Attachment VI-5

Design Engineering Report

For

Cells 8 through 13

CLEAN HARBORS
GRASSY MOUNTAIN FACILITY

LANDFILL CELLS 8 THROUGH 13
DESIGN ENGINEERING REPORT

(HAL Project No.: 064.85.100)

AUGUST 2018 Rev 1

Appendix C and supporting calculations for design of the leachate collection and removal systems and the leak detection systems are provided in Appendix D.

Liner Systems

Utah Administrative Code R315-264-301(c)(1)(i)-(ii)

Top Liner System. The top liner system is designed as a composite system consisting of three components on the floor and 10 feet up the interior side slopes and two components the rest of the distance up the interior side slopes. An 80-mil HDPE geomembrane provides the upper component which extends across the floor and up the interior slopes of the landfill cells. The middle and bottom components on the floor and 10 feet up the interior side slopes consists of a geosynthetic clay liner (GCL) and a bottom 80-mil HDPE geomembrane. The two components the rest of the distance up the interior side slopes consists of a single 80-mil HDPE geomembrane and a GCL. The upper 80-mil HDPE geomembrane provides an impermeable barrier to prevent migration of hazardous constituents into the liner and provides a barrier on which the top leachate collection system is placed. Clean Harbors is providing the added GCL and the lower 80-mil HDPE geomembrane components described above for extra protection (beyond regulatory requirements) against leachate migration through the liner system. As presented earlier in this report, the geomembrane liner has material properties and strength sufficient to prevent failure from pressure gradients, physical contact with the liquids to which it will be exposed, climatic conditions, installation stresses, and stresses from daily operation. The foundation materials to the liner system provide support necessary to resist pressure gradients, and to prevent failure from settlement, compression, and uplift. The liner system will also cover all earth materials likely to be in contact with the waste or leachate that will be placed in the landfill cell.

Bottom Composite Liner System. The bottom composite liner system consists of a 60-mil HDPE geomembrane placed directly over and in contact with a 3-foot thick compacted clay liner. The geomembrane meets the same criteria in materials and strength as stated above for the top liner system. The compacted clay liner is designed to meet a minimum permeability of 1×10^{-7} cm/sec as required by federal and state regulations.

The compacted clay liner will be processed and compacted generally using the same borrow source areas and methodologies that have historically been used at the site for clay liner construction. The methodology used is provided in the construction quality assurance plan for the facility. The geotechnical investigation report prepared by AGEC (provided in appendix B) includes recommended procedures for mining, processing, placement, compaction, and maintenance of the compacted clay liner.

Leachate Collection and Removal System (LCRS)

Utah Administrative Code R315-264-301(c)(2) & ((3)(iii)-(iv)

The landfill cells are divided into four separate sump drainage areas and the floor of each sump drainage area consists of two planar surfaces that slope toward each other (in the east/west direction) at a 2.3% slope and parallel to each other (in the north/south direction) at a 2.3% slope. Slopes of 2.3% were provided to leave a resulting slope greater than 1% after projected differential settlement occurs. The two slopes form a resultant slope for the planar surfaces of 3.25% (at an angle of 45 degrees from the 2.3% slopes) toward the sumps located at the low point of each sump drainage area. A valley is formed at the line of intersection between the two planar surfaces that has a slope of 2.3% toward the sumps. After settlement occurs, the resulting minimum slopes will be 1.7% toward the valley between the two planar surfaces, 1.4% parallel to and along the valley, and a resultant of 2.3%.

The leachate collection and removal system (LCRS) is located on the floor area of the cells above the top liner system and is provided with the slopes and configuration described in the previous paragraph. The LCRS is designed as a double-sided geocomposite consisting of 8 oz. non-woven geotextile on both sides of the geonet. A 4-inch diameter HDPE perforated pipe will also be placed along the valley within each sump drainage area to collect leachate that concentrates along the valley and convey the leachate to the sumps for removal.

U.S. Environmental Protection Agency's "Hydrologic Evaluation of Landfill Performance (HELP)" computer model was used to estimate the design leachate rate for the leachate collection system. Input date for the HELP model and calculated results from the model are provided in Appendix D. The following tables provide a summary of the results generated by the HELP model for the following four scenarios: 1) the cells with only protective soil cover and no waste; 2) the cells with 10 feet of waste; 3) the cells with 30 feet of waste; and, 4) the cells with 48 feet of waste above the protective soil cover. Sump drainage areas used to calculate leachate volumes are 154,869 square feet and 158,586 square feet for Landfill Cell 8 and for Landfill Cells 9-13, respectively. Since calculated leachate volumes generated in Landfill Cells 9-13 are slightly higher than those generated in Landfill Cell 8, design of the leachate collection and removal system will be based on the leachate volumes for Landfill Cells 9-13.

TABLE 2.1 - AVERAGE ANNUAL AND AVERAGE DAY LEACHATE RATES
LANDFILL CELL 8

Waste height	Average Annual Leachate Rates			Average Day Leachate Rates	
(ft)	(in)	(cf/sump)	(gal/sump)	(cf/sump)	(gal/sump)
0	1.33143	17,179.8	128,505	47.1	352
10	1.43115	18,466.5	138,129	50.6	378
30	1.04327	13,461.6	100,693	36.9	276
48	0.69773	9,003.0	67,342	24.7	184

Average Day Leachate Rates are calculated from the Average Annual Leachate Rates

TABLE 2.2 - AVERAGE ANNUAL AND AVERAGE DAY LEACHATE RATES
LANDFILL CELLS 9-13

Waste height	Average Annual Leachate Rates			Average Day Leachate Rates	
(ft)	(in)	(cf/sump)	(gal/sump)	(cf/sump)	(gal/sump)
0	1.33143	17,595.5	131,614	48.2	361
10	1.43115	18,913.4	141,472	51.8	388
30	1.04327	13,787.3	103,129	37.8	283
48	0.69773	9,220.9	68,972	25.3	189

Average Day Leachate Rates are calculated from the Average Annual Leachate Rates

TABLE 2.3 - PEAK DAY LEACHATE RATES FOR LANDFILL CELL 8

Waste height	Peak Day Leachate Rates		
(ft)	(in)	(cf/sump)	(gal/sump)
0	0.13165	1,739.8	13,014
10	0.01934	255.6	1,912
30	0.01646	217.5	1,627
48	0.01546	204.3	1,528

TABLE 2.4 - PEAK DAY LEACHATE RATES FOR LANDFILL CELLS 9-13

Waste height	Peak Day Leachate Rates		
(ft)	(in)	(cf/sump)	(gal/sump)
0	0.13165	1,739.8	13,014
10	0.01934	255.6	1,912
30	0.01646	217.5	1,627
48	0.01546	204.3	1,528

A peak day flowrate of 2.87 ft^3/ft-day was calculated using the highest peak day leachate rate (0.13165 inch/day), the longest flow path within the geocomposite (262 feet), and a flow width of 1-foot within the geocomposite. Applying a safety factor of 4.5 to the peak day flowrate (accounting for creep deformation of the geonet, biological clogging, and chemical clogging) results in a design leachate flow rate of 12.915 ft^3/ft-day. The geocomposite should have a minimum transmissivity of $6.0x10^{-4}$ m^2/sec to provide sufficient capacity to convey the design leachate flowrate within the leachate collection system to the leachate collection pipe and to the sumps. The conditions under which the geocomposite must meet the minimum transmissivity include a minimum normal loading of 6,400 lbs/ft^2, a gradient of 3.25%, a layer of soil for the upper boundary, and HDPE geomembrane for the lower boundary. Double sided geocomposite tests results showing a minimum transmissivity of $6.0x10^{-4}$ m^2/sec under more conservative testing conditions is acceptable.

The total drainage area contributing leachate flow to the 4-inch diameter HDPE perforated leachate collection pipe is 89,110 ft^2. Multiplying the peak day leachate rate (0.13165 inch/day) by the drainage area results in a flow rate of 5.1 gpm through each leachate collection pipe. A design flowrate of 23 gpm for the leachate collection pipe results when a safety factor of 4.5 is applied to the leachate flow rate. A slope of 0.12% (much less than the anticipated slope of 1.4% after differential settlement occurs) is required for a 4-inch diameter HDPE pipe to convey 23 gpm to the sumps assuming the pipe flows at 80% capacity to maintain gravity flow. Therefore, the leachate collection pipes have sufficient capacity to convey the peak day leachate rate to the sumps.

Leachate collected within the sumps will be removed using leachate pumps that will be installed in the sumps through leachate withdrawal pipes that extend from the sumps to the top of the embankment slopes directly above the sumps. The leachate collection sumps have a capacity of about 1,280 gallons at 1 foot of leachate depth above the lowest point in the sumps, 3,650 gallons prior to the leachate backing up onto the floor area outside the sumps (at the lowest point around the top perimeter of the sumps), and 4,380 gallons at full sump capacity (the total capacity in pore spaces of the rock and leachate withdrawal pipe within the leachate collection sumps at the highest elevation around the top perimeter of the sumps), and a total leachate storage capacity within the leachate collection sumps, the leachate withdrawal pipe, the geocomposite (leachate collection system), and the overlying protective soil cover (to 1-foot of depth above the lowest point around the top perimeter of the sumps) of about 8,190 gallons.

The average frequency that leachate may be pumped from the sumps depends on the rate at which leachate enters the sumps and the depth to which leachate is allowed to pond within the sumps to accommodate pumping operations. Based on average daily leachate rates projected using the HELP model (189 to 388 gallons per sump), the estimated pumping frequency will be between 3 and 7 days assuming a limiting leachate depth of 1 foot above the lowest point in the sumps. The estimated pumping frequency will increase to 10 to 19 days if the leachate depth in the sumps is allowed to reach the lowest point around the perimeter of the sumps (prior to backing up into the leachate collection system outside the sumps). There may, however, be precipitation events when waste placement within a cell is beginning and much of the protective soil cover on the floor area is still exposed. Assuming no waste, or very little waste, the peak day leachate rate obtained from the HELP model over the drainage area contributing to each sump is 12,706 gallons, which exceeds the total leachate storage capacity. Should a peak day condition occur, pumping will be required until leachate generated within the sumps slows to allow less frequent pumping to occur. When the waste level within the cells is about 10 feet the peak day leachate rate is only expected to be about 1,912 gallons and gradually gets lower as the waste level within the cells gets higher. Also, during dry periods of little to no precipitation, the leachate generation rate will be very low and the pumping frequency may be less than projected by the HELP model. The above information is intended to provide an estimate of conditions that may be experienced and provide a baseline frequency for leachate removal. The actual pumping frequency will be determined operationally based on recorded volumes as leachate is removed from the sumps.

As presented earlier in this report, the geocomposite has material properties chemically resistant to the waste materials and leachate expected to be present in the landfill cells, and strength sufficient to prevent collapse under the pressures exerted by overlying waste and cover materials. The safety factor of 4.5 applied to the design provides for creep deformation and the potential for biological and chemical clogging.

Leak Detection System (Bottom Leachate Collection and Removal System)

Utah Administrative Code R315-264-301(c)(3)(i)-(v)

The leak detection system must be capable of detecting, collecting, and removing leaks of hazardous constituents at the earliest practicable time through all areas of the top liner system likely to be exposed to waste or leachate during the active life and post-closure care period. The HELP model was used to determine potential leakage rates based on a good quality installation of the geomembrane materials with 1 defect per acre and 1 pinhole per acre. The following tables provide the estimated leakage rates for Landfill Cells 8-13 based on the HELP model assumptions. The sump drainage areas of Landfill Cells 9-13 are slightly larger than the sump drainage areas for Landfill Cell 8 resulting in higher leakage volume estimates. Therefore, leakage volume estimates for Landfill Cells 9-13 were also conservatively used for Landfill Cell 8. HELP model parameters and results and supporting calculations for the leak detection system are included in Appendix D.

TABLE 2.5 – AVERAGE ANNUAL LEAKAGE RATES FOR LANDFILL CELL 8

Waste height	Average Annual Leakage Rates			Average Day Leakage Rates	
(ft)	(in)	(cf/sump)	(gal/sump)	(cf/sump)	(gal/sump)
0	0.44601	5,755.0	43,047	15.8	118
10	0.46899	6,051.5	45,265	16.6	124
30	0.35085	4,527.1	33,863	12.4	93
48	0.24477	3,158.3	23,624	8.7	65

TABLE 2.6 - AVERAGE ANNUAL LEAKAGE RATES FOR LANDFILL CELLS 9-13

Waste height	Average Annual Leakage Rates			Average Day Leakage Rates	
(ft)	(in)	(cf/sump)	(gal/sump)	(cf/sump)	(gal/sump)
0	0.44601	5,894.2	44,089	16.1	121
10	0.46899	6,197.9	46,361	17.0	127
30	0.35085	4,636.7	34,682	12.7	95
48	0.24477	3,234.8	24,196	8.9	66

TABLE 2.7 – PEAK DAY LEAKAGE RATES FOR LANDFILL CELL 8

Waste height	Peak Day Leachate Rates		
(ft)	(in)	(cf/sump)	(gal/sump)
0	0.13165	1,698.7	12,706
10	0.01934	249.5	1,867
30	0.01646	212.4	1,589
48	0.01546	199.5	1,492

TABLE 2.8 – PEAK DAY LEAKAGE RATES FOR LANDFILL CELLS 9-13

Waste height	Peak Day Leachate Rates		
(ft)	(in)	(cf/sump)	(gal/sump)
0	0.13165	1,739.8	13,014
10	0.01934	255.6	1,912
30	0.01646	217.5	1,627
48	0.01546	204.3	1,528

Each of the landfill cells are divided into four sections or sump drainage areas with sumps located at the low points of the floor in each of the four sections. The leak detection system is located between the geomembrane components of the bottom and top liner systems throughout the entire lined area of the landfill cells. Leachate that leaks through the top liner system enters the leak detection system and is conveyed within the leak detection system to the sumps where the leachate is collected for leak detection and removal.

The floor within each sump drainage area is divided into two planar sections that are designed at slopes of 2.3% toward each other to form a valley along their line of intersection. The valley and the two planar sections of the floor also slope at a 2.3% slope toward the sumps. The resultant design slope of each of the planar floor sections is 3.25% which is at a 45 degree angle in the general direction toward the sumps. After projected differential settlement occurs, the minimum slope of the planar slopes directly toward (or perpendicular to) the valley formed by the intersection of the floor sections is about 1.7%. The minimum slope of the valley and the planar floor sections parallel to the valley after projected differential settlement is about 1.4% and the minimum resultant slope after projected differential settlement is about 2.3%.

The leak detection system consisting of a geocomposite, with a minimum transmissivity of 2.7×10^{-4} m^2/sec, will be installed between the top and bottom liner systems. This exceeds the minimum transmissivity requirements (3×10^{-5} m^2/sec) for geonets/geocomposites in the federal and state regulations.

As presented earlier in this report, the geocomposite has material properties chemically resistant to the waste materials and leachate expected to be present in the landfill cells, and strength sufficient to prevent collapse under the pressures exerted by overlying waste and cover materials. The amount of flow within the leak detection system is expected to follow flow paths that are downgradient from leaks that may be present in the top liner system. Should any clogging occur, flow paths will naturally widen to allow flow to the sump for quick detection of leaks and removal of leachate that enters the sumps.

The leak detection sump will consist of ¾-inch rounded washed rock which is assumed to have a porosity of 32%. The total sump capacity within the pore spaces of the rock is estimated to be 2,318 gallons. The pump for the leak detection system should have a minimum capacity of 7.5 gallons per minute. Assuming 4 hours of operation per day, the pump will have the capacity to remove 1,800 gallons of leachate per day (slightly higher than the maximum ALR) in the four hours of operation. Therefore the leak detection sump will have sufficient capacity within the void spaces of the rock and the pump will have sufficient capacity for collection and removal of leachate minimal potential for liquids backing up into the drainage system.

Leak Detection System Operation
Utah Administrative Code R315-264-301(c)(4) & (5)

Attachment II-3 of the Grassy Mountain Facility Permit requires inspections to occur at a minimum every 7 days for the presence of leachate in and for the proper functioning of the leak detection system. The inspection schedule provided should result in proper collection and removal of leachate within the leak detection system to maintain a leachate depth of less than one foot on the bottom liner system and to minimize the potential for liquids backing up into the drainage system. If leakage rates are sufficient to require more frequent inspection and removal of leachate from the leak detection system, the inspection schedule should be adjusted accordingly.

Should ground water elevations rise sufficiently to make contact with the bottom liner system, contact will most likely be limited to the lower portion of the bottom sumps since the floor area outside the sumps is above the existing ground surface elevation which is above the historic ground water elevation. If ground groundwater rises high enough to enter the leak detection system, it will need to flow through the compacted clay liner and must be exposed to a hole in the bottom geomembrane. Since groundwater will flow very slowly through the compacted clay liner and a very small area of the bottom geomembrane will be exposed to groundwater, effects of groundwater on the leak detection system will be negligible.

ALTERNATIVE DESIGNS, WAIVERS, AND EXEMPTIONS

Utah Administrative Code R315-264-301(d)-(f)

No alternative designs, waivers, or exemptions are requested regarding the design standards for the landfill cells.

RUN-ON CONTROL SYSTEM

Utah Administrative Code R315-264-301(g)

The landfill cells are constructed with raised embankments designed to be approximately 25 feet or more above the existing ground surface. The raise embankments will prevent storm water flows from surrounding areas from entering the active area the landfill cells.

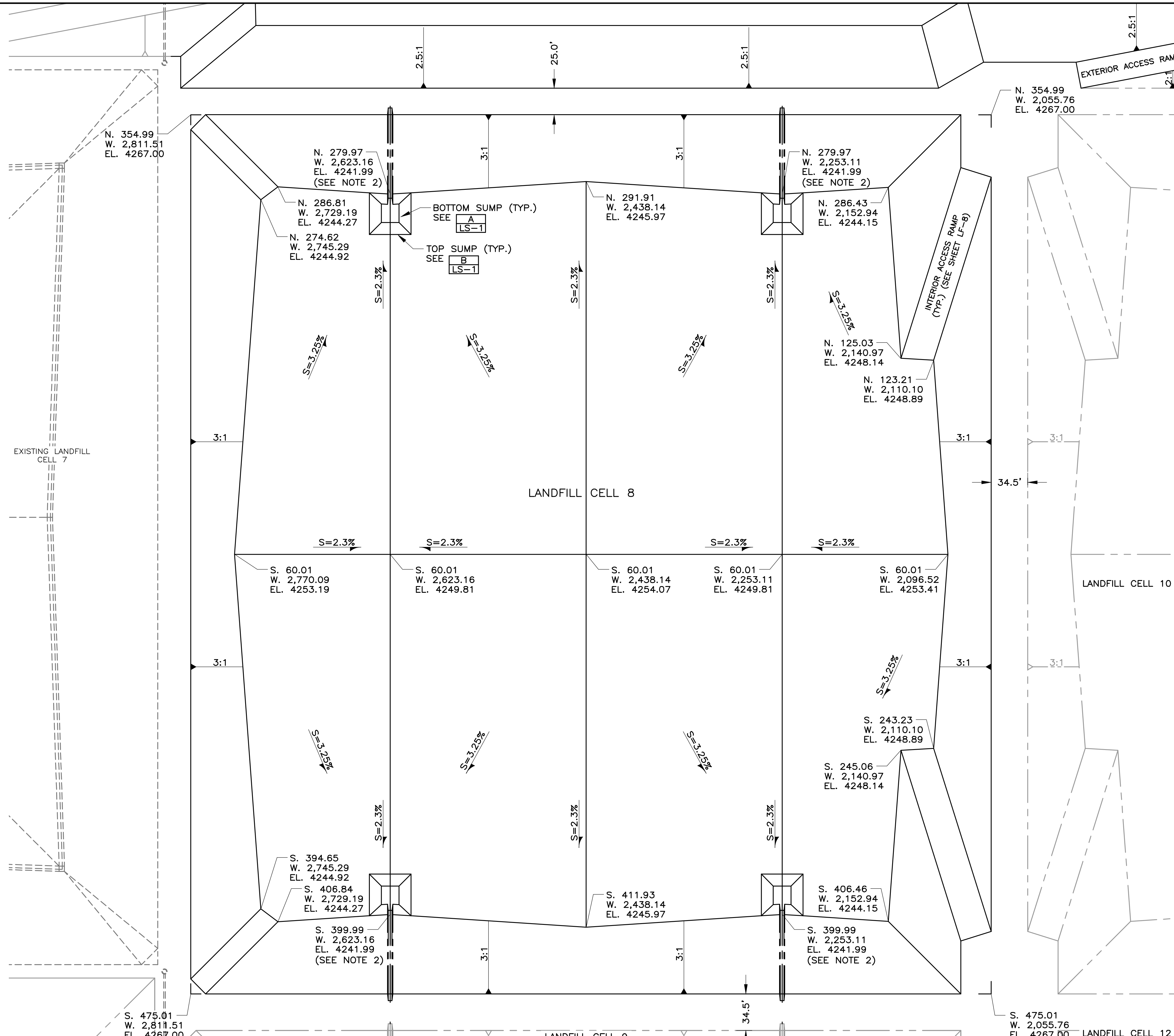
Closures of adjacent landfill cells are designed to collect and convey storm water off the top areas of the closure caps and to bottom outside toe of the cell embankments. Raised embankments of active landfill cells will prevent storm water from entering active areas of those cells once storm water from adjacent closure caps is conveyed to the bottom outside toe of the cell embankments.

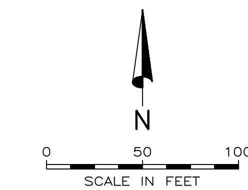
Erosion Protection

Erosion protection of embankments and closure caps outside the active areas of the landfill cells is a part of run-on control and for long term protection of the embankments and closure caps. On-site observations show that erosion of the exterior embankment slopes and closure caps of the existing landfill cells at the Grassy Mountain Facility has generally been effectively controlled by the placement of a gravel layer (stone mulch or gravel armor plating) on the embankment slopes and closure cap surfaces. All outside slopes and top surfaces of the raised embankments and all surfaces of the closure caps are designed to receive a six-inch thick layer of stone mulch.

Use of the stone mulch material is in keeping with procedures for controlling erosion on steep side slopes of embankments or cuts as proposed by the Federal Highway Administration in the National Cooperative Highway Research Project NCHRP Report 221 "Erosion Control During Highway Construction Manual on Principles and Practices," (Israelsen, et. al., 1980). The principles presented in this manual were developed for the Transportation Research Board by personnel of the Utah Water Research Laboratory, College of Engineering, Utah State University in Logan, Utah. These same principles, but specific to Utah, were published by the Utah Water Research Laboratory in a report entitled, "Erosion and Sedimentation in Utah: A guide for Control," (Israelsen, et. al., 1984).

The above referenced documents identify a procedure for designing a "stone mulch" to provide erosion control on steep embankment slopes. The stone mulch (gravel armor plating) material used historically at the facility and proposed for use on Landfill Cells 8-13 meets the criteria for





NOTES:

1. COORDINATES & ELEVATIONS ARE TOP OF COMPACTED CLAY LINER.
2. SUMP REFERENCE POINT SEE SHEET LS-1 FOR SUMP PLAN.
3. ALL LINES SHOWING THE INSIDE OF LANDFILL CELLS ARE DEPICTING TOP OF CLAY SURFACE.

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\LF-1 CELL 8 PLAN VIEW_R1.DWG
FILE DATE: 8.6.2018 11:32:47 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED KCS	3					SCALE NOT TO SCALE
DRAFTED CAH	2					
CHECKED GLJ	1					
DATE AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.	

CleanHarbors ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8–13
LANDFILL
PLAN VIEW CELL 8

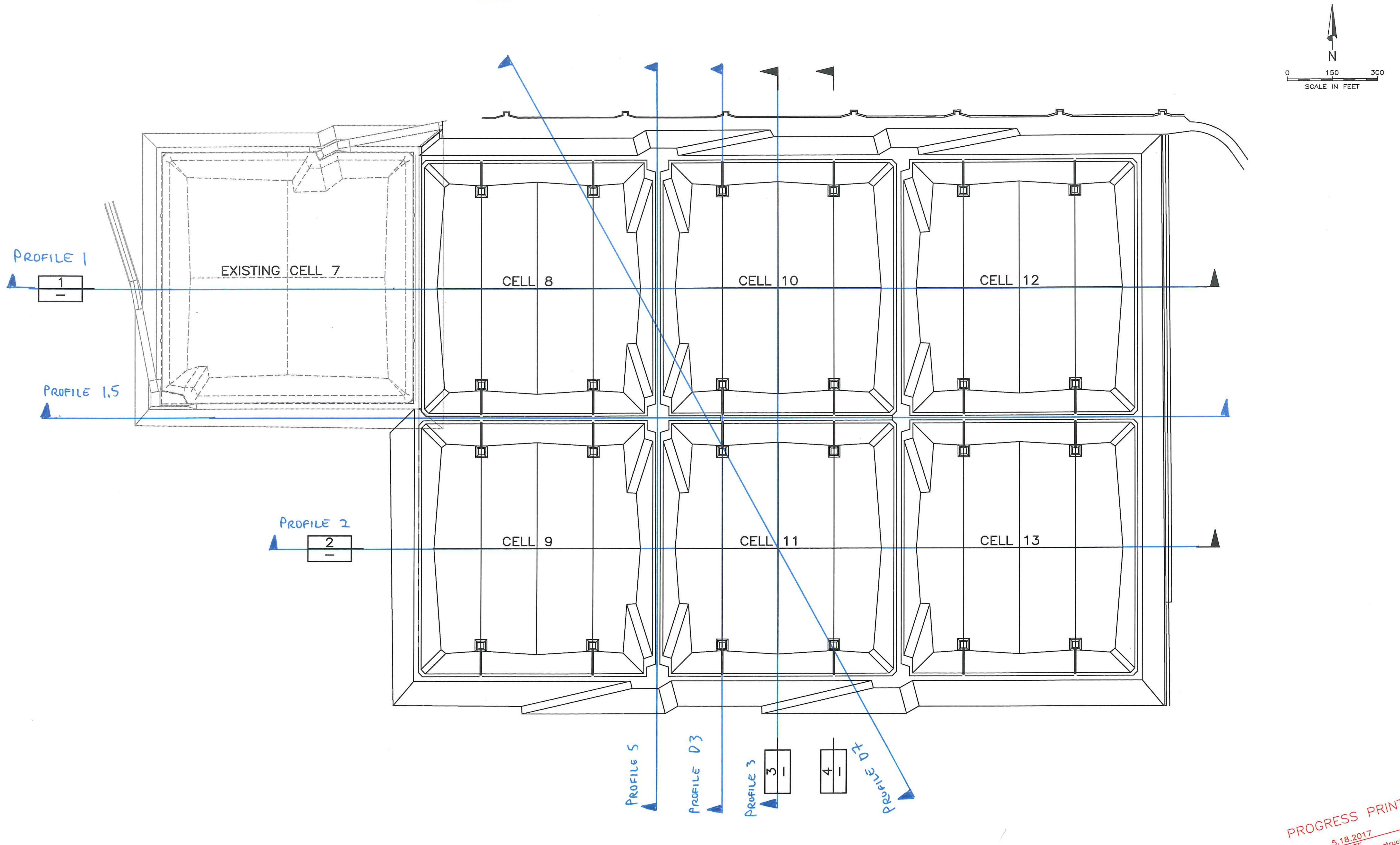
SHEET LF–1

064.85.100

10/07

CLEAN HARBORS 1160246 TJN 6/29/17

Predicted Settlement Profiles



PLAN VIEW

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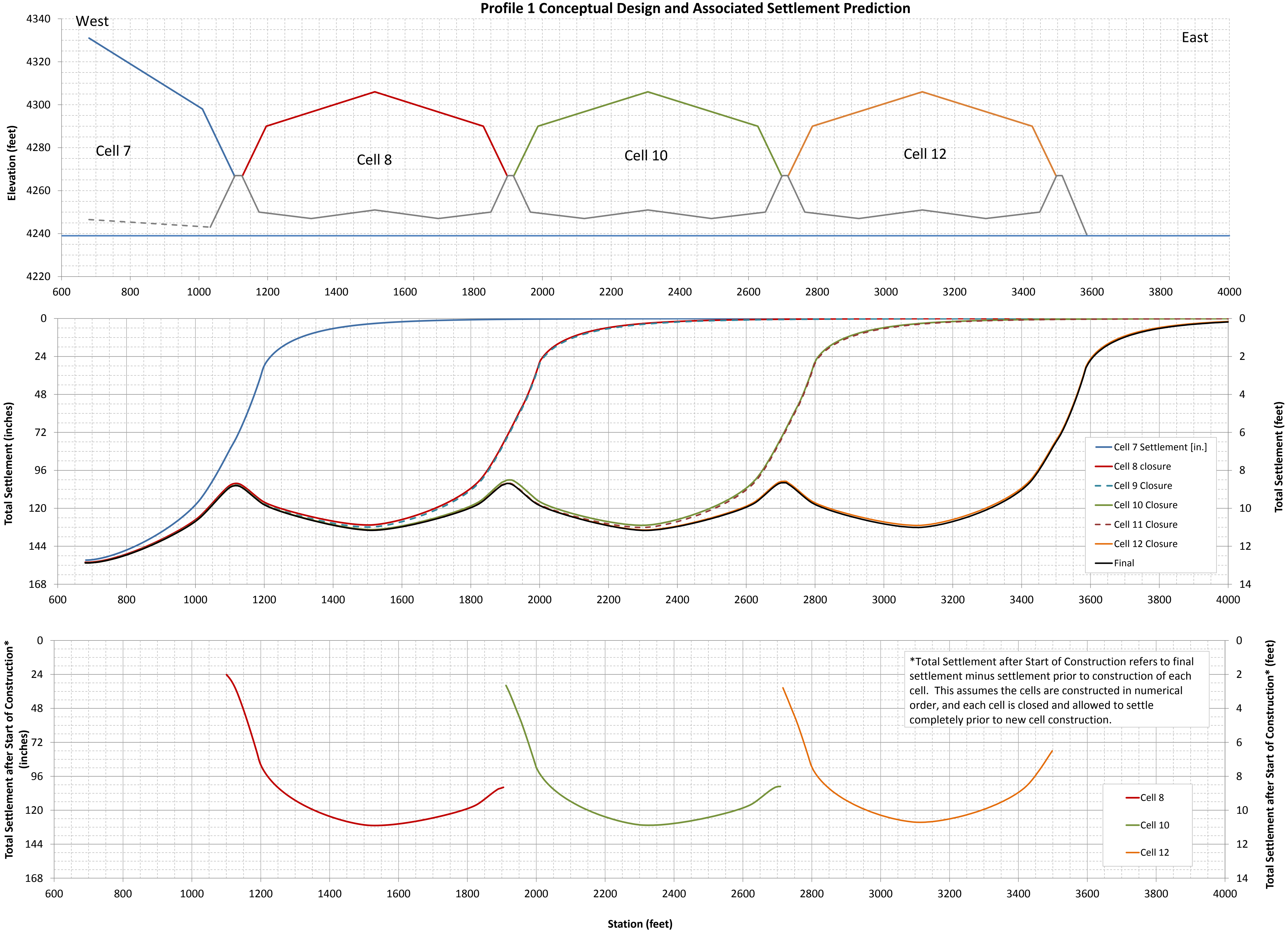
Hansen, Allen, & Luce, Inc.
Consultants/Engineers

Profile 1 Conceptual Design and Associated Settlement Prediction



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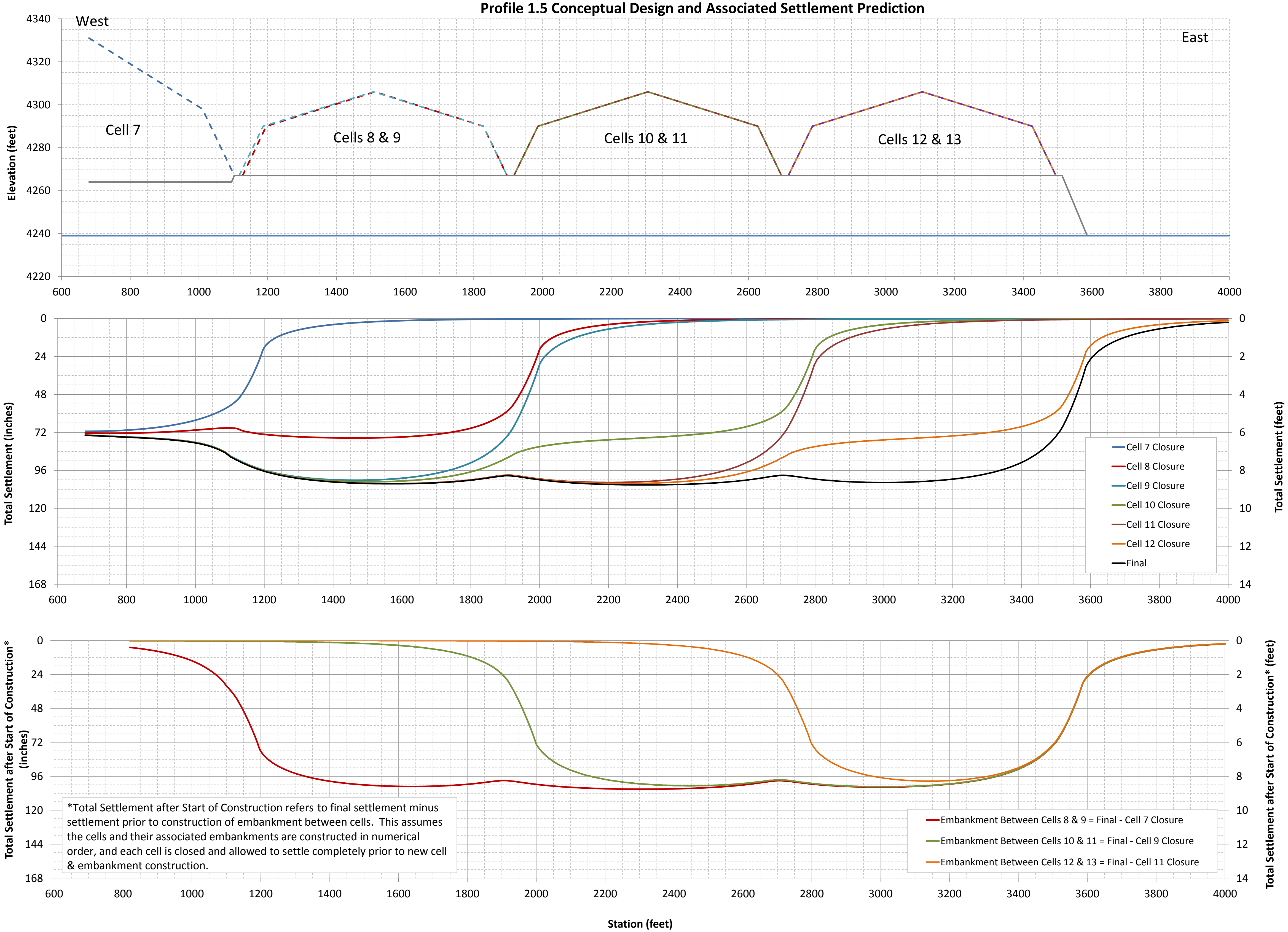
Profile 1.5 Conceptual Design and Associated Settlement Prediction



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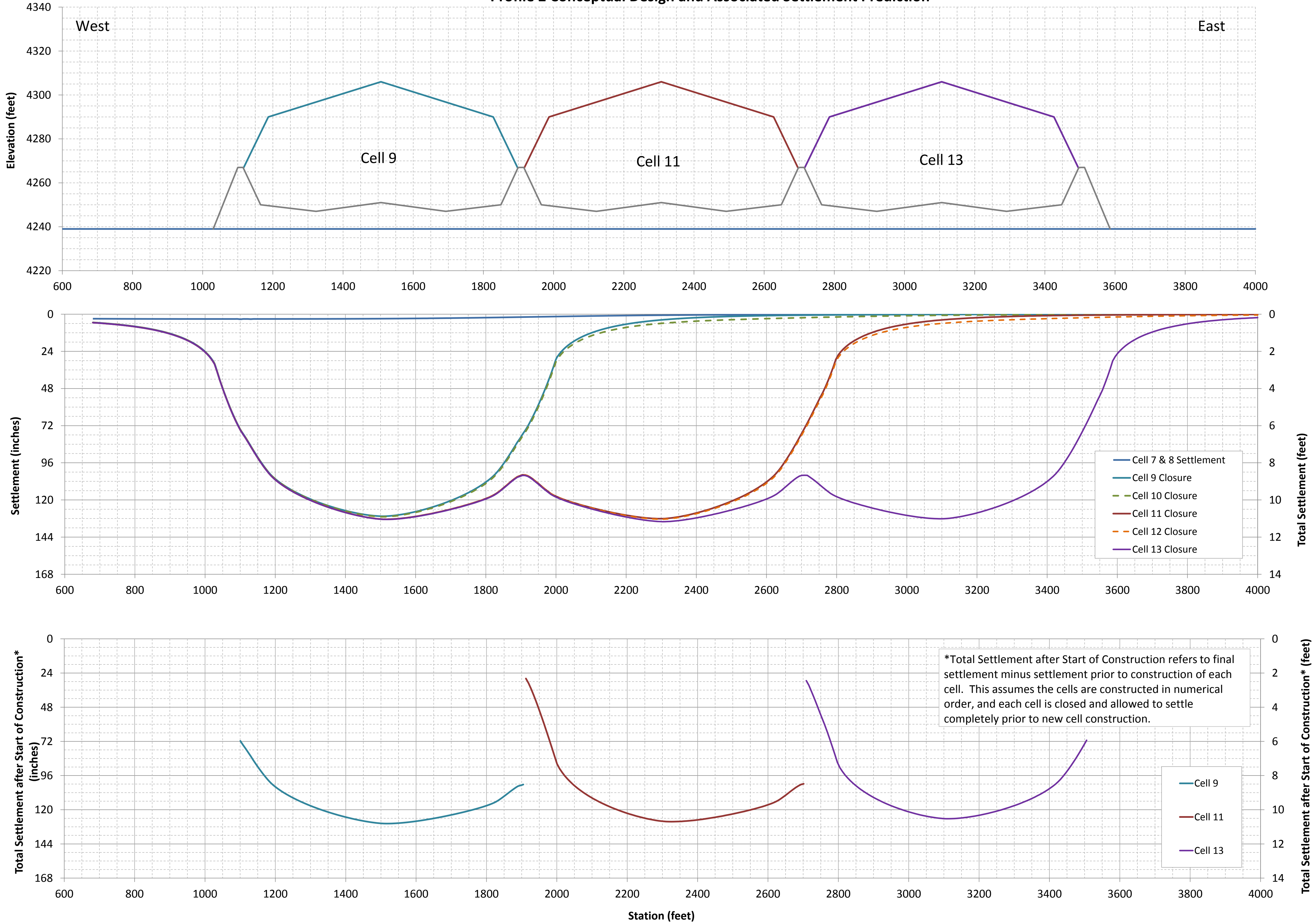
Profile 2 Conceptual Design and Associated Settlement Prediction



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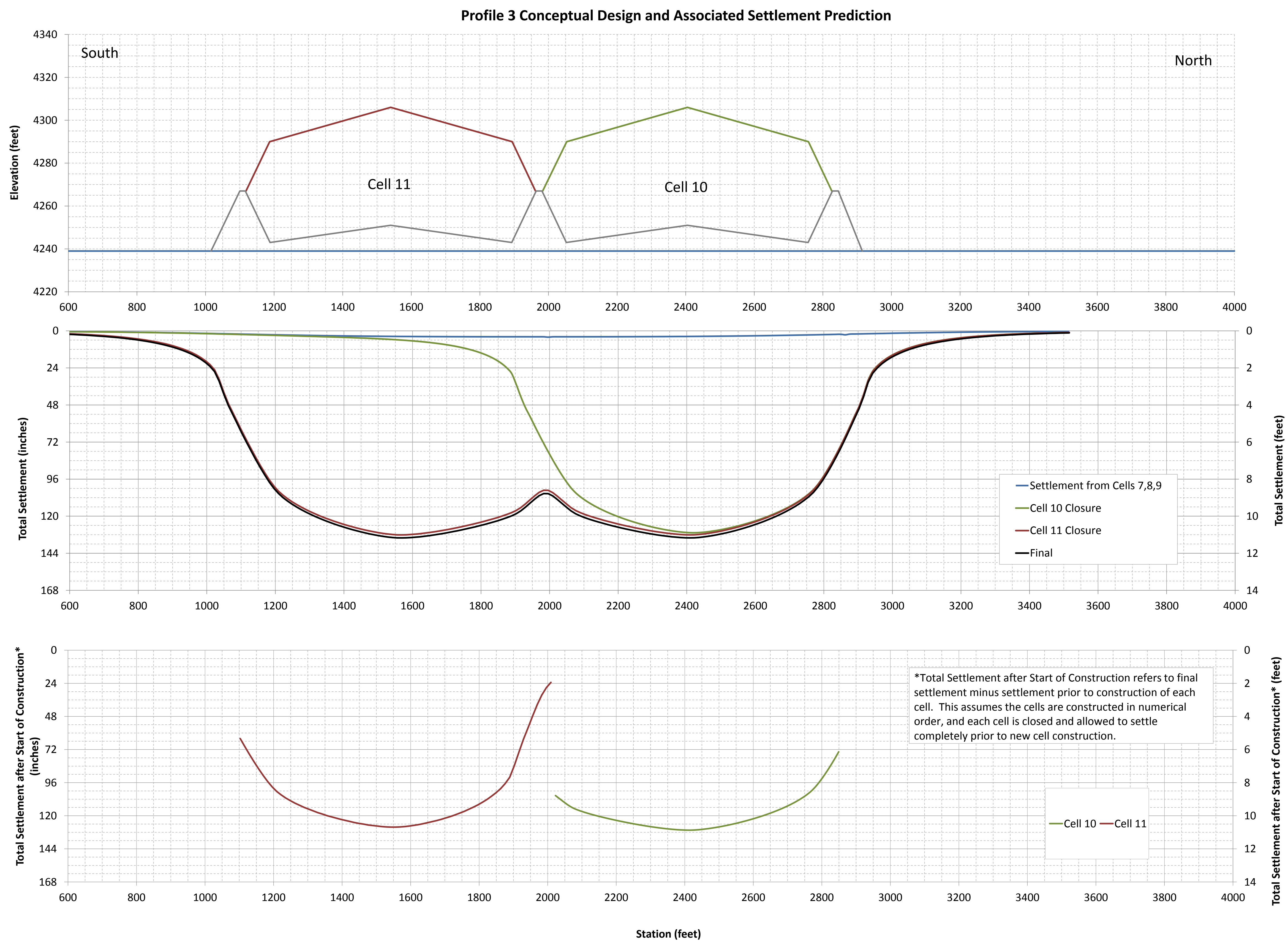
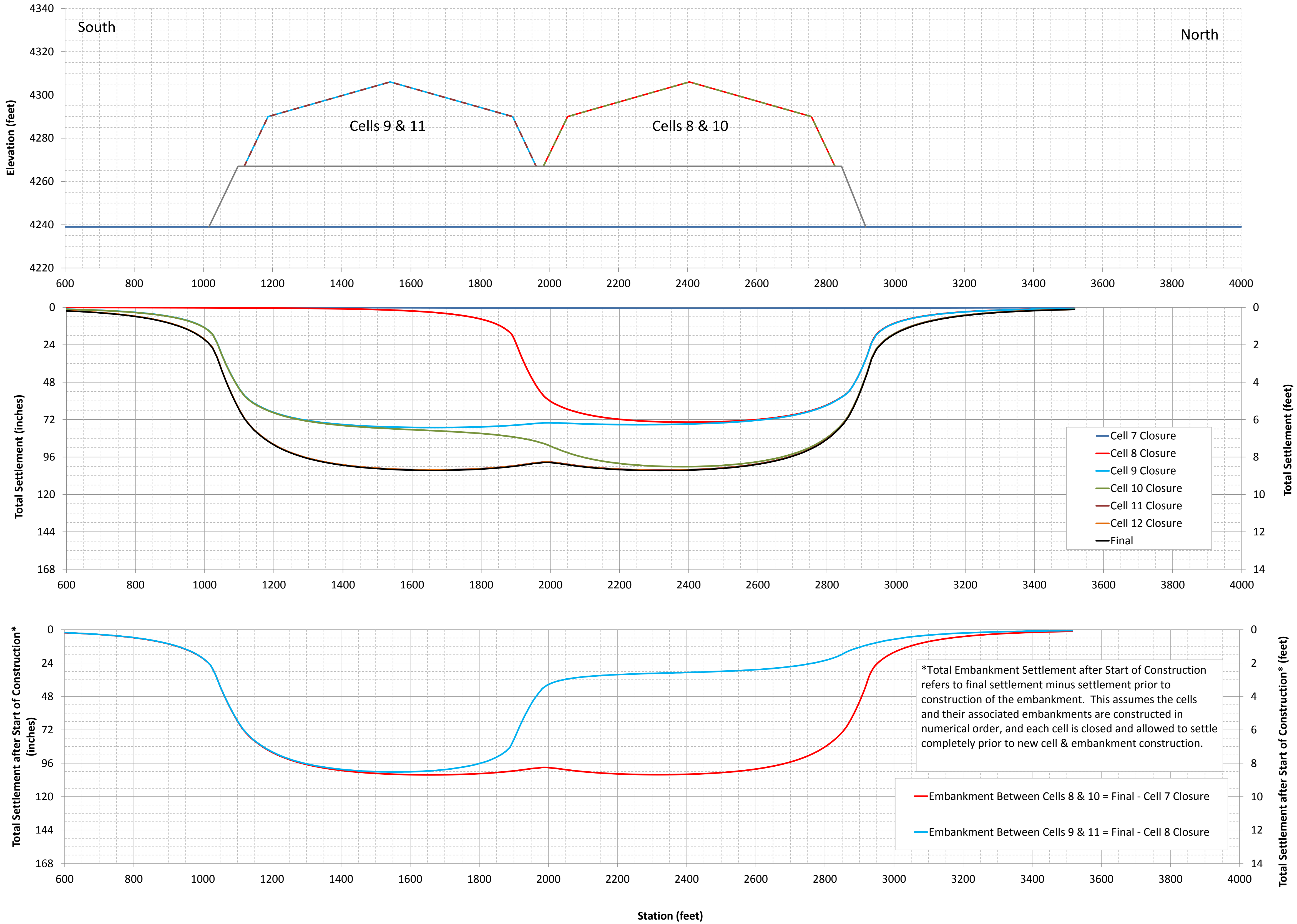


Profile 3 Conceptual Design and Associated Settlement Prediction
South
North
Cell 11
Cell 10
Elevation (feet)
Total Settlement (inches)
Total Settlement (feet)
Settlement from Cells 7,8,9
Cell 10 Closure
Cell 11 Closure
Final
Total Settlement after Start of Construction* (inches)
Total Settlement after Start of Construction* (feet)
*Total Settlement after Start of Construction refers to final settlement minus settlement prior to construction of each cell. This assumes the cells are constructed in numerical order, and each cell is closed and allowed to settle completely prior to new cell construction.
Cell 10
Cell 11
Station (feet)

Profile 5 Conceptual Design and Associated Settlement Prediction



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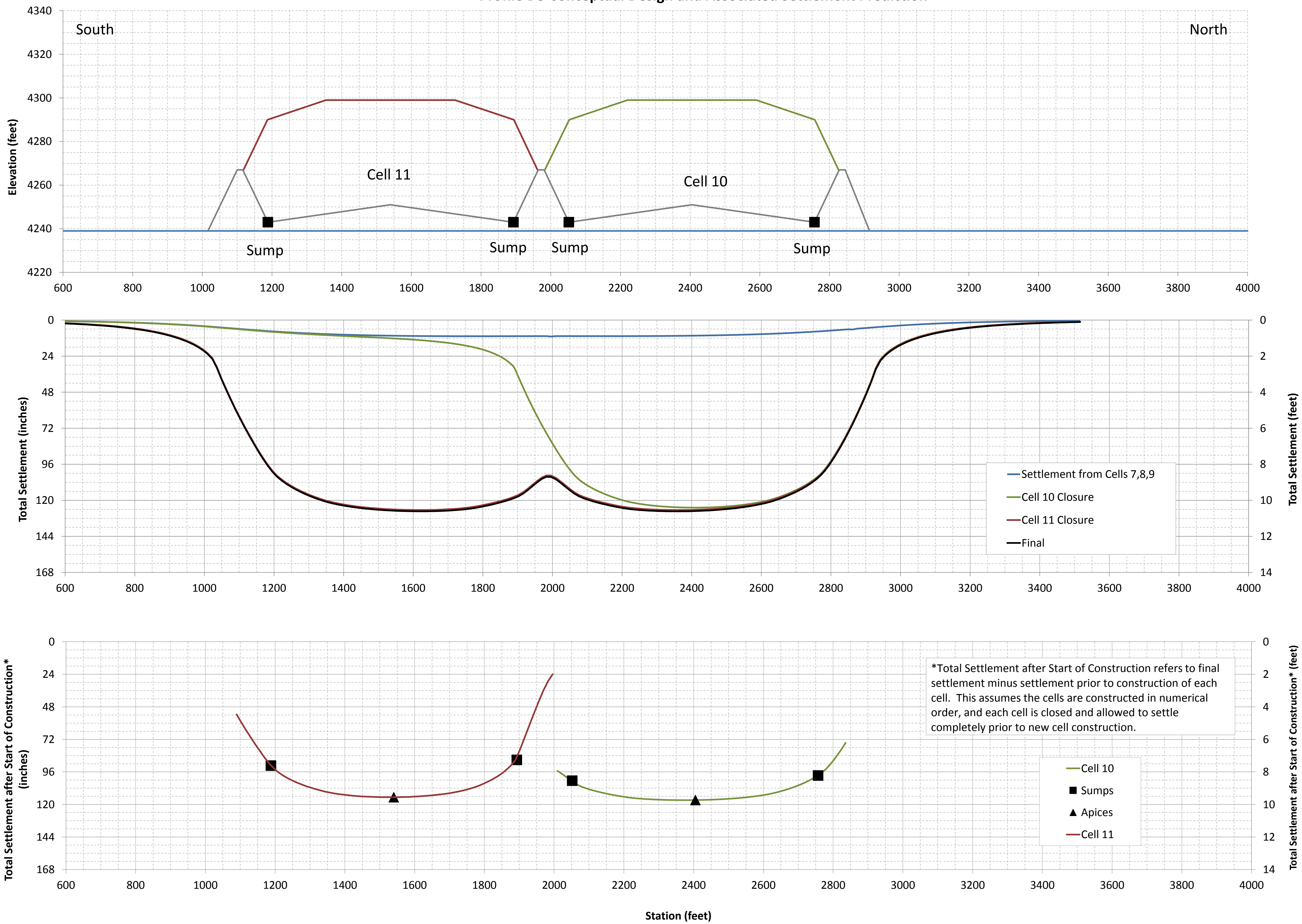
Profile D3 Conceptual Design and Associated Settlement Prediction



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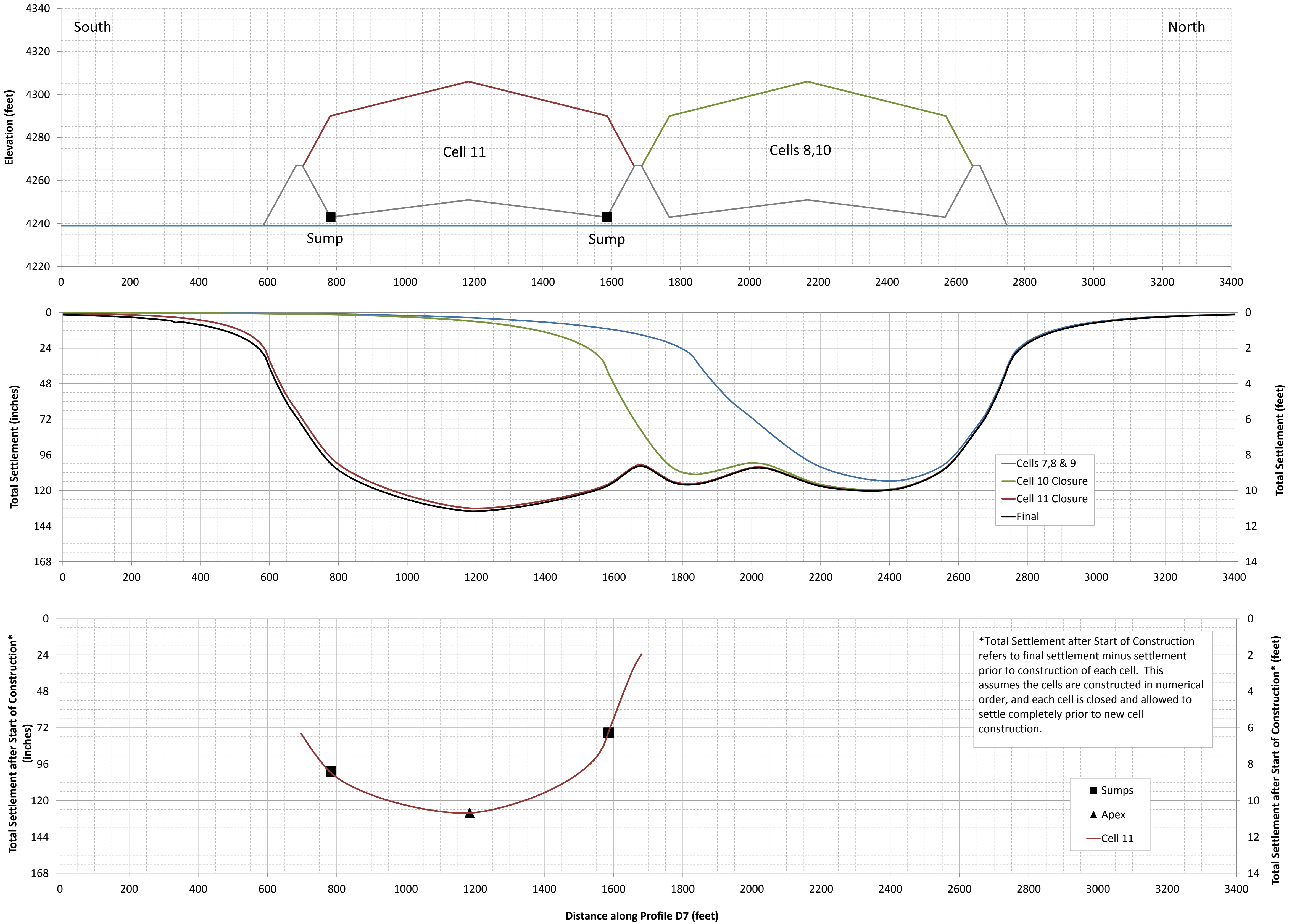
Profile D7 Conceptual Design and Associated Settlement Prediction



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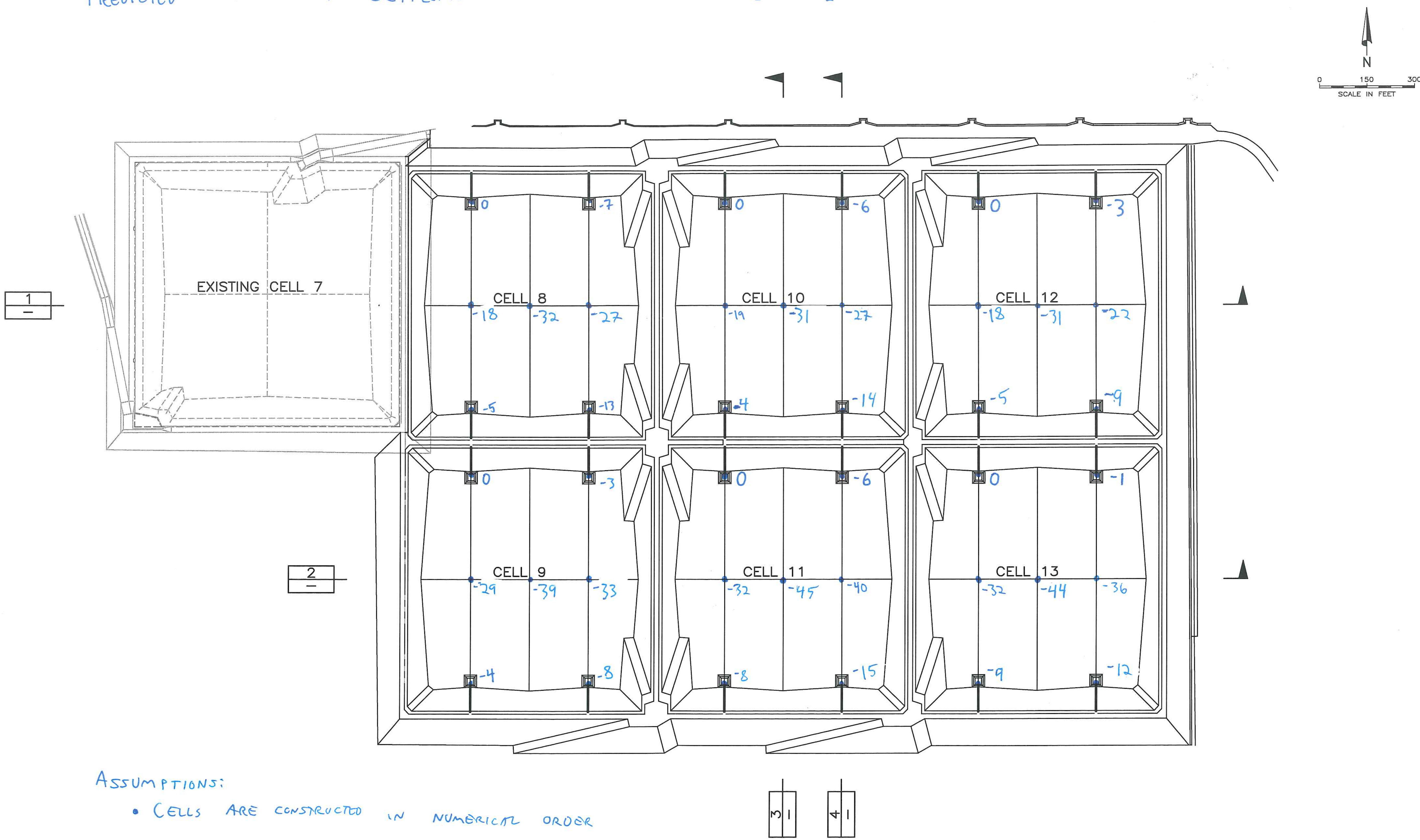
Clean Harbors 116024-6 IJN 6/29/17
Updated 10/2/17

Predicted Differential Settlement within Each Cell [Inches]



Assumptions:

- Cells are constructed in numerical order
- Each cell is closed and allowed to settle completely prior to new cell construction

Individual datums (0) set for each cell, as the highest of the 7 points labelled for any given cell.

PLAN VIEW

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Consultants/Engineers

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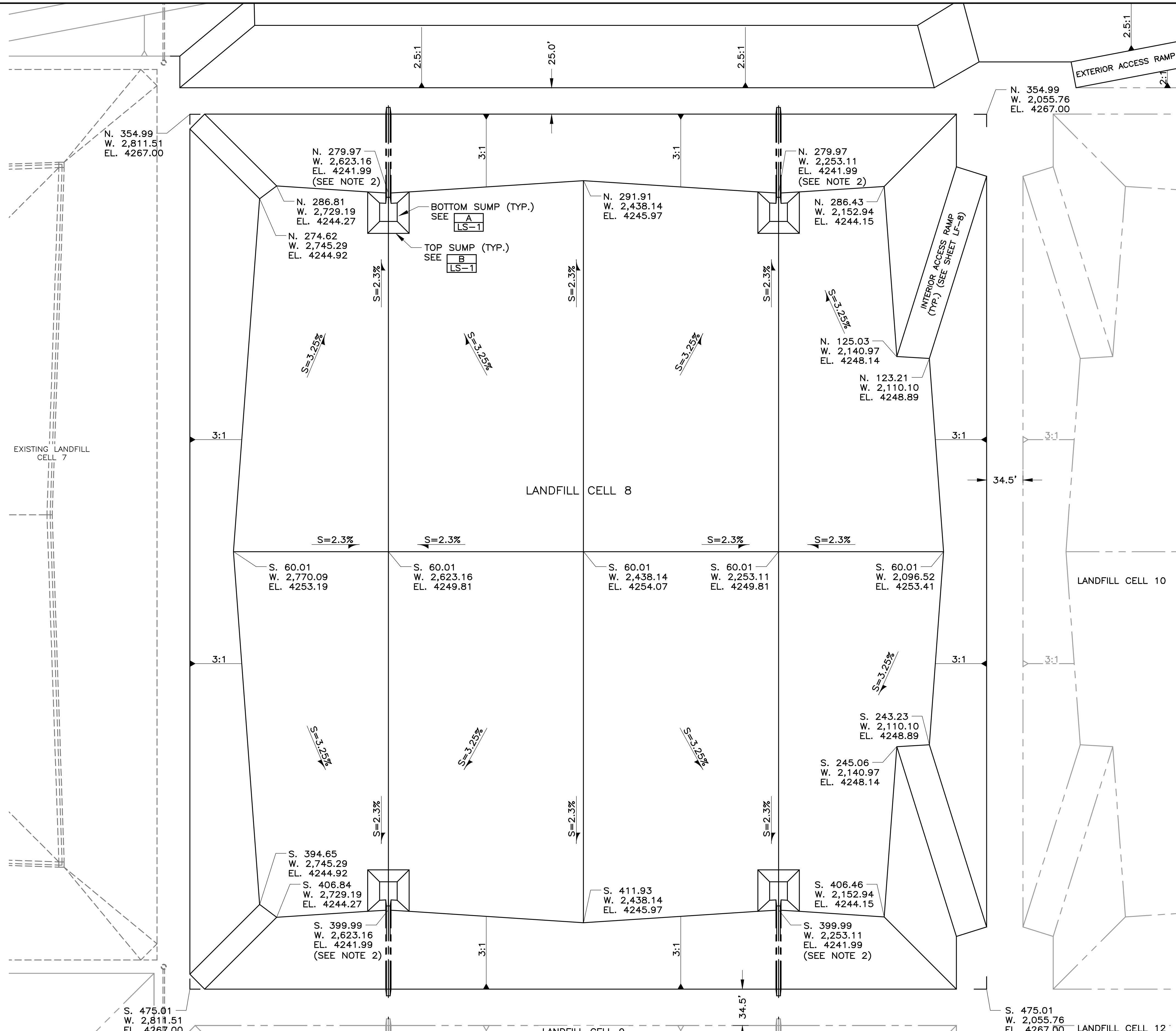

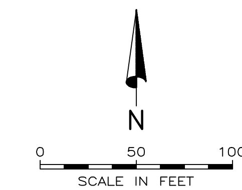

NOTES:

1. COORDINATES & ELEVATIONS ARE TOP OF COMPACTED CLAY LINER.
2. SUMP REFERENCE POINT SEE SHEET LS–1 FOR SUMP PLAN.
3. ALL LINES SHOWING THE INSIDE OF LANDFILL CELLS ARE DEPICTING TOP OF CLAY SURFACE.

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HANSEN ALLEN & LUCE inc ENGINEERS

PROFESSIONAL ENGINEER No. 5048470-2202 GORDON L. JONES 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

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SCALE
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CleanHarbors® ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8–13
LANDFILL
PLAN VIEW CELL 8

SHEET
LF–1
064.85.100

10/07

CLEAN HARBORS
GRASSY MOUNTAIN FACILITY

LANDFILL CELLS 8 THROUGH 13
DESIGN ENGINEERING REPORT

(HAL Project No.: 064.85.100)

AUGUST 2018 Rev 1

CHAPTER 3 – STORM WATER MANAGEMENT

GENERAL DESCRIPTION OF STORM WATER MANAGEMENT SYSTEM

Storm water management at the Grassy Mountain Facility provides for the control of surface water drainage resulting from precipitation events on and around the landfill cells and surface impoundments. A portion of the precipitation that falls on the site will infiltrate directly into the ground, a portion will evaporate, some will adhere directly to vegetation, soil, and gravel surfaces, and some will run off and be directed towards collection points or drainage ditches, and then conveyed to containment ponds or retained in containment areas. Run-off management will include systems capable of collecting and containing the volume of storm water runoff from within active waste containment areas of the landfill cells and surface impoundments. Run-on management will consist of systems designed to collect, convey, and contain storm water runoff from non-contaminated areas outside active waste containment areas. These areas include the tops and exterior slopes of landfill cell and surface impoundment embankments, landfill cell closure caps, ground surfaces surrounding landfill cells and surface impoundments, containment dikes, conveyance facilities, and containment ponds.

It should be noted that use of the single, non-hyphenated word "runoff" is applied as a general term to all storm water that generates flows and volumes of water used for design of the run-off and run-on systems. Design of run-off and run-on storm water management systems are required to collect, convey and contain runoff water resulting from a 25-year, 24-hour storm event. Clean Harbors has conservatively chosen to design the systems based on a 100-year, 24-hour storm event.

Due to the flatness of the terrain on which the Grassy Mountain Facility is located; storm water control facilities are needed to minimize accumulation of storm water along the exterior toes of embankment slopes and in low lying areas around the facility that may be a nuisance to facility operations. The existing storm water containment ponds at the facility provide a destination point for storm water to collect inside the containment dike systems inside the facility property. Existing conveyance ditches have been designed to collect and convey uncontaminated storm water to the storm water containment ponds. Design of run-off and run-on storm water management systems in this report is specific to Landfill Cells 8-13 and facilities affected by storm water runoff from those cells and there closures. This report does not discuss storm water management for other areas of the Grassy Mountain Facility.

HYDROLOGY

Hydrologic calculations were completed for the Landfill Cells 8-13 to determine peak flows and volumes for design purposes. The Soil Conservation Service (SCS) curve number methodology was used in conjunction with the Army Corps of Engineers HEC-HMS hydrology model to predict the peak flows and volumes.

Run-Off Management System

The run-off management system inside Landfill Cells 8-13 the landfill includes maintaining sufficient storage capacity inside of these facilities (while open and operating) to totally contain precipitation from the 100-year, 24-hour precipitation event. A discussion regarding containment of precipitation inside the landfill cells is provided in Chapter 2 under the section titled “Run-off Management System.”

Run-On Management System

The run-on management system is designed to collect, convey, and contain storm water runoff from landfill cell closure caps and embankments in a way that will protect the integrity of the landfill cells. This is accomplished by sloped surfaces, berms, pipes, open channels, and ponds as presented in the permit drawings provided in Appendix A. Supporting calculations are provided in Appendix F.

Methodology. Delineation of the sub-basins for Landfill Cells 8 through 13, shown in the figure included in Appendix F, was based on the landfill cell design discussed in Chapter 2. Each sub-basin is designed to drain runoff water directly off of closure caps and cell embankments or to direct flows to downspout and storm water pipes that convey runoff off the closure caps and cell embankments. Additional storm water facilities will then collect storm water discharged from the cells and convey the storm water to containment areas in the facility.

Curve numbers are generally determined based on the hydrologic soil type, soil vegetative cover, and other surface conditions. The hydrologic soil type is a general indication of the soil’s infiltration capacity. Soils are assigned a hydrologic soil type of A, B, C or D by the Natural Resource Conservation Service (NRCS). Soils of hydrologic soil type A have the highest infiltration rate, and therefore produce the least amount of runoff. Soils of hydrologic soil type D have the lowest infiltration rate, and therefore produce the highest amount of runoff. Cover conditions are usually combined with the hydrologic soil type to produce a curve number based on Table 2-2d of Technical Release 55 “Urban Hydrology of Small Watersheds” (TR-55). In order to remain consistent with previous hydrologic calculations for design and permitting of previous cells, a curve number of 83 was selected for the model.

The lag times (T_L), defined as the time to the hydrograph peak, were calculated by using the time of concerntration (T_C) and the equation $T_L = 0.6T_C$. The time of concentration was calculated using the criteria found in Worksheet 3 in TR-55 with a minimum lag time of 3.6 minutes being applied to sub-basins where the calculated value was less than 3.6 minutes. Lag times for the delineated sub-basins are provided in Appendix F.

The SCS Type II Distribution was used with the 100-year 24-hour storm, exceeding the requirement of R315-264-251(g). The rainfall amount was taken from the Point Precipitation Frequency Estimates from NOAA Atlas 14, based on a location defined at the center of the study area. The value of the 100-year 24-year precipitation event is 1.85 inches.

Peak Design Flows. The hydrologic parameters presented above were used in the HEC-HMS model to generate peak design flows for each of the subbasins defined for the cells and their closures and for the downspout and other storm drainage piping located at along the landfill cell embankments.

HYDRAULICS

The peak flow rates based on the hydrologic modelling discussed above provided the basis for the design of the drainage conveyances. Hydraulic capacity for channels and pipes was determined using Manning's equation. Should channel or pipe capacities be exceeded and cause temporary flooding of roads and other facility areas in extreme precipitation events, the raised embankments of the landfill cells will prevent the run-on storm water from entering the active waste disposal areas. Water from extreme events then is limited to be nuisance water for facility operations.

Storm Drainage Channels

An existing channel along the north sides of Landfill Cells 8, 10, and 12 currently receives storm water runoff from portions of Cells 3, 4, 5, and 6 and conveys the water to the pond located east of Landfill Cell 12. An existing 24-inch diameter storm drainage pipe is currently provided to convey the peak design flow (16 cfs) from the channel to the containment pond.

The projected peak flow (29 cfs) from the northeast quarter of Cell 7 and from the north sides of Cells 8, 10, and 12 (resulting from the HEC-HMS model) will combine with the current peak flow (16 cfs) and will convey the storm water through the channel to the east containment pond. Pipes conveying runoff from the Cells 8, 10, and 12 will discharge into the channel through energy dissipation outlet structures. The channel is formed by the outside embankment slopes of Landfill Cells 4, 5, and 6 on the north side and the access road to Landfill Cells 8, 10, and 12 on the south side. The channel has a bottom slope of 0.1 percent and will behave much like a series of retention ponds behind each monitoring well mound that extends to the north from the access road. At a flow depth of 2 feet, storm water will flow past the monitoring well mounds at about 3 fps and will flow in the wider portions of the channel at less than 1 fps.

Replacing the existing 24-inch diameter storm drainage pipe with three 24-inch diameter pipes will provide the added capacity to convey the peak flow of 45 cfs from the channel into the containment pond with a head water depth of about 2.3 feet. The pipes should be installed at the time the closure cap for Landfill Cell 8, 10, or 12 is constructed and the invert of the pipes should be installed a minimum of 3 feet below the road surface, or nearby monitoring well pads. The depth may also be provided by constructing the access road and setting other facilities to a height that is 3 feet above the bottom of the channel at the pipe inlet, by installing a concrete inlet box that allows the channel bottom to drop suddenly to the invert of the pipes, or by providing a slope in the channel near the inlet to the pipes and providing concrete, rip rap, or some other form of erosion protection for the steeper slope.

A proposed channel on the east side of Cells 12 and 13 will convey runoff from parts of Cells 10, 11, 12, and 13 to a containment pond south of Cell 13. Pipes conveying runoff from the top of the landfill cells and their closure caps will discharge into the channel through energy dissipation outlet structures. The channel is 13 feet wide and has a projected peak flow of 29 cfs. The first reach of the channel is designed with a slope of 0.1% bottom slope resulting in a calculated flow depth of 1 foot and flow velocity is 1.7 fps which is a non-eroding velocity. The second reach of the channel is the pond inlet and is designed with a bottom slope of 2.6%. The calculated velocity is 5.1 fps (an eroding velocity) and 6 inches of rock erosion protection (D_{50} = 3 inches) is needed.

There are two inlet channels to the proposed pond west of Landfill Cell 9 that convey storm water from the storm drainage downspout pipes on the west side of Cell 9 to the pond. The north inlet channel has a bottom width of 10 feet, a bottom slope of 2.1%, and a projected peak flow rate of 25 cfs. The calculated flow depth is 0.4 foot resulting in an erosive velocity of 4.8 fps requiring 6 inches of rock erosion protection (D_{50} = 3 inches). The south inlet channel has a bottom width of 10 feet, a bottom slope of 1.5%, and a projected peak flow rate of 5 cfs. The calculated flow depth is 0.2 foot resulting in a non-erosive velocity of 2.4 fps requiring no erosion protection.

Storm Drainage Pipes

Hydrologic calculations for runoff described above were used to determine the design flows for the downspouts pipes to convey storm water off the closure caps and off the top of the common cell embankments. The downspout pipes are designed with a diameter of 18 inches to convey to peak storm water flow of 2.4 cfs off the closure caps, to provide ease of cleaning, and to reduce the potential of plugging. The steep slope of the downspout pipes provides for inlet control conditions and a head water depth of 0.65 foot for the 2.4 cfs to enter the downspouts. The height of the berms at the corners of the closure caps is approximately 2.5 feet above the downspout inverts resulting in about 1.8 feet of freeboard.

Embankments between the closure caps are designed to be graded at a 1% slope toward manholes with grated inlets. Storm water will enter the manholes through the grated inlets and will then be conveyed through 18-inch diameter and 24-inch diameter drainage pipes to the bottom of the outside embankments of the cells. The storm drainage pipes along the top of the east/west common embankments are designed at a slope of 0.5% and have sufficient capacity to receive and convey the combined projected peak flows from the closure caps and tops of the common cell embankments to the bottom of the east and west bottom toes of the cell embankments. Storm water will discharge from the pipes through energy dissipation structures to storm drainage channels or graded surfaces that will convey the storm water to containment ponds and containment areas within the berm system surrounding the facility.

As presented earlier with the north storm drainage channel, three 24-inch diameter culverts will be installed under the access road to convey storm water from the north drainage channel to the east containment pond. The culverts have the capacity to convey the projected peak flow of 45 cfs to the pond with 2.3 feet of head water depth. The inlet to the culverts will be installed at a depth that is at least 3 feet below the surface of the access road and the nearest monitoring well pad. This will provide a minimum 0.7 foot of freeboard to the road surface and monitoring well pads.

RUNOFF VOLUME AND STORM WATER CONTAINMENT

Runoff volumes were determined through the hydrology methods described above. Runoff from the 100-year 24-hour precipitation event will be wholly contained in three containment ponds located on the site. Supporting calculations are provided in Appendix F.

The east containment pond currently is located south of Cell B6 and will be east of Cell 12 and has a current capacity of 9.0 acre feet for containment of storm water from portions of Cells 3, 4, 5, and B6, from Cells X, Y, and Z, and from facility areas and roads around those cells.. The east containment pond will be expanded to accommodate additional an additional 1.74 acre feet (a total minimum capacity of 10.74 acre feet) for storm water that will be received from the north half of Cells 8, 10, and 12, and the northeast quarter of Cell 7 as seen in appendix F. Expanding the existing pond an additional 208.5 feet will provide the capacity needed.

The west containment pond will be located west of Cell 9 and south of Cell 7. The containment pond will receive storm water from portions of Cells 7, 8, 9, 10, and 11, the proposed Surface

Impoundment B embankments and some of the surrounding areas. The west containment pond will be provided with a minimum capacity of 3.0 acre feet. A pond that has equivalent floor dimensions of 130 feet x 295 feet and a depth of 4 feet will provide the required capacity. This will provide a water depth of 3 feet and allow for 1 foot of freeboard.

The south containment pond will be located south of Cell 13 and will receive storm water from portions of Cells 10, 11, 12, and 13 and some of the surrounding area. The south containment pond will be provided with a minimum capacity of 3.37 acre feet. A pond that has equivalent dimension of 212 feet x 212 feet and a depth of 4 feet will provide the required capacity. This will provide a water depth of 3 feet and allow for 1 foot of freeboard.

The complete area to the west, south, and east of the proposed landfill cells is also within the berm system for the former land treatment area that has been cleaned and closed. The south and west ponds are also within the berm system. Therefore, the south and west ponds have an added containment system and any storm water from areas within the berm system will naturally be contained on the facility. The facility will provide drainage and containment areas as needed to control nuisance water and to facilitate facility operations.

APPENDIX F

Storm Water Management Calculations

Purpose: To design the storm drainage facilities to convey runoff from the closure cap and cell embankments.

Method: The SCS curve number method was used in a HEC-HMS hydrology model.

Required: In order to calculate the runoff, the following steps and information are required:

- A delineation of the tributary area.
- A representative Soil Conservation Service (SCS) curve number (CN) for the tributary area.
- Lag time.
- Storm Distribution.
- 100-year 24-hour precipitation depth.

Delineation: The delineation of the subbasins, shown in Figure 1, was based on the landfill cell closure cap design. Each basin would drain into a channel which would convey the runoff to an inlet that conveys the water to an open ditch or an additional storm drain network (Shown on Figure 2).

Curve Numbers: In order to match the design for surrounding cells, a curve number of 83 was selected for the model. The cell cap will be a gravel cover over a silty sand layer over an impervious liner.

Precipitation: A 100-year 24-hour event was conservatively used for the design storm. The rainfall amount was taken from the "Point Precipitation Frequency Estimates from NOAA Atlas 14. The value for a 100-year 24-hour event was 1.85 inches.

Storm Distribution: The distribution used for the 24-hour event was the SCS Type II.

Lag Time: Lag time (T_L) for each subbasin was calculated by using the time of concentration (T_C) and the equation $T_L = 0.6T_C$. T_C was calculated using Worksheet 3 in TR-55. A minimum lag time of 3.6 minutes was used in the HEC-HMS model (as recommended in TR-55) since calculated lag times are less than 3.6 minutes.

Results: Results are summarized in Table 1 below. Runoff results can also be seen on Figure 1. The expected flows for each pipe, along with the design slope and recommended pipe diameter can be seen on Figure 3. The minimum pipe size is 18 inches in diameter, and the maximum proposed pipe size is 24 inches in diameter. The total volume of runoff for each tributary area can be seen on Figure 4. In general, peak flows are about 0.95 cfs/acre and runoff volume is about 0.05 ac-ft/acre.

North Channel: The peak design flow of the existing channel along the south side of Landfill Cells 4, 5, and 6 (located north of the access road for the proposed Landfill Cells 8, 10, and 12) is 16 cfs. This is a result of runoff from portions of Landfill Cells 3 through 6. Runoff from the north half of Landfill Cells 8, 10, and 12 and from the northeast quarter of Landfill Cell 7 will add an additional 29 cfs to the peak flow for a total peak design flow within the channel of 45 cfs at the pipes entering the containment pond east of Cell 12. The flow in the channel increases as each downspout pipe and the embankment side slopes contribute flow to the channel.

The channel has a slope of about 0.1% which is flat and acts similar to several retention ponds that buffer the flow to the containment pond. The retention ponds created by the channel are created by the mounds that extend from the access road to the monitoring wells along the road. The bottom width of the channel between the monitoring well mounds and the toe of the embankment slopes for Landfill Cells 4, 5, and 6 is about 5 feet or more.

Using Manning's equation for a bottom width of 5 feet, a 2.5H:1V slopes on one side, a 3H:1V slopes on the other side, and a hydraulic slope of 0.2% through the channel at the monitoring wells (a little steeper than the channel slope, but still very flat) results in a flow depth of 1.7 feet and a velocity of 2.8 fps. The channel bottom width upstream and downstream of the monitoring wells is about 22 feet and will result in a flow depth of about 1.0 foot and a velocity of about 1.8 fps using the bottom slope of 0.01%. Therefore, the flow depth around the monitoring wells is less than 2 feet and the depth will decrease in the upstream direction from the monitoring wells. The velocities are non-erosive.

Install 3 pipes, 24 inches in diameter, to convey the peak flow from the channel into the containment pond to the east. Each pipe, with inlet control, will convey 15 cfs at a headwater depth of 2.3 feet. Therefore, slope the bottom of the channel or install a concrete inlet that drops the inlet of the pipes to 3 feet below the road or the closest monitoring well to avoid flooding of the road or monitoring well.

East Channel: The channel east of Landfill Cells 12 and 13 has a project peak flow rate of about 29 cfs, a bottom width of about 13 feet, and a bottom slope of 0.1%. Assuming a hydraulic grade line equal to the bottom slope of the channel results in a flow depth of 1 foot and a velocity of 1.7 fps. The velocity is non-erosive so no erosion protection is required. The berm along the east side of the channel should be 2 feet above the bottom of the channel to maintain 1 foot of freeboard under peak flow conditions. The steep portion of the channel entering the containment pond has a slope of 2.6% resulting in a calculated flow depth of 0.4 foot and a velocity of 5.1 fps requiring 6 inches of rock (D50 = 3 inches) for erosion protection.

West Channels: The west channels consist of inlets to the west pond. The north inlet will have flow of about 25 cfs, a slope of about 2.1%, and a bottom width of about 10 feet. The calculated flow depth is 0.4 foot with a velocity of 4.8 fps requiring 6 inches of rock (D50 = 3 inches) for erosion protection. The south inlet will have flow of about 5.0 cfs, a slope of about 1.5%, and a bottom width of about 10 feet. The calculated flow depth is 0.2 foot with a velocity of 2.4 fps which is a non-erosive velocity requiring no erosion protection

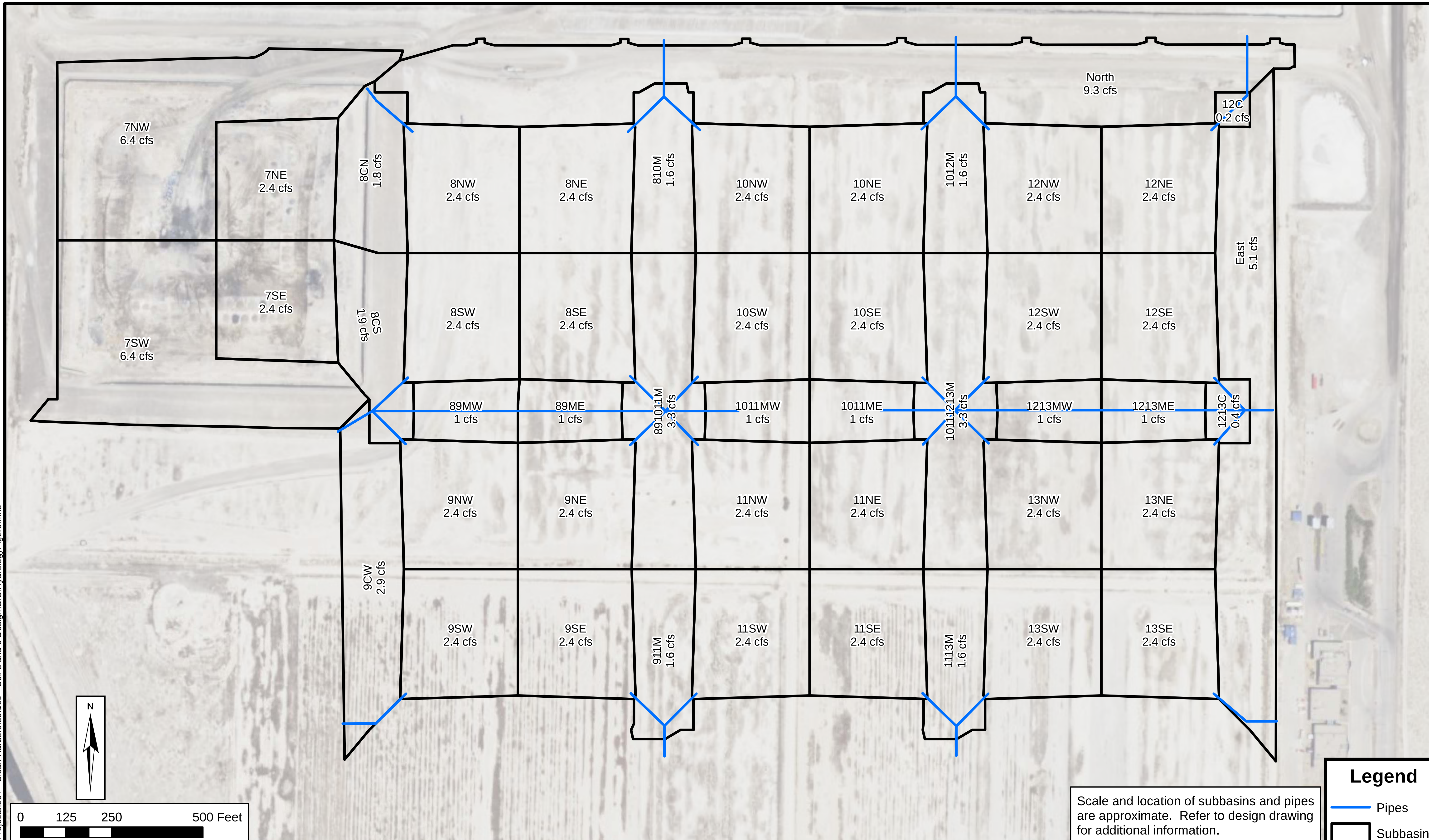
East Pond: The current capacity of the east containment pond is designed with a capacity of 9.0 acre-feet. This is to contain runoff volume from portions of Landfill Cells 3-5, Landfill Cell 6, Landfill Cells X, Y, and Z, and portions of the operations area and roads around the cells listed. The added area contributing storm water to the containment pond east of Cell 12 includes the north half of cells 8, 10, and 12, and the northeast quarter of Cell 7 which is about 34.7 acres. The pond needs to be enlarged an additional 1.74 acre feet for a total of 10.74 acre feet. The pond should be enlarged at the time any of the proposed cells (Cells 8-13) is closed. The bottom width of the pond is 196 feet. Assuming 3H:1V slopes, a bottom elevation of 4231.5, a water surface elevation of 4237, and a bottom length of 384 (using the short side of the pond), the pond will provide more than 10.74 acre feet of capacity.

South Pond: There is an existing containment pond located southeast of the existing Landfill Cell 7. That containment pond will provide sufficient capacity to contain storm water from the area after construction of Landfill Cell 8. However, at the time Cell 9 or Cell 10 are constructed, the area of containment will expand beyond the berm system for the current pond and the pond south of Cell 13 will need to be constructed. This pond will receive runoff from portions or Cells 9, 10, 11, 12, and 13. The potential drainage area to the pond south of Cell 13 is 67.4 acres and will need to have a capacity of 3.37 acre feet. Assuming the water depth in the pond to be 3 feet, 3H:1V side slopes, and a bottom area 212’ x 212’ will provide a capacity of more than 3.37 acre-feet.

West Pond: A new pond proposed to be constructed between the proposed Surface Impoundment B and the proposed Landfill Cell 9. This pond will receive runoff from portions of Landfill Cell 7, 8, 9, 10, and 11, from the top and outside slopes of proposed Surface Impoundment B, and area south of Cell 7 and west of Cell 9 (60.0 acres). The pond will need to provide 3.0 acre feet of storm water capacity. Assuming the water depth in the pond to be 3 feet, 3H:1V side slopes, and a bottom area 130’ x 295’ will provide a capacity of more than 3.0 acre-feet.

TABLE 1
MODELED RUNOFF RESULTS

Subbasin	Area (ac)	Peak Runoff (cfs)	Runoff Volume (ac-ft)
8NW	2.5536	2.4	0.126
8NE	2.5536	2.4	0.126
8SE	2.5536	2.4	0.126
8SW	2.5536	2.4	0.126
9NW	2.5536	2.4	0.126
9NE	2.5536	2.4	0.126
9SE	2.5536	2.4	0.126
9SW	2.5536	2.4	0.126
10NW	2.5536	2.4	0.126
10NE	2.5536	2.4	0.126
10SE	2.5536	2.4	0.126
10SW	2.5536	2.4	0.126
11NW	2.5536	2.4	0.126
11NE	2.5536	2.4	0.126
11SE	2.5536	2.4	0.126
11SW	2.5536	2.4	0.126
12NW	2.5536	2.4	0.126
12NE	2.5536	2.4	0.126
12SE	2.5536	2.4	0.126
12SW	2.5536	2.4	0.126
13NW	2.5536	2.4	0.126
13NE	2.5536	2.4	0.126
13SE	2.5536	2.4	0.126
13SW	2.5536	2.4	0.126
891011M	3.4944	3.3	0.172
10111213M	3.4944	3.3	0.172
810M	1.7344	1.6	0.085
1012M	1.7344	1.6	0.085
1113M	1.7344	1.6	0.085
911M	1.7344	1.6	0.085
1213ME	1.0816	1	0.053
1213MW	1.0816	1	0.053
1011ME	1.0816	1	0.053
1011MW	1.0816	1	0.053
89ME	1.0816	1	0.053
89MW	1.0816	1	0.053
8CN	1.8496	1.8	0.091
8CS	2.0352	1.9	0.100
12C	0.2048	0.2	0.010
1213C	0.4672	0.4	0.023
9CW	3.0656	2.9	0.151
North	11.008	9.3	0.541
East	5.8944	5.1	0.290
7NW	6.7264	6.4	0.331
7SW	6.688	6.4	0.329
7NE	2.5536	2.4	0.126
7SE	2.5536	2.4	0.126



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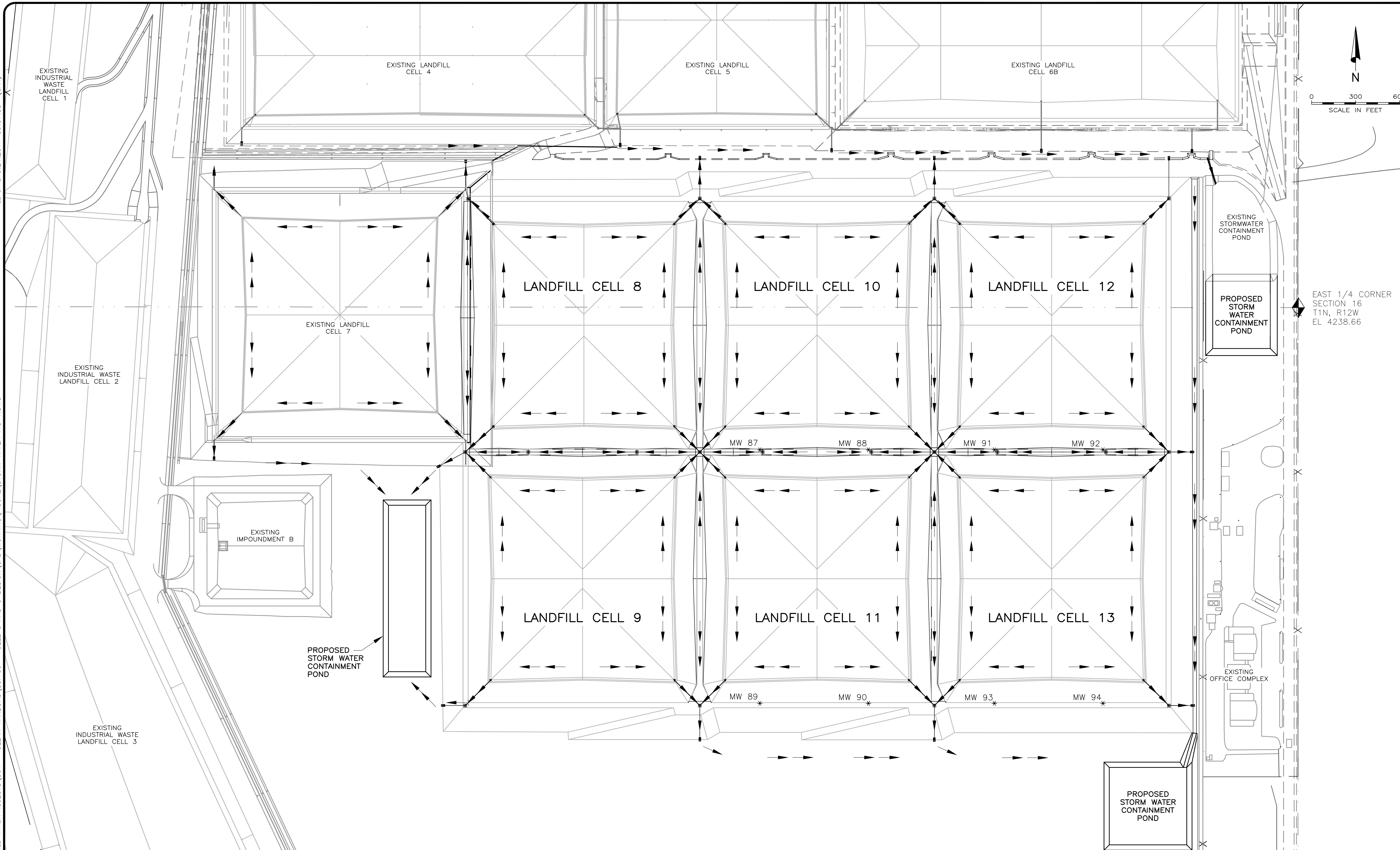
CLEAN HARBORS - GRASSY MOUNTAIN FACILITY
CELLS 8-13 HYDROLOGY

SUBBASIN PEAK RUNOFF

FIGURE 1



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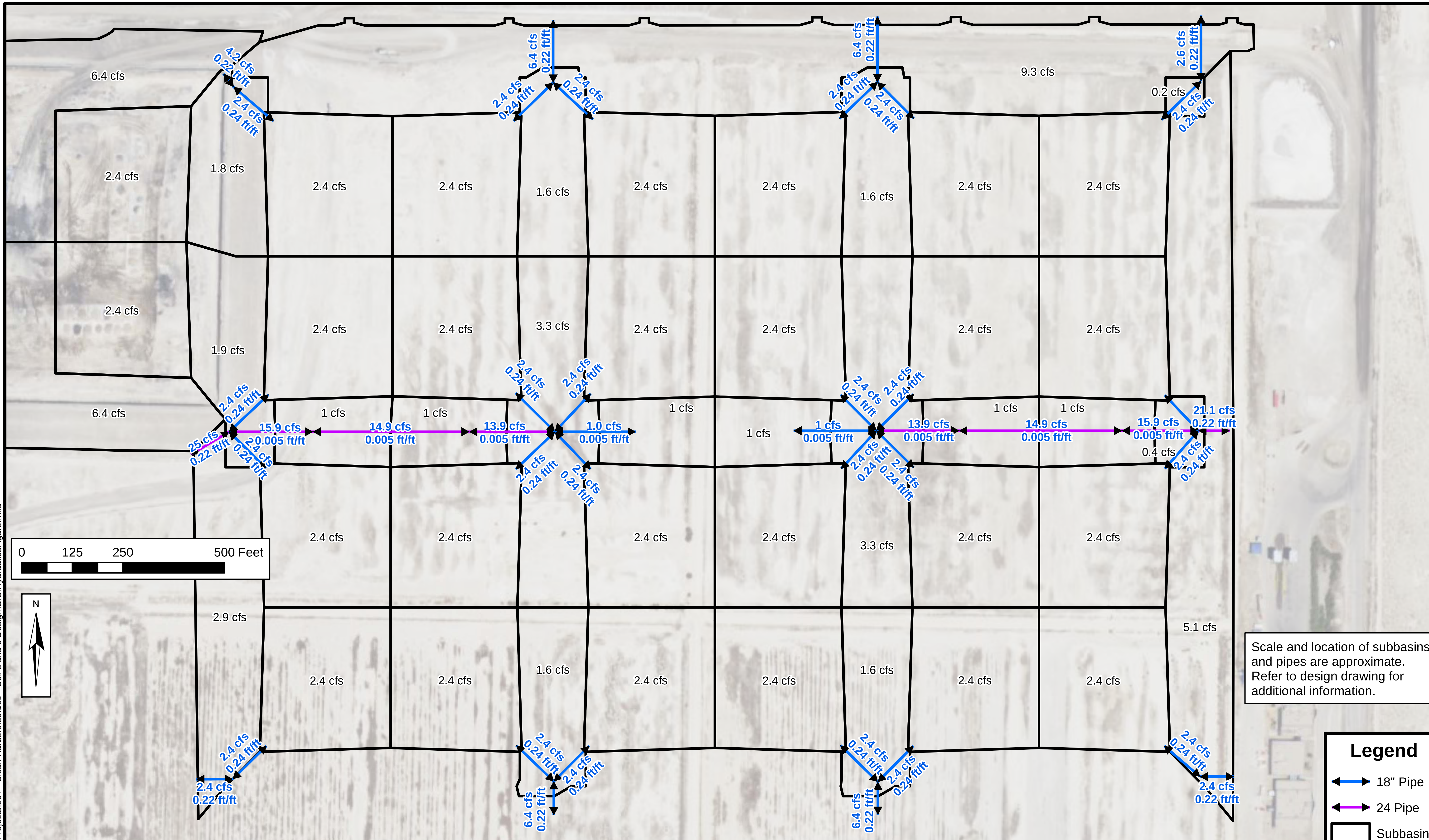
STORM WATER DRAINAGE

CleanHarbors® ENVIRONMENTAL SERVICES, INC.

FIGURE 2



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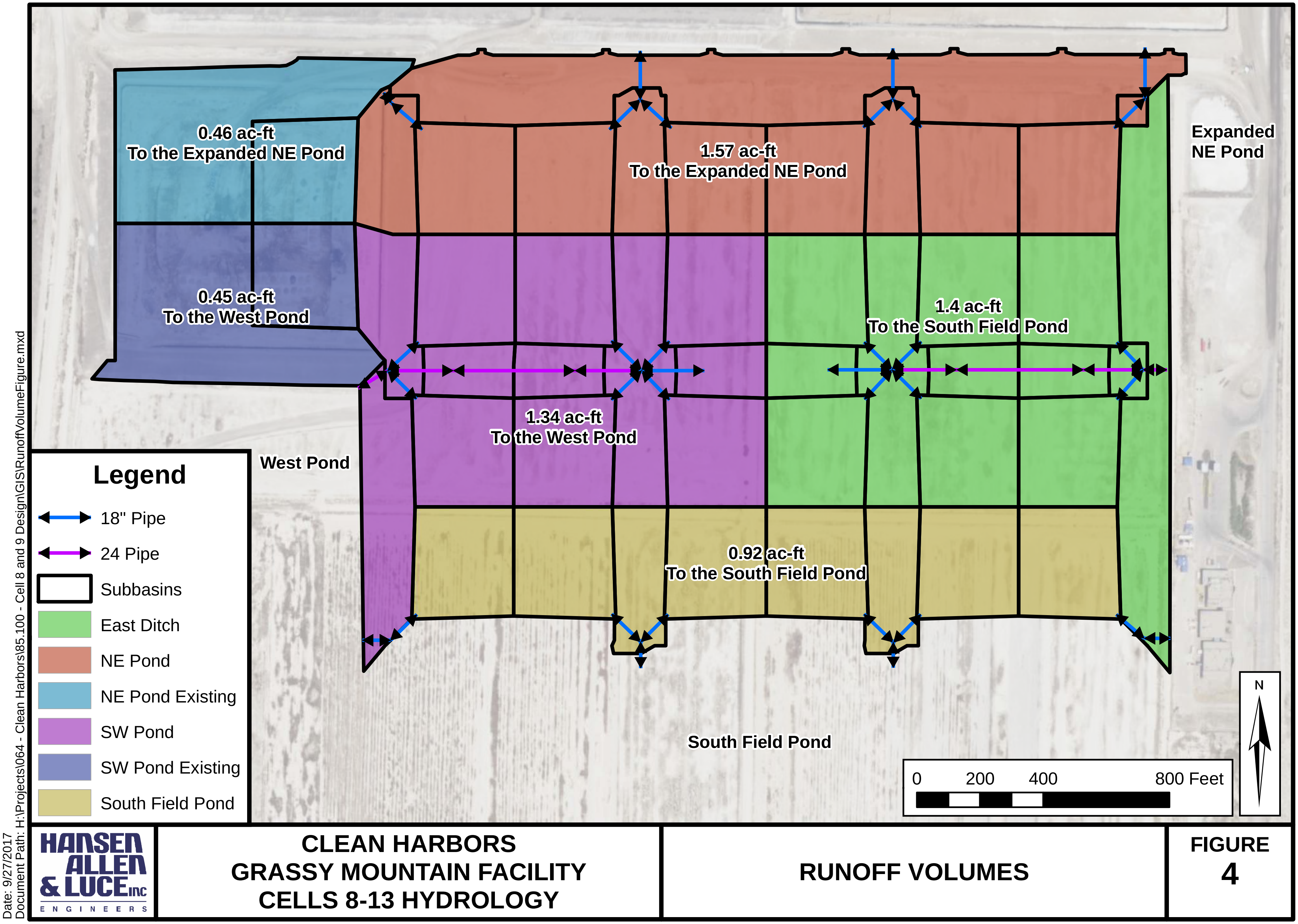
CLEAN HARBORS - GRASSY MOUNTAIN FACILITY
CELLS 8-13 HYDROLOGY

HYDRAULICS

FIGURE
3



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CLEAN HARBORS
GRASSY MOUNTAIN FACILITY
CELLS 8-13 HYDROLOGY

RUNOFF VOLUMES

FIGURE
4

Clean Harbors Cells 8 and 9
Lag Time Calculations
Computed: JGH
9/19/2017

Sheet flow

Subbasin Name	Manning N	Flow Length (ft)	Design rainfall (in)	High Elevation	Low Elevation	Slope (ft/ft)	Tt (hr)
Quadrants	0.015	300	0.9	4306.0	4290.9	0.05	0.080
Centers	0.015	81	0.9	4292.9	4267.0	0.32	0.013
NS Margins	0.015	81	0.9	4292.9	4267.0	0.32	0.013
North	0.015	160	0.9	4292.8	4244.0	0.31	0.024
Center Margins	0.015	81	0.9	4292.9	4267.0	0.32	0.013
East	0.015	162	0.9	4292.7	4244.0	0.30	0.024
9CW	0.015	169	0.9	4292.0	4240.0	0.31	0.025

Equation Used:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{[eq. 3-3]}$$

where:

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

Channel Flow

Subbasin Name	Manning N*	Flow Length (ft)	High Elevation	Low Elevation	Slope (ft/ft)	Hydraulic Radius	Velocity (ft/s)	Tt (hr)
Quadrants	0.033	344.0	4290.9	4287.5	0.01	1.5	5.88	0.016
Centers	0.033	433	4,271	4,267	0.010	1.5	5.83	0.021
NS Margins	0.033	433	4,271	4,267	0.010	1.5	5.83	0.021
North	0.033	2,386	4244.2	4241.2	0.001	4.4	4.29	0.154
Center Margins	0.033	185	4268.8	4267.0	0.010	1.5	5.84	0.009
East	0.033	1,896	NA	NA	0.001	4.4	3.83	0.138
9CW	0.033	520	4240.0	NA	0.001	2	2.27	0.064

Equation used:

$$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n} \qquad \text{[eq. 3-4]}$$

where:

V = average velocity (ft/s)
r = hydraulic radius (ft) and is equal to a/p_w
a = cross sectional flow area (ft^2)
p_w = wetted perimeter (ft)
s = slope of the hydraulic grade line (channel slope, ft/ft)
n = Manning's roughness coefficient for open channel flow.

Results:

Subbasin Name	Tc (hr)	Tl (hr)	Lag Time (min)	Model Lag Time (min)
Quadrants	0.097	0.058	3.48	3.60
Centers	0.034	0.020	1.23	3.60
NS Margins	0.034	0.020	1.23	3.60
North	0.178	0.107	6.41	6.41
Center Margins	0.022	0.013	0.80	3.60
East	0.162	0.097	5.82	5.82
9CW	0.088	0.053	3.18	3.60

Clean Harbors Cells 8 and 9
Pipe Capacity Calculations
Computed: JGH
9/21/2017

Pipe Capacity with Mannings Equation

Pipe	Description	Design Flow	Diameter		Pipe Capacity	Area	Wetted Perimeter	Slope	k	Mannings n*
					Q	A	P	S		
		cfs	in	ft	cfs	ft^2	ft	ft/ft		
P1	Cell Quadrants	**2.4**	18	1.5	**51.46**	1.77	4.71	0.24	1.486	0.013
P2	2 Quads and margin	**6.4**	18	1.5	**49.27**	1.77	4.71	0.22	1.486	0.013
P3	Center line 1	**1**	18	1.5	**7.43**	1.77	4.71	0.005	1.486	0.013
P4	Center line 2	**13.9**	24	2	**16.00**	3.14	6.28	0.005	1.486	0.013
P5	Center line 3	**14.9**	24	2	**16.00**	3.14	6.28	0.005	1.486	0.013
P6	Center line 4	**15.9**	24	2	**16.00**	3.14	6.28	0.005	1.486	0.013
P7	Center line 5	**25**	24	2	**106.11**	3.14	6.28	0.22	1.486	0.013
P8	East center	**21.1**	24	2	**106.11**	3.14	6.28	0.22	1.486	0.013
P9	South ditch	**6.4**	15	1.3	**30.30**	1.23	3.93	0.22	1.486	0.013

*Mannings n reflects values for cement pipe.

Mannings Equation: $Q = \frac{k}{n} A \left(\frac{A}{P}\right)^{2/3} S^{1/2}$

NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: UT

Data description

Data type: Precipitation depth **Units:** English **Time series type:** Partial duration

Select location

1) Manually:

a) By location (decimal degrees, use "-" for S and W): Latitude: Longitude: Submit

b) By station (list of UT stations): Select station

c) By address Search

2) Use map (if ESRI interactive map is not loading, try adding the host: **https://js.arcgis.com/** to the firewall, or contact us at hdsc.questions@noaa.gov):

a) Select location
Move crosshair or double click

b) Click on station icon
Show stations on map

Location information:
Name: Wendover, Utah, USA*
Latitude: 40.8145°
Longitude: -113.2050°
Elevation: 4236.05 ft **

* Source: ESRI Maps
** Source: USGS

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 1, Version 5

PF tabular PF graphical Supplementary information Print page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.093** (0.080-0.110)	**0.118** (0.102-0.140)	**0.165** (0.143-0.195)	**0.209** (0.179-0.246)	**0.283** (0.235-0.334)	**0.350** (0.284-0.417)	**0.432** (0.339-0.517)	**0.526** (0.398-0.640)	**0.677** (0.489-0.840)	**0.812** (0.563-1.02)
10-min	**0.142** (0.122-0.167)	**0.180** (0.156-0.212)	**0.252** (0.217-0.297)	**0.318** (0.272-0.375)	**0.430** (0.358-0.508)	**0.533** (0.432-0.634)	**0.656** (0.516-0.787)	**0.801** (0.606-0.974)	**1.03** (0.744-1.28)	**1.24** (0.857-1.56)
15-min	**0.176** (0.151-0.208)	**0.223** (0.193-0.263)	**0.312** (0.269-0.368)	**0.395** (0.337-0.465)	**0.533** (0.444-0.630)	**0.661** (0.536-0.786)	**0.814** (0.640-0.975)	**0.992** (0.752-1.21)	**1.28** (0.922-1.58)	**1.53** (1.06-1.93)
30-min	**0.237** (0.204-0.280)	**0.301** (0.260-0.355)	**0.420** (0.363-0.495)	**0.531** (0.454-0.626)	**0.718** (0.597-0.848)	**0.890** (0.721-1.06)	**1.10** (0.862-1.31)	**1.34** (1.01-1.63)	**1.72** (1.24-2.13)	**2.06** (1.43-2.60)
60-min	**0.293** (0.252-0.346)	**0.372** (0.322-0.439)	**0.519** (0.449-0.613)	**0.658** (0.562-0.774)	**0.889** (0.739-1.05)	**1.10** (0.892-1.31)	**1.36** (1.07-1.63)	**1.65** (1.25-2.01)	**2.13** (1.54-2.64)	**2.55** (1.77-3.21)
2-hr	**0.359** (0.319-0.415)	**0.451** (0.400-0.521)	**0.597** (0.527-0.689)	**0.735** (0.643-0.846)	**0.961** (0.819-1.11)	**1.17** (0.970-1.36)	**1.41** (1.14-1.67)	**1.70** (1.32-2.04)	**2.16** (1.60-2.65)	**2.58** (1.82-3.23)
3-hr	**0.405** (0.364-0.460)	**0.502** (0.449-0.574)	**0.648** (0.578-0.733)	**0.777** (0.689-0.879)	**0.987** (0.858-1.12)	**1.18** (0.999-1.38)	**1.43** (1.17-1.68)	**1.72** (1.36-2.06)	**2.18** (1.65-2.68)	**2.60** (1.89-3.26)
6-hr	**0.495** (0.451-0.548)	**0.608** (0.553-0.677)	**0.761** (0.692-0.846)	**0.895** (0.808-0.995)	**1.09** (0.973-1.22)	**1.26** (1.10-1.42)	**1.46** (1.25-1.70)	**1.74** (1.43-2.08)	**2.21** (1.73-2.71)	**2.63** (2.00-3.29)
12-hr	**0.582**	**0.716**	**0.885**	**1.02**	**1.22**	**1.38**	**1.55**	**1.75**	**2.23**	**2.66**

	(0.534-0.640)	(0.656-0.790)	(0.810-0.974)	(0.932-1.12)	(1.10-1.35)	(1.23-1.53)	(1.36-1.74)	(1.51-2.11)	(1.74-2.74)	(2.02-3.33)
24-hr	**0.743** (0.677-0.822)	**0.920** (0.837-1.02)	**1.13** (1.02-1.24)	**1.29** (1.17-1.42)	**1.51** (1.37-1.66)	**1.68** (1.52-1.85)	**1.85** (1.66-2.04)	**2.02** (1.81-2.24)	**2.25** (1.99-2.76)	**2.68** (2.13-3.36)
2-day	**0.803** (0.733-0.885)	**0.989** (0.905-1.09)	**1.20** (1.10-1.32)	**1.37** (1.25-1.50)	**1.59** (1.45-1.74)	**1.75** (1.59-1.93)	**1.92** (1.73-2.11)	**2.08** (1.88-2.30)	**2.29** (2.05-2.79)	**2.71** (2.18-3.39)
3-day	**0.863** (0.790-0.947)	**1.06** (0.974-1.16)	**1.28** (1.18-1.40)	**1.46** (1.34-1.60)	**1.70** (1.56-1.85)	**1.88** (1.71-2.05)	**2.06** (1.87-2.25)	**2.24** (2.02-2.46)	**2.48** (2.22-2.86)	**2.79** (2.36-3.41)
4-day	**0.923** (0.847-1.01)	**1.14** (1.04-1.24)	**1.37** (1.26-1.49)	**1.56** (1.43-1.69)	**1.81** (1.66-1.97)	**2.01** (1.83-2.18)	**2.21** (2.00-2.40)	**2.41** (2.17-2.62)	**2.67** (2.39-2.93)	**2.87** (2.55-3.43)
7-day	**1.02** (0.938-1.12)	**1.26** (1.15-1.37)	**1.51** (1.38-1.64)	**1.70** (1.56-1.85)	**1.96** (1.80-2.13)	**2.14** (1.96-2.33)	**2.33** (2.12-2.53)	**2.50** (2.28-2.73)	**2.72** (2.46-2.97)	**2.89** (2.59-3.46)
10-day	**1.11** (1.01-1.23)	**1.37** (1.25-1.51)	**1.64** (1.50-1.80)	**1.85** (1.69-2.03)	**2.12** (1.94-2.32)	**2.32** (2.12-2.54)	**2.50** (2.28-2.75)	**2.68** (2.44-2.95)	**2.89** (2.62-3.19)	**3.03** (2.74-3.50)
20-day	**1.33** (1.21-1.46)	**1.63** (1.49-1.80)	**1.96** (1.80-2.15)	**2.21** (2.02-2.41)	**2.51** (2.30-2.74)	**2.72** (2.49-2.98)	**2.92** (2.67-3.20)	**3.10** (2.83-3.39)	**3.30** (3.01-3.62)	**3.43** (3.13-3.77)
30-day	**1.49** (1.36-1.64)	**1.83** (1.67-2.01)	**2.19** (2.00-2.39)	**2.44** (2.24-2.67)	**2.77** (2.54-3.02)	**2.99** (2.74-3.26)	**3.21** (2.93-3.50)	**3.39** (3.09-3.71)	**3.61** (3.28-3.96)	**3.74** (3.40-4.12)
45-day	**1.76** (1.62-1.93)	**2.16** (1.98-2.35)	**2.55** (2.35-2.76)	**2.82** (2.61-3.05)	**3.14** (2.92-3.38)	**3.34** (3.12-3.59)	**3.51** (3.28-3.75)	**3.62** (3.40-3.86)	**3.68** (3.50-4.00)	**3.78** (3.53-4.16)
60-day	**2.01** (1.85-2.20)	**2.46** (2.26-2.68)	**2.89** (2.67-3.14)	**3.22** (2.97-3.47)	**3.60** (3.34-3.88)	**3.85** (3.58-4.14)	**4.07** (3.78-4.36)	**4.23** (3.95-4.53)	**4.36** (4.11-4.67)	**4.39** (4.17-4.69)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Estimates from the table in CSV format: Precipitation frequency estimates Submit

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Water Prediction (OWP)
1325 East West Highway
Silver Spring, MD 20910
Page Author: HDSC webmaster
Page last modified: April 21, 2017

Client	*Clean Harbors*	Sheet	
Project	*Landfill Cells 8 - 13 Design*	Comp.	*KCS*
Feature	*North Storm Drainage Channel*	Chck'd	
Project #	*064.85.100*	Date	*30-Oct-17*

Trapezoidal Channel Flow Calculations

GENERAL CRITERIA:

Design Flow:	45.00	cfs
Bottom Width:	22.0	feet
Side Slope1:	2.5	m1
Side Slope2:	3.0	m2
Friction Factor:		
Assumed D50:	0.1	

Anderson et al. (1970) If X=1, n=0.0395(D50)^1/6

Abt. et al. (1987, 1988) If X=2, n=0.0456(D50*S)^0.0159

If X=3, n={D50^1/6*(R/D50)^1/6}/{3.82*[2.25+5.23*LOG(R/D50)]}

Generally Applicable for R/D50 > 0.5

Jarrett (1984) If X=4, n=0.39*(S^0.38)*(R^0.16)

If X=5, n=input n value

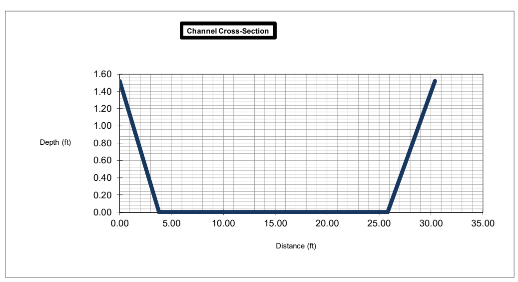
X:	1	
Input n Value when X=5:	0.025	
Calc (used) n Value:	0.025	
Min. Bottom Slope:	0.001	ft/ft
Max. Bottom Slope:	0.001	ft/ft
Freeboard:	0.5	feet

Depth (Min. Slope):	1.02	feet
Q-1.49AR(2/3)S(1/2)/n=	-0.114	Accuracy
Required Depth:	1.52	feet
Area:	25.30	ft2
Perimeter:	27.97	feet
Hydraulic Radius:	0.90	feet
Velocity:	1.78	ft/sec
Froude Number:	0.33	

Depth (Max. Slope):	0.43	feet
Q-1.49AR(2/3)S(1/2)/n=	34.507	Accuracy
Required Depth:	0.93	feet
Area:	10.01	ft2
Perimeter:	24.53	feet
Hydraulic Radius:	0.41	feet
Velocity:	4.50	ft/sec
Froude Number:	1.24	

Channel Design Summary:

Bottom Width:	22.00	feet
Side Slope1:	2.50	1/m1
Side Slope2:	3.00	1/m2
Min. Bottom Slope:	0.001	ft/ft
Max. Bottom Slope:	0.001	ft/ft
Min. Channel Depth:	1.52	feet
Channel Top Width:	30.36	feet



Channel Cross Section

HANSEN ALLEN & LUCE INC ENGINEERS

Client	*Clean Harbors*	Sheet	
Project	*Landfill Cells 8 - 13 Design*	Comp.	*KCS*
Feature	*North Storm Drainage Channel*	Chck'd	
Project #	*064.85.100*	Date	*30-Oct-17*

Trapezoidal Channel Flow Calculations

GENERAL CRITERIA:

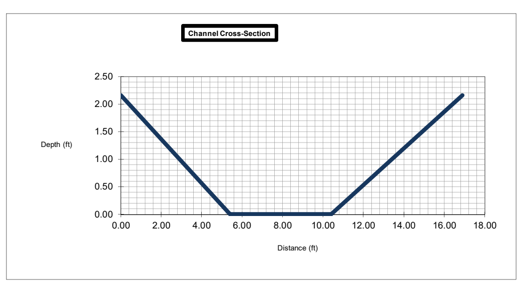
	Design Flow:	45.00	cfs
	Bottom Width:	5.0	feet
	Side Slope1:	2.5	m1
	Side Slope2:	3.0	m2
	Friction Factor:		
	Assumed D50:	0.1	
Anderson et al. (1970)	If X=1, n=0.0395(D50)^1/6		
Abt. et al. (1987, 1988)	If X=2, n=0.0456(D50*S)^0.0159		
	If X=3, n={D50^1/6*(R/D50)^1/6}/{3.82*[2.25+5.23*LOG(R/D50)]}		
	Generally Applicable for R/D50 > 0.5		
Jarrett (1984)	If X=4, n=0.39*(S^0.38)*(R^0.16)		
	If X=5, n=input n value		
	X:	1	
	Input n Value when X=5:	0.025	
	Calc (used) n Value:	0.025	
	Min. Bottom Slope:	0.002	ft/ft
	Max. Bottom Slope:	0.002	ft/ft
	Freeboard:	0.5	feet

Depth (Min. Slope):	1.66	feet
Q-1.49AR(2/3)S(1/2)/n=	-0.028	Accuracy
Required Depth:	2.16	feet
Area:	15.88	ft2
Perimeter:	14.72	feet
Hydraulic Radius:	1.08	feet
Velocity:	2.83	ft/sec
Froude Number:	0.47	

Depth (Max. Slope):	1.66	feet
Q-1.49AR(2/3)S(1/2)/n=	-0.028	Accuracy
Required Depth:	2.16	feet
Area:	15.88	ft2
Perimeter:	14.72	feet
Hydraulic Radius:	1.08	feet
Velocity:	2.83	ft/sec
Froude Number:	0.47	

Channel Design Summary:

Bottom Width:	5.00	feet
Side Slope1:	2.50	1/m1
Side Slope2:	3.00	1/m2
Min. Bottom Slope:	0.002	ft/ft
Max. Bottom Slope:	0.002	ft/ft
Min. Channel Depth:	2.16	feet
Channel Top Width:	16.88	feet



Channel Cross Section

Client	*Clean Harbors*	Sheet	
Project	*Landfill Cells 8 - 13 Design*	Comp.	*KCS*
Feature	*East Storm Drainage Channel and Pond Inlet*	Chck'd	
Project #	*064.85.100*	Date	*30-Oct-17*

Trapezoidal Channel Flow Calculations

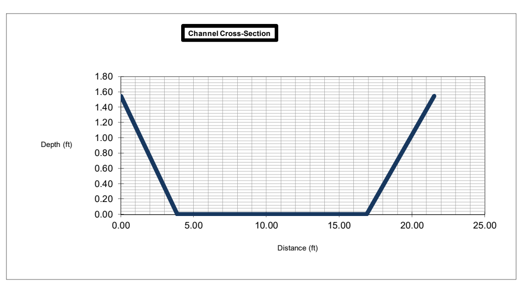
GENERAL CRITERIA:

	Design Flow:	29.00	cfs
	Bottom Width:	13.0	feet
	Side Slope1:	2.5	m1
	Side Slope2:	3.0	m2
	Friction Factor:		
	Assumed D50:	0.1	
Anderson et al. (1970)	If X=1, n=0.0395(D50)^1/6		
Abt. et al. (1987, 1988)	If X=2, n=0.0456(D50*S)^0.0159		
	If X=3, n={D50^1/6*(R/D50)^1/6}/{3.82*[2.25+5.23*LOG(R/D50)]}		
	Generally Applicable for R/D50 > 0.5		
Jarrett (1984)	If X=4, n=0.39*(S^0.38)*(R^0.16)		
	If X=5, n=input n value		
	X:	1	
	Input n Value when X=5:	0.025	
	Calc (used) n Value:	0.025	
	Min. Bottom Slope:	0.001	ft/ft
	Max. Bottom Slope:	0.026	ft/ft
	Freeboard:	0.5	feet

Depth (Min. Slope):	1.05	feet
Q-1.49AR(2/3)S(1/2)/n=	-0.011	Accuracy
Required Depth:	1.55	feet
Area:	16.68	ft2
Perimeter:	19.15	feet
Hydraulic Radius:	0.87	feet
Velocity:	1.74	ft/sec
Froude Number:	0.33	
Depth (Max. Slope):	0.40	feet
Q-1.49AR(2/3)S(1/2)/n=	0.864	Accuracy
Required Depth:	0.90	feet
Area:	5.64	ft2
Perimeter:	15.34	feet
Hydraulic Radius:	0.37	feet
Velocity:	5.14	ft/sec
Froude Number:	1.49	

Channel Design Summary:

Bottom Width:	13.00	feet
Side Slope1:	2.50	1/m1
Side Slope2:	3.00	1/m2
Min. Bottom Slope:	0.001	ft/ft
Max. Bottom Slope:	0.026	ft/ft
Min. Channel Depth:	1.55	feet
Channel Top Width:	21.53	feet



DESIGN CRITERIA:

Design Flow:	29.00	cfs
Bottom Width:	13.00	feet
Side Slope1:	2.50	1/m1
Side Slope2:	3.00	1/m2
Friction Factor:	0.02	
Min. Bottom Slope:	0.1	%
Max. Bottom Slope:	2.6	%
Flow Depth (Min. S):	1.05	feet
Flow Depth (Max. S):	0.40	feet
Angle Repose (Ar):	42.0	degrees
Specific Gravity	2.65	

Reynolds No. = U*D50/v, where U=Shear Velocity, v=viscosity

U=(gRS)^0.5 for Smin	0.17	
Reynolds # for Smin	718	
U=(gRS)^0.5 for Smax	0.55	
Reynolds # for Smax	2,378	

T = G*d*S where G=Unit weight of Water

Nb = F*T/(G(SD-1)D50)

F=(1/0.047)=21.3 for flat slopes with Reynolds No. < 500

F=(1/0.062)=16.1 for 500 < Reynolds No. < 40,000

F=varies from (1/0.062)=16.1 for Reynolds No. = 40,000 to (1/0,25)=4 for Reynolds No. = 500,000 or larger

K for S min (See K vs. R Chart)	0.047
K for S max (See K vs. R Chart)	0.062
F for S min	16.1
F for S max	16.1

SFb = (Cos a tan b)/(sin a + Nb tan b)

Tmax= Ks*G*d*S

Set Ks=0.75 for 1.5:1 slope, 0.76 for 2:1 slope, and 0.85 for 3:1 slope

Ks: 0.76

Ns = F*Tmax/(G(SG-1)D)

A = Atan(1/m)

B = Atan(Cos(Ar)/(2Sin(A)/NsTan)Ar))+Sin(Ar))

Nsp = Ns(1+Sin(Ar+B)/2)

SFs = Cos(A)Tan(Ar)/(nTan(Ar)+Sin(A)Cos(B))

RIPRAP DESIGN:

	Smin	Smax	
D50	0.02	0.25	feet
T	0.07	0.65	lb/ft2
Nb	0.51	0.41	
Tmax	0.05	0.49	lb/ft2
Ns	0.39	0.31	
m Critical	2.50	2.50	
A (m crit)	21.80	21.80	degrees
B	25.29	20.35	degrees
Nsp	0.28	0.21	
SFb	1.94	2.30	
SFs	1.43	1.55	

HANSEN ALLEN & LUCE INC ENGINEERS

Client	Clean Harbors	Sheet	
Project	Landfill Cells 8 - 13 Design	Comp.	KCS
Feature	West Storm Drainage North Pond Inlet Channel	Chck'd	
Project #	064.85.100	Date	30-Oct-17

Trapezoidal Channel Flow Calculations

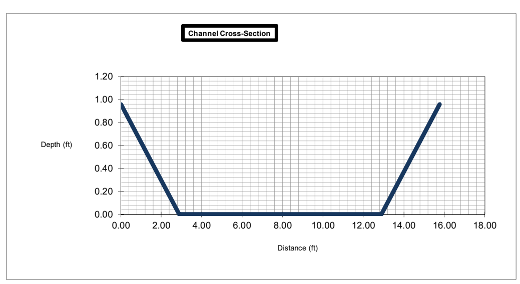
GENERAL CRITERIA:

	Design Flow:	25.00	cfs
	Bottom Width:	10.0	feet
	Side Slope1:	3.0	m1
	Side Slope2:	3.0	m2
	Friction Factor:		
	Assumed D50:	0.1	
Anderson et al. (1970)	If X=1, n=0.0395(D50)^1/6		
Abt. et al. (1987, 1988)	If X=2, n=0.0456(D50*S)^0.0159		
	If X=3, n={D50^1/6*(R/D50)^1/6}/{3.82*[2.25+5.23*LOG(R/D50)]}		
	Generally Applicable for R/D50 > 0.5		
Jarrett (1984)	If X=4, n=0.39*(S^0.38)*(R^0.16)		
	If X=5, n=input n value		
	X:	1	
	Input n Value when X=5:	0.025	
	Calc (used) n Value:	0.025	
	Min. Bottom Slope:	0.021	ft/ft
	Max. Bottom Slope:	0.021	ft/ft
	Freeboard:	0.5	feet

Depth (Min. Slope):	0.46	feet
Q-1.49AR(2/3)S(1/2)/n=	-0.056	Accuracy
Required Depth:	0.96	feet
Area:	5.23	ft2
Perimeter:	12.91	feet
Hydraulic Radius:	0.41	feet
Velocity:	4.78	ft/sec
Froude Number:	1.31	
Depth (Max. Slope):	0.46	feet
Q-1.49AR(2/3)S(1/2)/n=	-0.056	Accuracy
Required Depth:	0.96	feet
Area:	5.23	ft2
Perimeter:	12.91	feet
Hydraulic Radius:	0.41	feet
Velocity:	4.78	ft/sec
Froude Number:	1.31	

Channel Design Summary:

Bottom Width:	10.00	feet
Side Slope1:	3.00	1/m1
Side Slope2:	3.00	1/m2
Min. Bottom Slope:	0.021	ft/ft
Max. Bottom Slope:	0.021	ft/ft
Min. Channel Depth:	0.96	feet
Channel Top Width:	15.76	feet



Channel Cross Section

Client	*Clean Harbors*	Sheet	*of*
Project	*Landfill Cells 8 - 13 Design*	Comp.	*KCS*
Feature	*West Storm Drainage North Pond Inlet Channel*	Chck'd	
Project #	*064.85.100*	Date	*30-Oct-17*

DESIGN CRITERIA:

Design Flow:	25.00	cfs
Bottom Width:	10.00	feet
Side Slope1:	3.00	1/m1
Side Slope2:	3.00	1/m2
Friction Factor:	0.02	
Min. Bottom Slope:	2.1	%
Max. Bottom Slope:	2.1	%
Flow Depth (Min. S):	0.46	feet
Flow Depth (Max. S):	0.46	feet
Angle Repose (Ar):	42.0	degrees
Specific Gravity	2.65	

Reynolds No. = U*D50/v, where U=Shear Velocity, v=viscosity

U=(gRS)^0.5 for Smin	0.52	
Reynolds # for Smin	2,244	
U=(gRS)^0.5 for Smax	0.52	
Reynolds # for Smax	2,244	

T = G*d*S where G=Unit weight of Water

Nb = F*T/(G(SD-1)D50)

F=(1/0.047)=21.3 for flat slopes with Reynolds No. < 500

F=(1/0.062)=16.1 for 500 < Reynolds No. < 40,000

F=varies from (1/0.062)=16.1 for Reynolds No. = 40,000 to (1/0,25)=4 for Reynolds No. = 500,000 or larger

K for S min (See K vs. R Chart)	0.062
K for S max (See K vs. R Chart)	0.062
F for S min	16.1
F for S max	16.1

SFb = (Cos a tan b)/(sin a + Nb tan b)

Tmax= Ks*G*d*S

Set Ks=0.75 for 1.5:1 slope, 0.76 for 2:1 slope, and 0.85 for 3:1 slope

Ks: 0.85

Ns = F*Tmax/(G(SG-1)D)

A = Atan(1/m)

B = Atan(Cos(Ar)/(2Sin(A)/NsTan)Ar))+Sin(Ar))

Nsp = Ns(1+Sin(Ar+B)/2)

SFs = Cos(A)Tan(Ar)/(nTan(Ar)+Sin(A)Cos(B))

RIPRAP DESIGN:

	Smin	Smax	
D50	0.18	0.25	feet
T	0.60	0.60	lb/ft2
Nb	0.52	0.38	
Tmax	0.51	0.51	lb/ft2
Ns	0.45	0.32	
m Critical	3.00	3.00	
A (m crit)	18.44	18.44	degrees
B	32.06	24.35	degrees
Nsp	0.35	0.23	
SFb	1.82	2.49	
SFs	1.48	1.73	

Client	*Clean Harbors*	Sheet	
Project	*Landfill Cells 8 - 13 Design*	Comp.	*KCS*
Feature	*West Storm Drainage South Pond Inlet Channel*	Chck'd	
Project #	*064.85.100*	Date	*30-Oct-17*

Trapezoidal Channel Flow Calculations

GENERAL CRITERIA:

Design Flow:	5.00	cfs
Bottom Width:	10.0	feet
Side Slope1:	3.0	m1
Side Slope2:	3.0	m2
Friction Factor:		
Assumed D50:	0.1	

Anderson et al. (1970) If X=1, n=0.0395(D50)^1/6

Abt. et al. (1987, 1988) If X=2, n=0.0456(D50*S)^0.0159

If X=3, n={D50^1/6*(R/D50)^1/6}/{3.82*[2.25+5.23*LOG(R/D50)]}

Generally Applicable for R/D50 > 0.5

Jarrett (1984) If X=4, n=0.39*(S^0.38)*(R^0.16)

If X=5, n=input n value

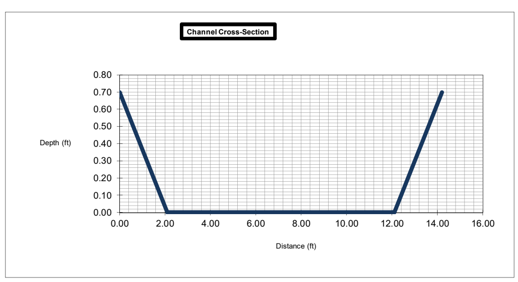
X:	1	
Input n Value when X=5:	0.025	
Calc (used) n Value:	0.025	
Min. Bottom Slope:	0.015	ft/ft
Max. Bottom Slope:	0.015	ft/ft
Freeboard:	0.5	feet

Depth (Min. Slope):	0.20	feet
Q-1.49AR(2/3)S(1/2)/n=	-0.141	Accuracy
Required Depth:	0.70	feet
Area:	2.12	ft2
Perimeter:	11.26	feet
Hydraulic Radius:	0.19	feet
Velocity:	2.36	ft/sec
Froude Number:	0.96	

Depth (Max. Slope):	0.20	feet
Q-1.49AR(2/3)S(1/2)/n=	-0.141	Accuracy
Required Depth:	0.70	feet
Area:	2.12	ft2
Perimeter:	11.26	feet
Hydraulic Radius:	0.19	feet
Velocity:	2.36	ft/sec
Froude Number:	0.96	

Channel Design Summary:

Bottom Width:	10.00	feet
Side Slope1:	3.00	1/m1
Side Slope2:	3.00	1/m2
Min. Bottom Slope:	0.015	ft/ft
Max. Bottom Slope:	0.015	ft/ft
Min. Channel Depth:	0.70	feet
Channel Top Width:	14.20	feet



HY-8 Culvert Analysis Report
NORTH CHANNEL TO EMPTY POND

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Design Flow: 45 cfs

Table 1 - Summary of Culvert Flows at Crossing: North Channel to East Pond

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
4240.53	45.00	45.00	0.00	1
4241.00	71.39	71.39	0.00	Overtopping

Rating Curve Plot for Crossing: North Channel to East Pond

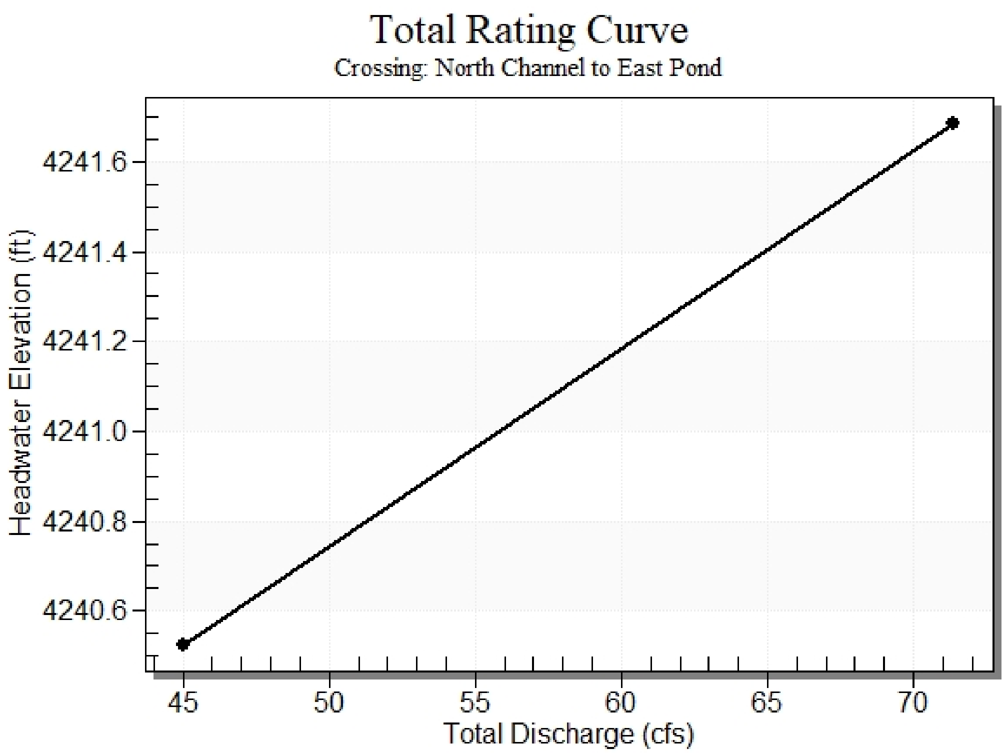


Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
45.00	45.00	4240.53	2.181	3.026	4-FFf	0.973	1.392	2.000	1.013	4.775	2.222
45.00	45.00	4240.53	2.181	3.026	4-FFf	0.973	1.392	2.000	1.013	4.775	2.222

****

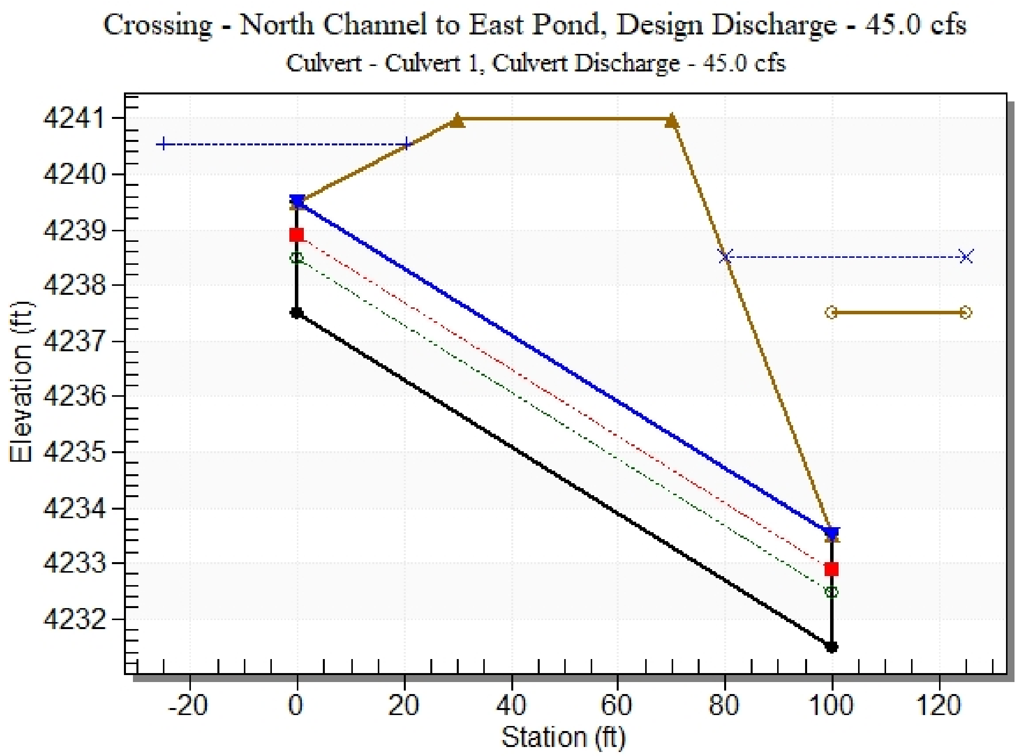
Straight Culvert

Inlet Elevation (invert): 4237.50 ft, Outlet Elevation (invert): 4231.50 ft

Culvert Length: 100.18 ft, Culvert Slope: 0.0600

****

Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 4237.50 ft

Outlet Station: 100.00 ft

Outlet Elevation: 4231.50 ft

Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 2.00 ft

Barrel Material: Corrugated PE

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: North Channel to East Pond)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
45.00	4238.51	1.01	2.22	0.06	0.39
45.00	4238.51	1.01	2.22	0.06	0.39

Tailwater Channel Data - North Channel to East Pond

Tailwater Channel Option: Rectangular Channel

Bottom Width: 20.00 ft

Channel Slope: 0.0010

Channel Manning's n: 0.0200

Channel Invert Elevation: 4237.50 ft

Roadway Data for Crossing: North Channel to East Pond

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 40.00 ft

Crest Elevation: 4241.00 ft

Roadway Surface: Gravel

Roadway Top Width: 40.00 ft

HY-8 Culvert Analysis Report
CULVERT FROM NORTH CHANNEL TO EAST CONTAINMENT POND

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Design Flow: 45 cfs

Table 1 - Summary of Culvert Flows at Crossing: North Channel to East Pond

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
4240.68	45.00	45.00	0.00	1
4241.00	48.03	48.03	0.00	Overtopping

Rating Curve Plot for Crossing: North Channel to East Pond

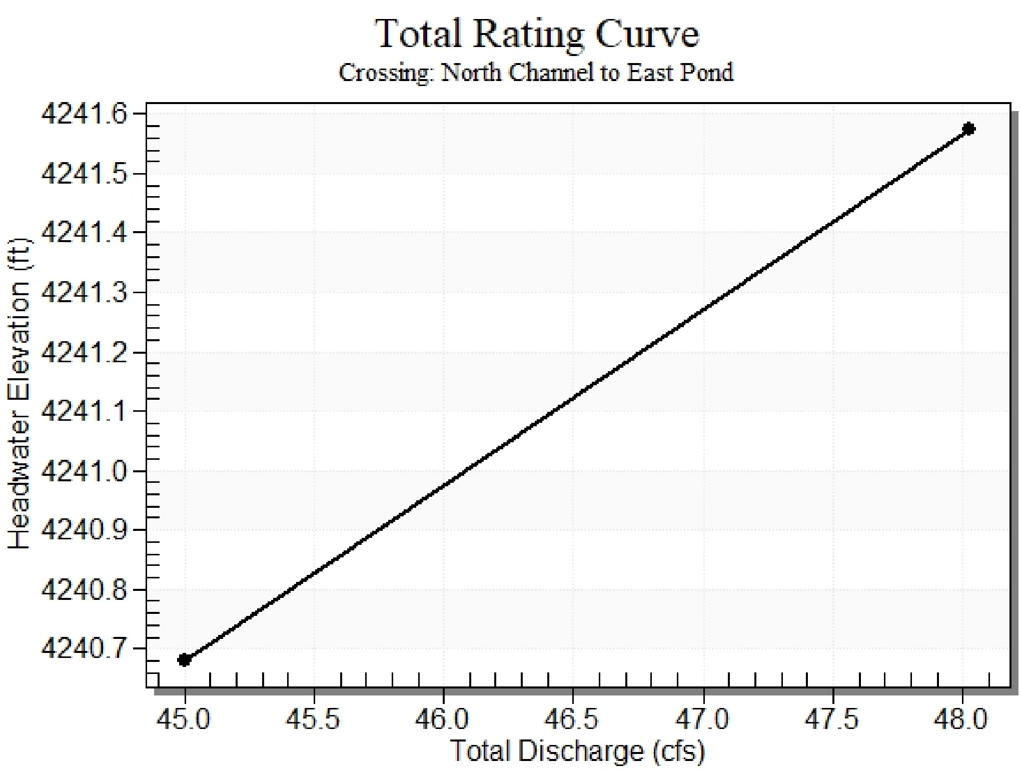


Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
45.00	45.00	4240.68	2.236	3.181	7-M2t	2.000	1.392	1.513	1.013	5.884	2.222
45.00	45.00	4240.68	2.236	3.181	7-M2t	2.000	1.392	1.513	1.013	5.884	2.222

****

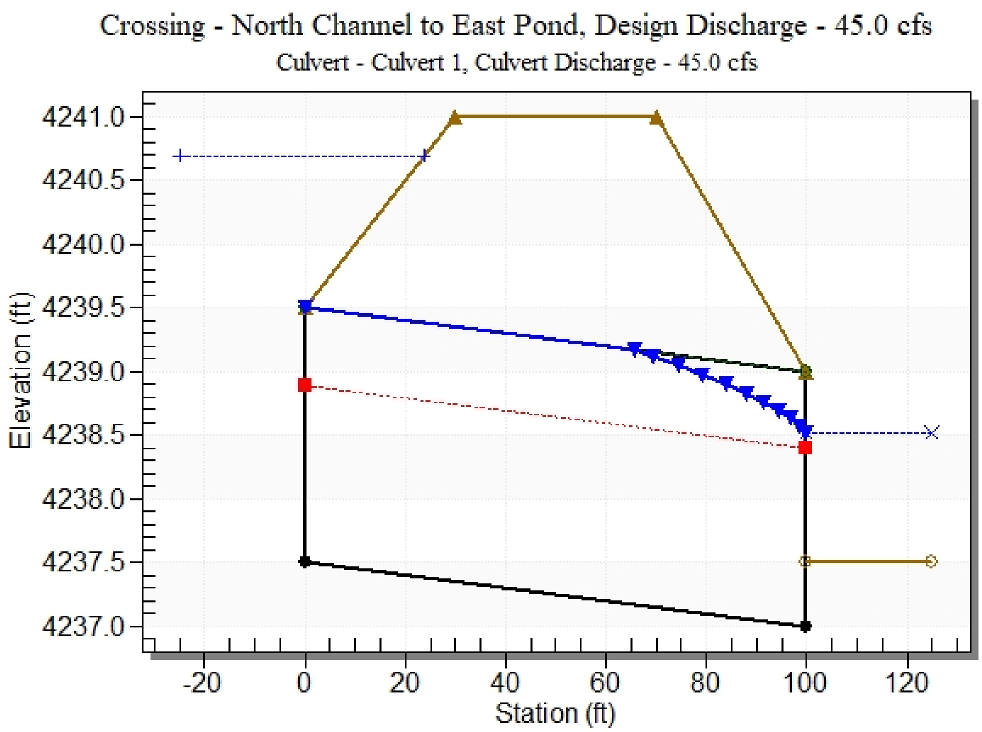
Straight Culvert

Inlet Elevation (invert): 4237.50 ft,   Outlet Elevation (invert): 4237.00 ft

Culvert Length: 100.00 ft,   Culvert Slope: 0.0050

****

Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 4237.50 ft

Outlet Station: 100.00 ft

Outlet Elevation: 4237.00 ft

Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 2.00 ft

Barrel Material: Corrugated PE

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: North Channel to East Pond)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
45.00	4238.51	1.01	2.22	0.06	0.39
45.00	4238.51	1.01	2.22	0.06	0.39

Roadway Data for Crossing: North Channel to East Pond

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 40.00 ft

Crest Elevation: 4241.00 ft

Roadway Surface: Gravel

Roadway Top Width: 40.00 ft

HY-8 Culvert Analysis Report
CLOSURE CAP DOWNSPOUTS

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Design Flow: 2.4 cfs

Table 1 - Summary of Culvert Flows at Crossing: Cap Downspouts

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
4287.19	2.40	2.40	0.00	1
4289.71	13.87	13.87	0.00	Overtopping

Rating Curve Plot for Crossing: Cap Downspouts

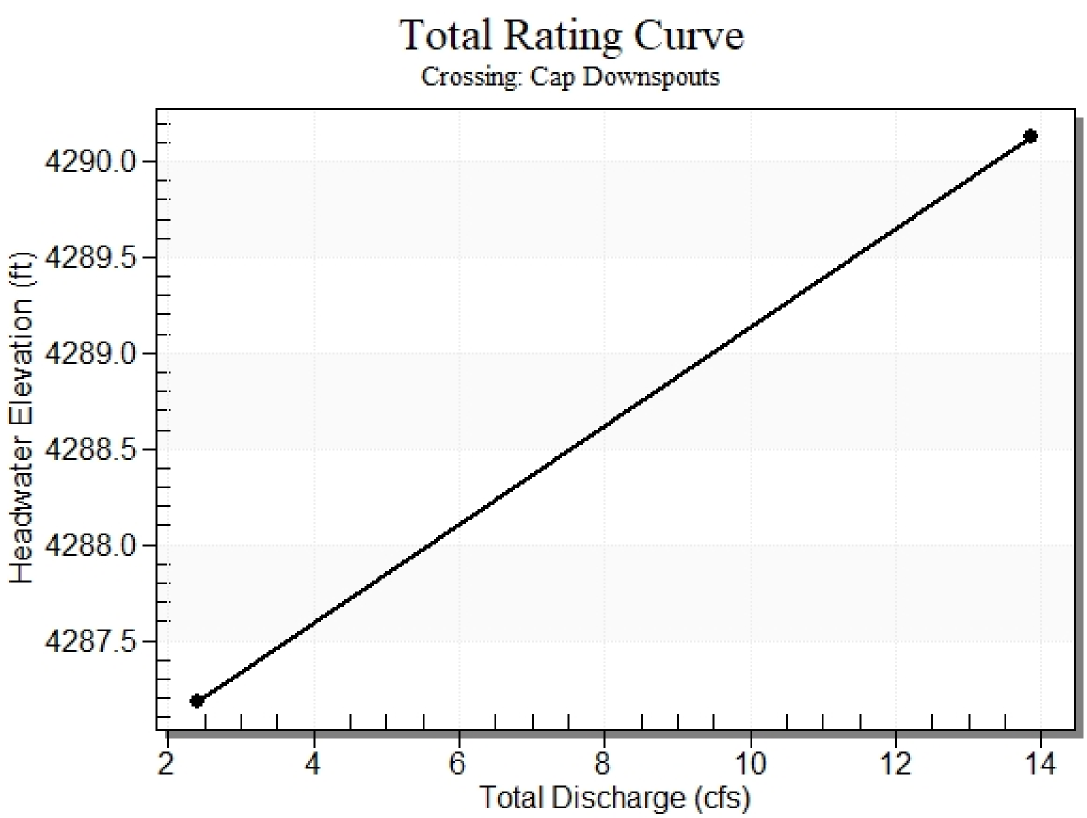


Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2.40	2.40	4287.19	0.647	0.0*	1-JS1f	0.278	0.582	1.500	0.568	1.358	2.480

* Full Flow Headwater elevation is below inlet invert.

****

Straight Culvert

Inlet Elevation (invert): 4286.54 ft,   Outlet Elevation (invert): 4264.00 ft

Culvert Length: 83.11 ft,   Culvert Slope: 0.2817

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 4286.54 ft

Outlet Station: 80.00 ft

Outlet Elevation: 4264.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 1.50 ft

Barrel Material: Corrugated PE

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

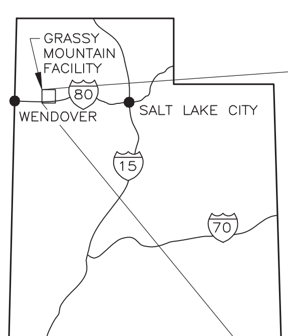
CleanHarbors®
ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY
LANDFILL CELLS 8-13
PERMIT DRAWINGS

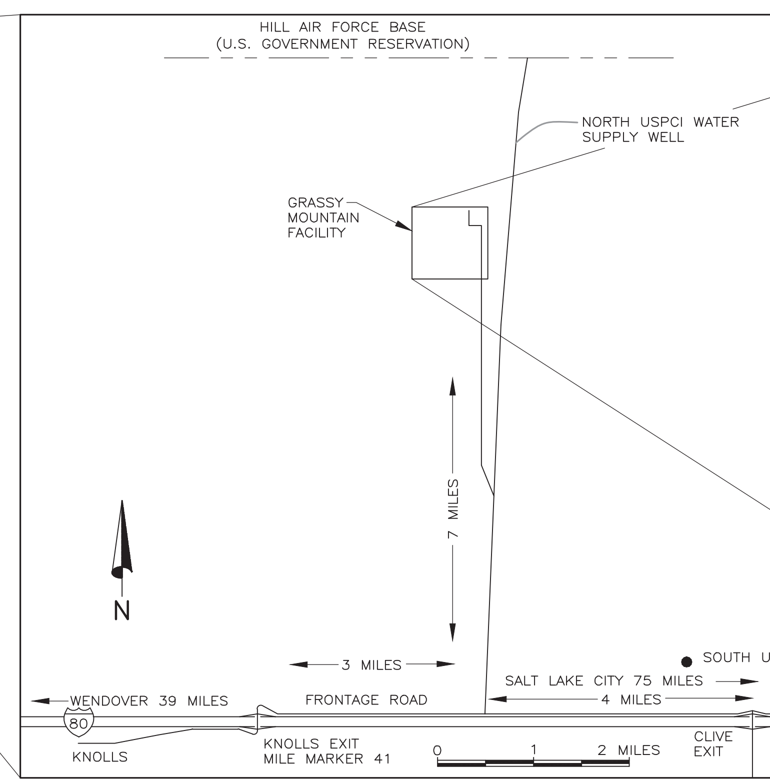
AUGUST 2018 REV 1

FACILITY LOCATION
KNOLLS, UTAH
Phone: (435) 884–8900

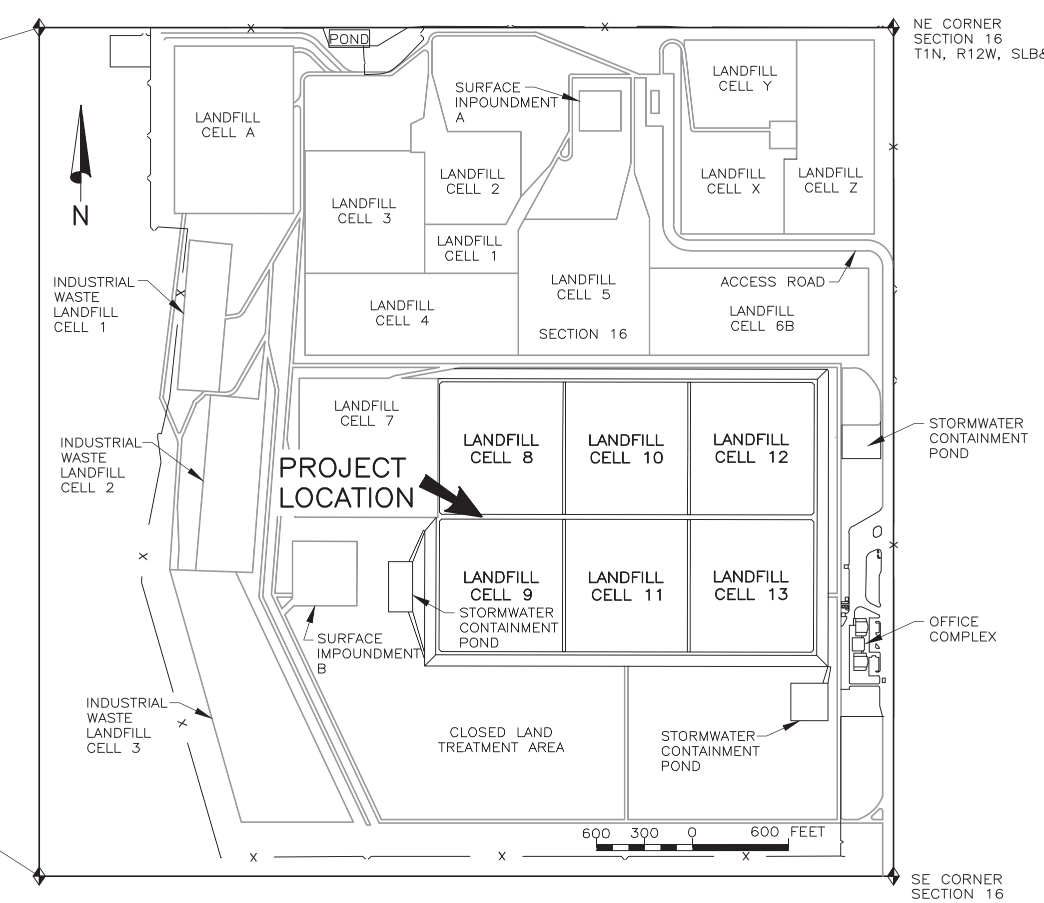
REGIONAL HEADQUARTERS
42 LONGWATER DRIVE
NORWELL, MA 02061
Phone: (781) 792–5000



STATE OF UTAH



VICINITY MAP



PROJECT LOCATION

PROFESSIONAL ENGINEER
GORDON L. JONES
No. 5048470-2202
8/6/2018
STATE OF UTAH

HANSEN ALLEN & LUCE INC ENGINEERS
CONSULTANTS ENGINEERS
Salt Lake City Utah

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\G-1 COVER__R1.DWG
FILE DATE: 8.6.2018 10:40:54 (CAH)

7/95

GENERAL NOTES

1. COORDINATES AND ELEVATIONS PROVIDED ARE BASED ON SITE SPECIFIC COORDINATE SYSTEM AND DATUM CONTROL ESTABLISHED AT THE EAST ¼ CORNER OF SECTION 16, T1N, R2W (N 0.00, E 0.00, EL. 4238.66). ELEVATIONS ARE APPROXIMATE FEET ABOVE MEAN SEA LEVEL.
2. ALL ELEVATIONS PROVIDED ARE BASED ON ORIGINAL EMBANKMENT DESIGN AND CONSTRUCTION ELEVATIONS. ADJUSTMENTS SHALL BE MADE PRIOR TO CLOSURE TO ACCOUNT FOR SETTLEMENT.

LINING SYSTEM SUBGRADES & SOIL FILL

1. ALL SURFACES PROVIDING SUBGRADES FOR LINING SYSTEMS SHALL BE PROOF ROLLED FOR SOFT AND/OR YIELDING SURFACES. SOFT AND/OR YIELDING SURFACES SHALL BE COMPACTED TO PROVIDE A FIRM SUBGRADE FOR LINING SYSTEMS.
2. ALL CLAY LINER MATERIALS SHALL BE COMPACTED TO 95% OF ASTM D-698 AT A MOISTURE CONTENT TYPICALLY BETWEEN MINUS 2% AND PLUS 4% OF OPTIMUM. ALL CLAY LINER SHALL MEET THE REQUIRED PERMEABILITY OF 1 X 10-7 CM/SEC.
3. THE SUB-GRADE FOR THE GEOSYNTHETIC MATERIALS SHALL BE FREE OF PROTRUDING ROCKS AND DEBRIS THAT MAY POTENTIALLY CAUSE DAMAGE TO THE GEOSYNTHETIC MATERIALS. THE SUBGRADE SHALL ALSO BE ROLLED WITH A SMOOTH DRUM ROLLER TO LEAVE THE SURFACE SMOOTH.
4. ALL FILL MATERIALS REQUIRING COMPACTION SHALL BE COMPACTED TO 95% OF ASTM D-698.
5. PIPE BACKFILL AND ANCHOR TRENCH BACKFILL SHALL BE COMPACTED TO 90% OF ASTM D-698.
6. COMPACTED CLAY SOIL ON ABOVE THE HDPE LINER THE PERIMETER SLOPES OF THE CLOSURE CAP HAS NO PERMEABILITY REQUIREMENT AND SHALL BE COMPACTED TO 95% OF ASDM D-698.

GENERAL GEOSYNTHETICS

1. MANUFACTURER'S CERTIFICATIONS SHALL BE PROVIDED FOR ALL RAW AND MANUFACTURED MATERIALS. CERTIFICATIONS SHALL BE IN ACCORDANCE WITH THE MANUFACTURER'S MATERIAL SPECIFICATIONS AND PROJECT CQA PLAN CRITERIA AND SHALL INCLUDE ALL TEST DATA FOR MATERIALS DELIVERED AND MEET THE MINIMUM TEST FREQUENCIES DESIGNATED IN THE MANUFACTURER'S QUALITY ASSURANCE MANUALS AND SPECIFICATIONS AND THE CQA PLAN.
2. ALL GEOSYNTHETIC MATERIALS SHALL BE LOADED, TRANSPORTED, OFF-LOADED, STORED, AND HANDLED IN ACCORDANCE WITH MANUFACTURER RECOMMENDATIONS.
3. AT A MINIMUM, ALL GEOSYNTHETIC MATERIALS SHALL BE INSTALLED IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS AND INSTALLATION GUIDES AND IN ACCORDANCE WITH THE PROJECT SPECIFICATIONS AND CQA PLAN.

GEOSYNTHETIC CLAY LINER (GCL)

1. ALL GCL MATERIALS SHALL BE NEEDLE PUNCH REINFORCED.
2. GCL SHALL BE DEPLOYED WITH NON-WOVEN GEOTEXTILE SIDE UP.
3. ALL DEPLOYED GCL MATERIALS SHALL BE COVERED BY THE END OF EACH WORK DAY TO MINIMIZE EVAPORATION OF MOISTURE WITHIN THE BENTONITE AND TO PROTECT THE GCL MATERIALS FROM EXPOSURE TO RAINY AND SNOWY WEATHER.
4. SEAMING SHALL BE IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS, THE PROJECT SPECIFICATIONS, AND THE CQA PLAN.
5. GCL MATERIALS THAT ARE MANUFACTURED TO PROVIDE SELF-SEALING SEAMS AND DO NOT REQUIRE A BENTONITE BEAD SHALL RECEIVE A BENTONITE BEAD WHEN THE SELF-SEALING DESIGN IS COMPROMISED ON THE ENDS OF PANELS AND WHERE THE SELF-SEALING GROOVE (IF PART OF THE SELF-SEALING DESIGN) HAS BEEN REMOVED FROM PARTIAL WIDTH ROLLS.
6. GCL MATERIALS THAT HAVE NOT BEEN MANUFACTURED TO PROVIDE SELF SEALING SEAMS SHALL RECEIVE A BENTONITE BEAD TO PROVIDE THE SEAM SEAL IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS.

GEOMEMBRANE LINER

1. ALL GEOMEMBRANE MATERIALS SHALL BE TEXTURED ON BOTH SIDES.
2. NO GEOMEMBRANE MATERIALS SHALL BE DEPLOYED IN SUB-FREEZING TEMPERATURES UNLESS APPROVED BY OWNER WITH AN APPROVED COLD WEATHER DEPLOYMENT PLAN.
3. NO SEAMING SHALL BE ALLOWED IN SUB-FREEZING TEMPERATURES WITHOUT OWNER APPROVAL OF AN APPROPRIATE COLD WEATHER SEAMING PLAN AND ONLY AFTER PROPER DEMONSTRATION OF PRE-QUALIFIED TEST SEAMS.
4. FIELD TESTING AND QUALITY CONTROL SHALL FOLLOW, AT A MINIMUM, THE REQUIREMENTS PROVIDED IN THE MOST RECENT VERSION MANUFACTURERS INSTALLATION PROCEDURES, AND/OR THE PROJECT SPECIFICATIONS AND CQA PLAN, WHICHEVER IS MOST STRINGENT.

GEOCOMPOSITE

1. GEOCOMPOSITE SHALL HAVE A TRANSMISSIVITY OF 6.0 X 10^{-4} M^2/SEC.
2. DOUBLE-SIDED GEOCOMPOSITE SHALL CONSIST OF 8 OZ. NON-WOVEN GEOTEXTILE BONDED TO BOTH SIDES OF GEONET.
3. GEOMEMBRANE MATERIALS SHALL BE CLEANED OF DIRT AND DEBRIS PRIOR TO DEPLOYMENT OF GEOCOMPOSITE.
4. GEOCOMPOSITE SHALL BE FASTENED OR SECURED WITH HEAT BONDING, SEWING OR OTHER APPROVED METHOD, BETWEEN GEOTEXTILE FABRIC MATERIALS ALONG THE ENTIRE LENGTH OF THE SEAMS.
5. OVERLAPS OF SEAMS SHALL BE, AT A MINIMUM, THE DIMENSIONS RECOMMENDED BY THE MANUFACTURES.

PROTECTIVE SOIL COVER

1. CARE SHALL BE EXERCISED DURING PLACEMENT OF PROTECTIVE SOIL COVER MATERIALS. A MINIMUM COVER THICKNESS AS DESIGNATED IN THE PROJECT SPECIFICATIONS AND/OR THE CQA PLAN SHALL BE MAINTAINED AT ALL TIMES BETWEEN THE TIRES OR TRACKS OF EQUIPMENT AND THE UNDERLYING GEOSYNTHETIC MATERIALS.
2. NO SHARP, ABRUPT, OR PIVOTING TURNS SHALL BE ALLOWED BY EQUIPMENT USED ABOVE THE PROTECTIVE SOIL COVER THAT MAY CAUSE SOIL DISPLACEMENT AND DAMAGE TO UNDERLYING GEOSYNTHETIC MATERIALS.
3. ANY WAVES OR WRINKLES THAT BEGIN TO FORM SHALL BE TRAPPED BY PLACING SUFFICIENT PROTECTIVE SOIL COVER BEYOND THE WAVES OR WRINKLES TO HOLD THEM IN PLACE AND KEEP THEM FROM COMBINING INTO LARGER WAVES OR WRINKLES.

GRAVEL ARMOR PLATING (STONE MULCH)

1. STONE MULCH SHALL BE PLACED TO A MINIMUM THICKNESS OF 6 INCHES ON ALL SURFACES.
2. MINIMUM D50 SIZE FOR STONE MULCH SHALL BE 1.0 INCH AND SHALL BE VERIFIED BY TESTING.

STORM DRAINAGE SYSTEM

1. ALL MANHOLES, LIDS, AND RINGS AND COVERS SHALL BE RATED FOR H20 LOADINGS.
2. RINGS AND COVERS AND GRATED COVERS SHALL PROVIDE A MINIMUM OPENING FOR ACCESS OF 30 INCHES.
3. GRATED COVERS SHALL BE USED FOR EMBANKMENT DRAINAGE DITCH INLETS
4. A 10' X 10' CONCRETE APRON SHALL BE PLACED AROUND ALL MANHOLE COVERS.
5. RIPRAP APRON AT CONCRETE BAFFLED OUTLETS TO EXTEND A MINIMUM DISTANCE OF 5 FEET, TO BE 12 INCHES THICK, AND HAVE A D_{50}=3".

CLOSURE GCL COMPATIBILITY

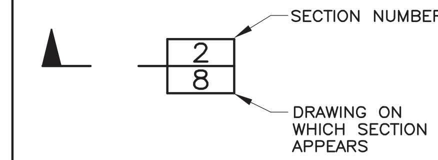
1. BORROW SOURCES FOR 6-INCH THICK SAND LAYER AND 2-FOOT THICK PROTECTIVE SOIL COVER LAYERS TO BE APPROVED BASED ON THE FOLLOWING TESTS USING LIQUID OBTAINED FROM SYNTHETIC LEACHATE PRODUCED USING BORROW SOURCE SOILS: 1. SCREENING CLAY PORTION OF GEOSYNTHETIC CLAY LINER FOR CHEMICAL COMPATIBILITY TO LIQUIDS (ASTM D6141); TESTING RESULTS SHALL DEMONSTRATE THAT THE MAXIMUM HYDRAULIC CONDUCTIVITY OF GCL SHALL MEET AN EQUIVALENCY OF A 2-FOOT THICK COMPACTED CLAY LINER WITH A HYDRAULIC CONDUCTIVITY OF 1X10-7 CM/SEC.

INDEX OF DRAWINGS

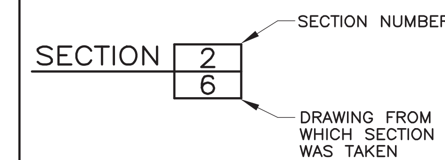
SECTION & DETAIL IDENTIFICATION

SECTION IDENTIFICATION

SECTION CUT ON DRAWING NO. 6 AND SHOWN ON DRAWING NO. 8
ON DRAWING NO. 6 THIS SECTION IS REFERENCED AS:

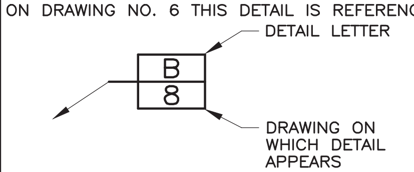


ON DRAWING NO. 8, THIS SECTION IS IDENTIFIED AS:

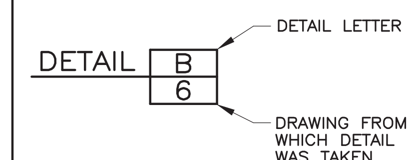


DETAIL IDENTIFICATION

DETAIL CALL-OUT ON DRAWING NO. 6 AND SHOWN ON DRAWING NO. 8
ON DRAWING NO. 6 THIS DETAIL IS REFERENCED AS:



ON DRAWING NO. 8, THIS DETAIL IS IDENTIFIED AS:



NOTES:
1. IF SECTION AND DETAILS ARE SHOWN ON THE SAME DRAWING AS SECTION CUTS AND SECTION OR DETAIL CALL-OUTS DRAWING NUMBER IS REPLACED BY A LINE.
2. DETAIL LETTERS "I" AND "O" NOT USED.

TABLE OF ABBREVIATIONS

●	= AIR GAS VENT		MH	=	MANHOLE
@	= AT		MIN.	=	MINIMUM
AVG.	= AVERAGE		N.	=	NORTH
C.C.	= CENTER TO CENTER		N.T.S.	=	NOT TO SCALE
℄	= CENTER LINE		O.C.	=	ON CENTER
CLR.	= CLEARANCE		PC	=	POINT OF CURVE
CONT.	= CONTINUOUS		PI	=	POINT OF INTERSECTION
CPP	= CORRUGATED POLYETHYLENE PIPE		PSI	=	POUND PER SQUARE INCH
DIA.	= DIAMETER		PT	=	POINT OF TANGENT
DWG	= DRAWING		REINF	=	REINFORCEMENT
E.	= EAST		SDR	=	STANDARD DIMENSIONAL RATIO
EF	= EACH FACE		SF	=	SQUARE FEET
EL.	= ELEVATION		SQ.	=	SQUARE
E.W.	= EACH WAY		STA.	=	STATION
FL	= FLOW LINE		TL	=	TOP OF LINER
HDPE	= HIGH DENSITY POLYETHYLENE		T.O.C.	=	TOP OF CONCRETE
ID	= INSIDE DIAMETER		TYP.	=	TYPICAL
MAX.	= MAXIMUM		UBC	=	UNTREATED BASE COURSE

FILE NAME: PROJECTS\064 - CLEAN HARBORS\85.100 - CELL 8 AND 9 DESIGN\CAD\WORKING\G-2 INDEX SHEET__R1.DWG
FILE DATE: 8.6.2018 11:01:16 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER No. 5048470-2202 GORDON L. JONES 8/6/2018 STATE OF UTAH
PROJECT ENGINEER

DESIGNED	KCS	3			
DRAFTED	CAH	2			
CHECKED	GLJ	1			
DATE	AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY / APVD.

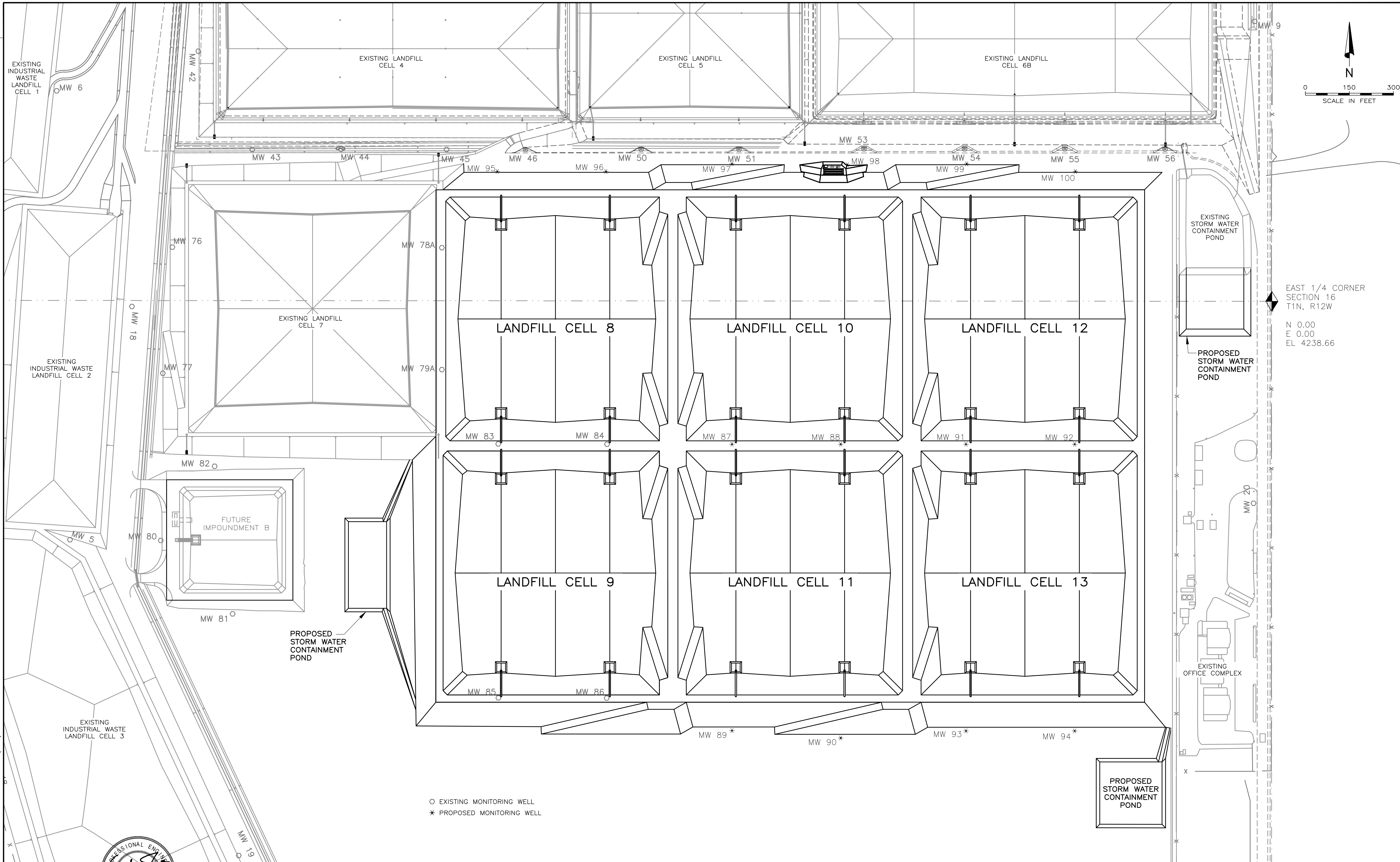
SCALE: NOT TO SCALE

CleanHarbors® ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8-13
GENERAL
GENERAL NOTES, LEGEND & INDEX OF DRAWINGS

SHEET G-2
064.85.100

10/07



FILE NAME: PROJECTS\064 - CLEAN HARBORS\85.100 - CELL 8 AND 9 DESIGN\CAD\WORKING\G-3 OVERALL SITE PLAN__R1.DWG
FILE DATE: 8.6.2018 11:02:53 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 3/1/2019 STATE OF UTAH

PROJECT ENGINEER

DESIGNED	KCS	3			
DRAFTED	CAH	2			
CHECKED	GLJ	1	2/2019	MODIFIED LOCATION OF MW's 80–94 TO CONSTRUCTED AND PROPOSED LOCATIONS AND ADDED PROPOSED MW's 95–100	
DATE	AUGUST 2018	NO.	DATE	REVISIONS	BY / APVD.

SCALE: NOT TO SCALE

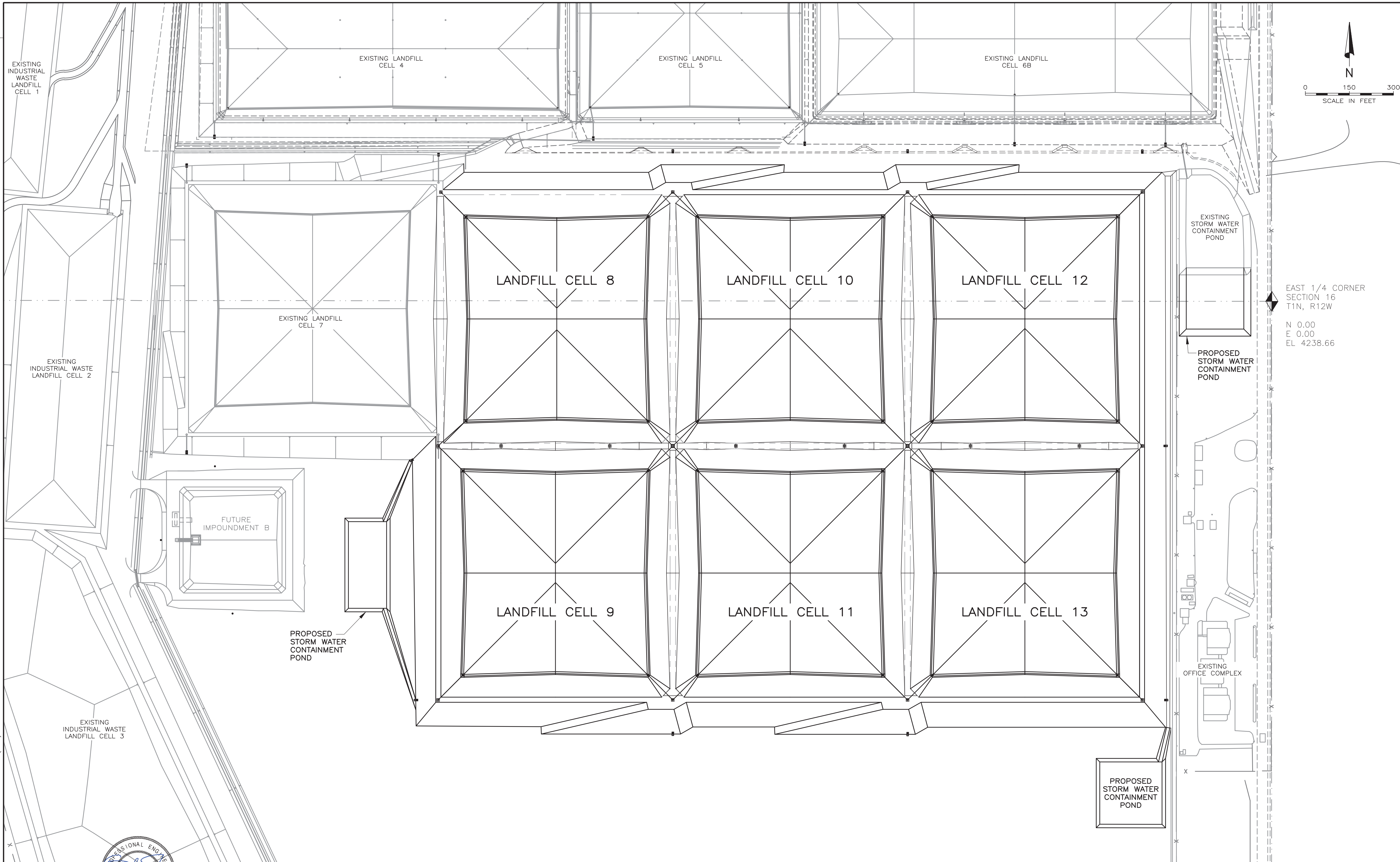
CleanHarbors® ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8–13
GENERAL
OVERALL FLOOR PLAN

SHEET G–3

064.85.100

10/07



FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\G-4 OVERALL CLOSURE PLAN__R1.DWG
FILE DATE: 8.6.2018 11:03:57 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER No. 5048470-2202 GORDON L. JONES 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED KCS	3					
DRAFTED CAH	2					
CHECKED GLJ	1					
DATE AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.	

SCALE: NOT TO SCALE

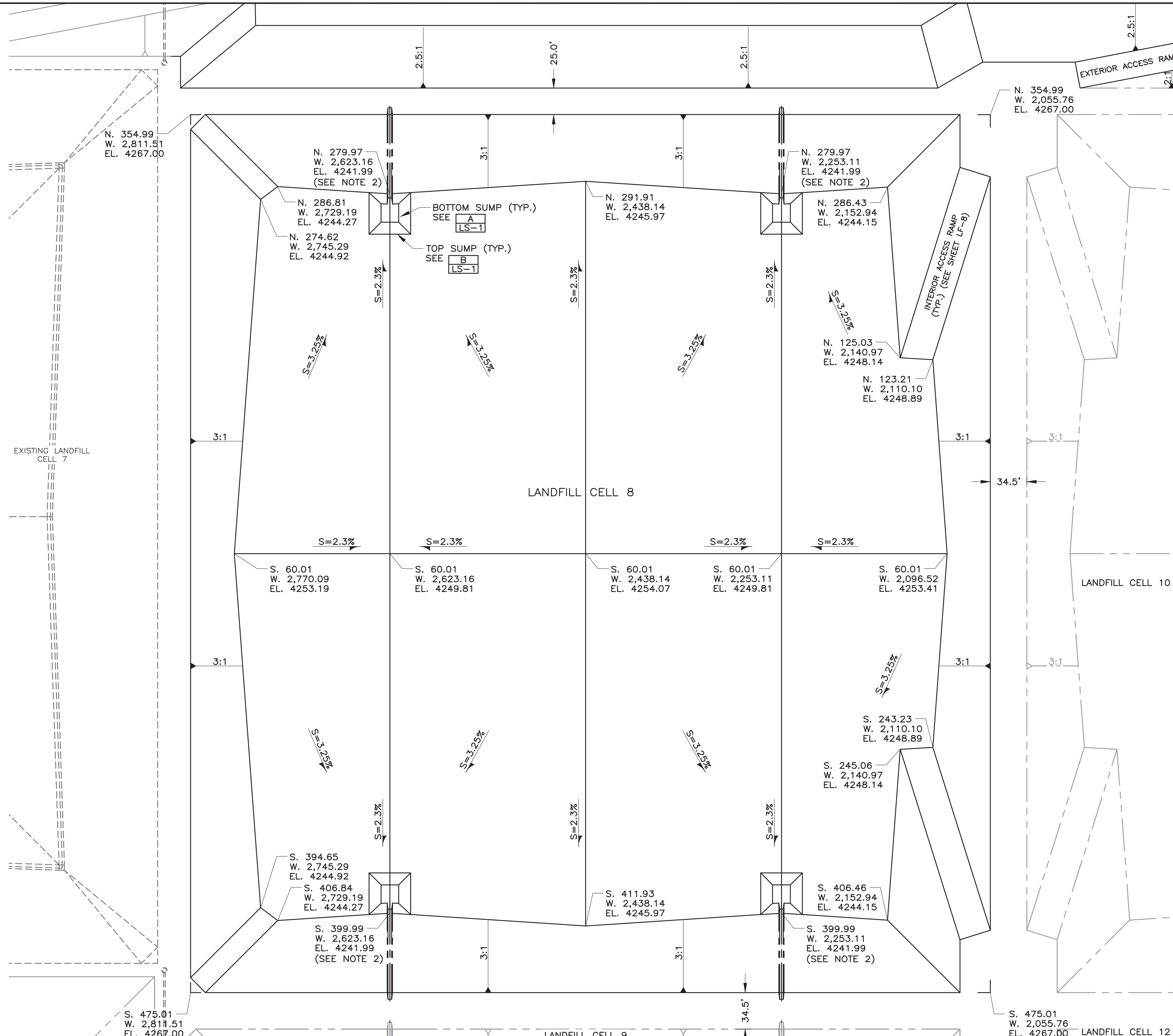
CleanHarbors® ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8–13
GENERAL
OVERALL CLOSURE PLAN

SHEET G-4

064.85.100

10/07



N

0 50 100
SCALE IN FEET

NOTES:

1. COORDINATES & ELEVATIONS ARE TOP OF COMPACTED CLAY LINER.
2. SUMP REFERENCE POINT SEE SHEET LS-1 FOR SUMP PLAN.
3. ALL LINES SHOWING THE INSIDE OF LANDFILL CELLS ARE DEPICTING TOP OF CLAY SURFACE.

FILE NAME: PROJECTS\064 - CLEAN HARBORS\85.100 - CELL 8 AND 9 DESIGN\CAD\WORKING\LF-1 CELL 8 PLAN VIEW__R1.DWG
FILE DATE: 8.6.2018 11:32:47 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED KCS	3			
DRAFTED CAH	2			
CHECKED GLJ	1			
DATE AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY APVD.

SCALE
NOT TO SCALE

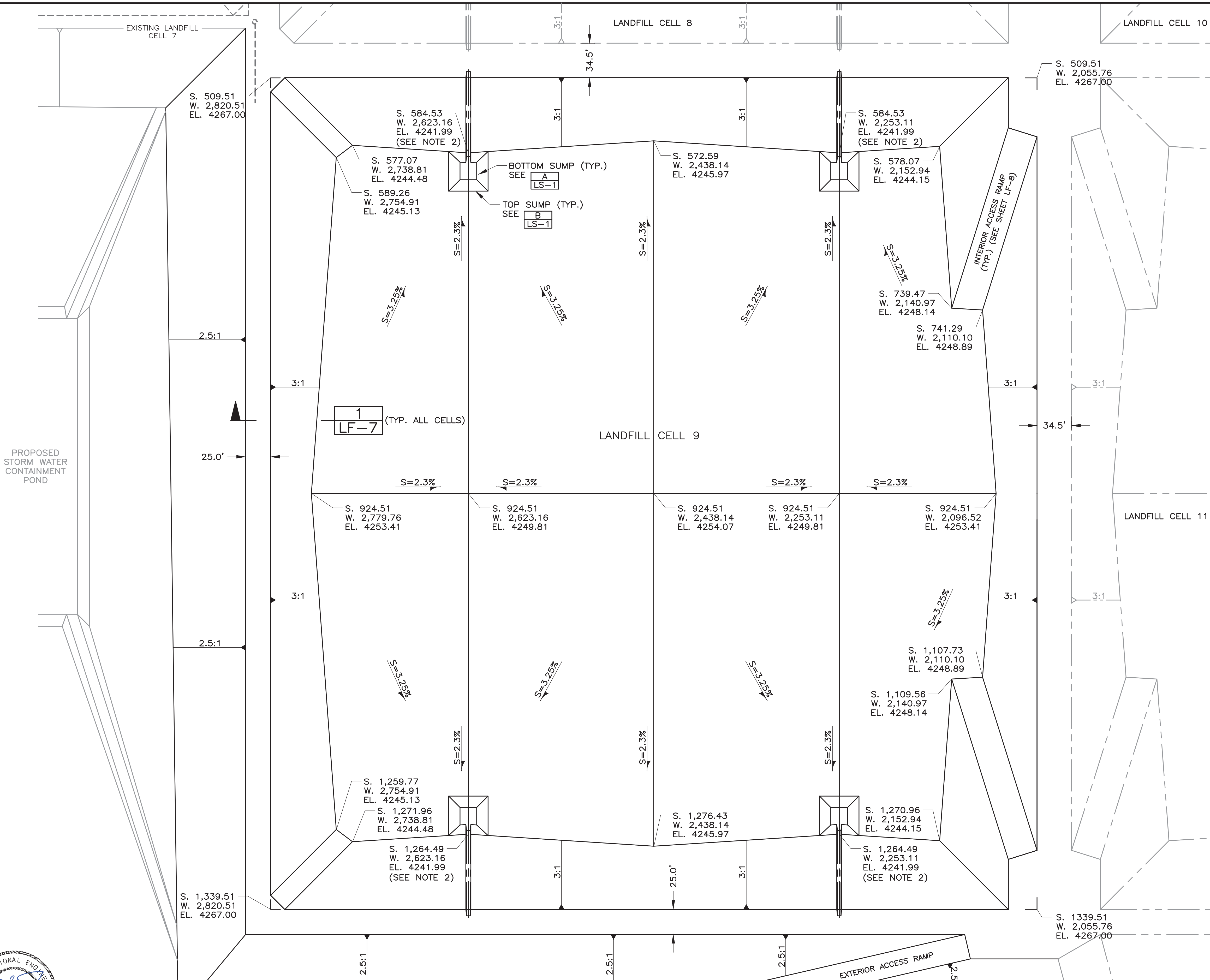
CleanHarbors ENVIRONMENTAL SERVICES, INC.

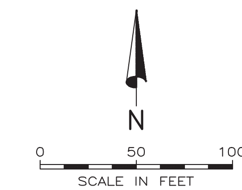
GRASSY MOUNTAIN FACILITY CELLS 8–13
LANDFILL
PLAN VIEW CELL 8

SHEET LF–1

064.85.100

10/07





NOTES:

1. COORDINATES & ELEVATIONS ARE TOP OF COMPACTED CLAY LINER.
2. SUMP REFERENCE POINT SEE SHEET LS-1 FOR SUMP PLAN.
3. ALL LINES SHOWING THE INSIDE OF LANDFILL CELLS ARE DEPICTING TOP OF CLAY SURFACE.

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\LF-2 CELL 9 PLAN VIEW__R1.DWG
FILE DATE: 8.6.2018 11:33:47 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED	KCS	3			
DRAFTED	CAH	2			
CHECKED	GLJ	1			
DATE	AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY / APVD.

SCALE: NOT TO SCALE

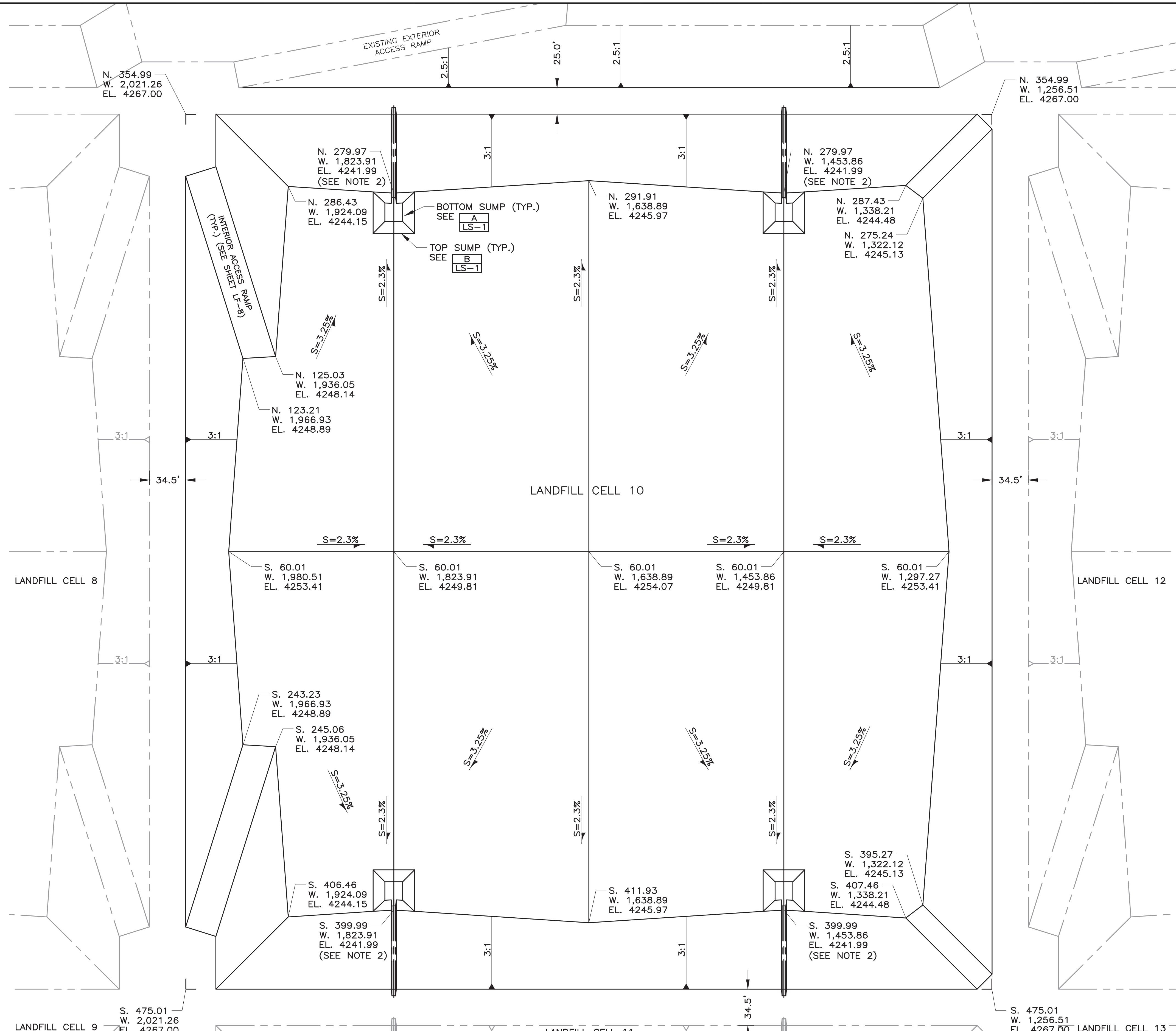
CleanHarbors ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8–13
LANDFILL
PLAN VIEW CELL 9

SHEET LF–2

064.85.100

10/07



NOTES:

1. COORDINATES & ELEVATIONS ARE TOP OF COMPACTED CLAY LINER.
2. SUMP REFERENCE POINT SEE SHEET LS-1 FOR SUMP PLAN.
3. ALL LINES SHOWING THE INSIDE OF LANDFILL CELLS ARE DEPICTING TOP OF CLAY SURFACE.

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\LF-3 CELL 10 PLAN VIEW__R1.DWG
FILE DATE: 8.6.2018 11:34:33 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED	KCS	3				
DRAFTED	CAH	2				
CHECKED	GLJ	1				
DATE	AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.

SCALE: NOT TO SCALE

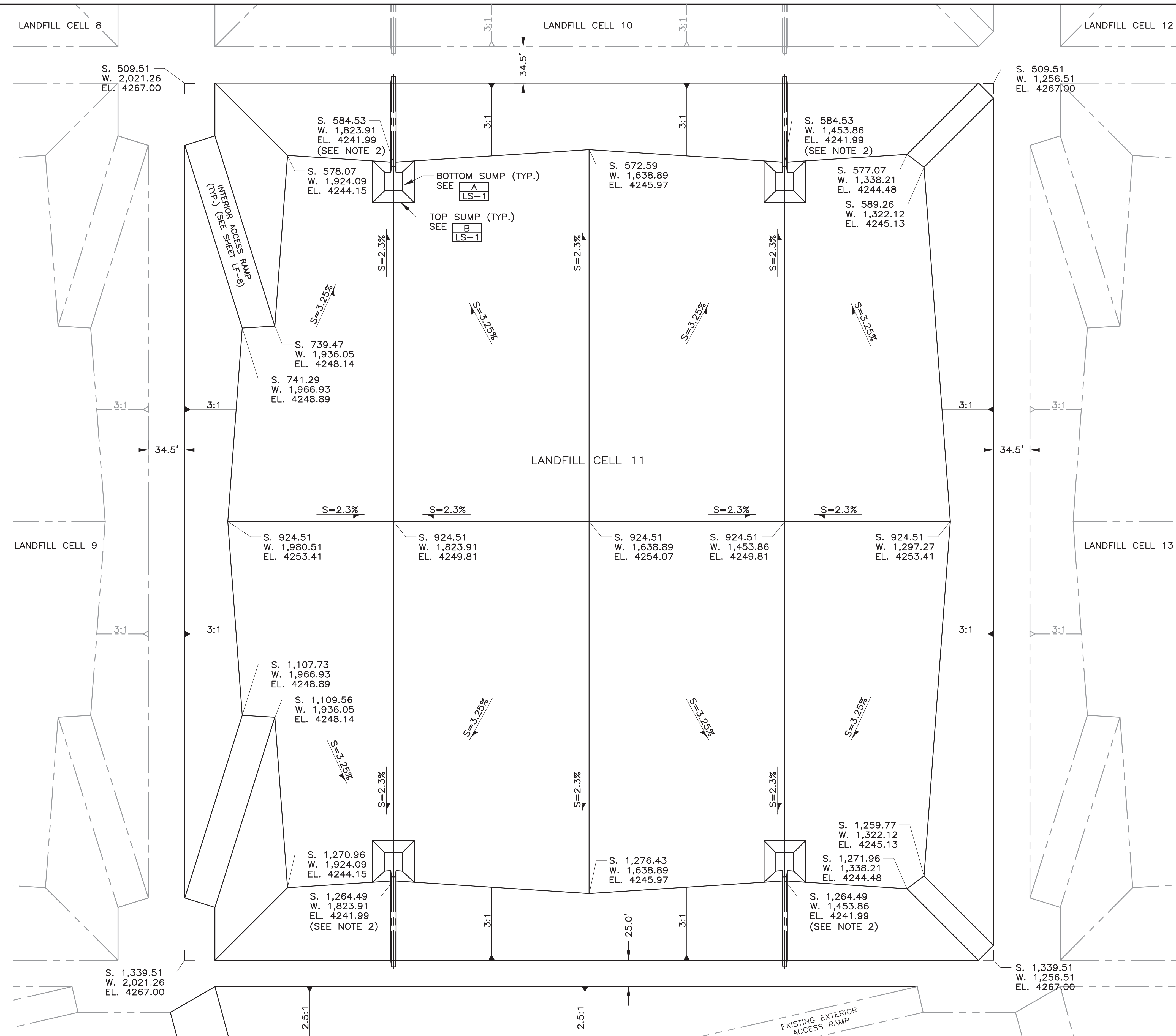
CleanHarbors® ENVIRONMENTAL SERVICES, INC.

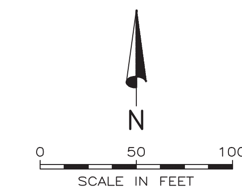
GRASSY MOUNTAIN FACILITY CELLS 8–13
LANDFILL
PLAN VIEW CELL 10

SHEET LF–3

064.85.100

10/07





NOTES:

1. COORDINATES & ELEVATIONS ARE TOP OF COMPACTED CLAY LINER.
2. SUMP REFERENCE POINT SEE SHEET LS-1 FOR SUMP PLAN.
3. ALL LINES SHOWING THE INSIDE OF LANDFILL CELLS ARE DEPICTING TOP OF CLAY SURFACE.

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\LF-4 CELL 11 PLAN VIEW__R1.DWG
FILE DATE: 8.6.2018 11:35:36 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED	KCS	3	
DRAFTED	CAH	2	
CHECKED	GLJ	1	
DATE	AUGUST 2018 REV 1	NO.	DATE / REVISIONS / BY / APVD.

SCALE: NOT TO SCALE

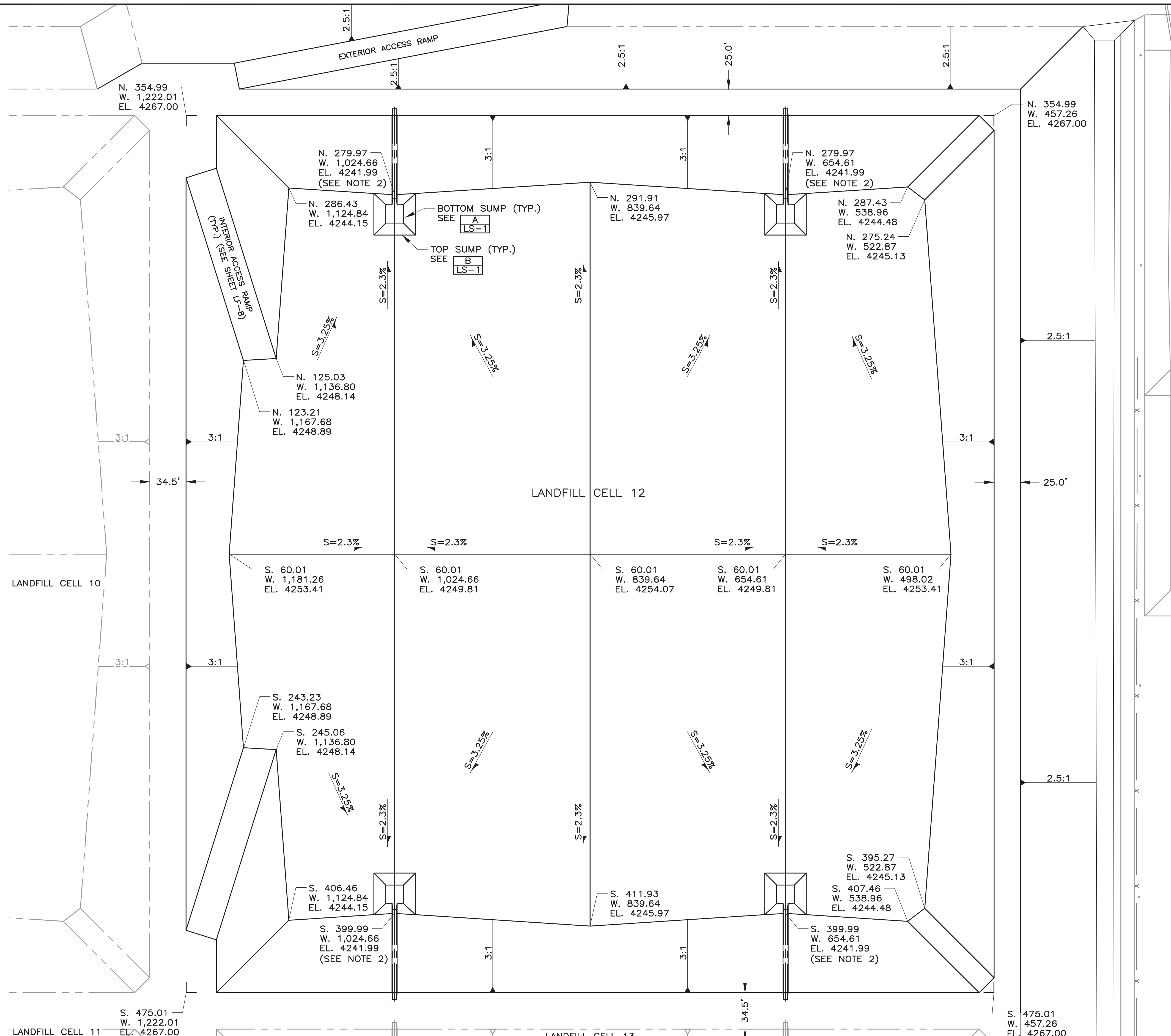
CleanHarbors ENVIRONMENTAL SERVICES, INC.

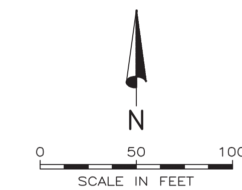
GRASSY MOUNTAIN FACILITY CELLS 8–13
LANDFILL
PLAN VIEW CELL 11

SHEET LF–4

064.85.100

10/07





NOTES:

1. COORDINATES & ELEVATIONS ARE TOP OF COMPACTED CLAY LINER.
2. SUMP REFERENCE POINT SEE SHEET LS-1 FOR SUMP PLAN.
3. ALL LINES SHOWING THE INSIDE OF LANDFILL CELLS ARE DEPICTING TOP OF CLAY SURFACE.

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\LF-5 CELL 12 PLAN VIEW__R1.DWG
FILE DATE: 8.6.2018 11:36:35 (CAH)

10/07

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED	KCS	3			
DRAFTED	CAH	2			
CHECKED	GLJ	1			
DATE	AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.

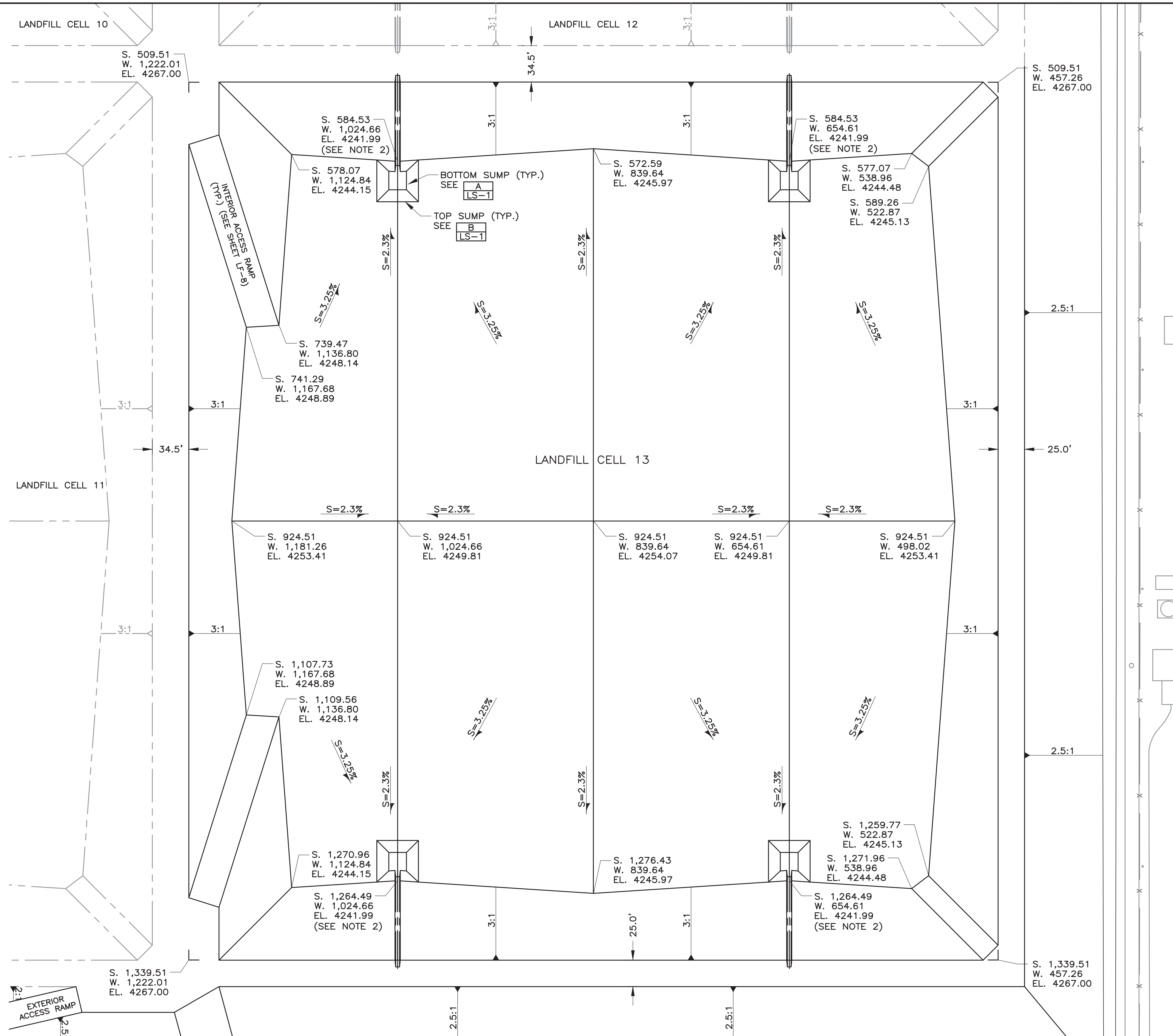
SCALE: NOT TO SCALE

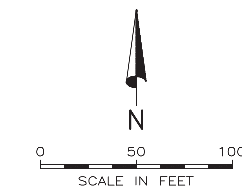
CleanHarbors® ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8–13
LANDFILL
PLAN VIEW CELL 12

SHEET LF-5

064.85.100





NOTES:

1. COORDINATES & ELEVATIONS ARE TOP OF COMPACTED CLAY LINER.
2. SUMP REFERENCE POINT SEE SHEET LS-1 FOR SUMP PLAN.
3. ALL LINES SHOWING THE INSIDE OF LANDFILL CELLS ARE DEPICTING TOP OF CLAY SURFACE.

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\LF-6 CELL 13 PLAN VIEW__R1.DWG
FILE DATE: 8.6.2018 11:37:47 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED	KCS	3				
DRAFTED	CAH	2				
CHECKED	GLJ	1				
DATE	AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.

SCALE: NOT TO SCALE

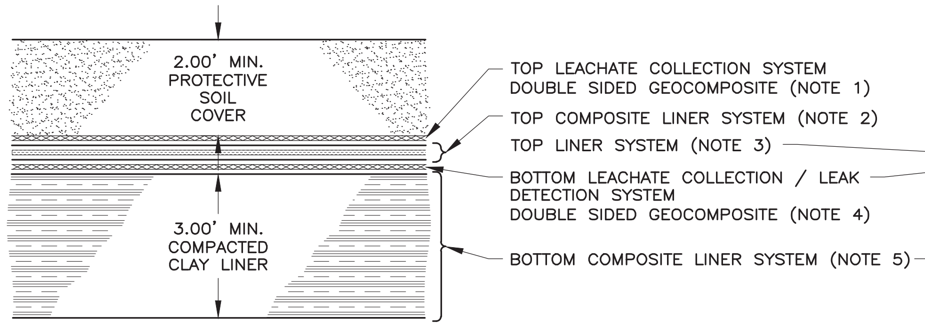
CleanHarbors® ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8–13
LANDFILL
PLAN VIEW CELL 13

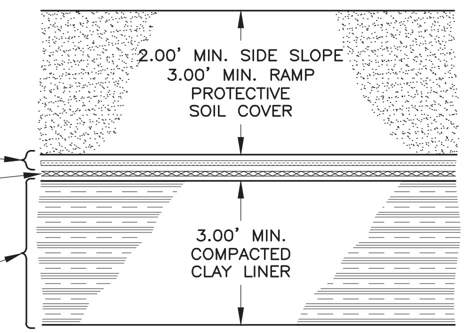
SHEET LF–6

064.85.100

10/07



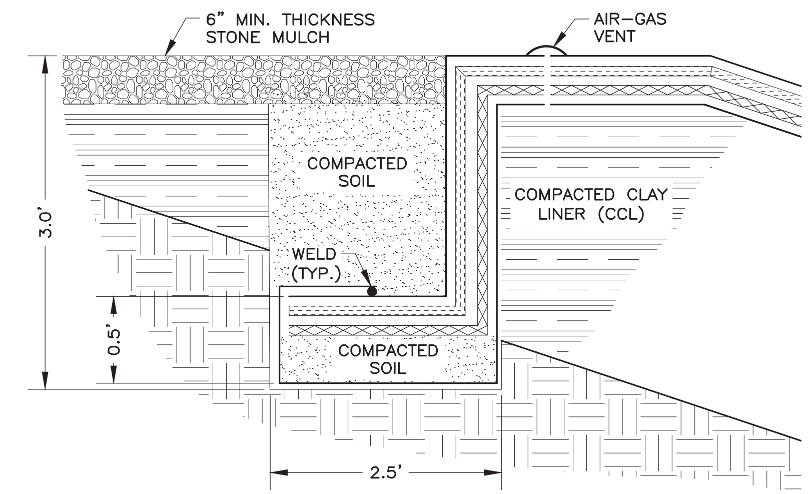
FLOOR LINER SYSTEM DETAIL A/– A/LF–8
N.T.S.



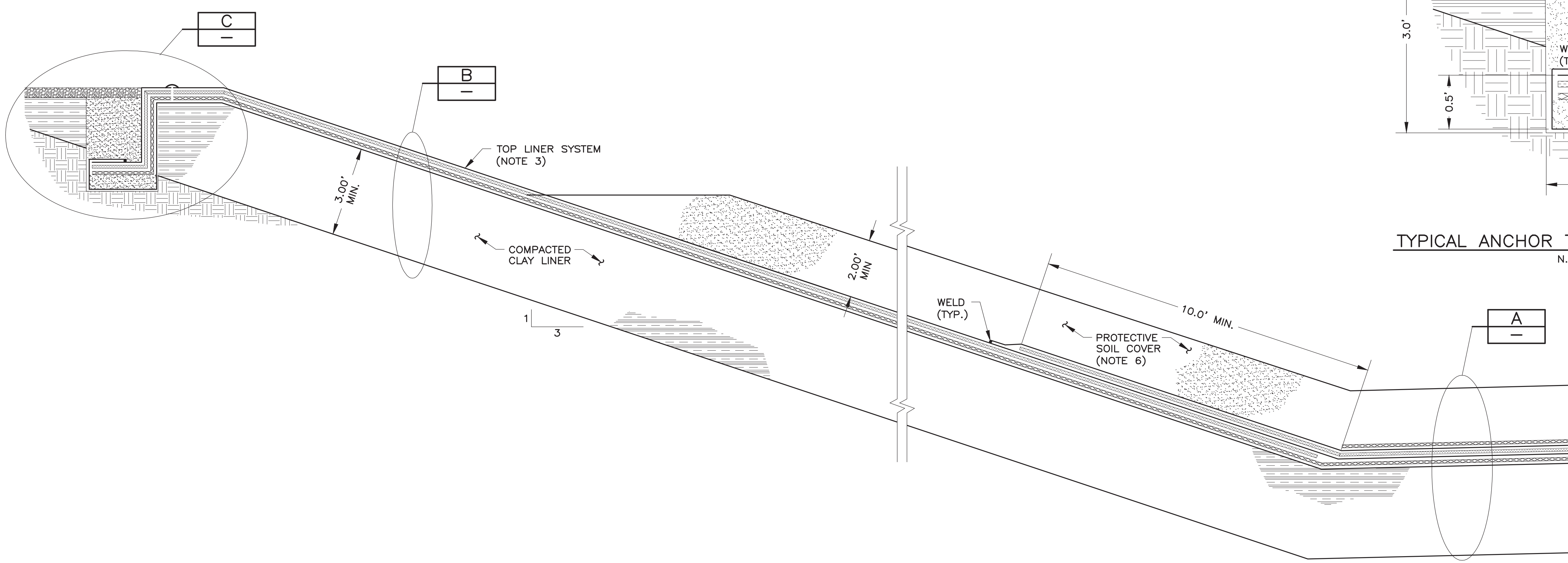
SIDESLOPE LINER SYSTEM DETAIL B/– B/LF–8
N.T.S.

NOTES:

1. TOP LEACHATE COLLECTION SYSTEM CONSISTS OF DOUBLE SIDED GEOCOMPOSITE AS FOLLOWS:
   8 OZ. NON–WOVEN GEOTEXTILE
   GEONET
   8 OZ. NON–WOVEN GEOTEXTILE
   } MIN. GEOCOMPOSITE TRANSMISSIVITY OF 6.0×10^{-4} M^2/SEC, TYP.)
2. TOP COMPOSITE LINER SYSTEM ON THE FLOOR AND TO A DISTANCE OF 10 FEET UP THE INTERIOR SLOPES CONSISTS OF:
   80–MIL HDPE GEOMEMBRANE (TEXTURED)
   GEOSYNTHETIC CLAY LINER (GCL)
   80–MIL HDPE GEOMEMBRANE (TEXTURED)
3. TOP LINER SYSTEM ON THE INTERIOR SIDESLOPES FROM A DISTANCE OF 10 FEET UP THE SLOPES TO THE ANCHOR TRENCH AT THE TOP OF THE SLOPES CONSISTS OF:
   80–MIL HDPE GEOMEMBRANE (TEXTURED)
   GEOSYNTHETIC CLAY LINER (GCL)
4. BOTTOM LEACHATE COLLECTION / LEAK DETECTION SYSTEM CONSISTS OF DOUBLE SIDED GEOCOMPOSITE AS FOLLOWS:
   8 OZ. NON–WOVEN GEOTEXTILE
   GEONET
   8 OZ. NON–WOVEN GEOTEXTILE
   } MIN. GEOCOMPOSITE TRANSMISSIVITY OF 2.7×10^{-4} M^2/SEC, TYP.)
5. BOTTOM COMPOSITE LINER SYSTEM CONSISTS OF:
   60–MIL HDPE GEOMEMBRANE (TEXTURED)
   COMPACTED CLAY LINER (CCL)
6. PROTECTIVE SOIL COVER PLACED ON THE INTERIOR SLOPES SHALL ONLY BE PLACED TO A VERTICAL HEIGHT OF 10–FEET ABOVE THE LEVEL OF THE COVER ON WASTE MATERIALS IN THE LANDFILL CELLS.
7. PROTECTIVE SOIL COVER ON RAMP TO CONSIST OF 18 INCHES OF COMPACTED SOIL (95% ASTM D–698) AND 18 INCHES OF ROAD BASE AGGREGATE AS SHOWN ON SHEET LF–8.
8. PROTECTIVE SOIL COVER ON FLOOR EXTENDING A DISTANCE OF 20 FEET FROM THE BASE OF THE RAMP TO CONSIST OF 12 INCHES OF COMPACTED SOIL (95% ASTM D–698) AND 12 INCHES OF ROAD BASE AGGREGATE AS SHOWN ON SHEET LF–8.



TYPICAL ANCHOR TRENCH DETAIL C/–
N.T.S.



TYPICAL SIDESLOPE LINER SYSTEM DETAILS 1/LF–2
N.T.S.

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\LF–7 DETAILS__R1.DWG
FILE DATE: 8.6.2018 11:38:39 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH
PROJECT ENGINEER

DESIGNED KCS	3				
DRAFTED CAH	2				
CHECKED GLJ	1				
DATE AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.

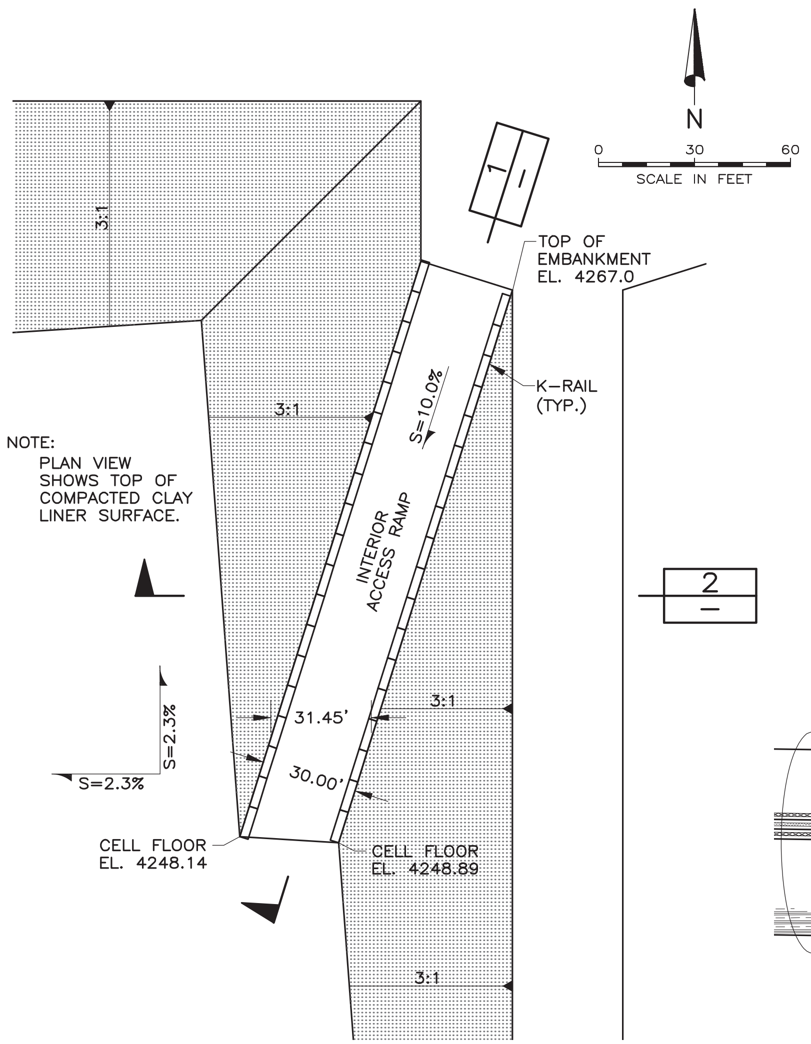
SCALE AS SHOWN

CleanHarbors ENVIRONMENTAL SERVICES, INC.

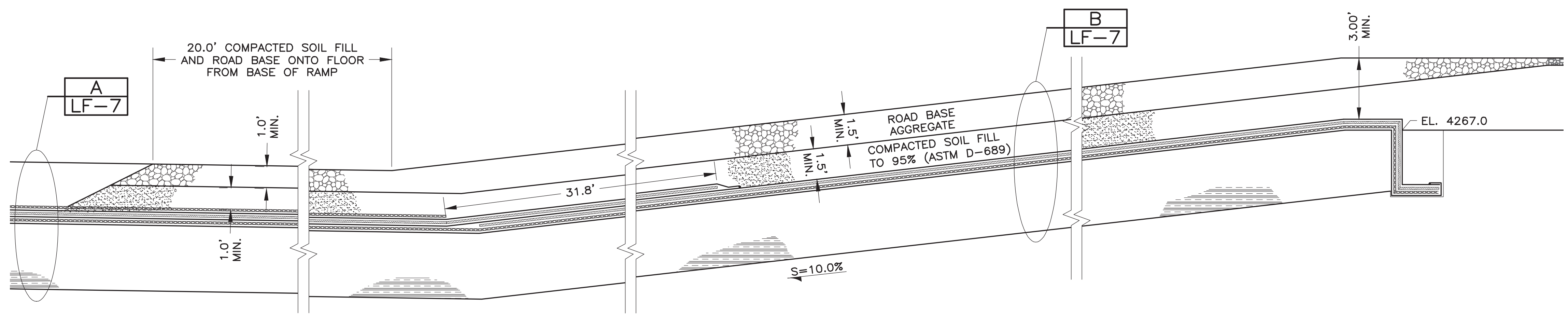
GRASSY MOUNTAIN FACILITY CELLS 8–13
LANDFILL
DETAILS

SHEET LF–7
064.85.100

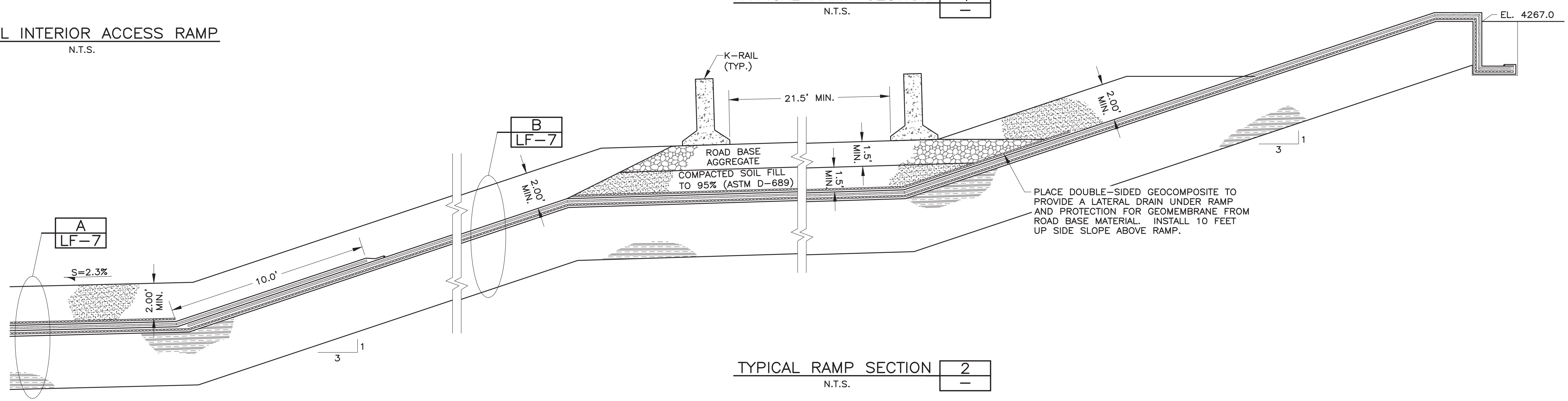
10/07



TYPICAL INTERIOR ACCESS RAMP
N.T.S.



TYPICAL RAMP SECTION 1
—
N.T.S.



TYPICAL RAMP SECTION 2
—
N.T.S.

FILE NAME: PROJECTS\064 - CLEAN HARBORS\85.100 - CELL 8 AND 9 DESIGN\CAD\WORKING\LF-8 RAMP SECTIONS__R1.DWG
FILE DATE: 8.6.2018 11:39:28 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH
PROJECT ENGINEER

DESIGNED KCS	3				
DRAFTED CAH	2				
CHECKED GLJ	1				
DATE AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.

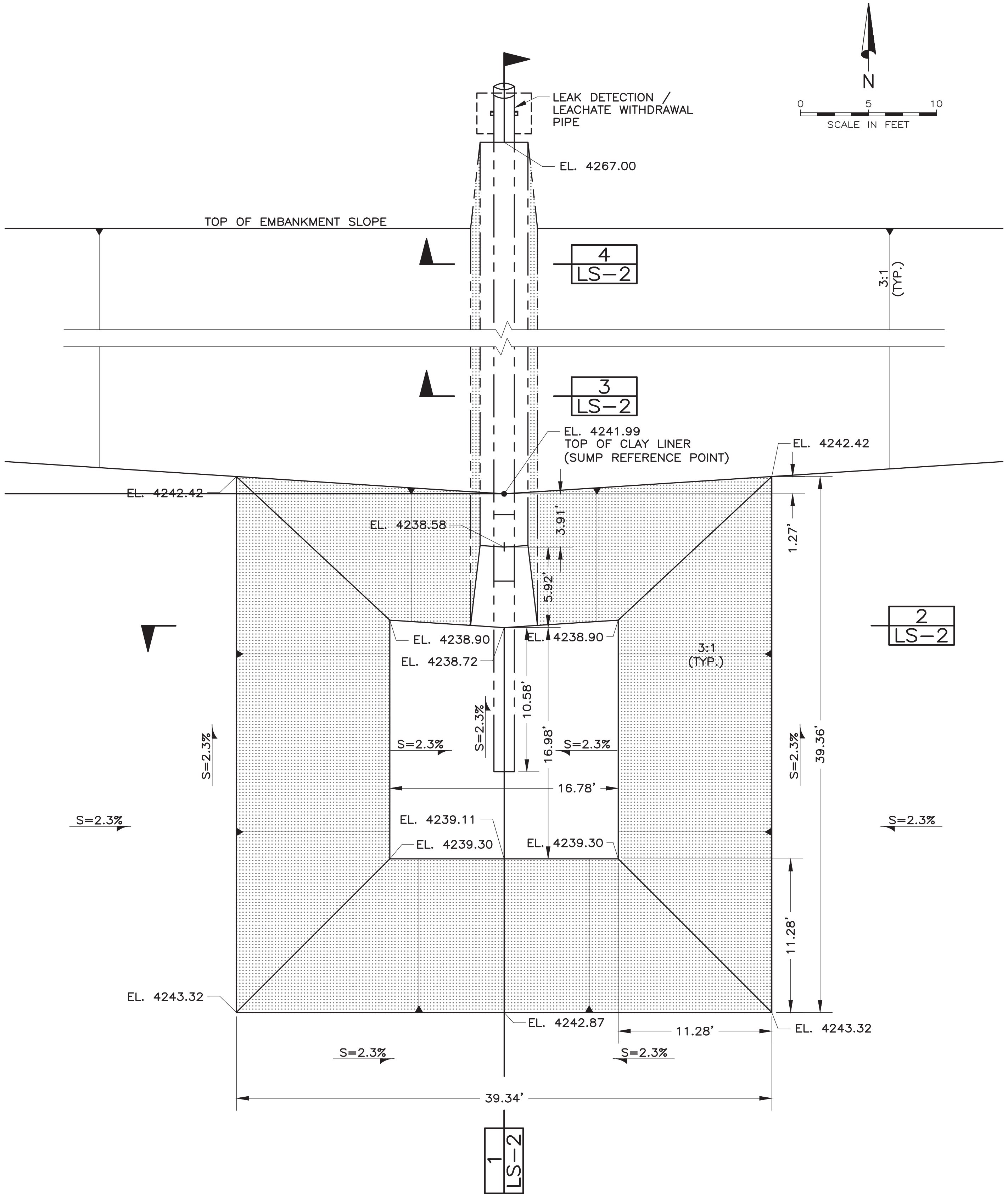
SCALE
AS SHOWN

CleanHarbors®
ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8-13
LANDFILL
TYPICAL ACCESS RAMPS

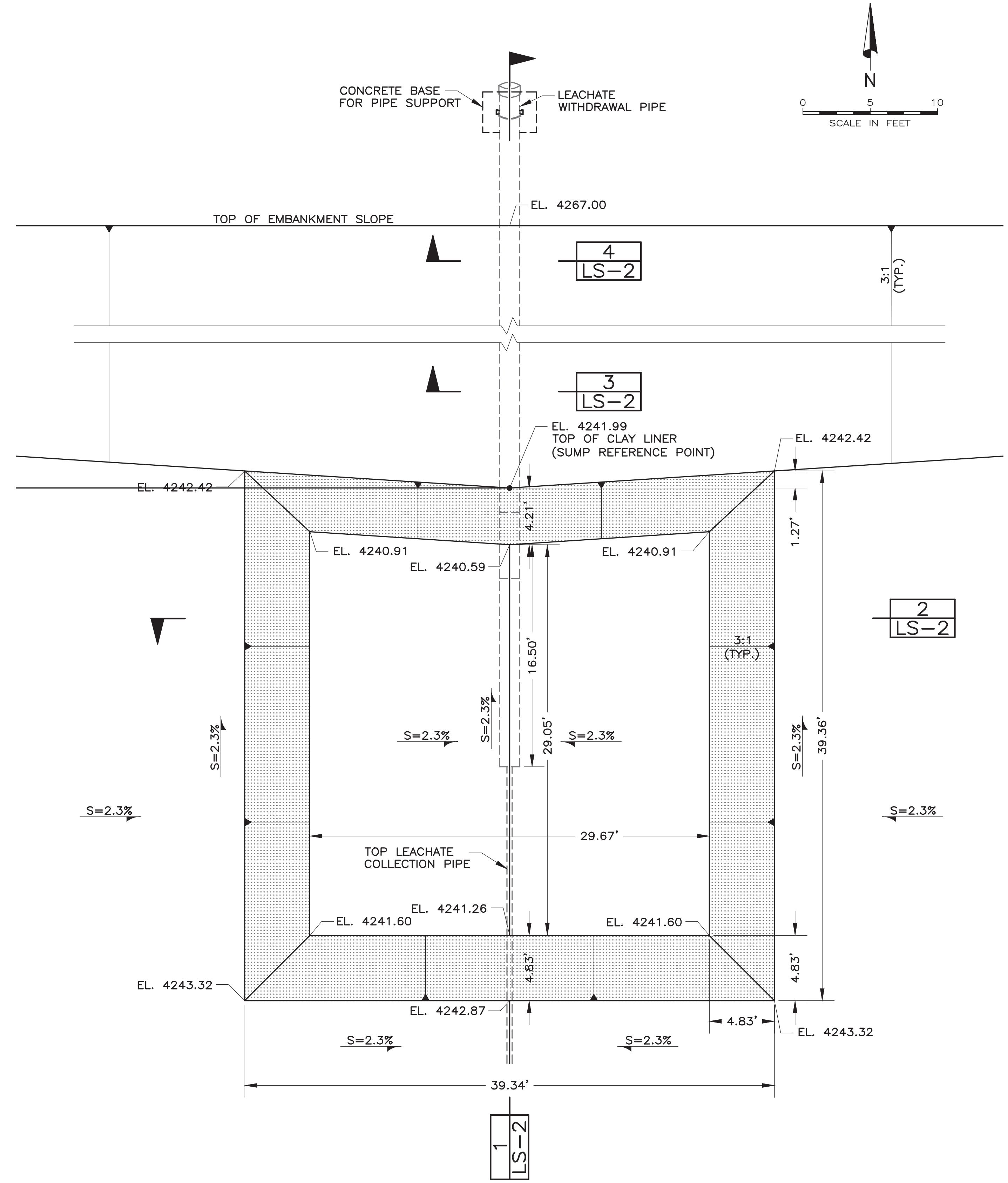
SHEET
LF-8
064.85.100

10/07



TYPICAL BOTTOM (LEAK DETECTION) SUMP
N.T.S.

A	A	A	A	A	A
LF–1	LF–2	LF–3	LF–4	LF–5	LF–6



TYPICAL TOP (LEACHATE COLLECTION) SUMP
N.T.S.

B	B	B	B	B	B
LF–1	LF–2	LF–3	LF–4	LF–5	LF–6

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\LS–1 SUMP PLANS__R1.DWG
FILE DATE: 8.6.2018 11:40:41 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED KCS	3				
DRAFTED CAH	2				
CHECKED GLJ	1				
DATE AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.

SCALE: NOT TO SCALE

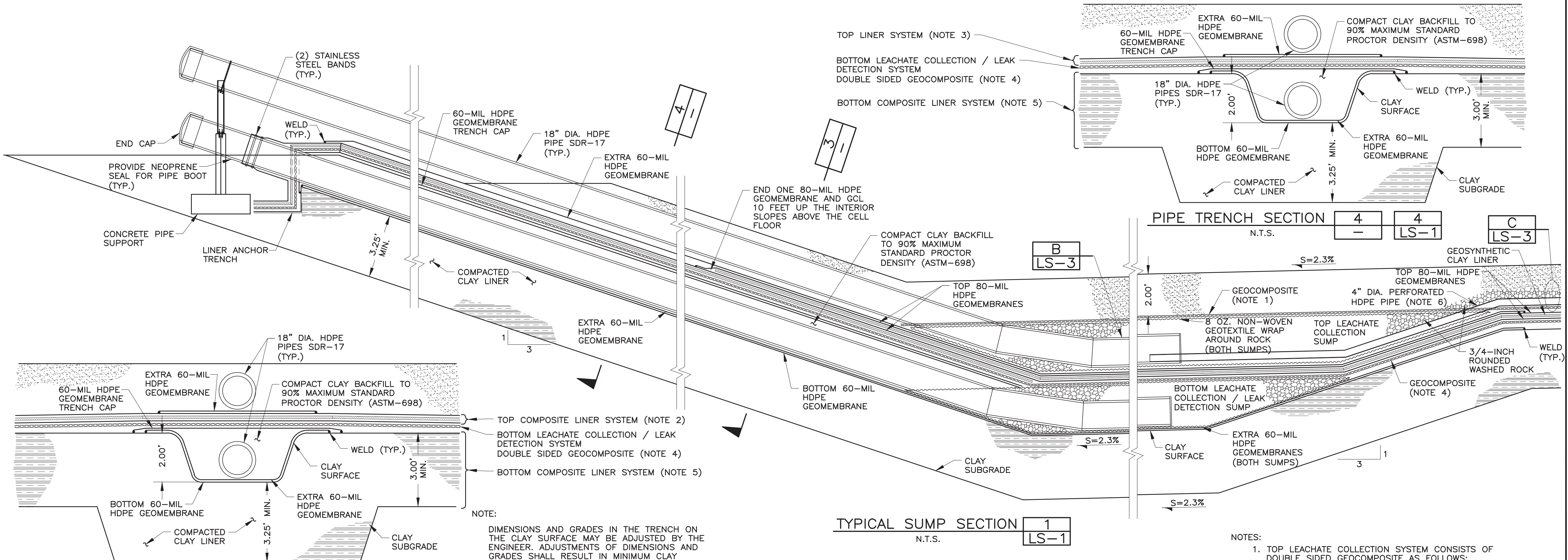
CleanHarbors® ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8–13
LCRS
SUMP PLANS

SHEET LS–1

064.85.100

10/07



TYPICAL SUMP SECTION 1 / LS-1

N.T.S.

PIPE TRENCH SECTION 4 / – 4 / LS-1

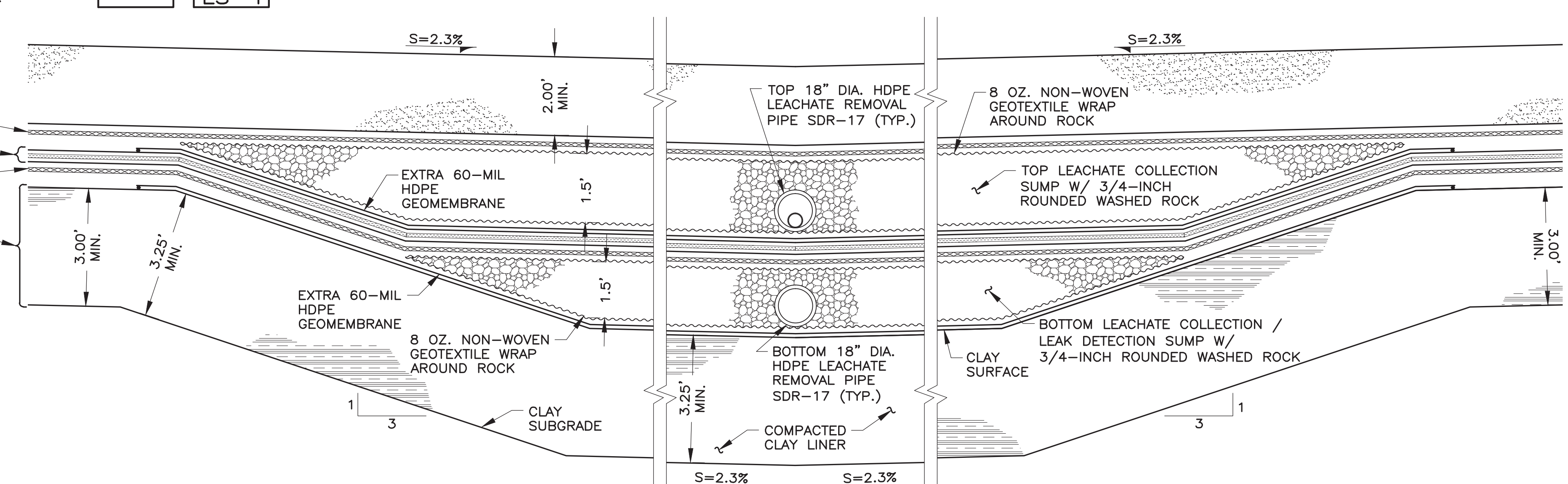
N.T.S.

NOTE:

DIMENSIONS AND GRADES IN THE TRENCH ON THE CLAY SURFACE MAY BE ADJUSTED BY THE ENGINEER. ADJUSTMENTS OF DIMENSIONS AND GRADES SHALL RESULT IN MINIMUM CLAY THICKNESS AS DESIGNATED ON THIS SECTION.

PIPE TRENCH SECTION 3 / – 3 / LS-1

N.T.S.



TYPICAL SUMP SECTION 2 / LS-1

N.T.S.

NOTES:

1. TOP LEACHATE COLLECTION SYSTEM CONSISTS OF DOUBLE SIDED GEOCOMPOSITE AS FOLLOWS:
   - 8 OZ. NON-WOVEN GEOTEXTILE
   - GEONET
   - 8 OZ. NON-WOVEN GEOTEXTILE

   MIN. GEOCOMPOSITE TRANSMISSIVITY OF 6.0×10^{-4} M^2/SEC, TYP.)
2. TOP COMPOSITE LINER SYSTEM ON THE FLOOR AND TO A DISTANCE OF 10 FEET UP THE INTERIOR SLOPES CONSISTS OF:
   - 80-MIL HDPE GEOMEMBRANE (TEXTURED)
   - GEOSYNTHETIC CLAY LINER (GCL)
   - 80-MIL HDPE GEOMEMBRANE (TEXTURED)
3. TOP LINER SYSTEM ON THE INTERIOR SIDESLOPES FROM A DISTANCE OF 10 FEET UP THE SLOPES TO THE ANCHOR TRENCH AT THE TOP OF THE SLOPES CONSISTS OF:
   - 80-MIL HDPE GEOMEMBRANE (TEXTURED)
   - GEOSYNTHETIC CLAY LINER (GCL)
4. BOTTOM LEACHATE COLLECTION / LEAK DETECTION SYSTEM CONSISTS OF DOUBLE SIDED GEOCOMPOSITE AS FOLLOWS:
   - 8 OZ. NON-WOVEN GEOTEXTILE
   - GEONET
   - 8 OZ. NON-WOVEN GEOTEXTILE

   MIN. GEOCOMPOSITE TRANSMISSIVITY OF 2.7×10^{-4} M^2/SEC, TYP.)
5. BOTTOM COMPOSITE LINER SYSTEM CONSISTS OF:
   - 60-MIL HDPE GEOMEMBRANE (TEXTURED)
   - COMPACTED CLAY LINER (CCL)
6. EXTEND 4" DIA. PERFORATED HDPE PIPE THE FULL LENGTH OF THE VALLEY EXTENDING ACROSS THE CELL FLOOR FROM THE SUMPS.

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\LS-2 SUMP SECTIONS__R1.DWG
FILE DATE: 8.6.2018 11:44:55 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED KCS	3				
DRAFTED CAH	2				
CHECKED GLJ	1				
DATE AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.

SCALE AS SHOWN

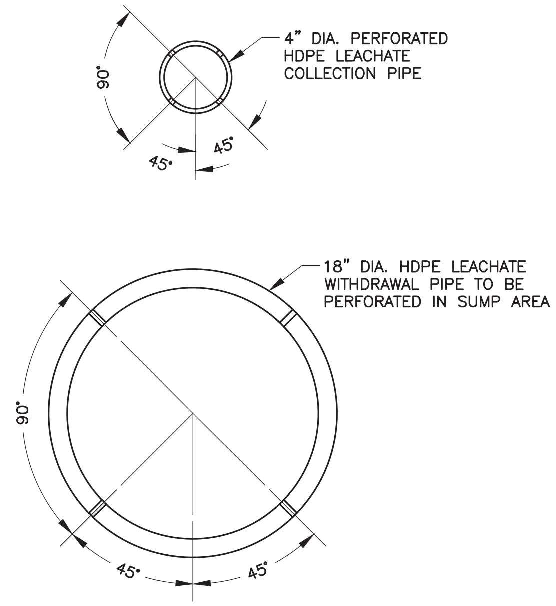
CleanHarbors ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8-13
LCRS
SUMP SECTIONS

SHEET LS-2

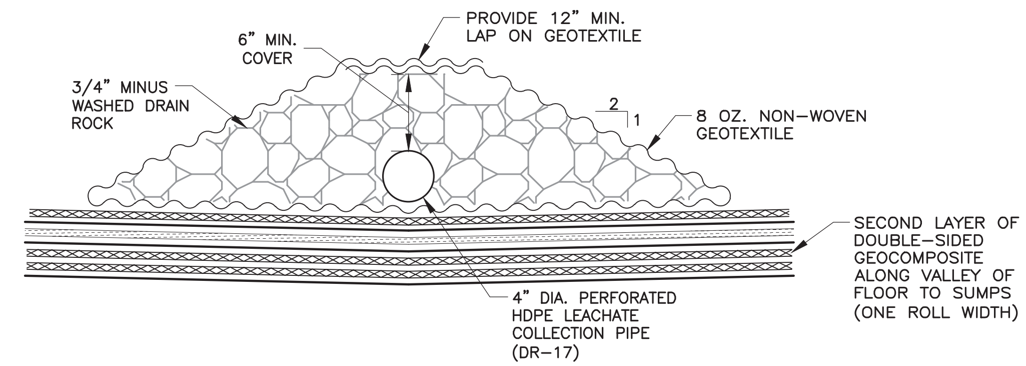
064.85.100

10/07



PERFORATION DETAIL | A / —

N.T.S.

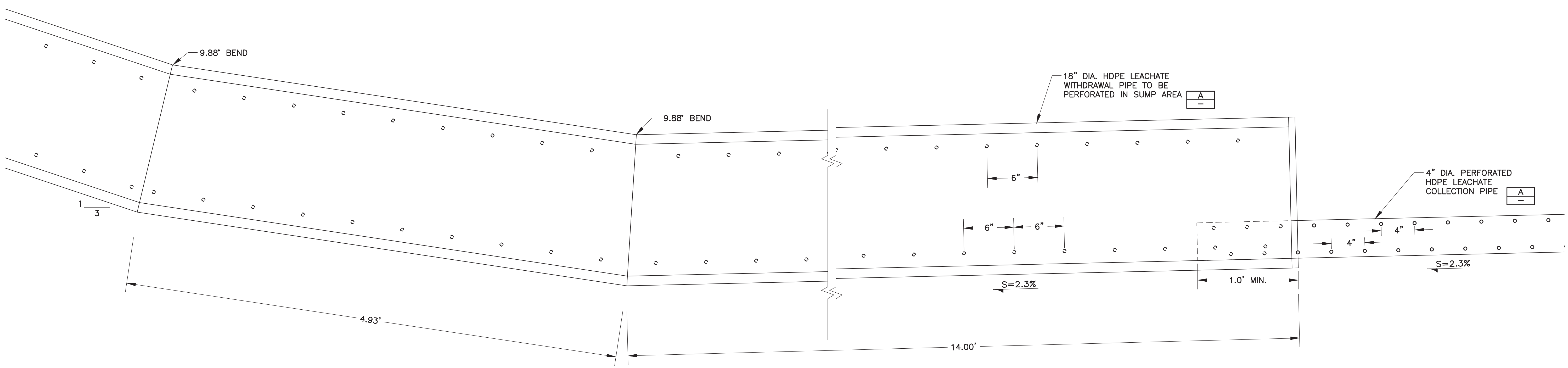


TYPICAL LEACHATE CONVEYANCE PIPE WRAP DETAIL | C / LS-2

N.T.S.

NOTES:

1. 3/4" MINUS WASHED DRAIN ROCK TO BE PLACED AROUND PERFORATED HDPE LEACHATE COLLECTION. A MINIMUM COVER OF 6 INCHES TO BE PROVIDED OVER PIPES.
2. PERFORATED HDPE PIPE TO EXTEND ENTIRE LENGTH OF THE VALLEY OF EACH SUMP DRAINAGE AREA.
3. 18-INCH AND 4-INCH DIA. PERFORATED HDPE PIPES TO RECEIVE 4 ROWS OF 3/8-INCH DIA. PERFORATIONS STAGGERRED AS SHOWN. PERFORATIONS IN 18-INCH DIA. HDPE PIPE ONLY REQUIRED FOR THE PORTION OF THE PIPE WITHIN THE SUMPS. PERFORATIONS IN THE 4-INCH DIA. HDPE PIPE TO BE ALONG THE FULL LENGTH OF THE PIPE.



HDPE PIPE "TIE-IN" DETAIL | B / LS-2

N.T.S.

FILE NAME: PROJECTS\064 - CLEAN HARBORS\85.100 - CELL 8 AND 9 DESIGN\CAD\WORKING\LS-3 LCRS DETAILS__R1.DWG
FILE DATE: 8.6.2018 11:45:47 (CAH)

10/07

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED KCS	3				
DRAFTED CAH	2				
CHECKED GLJ	1				
DATE AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.

SCALE AS SHOWN

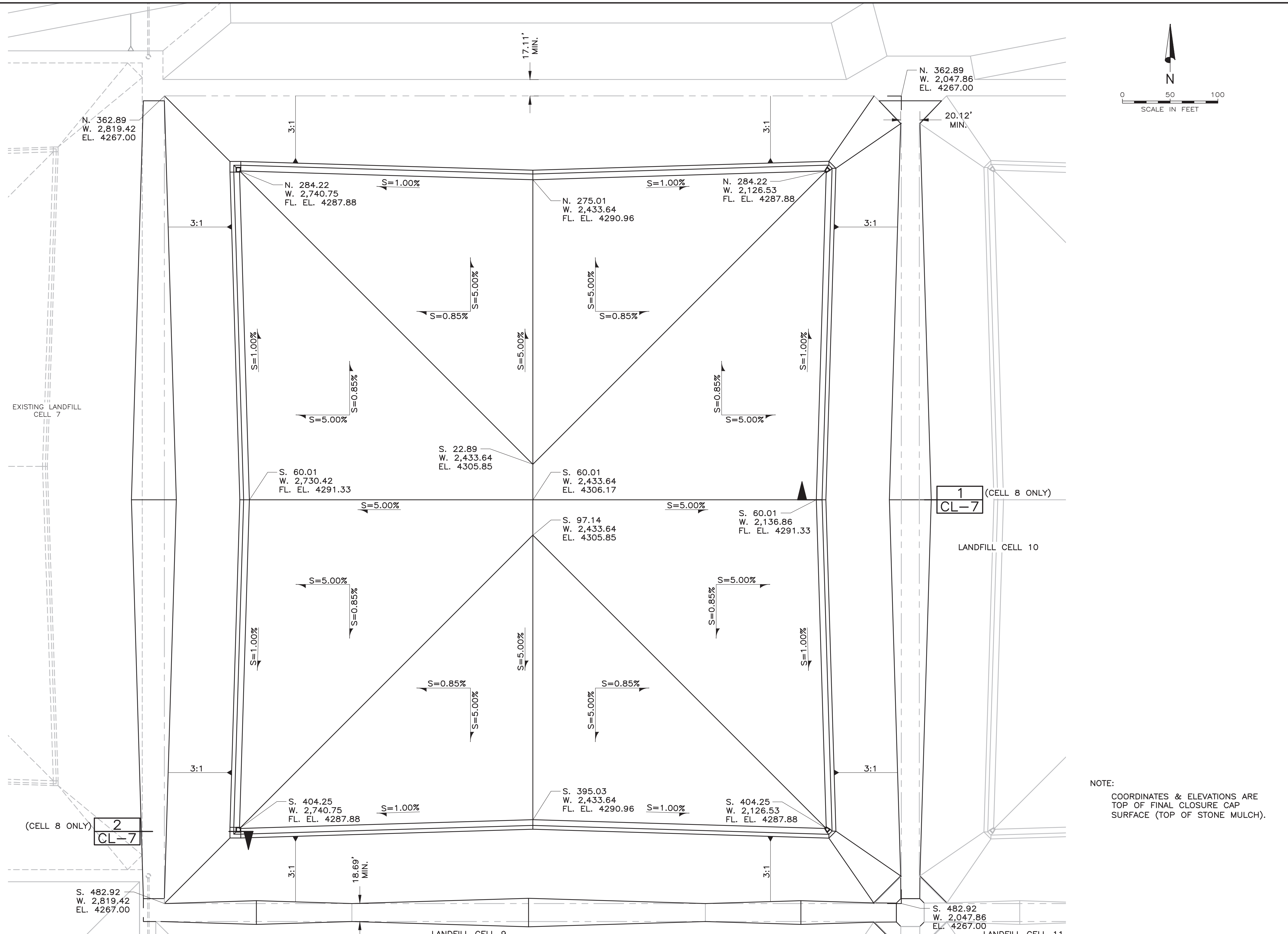
CleanHarbors® ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8-13
LCRS
LCRS DETAILS

SHEET LS-3

064.85.100

FILE NAME: PROJECTS\064 - CLEAN HARBORS\85.100 - CELL 8 AND 9 DESIGN\CAD\WORKING\CL-1 CELL 8 CLOSURE PLAN__R1.DWG
FILE DATE: 8.6.2018 11:47:04 (CAH)



NOTE:
COORDINATES & ELEVATIONS ARE TOP OF FINAL CLOSURE CAP SURFACE (TOP OF STONE MULCH).

HANSEN ALLEN & LUCE INC
ENGINEERS

PROFESSIONAL ENGINEER
GORDON L. JONES
No. 5048470-2202
8/6/2018
STATE OF UTAH

PROJECT ENGINEER

DESIGNED KCS	3			
DRAFTED CAH	2			
CHECKED GLJ	1			
DATE AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY APVD.

SCALE
NOT TO SCALE

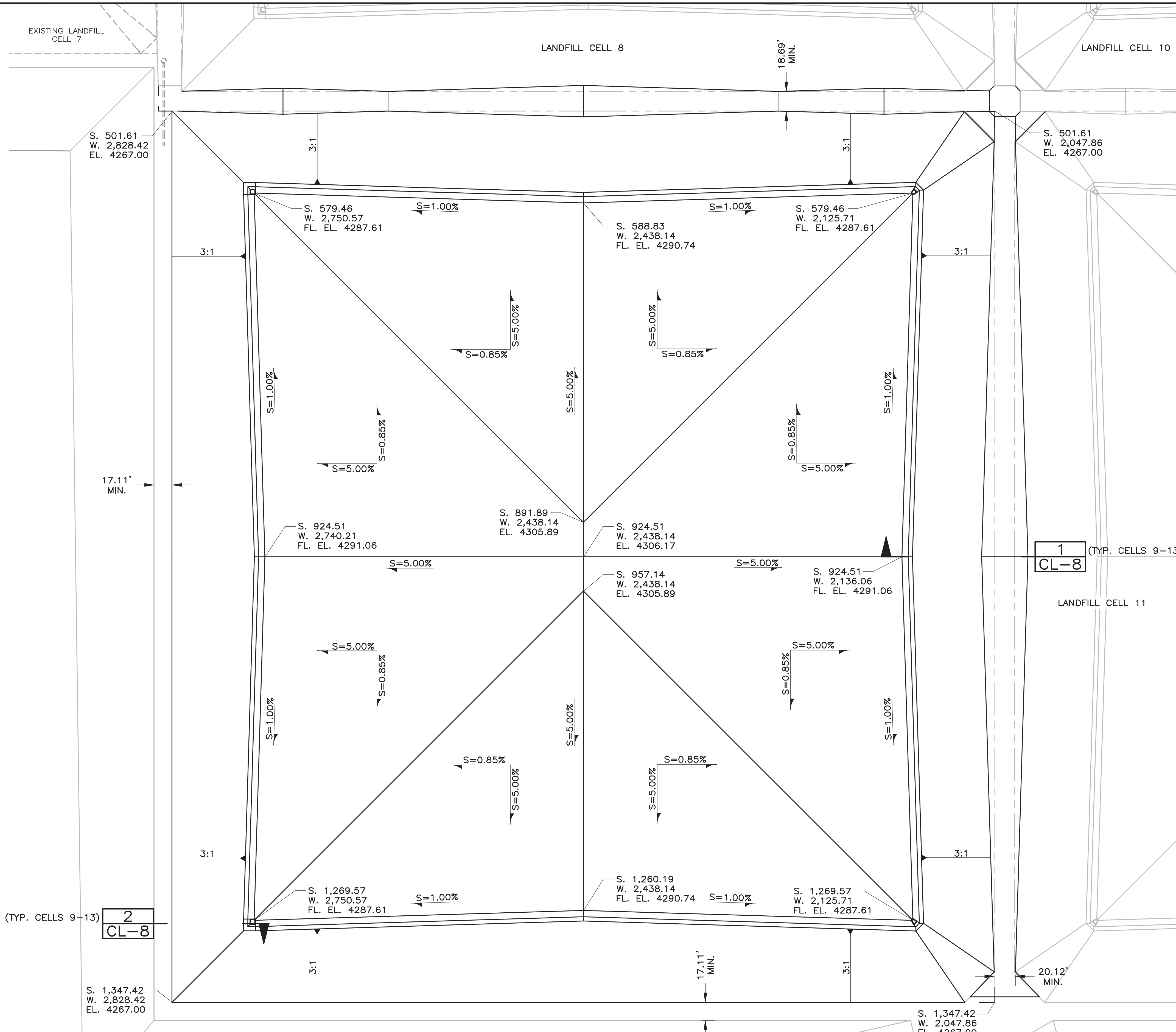
CleanHarbors®
ENVIRONMENTAL SERVICES, INC.

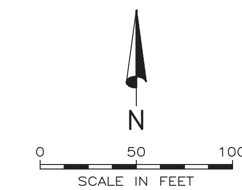
GRASSY MOUNTAIN FACILITY CELLS 8-13
CLOSURE
PLAN VIEW CELL 8

SHEET
CL-1
064.85.100

10/07

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\CL-2 CELL 9 CLOSURE PLAN__R1.DWG
FILE DATE: 8.6.2018 11:50:50 (CAH)

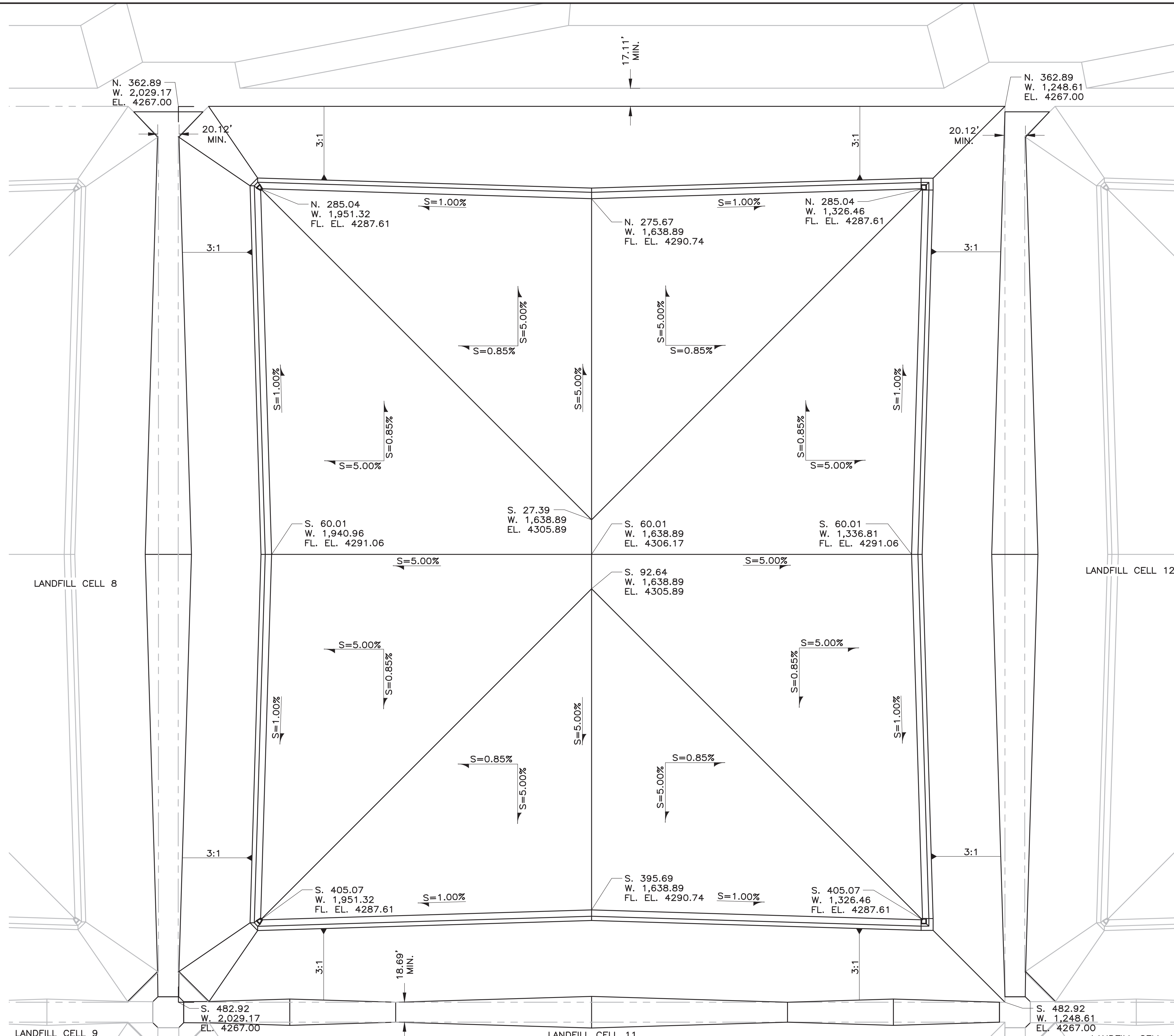


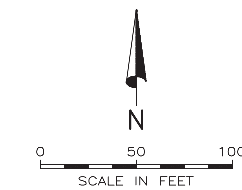


NOTE:

COORDINATES & ELEVATIONS ARE TOP OF FINAL CLOSURE CAP SURFACE (TOP OF STONE MULCH).

HANSEN ALLEN & LUCE INC ENGINEERS	PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH — PROJECT ENGINEER	DESIGNED KCS	3			SCALE NOT TO SCALE	CleanHarbors ENVIRONMENTAL SERVICES, INC.
		DRAFTED CAH	2				GRASSY MOUNTAIN FACILITY CELLS 8–13 CLOSURE PLAN VIEW CELL 9
		CHECKED GLJ	1				SHEET CL–2
10/07		DATE AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.	064.85.100





NOTE:

COORDINATES & ELEVATIONS ARE TOP OF FINAL CLOSURE CAP SURFACE (TOP OF STONE MULCH).

FILE NAME: PROJECTS\064 - CLEAN HARBORS\85.100 - CELL 8 AND 9 DESIGN\CAD\WORKING\CL-3 CELL 10 CLOSURE PLAN__R1.DWG
FILE DATE: 8.6.2018 11:51:43 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED	KCS	3				
DRAFTED	CAH	2				
CHECKED	GLJ	1				
DATE	AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.

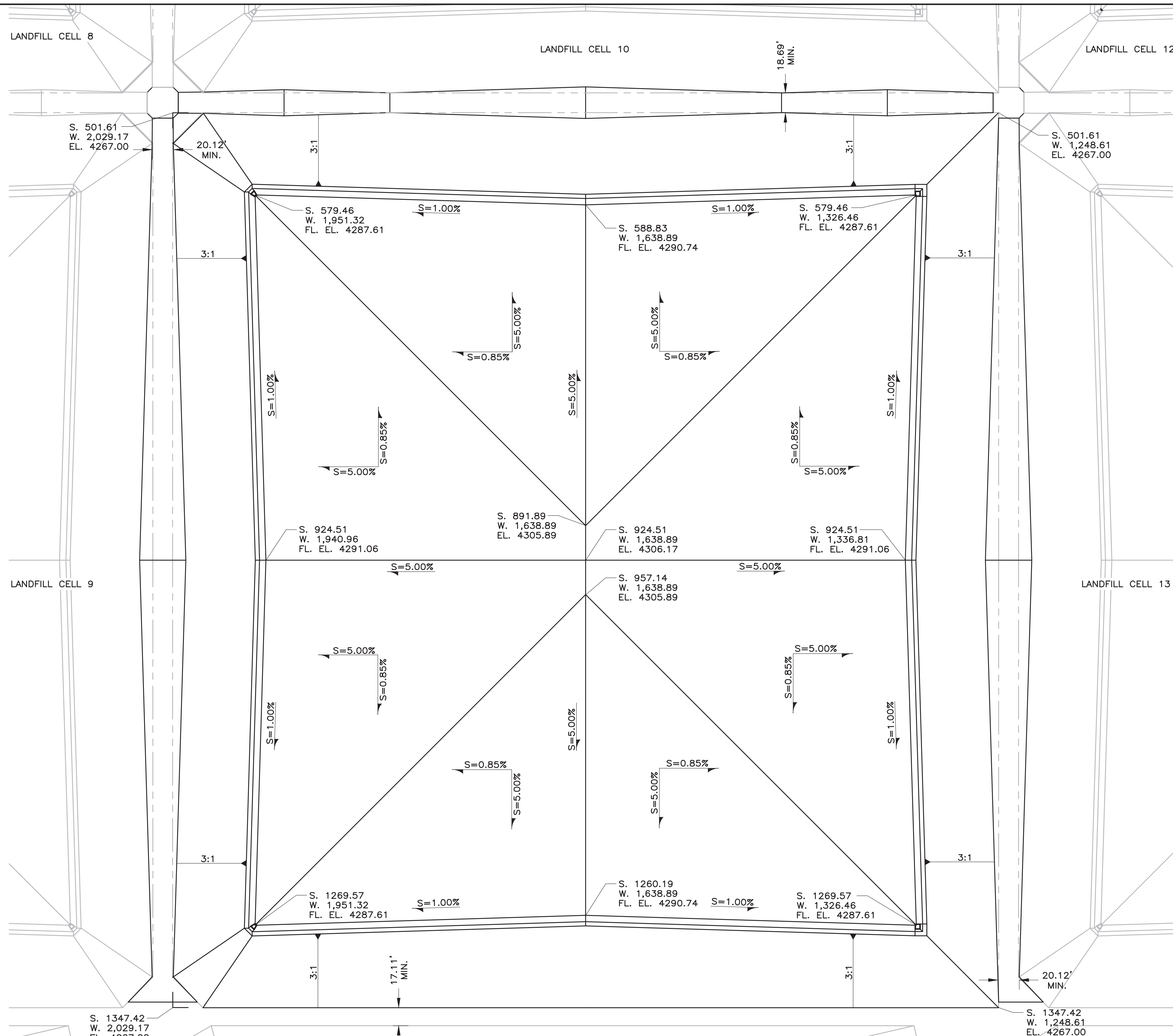
SCALE
NOT TO SCALE

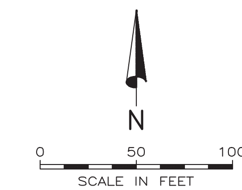
CleanHarbors® ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8–13
CLOSURE
PLAN VIEW CELL 10

SHEET
CL–3
064.85.100

10/07





NOTE:

COORDINATES & ELEVATIONS ARE TOP OF FINAL CLOSURE CAP SURFACE (TOP OF STONE MULCH).

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\CL-4 CELL 11 CLOSURE PLAN__R1.DWG
FILE DATE: 8.6.2018 11:52:45 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED	KCS	3			
DRAFTED	CAH	2			
CHECKED	GLJ	1			
DATE	AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY APVD.

SCALE: NOT TO SCALE

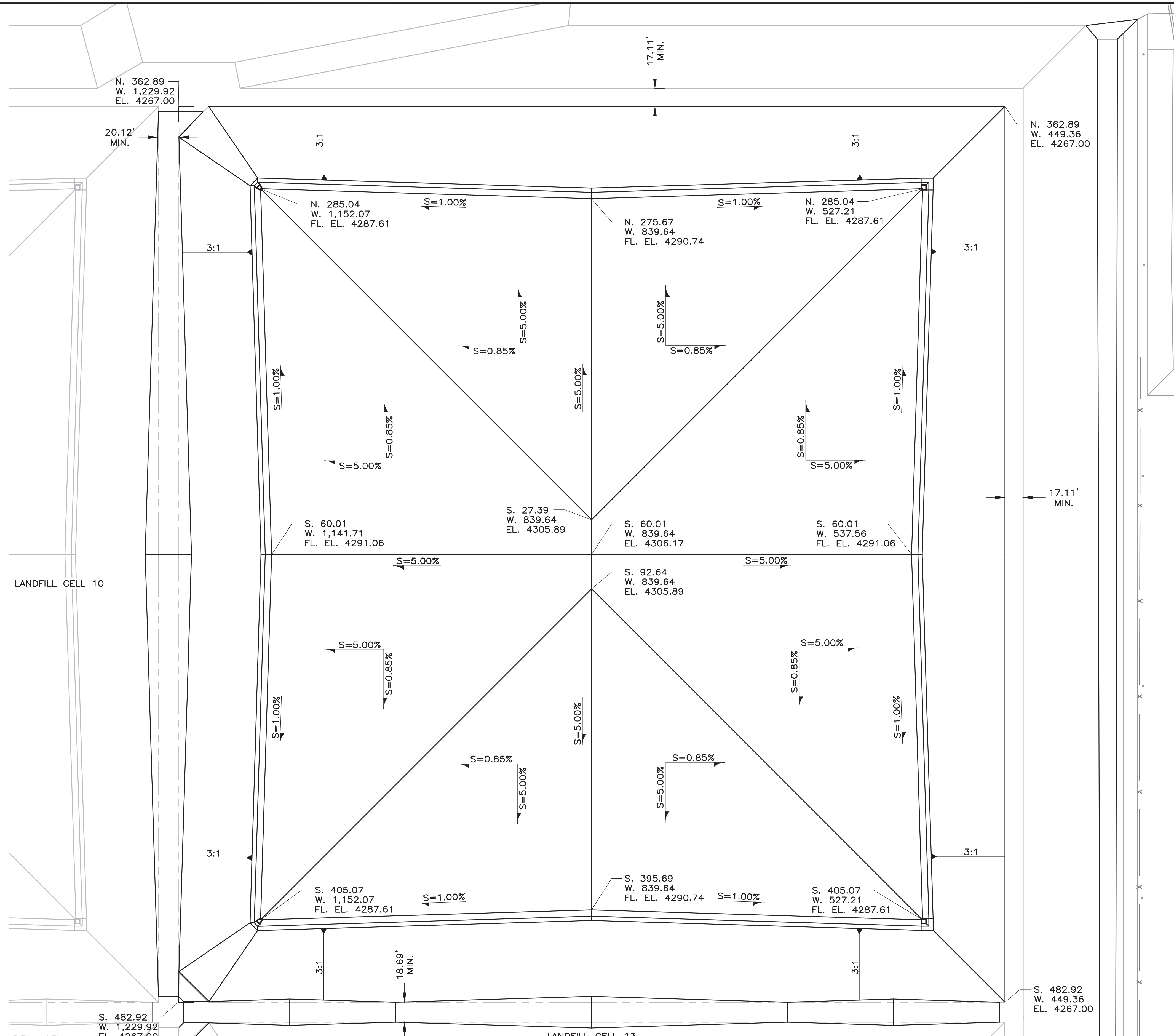
CleanHarbors ENVIRONMENTAL SERVICES, INC.

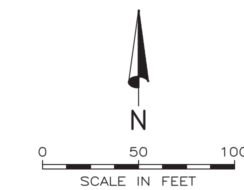
GRASSY MOUNTAIN FACILITY CELLS 8–13 CLOSURE
PLAN VIEW CELL 11

SHEET CL–4

064.85.100

10/07





NOTE:

COORDINATES & ELEVATIONS ARE TOP OF FINAL CLOSURE CAP SURFACE (TOP OF STONE MULCH).

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\CL-5 CELL 12 CLOSURE PLAN__R1.DWG
FILE DATE: 8.6.2018 11:53:48 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED KCS	3				
DRAFTED CAH	2				
CHECKED GLJ	1				
DATE AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.

SCALE: NOT TO SCALE

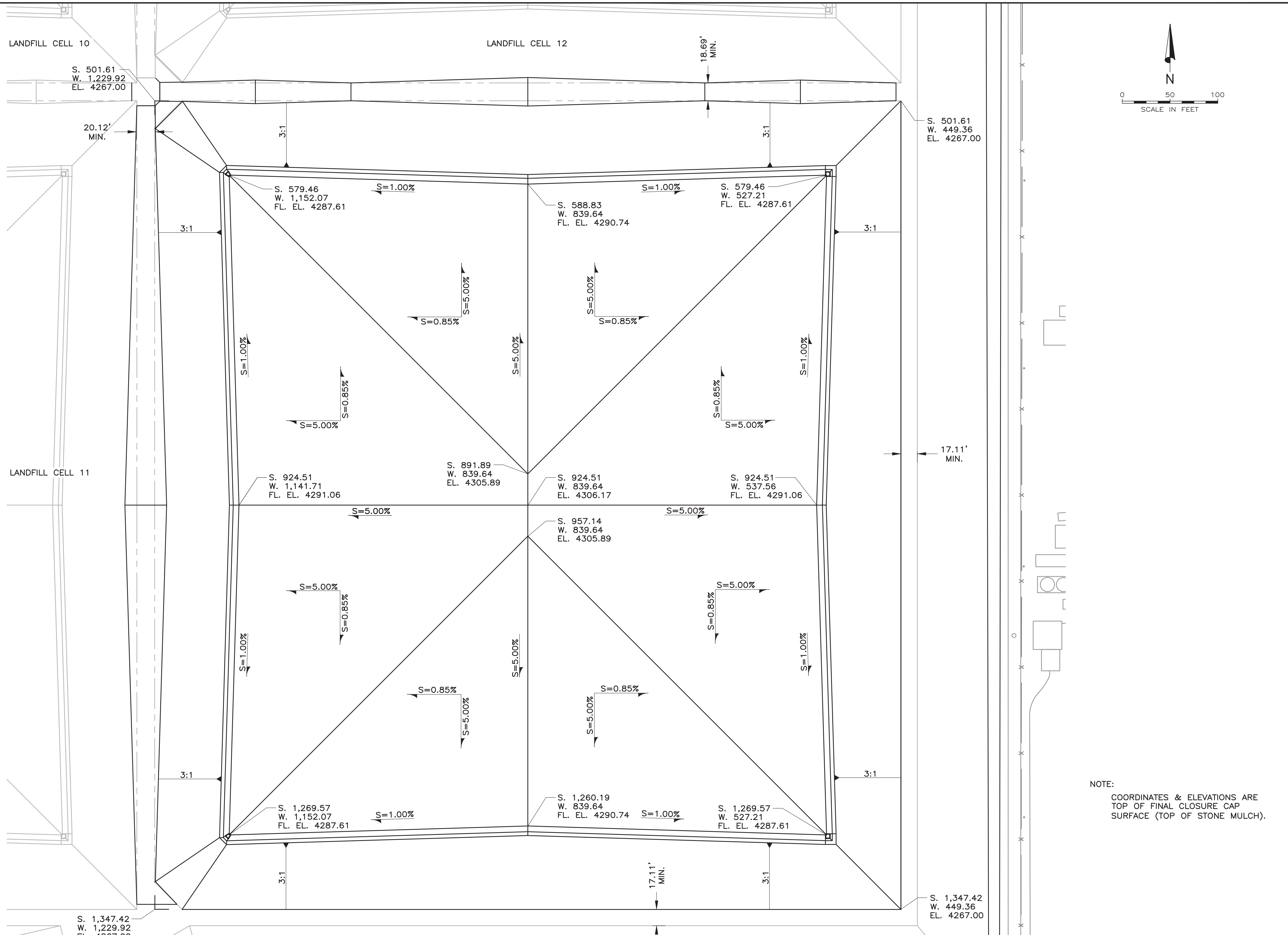
CleanHarbors® ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8–13
CLOSURE
PLAN VIEW CELL 12

SHEET CL–5

064.85.100

10/07



NOTE:

COORDINATES & ELEVATIONS ARE TOP OF FINAL CLOSURE CAP SURFACE (TOP OF STONE MULCH).

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\CL-6 CELL 13 CLOSURE PLAN__R1.DWG
FILE DATE: 8.6.2018 11:54:59 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED	KCS	3			
DRAFTED	CAH	2			
CHECKED	GLJ	1			
DATE	AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY / APVD.

SCALE: NOT TO SCALE

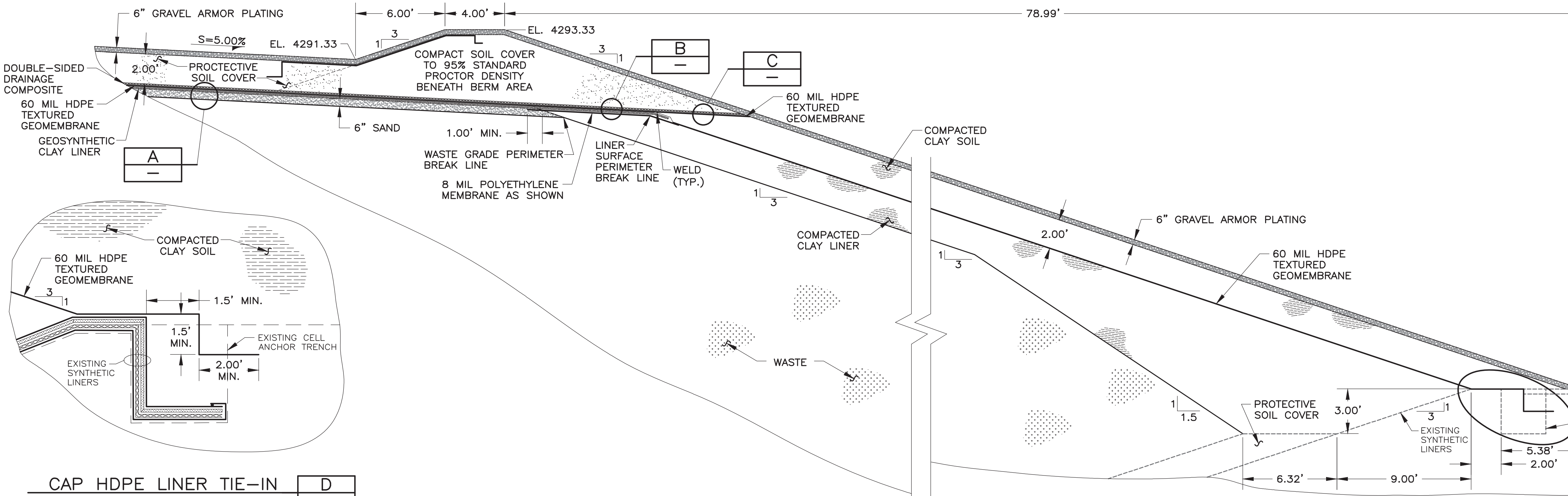
CleanHarbors® ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8–13
CLOSURE
PLAN VIEW CELL 13

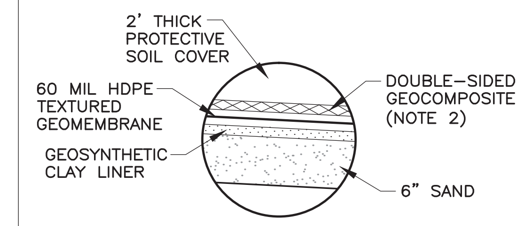
SHEET CL–6

064.85.100

10/07

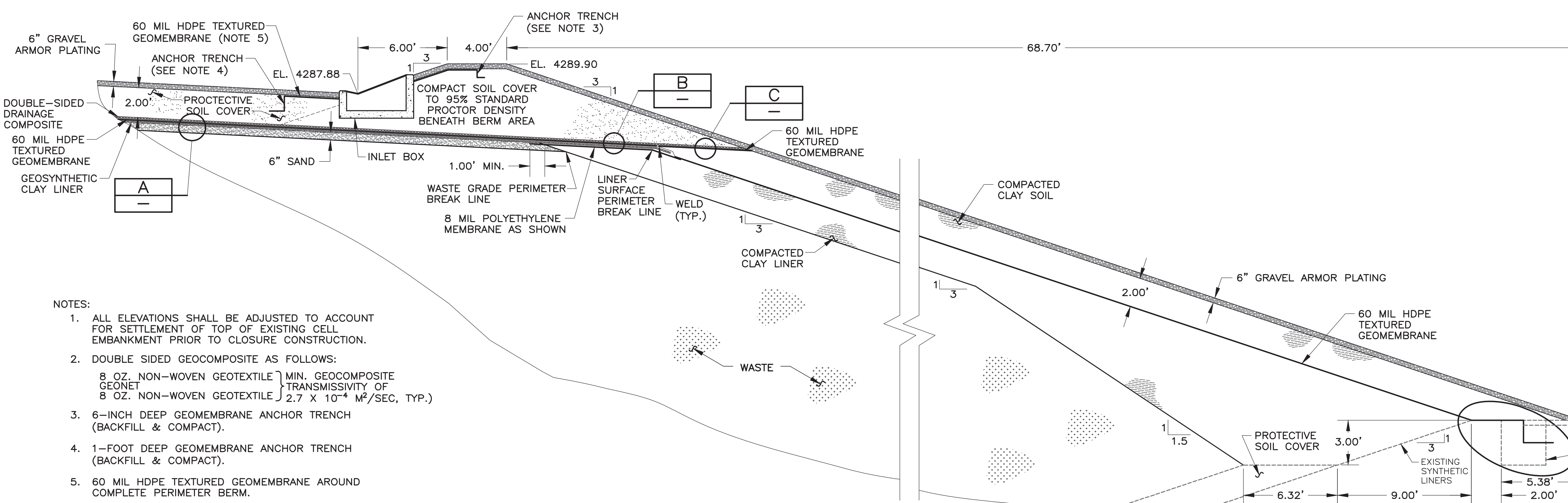


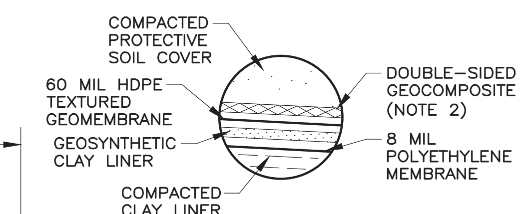
CAP HDPE LINER TIE-IN DETAIL AT ANCHOR TRENCH D —



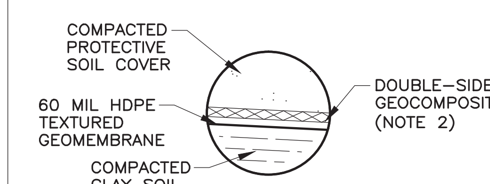
LINER DETAIL A (TYP.) —

TYPICAL EAST & WEST HIGH SECTION 1 CL-1





LINER DETAIL B (TYP.) —



LINER DETAIL C (TYP.) —

NOTES:

1. ALL ELEVATIONS SHALL BE ADJUSTED TO ACCOUNT FOR SETTLEMENT OF TOP OF EXISTING CELL EMBANKMENT PRIOR TO CLOSURE CONSTRUCTION.
2. DOUBLE SIDED GEOCOMPOSITE AS FOLLOWS:
   8 OZ. NON-WOVEN GEOTEXTILE / GEONET / 8 OZ. NON-WOVEN GEOTEXTILE } MIN. GEOCOMPOSITE TRANSMISSIVITY OF 2.7×10^{-4} M²/SEC, TYP.)
3. 6-INCH DEEP GEOMEMBRANE ANCHOR TRENCH (BACKFILL & COMPACT).
4. 1-FOOT DEEP GEOMEMBRANE ANCHOR TRENCH (BACKFILL & COMPACT).
5. 60 MIL HDPE TEXTURED GEOMEMBRANE AROUND COMPLETE PERIMETER BERM.

TYPICAL LOW SECTION 2 CL-1

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\CL-7 HIGH LOW SECTIONS 8__R1.DWG
FILE DATE: 8.6.2018 11:55:53 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED KCS	3					
DRAFTED CAH	2					
CHECKED GLJ	1					
DATE AUGUST 2018 REV 1	NO.	DATE	REVISIONS		BY	APVD.

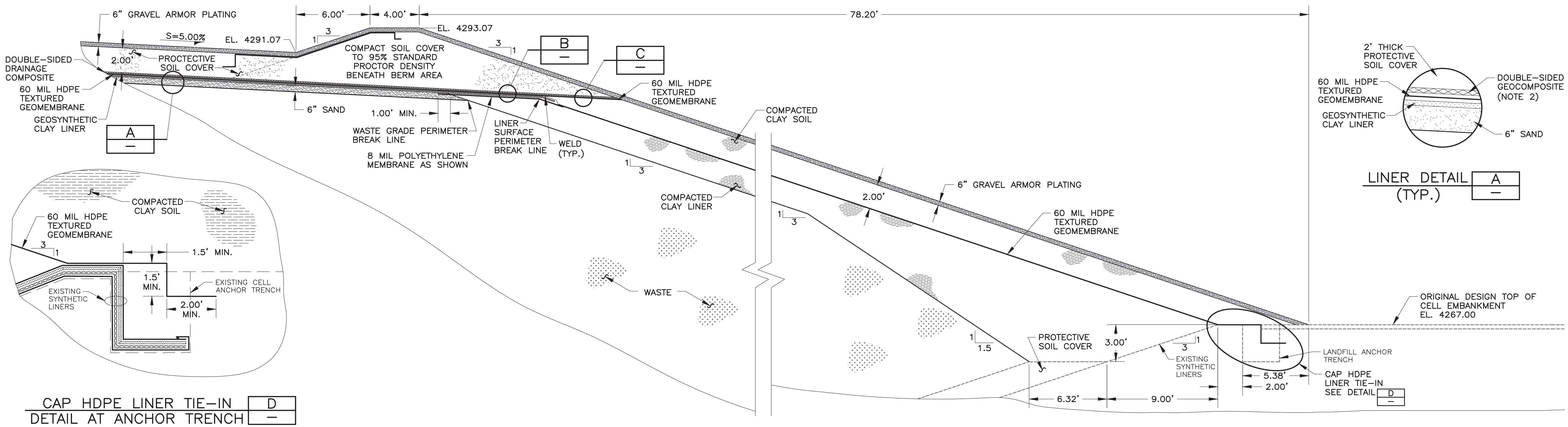
SCALE NOT TO SCALE

CleanHarbors® ENVIRONMENTAL SERVICES, INC.

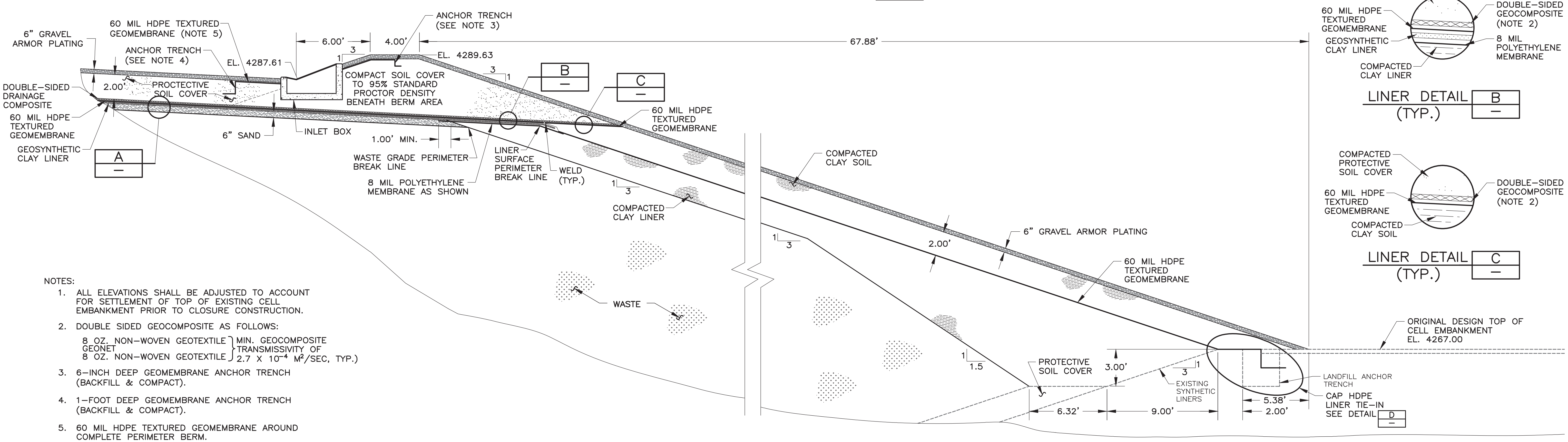
GRASSY MOUNTAIN FACILITY CELLS 8-13 CLOSURE
HIGH-LOW SECTIONS CELL 8

SHEET CL-7
064.85.100

10/07



TYPICAL EAST & WEST HIGH SECTION 1 CL-2



NOTES:

1. ALL ELEVATIONS SHALL BE ADJUSTED TO ACCOUNT FOR SETTLEMENT OF TOP OF EXISTING CELL EMBANKMENT PRIOR TO CLOSURE CONSTRUCTION.
2. DOUBLE SIDED GEOCOMPOSITE AS FOLLOWS:
   8 OZ. NON-WOVEN GEOTEXTILE
   GEONET
   8 OZ. NON-WOVEN GEOTEXTILE } MIN. GEOCOMPOSITE TRANSMISSIVITY OF 2.7×10^{-4} M^2/SEC, TYP.)
3. 6-INCH DEEP GEOMEMBRANE ANCHOR TRENCH (BACKFILL & COMPACT).
4. 1-FOOT DEEP GEOMEMBRANE ANCHOR TRENCH (BACKFILL & COMPACT).
5. 60 MIL HDPE TEXTURED GEOMEMBRANE AROUND COMPLETE PERIMETER BERM.

TYPICAL LOW SECTION 2 CL-2

FILE NAME: PROJECTS\064 - CLEAN HARBORS\85.100 - CELL 8 AND 9 DESIGN\CAD\WORKING\CL-8 HIGH LOW SECTIONS 9-13__R1.DWG
FILE DATE: 8.6.2018 11:56:51 (CAH)

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED KCS	3					
DRAFTED CAH	2					
CHECKED GLJ	1					
DATE AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.

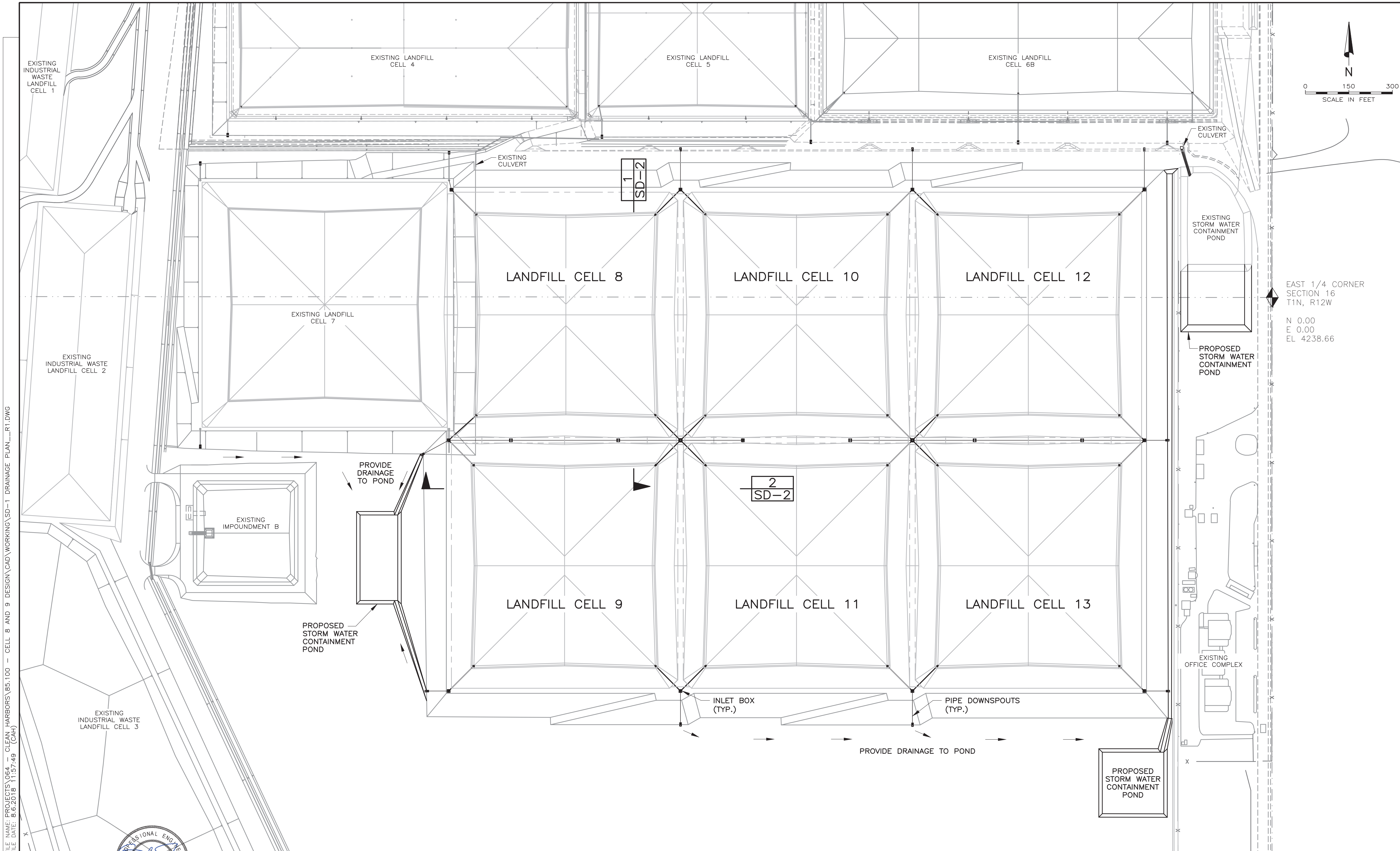
SCALE NOT TO SCALE

CleanHarbors ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8-13
CLOSURE
HIGH-LOW SECTIONS CELLS 9-13

SHEET CL-8
064.85.100

10/07



HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER No. 5048470-2202 GORDON L. JONES 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED KCS	3					
DRAFTED CAH	2					
CHECKED GLJ	1					
DATE AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.	

SCALE: NOT TO SCALE

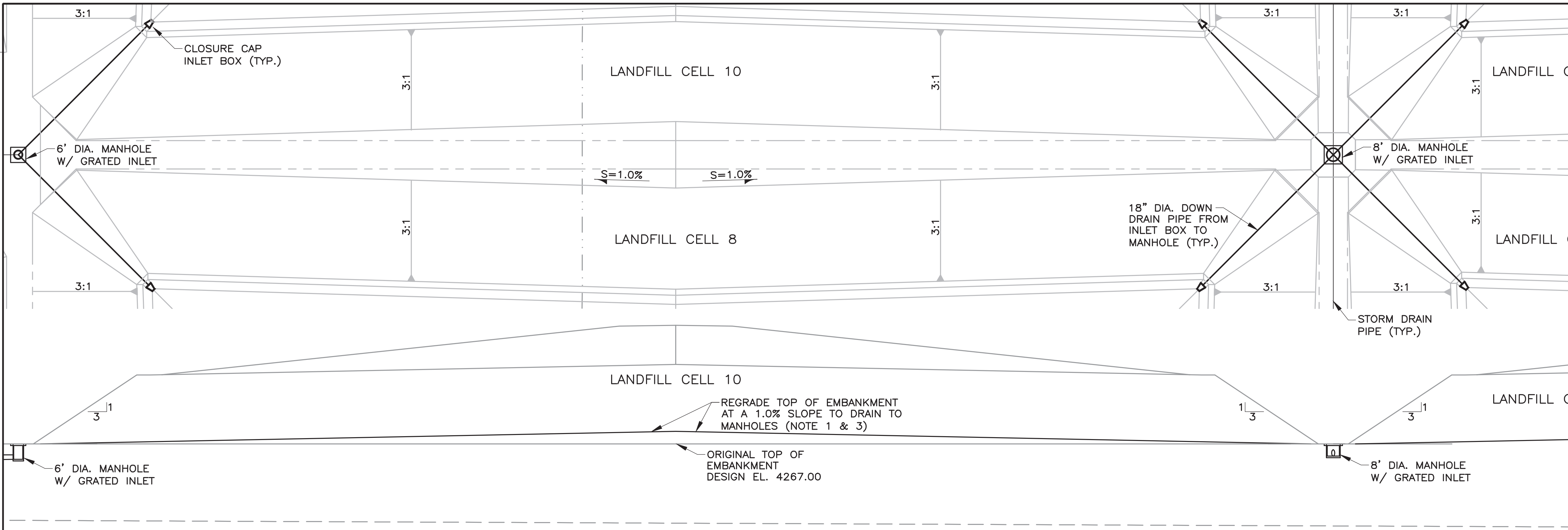
CleanHarbors ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8-13
STORM DRAIN
DRAINAGE PLAN

SHEET SD-1

064.85.100

10/07

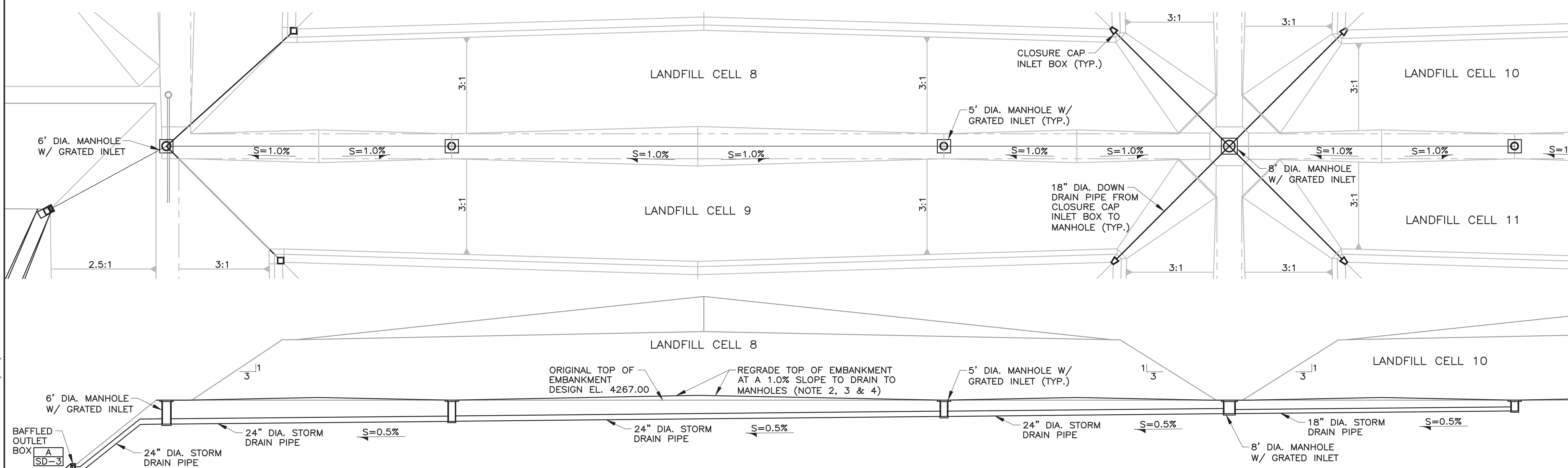


NORTH & SOUTH SECTION 1 / SD-1

0 40 80
SCALE IN FEET

NOTES:

1. TOP OF EMBANKMENT GRADING ON THE NORTH & SOUTH SECTION IS REPRESENTATIVE OF NORTH & SOUTH GRADING BETWEEN ALL CLOSURE CAPS.
2. GRADING AND STORM DRAIN PIPING ON EAST & WEST SECTION IS REPRESENTATIVE OF THE GRADING AND PIPING BETWEEN CELLS 10 & 11 AND 12 & 13.
3. GRADE TOP OF EMBANKMENT AT 1% SLOPE TOWARD MANHOLES UPON COMPLETION OF ADJACENT CLOSURE CAPS.
4. STORM DRAINAGE PIPE AND MANHOLES TO BE INSTALLED AT TIME OF CLOSURE WHEN ADJACENT LANDFILLS ARE MOSTLY FILLED AND DIFFERENTIAL SETTLEMENT HAS MOSTLY OCCURRED.

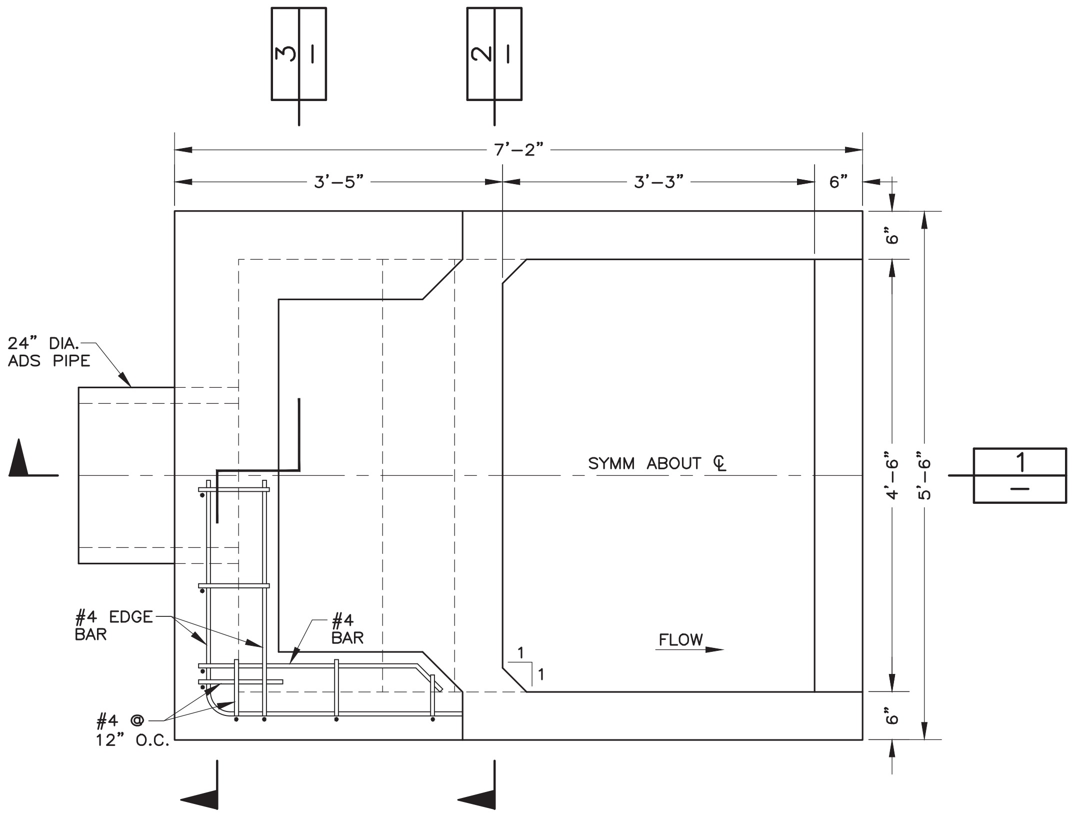


EAST & WEST SECTION 2 / SD-1

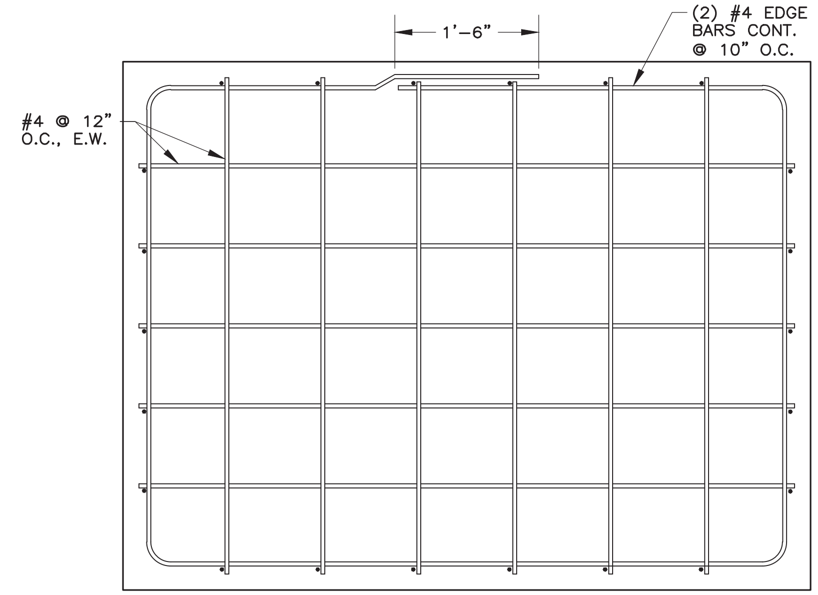
N
0 40 80
SCALE IN FEET

HANSEN ALLEN & LUCE INC ENGINEERS	PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH — PROJECT ENGINEER	DESIGNED KCS / DRAFTED CAH / CHECKED GLJ / DATE AUGUST 2018 REV 1	NO. 3, 2, 1 — DATE — REVISIONS — BY — APVD.
SCALE AS SHOWN	CleanHarbors ENVIRONMENTAL SERVICES, INC.	GRASSY MOUNTAIN FACILITY CELLS 8–13 STORM DRAIN DRAINAGE SECTIONS	SHEET SD-2 064.85.100

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\SD-2 SECTIONS__R1.DWG
FILE DATE: 8.6.2018 11:58:43 (CAH)
10/07



PLAN VIEW A / SD–2
N.T.S.



SECTION 4 / —
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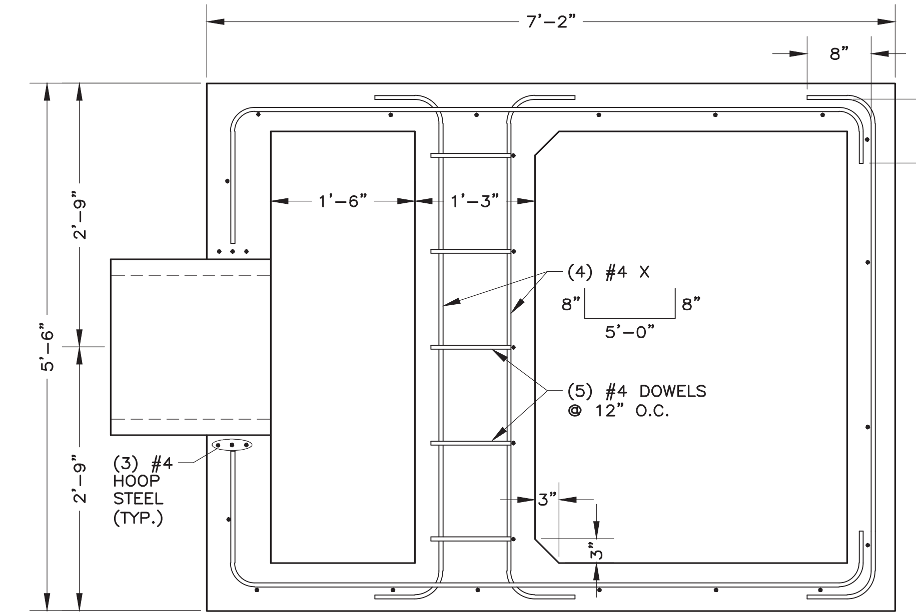

SECTION 5 / —
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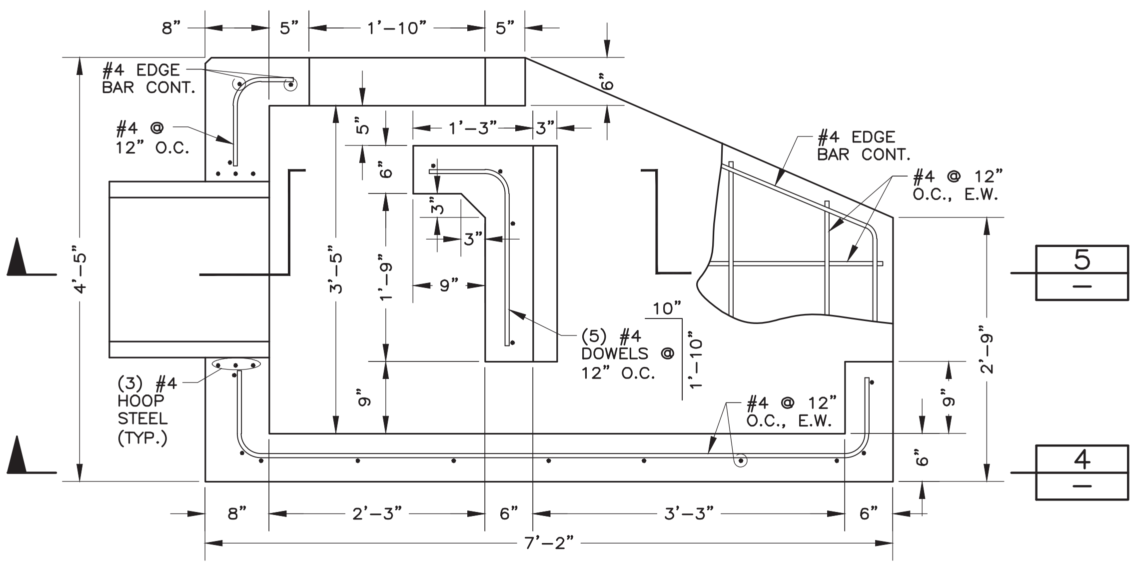
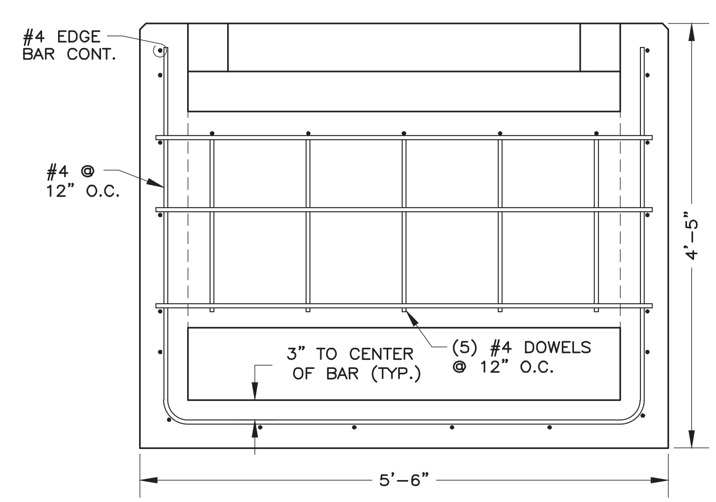
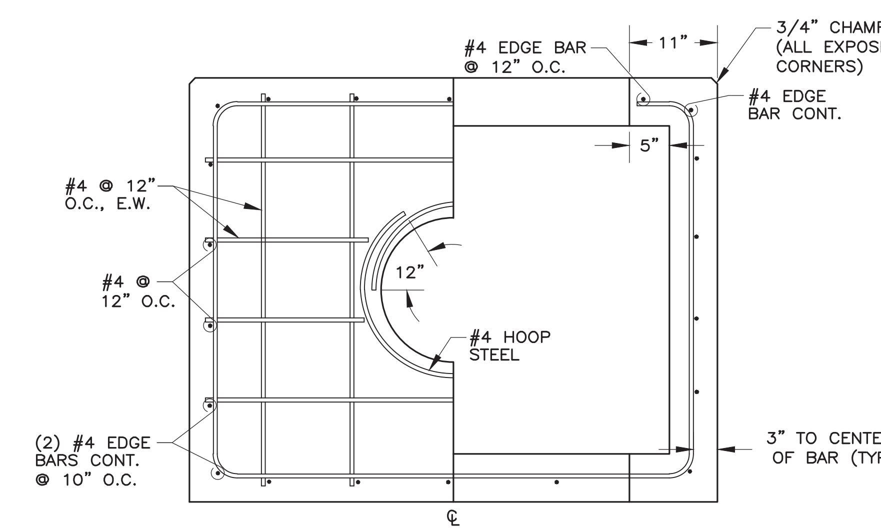


SECTION 1 / —
N.T.S.



SECTION 2 / —
N.T.S.



SECTION 3 / —
N.T.S.

FILE NAME: PROJECTS\064 – CLEAN HARBORS\85.100 – CELL 8 AND 9 DESIGN\CAD\WORKING\SD–3 BAFFLE BOX__R1.DWG
FILE DATE: 8.6.2018 12:00:00 (CAH)

10/07

HANSEN ALLEN & LUCE INC ENGINEERS

PROFESSIONAL ENGINEER GORDON L. JONES No. 5048470-2202 8/6/2018 STATE OF UTAH

PROJECT ENGINEER

DESIGNED KCS	3					SCALE
DRAFTED CAH	2					
CHECKED GLJ	1					
DATE AUGUST 2018 REV 1	NO.	DATE	REVISIONS	BY	APVD.	

CleanHarbors® ENVIRONMENTAL SERVICES, INC.

GRASSY MOUNTAIN FACILITY CELLS 8–13
STORM DRAIN
BAFFLED OUTLET BOX

SHEET SD–3

064.85.100