2017 Construction Inspection Report - Phase 8A Base Liner and Leachate Collection System

65 Green Mountain Road West
Stoney Creek, ON

Terrapure Environmental Stoney Creek Landfill

GHD | 455 Phillip Street Waterloo Ontario N2L 3X2 Canada

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1. Introduction

1.1 Background

Terrapure Environmental (Terrapure) owns and operates the Stoney Creek Regional Facility (SCRF) located at 65 Green Mountain Road West in Stoney Creek, Ontario. The site has been operating since December 1996 under Environmental Compliance Approval (ECA) No. A181008 issued by the Ministry of the Environment and Climate Change (MOECC). Key conditions relating to the construction of the site's base liner and leachate collection system include:

- ***Condition 14.1:***
  "*Specifications and a detailed quality assurance/quality control program for construction of the Major Works, and provisions for quality assurance procedures, with respect to the liner, to be undertaken by an independent third-party consulting firm experienced in liner construction, reporting to the Ministry.*"
- ***Condition 14.3:***
  "*The Company shall construct Major Works in accordance with the approved final detailed design and shall implement the quality assurance procedures as approved by the Director.*"
- ***Condition 14.4:***
  "*No landfilling of wastes shall occur on any part of the liner until the Regional Director has received an inspection report from the independent third party referred to in condition 14.1, indicating that the part of the liner was constructed as required by this certificate. A copy of these inspection reports shall also be provided to the City and the CLC*."

The design and development of the SCRF is presented in the site's Design and Operations Report (Gartner Lee, 1995). The base liner and leachate collection system (liner/lcs) is being constructed in phases over the site's operating period. The layout of the phases and a typical cross-section through the liner/lcs are shown in Figures 1 and 2, respectively. As of the end of the 2017 construction season, the liner/lcs has been constructed in Phases 1 through 8A. Construction quality assurance work undertaken for these phases has been documented in previous reports (refer to Section 6 of this report – References).

In 2017 Terrapure undertook the construction of the Phase 8A liner/lcs, the extents of which are shown in Figure 3. Condition 14.1 of the ECA has been satisfied by Terrapure's submission of Detailed Design Drawings and Specifications for the Phase 8A liner/lcs to the MOECC for review and subsequent approval. GHD was retained by Terrapure to carry out the associated construction quality assurance work for Phase 8A. The completion and documentation of this work satisfies Conditions 14.3 and 14.4 of the ECA.

Construction generally took place between June and December, 2017, with the following being completed:

a. The complete base liner system was constructed for Phase 8A, generally between local coordinates N1250 and N1375, and between E1025 and E1325.

b. A temporary berm was constructed along the eastern perimeter to provide containment within the completed liner area.

c. A groundwater collection trench and associated cleanout structures were constructed generally between E1025 and E1325.

The MOECC permits Terrapure to commence waste disposal operations on completed portions of the liner/lcs upon receipt of a letter prepared by the firm which has carried out the construction inspection work, confirming that the construction was carried out in conformance with the approved design. This is also permitted on the understanding that complete quality assurance documentation would be subsequently provided. A letter pertaining to Phase 8A was submitted to the MOECC on January 25, 2018. Submission of this report constitutes the remainder of the required quality assurance documentation. A copy of the letter to the MOECC is provided in Appendix A.

1.2 Scope of Report

The remainder of this report is organized as follows:

a. Section 2 presents a brief overview of the construction activities.

b. Section 3 summarizes the results of:

- Conformance testing of the materials used.
- Inspections to confirm that construction methods were achieving the desired result.
- Evaluation of the performance of the compacted clay liners.

c. Sections 4 and 5 present major conclusions and recommendations, respectively.

d. Section 6 provides a list of references.

Results of the various field and laboratory testing carried out during the Phase 8A work are presented in Appendices B through I of this report.

2. Construction Activities

2.1 Overview

The general contractor carrying out the work was Dufferin Construction Company (Dufferin). Dufferin's main subcontractor was Terrafix Environmental Technology Inc. (Terrafix), who was responsible for the supply and installation of the geotextiles and geomembrane liner.

Construction commenced on June 19, 2017 and concluded on December 7, 2017. Work was typically carried out Monday to Friday, between the hours of 7:00 a.m. and 5:00 p.m. (except during or immediately after periods of inclement weather). Construction, testing and inspection work was extended into weekends and evenings periodically to take advantage of good weather conditions, with the approval of the Regional MOECC office.

2.2 Key Contractors

The key contractors/subcontractors involved in the construction of the Phase 8A base liner and leachate collection system, as well as their various roles and responsibilities are outlined in Table 2.1.

Table 2.1 Roles and Responsibilities of Key Contractors

Company	Role	Responsibilities
Dufferin Construction Company	General Contractor	• Construction of all components of the liner and leachate collection system other than those noted below.
Terrafix Geosynthetics Inc.	Sub-Contractor	• Deployment and seaming of geotextiles. • Installation, seaming, testing, and repairs of geomembrane.
Sandale Utility Products	Sub-Contractor	• On-site fusion services for perforated and non-perforated HDPE pipe.

2.3 Construction Materials

The main suppliers and manufacturers of materials involved in the construction of the Phase 8A base liner and leachate collection system are outlined in Table 2.2.

Table 2.2 Suppliers and Manufacturers of Key Construction Materials

Material(s)	Supplier	Manufacturer(s)
Soils	Terrapure Environmental	Sourced from on-site material stockpiles
Aggregate	Terrapure Environmental	Sourced from on-site material stockpiles and material imported from Vinemount Quarry, Mlton Quarry, and Flamborough Quarry
Type A Geotextile	Terrafix Geosynthetics Inc.	SKAPS Industries
Type B Geotextile	Terrafix Geosynthetics Inc.	SKAPS Industries
80 mil Geomembrane	Terrafix Geosynthetics Inc.	Solmax International Inc.
HDPE Pipe	Sandale Utility Products	WL Plastics

2.4 Construction Equipment

Major equipment employed during construction consisted of the following:

a. Tracked Excavators (Caterpillar 307 E, John Deere 470 G LC, 245 G LC, 60 D).

- Loading of clay, engineered fill, aggregate, and spoil materials.
- Placement and removal of temporary berms.
- Placement of granular 'A' pads for cleanout structures.
- Bedrock excavation (when equipped with a hydraulic hoe-ram).

- Excavation of anchor trenches.
- Placement and grading of granular materials on sidewalls.
- Installation of leachate collection piping.
- Transport and support of large, heavy construction materials (e.g., geotextile rolls, cleanout structures).
- Conditioning clay liner soils prior to compaction (i.e., breaking down of soil clods, locating/removing boulders present in the soil, mixing in added water, and reworking soil to aid in drying).

b. Komatsu 51 EX, John Deere 750 J, 750 K Bulldozers.

- Spreading granular 'A' for base grading layer.
- Spreading soils for clay liners, engineered fill, and temporary berms.
- Spreading 50 mm clear stone for hydraulic control layer.
- Spreading 19 mm clear stone and granular 'A' for leachate collection drainage blanket.
- Fine grading of completed surfaces.

c. Caterpillar CS 53 3E, CS 44 Self-Propelled Smooth-Drum Rollers.

- Compacting base grading layer, hydraulic control layer, and foundation pads for leachate collection system cleanouts.
- Smooth-rolling final lift of clay liners.

d. Caterpillar 972 M Wheel Loader.

- Loading granular and clear stone stockpiles into rock trucks.

e. Caterpillar 735, Case 330 B Rock Trucks.

- Haulage of clay soils and granular materials.
- Haulage of excavation spoil.

f. Water Tank Trucks with Spray Hoses.

- Addition of water to clay soils or granular materials prior to compaction.
- Application of water to haul roads for dust control.

g. Caterpillar CS 563 E, CP 56 B, Bomag BW 213 PDH-40 Padfoot Compactors.

- Compaction of clay liners and base grading layer on the landfill base and sidewall.

h. Merlo Panoramic P38.13 plus "Zoom-Boom" Telescopic Fork-Lift.

- Movement and placement of geomembrane and geotextile rolls.

Other minor equipment used included diesel pumps, hand-guided augers, geotextile seaming equipment, geomembrane welding equipment, and plate tampers.

3. Construction Inspection and Testing

3.1 Overview

The benchmark for the quality assurance program was the Phase 8A Final Design Drawings and Specifications. Minor modifications to the design and quality assurance protocols were occasionally made in the field in order to accommodate specific site conditions or to incorporate 'lessons learned' from previous liner/lcs construction events. None of these modifications resulted in a deviation from the design intent or a decrease in the degree of containment provided by the liner system. All such modifications are documented in this report.

GHD staff were on site to carry out quality assurance inspection and field testing during construction of the Phase 8A base liner and leachate collection system, as well as the groundwater collection system. GHD carried out the inspection and testing of the clay liners, as well as the inspection and quality assurance work related to the geomembrane installation.

GHD and Dufferin both carried out routine surveying to establish control points and check proper alignment and grading of the various components. Dufferin also utilized Global Positioning Satellite hardware and software on select earth moving equipment. The constructed extents of the Phase 8A base liner and leachate collection system were surveyed and documented in As-Built construction drawings.

In addition to the testing and inspection discussed herein, GHD also carried out routine contract administration duties, and recorded the contractor's activities in daily field inspection records. Photographs showing typical construction activities are presented in Appendix B. Daily site activity logs are presented in Appendix C.

3.2 Construction Materials Testing

3.2.1 Grading Soils

Engineered fill was used for the Phase 8A sidewall construction. The material was sourced from on-site stockpiles. The engineered fill was tested for Standard Proctor Maximum Dry Density (SPMDD) and Optimum Water Content. Results are provided in Appendix D.

3.2.2 Liner Soils

Soil for clay liner construction was obtained from on-site stockpiles of quarry overburden strippings, and was similar to the soil used for liner construction in previous years. Soil used in the construction of Phase 8A was also routinely tested during construction for basic geotechnical properties including SPMDD, Sieve Analysis, Optimum Water Content, Remoulded Permeability, and Atterberg Limits. Laboratory testing results for these materials are provided in Appendix D.

3.2.3 Granular 'A'

Granular 'A' was used for the base grading layer, the leachate collection system graded filter, and for various other minor applications. Granular 'A' used in the construction of Phase 8A was obtained from on-site stockpiles of product manufactured within the East Quarry and imported from Vinemount Quarry. Laboratory testing results for these materials are provided in Appendix D.

3.2.4 Clear Stone

For construction, 19 mm clear stone was used for the groundwater collection trench, the leachate collection system drainage layer and within the temporary berm; and 50 mm clear stone was used for the hydraulic control layer.

Clear stone used in construction was obtained from on-site stockpiles. Additional 50 mm and 19 mm clear stone was imported from Dufferin Aggregates – Milton Quarry and Dufferin Aggregates – Flamborough Quarry, respectively. Laboratory testing results for these materials are provided in Appendix D.

3.2.5 Geotextiles

Type A geotextile was installed over the groundwater collection trench, on top of and beneath the hydraulic control layer, and within the temporary berm. The material installed was a non-woven, polypropylene geotextile known as SKAPS GE110.

Type B geotextile was installed over the geomembrane liner and within the temporary berm. The material installed was a non-woven, polypropylene geotextile known as SKAPS GE114.

The material was shipped from SKAPS Industries (Nonwoven Division) a geosynthetics manufacturer in Athens, Georgia, U.S.A.

3.2.5.1 Geotextile Material Testing

The Specifications require that the contractor submit manufacturer's certificates that confirm that the geotextile meets the requirements of the Specifications prior to shipment of the geotextile to the site. These certificates report the results of testing done by the manufacturer at their own plant prior to and during the manufacturing process. Manufacturer's certificates submitted to GHD for review indicated that the material supplied was in general conformance with the Specifications.

GHD coordinated and oversaw the geotextile sampling program and reviewed the results to determine conformance. Terrafix collected geotextile material samples for conformance testing (carried out at the Sageos laboratory) at a frequency of one sample per 5,000 m² of geotextile installed. Complete results of the geotextile material testing program are reported in Appendix E1.

3.2.5.1.1 Geotextile Type A

A total of four samples of Type A geotextile were tested for conformance with the Specifications. Overall test results indicated that the samples met the required specifications. The results are summarized in Table 3.1.

Table 3.1 Summary of Type A Geotextile Laboratory Testing

Test	Test Method	No. of Tests	Specified Value[1]	Min.	Avg.	Max.
Mass per Unit Area	ASTM D5261	4	230 g/m²	359	360	375
Thickness	ASTM D5199	4	2.5 mm	3.28	3.34	3.44
Mullen Burst Resistance	ASTM D3786	4	2,000 kPa	3,243	3,401	3,467
Permittivity	ASTM D4491	1	2 s^{-1} (Maximum Value)		1.09	
Grab Tensile	ASTM D4631	4	1,200 N (Machine Direction)	1244.5	1278.2	1304.3
			1,200 N (Cross Direction)	1322.0	1366.1	1409.1
Trapezoidal Tear	ASTM D4533	4	450 N (Machine Direction)	461.6	478.8	495.9
			450 N (Cross Direction)	480.2	528.0	571.1
Apparent Opening Size	ASTM D4751	1	0.212 mm (Maximum Value)		0.150	
Puncture Resistance	ASTM D4833	4	490 N	774.3	785.4	812.7
UV Resistance	ASTM D4355	1	> 70%/ 500 hrs, Machine Direction		74	
			> 70%/ 500 hrs, Cross Direction		65	

Notes:
1. All specified values are minimum required values unless stated otherwise

One of the Type A geotextile samples tested had a UV resistance value in the cross direction that was marginally below the specified value.

The material manufacturer (SKAPS) provided a supporting letter certifying that the Type A geotextile (GE110) meets or exceeds the specified UV resistance requirements based on quality control testing carried out as part of the manufacturing process. The letter and supporting test results are provided in Appendix E1.3.

In addition, geotextile rolls were wrapped in plastic film and covered with a tarp to further limit UV exposure during storage on-site. Prior to use, the outer layer of each roll was discarded to limit the use of material that had a higher potential of UV exposure. During construction the geotextile was immediately covered with overlying materials (granular A, clear stone, or clay). Based on the supporting letter and the precautionary and preventative measures the Type A geotextile was permitted for use in liner construction.

3.2.5.1.2 Geotextile Type B

A total of two samples of Type B geotextile were tested for conformance with the Specifications. Overall test results indicated that the samples met the required specifications. The results are summarized in Table 3.2.

Table 3.2 Summary of Type B Geotextile Laboratory Testing

Test	Test Method	No. of Tests	Specified Value[1]	Min.	Avg.	Max.
Mass per Unit Area	ASTM D5261	2	445 g/m²	498	511	524
Thickness	ASTM D5199	2	3.5 mm	4.26	4.33	4.40
Mullen Burst Resistance	ASTM D3786	2	2,200 kPa	4,833	4,834	4,834
Permittivity	ASTM D4491	1	2 s^{-1} (Maximum Value)		0.84	
Grab Tensile	ASTM D4631	2	1,320 N (Machine Direction)	1,773.5	1787.3	1,801.1
			1,320 N (Cross Direction)	1,793.4	1,899.4	2,005.4
Trapezoidal Tear	ASTM D4533	2	490 N (Machine Direction)	630.4	637.0	643.6
			490 N (Cross Direction)	685.4	719.5	753.6
Apparent Opening Size	ASTM D4833	1	0.212 mm (Maximum Value)		0.141	
Puncture Resistance	ASTM D4833	2	550 N	1,123.8	1,135	1,146.2
UV Resistance	ASTM D4355	1	> 70%/ 500 hrs, Machine Direction		77.9	
			> 70%/ 500 hrs, Cross Direction		70.2	

Notes:
1. All specified values are minimum required values unless stated otherwise

3.2.6 Geomembrane

An 80 mil (i.e., 2 mm thick) geomembrane was installed directly on top of the primary clay liner. The material installed was a textured high-density polyethylene (HDPE) geomembrane known as Solmax HDPE Series, 2.00 mm – White Reflective, Textured, 1030510.

3.2.6.1 Geomembrane Material Testing

The Specifications require that the contractor submit manufacturer's certificates that confirm that the geomembrane meets the requirements of the Specifications prior to shipment of the geomembrane to the site. These certificates report the results of testing done by the manufacturer at their own plant prior to and during the manufacturing process. Manufacturer's certificates submitted to GHD for review indicated that the material supplied was in general conformance with the Specifications.

GHD coordinated and oversaw the sampling program and reviewed results to determine conformance. Terrafix collected the geomembrane samples for conformance testing at the specified frequency of one set of tests for each parameter in the Specifications per 4,000 m^2 of geomembrane installed. Sageos, a specialist geosynthetics laboratory in St. Hyacinthe, Quebec carried out laboratory testing of the geomembrane. Complete results of the geomembrane material testing program are reported in Appendix E2. Inspection work relating to the installation of the geomembrane is discussed in Section 3.3.7.

A total of three samples of 80 mil textured geomembrane were tested for conformance with the Specifications. Overall test results indicated that the samples met the required specifications. The results are summarized in Table 3.3.

Table 3.3 Summary of 80 mil Textured Geomembrane Laboratory Testing

Test	Test Method	No. of Tests	Specified Value[1]	Min.	Avg.	Max.
Density of Formulated Sheet	ASTM D792 method B	3	0.94 g/cm^3	0.948	0.948	0.948
Thickness	ASTM D5994	3	2.0 mm	2.03	2.05	2.08
Asperity Height	ASTM D7466	3	0.25 mm, Side A	0.56	0.67	0.82
			0.25 mm, Side B	0.54	0.56	0.59
Tensile Strength at Yield	ASTM D6693	3	29 kN/m (Machine Direction)	35.9	36.8	38.2
			29 kN/m (Cross Direction)	36.8	37.3	37.7
Tensile Strength at Break		3	21 kN/m (Machine Direction)	47.1	48.3	49.2
			21 kN/m (Cross Direction)	38.4	40.1	41.5
Elogation at Yield		3	12% (33 mm gauge length) (Machine Direction)	16	17	17
			12% (Cross Direction)	16	16	17
Elogation at Break		3	100% (50 mm gauge length) (Machine Direction)	556	563	570
			100% (Cross Direction)	446	476	510
Puncture Resistance	ASTM D4833	3	534 N	800.0	805.7	813.5
Tear Resistance	ASTM D1004	3	243 N (Machine Direction)	327	336	338
			243 N (Cross Direction)	317	323	327

Table 3.3 Summary of 80 mil Textured Geomembrane Laboratory Testing

Test	Test Method	No. of Tests	Specified Value[1]	Min.	Avg.	Max.
Stress Crack Resistance	ASTM D5397	3	300 hours	All values >500		
Carbon Black Content	ASTM D1603	3	2 to 3%	2.64	2.68	2.74
Carbon Black Dispersion	ASTM D5596	3	At least 9 views in Categories 1 or 2 and no more than 1 in Category 3	All samples had at least 9 views in Categories 1 or 2 and no more than 1 in Category 3		
Oxidative Induction Time	ASTM D3895	3	100 min	214	217	221
Oven Aging	ASTM D5885	1	80%	77.0		
UV Resistance	ASTM D5885	1	50%	85.9		

Notes:
1. All specified values are minimum required values unless stated otherwise

One of the 80 mil textured geomembrane samples tested had an oven aging value that was marginally below the specified value.

The geomembrane manufacturer (Solmax) provided a supporting letter certifying that the geomembrane complies with the project specifications for oven aging based on quality control testing carried out during the manufacturing process on a sample with the same resin formulation. The supporting letter can be found in Appendix E2.1.

Prior to use, the outer layer of each roll was discarded to limit the use of material that had a higher potential of UV exposure. During construction the geomembrane was immediately covered with overlying materials (Type B geotextile and clear stone). Based on the supporting letter and the precautionary and preventative measures the geomembrane was permitted for use in liner construction.

3.2.7 HDPE Pipes

Both perforated and non-perforated 200 mm diameter HDPE pipe were installed for the leachate collection layer (DR 9) and groundwater collection system (DR 17). Pipes delivered to the site were inspected and confirmed to be in conformance with the Specifications.

3.3 Construction Methods Inspection and Testing

3.3.1 General

Various pre-construction and general items were necessary in order to facilitate construction of Phase 8A. These items include but are not necessarily limited to:

a. Excavation of bedrock where required and removal of spoil.

b. Relocation of nearby material stockpiles to provide clear access.

c. Regrading of waste slopes to provide safe access.

d. Control of groundwater and surface water during liner construction.

e. Construction of temporary access ramps.

3.3.2 Bedrock Excavation and Groundwater Collection Trench Installation

Inspection of the bedrock excavation and groundwater collection trench installation activities generally included:

a. Excavation and removal of spoil.

b. Grade control and alignment for the excavated trench.

c. Visual observation of the placement and fusing of groundwater collection system piping and cleanout structures.

d. Grade control and alignment for the piping.

e. Backfilling of trenches with 19 mm clear stone.

f. Placement of Type A geotextile over the top of the backfilled trench.

g. Placement of a protective granular 'A' layer over the geotextile.

3.3.3 Sidewall Berm

Inspection and testing during the sidewall berm construction consisted of:

a. Visual observation of adequate bedrock surface preparation prior to material placement (i.e., removal of sediment and loose rock).

b. Laboratory analysis of engineered fill material for SPMDD.

c. Visual observation of lift thickness.

d. Removal of any foreign material or large rocks.

e. In-situ density and moisture content measurements of material placed using a nuclear density gauge.

The engineered fill used for the sidewall berm could typically be compacted to the required 95% SPMDD without difficulty. Water was added during dry periods to bring the material close to its optimum moisture content to facilitate compaction. If the material moisture content was too high, the lift would be allowed to air dry and be retested before commencing further material placement.

The results of the in-situ density and moisture content testing are presented in Appendix D. Each test carried out is numbered sequentially and the location identified (lift number, coordinates referenced to closest ground water clean out structure). In many cases, a given area is represented by several tests, where the first test shows inadequate compaction or moisture content and subsequent tests confirm that the required density and moisture was achieved.

3.3.4 Base Grading Layer

Inspection and testing during base grading layer construction consisted of:

a. Visual observation of adequate bedrock surface preparation prior to material placement (i.e., removal of sediment and loose rock).

b. In-situ density and moisture content measurements of material placed using a nuclear density gauge.

c. Visual observation for correct lift thickness and for occurrence of any segregation of finer and coarser fractions during placement.

The granular ’A’ used for the base grading layer could typically be compacted to the required 95% SPMDD without difficulty. Water was added during dry periods to bring the material close to its optimum moisture content to facilitate compaction. Material segregation problems generally did not occur and in any instance where segregation was observed (e.g., if placement was attempted during significant wet periods) the affected materials were removed and replaced.

The results of the in-situ density and moisture content testing are presented in Appendix D. Each test carried out is numbered sequentially and the location identified (lift number, coordinates referenced to closest ground water clean out structure). In many cases, a given area is represented by several tests, where the first test shows inadequate compaction or moisture content and subsequent tests confirm that the required density and moisture was achieved.

3.3.5 Secondary and Primary Clay Liners

Inspection and testing during clay liner construction consisted of the following:

a. Visual inspection of on-site soil stockpiles for construction and conditioning operations.

b. Laboratory analysis of clay material for SPMDD, Sieve Analysis, Optimum Water Content, Remoulded Permeability, and Atterberg Limits.

c. Visual inspection of the finished subgrade prior to construction.

d. Visual inspection of the material placement and benching at the connection to existing clay liners.

e. Visual inspection of action of the compaction and hauling equipment on the lifts.

f. Visual inspection of the number of passes used to compact each lift.

g. In-situ density and moisture content measurements using a nuclear density gauge.

h. Laboratory and in-situ hydraulic conductivity testing.

i. Test holes to verify the adequacy of bonding between successive lifts and material consistency.

j. Visual inspection of the finished surface of the clay liners.

The results of the in-situ density and moisture content testing are presented in Appendix D. Each test carried out is numbered sequentially and the location identified (lift number, coordinates referenced to closest ground water clean out structure). In many cases, a given area is represented by several tests, where the first test shows inadequate compaction or moisture content and subsequent tests confirm that the required density and moisture was achieved.

Moisture content was also determined as part of the laboratory hydraulic conductivity testing carried out by GHD at their laboratory in Waterloo, Ontario. These results are presented in Appendix F. Hydraulic conductivity testing is discussed further in Section 3.3.5.2.

The compaction and moisture content specification for the clay liners requires that each lift be compacted to at least 98% of the SPMDD with a moisture content within 1% to 3% wet of optimum moisture content. At the discretion of the Engineer, the Specifications allow the reduction of the required compaction density from 98% to 95% of SPMDD with a corresponding increase of the moisture content from 1% to 3% wet of the optimum moisture. The results of the in-situ testing can generally be summarized as follows:

a. Densities and moisture contents within the desired range were routinely achieved.

b. In isolated cases density or moisture content measurements outside of the desired range were accepted based on the observed appearance and handling characteristics of the soil. This was done in cases where the measurement was made in an area where the soil was well re-moulded, where it was known that adequate compactor passes were made (based on the number of passes required to reach the required density in adjacent areas) and where the moisture condition was visually similar to surrounding areas where in-situ measurements were within the range. Such judgments were made on a case-by-case basis by the GHD soils inspector.

3.3.5.1 Construction Method

The first (i.e., lowest) lift of each clay liner was typically constructed with a lift thickness of approximately 250 mm. This thickness ensured that the underlying materials (either the base grading layer or sidewall berm in the case of the secondary liner, or the Type A geotextile in the case of the primary liner) were not disturbed by the kneading action of the padfoot compactor. The remaining lifts for each liner were typically constructed with an average compacted lift thickness of 200 mm. In all cases each clay liner was constructed in five lifts.

The top lift of the primary liner was also typically overbuilt by about 50 mm and then cut down to the required grade and smooth rolled immediately prior to geomembrane placement. This reduced productivity losses in the event of rainfall since only the overbuilt surficial soils would typically be affected and could be rapidly removed.

Each lift of the clay liner was benched into existing sections of the clay liner with at least one metre wide benches to ensure good continuity between the new and previously constructed liner. While preparing the existing base liner for connection, it was observed that the extents of the existing secondary clay liner extended further north than the proposed connection alignment for the Phase 8A base liner. Given the configuration of the existing temporary berm and the proximity of the existing waste in Phases 1 and 2 behind the temporary berm, it was determined that the proposed connection alignment for the Phase 8A base liner would not allow adequate space to properly bench the layers of the clay liners. In order to accommodate the existing field conditions, it was necessary to shift the connection alignment of the secondary clay liner (as well as the limits of subsequent layers) approximately 4.5 metres to the north. This change improved constructability of the base liner and ensured that there was enough space to properly bench into the existing clay layers, maintaining the integrity of the overall base liner system.

Soil conditioning prior to compaction was carried out at the liner construction area and included rock removal, breaking up of soil clods, and moisture adjustment. Water was added as required using a tanker truck equipped with a spray hose. Wet lift surfaces were allowed to air dry prior to placement of the subsequent lift.

The removal of debris/rock from stockpiled soils was carried out routinely by Dufferin prior to clay placement. Scarification using an excavator bucket with teeth served to expose any hidden stones in the clay and improve bonding between lifts. Clay surfaces exposed to the environment overnight were also subject to scarification.

Test pits were excavated through the final lift and into underlying lifts using an excavator bucket. A homogeneous soil mass with no evidence of stratification or voids was typically observed. Test pits were repaired by backfilling and re-compacting per the Specifications, and repairs were inspected to ensure uniformity with the surrounding liner soils. Test pit records for the secondary and primary clay liners are provided in Appendix G.

3.3.5.2 Performance Testing

Vertical hydraulic conductivity measurements of the completed clay liners were made both in the laboratory and in the field. The frequency of testing was in conformance with the Specifications, which requires one test location per 2,000 m^2 of clay liner.

Approximately half of the tests consisted of laboratory tests on Shelby tube samples. Shelby tubes were recovered from nine locations. Two Shelby tubes were recovered from each location; one sample for testing and one sample to serve as a backup should further testing be required. The laboratory test results are provided in Appendix F.

The remaining locations were tested by an in-situ method, using permeameters to conduct Stage 1 of the Two Stage Borehole Test (Boutwell and Tsai, 1982). Permeameters were installed in four locations. Two permeameters and one control were installed at each location. The in-situ test results are provided in Appendix H.

Holes left following the removal of either the Shelby tubes or the permeameters were repaired by excavating soils around the sample area, then backfilling and re-compacting the clay in lifts as per the Specifications. Repairs were inspected to ensure adequate benching and uniformity with surrounding liner soils.

If a given test result was considered to be unsatisfactory, investigations were conducted to determine the reason for the unsatisfactory result as follows:

a. The test apparatus and test location were examined for any anomalies.

b. Field notes and other hydraulic conductivity testing results completed in the vicinity were reviewed to identify possible anomalies that could have caused the test to fail.

c. Another hydraulic conductivity test was conducted in the immediate vicinity to help determine if the failure was due to an improperly installed apparatus.

d. If the apparatus was not found to be at fault, test pits were excavated around the initial test location. Visual observations of the clay liner within the area of concern were documented.

e. Hydraulic conductivity tests were conducted farther away from the initial test location to help identify the limits of the area of concern.

f. Once the area of concern was identified, the clay liner was removed from that area and reconstructed as per the Specifications. The repairs were inspected to ensure adequate benching and uniformity with the surrounding clay soils.

3.3.5.2.1 Laboratory Hydraulic Conductivity Tests

A total of eighteen Shelby tube samples were recovered from nine locations within Phase 8A. Three pairs were recovered from the secondary liner, and six pairs were recovered from the primary liner, in the locations shown in Figures 5 and 6, respectively. Shelby tube ends were immediately trimmed and sealed with molten wax. Samples were delivered to the GHD laboratory in Waterloo for testing.

The hydraulic conductivity measured for the secondary liner ranged between 1.3×10^{-8} cm/s and 1.5×10^{-8} cm/s, while the hydraulic conductivity measured for the primary liner ranged between 8.8×10^{-9} cm/s and 3.3×10^{-8} cm/s. All laboratory hydraulic conductivity test results were below the design maximum of 5×10^{-8} cm/s. Complete testing results are presented in Appendix F.

3.3.5.2.2 Field Hydraulic Conductivity Tests

A total of four in-situ hydraulic conductivity tests were carried out at various locations in the clay liner during Phase 8A. Two sets were installed in the secondary liner, and two sets were installed in the primary liner in the locations shown in Figures 5 and 6 respectively.

The hydraulic conductivity measured for the secondary liner ranged between 3.35×10^{-9} cm/s and 4.99×10^{-8} cm/s, while the hydraulic conductivity measured for the primary liner ranged between 3.99×10^{-9} cm/s and 4.88×10^{-8} cm/s. All in-situ hydraulic conductivity test results were below the design maximum of 5.0×10^{-8} cm/s. Detailed test results, and a description of the test method and apparatus are presented in Appendix H.

3.3.6 Hydraulic Control Layer and Leachate Collection System Granular Materials

Visual inspections were carried out during placement of the 50 mm clear stone for the hydraulic control layer and the 19 mm clear stone and Granular A for the leachate collection system granular blanket. Inspection of the placement of these materials generally included the following:

a. Lift thickness and grade control.

b. Ensuring that trucks hauling the clear stone did not damage the underlying layers (i.e., clay liners, geotextiles or geomembranes).

c. Ensuring that vehicles did not traverse directly over an exposed geotextile or geomembrane surface.

d. Ensuring that wrinkles in the membrane were distributed/minimized and no wrinkle 'fold-over' occurred when granular was placed over the textile-covered membrane.

e. Ensuring that compactive effort was not applied to the stone layers in a manner that would risk damaging underlying geotextiles or geomembranes.

The Granular A was also compacted to at least 95 percent SPMDD, using a smooth drum roller. Care was taken to not damage the underlying geotextile and geomembrane. Results of the compaction can be found in Appendix D.

In general, the clay liners are relatively good construction platforms for the overlying granular layers. Vehicular traffic from loaded haulage trucks was kept to haul roads at least one metre thick in order to minimize potential for damage to the underlying layers. Granular materials were typically spread in one or two lifts using dozers, while care was taken to avoid the spinning of tracks. Excavators equipped with smooth-edged buckets were also used to create the grading required for the leachate collection system piping. Test pits were excavated to ensure that the underlying materials were not adversely affected by the placement of the stone. Test pit records for the leachate collection system granular materials can be found in Appendix G.

3.3.7 Geotextile Installation

Visual inspections were carried out during all aspects of geotextile installation to ensure that:

a. The fabric and seams were not damaged during handling or placement.

b. Field seaming was carried out in a neat and uniform manner.

c. No seams were installed perpendicular to the sidewall slope.

d. Fabrics were covered with overlying layers in a timely manner (e.g., within four weeks) to minimize UV exposure.

e. When the geotextile was overlapped instead of seamed, a minimum 600 mm overlap was used.

Material was generally placed by hand, with the assistance of an excavator or a zoom-boom. The passage of vehicles on the geotextile was not permitted at any time. Torn or punctured material was either patched with sufficient overlap to prevent separation or replaced. In order to prevent wind damage to the geotextile, sand bags were placed along the edges and ends of the panels immediately following deployment, until the overlying materials could be placed.

Test pits were regularly excavated to ensure that the geotextile had not been damaged during placement of the overlying material. No instances of damaged fabric were noted, indicating that the material inspected performed adequately in the field. Inspection records for the test pits are presented in Appendix G.

3.3.7.1 Geotextile Seaming

Geotextile seams were seamed in the field using a hand-held sewing machine. In cases where the geotextile was not seamed such as repair areas, an overlap of at least 600 mm was used. No factory fabricated seams were included in the rolls supplied.

The seams were threaded with 16 oz. NWP/453 GM white Anefil Nylon. The average stitching amounted to approximately 16 stitches every 10 centimeters.

Seam strength is of concern primarily during fabric installation when the seam is subjected to construction stresses (e.g., covering with granular or soil). To reduce the seam stress during construction, seams oriented perpendicular to slopes were not permitted. Test pits were routinely excavated to ensure that the geotextile seams had not been damaged during placement of the overlying material. No instances of separated seams were noted, indicating that the seams inspected performed adequately in the field. Inspection reports for these test pits are presented in Appendix G.

3.3.8 Geomembrane Installation

All quality assurance work relating to the geomembrane installation, testing and inspection was undertaken by GHD and performed in general accordance with the Phase 8A Design Drawings and Specifications.

A summary of the general inspection and testing results for the geomembrane liner is provided in Table 3.4. Detailed results of the field quality assurance program are discussed below and presented in Appendix I.

Table 3.4 Summary of Geomembrane Inspection Results

	80 mil Textured Geomembrane
Area Installed (m^2)	9,301
Length of Welded Seams (m)	1,714
Repairs	139
Calibration Tests	37
Pressure Tests	119
Vacuum Box Tests	138
Destructive Tests	9

3.3.8.1 Deployment

Prior to the deployment of geomembrane, the subgrade was visually inspected to ensure that no standing water or excess moisture was present on the clay liner surface and to remove any rocks or debris that might lead to damage of the geomembrane. Placement was generally not permitted under conditions of rain, snow, high winds, blowing sand, excessive fog or dew, or any other conditions that may affect the quality of the work.

Material was generally placed by hand, with the assistance of a zoom-boom or an excavator. The passage of vehicles on the geomembrane was not permitted at any time. In order to prevent wind damage to the geomembrane, sand bags were placed along the edges and ends of the panels immediately following deployment.

3.3.8.2 Pre-Weld Testing

Pre-weld (calibration) tests were carried out for each fusion welder and extrusion welder prior to the instrument being used to weld the geomembrane. Additional tests were carried out when the instrument had been idle for two hours or more, when ambient air temperatures changed by more than 10°C or when seam work was carried over to the afternoon from the morning. A set of ten specimens was taken from each pre-weld sample, and tested for peel and shear using a field tensiometer. The pre-weld test results for the fusion and extrusion welders used during seaming are summarized in Table 3.5 and Table 3.6. Complete test results are presented in Appendix I.

Table 3.5 Summary of Pre-Weld Test Results

Type of Weld	Test	Specified Value	Min.	Avg.	Max.
Extrusion	Peel Resistance	108 lbs/in	109	153	199
	Shear Resistance	160 lbs/in	172	244	396
Fusion	Peel Resistance	126 lbs/in	125	165	223
	Shear Resistance	160 lbs/in	155	244	327

Table 3.6 Summary of Pre-Weld Test Breaks

Type of Weld	Test	SE1	SE3	BRK	ALL
Extrusion	Peel Resistance	0	17	0	0
	Shear Resistance	16	0	0	1
Fusion	Peel Resistance	0	20	0	0
	Shear Resistance	9	0	0	11

Note:
Acceptable break types include:

- SE1 – Break at seam edge in the bottom sheet. (Shear only)
- SE3 – Break at seam edge in the top sheet. (Peel only)
- BRK – Break in sheeting. Break can be in either top or bottom sheet.
- ALL – Elongation of the sheet without rupture, until the tensiometer limit is reached.

3.3.8.3 Seaming

Geomembrane seams were fusion welded in the field using a dual-track wedge welder, or extruded using an extrusion welder when wedge welding was not suitable. No factory fabricated seams were included in the rolls supplied. Visual inspections of the geomembrane field seaming were carried out to ensure that:

a. Work was carried out in a neat and uniform manner.

b. Welds were free from moisture or debris.

c. Panel overlaps were down gradient.

d. No seams were installed perpendicular to a slope.

A letter from the manufacturer was obtained in accordance to GRI GM9 to allow for geomembrane welding below 0°C. The letter is presented in Appendix E2.1. Test results presented in Appendix I1 confirmed that the quality of the welded seams met the required specifications.

3.3.8.4 Repairs

Repairs were made to the geomembrane in areas where the liner had been torn, punctured, or otherwise damaged. Geomembrane surfaces were first prepared using a grinder, and then repaired using an extrusion welder. Small repairs were completed using a bead of extrudate, while larger repairs were covered with a patch.

3.3.8.5 Non-Destructive Testing

Non-destructive testing was carried out on all seams and repairs. Fusion welded seams were subjected to an air test. The central air channel of the seam was clamped shut at one end of the seam, and fitted with a pressure gauge at the other end. The seam was pressurized and the initial pressure was recorded. Seams were considered to be acceptable if the pressure drop over a five minute period was within the Specifications.

Extrusion welded seams and repairs were subjected to a vacuum box test. A soapy solution was applied to the seam/repair, and a vacuum affixed to a transparent box was used to create a tight seal around the area being tested. The area was considered acceptable if no bubbling was observed in the soapy solution over a period of 15 seconds.

Seams that did not pass the initial non-destructive test were inspected for defects, repaired and re-tested. If no defects could be found, the entire seam was subjected to vacuum box testing.

3.3.8.6 Destructive Testing

Destructive tests were carried out for fusion welded seams following the completion of the non-destructive testing. Destructive samples approximately on metre long were cut directly from installed seams. A set of at least ten specimens was taken from each destructive sample and tested for peel and shear strength using a field tensiometer.

The destructive test results for the fusion welds are summarized in Table 3.7 and Table 3.8. Complete results are presented in Appendix I.

Table 3.7 Summary of Destructive Test Results

Type of Weld	Test	Specified Value	Min.	Avg.	Max.
Fusion	Peel Resistance	126	121	164	212
	Shear Resistance	160	161	254	305

Table 3.8 Summary of Destructive Test Breaks

Type of Weld	Test	SE1	SE3	BRK	ALL
Fusion	Peel Resistance	0	9	0	0
	Shear Resistance	8	0	0	1

Note:
Acceptable break types include:

- SE1 – Break at seam edge in the bottom sheet. (Shear only)
- SE3 – Break at seam edge in the top sheet. (Peel only)
- BRK – Break in sheeting. Break can be in either top or bottom sheet.
- ALL – Elongation of the sheet without rupture, until the tensiometer limit is reached.

3.3.8.7 Placement of Overlying Materials

Prior to the deployment of overlying materials, the geomembrane surface was swept clear of any loose stones or debris that could adversely affect the integrity of the liner. Care was taken during the placement of overlying granular materials to ensure that wrinkles did not develop in the geomembrane. If wrinkles were noted, stone was placed directly on top of the wrinkle in an effort to spread it out and prohibit the formation of a crease. If a crease was observed, the affected geomembrane was cut out and repaired in accordance with the Specifications.

Test pits were regularly excavated to ensure that the geomembrane had not been damaged during placement of the overlying material. No instances of damaged seams or material were noted, indicating that the material and seams inspected performed adequately in the field. Inspection records for the test pits are presented in Appendix G.

3.3.9 Temporary Berms

3.3.9.1 Construction of the New Temporary Berm

Quality assurance work during berm construction included the following:

a. Inspection of the 80 mil geomembrane installation (as part of the overall base geomembrane installation and part of the temporary berm installation).

b. Vacuum box testing of the extrusion welds used to join the flap to the geomembrane.

c. Periodic visual inspections of:

- Placement of Type B geotextile within the berm.
- Placement of 19 mm clear stone within the berm.
- Inspection for loose stones or other impediments between the membrane and the geotextile.

- Placement of the leachate blanket over the inside of the berm.

The quality assurance work associated with the temporary berms is presented in Appendix I. The layout of the temporary berms is presented in Figure 4.

A key aspect of the construction sequence is that the leachate collection granular blanket be placed near the location of the extrusion weld for the flap before the 19 mm granular is placed within the berm. This sequence was based on a recommendation from previous construction reports and is intended to minimize the formation of wrinkles in the 80 mil geomembrane near the base of the temporary berm. It is recommended that this practice be continued.

3.3.9.2 Removal of the Existing Temporary Berm

The sequence of removal of the existing temporary berms adjacent to Phase 8A was generally as follows:

a. The outer, clay portion of the existing berm was excavated and removed. An important objective in this operation was to remove the desiccated soils on the outer part of the berm and expose non-desiccated soils for connection of the new liner.

b. The newly-constructed secondary liner, hydraulic control layer, and primary liner were each connected to the corresponding layers in the adjacent phase. Care was taken to ensure that each new layer was adequately connected to the existing layer (e.g., ensuring that the new clay liners were adequately benched into the existing liners, that the clear stone was continuous with the existing stone, and that the new Type A geotextile was adequately overlapped with the existing geotextile). These connections were completed prior to disturbing the geomembrane in the existing berms.

c. The temporary flap was cut down to a manageable height. The bulk of the 19 mm clear stone was then removed from between the flaps, while leaving enough in place to support the temporary flap.

d. The remaining clay supporting the outer (i.e., trailing) edge of the existing geomembrane was removed and the geomembrane was lowered onto the newly-connected primary liner surface. The edge of the existing geomembrane was either cleaned or cut back as required, and seamed to the newly placed Phase 8A geomembrane. At this point the outer portion of the temporary berm (clay and membrane) became continuous with the adjacent phase, but the inner flap of the previously-constructed temporary berm remained in place.

e. Construction of the new temporary berm (e.g., along the eastern edge of Phase 8A) was completed, resulting in the newly-constructed liner area being fully contained. The inner flap, which formerly defined the limit of the adjacent phase, was cut away. This included removal of the remaining stone between the flaps.

f. The Type B geotextile, the leachate drainage blanket, and the graded granular filter were made continuous.

Inspection work carried out during the removal of the existing temporary berms consisted of the following:

a. Ensuring that adequate benching, soil conditioning and compaction, and moisture control was achieved in connecting the clay liners and clay berms.

b. Quality assurance work related to the seaming of the new geomembrane to the formerly-constructed membranes.

c. Visual observation for any damage to the geomembrane as a result of the berm removal work, inspection of the repairs made to damaged areas, and the testing of the repairs.

d. Visual observation to ensure that stones were removed from the surface of the geomembrane before geotextile placement and from between geotextiles and geomembranes already in place.

e. Visual observation to ensure that the Type B geotextile, 19 mm clear stone drainage blanket, and graded granular filter were continuous.

3.3.10 Leachate Collection System Piping

Inspection of the leachate collection system piping included:

a. Visual observation of the placement and fusing of leachate collection system piping.

b. Grade control and alignment for the piping.

c. Placement of 19 mm clear stone and granular ‘A’ layer over the piping.

The construction of the leachate collection system occurred in general accordance with the Specifications.

4. Conclusions

The following conclusions are drawn from the results of the quality assurance work undertaken during construction of the Phase 8A base liner system in 2017:

a. Quality assurance work was carried out by GHD during Phase 8A construction. The quality assurance protocols were in general conformance with those described in the approved Detailed Design Drawings and Specifications. Based on this work, it is concluded that the Phase 8A base liner and leachate collection system have been constructed in general conformance with the approved Detailed Design Drawings and Specifications.

b. Some modifications were made to the design and quality assurance protocols to accommodate field conditions and material characteristics. We consider that these modifications are minor in nature and do not impact the overall intent and function of the design.

c. Clay liner performance testing has been carried out in conformance with the approved specifications. The testing results indicate that the vertical hydraulic conductivity of the clay liners is below the maximum specified design value of 5×10^{-8} cm/s.

5. Recommendations

Recommendations resulting from the 2017 construction work, as well as relevant recommendations from previous years' work are summarized herein.

5.1 Geotextile

a. Although the Specifications require that the contractor submit manufacturer's certificates confirming the geotextiles meet the required specifications prior to shipment to site, independent laboratory testing of the materials following shipment, and sometimes deployment, has shown deficiencies. It is recommended that independent testing be done to confirm acceptability of geotextiles prior to the full shipment of materials, and definitely prior to installation.

5.2 Clay Liner Construction

a. Future clay liner construction should continue to utilize newer stockpiles within the SCRF as much as possible in order to minimize the effort needed for removal of quarry rock and debris from the clay.

b. When it is necessary to utilize stockpiles which have a potential for a high rock content, additional visual inspection focused on ensuring adequate removal of rock and debris is required.

c. Continued attention is required to ensure that lift surfaces that become smooth by construction traffic are thoroughly scarified prior to placement of overlying lifts.

d. Notwithstanding satisfactory laboratory test results, field construction trials should be conducted when liner construction using imported soils is contemplated, to ensure that the desired permeability can be produced.

e. Scarifying the first lift must be done carefully to ensure that there is no damage to any of the underlying materials (e.g., Type A geotextile).

f. The lift thickness must not exceed 200 mm (except on the first lift) since the padfoots do not penetrate the clay as deeply as the sheepsfoot compactor.

g. Scarifying of the newly placed clay must be thorough enough to ensure removal of all rocks and clods.

h. Scarifying of the lift surface must be thorough enough to produce interlift bonding.

i. Periodic routine excavation of test pits should be carried out to ensure that stratification is not observed between lifts.

5.3 Granular Placement

a. Attention must be paid to the construction sequence for placement of the leachate collection granular blanket near the location of the extrusion weld for the flap at the temporary berm. Granular should be placed at the base of the berm, near the extrusion weld, before the

19 mm granular is built up within the berm (e.g., between the flap and the clay/membrane outer portion).

5.4 Geomembrane

a. No equipment should be placed directly on the geomembrane liner at any time.

b. An effective method of dissipating small amounts of water trapped beneath the geomembrane which precludes cutting and repairing the membrane (e.g., which may be undesirable late in the construction season) is as follows:

    a. Granular may be placed around areas of ponded water to isolate the water in pockets of approximately 20 m by 20 m.

    b. Granular can then be placed within these squares moving from the outside towards the centre. The granular can be placed onto textile-covered liner using an excavator to minimize the formation of wrinkles. Care should be taken to ensure that granular is not dropped onto the covered liner from an excessive height.

c. In the rare instance that significant amounts of water accumulate under the geomembrane liner, (e.g., heavy precipitation) a small hole should be cut, the water pumped out, and the geomembrane subsequently repaired.

d. Wrinkles that occur in the geomembrane should be dealt with by one of two methods:

    a. Whenever possible, wrinkles should be cut out and the areas patched.

    b. When a wrinkle cannot be removed, care should be taken during stone placement to ensure the stone is placed directly on top of the wrinkle in an effort to spread it out and prohibit the formation of a crease.

e. A geomembrane repair crew, equipped with an extrusion welder and vacuum box, should be standing by during any soil removal work near geomembranes. This will ensure that any required repairs can be made and tested expediently.

f. Ensure that are an adequate number of sandbags placed to secure the geomembrane. This will reduce the risk of damage to the geomembrane caused by wind.

5.5 Construction/Removal of Temporary Berms

a. Effort should be made to ensure that desiccated material on the outside face of existing temporary berms is removed prior to the connection of newly constructed areas.

b. The removal of the clay soil in close proximity to the geomembrane (e.g., outer portion of berm) can be problematic because of the potential for the excavator bucket to tear or puncture the geomembrane. It can also be difficult for excavators to pick up soil from the membrane surface in wet conditions because the soil mass easily slides on the membrane surface, possibly causing abrasion. It is therefore recommended that excavation equipment working in close proximity to the membrane be equipped with smooth-edged buckets to minimize potential for membrane puncture in the event of bucket contact with the membrane.

c. Use of 19 mm clear stone within the temporary berms should be continued in future phases, in order to minimize the need for heavy equipment to work in close proximity of the membrane.

d. Stone within the old temporary berm should be removed prior to the placement of the final lift of the PCL, minimizing the possibility of having rocks directly under the HDPE membrane.

e. Wet weather, which occurs frequently in the autumn, makes it more difficult for the landfill operator to reduce leachate levels in the landfill. This increases the requirements for temporary dyking and pumping, and complicates membrane seaming, repairs, and testing. It is recommended that, where possible, berm connection and removal be scheduled to occur during dry periods (e.g., ideally the summer season).

5.6 Landfilling Operations

a. Effort should be made to place wastes uniformly around the leachate collection system cleanout structures and permanent pumping station structure in order to minimize differential loading on these structures. The waste grade should not differ by more than 0.5 m at any point around these structures at any time.

b. The waste should be kept several metres back from the temporary berm constructed at the end of the construction season in order to reduce the need to pull back the waste at the beginning of the next construction season.

c. Continued and careful attention must be paid to ensuring that temporary containment of the active landfill is maintained at all times during construction.

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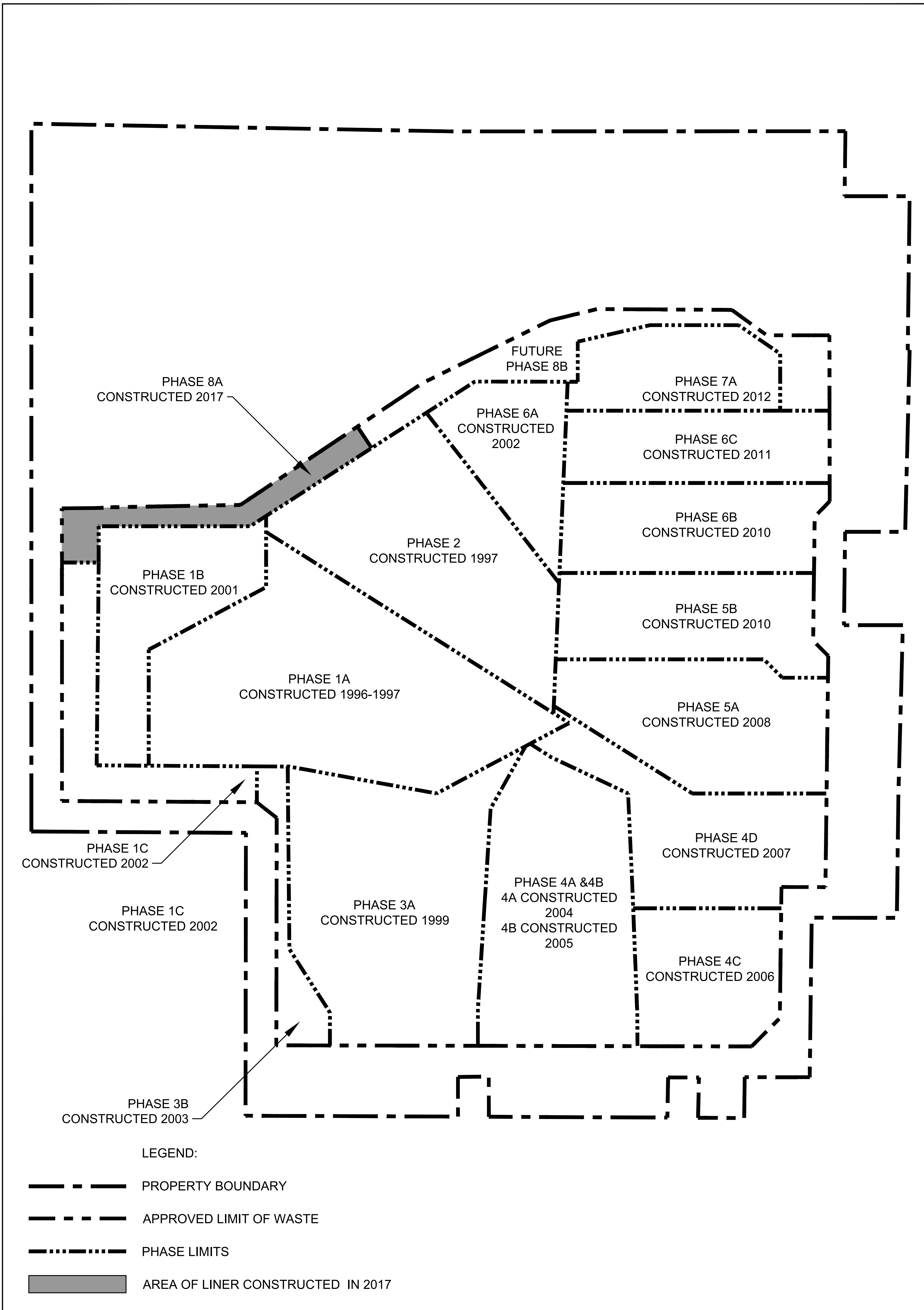
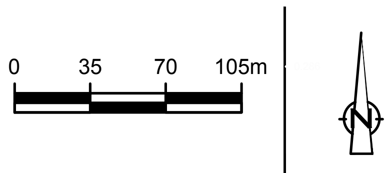
Figures





TERRAPURE ENVIRONMENTAL
STONEY CREEK ONTARIO
PHASE 8A INSPECTION REPORT

LAYOUT OF LANDFILL PHASES

11103232-01
Apr 17, 2018

FIGURE 1

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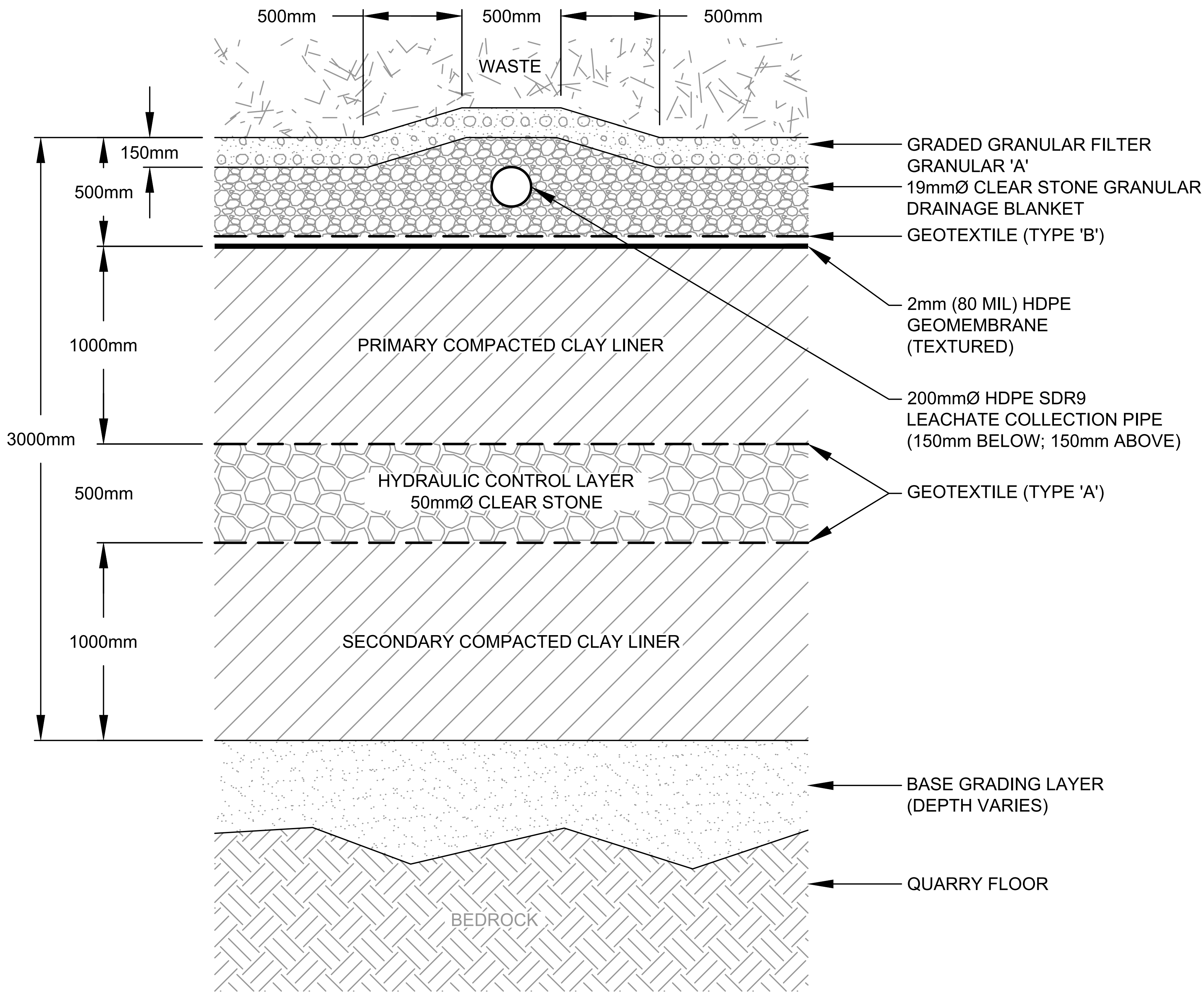

TYPICAL CROSS SECTION THROUGH BASE LINER SYSTEM

TERRAPURE ENVIRONMENTAL
STONEY CREEK REGIONAL FACILITY
PHASE 8A INSPECTION REPORT
TYPICAL CROSS SECTION THROUGH BASE LINER SYSTEM

11103232-01
Apr 17, 2018

FIGURE 2

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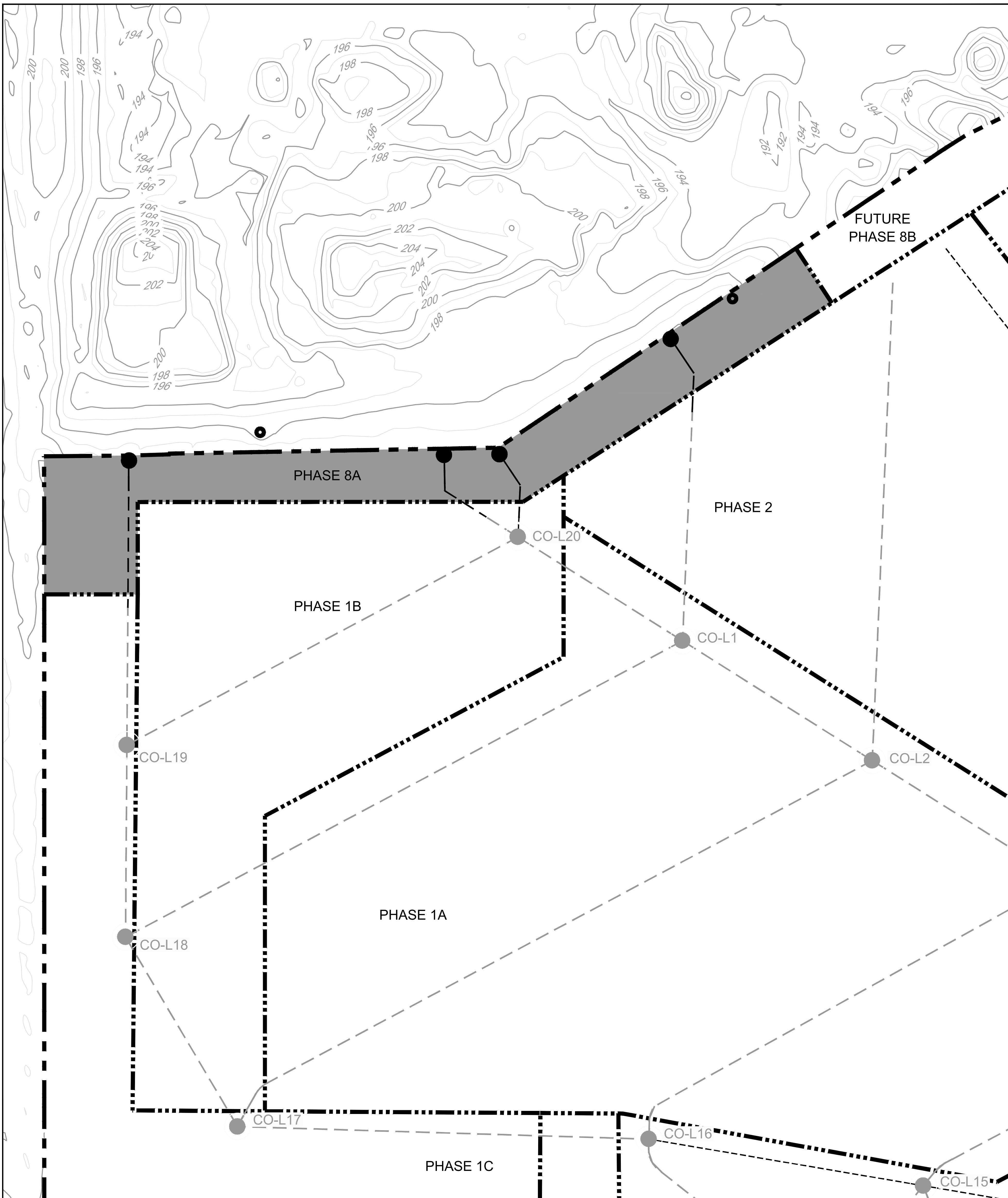


LEGEND:

- APPROVED LIMIT OF WASTE
- PHASE LIMITS
- LEACHATE COLLECTION PIPE (PERFORATED) INSTALLED IN 2017
- LEACHATE COLLECTION PIPE (NON-PERFORATED) INSTALLED IN 2017
- LEACHATE COLLECTION SYSTEM CLEANOUT INSTALLED IN 2017
- GROUNDWATER COLLECTION TRENCH CLEANOUT
- LEACHATE COLLECTION PIPE (PERFORATED)
- LEACHATE COLLECTION PIPE (NON-PERFORATED)
- CO-L17 LEACHATE COLLECTION SYSTEM CLEANOUT

SOURCE: EXISTING TOPOGRAPHY BASED ON AERIAL SURVEY COMPLETED JANUARY 25 2018 BY AUTOMATED ENGINEERING TECHNOLOGIES LTD.

0 15 30 45m

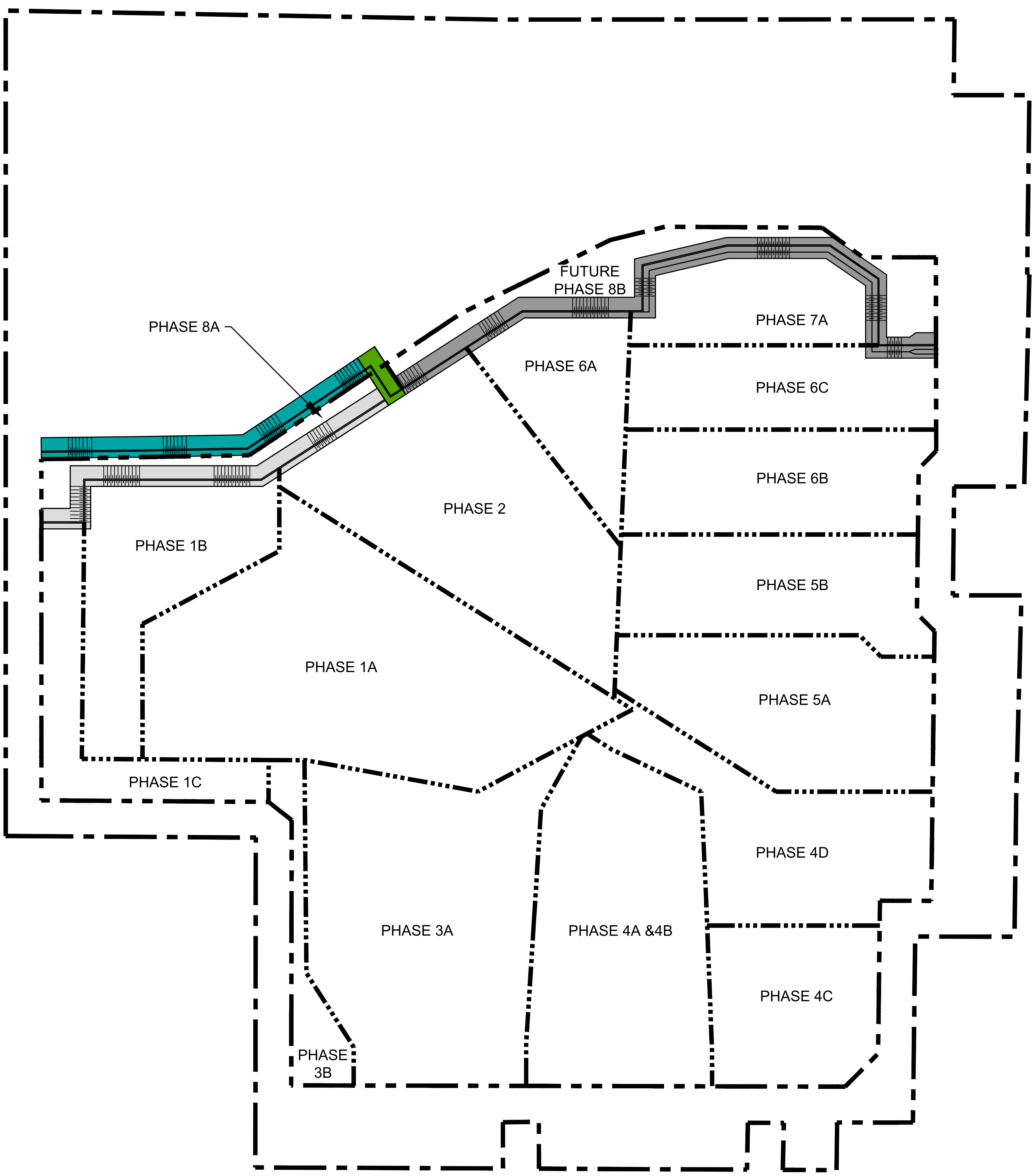
GHD

TERRAPURE ENVIRONMENTAL
STONEY CREEK ONTARIO
PHASE 8A INSPECTION REPORT

EXTENT OF LINER CONSTRUCTION COMPLETED

11103232-01
Apr 17, 2018

FIGURE 3



LEGEND:

PROPERTY BOUNDARY	TEMPORARY BERM CONSTRUCTED IN 2017
APPROVED LIMIT OF WASTE	TEMPORARY BERM REMOVED IN 2017
PHASE LIMITS	EXISTING TEMPORARY BERM
SIDEWALL BERM CONSTRUCTED IN 2017	

0 35 70 105m

TERRAPURE ENVIRONMENTAL
STONEY CREEK ONTARIO
PHASE 8A INSPECTION REPORT

LAYOUT OF TEMPORARY BERMS

11103232-01
Apr 17, 2018

FIGURE 4

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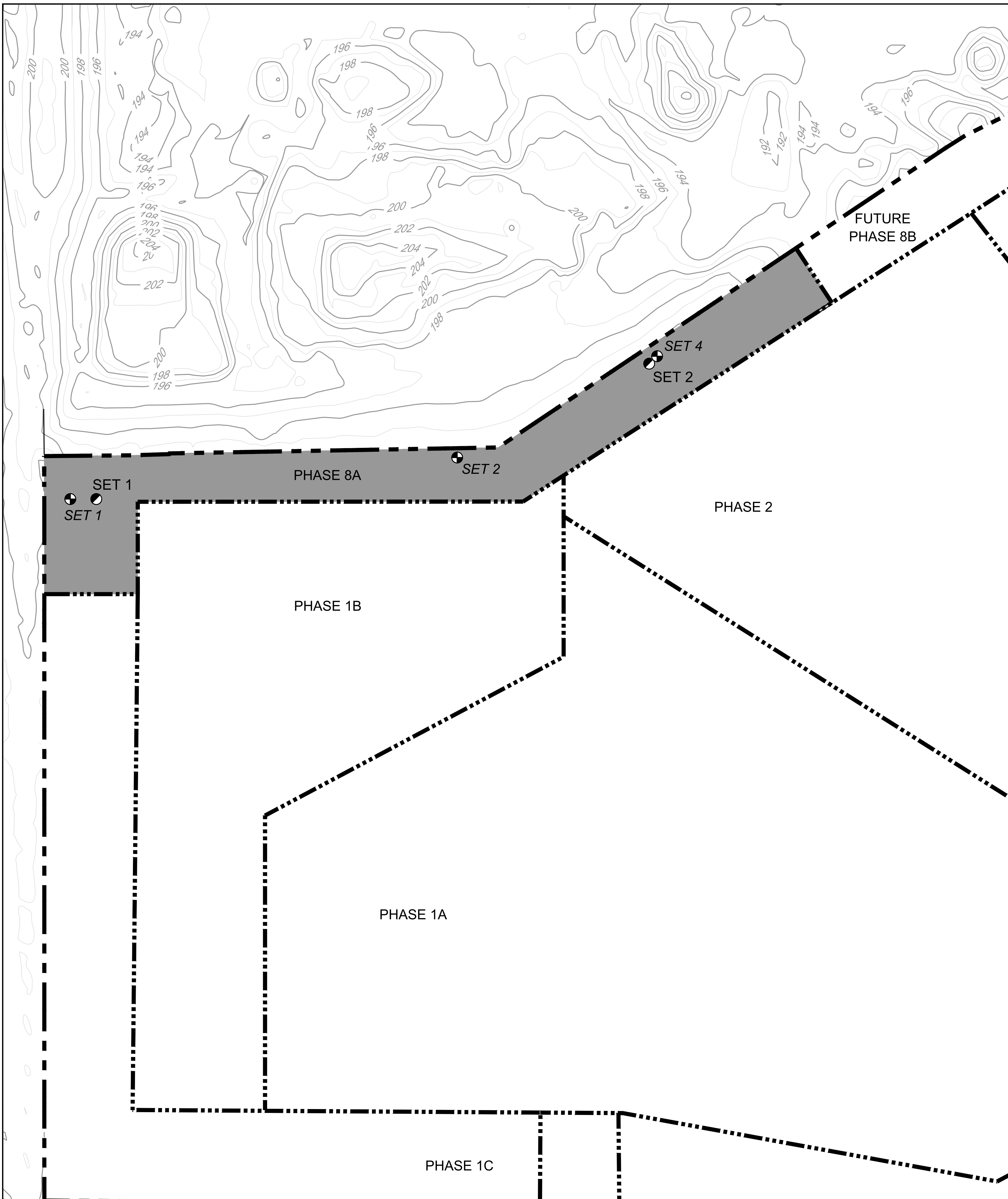

LEGEND:

APPROVED LIMIT OF WASTE

PHASE LIMITS

SET 1 SHELBY TUBE LOCATION

SET 1 IN-SITU HYDRAULIC CONDUCTIVITY TEST LOCATION

SOURCE: EXISTING TOPOGRAPHY BASED ON AERIAL SURVEY COMPLETED JANUARY 25 2018 BY AUTOMATED ENGINEERING TECHNOLOGIES LTD.

0 15 30 45m

GHD

TERRAPURE ENVIRONMENTAL
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PHASE 8A INSPECTION REPORT

LOCATION OF SHELBY TUBE AND IN-SITU HYDRAULIC CONDUCTIVITY TESTS IN THE SECONDARY CLAY LINER

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FIGURE 5

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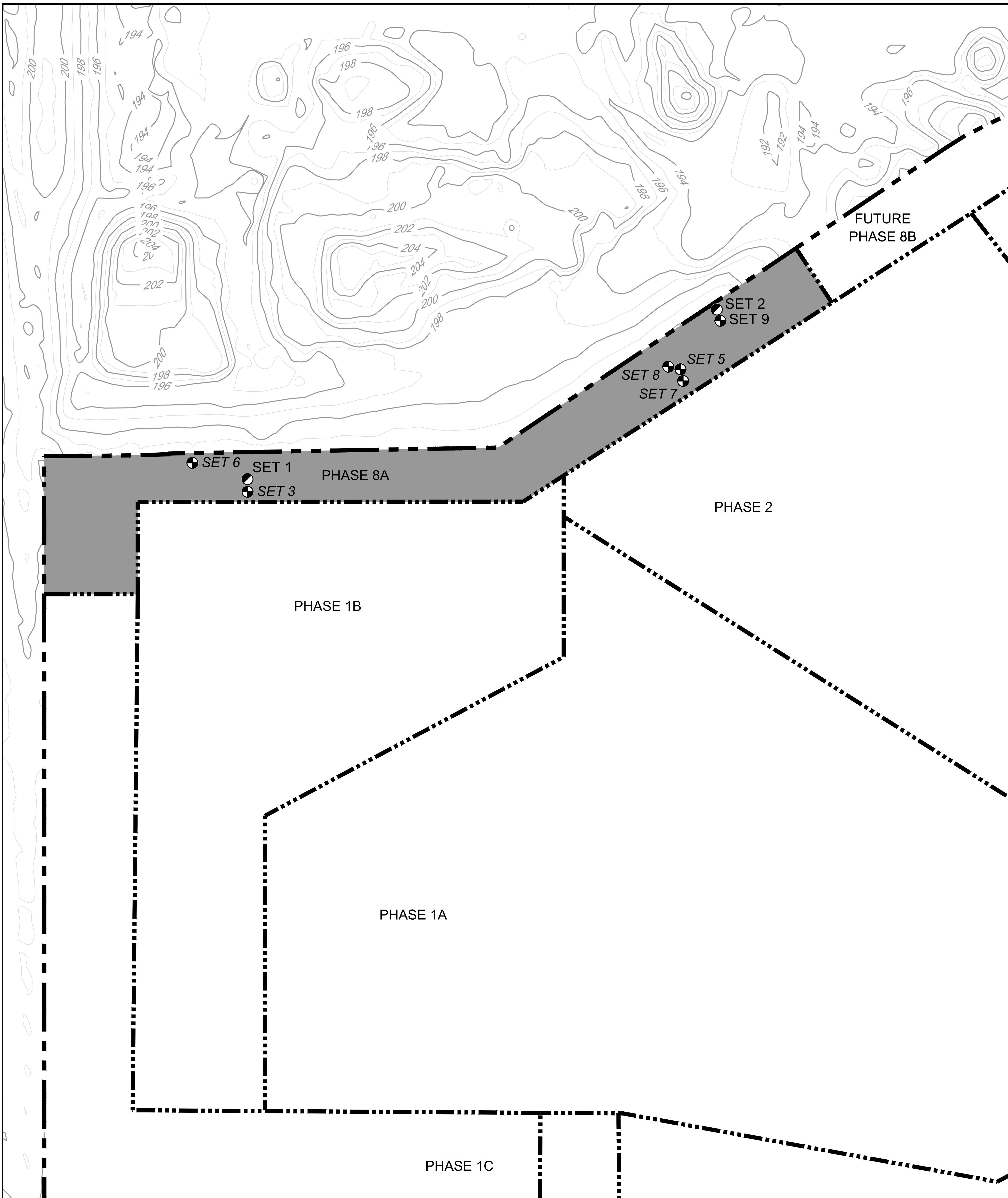

LEGEND:

APPROVED LIMIT OF WASTE

PHASE LIMITS

SHELBY TUBE LOCATION

SET 1 IN-SITU HYDRAULIC CONDUCTIVITY TEST LOCATION

SOURCE: EXISTING TOPOGRAPHY BASED ON AERIAL SURVEY COMPLETED JANUARY 25 2018 BY AUTOMATED ENGINEERING TECHNOLOGIES LTD.

TERRAPURE ENVIRONMENTAL
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PHASE 8A INSPECTION REPORT

LOCATION OF SHELBY TUBE AND IN-SITU HYDRAULIC CONDUCTIVITY TESTS IN THE PRIMARY CLAY LINER

11103232-01
Apr 17, 2018

FIGURE 6

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