the leachate drainage layer material in the Site 2 North Expansion. An 8-ounce geotextile filter will be placed on top of the leachate drainage layer in the Site 2 North Expansion. And a 6-oz/yd^2 geotextile layer will be placed on top of the coarse aggregate bedding of the underdrain collection pipe system.

This section is divided into three major subheadings, which cover the quality assurance requirements for Pre-Installation (includes Geotextile Manufacturers), Installation, and Post-Installation (includes the final examination of the geotextiles prior to placing the appropriate material above the geotextile). The terms Pre-Installation, Installation, and Post-Installation are applicable only to the geotextile installation and do not apply to the overall construction of the landfill facility.

12.1 Pre-Installation

12.1.1 Manufacturing

Material Specifications

The following list specifies the required geotextile materials for construction of the Site 2 North Expansion:

Composite liner

Above coarse aggregate bedding of the underdrain collection pipe system	6 oz/yd^2
Above granular drainage layer/coarse aggregate on composite liner and sideslopes	8 oz/yd^2
Below granular drainage layer/coarse aggregate on composite liner and sideslopes	12 oz/yd^2

The Geotextile Manufacturer shall provide the Project Manager and the CQA Officer with a list of guaranteed properties for the type of geotextile to be supplied. The Geotextile Manufacturer shall provide the Project Manager and the CQA Officer with a written certification signed by a responsible party that the geotextile actually delivered has properties that meet or exceed the guaranteed properties. Material property values are provided in Tables 5, 6, 7, and 8.

Quality Control Requirements

Every roll of geotextile for delivery to the site must be manufactured and inspected by the Geotextile Manufacturer, according to the following requirements:

- ❑ The geotextile must contain no needles used for punching.
- ❑ The geotextile must be free of holes and any other sign of contamination by foreign matter.

12.1.2 Delivery, Handling, and Storage of Geotextile Rolls

Each geotextile roll, for use at the landfill facility, will be marked by the Geotextile Manufacturer with the following information and in the following manner:

- ❑ When fabric is rolled on a core, identify each roll with a durable gummed label, or an equivalent, on the inside of the core and on the outside of the protective wrapping for the roll.
- ❑ Each roll label will contain the following information at a minimum:
  - Name of manufacturer (or supplier)
  - Style and type number
  - Unit weight (ounces per square yard)
  - Roll length and width
  - Batch (or lot) number
  - Nominal product thickness
  - Date of manufacture
  - Direction for unrolling
  - Roll number

The Geotextile Manufacturer will use the following guidelines in packaging, wrapping, and preparing all geotextile rolls for shipment:

- ❑ When cores are required, use those that have a crushing strength sufficient to avoid collapse or other damage while in use.
- ❑ Cover each roll with a wrapping material that will protect the geotextile from damage due to shipment, water, sunlight, or contaminants.

The following practices should be used as a minimum in receiving and storing geotextile rolls in the designated storage area at the job-site:

- ❑ While unloading or transferring the geotextile rolls from one location to another, prevent damage to the wrapping or to the geotextile itself. If practicable, use fork lift trucks fitted with poles that can be inserted into the cores of rolls. Be sure that the poles are at least two-thirds the length of the rolls to avoid breaking the cores and possibly damaging the geotextile. Do not drag rolls.
- ❑ Store the geotextile rolls to ensure that they are adequately protected from the following:
  - Precipitation
  - Ultraviolet radiation, including sunlight
  - Strong oxidizing chemicals, acids or bases
  - Flames, including welding sparks
  - Temperatures in excess of 160°F
  - Soiling

The COIA will be responsible throughout the pre-installation, installation, and post-installation periods for observing and documenting that the Installer provides adequate handling equipment used for moving geotextile rolls and the equipment and that the handling methods used do not pose any risk of damage.

The COIA will be responsible for making certain that the Manufacturer, type, and thickness of each roll are correct. The COIA will also maintain a log of geotextile roll deliveries. The following information, at a minimum, will be recorded on the log for each shipment received at the job-site:

- Date of shipment from Geotextile Manufacturer
- Date of receipt of delivery at job-site
- For each geotextile roll the following information will be noted:
  - Roll number
  - Batch lot number

12.2 Installation

This section describes the quality assurance requirements applicable to the installation of non-woven geotextiles.

12.2.1 Placement

The Installer will install all geotextiles in such a manner to ensure that they are not damaged in any way and in a manner that complies with the following:

- On sideslopes, the geotextiles will be securely anchored and then rolled down the slope, or each roll will be mounted on a spreader bar suspended from a loader, lift, or similar heavy equipment and the geotextile will be unrolled by pulling down the slope. Geotextile panels will be deployed in such a manner as to continually keep the geotextile in tension.
- In the presence of winds, all geotextiles will be secured by other suitable methods. The temporary weighted material will be left in place until replaced with cover material as shown on the design plans and specifications.
- In-place geotextiles will be cut with special care to protect other materials from damage that could be caused by the cutting of the geotextiles.
- The Installer will take necessary precautions to prevent damage to any underlying layers during placement of the geotextile.
- During placement of geotextiles, care will be taken not to entrap in the geotextile any stones, excessive dust, or moisture that could damage the geotextile, or generate clogging of drains or filters.
- A visual examination of the geotextile will be carried out over the entire surface after installation by the Installer to ensure that no potentially harmful foreign objects, such as needles, are present.

The COIA will observe and document that each of the above steps are performed by the Installer. Any noncompliance with the above requirements will be reported by the COIA to the CQA Officer.

12.2.2 Seams and Overlaps

The following requirements will be met with regard to seaming and overlapping of geotextile rolls:

- ❑ Geotextile seams will be joined by overlapping, continuously sewing, wedge welding, or other methods approved by CQA Officer. Geotextiles will be overlapped by 6 inches. Seaming and stitching, if performed, will be done in the middle of the overlap.
- ❑ The Installer will pay particular attention to seams to ensure that no deleterious earthen materials could be inadvertently trapped beneath the geotextile.
- ❑ Sewing will be performed with thread made from the same base material as the geotextile, or suitable equivalent

The COIA will be responsible for observing and documenting that the above provisions are performed by the Installer in an acceptable manner. Any noncompliance with the above requirements will be reported by the COIA to the CQA Officer.

Any holes or tears in the geotextile can be repaired as follows:

- ❑ A patch from the same geotextile will be sewn or heat bonded in place with a 12- inch minimum overlap in all directions.
- ❑ Care will be taken to remove any soil or other material that may have penetrated the torn geotextile.
- ❑ The COIA will observe and document that the repair of any geotextiles is performed according to the above procedure.

12.3 Post-Installation

12.3.1 Final Examination

The COIA will perform a final geotextile examination after installation of each geotextile layer has been completed. The objectives of the final examination are as follows:

- ❑ Examine for presence of holes, tears, or other deterioration.
- ❑ Examine geotextile for excessive tension due to stretching of the fabric during installation.

If there will be an extended time delay between completion of the geotextile and the start of the installation of any overlying cover, then the Installer will make provisions, by temporarily covering or using other suitable methods, to protect the geotextile against exposure to sunlight and ultraviolet radiation.

12.3.2 Placement of Soil Materials

The Construction Contractor will place all soil materials located on top of a geotextile in such a manner as to minimize the following:

- ❑ Damage of the geotextile.
- ❑ Slippage of the geotextile on underlying layers.

- ❑ Excessive tensile stresses imposed on the geotextile.

The COIA shall document that the following general criteria is met:

- ❑ Do not place soil on the geotextile at an ambient temperature below 32°F nor above 104°F, unless otherwise specified.
- ❑ Do not drive equipment used for placing the soil directly on the geotextile.

13.0 GEOSYNTHETIC CLAY LINER

Geosynthetic Clay Liner (GCL) shall be installed in the leachate collection sumps, placed in between the low-permeability soil liner and Geomembrane liner. A summary of the required physical properties of the GCL can be found in the attached Table 11 (Geosynthetic Clay Liner Properties).

This section is divided into three major subheadings which cover the quality assurance requirements for Pre-Installation (includes GCL Manufacturers), Installation, and Post-Installation (includes the final examination of the GCL prior to placing the appropriate material above it). The terms Pre-Installation, Installation, and Post-Installation are applicable only to the geonet installation and do not apply to the overall construction of the landfill facility.

13.1 Pre-Installation

13.1.1 Manufacturing

The GCL Manufacturer shall provide the Project Manager and the CQA Officer with a list of guaranteed properties for the type of GCL to be supplied. The GCL Manufacturer shall provide the Project Manager and the CQA Officer with a written certification signed by a responsible party that the GCL actually delivered has properties that meet or exceed the guaranteed properties. Material property values are provided in Table 11.

13.1.2 Delivery, Handling, and Storage of GCL Rolls

Each GCL roll for use at the landfill facility will be marked by the GCL Manufacturer with the following information and in the following manner:

- ❑ Identify each roll with a durable gummed label, or an equivalent, on the inside of the core and on the outside of the protective wrapping for the roll.
- ❑ Each roll label will contain the following information at a minimum:
    - Name of manufacturer (or supplier)
    - Style and type number
    - Roll length and width
    - Batch lot number
- ❑ Date of manufacture
- ❑ Direction for unrolling
- ❑ Roll number

The GCL Manufacturer will use the following guidelines in packaging and preparing all geonet rolls for shipment:

- ❑ When cores are required, use those that have a crushing strength sufficient to avoid collapse or other damage while in use.

The following practices should be used as a minimum in receiving and storing GCL rolls in the covered storage area at the job-site:

- ❑ While unloading or transferring the GCL rolls from one location to another, prevent damage to the GCL. If practicable, use fork lift trucks fitted with poles that can be inserted into the cores of rolls. Be sure that the poles are at least two- thirds the length of the rolls to avoid breaking the cores and possibly damaging the GCL. Do not drag the rolls.

- ❑ Store the GCL rolls to ensure that they are adequately covered to protect from the following:
  - Precipitation
  - Ultraviolet radiation, including sunlight
  - Strong oxidizing chemicals, acids or bases
  - Flames, including welding sparks
  - Temperatures in excess of 160°F
  - Soiling

The COIA will be responsible throughout the pre-installation, installation, and post-installation periods, for observing and documenting that the Installer provides adequate handling equipment used for moving geonet rolls and that the equipment and handling methods used do not pose any risk of damage.

13.2 Installation

This section describes the quality assurance requirements applicable to the installation of GCL rolls.

- ❑ Ensure subgrade has been smooth rolled and free of debris, wheel ruts, sticks, rocks, or roots larger than 1 inch,
- ❑ Disapprove GCL deployment during inclement weather such as heavy rain, wind, snow, etc. unless specifically approved by the CQA Officer,
- ❑ Observe the GCL for defects prior to, during and after placement,
- ❑ Verify that the panels are placed as shown on the approved drawing, or as otherwise approved by the CQA Officer,
- ❑ Confirm that adjoining panels are overlapped, shingled, and loose granular bentonite has been applied in between.
- ❑ Confirm rub sheets are utilized for textured liner components installed above GCL,
- ❑ Observe the Contractor’s methods of placing and constructing the GCL into the leachate sumps, along with the overlying liner components to confirm that such methods do not damage the GCL, and
- ❑ Confirm that the in-place GCL is adequately ballasted to prevent displacement.

13.3 Post-Installation

The COIA will perform a final GCL examination after installation has been completed. The objectives of this step are as follows:

- ❑ Examine for presence of tears or defects.
- ❑ Examine overlaps and observe for excessive slack or wrinkles.

If any portion of the GCL requires repairs or replacements due to the above examination, they will be performed. The COIA will document the result of the final examination, including any subsequent repairs or replacements.

14.0 GEOCOMPOSITE

This section of the CQA Plan applies to geocomposites installed within the final cover drainage layer slopes and as required on floor subgrade and sideslope excavations. The double-sided geocomposite liner shall consist of non-woven 6-oz/yd^2 geotextile fabric heat bonded to the top and bottom of a geonet.

This section is divided into three major subheadings, which cover the quality assurance requirements for Pre-Installation, Installation, and Post-Installation. The terms Pre-Installation, Installation, and Post-Installation are applicable only to the geocomposite installation and do not apply to the overall construction.

14.1 Pre-Installation

The Geocomposite Manufacturer will provide the project manager and the CQA Officer with a list of guaranteed properties for the type of geocomposite to be supplied, per Tables 6 and 9 in Section 20 of this Plan. The Geocomposite Manufacturer will provide the project manager and the CQA Officer with a written certification signed by a responsible party that the geocomposites actually delivered have properties that meet or exceed the guaranteed properties. Material property values are provided in Table 10.

14.1.1 Interface Shear Testing

Additionally, the Operator will coordinate with the Geocomposite Manufacturer to submit a representative sample of the geocomposite to the qualified laboratory independent of the Geocomposite Drainage Layer Manufacturer for shear testing. Interface shear testing shall be once per construction season installation (or change in the manufacturer, materials, or manufacturing process) of the 4H:1Vor greater final cover slopes, and at least once every 18 months, as applicable:

- ❑ Geocomposite Drainage Layer vs. Protective Cover Soil
- ❑ Geocomposite Drainage Layer vs. 40-mil Textured LLDPE Geomembrane

The geocomposite interface shear testing shall not be required for repairs and/or installations totaling less than 1,000 square feet individually, and 10,000 square feet combined over a 12-month period.

14.1.2 Delivery, Handling, and Storage of Geocomposite Rolls

Each geocomposite roll, for use at the landfill facility, will be marked by the Geocomposite Manufacturer with the following information and in the following manner:

- ❑ When fabric is rolled on a core, identify each roll with a durable gummed label, or an equivalent, on the inside of the core and on the outside of the protective wrapping for the roll.
- ❑ Each roll label will contain the following information at a minimum:
    - Name of manufacturer (or fabricator)
    - Style and type number
    - Roll length and width
    - Batch lot number, if applicable

- Date of manufacture
- Direction for unrolling
- Roll number

The Geocomposite Manufacturer will use the following guidelines in packaging, wrapping, and preparing all geocomposite rolls for shipment:

- ❑ When cores are required, use those that have a crushing strength sufficient to avoid collapse or other damage while in use.
- ❑ Cover each roll with a wrapping material that will protect the geotextile from damage due to shipment, water, sunlight, or contaminants.

The following practices should be used as a minimum in receiving and storing geocomposite rolls in the covered storage area at the job-site:

- ❑ While unloading or transferring the geocomposite rolls from one location to another, prevent damage to the geocomposite. If practicable, use fork lift trucks fitted with poles that can be inserted into the cores of rolls. Be sure that the poles are at least two-thirds the length of the rolls to avoid breaking the cores and possibly damaging the geocomposite. Do not drag the rolls.
- ❑ Store the geocomposite rolls to ensure that they are adequately covered to protect the geocomposite from the following:
    - Precipitation
    - Ultraviolet radiation, including sunlight
    - Strong oxidizing chemicals, acids or bases
    - Flames, including welding sparks
    - Temperatures in excess of 160°F
    - Soiling

The COIA will be responsible throughout the pre-installation, installation, and post-installation periods for observing and documenting that the Installer provides adequate handling equipment used for moving geocomposite rolls and that the equipment and handling methods used do not pose any risk of damage.

The COIA will maintain a log of geocomposite roll deliveries. The following information, at a minimum, will be recorded on the log for each shipment received at the job-site:

- ❑ Date of shipment from Geocomposite Manufacturer
- ❑ Date of receipt of delivery at job-site
- ❑ For each geocomposite roll, the following information will be noted:
    - Roll number
    - Batch lot number, if applicable

14.2 Installation

This section describes the quality assurance requirements applicable to the installation of geocomposites.

14.2.1 Placement

The Installer will install all geocomposites in such a manner as to ensure that they are not damaged in any way and in a manner that complies with the following:

- ❑ On sideslopes, the geocomposites will be securely anchored and then rolled down the slope, or each roll will be mounted on a spreader bar suspended from a loader, lift, or similar heavy equipment and the geocomposite will be unrolled by pulling down the slope. Geocomposite panels will be deployed in such a manner as to continually keep the geonet in tension. If necessary, the geocomposite will be positioned by hand after being unrolled to minimize wrinkles.
- ❑ In the presence of winds, all geocomposites will be secured by suitable methods. The temporary weighted material will be left in place until replaced with cover material as shown on the design plans and specifications.
- ❑ Cutting should be done according to Manufacturer's recommendations.
- ❑ The Installer will take necessary precautions to prevent damage to any underlying layers during placement of the geocomposite.
- ❑ During placement of geocomposites, care will be taken not to entrap any stones, excessive dust, or moisture that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane.

The COIA will observe and document that each of the above steps are performed by the Installer. Any noncompliance with the above requirements will be reported by the COIA to the CQA Officer.

14.2.2 Overlaps and Joining

The following requirements will be used with regard to the overlapping and joining of geocomposite rolls:

- ❑ The geonet portion of the geocomposite shall be overlapped a minimum of 4 inches. The geonet shall be joined by HDPE or nylon ties every 5 feet. At panel ends, the geonet shall be overlapped 12 inches and joined by HDPE or nylon ties every 12 inches.
- ❑ Geocomposite end seams to be covered with a strip of same geotextile (1-ft W x Panel L) after being joined by ties and heat bonded to geocomposite.
- ❑ The geotextile portion of the geocomposite shall be overlapped a minimum of 6 inches. The geotextile above the geonet shall be continuously sewn or wedge welded along the length of the roll per the Manufacturer's recommendation.
- ❑ The Installer will pay particular attention to the overlap areas to ensure that no earthen or foreign materials could be inadvertently trapped beneath the geocomposite.
- ❑ Adjoining roll lengths in anchor trenches shall be connected using HDPE or nylon ties spaced no farther than 6 inches.

The COIA will observe and document that each of the above steps are performed by the Installer. Any noncompliance with the above requirements will be reported by the COIA to the CQA Officer.

14.2.3 Repairs

Any tears or other defects in the geocomposite will be repaired by placing a patch extending a minimum of 2 feet beyond the edges of the hole or tear. The patch will be secured to the original geocomposite by tying the geonet component every 6 inches and heat bonding or sewing the geotextile component. If the tear or other defect width is more than 50 percent of the roll width, the damaged area will be cut out and replaced with new geocomposite material. Tying devices will be as indicated above. The COIA will examine and document that the repair of any geonets is performed according to the above procedure.

14.3 Post-Installation

14.3.1 Final Examination

The COIA will perform a final geocomposite examination after installation of each geocomposite layer has been completed. The objectives of this step are as follows:

- ❑ Examine for presence of tears or defects
- ❑ Examine overlaps to make certain that they are in conformance with the requirements.

If any portion of the geocomposite requires repairs due to the above examination, they will be performed according to the procedures established for that portion.

If there will be an extended time delay between completion of the geocomposite and the start of the installation of any overlying cover, the Installer will make provisions, by using a temporary covering or other suitable methods, to protect the upper geotextile component against exposure to sunlight and ultraviolet radiation.

14.3.2 Placement of Soil Materials

The Construction Contractor will place all soil materials located on top of a geocomposite in such a manner as to minimize the following:

- ❑ Damage of the geocomposite
- ❑ Slippage of the geocomposite on underlying layers
- ❑ Tensile stresses
- ❑ Time delays due to inclement weather or construction sequencing to the extent practical

15.0 PIPING

This section of the CQA Plan applies to piping used throughout the facility. Piping will be used for conveying leachate from the leachate extraction system and landfill gas and condensate from gas extraction system. Piping will also be used to collect and discharge water from the final cover drainage layer.

Quality assurance efforts relating to the manufacturing, fabricating, delivery, initial on-site handling, installation and Post-Construction observations will be the responsibility of the COIA.

This section is divided into three major subheadings, which cover the QA requirements for the Pre-Installation (includes piping Manufacturers and fabricators), Installation, and Post-Installation (includes the final observation and documentation of piping installations prior to installation of other materials over and around the pipe). The terms Pre-Installation, Installation, and Post-Installation are applicable only to the piping installation and do not apply to the overall construction.

As a typical representation of the piping to be used throughout the facility, pipes will be SDR 17 and will range in size from 2 inches to 24 inches in diameter depending upon the required piping application. Individual pipe sizes and standard dimension ratios (SDRs) to be used for each individual pipe installation are not detailed in this section; the plans and specifications should be used for the determination of correct size and wall thickness.

15.1 Pre-Installation

This section describes the QA measures that are applicable to the polyethylene (PE) or polyvinyl chloride (PVC) resin Manufacturers, piping manufactures, piping fabricator used to perforate the pipe, and finished piping delivery to the site prior to installation.

15.1.1 Manufacturing

Material Specifications

The HDPE pipe used must be made from extra high molecular weight polyethylene (PE) resin, and the manufactured piping must be classified as Type III, Class C, Category 5, Grade P34 material according to ASTM D1248 and also have a cell classification of 345464C as defined by ASTM D3350. The PVC pipe and fittings used shall be manufactured from a PVC compound which meets the requirements of Cell Classification 12454-B polyvinyl chloride as outlined in ASTM D-1784. Pipe shall be free of paint or other surface treatment.

Fabricator

The Piping Fabricator will be responsible for perforating the pipe delivered by the Piping Manufacturer according to the plans and specifications. The Piping Fabricator will be responsible for preparing and shipping the perforated pipe to the job-site.

15.1.2 Delivery, Handling, and Storage of Piping

The pipe will be protected, during shipment, from excessive heat or cold, puncture, or other damaging or deleterious conditions. The pipe will be stored on-site in a manner suitable to protect it from long-term ultraviolet exposure prior to actual installation.

The COIA will be responsible throughout the pre-construction, construction, and post construction periods for observing and documenting that the Installer provide adequate handling equipment for moving pipe and that the equipment and handling methods used do not pose any risk of damage. The contractor is responsible for means and methods to implement the work. The COIA will document that the Manufacturer and the type and size of each pipe is correct.

15.2 Installation

This section describes the requirements applicable to pipe installation. This section includes installation, testing, observations, and documentation of piping installation.

15.2.1 Pipe Seams

Unless approved otherwise by the CQA Officer, HDPE pipe seams will be made by the butt fusion procedure in accordance with Manufacturer's specifications. Care will be taken to make certain adequate pressures are used for fusing pipes and that sufficient cooling periods are allowed prior to testing, bending, or backfilling a pipe section. Unless approved otherwise by the CQA Officer, PVC pipe seams will be in accordance with ASTM D-2855. A coating of CPS primer as recommended by pipe supplier shall be applied to the entire interior surface of the fitting socket, and to an equivalent area on the exterior of the pipe prior to applying solvent cement. The solvent cement shall comply with the requirements of ASTM D-2564 and shall be applied in strict accordance with Manufacturer’s specifications.

15.2.2 Placement Requirements

Pipe placement will be done in accordance with the following procedures and requirements:

- ❑ Piping placement will not be performed in the presence of excessive moisture. The COIA will document that this condition is fulfilled. Additionally, the COIA will document that the supporting backfill has not been damaged by weather conditions. The COIA will inform the CQA Officer if any of the above conditions are not fulfilled for evaluation of the necessity of corrective action.
- ❑ The prepared surface underlying the piping has not deteriorated since previous acceptance, and it is still acceptable immediately prior to piping placement.
- ❑ Each piping system will be flushed with water. The COIA will observe and document that each flushing operation is carried out and will document that the pipes are free flowing. Any system that does not flush properly will be immediately reported to the CQA Officer, and corrective action will be taken to remedy the problem.
- ❑ Method used to place the piping does not cause damage to the piping and does not disturb the supporting backfill.
- ❑ The COIA will observe and document all pipe installation. Deviations from the plans and specifications will be brought to the attention of the CQA Officer for evaluation of the necessity of corrective action.

- Observations and measurements should be made to ensure that the pipes are the specified size, manufactured of the specified material, and that pipe perforations are sized and spaced as specified.
- All piping should be located as noted in the plans and specifications. Locations, grades, and size requirements are specified on the details of the plan set. Observations and surveying measurements should be made to insure the pipes are placed at the specified locations and grades, and the specified configuration. Observations should be made throughout the construction to ensure that backfilling is completed as specified in the plans and specifications and that, in the process, the pipe network is not damaged.
- Non-perforated pipe will be pressure tested: Landfill gas and gravity flow leachate pipes shall be pressure tested at 5 psi for 60 minutes; condensate pipe and forcemain pipes shall be pressure tested at 50 psi for 60 minutes; air supply lines shall be pressure tested at 150 psi for 60 minutes.

15.2.3 Damages

The COIA will examine each pipe after placement for damage. Damaged pipes or portions of pipes which have been rejected will be marked and removed from the installation area and documented by the COIA.

15.3 Post-Installation

Pipe inverts (or top of pipe elevations) and coordinate locations shall be surveyed at 50- foot intervals and at all tee connection locations. The maximum allowable tolerance for grade is 0.10 feet at each location. The minimum average slope shall be in accordance with the design drawings.

16.0 SURFACE WATER CONTROL FACILITIES

The CQA Plan applies only to permanent surface water control facilities, including retention basins, overflow structures, culverts, ditches, riprap, erosion matting, diversion berms, flumes, and velocity dissipaters. Temporary facilities such as silt fencing and temporary diversion berms are not subject to the requirements of this CQA Plan but may be subject to the facility's SWPPP.

16.1 Procedures and Observation

Construction observation by the COIA will be required for some, but not all, drainage facilities. Generally, construction observation will be required for drainage features that will be backfilled and cannot be subsequently documented. This will be the case for culverts greater than 50 feet in length and any required undercuts, i.e., undercut for riprap placement, etc. Other structures, including basins, ditches, and diversion berms, can be documented in-place following construction as soil testing will not be required for these structures.

The following procedures and observations will be used for the construction of surface water drainage facilities.

- ❑ Detention basins will be constructed by excavating soils to the designed basin grades.
- ❑ Drainage ditches will be constructed by excavation of existing soils along the ditch alignment.
- ❑ Low-permeability soil cover quality soil will be used for construction of diversion berms. The Construction Contractor shall employ reasonable compaction procedures; however, soil testing will not be required.
- ❑ The Construction Contractor shall employ reasonable compaction procedures for backfilling culverts; however, soil testing will not be required.
- ❑ The COIA will observe the placement of filter fabric below riprap areas.
- ❑ The COIA will field verify the placement of erosion matting.
- ❑ The COIA will observe the installation of basin overflow structures and verify components and sizes. Backfill procedures will be observed to verify reasonable compaction; however, testing will not be required.
- ❑ Low-permeability soil cover quality soil will be used for construction of spillway berms. The Construction Contractor shall employ reasonable compaction procedures; however, soil testing will not be required.

16.2 Surveying and Acceptance Criteria

Adequate survey information shall be obtained in the field following basin construction to plot the basin contours and prepare a record drawing. If a post- construction aerial topo is obtained, the topo will be supplemented with key spot elevations obtained from this survey. The survey information shall be sufficient enough for the CQA Officer to certify that basin construction has been completed within reasonable conformance with the design plan. The following tolerances will be observed:

- ❑ The tolerance for ditch invert elevations will be ±0.2 feet, providing positive drainage is maintained.

- ❑ Tolerance for diversion berm flow line elevations will be ±0.2 feet, providing positive drainage is maintained.
- ❑ Culvert invert elevations will be surveyed every 50 lineal feet (minimum), and culvert sizes will be field verified. The tolerance for culvert invert elevations will be ±0.1 feet, providing positive drainage is maintained.
- ❑ The subgrade and top of riprap areas will be measured at sufficient locations to verify the required thickness of riprap placement.
- ❑ Key components of basin overflow structures will be surveyed, including culvert inverts and inlet elevations. The tolerance for these elevations will be ±0.1 feet, providing positive drainage is maintained.

16.3 Deviations

The surface water design may be modified based upon unexpected conditions encountered in the field. Deviations from the designs that occur during construction/installation of stormwater runoff control structures shall be noted on the record drawings and accompanied by calculations showing that the hydraulic carrying capacity remains sufficient and erosion control principles were followed. Such deviations may include, but not be limited to, alternate slopes, locations, cross-sections, points of discharge and methods of erosion control.

17.0 GAS EXTRACTION WELLS

This section of the CQA Plan applies to standard gas extraction wells and vertical gas extraction caisson wells. Perforated high-density polyethylene (HDPE) or Polyvinyl Chloride (PVC) piping will be used for construction of the gas extraction wells. Horizontal gas extraction piping will be installed in accordance with the requirements in Section 15.0 of this CQA Plan.

Individual pipe sizes and standard dimension ratios (SDRs) to be used for each individual well installation are not detailed in this CQA Plan, rather the design and construction drawing plans should be used for the determination of correct size and wall thickness.

17.1 Installation of Gas Extraction Wells

The CQA Officer will observe well installation activities for conformance with the following procedures:

17.1.1 Drill or Bore Extraction Wells

The gas extraction wells will be drilled with minimum 36-inch diameter augers at the locations shown on the Drawings and to the total depth of the waste as directed by the CQA Officer. The CQA Officer (or surveyor) will survey and record the coordinates and surface elevation at each borehole location and obtain the corresponding landfill base elevation using available information. The depth to the landfill base will be calculated and provided to the driller. The driller will carefully monitor the auger depth and end each boring 10 feet from the landfill base. The actual location of the well may be adjusted if difficulty in drilling is encountered (rock, cables, metal, etc.) with approval of the CQA Officer. All wells will be drilled without drilling fluids.

All boreholes, regardless of depth, will be covered by plywood, barricaded, surrounded by orange safety mesh, or otherwise secured. Immediately after drilling and until completion of the well seal, an earthen berm around the borehole will be constructed and maintained to divert stormwater. All wells will be completed immediately after drilling to prevent loss of holes due to sloughing.

17.1.1.1 Waste Disposal

Drill cuttings shall be loaded and transported by the end of each day to the working face of the landfill and/or covered with approved daily cover or alternative daily cover material.

17.1.1.2 Well String

The well string is to be fabricated after completion of the boring and determination of actual well depths. This will allow for proper determination of perforated pipe length and proper finished elevation for the wellhead.

The well string, consisting of perforated and solid sections of HDPE or PVC pipe, will be joined together using the butt fusion process or glued and lag bolted, respectively according to the pipe Manufacturer specifications. A copy of the recommended fusion procedure supplied by the Manufacturer of the pipe used will be maintained on site at all times. The CQA Officer will inspect fused joints on the well string. Unacceptable joints will be cut out and re done.

The well string will be placed into the borehole and suspended. The well string will be centered and held in tension by the use of blocks, chains, etc., until the entire gravel pack and well seal has been installed.

17.1.1.3 Gravel Pack

The casing and gravel pack will be installed in the wells as soon as drilling is completed to prevent the loss of the holes due to sloughing.

The 1"- 3" stone should be carefully poured into the annular space. Care should be taken to keep the gravel clean and to keep the well string centered as much as possible. The gravel pack should be installed to a minimum of 1 foot above the perforations.

17.1.1.4 Geonet Layer and Lower Bentonite Plug

A geonet with heat bonded geotextile on one side shall be installed above the gravel pack to isolate the bentonite plug or seal from the gravel.

Following placement of the isolation layer, the lower bentonite plug is to be installed as follows:

- The lower well seal will be formed by evenly distributed one 50 lb. bag of dry Baroid "Benseal" or an approved equal around the annulus of the well and then adding 5 gallons of fresh water in a manner that will allow for a thorough saturating of the bentonite material. This process will be continued until a minimum plug thickness of three feet has been achieved.
- For proper installation of this well plug, the bentonite material must be placed evenly around the annulus before hydrating or gelling.

17.1.1.5 Soil Backfill

Above the lower bentonite plug, the boring annulus shall be backfilled with soil backfill up to the level indicated on the Drawings. Care must be taken in order to distribute the backfill around the annulus in a manner to provide as much compaction as possible.

17.1.1.6 Upper Bentonite Plug

Formation of the upper bentonite plug will be achieved in the same manner as described for the lower bentonite plug. A minimum thickness of 3 feet shall be achieved. The intent of this top plug is to tie into the existing cover or material while providing a positive seal against the well pipe. Actual field conditions encountered may require various adjustments or modifications to the plug as designed.

17.1.1.7 Well Completion

The wellhead assembly, or approved equal, will be attached to the pipe casing with a flexible coupling and stainless steel clamps. The lateral shall be connected with flex hose, clamps and a flexible coupling. After installation of the header system, lateral connections will be made to the well heads and the remote wellheads for the leachate cleanout risers.

17.1.2 Caisson Wells

Vertical gas extraction caisson wells may be installed in the landfill. Well construction may commence at either the top of the constructed granular drainage layer or installed after several lifts of waste. The primary components of the caisson well include a perforated well casing pipe for gas extraction, caisson pipe, and coarse aggregate. Caisson wells are similar to a traditional standard well; however, a perforated pipe will be used for the entire length of the well casing pipe until final conversion to a standard well.

For caissons installed starting from the top of the granular drainage layer, caisson well construction consists of placing of a minimum 3-foot diameter 10-foot tall column of coarse aggregate on the granular drainage layer. The stone column is constructed during initial waste placement. The well casing pipe and caisson pipe will be placed on top of the coarse aggregate column, and the annular space between the caisson and well casing pipes will be backfilled with coarse aggregate. The caisson pipe will typically be constructed of 36-inch HDPE pipe with an HDPE flange adapter welded to the top of the pipe. A larger diameter PVC slip cap will be temporarily placed on top of the perforated well casing pipe to inhibit deleterious materials and foreign objects from entering the well casing. Once the caisson is placed and backfilled with stone, the PVC slip cap will be removed, and the caisson top assembly will be placed over the perforated pipe.

Caisson wells that are installed after multiple waste lifts, an additional 20-foot by 20-foot coarse aggregate pad is centered above and in direct contact with the minimum 3-foot diameter 10-foot tall coarse aggregate column on the granular drainage layer. The stone pad is typically a minimum 2-feet thick and constructed during the initial waste lift placement. After the waste mass reaches the designated thickness over the stone pad, the caisson well is drilled in the same manner as traditional drill or bore extraction wells in Section 17.1.1 to the stone pad. The well casing pipe is placed, the borehole is backfilled with coarse aggregate and the caisson pipe and flange adapter installed per the design drawings.

Caissons wells will be raised as waste elevation increases. At the commencement of each caisson raising event, if necessary, the well will be disconnected from the gas collection and control system and the vacuum lateral riser will be properly capped and sealed. The caisson top will then be unbolted to expose the interior well casing pipe. With the perforated well casing pipe exposed, additional perforated pipe will be glued and lag bolted onto the existing well.

Once the perforated well casing pipe is extended, the caisson assembly will be gradually pulled up out of the waste mass using an excavator or equivalent. Waste will be placed around the raised caisson pipe at the required elevation for stability and protection during site operations. Once raised, additional stone will be placed in the annular space between the caisson and well casing pipes as needed. When the caisson top is reinstalled at the end of each raising event and bolted down, a flexible coupling and wellhead will be placed on the top of the caisson to allow the well to be placed into service for landfill gas extraction.

As waste reaches final grades, the caisson wells will be converted to standard wells, including installation of the geonet, bentonite plugs and solid pipe lengths consistent with design details. The caisson pipe will be permanently removed and the converted well will be added to the landfill gas collection network.

17.1.3 Documentation

The CQA Officer, with assistance from the Installer, will prepare an installation log for each extraction well including the following information:

- ❑ Number of Well Boring (from Site Plan Drawing)
- ❑ Date of Boring
- ❑ Total Depth of Boring
- ❑ Ground Surface Elevation
- ❑ Soil/Waste Profile
- ❑ Well Completion Details (including perforated length)
- ❑ Waste Temperature
- ❑ Other

18.0 SEEDING, FERTILIZING, AND MULCHING

Specifications for vegetative work shall follow Sections 250 and 251, “Seeding” and “Mulching”, in the Illinois Department of Transportation (IDOT) Standard Specifications for Construction. Seeding mixture should comply with Table 1 or equivalent as approved by the Engineer, with the specific seed mixture to be determined based on the planting time and location (sloped or flat area).

19.0 LEACHATE STORAGE TANKS

Specifications and installation requirements for the Leachate Storage Tanks will be based on the specific project and need at the time, type of tank chosen (i.e., shop fabricated, bolted, single-walled, double-walled, etc.), and the material of construction (i.e., steel, fiberglass, etc.). Once the type of tank and material of construction is decided for a given specific application, the Facility will prepare applicable specifications and installation requirements. Installation will also be done in accordance with the Manufacturer's specifications.

By field observations, review of the Manufacturer's literature and installation guidelines, the CQA Officer will document tank installation and tank capacity, leachate compatibility, secondary containment and tank integrity. Secondary containment volume should be equal to 110% of the capacity of the largest tank within each secondary containment structure.

20.0 MATERIAL ACCEPTANCE SPECIFICATION TABLES

Table 1 60-mil Textured HDPE Geomembrane Acceptance Specifications			
Properties	**Test Method**	**Required Values (14)**	**CQA Test Frequency**
Thickness mils (min. ave.) (1) (CT) • Lowest individual for 8 of 10 • Lowest individual, any of 10	D5994	60 mil (15) 57 mil (15) 57 mil (16)	1 per Roll
Asperity Height mils (min. ave.) (2) (CT)	D7466	20 mil	1 per 2 Rolls (3)
Sheet Density (min. ave.) (CT)	D1505/D792	0.940 g/cc	1 per 200,000 lb
Tensile Properties (min. ave.) (4) (CT) • Yield strength • Break strength • Yield elongation • Break elongation	D6693 Type IV	126 lb/in. 90 lb/in. 12% 100%	1 per 20,000 lb
Tear Resistance (min. ave.) (CT)	D1004	42 lb	1 per 45,000 lb
Puncture Resistance (min. ave.) (CT)	D4833	90 lb	1 per 45,000 lb
Stress Crack Resistance (5)	D5397 (App.)	500 hr	(13)
Carbon Black Content (range) (CT)	D4218 (6)	2.0-3.0%	1 per 20,000 lb
Carbon Black Dispersion (7) (CT)	D5596	(7)	1 per 45,000 lb
Oxidative Induction Time (OIT) (min. ave.) (8) • Standard OIT or • High Pressure OIT	D8117 D5885	100 min. 400 min.	1 per 200,000 lb (13)
Oven Aging at 85ºC (8) (9) • Standard OIT (min. ave.) - % retained after 90 days or • High Pressure OIT (min. ave.) - % retained after 90 days	D5721 D8117 D5885	55% 80%	1 per each formulation (13)
UV Resistance (8) • Standard OIT (min. ave.) (11) or • High Pressure OIT (min. ave.) - % retained after 1600 hrs (12)	D7238 D8117 D5885	N.R. (11) 50% (12)	1 per each formulation (13)
Required Peak Interface Friction Value (17)	D5321	See Table 12	1 per combination of materials in liner system cross-section per construction period

(CT) Conformance testing shall be performed on the geomembrane material by a 3rd party laboratory for these properties only, at the rates shown above in Table 1.
(1) Lowest reading ≥57 mil.
(2) Asperity height is owner designated and exceeds GRI GM-13, Rev. 16.
(3) Alternate the measurement side for double sided textured sheet.
(4) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
- Yield elongation is calculated using a gage length of 1.3 inches.
- Break elongation is calculated using a gage length of 2.0 inches.

(5) The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
(6) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.
(7) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
- 9 in Categories 1 or 2, and
- 1 in Category 3

Table 1 Notes Continued:

(8) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(9) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
(10) The condition of the test should be 20 hr. UV cycle at 75oC followed by 4 hr. condensation at 60oC.
(11) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
(12) UV resistance is based on percent retained value regardless of the original HP-OIT value.
(13) Manufacturer shall provide certification letter.No CQA Testing is Required.
(14) Based on GRI GM-13, Rev. 16. Current GRI standards shall be used in the event of changes to the GRI specifications.
(15) IEPA regulations are more stringent than GM-13, Rev. 16, specification of 57 mil.
(16) IEPA regulations are more stringent than GM-13, Rev. 16, specification of 51 mil.
(17) See Table 12 for shear strength acceptance criteria.

Table 2 60-mil Textured HDPE Geomembrane Seam Testing Summary			
Properties	**Test Method (3)**	**Minimum Field and Lab Test Frequency**	**Acceptance Criteria**
Shear Test (2)	ASTM D6392 (excl. Section 6.3, "Conditioning") GRI GM19a	1 test per 500 lf and at least 1 test per seaming crew per day	See GRI GM19a, Rev. 10 or current version at time of construction.
Peel Test (2) Hot Wedge Fusion	ASTM D6392 (excl. Section 6.3, "Conditioning") GRI GM19a	1 test per 500 lf and at least 1 test per seaming crew per day	See GRI GM19a, Rev. 10 or current version at time of construction.
Peel Test Fillet Extrusion	ASTM D6392 (excl. Section 6.3, "Conditioning") GRI GM19a	1 test per 500 lf and at least 1 test per seaming crew per day	See GRI GM19a, Rev. 10 or current version at time of construction.
Air-Pressure	ASTM D5820	All dual track seams tested by Air Pressure	<3 psi drop in 5 minutes with initial pressure 25-30 psi, following an initial relaxation period.
Vacuum	ASTM D5641	All single track wedge and extrusion seams tested by Vacuum	Examine weld for approximately 10 seconds through window at vacuum of minimum 3 psig

(1) Locus of break codes are provided in ASTM D6392 and GRI GM19a, Rev. 10. Current GRI standards shall be used in the event of changes to the GRI specifications.
(2) For double fusion welded seams, both tracks shall be tested for compliance with minimum property values listed above.
(3) Destructive seams will be evaluated for strength parameters according to ASTM D6392 (excluding section 6.3 "Conditioning") and GRI GM19a. Destructive seams will be evaluated for elongation during cold weather seaming. Refer to Cold Weather Operations section of CQA Plan.

Table 3 **40-mil Textured LLDPE Geomembrane Acceptance Specifications**			
Properties	**Test Method**	**Required Values (12)**	**CQA Test Frequency**
Thickness mils (min. ave.) (CT) • Lowest individual for 8 of 10 • Lowest individual for any of 10	D5994	40 mil (13) 38 mil (14) 38 mil (15)	1 per Roll
Asperity Height (min. ave.) (1)(2) (CT)	D7466	20 mil	1 per 2 Rolls
Sheet Density (max.) (CT)	D1505/D792	0.939 g/cc	1 per 200,000 lb
Tensile Properties (min. ave.) (3) (CT) • Break strength • Break elongation	D6693 Type IV	60 lb/in. 250%	1 per 20,000 lb
2% Modulus (max.)	D5323	2400 lb/in	1 per each formulation (11)
Tear Resistance (min. ave.) (CT)	D1004	22 lb	1 per 45,000 lb
Puncture Resistance (min. ave.) (CT)	D4833	44 lb	1 per 45,000 lb
Axi-Symmetric Break Resistance Strain (min.)	D5617	30%	1 per each formulation (11)
Carbon Black Content (range) (CT)	D4218 (4)	2.0-3.0%	1 per 45,000 lb
Carbon Black Dispersion (5) (CT)	D5596	(5)	1 per 45,000 lb
Oxidative Induction Time (OIT) (min. ave.) (6) • Standard OIT, or • High Pressure OIT	D8117 D5885	100 min. 400 min.	1 per 200,000 lb (11)
Oven Aging at 85ºC (6) (7) • Standard OIT (min. ave.), % retained after 90 days, or • High Pressure OIT (min. ave.) - % retained after 90 days	D5721 D8117 D5885	35% 60%	1 per each formulation (11)
UV Resistance (8) • Standard OIT (min. ave.) (9), or or • High Pressure OIT (min. ave.), % retained after 1600 hrs (10)	D7238 D8117 D5885	Note (9) 35% (10)	1 per each formulation (11)
Required Peak Interface Friction Value (16)(17)	D5321	See Table 12	1 per combination of materials in cover system cross-section per construction period

(CT) Conformance testing shall be performed on the geomembrane material by a 3rd party laboratory for these properties only, at the rates shown above in Table 3.
(1) Asperity Height is owner designated and exceeds GRI GM17, Rev. 14.
(2) Alternate the measurement side for double sided textured sheet.
(3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
- Break elongation is calculated using a gage length of 2.0 inches at 2.0 in./min.

(4) Other methods such as D 1603 (tube furnace) or D6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.
(5) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
- 9 in Categories 1 or 2, and
- 1 in Category 3

(6) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(7) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
(8) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
(9) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
(10) UV resistance is based on percent retained value regardless of the original HP-OIT value.
(11) Manufacturer shall provide certification letter.
(12) Based on GRI GM-17, Rev. 14. Current GRI standards shall be used in the event of changes to the GRI specifications.
(13) IEPA regulations are more stringent than GRI GM 17, Rev. 14 specification of 38 mil.
(14) IEPA regulations are more stringent than GRI GM 17, Rev. 14 specification of 36 mil.
(15) IEPA regulations are more stringent than GRI GM 17, Rev. 14 specification of 34 mil.

Table 3 Notes Continued:

(16) Required interface friction value: Equivalent shear strength at anticipated normal loads (in the range of 100 to 500 psf) to achieve required design values.

(17) It is noted that a number of possible definitions of minimum material peak interface strength may exist. If a material is generally close to the minimum limit, the new data should be used in a stability model to verify the material's suitability. See Appendix J.2-A of the Site 2 North Permit Application for the acceptable window.

Table 4 40-mil Textured LLDPE Geomembrane Seam Testing Summary			
Properties	**Test Method (3)**	**Testing Frequency (minimum)**	**Acceptance Criteria**
Shear Test (2)	ASTM D6392 (excl. Section 6.3, “Conditioning”) GRI GM19a	1 test per 500 if and at least 1 test per seaming crew per day	See GRI GM19a, Rev. 10 or current version at time of construction.
Peel Test (2) Hot Wedge Fusion	ASTM D6392 (excl. Section 6.3, “Conditioning”) GRI GM19a	1 test per 500 if and at least 1 test per seaming crew per day	See GRI GM19a, Rev. 10 or current version at time of construction.
Peel Test Fillet Extrusion	ASTM D6392 (excl. Section 6.3, “Conditioning”) GRI GM19a	1 test per 500 if and at least 1 test per seaming crew per day	See GRI GM19a, Rev. 10 or current version at time of construction.
Air-Pressure	ASTM D5820	All dual track seams tested by Air Pressure	<3 psi drop in 5 minutes with initial pressure 25-30 psi, following an initial relaxation period.
Vacuum	ASTM D5641	All single track wedge and extrusion seams tested by Vacuum	Examine weld for approximately 10 seconds through window at vacuum of minimum 3 psig

(1) Locus of break codes are provided ASTM D6392 and GRI GM19a, Rev. 10. Current GRI standards shall be used in the event of changes to the GRI specifications.
(2) For double fusion welded seams, both tracks shall be tested for compliance with minimum property values listed above.
(3) Destructive seams will be evaluated for strength parameters according to ASTM D6392 (excluding Section 6.3 “Conditioning”) and GRI GM19a. Destructive seams will be evaluated for elongation during cold weather seaming. Refer to Cold Weather Operations section of CQA Plan.

Table 5 Geotextile Tests and Test Methods		
Property	**Test Methods (ASTM)**	**Conformance Testing Frequency**
Apparent Opening Size (AOS) (CT)	D4751	1 per 540,000 sf
Grab Tensile Properties -Tensile Strength -Break Elongation	D4632	-
Mass per Unit Area	D5261	-
Permittivity (2) (CT)	D4491	1 per 540,000 sf
Puncture Resistance	D4833	-
Trapezoidal Tear	D4533	-
UV Resistance	D4355	-
Water Flow Rate (2) (CT)	D4491	1 per 540,000 sf

(CT) Conformance testing shall be performed on the filter geotextile materials for these properties only.

(1) Geotextile manufacturer(s) shall provide written certification that geotextile material delivered and inventoried on site meets or exceeds material property values in tables 5, 6, 7 and 8. No additional conformance testing of received geotextiles is required to be performed.

(2) Property certified for filter geotextile application of tables 6 and 7.

Table 6 6 oz/yd^2 Filter Geotextile Acceptance Specifications			
Property	**Units**	**Type of Criterion**	**Acceptable Value (1)**
Apparent Opening Size (AOS) (CT)	mm	Minimum	0.210
Grab Tensile Properties (2) -Tensile Strength -Break Elongation	lb %	MARV	160 50
Mass per Unit Area	oz/yd^2	MARV	6
Permittivity (CT)	sec^{-1}	MARV	1.5
Puncture Resistance	lb	MARV	90 (4)
Trapezoidal Tear (2)	lb	MARV	65
UV Resistance (3)	%	Minimum	70
Water Flow Rate (CT)	gpm/ft^2	MARV	110

(CT) Conformance Testing to be performed at the rate shown in Table 5.
(1) Values are based on review of acceptable manufacturer's specifications and represent production values at the time this document was prepared.
(2) These tests will be performed and results reported in both the machine and cross directions.
(3) Evaluation to be on a 2.0 inch strip tensile specimens after 500 hours exposure.
(4) Acceptable value for ASTM D4833 testing for puncture strength.
(5) 6 oz/yd^2 Geotextile is a filter material above the coarse aggregate bedding of the underdrain collection pipe.

Table 7 8 oz/yd^2 Geotextile Acceptance Specifications			
Property	**Units**	**Type of Criterion**	**Acceptable Value (1)**
Apparent Opening Size (AOS) (CT)	mm	Minimum	0.180
Grab Tensile Properties (2) -Tensile Strength -Break Elongation	lb %	MARV	220 50
Mass per Unit Area	oz/yd^2	MARV	8
Permittivity (CT)	sec^{-1}	MARV	1.3
Puncture Resistance	lb	MARV	120 (4)
Trapezoidal Tear (2)	lb	MARV	90
UV Resistance (3)	%	Minimum	70
Water Flow Rate (CT)	gpm/ft^2	MARV	95

(CT) Conformance Testing to be performed at the rate shown in Table 5.
(1) Values are based on review of acceptable manufacturer's specifications and represent production values at the time this document was prepared.
(2) These tests will be performed and results reported in both the machine and cross directions.
(3) Evaluation to be on a 2.0 inch strip tensile specimens after 500 hours exposure.
(4) Acceptable value for ASTM D4833 testing for puncture strength.
(5) 8 oz/yd^2 Geotextile is approved as filter material above the granular drainage layer and pipe bedding for the Site 2 North Expansion.

Table 8 12 oz/yd^2 Geotextile Acceptance Specifications			
Property	**Units**	**Type of Criterion**	**Acceptable Value (1)**
Apparent Opening Size (AOS)	mm	Minimum	0.150
Grab Tensile Properties (2) -Tensile Strength -Break Elongation	lb %	MARV	 300 50
Mass per Unit Area	oz/yd^2	MARV	12
Puncture Resistance	lb	Minimum	190 (4)
Trapezoidal Tear (2)	lb	MARV	115
UV Resistance (3)	%	Minimum	70
Water Flow Rate	gpm/ft^2	MARV	60

(1) Values are based on GRI GT12(a), Rev. 2, and based on review of acceptable manufacturer's specifications and represent production values at the time this document was prepared.
(2) These tests will be performed and results reported in both the machine and cross directions.
(3) Evaluation to be on a 2.0 inch strip tensile specimens after 500 hours exposure.
(4) Acceptable value for ASTM D4833 testing for puncture strength.
(5) 12 oz/yd^2 Geotextile is a cushion material between the granular drainage layer and the 60-mil HDPE geomembrane for the Site 2 North Expansion.

Table 9 Geonet Properties				
Property	**Units**	**Acceptable Value (2)**	**Test Methods (ASTM)**	**Acceptance Criteria**
Thickness	mils	200	D5199	Min. Average
Density	g/cu cm	0.95	D1505/D792 Method B	Min. Average
Tensile Strength (MD)	lb/in	45	D5035/7179	Min. Average
Carbon Black Content	%	1.5-3.0	D1603/4218	Range
Compressive Strength	lb/in^2	120	D6364	Min. Average

(1) Testing will be performed and results reported in both the machine and cross directions.
(2) Values are based on GRI GN 4, Rev. 4, and based on review of acceptable manufacturer's specifications and represent production values at the time this document was prepared.
(3) Geonet will be part of 200-mil double-sided geocomposite.
(4) Geonet Manufacturer shall provide written certification that geonet used as part of the geocomposite delivered and inventoried on site meets or exceeds material property values in Table 9 prior to lamination.

Table 10 Geocomposite Properties(1)				
Properties	**Units**	**Acceptable Value**	**Test (ASTM)**	**Acceptance Criteria**
Top and Bottom 6 oz/yd^2 Geotextile Component				
Apparent Opening Size (AOS) (CT)	mm	0.210	D4751	Min. Average
Grab Tensile Properties (2) -Tensile Strength -Break Elongation	lb %	160 50	D4632	Min. Average
Mass per Unit Area	oz/yd^2	6	D5261	Min. Average
Permittivity (CT)	sec^{-1}	1.5	D4491	Min. Average
Puncture Resistance	lb	90 (3)	D4833	Min. Average
UV Resistance (2)	%	70	D4355	Min. Average
Water Flow Rate (CT)	gpm/ft^2	110	D4491	Min. Average
Geonet Core				
Geonet Core shall conform to the specifications in Table 9				
Completed Geocomposite				
Transmissivity (4)	gal/min/ft	0.5	D4716	Minimum
Ply Adhesion	lb/in	1.0	D7005	Min. Average

(CT) Conformance Testing of the 6 oz/yd^2 geotextile to be performed at the rate shown in Table 5.
(1) Design of the Site 2 North Expansion final cover and the underdrain system uses a double-sided geocomposite with a 6 oz/yd^2 geotextile on both the top and bottom.
(2) Tests will be performed and results reported in both the machine and cross directions.
(3) ASTM D4833 or D6241 can be utilized for conformance testing.
(4) Per the index specification, Transmissivity (ASTM D4716) of the geocomposite shall exhibit a minimum value of 0.5 gal/min/ft when tested between a geomembrane and geotextile with a gradient of 0.1 under a load of 10,000 psf and a seat time of 15 minutes. See Appendix J.5-C of the Site 2 North Expansion Permit Application to ensure the transmissivity of the geocomposite meets the required final cover transmissivity.
(5) The geocomposite shall be manufactured by heat bonding the geotextile to the geonet on both sides. No burn through geotextiles nor glue or adhesive shall be permitted. The bond between the geotextile and geonet shall exhibit an average peel strength of 1 pound per inch with a minimum peel strength 0.5 pounds per inch according to ASTM D7005.
(6) Component properties prior to lamination.
(7) Values are based on GRI GN 4, Rev. 4, and based on review of acceptable manufacturer's specifications and represent production values at the time this document was prepared.
(8) Geocomposite manufacturer shall provide written certification that geocomposite delivered and inventoried on site meets or exceeds material property values in Table 10. No conformance testing of received geocomposite is required to be performed.

Table 11 Geosynthetic Clay Liner (GCL) Properties				
Properties	**Unit**	**Acceptable Value (2)**	**Test Methods (ASTM)**	**Acceptance Criteria**
Bentonite Properties				
Swell Index	ml/2g	24	D5890	Minimum
Fluid Loss	ml	18	D5891	Maximum
Physical GCL (as manufactured)				
GCL mass per unit area (1)	lb/sf	0.81	D5993	Minimum
Bentonite mass per unit area (1)	lb/sf	0.75	D5993	Minimum
Moisture Content	%	35	D5993	Maximum
Tensile Strength (MD)	lb/in	23	D6768	Minimum
Peel Strength	lb/in	1.0	D6496	Minimum
Permeability, "or"	cm/sec	$5x10^{-9}$	D5887	Maximum
Index Flux	cm^3/sec-cm^2	$1x10^{-6}$	D5887	Maximum

(1) Mass of GCL and bentonite is measured after oven drying per the stated test method.
(2) Values are based on GRI GCL 3, Rev. 5, and based on review of acceptable manufacturer's specifications and represent production values at the time this document was prepared.
(3) GCL manufacturer shall provide written certification that GCL delivered and inventoried on site meets or exceeds material property values in Table 11. No conformance Testing of received GCL is required to be performed.
(4) GCL material to be installed in the leachate collection sumps of the Site 2 North Expansion.

Table 12 Shear Strength Criteria				
Interface	**Normal Stresses (psf)**	**Max. Strain Rate (in/min)**	**Minimum Peak Shear Strength**	
			Adhesion (psf)	**Friction Angle (degrees)**
Final Cover System				
Protective Cover Soil vs. Double-sided Geocomposite Drainage Layer	250, 500, and 1,000	0.04	Acceptable range between 0 psf and 21.9° 151.8 psf and 0° (8)	
Double-sided Geocomposite Drainage Layer vs. 40-mil Textured LLDPE Geocomposite		0.2		
40-mil Textured LLDPE Geocomposite vs. Final Cover Barrier Soil		0.04		
Bottom Liner System (Sideslope and Floor)				
Granular Drainage Layer vs. 12-oz/yd^2 Geotextile	4,200 and 16,800 (9)	0.04	Acceptable range between 0 psf and 24.1° 45 psf and 14.9° (10)	
12-oz/yd^2 Geotextile vs. 60-mil Textured HDPE Geomembrane		0.2		
60-mil Textured HDPE Geomembrane vs. Low-permeability Earth Liner		0.04		

(1) Interface shear testing shall be performed in accordance with ASTM D5321 for the construction of the Site 2 North Expansion.
(2) Interface shall be flooded and consolidated under the Normal Stress for at least 24 hours prior to shearing. Samples shall remain flooded during shearing.
(3) The maximum strain rates may be increased by a factor of 10 following the attainment of peak strength and continue to a minimal horizontal displacement of 2 inches.
(4) The shear strength criteria for the Final Cover System apply to the lowest interface peak strength.
(5) The shear strength criteria for the Landfill Floor Liner System and Landfill Sideslope Liner System apply to peak strength.
(6) Interface shear strength criteria may be revised upon approval of the design engineer. If the interface shear strength test results are less than the minimum values reported above, additional slope stability analyses can be performed by a qualified geotechnical engineer using the interface shear test results. The test results are acceptable if these analyses demonstrate adequate factors of safety.
(7) Interface shear tests shall be performed on geosynthetic materials representative of the materials that will be used during construction. Specific rolls used during construction need not be tested.
(8) Minimum peak interface shear strength window for the final cover system was determined in the Site 2 North Expansion Permit Application for the horizontal and vertical expansion and is shown below. The peak interface shear strength test results should be within the acceptable range shown below.
(9) Test at confining stresses between 4,200 and 16,800 psf. The latter number represents the peak landfill stress column as determined by the permit application settlement analysis.

(10) Minimum peak interface shear strength window for the landfill bottom liner floor system and landfill sideslope liner system was determined in the Site 2 North Expansion Permit Application for the horizontal and vertical expansion and is shown below. The peak interface shear strength test results should be within the acceptable range shown below.

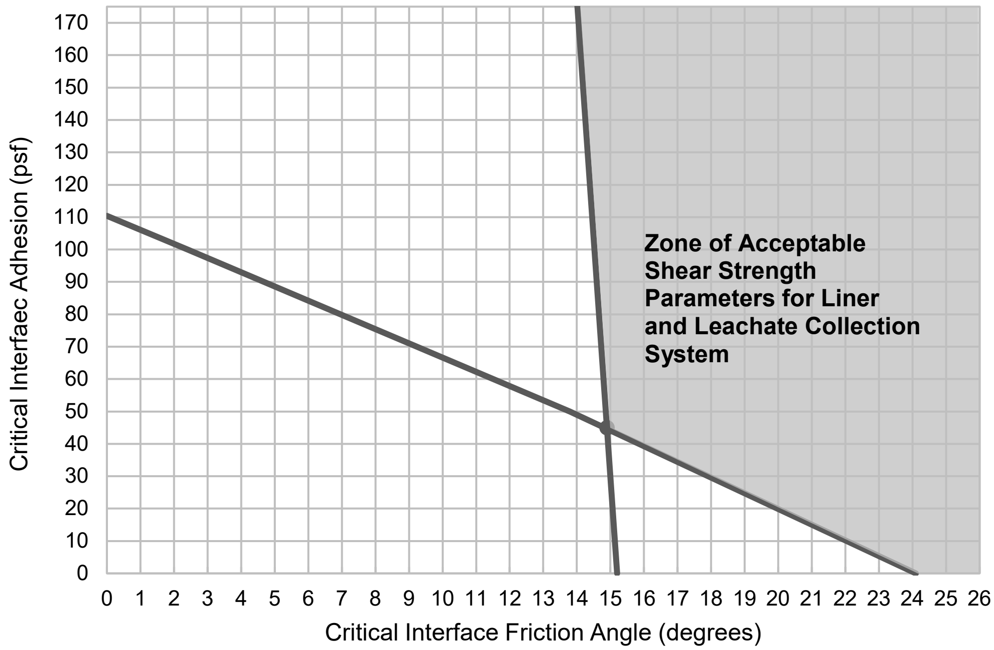

Table 13 Material Testing Methods and Frequency Summary				
Property	**Test Method**	**Minimum Testing Frequency**	**Typical Test per Lift**	**Specifications**
Landfill Foundation Subgrade (Underlies the 5' Earth Liner)				
Elevation	Survey	100' grid	-	N/A
Direct Shear or Triaxial Shear	ASTM D3080	1 test per cell construction	-	Acceptable range between 0 psf and 24.1° 45 psf and 14.9° (see window in Table 12)
Compacted Foundation Fill				
Soil Classification	D2487 (USCS)	1 test per 10,000 yd^3 or change in material type	1 test per 8 acres or per soil type	GM, GC, SC, ML, and CL
Standard or Modified Proctor	ASTM D 698 or D 1557	1 test per Source	-	Material Specific
Nuclear Density	ASTM D 6938	1 test per 1,000 yd^3	1 test per 1 acre	≥ 95% Standard Proctor OR ≥ 90% Modified Proctor
Grain Size Distribution	ASTM D6913/D7928	1 test per 10,000 yd^3	1 test per 8 acres	≥ 12% below 0.002 mm ≥ 50% below No. 200 sieve
Atterberg Limits	ASTM D4318	1 test per 10,000 yd^3	1 test per 8 acres	for ≥ 50% below No. 200 sieve PI >10 LL >20%
Lift Thickness	Visual Observation	Continuous	-	9-inch (loose) or thickness of compactor foot
Elevation	Survey	100' grid	-	N/A
Triaxial Laboratory Permeability	ASTM D5084 or SW 846-EPA Method 9100	1 test per 10,000 yd^3	1 test per 8 acres	$K \leq 1x10^{-7}$ cm/sec
Low-Permeability Earth Liner (5')				
Soil Classification	D2487 (USCS)	1 test per 10,000 yd^3 or change in material type	1 test per 8 acres or per soil type	CH, CL, CL-ML
Standard or Modified Proctor	ASTM D 698 or D 1557	1 test per 10,000 yd^3	1 test per 8 acres	Material Specific
Nuclear Density	ASTM D 6938	1 test per 10,000 yd^3	1 test per 10,000 yd^3	≥ 95% Standard Proctor OR ≥ 90% Modified Proctor
Grain Size Distribution	ASTM D6913/D7928	1 test per 10,000 yd^3	1 test per acre	≥ 50% below No. 200 sieve
Atterberg Limits	ASTM D4318	1 test per 10,000 yd^3	1 test per 8 acres	PI >10 (or PI >4 if hydraulic conductivity is ≥ 1 x 10^{-7}cm/sec) LL >20%
Lift Thickness	Visual Observation	Continuous	-	9-inch (loose) or thickness of compactor foot
Thickness	Topographic Survey	100' grid	-	≥ 5 feet nominal to surface
Elevation	Survey	100' grid	-	N/A
Triaxial Laboratory Permeability	ASTM D5084 or SW 846-EPA Method 9100	1 test per 10,000 yd^3	1 test per 8 acres	$K \leq 1x10^{-7}$ cm/sec
Internal Shear Strength (2) (4)	ASTM D 2166, D 2850, or D 4767	1 test per material type, and at least once every 18 months	Once per construction season or material change	Acceptable range between 0 psf and 24.1° 45 psf and 14.9° (see window in Table 12)
Sand Bedding for Granular Drainage Layer				
Soil Classification	D2487 (USCS)	1 test per 5,000 yd^3 or change in material type	-	G
Grain Size Distribution	ASTM D6913/D7928	1 test per source per phase	NA	$D_{100} \leq 1.0$ in. $D_{90} \leq 0.34$ in.
Sieve Analysis	ASTM C136	1 test per 5,000 yd^3	-	≤ 5% fines passing 200 sieve

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Table 13 Material Testing Methods and Frequency Summary				
Property	**Test Method**	**Minimum Testing Frequency**	**Typical Test per Lift**	**Specifications**
Hydraulic Conductivity	ASTM D2434	1 test per 5,000 yd^3	-	K ≥ $1x10^{-1}$ cm/sec
Thickness	Surveying	100' grid	-	≥ 1-foot normal to surface
HDPE/PVC Pipe				
Pipe Joints	Visual Inspection, ASTM D2657	Each joint	-	Intact, no cracks, no voids in bonding
Dimensions	-	Random measurements of diameters and hole spacing, and end sections of pipe and fittings	-	Design Specifications
Northing, Easting, and Elevation	Survey	Survey every 50' or at joints	-	Tolerance of 0.10 feet
Air Pressure Testing		Pneumatic piping Leachate forcemain carrier piping Leachate forcemain containment piping Non-perforated landfill gas piping		Pressurize to at least 150 psig for at least 1 hour – No greater than 5% drop Pressurize to at least 50 psig for at least 1 hour – No greater than 5% drop Pressurize to at least 50 psig for at least 1 hour – No greater than 5% drop Pressurize to at least 5 psig for at least 1 hour – No greater than 5% drop
Visual physical properties	-	Each lot	-	Equal to manufacturer's data
Washed Gravel Envelope/Backfill for Leachate Collection (Pipe Bedding)				
Grain Size Distribution	ASTM D6913	1 test per source per phase	NA	D_{100} < 2.5 in. D_{90} < 1.35 in.
Lift Thickness	Visual observation	1 observation every 100'	-	Design Specifications
Gravel Backfill for Landfill Gas Extraction Wells				
Grain Size Distribution	ASTM D6913/D7928	1 test per source per phase	NA	1.0 in. ≤ D ≤ 3.0 in.
Final Cover Barrier Soil (2')				
Soil Classification	D2487 (USCS)	1 test per 10,000 yd^3 or change in material type	1 test per 8 acres or per soil type	CH, CL, CL-ML, ML, SC, SM/SC
Standard or Modified Proctor	ASTM D 698 or D1557	1 test per 10,000 yd^3	1 test per 8 acres	Material Specific
Nuclear Density	ASTM D6938	1 test per 10,000 ft^2 per lift	1 test per 10,000 ft^2	≥ 90% Standard Proctor OR ≥ 85% Modified Proctor
Grain Size Distribution	ASTM D6913/D7928	1 test per 10,000 yd^3	1 test per 8 acres	≥ 50% below No. 200 sieve
Atterberg Limits	ASTM D 4318	1 test per 10,000 yd^3	1 test per 8 acres	PI >4 (or PI <4 if hydraulic conductivity is ≤ 1 x 10^{-5} cm/sec) LL >20%
Lift Thickness	Visual Observation	Continuous	NA	9-inch (loose) or thickness of compactor foot
Thickness	Topographic Survey	100' grid or major grade breaks	NA	≥ 24-inches normal to surface

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Table 13 Material Testing Methods and Frequency Summary				
Property	**Test Method**	**Minimum Testing Frequency**	**Typical Test per Lift**	**Specifications**
Elevation	Survey	100' grid	-	N/A
Triaxial Laboratory Permeability	ASTM D5084 or SW 846-EPA Method 9100	1 test per 10,000 yd^3	-	$K \leq 1x10^{-5}$ cm/sec
Low-Permeability Fill (Containment Berms, Temporary and Permanent Berms, Stormwater Basin Dikes, Fill Embankments) (3) (5)				
Soil Classification	D2487 (USCS)	1 test per 10,000 yd^3 or change in material type	1 test per 8 acres or per soil type	GM, GC, SC, ML, CL
Standard or Modified Proctor	ASTM D 698 or D1557	1 test per 10,000 yd^3	1 test per 8 acres	Material Specific
Nuclear Density	ASTM D6938	1 test per 1,000 yd^3	1 test per 1 acre	≥ 90% Standard Proctor OR ≥ 85% Modified Proctor
Grain Size Distribution	ASTM D6913/D7928	1 test per 10,000 yd^3	1 test per 8 acres	≥ 50% below No. 200 sieve
Atterberg Limits	ASTM D 4318	1 test per 10,000 yd^3	1 test per 8 acres	LL <60%
Lift Thickness	Visual Observation	Continuous	NA	9-inch (loose) or thickness of compactor foot
Elevation	Survey	100' grid	-	N/A
Triaxial Laboratory Permeability	ASTM D5084 or SW 846-EPA Method 9100	1 test per 10,000 yd^3	-	Detention basin sidewalls $K \leq 1x10^{-5}$ cm/sec
Internal Shear Strength When Placed on Slopes Greater than 4H:1V (4)	ASTM D 2166, D 2850, or D 4767,	1 test per material type	Once per construction season or material change	1.0 tsf
Final Cover Protective Layer (General Soils)				
Soil Classification	D2487 (USCS)	1 test per 10,000 yd^3 or change in material type	1 test per 8 acres or per soil type	GM, GC, SC, ML, CL
Thickness (1)	Topographic Survey	100' grid or major grade breaks	NA	≥ 36" normal to surface[1]
Internal Shear Strength (4)	ASTM D 2166, D 2850, or D 4767	1 test per material type	Once per construction season or material change	Acceptable range between 0 psf and 21.9° 151.8 psf and 0° (see window in Table 12)

Table 13 Notes:

(1) The upper six (6) inches of the random fill used for the final cover protective layer must be capable of supporting vegetation, else the upper six (6) inches must consist of topsoil.
(2) Minimum peak interface shear strength windows were determined in the Site 2 North Expansion permit application. See Note 8 and 9 in Table 12 for the acceptable range of the final cover and bottom liner interface values.
(3) Stormwater berms on the final cover do not need to meet the testing requirements of this section.
(4) CQA Officer has the discretion to forgo Internal shear strength testing provided the previous test liner results satisfy the material requirements specified in Table 13.
(5) Testing criteria for low-permeability fill applies to the listed site features only (Containment Berms, Temporary and Permanent Berms, Stormwater Basin Dikes, Fill Embankments).

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21.0 FORMS

OFFICER-IN-ABSENTIA
Zion Landfill

Date: ______________________________

Operator and Owner: ______________________________

Contractor: ______________________________

Third-party CQA Firms: ______________________________

____

Description of Construction: ______________________________

CQA Officer: ______________________________

Period of Designated Authority: ______________________________

Reason for CQA Officer's Absence: ______________________________

____

____

The undersigned understand and agree to the following:

Until further notice,____________________________________has been designated as the CQA Officer-in- Absentia as described above, and as such, shall exercise professional judgement in fulfilling the CQA Officer's duties as described in the site's CQA Plan. The CQA Officer assumes full personal responsibility for the performance of all inspections and reports prepared by, or under the direction of, the designated CQA Officer-in-Absentia.

CQA Officer

______________________ ______________________
Signature Date

____
Print Name

CQA Officer-in-Absentia

______________________ ______________________
Signature Date

____
Print Name

Operator/Owner

______________________ ______________________
Signature Date

____
Print Name

NOTE: This form (or similar) must be fully completed and must accompany the Construction Documentation Report.

Attachment 2

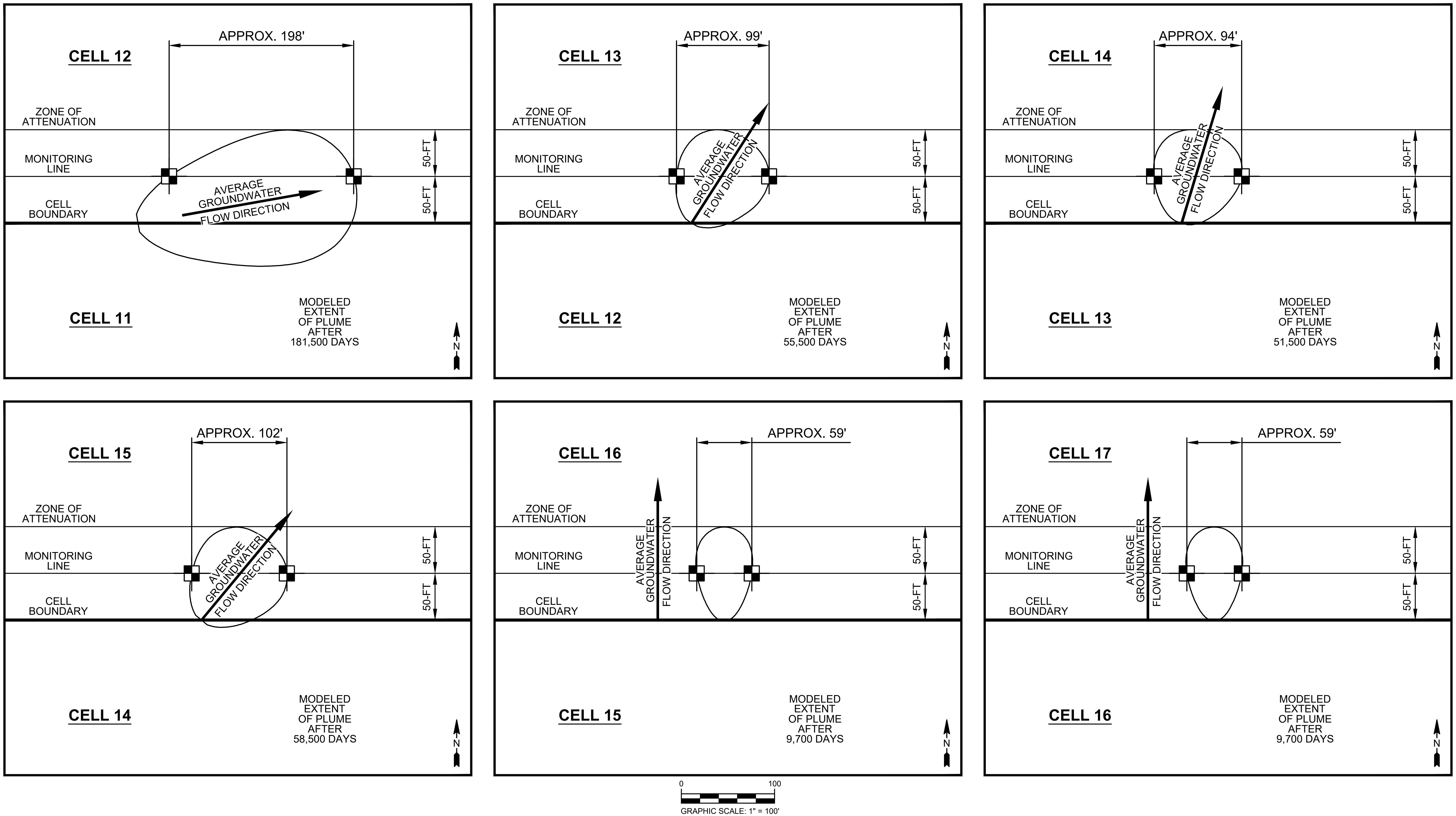
Summary Table of CQA Testing Changes

Zion Landfill - Proposed Changes to Testing Frequency			
Property	**Minimum Testing Frequency (Historical)**	**Minimum Testing Frequency (Expansion)**	**Explanation**
Low-Permeability Earth Liner (5')			
Soil Classification	1 test per 5,000 yd^3	1 test per 10,000 yd^3 or change in material type	The low permeability earth liner will be consist of the same clay soil present on site that has been used for the 48-year history of the site. Over the thousands of tests performed on this material, it has been demonstrated to be incredibly consistent. Due to the material's consistency, and the extensive history of the site, a testing frequency of once per 10,000 cubic yards will be sufficient to ensure that the material meets design specifications as is required by the Illinois Environmental Protection Act Section 840.146(7).
Standard or Modified Proctor	1 test per 5,000 yd^3	1 test per 10,000 yd^3	
Nuclear Density	1 test per 5,000 yd^3	1 test per 10,000 yd^3	
Grain Size Distribution	1 test per 5,000 yd^3	1 test per 10,000 yd^3	
Atterberg Limits	1 test per 5,000 yd^3	1 test per 10,000 yd^3	
Washed Gravel Envelope/Backfill for Leachate Collection (Pipe Bedding)			
Grain Size Distribution	1 test per 3,000 yd^3	1 test per source per phase	The testing frequency was changed from a volumetric basis to a source and construction phase basis to ensure that new sources of material are tested, and that material is retested in each construction phase.
Final Cover Barrier Soil (2')			
Nuclear Density	1 test per 5,000 yd^3, minimum of once per lift	1 test per 10,000 yd^3, minimum of once per lift	Similarly to the Low-Permeability Earth Liner material to be used on site, the final cover barrier soil will be the same material that has been used throughout the history of the site. It has been demonstrated to be incredibly consistent. Due to the material's consistency, and the extensive history of the site, a testing frequency of once per 10,000 cubic yards will be sufficient to ensure that the material meets design specifications as is required by the Illinois Environmental Protection Act Section 840.146(7).

Attachment 3

Temporary Well Modeling and Revised Monitoring Plans and Figures

Geo-Logic
ASSOCIATES



REV.	DATE	DESCRIPTION

This drawing has not been published but rather has been prepared by Geo-Logic Associates for use by the client named in the title block, solely in respect of the construction, operation, and maintenance of the facility named in the title block. Geo-Logic Associates shall not be liable for the use of this drawing on any other facility or for any other purpose.

Geo-Logic ASSOCIATES

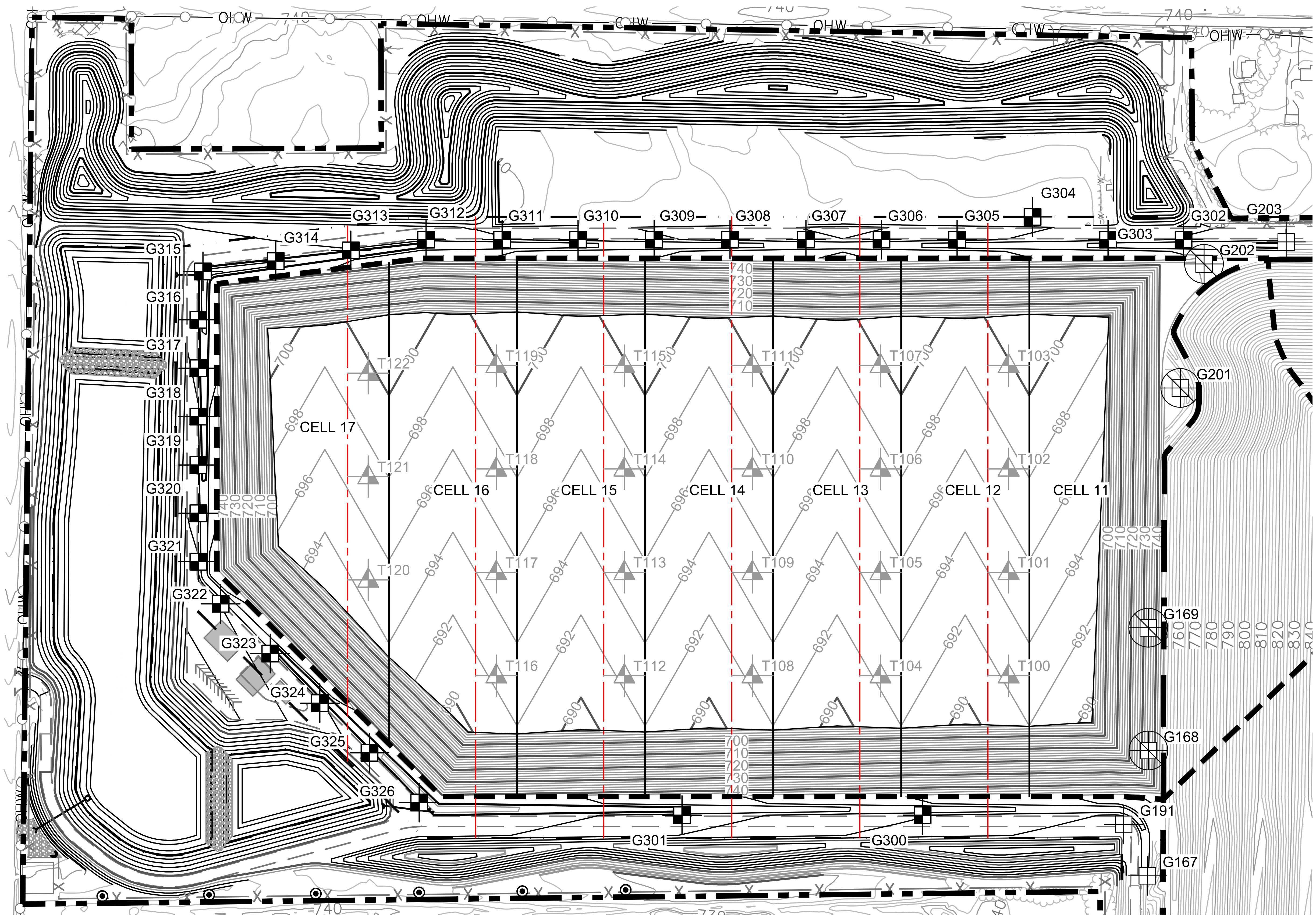
GFL GREEN FOR LIFE environmental

ZION LANDFILL - SITE 2 NORTH EXPANSION CITY OF ZION, ILLINOIS

FIGURE 1 TEMPORARY WELL SPACING DETERMINATION DIAGRAM

PROJECT NO.:	IL24.1033.00	DATE:	JUNE 2024
DESIGNED BY:	LN	FIGURE	
DRAWN BY:	BWM	1 OF 1	
CHECKED BY:	LN		
APPROVED BY:	DAM		

H:\GFL\IL24.1020.PR Zion LF Permitting\CAD\01-LocalSiting\01-Submittal\Hydrogeo\Well Spacing\Cell-11-16-Plume-TempWellSpacing.dwg, 6/13/2024 12:37:39 PM



GRAPHIC SCALE: 1" = 250'

LEGEND

- APPROXIMATE FACILITY BOUNDARY
- APPROXIMATE EXISTING WASTE BOUNDARY
- APPROXIMATE PROPOSED EXPANSION WASTE BOUNDARY
- APPROXIMATE ZONE OF ATTENUATION
- APPROXIMATE TEMPORARY ZONE OF ATTENUATION
- G302 — EXISTING MONITORING WELL - TO REMAIN
- G201 — EXISTING MONITORING WELL - TO BE REMOVED
- G301 — PROPOSED MONITORING WELL - TO BE INSTALLED
- T100 — PROPOSED TEMPORARY MONITORING WELL - TO BE INSTALLED

REV.	DATE	DESCRIPTION

Geo-Logic ASSOCIATES

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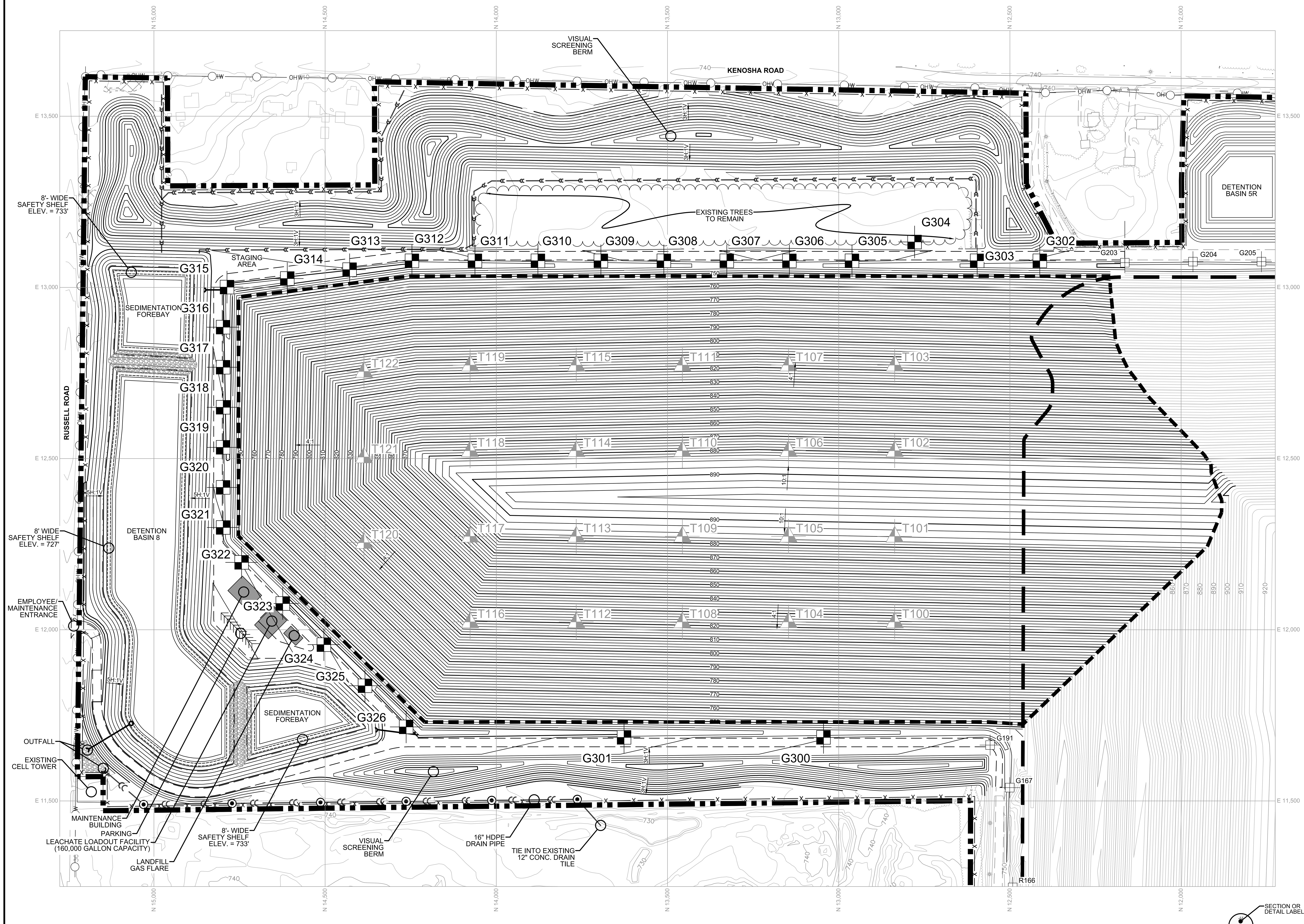
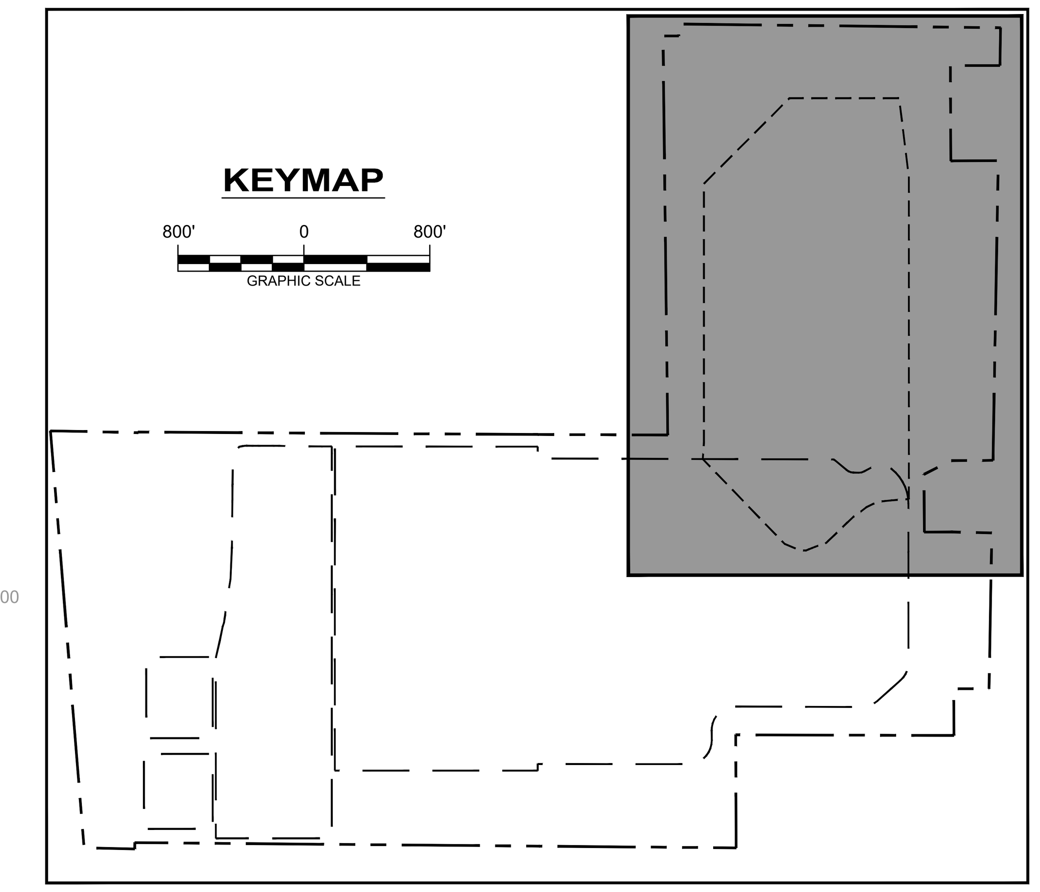
ZION LANDFILL - SITE 2 NORTH EXPANSION CITY OF ZION, ILLINOIS

FIGURE 2.8-2 PROPOSED MONITORING NETWORK

PROJECT NO.:	IL24.1033.00
DESIGNED BY:	LN
DRAWN BY:	BWM
CHECKED BY:	MNF
APPROVED BY:	DAM
DATE:	JULY 2024

FIGURE 1 OF 1





120' 0 120'
GRAPHIC SCALE

LEGEND

- APPROXIMATE FACILITY BOUNDARY
- APPROXIMATE EXISTING WASTE BOUNDARY
- APPROXIMATE PROPOSED EXPANSION WASTE BOUNDARY
- EXISTING CONTOUR
- EXISTING ROAD
- EXISTING VEGETATION
- EXISTING PERIMETER FENCE
- EXISTING POWER POLE
- EXISTING OVERHEAD WIRE
- EXISTING CULVERT
- PROPOSED CONTOUR
- PROPOSED ROAD
- PROPOSED FENCE
- PROPOSED CULVERT
- PROPOSED DRAIN TILE
- EXISTING MONITORING WELL (G201)
- PROPOSED MONITORING WELL (G301)
- STORMWATER MANHOLE
- STORMWATER HEADWALL
- TEMPORARY MONITORING WELL (T100)

NOTES

1. EXISTING CONTOURS DEVELOPED FROM SITE AERIAL TOPOGRAPHIC SURVEY PROVIDED BY CQM, INC. ON 10/22/2018 EXCEPT STORMWATER MANAGEMENT FEATURES ASSOCIATED WITH SITE 2 EAST (DITCHES AND BASIN 5R). STORMWATER DESIGN GRADES ARE SHOWN FOR THESE FEATURES FOR COMPLETENESS, AS NOT ALL GRADES ARE CAPTURED BY THE TOPOGRAPHIC SURVEY.
2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.
3. CURRENT TOPOGRAPHY MAY DIFFER FROM THAT SHOWN.
4. TOP OF PERMITTED FINAL COVER GRADES ARE SHOWN FOR THE EXISTING LANDFILL (CELLS 6,7, AND 9), WITH THE EXCEPTION OF THE SITE 2 NORTH VERTICAL EXPANSION AREA.
5. THE TOP OF PROPOSED FINAL COVER GRADES ARE SHOWN FOR THE SITE 2 NORTH HORIZONTAL AND VERTICAL EXPANSION. THE PROPOSED VERTICAL EXPANSION AREA FINAL COVER GRADES WILL TIE INTO THE PERMITTED FINAL COVER GRADES OF THE EXISTING LANDFILL AS SHOWN.
6. A NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) STORMWATER PERMIT SHALL BE OBTAINED FOR THE PROPOSED LANDFILL EXPANSION. STORMWATER EFFLUENT IS ANTICIPATED TO BE SAMPLED AT THE OUTFALL LOCATIONS OF THE STORMWATER DETENTION BASINS IN ACCORDANCE WITH NPDES SAMPLING REQUIREMENTS.
7. EXISTING GROUNDWATER MONITORING WELLS LOCATED WITHIN THE PROPOSED WASTE FOOTPRINT WILL BE ABANDONED FOLLOWING SITE WELL ABANDONMENT PROCEDURES AS PART OF EXPANSION CONSTRUCTION. THESE WELL LOCATIONS ARE OMITTED FROM THE DRAWING.

SECTIONS AND DETAIL KEY

SECTION OR DETAIL LABEL
DRAWING ON WHICH SECTION OR DETAIL IS SHOWN

REV. NO.	DATE	DESCRIPTION
REV. 1	07/08/24	TEMPORARY WELLS EDITED BY GEO-LOGIC ASSOCIATES

GFL GREEN FOR LIFE environmental

APTIM Environmental & Infrastructure, LLC

ZION LANDFILL - SITE 2 NORTH EXPANSION
CITY OF ZION, ILLINOIS

PROPOSED GROUNDWATER MONITORING PLAN

PROJ. NO.:	631020105	DATE:	JULY 2022
DESIGNED BY:	DAM/BWM	DRAWING NO.	
DRAWN BY:	BWM/NV/KM	D12	
CHECKED BY:	DAM		
APPROVED BY:	DAM	12 OF 37 SHEETS	

Section 2.8
Environmental Monitoring Program

Prepared for Zion Landfill Inc.
701 N. Green Bay Rd.
Zion, Illinois 60099

Prepared by Aptim Environmental & Infrastructure, LLC
1607 E. Main Street, Suite E
St. Charles, Illinois 60174

Revised in July 2024
by Geo-Logic Associates
St. Charles, Illinois 60174

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2.8 ENVIRONMENTAL MONITORING PROGRAM

Introduction

The proposed Zion Landfill Site 2 North Expansion (Site 2 North Expansion) has been designed to be protective of the public, health, safety and welfare. To assure that the facility functions as designed, this Environmental Monitoring Program has been developed in accordance with applicable regulations and sound environmental practices. It includes a description of groundwater, leachate, subsurface gas, ambient air, and other environmental monitoring which will take place at the facility. The details of the Environmental Monitoring Program are described in greater detail within the following sections and within other sections of this Application.

Groundwater Monitoring

Groundwater Monitoring Overview

A groundwater monitoring program has been developed in accordance with 35 Ill. Admin. Code, Sections 811.318 and 811.319. The Groundwater Impact Assessment (GIA) has determined that groundwater quality will not be impacted at or beyond the edge of the zone of attenuation (ZOA) within 100 years after closure of the landfill, as discussed in Section 2.7 of the Application. Furthermore, the groundwater monitoring network will serve as an additional safeguard to verify that the landfill is not having any adverse impact on the groundwater quality and to provide an early warning system in the unlikely event of an impact. In other words, the groundwater monitoring network has been developed to provide assurance that the landfill will function as designed. The proposed groundwater monitoring network has been developed in accordance with current regulatory requirements based on: 1) the geology and hydrogeology, 2) the proposed landfill design features, and 3) the results of the well spacing model.

Title 35 Ill. Admin. Code Sections 811.318(b)(3) requires that monitoring wells be located as close to the potential source as practicable without interfering with operations and within one-half the distance from the edge of the potential source to the edge of the ZOA. The ZOA is located 100 feet from the waste boundary. As such, all new detection monitoring wells for the Uppermost Aquifer have been proposed to be located within 50 feet of the waste boundary.

Additionally, Title 35 Ill. Admin. Code Section 811.318(b)(2) requires that monitoring wells be located in hydrostratigraphic horizons that could serve as preferred contaminant migration pathways. Therefore, the proposed groundwater monitoring network has been designed to target the Shallow Drift Aquifer. The selection of this zone for monitoring is based on these units meeting the definition of the Uppermost Aquifer as stated in the Hydrogeologic Investigation Section (Section 2.2).

Groundwater will be routinely sampled and analyzed from the groundwater monitoring network. These monitoring results will be statistically analyzed to check that the background groundwater quality is not exceeded as defined in 35 Ill. Admin. Code Section 811.320.

Monitoring results, including the results of the data comparisons will be promptly reported in the Illinois Environmental Protection Agency (IEPA) following each sampling period.

Monitoring Well Spacing Determination

The Monitoring Analysis Package (MAP) was utilized to develop the proposed monitoring network and assure that it exceeds IEPA requirements. The Plume Generation Model (PLUME), one of three modeling packages contained within the MAP application, was utilized to determine the appropriate monitoring well spacing while taking into account current hydrogeological characteristics.

PLUME utilizes a fundamental two-dimensional analytical transport model responsible for configuring plumes. The governing equation for the transport model, originally presented in Domenico and Robbins (1985) and later modified by Domenico (1987), is:

$$C(x,y,t) = \left(\frac{C_O}{4}\right) \exp\left\{\left(\frac{xv}{2\alpha_x}\right)\left[1-\left(1+\frac{4\lambda\alpha_X}{v^2}\right)^{1/2}\right]\right\}$$

$$efrc\left\{\frac{\left[x - vt\left(1+\frac{4\lambda\alpha_X}{v^2}\right)^{1/2}\right]}{2(\alpha_X t)^{1/2}}\right\}$$

$$\left\{erf\left[\frac{\left(y+\frac{S_W}{2}\right)}{2\left(\frac{\alpha_Y x}{v}\right)^{1/2}}\right] - erf\left[\frac{\left(y-\frac{S_W}{2}\right)}{2\left(\frac{\alpha_Y x}{v}\right)^{1/2}}\right]\right\}$$

where,

C (x,y,t) =	The concentration of the contaminant at location x, y from the source at time t;
C_O =	Source concentration - the highest concentration of the contaminant in the groundwater at the source;
x =	Distance from planar source to the location of concern along the center line of the plume;
y =	Distance from planar source to the location of concern perpendicular to the centerline of the plume;
λ =	1st order decay constant;
S_W =	Width of source area;
v =	Average Contaminant Velocity (ki/n_e);

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α_x = Dispersivity in the x direction;

α_y = Dispersivity in the y direction; and

t = Time.

To determine an appropriate down-gradient well spacing, hypothetical plumes were generated with PLUME using site specific input parameters presented in the Hydrogeologic Investigation Report (Section 2.2) and as described in greater detail within the following section. Source leaks at the landfill base were assumed and average advection times of 33,950 days on the northwest side, 23,900 days on the north side, 181,000 days on the northeast side, and 180,500 days on the southeast side of the landfill were found to maximize the extent of the PLUMES while assuring that they do not extend past the zone of attenuation on the northwest, northeast, and east (down-gradient) sides of the landfill. The modeled plumes were then able to be used to determine what minimum well spacing will be necessary to assure that any leak would be detected.

PLUME Input Data

Units. Consistent units of meters and days were used within the PLUME model.

Advection Time. As previously indicated, advection times of 33,950 days on the northwest side, 23,900 days on the north side, 180,500 days on the northeast side, and 165,000 days on the southeast side of the landfill were used in order to maximize the extent of the plumes while keeping them within the zone of attenuation along the northwest, northeast, and east (down-gradient) sides of the landfill.

Dilution Contours. Dilution contours are utilized by PLUME as criterion by which to illustrate the shape of the hypothetical plume at a percentage of the source concentration. The MAP User's Manual defines a dilution contour as the ratio of the concentration of the contaminant at the detected point in the plume to the concentration of the source. MAP documentation suggests that the concentration of the contaminant at the outermost perimeter of the plume (detection point) is equal to the laboratory's detection limit. The concentration at the source is the concentration of the constituent as it occurs in leachate. Chloride is chosen to represent the constituent released in a hypothetical plume from the landfill, because it is transported conservatively due to its resistance to degradation and non-sorbing properties. The laboratory detection limit of chloride is 1.0 mg/L. The IEPA recommends utilizing 2,000 mg/L as the concentration of chloride in leachate for the modeling purposes, however the model used a slightly more conservative site specific concentration of 1,945 mg/L, which is the average concentration of chloride in leachate at the existing landfill from 2010 through 2019. The resultant outermost dilution contour of 5.14×10^{-4} was used for the model to define the shape of the plume.

Longitudinal Dispersivity. Longitudinal dispersivity is derived from the following empirical equation developed by Schulze-Makuch (2005):

$$\alpha_L = 0.085(L)^{0.81}$$

where,

α_L = longitudinal dispersivity; and
L = flow path length.

It is conservatively assumed that a failure occurs at the downward gradient edge of the proposed landfill at the base of the landfill sideslope. Therefore, the flowpath length for the northwestern portion of the downgradient edge of the proposed expansion is determined as follows:

$$L = D1 + D2$$
$$= 221.18ft + 50ft$$
$$= 271.18ft = 82.66m$$

where,

L = Flow Path Length for the northwestern portion of the downgradient edge of the proposed expansion,
D1 = Average Distance from the base of the leachate collection system to the waste boundary across the northwestern edge of the proposed landfill; and
D2 = Average Distance from Waste Boundary to Compliance Point.

The flowpath length for the northern portion of the downgradient edge of the proposed expansion is determined as follows:

$$L = D1 + D2$$
$$= 136.13ft + 50ft$$
$$= 186.13ft = 56.73m$$

where,

L = Flow Path Length for the northern portion of the downgradient edge of the proposed expansion,
D1 = Average Distance from the base of the leachate collection system to the waste boundary across the northern edge of the proposed landfill; and
D2 = Average Distance from Waste Boundary to Compliance Point.

The flowpath length for the northeastern portion of the downgradient edge of the proposed expansion is determined as follows:

$$L = D1 + D2$$
$$= 181.90ft + 50ft$$
$$= 231.90ft = 70.68m$$

where,

L = Flow Path Length for the northeastern portion of the downgradient edge of the proposed expansion,
D1 = Average Distance from the base of the leachate collection system to the waste boundary across the northeastern edge of the proposed expansion; and
D2 = Average Distance from Waste Boundary to Compliance Point.

The flowpath length for the southeastern portion of the downgradient edge of the proposed expansion is determined as follows:

$$L = D1 + D2$$
$$= 203.92ft + 50ft$$
$$= 253.92ft = 77.39m$$

where,

L = Flow Path Length for the southeastern portion of the downgradient edge of the proposed expansion,
D1 = Average Distance from the base of the leachate collection system to the waste boundary across the southeastern edge of the proposed expansion; and
D2 = Average Distance from Waste Boundary to Compliance Point.

Longitudinal dispersivity for the northwestern edge of the proposed landfill is calculated as follows:

$$\alpha_L = 0.085(82.66)^{0.81} = 3.04m$$

Longitudinal dispersivity for the northern edge of the proposed landfill is calculated as follows:

$$\alpha_L = 0.085(56.73)^{0.81} = 2.24m$$

Longitudinal dispersivity for the northeastern edge of the proposed expansion is calculated as follows:

$$\alpha_L = 0.085(70.68)^{0.81} = 2.68m$$

Longitudinal dispersivity for the southeastern edge of the proposed expansion is calculated as follows:

$$\alpha_L = 0.085(77.39)^{0.81} = 2.88m$$

Transverse Dispersivity. In accordance with IEPA LPC-PA2, the transverse dispersivity is determined as 20% of the longitudinal dispersivity.

Diffusion Coefficient. The diffusion coefficient of the Uppermost Aquifer was assumed to be 0.064 m^2/y (1.75 x 10^{-4} m^2/d) which is the "free solution" diffusion coefficient for chloride at infinite dilution in water at 25^0 C[1]. This value is conservative when evaluating the movement of a contaminant through a porous media such as the Uppermost Aquifer.

Average Contaminant Velocity. The average contaminant velocity is defined as follows[2]:

$$V = \frac{ki}{n_e}$$

where,

- v = Average Contaminant Velocity;
- k = Geometric Mean Horizontal Hydraulic Conductivity;
- i = Average Gradient (February 2019 through February 2021)[3]; and
- n_e = Average Effective Porosity.

$$V(north) = \frac{112.58(0.002030)}{0.367} = 0.62\ m/yr$$

$$V\ (east) = \frac{112.58(0.000359)}{0.367} = 0.107\ m/yr$$

The Average Contaminant Velocity used for the north side is the highest calculated seepage velocity of 0.62 m/yr for the Uppermost Aquifer (0.0017 m/d).

The Average Contaminant Velocity used for the east side is the highest calculated seepage velocity of 0.107 m/yr for the Uppermost Aquifer (0.0003 m/d).

Width of Line Source. As suggested in IEPA LPC-PA2, the width of line source is 1.00 m. This value was used in the model.

R. Kerry Rowe, Robert M. Quigley, Richard W.I. Brachman & John R. Booker (2004). Barrier Systems for Waste Disposal Facilities. CRC Press, London.

[2] Walton, William C. (1991). Principals of Groundwater Engineering. Lewis Publishers, Inc., Chelsea, Michigan.

[3] The gradients used for calculation of the average contaminant velocity are the average of measurements taken from potentiometric data collected in February 2019 through February 2021 (data available at time of publication of the Application for Local Siting Approval for this proposed expansion).

Results of PLUME Model

The results of the PLUME evaluation indicate that well spacings of approximately 169.90 feet on the northwest, 117.48 feet on the north, 183.90 feet on the northeast, and 182.80 feet on the southeast (down-gradient) sides of the landfill will be adequate to detect any potential leak (refer to **Figures 2.8-1 and 2.8-2**). The output files from the PLUME models are included in **Appendix Q**.

It should be noted that the PLUME modeling is overly conservative and has resulted in a proposed well spacing that is much tighter than the minimum 200 foot spacing typically allowed by the IEPA. The modeling did not consider the significant environmental safeguards that are inherent in the landfill design or the conservative assumptions that have been used in the Groundwater Impact Assessment models.

The proposed landfill design includes a composite liner system consisting of a 60-mil HDPE geomembrane liner and a 4-foot compacted cohesive soil liner (1 x 10-7 cm/sec), leachate and landfill gas collection and removal systems, and a composite final cover. In addition, the base of the landfill will be below the potentiometric surface, creating an inward gradient landfill. The inward gradient will limit the potential outward migration of any contaminant to diffusion. Groundwater will flow into the landfill during the active life of the landfill and the post closure care period rather than leachate attempting to exit the landfill. The monitoring network serves as an additional safeguard to monitor the groundwater sources at the facility, verify that the landfill design is functioning as intended, and provide an early warning system in the unlikely event of a release.

Furthermore, in the PLUME models, liner failure was assumed to occur on the down gradient edge of the proposed landfill at the base of the landfill sideslope, therefore reducing the flow path length of the hypothetical plume. This reduced flow path length was used in the determination of the longitudinal dispersivity. It would be more realistic for a release to occur in areas other than the leachate sump and trench areas which will be lined with two 60-mil HDPE liners and a geosynthetic clay liner (sandwiched between the two 60 mil HDPE liners). It would seem reasonable to increase the flow path length and calculate it from the interior of the landfill. Calculating the flow path length from the interior of the landfill would increase the longitudinal dispersivity and widen the hypothetical plume. It would also increase the transverse dispersivity. As a result, an increased flow path length would result in a wider hypothetical plume that could be detected and, therefore, a wider well spacing.

In addition, the MEMO models assumed a line source of one (1) meter. However, a diffusion driven release from this inward gradient landfill will result in a wider source area, creating a wider hypothetical plume that could be detected.

Moreover, the results of the permitted Groundwater Impact Assessment have demonstrated that the facility will not have an adverse impact on the groundwater quality. This assessment included the use of conservative model assumptions including a constant concentration, outward gradient, poor liner contact used to determine the seepage rate, and did not include the application of adsorption of degradation. The GIA determined that the proposed landfill will not adversely impact the groundwater quality at or beyond the edge of the ZOA within 100 years of landfill closure.

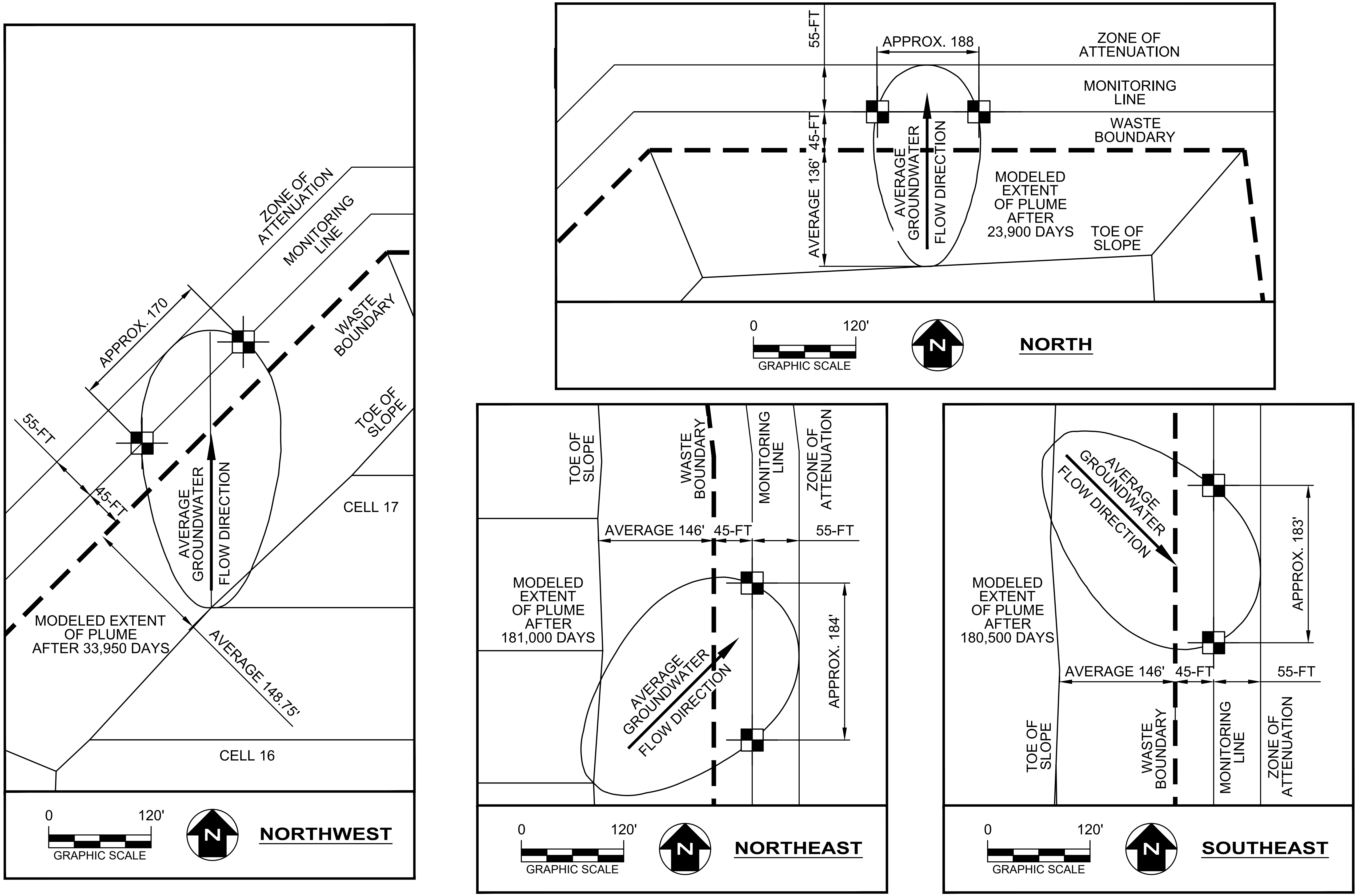
Description of the Proposed Monitoring Network

The proposed monitoring network for the landfill will include a total of 27 detection monitoring wells within the Uppermost Aquifer (G300 through G326). Down-gradient monitoring wells G302 through G306 have been spaced approximately 183 feet apart. Down-gradient monitoring wells G307 through G314 have been spaced approximately 184 feet apart. Down-gradient monitoring wells G315 through G321 have been spaced approximately 117 feet apart. Down-gradient monitoring wells G322 through G326 have been spaced approximately 170 feet apart. Additionally, two up-gradient monitoring wells (G300 and G301) have been added in order to provide continuous background groundwater quality data. The monitoring wells will be installed prior to waste placement in the cells to be monitored as cell development progresses. Proposed monitoring well G304 will be located down-gradient of the first cells to be constructed (Cell 11 and Cell 12) and will be installed at the compliance boundary (i.e. edge of the ZOA) in accordance with 35 Ill. Admin. Code Section 811.318(b)(5). This compliance boundary well is proposed to remain in operation during the life of the landfill and throughout the post-closure period.

Temporary monitoring wells are to be located north of each cell prior to cell operations. These wells will be spaced at 250 feet apart, and will be abandoned prior to construction of the subsequent cell.

The proposed monitoring network for the landfill is depicted on **Figure 2.8-2** and on **Drawing No. D12**. A typical monitoring well is shown in **Photograph 2.8-1**.

Photograph 2.8-1 Typical Monitoring Well



REV. NO.	DATE	DESCRIPTION

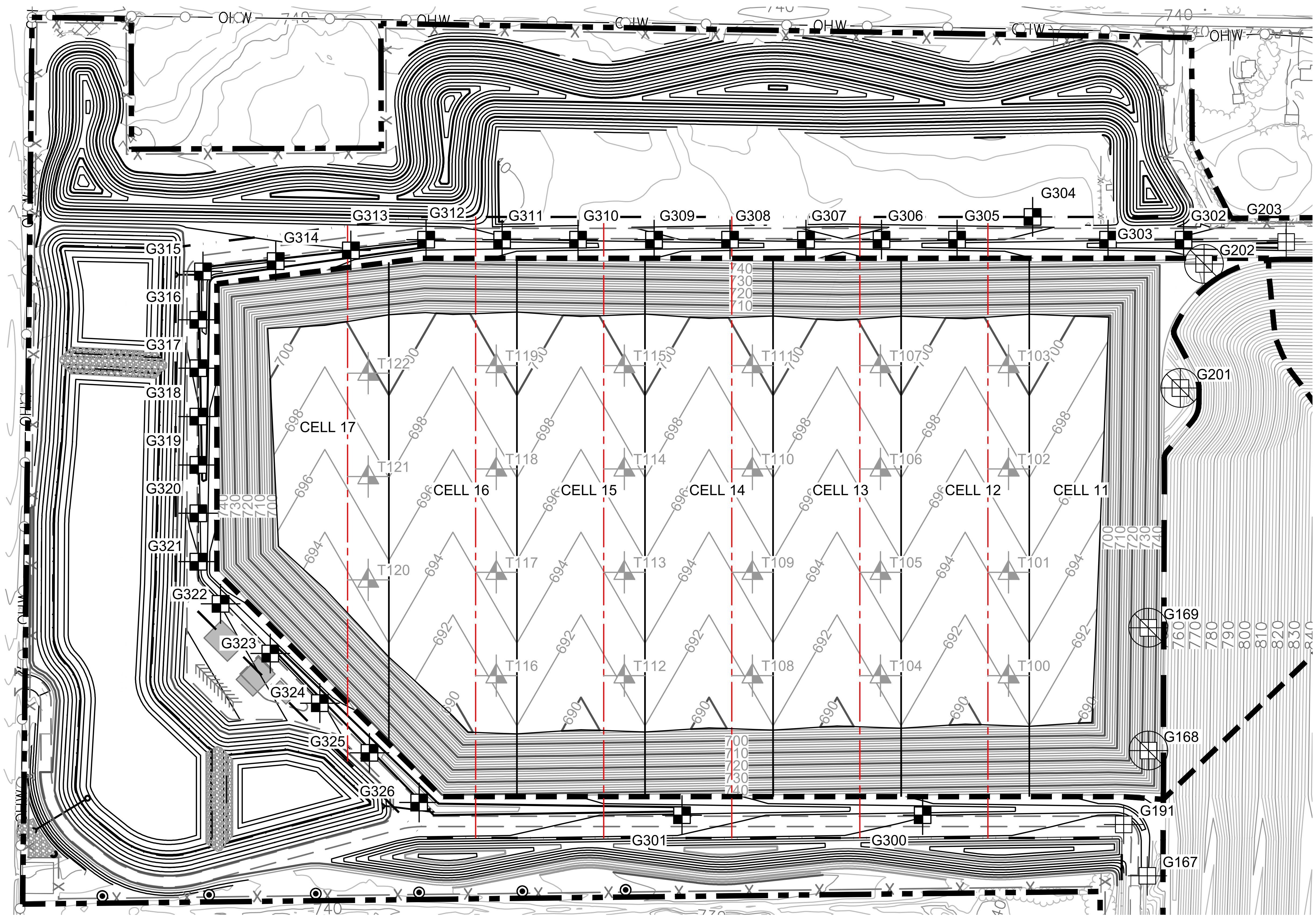
GFL GREEN FOR LIFE environmental

APTIM
APTIM Environmental & Infrastructure, LLC

ZION LANDFILL - SITE 2 NORTH EXPANSION
CITY OF ZION, ILLINOIS

FIGURE 2.8-1
WELL SPACING DETERMINATION DIAGRAM

DRAWN BY:	MRL	APPROVED BY:	DAM	PROJ. NO.:	631020105	DATE:	MAY 2022



GRAPHIC SCALE: 1" = 250'

0 250

LEGEND

	APPROXIMATE FACILITY BOUNDARY
	APPROXIMATE EXISTING WASTE BOUNDARY
	APPROXIMATE PROPOSED EXPANSION WASTE BOUNDARY
	APPROXIMATE ZONE OF ATTENUATION
	APPROXIMATE TEMPORARY ZONE OF ATTENUATION
G302	EXISTING MONITORING WELL - TO REMAIN
G201	EXISTING MONITORING WELL - TO BE REMOVED
G301	PROPOSED MONITORING WELL - TO BE INSTALLED
T100	PROPOSED TEMPORARY MONITORING WELL - TO BE INSTALLED

REV.	DATE	DESCRIPTION

Geo-Logic ASSOCIATES

GFL GREEN FOR LIFE environmental

ZION LANDFILL - SITE 2 NORTH EXPANSION CITY OF ZION, ILLINOIS

FIGURE 2.8-2 PROPOSED MONITORING NETWORK

PROJECT NO.:	IL24.1033.00
DESIGNED BY:	LN
DRAWN BY:	BWM
CHECKED BY:	MNF
APPROVED BY:	DAM
DATE:	JULY 2024

FIGURE 1 OF 1

H:\GFL\IL24.1033.00 Zion LF (IL) Expansion Permitting\IEPA DOI & Draft Denial Responses\(4) Draft Denial - 01.11.24\Attachments\Attachment 1 Backup\ZionLF-Fig-2.8-2-MSV-Well-Locs_IEPA Application-2024-07-08.dwg, 7/8/2024 4:05:06 PM

It should be noted that during the installation of the 27 new detection monitoring wells proposed withing this application, a nested well may also be installed within any saturated intra-till sediments that may be encountered above the Uppermost Aquifer. Should nested wells be necessary, the final monitoring network will consist of more than the 27 permanent monitoring wells indicated above.

Monitoring Well Phasing

The groundwater monitoring network will be developed in phases so that each well will be installed prior to accepting waste in the cell(s) that the wells are intended to monitor. **Table 2.8-1** provides a summary of the groundwater monitoring wells and the phasing status of each monitoring point.

Establishment of Applicable Groundwater Quality Standards

Applicable Groundwater Quality Standard (AGQS) values have been established for the Uppermost Aquifer (Shallow Drift Aquifer) and the Intratill Sediments at the existing Zion Landfill. These permitted AGQS values were used in the GIA model. Applicable pages of the permit which indicate permitted AGQS values for the existing Landfill have been provided in **Appendix Q**.

The AGQS values may be revised to incorporate new standards, additional wells, or intra-well evaluations as approved by the IEPA using Sanitas Groundwater Monitoring statistical software (Sanitas). Prior to calculation of the AGQS values, groundwater monitoring data will be evaluated for potential outliers and spatial variance using Sanitas.

Upon completion of the outlier and spatial variance evaluations, statistical analyses will then be performed in accordance with the USEPA 1992 Standards. Ultimately, the AGQS values will be determined using appropriate procedures specific to each constituent due to the characteristics of its data set (i.e. number of non-detects, normality, etc.).

The Sanitas software allows for the development of AGQSs through the use of a built-in decision logic framework that assures consistency with the USEPA's statistical requirements. The decision logic framework allows the software to move through the series of statistical step flow charts and testing algorithms, ultimately choosing the most appropriate statistical method and making any necessary adjustments or transformations.

For these analyses, normality will first be evaluated using Shapiro-Wilk Test with a specified alpha of 99 percent. Sanitas then utilizes a variety of power transformations in an attempt to normalize the distribution for use in the parametric tests (ladder of powers). The software then chooses the data transformation that normalizes the data with the least powerful transformation. When necessary, the software automatically substitutes a value of one half of the method detection limit for non-detects.

Parametric tests will be performed on normal and log normal datasets when the number of non-detects for a sample set is found to be less than 50 percent. Cohen's Adjustment will be used on the sample mean when the number of non-detects is found to be between 15 and 50 percent.

TABLE 2.8-1 PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING								
Well Name	**Location (Site-Specific Coordinate System)**		**Location (NAD83 Illinois State Planes, East Zone, US Foot)**		**Ground Surface Elevation**	**[1,2]Bottom of Screen Elevation**	**Depth to Bottom of Screen**	**Installation / Phasing**
	Northing	**Easting**	**Northing**	**Easting**	**ft MSL**	**ft MSL**	**ft bgs**	
G300	13044.49	11685.73	2120548.40	1109231.59	745.55	640.55	105.00	Up-gradient well to be installed within 50 feet of the waste boundary prior to Cell 11 operations.
G301	13626.9	11685.73	2121130.81	1109234.64	742.17	645.82	96.35	Up-gradient well to be installed within 50 feet of the waste boundary prior to Cell 11 operations.
G302	12412.86	13077.70	2119909.49	1110620.22	743.06	639.89	103.17	Up-gradient well to be installed within 50 feet of the waste boundary prior to Cell 11 operations.
G303	12595.66	13077.70	2120092.29	1110621.18	744.02	640.31	103.71	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 11 Operations.
G304	12778.46	13132.70	2120274.80	1110677.14	745.57	640.76	104.81	Down-gradient well to be installed at the Zone of Attenuation prior to Cell 11 operations.
G168	12497.75	11841.91	2120000.85	1109384.90	746.00	-	-	Existing well to be abandoned during Cell 11 construction.
G169	12498.20	12138.81	2119999.75	1109681.80	745.01	-	-	Existing well to be abandoned during Cell 11 construction.
G201	12420.64	12718.73	2119919.15	1110261.30	745.21	-	-	Existing well to be abandoned during Cell 11 construction.
G202	12363.21	13019.03	2119860.15	1110561.30	742.71	-	-	Existing well to be abandoned during Cell 11 construction.

TABLE 2.8-1
PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING

Well Name	Location (Site-Specific Coordinate System)		Location (NAD83 Illinois State Planes, East Zone, US Foot)		Ground Surface Elevation	[1,2]Bottom of Screen Elevation	Depth to Bottom of Screen	Installation / Phasing
	Northing	Easting	Northing	Easting	ft MSL	ft MSL	ft bgs	
G305	12961.26	13077.70	2120457.88	1110623.10	746.02	641.27	104.75	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 12 operations.
G306	13144.06	13077.70	2120640.68	1110624.05	746.26	642.18	104.08	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 13 operations.
G307	13326.86	13077.70	2120823.48	1110625.01	746.41	643.09	103.33	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 13 operations.
G308	13510.76	13077.70	2121007.38	1110625.98	746.00	643.80	102.20	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 14 operations.
G309	13694.66	13077.70	2121191.27	1110626.94	744.48	643.99	100.48	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 14 operations.
G310	13878.56	13077.70	2121375.17	1110627.90	744.01	644.12	99.89	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 15 operations.

TABLE 2.8-1 PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING								
Well Name	Location (Site-Specific Coordinate System)		Location (NAD83 Illinois State Planes, East Zone, US Foot)		Ground Surface Elevation	[1,2]Bottom of Screen Elevation	Depth to Bottom of Screen	Installation / Phasing
	Northing	Easting	Northing	Easting	ft MSL	ft MSL	ft bgs	
G311	14062.46	13077.70	2121559.07	1110628.87	743.19	644.18	99.01	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 16 operations.
G312	14246.36	13077.70	2121742.97	1110629.83	742.16	643.18	98.98	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 16 operations.
G326	14263.32	11716.31	2121767.05	1109268.55	740.00	646.90	93.11	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 16 operations.
G313	14428.42	13051.76	2121925.16	1110604.85	740.48	641.22	99.26	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G314	14610.49	13025.83	2122107.36	1110579.87	738.59	639.26	99.33	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G315	14786.52	13000.82	2122283.52	1110555.78	740.00	638.34	101.66	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G316	14797.81	12883.82	2122295.42	1110438.84	740.15	638.54	101.61	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.

TABLE 2.8-1 PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING								
Well Name	Location (Site-Specific Coordinate System)		Location (NAD83 Illinois State Planes, East Zone, US Foot)		Ground Surface Elevation	[1,2]Bottom of Screen Elevation	Depth to Bottom of Screen	Installation / Phasing
	Northing	Easting	Northing	Easting	ft MSL	ft MSL	ft bgs	
G317	14797.81	12766.82	2122296.03	1110321.84	740.46	639.00	101.46	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G318	14797.81	12649.82	2122296.64	1110204.84	742.01	639.45	102.56	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G319	14797.81	12532.82	2122297.26	1110087.84	742.04	639.90	102.14	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G320	14797.81	12415.82	2122297.87	1109970.84	742.34	640.35	101.99	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G321	14797.81	12298.82	2122298.48	1109853.85	744.00	641.08	102.92	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G322	14743.87	12196.86	2122245.08	1109751.61	743.78	642.15	101.62	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.

TABLE 2.8-1
PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING

Well Name	Location (Site-Specific Coordinate System)		Location (NAD83 Illinois State Planes, East Zone, US Foot)		Ground Surface Elevation	[1,2]Bottom of Screen Elevation	Depth to Bottom of Screen	Installation / Phasing
	Northing	Easting	Northing	Easting	ft MSL	ft MSL	ft bgs	
G323	14623.73	12076.73	2122125.57	1109630.85	742.22	643.78	98.44	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G324	14503.59	11956.59	2122006.07	1109510.08	742.08	644.96	97.12	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G325	14383.46	11836.45	2121886.56	1109389.32	740.40	645.93	94.47	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
T100	12836.55	12023.05	2120330.71	1109563.37	756.05	641.87	114.18	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 11 operations and abandoned prior to Cell 12 construction.
T101	12836.55	12273.05	2120330.71	1109813.37	751.37	643.63	107.74	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 11 operations and abandoned prior to Cell 12 construction.

TABLE 2.8-1 PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING								
Well Name	Location (Site-Specific Coordinate System)		Location (NAD83 Illinois State Planes, East Zone, US Foot)		Ground Surface Elevation	[1,2]Bottom of Screen Elevation	Depth to Bottom of Screen	Installation / Phasing
	Northing	Easting	Northing	Easting	ft MSL	ft MSL	ft bgs	
T102	12836.55	12523.05	2120330.71	1110063.37	741.97	644.73	97.24	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 11 operations and abandoned prior to Cell 12 construction.
T103	12836.55	12773.05	2120330.71	1110313.37	741.99	644.31	97.68	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 11 operations and abandoned prior to Cell 12 construction.
T104	13146.55	12023.05	2120640.71	1109563.37	753.10	645.14	107.96	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 12 operations and abandoned prior to Cell 13 construction.
T105	13146.55	12273.05	2120640.71	1109813.37	748.74	646.38	102.36	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 12 operations and abandoned prior to Cell 13 construction.

TABLE 2.8-1 PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING								
Well Name	Location (Site-Specific Coordinate System)		Location (NAD83 Illinois State Planes, East Zone, US Foot)		Ground Surface Elevation	[1,2]Bottom of Screen Elevation	Depth to Bottom of Screen	Installation / Phasing
	Northing	Easting	Northing	Easting	ft MSL	ft MSL	ft bgs	
T106	13146.55	12523.05	2120640.71	1110063.37	742.03	646.88	95.15	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 12 operations and abandoned prior to Cell 13 construction.
T107	13146.55	12773.05	2120640.71	1110313.37	744.00	646.20	97.80	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 12 operations and abandoned prior to Cell 13 construction.
T108	13456.55	12023.05	2120950.71	1109563.37	733.29	647.49	85.80	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 13 operations and abandoned prior to Cell 14 construction.
T109	13456.55	12273.05	2120950.71	1109813.37	742.05	648.19	93.86	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 13 operations and abandoned prior to Cell 14 construction.

TABLE 2.8-1
PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING

Well Name	Location (Site-Specific Coordinate System)		Location (NAD83 Illinois State Planes, East Zone, US Foot)		Ground Surface Elevation	[1,2]Bottom of Screen Elevation	Depth to Bottom of Screen	Installation / Phasing
	Northing	Easting	Northing	Easting	ft MSL	ft MSL	ft bgs	
T110	13456.55	12523.05	2120950.71	1110063.37	743.98	648.14	95.84	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 13 operations and abandoned prior to Cell 14 construction.
T111	13456.55	12773.05	2120950.71	1110313.37	744.00	646.69	97.31	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 13 operations and abandoned prior to Cell 14 construction.
T112	13766.55	12023.05	2121260.71	1109563.37	738.12	647.60	90.52	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 14 operations and abandoned prior to Cell 15 construction.
T113	13766.55	12273.05	2121260.71	1109813.37	742.47	648.28	94.19	Temporary Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 14 operations and abandoned prior to Cell 15 construction.

TABLE 2.8-1 PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING								
Well Name	Location (Site-Specific Coordinate System)		Location (NAD83 Illinois State Planes, East Zone, US Foot)		Ground Surface Elevation	[1,2]Bottom of Screen Elevation	Depth to Bottom of Screen	Installation / Phasing
	Northing	Easting	Northing	Easting	ft MSL	ft MSL	ft bgs	
T114	13766.55	12523.05	2121260.71	1110063.37	742.62	648.34	94.28	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 14 operations and abandoned prior to Cell 15 construction.
T115	13766.55	12773.05	2121260.71	1110313.37	744.00	646.92	97.08	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 14 operations and abandoned prior to Cell 15 construction.
T116	14076.55	12023.05	2121570.71	1109563.37	739.08	647.29	91.79	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 15 operations and abandoned prior to Cell 16 construction.
T117	14076.55	12273.05	2121570.71	1109813.37	744.92	645.95	98.97	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 15 operations and abandoned prior to Cell 16 construction.

TABLE 2.8-1 PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING								
Well Name	Location (Site-Specific Coordinate System)		Location (NAD83 Illinois State Planes, East Zone, US Foot)		Ground Surface Elevation	[1,2]Bottom of Screen Elevation	Depth to Bottom of Screen	Installation / Phasing
	Northing	Easting	Northing	Easting	ft MSL	ft MSL	ft bgs	
T118	14076.55	12523.05	2121570.71	1110063.37	743.17	646.24	96.93	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 15 operations and abandoned prior to Cell 16 construction.
T119	14076.55	12773.05	2121570.71	1110313.37	743.74	645.61	98.12	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 15 operations and abandoned prior to Cell 16 construction.
T120	14386.55	12254.67	2121880.71	1109795.00	739.06	645.41	93.64	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 16 operations and abandoned prior to Cell 17 construction.
T121	14386.55	12504.67	2121880.71	1110045.00	741.03	644.64	96.40	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 16 operations and abandoned prior to Cell 17 construction.

TABLE 2.8-1
PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING

Well Name	Location (Site-Specific Coordinate System)		Location (NAD83 Illinois State Planes, East Zone, US Foot)		Ground Surface Elevation	[1,2]Bottom of Screen Elevation	Depth to Bottom of Screen	Installation / Phasing
	Northing	Easting	Northing	Easting	ft MSL	ft MSL	ft bgs	
T122	14386.55	12754.67	2121880.71	1110294.996	741.51	643.89	97.62	Temporary down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 16 operations and abandoned prior to Cell 17 construction.

Notes:
1. The screened interval will be approximately 5-10 feet.
2. The proposed groundwater monitoring network has been designed to target the Uppermost Aquifer (Shallow Drift Aquifer).

Additionally, if all the background values are less than the MDL for a given parameter, the Practical Quantitation Limit (PQL) will be used to evaluate data from the monitoring wells. Therefore, the AGQSs for the parameters which are non-detections will be set at their respective PQLs.

It should be noted that following the USEPA statistical requirements, as well as the use of Sanitas software, has traditionally been accepted by the IEPA.

Maximum Allowable Predicted Concentrations (MAPCs)

The GIA in Section 2.7 demonstrates that the proposed expansion will not cause an exceedence of any of the constituent concentrations over the AGQS values at or beyond the edge of the ZOA within 100 years of landfill closure for the Uppermost Aquifer. MAPC values were conservatively set equal to the AGQS values.

Design and Construction of Monitoring Wells

All monitoring wells for the Site 2 North Expansion will be designed and constructed in accordance with the following procedures:

1. Standards established in 35 Ill. Admin. Code, Section 811.318(d);

2. IEPA guidance;

3. Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers, ASTM D 5092-90; and

4. Monitoring Well Design and Construction, Chapter 3, RCRA Groundwater Monitoring Technical Enforcement Guidance Document, U.S. EPA, September 1986.

A typical as-built diagram for groundwater monitoring well construction is provided in **Appendix Q** and on **Drawing No. D20**. The monitoring wells will be constructed to yield groundwater samples that represent the quality of groundwater at the landfill site.
The procedure for constructing the monitoring wells at the landfill will typically consist of the following steps:

1. Prior to well construction, all monitoring well locations will be staked in the field by a survey crew under the supervision of a Professional Land Surveyor licensed in the State of Illinois;

2. Borings will be drilled and continuously sampled to the target depth at each monitoring well location. Drilling fluids will be avoided to the extent practical. Soil samples will typically be obtained by either advancing a 5-foot continuous split core barrel (or similar), driving a 2-inch outside diameter split-spoon sampler (ASTM D 1586) or pushing a thin-walled 3-inch diameter Shelby tube sampler (ASTM D 1587). A geologist or geotechnical engineer will direct the field exploration operations, log the

soil samples, and document the well construction. Boreholes within 10 feet of an existing continuously sampled boring need not be continuously sampled through the depth intervals that were previously sampled;

3. Each monitoring well will be constructed using a 2-inch inside diameter, flush joint, well screen and riser pipes. The screen length for the proposed monitoring wells will be approximately 5 or 10 feet. An end plug will be placed at the bottom of the screen and a vented cap will be placed on the top. Monitoring wells may be constructed of PVC, stainless steel, Teflon, or other materials approved by the IEPA. All threaded joints will be sealed using either manufacturer supplied O-rings or Teflon tape;

4. A filter pack will be constructed in each well by filling the annular space with silica sand (approximately 2-1/2 to 3 times larger than the 50% grain size of the zone being monitored) to a depth of approximately 2 feet above the top of the screen. If the in-situ material is appropriate (i.e. sand and gravel), then the formation may be allowed to collapse around the well screen to the desired elevation;

5. A minimum 2-foot-thick bentonite chip or pellet seal may be placed above the top of the filter pack if the seal can be placed without bridging the chips or pellets. Otherwise, an approximate 3-foot thick bentonite slurry seal may be placed above the sandpack using a tremie pipe method;

6. The annular space above the bentonite seal and/or sand pack will be grouted to within 2 to 4 feet of the ground surface with a bentonite Volclay® grout, or equivalent, using the tremie method;

7. Concrete will be used to top off the annular space at the ground surface;

8. A well protector with a locking lid will then be installed in the concrete to protect and secure the monitoring well;

9. The well protector will be clearly labeled with the monitoring well number;

10. A concrete pad will be constructed around the well protector. The pad will be sloped to divert surface water away from the well;

11. The drill tooling, sampling equipment, and well screen/riser pipe that contact the in-situ geologic materials will be decontaminated using a hot water pressure washer prior to drilling each borehole. Field decontamination of certified pre-cleaned well screen/riser pipe materials will not be required. The sampling equipment will be washed in a solution of Alconox™ (or equivalent) and potable water and then rinsed in potable water prior to each use; and

12. The monitoring wells will be developed to ensure that the well screens are unobstructed and that representative groundwater is flowing into the wells.

The construction of each monitoring well will be documented by completing and submitting the IEPA Well Completion Report, the Illinois Department of Public Health (IDPH) Well Construction Report form, and an as-built diagram as provided in **Appendix Q**.

Monitoring Well and Boring, Plugging, and Abandonment

Test borings, damaged wells or piezometers and wells or piezometers no longer used for long-term monitoring at the landfill will be abandoned in accordance with 35 Ill. Admin. Code, Section 811.315 and 811.316 Plugging and Sealing of Drill Holes, and in accordance with 77 Ill. Admin. Code, Section 920.120. Abandonment procedures as described below will be followed in the event a monitoring well becomes unserviceable and must be replaced. Abandonment procedures will also be used if any unknown wells are encountered during site development. The grout used to abandon the wells will typically be a pure bentonite grout. The specific abandonment procedures are provided in the following sections.

Test Boring Abandonment

Any test borings to be drilled at the landfill for site development will be surveyed and properly abandoned as described in this section. Abandoment will be documented by a geologist or engineer.

Test borings temporarily left unattended (e.g., to obtain water elevation readings) will be temporarily covered and marked (e.g., using flagged lath). The temporary cover will minimize the flow of stormwater runoff into the boring and prevent accidental entry by animals. If an uncased boring partially or completely collapses, resulting in a potential contaminant migration pathway, the borehole will be redrilled prior to abandonment. Immediately after the required data has been collected or the boring has been redrilled, the boring will be abandoned in accordance with the following procedure.

A tremie pipe will be inserted to the bottom of each boring to be advanced. If the boring collapses, the tremie pipe will be inserted through the hollow stem augers or casing. The slurry will be tremied under pressure. As the formation water is displaced, the tremie pipe will be withdrawn. The bottom of the augers and the tremie pipe will remain just below the top of the slurry until the grout reaches the ground surface.

The surveyed ground elevation and the location of the abandoned borehole will be recorded by the supervising engineer, geologist. An abandoned boring certification form will be completed and submitted to the IEPA in accordance with permit conditions and the IDPH requirements. A copy of this form is included in **Appendix Q.**

Monitoring Well or Piezometer Abandonment

A groundwater monitoring well or piezometer required to be removed from service will be abandoned in accordance with the following procedure.

For monitoring wells or piezometers in which the well is screened in bedrock, the following plugging procedure should typically be used (it is assumed that any obstruction in the well casing will be removed prior to this procedure; if an obstruction is not able to be removed, the second procedure described below should be followed):

1. Cut casing off at desired depth;

2. Mix grout;

3. Insert tremie pipe into well and extend to bottom;

4. Slowly pump slurry under low pressure through tremie pipe;

5. Slowly withdraw tremie pipe making sure bottom of pipe remains below the grout slurry mix; and

6. Continue slow pumping until all formation water and the grout is displaced from top of casing.

For monitoring wells or piezometers which were screened in unconsolidated sediments, the following procedure should typically be used:

1. Knock out and remove thin surface concrete plug, if present;

2. Re-auger entire length of well;

3. Remove well casing from re-augered borehole;

4. Mix grout;

5. Insert tremie pipe into augers and extend to bottom;
6. Slowly pump grout under low pressure through tremie pipe;

7. Continue slow pumping until all formation water and the watery slurry mix is displaced from top of casing;

8. Slowly withdraw tremie pipe making sure bottom of pipe remains below the grout;

9. Pull a flight of augers; and

10. Top off grout after each flight is removed.

The ground elevation and the location of the abandoned monitoring well or piezometer will be recorded by the supervising engineer or geologist. An abandoned monitoring well certification form will be completed and will be submitted to the IDPH and the IEPA in accordance with permit conditions and IDPH requirements.

Groundwater and Leachate Sampling Procedures

Upon approval of the IEPA, dedicated submersible pumps will be utilized to sample each monitoring well using low flow purging techniques. The detailed sampling procedure (including procedures for sample preservation and chain of custody) that will be followed to collect leachate or groundwater samples from the monitoring wells where a dedicated submersible pump is utilized is provided in **Appendix Q**. Care will be taken to decontaminate all equipment to prevent possible cross contamination of wells. Depth to water from top of riser and elevation of the groundwater surface in reference to Mean Sea Level (MSL) datum will also be provided.

Traditional Groundwater Sampling for a Well Without a Dedicated Pump

In the case that traditional groundwater sampling is required, the following procedures will be followed:

After unlocking the monitoring well protector and removing the vented cap, the water level will generally be obtained utilizing an electronic water level indicator. After the water level is recorded, a minimum of three (3) well volumes of water will be evacuated from the monitoring well if possible. Field measurements of water level, water temperature, pH, conductivity and well depth will be recorded after each well volume is removed.

The groundwater sample will be marked appropriately and logged on the water sample chain of custody records. Water samples will be stored on ice and transported or shipped to the laboratory in a cooler or other suitable container. The laboratory will be capable of performing all analytical analysis in accordance with standard testing methods as approved by the state. Upon arrival at the laboratory, water samples and the chain of custody records will be surrendered to the laboratory. By following these quality assurance procedures, the potential for false positives should be minimized. **Photograph 2.8-2** depicts a sample being pulled from a typical monitoring well.

Sampling and testing will be governed by the approved IEPA permit and applicable State regulations.

Detection Monitoring Parameters, Frequency and Data Analyses

Groundwater monitoring at the landfill can be divided into the following three stages:

1. Monitoring prior to accepting waste;
2. Monitoring during the landfill operations; and
3. Monitoring during post-closure.

The specific monitoring program for each stage is detailed in the following sections.

Photograph 2.8-2 Sampling of a typical monitoring well

Monitoring Prior to Accepting Waste

As cell development progresses, all groundwater monitoring wells designated for each cell will be installed prior to accepting waste in that cell. Documentation of well construction will generally be provided with the application for a significant permit modification for operating authorization for each landfill cell.

Detection Monitoring During Landfill Operation

Groundwater monitoring will be performed quarterly in accordance with 35 Ill. Admin. Code, Section 811.319 for the indicator parameters required within 35 Ill. Adm. Code, Section (a)(2). Organic constituents will be monitored within each new well within three months of installation and will be added to the monitoring list on a semi-annual basis in accordance with 35 Ill. Admin. Code, Section 811.319(a)(3). The detection monitoring analytical results for the permitted monitoring wells will be evaluated in accordance with 35 Ill. Admin. Code, Section 811.319(a)(4).

Monitoring During Post-Closure

Monitoring during post-closure will remain unchanged from that performed during landfill operations, unless a change to the monitoring program is approved by the IEPA as provided for in 35 Ill. Admin. Code, Section 811.319.

Statistical Analysis of Groundwater Quality Data

As required by 35 Ill. Admin. Code, Section 811.320, routine groundwater quality monitoring data will be analyzed by comparing the results of the groundwater sampling to AGQS and MAPC values which have been established at the site using the applicable statistical procedure specific to each particular constituent and its background data set.

The routine groundwater quality monitoring data will be compared to the AGQS and MAPC values. The applicable water quality standards may be revised to incorporate new standards, additional wells, or intra-well evaluations as approved by the IEPA. The AGQS values that will be used for groundwater quality evaluation are summarized in the GIA in Section 2.7 of the Application. Additionally, applicable pages of the permit which indicate permitted AGQS values for the existing landfill have been provided in **Appendix Q**.

Evaluation of Groundwater Quality Data

The groundwater quality data for the routine monitoring parameters will be evaluated in accordance with Title 35 Ill. Admin. Code, Section 811.319(a)(4). The current required evaluations include the comparison of the concentration of constituents in wells:

1. Over the last eight consecutive monitoring periods;

2. To the applicable MAPC values (if established);

3. To the preceding measured concentration (for the organic constituents); and

4. To the applicable AGQS values.

As the AGQS and MAPC values have been established pursuant to statistical procedures, the comparison in item numbers 2 and/or 4 above will satisfy the requirement of Title 35 Ill. Admin. Code, Section 811.320(e) for statistical analysis of groundwater monitoring data. According to current regulations, a monitored (observed) increase occurs when:

1. The concentration of any constituent monitored in a particular monitoring well shows a progressive increase over eight consecutive monitoring periods;

2. The concentration of any constituent in a particular monitoring well exceeds the MAPC values at an established monitoring point within the zone of attenuation;

3. The concentration of any organic constituent monitored annually in a particular monitoring well exceeds the preceding measured concentration; and

4. The concentration of any constituent monitored in a particular monitoring well at or beyond the zone of attenuation exceeds its AGQS value.

In the event a monitored (observed) increase occurs, Zion Landfill, Inc. will, within 48 hours of the observed increase, obtain a representative sample of the source water in each well which is located within 200 feet of the affected well and whose owners have agreed to participate in the monitoring program per the terms of the host agreements in Appendix C.

Confirmation of Observed Increase

The observed increase will be confirmed in accordance with 35 Ill. Admin. Code, Section 811.319(a)(4)(B). Current confirmation procedures generally includes taking additional samples within 90 days of the initial observation to confirm the validity of the initial sample. In the event an observed increase is confirmed, the following procedures are generally followed:

1. Determine the source of any confirmed increase, which may include, but not be limited to, natural phenomena, sampling or analytical errors, or an off-site source;

2. The IEPA will be notified in writing no later than 180 days after the original sampling event of any confirmed increase. Within this notification, a demonstration will be made, if possible, that the increase is a result of a source other than the Facility, providing rationale used in such a determination; and

3. If an alternate source demonstration cannot be made or is denied by the IEPA, assessment monitoring will be proposed.

In the event that there is a confirmed increase in the concentration of any constituent in any monitoring well, and a demonstration that the confirmed increase is not caused by the landfill is not made, the necessary steps will be implemented immediately. These steps may include the following:

1. Assessment monitoring as outlined in 35 Ill. Admin. Code, Section 811.319(b);

2. Assessment of potential groundwater impact as outlined in 35 Ill. Admin. Code, Section 811.319(c); and

3. Corrective action as outlined in 35 Ill. Admin. Code, Section 811.324, 811.325, and 811.326.

A remedy that will protect human health and the environment will be selected in accordance with 35 Ill. Admin. Code, Section 811.325. The corrective action, if appropriate, will be implemented and completed in accordance with the requirements of 35 Ill. Admin. Code, Section 811.326.

Leachate Monitoring

The existing facility has a leachate monitoring network as illustrated on Drawing No. D5. There will ultimately be a total of 7 new leachate monitoring points for the expansion area; one corresponding to each sump location as illustrated in Drawing No. 10. Leachate will be sampled on a semi-annual basis in accordance with 35 Ill. Admin. Code 811.309(g) and 35 IAC 811.319(a)(3)(C). Sampling will be conducted as long as the leachate collection system is in operation (a minimum of 30 years after closure of the facility), unless a reduced post closure sampling period is found to sufficiently protect the public health and the environment. All test results will be submitted to the IEPA. At a minimum, leachate will be analyzed for the same list of parameters as the groundwater monitoring wells. The sampling procedure that will be followed to collect leachate samples is provided in **Appendix Q**.

Landfill Gas Monitoring

Subsurface Monitoring

Subsurface landfill gas monitoring at the Site 2 North Expansion is proposed to be conducted in accordance with the requirements of 35 Ill. Admin. Code Section 811.310. The proposed landfill gas probe network will be utilized to verify that the landfill gas collection and containment systems are functioning as designed. The proposed landfill gas monitoring network is illustrated on **Drawing No. D14**. A schematic of a typical landfill gas probe is illustrated in **Diagram 2.8-1**. Landfill gas probes will be inspected at the time of monitoring events for structural integrity and proper operations.

Perimeter landfill gas monitoring probes are proposed to be constructed (see **Drawing No. D20**) of 1-inch diameter Schedule 40, or equivalent material which will not react with or be corroded by landfill gas. The probes will be equipped with valve/hose pressure fitting(s), etc. as necessary to measure pressure and allow collection of a representative sample of gas within the probes.

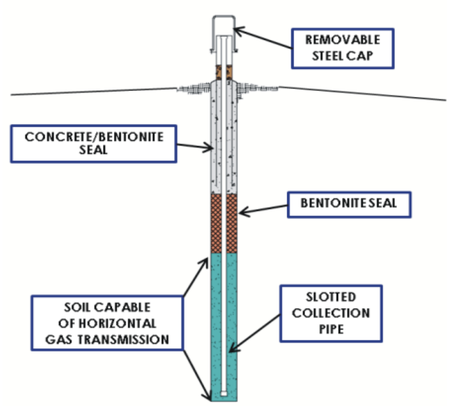


Diagram 2.8-1 Schematic of a typical gas monitoring probe

The monitoring zone for these probes will be in accordance with 811.310. Pipe joints and fittings will be maintained in air-tight condition, and the probe will be installed with a bentonite seal at the surface to minimize leakage. The design and construction of the landfill gas monitoring system will not interfere with the operations of the liner or leachate collection system, or delay the construction of the final cover system.

Subsurface landfill gas monitoring devices will be sampled on a periodic basis in accordance with 811.310(c). At a minimum, below ground monitoring points will be screened for methane, pressure, nitrogen, oxygen, and carbon dioxide as required by the IEPA. Monitoring will be adjusted as necessary to comply with the federal, state, and local regulations to ensure proper operation procedures.

Surface Emission Monitoring (SEM) and Ambient Air Monitoring

As discussed within Section 2.3 of this Application, in addition to subsurface landfill gas monitoring, ambient air monitoring will be conducted around the perimeter of the unit and in on-site buildings to verify that the landfill gas collection and containment systems are functioning as designed. At least three ambient air monitoring locations will be chosen, and samples must be taken no higher than 1 inch above the ground and 100 feet downwind from the edge of the waste boundary or at the property boundary, whichever is closer to the waste boundary. All buildings within the facility will be monitored for methane by utilizing continuous detection devices located at likely points where methane might enter each building. Ambient air monitoring locations at the site will be monitored in conformance with the requirements of the prevailing regulations which require sampling on a monthly basis for the entire operating period and for a minimum of five years after closure. The sampling frequency may be reduced to a quarterly frequency after five years of closure upon approval by the IEPA.

Surface emissions monitoring (SEM) will be performed in accordance with 40 CFR 60.755 (c) and (d); 40 CFR 60, Appendix A, Method 21; and Title 35 IAC 220.240(c). A flame ionization detector will be used to monitor the landfill surface along a site-specific traverse pattern, and at areas suspected of exceeding 500 ppm methane, including signs of gas bubbles, odors, stressed piping, etc. SEM events will be performed on a quarterly basis for the entire landfill. Prior to each monitoring event, background will be established as outlined in 40 CFR 60.755. The existing SEM Plan has been updated to include the Site 2 North Expansion Area within **Appendix L**.

In the event of a methane exceedance of 500 ppm above background, the following actions will be taken in accordance with 35 IAC 220.240(c)(4).

1. The location of each monitored exceedance will be marked and the location recorded.

2. Cover maintenance or adjustments to the vacuum of the adjacent wells to increase the gas collection in the vicinity of each exceedance shall be made and the location will be re-monitored within 10 calendar days after detecting the exceedance.

3. If the re-monitoring of the location shows a second exceedance, additional corrective action will be taken, and the location will be monitored again within 10 days after the second exceedance. If the

re-monitoring shows a third exceedance for the same location, the action specified in number 5 below will be taken.

4. If re-monitoring of the location does not show an exceedance, as specified in numbers 2 or 3 above, the location shall be re-monitored 1 month from the initial exceedance. If the 1-month re-monitoring shows a concentration less than 500 ppm above background, no further monitoring of that location is required until the next quarterly monitoring period. If the 1-month re-monitoring shows an exceedance, the actions specified in numbers 3 above or 5 below, as appropriate, will be taken.

5. For any location where there are three monitored exceedances within a quarterly period, a new well or other collection device will be installed within 120 calendar days after the initial exceedance. An alternate remedy to the exceedance, such as upgrading the blower, header pipes, or control device, and a corresponding timeline for installation may be submitted to the IEPA for approval.

Surface Water Monitoring

A Stormwater Management Plan for the Site 2 North Expansion has been designed to efficiently collect, route, and detain stormwater runoff from the Facility in an environmentally sound manner as described in greater detail within Section 2.4 of this Application. Environmental monitoring of surface water will occur in accordance with NPDES permits which will be modified for the proposed expansion as development progresses. Surface water monitoring and analysis will be performed per the site-specific Stormwater Pollution Prevention Plan and NPDES Permits.

Conclusions

The potential for the Site 2 North Expansion to impact the environment has been evaluated. In addition to the results of the GIA which demonstrate that the facility will not have an adverse impact on the groundwater quality, a comprehensive groundwater monitoring program has been designed for the Site 2 North Expansion. Additionally, Facility operations will include leachate monitoring, subsurface landfill gas monitoring, ambient air monitoring, and surface water monitoring. The Environmental Monitoring Plan at the Facility will serve as an additional safeguard to:

- Monitor potential sources of environmental impact at the facility;
- Verify that the facility design and construction are properly functioning to protect the public health, safety and welfare; and
- Provide an early warning system in the unlikely event of a leachate or landfill gas release.

Monitoring will follow strict quality control, quality assurance, and chain of custody procedures.

Attachment 4

MIGRATE Model Sensitivity Analysis

Geo-Logic ASSOCIATES

MIGRATE Sensitivity Analysis - Zion Landfill Site 2 North Expansion

The potential impact from the proposed landfill was evaluated by first developing a conceptual model of the site stratigraphy and hydrogeologic conditions, and then assigning physical characteristics and engineering properties to the principal material types to be included as model input parameters for the conceptual model. The baseline model was then used to evaluate the site hydrogeologic conditions after development of the landfill and site closure. The baseline model considered the properties and physical conditions most likely to represent expected site conditions. Conservative assumptions were used in the modeling. The results of the baseline model were evaluated at the base of the Wadsworth Formation prior to reaching the Shallow Drift Aquifer (uppermost aquifer) and the Zone of Attenuation (ZOA).

While the baseline model conservatively generated a Groundwater Concentration Prediction Factor (GCPF) prior to the ZOA, there was a concern that the baseline model was not taking into account the landfill base length in the direction of groundwater flow in the uppermost aquifer. Therefore, this MIGRATE sensitivity analysis was preformed to determine if adding the landfill base would generate a higher predicted GCPF in the uppermost aquifer at the ZOA.

MIGRATE Sensitivity Analysis Input

The following information documents the assumptions and values used for the MIGRATE sensitivity model. The sensitivity model represents the anticipated site conditions for the design and hydrogeologic setting of the proposed Site 2 North Expansion and Site 2. The assumptions and values are based on the actual design and CQA plan proposed in the application and the information obtained from the hydrogeologic investigation (Section 2.2). When site specific or permitted values were not available, appropriate and conservative values from literature or values recommended by the IEPA were used.

Model Input

MIGRATE requires values for the input parameters identified in Table 1. The sources of the assigned parameter values for this sensitivity analysis are described as follows. To the extent possible, site- or chemical-specific values were used. As previously mentioned, when site- or chemical-specific parameters were not available, appropriate values were obtained from published literature or by values recommended by the IEPA. In general, the input parameter values assigned for use in this sensitivity analysis were intentionally biased when site-specific values were not available, to result in a higher predicted GCPF in the uppermost aquifer to conform to IEPA conservative approaches. An example of a "conservative" value is using an adsorption coefficient, Kd, equal to zero for constituents that would readily be adsorbed to the liner material and in-situ till of the Wadsworth Formation.

All model input must have consistent units. Each of the model input parameters are discussed briefly in the following paragraphs. Documentation for model input parameters is included within Attachment 1 at the end of this sensitivity analysis.

TABLE 1
SENSITIVITY ANALYSIS - INPUT PARAMETER VALUES

Parameter	**Value**	**Notes**	**Data**
Landfill Base Length (L)(m)	673.89	Longest Distance Across the Landfill Base	1,2,3
Initial Leachate Concentration (Co)	1	Unit Leachate Concentration	2,3
Number of Layers	4	Total Number of Modeled Layers	1,2
Modeling Period (years)	147	47 Years of Active Life Plus 100 Years Past Closure	1,2
TALBOT PARAMETERS			
TAU	7	Talbot Parameters for the Numerical Inversion of the Laplace Transform	2
Sigma	0		2
RNU	4		2
N	40		2
GAUSS INTEGRATION PARAMETERS			
Gauss Integration Parameters	Select	Selected Gauss Integration Parameters	2
Layer 1 – 60-mil HDPE Geomembrane Liner			
Sublayers	1	Model Parameter	2
Thickness (b) (m)	0.0015	Design Specification	1,2
Porosity (n)	1	Assume all Flow through Pinholes	1,2
Adsorption Coefficient (K) (Kg/m^3)	0.0	No Adsorption Modeled	2,3
Degradation (λ)	0.0	No Degradation Modeled	2,3
Density (ρ) (Kg/m^3)	940	HDPE Manufacturer's Specification	1,2
Vertical Darcy Velocity (m/yr)	3.08×10^{-4}	Downward Seepage Rate with 12-Inch Head	2
Horizontal Darcy Velocity (m/yr)	0.0	Assuming Vertical Flow in Liner (only)	1,2
Effective Diffusion Coefficient (D*) (m^2/yr)	3.0×10^{-5}	IEPA Recommended Value	2,3

TABLE 1 (Continued) SENSITIVITY ANALYSIS - INPUT PARAMETER VALUES			
Parameter	**Value**	**Notes**	**Data**
Mechanical Dispersion Coef. (Dm) (m^2/yr)	3.0 x 10^{-5}	Dm = D* (Dispersion was set equal to diffusion due to the low seepage rate out of the liner, movement will be dominated by diffusion)	2,3
Coef. of Hydrodynamic Disp. (D) (m^2/yr)	3.0 x 10^{-5}	D = D* (Due to the low seepage rate, movement will be dominated be diffusion)	2,3
Layer 2 – Recompacted Cohesive Soil Liner			
Sublayers	5	Model Parameter	2
Thickness (b) (m)	1.524	Design Specification	1,2
Porosity (n)	0.25	Derived from the average total porosity from laboratory results for the Wadsworth Formation based on Sara (1994). (Used in Liner Construction)	1,2
Adsorption Coefficient (K) (Kg/m^3)	0.0	No Adsorption Modeled	2,3
Degradation (λ)	0.0	No Degradation Modeled	2,3
Density (ρ) (Kg/m^3)	1,896.5	Value Obtained from Laboratory Results for the Wadsworth Formation	1,2
Vertical Darcy Velocity (m/yr)	3.08 x 10^{-4}	Assuming Outward Gradient	2,3
Horizontal Darcy Velocity (m/yr)	0.0	Assuming Vertical Flow in Liner (only)	1,2
Effective Diffusion Coefficient (D*) (m^2/yr)	0.019	IEPA Accepted Value	2,3
Mechanical Dispersion Coef. (Dm) (m^2/yr)	0.019	$D_m = D^*$ (Dispersion equal to diffusion)	2,3
Coef. of Hydrodynamic Disp. (D) (m^2/yr)	0.019	Movement Dominated by Diffusion	2,3
Layer 3 – Wadsworth Formation			
Sublayers	11	Model Parameter	2
Thickness (b) (m)	10.27	Average Thickness of Wadsworth Formation to Remain Between the Liner System and uppermost aquifer	1,2
Porosity (n)	0.25	Derived from the average total porosity from laboratory results for the Wadsworth Formation based on Sara (1994).	1,2

TABLE 1 (Continued)
SENSITIVITY ANALYSIS - INPUT PARAMETER VALUES

Parameter	Value	Notes	Data
Adsorption Coefficient (K) (Kg/m^3)	0.0	No Adsorption Modeled	2,3
Degradation (λ)	0.0	No Degradation Modeled	2,3
Density (ρ) (Kg/m^3)	1,896.5	Value Obtained from Laboratory Results for the Wadsworth Formation	1,2
Vertical Darcy Velocity (m/yr)	3.08 x 10^{-4}	Assuming Outward Gradient	2,3
Horizontal Darcy Velocity (m/yr)	0.0	Assuming Vertical Flow (only)	1,2
Effective Diffusion Coefficient (D*) (m^2/yr)	0.019	IEPA Accepted Value	2,3
Mechanical Dispersion Coef. (Dm) (m^2/yr)	0.019	D_m = D* (Dispersion equal to diffusion)	2,3
Coef. of Hydrodynamic Disp. (D) (m^2/yr)	0.019	Movement Dominated by Diffusion	2,3
Layer 4 – Shallow Drift Aquifer (Uppermost Aquifer)			
Sublayers	5	Model Parameter	2
Thickness (b) (m)	11.46	Average Thickness of Uppermost Aquifer	2
Porosity (n)	0.37	Derived from the average total porosity from laboratory results for the Shallow Drift Aquifer based on Sara (1994).	1,2
Adsorption Coefficient (K) (Kg/m^3)	0.0	No Adsorption Modeled	2,3
Degradation (λ)	0.0	No Degradation Modeled	2,3
Density (ρ) (Kg/m3)	1,678.7	Value Obtained from Laboratory Results for the Shallow Drift Aquifer	1,2
Vertical Darcy Velocity (m/yr)	3.08 x 10^{-4}	Assuming Outward Gradient	2
Horizontal Hydraulic Conductivity (cm/s)	3.57E-04	Site-Specific Geometric Mean Horizontal Hydraulic Conductivity for the Shallow Drift Aquifer	1
Horizontal Hydraulic Gradient	0.002401	Site-Specific Northerly Average Gradient for the Shallow Drift Aquifer	1
Horizontal Darcy Velocity (m/yr)	0.27	Calculated Using the Site-Specific Geometric Mean Hydraulic Conductivity and Northerly Average Gradient of the Shallow Drift Aquifer	1,2
Effective Diffusion Coefficient (D*) (m^2/yr)	0.064	Free Solution Diffusion of Chloride at Infinite Dilution 25 deg. C	2,3

TABLE 1 (Continued) SENSITIVITY ANALYSIS - INPUT PARAMETER VALUES			
Parameter	**Value**	**Notes**	**Data**
Horizontal Dispersivity (m/yr)	7.45	Per Xu and Eckstein, 1995 (0.83(log landfill length)^2.414 = 0.83 (log 673.89)^2.414 = 10.21 m) Multiplied by the Horizontal Groundwater Seepage Velocity (darcy velocity/porosity)	1,2
Vertical Dispersivity (m/yr)	0.745	Ten Percent of the Vertical Dispersivity	1,2

Explanation of Data:

1. Value is based on actual anticipated site conditions
2. Value is required model input parameter
3. Value is conservative value which will result in higher predicted concentrations than the actual anticipated site conditions

Landfill Length

The landfill flow length must be specified in MIGRATE. For modeling purposes, this value is the length of the bottom of the leachate collection system along the uppermost aquifer groundwater flow path. Generally, groundwater flow in the uppermost aquifer flows easterly and northerly. As a result, the sensitivity analysis landfill flow length was conservatively measured from southwest to northeast across the entire landfill at the longest southwest to northeast distance below the landfill. The estimated landfill flow length is approximately 673.89 m (2,210.94 ft). Documentation establishing the landfill flow length is included in Attachment 1 at the end of this sensitivity analysis.

Initial Leachate Concentration

The initial leachate concentration input used was one (1). This value is unit-less because it represents unit leachate concentration of any given constituent. Therefore, the model results represent a fraction of the initial leachate concentration for any particular constituent.

Model Layers

Four layers were modeled in this sensitivity analysis; a 60-mil HDPE geomembrane liner, a 5-foot recompacted cohesive soil liner (1.0 x 10^{-7} cm/sec), approximately 33.7 feet (10.27 m) of the Wadsworth Formation, and approximately 37.59 ft (11.46 m) of the Shallow Drift Aquifer (uppermost aquifer).

MIGRATE also allows a layer to be subdivided so that the predicted concentration distribution within a layer can be evaluated. The HDPE geomembrane liner, recompacted cohesive soil liner, Wadsworth Formation, and Shallow Drift Aquifer were divided into 1, 5, 11, and 5 sublayers, respectively.

Modeling Period

The modeling period is the expected life of the landfill plus 100 years after closure. The expected life of the landfill has been estimated to be approximately 47 years (1998 to 2044), resulting in a modeling period of 147 years. The expected life of approximately 47 years is based on the time when waste placement activities commenced at the first Site 2 Expansion in March 1998 and an ending operating life of 2044.

Talbot Parameters

MIGRATE uses a Laplace transform to find the solution to the advection-dispersion equation. The numerical inversion of the Laplace transform depends on the Talbot parameters. The model provides default values for the Talbot parameters or they can be selected by the user. The Talbot parameters were selected in this sensitivity analysis (Tau = 7, N = 40, Sig = 0, and RNU = 4).

Gauss Integration Parameters

MIGRATE performs numerical integration to arrive at a final solution. These numerical integrations are performed by dividing the integration range into a number of subintervals and then using Gauss quadrature within each subinterval. Three (3) parameters must be specified in the data input. These parameters are the integration step size, the number of integration steps, and the number of sample points. The program offers three (3) sets of default values or the ability to select each of the parameters. For this sensitivity analysis, integration values were selected. Although selecting integration values requires additional computational effort and time, this option was employed to provide adequate integration for the modeled layers at the subject site to calculate the groundwater concentration prediction factor.

Boundary Conditions

MIGRATE requires the specification of an upper and lower boundary condition. The top boundary condition typically represents the landfill as a potential source. When modeling the landfill as a surface boundary, the concentration of each constituent in leachate can be assumed to be constant or a specific mass can be assumed to be present. Assuming finite mass results in a decreasing source concentration over time, which would most accurately represent the fact that leachate concentrations in landfills with leachate collection and removal systems will gradually decrease over time. However, a constant concentration was assumed as it results in conservative model results.

The lower boundary condition can be specified as permeable, impermeable, or zero concentration. For this sensitivity analysis, the impermeable bottom boundary condition was utilized. The impermeable bottom boundary is conservative as it does not allow any transmission of contaminant across this boundary. If the bottom boundary was not assumed to be impermeable, contaminants would actually diffuse across this boundary and move slowly into the Lower Till below the site (diluting concentrations).

Darcy Velocity

MIGRATE requires the input of the Darcy velocity for each layer in horizontal and vertical directions.

This sensitivity analysis was modeled outward through all modeled layers with 1-foot of leachate head acting on the system (a calculated outward vertical Darcy Velocity of 3.08×10^{-4} m\yr).

In addition to the outward vertical Darcy Velocity, a horizontal Darcy Velocity will also be applied to the Shallow Drift Aquifer (uppermost aquifer). Analysis of the potentiometric maps developed for the uppermost aquifer indicate the presence of an average horizontal gradient of approximately 0.002401 in the northerly direction, 0.000386 in the easterly direction, and overall average 0.001393. The average horizontal gradient of approximately 0.002401 in the northerly direction was conservatively used for this sensitivity analysis. Using the geometric mean horizontal hydraulic conductivity for the Shallow Drift Aquifer (3.57×10^{-4} cm/sec). With a gradient of 0.002401, a Darcy velocity of 0.27 m/yr was calculated.

Hydrodynamic Dispersion Coefficient

MIGRATE requires the input of hydrodynamic dispersion coefficients for both the vertical and horizontal directions for each layer. The hydrodynamic dispersion coefficient is calculated by the following equation:

$$D = D^* + \alpha v \qquad \text{(Equation 1)}$$

where,

D	=	the hydrodynamic dispersion coefficient (m2/y);
α	=	the dispersivity (m);
v	=	the groundwater seepage velocity (m/y);
D*	=	the effective diffusion coefficient (m2/y).

Table 1 lists the model input dispersion coefficient values. The dominant transport mechanism for the HDPE, recompacted cohesive soil liner, and Wadsworth Formation is diffusion due to the low outward seepage rate (3.08 x 10^{-4} m/yr). Dispersivity is negligible due to the low outward seepage rate, therefore the hydrodynamic dispersion coefficient is equal to the effective diffusion coefficient. The diffusion rate in the clay liner and Wadsworth Formation will be greater than the conservative seepage rate out of the landfill. An effective diffusion coefficient of 3.0 x 10^{-5} m^2/y has historically been recommended by the IEPA for the 60 mil HDPE geomembrane liner. This value was used in the sensitivity analysis. An input of 0.019 m^2/yr (Rowe, Quigley, Brachman, and Booker, 2004) was used to represent the effective diffusion coefficient in the five (5) foot recompacted cohesive soil liner and Wadsworth Formation. Documentation of the Hydrodynamic Dispersion Coefficients is provided in Attachment 1.

In the Shallow Drift Aquifer (uppermost aquifer), dispersion needs to be considered in the hydrodynamic dispersion coefficient. The weighted least-squares method described by Xu and Eckstein (1995) was used to determine the horizontal dispersivity (0.83(Log Landfill Length)$^{2.414}$ = 0.83(Log 673.89)$^{2.414}$ = 10.21 m). The horizontal dispersion coefficient was then obtained by taking the horizontal Darcy velocity 0.27 m/yr dividing by the porosity (0.37) (creating the groundwater seepage velocity 0.73 m/yr) and multiply by the dispersivity (10.21 m). A horizontal dispersion coefficient value of 7.45 m/yr was obtained and used in the sensitivity analysis. With the dispersion coefficient dominating over the diffusion coefficient, the Hydrodynamic Dispersion Coefficient will be set equal to the dispersion coefficient. The vertical dispersion was estimated to be ten percent of the horizontal dispersion.

Porosity and Dry Density Input

Table 1 lists the porosity and effective porosity and dry density values for the model layers. The porosity of the 60 mil HDPE geomembrane liner was assumed to be one (1) with all flow occurring through the pinholes in the liner. The density of the HDPE liner was obtained from manufacturer’s specifications.

The effective porosity value for the recompacted cohesive soil liner and Wadsworth Formation was derived from laboratory data for the Wadsworth Formation, which has been provided in Section 2.2 of the Application. The laboratory measured porosity values of the Wadsworth Formation were converted to effective porosities based on empirical data provided by Sara (1994) as shown in Attachment 1. As provided in Attachment 1, the effective porosity of the Wadsworth Formation ranges from 0.21 to 0.32, with an average of 0.25. The percentage difference between the total and effective porosity for a clay was conservatively used to calculate the effective porosities. The clay from the Wadsworth Formation will be used for construction of the recompacted cohesive soil liner.

The effective porosity value for the Shallow Drift Aquifer was derived from laboratory data for the Shallow Drift Aquifer, which has been provided in Section 2.2 of the Application. The laboratory measured porosity values of the Wadsworth Formation were converted to effective porosities based on empirical data provided by Sara (1994) as shown in Attachment 1. As provided in Attachment 1, the effective porosity of the Shallow Drift Aquifer ranges from 0.321 to 0.395, with an average of 0.367. The percentage difference between the total and effective porosity for a loamy sand was conservatively used to calculate the effective porosities.

Adsorption Coefficient

The adsorption coefficient (Kd) is used to simulate retardation of constituents in the subsurface. The adsorption coefficient is specific to each particular compound and the geologic material.

Although adsorption can play a significant role in retarding the migration of numerous constituents in groundwater, it is conservatively assumed that the adsorption coefficients are zero in this sensitivity analysis.

Degradation

Degradation is used to simulate degradation of constituents in the subsurface. Degradation is specific to each particular compound.

Although degradation can play a significant role in reducing the migration of numerous constituents in groundwater, it is conservatively assumed that degradation is not present in this sensitivity analysis.

Model Assessment Distance

The model assessment distance is not a model input parameter. However, this distance is needed in order to evaluate the results of this sensitivity analysis since the model only provides results for specified distances. The results provided by MIGRATE for a particular distance are relative to the center of the landfill along the longest groundwater flow path. Therefore, when evaluating the results reported for all the various distances evaluated in the various modeling steps, the lateral distance to the center of the landfill needs to be considered and augmented accordingly. The model assessment distance is thus defined here as the distance from the center of the landfill to the edge of the ZOA along the longest flow path. The ZOA, as defined in 35 Ill. Admin. Code 810.103, is the "three-dimensional region formed by excluding the volume occupied by the waste placement from the smaller of the volumes resulting from the vertical planes drawn to the bottom of the uppermost aquifer at the property boundary or 100 feet from the edge of one or more adjacent units." For the proposed landfill, the edge of the ZOA is 100 feet from the waste boundary.

Thus, the model assessment distance becomes the sum of half of the landfill length plus the sidewall distance plus the compliance distance along the longest flow path. As stated, before in the landfill length section, the landfill length is 673.89 m (2,210.94 ft). The distance created by the minimum side wall width at the northern end of the landfill is 37.44 m (122.84 ft) and the compliance distance is 30.48 m (100 ft). The corresponding model assessment distance is 404.87 m ((673.89/2) + 37.44 + 30.48). The concentrations are also predicted at 1/3 and 2/3 of the distance between the waste boundary and the limit of the ZOA. The corresponding model assessment distances are 384.55 m ((673.89/2) + 37.44 + (30.48*1/3)) and 394.71 m ((673.89/2) + 37.44 + (30.48*2/3)).

MIGRATE Sensitivity Analysis Results

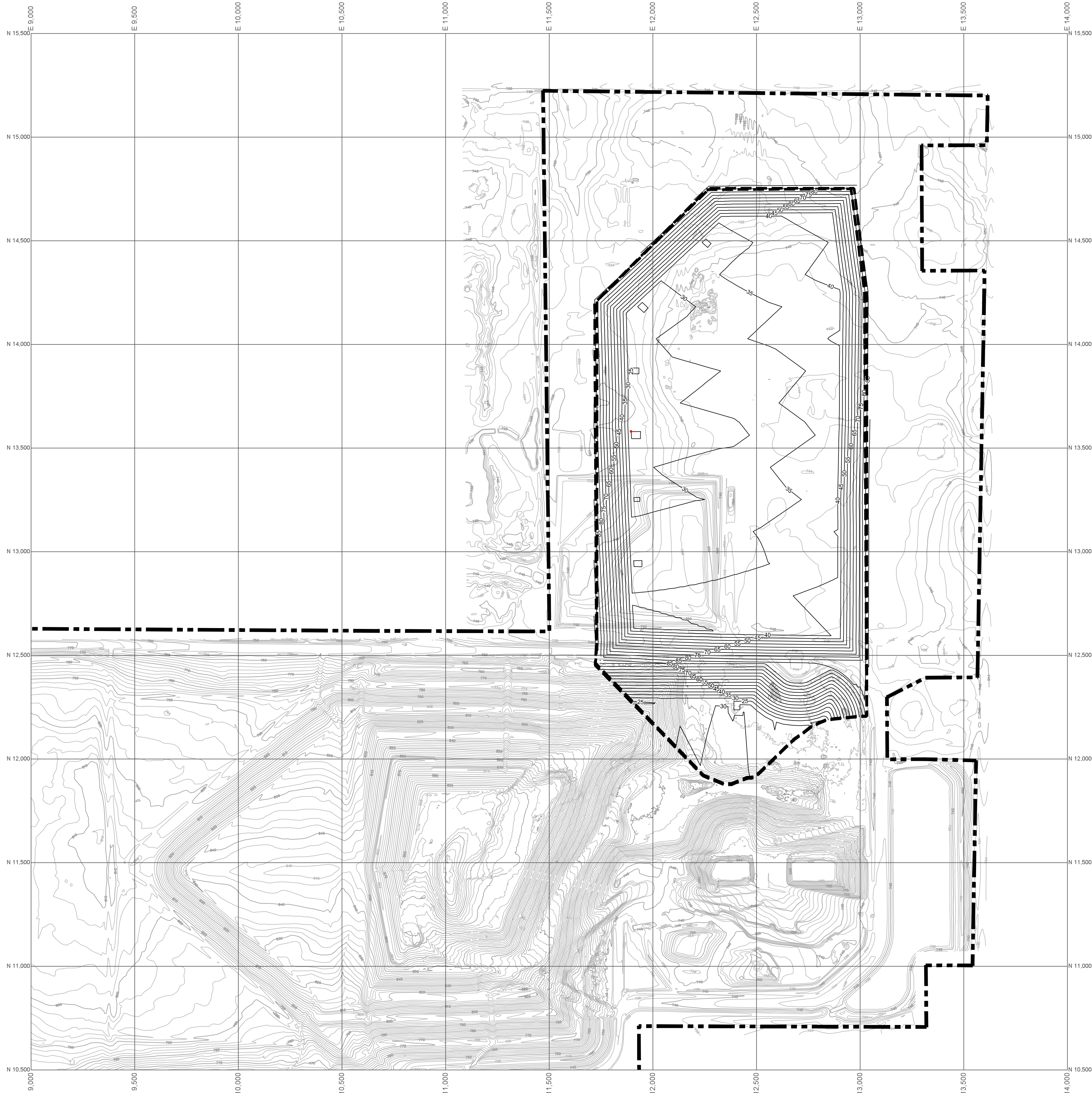
The MIGRATE sensitivity analysis output for the Site 2 North Expansion is included in Attachment 1. The model-predicted representative maximum GCPF for the entire 147-year simulation period at the edge of the zone of attenuation in the Shallow Drift Aquifer (uppermost aquifer) is 8.19 x 10^{-10}. The Shallow Drift Aquifer (uppermost aquifer) was subdivided into 5 sublayers. Therefore, 5 GCPFs were calculated in the Shallow Drift Aquifer. The highest GCPF was used for calculating predicted groundwater concentrations.

Attachment 1

MIGRATE Sensitivity Analysis Input

Geo-Logic ASSOCIATES

Thickness of Wadsworth Formation/Till below Excavation Grades



LEGEND

- APPROXIMATE PROPOSED FACILITY BOUNDARY
- APPROXIMATE PROPOSED EXPANSION WASTE BOUNDARY
- 30 INTERPOLATED THICKNESS CONTOUR

NOTES

1. EXISTING CONTOURS DEVELOPED FROM SITE AERIAL TOPOGRAPHIC SURVEY BY CQM ON 10/22/2018.
2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.
3. CURRENT TOPOGRAPHY MAY DIFFER FROM THAT SHOWN.
4. THICKNESS OF WADSWORTH TILL BELOW EXCAVATION GRADES DEVELOPED FROM COMPARING THE DESIGN BOTTOM OF LINER/EXCAVATION AND THE TOP ELEVATION OF SHALLOW DRIFT SURFACE.
5. THICKNESS OF WADSWORTH TILL UNDER LINER FLOOR (EXCLUDES SIDESLOPES)
   MINIMUM THICKNESS = 19.7'
   MAXIMUM THICKNESS = 43.6'
   AVERAGE THICKNESS = 33.7'

REV. NO.	DATE	DESCRIPTION

GFL GREEN FOR LIFE environmental

APTIM Environmental & Infrastructure, LLC

ZION LANDFILL - SITE 2 NORTH EXPANSION
CITY OF ZION, ILLINOIS

DRAWING 1
THICKNESS OF WADSWORTH TILL BELOW BASE EXCAVATION GRADES

PROJ. NO.:	631020105	DATE:	AUGUST 2021
DESIGNED BY:	DAM	DRAWING NO.	1
DRAWN BY:	NV		
CHECKED BY:	MNF		
APPROVED BY:	DAM	1 OF 1 SHEETS	

Vertical Seepage Calculation

APTIM

Client: GFL Everglades Holdings, LLC
Project: Site 2 North Expansion
Calculated By: LYN **Date: 4/3/2020**
Title: Giroud et al. Calculation **Checked By: DJD** **Date: 4/3/2020**

Problem Statement

Calculate outward leakage through the composite liner design based on Giroud et al. (1989).

Given

1 Outward gradient with 1 foot of differential head acting on the liner during operational and post-closure periods.
2 Poor contact between the geomembrane and the compacted soil liner (CSL) is conservatively assumed.
3 Illinois Environmental Protection Agency (IEPA) accepted geomembrane defect area of 4 cm^2 per acre.

Solution

The volumetric rate of leakage through geomembrane defect (Q) expressed in m3/s/acre =

$Q = 1.15\ hw^{0.9}\ a^{0.1}\ ks^{0.74}$ Giroud et al. (1989)

Where,

hw =	Differential head acting on top of the composite liner
a =	Area of the geomembrane defect
ks =	Saturated hydraulic conductivity of the CSL
Q =	Volumetric rate of leakage = $1.15\ hw^{0.9}\ a^{0.1}\ ks^{0.74}$
q_v =	Vertical leakage rate in m/s = (Q/1 acre/4047 m^2)

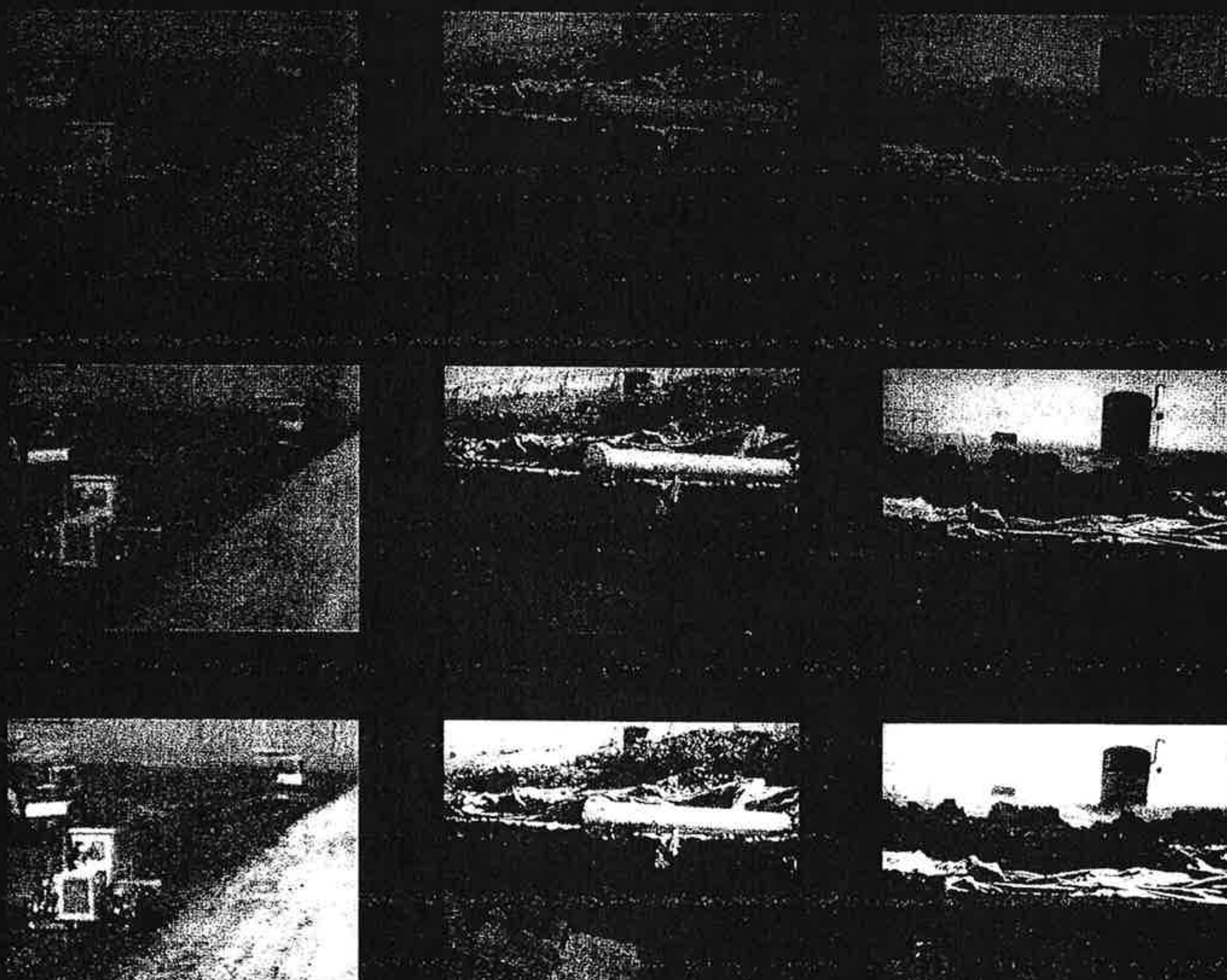
1) 1 foot of differential head on CSL (1 E-07 cm/s).

hw =	Differential head acting on the composite liner =	1.0	ft =	0.3048	m
a =	Area of the geomembrane defect =	4.00	cm^2/acre=	0.0004	m^2/acre
ks =	Saturated hydraulic conductivity of the CSL=	1E-07	cm/s =	1E-09	m/s
Q =	Volumetric rate of leakage = $1.15\ hw^{0.9}\ a^{0.1}\ ks^{0.74}$ =	3.95E-08	m^3/s/acre		
q_v =	Vertical leakage rate in m/s = (Q/1 acre/4047 m^2) =	9.76E-12	m/s =	**3.08E-04**	**m/y**

Reference

Giroud, J.P., A. Khatami, and K. Badu-Tweneboah. Geotextiles and Geomembranes, Vol. 8, 1989, pp. 337 - 340.

Diffusion Coefficient Documentation



BARRIER SYSTEMS FOR WASTE DISPOSAL FACILITIES

2ND EDITION

R. Kerry Rowe, Robert M. Quigley,
Richard W.I. Brachman & John R. Booker

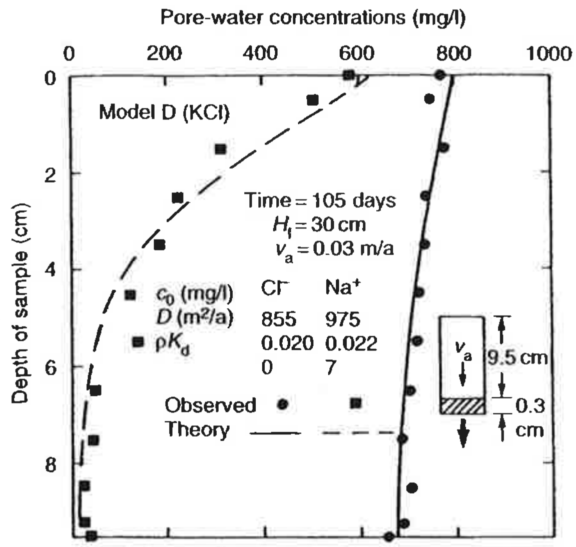


Figure 8.10 Chloride and potassium concentration versus depth in sample for model D (modified from Rowe *et al.*, 1988).

variation in concentration with depth in the soil at the end of each test. The consistency of results demonstrates the power of the analytical model (program POLLUTE) and provides some confidence in the parameters D and ρK_d for the clay and source fluids examined.

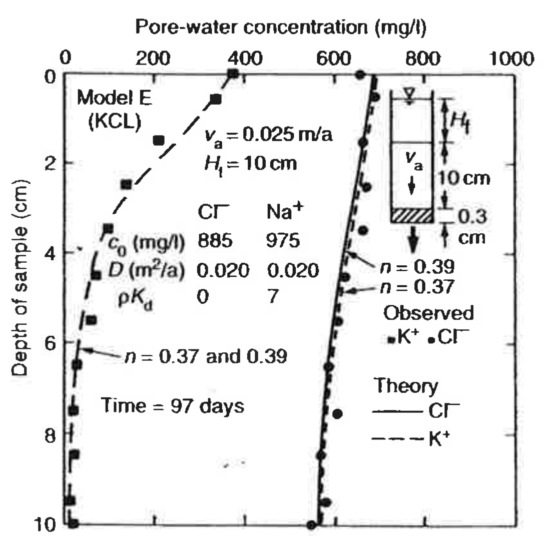


Figure 8.11 Chloride and potassium concentration versus depth in sample for model E (modified from Rowe *et al.*, 1988).

To provide an indication of parameter variation that might be expected for a given soil, a number of tests were duplicated. The diffusion coefficient, D, for chloride was deduced for each model and ranged between 0.018 and 0.02 m^2/a with an average value of 0.019 m^2/a. This small variation in D does not appear to be related to small differences in Darcy velocity, nor does it appear to be particularly related to the nature of the associated cation (see Table 8.3). Rather, the variability from 0.018 to 0.02 m^2/a is seen as an indication of the level of repeatability that may be achieved for this type of test.

The application of an effective stress to the soil sample adopted in these tests is not an essential part of the proposed technique for determining the parameters D and K_d. Tests performed for the particular combination of clay and permeants considered herein gave similar results both with and without the application of the effective stress. However, for some combinations of clay and permeant, shrinkage of the clay may occur in the absence of a confining stress and this can give quite misleading results (e.g., see Quigley and Fernandez, 1989). For these clays, and for GCLs (see Chapter 12), tests should be performed at an effective stress similar to that anticipated in the field.

8.3.2 Pure diffusion tests

In many cases, it is not necessary to perform an advection–diffusion test. Under these circumstances, a simple diffusion test can be performed for boundary conditions shown in Figure 8.2. In this test, the soil sample is placed in a Plexiglass cylinder by trimming the sample to a size marginally greater than the specimen and then pressing the specimen into the cylinder, using a cutting shoe attached to the cylinder, to perform the final trim. This procedure is found to work well for many clays. However, it does not work well for clays with a significant stone content because the

Porosity Documentation

MIG[illegible]ATI

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[illegible]ide

Sublayers

The number of sublayers in each layer is primarily used in the output of the calculated concentrations with depth; a concentration will be calculated at each sublayer interface.

The maximum thickness of each sublayer is 5 units. The number of sublayers is automatically increased if required to keep their thickness to less than 5. For example, if the layer thickness was 50 m and it had 5 sublayers (giving a sublayer thickness of 10), the program will automatically adjust the number of sublayers to 10.

If the time-varying properties is selected, the accuracy of the results will depend on the number of sublayers.

Thickness

The thickness of the layer must be specified, this is the total thickness of all the sublayers in the layer.

Dry Density

The dry density of the layer, expressed in consistent units with those used throughout the model.

Porosity

This is the porosity of the layer, which must be greater than 0 and less than or equal to 1. If the layer is being used to represent a geomembrane the porosity should be set to 1.

POROSITY OF HDPE

Horizontal & Vertical Diffusion/ Dispersion Coefficients

These are the horizontal and vertical coefficients of hydrodynamic dispersion for the layer:

$$D_{xx} = D_{dx} + D_{mdx}$$
$$D_{zz} = D_{dz} + D_{mdz}$$

where,
D_{dx} and D_{dz} = diffusion coefficients for the species,
D_{mdx} and D_{mdz} = coefficients of mechanical dispersion.

For intact clayey layers, diffusion will usually be the controlling factor and dispersion will often be negligible [Gilliham and Cherry, 1982, Rowe, 1987]. In sandy layers, dispersion will tend to be the controlling factor.

Horizontal and Vertical Darcy Velocities

The horizontal and vertical ...

$$V_{ax} = nv_x$$
$$V_{az} = nv_z$$

where,
n = effective porosity,
v_x and v_z = seepage or groundwater velocities.

Distribution Coefficient

This is the distribution coefficient for the layer. Th sorption-desorption of a non-conservative species of contaminant i assumed to be linear such that:

$$S = K_d * c$$

where,
S = solute sorbed per unit weight of soil,
K_d = distribution (partitioning) coefficient,
c = concentration of contaminant.

This is a reasonable approximation for low concentrations c contaminant, however at high concentrations sorption may not b linear and more complex relationships should be used. If there is n sorption (i.e., a conservative species) the distribution coefficient zero.

Half-Life

If the contaminant species experiences radioactive or biologic decay in a layer, this option can be used to specify the half-life the species in the layer. First order (exponential) decay is assum for both radioactive and biological decay, eg.

$$c(t) = c(0)\,e^{-\lambda t}$$

where,
c (t) = concentration at time t,
c (0) = initial concentration,
λ = decay constant = 0.693147/half-life,

If there is no decay of the species in the layer, the half-life shou be specified as zero which is the same as an infinite half-life (i. $\lambda = 0$).

STANDARD HANDBOOK for SOLID and HAZARDOUS WASTE FACILITY ASSESSMENTS

Martin N. Sara

STANDARD HANDBOOK for SOLID and HAZARDOUS WASTE FACILITY ASSESSMENTS

Martin N. Sara

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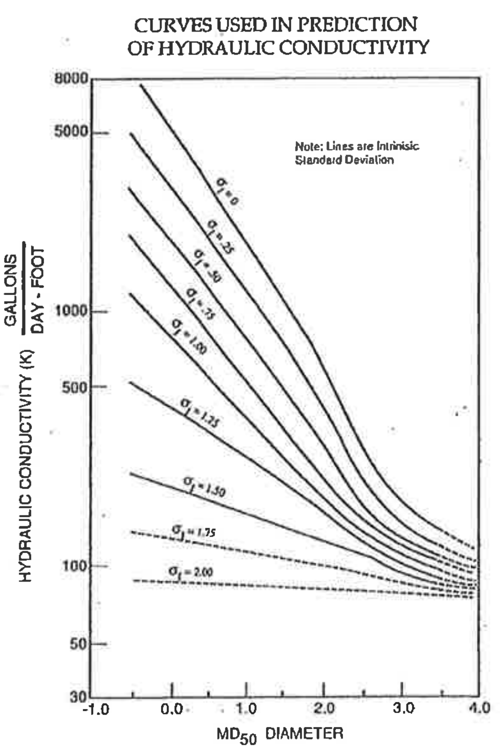
read directly off the various density hydraulic conductivity graphs (see Figure 5-36). The uniformity coefficient (Cu) is defined as the ratio of the D_{60} size of the soil (the size than which 60% of the soil is finer) to the D_{10}.

The above can be used where appropriate, to support field tests of hydraulic conductivity. Building an adequate data base of both field and laboratory hydraulic conductivity tests then provides the basis for definition of vertical and horizontal components of hydraulic conductivity in later flow net constructions.

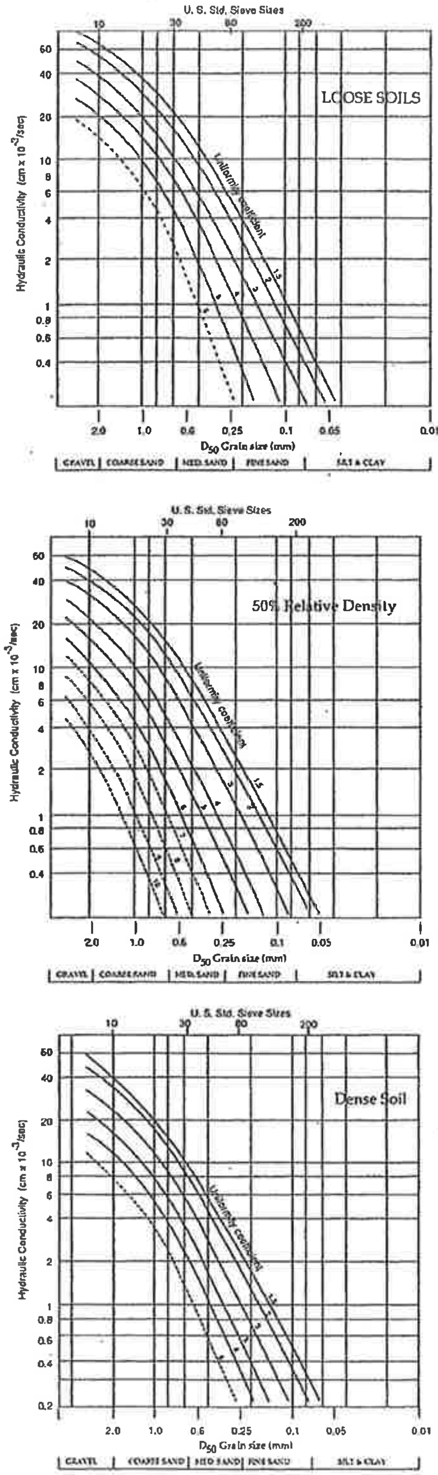
5.6.7 Laboratory Tests For Effective Porosity

An important aquifer characteristic of geologic environments used in time of travel calculations, is effective porosity. Fetter (1980) defines effective porosity as follows: "The amount of interconnected pore space through which fluids can pass, expressed as a percent of bulk volume. Part of the total porosity will be occupied by static fluid being held to the mineral surface by surface tension, so effective porosity will be less than total porosity." The relative value of effective porosity for fine grained sediments such as clays has been the point of significant disagreements between regulatory agencies and



Source: Modified from Masch & Denny, 1966, WRR Vol 2 No. 4

Figure 5-35 Masch and Denny Curves



Source: Modified from Powers(1981)

Figure 5-36 Powers Curves for Density and K the regulated community for a number of years since effective porosity is used in the following equation of seepage velocity:

$$V = \frac{Ki}{n_e} \qquad \text{Equation 5-39}$$

V is the average lineal velocity;
n_e is the effective porosity.
i is the gradient, and K is hydraulic conductivity.

There is a current controversy centering around using very low values of ne for fine grained clay sediments. A U.S. EPA guidance document (EPA 1986) proposed using values of effective porosity on the level of 1% for clays. The basis of this low figure is from specific yield determinations of sediments derived from water supply literature (see Walton 1970, p. 34). However, the Glossary of Geology (1987) defines effective porosity as follows: "The percentage of the total volume of a given mass of soil or rock that consists of interconnected interstices. The use of this term as a syn. of specific yield is to be "discouraged." The definition of effective porosity is recognized as not synonymous with specific yield in the technical literature. This departure of n_e from specific yield is especially important in fine grained sediments, since the value of lineal velocity V is so dependent on effective porosity. For example, using a low effective porosity of 1% (as compared to 30%) for a clay confining unit, will change the calculations of lineal velocity as follows:

Assuming $K = 1x10^{-7}$ cm/sec
$i = dh/dl = 0.5$
$n_e = 0.01, 0.30$
1.57 m/year (at 0.01 n_e)
0.053 m/year (at 0.30 n_e)

Considering the average facility can have thirty years of active life the difference in the two calculations can represent the difference between breaking through confining units some thirty times faster than with the larger value of n_e. The controversy surrounding n_e is difficult, in some ways to understand on a scientific basis, considering effective porosity can be calculated from breakthrough column tests. The following test is described for quantification of n_e for a series of glacial till (confining unit) samples. This testing was performed to: 1) determine the effective transport porosity; and, 2) to allow evaluation of the effect of leachate on the hydraulic conductivity of these potential clay liner materials. These results can ultimately be used in design of recompacted clay liners for future hazardous waste disposal cells at a potential site, and can be used to estimate effective porosity of unfractured confining unit materials.

A testing program should include both hydraulic conductivity testing and saline solution breakthrough evaluation of a number of confining unit samples. In addition, one should also conduct several reverse breakthrough tests using fresh water as the permeant.

Breakthrough and Leachate Solutions

The initial stages of laboratory tests for specific porosity, including saturation and hydraulic conductivity determination, should be conducted using actual site water obtained during the site assessment investigation.

An example tracer solution used for the column breakthrough portion of the tests consisted of a lithium chloride salt in water. The concentrations of lithium and chloride in the breakthrough tracer solution for the example below were:

- Lithium: 4,800 mg/l
- Chloride: 25,000 mg/l

Experience with the initial portion of column breakthrough testing shows that one will observe that the chloride ions will pass through soil samples at a much faster rate than the lithium ions. The likely reason is that due to cation exchange effects within the clay particles slowed down the passage of the lithium ions. The variation of the observed chloride concentration with time is considered to be the more accurate indicator of breakthrough time and, hence, pore fluid velocity. Therefore, only chloride ion concentrations is measured for the reverse breakthrough tests to maintain a conservative approach to the testing program.

The tracer solution is placed into a tri-axial cell upgradient accumulator (see Figure 5-33) and the concentration of lithium and chloride is then measured in the fluid that permeates out of the sample and is collected in the downgradient accumulator. During the initial portion of the test a gradient of 5 pounds per square inch (psi) is imposed on the sample. One may find with low hydraulic conductivity geologic test materials there is a resistant low flow rate, therefore, the gradient may be increased later in the test program to 10 psi. During the breakthrough portion of the test, at least 2 pore volumes of fluid should be passed through the sample.

Determination of Effective Porosity

Based on the principles of Darcian flow, the velocity

(v) of a soluble constituent flowing through a porous medium can be estimated using the Equation 5-39:

$$v = Ki/n_e$$

where:
K is the hydraulic conductivity);
i = the hydraulic gradient, and,
n_e = the effective porosity.

For the purposes of calculating breakthrough velocity, breakthrough is defined as the point where the constituent concentration in the permeant leaving the sample is fifty percent of that entering the sample. The effective porosity is the porosity through which flow is actually occurring. As such, it is always less than or equal to the total porosity. The incorporation of effective porosity into the Darcy equation, then, takes into account bound water and closed voids within the sample.

Since it is typical for effective porosity samples under going testing have different values for hydraulic conductivity, it would be considered appropriate to examine the change in concentration of the constituent being measured in the permeant (in this case, chloride) leaving the sample in terms of the number of pore volumes of fluid passing through the sample. Since these small samples are relatively homogeneous, the ratio of the effective porosity to the total porosity is equal to the number of pore volumes passing through the sample at breakthrough. Values of effective porosity based on this method of analysis are shown in Table 5-9. The effective porosity obtained in the test series for glacial tills ranged from 0.26 to 0.34. (Golder 1987)

*These values can be compared with work performed by Rawls, Brakensiek & Saxton (1982) on 1,323 soils with 5,350 horizons from 32 states that provided the total porosity, residual saturation, and effective porosity (among other soil properties) for this large spectrum of soil tests. Table 5-10 shows effective porosity for clay at 38.5%. This value is consistent with column tests performed in site investigations for clays. ↑

5.6.8 Laboratory Hydraulic Properties Of Rocks

Samples for laboratory testing should be selected from available cores, and should be representative of site bedrock geologic units. Where possible, horizontal and vertical plugs of 25 mm diameter should be cut from drilled rock cores of 50–100 mm diameter. However, if the sample is friable and subject to breakup in handling, testing it may not be possible to measure hydraulic conductivity. The engineer should keep in mind that such laboratory procedures represent tests on core that is essentially so disturbed in terms of preservation of open discontinuities as to be of limited actual value.

Table 5-9 Summary of Effective Porosity Results

Sample	Porosity	Pore Volumes at Breakthrough	Effective Porosity
TP-1	0.38	1.05	0.29
TP-3	0.38	0.68	0.26
TP-5	0.39	0.88	0.34
TP-9	0.38	0.88	0.33

Hydraulic Conductivity

The hydraulic conductivity of rock plugs can be measured in a standard gas permeameter, with nitrogen as the test fluid (API, 1966), with results empirically corrected for gas slippage and expressed for water at 20°C (approximate ground–water temperature in the field).

Effective Porosity, Bulk, and Matrix Density

The rock plugs or sample fragments may then be tested by the liquid resaturation method, employing propanol as the test fluid (API, 1966) in order to avoid a swelling reaction with any altered clayey materials, a situation that would lead to erroneous permeability determinations.

Pore–Size Distribution and Specific Yield

If the rock has exceptional porosity, further laboratory measurements can be undertaken on a smaller number of selected samples to investigate the distribution of pore–sizes and gravity–drainage characteristics.

When dealing with friable rock, the preferred method is by mercury injection porosimeter (Fatt, 1956). This technique involves forcing mercury into the pore spaces of the sample, progressively smaller pore necks being invaded at successively higher pressures, generating a curve of invaded pore–volume against injection–pressure.

The curves should be examined in detail to determine if an incomplete invasion of mercury has occurred. This could result from one of two reasons: either there exist many pores that are too small to be invaded, or some of the

TABLE 5-10 Porosity, Residual Saturation, and Effective Porosity of Common Soils

Texture Class	Sample Size	Total Porosity (ϕ). cm^3/cm^3	Residual Saturation (ϕ_r) cm^3/cm^3	Effective Porosity (ϕ_e). cm^3/cm^3
Sand	762	0.437 (0.374: 0.500)	0.020 (0.001: 0.039)	0.417 (0.354: 0.480)
Loamy Sand	338	0.437 (0.368: 0.506)	0.035 (0.003: 0.067)	0.401 (0.329: 0.473)
Sandy Loam	666	0.453 (0.351: 0.555)	0.041 (0.0: 0.106)	0.412 (0.283: 0.541)
Loam	383	0.463 (0.375: 0.551)	0.027 (0.0: 0.074)	0.434 (0.334: 0.534)
Silt Loam	1206	0.501 (0.420: 0.582)	0.015 (0.0: 0.058)	0.486 (0.394: 0.578)
Sandy Clay Loam	498	0.398 (0.332: 0.464)	0.068 (0.0: 0.137)	0.330 (0.235: 0.425)
Clay Loam	366	0.464 (0.409: 0.519)	0.076 (0.0: 0.174)	0.390 (0.279: 0.501)
Silty Clay Loam	689	0.471 (0.428: 0.524)	0.040 (0.0: 0.118)	0.432 (0.347: 0.517)
Sandy Clay	45	0.430 (0.370: 0.490)	0.109 (0.0: 0.205)	0.321 (0.207: 0.435)
Silty Clay	127	0.479 (0.425: 0.533)	0.056 (0.0: 0.136)	0.423 (0.334: 0.512)
Clay	291	0.475 (0.427: 0.523)	0.090 (0.0: 0.195)	0.385 (0.269: 0.501)

**First line is the mean value
Second line is + one standard deviation about the mean

Reference: Rawls, W.J., D.C. Brakensiek, K.E. Saxton 1982
Transactions of the ASCE Soil & Water Division Paper 81-2510, pp. 1318

Effective Porosities by Soil Type from SARA 1994					
Texture Class	Sample Size	Total Porosity	Residual Saturation	Effective Porosity	Percentage Difference Between Total Porosity and Effective Porosity
Sand	762	0.437	0.02	0.417	0.046
Loamy Sand	338	0.437	0.035	0.401	0.082
Sandy Loam	666	0.453	0.041	0.412	0.091
Loam	383	0.463	0.027	0.434	0.063
Silt Loam	1206	0.501	0.015	0.486	0.03
Sandy Clay Loam	498	0.398	0.068	0.33	0.171
Clay Loam	366	0.464	0.076	0.39	0.159
Silty Clay Loam	689	0.471	0.04	0.432	0.083
Sandy Clay	45	0.43	0.109	0.321	0.253
Silty Clay	127	0.479	0.056	0.423	0.117
Clay	291	0.475	0.09	0.385	0.189

TABLE 1
ZION LANDFILL SITE 2 NORTH EXPANSION
SUMMARY OF GEOTECHNICAL LABORATORY TEST RESULTS FOR WADSWORTH TILL

Boring No.	Sample No.	Depth BGS (feet)	USCS Soil Class.	Soil	Grain Size Analysis: ASTM C136 & ASTM D1140				Atterberg Limits: ASTM D4318			Properties Below Taken from Hydraulic Conductivity Test Data (ASTM D5084) or Specific Gravity Test Data (ASTM D854)								Hydr. Cond. "k" (cm/sec)
					Gravel (%)	Sand (%)	Silt (%)	Clay (%)	PL	LL	PI	Specific Gravity "G_s"	Void Ratio "e"	Porosity "n"	Saturation "S" (%)	Moisture Content "w" (%)	Dry Unit Weight "γ_{dry}" (pcf)	Total Unit Weight "γ_{total}" (pcf)	Sat. Unit Weight "γ_{sat}" (pcf)	
B-01-18	ST-35	68.0 - 70.0'	CL	Grey CLAY	-	-	-	-	-	-	-	2.750	0.42	0.30	98.0	15.0	120.7	138.9	139.3	2.38E-08
B-03-18	ST-34	66.0 - 68.0'	CL	Dark Grey Silty CLAY	-	-	-	-	-	-	-	2.750	0.38	0.28	92.0	12.7	124.3	140.2	141.5	4.77E-08
B-05-18	ST-37	72.0 - 74.0'	CL	Brown-Grey CLAY	-	-	-	-	-	-	-	2.750	0.67	0.40	99.0	24.3	102.6	127.5	127.8	4.85E-08
B-10-18	ST-30	58.0 - 60.0'	CL-ML	Grey Silty CLAY with thin layers of dry SILT	-	-	-	-	-	-	-	2.750	0.45	0.31	87.0	14.3	118.1	135.0	137.6	9.84E-08
B-11-18	ST-29	56.0 - 58.0'	CL	Grey CLAY	-	-	-	-	-	-	-	2.750	0.46	0.31	100.0	16.6	117.9	137.5	137.4	3.63E-08
B-14-18	ST-33	64.0 - 66.0'	CL	Grey Silty CLAY	-	-	-	-	-	-	-	2.750	0.35	0.26	84.0	10.8	126.9	140.6	143.2	3.65E-08
B-01-18	SS-23	44.0 - 46.0'	CL	Grey Lean CLAY with Sand	2.2	19.1	51.8	26.9	11	26	15	-	-	-	-	-	-	-	-	-
B-01-18	SS-27	52.0 - 54.0'	CL	Light Grey Lean CLAY	0.8	5.5	52.9	40.8	12	34	22	-	-	-	-	-	-	-	-	-
B-02-18	SS-30	58.0 - 60.0'	CL	Light Brown Lean CLAY	0.2	7.7	55.9	36.2	12	30	18	-	-	-	-	-	-	-	-	-
B-02-18	SS-33	64.0 - 66.0'	CL	Grey Silty Lean CLAY with Sand	1.3	18.1	58.5	22.1	10	21	11	-	-	-	-	-	-	-	-	-
B-03-18	SS-29	56.0 - 58.0'	CL	Grey Lean CLAY	1.7	7.7	55.6	35.0	15	30	15	-	-	-	-	-	-	-	-	-
B-03-18	SS-32	62.0 - 64.0'	CL	Grey Silty Lean CLAY	0.9	6.4	52.2	40.5	15	32	17	-	-	-	-	-	-	-	-	-
B-04-18	SS-20	38.0 - 40.0'	CL	Greay Sandy Lean CLAY	9.4	27.4	51.2	12.0	11	19	8	-	-	-	-	-	-	-	-	-
B-04-18	SS-23	44.0 - 46.0'	CL	Light Grey Lean CLAY with Sand	2.9	19.8	48.0	29.3	11	29	18	-	-	-	-	-	-	-	-	-
B-05-18	SS-31	60.0 - 62.0'	CL	Light Grey Lean CLAY	0.0	12.3	52.9	34.8	13	28	15	-	-	-	-	-	-	-	-	-
B-06-18	SS-31	60.0 - 62.0'	CL	Grey Lean CLAY	1.1	11.2	52.3	35.4	12	33	21	-	-	-	-	-	-	-	-	-
B-07-18	SS-15	28.0 - 30.0'	CL	Light Brown Lean CLAY	0.9	12.5	64.7	21.9	14	23	9	-	-	-	-	-	-	-	-	-
B-07-18	SS-24	46.0 - 48.0'	CL	Grey Lean CLAY with Sand	1.4	18.0	56.8	23.8	13	27	14	-	-	-	-	-	-	-	-	-
B-08-18	SS-30	58.0 - 60.0'	CL	Brown, Grey Lean CLAY with Sand	0.6	19.1	53.2	27.1	13	28	15	-	-	-	-	-	-	-	-	-
B-09-18	SS-22	42.0 - 44.0'	CL-ML	Grey Silty CLAY with Sand	1.0	27.4	62.0	9.6	14	18	4	-	-	-	-	-	-	-	-	-
B-09-18	SS-28	54.0 - 56.0'	CL	Grey Lean CLAY with SAND	2.0	17.2	52.1	28.7	14	27	13	-	-	-	-	-	-	-	-	-
B-10-18	SS-23	44.0 - 46.0'	CL	Brown-Grey Lean CLAY with Sand	2.6	17.6	49.7	30.1	14	26	12	-	-	-	-	-	-	-	-	-
B-10-18	SS-28	54.0 - 56.0'	CL	Grey Lean CLAY with SAND	3.2	16.6	49.7	30.5	14	28	14	-	-	-	-	-	-	-	-	-
B-11-18	SS-22	42.0 - 44.0'	CL-ML	Grey Sandy Silty CLAY	3.1	36.2	49.4	11.3	12	17	5	-	-	-	-	-	-	-	-	-
B-11-18	SS-28	54.0 - 56.0'	CL	Grey Lean CLAY with Sand	0.9	19.2	50.4	29.5	14	27	13	-	-	-	-	-	-	-	-	-
B-12-18	SS-27	52.0 - 54.0'	CL	Grey Lean CLAY with Sand	4.4	18.1	49.2	28.3	13	25	12	-	-	-	-	-	-	-	-	-
B-12-18	SS-32	62.0 - 64.0'	CL	Grey Lean CLAY with Sand	3.6	17.4	55.7	23.3	12	25	13	-	-	-	-	-	-	-	-	-
B-13-18	SS-17	32.0 - 34.0'	CL-ML	Grey Silty CLAY	0.0	1.5	79.5	19.0	15	22	7	-	-	-	-	-	-	-	-	-
B-13-18	SS-26	50.0 - 52.0'	CL	Grey Lean CLAY with Sand	5.5	17.8	50.8	25.9	14	26	12	-	-	-	-	-	-	-	-	-
B-14-18	SS-26	50.0 - 52.0'	CL	Grey Lean CLAY	0.0	0.4	49.7	49.9	18	40	22	-	-	-	-	-	-	-	-	-
B-14-18	SS-31	60.0 - 62.0'	CL-ML	Brownish Grey Sandy Silty CLAY	0.6	41.6	43.8	14.0	12	18	6	-	-	-	-	-	-	-	-	-
B-15-18	SS-24	46.0 - 48.0'	CL	Greay Sandy Lean CLAY	6.0	25.2	42.9	25.9	14	28	14	-	-	-	-	-	-	-	-	-
B-15-18	SS-29	56.0 - 58.0'	CL	Grey Lean CLAY	0.0	1.5	54.9	43.6	15	32	17	-	-	-	-	-	-	-	-	-
				Minimum:	0.0	0.4	42.9	9.6	10.0	17.0	4.0	2.750	0.35	**0.26**	84.0	10.8	**102.6**	127.5	127.8	2.38E-08
				Maximum:	9.4	41.6	79.5	49.9	18.0	40.0	22.0	2.750	0.67	**0.40**	100.0	24.3	**126.9**	140.6	143.2	9.84E-08
				Average:	2.1	16.4	53.5	28.0	13.2	26.6	13.4	2.750	0.46	**0.31**	93.3	15.6	**118.4**	136.6	137.8	4.85E-08

Note:

1) Values in cells shaded in gray were calculated using the soil density relationships below.

Soil Density Relationships:

γ_{dry} = $[(G_s \times \gamma_w] / (1+e)$

γ_{total} = $[(G_s + Se) \times \gamma_w] / (1+e)$

γ_{total} = $\gamma_d \times (1 + (w\% / 100))$

γ_{sat} = $[(G_s + e) \times \gamma_w] / (1+e)$

$S\% = (w \times G_s) / e$

$n = e / (1+e)$

$e = n / (1-n)$

	Porosity	Effective Porosity
Average	0.31	0.31 × 0.81 = **0.25**
Minimum	0.26	0.26 × 0.81 = **0.21**
Maximum	0.4	0.40 × 0.81 = **0.32**

Dry Density Average = 118.4 pcf = **1,896.5 kg/m^3**

TABLE 2
ZION LANDFILL SITE 2 NORTH EXPANSION
SUMMARY OF GEOTECHNICAL LABORATORY TEST RESULTS FOR SHALLOW DRIFT AQUIFER

Boring No.	Sample No.	Depth BGS (feet)	USCS Soil Class.	Soil	Grain Size Analysis: ASTM C136 & ASTM D1140				Properties Below Taken from Hydraulic Conductivity Test Data (ASTM D5084) or Specific Gravity Test Data (ASTM D854)							
					Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Specific Gravity "G_s"	Void Ratio "e"	Porosity "n"	Saturation "S" (%)	Moisture Content "w" (%)	Dry Unit Weight "γ_{dry}" (pcf)	Total Unit Weight "γ_{total}" (pcf)	Sat. Unit Weight "γ_{sat}" (pcf)
B-05-18	SS-59	116.0 - 118.0'	SM	Grey Silty SAND	0.0	77.6	20.6	1.8	2.789	0.76	0.43	63.0	17.1	99.0	116.0	125.9
B-06-18	SS-53	104.0 - 106.0'	SM	Grey Silty SAND	4.4	82.7	12.3	0.6	2.814	0.53	0.35	75.0	14.2	114.5	130.8	136.2
B-08-18	SS-61	120.0 - 122.0'	SM	Grey Silty SAND	0.0	81.7	16.3	2.0	2.790	0.73	0.42	84.0	22.0	100.8	123.0	127.2
				Minimum:	0.0	77.6	12.3	0.6	2.789	0.53	0.35	63.0	14.2	99.0	116.0	125.9
				Maximum:	4.4	82.7	20.6	2.0	2.814	0.76	0.43	84.0	22.0	114.5	130.8	136.2
				Average:	1.5	80.7	16.4	1.5	2.798	0.67	0.40	74.0	17.8	104.8	123.3	129.8

Soil Density Relationships:

$\gamma_{dry} = [(G_s \times \gamma_w] / (1+e)$

$\gamma_{total} = [(G_s + Se) \times \gamma_w] / (1+e)$

$\gamma_{total} = \gamma_d \times (1 + (w\% / 100))$

$\gamma_{sat} = [(G_s + e) \times \gamma_w] / (1+e)$

$S\% = (w \times G_s) / e$

$n = e / (1+e)$

$e = n / (1-n)$

DENSITY = 1,678.7 Kg/m³

EFFECTIVE POROSITY

0.43 x 0.918 = 0.395

AVERAGE - 0.40 x 0.918 = 0.367 *

0.35 x 0.918 = 0.321

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Density Documentation

TABLE 1
ZION LANDFILL SITE 2 NORTH EXPANSION
SUMMARY OF GEOTECHNICAL LABORATORY TEST RESULTS FOR WADSWORTH TILL

					Grain Size Analysis: ASTM C136 & ASTM D1140				Atterberg Limits: ASTM D4318			Properties Below Taken from Hydraulic Conductivity Test Data (ASTM D5084) or Specific Gravity Test Data (ASTM D854)								
Boring No.	Sample No.	Depth BGS (feet)	USCS Soil Class.	Soil	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	PL	LL	PI	Specific Gravity "G_s"	Void Ratio "e"	Porosity "n"	Saturation "S" (%)	Moisture Content "w" (%)	Dry Unit Weight "γ_{dry}" (pcf)	Total Unit Weight "γ_{total}" (pcf)	Sat. Unit Weight "γ_{sat}" (pcf)	Hydr. Cond. "k" (cm/sec)
B-01-18	ST-35	68.0 - 70.0'	CL	Grey CLAY	-	-	-	-	-	-	-	2.750	0.42	0.30	98.0	15.0	120.7	138.9	139.3	2.38E-08
B-03-18	ST-34	66.0 - 68.0'	CL	Dark Grey Silty CLAY	-	-	-	-	-	-	-	2.750	0.38	0.28	92.0	12.7	124.3	140.2	141.5	4.77E-08
B-05-18	ST-37	72.0 - 74.0'	CL	Brown-Grey CLAY	-	-	-	-	-	-	-	2.750	0.67	0.40	99.0	24.3	102.6	127.5	127.8	4.85E-08
B-10-18	ST-30	58.0 - 60.0'	CL-ML	Grey Silty CLAY with thin layers of dry SILT	-	-	-	-	-	-	-	2.750	0.45	0.31	87.0	14.3	118.1	135.0	137.6	9.84E-08
B-11-18	ST-29	56.0 - 58.0'	CL	Grey CLAY	-	-	-	-	-	-	-	2.750	0.46	0.31	100.0	16.6	117.9	137.5	137.4	3.63E-08
B-14-18	ST-33	64.0 - 66.0'	CL	Grey Silty CLAY	-	-	-	-	-	-	-	2.750	0.35	0.26	84.0	10.8	126.9	140.6	143.2	3.65E-08
B-01-18	SS-23	44.0 - 46.0'	CL	Grey Lean CLAY with Sand	2.2	19.1	51.8	26.9	11	26	15	-	-	-	-	-	-	-	-	-
B-01-18	SS-27	52.0 - 54.0'	CL	Light Grey Lean CLAY	0.8	5.5	52.9	40.8	12	34	22	-	-	-	-	-	-	-	-	-
B-02-18	SS-30	58.0 - 60.0'	CL	Light Brown Lean CLAY	0.2	7.7	55.9	36.2	12	30	18	-	-	-	-	-	-	-	-	-
B-02-18	SS-33	64.0 - 66.0'	CL	Grey Silty Lean CLAY with Sand	1.3	18.1	58.5	22.1	10	21	11	-	-	-	-	-	-	-	-	-
B-03-18	SS-29	56.0 - 58.0'	CL	Grey Lean CLAY	1.7	7.7	55.6	35.0	15	30	15	-	-	-	-	-	-	-	-	-
B-03-18	SS-32	62.0 - 64.0'	CL	Grey Silty Lean CLAY	0.9	6.4	52.2	40.5	15	32	17	-	-	-	-	-	-	-	-	-
B-04-18	SS-20	38.0 - 40.0'	CL	Greay Sandy Lean CLAY	9.4	27.4	51.2	12.0	11	19	8	-	-	-	-	-	-	-	-	-
B-04-18	SS-23	44.0 - 46.0'	CL	Light Grey Lean CLAY with Sand	2.9	19.8	48.0	29.3	11	29	18	-	-	-	-	-	-	-	-	-
B-05-18	SS-31	60.0 - 62.0'	CL	Light Grey Lean CLAY	0.0	12.3	52.9	34.8	13	28	15	-	-	-	-	-	-	-	-	-
B-06-18	SS-31	60.0 - 62.0'	CL	Grey Lean CLAY	1.1	11.2	52.3	35.4	12	33	21	-	-	-	-	-	-	-	-	-
B-07-18	SS-15	28.0 - 30.0'	CL	Light Brown Lean CLAY	0.9	12.5	64.7	21.9	14	23	9	-	-	-	-	-	-	-	-	-
B-07-18	SS-24	46.0 - 48.0'	CL	Grey Lean CLAY with Sand	1.4	18.0	56.8	23.8	13	27	14	-	-	-	-	-	-	-	-	-
B-08-18	SS-30	58.0 - 60.0'	CL	Brown, Grey Lean CLAY with Sand	0.6	19.1	53.2	27.1	13	28	15	-	-	-	-	-	-	-	-	-
B-09-18	SS-22	42.0 - 44.0'	CL-ML	Grey Silty CLAY with Sand	1.0	27.4	62.0	9.6	14	18	4	-	-	-	-	-	-	-	-	-
B-09-18	SS-28	54.0 - 56.0'	CL	Grey Lean CLAY with SAND	2.0	17.2	52.1	28.7	14	27	13	-	-	-	-	-	-	-	-	-
B-10-18	SS-23	44.0 - 46.0'	CL	Brown-Grey Lean CLAY with Sand	2.6	17.6	49.7	30.1	14	26	12	-	-	-	-	-	-	-	-	-
B-10-18	SS-28	54.0 - 56.0'	CL	Grey Lean CLAY with SAND	3.2	16.6	49.7	30.5	14	28	14	-	-	-	-	-	-	-	-	-
B-11-18	SS-22	42.0 - 44.0'	CL-ML	Grey Sandy Silty CLAY	3.1	36.2	49.4	11.3	12	17	5	-	-	-	-	-	-	-	-	-
B-11-18	SS-28	54.0 - 56.0'	CL	Grey Lean CLAY with Sand	0.9	19.2	50.4	29.5	14	27	13	-	-	-	-	-	-	-	-	-
B-12-18	SS-27	52.0 - 54.0'	CL	Grey Lean CLAY with Sand	4.4	18.1	49.2	28.3	13	25	12	-	-	-	-	-	-	-	-	-
B-12-18	SS-32	62.0 - 64.0'	CL	Grey Lean CLAY with Sand	3.6	17.4	55.7	23.3	12	25	13	-	-	-	-	-	-	-	-	-
B-13-18	SS-17	32.0 - 34.0'	CL-ML	Grey Silty CLAY	0.0	1.5	79.5	19.0	15	22	7	-	-	-	-	-	-	-	-	-
B-13-18	SS-26	50.0 - 52.0'	CL	Grey Lean CLAY with Sand	5.5	17.8	50.8	25.9	14	26	12	-	-	-	-	-	-	-	-	-
B-14-18	SS-26	50.0 - 52.0'	CL	Grey Lean CLAY	0.0	0.4	49.7	49.9	18	40	22	-	-	-	-	-	-	-	-	-
B-14-18	SS-31	60.0 - 62.0'	CL-ML	Brownish Grey Sandy Silty CLAY	0.6	41.6	43.8	14.0	12	18	6	-	-	-	-	-	-	-	-	-
B-15-18	SS-24	46.0 - 48.0'	CL	Greay Sandy Lean CLAY	6.0	25.2	42.9	25.9	14	28	14	-	-	-	-	-	-	-	-	-
B-15-18	SS-29	56.0 - 58.0'	CL	Grey Lean CLAY	0.0	1.5	54.9	43.6	15	32	17	-	-	-	-	-	-	-	-	-
				Minimum:	0.0	0.4	42.9	9.6	10.0	17.0	4.0	2.750	0.35	**0.26**	84.0	10.8	**102.6**	127.5	127.8	2.38E-08
				Maximum:	9.4	41.6	79.5	49.9	18.0	40.0	22.0	2.750	0.67	**0.40**	100.0	24.3	**126.9**	140.6	143.2	9.84E-08
				Average:	2.1	16.4	53.5	28.0	13.2	26.6	13.4	2.750	0.46	**0.31**	93.3	15.6	**118.4**	136.6	137.8	4.85E-08

Note:

1) Values in cells shaded in gray were calculated using the soil density relationships below.

Soil Density Relationships:

$\gamma_{dry} = [(G_s \times \gamma_w] / (1+e)$

$\gamma_{total} = [(G_s + Se) \times \gamma_w] / (1+e)$

$\gamma_{total} = \gamma_d \times (1 + (w\% / 100))$

$\gamma_{sat} = [(G_s + e) \times \gamma_w] / (1+e)$

$S\% = (w \times G_s) / e$

$n = e / (1+e)$

$e = n / (1-n)$

	Porosity	Effective Porosity
Average	0.31	0.31 × 0.81 = **0.25**
Minimum	0.26	0.26 × 0.81 = **0.21**
Maximum	0.4	0.40 × 0.81 = **0.32**

Dry Density Average = 118.4 pcf = **1,896.5 kg/m³**

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TABLE 2
ZION LANDFILL SITE 2 NORTH EXPANSION
SUMMARY OF GEOTECHNICAL LABORATORY TEST RESULTS FOR SHALLOW DRIFT AQUIFER

Boring No.	Sample No.	Depth BGS (feet)	USCS Soil Class.	Soil	Grain Size Analysis: ASTM C136 & ASTM D1140				Properties Below Taken from Hydraulic Conductivity Test Data (ASTM D5084) or Specific Gravity Test Data (ASTM D854)							
					Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Specific Gravity "G_s"	Void Ratio "e"	Porosity "n"	Saturation "S" (%)	Moisture Content "w" (%)	Dry Unit Weight "γ_{dry}" (pcf)	Total Unit Weight "γ_{total}" (pcf)	Sat. Unit Weight "γ_{sat}" (pcf)
B-05-18	SS-59	116.0 - 118.0'	SM	Grey Silty SAND	0.0	77.6	20.6	1.8	2.789	0.76	0.43	63.0	17.1	99.0	116.0	125.9
B-06-18	SS-53	104.0 - 106.0'	SM	Grey Silty SAND	4.4	82.7	12.3	0.6	2.814	0.53	0.35	75.0	14.2	114.5	130.8	136.2
B-08-18	SS-61	120.0 - 122.0'	SM	Grey Silty SAND	0.0	81.7	16.3	2.0	2.790	0.73	0.42	84.0	22.0	100.8	123.0	127.2
				Minimum:	0.0	77.6	12.3	0.6	2.789	0.53	0.35	63.0	14.2	99.0	116.0	125.9
				Maximum:	4.4	82.7	20.6	2.0	2.814	0.76	0.43	84.0	22.0	114.5	130.8	136.2
				Average:	1.5	80.7	16.4	1.5	2.798	0.67	0.40	74.0	17.8	104.8	123.3	129.8

Soil Density Relationships:

$\gamma_{dry} = [(G_s \times \gamma_w] / (1+e)$

$\gamma_{total} = [(G_s + Se) \times \gamma_w] / (1+e)$

$\gamma_{total} = \gamma_d \times (1 + (w\% / 100))$

$\gamma_{sat} = [(G_s + e) \times \gamma_w] / (1+e)$

$S\% = (w \times G_s) / e$

$n = e / (1+e)$

$e = n / (1-n)$

DENSITY = 1,678.7 Kg/m³

EFFECTIVE POROSITY

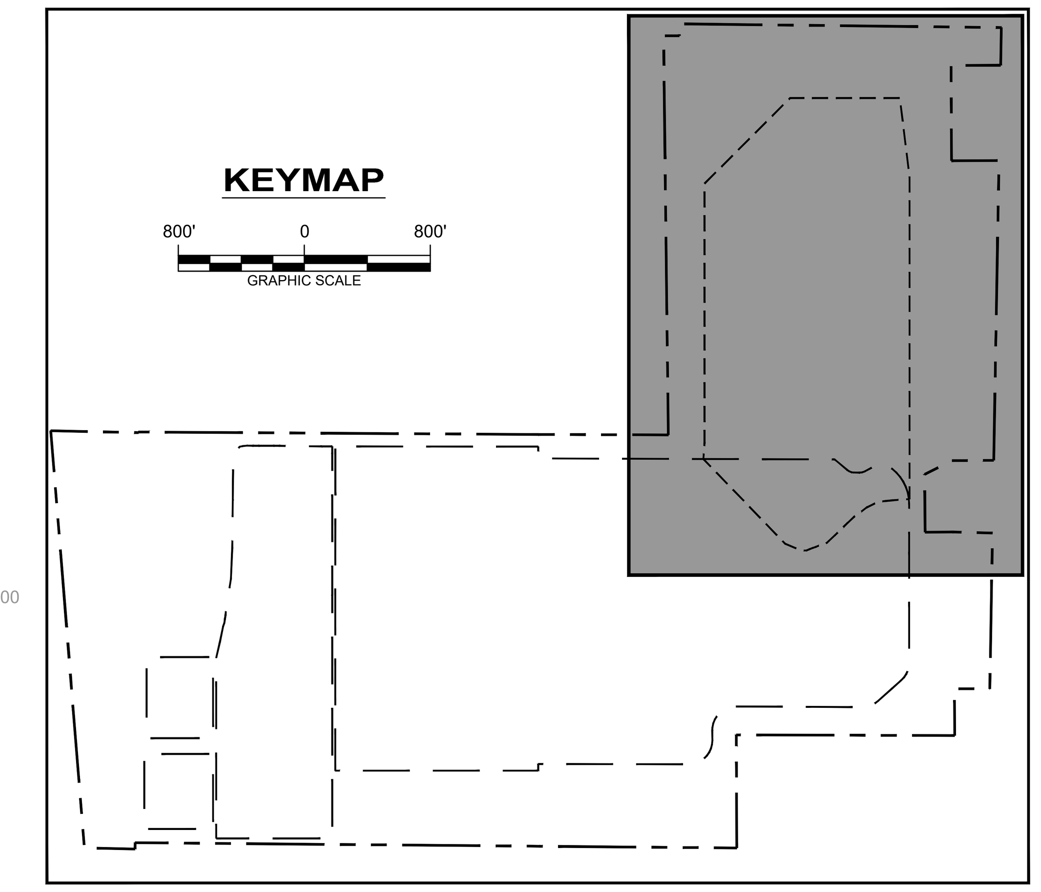
0.43 x 0.918 = 0.395

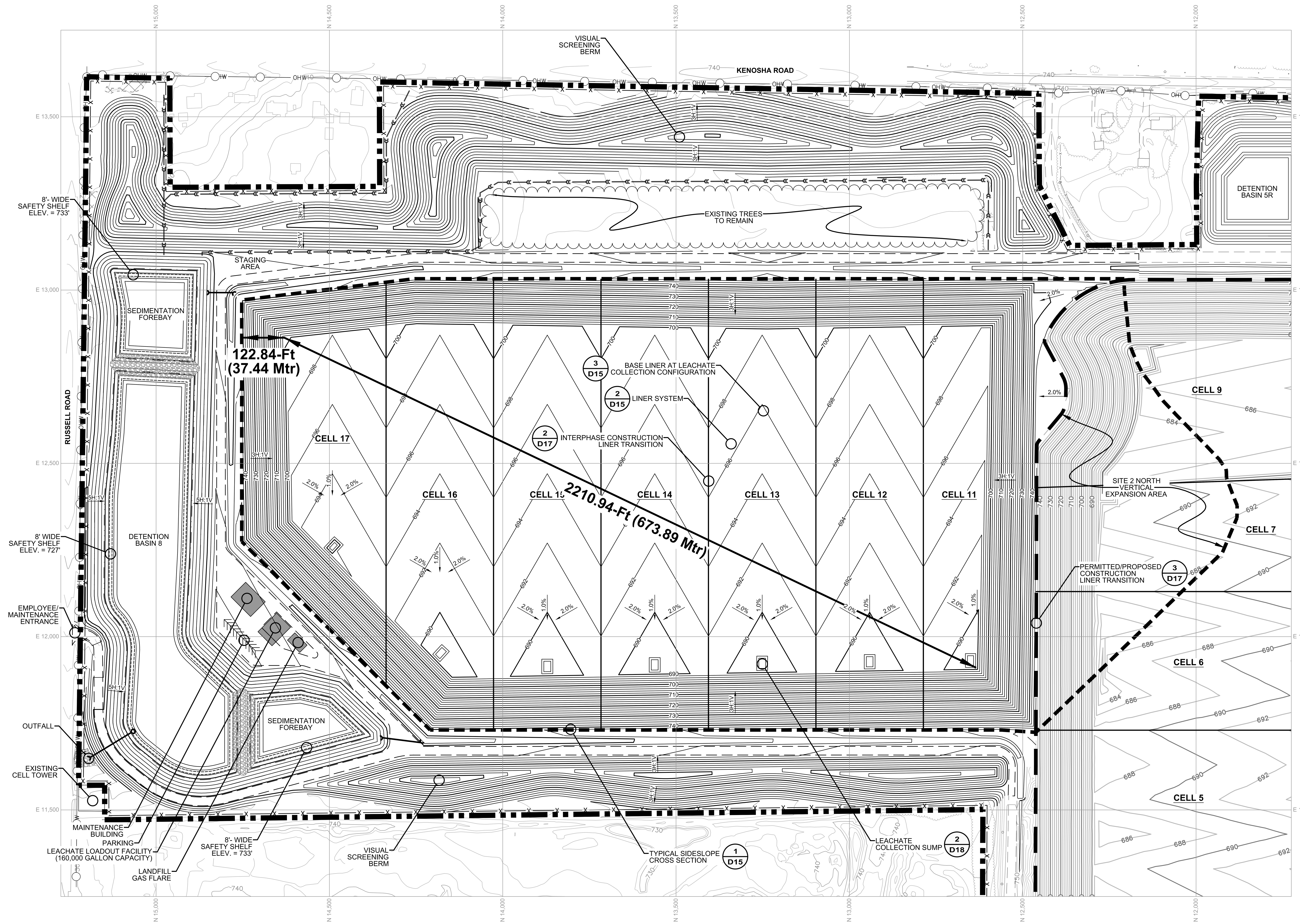
AVERAGE - 0.40 x 0.918 = 0.367 *

0.35 x 0.918 = 0.321

APTIM

Landfill Base Length and Sidewall Width





120' 0 120'
GRAPHIC SCALE

LEGEND

- APPROXIMATE FACILITY BOUNDARY
- APPROXIMATE EXISTING WASTE BOUNDARY
- APPROXIMATE PROPOSED EXPANSION WASTE BOUNDARY
- EXISTING CONTOUR
- EXISTING ROAD
- EXISTING VEGETATION
- EXISTING FENCE
- EXISTING POWER POLE
- EXISTING OVERHEAD WIRE
- EXISTING CULVERT
- PROPOSED CONTOUR
- PROPOSED ROAD
- PROPOSED PERIMETER FENCE
- PROPOSED CULVERT
- PROPOSED DRAIN TILE

NOTES

1. EXISTING CONTOURS DEVELOPED FROM SITE AERIAL TOPOGRAPHIC SURVEY BY CQM, INC. ON 10/22/2018 EXCEPT STORMWATER MANAGEMENT FEATURES ASSOCIATED WITH SITE 2 EAST (DITCHES AND BASIN 5R). STORMWATER DESIGN GRADES ARE SHOWN FOR THESE FEATURES FOR COMPLETENESS, AS NOT ALL GRADES ARE CAPTURED BY THE TOPOGRAPHIC SURVEY.
2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.
3. CURRENT TOPOGRAPHY MAY DIFFER FROM THAT SHOWN.
4. TOP OF PERMITTED COMPOSITE BASE LINER GRADES ARE SHOWN FOR THE EXISTING LANDFILL (CELLS 5,6,7 AND 9). LEACHATE COLLECTION SUMPS ARE NOT SHOWN FOR EXISTING CELLS 5 AND 6. THE SITE 2 NORTH VERTICAL EXPANSION WILL OVERLIE THESE PERMITTED GRADES IN THE AREA SHOWN. IT IS NOTED THAT THE COMPOSITE BASE LINER FOR THESE CELLS HAS BEEN CONSTRUCTED AND THE CELLS HAVE BEEN PARTIALLY FILLED WITH WASTE.
5. THE PROPOSED TOP OF COMPOSITE BASE LINER GRADES ARE SHOWN FOR THE SITE 2 NORTH HORIZONTAL EXPANSION AREA (CELLS 11 THROUGH 17).
6. THE COMPOSITE BASE LINER SHALL BE A MINIMUM 5-FOOT THICK ABOVE THE CONSTRUCTED TOP OF EXCAVATION GRADES.
7. CELL DEVELOPMENT WILL PROCEED IN NUMERICAL ORDER. VERTICAL EXPANSION WILL PROGRESS CONCURRENT WITH CELL 11 FILLING.

SECTION OR DETAIL LABEL
DRAWING ON WHICH SECTION OR DETAIL IS SHOWN

SECTIONS AND DETAIL KEY

REV.	DATE	DESCRIPTION	APPROVED BY:

This drawing has not been published but rather has been prepared by Geo-Logic Associates for use by the client named in the title block, solely in respect of the construction, operation, and maintenance of the facility named in the title block. Geo-Logic Associates shall not be liable for the use of this drawing on any other facility or for any other purpose.

Geo-Logic ASSOCIATES

GFL GREEN FOR LIFE environmental

ZION LANDFILL - SITE 2 NORTH EXPANSION CITY OF ZION, ILLINOIS

LANDFILL BASE LENGTH AND SIDEWALL WIDTH

PROJECT NO.:	IL24.1033.00	DATE:	JUNE 2024
DESIGNED BY:	DAM/BWM		1
DRAWN BY:	BWM		
CHECKED BY:	DD		
APPROVED BY:	DAM	1 OF 1 SHEETS	

H:\GFL\IL24.1020.PR Zion LF Permitting\CAD\01-Submittal\Hydrogeo\Well Spacing\LF-Base-SideWall-Length.dwg, 6/27/2024 4:16:49 PM

Horizontal Gradient Summary Table

Geo-Logic Associates

Horizontal Gradient Summary Table Upper Shallow Drift Zion Landfill Site 2 North Expansion			
Date	**Section**	**Gradient**	**Combined Gradient**
Feb-19	Northerly	0.00339	0.001873
	Easterly	0.000356	
Mar-19	Northerly	0.00291	0.001657
	Easterly	0.000403	
May-19	Northerly	0.00319	0.001783
	Easterly	0.000376	
Jun-19	Northerly	0.003340	0.001855
	Easterly	0.00037	
Jul-19	Northerly	0.00374	0.002062
	Easterly	0.000383	
Oct-19	Northerly	0.000899	0.000631
	Easterly	0.000363	
Feb-20	Northerly	0.000857	0.000561
	Easterly	0.000264	
May-20	Northerly	0.000993	0.000520
	Easterly	0.0000462	
Aug-20	Northerly	0.00141	0.000870
	Easterly	0.000330	
Oct-20	Northerly	0.000899	0.000710
	Easterly	0.000521	
Feb-21	Northerly	0.000700	0.000617
	Easterly	0.000534	
May-21	Northerly	0.00400	0.002233
	Easterly	0.000462	
Aug-21	Northerly	0.00410	0.002237
	Easterly	0.000376	
Nov-21	Northerly	0.00313	0.001807
	Easterly	0.000488	
Feb-22	Northerly	0.00246	0.001486
	Easterly	0.000515	
		Northerly Average	**0.002401**
		Easterly Average	**0.000386**
		Overall Upper Shallow Drift Average	**0.001393**

APTIM

MIGRATE Sensitivity Analysis Output

Geo-Logic ASSOCIATES

1

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**************************************************
*                                                *
*                                                *
*     M I G R A T E v 9   S I M U L A T I O N    *
*                                                *
*              RUN DATE -   28- 6-24             *
*              TIME     -   84:40:24             *
*                                                *
*              REVISION - 09/05/1996             *
*                                                *
*                   VERSION 9.0.9                *
*                                                *
* COPYRIGHT(c) R.K. ROWE & J.R. BOOKER  1983-1996 *
*                                                *
*  LICENSED USER: Geo-Logic Associates           *
*                                                *
**************************************************
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**************************************************************************
 Zion Landfill Site 2 North Expansion
**************************************************************************


SURFACE BOUNDARY
~~~~~~~~~~~~~~~~

SURFACE BOUNDARY CONDITION DEFINED BY A CONSTANT CONCENTRATION C0


OFFSET OF CENTER OF LANDFILL    1 IS     0.0000E+00

WIDTH OF BASE OF LANDFILL IS BETWEEN      -336.9450< X <  336.9450
WIDTH OF SURFACE OF LANDFILL IS BETWEEN   -336.9450< X <  336.9450


THE INITIAL SOURCE CONCENTRATION              =   0.1000E+01

BASE BOUNDARY
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BASE BOUNDARY CONDITION DEFINED BY
AN IMPERMEABLE BASE(I.E. ZERO FLUX)
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PROPERTIES OF THE MATRIX

LAYER	DISPERSION COEFF. VERT.	DISPERSION COEFF. HORZ.	POROSITY	ADSORPTION COEFF.	DENSITY	ADV. VELOCITY HORZ.	ADV. VELOCITY VERT.	THICKNESS
1	.300E-04	.300E-04	1.000	0.000E+00	940.000	0.0000	0.0003	0.15E-02
2	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.30
3	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.30
4	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.30
5	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.30
6	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.30
7	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.93
8	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.93
9	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.93
10	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.93
11	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.93
12	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.93
13	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.93
14	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.93
15	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.93
16	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.93
17	.190E-01	.190E-01	0.250	0.000E+00	1896.500	0.0000	0.0003	0.93
18	.745E+00	.745E+01	0.367	0.000E+00	1678.700	0.2700	0.0003	2.29
19	.745E+00	.745E+01	0.367	0.000E+00	1678.700	0.2700	0.0003	2.29
20	.745E+00	.745E+01	0.367	0.000E+00	1678.700	0.2700	0.0003	2.29
21	.745E+00	.745E+01	0.367	0.000E+00	1678.700	0.2700	0.0003	2.29
22	.745E+00	.745E+01	0.367	0.000E+00	1678.700	0.2700	0.0003	2.29

INTEGRATION PARAMETERS

THE PARAMETERS USED TO INVERT THE LAPLACE TRANSFORM ARE
TAU =0.700E+01 N = 40 SIG =0.000E+00 RNU =0.400E+01

SELECTED GAUSS QUADRATURE SAMPLE POINTS ARE:

GAUSSIAN INTEGRATION SUBINTERVAL SIZE = 0.100E+00
NUMBER OF SUBINTERVALS = 12
NUMBER OF SAMPLE POINTS USED PER STEP = 200

TOTAL WIDTH OF INTEGRATION   0.1200E+01

TOTAL NUMBER OF INTEGRATION POINTS   4800

RESULTS
=======

CALCULATED CONCENTRATIONS AT SELECTED DEPTHS,
LATERAL DISTANCES AND TIMES:

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
0.5000E+01	0.3744E+03	0.0000E+00	0.2428E-01	0.3408E+02	0.0000E+00
		0.1500E-02	0.1562E-01		
		0.3063E+00	0.6469E-02		
		0.6111E+00	0.1863E-02		
		0.9159E+00	0.3597E-03		
		0.1221E+01	0.4548E-04		
		0.1525E+01	0.3702E-05		
		0.2459E+01	0.9946E-10		
		0.3393E+01	0.1514E-14		
		0.4326E+01	0.8688E-17		
		0.5260E+01	0.1605E-19		
		0.6194E+01	0.8966E-23		
		0.7127E+01	0.1464E-26		
		0.8061E+01	0.1050E-30		
		0.8995E+01	0.7410E-34		
		0.9928E+01	0.0000E+00		
		0.1086E+02	0.0000E+00		
		0.1180E+02	0.0000E+00		
		0.1409E+02	0.0000E+00		
		0.1638E+02	0.0000E+00		
		0.1867E+02	0.0000E+00		
		0.2096E+02	0.0000E+00		
		0.2326E+02	0.0000E+00		
0.5000E+01	0.3845E+03	0.0000E+00	0.2507E-01	0.3408E+02	0.0000E+00
		0.1500E-02	0.1612E-01		
		0.3063E+00	0.6664E-02		
		0.6111E+00	0.1917E-02		
		0.9159E+00	0.3701E-03		
		0.1221E+01	0.4678E-04		
		0.1525E+01	0.3807E-05		
		0.2459E+01	0.1023E-09		
		0.3393E+01	0.1542E-14		
		0.4326E+01	0.8849E-17		
		0.5260E+01	0.1634E-19		
		0.6194E+01	0.9130E-23		
		0.7127E+01	0.1491E-26		
		0.8061E+01	0.1067E-30		

		0.8995E+01	0.3843E-34		
		0.9928E+01	0.0000E+00		
		0.1086E+02	0.0000E+00		
		0.1180E+02	0.0000E+00		
		0.1409E+02	0.0000E+00		
		0.1638E+02	0.0000E+00		
		0.1867E+02	0.0000E+00		
		0.2096E+02	0.0000E+00		
		0.2326E+02	0.0000E+00		
0.5000E+01	0.3947E+03	0.0000E+00	0.2528E-01	0.3408E+02	0.0000E+00
		0.1500E-02	0.1624E-01		
		0.3063E+00	0.6713E-02		
		0.6111E+00	0.1931E-02		
		0.9159E+00	0.3727E-03		
		0.1221E+01	0.4709E-04		
		0.1525E+01	0.3833E-05		
		0.2459E+01	0.1029E-09		
		0.3393E+01	0.1548E-14		
		0.4326E+01	0.8879E-17		
		0.5260E+01	0.1640E-19		
		0.6194E+01	0.9160E-23		
		0.7127E+01	0.1496E-26		
		0.8061E+01	0.1070E-30		
		0.8995E+01	0.2190E-34		
		0.9928E+01	0.0000E+00		
		0.1086E+02	0.0000E+00		
		0.1180E+02	0.0000E+00		
		0.1409E+02	0.0000E+00		
		0.1638E+02	0.0000E+00		
		0.1867E+02	0.0000E+00		
		0.2096E+02	0.0000E+00		
		0.2326E+02	0.0000E+00		
0.5000E+01	0.4049E+03	0.0000E+00	0.2551E-01	0.3408E+02	0.0000E+00
		0.1500E-02	0.1638E-01		
		0.3063E+00	0.6767E-02		
		0.6111E+00	0.1946E-02		
		0.9159E+00	0.3754E-03		
		0.1221E+01	0.4743E-04		
		0.1525E+01	0.3860E-05		
		0.2459E+01	0.1037E-09		
		0.3393E+01	0.1552E-14		
		0.4326E+01	0.8900E-17		
		0.5260E+01	0.1643E-19		
		0.6194E+01	0.9181E-23		
		0.7127E+01	0.1499E-26		
		0.8061E+01	0.1071E-30		
		0.8995E+01	0.7462E-35		
		0.9928E+01	0.0000E+00		

		0.1086E+02	0.0000E+00		
		0.1180E+02	0.0000E+00		
		0.1409E+02	0.0000E+00		
		0.1638E+02	0.0000E+00		
		0.1867E+02	0.0000E+00		
		0.2096E+02	0.0000E+00		
		0.2326E+02	0.0000E+00		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.1000E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.5556E+02	0.0000E+00
		0.1500E-02	0.1764E-01		
		0.3063E+00	0.9996E-02		
		0.6111E+00	0.4752E-02		
		0.9159E+00	0.1866E-02		
		0.1221E+01	0.5983E-03		
		0.1525E+01	0.1553E-03		
		0.2459E+01	0.6304E-06		
		0.3393E+01	0.2987E-09		
		0.4326E+01	0.2402E-13		
		0.5260E+01	0.3398E-15		
		0.6194E+01	0.7797E-17		
		0.7127E+01	0.1002E-18		
		0.8061E+01	0.7105E-21		
		0.8995E+01	0.2744E-23		
		0.9928E+01	0.5706E-26		
		0.1086E+02	0.6759E-29		
		0.1180E+02	0.2294E-32		
		0.1409E+02	0.3111E-33		
		0.1638E+02	0.4406E-34		
		0.1867E+02	0.5160E-35		
		0.2096E+02	0.7734E-36		
		0.2326E+02	0.3805E-35		
0.1000E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.5556E+02	0.0000E+00
		0.1500E-02	0.1819E-01		
		0.3063E+00	0.1028E-01		
		0.6111E+00	0.4882E-02		
		0.9159E+00	0.1916E-02		
		0.1221E+01	0.6138E-03		
		0.1525E+01	0.1592E-03		
		0.2459E+01	0.6459E-06		
		0.3393E+01	0.3060E-09		
		0.4326E+01	0.2449E-13		
		0.5260E+01	0.3433E-15		
		0.6194E+01	0.7876E-17		
		0.7127E+01	0.1012E-18		
		0.8061E+01	0.7176E-21		

		0.8995E+01	0.2771E-23		
		0.9928E+01	0.5763E-26		
		0.1086E+02	0.6823E-29		
		0.1180E+02	0.2297E-32		
		0.1409E+02	0.3097E-33		
		0.1638E+02	0.4749E-34		
		0.1867E+02	0.8682E-35		
		0.2096E+02	0.2697E-35		
		0.2326E+02	0.2740E-35		
0.1000E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.5556E+02	0.0000E+00
		0.1500E-02	0.1832E-01		
		0.3063E+00	0.1035E-01		
		0.6111E+00	0.4913E-02		
		0.9159E+00	0.1927E-02		
		0.1221E+01	0.6173E-03		
		0.1525E+01	0.1601E-03		
		0.2459E+01	0.6494E-06		
		0.3393E+01	0.3076E-09		
		0.4326E+01	0.2458E-13		
		0.5260E+01	0.3437E-15		
		0.6194E+01	0.7884E-17		
		0.7127E+01	0.1013E-18		
		0.8061E+01	0.7183E-21		
		0.8995E+01	0.2774E-23		
		0.9928E+01	0.5768E-26		
		0.1086E+02	0.6829E-29		
		0.1180E+02	0.2296E-32		
		0.1409E+02	0.3107E-33		
		0.1638E+02	0.5121E-34		
		0.1867E+02	0.2863E-35		
		0.2096E+02	0.2351E-35		
		0.2326E+02	0.1839E-35		
0.1000E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.5556E+02	0.0000E+00
		0.1500E-02	0.1848E-01		
		0.3063E+00	0.1043E-01		
		0.6111E+00	0.4946E-02		
		0.9159E+00	0.1939E-02		
		0.1221E+01	0.6209E-03		
		0.1525E+01	0.1610E-03		
		0.2459E+01	0.6529E-06		
		0.3393E+01	0.3092E-09		
		0.4326E+01	0.2466E-13		
		0.5260E+01	0.3434E-15		
		0.6194E+01	0.7876E-17		
		0.7127E+01	0.1012E-18		
		0.8061E+01	0.7175E-21		
		0.8995E+01	0.2771E-23		
		0.9928E+01	0.5762E-26		

		0.1086E+02	0.6821E-29		
		0.1180E+02	0.2250E-32		
		0.1409E+02	0.2834E-33		
		0.1638E+02	0.4013E-34		
		0.1867E+02	0.5663E-35		
		0.2096E+02	-0.2525E-36		
		0.2326E+02	0.1113E-35		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
~~	~~~~~~~~~	~~~~~~~~~	~~~~~~~~~~~~~	~~~~~~~~~~	~~~~~~~~~~~
0.1500E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.7301E+02	0.0000E+00
		0.1500E-02	0.1865E-01		
		0.3063E+00	0.1197E-01		
		0.6111E+00	0.6857E-02		
		0.9159E+00	0.3469E-02		
		0.1221E+01	0.1539E-02		
		0.1525E+01	0.5953E-03		
		0.2459E+01	0.1324E-04		
		0.3393E+01	0.7208E-07		
		0.4326E+01	0.9213E-10		
		0.5260E+01	0.3705E-13		
		0.6194E+01	0.7949E-15		
		0.7127E+01	0.4255E-16		
		0.8061E+01	0.1556E-17		
		0.8995E+01	0.3846E-19		
		0.9928E+01	0.6384E-21		
		0.1086E+02	0.7059E-23		
		0.1180E+02	0.9832E-26		
		0.1409E+02	0.1246E-26		
		0.1638E+02	0.1502E-27		
		0.1867E+02	0.1750E-28		
		0.2096E+02	0.2170E-29		
		0.2326E+02	0.6069E-30		
0.1500E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.7301E+02	0.0000E+00
		0.1500E-02	0.1922E-01		
		0.3063E+00	0.1230E-01		
		0.6111E+00	0.7034E-02		
		0.9159E+00	0.3554E-02		
		0.1221E+01	0.1575E-02		
		0.1525E+01	0.6089E-03		
		0.2459E+01	0.1353E-04		
		0.3393E+01	0.7361E-07		
		0.4326E+01	0.9406E-10		
		0.5260E+01	0.3768E-13		
		0.6194E+01	0.7994E-15		
		0.7127E+01	0.4279E-16		
		0.8061E+01	0.1564E-17		

		0.8995E+01	0.3866E-19		
		0.9928E+01	0.6417E-21		
		0.1086E+02	0.7096E-23		
		0.1180E+02	0.9847E-26		
		0.1409E+02	0.1251E-26		
		0.1638E+02	0.1512E-27		
		0.1867E+02	0.1734E-28		
		0.2096E+02	0.1979E-29		
		0.2326E+02	0.4654E-30		
0.1500E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.7301E+02	0.0000E+00
		0.1500E-02	0.1936E-01		
		0.3063E+00	0.1238E-01		
		0.6111E+00	0.7075E-02		
		0.9159E+00	0.3573E-02		
		0.1221E+01	0.1583E-02		
		0.1525E+01	0.6119E-03		
		0.2459E+01	0.1359E-04		
		0.3393E+01	0.7393E-07		
		0.4326E+01	0.9446E-10		
		0.5260E+01	0.3779E-13		
		0.6194E+01	0.7994E-15		
		0.7127E+01	0.4278E-16		
		0.8061E+01	0.1564E-17		
		0.8995E+01	0.3866E-19		
		0.9928E+01	0.6416E-21		
		0.1086E+02	0.7095E-23		
		0.1180E+02	0.9841E-26		
		0.1409E+02	0.1249E-26		
		0.1638E+02	0.1503E-27		
		0.1867E+02	0.1708E-28		
		0.2096E+02	0.1896E-29		
		0.2326E+02	0.4174E-30		
0.1500E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.7301E+02	0.0000E+00
		0.1500E-02	0.1952E-01		
		0.3063E+00	0.1247E-01		
		0.6111E+00	0.7116E-02		
		0.9159E+00	0.3592E-02		
		0.1221E+01	0.1591E-02		
		0.1525E+01	0.6146E-03		
		0.2459E+01	0.1364E-04		
		0.3393E+01	0.7420E-07		
		0.4326E+01	0.9479E-10		
		0.5260E+01	0.3787E-13		
		0.6194E+01	0.7978E-15		
		0.7127E+01	0.4269E-16		
		0.8061E+01	0.1560E-17		
		0.8995E+01	0.3858E-19		
		0.9928E+01	0.6402E-21		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.7080E-23		
		0.1180E+02	0.9686E-26		
		0.1409E+02	0.1159E-26		
		0.1638E+02	0.1283E-27		
		0.1867E+02	0.1353E-28		
		0.2096E+02	0.1411E-29		
		0.2326E+02	0.2944E-30		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.2000E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.8815E+02	0.0000E+00
		0.1500E-02	0.1929E-01		
		0.3063E+00	0.1327E-01		
		0.6111E+00	0.8401E-02		
		0.9159E+00	0.4856E-02		
		0.1221E+01	0.2549E-02		
		0.1525E+01	0.1210E-02		
		0.2459E+01	0.6379E-04		
		0.3393E+01	0.1188E-05		
		0.4326E+01	0.7545E-08		
		0.5260E+01	0.1605E-10		
		0.6194E+01	0.1948E-13		
		0.7127E+01	0.9102E-15		
		0.8061E+01	0.7483E-16		
		0.8995E+01	0.4630E-17		
		0.9928E+01	0.2139E-18		
		0.1086E+02	0.7343E-20		
		0.1180E+02	0.3590E-22		
		0.1409E+02	0.7744E-23		
		0.1638E+02	0.1643E-23		
		0.1867E+02	0.3520E-24		
		0.2096E+02	0.8015E-25		
		0.2326E+02	0.3351E-25		
0.2000E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.8815E+02	0.0000E+00
		0.1500E-02	0.1987E-01		
		0.3063E+00	0.1363E-01		
		0.6111E+00	0.8608E-02		
		0.9159E+00	0.4968E-02		
		0.1221E+01	0.2605E-02		
		0.1525E+01	0.1235E-02		
		0.2459E+01	0.6502E-04		
		0.3393E+01	0.1210E-05		
		0.4326E+01	0.7682E-08		
		0.5260E+01	0.1634E-10		
		0.6194E+01	0.1971E-13		
		0.7127E+01	0.9130E-15		
		0.8061E+01	0.7505E-16		

		0.8995E+01	0.4643E-17		
		0.9928E+01	0.2145E-18		
		0.1086E+02	0.7363E-20		
		0.1180E+02	0.3589E-22		
		0.1409E+02	0.7699E-23		
		0.1638E+02	0.1587E-23		
		0.1867E+02	0.3143E-24		
		0.2096E+02	0.6221E-25		
		0.2326E+02	0.2254E-25		
0.2000E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.8815E+02	0.0000E+00
		0.1500E-02	0.2001E-01		
		0.3063E+00	0.1371E-01		
		0.6111E+00	0.8654E-02		
		0.9159E+00	0.4992E-02		
		0.1221E+01	0.2616E-02		
		0.1525E+01	0.1240E-02		
		0.2459E+01	0.6526E-04		
		0.3393E+01	0.1214E-05		
		0.4326E+01	0.7708E-08		
		0.5260E+01	0.1640E-10		
		0.6194E+01	0.1974E-13		
		0.7127E+01	0.9126E-15		
		0.8061E+01	0.7502E-16		
		0.8995E+01	0.4641E-17		
		0.9928E+01	0.2144E-18		
		0.1086E+02	0.7359E-20		
		0.1180E+02	0.3582E-22		
		0.1409E+02	0.7648E-23		
		0.1638E+02	0.1559E-23		
		0.1867E+02	0.3024E-24		
		0.2096E+02	0.5759E-25		
		0.2326E+02	0.1984E-25		
0.2000E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.8815E+02	0.0000E+00
		0.1500E-02	0.2017E-01		
		0.3063E+00	0.1380E-01		
		0.6111E+00	0.8700E-02		
		0.9159E+00	0.5014E-02		
		0.1221E+01	0.2626E-02		
		0.1525E+01	0.1245E-02		
		0.2459E+01	0.6544E-04		
		0.3393E+01	0.1217E-05		
		0.4326E+01	0.7726E-08		
		0.5260E+01	0.1643E-10		
		0.6194E+01	0.1975E-13		
		0.7127E+01	0.9106E-15		
		0.8061E+01	0.7485E-16		
		0.8995E+01	0.4630E-17		
		0.9928E+01	0.2139E-18		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.7343E-20		
		0.1180E+02	0.3447E-22		
		0.1409E+02	0.6729E-23		
		0.1638E+02	0.1245E-23		
		0.1867E+02	0.2249E-24		
		0.2096E+02	0.4078E-25		
		0.2326E+02	0.1363E-25		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.2500E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.1017E+03	0.0000E+00
		0.1500E-02	0.1974E-01		
		0.3063E+00	0.1421E-01		
		0.6111E+00	0.9582E-02		
		0.9159E+00	0.6019E-02		
		0.1221E+01	0.3505E-02		
		0.1525E+01	0.1886E-02		
		0.2459E+01	0.1681E-03		
		0.3393E+01	0.6582E-05		
		0.4326E+01	0.1099E-06		
		0.5260E+01	0.7673E-09		
		0.6194E+01	0.2250E-11		
		0.7127E+01	0.8446E-14		
		0.8061E+01	0.7820E-15		
		0.8995E+01	0.8352E-16		
		0.9928E+01	0.7100E-17		
		0.1086E+02	0.4772E-18		
		0.1180E+02	0.5033E-20		
		0.1409E+02	0.1559E-20		
		0.1638E+02	0.5042E-21		
		0.1867E+02	0.1726E-21		
		0.2096E+02	0.6479E-22		
		0.2326E+02	0.3910E-22		
0.2500E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.1017E+03	0.0000E+00
		0.1500E-02	0.2032E-01		
		0.3063E+00	0.1458E-01		
		0.6111E+00	0.9808E-02		
		0.9159E+00	0.6149E-02		
		0.1221E+01	0.3576E-02		
		0.1525E+01	0.1922E-02		
		0.2459E+01	0.1710E-03		
		0.3393E+01	0.6690E-05		
		0.4326E+01	0.1116E-06		
		0.5260E+01	0.7792E-09		
		0.6194E+01	0.2284E-11		
		0.7127E+01	0.8496E-14		
		0.8061E+01	0.7833E-15		

		0.8995E+01	0.8364E-16		
		0.9928E+01	0.7110E-17		
		0.1086E+02	0.4778E-18		
		0.1180E+02	0.4936E-20		
		0.1409E+02	0.1458E-20		
		0.1638E+02	0.4235E-21		
		0.1867E+02	0.1230E-21		
		0.2096E+02	0.3839E-22		
		0.2326E+02	0.2064E-22		
0.2500E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.1017E+03	0.0000E+00
		0.1500E-02	0.2047E-01		
		0.3063E+00	0.1467E-01		
		0.6111E+00	0.9857E-02		
		0.9159E+00	0.6176E-02		
		0.1221E+01	0.3591E-02		
		0.1525E+01	0.1929E-02		
		0.2459E+01	0.1715E-03		
		0.3393E+01	0.6709E-05		
		0.4326E+01	0.1119E-06		
		0.5260E+01	0.7812E-09		
		0.6194E+01	0.2290E-11		
		0.7127E+01	0.8500E-14		
		0.8061E+01	0.7828E-15		
		0.8995E+01	0.8360E-16		
		0.9928E+01	0.7106E-17		
		0.1086E+02	0.4775E-18		
		0.1180E+02	0.4898E-20		
		0.1409E+02	0.1423E-20		
		0.1638E+02	0.3985E-21		
		0.1867E+02	0.1085E-21		
		0.2096E+02	0.3054E-22		
		0.2326E+02	0.1494E-22		
0.2500E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.1017E+03	0.0000E+00
		0.1500E-02	0.2063E-01		
		0.3063E+00	0.1476E-01		
		0.6111E+00	0.9905E-02		
		0.9159E+00	0.6200E-02		
		0.1221E+01	0.3602E-02		
		0.1525E+01	0.1935E-02		
		0.2459E+01	0.1718E-03		
		0.3393E+01	0.6719E-05		
		0.4326E+01	0.1120E-06		
		0.5260E+01	0.7821E-09		
		0.6194E+01	0.2292E-11		
		0.7127E+01	0.8491E-14		
		0.8061E+01	0.7813E-15		
		0.8995E+01	0.8344E-16		
		0.9928E+01	0.7092E-17		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.4766E-18		
		0.1180E+02	0.4586E-20		
		0.1409E+02	0.1193E-20		
		0.1638E+02	0.3019E-21		
		0.1867E+02	0.7659E-22		
		0.2096E+02	0.2042E-22		
		0.2326E+02	0.9613E-23		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.3000E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.1142E+03	0.0000E+00
		0.1500E-02	0.2007E-01		
		0.3063E+00	0.1492E-01		
		0.6111E+00	0.1052E-01		
		0.9159E+00	0.6996E-02		
		0.1221E+01	0.4374E-02		
		0.1525E+01	0.2563E-02		
		0.2459E+01	0.3254E-03		
		0.3393E+01	0.2099E-04		
		0.4326E+01	0.6688E-06		
		0.5260E+01	0.1036E-07		
		0.6194E+01	0.7726E-10		
		0.7127E+01	0.2949E-12		
		0.8061E+01	0.4247E-14		
		0.8995E+01	0.5829E-15		
		0.9928E+01	0.7424E-16		
		0.1086E+02	0.7773E-17		
		0.1180E+02	0.1448E-18		
		0.1409E+02	0.6065E-19		
		0.1638E+02	0.2734E-19		
		0.1867E+02	0.1294E-19		
		0.2096E+02	0.6615E-20		
		0.2326E+02	0.4811E-20		
0.3000E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.1142E+03	0.0000E+00
		0.1500E-02	0.2066E-01		
		0.3063E+00	0.1530E-01		
		0.6111E+00	0.1076E-01		
		0.9159E+00	0.7140E-02		
		0.1221E+01	0.4457E-02		
		0.1525E+01	0.2609E-02		
		0.2459E+01	0.3305E-03		
		0.3393E+01	0.2129E-04		
		0.4326E+01	0.6781E-06		
		0.5260E+01	0.1050E-07		
		0.6194E+01	0.7829E-10		
		0.7127E+01	0.2985E-12		
		0.8061E+01	0.4256E-14		

		0.8995E+01	0.5834E-15		
		0.9928E+01	0.7429E-16		
		0.1086E+02	0.7778E-17		
		0.1180E+02	0.1347E-18		
		0.1409E+02	0.5049E-19		
		0.1638E+02	0.1926E-19		
		0.1867E+02	0.7668E-20		
		0.2096E+02	0.3442E-20		
		0.2326E+02	0.2372E-20		
0.3000E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.1142E+03	0.0000E+00
		0.1500E-02	0.2081E-01		
		0.3063E+00	0.1539E-01		
		0.6111E+00	0.1081E-01		
		0.9159E+00	0.7169E-02		
		0.1221E+01	0.4473E-02		
		0.1525E+01	0.2617E-02		
		0.2459E+01	0.3313E-03		
		0.3393E+01	0.2134E-04		
		0.4326E+01	0.6795E-06		
		0.5260E+01	0.1052E-07		
		0.6194E+01	0.7843E-10		
		0.7127E+01	0.2990E-12		
		0.8061E+01	0.4255E-14		
		0.8995E+01	0.5831E-15		
		0.9928E+01	0.7425E-16		
		0.1086E+02	0.7774E-17		
		0.1180E+02	0.1312E-18		
		0.1409E+02	0.4700E-19		
		0.1638E+02	0.1654E-19		
		0.1867E+02	0.5851E-20		
		0.2096E+02	0.2274E-20		
		0.2326E+02	0.1430E-20		
0.3000E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.1142E+03	0.0000E+00
		0.1500E-02	0.2097E-01		
		0.3063E+00	0.1548E-01		
		0.6111E+00	0.1086E-01		
		0.9159E+00	0.7193E-02		
		0.1221E+01	0.4485E-02		
		0.1525E+01	0.2623E-02		
		0.2459E+01	0.3317E-03		
		0.3393E+01	0.2135E-04		
		0.4326E+01	0.6797E-06		
		0.5260E+01	0.1052E-07		
		0.6194E+01	0.7845E-10		
		0.7127E+01	0.2990E-12		
		0.8061E+01	0.4250E-14		
		0.8995E+01	0.5822E-15		
		0.9928E+01	0.7414E-16		

		0.1086E+02	0.7762E-17		
		0.1180E+02	0.1191E-18		
		0.1409E+02	0.3759E-19		
		0.1638E+02	0.1187E-19		
		0.1867E+02	0.3871E-20		
		0.2096E+02	0.1396E-20		
		0.2326E+02	0.8358E-21		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.3500E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.1257E+03	0.0000E+00
		0.1500E-02	0.2033E-01		
		0.3063E+00	0.1549E-01		
		0.6111E+00	0.1128E-01		
		0.9159E+00	0.7826E-02		
		0.1221E+01	0.5154E-02		
		0.1525E+01	0.3213E-02		
		0.2459E+01	0.5268E-03		
		0.3393E+01	0.4861E-04		
		0.4326E+01	0.2463E-05		
		0.5260E+01	0.6751E-07		
		0.6194E+01	0.9909E-09		
		0.7127E+01	0.7785E-11		
		0.8061E+01	0.4377E-13		
		0.8995E+01	0.2427E-14		
		0.9928E+01	0.4009E-15		
		0.1086E+02	0.5741E-16		
		0.1180E+02	0.1751E-17		
		0.1409E+02	0.9430E-18		
		0.1638E+02	0.5390E-18		
		0.1867E+02	0.3136E-18		
		0.2096E+02	0.1937E-18		
		0.2326E+02	0.1559E-18		
0.3500E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.1257E+03	0.0000E+00
		0.1500E-02	0.2093E-01		
		0.3063E+00	0.1588E-01		
		0.6111E+00	0.1153E-01		
		0.9159E+00	0.7980E-02		
		0.1221E+01	0.5246E-02		
		0.1525E+01	0.3266E-02		
		0.2459E+01	0.5342E-03		
		0.3393E+01	0.4924E-04		
		0.4326E+01	0.2493E-05		
		0.5260E+01	0.6830E-07		
		0.6194E+01	0.1002E-08		
		0.7127E+01	0.7872E-11		
		0.8061E+01	0.4413E-13		

		0.8995E+01	0.2429E-14		
		0.9928E+01	0.4011E-15		
		0.1086E+02	0.5741E-16		
		0.1180E+02	0.1498E-17		
		0.1409E+02	0.6905E-18		
		0.1638E+02	0.3339E-18		
		0.1867E+02	0.1717E-18		
		0.2096E+02	0.9965E-19		
		0.2326E+02	0.7900E-19		
0.3500E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.1257E+03	0.0000E+00
		0.1500E-02	0.2107E-01		
		0.3063E+00	0.1596E-01		
		0.6111E+00	0.1158E-01		
		0.9159E+00	0.8010E-02		
		0.1221E+01	0.5263E-02		
		0.1525E+01	0.3276E-02		
		0.2459E+01	0.5353E-03		
		0.3393E+01	0.4932E-04		
		0.4326E+01	0.2497E-05		
		0.5260E+01	0.6840E-07		
		0.6194E+01	0.1004E-08		
		0.7127E+01	0.7882E-11		
		0.8061E+01	0.4417E-13		
		0.8995E+01	0.2428E-14		
		0.9928E+01	0.4009E-15		
		0.1086E+02	0.5738E-16		
		0.1180E+02	0.1402E-17		
		0.1409E+02	0.5940E-18		
		0.1638E+02	0.2543E-18		
		0.1867E+02	0.1139E-18		
		0.2096E+02	0.5838E-19		
		0.2326E+02	0.4371E-19		
0.3500E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.1257E+03	0.0000E+00
		0.1500E-02	0.2124E-01		
		0.3063E+00	0.1605E-01		
		0.6111E+00	0.1163E-01		
		0.9159E+00	0.8034E-02		
		0.1221E+01	0.5275E-02		
		0.1525E+01	0.3281E-02		
		0.2459E+01	0.5356E-03		
		0.3393E+01	0.4932E-04		
		0.4326E+01	0.2497E-05		
		0.5260E+01	0.6837E-07		
		0.6194E+01	0.1003E-08		
		0.7127E+01	0.7878E-11		
		0.8061E+01	0.4414E-13		
		0.8995E+01	0.2425E-14		
		0.9928E+01	0.4005E-15		

		0.1086E+02	0.5730E-16		
		0.1180E+02	0.1227E-17		
		0.1409E+02	0.4502E-18		
		0.1638E+02	0.1710E-18		
		0.1867E+02	0.6968E-19		
		0.2096E+02	0.3293E-19		
		0.2326E+02	0.2365E-19		
TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.4000E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.1366E+03	0.0000E+00
		0.1500E-02	0.2054E-01		
		0.3063E+00	0.1595E-01		
		0.6111E+00	0.1192E-01		
		0.9159E+00	0.8540E-02		
		0.1221E+01	0.5852E-02		
		0.1525E+01	0.3825E-02		
		0.2459E+01	0.7610E-03		
		0.3393E+01	0.9203E-04		
		0.4326E+01	0.6612E-05		
		0.5260E+01	0.2783E-06		
		0.6194E+01	0.6798E-08		
		0.7127E+01	0.9586E-10		
		0.8061E+01	0.8025E-12		
		0.8995E+01	0.1036E-13		
		0.9928E+01	0.1440E-14		
		0.1086E+02	0.2584E-15		
		0.1180E+02	0.1249E-16		
		0.1409E+02	0.8138E-17		
		0.1638E+02	0.5443E-17		
		0.1867E+02	0.3620E-17		
		0.2096E+02	0.2524E-17		
		0.2326E+02	0.2160E-17		
0.4000E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.1366E+03	0.0000E+00
		0.1500E-02	0.2114E-01		
		0.3063E+00	0.1634E-01		
		0.6111E+00	0.1217E-01		
		0.9159E+00	0.8700E-02		
		0.1221E+01	0.5951E-02		
		0.1525E+01	0.3884E-02		
		0.2459E+01	0.7707E-03		
		0.3393E+01	0.9308E-04		
		0.4326E+01	0.6683E-05		
		0.5260E+01	0.2811E-06		
		0.6194E+01	0.6865E-08		
		0.7127E+01	0.9679E-10		
		0.8061E+01	0.8100E-12		

		0.8995E+01	0.1040E-13		
		0.9928E+01	0.1440E-14		
		0.1086E+02	0.2582E-15		
		0.1180E+02	0.9759E-17		
		0.1409E+02	0.5416E-17		
		0.1638E+02	0.3182E-17		
		0.1867E+02	0.1975E-17		
		0.2096E+02	0.1353E-17		
		0.2326E+02	0.1160E-17		
0.4000E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.1366E+03	0.0000E+00
		0.1500E-02	0.2129E-01		
		0.3063E+00	0.1643E-01		
		0.6111E+00	0.1222E-01		
		0.9159E+00	0.8732E-02		
		0.1221E+01	0.5968E-02		
		0.1525E+01	0.3894E-02		
		0.2459E+01	0.7721E-03		
		0.3393E+01	0.9321E-04		
		0.4326E+01	0.6690E-05		
		0.5260E+01	0.2814E-06		
		0.6194E+01	0.6871E-08		
		0.7127E+01	0.9688E-10		
		0.8061E+01	0.8106E-12		
		0.8995E+01	0.1040E-13		
		0.9928E+01	0.1440E-14		
		0.1086E+02	0.2580E-15		
		0.1180E+02	0.8593E-17		
		0.1409E+02	0.4246E-17		
		0.1638E+02	0.2182E-17		
		0.1867E+02	0.1205E-17		
		0.2096E+02	0.7636E-18		
		0.2326E+02	0.6371E-18		
0.4000E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.1366E+03	0.0000E+00
		0.1500E-02	0.2145E-01		
		0.3063E+00	0.1652E-01		
		0.6111E+00	0.1227E-01		
		0.9159E+00	0.8755E-02		
		0.1221E+01	0.5979E-02		
		0.1525E+01	0.3898E-02		
		0.2459E+01	0.7721E-03		
		0.3393E+01	0.9316E-04		
		0.4326E+01	0.6685E-05		
		0.5260E+01	0.2811E-06		
		0.6194E+01	0.6864E-08		
		0.7127E+01	0.9677E-10		
		0.8061E+01	0.8097E-12		
		0.8995E+01	0.1039E-13		
		0.9928E+01	0.1439E-14		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.2576E-15		
		0.1180E+02	0.7183E-17		
		0.1409E+02	0.3026E-17		
		0.1638E+02	0.1373E-17		
		0.1867E+02	0.6933E-18		
		0.2096E+02	0.4137E-18		
		0.2326E+02	0.3370E-18		
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0.4500E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.1469E+03	0.0000E+00
		0.1500E-02	0.2072E-01		
		0.3063E+00	0.1634E-01		
		0.6111E+00	0.1246E-01		
		0.9159E+00	0.9161E-02		
		0.1221E+01	0.6477E-02		
		0.1525E+01	0.4395E-02		
		0.2459E+01	0.1018E-02		
		0.3393E+01	0.1521E-03		
		0.4326E+01	0.1435E-04		
		0.5260E+01	0.8439E-06		
		0.6194E+01	0.3066E-07		
		0.7127E+01	0.6842E-09		
		0.8061E+01	0.9388E-11		
		0.8995E+01	0.9314E-13		
		0.9928E+01	0.4263E-14		
		0.1086E+02	0.8373E-15		
		0.1180E+02	0.6227E-16		
		0.1409E+02	0.4634E-16		
		0.1638E+02	0.3437E-16		
		0.1867E+02	0.2502E-16		
		0.2096E+02	0.1894E-16		
		0.2326E+02	0.1686E-16		
0.4500E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.1469E+03	0.0000E+00
		0.1500E-02	0.2132E-01		
		0.3063E+00	0.1673E-01		
		0.6111E+00	0.1272E-01		
		0.9159E+00	0.9327E-02		
		0.1221E+01	0.6582E-02		
		0.1525E+01	0.4458E-02		
		0.2459E+01	0.1030E-02		
		0.3393E+01	0.1537E-03		
		0.4326E+01	0.1449E-04		
		0.5260E+01	0.8514E-06		
		0.6194E+01	0.3092E-07		
		0.7127E+01	0.6899E-09		
		0.8061E+01	0.9464E-11		

		0.8995E+01	0.9377E-13		
		0.9928E+01	0.4266E-14		
		0.1086E+02	0.8352E-15		
		0.1180E+02	0.4519E-16		
		0.1409E+02	0.2934E-16		
		0.1638E+02	0.1996E-16		
		0.1867E+02	0.1410E-16		
		0.2096E+02	0.1074E-16		
		0.2326E+02	0.9648E-17		
0.4500E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.1469E+03	0.0000E+00
		0.1500E-02	0.2147E-01		
		0.3063E+00	0.1682E-01		
		0.6111E+00	0.1277E-01		
		0.9159E+00	0.9358E-02		
		0.1221E+01	0.6600E-02		
		0.1525E+01	0.4469E-02		
		0.2459E+01	0.1031E-02		
		0.3393E+01	0.1538E-03		
		0.4326E+01	0.1450E-04		
		0.5260E+01	0.8520E-06		
		0.6194E+01	0.3094E-07		
		0.7127E+01	0.6903E-09		
		0.8061E+01	0.9470E-11		
		0.8995E+01	0.9380E-13		
		0.9928E+01	0.4265E-14		
		0.1086E+02	0.8340E-15		
		0.1180E+02	0.3713E-16		
		0.1409E+02	0.2123E-16		
		0.1638E+02	0.1285E-16		
		0.1867E+02	0.8386E-17		
		0.2096E+02	0.6145E-17		
		0.2326E+02	0.5464E-17		
0.4500E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.1469E+03	0.0000E+00
		0.1500E-02	0.2163E-01		
		0.3063E+00	0.1691E-01		
		0.6111E+00	0.1282E-01		
		0.9159E+00	0.9380E-02		
		0.1221E+01	0.6610E-02		
		0.1525E+01	0.4472E-02		
		0.2459E+01	0.1031E-02		
		0.3393E+01	0.1537E-03		
		0.4326E+01	0.1448E-04		
		0.5260E+01	0.8508E-06		
		0.6194E+01	0.3090E-07		
		0.7127E+01	0.6893E-09		
		0.8061E+01	0.9455E-11		
		0.8995E+01	0.9367E-13		
		0.9928E+01	0.4262E-14		

		0.1086E+02	0.8326E-15		
		0.1180E+02	0.2941E-16		
		0.1409E+02	0.1426E-16		
		0.1638E+02	0.7715E-17		
		0.1867E+02	0.4720E-17		
		0.2096E+02	0.3351E-17		
		0.2326E+02	0.2953E-17		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.5000E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.1566E+03	0.0000E+00
		0.1500E-02	0.2087E-01		
		0.3063E+00	0.1667E-01		
		0.6111E+00	0.1293E-01		
		0.9159E+00	0.9707E-02		
		0.1221E+01	0.7041E-02		
		0.1525E+01	0.4924E-02		
		0.2459E+01	0.1290E-02		
		0.3393E+01	0.2284E-03		
		0.4326E+01	0.2682E-04		
		0.5260E+01	0.2062E-05		
		0.6194E+01	0.1030E-06		
		0.7127E+01	0.3321E-08		
		0.8061E+01	0.6896E-10		
		0.8995E+01	0.9459E-12		
		0.9928E+01	0.1641E-13		
		0.1086E+02	0.2191E-14		
		0.1180E+02	0.2382E-15		
		0.1409E+02	0.1939E-15		
		0.1638E+02	0.1542E-15		
		0.1867E+02	0.1197E-15		
		0.2096E+02	0.9612E-16		
		0.2326E+02	0.8786E-16		
0.5000E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.1566E+03	0.0000E+00
		0.1500E-02	0.2147E-01		
		0.3063E+00	0.1706E-01		
		0.6111E+00	0.1319E-01		
		0.9159E+00	0.9876E-02		
		0.1221E+01	0.7149E-02		
		0.1525E+01	0.4991E-02		
		0.2459E+01	0.1303E-02		
		0.3393E+01	0.2305E-03		
		0.4326E+01	0.2704E-04		
		0.5260E+01	0.2078E-05		
		0.6194E+01	0.1037E-06		
		0.7127E+01	0.3345E-08		
		0.8061E+01	0.6944E-10		

		0.8995E+01	0.9523E-12		
		0.9928E+01	0.1646E-13		
		0.1086E+02	0.2180E-14		
		0.1180E+02	0.1651E-15		
		0.1409E+02	0.1211E-15		
		0.1638E+02	0.9149E-16		
		0.1867E+02	0.7061E-16		
		0.2096E+02	0.5767E-16		
		0.2326E+02	0.5332E-16		
0.5000E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.1566E+03	0.0000E+00
		0.1500E-02	0.2162E-01		
		0.3063E+00	0.1715E-01		
		0.6111E+00	0.1324E-01		
		0.9159E+00	0.9908E-02		
		0.1221E+01	0.7168E-02		
		0.1525E+01	0.5002E-02		
		0.2459E+01	0.1305E-02		
		0.3393E+01	0.2307E-03		
		0.4326E+01	0.2706E-04		
		0.5260E+01	0.2079E-05		
		0.6194E+01	0.1038E-06		
		0.7127E+01	0.3346E-08		
		0.8061E+01	0.6946E-10		
		0.8995E+01	0.9525E-12		
		0.9928E+01	0.1646E-13		
		0.1086E+02	0.2174E-14		
		0.1180E+02	0.1275E-15		
		0.1409E+02	0.8323E-16		
		0.1638E+02	0.5761E-16		
		0.1867E+02	0.4246E-16		
		0.2096E+02	0.3419E-16		
		0.2326E+02	0.3157E-16		
0.5000E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.1566E+03	0.0000E+00
		0.1500E-02	0.2178E-01		
		0.3063E+00	0.1724E-01		
		0.6111E+00	0.1329E-01		
		0.9159E+00	0.9929E-02		
		0.1221E+01	0.7176E-02		
		0.1525E+01	0.5004E-02		
		0.2459E+01	0.1304E-02		
		0.3393E+01	0.2304E-03		
		0.4326E+01	0.2702E-04		
		0.5260E+01	0.2076E-05		
		0.6194E+01	0.1036E-06		
		0.7127E+01	0.3340E-08		
		0.8061E+01	0.6933E-10		
		0.8995E+01	0.9508E-12		
		0.9928E+01	0.1644E-13		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.2168E-14		
		0.1180E+02	0.9570E-16		
		0.1409E+02	0.5358E-16		
		0.1638E+02	0.3403E-16		
		0.1867E+02	0.2419E-16		
		0.2096E+02	0.1929E-16		
		0.2326E+02	0.1780E-16		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
0.5500E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.1660E+03	0.0000E+00
		0.1500E-02	0.2100E-01		
		0.3063E+00	0.1695E-01		
		0.6111E+00	0.1333E-01		
		0.9159E+00	0.1019E-01		
		0.1221E+01	0.7551E-02		
		0.1525E+01	0.5414E-02		
		0.2459E+01	0.1569E-02		
		0.3393E+01	0.3197E-03		
		0.4326E+01	0.4492E-04		
		0.5260E+01	0.4304E-05		
		0.6194E+01	0.2789E-06		
		0.7127E+01	0.1216E-07		
		0.8061E+01	0.3555E-09		
		0.8995E+01	0.6992E-11		
		0.9928E+01	0.1070E-12		
		0.1086E+02	0.5458E-14		
		0.1180E+02	0.7429E-15		
		0.1409E+02	0.6416E-15		
		0.1638E+02	0.5358E-15		
		0.1867E+02	0.4365E-15		
		0.2096E+02	0.3658E-15		
		0.2326E+02	0.3408E-15		
0.5500E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.1660E+03	0.0000E+00
		0.1500E-02	0.2160E-01		
		0.3063E+00	0.1735E-01		
		0.6111E+00	0.1360E-01		
		0.9159E+00	0.1036E-01		
		0.1221E+01	0.7662E-02		
		0.1525E+01	0.5484E-02		
		0.2459E+01	0.1585E-02		
		0.3393E+01	0.3223E-03		
		0.4326E+01	0.4525E-04		
		0.5260E+01	0.4333E-05		
		0.6194E+01	0.2807E-06		
		0.7127E+01	0.1224E-07		
		0.8061E+01	0.3577E-09		

		0.8995E+01	0.7033E-11		
		0.9928E+01	0.1075E-12		
		0.1086E+02	0.5419E-14		
		0.1180E+02	0.5050E-15		
		0.1409E+02	0.4048E-15		
		0.1638E+02	0.3288E-15		
		0.1867E+02	0.2698E-15		
		0.2096E+02	0.2311E-15		
		0.2326E+02	0.2179E-15		
0.5500E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.1660E+03	0.0000E+00
		0.1500E-02	0.2175E-01		
		0.3063E+00	0.1744E-01		
		0.6111E+00	0.1365E-01		
		0.9159E+00	0.1039E-01		
		0.1221E+01	0.7680E-02		
		0.1525E+01	0.5495E-02		
		0.2459E+01	0.1586E-02		
		0.3393E+01	0.3225E-03		
		0.4326E+01	0.4527E-04		
		0.5260E+01	0.4334E-05		
		0.6194E+01	0.2808E-06		
		0.7127E+01	0.1224E-07		
		0.8061E+01	0.3577E-09		
		0.8995E+01	0.7033E-11		
		0.9928E+01	0.1075E-12		
		0.1086E+02	0.5395E-14		
		0.1180E+02	0.3731E-15		
		0.1409E+02	0.2718E-15		
		0.1638E+02	0.2081E-15		
		0.1867E+02	0.1669E-15		
		0.2096E+02	0.1429E-15		
		0.2326E+02	0.1351E-15		
0.5500E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.1660E+03	0.0000E+00
		0.1500E-02	0.2191E-01		
		0.3063E+00	0.1753E-01		
		0.6111E+00	0.1370E-01		
		0.9159E+00	0.1042E-01		
		0.1221E+01	0.7688E-02		
		0.1525E+01	0.5497E-02		
		0.2459E+01	0.1585E-02		
		0.3393E+01	0.3220E-03		
		0.4326E+01	0.4519E-04		
		0.5260E+01	0.4326E-05		
		0.6194E+01	0.2802E-06		
		0.7127E+01	0.1221E-07		
		0.8061E+01	0.3570E-09		
		0.8995E+01	0.7018E-11		
		0.9928E+01	0.1073E-12		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.5373E-14		
		0.1180E+02	0.2682E-15		
		0.1409E+02	0.1717E-15		
		0.1638E+02	0.1242E-15		
		0.1867E+02	0.9823E-16		
		0.2096E+02	0.8431E-16		
		0.2326E+02	0.7995E-16		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.6000E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.1749E+03	0.0000E+00
		0.1500E-02	0.2111E-01		
		0.3063E+00	0.1720E-01		
		0.6111E+00	0.1369E-01		
		0.9159E+00	0.1062E-01		
		0.1221E+01	0.8015E-02		
		0.1525E+01	0.5869E-02		
		0.2459E+01	0.1852E-02		
		0.3393E+01	0.4243E-03		
		0.4326E+01	0.6928E-04		
		0.5260E+01	0.7976E-05		
		0.6194E+01	0.6426E-06		
		0.7127E+01	0.3604E-07		
		0.8061E+01	0.1402E-08		
		0.8995E+01	0.3779E-10		
		0.9928E+01	0.7290E-12		
		0.1086E+02	0.1795E-13		
		0.1180E+02	0.1979E-14		
		0.1409E+02	0.1771E-14		
		0.1638E+02	0.1532E-14		
		0.1867E+02	0.1294E-14		
		0.2096E+02	0.1120E-14		
		0.2326E+02	0.1059E-14		
0.6000E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.1749E+03	0.0000E+00
		0.1500E-02	0.2171E-01		
		0.3063E+00	0.1760E-01		
		0.6111E+00	0.1396E-01		
		0.9159E+00	0.1080E-01		
		0.1221E+01	0.8128E-02		
		0.1525E+01	0.5942E-02		
		0.2459E+01	0.1869E-02		
		0.3393E+01	0.4274E-03		
		0.4326E+01	0.6973E-04		
		0.5260E+01	0.8023E-05		
		0.6194E+01	0.6461E-06		
		0.7127E+01	0.3623E-07		
		0.8061E+01	0.1409E-08		

		0.8995E+01	0.3798E-10		
		0.9928E+01	0.7325E-12		
		0.1086E+02	0.1786E-13		
		0.1180E+02	0.1348E-14		
		0.1409E+02	0.1143E-14		
		0.1638E+02	0.9756E-15		
		0.1867E+02	0.8362E-15		
		0.2096E+02	0.7409E-15		
		0.2326E+02	0.7079E-15		
0.6000E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.1749E+03	0.0000E+00
		0.1500E-02	0.2186E-01		
		0.3063E+00	0.1769E-01		
		0.6111E+00	0.1401E-01		
		0.9159E+00	0.1083E-01		
		0.1221E+01	0.8146E-02		
		0.1525E+01	0.5952E-02		
		0.2459E+01	0.1871E-02		
		0.3393E+01	0.4276E-03		
		0.4326E+01	0.6974E-04		
		0.5260E+01	0.8023E-05		
		0.6194E+01	0.6461E-06		
		0.7127E+01	0.3623E-07		
		0.8061E+01	0.1409E-08		
		0.8995E+01	0.3798E-10		
		0.9928E+01	0.7323E-12		
		0.1086E+02	0.1778E-13		
		0.1180E+02	0.9750E-15		
		0.1409E+02	0.7664E-15		
		0.1638E+02	0.6302E-15		
		0.1867E+02	0.5358E-15		
		0.2096E+02	0.4777E-15		
		0.2326E+02	0.4586E-15		
0.6000E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.1749E+03	0.0000E+00
		0.1500E-02	0.2202E-01		
		0.3063E+00	0.1778E-01		
		0.6111E+00	0.1406E-01		
		0.9159E+00	0.1085E-01		
		0.1221E+01	0.8153E-02		
		0.1525E+01	0.5953E-02		
		0.2459E+01	0.1869E-02		
		0.3393E+01	0.4269E-03		
		0.4326E+01	0.6961E-04		
		0.5260E+01	0.8007E-05		
		0.6194E+01	0.6448E-06		
		0.7127E+01	0.3615E-07		
		0.8061E+01	0.1406E-08		
		0.8995E+01	0.3789E-10		
		0.9928E+01	0.7308E-12		

		0.1086E+02	0.1770E-13		
		0.1180E+02	0.6854E-15		
		0.1409E+02	0.4858E-15		
		0.1638E+02	0.3863E-15		
		0.1867E+02	0.3281E-15		
		0.2096E+02	0.2951E-15		
		0.2326E+02	0.2846E-15		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
0.6500E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.1836E+03	0.0000E+00
		0.1500E-02	0.2121E-01		
		0.3063E+00	0.1742E-01		
		0.6111E+00	0.1402E-01		
		0.9159E+00	0.1101E-01		
		0.1221E+01	0.8438E-02		
		0.1525E+01	0.6292E-02		
		0.2459E+01	0.2136E-02		
		0.3393E+01	0.5404E-03		
		0.4326E+01	0.1002E-03		
		0.5260E+01	0.1349E-04		
		0.6194E+01	0.1306E-05		
		0.7127E+01	0.9069E-07		
		0.8061E+01	0.4495E-08		
		0.8995E+01	0.1587E-09		
		0.9928E+01	0.4023E-11		
		0.1086E+02	0.8648E-13		
		0.1180E+02	0.4730E-14		
		0.1409E+02	0.4254E-14		
		0.1638E+02	0.3764E-14		
		0.1867E+02	0.3268E-14		
		0.2096E+02	0.2901E-14		
		0.2326E+02	0.2770E-14		
0.6500E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.1836E+03	0.0000E+00
		0.1500E-02	0.2181E-01		
		0.3063E+00	0.1782E-01		
		0.6111E+00	0.1428E-01		
		0.9159E+00	0.1119E-01		
		0.1221E+01	0.8553E-02		
		0.1525E+01	0.6367E-02		
		0.2459E+01	0.2153E-02		
		0.3393E+01	0.5440E-03		
		0.4326E+01	0.1008E-03		
		0.5260E+01	0.1355E-04		
		0.6194E+01	0.1313E-05		
		0.7127E+01	0.9110E-07		
		0.8061E+01	0.4515E-08		

		0.8995E+01	0.1594E-09		
		0.9928E+01	0.4039E-11		
		0.1086E+02	0.8643E-13		
		0.1180E+02	0.3297E-14		
		0.1409E+02	0.2826E-14		
		0.1638E+02	0.2487E-14		
		0.1867E+02	0.2199E-14		
		0.2096E+02	0.1996E-14		
		0.2326E+02	0.1926E-14		
0.6500E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.1836E+03	0.0000E+00
		0.1500E-02	0.2196E-01		
		0.3063E+00	0.1791E-01		
		0.6111E+00	0.1434E-01		
		0.9159E+00	0.1122E-01		
		0.1221E+01	0.8571E-02		
		0.1525E+01	0.6377E-02		
		0.2459E+01	0.2155E-02		
		0.3393E+01	0.5441E-03		
		0.4326E+01	0.1008E-03		
		0.5260E+01	0.1355E-04		
		0.6194E+01	0.1313E-05		
		0.7127E+01	0.9109E-07		
		0.8061E+01	0.4514E-08		
		0.8995E+01	0.1594E-09		
		0.9928E+01	0.4038E-11		
		0.1086E+02	0.8621E-13		
		0.1180E+02	0.2404E-14		
		0.1409E+02	0.1925E-14		
		0.1638E+02	0.1652E-14		
		0.1867E+02	0.1460E-14		
		0.2096E+02	0.1339E-14		
		0.2326E+02	0.1298E-14		
0.6500E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.1836E+03	0.0000E+00
		0.1500E-02	0.2212E-01		
		0.3063E+00	0.1800E-01		
		0.6111E+00	0.1438E-01		
		0.9159E+00	0.1124E-01		
		0.1221E+01	0.8577E-02		
		0.1525E+01	0.6377E-02		
		0.2459E+01	0.2152E-02		
		0.3393E+01	0.5431E-03		
		0.4326E+01	0.1006E-03		
		0.5260E+01	0.1352E-04		
		0.6194E+01	0.1310E-05		
		0.7127E+01	0.9088E-07		
		0.8061E+01	0.4503E-08		
		0.8995E+01	0.1590E-09		
		0.9928E+01	0.4029E-11		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.8588E-13		
		0.1180E+02	0.1710E-14		
		0.1409E+02	0.1246E-14		
		0.1638E+02	0.1047E-14		
		0.1867E+02	0.9313E-15		
		0.2096E+02	0.8633E-15		
		0.2326E+02	0.8416E-15		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.7000E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.1919E+03	0.0000E+00
		0.1500E-02	0.2130E-01		
		0.3063E+00	0.1762E-01		
		0.6111E+00	0.1430E-01		
		0.9159E+00	0.1137E-01		
		0.1221E+01	0.8827E-02		
		0.1525E+01	0.6686E-02		
		0.2459E+01	0.2416E-02		
		0.3393E+01	0.6662E-03		
		0.4326E+01	0.1379E-03		
		0.5260E+01	0.2121E-04		
		0.6194E+01	0.2407E-05		
		0.7127E+01	0.2007E-06		
		0.8061E+01	0.1224E-07		
		0.8995E+01	0.5453E-09		
		0.9928E+01	0.1775E-10		
		0.1086E+02	0.4430E-12		
		0.1180E+02	0.1088E-13		
		0.1409E+02	0.9250E-14		
		0.1638E+02	0.8217E-14		
		0.1867E+02	0.7273E-14		
		0.2096E+02	0.6578E-14		
		0.2326E+02	0.6332E-14		
0.7000E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.1919E+03	0.0000E+00
		0.1500E-02	0.2190E-01		
		0.3063E+00	0.1802E-01		
		0.6111E+00	0.1457E-01		
		0.9159E+00	0.1154E-01		
		0.1221E+01	0.8943E-02		
		0.1525E+01	0.6762E-02		
		0.2459E+01	0.2435E-02		
		0.3393E+01	0.6702E-03		
		0.4326E+01	0.1386E-03		
		0.5260E+01	0.2130E-04		
		0.6194E+01	0.2417E-05		
		0.7127E+01	0.2014E-06		
		0.8061E+01	0.1229E-07		

		0.8995E+01	0.5473E-09		
		0.9928E+01	0.1782E-10		
		0.1086E+02	0.4437E-12		
		0.1180E+02	0.8004E-14		
		0.1409E+02	0.6382E-14		
		0.1638E+02	0.5631E-14		
		0.1867E+02	0.5073E-14		
		0.2096E+02	0.4688E-14		
		0.2326E+02	0.4555E-14		
0.7000E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.1919E+03	0.0000E+00
		0.1500E-02	0.2205E-01		
		0.3063E+00	0.1811E-01		
		0.6111E+00	0.1463E-01		
		0.9159E+00	0.1158E-01		
		0.1221E+01	0.8961E-02		
		0.1525E+01	0.6772E-02		
		0.2459E+01	0.2436E-02		
		0.3393E+01	0.6703E-03		
		0.4326E+01	0.1386E-03		
		0.5260E+01	0.2130E-04		
		0.6194E+01	0.2416E-05		
		0.7127E+01	0.2014E-06		
		0.8061E+01	0.1228E-07		
		0.8995E+01	0.5471E-09		
		0.9928E+01	0.1781E-10		
		0.1086E+02	0.4430E-12		
		0.1180E+02	0.6124E-14		
		0.1409E+02	0.4484E-14		
		0.1638E+02	0.3859E-14		
		0.1867E+02	0.3486E-14		
		0.2096E+02	0.3256E-14		
		0.2326E+02	0.3181E-14		
0.7000E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.1919E+03	0.0000E+00
		0.1500E-02	0.2221E-01		
		0.3063E+00	0.1820E-01		
		0.6111E+00	0.1467E-01		
		0.9159E+00	0.1159E-01		
		0.1221E+01	0.8966E-02		
		0.1525E+01	0.6771E-02		
		0.2459E+01	0.2433E-02		
		0.3393E+01	0.6690E-03		
		0.4326E+01	0.1383E-03		
		0.5260E+01	0.2125E-04		
		0.6194E+01	0.2411E-05		
		0.7127E+01	0.2009E-06		
		0.8061E+01	0.1226E-07		
		0.8995E+01	0.5459E-09		
		0.9928E+01	0.1777E-10		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.4417E-12		
		0.1180E+02	0.4625E-14		
		0.1409E+02	0.3017E-14		
		0.1638E+02	0.2539E-14		
		0.1867E+02	0.2312E-14		
		0.2096E+02	0.2185E-14		
		0.2326E+02	0.2145E-14		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.7500E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.2000E+03	0.0000E+00
		0.1500E-02	0.2138E-01		
		0.3063E+00	0.1780E-01		
		0.6111E+00	0.1457E-01		
		0.9159E+00	0.1169E-01		
		0.1221E+01	0.9185E-02		
		0.1525E+01	0.7054E-02		
		0.2459E+01	0.2693E-02		
		0.3393E+01	0.8000E-03		
		0.4326E+01	0.1821E-03		
		0.5260E+01	0.3147E-04		
		0.6194E+01	0.4098E-05		
		0.7127E+01	0.4004E-06		
		0.8061E+01	0.2925E-07		
		0.8995E+01	0.1594E-08		
		0.9928E+01	0.6476E-10		
		0.1086E+02	0.1989E-11		
		0.1180E+02	0.2655E-13		
		0.1409E+02	0.1917E-13		
		0.1638E+02	0.1646E-13		
		0.1867E+02	0.1465E-13		
		0.2096E+02	0.1342E-13		
		0.2326E+02	0.1300E-13		
0.7500E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.2000E+03	0.0000E+00
		0.1500E-02	0.2198E-01		
		0.3063E+00	0.1820E-01		
		0.6111E+00	0.1483E-01		
		0.9159E+00	0.1187E-01		
		0.1221E+01	0.9302E-02		
		0.1525E+01	0.7130E-02		
		0.2459E+01	0.2712E-02		
		0.3393E+01	0.8044E-03		
		0.4326E+01	0.1830E-03		
		0.5260E+01	0.3159E-04		
		0.6194E+01	0.4113E-05		
		0.7127E+01	0.4017E-06		
		0.8061E+01	0.2935E-07		

		0.8995E+01	0.1599E-08		
		0.9928E+01	0.6496E-10		
		0.1086E+02	0.1993E-11		
		0.1180E+02	0.2131E-13		
		0.1409E+02	0.1394E-13		
		0.1638E+02	0.1170E-13		
		0.1867E+02	0.1056E-13		
		0.2096E+02	0.9860E-14		
		0.2326E+02	0.9628E-14		
0.7500E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.2000E+03	0.0000E+00
		0.1500E-02	0.2213E-01		
		0.3063E+00	0.1829E-01		
		0.6111E+00	0.1489E-01		
		0.9159E+00	0.1190E-01		
		0.1221E+01	0.9320E-02		
		0.1525E+01	0.7140E-02		
		0.2459E+01	0.2714E-02		
		0.3393E+01	0.8044E-03		
		0.4326E+01	0.1829E-03		
		0.5260E+01	0.3158E-04		
		0.6194E+01	0.4111E-05		
		0.7127E+01	0.4016E-06		
		0.8061E+01	0.2934E-07		
		0.8995E+01	0.1599E-08		
		0.9928E+01	0.6493E-10		
		0.1086E+02	0.1991E-11		
		0.1180E+02	0.1774E-13		
		0.1409E+02	0.1033E-13		
		0.1638E+02	0.8315E-14		
		0.1867E+02	0.7497E-14		
		0.2096E+02	0.7070E-14		
		0.2326E+02	0.6938E-14		
0.7500E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.2000E+03	0.0000E+00
		0.1500E-02	0.2229E-01		
		0.3063E+00	0.1838E-01		
		0.6111E+00	0.1493E-01		
		0.9159E+00	0.1192E-01		
		0.1221E+01	0.9324E-02		
		0.1525E+01	0.7138E-02		
		0.2459E+01	0.2710E-02		
		0.3393E+01	0.8029E-03		
		0.4326E+01	0.1825E-03		
		0.5260E+01	0.3151E-04		
		0.6194E+01	0.4102E-05		
		0.7127E+01	0.4007E-06		
		0.8061E+01	0.2927E-07		
		0.8995E+01	0.1595E-08		
		0.9928E+01	0.6478E-10		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.1986E-11		
		0.1180E+02	0.1464E-13		
		0.1409E+02	0.7359E-14		
		0.1638E+02	0.5685E-14		
		0.1867E+02	0.5153E-14		
		0.2096E+02	0.4913E-14		
		0.2326E+02	0.4844E-14		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.8000E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.2078E+03	0.0000E+00
		0.1500E-02	0.2145E-01		
		0.3063E+00	0.1796E-01		
		0.6111E+00	0.1480E-01		
		0.9159E+00	0.1199E-01		
		0.1221E+01	0.9516E-02		
		0.1525E+01	0.7397E-02		
		0.2459E+01	0.2964E-02		
		0.3393E+01	0.9403E-03		
		0.4326E+01	0.2328E-03		
		0.5260E+01	0.4453E-04		
		0.6194E+01	0.6541E-05		
		0.7127E+01	0.7345E-06		
		0.8061E+01	0.6284E-07		
		0.8995E+01	0.4087E-08		
		0.9928E+01	0.2017E-09		
		0.1086E+02	0.7588E-11		
		0.1180E+02	0.7333E-13		
		0.1409E+02	0.4068E-13		
		0.1638E+02	0.3142E-13		
		0.1867E+02	0.2740E-13		
		0.2096E+02	0.2518E-13		
		0.2326E+02	0.2446E-13		
0.8000E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.2078E+03	0.0000E+00
		0.1500E-02	0.2205E-01		
		0.3063E+00	0.1836E-01		
		0.6111E+00	0.1507E-01		
		0.9159E+00	0.1216E-01		
		0.1221E+01	0.9634E-02		
		0.1525E+01	0.7475E-02		
		0.2459E+01	0.2984E-02		
		0.3393E+01	0.9450E-03		
		0.4326E+01	0.2337E-03		
		0.5260E+01	0.4468E-04		
		0.6194E+01	0.6561E-05		
		0.7127E+01	0.7366E-06		
		0.8061E+01	0.6302E-07		

		0.8995E+01	0.4098E-08		
		0.9928E+01	0.2022E-09		
		0.1086E+02	0.7604E-11		
		0.1180E+02	0.6444E-13		
		0.1409E+02	0.3178E-13		
		0.1638E+02	0.2328E-13		
		0.1867E+02	0.2034E-13		
		0.2096E+02	0.1899E-13		
		0.2326E+02	0.1859E-13		
0.8000E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.2078E+03	0.0000E+00
		0.1500E-02	0.2220E-01		
		0.3063E+00	0.1845E-01		
		0.6111E+00	0.1513E-01		
		0.9159E+00	0.1220E-01		
		0.1221E+01	0.9652E-02		
		0.1525E+01	0.7485E-02		
		0.2459E+01	0.2985E-02		
		0.3393E+01	0.9450E-03		
		0.4326E+01	0.2336E-03		
		0.5260E+01	0.4467E-04		
		0.6194E+01	0.6559E-05		
		0.7127E+01	0.7363E-06		
		0.8061E+01	0.6299E-07		
		0.8995E+01	0.4096E-08		
		0.9928E+01	0.2022E-09		
		0.1086E+02	0.7599E-11		
		0.1180E+02	0.5814E-13		
		0.1409E+02	0.2544E-13		
		0.1638E+02	0.1732E-13		
		0.1867E+02	0.1492E-13		
		0.2096E+02	0.1402E-13		
		0.2326E+02	0.1377E-13		
0.8000E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.2078E+03	0.0000E+00
		0.1500E-02	0.2236E-01		
		0.3063E+00	0.1854E-01		
		0.6111E+00	0.1517E-01		
		0.9159E+00	0.1221E-01		
		0.1221E+01	0.9655E-02		
		0.1525E+01	0.7482E-02		
		0.2459E+01	0.2980E-02		
		0.3393E+01	0.9431E-03		
		0.4326E+01	0.2331E-03		
		0.5260E+01	0.4457E-04		
		0.6194E+01	0.6544E-05		
		0.7127E+01	0.7347E-06		
		0.8061E+01	0.6285E-07		
		0.8995E+01	0.4087E-08		
		0.9928E+01	0.2017E-09		

		0.1086E+02	0.7581E-11		
		0.1180E+02	0.5151E-13		
		0.1409E+02	0.1936E-13		
		0.1638E+02	0.1231E-13		
		0.1867E+02	0.1059E-13		
		0.2096E+02	0.1005E-13		
		0.2326E+02	0.9915E-14		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.8500E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.2154E+03	0.0000E+00
		0.1500E-02	0.2152E-01		
		0.3063E+00	0.1811E-01		
		0.6111E+00	0.1502E-01		
		0.9159E+00	0.1226E-01		
		0.1221E+01	0.9824E-02		
		0.1525E+01	0.7720E-02		
		0.2459E+01	0.3229E-02		
		0.3393E+01	0.1086E-02		
		0.4326E+01	0.2894E-03		
		0.5260E+01	0.6059E-04		
		0.6194E+01	0.9900E-05		
		0.7127E+01	0.1257E-05		
		0.8061E+01	0.1236E-06		
		0.8995E+01	0.9399E-08		
		0.9928E+01	0.5513E-09		
		0.1086E+02	0.2495E-10		
		0.1180E+02	0.2215E-12		
		0.1409E+02	0.9478E-13		
		0.1638E+02	0.6050E-13		
		0.1867E+02	0.4915E-13		
		0.2096E+02	0.4440E-13		
		0.2326E+02	0.4303E-13		
0.8500E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.2154E+03	0.0000E+00
		0.1500E-02	0.2212E-01		
		0.3063E+00	0.1851E-01		
		0.6111E+00	0.1529E-01		
		0.9159E+00	0.1244E-01		
		0.1221E+01	0.9943E-02		
		0.1525E+01	0.7798E-02		
		0.2459E+01	0.3249E-02		
		0.3393E+01	0.1091E-02		
		0.4326E+01	0.2905E-03		
		0.5260E+01	0.6077E-04		
		0.6194E+01	0.9927E-05		
		0.7127E+01	0.1260E-05		
		0.8061E+01	0.1239E-06		

		0.8995E+01	0.9420E-08		
		0.9928E+01	0.5525E-09		
		0.1086E+02	0.2500E-10		
		0.1180E+02	0.2068E-12		
		0.1409E+02	0.7995E-13		
		0.1638E+02	0.4694E-13		
		0.1867E+02	0.3746E-13		
		0.2096E+02	0.3422E-13		
		0.2326E+02	0.3339E-13		
0.8500E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.2154E+03	0.0000E+00
		0.1500E-02	0.2227E-01		
		0.3063E+00	0.1860E-01		
		0.6111E+00	0.1534E-01		
		0.9159E+00	0.1247E-01		
		0.1221E+01	0.9960E-02		
		0.1525E+01	0.7808E-02		
		0.2459E+01	0.3250E-02		
		0.3393E+01	0.1091E-02		
		0.4326E+01	0.2904E-03		
		0.5260E+01	0.6075E-04		
		0.6194E+01	0.9922E-05		
		0.7127E+01	0.1260E-05		
		0.8061E+01	0.1239E-06		
		0.8995E+01	0.9416E-08		
		0.9928E+01	0.5522E-09		
		0.1086E+02	0.2499E-10		
		0.1180E+02	0.1962E-12		
		0.1409E+02	0.6931E-13		
		0.1638E+02	0.3699E-13		
		0.1867E+02	0.2844E-13		
		0.2096E+02	0.2593E-13		
		0.2326E+02	0.2536E-13		
0.8500E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.2154E+03	0.0000E+00
		0.1500E-02	0.2243E-01		
		0.3063E+00	0.1868E-01		
		0.6111E+00	0.1538E-01		
		0.9159E+00	0.1248E-01		
		0.1221E+01	0.9963E-02		
		0.1525E+01	0.7804E-02		
		0.2459E+01	0.3245E-02		
		0.3393E+01	0.1088E-02		
		0.4326E+01	0.2898E-03		
		0.5260E+01	0.6062E-04		
		0.6194E+01	0.9901E-05		
		0.7127E+01	0.1257E-05		
		0.8061E+01	0.1236E-06		
		0.8995E+01	0.9395E-08		
		0.9928E+01	0.5510E-09		

0.1086E+02	0.2493E-10
0.1180E+02	0.1801E-12
0.1409E+02	0.5560E-13
0.1638E+02	0.2724E-13
0.1867E+02	0.2074E-13
0.2096E+02	0.1909E-13
0.2326E+02	0.1875E-13

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.9000E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.2229E+03	0.0000E+00
		0.1500E-02	0.2158E-01		
		0.3063E+00	0.1824E-01		
		0.6111E+00	0.1522E-01		
		0.9159E+00	0.1251E-01		
		0.1221E+01	0.1011E-01		
		0.1525E+01	0.8022E-02		
		0.2459E+01	0.3487E-02		
		0.3393E+01	0.1235E-02		
		0.4326E+01	0.3517E-03		
		0.5260E+01	0.7978E-04		
		0.6194E+01	0.1433E-04		
		0.7127E+01	0.2030E-05		
		0.8061E+01	0.2261E-06		
		0.8995E+01	0.1974E-07		
		0.9928E+01	0.1350E-08		
		0.1086E+02	0.7219E-10		
		0.1180E+02	0.6735E-12		
		0.1409E+02	0.2455E-12		
		0.1638E+02	0.1256E-12		
		0.1867E+02	0.8877E-13		
		0.2096E+02	0.7582E-13		
		0.2326E+02	0.7249E-13		
0.9000E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.2229E+03	0.0000E+00
		0.1500E-02	0.2218E-01		
		0.3063E+00	0.1865E-01		
		0.6111E+00	0.1549E-01		
		0.9159E+00	0.1269E-01		
		0.1221E+01	0.1023E-01		
		0.1525E+01	0.8101E-02		
		0.2459E+01	0.3508E-02		
		0.3393E+01	0.1240E-02		
		0.4326E+01	0.3529E-03		
		0.5260E+01	0.8000E-04		
		0.6194E+01	0.1437E-04		
		0.7127E+01	0.2035E-05		
		0.8061E+01	0.2265E-06		

		0.8995E+01	0.1978E-07		
		0.9928E+01	0.1353E-08		
		0.1086E+02	0.7231E-10		
		0.1180E+02	0.6472E-12		
		0.1409E+02	0.2187E-12		
		0.1638E+02	0.1015E-12		
		0.1867E+02	0.6879E-13		
		0.2096E+02	0.5912E-13		
		0.2326E+02	0.5695E-13		
0.9000E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.2229E+03	0.0000E+00
		0.1500E-02	0.2233E-01		
		0.3063E+00	0.1874E-01		
		0.6111E+00	0.1554E-01		
		0.9159E+00	0.1272E-01		
		0.1221E+01	0.1025E-01		
		0.1525E+01	0.8111E-02		
		0.2459E+01	0.3509E-02		
		0.3393E+01	0.1240E-02		
		0.4326E+01	0.3527E-03		
		0.5260E+01	0.7997E-04		
		0.6194E+01	0.1436E-04		
		0.7127E+01	0.2034E-05		
		0.8061E+01	0.2264E-06		
		0.8995E+01	0.1977E-07		
		0.9928E+01	0.1352E-08		
		0.1086E+02	0.7227E-10		
		0.1180E+02	0.6290E-12		
		0.1409E+02	0.2006E-12		
		0.1638E+02	0.8499E-13		
		0.1867E+02	0.5417E-13		
		0.2096E+02	0.4588E-13		
		0.2326E+02	0.4419E-13		
0.9000E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.2229E+03	0.0000E+00
		0.1500E-02	0.2249E-01		
		0.3063E+00	0.1882E-01		
		0.6111E+00	0.1558E-01		
		0.9159E+00	0.1274E-01		
		0.1221E+01	0.1025E-01		
		0.1525E+01	0.8107E-02		
		0.2459E+01	0.3503E-02		
		0.3393E+01	0.1238E-02		
		0.4326E+01	0.3520E-03		
		0.5260E+01	0.7979E-04		
		0.6194E+01	0.1433E-04		
		0.7127E+01	0.2029E-05		
		0.8061E+01	0.2259E-06		
		0.8995E+01	0.1973E-07		
		0.9928E+01	0.1349E-08		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.7211E-10		
		0.1180E+02	0.5849E-12		
		0.1409E+02	0.1654E-12		
		0.1638E+02	0.6409E-13		
		0.1867E+02	0.4025E-13		
		0.2096E+02	0.3448E-13		
		0.2326E+02	0.3339E-13		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.9500E+02	0.3744E+03	0.0000E+00	0.2428E-01	0.2301E+03	0.0000E+00
		0.1500E-02	0.2163E-01		
		0.3063E+00	0.1837E-01		
		0.6111E+00	0.1541E-01		
		0.9159E+00	0.1274E-01		
		0.1221E+01	0.1038E-01		
		0.1525E+01	0.8308E-02		
		0.2459E+01	0.3738E-02		
		0.3393E+01	0.1388E-02		
		0.4326E+01	0.4192E-03		
		0.5260E+01	0.1022E-03		
		0.6194E+01	0.1998E-04		
		0.7127E+01	0.3122E-05		
		0.8061E+01	0.3885E-06		
		0.8995E+01	0.3842E-07		
		0.9928E+01	0.3015E-08		
		0.1086E+02	0.1872E-09		
		0.1180E+02	0.1947E-11		
		0.1409E+02	0.6711E-12		
		0.1638E+02	0.2920E-12		
		0.1867E+02	0.1722E-12		
		0.2096E+02	0.1315E-12		
		0.2326E+02	0.1215E-12		
0.9500E+02	0.3845E+03	0.0000E+00	0.2507E-01	0.2301E+03	0.0000E+00
		0.1500E-02	0.2224E-01		
		0.3063E+00	0.1877E-01		
		0.6111E+00	0.1568E-01		
		0.9159E+00	0.1292E-01		
		0.1221E+01	0.1050E-01		
		0.1525E+01	0.8387E-02		
		0.2459E+01	0.3760E-02		
		0.3393E+01	0.1393E-02		
		0.4326E+01	0.4204E-03		
		0.5260E+01	0.1024E-03		
		0.6194E+01	0.2003E-04		
		0.7127E+01	0.3128E-05		
		0.8061E+01	0.3892E-06		

		0.8995E+01	0.3849E-07		
		0.9928E+01	0.3019E-08		
		0.1086E+02	0.1875E-09		
		0.1180E+02	0.1888E-11		
		0.1409E+02	0.6107E-12		
		0.1638E+02	0.2398E-12		
		0.1867E+02	0.1327E-12		
		0.2096E+02	0.1016E-12		
		0.2326E+02	0.9483E-13		
0.9500E+02	0.3947E+03	0.0000E+00	0.2528E-01	0.2301E+03	0.0000E+00
		0.1500E-02	0.2238E-01		
		0.3063E+00	0.1886E-01		
		0.6111E+00	0.1573E-01		
		0.9159E+00	0.1296E-01		
		0.1221E+01	0.1051E-01		
		0.1525E+01	0.8396E-02		
		0.2459E+01	0.3760E-02		
		0.3393E+01	0.1393E-02		
		0.4326E+01	0.4203E-03		
		0.5260E+01	0.1024E-03		
		0.6194E+01	0.2002E-04		
		0.7127E+01	0.3126E-05		
		0.8061E+01	0.3890E-06		
		0.8995E+01	0.3847E-07		
		0.9928E+01	0.3018E-08		
		0.1086E+02	0.1874E-09		
		0.1180E+02	0.1853E-11		
		0.1409E+02	0.5768E-12		
		0.1638E+02	0.2103E-12		
		0.1867E+02	0.1080E-12		
		0.2096E+02	0.8026E-13		
		0.2326E+02	0.7465E-13		
0.9500E+02	0.4049E+03	0.0000E+00	0.2551E-01	0.2301E+03	0.0000E+00
		0.1500E-02	0.2254E-01		
		0.3063E+00	0.1894E-01		
		0.6111E+00	0.1577E-01		
		0.9159E+00	0.1297E-01		
		0.1221E+01	0.1052E-01		
		0.1525E+01	0.8391E-02		
		0.2459E+01	0.3754E-02		
		0.3393E+01	0.1390E-02		
		0.4326E+01	0.4194E-03		
		0.5260E+01	0.1022E-03		
		0.6194E+01	0.1997E-04		
		0.7127E+01	0.3120E-05		
		0.8061E+01	0.3882E-06		
		0.8995E+01	0.3839E-07		
		0.9928E+01	0.3012E-08		

		0.1086E+02	0.1870E-09		
		0.1180E+02	0.1726E-11		
		0.1409E+02	0.4790E-12		
		0.1638E+02	0.1598E-12		
		0.1867E+02	0.8064E-13		
		0.2096E+02	0.6097E-13		
		0.2326E+02	0.5722E-13		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.1000E+03	0.3744E+03	0.0000E+00	0.2428E-01	0.2372E+03	0.0000E+00
		0.1500E-02	0.2168E-01		
		0.3063E+00	0.1848E-01		
		0.6111E+00	0.1558E-01		
		0.9159E+00	0.1296E-01		
		0.1221E+01	0.1063E-01		
		0.1525E+01	0.8577E-02		
		0.2459E+01	0.3982E-02		
		0.3393E+01	0.1542E-02		
		0.4326E+01	0.4914E-03		
		0.5260E+01	0.1278E-03		
		0.6194E+01	0.2699E-04		
		0.7127E+01	0.4605E-05		
		0.8061E+01	0.6335E-06		
		0.8995E+01	0.7007E-07		
		0.9928E+01	0.6222E-08		
		0.1086E+02	0.4422E-09		
		0.1180E+02	0.5233E-11		
		0.1409E+02	0.1823E-11		
		0.1638E+02	0.7406E-12		
		0.1867E+02	0.3764E-12		
		0.2096E+02	0.2475E-12		
		0.2326E+02	0.2151E-12		
0.1000E+03	0.3845E+03	0.0000E+00	0.2507E-01	0.2372E+03	0.0000E+00
		0.1500E-02	0.2229E-01		
		0.3063E+00	0.1889E-01		
		0.6111E+00	0.1585E-01		
		0.9159E+00	0.1314E-01		
		0.1221E+01	0.1075E-01		
		0.1525E+01	0.8656E-02		
		0.2459E+01	0.4004E-02		
		0.3393E+01	0.1548E-02		
		0.4326E+01	0.4927E-03		
		0.5260E+01	0.1281E-03		
		0.6194E+01	0.2704E-04		
		0.7127E+01	0.4613E-05		
		0.8061E+01	0.6344E-06		

		0.8995E+01	0.7016E-07		
		0.9928E+01	0.6230E-08		
		0.1086E+02	0.4428E-09		
		0.1180E+02	0.5067E-11		
		0.1409E+02	0.1653E-11		
		0.1638E+02	0.6003E-12		
		0.1867E+02	0.2790E-12		
		0.2096E+02	0.1823E-12		
		0.2326E+02	0.1609E-12		
0.1000E+03	0.3947E+03	0.0000E+00	0.2528E-01	0.2372E+03	0.0000E+00
		0.1500E-02	0.2243E-01		
		0.3063E+00	0.1897E-01		
		0.6111E+00	0.1590E-01		
		0.9159E+00	0.1317E-01		
		0.1221E+01	0.1077E-01		
		0.1525E+01	0.8665E-02		
		0.2459E+01	0.4004E-02		
		0.3393E+01	0.1547E-02		
		0.4326E+01	0.4925E-03		
		0.5260E+01	0.1280E-03		
		0.6194E+01	0.2702E-04		
		0.7127E+01	0.4611E-05		
		0.8061E+01	0.6341E-06		
		0.8995E+01	0.7013E-07		
		0.9928E+01	0.6227E-08		
		0.1086E+02	0.4425E-09		
		0.1180E+02	0.4989E-11		
		0.1409E+02	0.1577E-11		
		0.1638E+02	0.5378E-12		
		0.1867E+02	0.2314E-12		
		0.2096E+02	0.1446E-12		
		0.2326E+02	0.1266E-12		
0.1000E+03	0.4049E+03	0.0000E+00	0.2551E-01	0.2372E+03	0.0000E+00
		0.1500E-02	0.2259E-01		
		0.3063E+00	0.1906E-01		
		0.6111E+00	0.1594E-01		
		0.9159E+00	0.1319E-01		
		0.1221E+01	0.1077E-01		
		0.1525E+01	0.8660E-02		
		0.2459E+01	0.3998E-02		
		0.3393E+01	0.1544E-02		
		0.4326E+01	0.4915E-03		
		0.5260E+01	0.1278E-03		
		0.6194E+01	0.2697E-04		
		0.7127E+01	0.4602E-05		
		0.8061E+01	0.6328E-06		
		0.8995E+01	0.6999E-07		
		0.9928E+01	0.6215E-08		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.4417E-09		
		0.1180E+02	0.4633E-11		
		0.1409E+02	0.1306E-11		
		0.1638E+02	0.4066E-12		
		0.1867E+02	0.1708E-12		
		0.2096E+02	0.1093E-12		
		0.2326E+02	0.9707E-13		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.1050E+03	0.3744E+03	0.0000E+00	0.2428E-01	0.2441E+03	0.0000E+00
		0.1500E-02	0.2173E-01		
		0.3063E+00	0.1859E-01		
		0.6111E+00	0.1574E-01		
		0.9159E+00	0.1317E-01		
		0.1221E+01	0.1086E-01		
		0.1525E+01	0.8831E-02		
		0.2459E+01	0.4219E-02		
		0.3393E+01	0.1698E-02		
		0.4326E+01	0.5679E-03		
		0.5260E+01	0.1567E-03		
		0.6194E+01	0.3546E-04		
		0.7127E+01	0.6554E-05		
		0.8061E+01	0.9870E-06		
		0.8995E+01	0.1208E-06		
		0.9928E+01	0.1200E-07		
		0.1086E+02	0.9639E-09		
		0.1180E+02	0.1305E-10		
		0.1409E+02	0.4748E-11		
		0.1638E+02	0.1933E-11		
		0.1867E+02	0.9137E-12		
		0.2096E+02	0.5294E-12		
		0.2326E+02	0.4288E-12		
0.1050E+03	0.3845E+03	0.0000E+00	0.2507E-01	0.2441E+03	0.0000E+00
		0.1500E-02	0.2233E-01		
		0.3063E+00	0.1899E-01		
		0.6111E+00	0.1601E-01		
		0.9159E+00	0.1335E-01		
		0.1221E+01	0.1098E-01		
		0.1525E+01	0.8911E-02		
		0.2459E+01	0.4241E-02		
		0.3393E+01	0.1703E-02		
		0.4326E+01	0.5693E-03		
		0.5260E+01	0.1570E-03		
		0.6194E+01	0.3551E-04		
		0.7127E+01	0.6564E-05		
		0.8061E+01	0.9883E-06		

		0.8995E+01	0.1210E-06		
		0.9928E+01	0.1201E-07		
		0.1086E+02	0.9648E-09		
		0.1180E+02	0.1254E-10		
		0.1409E+02	0.4230E-11		
		0.1638E+02	0.1516E-11		
		0.1867E+02	0.6372E-12		
		0.2096E+02	0.3579E-12		
		0.2326E+02	0.2936E-12		
0.1050E+03	0.3947E+03	0.0000E+00	0.2528E-01	0.2441E+03	0.0000E+00
		0.1500E-02	0.2248E-01		
		0.3063E+00	0.1908E-01		
		0.6111E+00	0.1606E-01		
		0.9159E+00	0.1338E-01		
		0.1221E+01	0.1100E-01		
		0.1525E+01	0.8920E-02		
		0.2459E+01	0.4242E-02		
		0.3393E+01	0.1703E-02		
		0.4326E+01	0.5691E-03		
		0.5260E+01	0.1569E-03		
		0.6194E+01	0.3549E-04		
		0.7127E+01	0.6560E-05		
		0.8061E+01	0.9878E-06		
		0.8995E+01	0.1209E-06		
		0.9928E+01	0.1201E-07		
		0.1086E+02	0.9643E-09		
		0.1180E+02	0.1233E-10		
		0.1409E+02	0.4030E-11		
		0.1638E+02	0.1358E-11		
		0.1867E+02	0.5261E-12		
		0.2096E+02	0.2785E-12		
		0.2326E+02	0.2250E-12		
0.1050E+03	0.4049E+03	0.0000E+00	0.2551E-01	0.2441E+03	0.0000E+00
		0.1500E-02	0.2264E-01		
		0.3063E+00	0.1916E-01		
		0.6111E+00	0.1610E-01		
		0.9159E+00	0.1339E-01		
		0.1221E+01	0.1100E-01		
		0.1525E+01	0.8914E-02		
		0.2459E+01	0.4235E-02		
		0.3393E+01	0.1700E-02		
		0.4326E+01	0.5680E-03		
		0.5260E+01	0.1566E-03		
		0.6194E+01	0.3543E-04		
		0.7127E+01	0.6548E-05		
		0.8061E+01	0.9860E-06		
		0.8995E+01	0.1207E-06		
		0.9928E+01	0.1199E-07		

		0.1086E+02	0.9626E-09		
		0.1180E+02	0.1139E-10		
		0.1409E+02	0.3310E-11		
		0.1638E+02	0.1015E-11		
		0.1867E+02	0.3797E-12		
		0.2096E+02	0.2049E-12		
		0.2326E+02	0.1688E-12		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.1100E+03	0.3744E+03	0.0000E+00	0.2428E-01	0.2509E+03	0.0000E+00
		0.1500E-02	0.2178E-01		
		0.3063E+00	0.1869E-01		
		0.6111E+00	0.1589E-01		
		0.9159E+00	0.1336E-01		
		0.1221E+01	0.1109E-01		
		0.1525E+01	0.9072E-02		
		0.2459E+01	0.4449E-02		
		0.3393E+01	0.1854E-02		
		0.4326E+01	0.6483E-03		
		0.5260E+01	0.1887E-03		
		0.6194E+01	0.4549E-04		
		0.7127E+01	0.9043E-05		
		0.8061E+01	0.1479E-05		
		0.8995E+01	0.1985E-06		
		0.9928E+01	0.2184E-07		
		0.1086E+02	0.1960E-08		
		0.1180E+02	0.3032E-10		
		0.1409E+02	0.1170E-10		
		0.1638E+02	0.4959E-11		
		0.1867E+02	0.2326E-11		
		0.2096E+02	0.1265E-11		
		0.2326E+02	0.9756E-12		
0.1100E+03	0.3845E+03	0.0000E+00	0.2507E-01	0.2509E+03	0.0000E+00
		0.1500E-02	0.2238E-01		
		0.3063E+00	0.1909E-01		
		0.6111E+00	0.1616E-01		
		0.9159E+00	0.1354E-01		
		0.1221E+01	0.1121E-01		
		0.1525E+01	0.9152E-02		
		0.2459E+01	0.4471E-02		
		0.3393E+01	0.1860E-02		
		0.4326E+01	0.6498E-03		
		0.5260E+01	0.1890E-03		
		0.6194E+01	0.4555E-04		
		0.7127E+01	0.9054E-05		
		0.8061E+01	0.1480E-05		

		0.8995E+01	0.1987E-06		
		0.9928E+01	0.2186E-07		
		0.1086E+02	0.1961E-08		
		0.1180E+02	0.2880E-10		
		0.1409E+02	0.1015E-10		
		0.1638E+02	0.3727E-11		
		0.1867E+02	0.1521E-11		
		0.2096E+02	0.7775E-12		
		0.2326E+02	0.5990E-12		
0.1100E+03	0.3947E+03	0.0000E+00	0.2528E-01	0.2509E+03	0.0000E+00
		0.1500E-02	0.2253E-01		
		0.3063E+00	0.1918E-01		
		0.6111E+00	0.1621E-01		
		0.9159E+00	0.1357E-01		
		0.1221E+01	0.1122E-01		
		0.1525E+01	0.9161E-02		
		0.2459E+01	0.4472E-02		
		0.3393E+01	0.1859E-02		
		0.4326E+01	0.6495E-03		
		0.5260E+01	0.1890E-03		
		0.6194E+01	0.4553E-04		
		0.7127E+01	0.9050E-05		
		0.8061E+01	0.1480E-05		
		0.8995E+01	0.1986E-06		
		0.9928E+01	0.2185E-07		
		0.1086E+02	0.1960E-08		
		0.1180E+02	0.2823E-10		
		0.1409E+02	0.9599E-11		
		0.1638E+02	0.3294E-11		
		0.1867E+02	0.1226E-11		
		0.2096E+02	0.5790E-12		
		0.2326E+02	0.4337E-12		
0.1100E+03	0.4049E+03	0.0000E+00	0.2551E-01	0.2509E+03	0.0000E+00
		0.1500E-02	0.2268E-01		
		0.3063E+00	0.1926E-01		
		0.6111E+00	0.1625E-01		
		0.9159E+00	0.1358E-01		
		0.1221E+01	0.1122E-01		
		0.1525E+01	0.9155E-02		
		0.2459E+01	0.4464E-02		
		0.3393E+01	0.1856E-02		
		0.4326E+01	0.6482E-03		
		0.5260E+01	0.1886E-03		
		0.6194E+01	0.4544E-04		
		0.7127E+01	0.9034E-05		
		0.8061E+01	0.1477E-05		
		0.8995E+01	0.1983E-06		
		0.9928E+01	0.2181E-07		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.1957E-08		
		0.1180E+02	0.2589E-10		
		0.1409E+02	0.7804E-11		
		0.1638E+02	0.2427E-11		
		0.1867E+02	0.8612E-12		
		0.2096E+02	0.4079E-12		
		0.2326E+02	0.3104E-12		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.1150E+03	0.3744E+03	0.0000E+00	0.2428E-01	0.2575E+03	0.0000E+00
		0.1500E-02	0.2182E-01		
		0.3063E+00	0.1878E-01		
		0.6111E+00	0.1603E-01		
		0.9159E+00	0.1354E-01		
		0.1221E+01	0.1130E-01		
		0.1525E+01	0.9301E-02		
		0.2459E+01	0.4672E-02		
		0.3393E+01	0.2011E-02		
		0.4326E+01	0.7321E-03		
		0.5260E+01	0.2238E-03		
		0.6194E+01	0.5715E-04		
		0.7127E+01	0.1214E-04		
		0.8061E+01	0.2142E-05		
		0.8995E+01	0.3127E-06		
		0.9928E+01	0.3776E-07		
		0.1086E+02	0.3749E-08		
		0.1180E+02	0.6613E-10		
		0.1409E+02	0.2720E-10		
		0.1638E+02	0.1220E-10		
		0.1867E+02	0.5884E-11		
		0.2096E+02	0.3173E-11		
		0.2326E+02	0.2408E-11		
0.1150E+03	0.3845E+03	0.0000E+00	0.2507E-01	0.2575E+03	0.0000E+00
		0.1500E-02	0.2242E-01		
		0.3063E+00	0.1919E-01		
		0.6111E+00	0.1630E-01		
		0.9159E+00	0.1372E-01		
		0.1221E+01	0.1142E-01		
		0.1525E+01	0.9381E-02		
		0.2459E+01	0.4695E-02		
		0.3393E+01	0.2017E-02		
		0.4326E+01	0.7336E-03		
		0.5260E+01	0.2242E-03		
		0.6194E+01	0.5722E-04		
		0.7127E+01	0.1216E-04		
		0.8061E+01	0.2143E-05		

		0.8995E+01	0.3130E-06		
		0.9928E+01	0.3779E-07		
		0.1086E+02	0.3752E-08		
		0.1180E+02	0.6188E-10		
		0.1409E+02	0.2291E-10		
		0.1638E+02	0.8776E-11		
		0.1867E+02	0.3642E-11		
		0.2096E+02	0.1808E-11		
		0.2326E+02	0.1350E-11		
0.1150E+03	0.3947E+03	0.0000E+00	0.2528E-01	0.2575E+03	0.0000E+00
		0.1500E-02	0.2257E-01		
		0.3063E+00	0.1927E-01		
		0.6111E+00	0.1635E-01		
		0.9159E+00	0.1375E-01		
		0.1221E+01	0.1143E-01		
		0.1525E+01	0.9389E-02		
		0.2459E+01	0.4695E-02		
		0.3393E+01	0.2016E-02		
		0.4326E+01	0.7333E-03		
		0.5260E+01	0.2241E-03		
		0.6194E+01	0.5720E-04		
		0.7127E+01	0.1215E-04		
		0.8061E+01	0.2142E-05		
		0.8995E+01	0.3128E-06		
		0.9928E+01	0.3777E-07		
		0.1086E+02	0.3750E-08		
		0.1180E+02	0.6034E-10		
		0.1409E+02	0.2140E-10		
		0.1638E+02	0.7589E-11		
		0.1867E+02	0.2836E-11		
		0.2096E+02	0.1274E-11		
		0.2326E+02	0.9101E-12		
0.1150E+03	0.4049E+03	0.0000E+00	0.2551E-01	0.2575E+03	0.0000E+00
		0.1500E-02	0.2273E-01		
		0.3063E+00	0.1936E-01		
		0.6111E+00	0.1639E-01		
		0.9159E+00	0.1376E-01		
		0.1221E+01	0.1143E-01		
		0.1525E+01	0.9383E-02		
		0.2459E+01	0.4687E-02		
		0.3393E+01	0.2012E-02		
		0.4326E+01	0.7319E-03		
		0.5260E+01	0.2237E-03		
		0.6194E+01	0.5710E-04		
		0.7127E+01	0.1213E-04		
		0.8061E+01	0.2139E-05		
		0.8995E+01	0.3123E-06		
		0.9928E+01	0.3771E-07		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.3744E-08		
		0.1180E+02	0.5494E-10		
		0.1409E+02	0.1720E-10		
		0.1638E+02	0.5505E-11		
		0.1867E+02	0.1937E-11		
		0.2096E+02	0.8534E-12		
		0.2326E+02	0.6116E-12		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.1200E+03	0.3744E+03	0.0000E+00	0.2428E-01	0.2640E+03	0.0000E+00
		0.1500E-02	0.2186E-01		
		0.3063E+00	0.1887E-01		
		0.6111E+00	0.1616E-01		
		0.9159E+00	0.1371E-01		
		0.1221E+01	0.1149E-01		
		0.1525E+01	0.9518E-02		
		0.2459E+01	0.4889E-02		
		0.3393E+01	0.2167E-02		
		0.4326E+01	0.8190E-03		
		0.5260E+01	0.2619E-03		
		0.6194E+01	0.7052E-04		
		0.7127E+01	0.1593E-04		
		0.8061E+01	0.3010E-05		
		0.8995E+01	0.4748E-06		
		0.9928E+01	0.6244E-07		
		0.1086E+02	0.6802E-08		
		0.1180E+02	0.1364E-09		
		0.1409E+02	0.5986E-10		
		0.1638E+02	0.2852E-10		
		0.1867E+02	0.1436E-10		
		0.2096E+02	0.7915E-11		
		0.2326E+02	0.6038E-11		
0.1200E+03	0.3845E+03	0.0000E+00	0.2507E-01	0.2640E+03	0.0000E+00
		0.1500E-02	0.2246E-01		
		0.3063E+00	0.1927E-01		
		0.6111E+00	0.1643E-01		
		0.9159E+00	0.1389E-01		
		0.1221E+01	0.1161E-01		
		0.1525E+01	0.9598E-02		
		0.2459E+01	0.4911E-02		
		0.3393E+01	0.2173E-02		
		0.4326E+01	0.8205E-03		
		0.5260E+01	0.2623E-03		
		0.6194E+01	0.7060E-04		
		0.7127E+01	0.1594E-04		
		0.8061E+01	0.3012E-05		

		0.8995E+01	0.4751E-06		
		0.9928E+01	0.6248E-07		
		0.1086E+02	0.6806E-08		
		0.1180E+02	0.1254E-09		
		0.1409E+02	0.4882E-10		
		0.1638E+02	0.1969E-10		
		0.1867E+02	0.8513E-11		
		0.2096E+02	0.4294E-11		
		0.2326E+02	0.3200E-11		
0.1200E+03	0.3947E+03	0.0000E+00	0.2528E-01	0.2640E+03	0.0000E+00
		0.1500E-02	0.2261E-01		
		0.3063E+00	0.1936E-01		
		0.6111E+00	0.1648E-01		
		0.9159E+00	0.1392E-01		
		0.1221E+01	0.1163E-01		
		0.1525E+01	0.9607E-02		
		0.2459E+01	0.4911E-02		
		0.3393E+01	0.2172E-02		
		0.4326E+01	0.8201E-03		
		0.5260E+01	0.2621E-03		
		0.6194E+01	0.7056E-04		
		0.7127E+01	0.1593E-04		
		0.8061E+01	0.3011E-05		
		0.8995E+01	0.4749E-06		
		0.9928E+01	0.6245E-07		
		0.1086E+02	0.6802E-08		
		0.1180E+02	0.1214E-09		
		0.1409E+02	0.4491E-10		
		0.1638E+02	0.1658E-10		
		0.1867E+02	0.6378E-11		
		0.2096E+02	0.2864E-11		
		0.2326E+02	0.2019E-11		
0.1200E+03	0.4049E+03	0.0000E+00	0.2551E-01	0.2640E+03	0.0000E+00
		0.1500E-02	0.2276E-01		
		0.3063E+00	0.1944E-01		
		0.6111E+00	0.1652E-01		
		0.9159E+00	0.1393E-01		
		0.1221E+01	0.1163E-01		
		0.1525E+01	0.9600E-02		
		0.2459E+01	0.4904E-02		
		0.3393E+01	0.2168E-02		
		0.4326E+01	0.8187E-03		
		0.5260E+01	0.2617E-03		
		0.6194E+01	0.7045E-04		
		0.7127E+01	0.1591E-04		
		0.8061E+01	0.3006E-05		
		0.8995E+01	0.4742E-06		
		0.9928E+01	0.6236E-07		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.6792E-08		
		0.1180E+02	0.1097E-09		
		0.1409E+02	0.3565E-10		
		0.1638E+02	0.1183E-10		
		0.1867E+02	0.4242E-11		
		0.2096E+02	0.1830E-11		
		0.2326E+02	0.1273E-11		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.1250E+03	0.3744E+03	0.0000E+00	0.2428E-01	0.2704E+03	0.0000E+00
		0.1500E-02	0.2189E-01		
		0.3063E+00	0.1895E-01		
		0.6111E+00	0.1629E-01		
		0.9159E+00	0.1387E-01		
		0.1221E+01	0.1168E-01		
		0.1525E+01	0.9725E-02		
		0.2459E+01	0.5099E-02		
		0.3393E+01	0.2323E-02		
		0.4326E+01	0.9084E-03		
		0.5260E+01	0.3028E-03		
		0.6194E+01	0.8562E-04		
		0.7127E+01	0.2046E-04		
		0.8061E+01	0.4119E-05		
		0.8995E+01	0.6978E-06		
		0.9928E+01	0.9928E-07		
		0.1086E+02	0.1178E-07		
		0.1180E+02	0.2676E-09		
		0.1409E+02	0.1252E-09		
		0.1638E+02	0.6330E-10		
		0.1867E+02	0.3340E-10		
		0.2096E+02	0.1905E-10		
		0.2326E+02	0.1475E-10		
0.1250E+03	0.3845E+03	0.0000E+00	0.2507E-01	0.2704E+03	0.0000E+00
		0.1500E-02	0.2249E-01		
		0.3063E+00	0.1935E-01		
		0.6111E+00	0.1656E-01		
		0.9159E+00	0.1405E-01		
		0.1221E+01	0.1180E-01		
		0.1525E+01	0.9805E-02		
		0.2459E+01	0.5121E-02		
		0.3393E+01	0.2329E-02		
		0.4326E+01	0.9100E-03		
		0.5260E+01	0.3032E-03		
		0.6194E+01	0.8570E-04		
		0.7127E+01	0.2047E-04		
		0.8061E+01	0.4122E-05		

		0.8995E+01	0.6982E-06		
		0.9928E+01	0.9933E-07		
		0.1086E+02	0.1178E-07		
		0.1180E+02	0.2412E-09		
		0.1409E+02	0.9882E-10		
		0.1638E+02	0.4211E-10		
		0.1867E+02	0.1917E-10		
		0.2096E+02	0.1005E-10		
		0.2326E+02	0.7609E-11		
0.1250E+03	0.3947E+03	0.0000E+00	0.2528E-01	0.2704E+03	0.0000E+00
		0.1500E-02	0.2264E-01		
		0.3063E+00	0.1944E-01		
		0.6111E+00	0.1661E-01		
		0.9159E+00	0.1408E-01		
		0.1221E+01	0.1182E-01		
		0.1525E+01	0.9814E-02		
		0.2459E+01	0.5121E-02		
		0.3393E+01	0.2328E-02		
		0.4326E+01	0.9096E-03		
		0.5260E+01	0.3031E-03		
		0.6194E+01	0.8566E-04		
		0.7127E+01	0.2046E-04		
		0.8061E+01	0.4120E-05		
		0.8995E+01	0.6979E-06		
		0.9928E+01	0.9929E-07		
		0.1086E+02	0.1178E-07		
		0.1180E+02	0.2316E-09		
		0.1409E+02	0.8929E-10		
		0.1638E+02	0.3445E-10		
		0.1867E+02	0.1382E-10		
		0.2096E+02	0.6400E-11		
		0.2326E+02	0.4560E-11		
0.1250E+03	0.4049E+03	0.0000E+00	0.2551E-01	0.2704E+03	0.0000E+00
		0.1500E-02	0.2280E-01		
		0.3063E+00	0.1953E-01		
		0.6111E+00	0.1665E-01		
		0.9159E+00	0.1409E-01		
		0.1221E+01	0.1182E-01		
		0.1525E+01	0.9807E-02		
		0.2459E+01	0.5113E-02		
		0.3393E+01	0.2324E-02		
		0.4326E+01	0.9081E-03		
		0.5260E+01	0.3026E-03		
		0.6194E+01	0.8553E-04		
		0.7127E+01	0.2043E-04		
		0.8061E+01	0.4115E-05		
		0.8995E+01	0.6970E-06		
		0.9928E+01	0.9916E-07		

		0.1086E+02	0.1176E-07		
		0.1180E+02	0.2074E-09		
		0.1409E+02	0.6998E-10		
		0.1638E+02	0.2417E-10		
		0.1867E+02	0.8963E-11		
		0.2096E+02	0.3923E-11		
		0.2326E+02	0.2726E-11		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
0.1300E+03	0.3744E+03	0.0000E+00	0.2428E-01	0.2767E+03	0.0000E+00
		0.1500E-02	0.2193E-01		
		0.3063E+00	0.1903E-01		
		0.6111E+00	0.1640E-01		
		0.9159E+00	0.1402E-01		
		0.1221E+01	0.1186E-01		
		0.1525E+01	0.9922E-02		
		0.2459E+01	0.5302E-02		
		0.3393E+01	0.2477E-02		
		0.4326E+01	0.1000E-02		
		0.5260E+01	0.3465E-03		
		0.6194E+01	0.1025E-03		
		0.7127E+01	0.2579E-04		
		0.8061E+01	0.5508E-05		
		0.8995E+01	0.9965E-06		
		0.9928E+01	0.1524E-06		
		0.1086E+02	0.1956E-07		
		0.1180E+02	0.5025E-09		
		0.1409E+02	0.2501E-09		
		0.1638E+02	0.1337E-09		
		0.1867E+02	0.7383E-10		
		0.2096E+02	0.4371E-10		
		0.2326E+02	0.3448E-10		
0.1300E+03	0.3845E+03	0.0000E+00	0.2507E-01	0.2767E+03	0.0000E+00
		0.1500E-02	0.2253E-01		
		0.3063E+00	0.1943E-01		
		0.6111E+00	0.1667E-01		
		0.9159E+00	0.1420E-01		
		0.1221E+01	0.1198E-01		
		0.1525E+01	0.1000E-01		
		0.2459E+01	0.5325E-02		
		0.3393E+01	0.2483E-02		
		0.4326E+01	0.1002E-02		
		0.5260E+01	0.3469E-03		
		0.6194E+01	0.1026E-03		
		0.7127E+01	0.2581E-04		
		0.8061E+01	0.5512E-05		

		0.8995E+01	0.9970E-06		
		0.9928E+01	0.1525E-06		
		0.1086E+02	0.1956E-07		
		0.1180E+02	0.4435E-09		
		0.1409E+02	0.1911E-09		
		0.1638E+02	0.8608E-10		
		0.1867E+02	0.4143E-10		
		0.2096E+02	0.2278E-10		
		0.2326E+02	0.1762E-10		
0.1300E+03	0.3947E+03	0.0000E+00	0.2528E-01	0.2767E+03	0.0000E+00
		0.1500E-02	0.2268E-01		
		0.3063E+00	0.1952E-01		
		0.6111E+00	0.1673E-01		
		0.9159E+00	0.1423E-01		
		0.1221E+01	0.1200E-01		
		0.1525E+01	0.1001E-01		
		0.2459E+01	0.5325E-02		
		0.3393E+01	0.2483E-02		
		0.4326E+01	0.1001E-02		
		0.5260E+01	0.3467E-03		
		0.6194E+01	0.1025E-03		
		0.7127E+01	0.2580E-04		
		0.8061E+01	0.5509E-05		
		0.8995E+01	0.9966E-06		
		0.9928E+01	0.1525E-06		
		0.1086E+02	0.1955E-07		
		0.1180E+02	0.4215E-09		
		0.1409E+02	0.1692E-09		
		0.1638E+02	0.6832E-10		
		0.1867E+02	0.2878E-10		
		0.2096E+02	0.1397E-10		
		0.2326E+02	0.1019E-10		
0.1300E+03	0.4049E+03	0.0000E+00	0.2551E-01	0.2767E+03	0.0000E+00
		0.1500E-02	0.2283E-01		
		0.3063E+00	0.1960E-01		
		0.6111E+00	0.1676E-01		
		0.9159E+00	0.1424E-01		
		0.1221E+01	0.1200E-01		
		0.1525E+01	0.1000E-01		
		0.2459E+01	0.5317E-02		
		0.3393E+01	0.2478E-02		
		0.4326E+01	0.9998E-03		
		0.5260E+01	0.3462E-03		
		0.6194E+01	0.1024E-03		
		0.7127E+01	0.2576E-04		
		0.8061E+01	0.5502E-05		
		0.8995E+01	0.9953E-06		
		0.9928E+01	0.1523E-06		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.1953E-07		
		0.1180E+02	0.3740E-09		
		0.1409E+02	0.1308E-09		
		0.1638E+02	0.4710E-10		
		0.1867E+02	0.1823E-10		
		0.2096E+02	0.8274E-11		
		0.2326E+02	0.5843E-11		
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0.1350E+03	0.3744E+03	0.0000E+00	0.2428E-01	0.2829E+03	0.0000E+00
		0.1500E-02	0.2196E-01		
		0.3063E+00	0.1910E-01		
		0.6111E+00	0.1651E-01		
		0.9159E+00	0.1416E-01		
		0.1221E+01	0.1203E-01		
		0.1525E+01	0.1011E-01		
		0.2459E+01	0.5500E-02		
		0.3393E+01	0.2631E-02		
		0.4326E+01	0.1094E-02		
		0.5260E+01	0.3927E-03		
		0.6194E+01	0.1211E-03		
		0.7127E+01	0.3199E-04		
		0.8061E+01	0.7214E-05		
		0.8995E+01	0.1387E-05		
		0.9928E+01	0.2269E-06		
		0.1086E+02	0.3131E-07		
		0.1180E+02	0.9076E-09		
		0.1409E+02	0.4788E-09		
		0.1638E+02	0.2695E-09		
		0.1867E+02	0.1553E-09		
		0.2096E+02	0.9537E-10		
		0.2326E+02	0.7663E-10		
0.1350E+03	0.3845E+03	0.0000E+00	0.2507E-01	0.2829E+03	0.0000E+00
		0.1500E-02	0.2256E-01		
		0.3063E+00	0.1951E-01		
		0.6111E+00	0.1678E-01		
		0.9159E+00	0.1434E-01		
		0.1221E+01	0.1215E-01		
		0.1525E+01	0.1019E-01		
		0.2459E+01	0.5523E-02		
		0.3393E+01	0.2637E-02		
		0.4326E+01	0.1096E-02		
		0.5260E+01	0.3931E-03		
		0.6194E+01	0.1212E-03		
		0.7127E+01	0.3200E-04		
		0.8061E+01	0.7217E-05		

		0.8995E+01	0.1388E-05		
		0.9928E+01	0.2270E-06		
		0.1086E+02	0.3131E-07		
		0.1180E+02	0.7832E-09		
		0.1409E+02	0.3547E-09		
		0.1638E+02	0.1688E-09		
		0.1867E+02	0.8581E-10		
		0.2096E+02	0.4953E-10		
		0.2326E+02	0.3923E-10		
0.1350E+03	0.3947E+03	0.0000E+00	0.2528E-01	0.2829E+03	0.0000E+00
		0.1500E-02	0.2271E-01		
		0.3063E+00	0.1959E-01		
		0.6111E+00	0.1684E-01		
		0.9159E+00	0.1437E-01		
		0.1221E+01	0.1217E-01		
		0.1525E+01	0.1020E-01		
		0.2459E+01	0.5523E-02		
		0.3393E+01	0.2636E-02		
		0.4326E+01	0.1095E-02		
		0.5260E+01	0.3930E-03		
		0.6194E+01	0.1212E-03		
		0.7127E+01	0.3199E-04		
		0.8061E+01	0.7214E-05		
		0.8995E+01	0.1387E-05		
		0.9928E+01	0.2269E-06		
		0.1086E+02	0.3129E-07		
		0.1180E+02	0.7358E-09		
		0.1409E+02	0.3075E-09		
		0.1638E+02	0.1300E-09		
		0.1867E+02	0.5766E-10		
		0.2096E+02	0.2951E-10		
		0.2326E+02	0.2214E-10		
0.1350E+03	0.4049E+03	0.0000E+00	0.2551E-01	0.2829E+03	0.0000E+00
		0.1500E-02	0.2287E-01		
		0.3063E+00	0.1968E-01		
		0.6111E+00	0.1687E-01		
		0.9159E+00	0.1439E-01		
		0.1221E+01	0.1217E-01		
		0.1525E+01	0.1019E-01		
		0.2459E+01	0.5514E-02		
		0.3393E+01	0.2632E-02		
		0.4326E+01	0.1093E-02		
		0.5260E+01	0.3924E-03		
		0.6194E+01	0.1210E-03		
		0.7127E+01	0.3195E-04		
		0.8061E+01	0.7205E-05		
		0.8995E+01	0.1385E-05		
		0.9928E+01	0.2267E-06		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.3125E-07		
		0.1180E+02	0.6466E-09		
		0.1409E+02	0.2343E-09		
		0.1638E+02	0.8803E-10		
		0.1867E+02	0.3573E-10		
		0.2096E+02	0.1701E-10		
		0.2326E+02	0.1233E-10		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.1400E+03	0.3744E+03	0.0000E+00	0.2428E-01	0.2889E+03	0.0000E+00
		0.1500E-02	0.2199E-01		
		0.3063E+00	0.1917E-01		
		0.6111E+00	0.1662E-01		
		0.9159E+00	0.1430E-01		
		0.1221E+01	0.1219E-01		
		0.1525E+01	0.1029E-01		
		0.2459E+01	0.5692E-02		
		0.3393E+01	0.2783E-02		
		0.4326E+01	0.1190E-02		
		0.5260E+01	0.4414E-03		
		0.6194E+01	0.1415E-03		
		0.7127E+01	0.3909E-04		
		0.8061E+01	0.9273E-05		
		0.8995E+01	0.1887E-05		
		0.9928E+01	0.3286E-06		
		0.1086E+02	0.4848E-07		
		0.1180E+02	0.1583E-08		
		0.1409E+02	0.8822E-09		
		0.1638E+02	0.5205E-09		
		0.1867E+02	0.3118E-09		
		0.2096E+02	0.1982E-09		
		0.2326E+02	0.1620E-09		
0.1400E+03	0.3845E+03	0.0000E+00	0.2507E-01	0.2889E+03	0.0000E+00
		0.1500E-02	0.2259E-01		
		0.3063E+00	0.1957E-01		
		0.6111E+00	0.1689E-01		
		0.9159E+00	0.1448E-01		
		0.1221E+01	0.1231E-01		
		0.1525E+01	0.1037E-01		
		0.2459E+01	0.5714E-02		
		0.3393E+01	0.2789E-02		
		0.4326E+01	0.1191E-02		
		0.5260E+01	0.4418E-03		
		0.6194E+01	0.1416E-03		
		0.7127E+01	0.3911E-04		
		0.8061E+01	0.9277E-05		

		0.8995E+01	0.1887E-05		
		0.9928E+01	0.3287E-06		
		0.1086E+02	0.4848E-07		
		0.1180E+02	0.1335E-08		
		0.1409E+02	0.6348E-09		
		0.1638E+02	0.3186E-09		
		0.1867E+02	0.1707E-09		
		0.2096E+02	0.1032E-09		
		0.2326E+02	0.8358E-10		
0.1400E+03	0.3947E+03	0.0000E+00	0.2528E-01	0.2889E+03	0.0000E+00
		0.1500E-02	0.2274E-01		
		0.3063E+00	0.1966E-01		
		0.6111E+00	0.1694E-01		
		0.9159E+00	0.1451E-01		
		0.1221E+01	0.1233E-01		
		0.1525E+01	0.1038E-01		
		0.2459E+01	0.5714E-02		
		0.3393E+01	0.2788E-02		
		0.4326E+01	0.1191E-02		
		0.5260E+01	0.4416E-03		
		0.6194E+01	0.1416E-03		
		0.7127E+01	0.3909E-04		
		0.8061E+01	0.9273E-05		
		0.8995E+01	0.1887E-05		
		0.9928E+01	0.3286E-06		
		0.1086E+02	0.4845E-07		
		0.1180E+02	0.1238E-08		
		0.1409E+02	0.5380E-09		
		0.1638E+02	0.2381E-09		
		0.1867E+02	0.1114E-09		
		0.2096E+02	0.6021E-10		
		0.2326E+02	0.4648E-10		
0.1400E+03	0.4049E+03	0.0000E+00	0.2551E-01	0.2889E+03	0.0000E+00
		0.1500E-02	0.2290E-01		
		0.3063E+00	0.1975E-01		
		0.6111E+00	0.1698E-01		
		0.9159E+00	0.1452E-01		
		0.1221E+01	0.1233E-01		
		0.1525E+01	0.1037E-01		
		0.2459E+01	0.5705E-02		
		0.3393E+01	0.2784E-02		
		0.4326E+01	0.1189E-02		
		0.5260E+01	0.4410E-03		
		0.6194E+01	0.1414E-03		
		0.7127E+01	0.3904E-04		
		0.8061E+01	0.9263E-05		
		0.8995E+01	0.1884E-05		
		0.9928E+01	0.3282E-06		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.4839E-07		
		0.1180E+02	0.1077E-08		
		0.1409E+02	0.4040E-09		
		0.1638E+02	0.1585E-09		
		0.1867E+02	0.6763E-10		
		0.2096E+02	0.3398E-10		
		0.2326E+02	0.2535E-10		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
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0.1450E+03	0.3744E+03	0.0000E+00	0.2428E-01	0.2949E+03	0.0000E+00
		0.1500E-02	0.2202E-01		
		0.3063E+00	0.1924E-01		
		0.6111E+00	0.1672E-01		
		0.9159E+00	0.1443E-01		
		0.1221E+01	0.1235E-01		
		0.1525E+01	0.1046E-01		
		0.2459E+01	0.5878E-02		
		0.3393E+01	0.2933E-02		
		0.4326E+01	0.1286E-02		
		0.5260E+01	0.4923E-03		
		0.6194E+01	0.1637E-03		
		0.7127E+01	0.4713E-04		
		0.8061E+01	0.1172E-04		
		0.8995E+01	0.2514E-05		
		0.9928E+01	0.4641E-06		
		0.1086E+02	0.7288E-07		
		0.1180E+02	0.2676E-08		
		0.1409E+02	0.1569E-08		
		0.1638E+02	0.9660E-09		
		0.1867E+02	0.5997E-09		
		0.2096E+02	0.3933E-09		
		0.2326E+02	0.3267E-09		
0.1450E+03	0.3845E+03	0.0000E+00	0.2507E-01	0.2949E+03	0.0000E+00
		0.1500E-02	0.2262E-01		
		0.3063E+00	0.1964E-01		
		0.6111E+00	0.1699E-01		
		0.9159E+00	0.1461E-01		
		0.1221E+01	0.1247E-01		
		0.1525E+01	0.1054E-01		
		0.2459E+01	0.5900E-02		
		0.3393E+01	0.2940E-02		
		0.4326E+01	0.1288E-02		
		0.5260E+01	0.4928E-03		
		0.6194E+01	0.1638E-03		
		0.7127E+01	0.4715E-04		
		0.8061E+01	0.1173E-04		

		0.8995E+01	0.2515E-05		
		0.9928E+01	0.4643E-06		
		0.1086E+02	0.7286E-07		
		0.1180E+02	0.2205E-08		
		0.1409E+02	0.1100E-08		
		0.1638E+02	0.5808E-09		
		0.1867E+02	0.3268E-09		
		0.2096E+02	0.2063E-09		
		0.2326E+02	0.1705E-09		
0.1450E+03	0.3947E+03	0.0000E+00	0.2528E-01	0.2949E+03	0.0000E+00
		0.1500E-02	0.2277E-01		
		0.3063E+00	0.1973E-01		
		0.6111E+00	0.1704E-01		
		0.9159E+00	0.1464E-01		
		0.1221E+01	0.1248E-01		
		0.1525E+01	0.1055E-01		
		0.2459E+01	0.5900E-02		
		0.3393E+01	0.2939E-02		
		0.4326E+01	0.1288E-02		
		0.5260E+01	0.4926E-03		
		0.6194E+01	0.1637E-03		
		0.7127E+01	0.4713E-04		
		0.8061E+01	0.1172E-04		
		0.8995E+01	0.2514E-05		
		0.9928E+01	0.4641E-06		
		0.1086E+02	0.7282E-07		
		0.1180E+02	0.2016E-08		
		0.1409E+02	0.9106E-09		
		0.1638E+02	0.4220E-09		
		0.1867E+02	0.2081E-09		
		0.2096E+02	0.1186E-09		
		0.2326E+02	0.9405E-10		
0.1450E+03	0.4049E+03	0.0000E+00	0.2551E-01	0.2949E+03	0.0000E+00
		0.1500E-02	0.2293E-01		
		0.3063E+00	0.1981E-01		
		0.6111E+00	0.1708E-01		
		0.9159E+00	0.1465E-01		
		0.1221E+01	0.1248E-01		
		0.1525E+01	0.1054E-01		
		0.2459E+01	0.5891E-02		
		0.3393E+01	0.2934E-02		
		0.4326E+01	0.1286E-02		
		0.5260E+01	0.4919E-03		
		0.6194E+01	0.1635E-03		
		0.7127E+01	0.4708E-04		
		0.8061E+01	0.1171E-04		
		0.8995E+01	0.2511E-05		
		0.9928E+01	0.4636E-06		

TIME	LATERAL DISTANCE	DEPTH	CONCENTRATION	TOTAL MASS INTO SOIL	TOTAL MASS INTO BASE
		0.1086E+02	0.7273E-07		
		0.1180E+02	0.1734E-08		
		0.1409E+02	0.6734E-09		
		0.1638E+02	0.2759E-09		
		0.1867E+02	0.1240E-09		
		0.2096E+02	0.6585E-10		
		0.2326E+02	0.5060E-10		
0.1470E+03	0.3744E+03	0.0000E+00	0.2428E-01	0.2973E+03	0.0000E+00
		0.1500E-02	0.2203E-01		
		0.3063E+00	0.1926E-01		
		0.6111E+00	0.1676E-01		
		0.9159E+00	0.1448E-01		
		0.1221E+01	0.1241E-01		
		0.1525E+01	0.1053E-01		
		0.2459E+01	0.5951E-02		
		0.3393E+01	0.2993E-02		
		0.4326E+01	0.1326E-02		
		0.5260E+01	0.5133E-03		
		0.6194E+01	0.1731E-03		
		0.7127E+01	0.5062E-04		
		0.8061E+01	0.1282E-04		
		0.8995E+01	0.2805E-05		
		0.9928E+01	0.5295E-06		
		0.1086E+02	0.8514E-07		
		0.1180E+02	0.3275E-08		
		0.1409E+02	0.1958E-08		
		0.1638E+02	0.1224E-08		
		0.1867E+02	0.7702E-09		
		0.2096E+02	0.5112E-09		
		0.2326E+02	0.4271E-09		
0.1470E+03	0.3845E+03	0.0000E+00	0.2507E-01	0.2973E+03	0.0000E+00
		0.1500E-02	0.2263E-01		
		0.3063E+00	0.1967E-01		
		0.6111E+00	0.1703E-01		
		0.9159E+00	0.1466E-01		
		0.1221E+01	0.1253E-01		
		0.1525E+01	0.1061E-01		
		0.2459E+01	0.5973E-02		
		0.3393E+01	0.2999E-02		
		0.4326E+01	0.1327E-02		
		0.5260E+01	0.5137E-03		
		0.6194E+01	0.1732E-03		
		0.7127E+01	0.5065E-04		
		0.8061E+01	0.1282E-04		

		0.8995E+01	0.2806E-05		
		0.9928E+01	0.5296E-06		
		0.1086E+02	0.8511E-07		
		0.1180E+02	0.2673E-08		
		0.1409E+02	0.1359E-08		
		0.1638E+02	0.7317E-09		
		0.1867E+02	0.4195E-09		
		0.2096E+02	0.2691E-09		
		0.2326E+02	0.2240E-09		
0.1470E+03	0.3947E+03	0.0000E+00	0.2528E-01	0.2973E+03	0.0000E+00
		0.1500E-02	0.2278E-01		
		0.3063E+00	0.1975E-01		
		0.6111E+00	0.1708E-01		
		0.9159E+00	0.1469E-01		
		0.1221E+01	0.1254E-01		
		0.1525E+01	0.1062E-01		
		0.2459E+01	0.5973E-02		
		0.3393E+01	0.2998E-02		
		0.4326E+01	0.1327E-02		
		0.5260E+01	0.5135E-03		
		0.6194E+01	0.1731E-03		
		0.7127E+01	0.5063E-04		
		0.8061E+01	0.1282E-04		
		0.8995E+01	0.2805E-05		
		0.9928E+01	0.5294E-06		
		0.1086E+02	0.8506E-07		
		0.1180E+02	0.2429E-08		
		0.1409E+02	0.1114E-08		
		0.1638E+02	0.5260E-09		
		0.1867E+02	0.2648E-09		
		0.2096E+02	0.1540E-09		
		0.2326E+02	0.1234E-09		
0.1470E+03	0.4049E+03	0.0000E+00	0.2551E-01	0.2973E+03	0.0000E+00
		0.1500E-02	0.2294E-01		
		0.3063E+00	0.1984E-01		
		0.6111E+00	0.1712E-01		
		0.9159E+00	0.1470E-01		
		0.1221E+01	0.1254E-01		
		0.1525E+01	0.1061E-01		
		0.2459E+01	0.5964E-02		
		0.3393E+01	0.2994E-02		
		0.4326E+01	0.1325E-02		
		0.5260E+01	0.5128E-03		
		0.6194E+01	0.1729E-03		
		0.7127E+01	0.5057E-04		
		0.8061E+01	0.1281E-04		
		0.8995E+01	0.2802E-05		
		0.9928E+01	0.5289E-06		

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0.1086E+02  0.8495E-07
0.1180E+02  0.2080E-08
0.1409E+02  0.8191E-09
0.1638E+02  0.3416E-09
0.1867E+02  0.1568E-09
0.2096E+02  0.8509E-10
0.2326E+02  0.6615E-10
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N O T I C E

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*                                               *
*      M I G R A T E   S I M U L A T I O N      *
*                                               *
*             ANALYSIS      COMPLETED           *
*                                               *
*           TIME     -       84:44: 2           *
*           EXECUTION TIME    0: 3:38           *
*                                               *
*                                               *
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