# City of Waco Landfill
# McLennan and Limestone Counties
# TCEQ Permit No. MSW-2400

# October 2020 Technical Notice-of-Deficiency Response
# **Unmarked Version, Volume 2 of 2**

*Prepared for*

**City of Waco**

Solid Waste Services
501 Schroeder Drive
Waco, Texas 76710

*Prepared by:*

SCS ENGINEERS

SCS Project No. 16216088.00
Revision 3 (Parts I/II) and Revision 1 (Part III/IV) – October 2020

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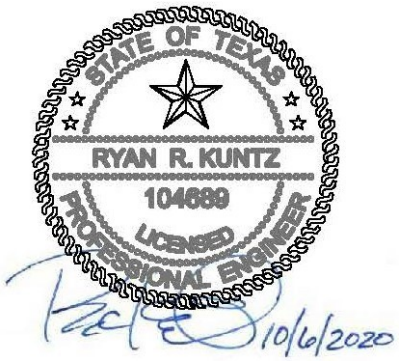
**CITY OF WACO LANDFILL**
**TCEQ PERMIT NO. MSW-2400**
**McLENNAN AND LIMESTONE COUNTIES, TEXAS**

# PART III
# SITE DEVELOPMENT PLAN NARRATIVE

**Prepared for:**

**CITY OF WACO**

Solid Waste Services
501 Schroeder Drive
Waco, TX 76710

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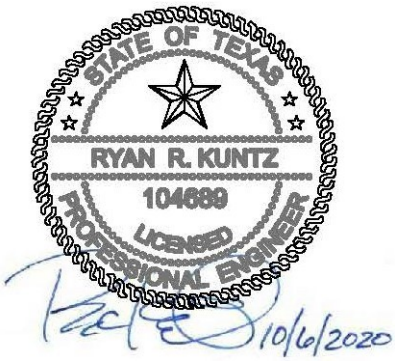


**SCS Engineers**
**TBPE Reg. # F-3407**

# 1 INTRODUCTION (30 TAC §330.63)

The City of Waco (Owner) proposes to develop and operate a Type I Municipal Solid Waste (MSW) Landfill on 502.5 acres of land located in McLennan and Limestone Counties, Texas. The landfill entrance will be located approximately 0.4 miles south of the intersection of State Highway 31 and T K Parkway (also known as Farm-to-Market [FM] 939). The waste disposal footprint will encompass approximately 173.8 acres, separated into two (2) disposal areas, with the East Disposal Area comprised of approximately 112.2 acres and West Disposal Area comprised of approximately 61.6 acres. Refer to Attachment 1 for drawings that depict the existing conditions, landfill permit boundary, waste footprint, and general site layout.

The landfill will serve residences, businesses, and industries in the communities of McLennan and Limestone County and other nearby counties transported to the landfill by municipal, private, and public haulers. The landfill will accept municipal solid waste, household waste, yard waste, commercial solid waste, Class 2 and Class 3 non-hazardous industrial wastes, construction-demolition waste, and special wastes as authorized by the Texas Commission on Environmental Quality (TCEQ). The categories of waste that will be accepted at the landfill are defined in Part I/II, Section 2.2.2 of this permit application. Any special waste accepted at the landfill will be in accordance with 30 TAC §330.171. Consistent with 30 TAC §330.15(e) the facility will not accept regulated hazardous waste, polychlorinated biphenyls (PCBs), and all other prohibited waste defined therein. Additionally, Class 1 industrial solid waste will not be accepted at this facility.

This permit application for the City of Waco Landfill has been prepared consistent with the Municipal Solid Waste Regulations (MSWR), Title 30 of the Texas Administrative Code (TAC), Chapter 330. This Site Development Plan (SDP) Narrative provides a brief overview of the contents of the permit application, including the attachments of the SDP. The SDP has been separated into Attachments 1 through 12, which were prepared consistent with 30 TAC §330.63.

# 2 SOLID WASTE DATA (30 TAC §330.63(D)(4)(D))

The landfill will serve residences, businesses, and industry in the communities of McLennan and Limestone Counties and other nearby counties. As discussed in Parts I/II, Section 2.2, the landfill is expected to initially receive approximately 305,000 tons per year of solid waste (1,070 tons per day based on a 286-day operating schedule). The initial year of operation is anticipated following completion of disposal operations at the existing City of Waco Landfill (Permit No. MSW-948A), which is estimated to be 2024. The waste inflow rate is estimated to increase at a rate of approximately 1.25 percent annually over the life of the landfill. Over the life of the landfill, it is anticipated that the waste rate received at the landfill may vary as warranted by the needs of the area, market conditions, and recycling and waste diversion practices.

Consistent with 30 TAC §330.63(d)(4)(D), the following subsections describe the population equivalent and site operating life for the landfill.

## 2.1 POPULATION EQUIVALENT

As discussed in Parts I/II, Section 2.2.1, it is anticipated that the population served by the landfill will change over the life of the landfill as warranted by the needs of the area and market conditions. Based on an estimated 6.7 pounds of waste generated daily per person (ref: HOTCOG Regional Solid Waste Plan, 2013 Update) and an initial disposal rate of 1,070 tons per day, the number of people served by the landfill initially will be approximately 319,000 persons.

The major classifications of solid waste to be accepted at the landfill include municipal solid waste, household waste, yard waste, commercial solid waste, Class 2 and Class 3 non-hazardous industrial wastes, construction-demolition waste, and special wastes. Consistent with 30 TAC §330.15(e), the facility will not accept regulated hazardous waste, polychlorinated biphenyls (PCBs), and other prohibited waste defined herein. Additionally, Class 1 industrial solid waste will not be accepted at this facility. Waste classifications and further information on types of wastes expected to be received at the facility are included in Parts I/II, Section 2.2.2 - Properties and Characteristics of Waste.

## 2.2 SITE OPERATING LIFE PROJECTION

The landfill configuration provides an approximate estimate of 32 years of site operating life. Calculations and assumptions for the site operating life estimate are included in Appendix IIIA – Site Life Calculations.

# 3 DESIGN DATA (30 TAC §330.63(B))

In accordance with §330.639(b), this section summarizes the general facility design data, with detailed specifics of the facility design included in the various attachments of this Part III – Site Development Plan. General landfill methods are described in Section 3.1 and CCS methods are described in Section 3.11, while the remainder of this narrative summarizes the overall facility design, operations, and environmental protection.

Additionally, in accordance with §330.63(b)(2) a flow diagram for the waste movement through the facility is provided on Attachment 1, Drawing 1.6 – Waste Flow Diagram. As shown on this waste flow diagram, there are generally two operations that occur on the facility property, including the landfill and citizens' convenience station (CCS).

Part IV – Site Operating Plan describes the detailed operation of the facility, including the landfill and CCS.

## 3.1 LANDFILL METHODS (30 TAC §330.63(D)(4)(B),(C),(E))

The proposed landfill development method for the site is a combination of area excavation fill followed by aerial fill to the proposed landfill completion height. The landfill will be developed in two separate disposal areas, East Disposal Area and West Disposal Area. The East Disposal Area will be comprised of eight sectors, 1 through 8; and the West Disposal Area will be comprised of four sectors, 9 through 12. Each sector may be developed in multiple cells at the discretion of Owner.

The excavation sideslopes will be no steeper than 3H:1V, with an elevation of deepest excavation (EDE) of 505 feet mean sea level (ft MSL). The EDE will be achieved in the bottom of the leachate collection sump in Sector 8. Aerial fill sideslopes will be no steeper than 4H:1V and the aerial fill topslope will be no flatter than 5 percent (or 20H:1V). The maximum elevation of final cover will be no higher than 697.7 ft MSL and 661.3 ft MSL for East and West Disposal Areas, respectively. Final cover placement and closure of sectors will be in accordance with procedures set forth in the closure plan provided in Attachment 9 of this permit application.

Attachments to this application include drawings depicting the landfill development. Specifically, Attachment 1 through Attachment 3 include the following:

- **Attachment 1 –** Site Layout Plans, include existing site contours (July 3, 2018 topography, see Drawing 1.1), excavation, elevation of deepest excavation, disposal area layout, sector layout, and sequence of sector development.

- **Attachment 2 –** Fill Cross Sections, include cross-sections depicting the base grades, top of liner grades, maximum elevation of waste, maximum elevation of final cover, and geologic borings along the cross-sections.

- **Attachment 3 –** Landfill Completion Plan, include proposed final contours, surface water management system, and general facility layout at landfill completion.

## 3.2 WET-WEATHER OPERATIONS (30 TAC §330.63(D)(4)(A)

The landfill access roads (see Attachment 1 – Site Layout Plans), including perimeter roads and other constructed interior haul roads will be constructed of crushed stone, concrete rubble, masonry demolition debris, gravel, caliche, asphalt paving, or other suitable material and will provide access from the site entrance road to the disposal area(s). The landfill access roads will be passable under inclement weather conditions to allow access to the active disposal area. To enhance operating efficiency during wet weather, the Owner may reserve an active disposal area close to the all-weather roads for wet-weather operations where development sequence allows. Furthermore, the tracking of mud and trash onto public access roadways will be minimized by removing mud and associated debris from the landfill roads and site entrance, as described in Part IV – Site Operating Plan (SOP).

## 3.3 SITE ACCESS (30 TAC §330.63(B)(1))

### 3.3.1 Access from Highway

The main public roadways providing access to the site are State Highway (SH) 31 and T K Parkway (also known as Farm-to-Market [FM] 939). The landfill entrance will be located off FM 939, approximately 0.4 miles south of the intersection of SH 31 and FM 939. Refer to Parts I/II, Section 8 - Transportation for site access and other transportation information.

The site entrance is detailed on Attachment 1, Drawing 1.5 - Entrance Facility Plan. The site entrance consists of an all-weather road, site entrance gates, scale house, and scales (initially one inbound and one outbound scale). The site entrance will also include two inbound queue lanes that provide approximately 3,300 feet of queuing length from the scales back to FM 939. Furthermore, at some point in the future, an additional inbound scale may be installed to accommodate increases in the waste acceptance rate over the site operating life.

### 3.3.2 All-Weather Access

The site entrance road includes an asphalt or concrete paved roadway, or other suitable material that transitions into landfill access roads, either perimeter or interior haul roads, constructed of crushed stone, concrete rubble, masonry demolition debris, gravel, caliche, asphalt paving, or other suitable material and will provide access from the site entrance road to the waste disposal area(s). The site entrance road will serve as mud control for waste hauling vehicles prior to exiting the site and returning to public-access roads. The perimeter roads will be maintained for all-weather access by site personnel. Crushed stone, concrete rubble, masonry demolition debris, gravel, caliche, asphalt paving, or other similar material will be made available, as necessary, for use in maintaining passable perimeter roads. Grading equipment or other appropriate equipment will be used to control or remove mud accumulation at least once per day on days when mud and associated debris are being tracked onto FM 939, as specified in the SOP.

### 3.3.3 Access Control

Vehicle access to the landfill will be controlled at the site entrance by signs that direct all landfill traffic to the working face or CCS during site operating hours. Personnel on duty at the scale

house will regulate access to the landfill. The site entrance will be secured by two gates (primary and secondary entrance gates). The primary entrance gate will be opened at 5:30 AM on days that the facility is in operation to minimize queuing on FM 939, as described in the Transportation Impact Analysis (Part I/II, Appendix I/IID-2) The secondary entrance gate will remain locked outside operating hours to prevent unauthorized vehicle access to the landfill. A fence, either barbed wire, chain link, privacy, or a combination thereof will limit access around the perimeter of the landfill at the permit boundary, as described in the SOP.

The Owner will permit entry to the landfill to designated landfill personnel, solid waste haulers (including landfill customers) authorized to use the facility, TCEQ personnel, and properly identified persons whose entry is authorized by the Landfill Manager or designee. Owner reserves the right to deny access to the landfill to persons not demonstrating a legitimate purpose for visiting. Visitors will be allowed on the active disposal area of the landfill only when accompanied by the Landfill Manager or designee.

## 3.4 GEOLOGY AND GEOTECHNICAL REPORTS (30 TAC §330.63(E))

The regional and local stratigraphy and lithology for the proposed landfill are summarized in Parts I/II, Section 9 and described in detail in Attachment 4 – Geology Report, including depth, thickness, geometry, soil classifications, hydraulic conductivity, and depositional history of the local geological formations. In view of the depth of low-permeability clay and shale at the facility, the geologic setting of the site is considered suitable for landfill development.

Attachment 4 also includes the results of the subsurface investigation performed at the facility. Onsite geology is characterized by three layers as follows, from the ground surface downward to a maximum drilled depth of 100 feet:

- Unit 1: consists of surficial clayey and loamy alluvium overlying silty or sandy clays with small subrounded gravel. The transition from Unit I to the underlying Unit II is transitional, and marked by increasing hardness and increasing fissility.

- Unit 2: beneath Unit I, consists of weathered silty shale with varying calcareous content. Some publications use the term “marl” to describe calcareous shale. The Unit II silty shale has thin, interbedded limestone and sand/silt partings/lenses, calcite-filled joints, and marine shell fragment fossils. Above the Unit II/Unit III line, the stratigraphy is generally more variable in color but are generally lighter-colored and have evidence of oxidation such as various rust- and yellow/brown colors. Below the Unit II/Unit III line, the stratigraphy is a homogenous very dark color, trending to black. Unit III also is less fissile than Unit II.

- Unit 3: beneath Unit II, consists of unweathered dark gray to black calcareous shale bedrock with thin, interbedded limestone and sand/silt lenses, and marine shell fragment fossils.

Attachment 5, Geotechnical/Stability Analyses, addresses the geotechnical properties of the landfill, including evaluation of the geotechnical properties of the subsurface soils, stability of the soils and strata for development of the landfill, and slope stability of the landfill.

## 3.5 GROUNDWATER PROTECTION (30 TAC §330.63(F) & §330.63(D)(4)(G))

### 3.5.1 Groundwater Monitoring System

Attachment 4, Geology Report, includes the result of the subsurface investigation, including the groundwater depth, if encountered, in the soil borings and piezometers. Also, Attachment 4 includes the elevations and gradient of groundwater across the landfill property and a detailed description of the proposed groundwater monitoring system, which will be used to verify the integrity of the liner system. Details of the plan for performing groundwater sampling, analysis, and reporting are addressed in Attachment 7 - Groundwater Sampling and Analysis Plan.

### 3.5.2 Liner Design

Consistent with 30 TAC §330.331(b), a soil-geomembrane composite liner system for a Type I landfill, is proposed for the landfill. Beginning from the waste and working down, the bottom liner system will be comprised of the following components:

- 24-inch thick soil protective cover;
- Single-sided geocomposite (non-woven geotextile on the top side only of geonet);
- 60-mil high-density polyethylene (HDPE) geomembrane (smooth);
- 2-foot-thick compacted clay liner ($k \leq 1x10^{-7}$ cm/sec); and
- Prepared subgrade (excavation grade).

The sideslope liner system will be comprised of the following components (from waste and working down):

- 24-inch thick soil protective cover;
- Double-sided geocomposite (non-woven geotextile on both sides of geonet);
- 60-mil textured HDPE geomembrane (textured on both sides);
- 2-foot-thick compacted clay liner ($k \leq 1x10^{-7}$ cm/sec); and
- Prepared subgrade (excavation grade).

The proposed liner system for the landfill is designed to meet the requirements outlined in 30 TAC §330.331. Attachment 10 – Soil and Liner Quality Control Plan (SLQCP) contains the construction quality control and quality assurance requirements for construction of the composite liner for the landfill.

### 3.5.3 Leachate Collection System

A leachate collection system (LCS) has been designed to control the accumulation of leachate within the waste disposal area during the active periods of landfilling, and after landfill closure; including being designed to meet Type I landfill requirements (30 TAC §330.331(a)(2) and §330.333) and maintaining leachate head over the liner of less than 30 centimeters. The LCS layout is shown on drawings included in Attachments 1 and 12 of this permit application. Design of the LCS is discussed in Attachment 12 - Leachate and Contaminated Water Management Plan. Information regarding materials and construction quality control and quality assurance are included in the SLQCP. The following provides a summary description of the LCS and associated features. Additional description is provided in Attachment 12. Representative details of the LCS are presented on drawings included in Attachment 12.

The primary collection component of the LCS is the leachate drainage layer, which consists of a geonet-geotextile composite (referred to as geocomposite) placed directly over the bottom and sideslope liner systems. The geocomposite consists of a HDPE geonet with a non-woven geotextile heat bonded to one or both sides of the geonet, where single-sided geocomposite will be placed on the bottom, and double-sided geocomposite will be placed on the sideslopes of the landfill. The geocomposite will have hydraulic properties that will provide adequate drainage of leachate to the leachate collection piping and sump, thereby maintaining less than 30-cm leachate head above the bottom liner system. Calculations demonstrating the minimum required material properties for the geocomposite are presented in Attachment 12.

A 2-foot-thick protective cover will be placed over the geocomposite prior to waste placement. To facilitate drainage into the leachate collection system, chimney drains, comprised of aggregate wrapped in a non-woven geotextile, will be constructed over the leachate collection piping. Leachate entering the LCS piping will discharge into sumps located at the perimeter of the landfill. Leachate collected in the sumps will be removed via submersible pumps lowered into the sumps through a riser pipe extending up the cell sideslope.

Additional descriptions of the LCS piping and sumps, including but not limited to pipe spacing and grading; sump sizing calculations; and demonstration that pipes and perforations will be resistant to clogging and collapse, are presented in Attachment 12. Leachate and contaminated water management, including storage and disposal, is presented in Attachment 12, Sections 4 and 5, respectively.

## 3.6 SURFACE WATER PROTECTION (30 TAC §330.63(C)(1))

### 3.6.1 General

The proposed landfill is located within the drainage basin of the Brazos River. Surface water generally drains southeast from the western portion of the property towards Horse Creek and

generally drains south/southwest from the eastern portion of the property towards Horse Creek and Packwood Creek.

Stormwater runoff from the developed landfill will be conveyed through a surface water management system designed in accordance with 30 TAC §330.63(c), as described in Section 3.6.3. Stormwater will be conveyed from the landfill property into natural drainage features, including Horse and Packwood Creeks. These creeks are tributaries of Soil Conservation Services Site 19 Reservoir, which discharges into Williams Creek located south of the property and eventually flows into Tehuacana Creek approximately 11 miles southwest of the property. Tehuacana Creek discharges into the Brazos River approximately 15 miles southwest of the property.

In accordance with 30 TAC §330.15(h), the landfill has been designed to prevent discharge of pollutants into waters of the State or waters of the United States, as defined by the Texas Water Code (§26.121) and the Federal Clean Water Act (§404), respectively. As described in Part I/II, Section 10.2, the Owner will file a notice of intent (NOI) with the TCEQ and develop and implement a Stormwater Pollution Prevention Plan prior to the commencement of landfill operations to obtain coverage under the Texas Pollutant Discharge Elimination System (TPDES) General Permit, TXR050000 for Stormwater Discharges associated with Industrial Activity.

### 3.6.2 Site Drainage Patterns

Consistent with 30 TAC §330.63(c), the surface water management system design for the landfill complies with 30 TAC §330.303. A complete description of the site drainage patterns for both the pre- and post-development landfill conditions is presented in Attachment 6A – Surface Water Drainage Plan of this permit application. As presented in Attachment 6A, the surface water drainage features, aerial fill controls and perimeter drainage system, have been designed to avoid adversely altering existing drainage patterns, as a result of landfill development, in accordance with 30 TAC §330.63(c)(1)(D)(iii). This has been demonstrated by evaluating pre- and post-development peak discharge rates and total discharge volumes at off-site discharge locations. Furthermore, the post-development locations of off-site discharges have been designed to be consistent with the pre-development conditions. The pre- and post-development hydrologic and hydraulic analysis are presented in Attachment 6A, including a description of the methodology, calculations, and results of said calculations.

### 3.6.3 Perimeter Drainage System

The stormwater controls for the landfill have been designed consistent with the 30 TAC §330 requirements for Type I MSW landfills. The perimeter drainage system is comprised of final cover controls (described in Section 3.6.5), perimeter drainage channels and detention basins. The perimeter drainage system has been designed for a 25-year, 24-hour storm event. The drainage features will be installed concurrent with the construction of up-gradient landfill disposal cells, such that when the cell grades are above existing grade, down-gradient drainage features are in-place, as described in Attachment 6A. Details and sizing criteria for the perimeter drainage system and associated calculations, including peak velocities, flow depths, and discharge rates are included in Attachment 6A of this permit application.

### 3.6.4 Below Grade

Control of stormwater run-on and runoff within excavation areas will be achieved using temporary diversion berms, ditches, and containment areas as needed. The temporary stormwater control structures will be used to divert stormwater away from the working face, thus reducing the volume of contaminated water generated during a storm event. Uncontaminated stormwater will be discharged consistent with the requirements of the TPDES General Permit.

Contaminated stormwater consists of stormwater that has come into contact with waste. Control of contaminated stormwater will be provided through temporary containment berms. Water that infiltrates into the underlying waste will be managed as leachate. Contaminated stormwater will be contained and managed at the working face in accordance with the guidelines set forth in Attachment 12 of this permit application.

### 3.6.5 Aerial Fill Controls

Additional stormwater controls will be necessary as the site is brought above grade. Temporary diversion and containment berms, channels, and containment areas will be used to separate and control uncontaminated and contaminated stormwater run-on and runoff for the aerial fill portions of the landfill.

As intermediate and final cover are placed on the landfill, vegetation will be established to provide erosion protection, as described in Attachment 6A and the SOP. Furthermore, as intermediate and final cover are placed, drainage features will be installed to control erosion and convey stormwater run-on and run-off from the landfill cover to the perimeter drainage system, as described in Section 3.6.6. Drainage features installed on the intermediate and final cover have been designed to convey stormwater associated with the 25-year, 24-hour storm event. Design details and sizing calculations, including peak velocity, flow depth, and discharge rate, for intermediate and final cover drainage features are described in Attachment 6A. In all cases, surface water run-on and runoff will be managed consistent with the 30 TAC §330, Subchapter G.

Areas that have received waste, but will be inactive for longer than 180 days will receive intermediate cover. Consistent with 30 TAC §330.165(a) and (c), runoff from areas with intact daily and/or intermediate cover will be considered uncontaminated. Also, by implementing: (1) the site design and proper operating practices; and (2) ongoing placement of daily, intermediate and final cover (as further described in Attachment 9 - Final Closure and Post-Closure Plan), contaminated water and leachate will be minimized. Details of the final cover design are provided in Attachments 6C and 9 of this permit application.

### 3.6.6 Erosion and Sedimentation Control Plan

On-site erosion and sedimentation control will be provided as follows: (1) during construction activities; and (2) as part of the ongoing operation of the landfill. Erosion and sedimentation control includes structural and non-structural controls for the intermediate and final cover systems and the perimeter drainage system. An Erosion and Sedimentation Control Plan is presented in Attachment 6A – Surface Water Drainage Plan, Section 6. Landfill management will control erosion and offsite sedimentation by implementing interim controls, as specified in

§330.305(e)(2), as described in Attachment 6A, Section 6. Furthermore, permanent erosion and sedimentation controls have been incorporated into the design of the landfill at completion and the perimeter drainage system.

Additionally, in accordance with §330.305(d), the landfill design will provide effective erosional stability to top dome surfaces and embankment sideslopes during all phases of landfill operation, including the closure and post-closure care period. The Erosion and Sedimentation Control Plan (Attachment 6A, Section 6) describes and includes the following:

- Erosion calculations using the Universal Soil Loss Equation (USLE)/Revised Universal Soil Loss Equation (RUSLE) to demonstrate that erosion on intermediate and final cover will be below permissible soil losses.

- Hydraulic calculations using standard engineering principles to demonstrate that velocities in drainage swales and downchutes and on intermediate and final cover slopes will be below permissible velocities.

- Operational requirements and guidelines for implementing erosion and offsite sedimentation controls, such as non-structural and structural best management practices (BMPs) for daily cover and soil stockpiles, intermediate cover, and final cover.

These features include perimeter drainage channels that have been designed with non-erosive velocities, or in areas where erosive velocities are anticipated, erosion protection or armoring of the channels in the form of rip rap, turf reinforcement matting, rock ditch checks, gabions, dissipation blocks, or other suitable structures will be provided, as needed. Permanent drainage and erosion protection measures for the final cover system (e.g., drainage swales and downchutes) are shown in Attachment 3 - Landfill Completion Plan. Erosion control practices for daily and intermediate cover are discussed in detail in Attachment 6A. Establishing vegetation on the intermediate and final cover, drainage swales, perimeter drainage system, and buffer zones will be ongoing as the site is developed (see Part III, Attachment 9 - Final Closure and Post-Closure Plan).

### 3.6.7 Wetlands

Information regarding wetlands is provided in Parts I/II, Section 11.2 and Appendix I/IIE – Section 404 Jurisdictional Determination in accordance with 30 TAC §330.553(b).

## 3.7 FLOODPLAIN PROTECTION (30 TAC §330.63(C)(2))

A portion of the Site is within the 100-year floodplains of Horse and Packwood Creeks. The floodplain limits were obtained from the currently effective Flood Insurance Rate Maps (Panels 48309C0250D dated December 20, 2019, and 48293C0125C dated September 16, 2011) obtained from FEMA for portions of McLennan and Limestone Counties. The floodplain limits have been designated by FEMA as Zone A, which indicates that no flood elevations have yet been determined along these creeks on the Site. The proposed waste disposal footprint is located entirely outside the limits of the 100-year floodplain. In accordance with 30 TAC §330.547(a),

no solid waste disposal operations will take place within the 100-year floodplain, and therefore no development is proposed in the 100-year floodplain.

Because the floodplain for the project area has been classified as Zone A, an additional flood study was performed to confirm that the proposed landfill and perimeter drainage system will not be impacted by a 100-year storm event. This 100-year flood study is presented in Attachment 6B – Floodplain Evaluation. As presented in this attachment, the waste disposal limits are not located within the 100-year flood study area, and will not be impacted by a water surface generated by a 100-year storm event. Additionally, the landfill has been designed with a perimeter berm above existing grade, which prevents washout from the 100-year storm event. Furthermore, the landfill has been designed such that there will be no surface water run-on from Horse and Packwood Creeks into the perimeter drainage system associated with a 100-year storm event. Therefore, the landfill and perimeter drainage system will not be impacted by the 100-year storm event.

Additionally, in accordance with 30 TAC §330.547(b), site operations and development will not restrict the flow or reduce the temporary storage capacity of the 100-year floodplain; nor will the site operations result in washout of solid waste associated with the 100-year floodplain, since construction within the 100-year floodplain is not proposed. Therefore, §330.63(c)(2)(D) is not applicable to this application. Furthermore, in accordance with 30 TAC §330.547(c), all storage and processing facilities (e.g., onsite CCS) will be located outside of the 100-year floodplain as delineated by FEMA and will not be impacted by the 100-year storm event, as shown in Attachment 6B.

Furthermore, the site will not require any levees or other improvements, including channel improvements, drainage works, or other projects on, along, or near any stream in the state that is subject to floods, freshets, or overflows, constructed so as to control, regulate, or otherwise change the floodwater of the stream. No portions of the landfill are located within a 100-year floodway. Therefore, the requirements of 30 TAC Chapter 301, Subchapter C, §301.31 to 301.46 relating to the Approval of Levees and Other Improvements, as referenced in 30 TAC §330.61(m)(1) and §330.63(c)(2)(D)(i), are not applicable.

## 3.8 LANDFILL CLOSURE AND POST CLOSURE-CARE (30 TAC §330.63(H), (I) & (J))

### 3.8.1 Final Cover Design

The final cover system will be a soil-geomembrane composite meeting the requirements of 30 TAC §330.457. Beginning from the surface and working down, the final cover system on the landfill topslopes will be comprised of the following components:

- Vegetation (native and/or introduced grasses);
- 24-inch thick (minimum) soil erosion layer, with the top six inches capable of sustaining vegetation;
- Single-sided geocomposite (non-woven geotextile on the top side only of geonet);

- 60-mil HDPE or 40-mil linear low density polyethylene (LLDPE) geomembrane (smooth);
- 18-inch thick (minimum) clayey soil infiltration layer ($k \leq 1x10^{-5}$ cm/sec); and
- 6-inch-thick daily cover or 12-inch-thick intermediate cover.

Beginning from the surface and working down, the final cover system on the landfill sideslopes will be comprised of the following components:

- Vegetation (native and/or introduced grasses);
- 24-inch thick soil erosion layer, with the top six inches capable of sustaining vegetation
- Double-sided geocomposite (non-woven geotextile on both sides of geonet);
- 60-mil HDPE or 40-mil LLDPE geomembrane (textured on both sides);
- 18-inch thick (minimum) clayey soil infiltration layer ($k \leq 1x10^{-5}$ cm/sec); and
- 6-inch-thick daily cover or 12-inch-thick intermediate cover.

The Final Closure and Post-Closure Care Plan, which is provided in Attachment 9, includes the final closure schedule, certification of closure, and an estimate of the largest area that will ever require final cover at the landfill in the year to follow closure. The final closure cost estimate for this area is provided in Attachment 8 – Closure and Post-Closure Care Cost Estimates.

### 3.8.2 Post Closure Care

At the time of closure, consistent with 30 TAC Subchapter K, the landfill will enter the 30-year post-closure care period. A description of the activities required during post-closure care are described in Attachment 9 of this application. A post-closure care cost estimate is provided in Attachment 8.

## 3.9 LANDFILL GAS MANAGEMENT (30 TAC §330.63(G))

Attachment 11 – Landfill Gas Management Plan provides procedures for monitoring landfill gas at the landfill perimeter and within onsite structures, layout or the perimeter landfill gas monitor probes, frequency for landfill gas monitoring, and procedures to be implemented in the event landfill gas is detected above regulatory limits. Drawing 11.1 – Landfill Gas Monitoring Probe Plan, provided in Attachment 11, depicts the layout of the perimeter landfill gas monitoring probe system.

## 3.10 PROTECTION OF ENDANGERED SPECIES (30 TAC §330.63(B)(5))

Information regarding the protection of endangered species in accordance with 30 TAC §330.157 is provided in Parts I/II, Section 12 – Protection of Endangered or Threatened Species.

## 3.11 CITIZENS' CONVENIENCE STATION METHODS

The Owner will construct a CCS on the facility property at the location shown on Attachment 1, Drawing 1.2. The CCS will be used to reduce traffic at the working face of the landfill, specifically associated with traffic from citizens with small or light vehicles. This CCS will be used for the acceptance and storage of waste, which will be disposed at the working face, and acceptance and storage of recyclables (i.e., aluminum, glass, plastic, cardboard/newspaper, scrap metal, large items and/or white goods, and whole used or scrap tires) for transport to an authorized recycling or disposal facility.

The CCS will be comprised of an elevated deck area (unloading area) with an all-weather surface, with collection containers situated behind a retaining wall for unloading of waste and recyclables into the containers. The retaining wall will be designed with a straight or z-pattern configuration for staging the containers behind the wall. The retaining wall will be constructed from either stackable reinforced concrete blocks, reinforced concrete, or other suitable materials, as designed by a professional engineer licensed in the State of Texas. The design of the CCS retaining wall and elevated unloading area will be maintained in the Site Operating Record of the landfill.

Waste and recyclable materials will be stored in separate containers (roll-offs) or locations (i.e., tires and large items and/or white goods) at the CCS. Each container or location will be properly identified for the types of waste or recyclable to be received. The type of container or storage mechanism will be based on the individual waste stream (see Part IV – Site Operating Plan for specifics on containers and storage locations).

Access to the CCS will be through the site entrance and all-weather landfill access roads, as described in Section 3.3. The Gate Attendant will direct citizens with small or light vehicles to unload waste at the CCS. Specifics on waste acceptance, waste unloading, fire protection, and overall operations of the CCS are provided in Part IV.

# APPENDIX IIIA

# SITE LIFE CALCULATIONS

**SCS Engineers**
**TBPE Reg. # F-3407**

**Inclusive of pages III-A-1 to III-A-3**

# CITY OF WACO LANDFILL
# TCEQ PERMIT NO. MSW - 2400
# WASTE DISPOSAL CAPACITY AND SITE OPERATING LIFE CALCULATIONS

**Required:** **Perform Disposal Capacity and Site Operating Life Calculations for Landfill**

1. Estimate Capacity of East Disposal Area.
2. Estimate Capacity of West Disposal Area
3. Estimate Total Waste Capacity of Landfill
4. Estimate Site Operating Life of Landfill

**Solution:**

1. Estimate Capacity of East Disposal Area.

| | | | |
|---|---|---|---|
| a. | Gross airspace from AutoCAD volume calculation = | 18,541,083 | cy |
| b. | Airspace consumed by final cover (cy) = 112.7 acres at 3.5 feet thick = | -636,379 | cy |
| c. | Airspace consumed by Bottom Liner and Protective Cover = 112.7 acres at 4 feet thick = | -727,291 | cy |
| d. | Adjusted Gross Airspace Volume = | 17,177,413 | cy |
| e. | Percent of airspace consumed by Daily and Intermediate cover = | 20 | percent |
| f. | Net Airspace Available for Waste Disposal = | 13,741,930 | cy |
| g. | In-place waste density = | 1,200 | lb/cy |
| h. | Total East Waste Disposal Capacity = | 8,245,158 | tons |

**Available East Waste Disposal Capacity (tons) = 8,245,158 tons**

2. Estimate Capacity of West Disposal Area

| | | | |
|---|---|---|---|
| a. | Total airspace from AutoCAD volume calculation = | 8,229,389 | cy |
| b. | Airspace consumed by final cover (cy) = 61.6 acres at 3.5 feet thick = | -347,835 | cy |
| c. | Airspace consumed by Bottom Liner and Protective Cover (assume 4' liner, Sideslopes Only) = 61.6 acres at 4 feet thick = | -397,525 | cy |
| d. | Adjusted Airspace Volume = | 7,484,029 | cy |
| e. | Percent of Airspace Consumed by Daily and Intermediate Cover = | 20 | percent (1) |
| f. | Net Total Airspace Available for Waste Disposal = | 5,987,223 | cy |
| g. | In-place Waste Density = | 1,200 | lb/cy |
| h. | Total West Waste Disposal Capacity = | 3,592,334 | tons |

**Available West Waste Disposal Capacity (tons) = 3,592,334 tons**

3. Estimate Total Waste Capacity of Landfill

From above:

| | | |
|---|---|---|
| Available East Waste Disposal Capacity (tons) = | 8,245,158 | tons |
| Available West Waste Disposal Capacity (tons) = | 3,592,334 | tons |

**Maximum Inventory of Waste at Time of Closure = 11,837,492 tons**

4. Estimate Site Operating Life of Landfill

For the Site operating life calculations, the Waste Acceptance Rate is based on the following assumptions:

| | | |
|---|---|---|
| Days of operation per year = | 286 | days |
| Initial Daily Waste Acceptance Rate = | 1,070 | tpd |
| Assumed Growth Rate (Life of Landfill) = | 1.25 | % (annually) |
| Initial Annual Waste Acceptance Rate = | 305,000 | tpy |
| Maximum Inventory of Waste at Time of Closure = | 11,837,492 | tons |

The following table calculates the waste stream growth, assuming the growth rates describe above, and the projected cumulative airspace consumed.

| Year | MSW Inflow (tons/yr) | Cumulative Disposal Capacity Consumed (tons) | Disposal Capacity Remaining (tons) | Disposal Year |
|---|---|---|---|---|
| 2024 | 305,000 | 305,000 | 11,532,492 | 1 |
| 2025 | 308,813 | 613,813 | 11,223,680 | 2 |
| 2026 | 312,673 | 926,485 | 10,911,007 | 3 |
| 2027 | 316,581 | 1,243,066 | 10,594,426 | 4 |
| 2028 | 320,538 | 1,563,605 | 10,273,888 | 5 |
| 2029 | 324,545 | 1,888,150 | 9,949,343 | 6 |
| 2030 | 328,602 | 2,216,751 | 9,620,741 | 7 |
| 2031 | 332,709 | 2,549,461 | 9,288,031 | 8 |
| 2032 | 336,868 | 2,886,329 | 8,951,163 | 9 |
| 2033 | 341,079 | 3,227,408 | 8,610,084 | 10 |
| 2034 | 345,343 | 3,572,751 | 8,264,741 | 11 |
| 2035 | 349,659 | 3,922,410 | 7,915,082 | 12 |
| 2036 | 354,030 | 4,276,440 | 7,561,052 | 13 |
| 2037 | 358,456 | 4,634,896 | 7,202,596 | 14 |
| 2038 | 362,936 | 4,997,832 | 6,839,660 | 15 |
| 2039 | 367,473 | 5,365,305 | 6,472,187 | 16 |
| 2040 | 372,066 | 5,737,371 | 6,100,121 | 17 |
| 2041 | 376,717 | 6,114,088 | 5,723,404 | 18 |
| 2042 | 381,426 | 6,495,515 | 5,341,978 | 19 |
| 2043 | 386,194 | 6,881,708 | 4,955,784 | 20 |
| 2044 | 391,021 | 7,272,730 | 4,564,762 | 21 |
| 2045 | 395,909 | 7,668,639 | 4,168,853 | 22 |
| 2046 | 400,858 | 8,069,497 | 3,767,995 | 23 |
| 2047 | 405,869 | 8,475,366 | 3,362,127 | 24 |
| 2048 | 410,942 | 8,886,308 | 2,951,184 | 25 |
| 2049 | 416,079 | 9,302,387 | 2,535,106 | 26 |
| 2050 | 421,280 | 9,723,666 | 2,113,826 | 27 |
| 2051 | 426,546 | 10,150,212 | 1,687,280 | 28 |
| 2052 | 431,878 | 10,582,090 | 1,255,402 | 29 |
| 2053 | 437,276 | 11,019,366 | 818,126 | 30 |
| 2054 | 442,742 | 11,462,108 | 375,384 | 31 |
| 2055 | 448,276 | 11,910,384 | -72,892 | 32 |

**Remaining available capacity will be consumed during 2056**
**Site life is projected to be approximately 32 years.**

**CITY OF WACO LANDFILL**
**TCEQ PERMIT NO. MSW-2400**
**McLENNAN AND LIMESTONE COUNTIES, TEXAS**

# PART III
# SITE DEVELOPMENT PLAN
# ATTACHMENT 1
# SITE LAYOUT PLANS

**Prepared for:**

**CITY OF WACO**

Solid Waste Services
501 Schroeder Drive
Waco, TX 76710

**Prepared by:**

**SCS ENGINEERS**
**Texas Board of Professional Engineers, Reg. No. F-3407**
Dallas/Fort Worth Office
1901 Central Drive, Suite 550
Bedford, Texas 76021
817/571-2288

Revision 0 – April 2020
Revision 1 – October 2020
SCS Project No. 16216088.00

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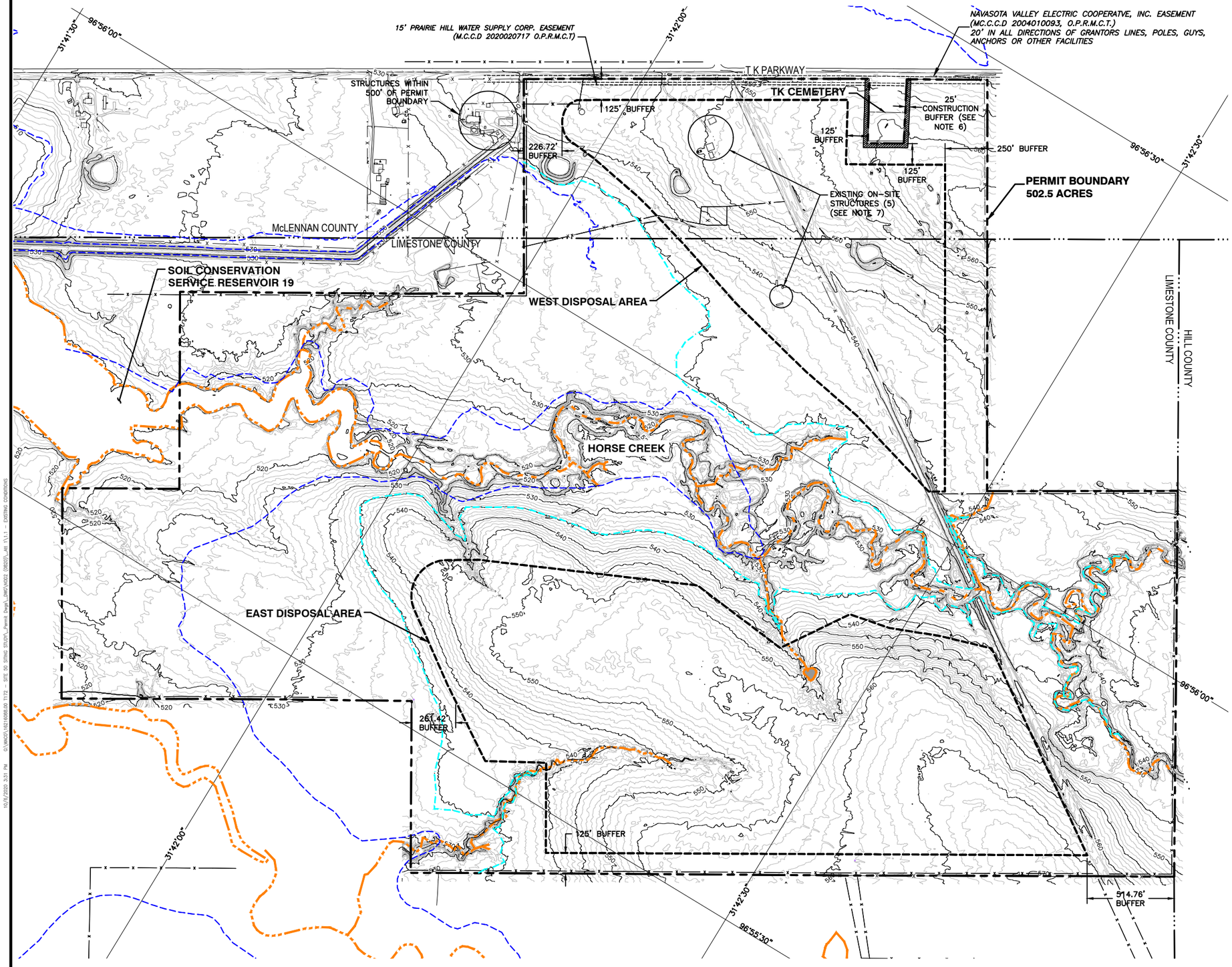
## Drawings

1.1 Existing Conditions Plan
1.2 Detailed Facility Layout and Sequence Plan
1.3 East Disposal Area Excavation Plan
1.4 West Disposal Area Excavation Plan
1.5 Entrance Facility Plan
1.6 Waste Flow Diagram

**SCS Engineers**
**TBPE Reg. # F-3407**

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## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- 560 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- COUNTY LINE
- x EXISTING FENCE
- 100-YEAR FLOOD PLAIN (SEE NOTE 2)
- POTENTIAL JURISDICTIONAL WATER LOCATION (SEE NOTE 4)
- 96°55'30" LATITUDE/LONGITUDE LINES
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR, REFER TO NOTE 5)

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.
2. 100-YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
3. CONSISTENT WITH TCEQ REGULATIONS A MINIMUM BUFFER ZONE OF 125' WILL BE MAINTAINED BETWEEN THE WASTE LIMIT BOUNDARY AND PERMIT BOUNDARY.
4. THE LOCATION OF THE POTENTIAL JURISDICTIONAL WATERS ARE REFERENCED FROM THE REPORT GENERAL JURISDICTION DETERMINATION PREPARED BY HORIZON ENVIRONMENTAL SERVICES, INC. (SEE APPENDIX I/IIA, AGENCY COORDINATION WITH THE COE).
5. A FLOWAGE EASEMENT EXISTS ON THE PROPERTY THAT IS UNDER THE JURISDICTION OF THE TECHUACANA CREEK WATER CONTROL AND IMPROVEMENT DISTRICT NUMBER (1) OF LEROY, TEXAS SUBJECT TO THE EASEMENT RECORDED IN VOLUME 498, PAGE 118, VOLUME 506, PAGE 181, VOLUME 507, PAGE 378, AND VOLUME 509, PAGE 417 OF THE DEED RECORDS OF LIMESTONE COUNTY, TEXAS.
6. IN ACCORDANCE WITH "AN INTENSIVE CULTURAL RESOURCES SURVEY OF THE CITY OF WACO'S PROPOSED SITE 50 LANDFILL PROJECT," PREPARED BY HORIZON ENVIRONMENTAL SERVICES, INC., DATED NOVEMBER 2018 (SEE APPENDIX I/IIA), A 25-FOOT CONSTRUCTION BUFFER WILL BE MAINTAINED AROUND TK CEMETERY TO PROTECT ANY POTENTIAL UNMARKED GRAVES OUTSIDE THE PRESENT MODERN DAY CEMETERY BOUNDARIES AND FENCING.
7. THE EXISTING STRUCTURES WITHIN THE BOUNDARY OF WASTE DISPOSAL AREA (WDA) WILL BE ABANDONED AND DEMOLISHED PRIOR TO DEVELOPMENT OF THE RESPECTIVE SECTORS (I.E. SECTORS 10 AND 11) OF THE WDA WHERE THE EXISTING STRUCTURE IS LOCATED.

STATE OF TEXAS
RYAN R. KUNTZ
104689
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

**FOR PERMITTING PURPOSES ONLY**

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOODPLAIN, FLOWAGE EASEMENT, WATER SUPPLY EASEMENT, FIBER OPTIC EASEMENT, LIMITS OF WASTE, NOTE 2, AND RENUMBERED NOTES. | RRK |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: **EXISTING CONDITIONS PLAN**

PROJECT TITLE: **CITY OF WACO LANDFILL**
**TYPE I MSW - PERMIT APPLICATION**

CLIENT: **CITY OF WACO**
**SOLID WASTE SERVICES**


**SCS ENGINEERS**
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
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| | |
|---|---|
| PROJ. NO. | 16216088.00 |
| DSN. BY: | BG/RRK |
| DWN. BY: | NR |
| CHK. BY: | BJD |
| D/A RVW BY: | RRK |
| APP. BY: | RRK |

CADD FILE: 1.1 – EXISTING CONDITIONS

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. **1.1**


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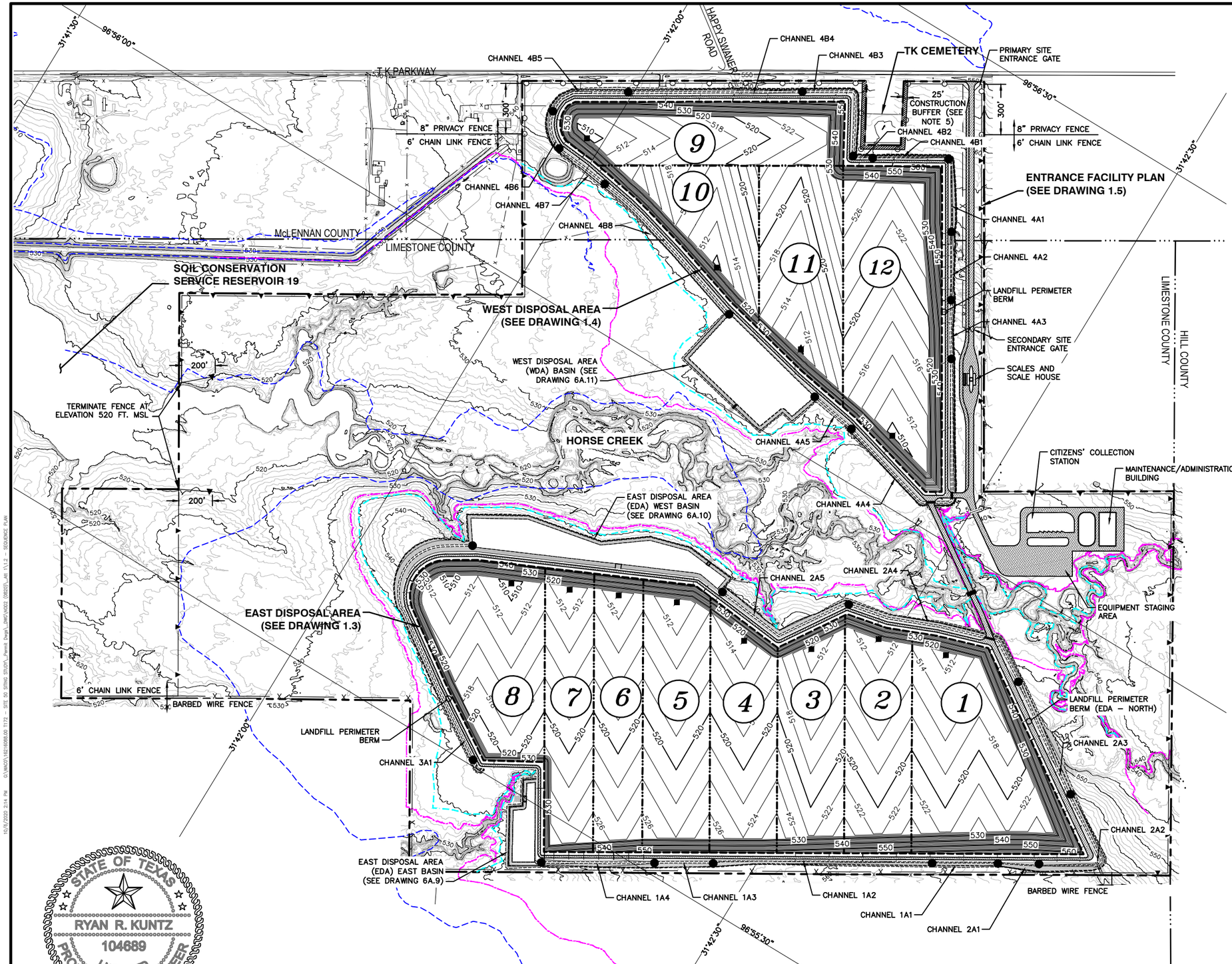


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## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- SECTOR BOUNDARY
- COUNTY LINE
- 560 — EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- 100–YEAR FLOOD PLAIN (SEE NOTE 2)
- 100–YEAR STORM EVENT WATER SURFACE (SEE NOTE 6)
- X — PROPOSED/EXISTING BARBED WIRE FENCE
- PROPOSED 6' CHAIN LINK FENCE
- PROPOSED 8' PRIVACY FENCE
- ACCESS ROAD
- 510 — EXCAVATION GRADE TOPOGRAPHIC CONTOURS (SEE NOTE 3)
- 96°55'30" — LATITUDE/LONGITUDE LINES
- X — SECTOR DESIGNATION (SEE NOTE 4)
- CHANNEL SECTION
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.
2. 100–YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
3. ELEVATIONS SHOWN ON THIS DRAWING WITHIN WASTE LIMITS ARE EXCAVATION GRADES (BOTTOM OF LINER) ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).
4. SECTOR DEVELOPMENT SEQUENCE REPRESENTED BY NUMBERING. SECTORS MAY BE DEVELOPED IN SMALLER INCREMENTS (AKA SUBSECTORS OR CELLS) WITH LINER CERTIFICATIONS SUBMITTED SEPARATELY TO TCEQ FOR REVIEW. IF SECTORS ARE DEVELOPED AS SMALLER CELLS, THE DOWN–GRADIENT CELLS WITH LEACHATE COLLECTION SUMP WILL BE DEVELOPED FIRST.
5. IN ACCORDANCE WITH "AN INTENSIVE CULTURAL RESOURCES SURVEY OF THE CITY OF WACO'S PROPOSED SITE 50 LANDFILL PROJECT," PREPARED BY HORIZON ENVIRONMENTAL SERVICES, INC., DATED NOVEMBER 2018 (SEE APPENDIX I/IIA), A 25–FOOT CONSTRUCTION BUFFER WILL BE MAINTAINED AROUND TK CEMETERY TO PROTECT ANY POTENTIAL UNMARKED GRAVES OUTSIDE THE PRESENT MODERN DAY CEMETERY BOUNDARIES AND FENCING.
6. 100–YEAR STORM EVENT WATER SURFACE WAS ESTIMATED USING HEC–HMS AND HEC–RAS MODELING AS DISCUSSED IN ATTACHMENT 6B OF THIS PERMIT APPLICATION.

STATE OF TEXAS
RYAN R. KUNTZ
104689
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

FOR PERMITTING PURPOSES ONLY

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOODPLAIN, FLOWAGE EASEMENT, BASIN CALLOUT, LIMITS OF WASTE, NOTE 2. | RRK |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: DETAILED FACILITY LAYOUT AND SEQUENCE PLAN

PROJECT TITLE: CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO
SOLID WASTE SERVICES

SCS ENGINEERS
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PROJ. NO. 16216088.00
DSN. BY: BG/RRK
DWN. BY: NR
CHK. BY: BJD
D/A RVW BY: RRK
APP. BY: RRK

CADD FILE: 1.2 – SEQUENCE PLAN
DATE: 04/2020
SCALE: AS SHOWN
DRAWING NO. 1.2

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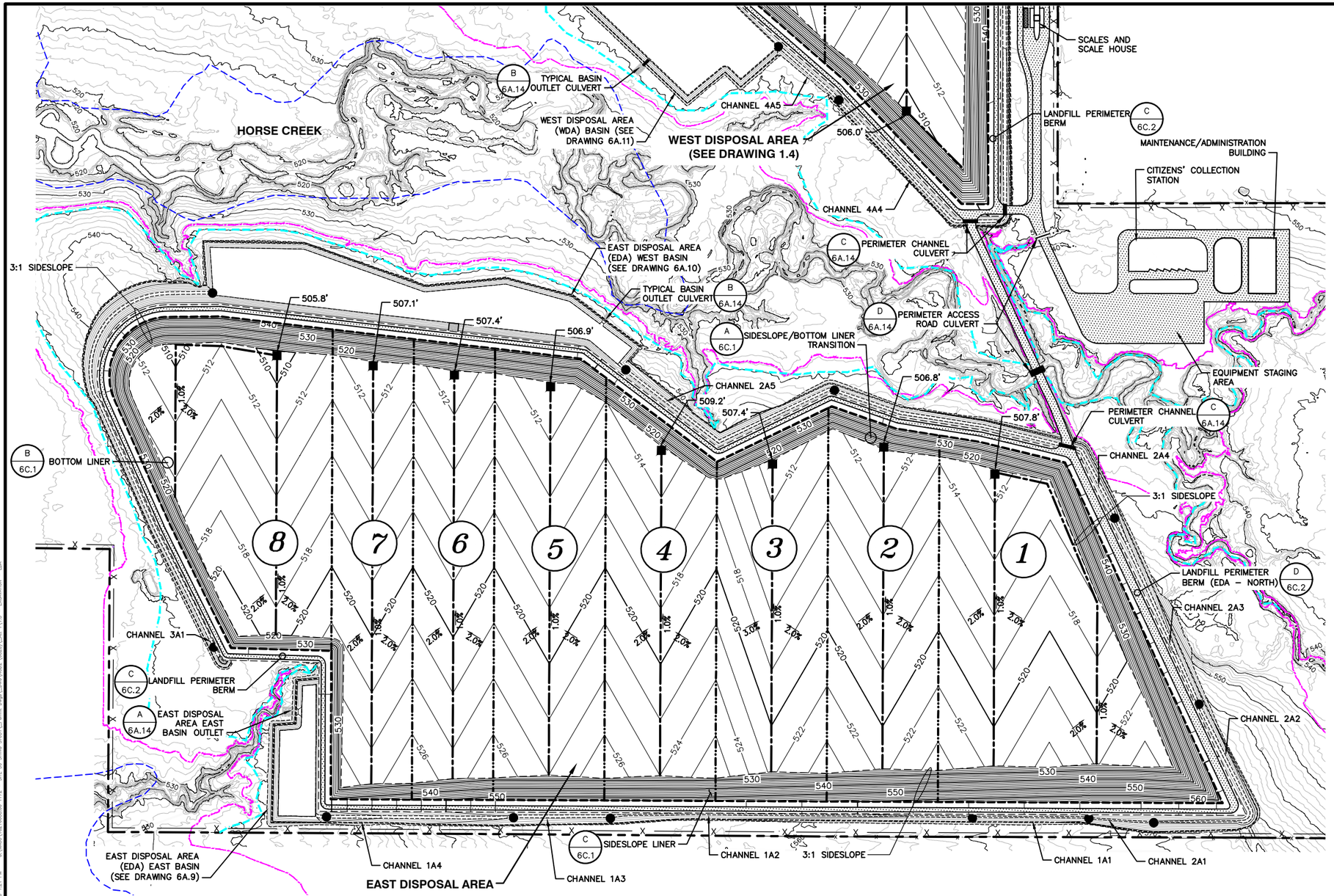


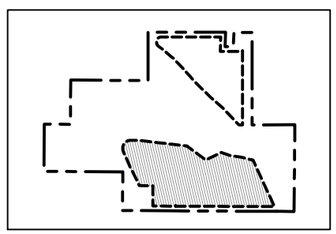

KEY MAP

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## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- SECTOR BOUNDARY
- 560 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- 100–YEAR FLOOD PLAIN (SEE NOTE 2)
- 100–YEAR STORM EVENT WATER SURFACE (SEE NOTE 5)
- X PROPOSED/EXISTING PERIMETER FENCE (CHAIN LINK OR BARBED WIRE)
- ACCESS ROAD
- 510 EXCAVATION GRADE TOPOGRAPHIC CONTOURS (SEE NOTE 3)
- LEACHATE COLLECTION TRENCH
- TOE/TOP OF SLOPE
- X SECTOR DESIGNATION (SEE NOTE 4)
- CHANNEL SECTION
- 506.0' BOTTOM OF SUMP ELEVATION
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.
2. 100–YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
3. ELEVATIONS SHOWN ON THIS DRAWING WITHIN WASTE LIMITS ARE EXCAVATION GRADES (BOTTOM OF LINER) ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).
4. SECTOR DEVELOPMENT SEQUENCE REPRESENTED BY NUMBERING. SECTORS MAY BE DEVELOPED IN SMALLER INCREMENTS (AKA SUBSECTORS OR CELLS) WITH LINER CERTIFICATIONS SUBMITTED SEPARATELY TO TCEQ FOR REVIEW. IF SECTORS ARE DEVELOPED AS SMALLER CELLS, THE DOWN–GRADIENT CELLS WITH LEACHATE COLLECTION SUMP WILL BE DEVELOPED FIRST.
5. 100–YEAR STORM EVENT WATER SURFACE WAS ESTIMATED USING HEC–HMS AND HEC–RAS MODELING AS DISCUSSED IN ATTACHMENT 6B OF THIS PERMIT APPLICATION.

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOODPLAIN, FLOWAGE EASEMENT, BASIN CALLOUT, LIMITS OF WASTE, NOTE 2. | RRK |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: EAST DISPOSAL AREA EXCAVATION PLAN

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES


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PROJ. NO. 16216068.00 | DSN. BY: RG/RRK | DWN. BY: NR | CHK. BY: BJD | D/A. R/W BY: | APP. BY: RRK

CADD FILE: 1.3 – EXCAVATION – EDA

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. 1.3

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T.K PARKWAY

B 6C.1 BOTTOM LINER

CHANNEL 4B5

CHANNEL 4B4

3:1 SIDESLOPE

CHANNEL 4B3

TK CEMETERY

PRIMARY SITE ENTRANCE GATE

25' CONSTRUCTION BUFFER (SEE NOTE 5)

ENTRANCE FACILITY PLAN (SEE DRAWING 1.5)

LANDFILL PERIMETER BERM

C 6C.2

CHANNEL 4B2

CHANNEL 4B1

CHANNEL 4B6

506.0'

CHANNEL 4B7

3:1 SIDESLOPE

A 6C.1 SIDESLOPE/BOTTOM LINER TRANSITION

CHANNEL 4A1

McLENNAN COUNTY

LIMESTONE COUNTY

CHANNEL 4B8

WEST DISPOSAL AREA

506.1'

CHANNEL 4A2

SECONDARY SITE ENTRANCE GATE

WEST DISPOSAL AREA (WDA) BASIN (SEE DRAWING 6A.11)

506.6'

CHANNEL 4A3

B 6A.14 TYPICAL BASIN OUTLET CULVERT

SCALES AND SCALE HOUSE

HORSE CREEK

CHANNEL 4A5

506.0'

C 6C.1 SIDESLOPE LINER

3:1 SIDESLOPE

CHANNEL 4A4

EAST DISPOSAL AREA (EDA) WEST BASIN (SEE DRAWING 6A.10)

EAST DISPOSAL AREA (SEE DRAWING 1.3)

C 6A.14 PERIMETER CHANNEL CULVERT

TYPICAL BASIN OUTLET CULVERT B 6A.14

D 6A.14 PERIMETER ACCESS ROAD CULVERT

505.8'

507.1'

507.4'

506.9'

CHANNEL 3A1

CHANNEL 2A5

CHANNEL 2A4

C 6C.2 LANDFILL PERIMETER BERM

9 10 11 12

0 200 400

SCALE IN FEET

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- SECTOR BOUNDARY
- COUNTY LINE
- 560 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- 100-YEAR FLOOD PLAIN (SEE NOTE 2)
- 100-YEAR STORM EVENT WATER SURFACE (SEE NOTE 6)
- X PROPOSED PERIMETER FENCE (CHAIN LINK)
- PROPOSED 8' PRIVACY FENCE
- ACCESS ROAD
- 510 EXCAVATION GRADE TOPOGRAPHIC CONTOURS (SEE NOTE 3)
- LEACHATE COLLECTION TRENCH
- TOE/TOP OF SLOPE
- X SECTOR DESIGNATION (SEE NOTE 4)
- CHANNEL SECTION
- 506.0' BOTTOM OF SUMP ELEVATION
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.
2. 100-YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
3. ELEVATIONS SHOWN ON THIS DRAWING WITHIN WASTE LIMITS ARE EXCAVATION GRADES (BOTTOM OF LINER) ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).
4. SECTOR DEVELOPMENT SEQUENCE REPRESENTED BY NUMBERING. SECTORS MAY BE DEVELOPED IN SMALLER INCREMENTS (AKA SUBSECTORS OR CELLS) WITH LINER CERTIFICATIONS SUBMITTED SEPARATELY TO TCEQ FOR REVIEW. IF SECTORS ARE DEVELOPED AS SMALLER CELLS, THE DOWN-GRADIENT CELLS WITH LEACHATE COLLECTION SUMP WILL BE DEVELOPED FIRST.
5. IN ACCORDANCE WITH "AN INTENSIVE CULTURAL RESOURCES SURVEY OF THE CITY OF WACO'S PROPOSED SITE 50 LANDFILL PROJECT," PREPARED BY HORIZON ENVIRONMENTAL SERVICES, INC., DATED NOVEMBER 2018 (SEE APPENDIX I/IIA), A 25-FOOT CONSTRUCTION BUFFER WILL BE MAINTAINED AROUND TK CEMETERY TO PROTECT ANY POTENTIAL UNMARKED GRAVES OUTSIDE THE PRESENT MODERN DAY CEMETERY BOUNDARIES AND FENCING.
6. 100-YEAR STORM EVENT WATER SURFACE WAS ESTIMATED USING HEC-HMS AND HEC-RAS MODELING AS DISCUSSED IN ATTACHMENT 6B OF THIS PERMIT APPLICATION.

KEY MAP

STATE OF TEXAS
RYAN R. KUNTZ
104689
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

FOR PERMITTING PURPOSES ONLY

| REV. | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOODPLAIN, FLOWAGE EASEMENT, BASIN CALLOUT, LIMITS OF WASTE, NOTES 2. | RRK |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: WEST DISPOSAL AREA EXCAVATION PLAN

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188

PROJ. NO. 16216088.00
DSN. BY: BG/RRK
DWN. BY: NR
CHK. BY: BJD
APP. BY: RRK
O/A KVM BY: RRK

CADD FILE: 1.4 - EXCAVATION - WDA

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. 1.4

O:\WACO\16216088.00 TT2 - SITE 50 SITING STUDY_Permit Dwgs_LMP\1.4XXX (2020)_LMP 1\1.4 - EXCAVATION - WDA
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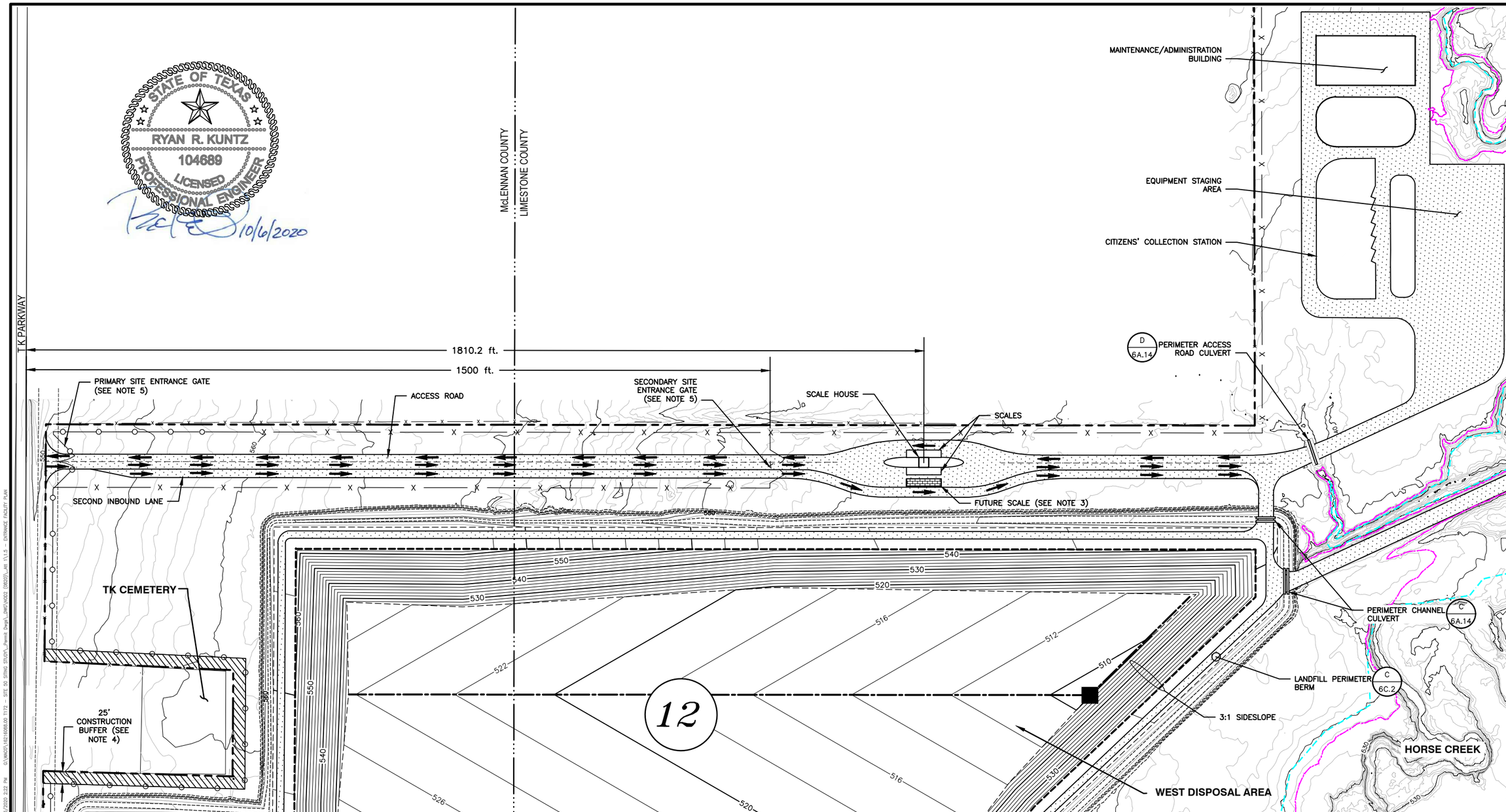



## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- COUNTY LINE
- 560 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- 100-YEAR STORM EVENT WATER SURFACE (SEE NOTE 6)
- X PROPOSED PERIMETER FENCE (CHAIN LINK)
- PROPOSED 8' PRIVACY FENCE
- ACCESS ROAD
- 520 EXCAVATION GRADE TOPOGRAPHIC CONTOURS (SEE NOTE 2)
- LEACHATE COLLECTION TRENCH
- TOE/TOP OF SLOPE
- TRAFFIC FLOW ARROW
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

0 100 200
SCALE IN FEET

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.
2. ELEVATIONS SHOWN ON THIS DRAWING WITHIN WASTE LIMITS ARE EXCAVATION GRADES (BOTTOM OF LINER) ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).
3. FUTURE INBOUND SCALE WILL BE INSTALLED AS NEEDED TO ACCOMMODATE INCREASES IN THE WASTE ACCEPTANCE RATE OVER THE SITE OPERATING LIFE.
4. IN ACCORDANCE WITH "AN INTENSIVE CULTURAL RESOURCES SURVEY OF THE CITY OF WACO'S PROPOSED SITE 50 LANDFILL PROJECT," PREPARED BY HORIZON ENVIRONMENTAL SERVICES, INC., DATED NOVEMBER 2018 (SEE APPENDIX I/IIA), A 25-FOOT CONSTRUCTION BUFFER WILL BE MAINTAINED AROUND TK CEMETERY TO PROTECT ANY POTENTIAL UNMARKED GRAVES OUTSIDE THE PRESENT MODERN DAY CEMETERY BOUNDARIES AND FENCING.
5. THE PRIMARY ENTRANCE GATE WILL BE OPENED AT 5:30 AM ON DAYS THE SITE IS IN OPERATION TO ALLOW VEHICLE QUEUING PRIOR TO OPENING THE SITE FOR WASTE ACCEPTANCE.
6. 100-YEAR STORM EVENT WATER SURFACE WAS ESTIMATED USING HEC-HMS AND HEC-RAS MODELING AS DISCUSSED IN ATTACHMENT 6B OF THIS PERMIT APPLICATION.

FOR PERMITTING PURPOSES ONLY

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOWAGE EASEMENT AND LIMITS OF WASTE. | RRK |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: ENTRANCE FACILITY PLAN

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES


SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188


PROJ. NO. 16216088.00 | DSN. BY: BG/RRK | DWN. BY: NR | CHK. BY: BJD | Q/A RVW BY: RRK | APP. BY: RRK

CADD FILE: 1.5 – ENTRANCE FACILITY PLAN

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. 1.5

REJECTED/UNAUTHORIZED WASTES

MUNICIPAL SOLID WASTE AND AUTHORIZED SPECIAL WASTES

DISPOSAL OF WASTE AT WORKING FACE

DIVERTED WHITE GOODS/LARGE ITEMS

DIVERTED BRUSH, WOOD WASTE, YARD WASTE

INTERMEDIATE COVER

BRUSH, WOOD WASTE, YARD WASTE

BRUSH, WOOD WASTE, YARD WASTE PROCESSING AREA

GRINDER

MULCH SALES

DIVERTED WHITE GOODS/LARGE ITEMS

INCOMING WASTE

SCALEHOUSE

MUNICIPAL SOLID WASTE

MSW ROLL-OFFS

REJECTED/UNAUTHORIZED WASTES

WHITE GOODS/LARGE ITEMS (REFRIGERATORS, WASHERS, STOVES, ETC.)

MATERIALS NOT SUITABLE FOR RECYCLING

WHITE GOODS/LARGE ITEMS SALVAGE AREA

RECYCLER

SMALL/LIGHT VEHICLES

CITIZENS' CONVENIENCE STATION (CCS)

ALUMINUM, GLASS, PLASTIC, CARDBOARD/NEWPSPAPER, SCRAP METAL

RECYCLABLES ROLL-OFFS

RECYCLER

REJECTED/UNAUTHORIZED WASTES

WHOLE USED/ SCRAP TIRES TRAILER

TRANSPORTED OFFSITE FOR FURTHER PROCESSING

STATE OF TEXAS
RYAN R. KUNTZ
104689
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

FOR PERMITTING PURPOSES ONLY

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| | | | |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: WASTE FLOW DIAGRAM

PROJECT TITLE: CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO
SOLID WASTE SERVICES


SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
19011 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188


| PROJ. NO. | DSN. BY: | Q/A RVW BY: | APP. BY: |
|---|---|---|---|
| 162216088.00 | NR | RRK | RRK |
| DSN. BY: BG/RRK | CHK. BY: BJD | | |

CADD FILE: 1.6 – WASTE FLOW DIAGRAM

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. 1.6

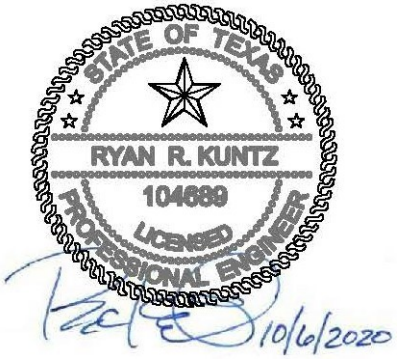

10/6/2020 4:57 PM G:\WACO\162216088.00 1172 – SITE SO SITING STUDY_Permit Dwgs_DWG\V002 (0820)\Att 1\1.6 – Waste Flow Diagram

**CITY OF WACO LANDFILL**
**TCEQ PERMIT NO. MSW-2400**
**McLENNAN AND LIMESTONE COUNTIES, TEXAS**

# PART III
# SITE DEVELOPMENT PLAN
# ATTACHMENT 2
# FILL CROSS SECTIONS

**Prepared for:**

**CITY OF WACO**




Solid Waste Services
501 Schroeder Drive
Waco, TX 76710

**Prepared by:**

**SCS ENGINEERS**
**Texas Board of Professional Engineers, Reg. No. F-3407**
Dallas/Fort Worth Office
1901 Central Drive, Suite 550
Bedford, Texas 76021
817/571-2288

Revision 0 – April 2020
Revision 1 – October 2020
SCS Project No. 16216088.00

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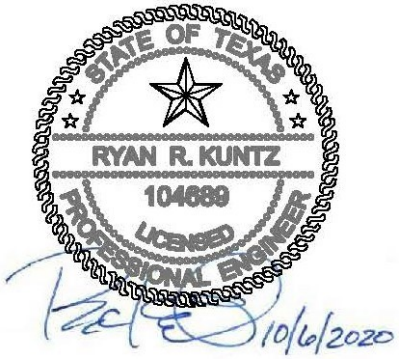
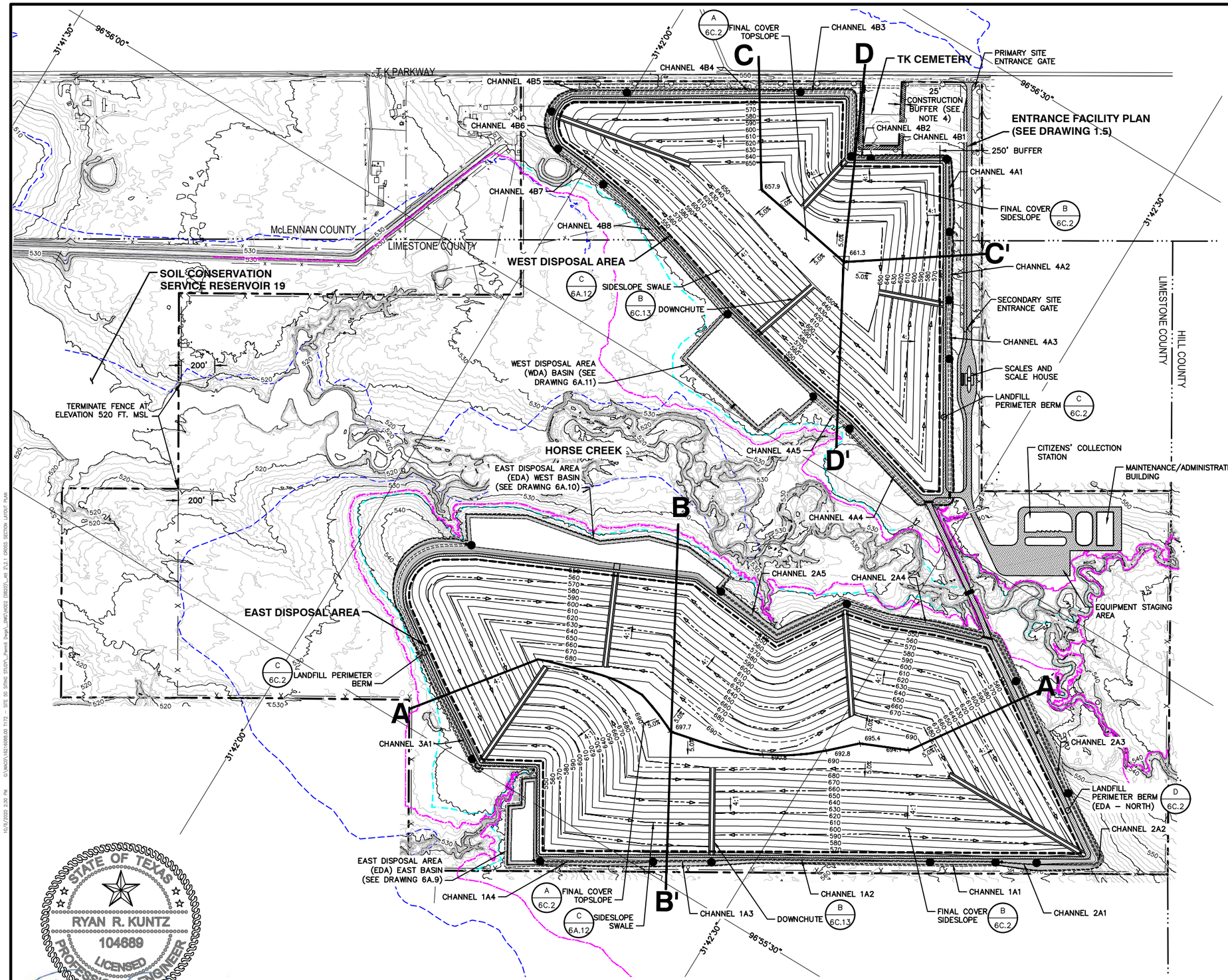
## Drawings

2.1 Cross Section Layout Plan
2.2 East Disposal Area Cross Section A-A'
2.3 East Disposal Area Cross Section B-B'
2.4 West Disposal Area Cross Sections C-C' and D-D'




**SCS Engineers**
**TBPE Reg. # F-3407**




0 300 600

SCALE IN FEET

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- COUNTY LINE
- 560 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- 100-YEAR FLOOD PLAIN (SEE NOTE 2)
- 100-YEAR STORM EVENT WATER SURFACE (SEE NOTE 5)
- 650 FINAL COVER TOPOGRAPHIC CONTOURS (SEE NOTE 3)
- PROPOSED/EXISTING PERIMETER FENCE (CHAIN LINK OR BARBED WIRE)
- PROPOSED 8' PRIVACY FENCE
- ACCESS ROAD
- DRAINAGE SWALES
- DOWNCHUTES
- CHANNEL SECTION
- A - A' CROSS-SECTION LOCATIONS
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.
2. 100-YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
3. ELEVATIONS SHOWN ON THIS DRAWING WITHIN WASTE LIMITS ARE TOP OF FINAL COVER ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).
4. IN ACCORDANCE WITH "AN INTENSIVE CULTURAL RESOURCES SURVEY OF THE CITY OF WACO'S PROPOSED SITE 50 LANDFILL PROJECT," PREPARED BY HORIZON ENVIRONMENTAL SERVICES, INC., DATED NOVEMBER 2018 (SEE APPENDIX I/IIA), A 25-FOOT CONSTRUCTION BUFFER WILL BE MAINTAINED AROUND TK CEMETERY TO PROTECT ANY POTENTIAL UNMARKED GRAVES OUTSIDE THE PRESENT MODERN DAY CEMETERY BOUNDARIES AND FENCING.
5. 100-YEAR STORM EVENT WATER SURFACE WAS ESTIMATED USING HEC-HMS AND HEC-RAS MODELING AS DISCUSSED IN ATTACHMENT 6B OF THIS PERMIT APPLICATION.

STATE OF TEXAS
RYAN R. KUNTZ
104689
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

FOR PERMITTING PURPOSES ONLY

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOODPLAIN, FLOWAGE EASEMENT, BASIN CALLOUT, LIMITS OF WASTE, AND NOTE 2. | RRK |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: **CROSS SECTION LAYOUT PLAN**

PROJECT TITLE: **CITY OF WACO LANDFILL**
**TYPE I MSW - PERMIT APPLICATION**

CLIENT: **CITY OF WACO**
**SOLID WASTE SERVICES**


**SCS ENGINEERS**
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188


| | |
|---|---|
| PROD. NO. | 162160088.00 |
| DSN. BY: | BG/RRK |
| DWN. BY: | NR |
| CHK. BY: | BJD |
| O/A RVW BY: | RRK |
| APP. BY: | RRK |

CADD FILE: 2.1 CROSS SECTION LAYOUT PLAN

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. **2.1**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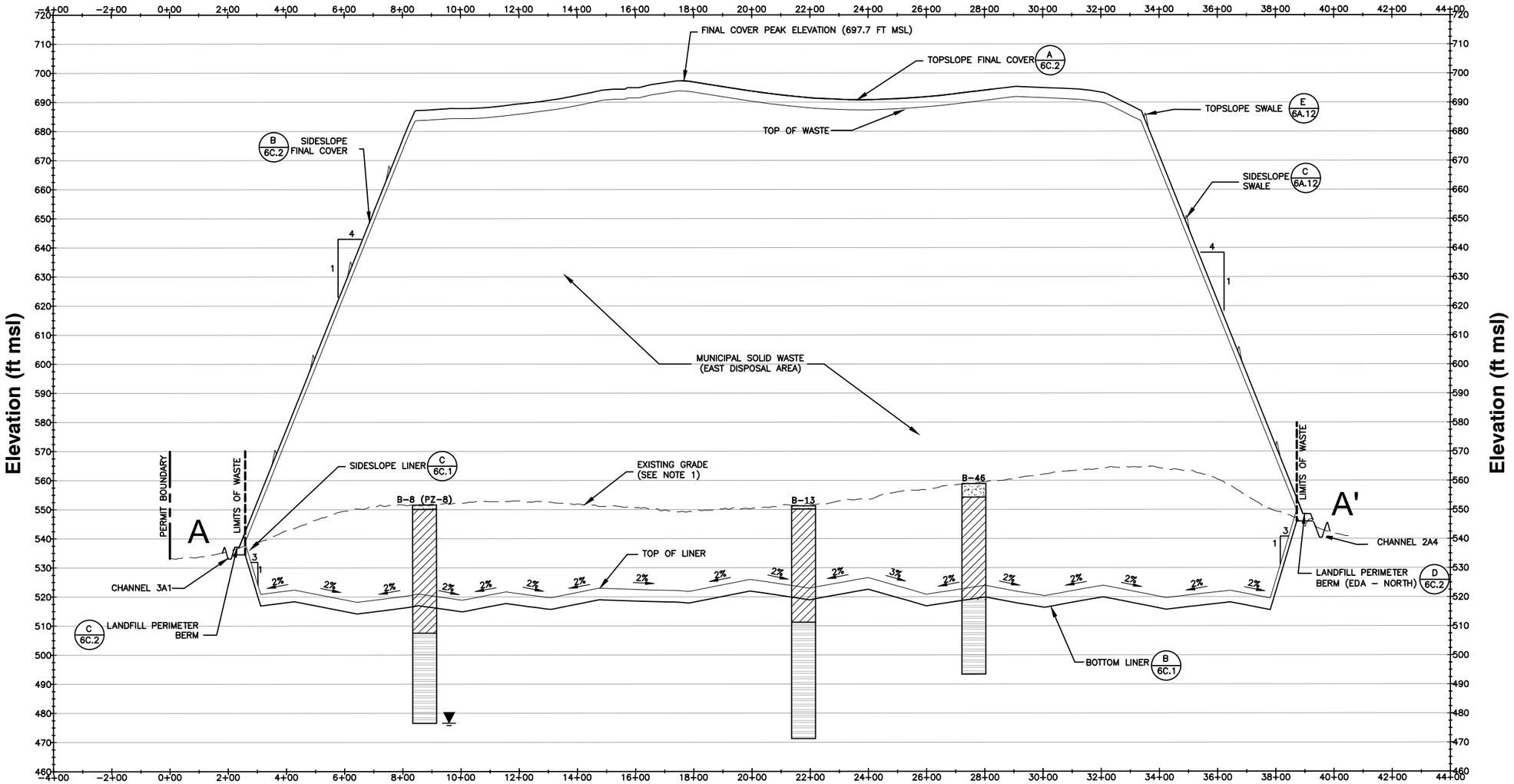
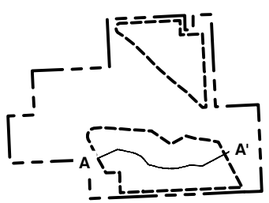



KEY MAP

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- SOIL (BROWN/BLACK CLAY)
- WEATHERED SHALE
- UNWEATHERED SHALE
- WATER LEVEL IN PIEZOMETER (05/01/2019)

0 200 400
HORIZONTAL SCALE IN FEET

0 20 40
VERTICAL SCALE IN FEET

NOTE:

1. EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL, FLOWN ON JULY 03, 2018.

STATE OF TEXAS
RYAN R. KUNTZ
104689
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

FOR PERMITTING PURPOSES ONLY

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS TO SOIL LAYER | RRK |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
EAST DISPOSAL AREA
CROSS SECTION A-A'

PROJECT TITLE
CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT
CITY OF WACO
SOLID WASTE SERVICES


SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188

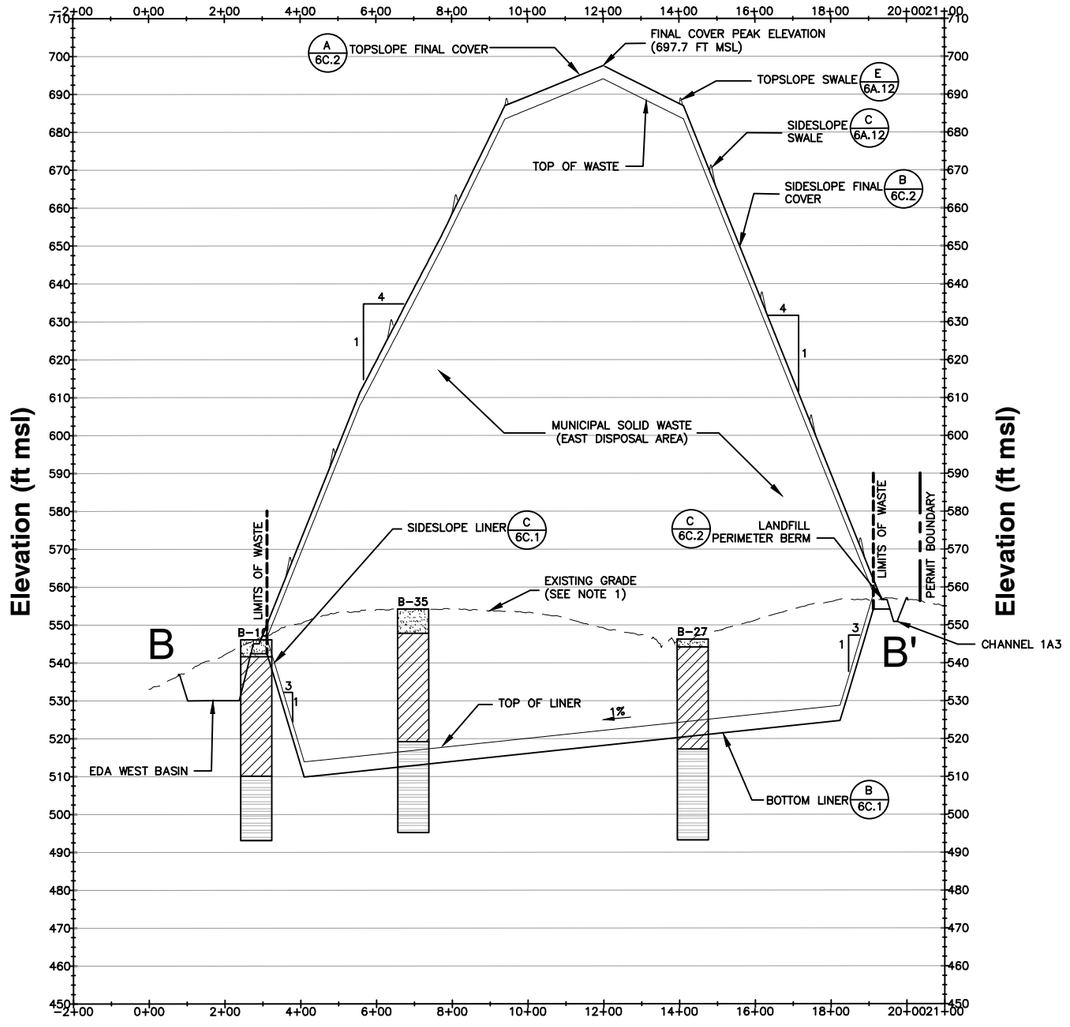

PROJ. NO. 16216088.00
DSN. BY: BG/RRK
DWN. BY: NR
CHK. BY: BJD
Q/A RVW BY: RRK
APP. BY: RRK

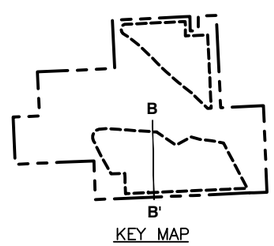
CADD FILE: 2.2 – 2.4 CROSS SECTIONS EAST AND WEST DISPOSAL AREAS

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. 2.2




KEY MAP

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- SOIL (BROWN/BLACK CLAY)
- WEATHERED SHALE
- UNWEATHERED SHALE

0 200 400
HORIZONTAL SCALE IN FEET

0 20 40
VERTICAL SCALE IN FEET

STATE OF TEXAS
RYAN R. KUNTZ
104689
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

NOTE:

1. EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL, FLOWN ON JULY 03, 2018.

FOR PERMITTING PURPOSES ONLY

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS TO SOIL LAYER | RRK |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: EAST DISPOSAL AREA CROSS SECTION B-B'

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES


SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188

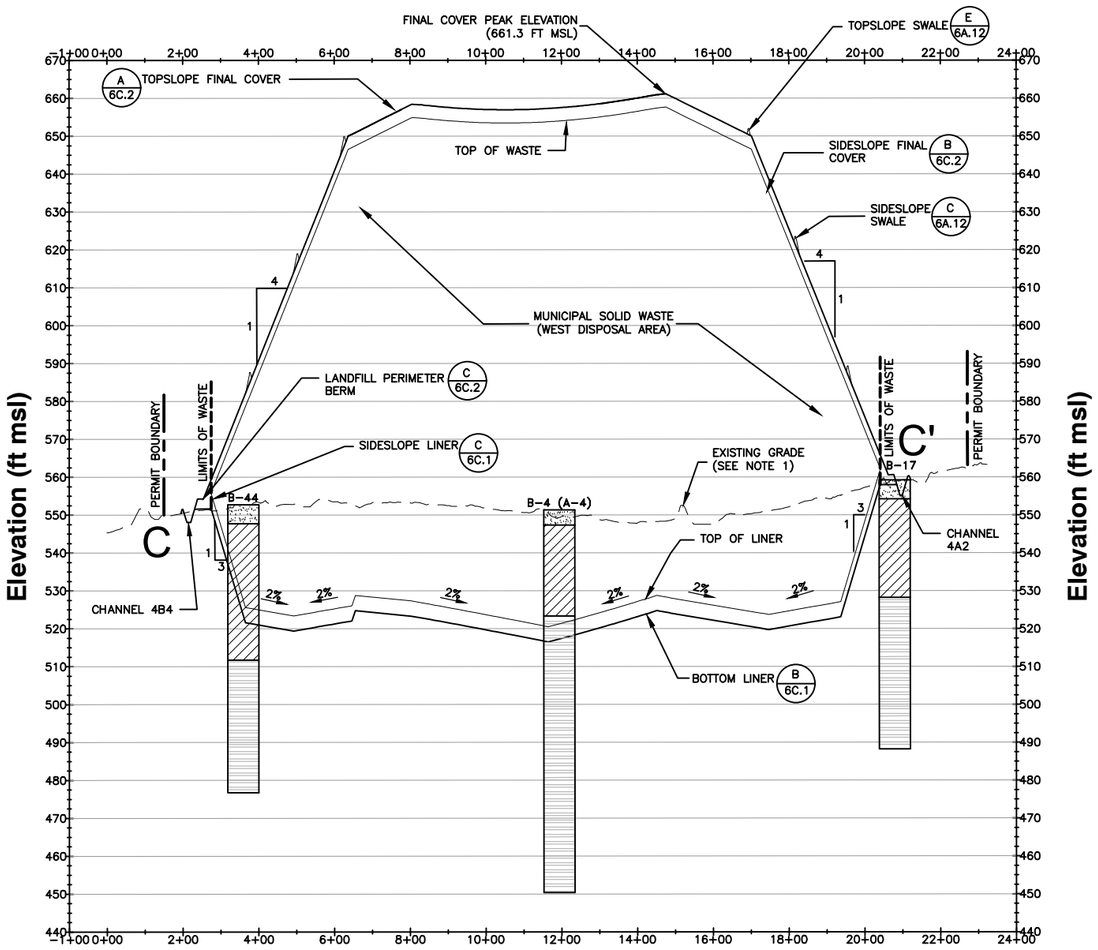

PROJ. NO. 16216088.00 | DSN. BY: BG/RRK | DWN. BY: NR | CHK. BY: BJD | Q/A RVW BY: RRK | APP. BY: RRK

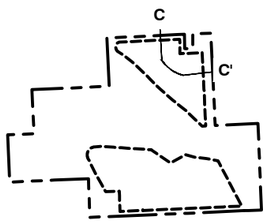
CADD FILE: 2.2 – 2.4 CROSS SECTIONS EAST AND WEST DISPOSAL AREAS

DATE: 04/2020

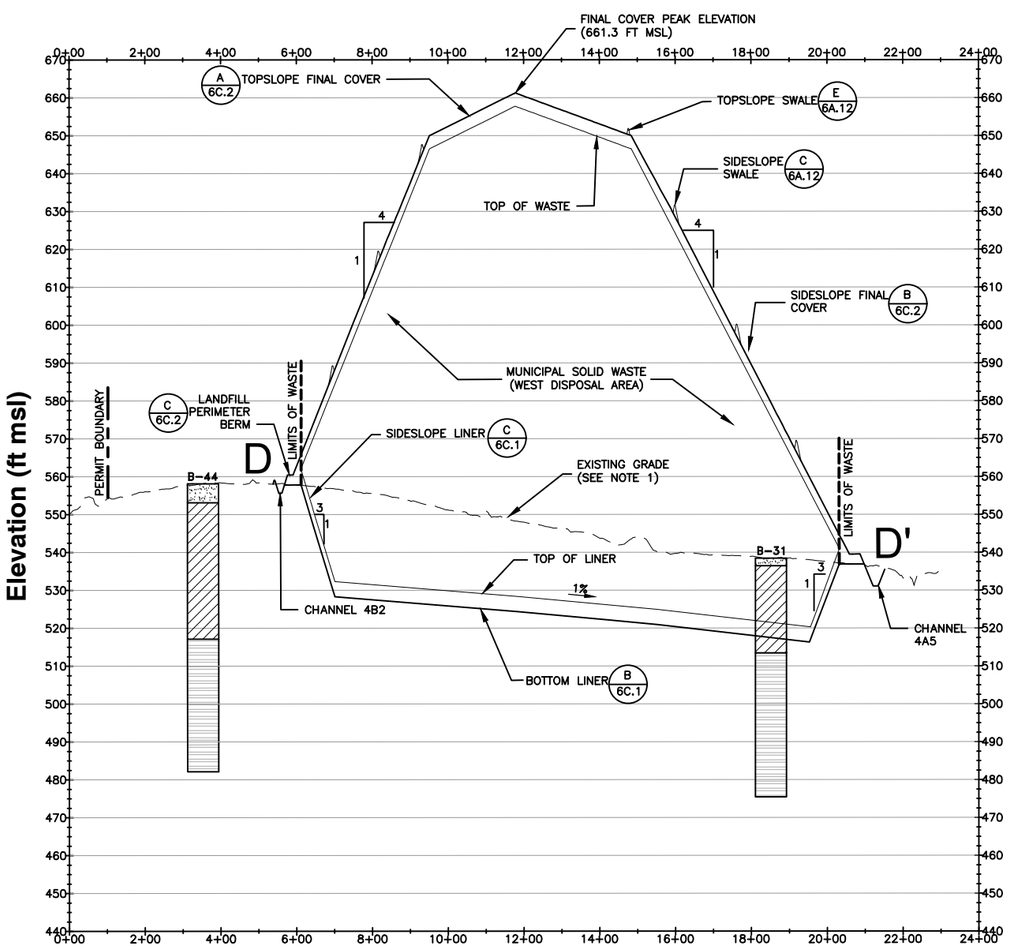
SCALE: AS SHOWN

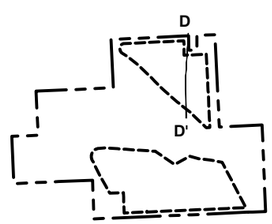
DRAWING NO. 2.3




KEY MAP




KEY MAP

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- SOIL (BROWN/BLACK CLAY)
- WEATHERED SHALE
- UNWEATHERED SHALE

0 200 400
HORIZONTAL SCALE IN FEET

0 20 40
VERTICAL SCALE IN FEET

NOTE:

1. EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL, FLOWN ON JULY 03, 2018.

STATE OF TEXAS
RYAN R. KUNTZ
104689
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

FOR PERMITTING PURPOSES ONLY

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS TO SOIL LAYER AND LIMITS OF WASTE | RRK |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: WEST DISPOSAL AREA CROSS SECTIONS C-C' AND D-D'

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES


SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188


PROJ. NO. 16216088.00 | DSN. BY: BG/RRK | DWN. BY: NR | CHK. BY: BJD | Q/A RVW BY: RRK | APP. BY: RRK

CADD FILE: 2.2 – 2.4 CROSS SECTIONS EAST AND WEST DISPOSAL AREAS

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. 2.4

# CITY OF WACO LANDFILL
# TCEQ PERMIT NO. MSW-2400
# McLENNAN AND LIMESTONE COUNTIES, TEXAS

## PART III
## SITE DEVELOPMENT PLAN
## ATTACHMENT 3
## LANDFILL COMPLETION PLAN

**Prepared for:**

**CITY OF WACO**

Solid Waste Services
501 Schroeder Drive
Waco, TX 76710

**Prepared by:**

**SCS ENGINEERS**
**Texas Board of Professional Engineers, Reg. No. F-3407**
Dallas/Fort Worth Office
1901 Central Drive, Suite 550
Bedford, Texas 76021
817/571-2288

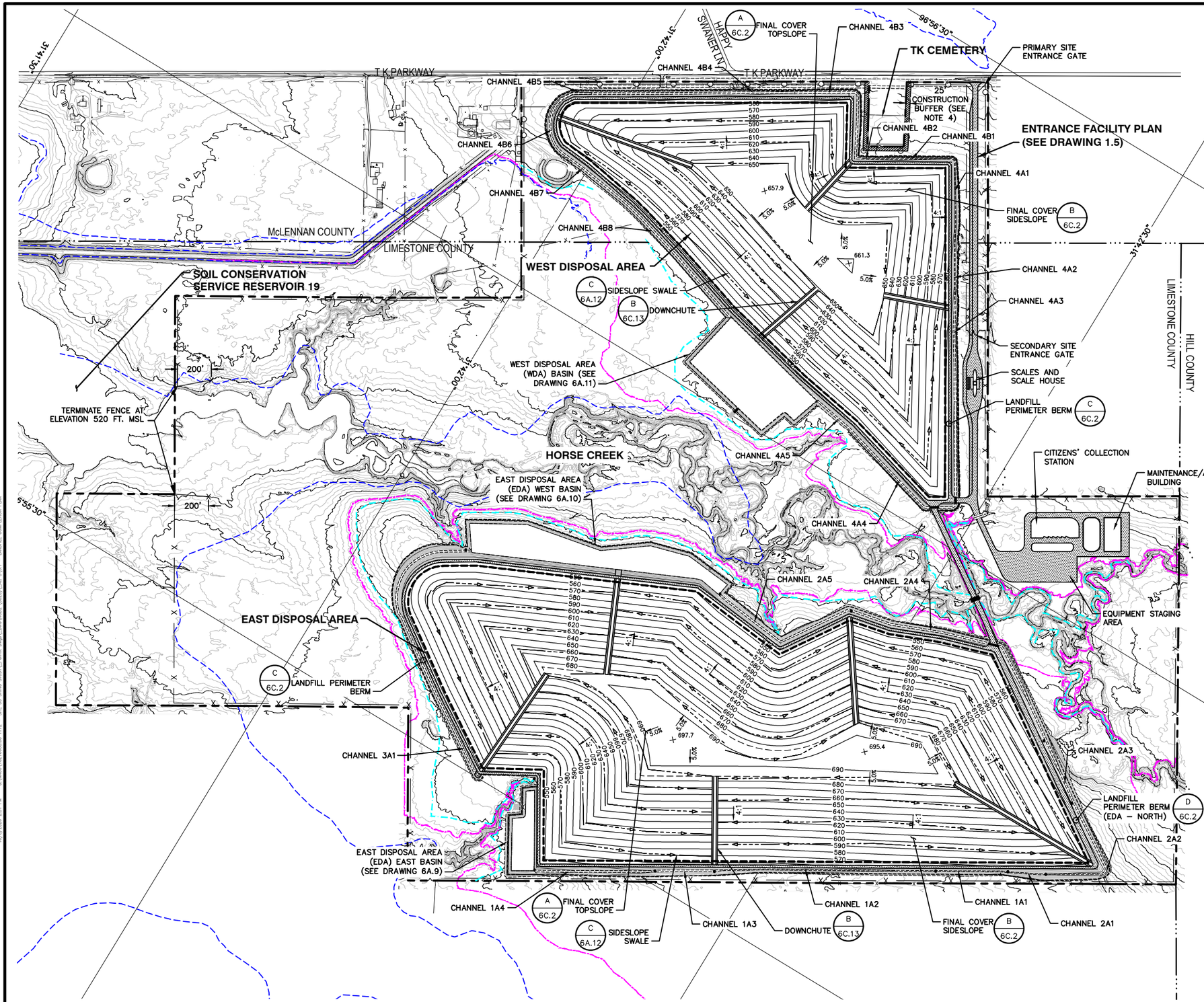
Revision 0 – April 2020
Revision 1 – October 2020
SCS Project No. 16216088.00

# TABLE OF CONTENTS

## Drawings

3.1 Landfill Completion Plan
3.2 East Disposal Area Landfill Completion Plan
3.3 West Disposal Area Landfill Completion Plan

**SCS Engineers**
**TBPE Reg. # F-3407**




0 300 600
SCALE IN FEET

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- COUNTY LINE
- 560 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- 100–YEAR FLOOD PLAIN (SEE NOTE 2)
- 100–YEAR STORM EVENT WATER SURFACE (SEE NOTE 5)
- 650 FINAL COVER TOPOGRAPHIC CONTOURS (SEE NOTE 3)
- X PROPOSED/EXISTING PERIMETER FENCE (CHAIN LINK OR BARBED WIRE)
- PROPOSED 8' PRIVACY FENCE
- ACCESS ROAD
- DRAINAGE SWALES
- DOWNCHUTES
- CHANNEL SECTION
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.
2. 100–YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
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5. 100–YEAR STORM EVENT WATER SURFACE WAS ESTIMATED USING HEC–HMS AND HEC–RAS MODELING AS DISCUSSED IN ATTACHMENT 6B OF THIS PERMIT APPLICATION.

STATE OF TEXAS
RYAN R. KUNTZ
104689
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

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TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: LANDFILL COMPLETION PLAN

PROJECT TITLE: CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO
SOLID WASTE SERVICES

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
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PROJ. NO. 16416088.00
DSN. BY: BG/RRK
DWN. BY: NR
CHK. BY: BJD
D/A RVW BY: RRK
APP. BY: RRK

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DATE: 04/2020
SCALE: AS SHOWN
DRAWING NO. 3.1

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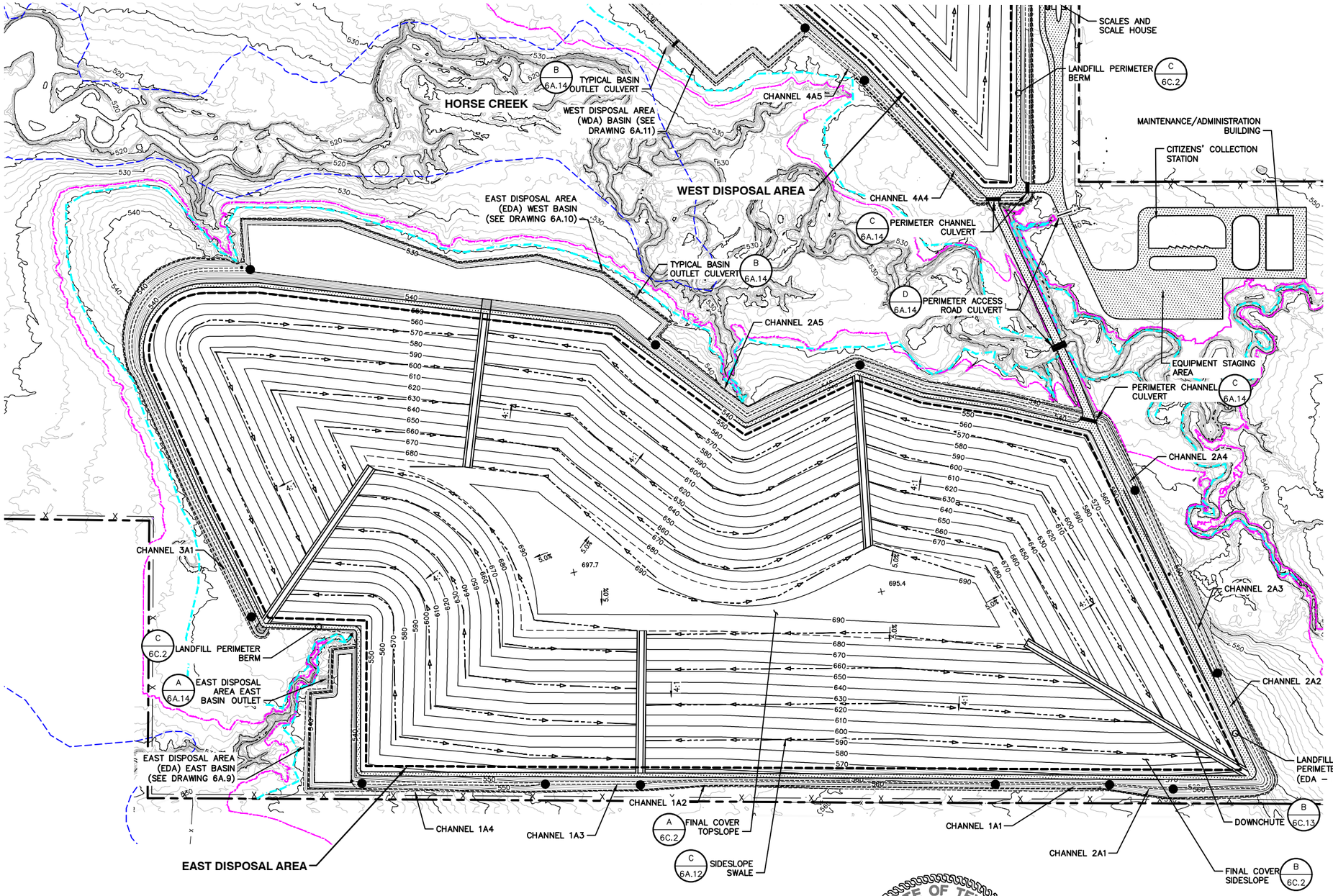


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## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- 560 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- 100-YEAR FLOOD PLAIN (SEE NOTE 2)
- 100-YEAR STORM EVENT WATER SURFACE (SEE NOTE 5)
- 650 FINAL COVER TOPOGRAPHIC CONTOURS (SEE NOTE 3)
- X PROPOSED/EXISTING PERIMETER FENCE (CHAIN LINK OR BARBED WIRE)
- ACCESS ROAD
- DRAINAGE SWALES
- DOWNCHUTES
- CHANNEL SECTION
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

NOTES:

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2. 100-YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
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STATE OF TEXAS
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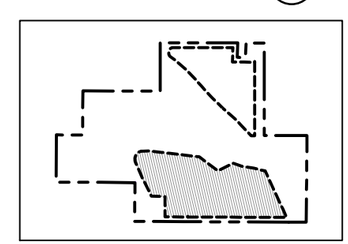
10/6/2020



KEY MAP

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| 1 | 10/2020 | REVISIONS INCLUDE: FLOODPLAIN, FLOWAGE EASEMENT, BASIN CALLOUT, LIMITS OF WASTE, AND NOTE 2. | RRK |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: EAST DISPOSAL AREA LANDFILL COMPLETION PLAN

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES


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DATE: 04/2020

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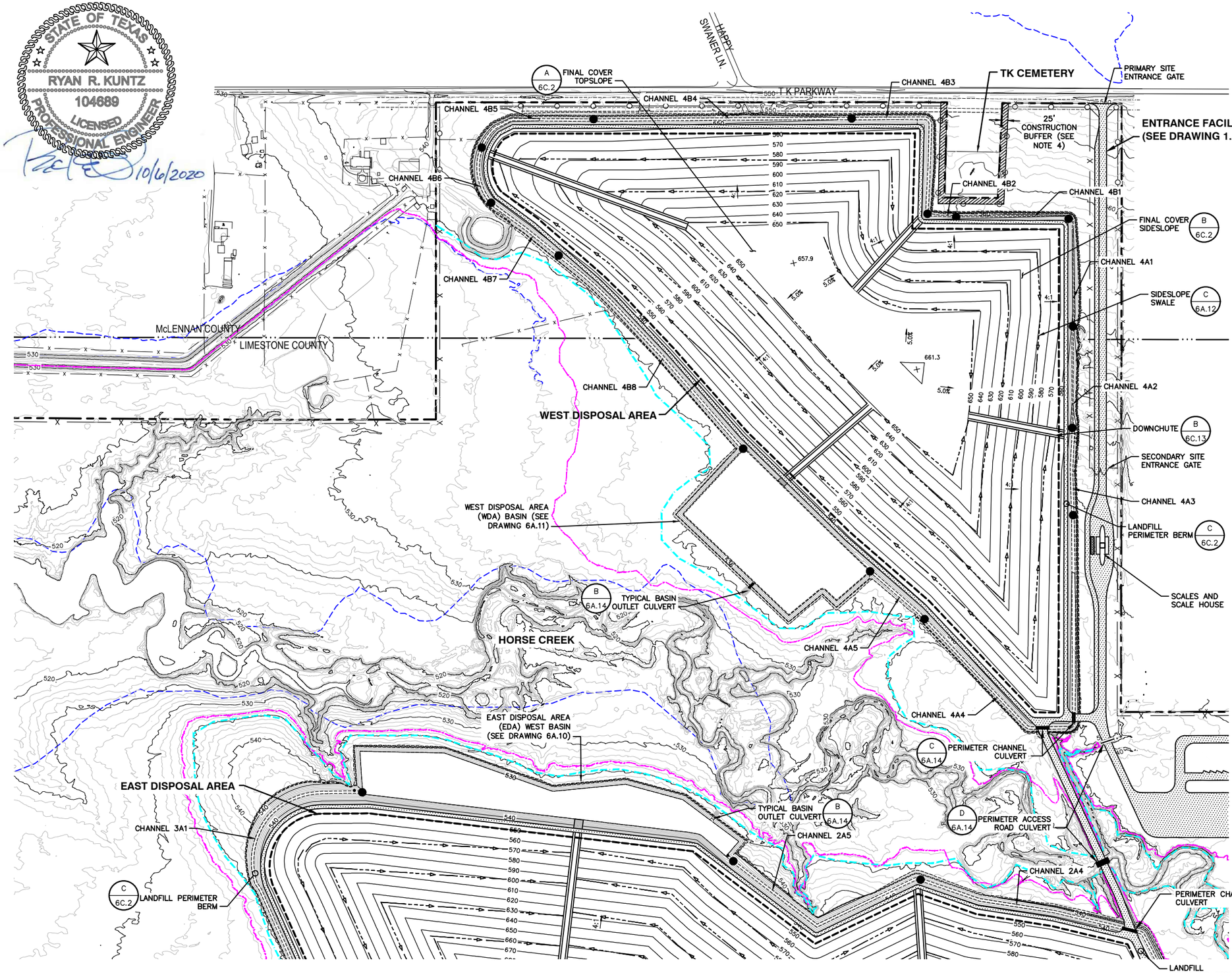
PROFESSIONAL ENGINEER
10/6/2020

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## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- COUNTY LINE
- 560 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- 100–YEAR FLOOD PLAIN (SEE NOTE 2)
- 100–YEAR STORM EVENT WATER SURFACE (SEE NOTE 6)
- 650 FINAL COVER TOPOGRAPHIC CONTOURS (SEE NOTE 3)
- X PROPOSED PERIMETER FENCE (CHAIN LINK)
- PROPOSED 8' PRIVACY FENCE
- ACCESS ROAD
- DRAINAGE SWALES
- DOWNCHUTES
- CHANNEL SECTION
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

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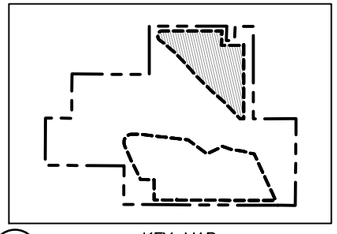

KEY MAP

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TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: WEST DISPOSAL AREA LANDFILL COMPLETION PLAN

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES


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| APP. BY: | RRK |

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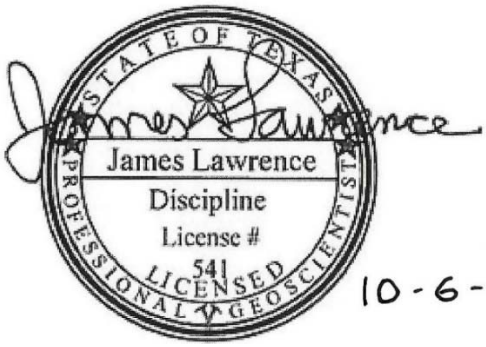
**CITY OF WACO LANDFILL**
**TCEQ PERMIT NO. MSW-2400**
**McLENNAN AND LIMESTONE COUNTIES, TEXAS**

# PART III - SITE DEVELOPMENT PLAN
# ATTACHMENT 4
# GEOLOGY AND GROUNDWATER REPORT

**Prepared for:**

**CITY OF WACO**

Solid Waste Services
501 Schroeder Drive
Waco, TX 76710




**Prepared by:**

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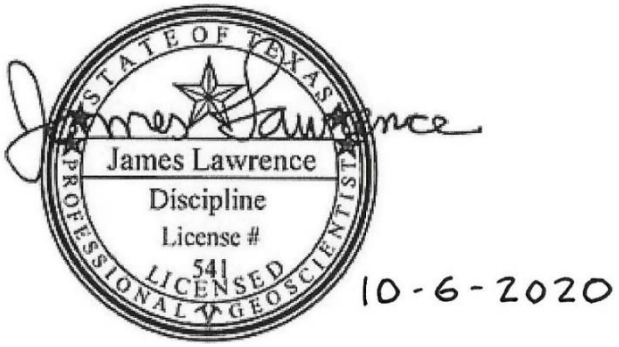

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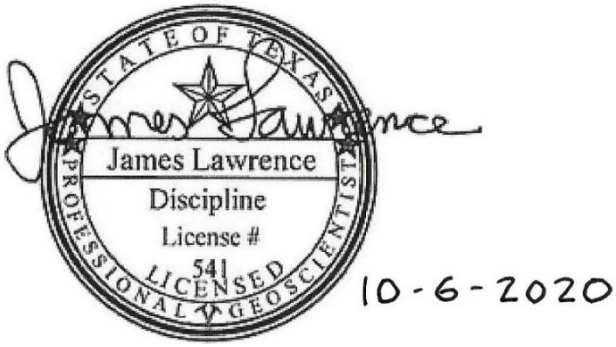


# 5 SUBSURFACE INVESTIGATION REPORT

## 5.1 PREVIOUS INVESTIGATION PROGRAMS

A soil boring plan for the Landfill was submitted September 7, 2018 and approved by the TCEQ in a letter dated October 4, 2018. Soil boring investigations of the Landfill began with drilling conducted in January 2018. A total of 5 borings (A-1 through A-5) were completed at that time, with depths ranging from 48 feet to 101 feet-bgs. A second phase of drilling occurred during October 2018 through January 2019, in which an additional 42 borings (B-6 through B-47) were advanced between 28 to 80 feet in depth (see Appendix III-4.C – Soil Boring Plan). In December 2019, additional deep borings were drilled adjacent to B-9 and B-43 to depths of 135 feet and 150 feet, respectively. Conventional standpipe piezometers were installed in the following ten borings: B-1 (PZ-1), B-3 (PZ-3), B-8 (PZ-8), B-9 (PZ-9), B-18 (PZ-18), B-20 (PZ-20), B-33 (PZ-33), B-41 (PZ-41), B-43 (PZ-43), and B-47 (PZ-47). Boring logs are included in Appendix III-4.D. State well reports are included in Appendix III-4.E.

Water level measurements obtained in the ten conventional standpipe piezometer installations described above indicated groundwater was observed in five out of ten piezometers. In order to obtain additional groundwater data, Vibrating Wire Piezometers [VWPs] were installed in 24 locations. VWPs are further described in Section 6.2. Initially, 17 shallow VWPs were installed at locations correlating to the existing conventional standpipe piezometers [10 VWPs] and seven other locations of interest corresponding to existing borings. Subsequently, in order to observe deeper Unit III conditions, an additional seven deep VWPs were installed at locations corresponding to existing conventional standpipe piezometers, for a total of 24 VWPs installed during the investigation.

The number and depth of borings were included in the determination to meet the requirements of 30 TAC §330.63(e)(4)(A) and (B) for the Landfill, as described in the boring plan that was approved by the TCEQ (Appendix III-4.C). A summary of borings with elevations and coordinates is provided in Table III-4.5. The Elevation of Deepest Excavation (EDE) is 505 ft-msl. As listed, 22 borings were advanced to an elevation 30 feet below the EDE and 2 borings [9D and 43D] were advanced to an elevation 100 feet below the EDE, whereas the total depth of the remaining 23 borings were generally drilled to an elevation 5-10 feet below the EDE. The locations of all the Landfill borings are shown on Figure-4.9.

The borings were advanced using hollow stem augers and were either completed as piezometers to provide groundwater elevation data or were plugged in accordance with 16 TAC §76.702 and §76.1004. Soil samples were collected during auger advancement utilizing Shelby tubes, two-foot split spoons (also used to collect standard penetration tests for geotechnical purposes), or five-foot NX continuous split barrels.

The boring logs from the site investigations are attached as Appendix III-4.D. Laboratory data on soil samples obtained during the investigations are found in Appendix III-4.F and summarized in Part III, Attachment 5, Geotechnical/Stability Analysis.

## 5.2 SITE STRATIGRAPHY

Site stratigraphy is consistent with the regional geologic setting described in Section 3.1. Site stratigraphy is illustrated through a series of 6 cross-sections (A-A' to F-F'), as shown on Figure-4.10 through Figure-4.15. These cross-sections utilize the borings completed by SCS Engineers.

Various parts of this application use the terms "shale" and "clay". Shale is classified by geologists as a rock-like material consisting primarily of the mineral clay. In shallower [near-surface] stratigraphy, where the lithology is a softer, more plastic material, the term "clay" is used as the descriptor. In deeper sections, the clay lithifies (hardens) due to overburden pressures and transitions to a more rock-like, fissile material termed "shale". This change from overlying clay to underlying shale is often transitional.

The geology observed in the site exploration program consisted primarily of clay and shale, with minor amounts of larger grain sizes. Three stratigraphic units have been identified at the Landfill:

- Unit I consists of surficial clayey and loamy sediments overlying silty or sandy clays with small subrounded gravel, and also exhibits organic material in the uppermost horizon due to vegetation. The Unit I thickness ranged between 0.5 and 7 feet. The transition from Unit I to the underlying Unit II is transitional, and marked by increasing hardness and increasing fissility.
- Unit II, beneath Unit I, consists of weathered silty shale with varying calcareous content. Some publications use the term "marl" to describe calcareous shale. The Unit II silty shale has thin, interbedded limestone and sand/silt partings/lenses, calcite-filled joints, and marine shell fragment fossils. The top of Unit II was encountered at elevations ranging from approximately 485 feet-msl to 559 feet-msl. The thickness of Unit II ranged between 11.8 and 49 feet. The transition from Unit II to the underlying Unit III is marked by a color change caused by the downward limit of oxidation. Above the Unit II/Unit III line, the stratigraphy is generally more variable in color but are generally lighter-colored and have evidence of oxidation such as various rust- and yellow/brown colors. Below the Unit II/Unit III line, the stratigraphy is a homogenous very dark color, trending to black. Unit III also is less fissile than Unit II.
- Unit III, beneath Unit II, consists of unweathered dark gray to black calcareous shale bedrock with thin, interbedded limestone and sand/silt lenses, and marine shell fragment fossils. The top of Unit III was encountered at elevations ranging from approximately 492.0 feet-msl to 531.85 feet-msl. Landfill borings did not encounter the bottom of Unit III.

The bottom of the landfill excavation will be founded in Unit II or Unit III, depending on the location and depth of the cell excavation. Laboratory testing has been completed on samples of all three units, in accordance with the requirements of 30 TAC §330.63(e)(5). The geotechnical evaluation of Landfill materials and slope/waste stability is included in Part III, Attachment 5, Geotechnical/Stability Analysis. This design report presents the geotechnical summary and engineering evaluations and analyses. These analyses indicate that the soils at the Landfill are suitable for the intended purpose.

## 5.3 SOIL ENGINEERING PROPERTIES

Table III-4.6 summarizes the engineering properties of Unit I, based on the results from geotechnical investigations conducted by SCS Engineers in September 2020. The test method utilized during the investigation is listed in the table.

Table III-4.7 summarizes the engineering properties of Unit II, based on the results from geotechnical investigations conducted by SCS Engineers. The test method utilized during the investigation is listed in the table. No piezometers were screened exclusively in Unit II. Hydraulic conductivity values obtained during the investigation [see Section 6.3] by slug test represent values at the screened interval at the Unit II/Unit III interface.

Table III-4.8 summarizes the properties of Unit III, based on the results from geotechnical investigations conducted by SCS Engineers. The test method utilized during the investigation is listed in the table. Hydraulic conductivity results obtained during the investigation are based on EM 1110-2-1906 lab results and slug test results performed on the piezometers screened in Unit III.

# 6 GROUNDWATER INVESTIGATION REPORT

## 6.1 STANDPIPE PIEZOMETERS

Subsurface soil borings have been drilled at the landfill for geological and hydrogeological characterization. Standpipe piezometers were installed in ten of these borings, as described in Section 5.1. A map of standpipe piezometer locations is provided in Figure-4.16. Piezometer completion information is tabulated in Table III-4.9. Stabilized water level data are tabulated in Table III-4.10. Five of ten existing standpipe piezometers did not have groundwater present. To provide additional data, vibrating wire piezometers were installed as further detailed below.

## 6.2 VIBRATING WIRE PIEZOMETERS

Vibrating wire piezometers (VWP) are pressure transducers that measure pore-water pressure. VWPs can detect pore-water pressure faster than conventional standpipe piezometers in low-permeability materials, because a newly installed standpipe piezometer may fill with water very slowly as it comes to equilibrium with groundwater. A newly installed VWP has a relatively much smaller cavity to fill with water, and therefore comes to equilibrium faster.

The VWP system consists of a pressure transducer, signal cable, and a readout device. It is installed as a dedicated instrument using a conventional drilling rig. After a borehole is drilled, the device is placed at the desired depth in filter media sand, and grouted from there to the ground surface.

After installation, pore-water enters the transducer through a filter and presses upon a diaphragm. This causes the diaphragm to deflect. This deflection is measured as a change in tension and frequency of vibration of the vibrating wire element. The square of the vibration frequency is directly proportional to the pressure applied to the diaphragm. The resulting pressure reading is a measure of water head pressure at that location. This water head pressure can be converted to a calculated groundwater elevation using device calibration information supplied for each device by the manufacturer. The Geokon 4500 VWP device was used for this investigation. The User Manual for the Geokon 4500 series and the calibration forms for each device are provided in Appendix III-4.G.

Seventeen VWP installations occurred in July 2019 through August 2019, two VWP installations occurred in October 2019, and five VWP installations occurred in December 2019; for a total of 24 VWP installations. Piezometer and VWP completion data are included in Appendix III-4.H and Appendix III-4.I, respectively. A summary of the VWP installations is provided in Table III-4.11. A map of VWP locations is provided in Figure-4.17. State well reports are the driller's responsibility. The driller stated that the VWP installations do not meet the State definition of a well, and therefore do not require reporting.

### 6.2.1 Shallow VWPs

From July 2019 through August 2019, 17 VWPs were installed at various depths to provide a spatial distribution of these VWPs to characterize the weathered/unweathered shale formation. Results showed that 5 of 17 VWPs (VWP-1, VWP-3, VWP-18, VWP-30, and VWP-44) indicated the presence of water, resulting in calculated groundwater elevations shown in Table III-4.12. Therefore, the data indicate the remaining 13 VWPs and the six adjacent dry standpipe piezometers were completed above any saturated zone.

Initial readings from VWP-20 indicated a small amount of water may have been carried down the borehole during drilling, but this dissipated to the in situ condition of no water indicated at this location.

### 6.2.2 Deep VWPs

In October 2019, to verify whether a continuous zone of saturation was located below existing dry standpipe piezometers and VWPs, two additional VWPs (VWP 41D and VWP 47D) were installed to a target elevation of 400 feet msl. Both VWPs indicated the presence of water, resulting in calculated groundwater elevations of 434 ft-msl (VWP-41D) and 425 ft-msl (VWP-47D) (see Table III-4.12). These data provide evidence of an existing continuous lower groundwater system.

To verify data from VWP-41D and VWP-47D, in December 2019, five additional deep VWPs (VWP-8D, VWP-9D, VWP-18D, VWP-33D, VWP-43D) were installed to the same target elevation of 400 feet msl. All five VWPs indicated the presence of water, resulting in calculated groundwater elevations ranging from approximately 420 feet to 519 feet (see Table III-4.12).

Due to shallow groundwater indicated by adjacent groundwater elevation readings of 519 feet at PZ-18 and 523 feet at VWP-18, casing was used during the installation of VWP-18D to eliminate infiltration from the upper groundwater system to the lower system within the borehole (Appendix III-4.I). Casing was set to an elevation of 461 feet. VWP-18D exhibits a stabilized calculated groundwater elevation of approximately 503 feet.

VWP-8D and VWP-9D both exhibited calculated groundwater elevations above the elevations of adjacent shallow VWPs (VWP-8 and VWP-9) and elevations of the bottom of screen elevation for adjacent standpipe piezometers (PZ-8 and PZ-9) at their corresponding locations. VWP-8 and VWP-9 transducers have zero water pressure, and PZ-8 and PZ-9 have both remained dry. The higher calculated groundwater elevations of VWP-8D and VWP-9D are attributed to being under elevated pore pressure not propagated to the elevations of the adjacent [higher] shallow VWPs and standpipe piezometers, due to the very low hydraulic conductivity and resulting slow travel/equilibration time. These observations indicate that shallower groundwater may occur in isolated pods.

## 6.3 GROUNDWATER INVESTIGATION RESULTS

Two groundwater zones were identified as a result of site field investigations, classified by elevation as “shallow” and “deep” zones that are not marked by significant changes in lithology. The shallow zone is considered unconfined and consists of isolated “pods” of saturation that are not always present everywhere at the site. The unconfined nature of this shallow saturation is due to the shallow occurrence and proximity to the ground surface. These zones of shallow saturation are discontinuous and do not appear to be connected to each other or to the deep zone. The deep zone is considered confined and is continuously saturated. The confined nature of this deep saturation zone is due to the depth, isolation from the atmosphere, and elevated pressure readings of some of the deep VWPs [see Section 6.2.2].

A comparison of precipitation records and water level data from newly installed piezometers in the east and west units of the Landfill is presented as Appendix III-4.J. Tabulated historic water level data, collected from piezometers from October 2018 to July 2020, are provided in Appendix III-4.K. Tabulated historic water level data, collected from VWPs from July 2019 to July 2020,

are provided in Appendix III-4.L. Using piezometer and shallow VWP data, a potentiometric map of the upper groundwater flow system present on the Landfill was prepared and is included as Figure-4.18. Using the deep VWP data, a potentiometric map of the lower groundwater flow system present on the Landfill was prepared and is included as Figure-4.19. The slug test results from the Landfill piezometers are provided in Appendix III-4.M.

Upper groundwater flow direction was determined using piezometer/shallow VWP data and lower groundwater flow direction was determined using deep VWP data. The Landfill groundwater flows towards the south-southeast (Figure-4.18 and Figure-4.19), consistent with local and regional topography.

### 6.3.1 Slug Testing

Slug testing was implemented in piezometers to determine hydraulic properties (Appendix III-4.M). The shale of lower Unit II and uppermost Unit III contains isolated pockets of groundwater. In limited locations, this is the uppermost water bearing unit below the landfill. The slug testing was conducted in piezometers with groundwater from the shallow zone, which is considered unconfined [see Section 6.3]. Seven of the ten piezometers installed were screened in the lower Unit II/upper Unit III zone. Slug tests were performed on PZ-1, PZ-3, PZ-18, and PZ-20 in the east and west areas to determine hydraulic conductivity. Results are summarized in Table III-4.13; Appendix III-4.M provides slug test data. A summary of hydraulic conductivity calculations is presented in Table III-4.13.

Slug tests performed at PZ-1 and PZ-18 used both the falling and rising head methods. The falling head method is implemented by introducing a "slug" into the water column, causing a temporary rise in head. The rising head method requires removing the "slug" from the water column, causing a temporary fall in head. The drop or rise in water level was then monitored with respect to time to determine hydraulic conductivity, using a logging pressure transducer. The results were analyzed using the Bouwer and Rice method.

An alternative falling head method was employed at PZ-3 and PZ-20 because the well screens were not fully submerged. Ten gallons of potable water were introduced into each well, such that the well screen was fully submerged. As the water level fell, a logging transducer recorded the falling head. The results were calculated using the Bouwer and Rice method.

### 6.3.2 Horizontal Flow Calculation

Horizontal travel velocities were estimated for the Unit II/III interface using the following formula:

$V_a = (K*I)/(7.5*N)$ (Driscoll, 1986)

where:
$V_a$ = actual travel velocity
K = hydraulic conductivity of the aquifer (geometric mean)
I = hydraulic gradient
N = effective porosity (5%) (Driscoll, 1986)

The hydraulic gradient was measured as the difference in water elevations between VWP-18D (503.6 feet-msl) and VWP-33D (419.7 feet-msl) divided by the distance between the two VWPs in feet (3,120 feet). Measurements were taken from the July 2020 deep VWP potentiometric map (see Figure-4.19).

Horizontal travel times of the uppermost groundwater (Unit II/Unit III interface) were determined to represent (1) the overall Landfill area, (2) the overall Landfill area regarding Unit II, (3) the eastern area of the Landfill, and (4) the western area of the Landfill. An upper and lower bound predicted horizontal flow rate was also determined using the highest and lowest hydraulic conductivities recorded from SCS performed slug tests. Values used for horizontal flow calculations and horizontal flow rates are as shown in Table III-4.14.

The highest hydraulic conductivity value was recorded at PZ-3. The predicted upper horizontal flow rate from this location was 0.039 feet per year.

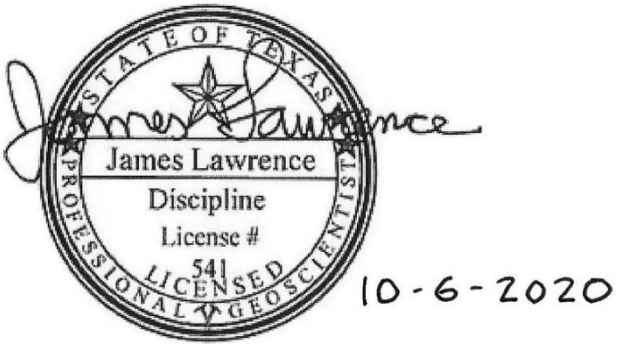
The lowest hydraulic conductivity value was recorded at PZ-18. The predicted lower horizontal flow rate from this location was 0.008 feet per year.

The horizontal travel time of the uppermost groundwater (Unit II/Unit III interface) across the entire Landfill area (PZ-1, PZ-3, PZ-18, PZ-20) was determined to be approximately 0.013 feet per year.

The horizontal travel time of the uppermost water across the Landfill area for Unit II (PZ-1, PZ-3, and PZ-20) was determined to be approximately 0.016 feet per year.

The horizontal travel time of the uppermost groundwater (lower Unit II/upper Unit III interface) in the eastern area of the Landfill (PZ-18, PZ-20) was approximately 0.01 feet per year.

The horizontal travel time of the uppermost groundwater (Unit II/Unit III interface) in the western area of the Landfill (PZ-1, PZ-3) was approximately 0.016 feet per year.



# 7 POLLUTANT PATHWAYS

Regionally, the groundwater generally flows in a southeast direction towards the Gulf of Mexico. Locally, the groundwater flows in a similar south to southeast direction. Excavation in the area of the Landfill will likely alter the groundwater flow path by creating a depression in the water table, and a resulting inward gradient. This may cause shallow groundwater in the eastern unit of the Landfill to flow west, and the western unit to flow east.

The sidewalls of the Landfill will be excavated partly in the weathered shale (Unit II), and partly in the underlying unweathered shale (Unit III). The base is generally in the unweathered shale. A potential release to the weathered shale zone would be expected to generally follow flow paths shown in Figure-4.18, moving downgradient to the south-southeast. Any potential leachate release in the unweathered shale is expected to also generally follow flow paths shown in Figure-4.19, moving down-gradient to the south-southeast. Potential leachate releases to the weathered zone or shallow unweathered zone (beneath the base of the Landfill) would be expected to move laterally and down-gradient. Potential releases are not expected to migrate downward into the lower-permeability zones of the unweathered shale because this is a lower-permeability, higher-resistance flow path. The predicted lateral flow of groundwater along bedding planes is due to horizontal hydraulic conductivity being generally greater than vertical hydraulic conductivity in flat lying sedimentary rocks, as hydraulic conductivity decreases with increasing depth (Heath, 1983; Harlow and Lecain, 1993). The Landfill groundwater monitoring system is designed to monitor the uppermost formation capable of yielding significant quantities of ground water (sufficient groundwater present in a well that can be sampled) encountered below the Landfill. Section 9.0 addresses the design of the proposed groundwater monitoring system.

The Facility will promptly notify, in writing, the Texas Commission on Environmental Quality (TCEQ), and any local pollution agency with jurisdiction that has requested to be notified, of future changes in facility construction or operation or changes in adjacent properties that affect, or are likely to affect, the direction and rate of groundwater flow and the potential for detecting groundwater contamination from a solid waste management unit.

## 7.1 LOCAL HYDROGEOLOGY

The Trinity Aquifer [see Section 4.1], which underlies the Landfill property, all of McLennan County, and the northwest corner of Limestone County, produces the majority of the total groundwater used in the area surrounding the Landfill (STGCD, 2015). In the Landfill area, Gulfian and Upper Comanche Series deposits (Table III-4.3) represent the upper most stratigraphy and are not considered hydrogeologic/aquifer type units due to their low permeability. The shallow stratigraphy in the Landfill vicinity does contain water, but is not considered a regional or local aquifer due to the inability to deliver enough usable water to a water supply well. The shallow clay/shale stratigraphy primarily transmit fluids via higher weathered zones with increased fissility/joints. The shallowest groundwater at the Landfill is at the base of Unit II. In the Landfill area, the deeper unweathered shale-marl stratigraphy of Unit III will act as an aquitard that inhibits vertical movement of groundwater due to decreased fissility and increased hardness, and resulting lower permeability.

# 9 GROUNDWATER MONITORING PLAN

## 9.1 EXISTING GROUNDWATER MONITORING SYSTEM

No groundwater monitoring wells currently exist at the Landfill.

## 9.2 PROPOSED GROUNDWATER MONITORING SYSTEM

The locations and depths of the monitoring wells are designed to determine the quality of groundwater passing the point of compliance and to detect groundwater impact from the waste units, and prior to any contaminants entering deeper portions of the stratigraphy interpreted as the Wolfe City Formation (30 TAC §330.403(a)(2)). The potential pathways for contaminant movement from the waste units are expected to be lateral [horizontal] via shale fractures that develop primarily horizontally as the overlying sediments unload over geologic time due to erosion.

Site drilling indicates that groundwater was generally not initially observed upon completion of a boring. Due to the sporadic distribution of site groundwater, two monitoring wells will be installed at each location, one with a specified shallow depth ("A" series) and the other with a specified deep depth ("B" series). Each well will be installed with a 40-foot monitoring well screen due to the sporadic distribution of groundwater. A map of the proposed groundwater monitoring system is provided in Figure-4.20.

Based on the groundwater conditions shown on Figure-4.18 and Figure 4.19, the proposed monitoring system will consist of twelve upgradient wells and fifty-six downgradient wells (Figure-4.20).

Initial proposed monitoring well installations will begin at the eastern disposal area of the Landfill, where waste will first be disposed. The eastern side monitoring well names begin with the designation 'P1'; western side well names begin with 'P2'. The letter 'A' denotes a shallow well and the letter 'B' denotes a deep well. Ten proposed monitoring wells will be installed prior to landfill operation (P1-MW 1 A/B, P1-MW 17 A/B, P1-MW 18 A/B, P1-MW 19 A/B, P1-MW 20 A/B). The remaining proposed monitoring wells will be installed when waste is within 1,000 feet of the proposed monitoring well location. Installation details for proposed monitoring wells are described below and in Table III-4.15. The new monitoring wells will be sampled for background data for eight quarters in accordance with the Groundwater Sampling and Analysis Plan (GWSAP, see Attachment 7). Semiannual detection monitoring will then be implemented in accordance with GWSAP.

Monitoring wells will be constructed in accordance with the Proposed Monitoring Well Construction Details indicated in Figure-4.21, which is in conformance with requirements outlined within 30 TAC §330.421(a)(2). In accordance with 30 TAC §330.421(a)(2)(B), no glue, solvents, field-cut slots, or field cloths will be used during the construction of the monitoring well screen. A qualified Texas-licensed driller will drill and install monitoring wells using equipment and methods that are appropriate for the Landfill conditions. A licensed professional geoscientist or engineer who is familiar with the geology of the area will supervise drilling, develop a detailed lithologic description of the boring, monitor well installation, and oversee well development (30 TAC §330.421(a)(1)(A)). The boring will be at least 4-inches larger than the outer diameter of the well casing and screen. If water is used in drilling, it will be from a potable source, and a current

chemical analysis will be provided with the monitoring well installation report. A licensed professional geoscientist or engineer who is familiar with the geology of the area will supervise or make a boring log for each monitoring well and shall seal, sign, and date the boring log.

In accordance with TAC §330.421(b), where monitoring wells are installed in unusual conditions, all aspects of the installation shall be approved in writing in advance by the executive director.

After a monitoring well is installed, it will be developed until excessive turbidity due to drilling/installation has been removed and field measurements of pH, specific conductance, and temperature have stabilized in accordance with 30 TAC §330.421(c). Development may be accomplished through the use of pumping and/or bailing.

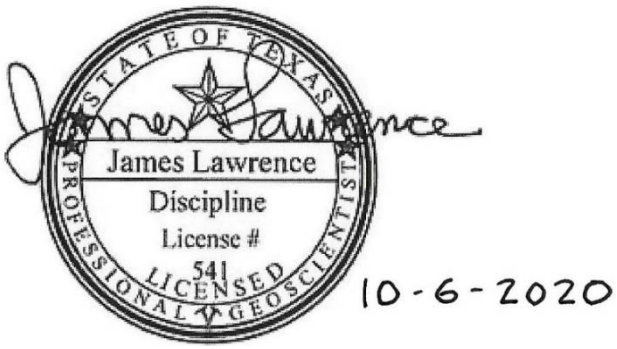
Upon completion of well installation activities, a registered professional surveyor will survey the locations with vertical measurements to the nearest 0.01-foot and referenced to mean sea level (with year of the sea-level datum shown). Survey points for each well will include the top of PVC casing (with referenced point marked), top of protective cap, and ground surface adjacent to the well pad. Horizontal locations will be determined to the nearest tenth of a second for latitude and longitude or accurately located relative to the Landfill grid system (30 TAC §330.421(d)).

Within 60 days of well completion, well installation and construction information will be submitted to the TCEQ on current forms. The report will include a detailed geologic log, any test results, a description of development procedures, and a site map (to scale) showing the location of all monitoring wells and the point of compliance (30 TAC §330.421(e)). Any monitoring well that is damaged to the extent that it is no longer suitable for sampling will be reported to the TCEQ with a recommendation to repair or replace the well (30 TAC §330.421(f)). Any monitoring well that is no longer used shall be properly abandoned and plugged in accordance with 16 TAC §76.702 and 76.1004 with prior authorization in writing from the TCEQ.

The wells will be operated and maintained so that they will yield representative groundwater samples for the appropriate hydrogeologic unit throughout the life of the groundwater monitoring program (30 TAC §330.421(a) and (e) and §330.403(d)). Groundwater monitoring will be conducted throughout the active life and the closure and post-closure care period of the Landfill.

## 9.3 GROUNDWATER MONITORING SYSTEM CERTIFICATION

I, James Lawrence, Texas P.G. #541, have reviewed the groundwater monitoring well system installation plan for the Landfill. In my professional opinion, the proposed groundwater monitoring system has been designed in accordance with 30 TAC §330.63(f) and §330.401(e).

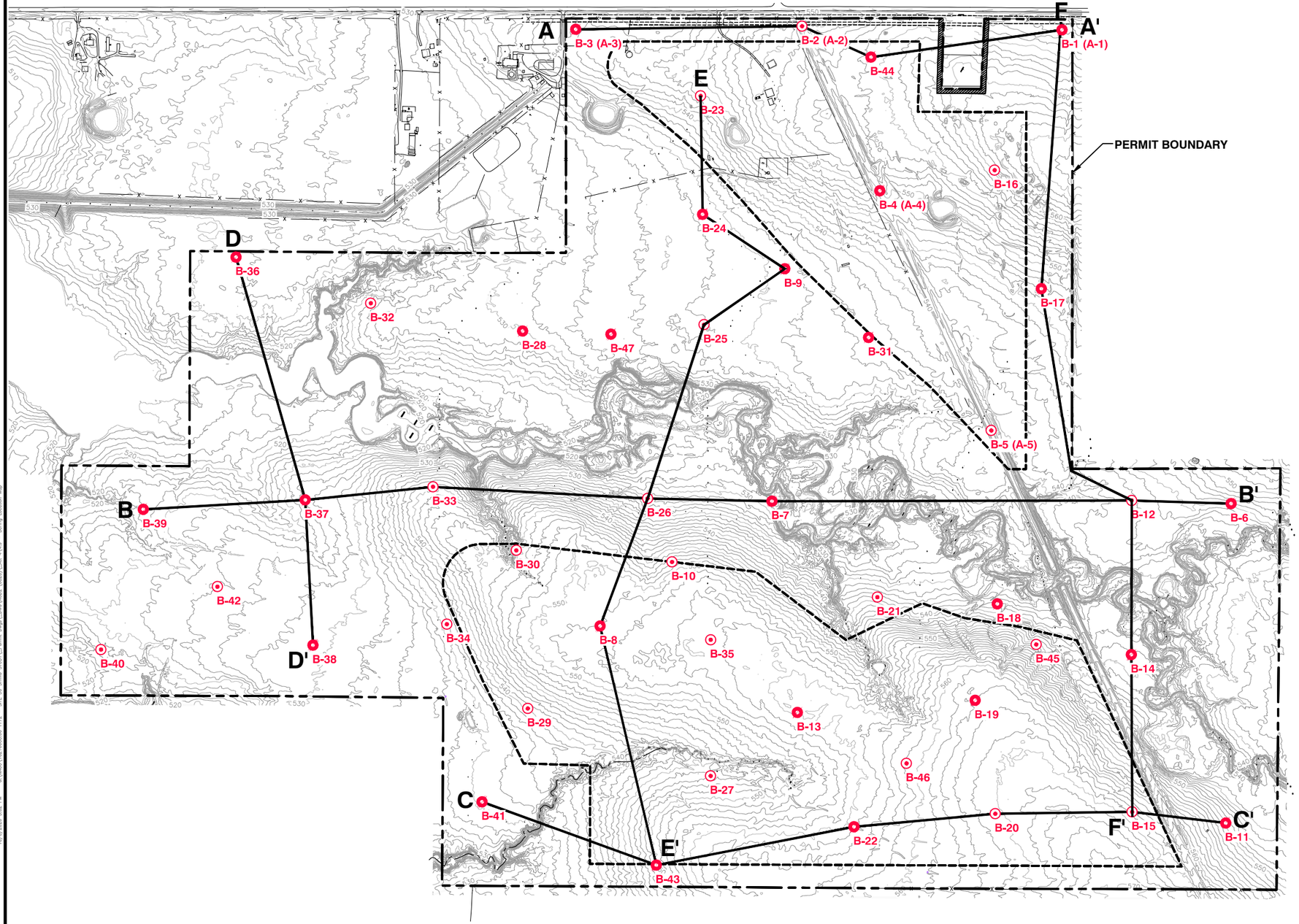



Signature of Qualified Groundwater Scientist

Seal

# FIGURES


- Figure - 4.1 Site Location Map
- Figure - 4.2 Physiographic Map of Texas
- Figure - 4.3 General Topographic Map
- Figure - 4.4 Geologic Map
- Figure - 4.5 Structural Cross Sections of Regional Geology and the Trinity Aquifer
- Figure - 4.6 Seismic Impact Zone Map
- Figure - 4.7 Tectonic Map of Texas
- Figure - 4.8 Trinity Aquifer
- Figure - 4.9 Boring Location Map
- Figure - 4.10 Geologic Cross Section A-A'
- Figure - 4.11 Geologic Cross Section B-B'
- Figure - 4.12 Geologic Cross Section C-C'
- Figure - 4.13 Geologic Cross Section D-D'
- Figure - 4.14 Geologic Cross Section E-E'
- Figure - 4.15 Geologic Cross Section F-F'
- Figure - 4.16 Piezometer Location Map
- Figure - 4.17 VWP Location Map
- Figure - 4.18 Piezometer/Shallow VWP Potentiometric Map
- Figure - 4.19 Deep VWP Potentiometric Map
- Figure - 4.20 Proposed GWM System Map
- Figure - 4.21 Typical Monitoring Well Detail




0 300 600

SCALE IN FEET

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- 535 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- B-9 EXISTING BORING LOCATION – I (SEE NOTE 2)
- B-14 EXISTING BORING LOCATION – II (SEE NOTE 2)
- A—A' CROSS–SECTION LOCATIONS

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.
2. EXISTING BORING LOCATIONS – I INDICATE SOIL BORINGS WHICH WERE DRILLED TO A DEPTH OF 5–FEET BELOW EDE (I.E., 500 FT MSL) AND EXISTING BORING LOCATIONS – II INDICATE SOIL BORINGS WHICH WERE DRILLED TO A DEPTH OF 30 FEET BELOW EDE (I.E., 475 FT MSL).

STATE OF TEXAS
James Lawrence
Discipline
License #
5411
LICENSED
PROFESSIONAL GEOSCIENTIST
10/6/2020

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| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | UPDATE LIMITS OF WASTE, ADD NOTE 3 AND ADD ADDITIONAL INFORMATION TO CROSS SECTION E–E' AND F–F' | JL |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: BORING LOCATION MAP

PROJECT TITLE: CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO
SOLID WASTE SERVICES

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
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DSN. BY: AB/JL
DRN. BY: JL1/NR
CHK. BY: BJD/AB
QA/QC BY: RRK
APP. BY: JL

CADD FILE: 4.9 – BORING LOCATION MAP

DATE: 05/2020

SCALE: AS SHOWN

FIGURE: 4.9

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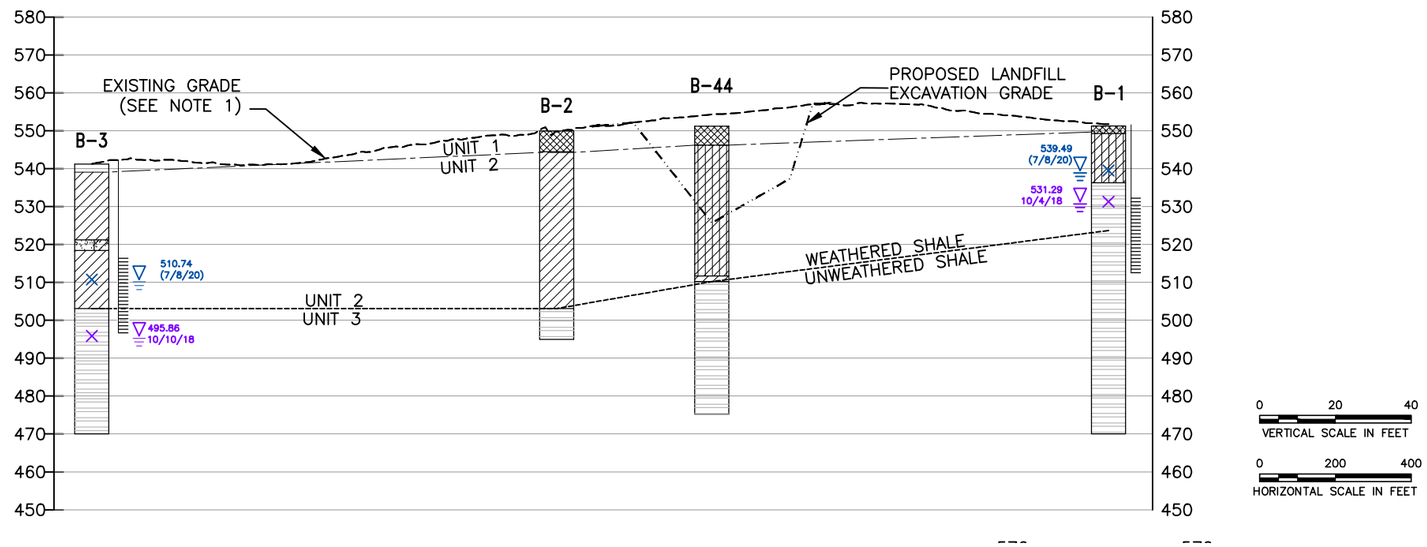
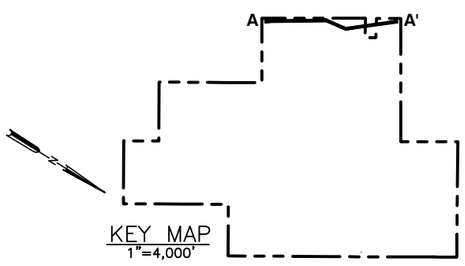



## CROSS SECTION A-A'




KEY MAP
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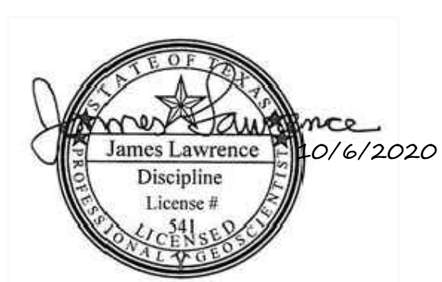


## LEGEND:

| | |
|---|---|
| - - - - - - - | EXISTING GRADE (SEE NOTE 1) |
| —·—·— | UNIT 1/UNIT 2 CONTACT |
| ---------- | WEATHERED/UNWEATHERED SHALE TRANSITIONAL CONTACT |
| -·-·-·- | PROPOSED LANDFILL EXCAVATION GRADE |
| 510.74 (7/8/20) ▽ | STATIC WATER LEVEL IN PIEZOMETER (DATE OF WATER LEVEL READING) |
| 539.49 (7/8/20) ▽ | INITIAL WATER LEVEL IN PIEZOMETER (DATE OF WATER LEVEL READING) |

NOTES:

1. EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL, FLOWN ON JULY 03, 2018.
2. SEE APPENDIX III-4.D FOR SUBSURFACE MATERIAL LEGEND.

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| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: WATER LEVEL READINGS AND EXTEND DEPTHS OF B-3 AND B-1; ADD UNIT 1/UNIT 2 CONTACT | JL |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
CROSS SECTION A-A'

PROJECT TITLE
CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT
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SOLID WASTE SERVICES


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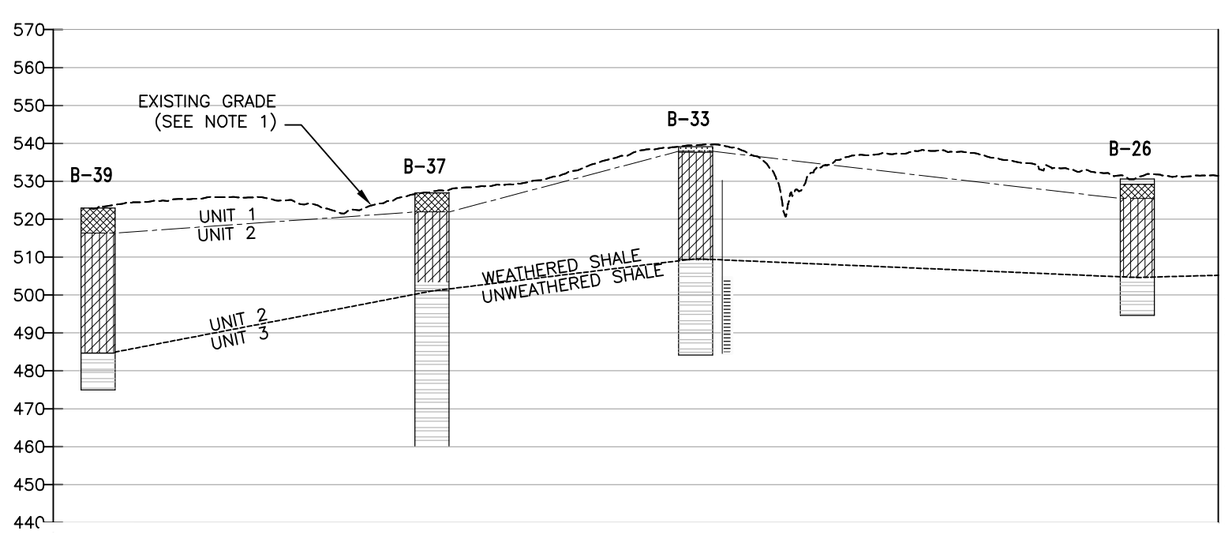
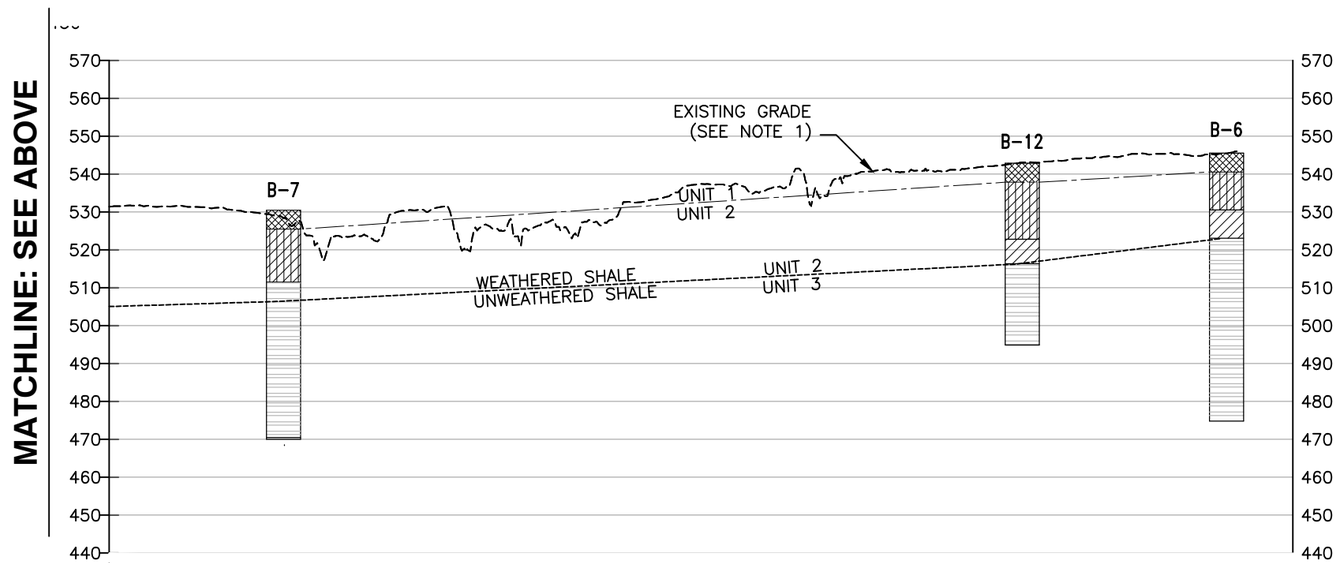
DATE: 05/2020

SCALE: AS SHOWN

FIGURE: 4.10



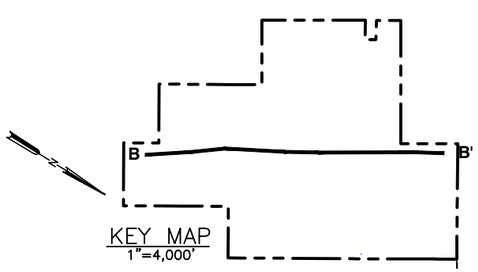

## CROSS SECTION B-B'

0 20 40
VERTICAL SCALE IN FEET

0 200 400
HORIZONTAL SCALE IN FEET

## LEGEND:

- - - - - - - EXISTING GRADE (SEE NOTE 1)
—·—·— UNIT 1/UNIT 2 CONTACT
- - - - - - - WEATHERED/UNWEATHERED SHALE TRANSITIONAL CONTACT




KEY MAP
1"=4,000'

STATE OF TEXAS
James Lawrence
Discipline
License #
541
LICENSED
PROFESSIONAL GEOSCIENTIST

10/6/2020

NOTES:

1. EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL, FLOWN ON JULY 03, 2018.
2. SEE APPENDIX III-4.D FOR SUBSURFACE MATERIAL LEGEND.

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| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: CORRECT SHALE CONTACT IN B-39; ADD UNIT1/UNIT 2 CONTACT | JL |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
CROSS SECTION B-B'

PROJECT TITLE
CITY OF WACO LANDFILL
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CLIENT
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SOLID WASTE SERVICES


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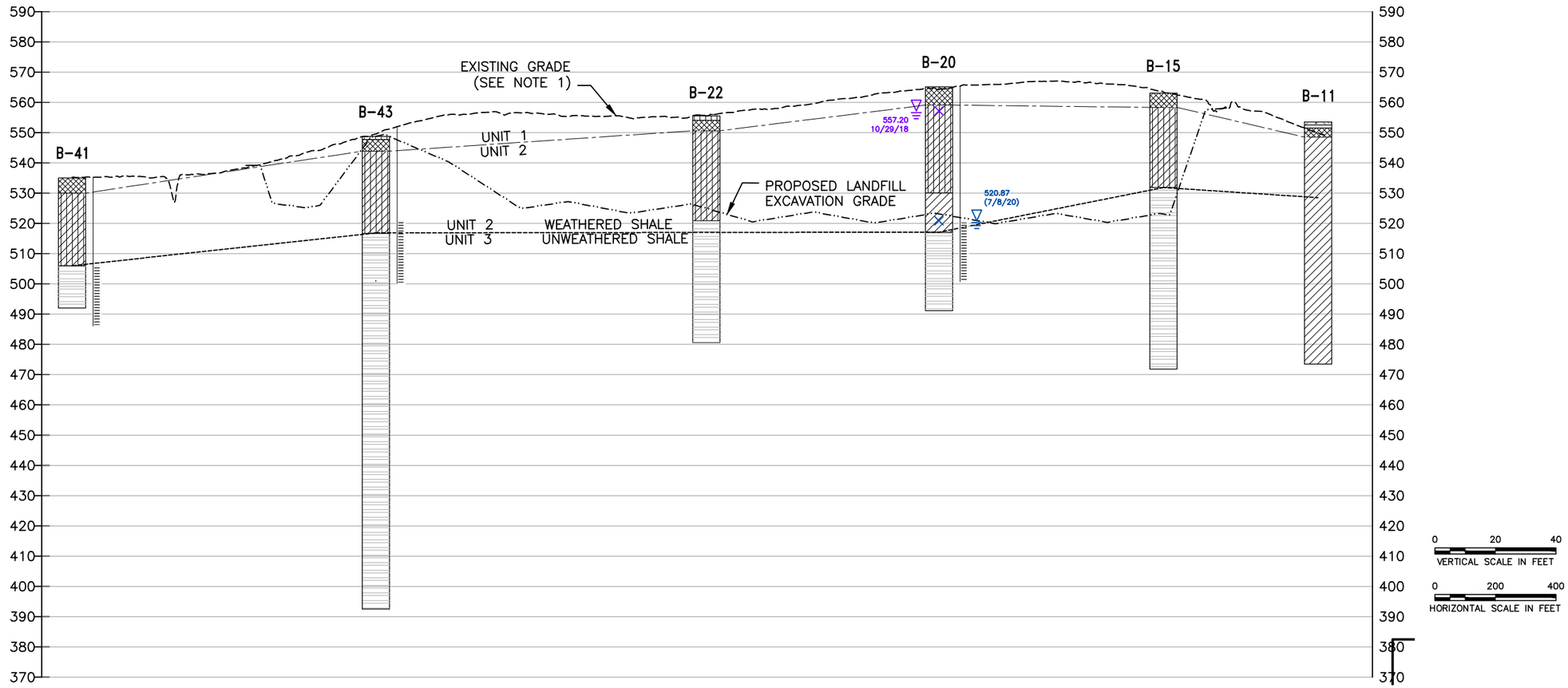
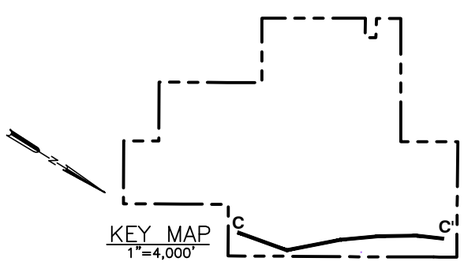
DATE: 05/2020

SCALE: AS SHOWN

FIGURE: 4.11




## CROSS SECTION C-C'




KEY MAP
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James Lawrence
Discipline
License #
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PROFESSIONAL GEOSCIENTIST

10/6/2020

## LEGEND:

| | |
|---|---|
| - - - - - - - | EXISTING GRADE (SEE NOTE 1) |
| —·—·— | UNIT 1/UNIT 2 CONTACT |
| ---------- | WEATHERED/UNWEATHERED SHALE TRANSITIONAL CONTACT |
| -··-··- | PROPOSED LANDFILL EXCAVATION GRADE |
| 510.74 (7/8/20) ▽ | STATIC WATER LEVEL IN PIEZOMETER (DATE OF WATER LEVEL READING) |
| 539.49 (7/8/20) ▽ | INITIAL WATER LEVEL IN PIEZOMETER (DATE OF WATER LEVEL READING) |

NOTES:

1. EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL, FLOWN ON JULY 03, 2018.
2. SEE APPENDIX III-4.D FOR SUBSURFACE MATERIAL LEGEND.

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| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: CORRECT SHALE CONTACT IN B-41, B-43; EXTEND DEPTH OF B-43; ADD UNIT 1/UNIT 2 CONTACT | JL |

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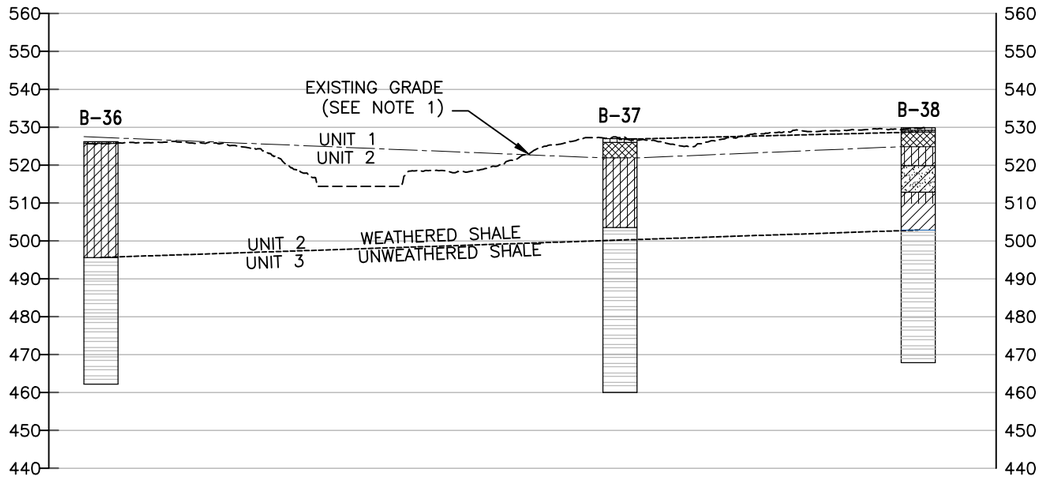
CADD FILE: 4.10-4.15 - GEOLOGIC CROSS SECTIONS

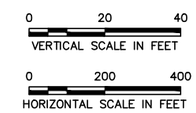
DATE: 05/2020

SCALE: AS SHOWN

FIGURE: 4.12

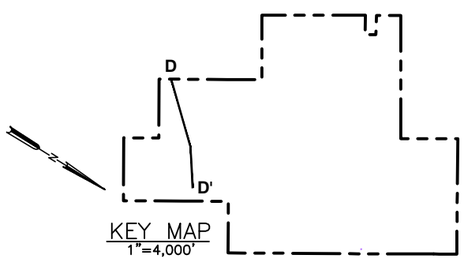



## CROSS SECTION D-D'




## LEGEND:

- - - - - - - EXISTING GRADE (SEE NOTE 1)
—·—·— UNIT 1/UNIT 2 CONTACT
- - - - - - - - - WEATHERED/UNWEATHERED SHALE TRANSITIONAL CONTACT




KEY MAP
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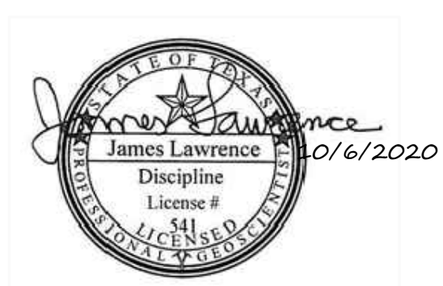


NOTES:

1. EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL, FLOWN ON JULY 03, 2018.
2. SEE APPENDIX III-4.D FOR SUBSURFACE MATERIAL LEGEND.

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| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FIX GRADE LEVEL AT B-36; ADD UNIT1/UNIT 2 CONTACT | JL |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
CROSS SECTION D-D'

PROJECT TITLE
CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT
CITY OF WACO
SOLID WASTE SERVICES


SCS ENGINEERS
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PH (817) 571-2288 FAX NO. (817) 571-2188


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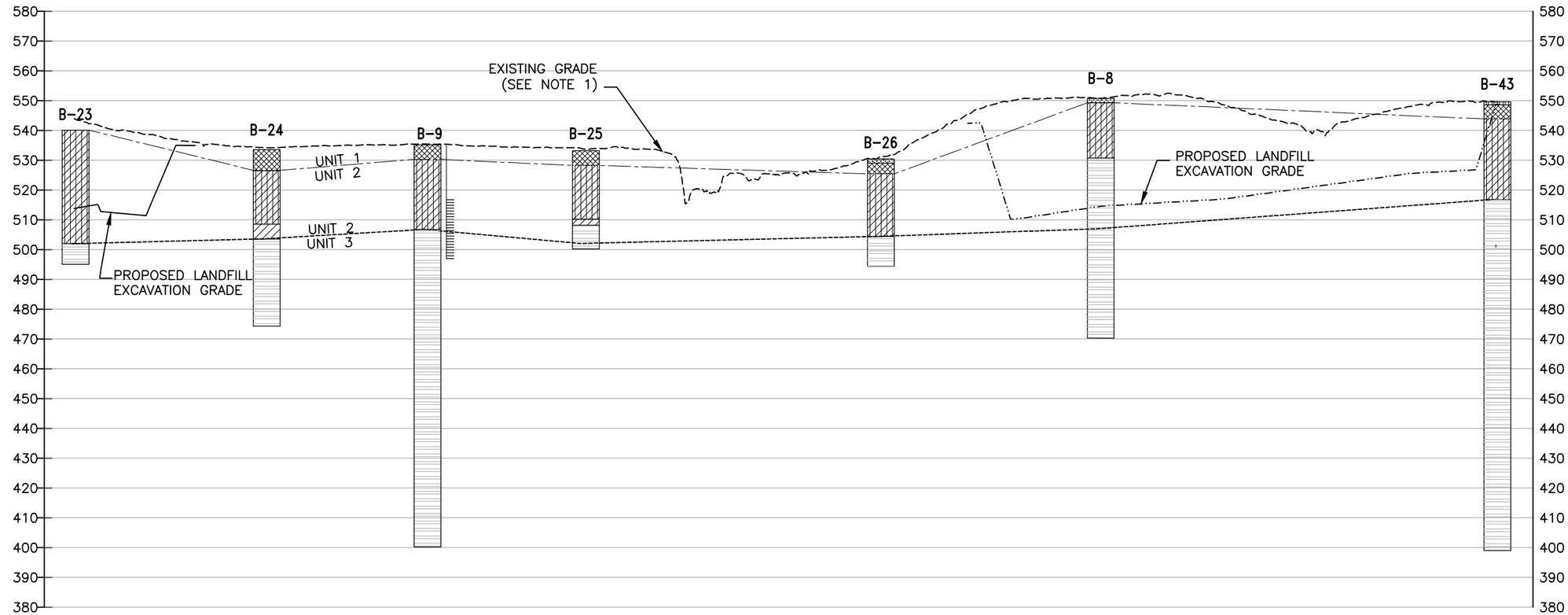
CADD FILE: 4.10-4.15 - GEOLOGIC CROSS SECTIONS

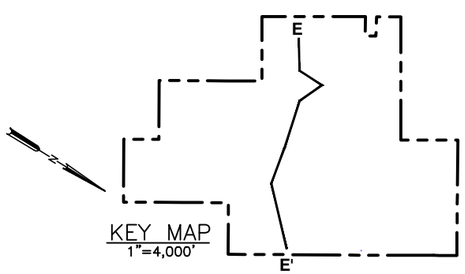
DATE: 05/2020

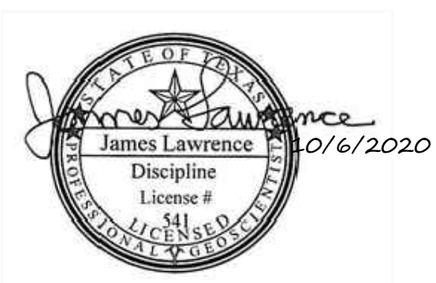
SCALE: AS SHOWN

FIGURE: 4.13




## CROSS SECTION E-E'




## LEGEND:

| | |
|---|---|
| - - - - - - - | EXISTING GRADE (SEE NOTE 1) |
| —·—·— | UNIT 1/UNIT 2 CONTACT |
| ---------- | WEATHERED/UNWEATHERED SHALE TRANSITIONAL CONTACT |
| -·-·-·- | PROPOSED LANDFILL EXCAVATION GRADE |
| 510.74 (7/8/20) ▽ | STATIC WATER LEVEL IN PIEZOMETER (DATE OF WATER LEVEL READING) |
| 539.49 (7/8/20) ▽ | INITIAL WATER LEVEL IN PIEZOMETER (DATE OF WATER LEVEL READING) |

NOTES:

1. EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL, FLOWN ON JULY 03, 2018.
2. SEE APPENDIX III-4.D FOR SUBSURFACE MATERIAL LEGEND.

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| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: ADD B-9 TO CROSS SECTION; EXTEND DEPTH OF B-43; CORRECT SHALE CONTACT IN B-43; ADD UNIT 1/UNIT 2 CONTACT | JL |

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DRAWING TITLE: CROSS SECTION E-E'

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES


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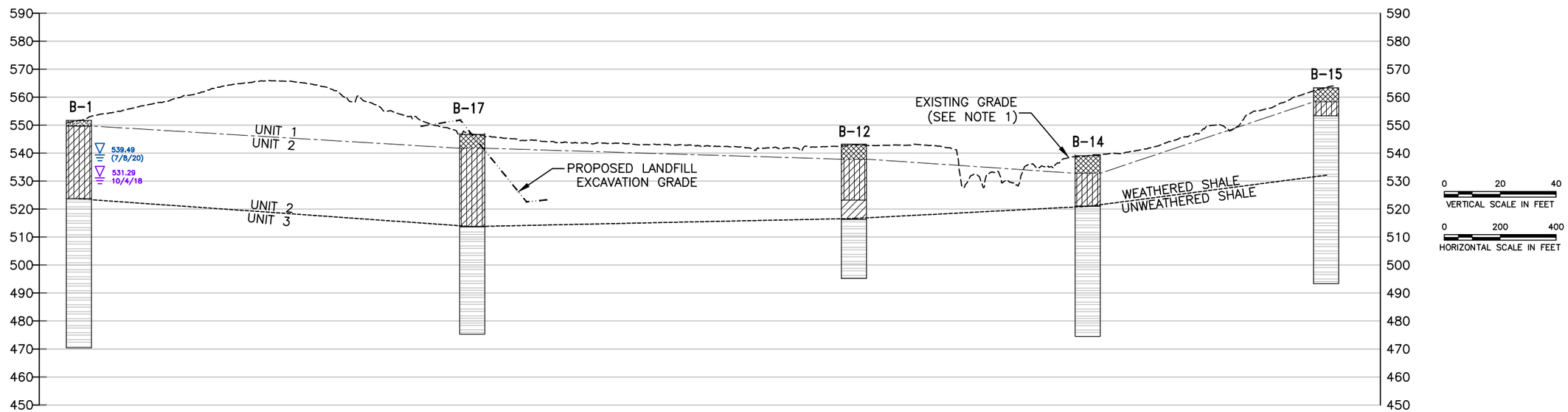
CADD FILE: 4.10-4.15 - GEOLOGIC CROSS SECTIONS

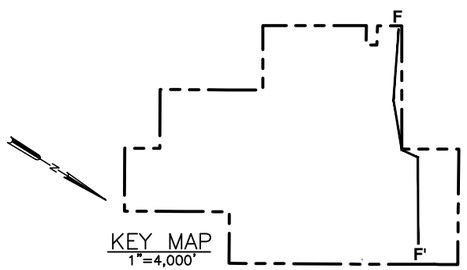
DATE: 05/2020

SCALE: AS SHOWN

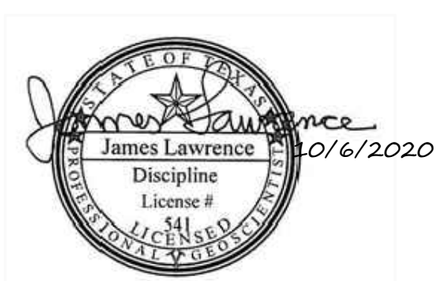
FIGURE: 4.14




## CROSS SECTION F-F'




KEY MAP
1"=4,000'




10/6/2020

## LEGEND:

- EXISTING GRADE (SEE NOTE 1)
- UNIT 1/UNIT 2 CONTACT
- WEATHERED/UNWEATHERED SHALE TRANSITIONAL CONTACT
- PROPOSED LANDFILL EXCAVATION GRADE

NOTES:

1. EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL, FLOWN ON JULY 03, 2018.
2. SEE APPENDIX III-4.D FOR SUBSURFACE MATERIAL LEGEND.

FOR PERMITTING PURPOSES ONLY

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: ADD B-1 AND B-17, ADD UNIT 1/UNIT 2 CONTACT | JL |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: CROSS SECTION F-F'

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES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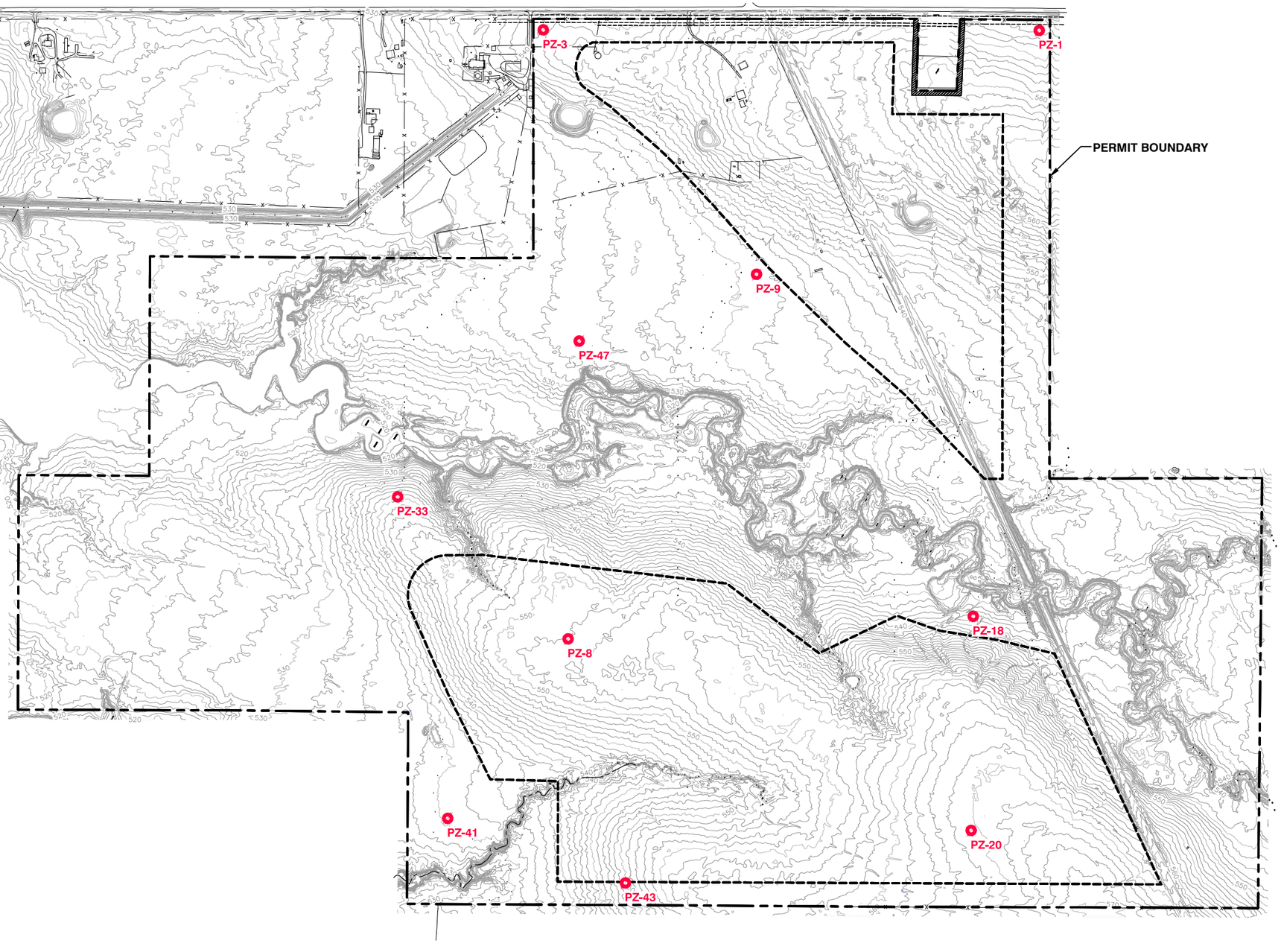
CADD FILE: 4.10-4.15 - GEOLOGIC CROSS SECTIONS

DATE: 05/2020

SCALE: AS SHOWN

FIGURE: 4.15




0 300 600

SCALE IN FEET

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- 535 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- PZ-1 EXISTING PIEZOMETER LOCATION

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.
2. SHALLOW AND/OR DEEP VWPS ARE LOCATED ADJACENT TO CONVENTIONAL PIEZOMETERS AS SHOWN ON FIGURE 4.17.

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|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: LIMITS OF WASTE | JL |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
PIEZOMETER LOCATION MAP

PROJECT TITLE
CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT
CITY OF WACO
SOLID WASTE SERVICES

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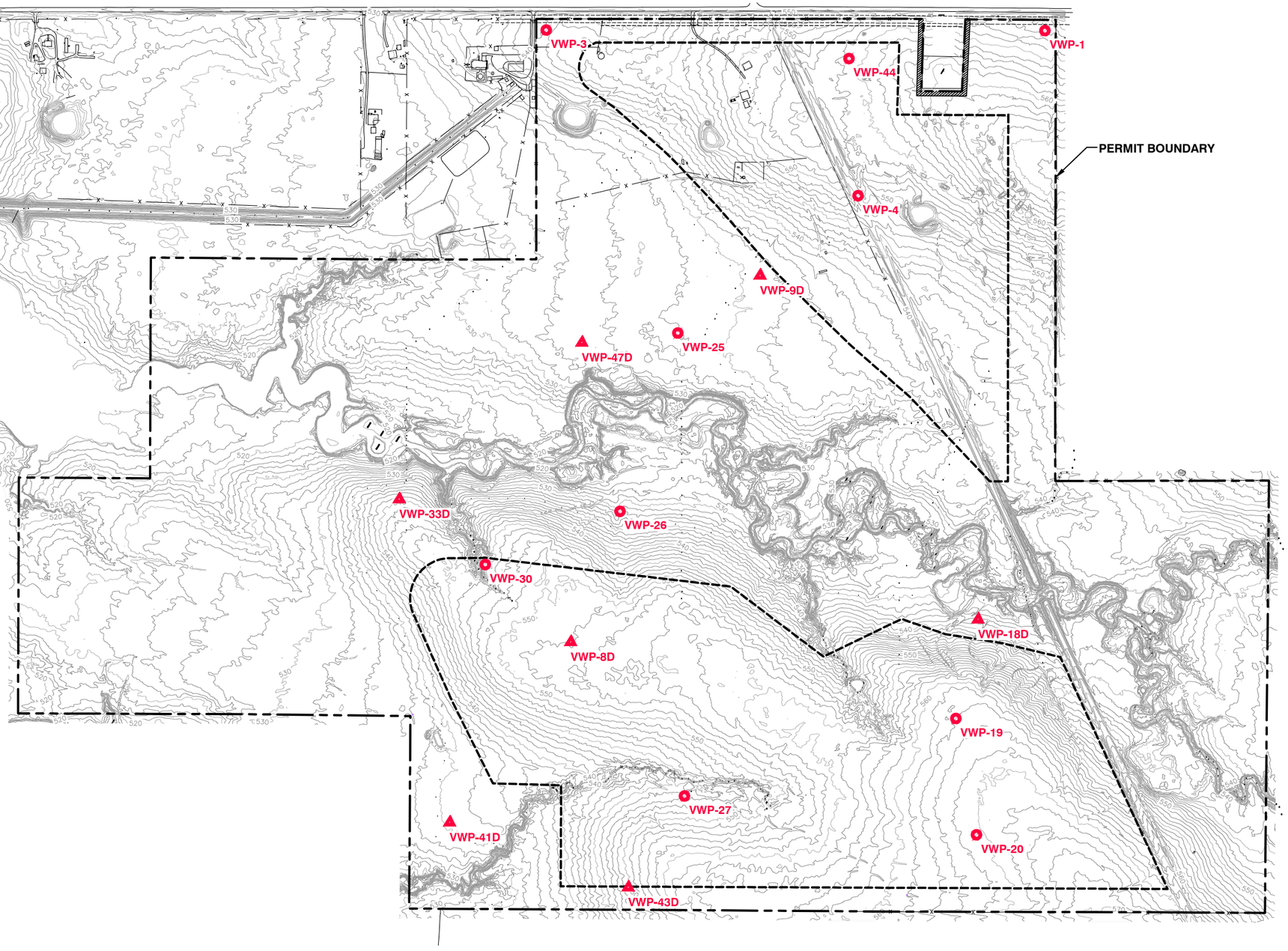
CADD FILE:
4.16 – PZ LOCATION MAP

DATE:
05/2020

SCALE:
AS SHOWN

FIGURE:
4.16

10/6/2020 2:26 PM G:\WACO\162160088.00 1172 – SITE 90 Settled SW2\PA_Permit_Dwgs_LNWD\WD02 (DSED)_Alt 4.4.16 – PZ Location Map




0 300 600
SCALE IN FEET

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- 535 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- VWP-1 VWP LOCATION – SHALLOW
- VWP-8D VWP LOCATION – SHALLOW/DEEP

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.

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|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: LIMITS OF WASTE AND NOTE 2. | JL |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: VWP LOCATION MAP

PROJECT TITLE: CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO
SOLID WASTE SERVICES

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CHK. BY: BJD/AB
D/A REVI BY: RRK
APP. BY: JL

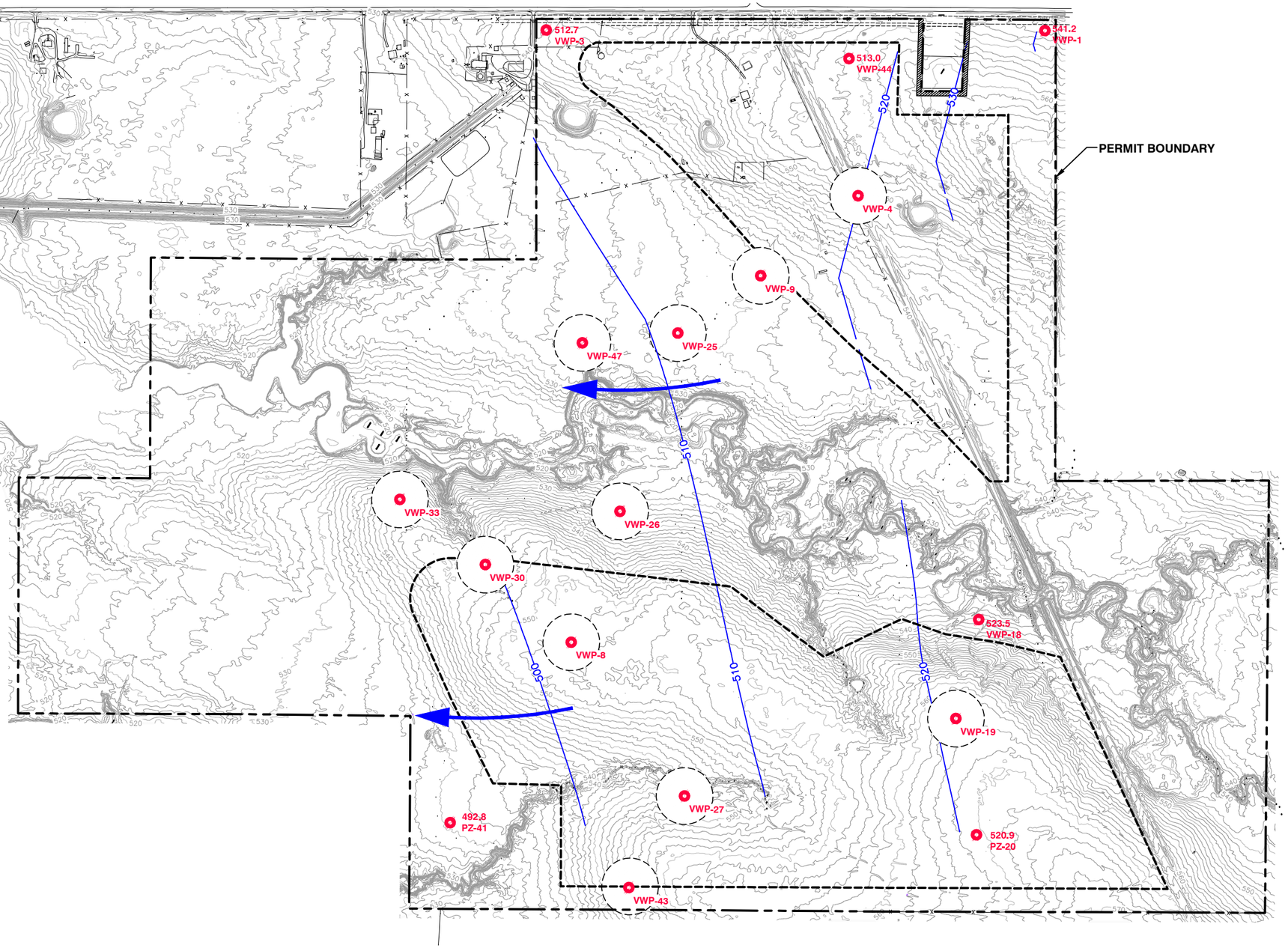
CADD FILE: 4.17 – VWP LOCATION MAP

DATE: 05/2020

SCALE: AS SHOWN

4.17

10/6/2020 3:57 PM G:\WACO\16216088.00 11TZ – SITE 50 Strings SWDFL_Permit_Dwgs_DWG\WD02 (DSED)_4X 4.17 – VWP Location Map




0 300 600
SCALE IN FEET

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- 535 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- 510 POSITIVE PRESSURE CONTOURS
- VWP-1 PZ/VWP LOCATION – SHALLOW
- 513.0 CALCULATED GROUNDWATER MSL ELEVATION
- VWP-4 VWP LOCATION WITH NO WATER OBSERVED
- INFERRED GROUNDWATER FLOW DIRECTION

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.

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|---|---|---|---|
| | | | |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: PIEZOMETER /SHALLOW VWP POTENTIOMETRIC MAP

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES


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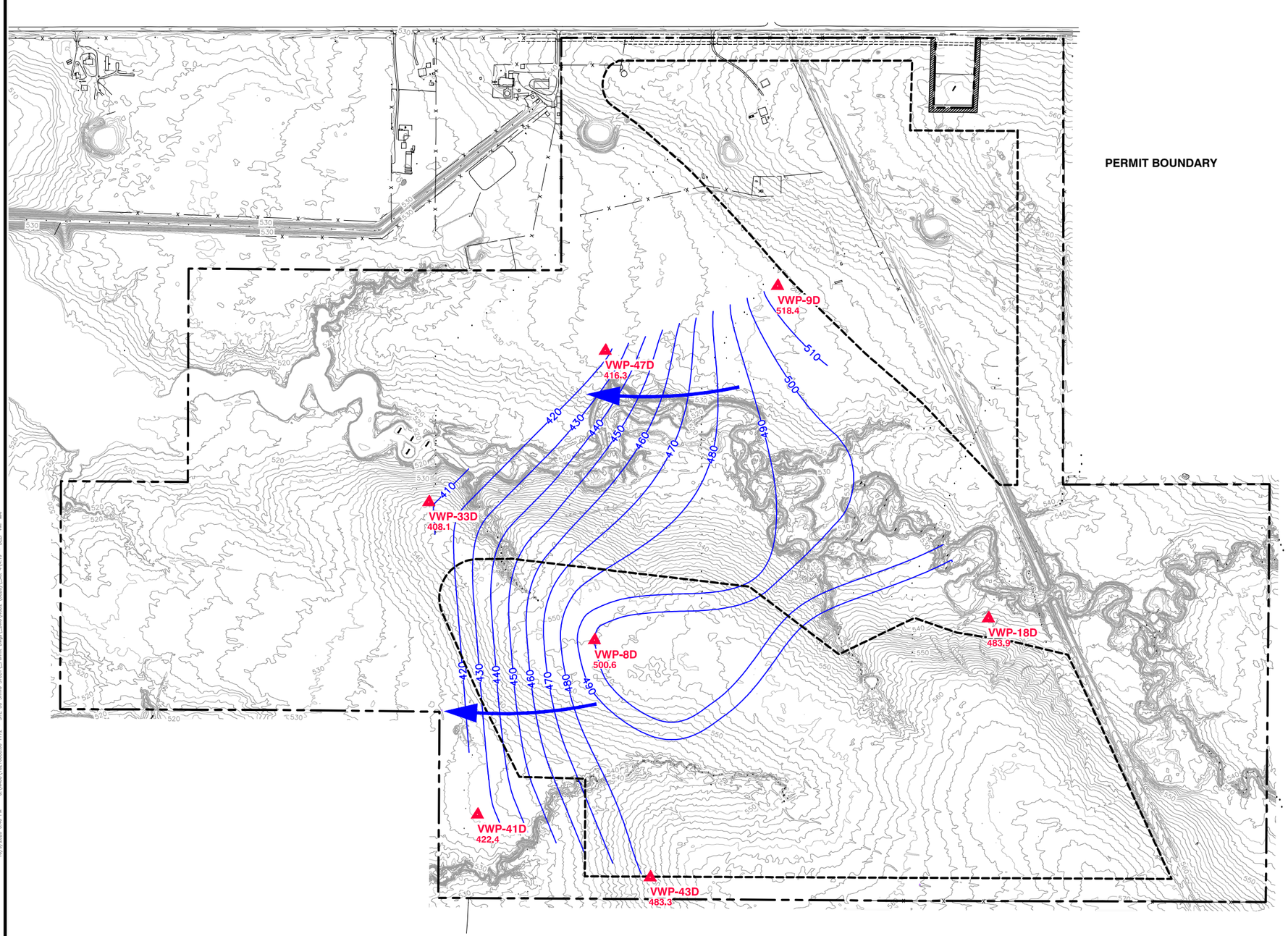
CADD FILE: 4.18 – SHALLOW VWP MAP

DATE: 05/2020

SCALE: AS SHOWN

FIGURE: 4.18




0 300 600
SCALE IN FEET

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- 535 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- 510 POSITIVE PRESSURE CONTOURS
- VWP-8D VWP LOCATION – DEEP
- 517.0 CALCULATED GROUNDWATER MSL ELEVATION
- INFERRED GROUNDWATER FLOW DIRECTION

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.

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|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: ORIGINALLY 4.18; DEEP VWP POTENTIOMETRIC MAP; NEW GW ELEVATION VALUES; REMOVE SHALLOW VWP'S | JL |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
DEEP VWP POTENTIOMETRIC MAP

PROJECT TITLE
CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT
CITY OF WACO
SOLID WASTE SERVICES


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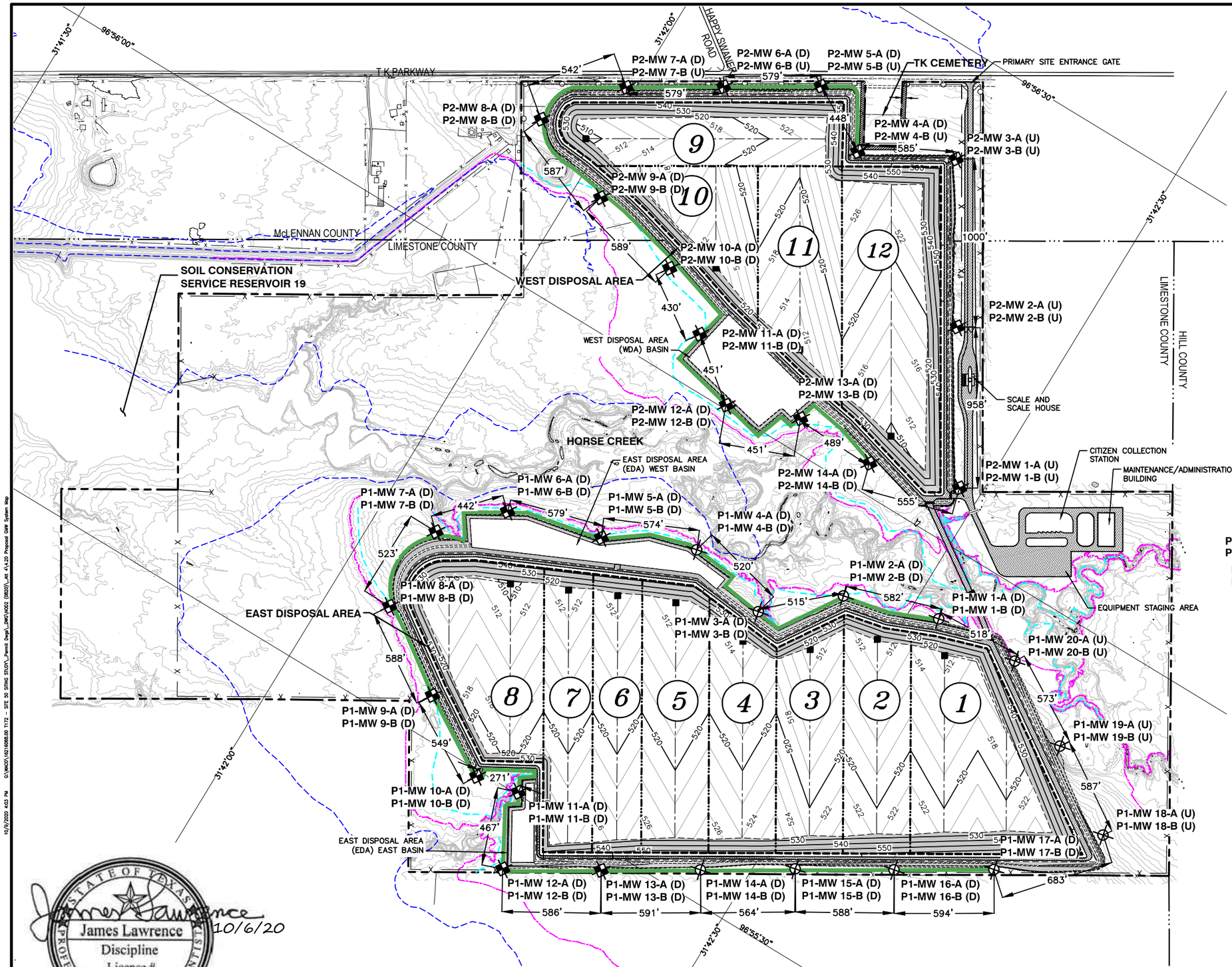
CADD FILE: 4.19 – DEEP VWP MAP

DATE: 05/2020

SCALE: AS SHOWN

FIGURE: 4.19




0 300 600

SCALE IN FEET

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- SECTOR BOUNDARY
- COUNTY LINE
- 560 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- 100-YEAR FLOOD PLAIN (SEE NOTE 2)
- 100-YEAR STORM EVENT WATER SURFACE (SEE NOTE 4)
- EXISTING UNDERGROUND WATER LINE
- X PROPOSED PERIMETER FENCE
- PROPOSED 8' PRIVACY FENCE
- ACCESS ROAD
- 510 EXCAVATION GRADE TOPOGRAPHIC CONTOURS (SEE NOTE 3)
- 96°55'30" LATITUDE/LONGITUDE LINES
- TOE/TOP OF SLOPE
- LEACHATE COLLECTION TRENCH
- POINT OF COMPLIANCE
- P1-MW 20-A (U) / P1-MW 20-B (U) GMW INSTALLED PRIOR TO LANDFILL OPERATION (SEE NOTES 5, 6)
- P2-MW 1-A (U) / P2-MW 1-B (U) GMW INSTALLED WHEN WASTE < 1,000 FEET (SEE NOTES 5, 6)
- X SECTOR DESIGNATION
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.
2. 100-YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
3. ELEVATIONS SHOWN ON THIS DRAWING ARE EXCAVATION GRADES OR BOTTOM OF LINER ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).
4. 100-YEAR STORM EVENT WATER SURFACE WAS ESTIMATED USING HEC-HMS AND HEC-RAS MODELING AS DISCUSSED IN ATTACHMENT 6B OF THIS PERMIT APPLICATION.
5. ALL GROUND MONITORING WELLS DEPICTED IN THIS FIGURE WILL INCLUDE A SHALLOW WELL (DENOTED BY "A") AND DEEP WELL (DENOTED BY "B") AS DEFINED IN ATTACHMENT 4, SECTION 9.
6. A "(U)" IN THE MONITORING WELL LABEL INDICATES A UPGRADIENT WELL AND "(D)" INDICATES A DOWNGRADIENT WELL.

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|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: ORIGINALLY 4.19; INDICATE DISTANCE BETWEEN EACH POINT OF COMPLIANCE WELL; LIST BOTH WELL NAMES AT EACH WELL LOCATION; NOTES 2 AND 5. | |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: PROPOSED GWM SYSTEM MAP

PROJECT TITLE: CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO
SOLID WASTE SERVICES

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DWN. BY: JL/NR
CHK. BY: BJD/AB
QA/QC BY: RRK
APP. BY: JL

CADD FILE: 4.20 PROPOSAL GMW SYSTEM MAP

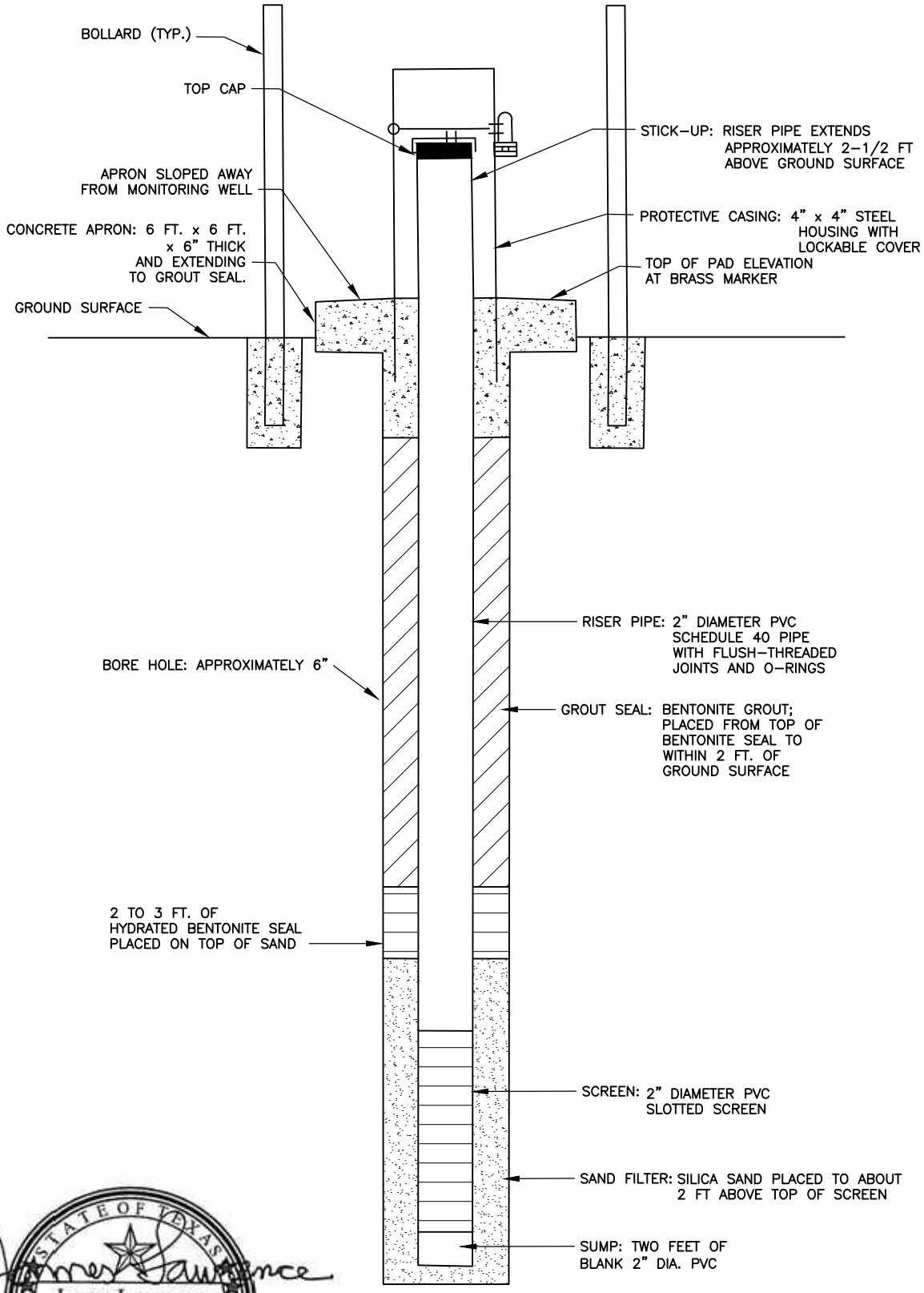
DATE: 05/2020

SCALE: AS SHOWN

FIGURE: 4.20

G:\WACO\162160088.00 TT2 - SITE 50 SITING STUDY_Permit Drgs_DWG\W002 (DB20)_Att 4\4.20 Proposal GMW System Map
10/6/2020 4:03 PM

# TYPICAL MONITORING WELL DETAIL

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10/6/2020

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|---|---|---|---|
| 1 | 10/2020 | REVISED DRAWING NUMBER AND LABEL | |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: TYPICAL MONITORING WELL DETAIL

PROJECT TITLE: CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO
SOLID WASTE SERVICES


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PROJ. NO. 16216088.00
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CHK. BY: BJD/AB
Q/A RVW BY: RRK
APP. BY: JL

CADD FILE: 4.21 – MONITOR WELL DTL

DATE: 04/2020

SCALE: AS SHOWN

FIGURE: **4.21**


10/9/2020 3:08 PM G:\WACO\16216088.00 1172 - SITE SO SITING STUDY_Permit Dwgs_DWG\N002 (0820)_Att 4\4.21 - monitor well dtl

# TABLES


- Table III-4.1 Regional Physiography
- Table III-4.2 Waco Average Monthly Rainfall
- Table III-4.3 Geologic Units and their Water-Bearing Properties
- Table III-4.4 Recorded Wells within 1 Mile
- Table III-4.5 Coordinates and Elevations of Borings
- Table III-4.6 Properties of Unit I
- Table III-4.7 Properties of Unit II
- Table III-4.8 Properties of Unit III
- Table III-4.9 Existing Piezometer Completion Data
- Table III-4.10 Summary Initial and Static Water Level Data
- Table III-4.11 Vibrating Wire Piezometer Completion Data
- Table III-4.12 Vibrating Wire Piezometer Inferred Groundwater Elevation Data
- Table III-4.13 Summary of Aquifer (Slug) Tests Performed by SCS Engineers
- Table III-4.14 Summary of Horizontal Flow Rate Calculation Data
- Table III-4.15 Proposed Monitoring Well Information

**Table III-4.5 Coordinates and Elevations of Borings Advanced at the Site by SCS Engineers**

| Boring Number | Easting | Northing | Hollow Stem Auger Type | Ground Elevation (ft-msl) | Depth Drilled (ft-bgs) | Elevation of Bottom (ft-msl) |
|---|---|---|---|---|---|---|
| B-1 | 3353867.3 | 10599904.81 | 7 ¼ | 551.67 | 82.0 | 469.7 |
| B-1 (PZ-1) | 3353867.3 | 10599904.81 | 7 ¼ | 551.74 | 39.5 | 512.24 |
| B-2 | 3354595.81 | 10598697.6 | 7 ¼ | 549.78 | 55.0 | 494.78 |
| B-3 | 3355259.69 | 10597665.32 | 7 ¼ | 541.1 | 72.0 | 469.1 |
| B-3 (PZ-3) | 3355259.69 | 10597665.32 | 7 ¼ | 541.20 | 45.0 | 496.2 |
| B-4 | 3355130.33 | 10599528 | 7 ¼ | 550.04 | 101.0 | 449.04 |
| B-5 | 3355913.87 | 10600728.3 | 7 ¼ | 541.38 | 47.0 | 494.38 |
| B-6 | 3355562.96 | 10602041.9 | 7 ¼ | 545.55 | 70.7 | 474.85 |
| B-7 | 3356670.83 | 10599929.6 | 8 ¼ | 530.50 | 55.5 | 475 |
| B-8 (PZ-8) | 3357935.82 | 10599489.18 | 8 ¼ | 550.34 | 75.0 | 475.34 |
| B-9 (PZ-9) | 3355762.31 | 10599314.37 | 8 ¼ | 535.30 | 40.0 | 495.30 |
| B-9 cont. | 3355762.31 | 10599314.37 | 8 ¼ | 535.30 | 135.0 | 400.30 |
| B-10 | 3356199.16 | 10602404.1 | 8 ¼ | 545.40 | 53.0 | 492.4 |
| B-11 | 3357048 | 10602933.5 | 7 ¼ | 553.50 | 78.5 | 475 |
| B-12 | 3355833.07 | 10601575 | 8 ¼ | 542.85 | 48.0 | 494.85 |
| B-13 | 3357768.09 | 10600645.6 | 8 ¼ | 555.15 | 80.0 | 475.15 |
| B-14 | 3356543.77 | 10602016.3 | 8 ¼ | 539.20 | 65.5 | 473.7 |
| B-15 | 3357265.27 | 10602471.1 | 7 ¼ | 563.35 | 70.0 | 493.35 |
| B-16 | 3354706.01 | 10599996.8 | 8 ¼ | 560.25 | 61.0 | 499.25 |
| B-17 | 3355568.96 | 10600519.6 | 7 ¼ | 546.75 | 71.0 | 475.75 |
| B-18 (PZ-18) | 3356694.76 | 10601254.04 | 8 ¼ | 534.84 | 56.0 | 478.84 |
| B-19 | 3357202 | 10601429 | 7 ¼ | 562.05 | 87.0 | 475.05 |
| B-20 (PZ-20) | 3357666.42 | 10601846.53 | 7 ¼ | 564.68 | 73.0 | 491.68 |
| B-21 | 3357008 | 10600682 | 8 ¼ | 538.75 | 45.0 | 493.75 |
| B-22 | 3358132.03 | 10601234 | 8 ¼ | 555.00 | 80.0 | 475 |
| B-23 | 3355207.68 | 10598431 | 8 ¼ | 540.08 | 45.7 | 494.38 |
| B-24 | 3355746.69 | 10598780.1 | 7 ¼ | 533.63 | 59.2 | 474.43 |
| B-25 | 3356251.06 | 10599102.9 | 7 ¼ | 533.25 | 33.0 | 500.25 |
| B-26 | 3356929.04 | 10599457.3 | 8 ¼ | 530.45 | 36.0 | 494.5 |
| B-27 | 3358308.89 | 10600427.7 | 8 ¼ | 546.65 | 53.0 | 493.65 |
| B-28 | 3356800.71 | 10598286.7 | 8 ¼ | 529.6 | 55.0 | 474.6 |
| B-29 | 3358523.03 | 10599393 | 8 ¼ | 540.25 | 45.0 | 495.25 |
| B-30 | 3357828.13 | 10598886.4 | 8 ¼ | 543.05 | 48.0 | 495.05 |
| B-31 | 3355837.8 | 10599897 | 8 ¼ | 537.55 | 63.0 | 474.55 |
| B-32 | 3357077.27 | 10597864.5 | 8 ¼ | 526.3 | 32.0 | 494.3 |
| B-33 (PZ-33) | 3357774.62 | 10598320.64 | 8 ¼ | 539.20 | 55.0 | 484.2 |
| B-34 | 3358367.31 | 10598778.6 | 8 ¼ | 535.65 | 41.0 | 494.65 |
| B-35 | 3357682.18 | 10600037.4 | 8 ¼ | 553.3 | 59.0 | 494.3 |
| B-36 | 3357239.12 | 10596730.2 | 8 ¼ | 532.5 | 58.0 | 474.5 |
| B-37 | 3358201.19 | 10597770.6 | 8 ¼ | 526.9 | 52.0 | 474.9 |
| B-38 | 3358847.64 | 10598223.2 | 8 ¼ | 529.85 | 55.0 | 474.85 |
| B-39 | 3358709.87 | 10597052.3 | 8 ¼ | 522.95 | 48.0 | 475 |
| B-40 | 3359476.22 | 10597259.9 | 8 ¼ | 522.80 | 28.0 | 494.8 |
| B-41 (PZ-41) | 3359083.91 | 10599450.64 | 8 ¼ | 534.62 | 60.0 | 474.62 |
| B-42 | 3358523.73 | 10597484.3 | 8 ¼ | 527.00 | 32.0 | 495.0 |
| B-43 (PZ-43) | 3358875.54 | 10600433.69 | 8 ¼ | 548.86 | 75.0 | 473.86 |
| B-43 cont. | 3358875.54 | 10600433.69 | 8 ¼ | 548.86 | 150 | 398.86 |

| Boring Number | Easting | Northing | Hollow Stem Auger Type | Ground Elevation (ft-msl) | Depth Drilled (ft-bgs) | Elevation of Bottom (ft-msl) |
|---|---|---|---|---|---|---|
| B-44 | 3354540.62 | 10599103.1 | 7 ¼ | 551.20 | 76.0 | 475.20 |
| B-45 | 3356769.83 | 10601549.1 | 8 ¼ | 545.50 | 51.0 | 494.5 |
| B-46 | 3357689.45 | 10601293.2 | 8 ¼ | 559.25 | 65.4 | 493.85 |
| B-47 (PZ-47) | 3356561.53 | 10598701.96 | 8 ¼ | 532.48 | 57.4 | 475.08 |

msl = mean sea level
b.g.s indicates depth is measured from below ground surface

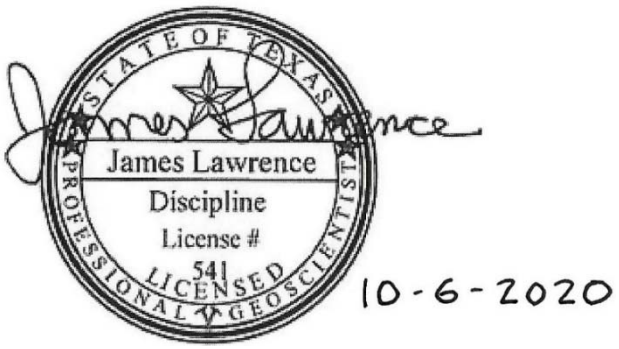

**Table III-4.6 Properties of Unit I**

| Lab Test | East Disposal Area | | West Disposal Area | | Test Method |
|---|---|---|---|---|---|
| | Average | Number of Tests | Average | Number of Tests | |
| Moisture Content | 17 | 3 | 24 | 5 | ASTM D2216 |
| Liquid Limit | 57 | 3 | 70 | 5 | ASTM D4318 |
| Plasticity Index | 37 | 3 | 47 | 5 | ASTM D4318 |
| Permeability (cm/s) | $4.54 \times 10^{-9}$ | 1 | $4.36 \times 10^{-9}$ | 1 | EM 1110-2-1906 |
| Hydraulic Conductivity (cm/s) | $4.54 \times 10^{-9}$ | 1 | $4.36 \times 10^{-9}$ | 1 | EM 1110-2-1906 |
| Hydraulic Conductivity (cm/s) (geometric mean) | n/a | n/a | n/a | n/a | Slug Test |

**Table III-4.7 Properties of Unit II**

| Lab Test | East Disposal Area | | West Disposal Area | | Test Method |
|---|---|---|---|---|---|
| | Average | Number of Tests | Average | Number of Tests | |
| Moisture Content | 18 | 24 | 21 | 29 | ASTM D2216 |
| Liquid Limit | 64 | 24 | 70 | 33 | ASTM D4318 |
| Plasticity Index | 42 | 24 | 47 | 33 | ASTM D4318 |
| Permeability (cm/s) | $5.02 \times 10^{-8}$ | 4 | $2.24 \times 10^{-8}$ | 4 | EM 1110-2-1906 |
| Hydraulic Conductivity (cm/s) | $5.02 \times 10^{-8}$ | 4 | $2.24 \times 10^{-8}$ | 4 | EM 1110-2-1906 |
| Hydraulic Conductivity (cm/s) (geometric mean) | $2.05 \times 10^{-8}$ | 1 | $3.07 \times 10^{-8}$ | 3 | Slug Test |

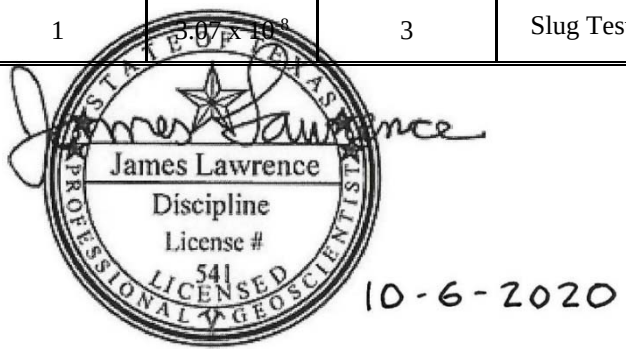

**Table III-4.8 Properties of Unit III**

| Lab Test | East Disposal Area | | West Disposal Area | | Test Method |
|---|---|---|---|---|---|
| | Average | Number of Tests | Average | Number of Tests | |
| Moisture Content | 14 | 21 | 15 | 20 | ASTM D2216 |
| Liquid Limit | 59 | 21 | 66 | 20 | ASTM D4318 |
| Plasticity Index | 39 | 21 | 45 | 20 | ASTM D4318 |
| Permeability (cm/s) | $9.25 \times 10^{-9}$ | 1 | $6.71 \times 10^{-6}$ | 1 | EM 1110-2-1906 |
| Hydraulic Conductivity (cm/s) | $9.25 \times 10^{-9}$ | 1 | $6.71 \times 10^{-6}$ | 1 | EM 1110-2-1906 |
| Hydraulic Conductivity (cm/s) (geometric mean) | $1.84 \times 10^{-8}$ | 2 | n/a | n/a | Slug Test |

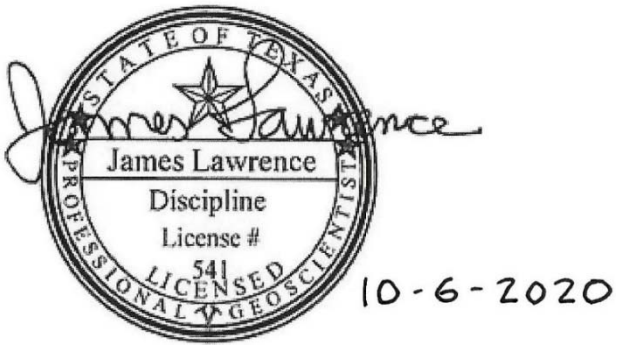

**Table III-4.9 Existing Piezometers Completion Data**

| Monitor Well No. | Drilled Depth (ft b.g.s) | Ground Surface Elevation (ft-msl) | Top of Pipe Elevation (ft-msl) | Screen | | Filter Pack | |
|---|---|---|---|---|---|---|---|
| | | | | Depth to Top (ft) | Depth to Base (ft) | Depth to Top (ft) | Depth to Base (ft) |
| PZ-1 | 39.5 | 551.7 | 555.12 | 19.19 | 39.19 | 16.00 | 39.47 |
| PZ-3 | 45.0 | 541.2 | 544.21 | 24.53 | 44.53 | 21.5 | 44.76 |
| PZ-8 | 75.0 | 550.3 | 553.39 | 54.47 | 74.47 | 52.70 | 74.70 |
| PZ-9 | 40.0 | 535.3 | 539.44 | 18.28 | 38.28 | 15.90 | 38.48 |
| PZ-18 | 56.0 | 534.8 | 537.80 | 25.18 | 45.18 | 22.80 | 45.50 |
| PZ-20 | 73.0 | 564.7 | 567.77 | 44.00 | 64.00 | 42.00 | 64.00 |
| PZ-33 | 55.0 | 539.2 | 542.49 | 34.63 | 54.63 | 33.00 | 54.90 |
| PZ-41 | 60.0 | 534.6 | 538.04 | 28.58 | 48.58 | 24.00 | 48.77 |
| PZ-43 | 75.0 | 548.9 | 551.31 | 28.20 | 48.20 | 24.00 | 48.45 |
| PZ-47 | 57.4 | 532.5 | 536.16 | 10.00 | 30.00 | 8.00 | 30.00 |

Notes:
Ground-surface elevations are to the nearest tenth of a foot above mean sea level (msl) and are based on as-built monitoring well and piezometer survey elevations. Top of casing elevations are to the nearest hundredth of a foot.
b.g.s indicates depth is measured from below ground surface.

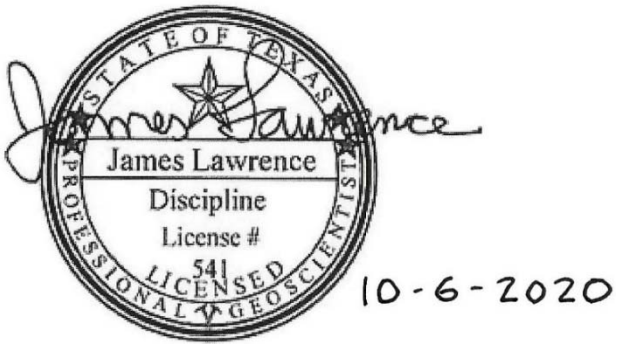

**Table III-4.10 Summary of Initial and Static Water Level Data**

| Boring/Well Number | Initial Water Level (ft-msl) | Static Water Level (ft-msl) | Date of Static Water Level Reading |
|---|---|---|---|
| ***B-1 (PZ-1)**** | 531.29 | 539.49 | 7/8/2020 |
| ***B-3 (PZ-3)**** | 495.86 (dry) | 510.74 | 7/8/2020 |
| B-8 (PZ-8)* | 476.30 (dry) | 476.30 (dry) | 7/8/2020 |
| B-9 (PZ-9)* | 510.05 | 501.45 (dry) | 7/8/2020 |
| ***B-18 (PZ-18)**** | 511.25 | 519.72 | 7/8/2020 |
| ***B-20 (PZ-20)**** | 557.20 | 520.87 | 7/8/2020 |
| B-33 (PZ-33)* | 484.95 (dry) | 484.95 (dry) | 7/8/2020 |
| ***B-41 (PZ-41)**** | 486.41 (dry) | 492.8 | 7/8/2020 |
| B-43 (PZ-43)* | 501.37 (dry) | 500.86 (dry) | 7/8/2020 |
| B-47 (PZ-47)* | 502.15 (dry) | 502.18 (dry) | 7/8/2020 |

* = Piezometer installed in bore hole.

Notes:

1. Initial water level information shown in this table was taken from the piezometers following installation.
2. PZ-1, PZ-3, PZ-9, and PZ-47 are piezometers in the west disposal area.
3. PZ-8, PZ-18, PZ-20, PZ-33, PZ-41, and PZ-43 are piezometers in the east disposal area.
4. PZ-1, PZ-3, PZ-9, PZ-20, PZ-41, and PZ-43 are screened in the weathered and unweathered shale-marl zones and across the interface.
5. PZ-8, PZ-18, PZ-33 are screened in the unweathered shale-marl zone, below the interface.
6. PZ-47 is screened in the weathered shale-mark zone, above the interface.

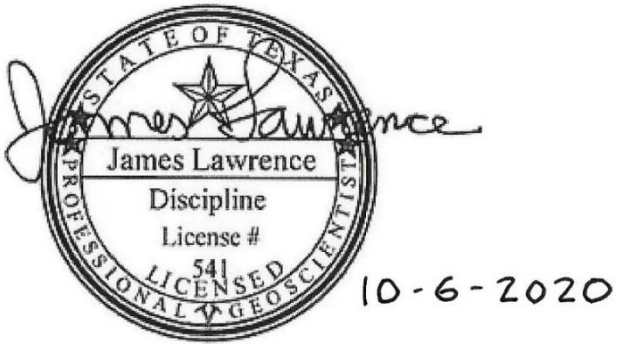

**Table III-4.11 Summary of Vibrating Wire Piezometers Completion Data**

| VWP No. | Drilled Depth (ft b.g.s) | Ground Surface Elevation (ft-msl) | VWP Elevation (ft-msl) | VWP Depth (ft) | Bentonite Backfill Depth to Top (ft) | Filter Pack Depth to Top (ft) | Bentonite Seal Depth to Top (ft) |
|---|---|---|---|---|---|---|---|
| VWP-1 | 35.0 | 551.4 | 522.5 | 28.9 | 29.0 | 27.9 | 24.9 |
| VWP-3 | 38.0 | 540.9 | 506.6 | 34.3 | 34.5 | 33.3 | 30.3 |
| VWP-4 | 28.7 | 549.6 | 527.0 | 22.6 | 22.8 | 21.6 | 18.6 |
| VWP-8 | 68.0 | 550.9 | 486.3 | 64.6 | 64.8 | 63.6 | 60.6 |
| VWP-8D | 160.0 | 551.0 | 400.0 | 151.0 | -- | 150.0 | 147.0 |
| VWP-9 | 35.0 | 535.3 | 506.9 | 28.4 | 28.5 | 27.3 | 24.3 |
| VWP-9D | 145.0 | 535.0 | 400.0 | 135.0 | -- | 134.0 | 131.0 |
| VWP-18 | 37.0 | 534.6 | 499.6 | 35.0 | 35.2 | 34.2 | 31.0 |
| VWP-18D | 145.0 | 535.0 | 400.0 | 135.0 | -- | 134.0 | 131.0 |
| VWP-19 | 53.0 | 562.1 | 511.0 | 51.1 | 51.3 | 50.3 | 47.0 |
| VWP-20 | 56.5 | 564.6 | 510.1 | 54.5 | 54.7 | 53.7 | 51.0 |
| VWP-25 | 32.0 | 533.8 | 505.0 | 28.8 | 29.0 | 27.8 | 24.8 |
| VWP-26 | 24.8 | 530.5 | 506.0 | 24.5 | -- | 23.5 | 20.5 |
| VWP-27 | 30.0 | 546.7 | 520.0 | 26.7 | 27.0 | 25.7 | 23.0 |
| VWP-30 | 40.0 | 544.0 | 506.0 | 38.0 | 38.1 | 37.0 | 34.0 |
| VWP-33 | 48.0 | 538.6 | 494.8 | 43.8 | 44.0 | 42.8 | 39.8 |
| VWP-33D | 150.0 | 539.0 | 401.0 | 138.0 | -- | 137.0 | 134.0 |
| VWP-41 | 39.0 | 534.8 | 496.4 | 38.4 | 38.7 | 37.5 | 34.5 |
| VWP-41D | 145.0 | 535.0 | 402.0 | 133.0 | -- | 132.0 | 129.0 |
| VWP-43 | 40.0 | 549.5 | 511.5 | 38.0 | 38.3 | 37.0 | 34.0 |
| VWP-43D | 160.0 | 549.0 | 400.0 | 149.0 | -- | 148.0 | 145.0 |
| VWP-44 | 55.0 | 554.4 | 505.2 | 49.2 | 49.3 | 48.2 | 45.2 |
| VWP-47 | 23.5 | 532.6 | 512.4 | 20.2 | 20.4 | 19.2 | 16.2 |
| VWP-47D | 142.0 | 532.0 | 400.0 | 132.0 | -- | 131.0 | 128.0 |

Notes:
Ground-surface and VWP elevations are to the nearest tenth of a foot above mean sea level (msl) and are based on piezometer survey elevations. b.g.s indicates depth is measured from below ground surface.

STATE OF TEXAS
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10-6-2020

**Table III-4.12 Summary of Vibrating Wire Piezometers Calculated Groundwater Elevations**

| VWP No. | Ground Surface Elevation (ft-msl) | VWP Elevation (ft-msl) | Temperature (°C) | Pressure (PSI) | Pressure Head (feet $H_2O$) | Calculated Groundwater Elevation (ft-msl) | Date of Reading |
|---|---|---|---|---|---|---|---|
| VWP-1 | 551.4 | 522.5 | 21.4 | 8.1 | 18.65 | 541.2 | 7/8/2020 |
| VWP-3 | 540.9 | 506.6 | 21.4 | 2.6 | 6.07 | 512.7 | 7/8/2020 |
| VWP-4 | 549.6 | 527.0 | 20.6 | -0.1 | -0.3 | 526.8 (dry) | 7/8/2020 |
| VWP-8 | 550.9 | 486.3 | 20.0 | 0.0 | -0.1 | 486.3 (dry) | 7/8/2020 |
| VWP-8D | 551.0 | 400.0 | 21.7 | 45.9 | 106.13 | 506.1 | 7/8/2020 |
| VWP-9 | 535.3 | 506.9 | 21.2 | -0.1 | -0.2 | 506.9 (dry) | 7/8/2020 |
| VWP-9D | 535.0 | 400.0 | 22.3 | 51.6 | 119.39 | 519.4 | 7/8/2020 |
| VWP-18 | 534.6 | 499.6 | 20.7 | 10.3 | 23.92 | 523.5 | 7/8/2020 |
| VWP-18D | 535.0 | 400.0 | 22.2 | 44.8 | 103.56 | 503.6 | 7/8/2020 |
| VWP-19 | 562.1 | 511.0 | 21.6 | -0.5 | -1.1 | 510.0 (dry) | 7/8/2020 |
| VWP-20 | 564.6 | 510.1 | 21.6 | -0.1 | -0.2 | 510.1 (dry) | 7/8/2020 |
| VWP-25 | 533.8 | 505.0 | 19.6 | -0.1 | -0.2 | 505.0 (dry) | 7/8/2020 |
| VWP-26 | 530.5 | 506.0 | 20.0 | -0.1 | -0.4 | 505.7 (dry) | 7/8/2020 |
| VWP-27 | 546.7 | 520.0 | 20.8 | -0.2 | -0.5 | 519.7 (dry) | 7/8/2020 |
| VWP-30 | 544.0 | 506.0 | 20.3 | 0.0 | -0.2 | 505.8 (dry) | 7/8/2020 |
| VWP-33 | 538.6 | 494.8 | 21.4 | -0.1 | -0.3 | 494.8 (dry) | 7/8/2020 |
| VWP-33D | 539.0 | 401.0 | 22.1 | 8.1 | 18.7 | 419.7 | 7/8/2020 |
| VWP-41 | 534.8 | 496.4 | 19.8 | 0.0 | -0.1 | 496.4 (dry) | 7/8/2020 |
| VWP-41D | 535.0 | 402.0 | 21.2 | 13.9 | 32.29 | 434.3 | 7/8/2020 |
| VWP-43 | 549.5 | 511.5 | 20.4 | -0.1 | -0.2 | 511.5 (dry) | 7/8/2020 |
| VWP-43D | 549.0 | 400.0 | 21.7 | 41.5 | 95.95 | 496.0 | 7/8/2020 |
| VWP-44 | 554.4 | 505.2 | 22.0 | 3.3 | 7.8 | 513.0 | 7/8/2020 |
| VWP-47 | 532.6 | 512.4 | 19.6 | -0.1 | -0.2 | 512.4 (dry) | 7/8/2020 |
| VWP-47D | 532.0 | 400.0 | 21.1 | 11.0 | 25.62 | 425.6 | 7/8/2020 |

Notes:
Ground-surface and VWP elevations are to the nearest tenth of a foot above mean sea level (msl) and are based on piezometer survey elevations.

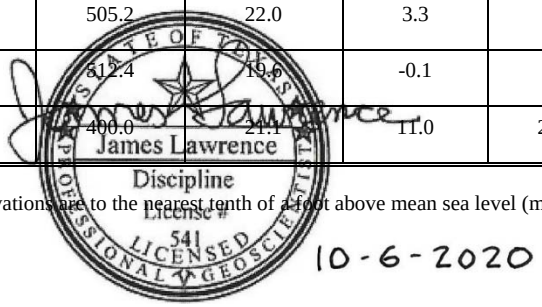


**Table III-4.13 Summary of Aquifer (Slug) Tests Performed by SCS Engineers**

| Piezometer Designation | Unit Tested | Slug Test Method | Hydraulic Conductivity (cm/sec) |
|---|---|---|---|
| PZA-1 | II/III | Bouwer-Rice | Slug in: $2.03 \times 10^{-8}$ cm/sec |
| | | | Slug out: $2.04 \times 10^{-8}$ cm/sec |
| PZA-3 | II/III | Bouwer-Rice | Slug in: $6.97 \times 10^{-8}$ cm/sec |
| PZ-18 | III | Bouwer-Rice | Slug in: $1.44 \times 10^{-8}$ cm/sec |
| | | | Slug out: $2.36 \times 10^{-8}$ cm/sec |
| PZ-20 | II/III | Bouwer-Rice | Slug in: $2.05 \times 10^{-8}$ cm/sec |
| Geometric Mean Hydraulic Conductivity = $2.42 \times 10^{-8}$ cm/sec | | | |
| Arithmetic Mean Hydraulic Conductivity = $2.82 \times 10^{-8}$ cm/sec | | | |

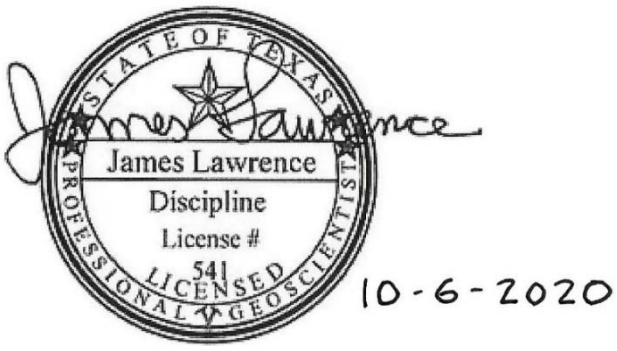
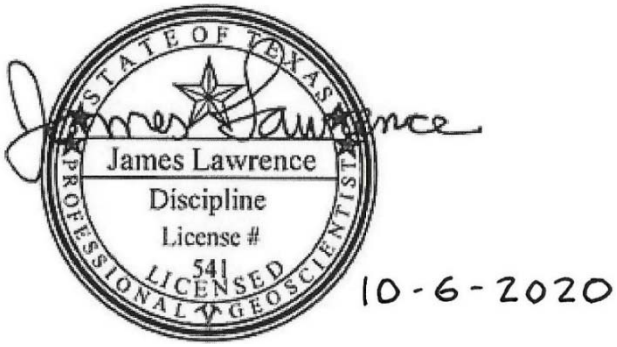


**Table III-4.14 Estimated Ground Water Velocities**

| Location | Hydraulic Conductivity (k)* (cm/sec) (Geometric Mean) | Hydraulic Gradient (i)** | Average Effective Porosity (n)*** | Velocities (v) ft/day | Velocity (v) ft/year |
|---|---|---|---|---|---|
| Entire Area (PZA-1, PZA-3, PZ-18, PZ-20) | $2.42 \times 10^{-8}$ | 0.027 | 0.05 | $3.6 \times 10^{-5}$ | 0.013 |
| Unit II (PZA-1, PZA-3, PZ-20) | $2.77 \times 10^{-8}$ | 0.027 | 0.05 | $4.32 \times 10^{-5}$ | 0.016 |
| West Disposal Area (PZA-1, PZA-3) | $3.07 \times 10^{-8}$ | 0.027 | 0.05 | $4.32 \times 10^{-5}$ | 0.016 |
| East Disposal Area (PZ-18, PZ-20) | $1.91 \times 10^{-8}$ | 0.027 | 0.05 | $2.88 \times 10^{-5}$ | 0.01 |
| PZA-3 (High) | $6.97 \times 10^{-8}$ | 0.027 | 0.05 | $1.08 \times 10^{-4}$ | 0.039 |
| PZ-18 (Low) | $1.44 \times 10^{-8}$ | 0.027 | 0.05 | $2.16 \times 10^{-5}$ | 0.008 |

* Hydraulic conductivity estimated from slug test results.
** Gradient estimated from July 2020 deep VWP potentiometric map (Figure III-4.19)
*** Typical porosity for shale (Driscoll, 1986)



## Table III-4.15 Proposed Monitoring Well Information

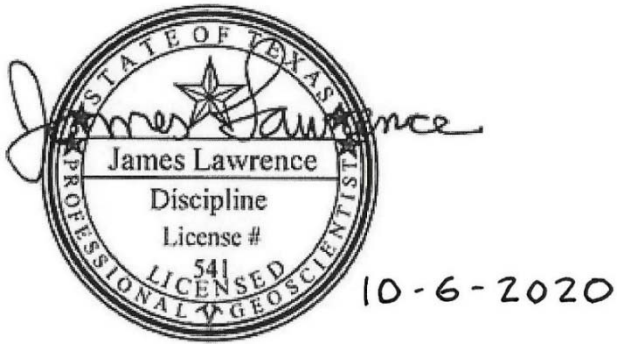
| Monitor Well No. | Cell Location | Installation | Northing | Easting | Estimated Ground Surface Elevation (ft-msl) | Proposed Well Bottom Elevation (ft-msl) | Proposed Screen Elevation (ft-msl) | Expected Water Elevation (ft-msl) |
|---|---|---|---|---|---|---|---|---|
| P1-MW 1-A (D) | East | Prior to Landfill Operation | 10601388.5' | 3356636.7' | 537.3 | 482 | 482-522 | 520 |
| P1-MW 1-B (D) | East | Prior to Landfill Operation | 10601388.5' | 3356636.7' | 537.3 | 400 | 400-440 | 520 |
| P1-MW 2-A (D) | East | Waste < 1,000 feet | 10600835.2' | 3356820.8' | 534.9 | 500 | 480-520 | 520 |
| P1-MW 2-B (D) | East | Waste < 1,000 feet | 10600835.2' | 3356820.8' | 534.9 | 400 | 400-440 | 520 |
| P1-MW 3-A (D) | East | Waste < 1,000 feet | 10600455.1' | 3357167.6' | 539.9 | 500 | 485-525 | 515 |
| P1-MW 3-B (D) | East | Waste < 1,000 feet | 10600455.1' | 3357167.6' | 539.9 | 400 | 400-440 | 515 |
| P1-MW 4-A (D) | East | Waste < 1,000 feet | 10599949.8' | 3357049.5' | 535.5 | 480 | 480-520 | 510 |
| P1-MW 4-B (D) | East | Waste < 1,000 feet | 10599949.8' | 3357049.5' | 535.5 | 400 | 400-440 | 500 |
| P1-MW 5-A (D) | East | Waste < 1,000 feet | 10599428.7' | 3357289.6' | 535.5 | 480 | 480-520 | 510 |
| P1-MW 5-B (D) | East | Waste < 1,000 feet | 10599428.7' | 3357289.6' | 535.5 | 400 | 400-440 | 480 |
| P1-MW 6-A (D) | East | Waste < 1,000 feet | 10598871.8' | 3357451.8' | 536.9 | 482 | 482-522 | 500 |
| P1-MW 6-B (D) | East | Waste < 1,000 feet | 10598871.8' | 3357451.8' | 536.9 | 400 | 400-440 | 440 |
| P1-MW 7-A (D) | East | Waste < 1,000 feet | 10598575.5' | 3357780.2' | 541.0 | 486 | 486-526 | 500 |
| P1-MW 7-B (D) | East | Waste < 1,000 feet | 10598575.5' | 3357780.2' | 541.0 | 400 | 400-440 | 410 |
| P1-MW 8-A (D) | East | Waste < 1,000 feet | 10598576.0' | 3358302.8' | 534.4 | 479 | 479-519 | 500 |
| P1-MW 8-B (D) | East | Waste < 1,000 feet | 10598576.0' | 3358302.8' | 534.4 | 400 | 400-440 | 410 |
| P1-MW 9-A (D) | East | Waste < 1,000 feet | 10599071.8' | 3358618.2' | 534.9 | 480 | 480-520 | 500 |
| P1-MW 9-B (D) | East | Waste < 1,000 feet | 10599071.8' | 3358618.2' | 534.9 | 400 | 400-440 | 420 |
| P1-MW 10-A (D) | East | Waste < 1,000 feet | 10599550.5' | 3358887.5' | 536.5 | 481 | 481-521 | 500 |
| P1-MW 10-B (D) | East | Waste < 1,000 feet | 10599550.5' | 3358887.5' | 536.5 | 400 | 400-440 | 430 |
| P1-MW 11-A (D) | East | Waste < 1,000 feet | 10599811.3' | 3358835.5' | 537.2 | 482 | 482-522 | 510 |
| P1-MW 11-B (D) | East | Waste < 1,000 feet | 10599811.3' | 3358835.5' | 537.2 | 400 | 400-440 | 460 |

| Monitor Well No. | Cell Location | Installation | Northing | Easting | Estimated Ground Surface Elevation (ft-msl) | Proposed Well Bottom Elevation (ft-msl) | Proposed Screen Elevation (ft-msl) | Expected Water Elevation (ft-msl) |
|---|---|---|---|---|---|---|---|---|
| P1-MW 12-A (D) | East | Waste < 1,000 feet | 10599973.5' | 3359272.3' | 535.2 | 480 | 480-520 | 510 |
| P1-MW 12-B (D) | East | Waste < 1,000 feet | 10599973.5' | 3359272.3' | 535.2 | 400 | 400-440 | 480 |
| P1-MW 13-A (D) | East | Waste < 1,000 feet | 10600475.2' | 3358969.8' | 548.7 | 494 | 494-534 | 510 |
| P1-MW 13-B (D) | East | Waste < 1,000 feet | 10600475.2' | 3358969.8' | 548.7 | 400 | 400-440 | 480 |
| P1-MW 14-A (D) | East | Waste < 1,000 feet | 10600975.4' | 3358654.1' | 557.9 | 503 | 503-543 | 515 |
| P1-MW 14-B (D) | East | Waste < 1,000 feet | 10600975.4' | 3358654.1' | 557.9 | 400 | 400-440 | 480 |
| P1-MW 15-A (D) | East | Waste < 1,000 feet | 10601450.3' | 3358350.5' | 559.1 | 504 | 504-544 | 520 |
| P1-MW 15-B (D) | East | Waste < 1,000 feet | 10601450.3' | 3358350.5' | 559.1 | 400 | 400-440 | 500 |
| P1-MW 16-A (D) | East | Waste < 1,000 feet | 10601952.9' | 3358044.6' | 562.9 | 508 | 508-548 | 520 |
| P1-MW 16-B (D) | East | Waste < 1,000 feet | 10601952.9' | 3358044.6' | 562.9 | 400 | 400-440 | 520 |
| P1-MW 17-A (D) | East | Prior to Landfill Operation | 10602455.6' | 3357728.7' | 568.7 | 514 | 514-554 | 520 |
| P1-MW 17-B (D) | East | Prior to Landfill Operation | 10602455.6' | 3357728.7' | 568.7 | 400 | 400-440 | 520 |
| P1-MW 18-A (U) | East | Prior to Landfill Operation | 10602898.2' | 3357210.8' | 557.1 | 502 | 502-542 | 520 |
| P1-MW 18-B (U) | East | Prior to Landfill Operation | 10602898.2' | 3357210.8' | 557.1 | 400 | 400-440 | 520 |
| P1-MW 19-A (U) | East | Prior to Landfill Operation | 10602401.2' | 3356897.4' | 539.8 | 485 | 485-525 | 520 |
| P1-MW 19-B (U) | East | Prior to Landfill Operation | 10602401.2' | 3356897.4' | 539.8 | 400 | 400-440 | 520 |
| P1-MW 20-A (U) | East | Prior to Landfill Operation | 10601906.1' | 3356610.0' | 539.5 | 485 | 485-525 | 520 |
| P1-MW 20-B (U) | East | Prior to Landfill Operation | 10601906.1' | 3356610.0' | 539.5 | 400 | 400-440 | 520 |
| P2-MW 1-A (U) | West | Waste < 1,000 feet | 10601080.1' | 3355911.8' | 541.3 | 486 | 486-526 | 520 |
| P2-MW 1-B (U) | West | Waste < 1,000 feet | 10601080.1' | 3355911.8' | 541.3 | 400 | 400-440 | 520 |

| Monitor Well No. | Cell Location | Installation | Northing | Easting | Estimated Ground Surface Elevation (ft-msl) | Proposed Well Bottom Elevation (ft-msl) | Proposed Screen Elevation (ft-msl) | Expected Water Elevation (ft-msl) |
|---|---|---|---|---|---|---|---|---|
| P2-MW 2-A (U) | West | Waste < 1,000 feet | 10600561.9' | 3355105.9' | 546.9 | 492 | 492-532 | 535 |
| P2-MW 2-B (U) | West | Waste < 1,000 feet | 10600561.9' | 3355105.9' | 546.9 | 400 | 400-440 | 535 |
| P2-MW 3-A (U) | West | Waste < 1,000 feet | 10600028.3' | 3354261.3' | 561.9 | 507 | 507-547 | 540 |
| P2-MW 3-B (U) | West | Waste < 1,000 feet | 10600028.3' | 3354261.3' | 561.9 | 400 | 400-440 | 540 |
| P2-MW 4-A (D) | West | Waste < 1,000 feet | 10599509.0' | 3354533.4' | 558.2 | 503 | 503-543 | 525 |
| P2-MW 4-B (D) | West | Waste < 1,000 feet | 10599509.0' | 3354533.4' | 558.2 | 400 | 400-440 | 525 |
| P2-MW 5-A (D) | West | Waste < 1,000 feet | 10599116.9' | 3354318.4' | 553.8 | 499 | 499-539 | 515 |
| P2-MW 5-B (D) | West | Waste < 1,000 feet | 10599116.9' | 3354318.4' | 553.8 | 400 | 400-440 | 515 |
| P2-MW 6-A (D) | West | Waste < 1,000 feet | 10598627.3' | 3354628.1' | 549.0 | 494 | 494-534 | 515 |
| P2-MW 6-B (D) | West | Waste < 1,000 feet | 10598627.3' | 3354628.1' | 549.0 | 400 | 400-440 | 515 |
| P2-MW 7-A (D) | West | Waste < 1,000 feet | 10598137.9' | 3354937.1' | 541.7 | 487 | 487-527 | 515 |
| P2-MW 7-B (D) | West | Waste < 1,000 feet | 10598137.9' | 3354937.1' | 541.7 | 400 | 400-440 | 515 |
| P2-MW 8-A (D) | West | Waste < 1,000 feet | 10597808.8' | 3355366.0' | 542.7 | 488 | 488-528 | 515 |
| P2-MW 8-B (D) | West | Waste < 1,000 feet | 10597808.8' | 3355366.0' | 542.7 | 400 | 400-440 | 515 |
| P2-MW 9-A (D) | West | Waste < 1,000 feet | 10598355.8' | 3355575.5' | 534.7 | 480 | 480-520 | 515 |
| P2-MW 9-B (D) | West | Waste < 1,000 feet | 10598355.8' | 3355575.5' | 534.7 | 400 | 400-440 | 500 |
| P2-MW 10-A (D) | West | Waste < 1,000 feet | 10598926.3' | 3355714.8' | 534.9 | 480 | 480-520 | 515 |
| P2-MW 10-B (D) | West | Waste < 1,000 feet | 10598926.3' | 3355714.8' | 534.9 | 400 | 400-440 | 500 |
| P2-MW 11-A (D) | West | Waste < 1,000 feet | 10599286.1' | 3355952.6' | 535.1 | 480 | 480-520 | 515 |
| P2-MW 11-B (D) | West | Waste < 1,000 feet | 10599286.1' | 3355952.6' | 535.1 | 400 | 400-440 | 440 |
| P2-MW 12-A (D) | West | Waste < 1,000 feet | 10599642.5' | 3356227.9' | 535.5 | 480 | 480-520 | 515 |
| P2-MW 12-B (D) | West | Waste < 1,000 feet | 10599642.5' | 3356227.9' | 535.5 | 400 | 400-440 | 440 |
| P2-MW 13-A (D) | West | Waste < 1,000 feet | 10600060.5' | 3356061.2' | 535.3 | 480 | 480-520 | 515 |

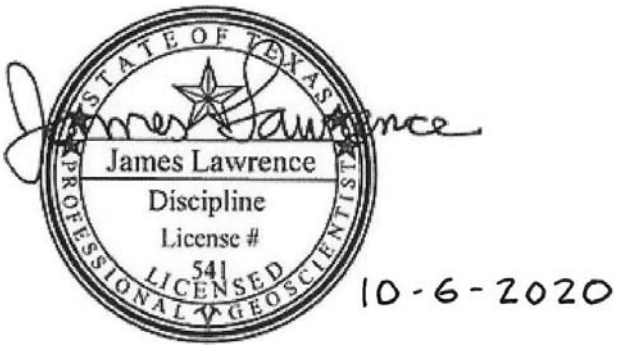
| Monitor Well No. | Cell Location | Installation | Northing | Easting | Estimated Ground Surface Elevation (ft-msl) | Proposed Well Bottom Elevation (ft-msl) | Proposed Screen Elevation (ft-msl) | Expected Water Elevation (ft-msl) |
|---|---|---|---|---|---|---|---|---|
| P2-MW 13-B (D) | West | Waste < 1,000 feet | 10600060.5' | 3356061.2' | 535.3 | 400 | 400-440 | 490 |
| P2-MW 14-A (D) | West | Waste < 1,000 feet | 10600549.7' | 3356070.2' | 536.9 | 482 | 482-522 | 515 |
| P2-MW 14-B (D) | West | Waste < 1,000 feet | 10600549.7' | 3356070.2' | 536.9 | 400 | 400-440 | 490 |

Notes:
Proposed shallow well bottom elevations are 55 feet below ground surface elevations. Proposed deep well bottom elevations will all be set at 400 ft-msl.



# APPENDIX III-4.D

# BORING LOGS



# KEY TO SYMBOLS

SCS Engineers
1901 Central Drive, Ste. 550
Bedford, Texas
Telephone: 817-571-2288

**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

## LITHOLOGIC SYMBOLS
## (Unified Soil Classification System)

CH: USCS High Plasticity Clay

CL: USCS Low Plasticity Clay

CL-ML: USCS Low Plasticity Silty Clay

CLS: USCS Low Plasticity Sandy Clay

UNIT 1

MH: USCS Elastic Silt

NO CORE

SC: USCS Clayey Sand

SHALE: Shale

SP: USCS Poorly-graded Sand

SP-SC: USCS Poorly-graded Sand with Clay

## SAMPLER SYMBOLS

Standard Penetration Test

Split Spoon

Shelby Tube

NOTE: If no symbol for sample type is shown: Sample Type = NXCB

## WELL CONSTRUCTION SYMBOLS

Bentonite Seal: 1 pipe group, 1 pipe

Slotted Pipe: 1 pipe group, 1 pipe

Top Cap: 1 pipe group, 1st pipe

## ABBREVIATIONS

LL - LIQUID LIMIT (%)
PI - PLASTIC INDEX (%)
W - MOISTURE CONTENT (%)
DD - DRY DENSITY (PCF)
NP - NON PLASTIC
-200 - PERCENT PASSING NO. 200 SIEVE
PP - POCKET PENETROMETER (TSF)
TV - TORVANE
PID - PHOTOIONIZATION DETECTOR
UC - UNCONFINED COMPRESSION
ppm - PARTS PER MILLION
▽ Water Level at Time Drilling, or as Shown
▼ Water Level at End of Drilling, or as Shown
▼ Water Level After Drilling, or as Shown

SYMBOLS2 - GINT STD US LAB.GDT - 10/2/20 13:36 - Z:\GIL\GINT FILES\WACO LANDFILL\SITE 50 WACO REV.GPJ

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# BORING NUMBER B-1 (A-1)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 1/25/18 **COMPLETED** 1/26/18
**GROUND ELEVATION** 551.67 ft **HOLE SIZE** 7.25 inches
**DRILLING CONTRACTOR** West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Hollow stem auger/air rotary
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Millbrand **CHECKED BY** J. Lawrence
**AT END OF DRILLING** ---
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | |
| | ST1 | 75 | PP = 3.5 tsf<br>0-16 feet logged from previous drilling in January 2018 | SC | | (SC) | |
| | | | | | | 2.0 (From previous log drilled 1/25/2018) | 549.7 |
| | ST2 | 50 | PP = 4.5+ tsf | | | (CH) Clay, dark brown, hard, moist, calcareous | |
| | | | | | | Pebbles 2-4 ft | |
| 5 | ST3 | 50 | PP = 4.5+ tsf | | | Color change to light brown at 6 ft | |
| | ST4 | 75 | PP = 4.5+ tsf | CH | | Color change to brown-grey at 8 ft | |
| | | | | | | Color change to reddish brown at 10 ft | |
| | ST5 | 80 | PP = 4.5+ tsf | | | | |
| 10 | ST6 | 85 | PP = 4.5+ tsf<br>MC = 31%<br>LL = 83<br>PL = 58 | | | | |
| | | | | | | 12.0 | 539.7 |
| | ST7 | 95 | PP = 4.5+ tsf | CH | | (CH) Clay, reddish brown, with gray sand, soft, moist | |
| 15 | ST8 | 95 | PP = 4.5+ tsf<br>MC = 30%<br>LL = 89<br>PL = 63 | | | | |
| | | | | | | 16.0 | 535.7 |
| | ST9 | 80 | PP = 4.5+ tsf | CH | | (CH) Clay, grey to brown, with silty sand lenses, hard, moist | |
| | | | | | | Fossil fragments 16-18 ft | |
| 20 | ST10 | 90 | PP = 4.5+ tsf<br>MC = 22%<br>LL = 79<br>PL = 56 | | | 20.0 | 531.7 |
| | ST11 | 50 | PP = 4.5+ tsf | SC | | (SC) Clayey sand, grey to dark grey, clay is reddish brown, soft, slightly saturated | |
| | | | | | | Quartz and calcite pebbles throughout | |
| | ST12 | 70 | PP = 4.5+ tsf | | | 24.0 | 527.7 |
| 25 | ST13 | 80 | PP = 4.5+ tsf | CH | | (CH) Clay, mottled red/grey/brown, with sand lenses, hard, moist | |
| | | | | | | Sand lenses are saturated | |
| | | | | | | 26.0 Calcite and quartz pebbles throughout | 525.7 |
| | ST14 | 70 | PP = 4.5+ tsf | CH | | (CH) Clay, reddish brown, with grey sand, soft, saturated | |
| | | | | | | 28.0 | 523.7 |
| 30 | ST15 | 50 | PP = 4.5+ tsf | | | Calcite and quartz throughout | |
| | | | | | | Weathered shale begins at 28 ft | |
| | | 100 | PP = 4.5+ tsf<br>MC = 14%<br>LL = 66<br>PL = 43 | | | Silty Clay Shale, gray to dark gray, very stiff to hard, hard, calcareous | |
| | | | | | | Fossil fragments throughout | |
| 35 | | | | | | Silty sand lenses throughout | |

*(Continued Next Page)*

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 10/2/20 13:40 - Z:\GIL\GINT FILES\WACO LANDFILL\SITE 50 WACO REV.GPJ

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Telephone: 817-571-2288

# BORING NUMBER B-1 (A-1)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | | | | | Silty Clay Shale, gray to dark gray, very stiff to hard, hard, calcareous<br>Fossil fragments throughout<br>Silty sand lenses throughout *(continued)* |
| 40 | | 100 | PP = 4.5+ tsf | | | |
| 45 | | 98 | PP = 4.5+ tsf<br>MC = 14%<br>LL = 73<br>PL = 52 | | | |
| 50 | | 35 | PP = 4.5+ tsf | | | |
| 55 | | 94 | PP = 4.5+ tsf | | | |
| 60 | | 81 | PP = 4.5+ tsf | | | |
| 65 | | 85 | PP = 4.5+ tsf<br>MC = 18%<br>LL = 72<br>PL = 52 | | | |
| 70 | | 100 | PP = 4.5+ tsf | | | |
| 75 | | 92 | PP = 4.5+ tsf | | | |

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GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 10/2/20 13:40 - Z:\GIL\GINT FILES\WACO LANDFILL\SITE 50 WACO REV.GPJ

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# BORING NUMBER B-1 (A-1)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 75 | | | | | | Silty Clay Shale, gray to dark gray, very stiff to hard, hard, calcareous |
| | | 27 | PP = 4.5+ tsf | | | Fossil fragments throughout |
| | | | | | | Silty sand lenses throughout *(continued)* |
| 80 | | | | | | |
| | | 100 | PP = 4.5+ tsf | | | |
| | | | | | 82.0 | 469.7 |

Bottom of borehole at 82.0 feet.

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 10/2/20 13:40 - Z:\GIL\GINT FILES\WACO LANDFILL\SITE 50 WACO REV.GPJ

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# WELL NUMBER B-1 (PZ-1)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/4/18 **COMPLETED** 10/4/18
**GROUND ELEVATION** 551.7 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** ---
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** 20.41 ft / Elev 531.29 ft
**NOTES**
**AFTER DRILLING** 12.21 ft / Elev 539.49 ft

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | Silty Clay, dark brown, slightly moist to moist, soft | |
| | | | | | | 2.0 549.7 | |
| 5 | | | | CL-ML | | (CL-ML) Silty Clay, red/orange to brown, slightly moist to moist, firm to stiff, with orange staining in joints | |
| 10 | | | | | | | |
| 15 | | | | | | 15.0 536.7 | |
| 20 | | 12 | PP = 3.25 tsf<br>MC = 23%<br>LL = 75<br>PL = 22<br>Fines = 93% | | | Silty Clay Shale, orange-brown mottled brown, slightly moist, stiff, non-calcareous, very weathered<br><br>Color change to orange-brown mottled tan to light gray and calcareous at 20 feet | |
| 25 | | 90 | PP = 3.0-3.25 tsf | | | | |
| 30 | | 32 | PP = 3.0-3.5 tsf<br>Weathered to Unweathered zone | | | 28.0 523.7<br>Silty Clay Shale, gray to dark gray, very stiff to hard, slightly moist to dry, calcareous, unweathered<br><br>Slight orange staining in joints 30-39 feet. | |
| 35 | | 60 | PP = 4.5+ tsf | | | | |

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 10/2/20 13:40 - Z:\GIL\GINT FILES\WACO LANDFILL\SITE 50 WACO REV.GPJ

*(Continued Next Page)*

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# WELL NUMBER B-1 (PZ-1)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|
| 35 | | | | | | | |
| | | 107 | PP = 4.5+ tsf<br>MC = 19%<br>LL = 69<br>PL = 24<br>Fines = 97% | | | Silty Clay Shale, gray to dark gray, very stiff to hard, slightly moist to dry, calcareous, unweathered<br><br>Slight orange staining in joints 30-39 feet. *(continued)* | |
| | | | | | 39.3 | | 512.4 |

Bottom of borehole at 39.3 feet.

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 10/2/20 13:40 - Z:\GIL\GINT FILES\WACO LANDFILL\SITE 50 WACO REV.GPJ

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# BORING NUMBER B-2 (A-2)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 1/22/18 **COMPLETED** 1/23/18
**GROUND ELEVATION** 549.78 ft **HOLE SIZE** 7.25 inches
**DRILLING CONTRACTOR** West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Hollow stem auger/air rotary
**AT TIME OF DRILLING** --- No water
**LOGGED BY** T. Millbrand **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No water
**NOTES**
**AFTER DRILLING** ---

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 0 | ST1 | 100 | | PP = 0 tsf | SC | | (SC) Topsoil, dark brown, soft, dry |
| | | | | | | | 2.0 547.8 |
| | | | | | | | No Recovery |
| | | | | | | | 4.0 545.8 |
| 5 | SS1 | 100 | 4-5-7 (12) | PP = 4.5+ tsf | GW-GM | | (GW-GM) Gravel, with dark brown silt, loose, moist |
| | | | | | | | 5.5 544.3 |
| | SS2 | 100 | 6-8-11 (19) | PP = 4.5+ tsf | | | 2 inch limestone layer at 5.5 feet<br>(CH) Clay, dark gray, hard, moist, calcareous |
| | ST2 | 100 | | PP = 4.5+ tsf | CH | | Color change to mottled gray/brown at 6 feet |
| 10 | ST3 | 100 | | PP = 4.5+ tsf | | | Color change to brown at 8 feet<br>Limestone pebbles 8-12 ft |
| | | | | | | | 12.0 537.8 |
| | ST4 | 100 | | PP = 4.5+ tsf | CH | | (CH) Clay, brown, with fine sand, hard, moist |
| | ST5 | 100 | | PP = 4.5+ tsf | | | Color change to reddish brown @ 14 ft |
| 15 | | | | | | | Color change to brown @ 16 ft<br>Limestone pebbles 16-18 ft |
| | ST6 | 100 | | PP = 4.5+ tsf | | | |
| | ST7 | 100 | | PP = 4.5+ tsf | | | |
| 20 | ST8 | 100 | | PP = 4.5+ tsf | | | |
| | | | | | | | 22.0 527.8 |
| | ST9 | 100 | | PP = 4.5+ tsf | CH | | (CH) Sandy Clay, brown/grey, hard, moist, calcareous |
| 25 | ST10 | 100 | | PP = 4.5+ tsf | | | Calcite and quartz throughout 24-26 ft |
| | ST11 | 100 | | PP = 4.5+ tsf | | | Color change to brown at 32 feet |
| | | | | | | | Color change to dark brown at 36 feet |
| | ST12 | 100 | | PP = 4.5+ tsf | | | Shale pieces throughout 36-38 feet |
| 30 | ST13 | 100 | | PP = 4.5+ tsf | | | |
| | ST14 | 100 | | PP = 4.5+ tsf | | | |
| 35 | | | | | | | |

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# BORING NUMBER B-2 (A-2)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|---|
| 35 | ST15 | 100 | | PP = 4.5+ tsf | CH | | | |
| | ST16 | 100 | | PP = 4.5+ tsf | | | 38.0 | 511.8 |
| 40 | ST17 | 188 | | PP = 4.5+ tsf weathered/unweathered zone | | | Shale, dark grey, with limestone lenses throughout, hard, calcareous | |
| 45 | | 90 | | PP = 4.5+ tsf | | | | |
| 50 | | 100 | | PP = 4.5+ tsf | | | | |
| 55 | | 100 | | PP = 4.5+ tsf | | | 55.0 | 494.8 |

Bottom of borehole at 55.0 feet.

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# BORING NUMBER B-3 (A-3)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 1/31/18 **COMPLETED** 1/31/18
**GROUND ELEVATION** 541.1 ft **HOLE SIZE** 7.25 inches
**DRILLING CONTRACTOR** West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Hollow stem auger/air rotary
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Millbrand **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|
| 0 | | | | | | |
| | ST1 | 50 | PP = 4.5+ tsf | | Topsoil | |
| | | | | | 2.0 | 539.1 |
| | ST2 | 100 | PP = 4.5+ tsf | | Clay, brown/redbrown, with chalk layers, moist, hard | |
| | | | | | Pebbles 2-4 ft | |
| 5 | ST3 | 80 | PP = 4.5+ tsf | | | |
| | ST4 | 90 | PP = 4.5+ tsf | | 8.0 | 533.1 |
| | ST5 | 100 | PP = 4.5+ tsf | | Clay, mottled red/gray/brown, with saturated fine sand layers, hard, moist | |
| 10 | | | | | Increasing hardness with depth | |
| | ST6 | 90 | PP = 4.5+ tsf | | Shale pieces at 30 ft | |
| | ST7 | 100 | PP = 4.5+ tsf | | Mineral deposits at 26 ft | |
| 15 | ST8 | 100 | PP = 4.5+ tsf | | | |
| | ST9 | 100 | PP = 4.5+ tsf | | | |
| | ST10 | 80 | PP = 4.5+ tsf | | | |
| 20 | ST11 | 100 | PP = 4.5+ tsf | | | |
| | ST12 | 70 | PP = 4.5+ tsf | | | |
| 25 | | | | | | |
| | ST13 | 90 | PP = 4.5+ tsf | | | |
| | ST14 | 100 | PP = 4.5+ tsf | | | |
| 30 | ST15 | 100 | PP = 4.5+ tsf | | 32.0 | 509.1 |
| | ST16 | 100 | PP = 4.5+ tsf | | Sand, brown/gray, with minor clay and mineral deposit layers, saturated, soft | |
| | | | | | 34.0 | 507.1 |
| 35 | | | | | No Recovery | |

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# BORING NUMBER B-3 (A-3)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|
| 35 | | | | | No Recovery *(continued)* |
| | | | | | 38.0 503.1 |
| 40 | ST17 | 100 | PP = 4.5+ tsf Weathered to unweathered zone | | Shale, dark gray to black, hard, dry, calcareous, with limestone and fine sand layers up to 1/8" thick |
| | | 98 | PP = 4.5+ tsf | | Very little sand 40-45 feet.<br>Limestone layer 1/2 thick at 45 feet. |
| 45 | | | | | More sand layers 1/8" thick throughout at 65 feet.<br>Fossil fragments 70-72 feet. |
| | | 97 | PP = 4.5+ tsf | | |
| 50 | | | | | |
| | | 100 | PP = 4.5+ tsf | | |
| 55 | | | | | |
| | | 100 | PP = 4.5+ tsf | | |
| 60 | | | | | |
| | | 98 | PP = 4.5+ tsf | | |
| 65 | | | | | |
| | | 98 | PP = 4.5+ tsf | | |
| 70 | | | | | |
| | | 100 | PP = 4.5+ tsf | | |
| | | | | | 72.0 469.1 |
| | | | | | Bottom of borehole at 72.0 feet. |

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# WELL NUMBER B-3 (PZ-3)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/10/18 **COMPLETED** 10/10/18
**GROUND ELEVATION** 541.2 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** 30.46 ft / Elev 510.74 ft No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|
| 0 | | | 0-20 feet logged from previous drilling in January 2018 | | | Topsoil | |
| | | | | | | 2.0 / 539.2 | |
| | | | | CL | | (CL) Clay, brown/redbrown, with chalk layers, moist, hard | |
| 5 | | | | | | Pebbles 2-4 ft | |
| | | | | | | 8.0 / 533.2 | |
| | | | | CL | | (CL) Clay, mottled red/gray/brown, with saturated fine sand layers, hard, moist | |
| 10 | | | | | | Increasing hardness with depth | |
| | | | | | | Shale pieces at 30 ft | |
| 15 | | | | | | Mineral deposits at 26 ft | |
| 20 | | | | | | 20.0 / 521.2 | |
| | | 52 | PP <1-4.5+ tsf | SP-SC | | (SP-SC) Sand, brown, soft, moist to wet, with traces of clay, fine to medium grained | |
| | | | | | | 22.6 / 518.6 | |
| | | | | | | 22.8 / 518.4 Silty Clay, dark brown, hard to stiff, moist | |
| 25 | | | | CL | | (CL) Silty Clay, orange-brown mottled brown, hard, slightly moist, calcareous, with weathered shale | |
| | | 78 | PP = 4.5+ tsf MC = 18% LL = 60 PL = 24 Fines = 93% | | | 27.0 / 514.2 | |
| 30 | | | | | | Silty Clay Shale, gray with orange-brown staining, very hard, slightly moist, calcareous, with mineral desposits in fractures, weathered | |
| | | | | | | No mineral deposits 35-39 feet | |
| 35 | | 74 | PP = 4.5+ tsf | | | | |

(Continued Next Page)

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# WELL NUMBER B-3 (PZ-3)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|
| 35 | | | | | | | |
| | | 56 | PP = 4.5+ tsf<br><br>Weathered to Unweathered zone | | | Silty Clay Shale, gray with orange-brown staining, very hard, slightly moist, calcareous, with mineral desposits in fractures, weathered<br><br>No mineral deposits 35-39 feet *(continued)* | |
| 40 | | | | | | 39.0 502.2<br>Silty Clay Shale, dark gray, very hard, slightly moist to dry, calcareous, unweathered | |
| | | 70 | PP = 4.5+ tsf<br>MC = 16%<br>LL = 63<br>PL = 20<br>Fines = 96% | | | | |
| 45 | | | | | | 45.0 496.2 | |

Bottom of borehole at 45.0 feet.

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# BORING NUMBER B-4 (A-4)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 1/23/18 **COMPLETED** 1/23/18
**GROUND ELEVATION** 550.04 ft **HOLE SIZE** 7.25 inches
**DRILLING CONTRACTOR** West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Hollow stem auger/air rotary
▽ **AT TIME OF DRILLING** 48.77 ft / Elev 501.27 ft
**LOGGED BY** T. Millbrand **CHECKED BY** J. Lawrence
▼ **AT END OF DRILLING** 96.59 ft / Elev 453.45 ft
**NOTES**
**AFTER DRILLING** ---

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|---|
| 0 | ST1 | 75 | | PP = 0 tsf<br>MC = 24%<br>LL = 67<br>PL = 46<br>Fines = 71% | SC | | (SC) Topsoil/Fill material | |
| 2.0 | | | | | | | | 548.0 |
| | SPT1 | 75 | 2-3-5 (8) | | | | Topsoil/Fill material, with dakr brown clay, soft, moist | |
| 4.0 | | | | PP = 4.0 tsf | | | | 546.0 |
| 5 | ST2 | 50 | | PP = 4.5+ tsf | | | (CH) Clay, dark brown, hard, moist, calcareous | |
| | ST3 | 75 | | PP = 4.5+ tsf | | | Color change to light brown at 8 feet. | |
| | ST4 | 50 | | PP = 4.5+ tsf | | | Pebbles throughout 8-10 ft | |
| 10 | ST5 | 50 | | PP = 4.5+ tsf<br>MC = 21%<br>LL = 75<br>PL = 51 | | | Color change to mottled brown/grey at 16 feet | |
| | ST6 | 70 | | PP = 4.5+ tsf | | | Sand lenses throughout 18-20 feet | |
| 15 | ST7 | 60 | | PP = 4.5+ tsf | CH | | | |
| | ST8 | 80 | | PP = 4.5+ tsf | | | | |
| | ST9 | 75 | | PP = 4.5+ tsf | | | | |
| 20 | ST10 | 80 | | PP = 4.5+ tsf<br>MC = 18% | | | | |
| | ST11 | 80 | | PP = 4.5+ tsf<br>MC = 21%<br>LL = 74<br>PL = 53 | | | | |
| 25 | ST12 | 80 | | PP = 4.5+ tsf | | | | |
| | ST13 | 80 | | PP = 4.5+ tsf | | | | |
| 28.0 | | | | | | | | 522.0 |
| | ST14 | 50 | | PP = 4.5+ tsf<br>Weathered to unweathered zone | | | Clayey shale, dark grey, fissile, calcareous | |
| 30.0 | | | | | | | | 520.0 |
| | ST15 | 100 | | PP = 4.5+ tsf | | | Shale, dark grey to black, with limestone lenses, hard, calcareous | |
| | | 85 | | PP = 4.5+ tsf<br>MC = 13%<br>LL = 55<br>PL = 37 | | | Sand lenses throughout<br>Fossil fragments throughout | |
| 35 | | | | | | | | |

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# BORING NUMBER B-4 (A-4)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 35 | | | | MC = 14% | | | Shale, dark grey to black, with limestone lenses, hard, calcareous |
| | | 98 | | PP = 4.5+ tsf | | | Sand lenses throughout<br>Fossil fragments throughout *(continued)* |
| 40 | | | | | | | |
| | | 98 | | PP = 4.5+ tsf | | | |
| 45 | | | | | | | |
| | | 98 | | PP = 4.5+ tsf<br>MC = 13%<br>LL = 62<br>PL = 44 | | | ▽ |
| 50 | | | | | | | |
| | | 98 | | PP = 4.5+ tsf | | | |
| 55 | | | | | | | |
| | | 98 | | PP = 4.5+ tsf | | | |
| 60 | | | | | | | |
| | | 97 | | PP = 4.5+ tsf | | | |
| 65 | | | | | | | |
| | | 98 | | PP = 4.5+ tsf | | | |
| 70 | | | | | | | |
| | | 98 | | PP = 4.5+ tsf | | | |
| 75 | | | | | | | |

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# BORING NUMBER B-4 (A-4)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 75 | | | | | | | Shale, dark grey to black, with limestone lenses, hard, calcareous |
| | | | | | | | Sand lenses throughout |
| | | | | | | | Fossil fragments throughout *(continued)* |
| 80 | | 100 | | PP = 4.5+ tsf | | | |
| 85 | | 98 | | PP = 4.5+ tsf | | | |
| 90 | | 99 | | PP = 4.5+ tsf<br>MC = 14%<br>LL = 74<br>PL = 53 | | | |
| 95 | | 100 | | PP = 4.5+ tsf | | | |
| 100 | | 99 | | PP = 4.5+ tsf | | | |
| | | | | | | | 101.0 449.0 |
| | | | | | | | Bottom of borehole at 101.0 feet. |

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# BORING NUMBER B-5 (A-5)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 1/25/18 **COMPLETED** 1/25/18
**GROUND ELEVATION** 541.38 ft **HOLE SIZE** 7.25 inches
**DRILLING CONTRACTOR** West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Hollow stem auger/air rotary
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Millbrand **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater, but muddy probe
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|---|
| 0 | SS1 | 90 | 4-11-10 (21) | | SC | | (SC) Topsoil/ Fill Material | |
| | | | | | | | No recovery 1.5-2 feet | |
| | | | | | | | 2.0 | 539.4 |
| | SS2 | 60 | 4-7-8 (15) | | | | Fill Material | |
| | | | | | | | No recovery 3.5-4 | |
| | | | | | | | 4.0 | 537.4 |
| 5 | SS3 | 50 | 4-6-8 (14) | | | | Fill material, dark brown, with clay, hard, moist | |
| | | | | | | | No reocvery 5.5-6 feet | |
| | | | | | | | 6.0 | 535.4 |
| | ST1 | 60 | | | CH | | (CH) Clay, light brown, with fill material, hard, moist, calcareous | |
| | | | | | | | Color change to mottled brown/grey at 8 feet | |
| 10 | ST2 | 40 | | | | | 10.0 | 531.4 |
| | ST3 | 70 | | | CH | | (CH) Clay, mottled light brown/grey, with fine sand, hard, moist, calcareous | |
| | ST4 | 100 | | MC = 16%<br>LL = 62<br>PL = 41 | | | Color change to light reddish brown at 14 feet | |
| 15 | ST5 | 40 | | | | | | |
| | ST6 | 40 | | | | | 18.0 | 523.4 |
| | ST7 | 60 | | | CH | | (CH) Clay, reddish brown, with grey sand, hard, moist, calcareous | |
| 20 | | | | | | | Calcite and Quartz throughout | |
| | ST8 | 95 | | | | | | |
| | ST9 | 80 | | MC = 18%<br>LL = 66<br>PL = 46 | | | | |
| 25 | ST10 | 60 | | | | | 26.0 | 515.4 |
| | ST11 | 70 | | Weathered to unweathered zone | | | Shale, dark grey to black, with limestone lenses, hard, calcareous | |
| | | | | | | | Silty sand lenses throughout | |
| 30 | ST11 | 50 | | | | | Fossil fragments 30-35 feet | |
| | | 93 | | MC = 17%<br>LL = 63<br>PL = 42 | | | | |
| 35 | | | | | | | | |

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# BORING NUMBER B-5 (A-5)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 35 | | | | | | | Shale, dark grey to black, with limestone lenses, hard, calcareous |
| | | 100 | | | | | Silty sand lenses throughout |
| | | | | | | | Fossil fragments 30-35 feet *(continued)* |
| 40 | | | | | | | |
| | | 95 | | | | | |
| 45 | | | | | | | |
| | | 100 | | | | | |
| | | | | | | 47.8 | 493.6 |

Bottom of borehole at 47.8 feet.

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# BORING NUMBER B-6



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/25/18 **COMPLETED** 10/26/18
**GROUND ELEVATION** 545.55 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0 | | | | | | |
| 5 | | 50 | PP = 2.0-3.5 tsf | CL-ML | | (CL-ML) Silty Clay, brown to reddish brown with orange-brown staining, soft to stiff, moist, with traces of gravel, organic |
| | | | | | | 5.0 540.6 |
| 10 | ST1 | 50 / 45 | PP = 4.5 tsf | CL-ML | | (CL-ML) Silty Clay, orange-brown mottled gray, hard, slightly moist, slightly calcareous<br>Chalk in fractures/joints 5-10 feet<br>Silty lenses 10-15 feet |
| 15 | ST2 | 50 / 50 | PP = 4.0 tsf | | | |
| | | | | | | 15.0 530.6 |
| 20 | ST3 | 38 / 66 | PP = 4.5 tsf | CL | | (CL) Silty Clay, orange-brown mottled brown-tan with some gray, hard, slightly moist, slightly calcareous, with weathered shale |
| | ST4 | 29 / 70 | PP = 4.5+ tsf Weathered to Unweathered zone | | | 22.5 523.1 |
| 25 | | | | | | Silty Shale, gray to dark gray, very hard, slightly moist, calcareous<br>Orange-brown staining at 22.5-23.5 feet<br>Thin limestone layers in fractures at 30-50 feet<br>Shells at 50-51 feet |
| 30 | ST5 | 21 / 84 | PP = 4.5+ tsf | | | |
| 35 | ST6 | 21 / 84 | PP = 4.5+ tsf | | | |

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# BORING NUMBER B-6



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | | | | | |
| | ST7 | 17 / 98 | PP = 4.5+ tsf | | | Silty Shale, gray to dark gray, very hard, slightly moist, calcareous |
| 40 | | 80 | PP = 4.5+ tsf | | | Orange-brown staining at 22.5-23.5 feet<br>Thin limestone layers in fractures at 30-50 feet<br>Shells at 50-51 feet *(continued)* |
| 45 | ST8 | 21 / 84 | PP = 4.5+ tsf | | | |
| 50 | | 80 | PP = 4.5+ tsf | | | |
| 55 | ST9 | 17 / 100 | PP = 4.5+ tsf | | | |
| 60 | | 94 | PP = 4.5+ tsf | | | |
| 65 | | 80 | PP = 4.5+ tsf | | | |
| 70 | ST10 | 29 | | | | 70.7 474.9<br>Bottom of borehole at 70.0 feet. |

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# BORING NUMBER B-7



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 1/9/19 **COMPLETED** 1/9/19
**GROUND ELEVATION** 530.5 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** 31.00 ft / Elev 499.50 ft

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | |
| 5 | | 62 | PP = 1.5-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, dark brown to olive brown, soft to hard, moist, with trace gravel | |
| | | | | | | 5.0 | 525.5 |
| 10 | | 100 | PP = 2.0-3.0 tsf | CL-ML | | (CL-ML) Silty Clay, olive brown to brown with some orange-brown and gray mottling, firm to stiff, moist, with trace sub-angular gravel and pebbles | |
| | | | | | | 10.0 | 520.5 |
| 15 | | 50 | PP = 3.5-4.0 tsf | CL-ML | | (CL-ML) Silty Clay, orange-brown mottled gray and brown, stiff, slightly moist to moist, calcareous | |
| 20 | | 52 | PP = 4.0-4.5 tsf | | | 19.0 | 511.5 |
| 25 | | 60 | PP = 4.5+ tsf<br>Weathered to Unweathered zone | | | Shale Marl, dark gray with trace of orange-brown mottling, hard to stiff, slightly moist, with silty/limey lenses, calcareous<br><br>Weathered to unweathered transition zone | |
| | | | | | | 24.0 | 506.5 |
| 30 | | 60 | PP = 4.5+ tsf | | | Shale Marl, dark gray, hard, slightly moist, with silty/limey lenses and fossils, calcareous, unweathered<br><br>Very wet zones 31-32 feet | |
| 35 | | 86 | PP = 4.5+ tsf | | | | |

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# BORING NUMBER B-7



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | 60 | PP = 4.5+ tsf | | | Shale Marl, dark gray, hard, slightly moist, with silty/limey lenses and fossils, calcareous, unweathered<br><br>Very wet zones 31-32 feet *(continued)* |
| 40 | | 50 | PP = 4.5+ tsf | | | |
| 45 | | 80 | PP = 4.5+ tsf | | | |
| 50 | | 50 | PP = 4.5+ tsf | | | |
| 55 | | | | | | 55.0 475.5<br>Bottom of borehole at 55.0 feet. |

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# WELL NUMBER B-8 (PZ-8)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 11/27/18 **COMPLETED** 11/28/18
**GROUND ELEVATION** 550.8 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | Clayey Silt, dark brown, firm, moist, with roots and organics | |
| 1.5 | | | | | | | | 549.3 |
| 5 | | 100 | | PP = 2.0-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, gray to light gray, stiff to hard, moist to slightly moist, with white calcareous chalky material<br><br>Trace of light gravel and orange-brown staining 6.5-10 feet | |
| | ST1 | 38 | 11-20-23 (43) | PP = 4.0-4.5+ tsf | | | | |
| | SS1 | 100 | | | | | | |
| 10 | | 100 | | | | | | |
| 10.0 | | | | | | | | 540.8 |
| | ST2 | 50 | | PP = 3.5 tsf<br>LL = 67<br>PL = 17<br>Fines = 85% | CL-ML | | (CL-ML) Silty Clay, orange-brown stained gray and brown, stiff to hard, slighty moist, calcareous, with white chalky material and silty gray interbeds | |
| 15 | | 63 | | | | | | |
| | ST3 | 33 | 20-26-35 (61) | | | | | |
| | SS2 | 100 | | PP = 4.0-4.5 tsf | | | | |
| 20 | | 93 | | | | | | |
| 20.0 | | | | | | | | 530.8 |
| | ST4 | 21 | | PP = 4.5 tsf | | | Silty Clay (Weathered Shale Marl), orange-brown mottled gray and brown, hard, slighty moist, calcareous<br><br>White chalky material and silty gray interbeds 20-25 feet<br><br>Crystalline material in joints/bedding 35-43.8 feet | |
| 25 | | 56 | | | | | | |
| | ST5 | 29 | 18-29-43 (72) | | | | | |
| | SS3 | 100 | | PP = 4.5-4.5+ tsf | | | | |
| 30 | | 64 | | | | | | |
| | ST6 | 21 | | PP = 4.5 tsf | | | | |
| 35 | | 67 | | | | | | |

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# WELL NUMBER B-8 (PZ-8)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|---|
| 35 | | | | | | | | |
| | ST7 | 21 | 15-24-28 (52) | | | | Silty Clay (Weathered Shale Marl), orange-brown mottled gray and brown, hard, slighty moist, calcareous | |
| | SS4 | 100 | | PP = 4.0-4.5+ tsf | | | White chalky material and silty gray interbeds 20-25 feet | |
| 40 | | | | | | | Crystalline material in joints/bedding 35-43.8 feet *(continued)* | |
| | ST8 | 25 | | PP = 4.5+ tsf<br>MC = 16%<br>DD = 106 pcf<br>LL = 58<br>PL = 20<br>Fines = 92%<br>Weathered to Unweathered zone | | | | |
| | | 68 | | | | | 43.8 | 507.0 |
| 45 | | | | | | | Silty Clay Shale Marl, gray, hard, slightly moist, calcareous, with silty/micaceous lenses and fossil remnants in interbeds, unweathered | |
| | ST9 | 17 | 28-50 | | | | | |
| | | 78 | | | | | Orange-brown staining 47-55 feet | |
| | SS5 | 100 | | PP = 4.5+ tsf | | | | |
| 50 | | | | | | | | |
| | ST10 | 17 | | PP = 4.5+ tsf<br>MC = 14%<br>DD = 116 pcf<br>LL = 58<br>PL = 20<br>Fines = 97% | | | | |
| | | 70 | | | | | | |
| 55 | | | | | | | | |
| | ST11 | 17 | | | | | | |
| | | 93 | | PP = 4.5+ tsf | | | | |
| 60 | | | | | | | | |
| | | 100 | | PP = 4.5+ tsf | | | | |
| 65 | | | | | | | | |
| | ST12 | 17 | | | | | | |
| | | 61 | | PP = 4.5+ tsf | | | | |
| 70 | | | | | | | | |
| | | 70 | | PP = 4.5+ tsf | | | | |
| 75 | | | | | | | 75.0 | 475.8 |

Bottom of borehole at 75.0 feet.

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# BORING NUMBER B-9 (new/ continued)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 12/12/19 **COMPLETED** 12/13/19
**GROUND ELEVATION** 535.3 ft **HOLE SIZE** 1.9 inches
**DRILLING CONTRACTOR** BEST Drilling; West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** ---
**LOGGED BY** A. Boudreaux **CHECKED BY** J. Lawrence
**AT END OF DRILLING** ---
**NOTES**
**AFTER DRILLING** ---

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0 | | | | | | |
| | | 92 | LL = 60<br>PL = 39<br>Fines = 82%<br>PP = 2.0-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, dark brown to gray, stiff, slightly moist to moist, organic rich, with limestone fragments and shells<br><br>Color change to gray at 2.5 feet |
| 5 | | | | | | 5.0 530.3 |
| | ST1 | 40<br>78 | PP = 4.5+ tsf<br>MC = 15%<br>LL = 53<br>PL = 18<br>Fines = 75% | CL-ML | | (CL-ML) Silty Clay, light gray/tan mottled orange-brown, hard, slightly moist, with minor sub-round gravel |
| 10 | | | | | | 10.0 525.3 |
| | ST2 | 36<br>44 | PP = 4.5+ tsf | | | Silty Clay Shale, gray and orange-brown mottled yellow-brown, hard, slightly moist to dry, calcareous, with trace of gravel<br><br>Chalk/limestone in joints 15-20 feet<br><br>Color change to orange-brown mottled gray at 20 feet<br><br>Limestone lenses in fracture |
| 15 | | | | | | |
| | ST3 | 24<br>57 | PP = 4.5+ tsf | | | |
| 20 | | | | | | |
| | ST4 | 24<br>57 | PP = 4.5+ tsf<br>MC = 20%<br>LL = 67<br>PL = 20<br>Fines = 91% | | | |
| 25 | | | | | | |
| | ST5 | 20<br>67 | PP = 4.5+ tsf<br>Weathered to Unweathered zone | | | 28.5 506.8 |
| 30 | | | | | | Silty Clay Shale, very hard, dry, calcareous, with carbonate rich lenses in fractures<br><br>Orange-brown staining in joints 28.5-20 feet |
| | ST6 | 20<br>67 | PP = 4.5+ tsf | | | |
| 35 | | | | | | |

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# BORING NUMBER B-9 (new/ continued)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | | | | | |
| | ST7 | 16<br>87 | PP = 4.5+ tsf<br>MC = 15%<br>LL = 62<br>PL = 20<br>Fines = 89% | | | Silty Clay Shale, very hard, dry, calcareous, with carbonate rich lenses in fractures<br>Orange-brown staining in joints 28.5-20 feet *(continued)* |
| 40 | | | | | | 40.0 495.3 |
| | | | | | | 40-45' no sample recovery |
| 45 | | | | | | 45.0 490.3 |
| | | | | | | Shale, minor fine sand, dark gray, hard to very hard, damp to moist, laminated |
| 50 | | | | | | |
| 55 | | | MC = 15%<br>LL = 63<br>PL = 41<br>Fines = 99% | | | |
| 60 | | | | | | |
| 65 | | | | | | |
| 70 | | | | | | |
| 75 | | | | | | |

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# BORING NUMBER B-9 (new/ continued)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 75 | | | MC = 14%<br>LL = 64<br>PL = 42<br>Fines = 93% | | | Shale, minor fine sand, dark gray, hard to very hard, damp to moist, laminated *(continued)*<br>Small fossils present from 75-80' |
| 80 | | | | | | becoming harder with depth |
| 85 | | | | | | |
| 90 | | | | | | fewer laminations with depth |
| 95 | | | | | | |
| 100 | | | | | | |
| 105 | | | LL = 73<br>PL = 51<br>Fines = 97% | | | |
| 110 | | | | | | very hard, moist, trace of laminations |
| 115 | | | | | | |

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# BORING NUMBER B-9 (new/ continued)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 115 | | | | | | Shale, minor fine sand, dark gray, hard to very hard, damp to moist, laminated *(continued)* |
| 120 | | | | | | becoming harder with depth |
| 125 | | | | | | fewer laminations with depth |
| 130 | | | MC = 16%<br>LL = 74<br>PL = 49<br>Fines = 89% | | | very hard, moist, scarce laminations |
| 135 | | | | | 135.0 | 400.3 |

Bottom of borehole at 135.0 feet.

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# WELL NUMBER B-9 (PZ-9)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/9/18 **COMPLETED** 10/10/18
**GROUND ELEVATION** 535.3 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
▽ **AT TIME OF DRILLING** 25.10 ft / Elev 510.20 ft
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** ---
**NOTES**
**AFTER DRILLING** ---

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | |
| 5 | | 92 | LL = 60<br>PL = 39<br>Fines = 82%<br>PP = 2.0-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, dark brown to gray, stiff, slightly moist to moist, organic rich, with limestone fragments and shells<br><br>Color change to gray at 2.5 feet | |
| 10 | ST1 | 40<br>78 | PP = 4.5+ tsf<br>MC = 15%<br>LL = 53<br>PL = 18<br>Fines = 75% | CL-ML | | 5.0 530.3<br>(CL-ML) Silty Clay, light gray/tan mottled orange-brown, hard, slightly moist, with minor sub-round gravel | |
| 15 | ST2 | 36<br>44 | PP = 4.5+ tsf | | | 10.0 525.3<br>Silty Clay Shale, gray and orange-brown mottled yellow-brown, hard, slightly moist to dry, calcareous, with trace of gravel<br><br>Chalk/limestone in joints 15-20 feet | |
| 20 | ST3 | 24<br>57 | PP = 4.5+ tsf | | | Color change to orange-brown mottled gray at 20 feet<br><br>Limestone lenses in fractures 25-28.5 feet | |
| 25 | ST4 | 24<br>57 | PP = 4.5+ tsf<br>MC = 20%<br>DD = 105 pcf<br>LL = 67<br>PL = 20<br>Fines = 91% | | | ▽ | |
| 30 | ST5 | 20<br>67 | PP = 4.5+ tsf<br>Weathered to Unweathered zone | | | 28.5 506.8<br>Silty Clay Shale, very hard, dry, calcareous, with carbonate rich lenses in fractures<br><br>Orange-brown staining in joints 28.5-20 feet | |
| 35 | ST6 | 20<br>67 | PP = 4.5+ tsf | | | | |

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# WELL NUMBER B-9 (PZ-9)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|
| 35 | | | | | | | |
| | ST7 | 16 / 87 | PP = 4.5+ tsf<br>MC = 15%<br>DD = 116 pcf<br>LL = 62<br>PL = 20<br>Fines = 89% | | | Silty Clay Shale, very hard, dry, calcareous, with carbonate rich lenses in fractures<br><br>Orange-brown staining in joints 28.5-20 feet *(continued)* | |
| 40 | | | | | 40.0 | 495.3 | |

Bottom of borehole at 40.0 feet.

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# BORING NUMBER B-10



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 12/13/18 **COMPLETED** 12/13/18
**GROUND ELEVATION** 548 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | MH | | (MH) Clayey Silt to Silty Clay, brown, soft to firm, moist, with roots and organics 1.0 547.0 |
| 5 | | 80 | | PP = 1.0-4.5 tsf | CL-ML | | (CL-ML) Silty Clay, brown, stiff, moist, with traces of sub-rounded gravel and roots 4.5 543.5 |
| 10 | ST1 / SS1 | 33 / 94 / 100 | 15-20-26 (46) | PP = 4.0-4.5 tsf | | | (CL-ML) Silty Clay, orange-brown mottled brown and gray, stiff, moist, with silty to very fine sand lenses and white chalky material<br>Crystalline pockets 30-34 feet |
| 15 | ST2 | 33 / 71 | | PP = 4.5 tsf<br>MC = 19%<br>LL = 65<br>PL = 24<br>Fines = 90% | | | |
| 20 | ST3 / SS2 | 21 / 100 / 100 | 20-30-37 (67) | PP = 4.0-4.5 tsf | CL-ML | | |
| 25 | ST4 | 21 / 56 | | PP = 4.0-4.5 tsf | | | |
| 30 | ST5 / SS3 | 21 / 100 / 100 | 17-27-34 (61) | PP = 4.0-4.5 tsf<br>MC = 15%<br>DD = 108 pcf<br>LL = 54<br>PL = 21<br>Fines = 94% | | | |
| 35 | ST6 | 21 / 78 | | PP = 4.5 tsf | | | 34.0 514.0 |

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# BORING NUMBER B-10



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 35 | ST7 | 21 | 50 | Weathered to Unweathered zone | | | 36.0 Shale Marl, gray, hard, slightly moist, with occasional orange-brown staining and silty lenses, calcareous, weathered 512.0 |
| | | 28 | | | | | |
| | SS4 | 100 | | PP = 4.5+ tsf | | | Transition zone *(continued)* |
| 40 | | | | | | | Shale Marl, gray, hard, slightly moist, with fossil remnants and silty/limey lenses, calcareous, unweathered |
| | ST8 | 17 | | PP = 4.5+ tsf<br>MC = 14%<br>LL = 59<br>PL = 20<br>Fines = 92% | | | |
| 45 | | 87 | | | | | |
| | SS5 | 17 | 34-50 | | | | |
| | | 95 | | PP = 4.5+ tsf | | | |
| 50 | | 33 | | PP = 4.5+ tsf | | | 53.0 495.0 |

Bottom of borehole at 53.0 feet.

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# BORING NUMBER B-11



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 11/5/18 **COMPLETED** 11/5/18
**GROUND ELEVATION** 553.5 ft **HOLE SIZE** 7.25 inches
**DRILLING CONTRACTOR** West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** A. Valerio **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | |
| | | | | | | Topsoil, dark brown | |
| 1.0 | | | | | | | 552.5 |
| | | 95 | PP = 1.5-3.5 tsf | CL | | (CL) Clay, dark brown to orange-tan, medium firm, with some organic material | |
| 5 | | | | | | 5.0 | 548.5 |
| | ST1 | 100 | PP = 0-4.5+ tsf | CL | | (CL) Clay, orange brown, very soft to very hard, dry, with minor silt | |
| 10 | | | | | | 10.0 | 543.5 |
| | ST2 | 100 | PP = 2.5-4.5+ tsf | CL | | (CL) Clay, medium brown, firm to hard, dry, with minor orange silt | |
| 15 | | | | | | | |
| | ST3 | 75 | PP = 2.5-4.0 tsf | | | | |
| 20 | | | | | | 20.0 | 533.5 |
| | ST4 | 50 | PP = 1.0-3.5 tsf<br>MC = 21%<br>DD = 95 pcf<br>LL = 75<br>PL = 26<br>Fines = 89% | CL | | (CL) Clay, medium to dark brown, firm to moderately firm, dry, with minor orange and gray silt | |
| 25 | | | | | | 25.0 | 528.5 |
| | ST5 | 93 | PP = 0.5-4.5+ tsf<br>Weathered to Unweathered zone | CL | | (CL) Clay, dark gray, soft to very firm, dry, with minor orange silt | |
| 30 | | | | | | 30.0 | 523.5 |
| | ST6 | 75 | PP = 4.0-4.5+ tsf | CL | | (CL) Clay, very dark gray, very firm, with minor light gray silt and pebbles<br><br>Sand/Silt parting at 33 feet | |
| 35 | | | | | | 35.0 | 518.5 |

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GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 10/2/20 13:41 - Z:\GIL\GINT FILES\WACO LANDFILL\SITE 50 WACO REV.GPJ

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# BORING NUMBER B-11



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | | | | | |
| | ST7 | 75 | PP = 2.0-4.5+ tsf | CL | | (CL) Clay, very dark gray, medium firm to very firm, dry, with some very dark gray weathered shale |
| 40 | | | | | | Minor silty sand 40-45 feet |
| | | 95 | PP = 3.5-4.5+ tsf | | | Limey, white, calcareous, pebbles up to 1/2" at 54 feet |
| 45 | | | | | | Minor calcareous silt with few pebbles up to 1/8" at 58 feet |
| | ST8 | 95 | PP = 3.5-4.5+ tsf<br>MC = 13%<br>DD = 120 pcf<br>LL = 55<br>PL = 22<br>Fines = 86% | | | Minor limey pebbles <1/8" at 67 feet |
| 50 | | | | | | Minor calcareous silt and pebbles <1/8" 70-75 feet |
| | | 75 | PP = 0.5-4.5+ tsf | | | |
| 55 | | | | | | |
| | ST9 | 95 | PP = 0.5-4.5 tsf | | | |
| 60 | | | | | | |
| | | 98 | PP = 1.5-4.5+ tsf | | | |
| 65 | | | | | | |
| | ST10 | 95 | PP = 1.0-4.5+ tsf | | | |
| 70 | | | | | | |
| | | 99 | PP = 0.5-4.5+ tsf | | | |
| 75 | | | | | | |

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# BORING NUMBER B-11



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 75 | | | | | | |
| 80 | | 99 | PP = 0.5-4.5+ tsf | CL | 80.0 | 473.5 |

Bottom of borehole at 80.0 feet.

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# BORING NUMBER B-12



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/12/18 **COMPLETED** 10/12/18
**GROUND ELEVATION** 542.85 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0 | | | | | | |
| 5 | | 93 | PP = 1.5-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, brown, soft to firm, slightly moist to moist<br>Organic 0-5 feet<br>Shell fragments 3-5 feet<br>Minor amounts of small sub-rounded gravel 3-10 feet |
| 10 | ST1 | 38<br>68 | PP = 4.5+ tsf | CL-ML | | 5.0 537.9<br>Mineral deposits in joints/bedding 5-10 feet<br>(CL-ML) Silty Clay, brown, soft to firm, slightly moist to moist<br>Organic 0-5 feet<br>Shell fragments 3-5 feet<br>Minor amounts of small sub-rounded gravel 3-10 feet |
| 15 | ST2 | 29<br>50 | PP = 4.5+ tsf | CL-ML | | 10.0 532.9<br>Mineral deposits in joints/bedding 5-10 feet<br>(CL-ML) Silty Clay, orange-brown mottled gray, hard, slightly moist, with traces of roots/organics, calcareous<br>Mineral desposits in fractures and traces of gravel 10-15 feet<br>Very fine sandy lenses in fractures 15-20 feet |
| 20 | ST3 | 21<br>50 | PP = 4.5+ tsf | CL-ML | | |
| 25 | ST4 | 21<br>60 | PP = 4.5+ tsf | CL | | 20.0 522.9<br>(CL) Silty Clay, orange-brown mottled brown to light gray, hard, slightly moist, calcareous, with weathered shale<br>Very fine sandy lenses 20-25 feet |
| 30 | ST5 | 38<br>60 | Weathered to Unweathered zone<br>PP = 4.5+ tsf | | | 26.5 516.4<br>Silty Clay Shale, dark gray, moderately to very hard, slightly moist, calcareous<br>Sandy lenses 26.5-30 feet<br>Trace of shell fragments 30-35 feet |
| 35 | ST6 | 17<br>100 | PP = 4.5+ tsf | | | Much softer and more calcareous 40-45 feet<br>Very hard 45-48 feet |

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# BORING NUMBER B-12



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | | | | | Silty Clay Shale, dark gray, moderately to very hard, slightly moist, calcareous |
| | ST7 | 21 | PP = 3.5-4.5+ tsf | | | Sandy lenses 26.5-30 feet |
| | | 50 | | | | Trace of shell fragments 30-35 feet |
| 40 | | | | | | Much softer and more calcareous 40-45 feet |
| | | 66 | PP = 1.5-2.5 tsf | | | Very hard 45-48 feet *(continued)* |
| 45 | | | | | | |
| | ST8 | 100 25 | PP = 4.5+ tsf | | | |
| | | | | | 48.0 | 494.9 |

Bottom of borehole at 48.0 feet.

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# BORING NUMBER B-13



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 11/29/18 **COMPLETED** 12/4/18
**GROUND ELEVATION** 555.15 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | 0.5 Silt, brown, soft, slightly moist, organic 554.7 |
| 5 | | 56 | | PP = 2.5-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, brown to orange-brown stained brown and gray, firm, with traces of sub-rounded gravel and chalk 5.0 550.2 |
| 10 | ST1 | 100<br>76 | 9-14-21 (35) | PP = 3.5-4.0 tsf | CL-ML | | (CL-ML) Silty Clay, orange-brown stained brown and gray, stiff to hard, slightly moist, calcareous, with silty lenses in interbeds, weathered<br>White chalky material 5-10 feet<br>Weathered shale throughout 33-39.9 feet |
| 15 | ST2 | 100<br>45 | | PP = 3.5-4.5+ tsf | | | |
| 20 | ST3 | 100<br>73 | 16-23-25 (48) | PP = 4.5+ tsf | | | |
| 25 | ST4 | 100<br>54 | | PP = 4.5+ tsf | | | |
| 30 | ST5 | 100<br>80 | 21-30-37 (67) | PP = 4.5+ tsf | | | |
| 35 | ST6 | 100<br>100 | | PP = 4.5+ tsf | | | |

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# BORING NUMBER B-13



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 35 | ST7 | 100 | 20-29-43 (72) | PP = 4.5+ tsf<br>MC = 20%<br>DD = 109 pcf<br>LL = 66<br>PL = 23<br>Fines = 94% | CL-ML | | (CL-ML) Silty Clay, orange-brown stained brown and gray, stiff to hard, slightly moist, calcareous, with silty lenses in interbeds, weathered |
| | | 100 | | | | | White chalky material 5-10 feet |
| 40 | | | | | | | Weathered shale throughout 33-39.9 feet *(continued)* |
| | | | | | | 39.9 | 515.3 |
| | ST8 | 100 | | Weathered to Unweathered zone | | | Silty Clay Shale, gray, hard, slightly moist to moist, calcareous, unweathered |
| 45 | | 56 | | PP = 4.5+ tsf | | | Orange-brown staining in joints at 40-41 feet<br>Fossil/shell fragments 45-50 feet |
| | ST9 | 100 | 50 | PP = 4.5+ tsf<br>MC = 15%<br>DD = 112 pcf<br>LL = 51<br>PL = 18<br>Fines = 95% | | | |
| 50 | | 60 | | | | | |
| | ST10 | 100 | | PP = 4.5+ tsf | | | |
| 55 | | 60 | | | | | |
| | ST11 | 100 | 50 | PP = 4.5+ tsf | | | |
| 60 | | 100 | | | | | |
| | | 50 | | PP = 4.5+ tsf | | | |
| 65 | | | | | | | |
| | ST12 | 100 | | PP = 4.5+ tsf | | | |
| 70 | | 43 | | | | | |
| | | 40 | | PP = 4.5+ tsf | | | |
| 75 | | | | | | | |

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# BORING NUMBER B-13



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 75 | | | | | | | |
| 80 | | 60 | | PP = 4.5+ tsf | | 80.0 | Silty Clay Shale, gray, hard, slightly moist to moist, calcareous, unweathered<br>Orange-brown staining in joints at 40-41 feet<br>Fossil/shell fragments 45-50 feet *(continued)* 475.2 |

Bottom of borehole at 80.0 feet.

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# BORING NUMBER B-14



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 11/5/18 **COMPLETED** 11/6/18
**GROUND ELEVATION** 539.2 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0 | | | | | | (CL-ML) Silty Clay, dark brown to brown, firm to stiff, moist to very moist, organic, with some small to medium sized sub-rounded gravel and chalk in fractures/joints |
| 5 | | 98 | PP = 1.5-4.5 tsf | CL-ML | | |
| | ST1 | 50 | PP = 2.5-3.5 tsf | | | |
| 10 | | 65 | | | | 6.4 532.8 (CL-ML) Silty Clay, orange-brown mottled brown and gray, stiff to hard, slightly moist, calcareous, weathered<br>Fossil fragments and silty lenses in bedding 10-15 feet |
| | ST2 | 58 | PP = 4.5 tsf | CL-ML | | |
| 15 | | 66 | | | | |
| | ST3 | 50 | PP = 3.0-4.5+ tsf<br>MC = 19%<br>DD = 104 pcf<br>LL = 58<br>PL = 23<br>Fines = 65%<br>Weathered to Unweathered zone | | | |
| 20 | | 60 | | | | 18.5 520.7 Silty Shale, gray, hard, slightly moist, calcareous, unweathered<br>Fossil fragments in bedding 20-35 feet<br>Silty lenses in bedding 18.5-45 feet |
| | ST4 | 21 | PP = 4.5+ tsf | | | |
| 25 | | 82 | | | | |
| | ST5 | 21 | PP = 4.5+ tsf | | | |
| 30 | | 56 | | | | |
| | | 60 | PP = 4.5+ tsf | | | |
| 35 | | | | | | |

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# BORING NUMBER B-14



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | | | | | Silty Shale, gray, hard, slightly moist, calcareous, unweathered |
| | ST6 | 17 / 70 | PP = 4.5+ tsf<br>MC = 15%<br>LL = 58<br>PL = 19<br>Fines = 94% | | | Fossil fragments in bedding 20-35 feet<br>Silty lenses in bedding 18.5-45 feet *(continued)* |
| 40 | | 64 | PP = 4.5+ tsf | | | |
| 45 | ST7 | 13 / 58 | PP = 4.5+ tsf | | | |
| 50 | | 60 | PP = 4.5+ tsf | | | |
| 55 | ST8 | 21 / 80 | PP = 4.5+ tsf | | | |
| 60 | | 60 | PP = 4.5+ tsf | | | |
| 65 | ST9 | 21 | | | 65.0 | 474.2<br>Bottom of borehole at 65.0 feet. |

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# BORING NUMBER B-15



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/26/18 **COMPLETED** 10/26/18
**GROUND ELEVATION** 563.35 ft **HOLE SIZE** 7.25 inches
**DRILLING CONTRACTOR** West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | |
| 5 | | 96 | PP = 2.5 tsf | CL-ML | | (CL-ML) Silty Clay, dark brown to brown with orange-brown staining, firm to stiff, moist, with trace of white gravel, organics in top 1-2 feet | |
| | | | | | | 5.0 | 558.4 |
| 10 | ST1 | 63<br>76 | PP = 4.0-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, orange-brown mottled brown and gray, stiff to hard, slightly moist, with weathered shale | |
| | | | | | | 10.0 | 553.4 |
| 15 | ST2 | 63<br>46 | PP = 4.5+ tsf | | | Silty Shale, orange-brown mottled brown and gray, hard, slightly moist<br><br>Silty lenses in interbeds 10-15 feet<br>Crystalline lenses in interbeds 15-25 feet | |
| 20 | ST3 | 75<br>83 | PP = 4.5+ tsf | | | | |
| 25 | ST4 | 75<br>89 | PP = 4.5+ tsf | | | | |
| | | | | | | 25.0 | 538.4 |
| 30 | ST5 | 75<br>72 | PP = 4.5+ tsf | | | Silty Shale, brown and gray stained orange-brown, hard, slightly moist, with crystalline lenses in interbeds, weathered | |
| | | | | | | 31.5 | 531.9 |
| 35 | ST6 | 83<br>100 | Weathered to Unweathered zone<br>PP = 4.5+ tsf | | | Silty Shale, gray, hard, slightly moist, calcareous<br><br>Minor shell fragments 45-50 feet | |

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# BORING NUMBER B-15



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | | | | | Silty Shale, gray, hard, slightly moist, calcareous |
| | ST7 | 38 | PP = 4.5+ tsf | | | Minor shell fragments 45-50 feet *(continued)* |
| 40 | | 100 | | | | |
| | | 84 | PP = 4.5+ tsf | | | |
| 45 | ST8 | 25 | PP = 4.5+ tsf | | | |
| 50 | | 100 | | | | |
| | | 100 | PP = 4.5+ tsf | | | |
| 55 | ST9 | 25 | PP = 4.5+ tsf<br>MC = 11%<br>DD = 116 pcf<br>LL = 57<br>PL = 20<br>Fines = 91% | | | |
| 60 | | 100 | | | | |
| | | 100 | PP = 4.5+ tsf | | | |
| 65 | ST10 | 29 | PP = 4.5+ tsf | | | |
| 70 | | 100 | | | | 70.0 493.4 |

Bottom of borehole at 70.0 feet.

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# BORING NUMBER B-16



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/4/18 **COMPLETED** 10/4/18
**GROUND ELEVATION** 560.25 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 0 | | | | LL = 75<br>PL = 51<br>Fines = 85% | | | Organic material<br>1.5 — 558.8 |
| | | 80 | | | CH | | (CH) Clay, dark gray, slightly moist, hard, non-calcareous to slightly calcareous, with trace of sub-rounded small gravel<br>4.0 — 556.3 |
| 5 | | | | | CH | | (CH) (CH) Silty Clay, olive green/ mustard brown, slightly moist, hard, very calcareous<br><br>Color change to yellow-brown at 6 feet with chalk/limestone in joints and trace of sub-rounded to angular gravel |
| | ST1 | 25 | | PP = 4.5+ tsf | | | |
| 10 | | 50 | | | | | 10.0 — 550.3 |
| | ST2 | 54 | | PP = 4.5+ tsf<br>MC = 19%<br>DD = 105 pcf<br>LL = 78<br>PL = 26<br>Fines = 91% | | | Shaley Clay, yellow to orange brown, slightly moist to dry, hard, calcareous, weathered<br><br>Chalk/limestone intrusions 10-15 feet<br><br>Tan to orange-brown at 15-20 feet<br><br>Orange-brown mottled brown 20-25 feet<br><br>Orange-brown staining in joints 30-34.5 feet |
| 15 | | 50 | | | | | |
| | ST3 | 54 | | PP = 4.5+ tsf | | | |
| 20 | | 50 | | | | | |
| | ST4 | 25 | | PP = 4.5+ tsf | | | |
| 25 | | 53 | | | | | |
| | ST5 | 54 | | PP = 4.5+ tsf<br>MC = 15%<br>DD = 116 pcf<br>LL = 60<br>PL = 22<br>Fines = 77% | | | |
| 30 | | 60 | | | | | |
| | ST6 | 29 | | PP = 4.5+ tsf | | | |
| | | 60 | | Weathered to | | | |
| 35 | | | | | | | 35.0 — 525.3 |

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# BORING NUMBER B-16



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 35 | | | | Unweathered zone | | | Silty Clay Shale, dark gray, hard, dry, calcareous, unweathered |
| | ST7 | 33 | | PP = 4.5+ tsf | | | Orange-brown staining in joints 35-45 feet |
| | | 60 | | | | | Shells in interbeds 60 feet |
| 40 | | | | | | | |
| | ST8 | 29 | | PP = 4.5+ tsf | | | |
| | | 60 | | | | | |
| 45 | | | | | | | |
| | | 50 | | PP = 4.5+ tsf | | | |
| 50 | | | | | | | |
| | ST9 | 25 | | PP = 4.5+ tsf<br>MC = 17%<br>DD = 115 pcf<br>LL = 64<br>PL = 21<br>Fines = 94% | | | |
| | | 60 | | | | | |
| 55 | | | | | | | |
| | | 69 | | PP = 4.5+ tsf | | | |
| 60 | | | | | | | |
| | SS1 | 50 | 21-50 | | | | 61.0 499.3 |

Bottom of borehole at 61.0 feet.

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 10/6/20 16:30 - Z:\GIL\GINT FILES\WACO LANDFILL\SITE 50 WACO REV.GPJ

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# BORING NUMBER B-17



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/8/18 **COMPLETED** 10/9/18
**GROUND ELEVATION** 546.75 ft **HOLE SIZE** 7.25 inches
**DRILLING CONTRACTOR** West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** V. Wooters **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0 | | | | | | 0.5 Limestone, white, hard, dry — 546.3 |
| | | 40 | PP = 4.5+ tsf | CL | | (CL) Clay, dark gray, slightly moist, hard, with sub-angular gravel <1/8-2" |
| 5 | | | | | | 5.0 — 541.8 |
| | ST1 | 40 | PP = 4.5+ tsf | | | (CL) Clay, yellow-brown mottled gray, slightly moist, hard |
| 10 | | | | CL | | |
| | ST2 | 80 | PP = 4.5+ tsf | | | |
| 15 | | | | | | 15.0 — 531.8 |
| | ST3 | 60 | PP = 4.5+ tsf<br>MC = 19%<br>DD = 106 pcf<br>LL = 66<br>PL = 25<br>Fines = 91% | | | (CL) Shaley Clay, tan to gray mottled orange, slightly moist to dry, hard, calcareous, weathered<br><br>Color change to tan to brown mottled orange at 20 feet.<br><br>Mineral deposits in fractures 20-22 feet. |
| 20 | | | | | | |
| | ST4 | 40 | PP = 4.5+ tsf | CL | | |
| 25 | | | | | | |
| | ST5 | 40 | PP = 4.5+ tsf<br>LL = 67<br>PL = 23 | | | |
| 30 | | | | | | 31.0 — 515.8 |
| | ST6 | 100 | PP = 4.5+ tsf<br>Weathered to Unweathered zone | | | Silty Clay Shale, dark gray, hard, dry, calcareous, weathered |
| 35 | | | | | | 33.0 — 513.8 |

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# BORING NUMBER B-17



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | ST7 | 60 | PP = 4.5+ tsf | | | Silty Clay Shale, dark gray, hard, dry, calcareous, unweathered<br><br>Limestone/chalk in fractures and joints 60-65 feet.<br><br>Weathered zones throughout from 60-71 feet. *(continued)* |
| 40 | ST8 | 60 | PP = 4.5+ tsf | | | |
| 45 | ST9 | 60 | PP = 4.5+ tsf<br>MC = 15%<br>DD = 120 pcf<br>LL = 60<br>PL = 19<br>Fines = 83% | | | |
| 50 | ST10 | 100 | PP = 4.5+ tsf | | | |
| 55 | ST11 | 100 | PP = 4.5+ tsf | | | |
| 60 | ST12 | 100 | PP = 0-4.5+ tsf | | | |
| 65 | | 100 | PP = 0-4.5+ tsf | | | |
| 70 | ST13 | | | | | 71.0 475.8<br>Bottom of borehole at 71.0 feet. |

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# WELL NUMBER B-18 (PZ-18)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/29/18 **COMPLETED** 10/30/18
**GROUND ELEVATION** 534.75 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** 23.50 ft / Elev 511.25 ft
**NOTES**
**AFTER DRILLING** 15.03 ft / Elev 519.72 ft

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | |
| | | 88 | PP = 1.5-4.5 tsf | CL-ML | | (CL-ML) Silty Clay Topsoil, dark brown, soft to firm, moist, organic | |
| | | | | | | 2.7 / 532.1 | |
| 5 | | | | CL-ML | | (CL-ML) Silty Clay, brown, firm to stiff, moist, with traces of small to medium gravel and chalk in fractures/joints | |
| | ST1 | 25 | PP = 4.5+ tsf | | | 6.8 / 528.0 | |
| | | 100 | | | | (CL-ML) Silty Clay, orange-brown mottled gray, hard, slightly moist, calcareous | |
| 10 | | | | | | Silty lenses in bedding 10-14.5 feet | |
| | ST2 | 25 | PP = 4.5+ tsf MC = 19% DD = 105 pcf LL = 66 PL = 21 Fines = 92% Weathered to Unweathered zone | CL-ML | | | |
| | | 77 | | | | 14.5 / 520.3 | |
| 15 | | | | | | Silty Shale, gray, hard, slightly moist, calcareous, unweathered | |
| | ST3 | 17 | PP = 4.5+ tsf | | | Slight orange-brown staining 14.5-30 feet | |
| | | 93 | | | | Trace of shells 30-56 feet | |
| 20 | | | | | | Silty lenses in bedding 30-35 feet | |
| | ST4 | 21 | PP = 4.5+ tsf | | | | |
| | | 78 | | | | | |
| 25 | | | | | | | |
| | ST5 | 25 | PP = 4.5+ tsf | | | | |
| | | 80 | | | | | |
| 30 | | | | | | | |
| | | 70 | PP = 4.5+ tsf | | | | |
| 35 | | | | | | | |

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# WELL NUMBER B-18 (PZ-18)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|
| 35 | ST6 | 21 | PP = 4.5+ tsf | | | Silty Shale, gray, hard, slightly moist, calcareous, unweathered | |
| | | 80 | | | | Slight orange-brown staining 14.5-30 feet | |
| 40 | | 76 | PP = 4.5+ tsf | | | Trace of shells 30-56 feet | |
| 45 | ST7 | 21 | PP = 4.5+ tsf<br>MC = 13%<br>DD = 109 pcf<br>LL = 57<br>PL = 19<br>Fines = 90% | | | Silty lenses in bedding 30-35 feet *(continued)* | |
| 50 | | 76 | | | | | |
| | | 80 | PP = 4.5+ tsf | | | | |
| 55 | ST8 | 17 | | | | 56.0 478.8<br>Bottom of borehole at 56.0 feet. | |

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# BORING NUMBER B-19



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/30/18 **COMPLETED** 10/30/18
**GROUND ELEVATION** 562.05 ft **HOLE SIZE** 7.25 inches
**DRILLING CONTRACTOR** West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** V. Wooters **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0 | | 100 | LL = 55<br>PL = 35<br>Fines = 82%<br>PP = 1.0 tsf | CL-ML | | (CL-ML) Silty Clay, dark brown, soft, moist, calcareous |
| 4.0 | | | | | | 558.1 |
| 5 | ST1 | 100 | PP = 4.5+ tsf | | | (CL-ML) Silty Clay, gray/tan mottled orange, hard, slightly moist, calcareous<br>Chalk in fractures/joints 4-20 feet<br>Very weathered zones 15-20 feet |
| 10 | ST2 | 50 | PP = 0-4.5+ tsf<br>LL = 83<br>PL = 24 | | | |
| 15 | ST3 | 100 | PP = 4.5+ tsf | | | |
| 20 | ST4 | 100 | PP = 4.5+ tsf | CL-ML | | |
| 25 | ST5 | 100 | PP = 0-4.5+ tsf | | | |
| 30 | ST6 | 100 | PP = 0-4.5+ tsf | | | |
| 35 | | | | | | |

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# BORING NUMBER B-19



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | | | | | |
| | ST7 | 100 | PP = 0-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, gray/tan mottled orange, hard, slightly moist, calcareous<br>Chalk in fractures/joints 4-20 feet<br>Very weathered zones 15-20 feet *(continued)* |
| 40 | | | | | | 40.0 522.1 |
| | ST8 | 100 | PP = 0-4.5+ tsf | CL | | (CL) Clay, dark gray with orange to tan mottling, dry, hard, calcareous, with soft weathered shale zones |
| 45 | | 100 | PP = 4.5+ tsf | | | |
| 50 | | | | | | 49.0 513.1 |
| | ST9 | 100 | PP = 4.5+ tsf<br>MC = 14%<br>DD = 117 pcf<br>LL = 63<br>PL = 19<br>Fines = 91%<br>Weathered to Unweathered zone | | | Silty Clay Shale, dark gray, hard, dry, calcareous, with chalk in joints/fractures, weathered |
| 55 | | | | | | 53.0 509.1 |
| | | 100 | PP = 0-4.5+ tsf | | | Silty Clay Shale, dark gray, hard, dry, calcareous, unweathered<br>Chalk in fractures/joints 53-65 feet<br>Intermittent weathered zones from 50-87 feet |
| 60 | | | | | | |
| | ST10 | 100 | PP = 0-4.5+ tsf | | | |
| 65 | | | | | | |
| | | 100 | PP = 4.5+ tsf | | | |
| 70 | | | | | | |
| | ST11 | 100 | PP = 0-4.5+ tsf<br>MC = 15%<br>LL = 57<br>PL = 19<br>Fines = 95% | | | |
| 75 | | | | | | |

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# BORING NUMBER B-19



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 75 | | 100 | PP = 0-4.5+ tsf | | | Silty Clay Shale, dark gray, hard, dry, calcareous, unweathered<br>Chalk in fractures/joints 53-65 feet<br>Intermittent weathered zones from 50-87 feet *(continued)* |
| 80 | ST12 | 100 | PP = 0-4.5+ tsf | | | |
| 85 | | 100 | PP = 4.5+ tsf | | | |
| | | | | | 87.0 | 475.1 |

Bottom of borehole at 87.0 feet.

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# WELL NUMBER B-20 (PZ-20)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/29/18 **COMPLETED** 10/29/18
**GROUND ELEVATION** 564.1 ft **HOLE SIZE** 7.25 inches
**DRILLING CONTRACTOR** West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** V. Wooters **CHECKED BY** J. Lawrence
**AT END OF DRILLING** 6.90 ft / Elev 557.20 ft
**NOTES**
**AFTER DRILLING** 43.23 ft / Elev 520.87 ft

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | |
| 5 | | 100 | LL = 56<br>PL = 38<br>Fines = 74%<br>PP = 4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, gray mottled tan, hard, dry, with <1/8" pebbles and chalk in fractures/joints, calcareous | |
| | | | | | | 5.0 559.1 | |
| 10 | ST1 | 60 | PP = 4.5+ tsf | | | (CL-ML) Silty Clay, tan/gray mottled orange, hard, dry, calcareous<br>▼ <1/8" pebbles 5-10 feet<br>Chalk in joints/fractures 5-10 feet<br>Very unconsolidated/weathered 15-35 feet<br>Mineral deposits 24-25 feet | |
| 15 | ST2 | 50 | PP = 4.5+ tsf | | | | |
| 20 | ST3 | 50 | PP = 0 tsf | | | | |
| 25 | ST4 | 50 | PP = 0 tsf | CL-ML | | | |
| 30 | ST5 | 50 | PP = 0 tsf | | | | |
| 35 | ST6 | 50 | PP = 0 tsf<br>LL = 61<br>PL = 41<br>Fines = 91% | | | | |
| | | | | | | 35.0 529.1 | |

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 10/7/20 09:06 - Z:\GIL\GINT FILES\WACO LANDFILL\SITE 50 WACO REV.GPJ

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# WELL NUMBER B-20 (PZ-20)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|
| 35 | | | | | | | |
| 40 | ST7 | 100 | PP = 4.5+ tsf | CL | | (CL) Clay, dark gray with orange/tan mottling, hard, dry, calcareous, with weathered shale<br><br>Mineral deposits in fractures 25-35 feet | |
| 45 | ST8 | 100 | PP = 4.5+ tsf | | | 43.0 521.1<br>Silty Clay Shale, dark gray, hard, dry, calcareous, weathered | |
| 50 | ST9 | 100 | Weathered to Unweathered zone<br>PP = 4.5+ tsf<br>MC = 13%<br>DD = 116 pcf<br>LL = 59<br>PL = 23<br>Fines = 95% | | | 47.0 517.1<br>Silty Clay Shale, dark gray, hard, dry, calcareous, unweathered<br><br>Orange-brown oxidation staining 50-55 feet<br><br>Chalk/limestone in fractures 50-55 feet<br><br>No oxidation staining beginning at 57.5 feet | |
| 55 | | 100 | PP = 0-4.5+ tsf | | | | |
| 60 | ST10 | 100 | PP = 4.5+ tsf<br>MC = 13%<br>DD = 109 pcf<br>LL = 58<br>PL = 21<br>Fines = 96% | | | | |
| 65 | | 100 | PP = 4.5+ tsf | | | | |
| 70 | ST11 | | | | | 73.0 491.1<br>Bottom of borehole at 73.0 feet. | |

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# BORING NUMBER B-21



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/29/18 **COMPLETED** 10/29/18
**GROUND ELEVATION** 538.75 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0 | | | | CL-ML | | (CL-ML) Silty Clay, dark brown to brown, firm, moist, organic, with traces of small gravel and shells |
| | | | | | | 2.3 536.5 |
| 5 | | 66 | PP = 3.0-4.0 tsf | | | (CL-ML) Silty Clay, orange-brown mottled brown and gray, hard, slightly moist, calcareous<br>Shell fragments 2.3-15 feet<br>Mineral deposits in fractures 5-10 feet |
| 10 | ST1 | 29<br>88 | PP = 4.5+ tsf | | | |
| 15 | ST2 | 25<br>80 | PP = 4.5+ tsf | CL-ML | | |
| 20 | ST3 | 33<br>43 | PP = 4.5+ tsf<br>MC = 19%<br>LL = 69<br>PL = 25<br>Fines = 97% | | | |
| 25 | ST4 | 29<br>56 | PP = 4.5+ tsf<br>Weathered to Unweathered zone | | | 24.9 513.9 |
| 30 | ST5 | 21<br>89 | PP = 4.5+ tsf | | | Silty Shale, gray, slightly moist to moist, hard, calcareous<br>Orange-brown staining in fractures 24.9-35 feet<br>Shell fragments 30-35 feet<br>Fossil remnants 35-45 feet |
| 35 | ST6 | 21<br>100 | PP = 4.0-4.5+ tsf | | | |

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# BORING NUMBER B-21



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | | | | | |
| | | 90 | PP = 4.5+ tsf<br>MC = 15%<br>DD = 108 pcf<br>LL = 57<br>PL = 18<br>Fines = 94% | | | Silty Shale, gray, slightly moist to moist, hard, calcareous<br>Orange-brown staining in fractures 24.9-35 feet<br>Shell fragments 30-35 feet<br>Fossil remnants 35-45 feet *(continued)* |
| 40 | | | | | | |
| | ST7 | 17<br>98 | PP = 4.5+ tsf<br>MC = 14%<br>LL = 61<br>PL = 21<br>Fines = 88% | | | |
| 45 | | | | | | 45.0 493.8<br>Bottom of borehole at 45.0 feet. |

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# BORING NUMBER B-22



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 12/18/18 **COMPLETED** 12/19/18
**GROUND ELEVATION** 555.5 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | Clayey Silt, brown, soft, moist, with some subrounded gravel and roots |
| | | | | | | | 1.5 554.0 |
| | | 46 | | PP <0.5-4.5 tsf | | | Silty Clay, brown, soft to firm, moist, with subrounded gravel and roots |
| 5 | | | | | | | 4.9 550.6 |
| | ST1 | 33 | 9-16-22 (38) | | | | Silty Clay, brown-gray stained orange-brown, firm, moist, with white chalky material and silty micaceous lenses, calcareous |
| | | 83 | | | | | |
| | SS1 | 66 | | PP = 3.5-4.5 tsf | | | Stiff to hard 10-34.7 feet |
| 10 | | | | | | | No white chalky material 10-34.7 feet |
| | | | | | | | Minor crystalline pockets 27-34.7 feet |
| | ST2 | 38 | | | | | |
| | | 61 | | PP = 4.0-4.5 tsf | | | |
| 15 | | | | | | | |
| | ST3 | 50 | | | | | |
| | | 100 | 15-26-29 (55) | | | | |
| | SS2 | 100 | | PP = 4.0 tsf | | | |
| 20 | | | | | | | |
| | ST4 | 17 | | | | | |
| | | 48 | | PP = 4.0 tsf | | | |
| 25 | | | | | | | |
| | ST5 | 25 | 18-24-35 (59) | | | | |
| | | 100 | | | | | |
| | SS3 | 86 | | PP = 4.0 tsf | | | |
| 30 | | | | | | | |
| | ST6 | 29 | | | | | |
| | | 70 | | PP = 4.5+ tsf<br>MC = 20%<br>LL = 74<br>PL = 27<br>Fines = 84% | | | |
| 35 | | | | | | | 34.7 520.8 |

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GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 10/2/20 13:41 - Z:\GIL\GINT FILES\WACO LANDFILL\SITE 50 WACO REV.GPJ

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# BORING NUMBER B-22



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 35 | | | | | CH | | (CH) Shale Marl, dark gray with orange-brown staining in joints, stiff to hard, slightly moist, with silty to very fine sand micaceous lenses and fossil remnants, calcareous |
| | ST7 | 25 | 21-27-50 (77) | | | | |
| | SS4 | 100 | | PP = 4.5+ tsf Weathered to Unweathered zone | CH | | Transition zone *(continued)* |
| 40 | | | | | | 38.5 | 517.0 Shale Marl, dark gray, hard, slightly moist, with silty micaceous lenses and fossil remnants, calcareous, unweathered |
| | ST8 | 21 | | | | | |
| | | 100 | | PP = 4.5+ tsf | | | |
| 45 | | | | | | | |
| | ST9 | 17 | 50 | | | | |
| | | 22 | | PP = 4.5+ tsf MC = 17% LL = 64 PL = 25 Fines = 92% | | | |
| | SS5 | 100 | | | | | |
| 50 | | | | | | | |
| | | 100 | | PP = 4.5+ tsf | | | |
| 55 | | | | | | | |
| | ST10 | 17 | | | | | |
| | | 76 | | PP = 4.5+ tsf | | | |
| 60 | | | | | | | |
| | | 76 | | PP = 4.5+ tsf | | | |
| 65 | | | | | | | |
| | | 90 | | PP = 4.5+ tsf | | | |
| 70 | | | | | | | |
| | | 80 | | PP = 4.5+ tsf | | | |
| 75 | | | | | | | |

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# BORING NUMBER B-22



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 75 | | | | | | | |
| 80 | | 80 | | PP = 4.5+ tsf | | 80.0 | Shale Marl, dark gray, hard, slightly moist, with silty micaceous lenses and fossil remnants, calcareous, unweathered *(continued)* 475.5 |

Bottom of borehole at 80.0 feet.

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# BORING NUMBER B-23



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/5/18 **COMPLETED** 10/5/18
**GROUND ELEVATION** 540.1 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** ---
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** ---
**NOTES**
**AFTER DRILLING** ---

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0 | | | | | | |
| | | 94 | MC = 32%<br>LL = 96<br>PL = 66<br>Fines = 69%<br>PP = 3.5-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, dark gray, slightly moist to moist, stiff, with some gravel, non-calcareous |
| | | | | | | Some fossil/shell fragments |
| | | | | | | 4.0 536.1 Color change to orange/brown mottled tan/brown and slightly moist to dry with calcareous material in joints at 10 ft |
| 5 | | | | | | |
| | ST1 | 28 | PP = 3.0-4.0 tsf | CL-ML | | (CL-ML) Silty Clay, dark gray, slightly moist to moist, stiff, with some gravel, non-calcareous |
| | | 49 | | | | Some fossil/shell fragments |
| | | | | | | Color change to orange/brown mottled tan/brown and slightly moist to dry with calcareous material in joints at 10 ft |
| 10 | | | | | | 10.0 530.1 |
| | ST2 | 36 | PP = 2.0-2.75 tsf<br>MC = 20%<br>DD = 108 pcf<br>LL = 73<br>PL = 23<br>Fines = 98% | CL-ML | | (CL-ML) Silty Clay, orange-brown mottled tan and gray, stiff to hard, slightly moist to dry, calcareous |
| | | 49 | | | | Chalk in joints 10-20 feet |
| 15 | | | | | | Shells in bedding 15-20 feet |
| | | | | | | Sandy lenses 30-38 feet |
| | ST3 | 36 | PP = 4.0-4.5+ tsf | | | |
| | | 46 | | | | |
| 20 | | | | | | |
| | ST4 | 24 | PP = 4.5+ tsf | | | |
| | | 52 | | | | |
| 25 | | | | | | |
| | ST5 | 24 | PP = 4.5+ tsf | | | |
| | | 55 | | | | |
| 30 | | | | | | |
| | ST6 | 28 | PP = 4.5+ tsf<br>MC = 18%<br>DD = 108 pcf<br>LL = 74<br>PL = 23<br>Fines = 85% | | | |
| | | 77 | | | | |
| 35 | | | | | | |

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 10/7/20 16:32 - Z:\GIL\GINT FILES\WACO LANDFILL\SITE 50 WACO REV.GPJ

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# BORING NUMBER B-23



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | ST7 | 24 | PP = 4.5+ tsf<br>MC = 20%<br>DD = 101 pcf<br>LL = 77<br>PL = 22<br>Fines = 89%<br>Weathered to Unweathered zone | CL-ML | | |
| | | 80 | | | | 38.0 502.1 |
| 40 | ST8 | 12 | PP = 4.5+ tsf<br>MC = 15%<br>LL = 70<br>PL = 20<br>Fines = 96% | | | Silty Clay Shale, dry, very hard, calcareous, unweathered, with sandy lenses in interbeds |
| | | 96 | | | | |
| 45 | ST9 | 28 | | | | 45.0 495.1 |

Bottom of borehole at 45.7 feet.

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# BORING NUMBER B-24



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/11/18 **COMPLETED** 10/11/18
**GROUND ELEVATION** 533.62 ft **HOLE SIZE** 7.25 inches
**DRILLING CONTRACTOR** West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** V. Wooters **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0 | | | | | | (CH) Clay, dark gray, hard, dry, non-calcareous, with sub-angular calcareous pebbles <1/8" |
| 5 | | 100 | PP = 2.0-4.5 tsf | CH | | Color change to light grayand slightly moist at 5 feet |
| 10 | ST1 | 80 | PP = 3-4.5+ tsf<br>MC = 15%<br>DD = 112 pcf<br>LL = 51<br>PL = 18<br>Fines = 73% | | | 7.0 526.6<br>(CL-ML) Silty Clay, orange-tan mottled gray, dry, hard, with chalk/limestone in joints and sand in fractures, slightly calcareous, weathered/crumbled |
| 15 | ST2 | 40 | PP = 3.0 tsf | CL-ML | | Sub-angular calcareous pebbles 7-10 feet |
| 20 | ST3 | 60 | PP = 2.0-4.5+ tsf<br>MC = 21%<br>DD = 99 pcf<br>LL = 74<br>PL = 22<br>Fines = 98% | | | |
| 25 | ST4 | 100 | PP = 3.0-4.5+ tsf | | | 25.0 508.6<br>(CL) Shaley Clay, dark gray with brown staining, soft, dry, calcareous, very weathered |
| 30 | ST5 | 80 | PP = 2.0 tsf<br>MC = 19%<br>DD = 103 pcf<br>LL = 69<br>PL = 25<br>Fines = 89% | CL | | 30.0 503.6<br>Silty Clay Shale, dark gray, hard, dry, calcareous, unweathered |
| 35 | ST6 | 80 | PP = 4.5+ tsf<br>Weathered to Unweathered zone | | | Limestone lenses in fractures 40-45 feet<br>Intermittent weathered zones 35-59 feet<br>Limestone lenses in fractures 50-59.2 feet |

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# BORING NUMBER B-24



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | ST7 | 80 | PP = 4.5+ tsf | | | Silty Clay Shale, dark gray, hard, dry, calcareous, unweathered<br>Limestone lenses in fractures 40-45 feet<br>Intermittent weathered zones 35-59 feet<br>Limestone lenses in fractures 50-59.2 feet *(continued)* |
| 40 | ST8 | 100 | PP = 4.5+ tsf | | | |
| 45 | ST9 | 100 | PP = 4.5+ tsf<br>LL = 59<br>PL = 26 | | | |
| 50 | | 80 | PP = 4.5+ tsf | | | |
| 55 | ST10 | 100 | PP = 4.5+ tsf | | | |
| 59.2 | ST11 | | | | | Bottom of borehole at 59.0 feet. |
| 474.4 | | | | | | |

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# BORING NUMBER B-25



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/11/18 **COMPLETED** 10/11/18
**GROUND ELEVATION** 533.25 ft **HOLE SIZE** 7.25 inches
**DRILLING CONTRACTOR** West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** V. Wooters **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | |
| 5 | | 100 | PP = 1.5-4.5 tsf | CL-ML | | (CL-ML) Silty Clay, dark gray, soft to hard, slightly moist to dry, calcareous, with chalk in joints<br>Color change to light gray 4-5 feet | |
| | | | | | | 5.0 | 528.3 |
| 10 | ST1 | 80 | PP = 4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, orange/gray/tan mottled, hard, slightly moist to dry, calcareous, with chalk in joints and sub-rounded pebbles 1/8"<br>No pebbles 15-20 feet<br>Silty Sand lenses in fractures 15-23 feet | |
| 15 | ST2 | 80 | PP = 3.0-4.5+ tsf | | | | |
| 20 | ST3 | 80 | PP = 3.0-4.5+ tsf | | | | |
| 25 | ST4 | 100 | PP = 1.0-3.0 tsf | | | | |
| | | | | | | 23.0 | 510.3 |
| | | | | CL | | (CL) Shaley Clay, dark gray, medium hard to soft, dry, calcareous, weathered | |
| | | | | | | 25.0 | 508.3 |
| 30 | ST5 | 100 | PP = 1.0-3.0 tsf Weathered to Unweathered zone | | | Silty Clay Shale, dark gray, hard, dry, calcareous, unweathered<br>Intermittent weathered zones 25-33 feet | |
| | ST6 | 100 | PP = 1.0-3.0 tsf | | | | |
| | | | | | | 33.0 | 500.3 |
| | | | | | | Bottom of borehole at 33.0 feet. | |

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# BORING NUMBER B-26



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 11/18/18 **COMPLETED** 11/18/18
**GROUND ELEVATION** 530.45 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Millbrand **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | Top Soil, black, soft, moist, with roots and small gravel |
| 1.4 | | | | | | | 529.1 |
| | | 36 | | PP = 1.5-4.0 tsf | CL-ML | | (CL-ML) Silty Clay, llight brown, hard, slightly moist, with small round to sub-rounded gravel up to 1/4", slightly calcareous |
| 5 | | | | | | | 5.0 525.5 |
| | ST1 | 33 | 14-25-35 (60) | PP = 4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, tan to light brown mottled orange and gray, very hard, dry, slightly calcareous |
| | | 83 | | | | | |
| | SS1 | 93 | | | | | Orange staining 10-15 feet |
| 10 | | | | | | | |
| | ST2 | 35 | | PP = 4.5+ tsf | | | |
| | | 37 | | | | | |
| 15 | | | | | | | 15.0 515.5 |
| | ST3 | 35 | 18-26-37 (63) | PP = 3.0-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, tan/brown with orange staining, hard to very hard, calcareous |
| | | 100 | | | | | |
| | SS2 | 75 | | | | | Color change to dark gray at 20 feet |
| 20 | | | | | | | 20.0 510.5 |
| | ST4 | 28 | | PP = 0.5-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, dark gray to gray with orange staining, very soft to very hard, dry, slightly to moderately calcareous |
| | | 51 | | | | | Transition zone into weathered shale |
| 25 | | | | | | | 26.0 504.5 |
| | ST5 | 24 | 28-50 | Weathered to Unweathered zone | | | Clay (Shale), dark gray, very soft to very hard, dry, with fossil remnants, slightly calcareous, unweathered |
| | | 33 | | | | | |
| | SS3 | 63 | | PP = 1.5-4.5+ tsf | | | Trace of orange staining 25-30 feet |
| 30 | | | | | | | |
| | ST6 | 26 | | PP = 2.5-4.0 tsf | | | |
| | | 47 | | | | | |
| 35 | | | | | | | |

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# BORING NUMBER B-26



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|---|
| 35 | | | | | | | | |
| | | | | | | | 36.0 | 494.5 |

Bottom of borehole at 36.0 feet.

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# BORING NUMBER B-27



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 11/14/18 **COMPLETED** 11/14/18
**GROUND ELEVATION** 546.65 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 0 | | | | LL = 59<br>PL = 38<br>Fines = 64%<br>PP = 0.5-4.5 tsf | MH | | (MH) Clayey Silt, dark brown, soft to firm, very moist, organic |
| 2.5 | | 90 | | | | | 544.2 |
| 5 | | | | | MH | | (MH) Clayey Silt, brown, stiff to hard, moist to slightly moist, with white chalk and fossil fragments, calcareous |
| | ST1 | 33 | | PP = 4.5+ tsf | | | |
| 10 | | 40 | | | | | 536.7 |
| | ST2 | 50 | 18-34-44 (78) | | CL-ML | | (CL-ML) Silty Clay, orange-brown mottled brown and gray, hard, slightly moist, calcareous |
| | SS1 | 100<br>60 | | PP = 4.5+ tsf | | | |
| 15 | | | | | | | 531.7 |
| | ST3 | 38 | | | | | Silty Shale, orange-brown mottled brown and light gray, hard, slightly moist, calcareous, weathered |
| | SS2 | 72<br>60 | 49-50 | PP = 4.5+ tsf | | | White crystalline lenses in interbeds 17.7-21.4 feet<br>Orange-brown and crystalline in interbeds 25-29 feet |
| 20 | | | | | | | |
| | ST4 | 29 | | | | | |
| | SS3 | 78<br>93 | 25-36-50 (86) | PP = 4.5+ tsf | | | |
| 25 | | | | | | | |
| | ST5 | 21<br>100 | 26-27-40 (67) | PP = 4.5+ tsf<br>MC = 18%<br>DD = 108 pcf<br>LL = 68<br>PL = 21<br>Fines = 87%<br>Weathered to Unweathered zone | | | |
| | SS4 | 68 | | | | | |
| 29.0 | | | | | | | 517.7 |
| 30 | | | | | | | Silty Shale, gray, hard, slightly moist, calcareous, micaceous, unweathered<br>Orange-brown staining in joints/bedding 29-40 feet<br>Occasional fossil fragments 33-38 feet<br>Fossil fragments 40.8-53 feet |
| | SS5 | 53<br>13 | 26-50 | | | | |
| | ST6 | 80 | | PP = 4.5+ tsf | | | |
| 35 | | | | | | | |

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# BORING NUMBER B-27



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 35 | | 60 | | PP = 4.5+ tsf | | | Silty Shale, gray, hard, slightly moist, calcareous, micaceous, unweathered<br>Orange-brown staining in joints/bedding 29-40 feet<br>Occasional fossil fragments 33-38 feet<br>Fossil fragments 40.8-53 feet *(continued)* |
| 40 | ST7<br>SS6 | 17<br>33<br>100 | 50 | PP = 4.5+ tsf<br>MC = 15%<br>DD = 118 pcf<br>LL = 61<br>PL = 21<br>Fines = 97% | | | |
| 45 | | 100 | | PP = 4.5+ tsf | | | |
| 50 | ST8<br>SS7 | 17<br>33<br>167 | 50 | PP = 4.5+ tsf | | | |
| | | | | | | | 53.0 493.7<br>Bottom of borehole at 53.0 feet. |

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# BORING NUMBER B-28



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/11/18 **COMPLETED** 10/11/18
**GROUND ELEVATION** 529.6 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0 | | | | | | (CL) Silty Clay, gray, soft to firm, moist, organic, with traces of small to large gravel and chalk material |
| 5 | | 98 | PP = 1.5-4.5+ tsf | CL | | 5.0 524.6 |
| 10 | ST1 | 21/51 | PP = 4.5+ tsf | | | Silty Clay, orange-brown mottled gray and brown, very hard, slightly moist, with some weathered shale, weathered<br>Chalky material interbedded 5-10 feet<br>Sub-rounded, small to large gravel 5-6 feet<br>Shell fragments 10-15 feet |
| 15 | ST2 | 54/64 | PP = 4.5+ tsf | | | Crystalline/mineral deposits 15-25 feet |
| 20 | ST3 | 33/100 | PP = 4.5+ tsf | | | |
| 25 | ST4 | 25/100 | PP = 4.5+ tsf | | | 25.0 504.6 |
| 30 | ST5 | 29/100 | PP = 4.5+ tsf Weathered to Unweathered zone | | | Silty Clay Shale, orange-brown mottled brown and gray, very hard, slightly moist, with shell fragments, weathered<br>28.0 501.6<br>Silty Clay Shale, gray to dark gray, very hard, slightly moist to dry, calcareous, unweathered<br>Mineral deposits 28-30 feet<br>Shell fragments 30-35 feet<br>Orange-brown staining 28-35 feet |
| 35 | ST6 | 13/100 | PP = 4.5+ tsf | | | |

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# BORING NUMBER B-28



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | | | | | |
| | ST7 | 21 | PP = 4.5+ tsf | | | Silty Clay Shale, gray to dark gray, very hard, slightly moist to dry, calcareous, unweathered<br><br>Mineral deposits 28-30 feet<br>Shell fragments 30-35 feet<br>Orange-brown staining 28-35 feet *(continued)* |
| | | 66 | | | | |
| 40 | | 58 | PP = 4.5+ tsf | | | |
| 45 | | | | | | |
| | ST8 | 21 | PP = 4.5+ tsf | | | |
| | | 71 | | | | |
| 50 | | 66 | PP = 4.5+ tsf | | | |
| 55 | | | | | | 55.0 474.6 |

Bottom of borehole at 55.0 feet.

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# BORING NUMBER B-29



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 11/16/18 **COMPLETED** 11/16/18
**GROUND ELEVATION** 540.25 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | MH | | (MH) Clayey Silt, dark brown, soft, moist, with organics |
| | | | | | | | 2.0 538.3 |
| 5 | | 73 | | PP = 0.5-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, brown to yellow-brown, hard to stiff, slightly moist to moist, with traces of sub-rounded gravel |
| | | | | | | | 5.0 535.3 |
| 10 | ST1 | 25 | 10-16-21 (37) | PP = 4.5+ tsf | CL-ML | | (CL-ML) Silty Clay (Weathered Shale/Marl), orange-brown stained gray and brown, hard to stiff, slightly moist, with white chalky material, calcareous, weathered |
| | SS1 | 89 67 | | | | | Traces of gravel 5-15 feet |
| | | | | | | | Black iron staining and limey lenses 15-25 feet |
| 15 | ST2 | 25 | | PP = 4.5+ tsf | | | Color transitioning into mostly gray at 20 feet |
| | | 40 | | | | | |
| 20 | ST3 | 29 | 10-24-36 (60) | PP = 4.5+ tsf | | | |
| | SS2 | 94 80 | | | | | |
| | ST4 | 21 | | PP = 4.5+ tsf | | | |
| 25 | | 50 | | | | | 25.0 515.3 |
| | SS3 | 78 | 25-50 | Weathered to Unweathered zone PP = 4.5+ tsf MC = 16% DD = 113 pcf LL = 60 PL = 21 Fines = 95% | | | Shale Marl, gray with some orange-brown staining, very hard, slightly moist, calcareous, weathered |
| | | 13 | | | | | 26.5 513.8 |
| | ST5 | 92 | | | | | Crystalline material in spots 25-26 feet |
| 30 | | | | | | | Silty Clay Shale Marl, gray with some orange-brown staining, very hard, slightly moist, calcareous, unweathered |
| | ST6 | 13 | | | | | Orange-brown limey/micaceous lenses 30-45 feet |
| | | 92 | | PP = 4.5+ tsf | | | Fossil remnants 25-45 feet |
| 35 | | | | | | | |

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# BORING NUMBER B-29



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 35 | SS4 | 28 | 50 | PP = 4.5+ tsf<br>MC = 11%<br>DD = 116 pcf<br>LL = 51<br>PL = 17<br>Fines = 90% | | | Silty Clay Shale Marl, gray with some orange-brown staining, very hard, slightly moist, calcareous, unweathered |
| | | 8 | | | | | |
| | ST7 | 72 | | | | | Orange-brown limey/micaceous lenses 30-45 feet |
| 40 | | | | | | | Fossil remnants 25-45 feet *(continued)* |
| | | 90 | | PP = 4.5+ tsf | | | |
| 45 | | | | | | 45.0 | 495.3 |

Bottom of borehole at 45.0 feet.

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# BORING NUMBER B-30



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 11/17/18 **COMPLETED** 11/18/18
**GROUND ELEVATION** 543.05 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | Top Soil, dark brown to black, very soft, with organic material and silt |
| | | | | | | | 2.0 541.1 |
| | 51.6 | 86 | | PP = 2.0-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, gray, medium to very hard, slightly moist, with some round to sub-rounded pebles and chalky white material |
| 5 | | | | | | | 5.0 538.1 |
| | ST1 | | | | | | (CL-ML) Silty Clay, gray mottled orange and brown, moderately hard, slightly moist, with some round to sub-rounded pebbles up to 1/2" and white chalky material, calcareous |
| | SS1 | 72 | 8-12-16 (28) | PP = 3.0-4.5+ tsf | CL-ML | | |
| | 57.6 | 96 | | | | | |
| 10 | | | | | | | 10.0 533.1 |
| | ST2 | 35 | | | | | (CL-ML) Silty Clay, orange-brown mottled gray and orange, medium soft, slightly moist, with white chalky material, calcareous |
| | 31.8 | 53 | | PP = 2.0 tsf | | | Minor pebbles less than 1/8" 10-15 feet |
| 15 | | | | | | | No pebbles or chalky white material 15-20 feet |
| | ST3 | 23 | 15-25-37 (62) | PP = 0-3.0 tsf MC = 18% DD = 115 pcf LL = 61 PL = 20 Fines = 90% | | | Turning gray 15-20 feet |
| | SS2 | 100 66 | | | CL-ML | | Crystalline deposits and very hard 20-25 feet |
| 20 | | | | | | | |
| | ST4 | 18 | | PP = 4.5+ tsf | | | |
| | | 36 | | | | | |
| 25 | | | | | | | 25.0 518.1 |
| | ST5 | 19 | 18-31-39 (70) | PP = 2.0-4.5+ tsf | | | (CL-ML) Silty Clay, light brown/orange to gray, medium hard to very hard, dry, calcareous, weathered |
| | SS3 | 100 58 | | | | | Red-brown staining along fractures, medium soft to hard, and crystalline deposits 30-35 feet |
| 30 | | | | | CL-ML | | |
| | ST6 | 45 | | PP = 1.5-3.5 tsf MC = 18% LL = 62 PL = 21 Fines = 94% | | | |
| | | 78 | | | | | |
| 35 | | | | | | | |

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# BORING NUMBER B-30



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 35 | ST7 | 25<br>55 | 31-50 | weathered/unweathered zone<br>PP = 1.5-4.5+ tsf | CL-ML | | |
| | SS4 | 100 | | | | | 37.3 505.8<br>Silty Clay Shale Marl, gray to dark gray, very hard, dry, with orange-brown staining, calcareous unweathered |
| 40 | | | | | | | Less orange staining 40-45 feet |
| | ST8 | 15<br>72 | | PP = 4.5+ tsf | | | Some orange mottling and hard to very hard 45-48 feet |
| 45 | ST9 | 20<br>36 | 50 | PP = 3.0-4.5 tsf | | | |
| | SS5 | 100 | | | | | 48.0 495.1 |

Bottom of borehole at 48.0 feet.

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# BORING NUMBER B-31



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/8/18 **COMPLETED** 10/9/18
**GROUND ELEVATION** 537.55 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0 | | | | CL-ML | | (CL-ML) Silty Clay, gray to dark gray, slightly moist to dry, stiff to hard, with trace of gravel, calcareous |
| | | | | | | 2.0 535.6 |
| 5 | | 100 | PP = 4.5+ tsf | | | Organic rich 0-2 feet<br>Color change to orange-brown mottled yellow-brown and chalk/limestone in joints 7.5-11.5 feet |
| | ST1 | 84 | PP = 4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, gray to dark gray, slightly moist to dry, stiff to hard, with trace of gravel, calcareous<br>Organic rich 0-2 feet<br>Color change to orange-brown mottled yellow-brown and chalk/limestone in joints 7.5-11.5 feet |
| 10 | | | | | | |
| | ST2 | 85 | PP = 4.5+ tsf | | | 11.5 526.1<br>(CL-ML) Silty Clay, orange/brown/gray mottled brown, hard, slightly moist to dry, calcareous, with traces of sub-rounded gravel |
| 15 | | | | | | |
| | ST3 | 85 | PP = 4.5+ tsf<br>LL = 66<br>PL = 27 | CL-ML | | Shell fragments at 20 feet |
| 20 | | | | | | |
| | ST4 | 64 | PP = 4.0-4.5+ tsf | | | |
| 25 | | | | | | 25.0 512.6 |
| | ST5 | 80 | PP = 4.5+ tsf<br>Weathered to Unweathered zone | | | Silty Clay Shale, dark gray, hard, dry, calcareous, unweathered<br>Orange-brown staining in fractures 25-30 feet<br>Limestone lenses in fractures 35-55 feet |
| 30 | | | | | | |
| | ST6 | 87 | PP = 4.0 tsf<br>MC = 18%<br>DD = 103 pcf<br>LL = 74<br>PL = 22<br>Fines = 90% | | | |
| 35 | | | | | | |

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# BORING NUMBER B-31



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | | | | | Silty Clay Shale, dark gray, hard, dry, calcareous, unweathered<br>Orange-brown staining in fractures 25-30 feet<br>Limestone lenses in fractures 35-55 feet *(continued)* |
| | ST7 | 53 | PP = 4.5+ tsf | | | |
| 40 | | 90 | PP = 4.5+ tsf | | | |
| 45 | ST8 | 67 | PP = 4.5+ tsf | | | |
| 50 | | 84 | PP = 4.5+ tsf | | | |
| 55 | ST9 | 89 | PP = 4.5+ tsf<br>MC = 14%<br>LL = 60<br>PL = 23<br>Fines = 96% | | | |
| 60 | | 67 | PP = 4.5+ tsf | | | |
| | | | | | 63.0 | 474.6 |

Bottom of borehole at 63.0 feet.

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# BORING NUMBER B-32



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/11/18 **COMPLETED** 10/12/18
**GROUND ELEVATION** 526.3 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|
| 0 | | | | MH | | 0.5 (MH) Clayey Silt, brown, slightly moist to moist, soft to hard, organic | 525.8 |
| | | | | | | (CL-ML) Silty Clay, orange-brown mottled brown and gray, slightly moist to dry, hard, calcareous, with weathered shale | |
| | | 60 | PP = 4.5+ tsf | | | | |
| 5 | | | | | | Traces of small sub-rounded gravel 2.5-5 feet<br>Chalk in joints 5-10 feet | |
| | ST1 | 50 | PP = 4.5+ tsf | | | | |
| 10 | | 50 | | | | | |
| | ST2 | 25 | PP = 4.5+ tsf | CL-ML | | | |
| 15 | | 56 | | | | | |
| | ST3 | 25 | PP = 4.5+ tsf | | | | |
| 20 | | 47 | | | | | |
| | ST4 | 29 | PP = 4.5+ tsf | | | | |
| | | 58 | | | | | |
| 25 | | | Weathered to Unweathered zone | | | 24.5 | 501.8 |
| | | | | | | Silty Clay Shale, dark gray to gray, very hard, slightly moist, with orange-brown staining in joints, weathered | |
| | ST5 | 25 | PP = 4.5+ tsf | | | | |
| | | 68 | | | | 29.0 | 497.3 |
| 30 | | | | | | Silty Clay Shale, dark gray to gray, very hard, slightly moist, calcareous, with lighter colored material, unweathered | |
| | ST6 | 100 25 | PP = 4.5+ tsf | | | 32.0 | 494.3 |
| | | | | | | Bottom of borehole at 32.0 feet. | |

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# WELL NUMBER B-33 (PZ-33)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 11/19/18 **COMPLETED** 11/20/18
**GROUND ELEVATION** 539.4 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | Clayey Silt Topsoil, dark brown, soft to firm, moist, with roots and organics | |
| 1.5 | | | | | | | | 537.9 |
| 5 | | 60 | | PP = 1.0-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, orange-brown mottled brown/tan, hard, moist to slightly moist, with white chalky material, calcareous<br><br>Silty/micaceous interbeds 5-15 feet | |
| | ST1 | 33 | 13-29-37 (66) | | | | | |
| | SS1 | 89<br>100 | | PP = 4.5+ tsf | | | | |
| 10 | ST2 | 33 | 22-50 | | | | | |
| | SS2 | 67<br>43 | | PP = 4.5+ tsf | | | | |
| 15 | | | | | | | | |
| 15.0 | | | | | | | | 524.4 |
| | ST3 | 21 | | | | | (CL-ML) Silty Clay, orange-brown mottled brown and light gray, hard, slightly moist, with black iron staining, fossil remnants, and silty/micaceous interbeds, calcareous<br><br>Weathered shale marl transition zone and mostly gray color at 25 feet | |
| 20 | | 89 | | PP = 4.5+ tsf | | | | |
| | ST4 | 21 | | | CL-ML | | | |
| 25 | | 49 | | PP = 4.5+ tsf | | | | |
| | ST5 | 25 | 20-40-50 (90) | | | | | |
| | SS3 | 94<br>100 | | PP = 4.5+ tsf Weathered to Unweathered zone | | | | |
| 28.0 | | | | | | | | 511.4 |
| 30 | | | | | CL-ML | | (CL-ML) Silty Clay Shale Marl, gray, hard, slightly moist, calcareous, unweathered | |
| 30.0 | | | | | | | | 509.4 |
| | ST6 | 17 | | | | | Orange-brown staining at 28.2 and 29.7 feet<br>Shale Marl, gray, very hard, slightly moist, with fossil remnants, calcareous, unweathered | |
| | | 100 | | PP = 4.5+ tsf | | | | |
| 35 | | | | | | | | |

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# WELL NUMBER B-33 (PZ-33)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|---|
| 35 | | | | | | | Shale Marl, gray, very hard, slightly moist, with fossil remnants, calcareous, unweathered *(continued)* | |
| | ST7 | 17<br>28 | 50 | | | | | |
| | SS4 | 100 | | PP = 4.5+ tsf | | | | |
| 40 | | 74 | | PP = 4.5+ tsf | | | | |
| 45 | ST8 | 21<br>28 | 50 | | | | | |
| | SS5 | 90 | | PP = 4.5+ tsf | | | | |
| 50 | | 76 | | PP = 4.5+ tsf | | | | |
| 55 | | | | | | | 55.0 | 484.4 |

Bottom of borehole at 55.0 feet.

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# BORING NUMBER B-34



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 11/17/18 **COMPLETED** 11/17/18
**GROUND ELEVATION** 535.65 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Millbrand **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | |
| | | 50 | | PP = 4.5+ tsf | | | Topsoil, dark brown to black, very soft, with roots, organic material, and silt | |
| 2.0 | | | | | | | | 533.7 |
| | | | | | CL-ML | | (CL-ML) Silty Clay, light brown mottled white, very hard, dry, with some chalky material, calcareous | |
| 5.0 | | | | | | | | 530.7 |
| | ST1 | 23 | 14-22-34 (56) | | | | (CL-ML) Silty Clay, brown-orange, very hard, dry to slightly moist, with some sub-round to round pebbles, calcareous | |
| | SS1 | 83/20 | | PP = 4.0-4.5+ tsf | CL-ML | | | |
| 10.0 | | | | | | | | 525.7 |
| | ST2 | 28/32 | | PP = 0.5-3.0 tsf MC = 14% LL = 57 PL = 19 Fines = 82% | CL-ML | | (CL-ML) Silty Clay, light brown to white mottled gray, medium soft to medium hard, dry, with some orange staining and chalky white material, calcareous | |
| 15.0 | | | | | | | | 520.7 |
| | ST3 | 75 | | | | | (CL-ML) Silty Clay, light brown to orange mottled gray, medium hard, dry, calcareous | |
| | SS2 | 60/133 | 13-20-29 (49) | PP = 2.0-3.0 tsf | CL-ML | | Less chalky white material throughout<br>Transition zone | |
| 20.0 | | | | | | | | 515.7 |
| | ST4 | 15/31 | | PP = 3.0-4.5+ tsf MC = 16% DD = 111 pcf LL = 63 PL = 20 Fines = 95% | | | Clayey Shale, gray with orange-brown staining, moderately hard to very hard, dry, calcareous, weathered | |
| 25 | | | | | | | | |
| 26.0 | | | | | | | | 509.7 |
| | ST5 | 15/33 | 24-50 | Weathered to Unweathered zone PP = 4.5+ tsf | | | Clayey Shale, light gray with some orange-brown, very hard, dry, with some crystalline mineral deposits, calcareous | |
| | SS3 | 100 | | | | | | |
| 30.0 | | | | | | | | 505.7 |
| | ST6 | 15/100 | | PP = 4.5+ tsf | | | Shale Marl, dark gray with very little orange staining, very hard, dry, with minor fossil fragments, slightly calcareous | |
| 35 | | | | | | | | |

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# BORING NUMBER B-34



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 35 | ST7 | 15<br>33 | 50 | PP = 4.5+ tsf | | | Shale Marl, dark gray with very little orange staining, very hard, dry, with minor fossil fragments, slightly calcareous *(continued)* |
| | SS4 | 92 | | | | | |
| 40 | ST8 | 100<br>50 | | PP = 4.5+ tsf | | | 41.0 494.7 |

Bottom of borehole at 42.1 feet.

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# BORING NUMBER B-35



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 12/12/18 **COMPLETED** 12/12/18
**GROUND ELEVATION** 553.3 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | Clayey Silt (top 0.5') to Silty Clay, brown, soft to firm, moist to very moist, with roots and organics | |
| | | | | | | | | 2.0 / 551.3 |
| 5 | | 100 | | PP = 2.0-4.5+ tsf | | | Silty Clay, brown, stiff, moist, with traces of sub-rounded gravel and roots | 5.5 / 547.8 |
| | ST1 | 33 | 15-18-18 (36) | | | | Silty Clay, orange-brown stained gray and brown, stiff, moist, weathered | |
| | SS1 | 78 / 74 | | PP = 4.5 tsf | | | White chalky zone 6.5-7 feet<br>Sandy zone (gray to brown) at 9 feet<br>White chalky material 9-10 feet | |
| 10 | | | | | | | | 10.0 / 543.3 |
| | ST2 | 38 | | | | | (CH) Silty Clay Shale Marl, orange-brown stained gray and brown, stiff to hard, slightly moist to moist, calcareous, weathered | |
| | | 85 | | PP = 4.5 tsf | | | Traces of white gravel | |
| 15 | | | | | | | Gray silty lenses 15-34.8 feet | |
| | ST3 | 33 | 19-24-34 (58) | | | | | |
| | SS2 | 100 / 85 | | PP = 4.5 tsf | | | | |
| 20 | | | | | | | | |
| | ST4 | 29 | | | CH | | | |
| | | 46 | | PP = 3.0-4.5 tsf | | | | |
| 25 | | | | | | | | |
| | ST5 | 21 | 21-36-40 (76) | | | | | |
| | SS3 | 117 / 100 | | PP = 4.5 tsf | | | | |
| 30 | | | | | | | | |
| | ST6 | 21 | | | | | | |
| | | 56 | | PP = 4.5-4.5+ tsf | | | | |
| | | | | Weathered to | | | | 34.8 / 518.5 |
| 35 | | | | | | | | |

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# BORING NUMBER B-35



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 35 | SS4 | 28 | 50 | Unweathered zone<br>PP = 4.5+ tsf | | | Silty Shale Marl, gray, hard, slightly moist, calcareous, unweathered |
| | | 13 | | | | | Orange-brown stained zone 37.5-38 feet |
| | ST7 | 90 | | PP = 4.5+ tsf | | | Trace of fossil remnants and silty/limey lenses 40-59 feet *(continued)* |
| 40 | | 76 | | | | | |
| 45 | ST8 | 17 | 50 | PP = 4.5+ tsf<br>MC = 13%<br>DD = 109 pcf<br>LL = 54<br>PL = 21<br>Fines = 75% | | | |
| | SS5 | 28 | | | | | |
| 50 | | 70 | | | | | |
| | | 73 | | PP = 4.5+ tsf | | | |
| 55 | | 108 | | PP = 4.5+ tsf | | | |
| | | | | | | | 59.0 494.3 |

Bottom of borehole at 59.0 feet.

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# BORING NUMBER B-36



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 1/8/19 **COMPLETED** 1/9/19
**GROUND ELEVATION** 532.5 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | MH | | 0.5 (MH) Clayey Silt, brown, soft, moist, with roots and organics 532.0 |
| | | 100 | | | CL-ML | | (CL-ML) Silty Clay, brown grading to light gray, firm to stiff, moist, with organics in top layer and trace of subrounded gravel in bottom layer |
| 5 | | | | | | | 5.0 527.5 |
| | ST1 | 58 | 10-14-19 (33) | | | | (CL-ML) Silty Clay, light gray, stiff, slightly moist to moist, with some orange-brown staining, white chalky material, and some gravel, calcareous |
| | SS1 | 94 / 100 | | | | | Color change to orange-brown mottled gray and brown at 7.5 feet |
| 10 | | | | | CL-ML | | |
| | ST2 | 50 / 100 | | | | | |
| 15 | | | | | | | 15.0 517.5 |
| | ST3 | 29 / 94 | 15-24-31 (55) | MC = 18%<br>LL = 56<br>PL = 21<br>Fines = 91% | | | Silty Clay Shale Marl, orange-brown stained gray and brown, stiff to hard, slightly moist, with very fine sandy laminate layers |
| | SS2 | 71 | | | | | Crystalline material in joints at 25 feet |
| 20 | | | | | | | Color change to mostle dark gray at 27 feet |
| | ST4 | 25 / 40 | | | | | |
| 25 | | | | | | | |
| | ST5 | 17 / 94 | 7-15-50 (65) | | | | |
| | SS3 | 71 | | | | | |
| 30 | | | | | | | |
| | ST6 | 25 / 68 | | MC = 17%<br>DD = 115 pcf<br>LL = 64<br>PL = 26<br>Fines = 93%<br>Weathered to | | | 34.0 498.5 |
| 35 | | | | | | | |

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# BORING NUMBER B-36



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 35 | | | | Unweathered zone | | | Shale Marl, dark gray, hard, slightly moist, calcareous, unweathered |
| | ST7 | 17<br>50 | 35-50 | | | | Occasional orange-brown staining 34-40 feet |
| | SS4 | 54 | | | | | Silty/limey laminate layers 42-58 feet *(continued)* |
| 40 | ST8 | 21 | | | | | |
| | | 44 | | | | | |
| 45 | ST9 | 25<br>50 | 33-50 | | | | |
| | SS5 | 100 | | | | | |
| 50 | | | | | | | |
| | | 100 | | | | | |
| 55 | ST10 | 21<br>28<br>60 | 50 | | | | |
| | SS6 | | | | | | 58.0 474.5 |

Bottom of borehole at 58.0 feet.

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# BORING NUMBER B-37



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 12/6/18 **COMPLETED** 12/11/18
**GROUND ELEVATION** 526.9 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|
| 0 | | | | ML | | (ML) Silt, gray, soft, moist, with a trace of clay and roots/organics | 525.9 |
| | | | | | | 1.0 | |
| 5 | | 86 | PP <0.5-4.5 tsf | CL-ML | | (CL-ML) Silty Clay, light gray, firm to stiff, slightly moist to moist, with white chalky material in areas, trace of gravel, and roots | |
| | | | | | | 5.0 | 521.9 |
| 10 | | 56 | PP = 4.0-4.5 tsf | CL-ML | | (CL-ML) Silty Clay, light gray to brown, stiff, slightly moist to moist, with white chalky areas and trace of sub-rounded gravel | |
| | | | | | | 10.0 | 516.9 |
| 15 | | 90 | PP = 2.0-4.5 tsf | CL-ML | | 11.0 (CL-ML) Sandy Silty Clay, light brown to tan, firm, slightly moist to moist, trace of gravel | 515.9 |
| | | | | | | (CL-ML) Silty Clay, orange-brown mottled gray and brown, hard, slightly moist to moist, with white chalky material in joints/bedding, calcareous, weathered | |
| 20 | | 90 | PP = 4.5 tsf | CL-ML | | | |
| 25 | | 90 | PP = 4.5+ tsf | | | | |
| | | | | | | 23.5 | 503.4 |
| | | | | | | Shale Marl (Silty Clay), gray with trace of orange-brown staining, hard, slightly moist, calcareous, weathered | |
| 30 | | 98 | Weathered to Unweathered zone PP = 4.5+ tsf | | | 26.0 Transition zone | 500.9 |
| | | | | | | Shale Marl (Silty Clay), gray, hard, slightly moist, with fossil remnants, calcareous, unweathered | |
| 35 | | 84 | PP = 4.5+ tsf | | | | |

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# BORING NUMBER B-37



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | 96 | PP = 4.5+ tsf | | | Shale Marl (Silty Clay), gray, hard, slightly moist, with fossil remnants, calcareous, unweathered *(continued)* |
| 40 | | 90 | PP = 4.5+ tsf | | | |
| 45 | | 100 | PP = 4.5+ tsf | | | |
| 50 | | 100 | PP = 4.5+ tsf | | | |
| | | | | | 52.0 | 474.9 |

Bottom of borehole at 52.0 feet.

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# BORING NUMBER B-38



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 12/4/18 **COMPLETED** 12/5/18
**GROUND ELEVATION** 529.85 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | |
| | | | | PP = 0.5-4.5+ tsf | ML | | 0.7 (ML) Silt, brown, dry to slightly moist, soft | 529.2 |
| | | 66 | | | CL-ML | | (CL-ML) Silty Clay, dark brown to brown, firm to hard with depth, slightly moist to moist, with roots/organics and trace gravel | |
| 5 | | | | | | | 5.0 | 524.9 |
| | ST1 | 29 | 15-25-25 (50) | PP = 2.0-3.5 tsf | CL-ML | | (CL-ML) Silty Clay, light gray with orange-brown staining, slightly moist, firm to stiff, with white chalky material and trace sub-rounded gravel | |
| | SS1 | 94 / 63 | | | | | | |
| 10 | | | | | | | 10.0 | 519.9 |
| | | 36 | | PP = 3.0-3.5 tsf | | | Sandy Clay, brown, firm to stiff, slightly moist, with trace of white chalky spots and trace sub-rounded gravel at top, calcareous<br><br>Fossil remnants 15-17 ft | |
| 15 | | | | | | | 17.0 | 512.9 |
| | | 22 | | PP = 3.0-4.0 tsf | CL-ML | | (CL-ML) Silty Clay, brown, stiff, slightly moist, with trace of white chalky material and gravel, calcareous | |
| 20 | | | | | | | 20.0 | 509.9 |
| | | 40 | | PP = 4.0 tsf | | | Silty Clay Shale Marl, brown and gray, stiff, slightly moist to moist, with orange-brown staining and trace fossil remnants, calcareous, weathered | |
| 25 | | | | | | | 27.0 | 502.9 |
| | | 66 | | Weathered to Unweathered zone PP = 4.5+ tsf | | | Shale Marl (Silty Clay), gray, hard, slightly moist to moist, with fossil remnants, calcareous<br><br>Orange-brown staining 28-28.2 feet | |
| 30 | | | | | | | | |
| | | 48 | | PP = 4.5+ tsf | | | Light gray limey lenses 40-55 feet | |
| 35 | | | | | | | | |

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# BORING NUMBER B-38



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 35 | | | | | | | Shale Marl (Silty Clay), gray, hard, slightly moist to moist, with fossil remnants, calcareous |
| | | 54 | | PP = 4.5+ tsf | | | Orange-brown staining 28-28.2 feet |
| 40 | | | | | | | Light gray limey lenses 40-55 feet *(continued)* |
| | | 66 | | PP = 4.5+ tsf | | | |
| 45 | | | | | | | |
| | | 60 | | PP = 4.5+ tsf | | | |
| 50 | | | | | | | |
| | | 44 | | PP = 4.5+ tsf | | | |
| 55 | | | | | | | 55.0 474.9 |

Bottom of borehole at 55.0 feet.

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# BORING NUMBER B-39



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 12/5/18 **COMPLETED** 12/6/18
**GROUND ELEVATION** 522.95 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|
| 0 | | | | ML | | 0.6 (ML) Silt, dark brown to brown, soft, moist, with a trace of clay and roots | 522.4 |
| 5 | ST1 | 84 | PP = 0.5-4.5 tsf | CL-ML | | (CL-ML) Silty Clay, brown to gray, firm to stiff, slightly moist to moist, with trace gravel, roots, fossil remnants, and white chalky material<br><br>Color change to orange-brown mottled gray and brown at 5 feet<br><br>Sandy from 5-7 feet | |
| 10 | ST2 | 100 | PP = 4.5-4.5+ tsf | | | 8.6 | 514.4 |
| 15 | ST3 | 60 | PP = 4.5+ tsf | | | (CL-ML) Silty Clay, orange-brown mottled gray and brown, hard, slightly moist, with trace of white chalky material and gravel, calcareous | |
| 20 | ST4 | 76 | PP = 4.5+ tsf | CL-ML | | | |
| 25 | ST5 | 52 | PP = 4.5+ tsf | | | | |
| 30 | ST6 | 70 | PP = 4.5+ tsf | | | 29.0 | 494.0 |
| 35 | ST7 | 66 | PP = 4.5+ tsf | | | Shale Marl, mostly gray with orange-brown staining, hard, slightly moist, with trace chalky white material, fossil remnants, and limey lenses, calcareous<br><br>Transition zone from weathered to unweathered | |

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# BORING NUMBER B-39



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | | | | | Shale Marl, mostly gray with orange-brown staining, hard, slightly moist, with trace chalky white material, fossil remnants, and limey lenses, calcareous<br><br>Transition zone from weathered to unweathered *(continued)* |
| | ST8 | 100 | PP = 4.5+ tsf Weathered to Unweathered zone | | | 38.0 485.0 |
| 40 | | | | | | Shale Marl, gray, hard, slightly moist, with limey lenses, calcareous, unweathered |
| | ST9 | 80 | PP = 4.5+ tsf | | | |
| 45 | | | | | | |
| | ST10 | 100 | PP = 4.5+ tsf | | | 48.0 475.0 |

Bottom of borehole at 48.0 feet.

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# BORING NUMBER B-40



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 12/5/18 **COMPLETED** 12/5/18
**GROUND ELEVATION** 522.8 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | |
| 5 | | 40 | PP = 2.0-4.5 tsf | CL-ML | | (CL-ML) Silty Clay, brown, firm to stiff, slightly moist to moist, with trace sub-rounded gravel, fossil remnants, roots<br><br>Sandy at 5 feet | |
| 10 | | 100 | PP = 3.0-4.0 tsf | | | 7.0 | 515.8 |
| 15 | | 88 | PP = 3.5-4.5 tsf | CL-ML | | (CL-ML) Silty Clay, orange-brown mottled brown and gray, stiff, slightly moist to moist, with white chalky material/gravel and fossil remnants, calcareous<br><br>Crystalline pockets 10-19 feet | |
| 20 | | 76 | PP = 4.5-4.5+ tsf | | | 19.0 | 503.8 |
| 25 | | 54 | PP = 4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, gray with trace of orange-brown staining, hard, slightly moist, with fossil remnants, calcareous, unweathered<br><br>Transition zone | |
| | | 100 | Weathered to Unweathered zone PP = 4.5+ tsf | | | 26.0 | 496.8 |
| | | | | | | Shale Marl, gray, hard, slightly moist, with fossil remnants, calcareous, unweathered | |
| | | | | | | 28.0 | 494.8 |
| | | | | | | Bottom of borehole at 28.0 feet. | |

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# WELL NUMBER B-41 (PZ-41)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 12/17/18 **COMPLETED** 12/18/18
**GROUND ELEVATION** 534.62 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** 41.82 ft / Elev 492.80 ft

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | |
| 5 | | 72 | PP = 1.0-4.5 tsf | CL-ML | | (CL-ML) Silty Clay, dark brown to gray, soft to stiff, moist to very moist, with a trace of gravel and roots/organics | |
| | | | | | | 5.0 / 529.6 | |
| 10 | | 44 | PP = 4.5 tsf | CL-ML | | (CL-ML) Silty Clay, gray grading to brown and orange-brown stained, stiff, moist, with trace of small to large sub-rounded gravel and white chalky material<br><br>Color change to orange-brown stained brown at 10 feet | |
| 15 | | 34 | PP = 4.5-4.5+ tsf | | | 12.0 / 522.6<br>(CL-ML) Silty Clay Shale Marl, orange-brown stained brown and gray, stiff to hard, moist, with white crystalline lenses in bedding, calcareous | |
| 20 | | 82 | PP = 4.5+ tsf | | | | |
| 25 | | 44 | PP = 4.5+ tsf | CL-ML | | | |
| 30 | | 54 | PP = 4.5+ tsf<br>weathered/unweathered zone from 29 ft to 43 ft | | | 29.0 / 505.6<br>Shale Marl, dark gray with orange-brown stainining in joints, hard, slightly moist to moist, calcareous, unweathered<br><br>Trace of crystalline areas 29-30 feet | |
| 35 | | 56 | PP = 4.5+ tsf | | | | |

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GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 10/2/20 13:41 - Z:\GIL\GINT FILES\WACO LANDFILL\SITE 50 WACO REV.GPJ

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Bedford, Texas
Telephone: 817-571-2288

# WELL NUMBER B-41 (PZ-41)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|
| 35 | | | | | | Shale Marl, dark gray with orange-brown stainining in joints, hard, slightly moist to moist, calcareous, unweathered | |
| | | 56 | PP = 4.5+ tsf | | | Trace of crystalline areas 29-30 feet *(continued)* | |
| 40 | | | | | | | |
| | | 100 | PP = 4.5+ tsf | | | ▼ | |
| | | | | | | 43.0 | 491.6 |
| 45 | | | | | | Shale Marl, gray to dark gray, hard, slightly moist, with lighter limey/silty lenses, fossil remnants, and crystalline areas, unweathered | |
| | | 100 | PP = 4.5+ tsf | | | | |
| 50 | | | | | | | |
| | | 100 | PP = 4.5+ tsf | | | | |
| 55 | | | | | | | |
| | | 50 | PP = 4.5+ tsf | | | | |
| 60 | | | | | | 60.0 | 474.6 |

Bottom of borehole at 60.0 feet.

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# BORING NUMBER B-42



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 12/6/18 **COMPLETED** 12/6/18
**GROUND ELEVATION** 527 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | |
|---|---|---|---|---|---|---|---|
| 0 | | | | ML | | 0.5 (ML) Silt, gray, soft, moist, with roots and organics | 526.5 |
| 5 | | 100 | PP = 0.5-4.5 tsf | CL-ML | | (CL-ML) Silty Clay, brown-gray, firm to stiff, moist, with a trace of gravel, roots, and white spots<br>5.0 | 522.0 |
| 10 | | 72 | PP = 0.5-4.5 tsf | CL-ML | | (CL-ML) Silty Clay, gray, stiff, moist, with white chalky material and trace of sub-rounded gravel<br>Orange-brown staining at 9-10 feet<br>10.0 | 517.0 |
| 15 | | 86 | PP = 4.0-4.5 tsf | CL-ML | | (CL-ML) Silty Clay, gray and brown with orange-brown staining, stiff to hard, slightly moist to moist, with white chalky material/spots, weathered<br>15.0 | 512.0 |
| 20 | | 80 | PP = 3.5-4.0 tsf | CL-ML | | (CL-ML) Silty Clay (Shale Marl), gray and brown with orange-brown staining, stiff to hard, slightly moist to moist, with white chalky material/spots, weathered<br>More gray 28-30 feet (transition zone) | |
| 25 | | 84 | PP = 4.0-4.5 tsf | | | | |
| 30 | | 80 | PP = 4.5 tsf | | | | |
| | | 100 | PP = 4.5 tsf Weathered to Unweathered zone | | | 31.0 | 496.0 |
| | | | | | | Shale Marl, gray, hard, slightly moist, with white chalky material/specs, calcareous<br>32.0 | 495.0 |
| | | | | | | Bottom of borehole at 32.0 feet. | |

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# BORING NUMBER B-43 (new/continued)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** _____ **COMPLETED** _____
**GROUND ELEVATION** _____ **HOLE SIZE** inches
**DRILLING CONTRACTOR** _____
**GROUND WATER LEVELS:**
**DRILLING METHOD** _____
**AT TIME OF DRILLING** ---
**LOGGED BY** A. Boudreaux **CHECKED BY** J. Lawrence
**AT END OF DRILLING** ---
**NOTES** _____
**AFTER DRILLING** ---

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | MH | | (MH) Clayey Silt, dark brown, soft, very moist, with trace of gravel and organics |
| 1.0 | | | | | | | (CL-ML) Silty Clay, dark brown, hard, moist, with trace of gravel and organics |
| 5 | | 47 | | PP = 0.5-4.5 tsf | CL-ML | | |
| 5.0 | | | | | | | (CL-ML) Silty Clay, orange-brown mottled gray and brown, stiff to hard, slightly moist to moist, with white chalky material in interbeds, calcareous |
| 10 | ST1 | 29 | 15-27-50 (77) | PP = 4.5 tsf | CL-ML | | |
| | SS1 | 93 / 67 | | | | | |
| 10.0 | | | | | | | (CL-ML) Silty Clay (weathered shale/marl), orange-brown stained light gray and brown, stiff to hard, slightly moist, calcareous, weathered |
| 15 | ST2 | 29 | | PP = 4.5 tsf<br>MC = 18%<br>DD = 111 pcf<br>LL = 60<br>PL = 20<br>Fines = 95% | CL-ML | | White chalky material in interbeds 10-16 feet |
| | | 28 | | | | | Black iron staining in joints/interbeds 20-24 feet |
| 20 | ST3 | 25 | 21-39-50 (89) | PP = 4.5 tsf | CL-ML | | Weathered to unweathered transition at 25 feet |
| | SS2 | 93 / 67 | | | | | |
| 25 | ST4 | 25 | | PP = 4.5+ tsf | CL-ML | | |
| | | 80 | | | | | |
| 25.0 | | | | | | | (CL-ML) Silty Clay, (shale/marl) gray with some orange-brown staining, hard, calcareous, with white fossil remnants |
| 30 | ST5 | 17 | 26-50 | PP = 4.5+ tsf<br>MC = 16%<br>DD = 117 pcf<br>LL = 61<br>PL = 19<br>Fines = 94% | CL-ML | | |
| | SS3 | 72 / 70 | | | | | |
| 32.0 | | | | | | | |
| 35 | ST6 | 21 | | Weathered to Unweathered zone<br>PP = 4.5+ tsf | | | |
| | | 60 | | | | | |

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# BORING NUMBER B-43 (new/continued)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 35 | ST7 | 19 | | | | | Silty Shale Marl, gray, hard, slightly moist, calcareous, unweathered |
| | | 50 | | | | | Occasional orange-brown staining and fossil remnants in beds 32-43 feet |
| 40 | ST8 | 17 | | | | | White crystalline material in bedding/joints at 35 feet |
| | | 80 | | PP = 4.5+ tsf | | | Micaceous interbeds and traces of fossil remnants 45-70 feet *(continued)* |
| 45 | ST9 | 21 | 50 | PP = 4.5+ tsf | | | |
| | | 28 | | MC = 16% | | | |
| | SS4 | 70 | | DD = 108 pcf<br>LL = 63<br>PL = 23<br>Fines = 95% | | | |
| 50 | | 60 | | PP = 4.5+ tsf | | | |
| 55 | ST10 | 17 | 50 | | | | |
| | | 22 | | | | | |
| | SS5 | 43 | | PP = 4.5+ tsf | | | |
| 60 | | 87 | | PP = 4.5+ tsf | | | |
| 65 | ST11 | 17 | | | | | |
| | | 67 | | PP = 4.5+ tsf | | | |
| 70 | | 83 | | MC = 15%<br>LL = 60<br>PL = 40<br>Fines = 91%<br>PP = 4.5+ tsf | | | |
| 75 | | | | | | | |

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# BORING NUMBER B-43 (new/continued)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 75 | | | | | | | Silty Shale Marl, gray, hard, slightly moist, calcareous, unweathered |
| | | | | | | | Occasional orange-brown staining and fossil remnants in beds 32-43 feet |
| | | | | | | | White crystalline material in bedding/joints at 35 feet |
| 80 | | | | | | | Micaceous interbeds and traces of fossil remnants 45-70 feet *(continued)*<br>minor, very fine sand, dark gray, very hard, moist, laminated<br>small fossils<br>harder with depth, small mica flakes from 80-85'<br>fewer laminations with depth |
| 85 | | | | | | | some fossils from 85-90' |
| 90 | | | | | | | |
| 95 | | | | | | | |
| 100 | | | | | | | |
| 105 | | | | | | | |
| 110 | | | | | | | large bivalve fossil |
| | | | | | | | trace of laminations |
| 115 | | | | | | | |

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# BORING NUMBER B-43 (new/continued)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 115 | | | | MC = 12%<br>LL = 68<br>PL = 46<br>Fines = 81% | | | Silty Shale Marl, gray, hard, slightly moist, calcareous, unweathered |
| | | | | | | | Occasional orange-brown staining and fossil remnants in beds 32-43 feet |
| | | | | | | | White crystalline material in bedding/joints at 35 feet |
| 120 | | | | | | | Micaceous interbeds and traces of fossil remnants 45-70 feet *(continued)* becoming hard with depth |
| 125 | | | | | | | trace of sands transitioning to no sands below 125' |
| 130 | | | | | | | scarce laminations |
| 135 | | | | | | | featureless |
| 140 | | | | | | | |
| 145 | | | | MC = 15%<br>LL = 75<br>PL = 50<br>Fines = 99% | | | no laminations |
| 150 | | | | | | 150.0 | |

Bottom of borehole at 150.0 feet.

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# WELL NUMBER B-43 (PZ-43)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 11/15/18 **COMPLETED** 11/16/18
**GROUND ELEVATION** 548.86 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** ---

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | MH | | 1.0 (MH) Clayey Silt, dark brown, soft, very moist, with trace of gravel and organics 547.9 | |
| 5 | | 47 | | PP = 0.5-4.5 tsf | CL-ML | | (CL-ML) Silty Clay, dark brown, hard, moist, with trace of gravel and organics 5.0 543.9 | |
| 10 | ST1 / SS1 | 29 / 93 / 67 | 15-27-50 (77) | PP = 4.5 tsf | CL-ML | | (CL-ML) Silty Clay, orange-brown mottled gray and brown, stiff to hard, slightly moist to moist, with white chalky material in interbeds, calcareous 10.0 538.9 | |
| 15 | ST2 | 29 / 28 | | PP = 4.5 tsf<br>MC = 18%<br>DD = 111 pcf<br>LL = 60<br>PL = 20<br>Fines = 95% | CL-ML | | (CL-ML) Silty Clay (weathered shale/marl), orange-brown stained light gray and brown, stiff to hard, slightly moist, calcareous, weathered<br><br>White chalky material in interbeds 10-16 feet<br><br>Black iron staining in joints/interbeds 20-24 feet<br><br>Weathered to unweathered transition at 25 feet | |
| 20 | ST3 / SS2 | 25 / 93 / 67 | 21-39-50 (89) | PP = 4.5 tsf | CL-ML | | | |
| 25 | ST4 | 25 / 80 | | PP = 4.5+ tsf | CL-ML | | 25.0 523.9 | |
| 30 | ST5 / SS3 | 17 / 72 / 70 | 26-50 | PP = 4.5+ tsf<br>MC = 16%<br>DD = 117 pcf<br>LL = 61<br>PL = 19<br>Fines = 94% | CL-ML | | (CL-ML) Silty Clay, (shale/marl) gray with some orange-brown staining, hard, calcareous, with white fossil remnants | |
| 35 | ST6 | 21 / 60 | | Weathered to Unweathered zone<br>PP = 4.5+ tsf | | | 32.0 516.9 | |

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# WELL NUMBER B-43 (PZ-43)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|---|
| 35 | | | | | | | | |
| | ST7 | 19 | | | | | Silty Shale Marl, gray, hard, slightly moist, calcareous, unweathered | |
| | | 50 | | | | | Occasional orange-brown staining and fossil remnants in beds 32-43 feet | |
| 40 | | | | | | | White crystalline material in bedding/joints at 35 feet | |
| | ST8 | 17 | | | | | Micaceous interbeds and traces of fossil remnants 45-70 feet *(continued)* | |
| | | 80 | | PP = 4.5+ tsf | | | | |
| 45 | | | | | | | | |
| | ST9 | 21 | 50 | PP = 4.5+ tsf | | | | |
| | | 28 | | MC = 16% | | | | |
| | SS4 | 70 | | DD = 108 pcf | | | | |
| | | | | LL = 63 | | | | |
| 50 | | | | PL = 23 | | | | |
| | | | | Fines = 95% | | | | |
| | | 60 | | PP = 4.5+ tsf | | | | |
| 55 | | | | | | | | |
| | ST10 | 17 | 50 | | | | | |
| | | 22 | | | | | | |
| | SS5 | 43 | | PP = 4.5+ tsf | | | | |
| 60 | | | | | | | | |
| | | 87 | | PP = 4.5+ tsf | | | | |
| 65 | | | | | | | | |
| | ST11 | 17 | | | | | | |
| | | 67 | | PP = 4.5+ tsf | | | | |
| 70 | | | | | | | | |
| | | 83 | | PP = 4.5+ tsf | | | | |
| 75 | | | | | | | 75.0 | 473.9 |

Bottom of borehole at 75.0 feet.

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# BORING NUMBER B-44



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/10/18 **COMPLETED** 10/10/18
**GROUND ELEVATION** 551.2 ft **HOLE SIZE** 7.25 inches
**DRILLING CONTRACTOR** West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** V. Wooters **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0 | | | | | | |
| 5 | | 100 | PP = 4.5+ tsf | CL | | (CL) Clay, dark brown to black, hard, moist, non-calcareous<br>Calcareous 4-5 feet. |
| | | | | | | 5.0 546.2 |
| 10 | ST1 | 100 | PP = 3.75-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, orange-tan mottled gray, hard, slightly moist, with chalk/limestone deposits in joints and fractures, calcareous<br>No chalk/limestone in fractures 15-25 feet<br>Minor sand and silt in fractures (gray) 15-39.5 feet |
| 15 | ST2 | 80 | PP = 4.5+ tsf<br>MC = 20%<br>DD = 108 pcf<br>LL = 71<br>PL = 22<br>Fines = 91% | | | |
| 20 | ST3 | 80 | PP = 4.5+ tsf | | | |
| 25 | ST4 | 60 | PP = 4.5+ tsf<br>MC = 21%<br>DD = 105 pcf<br>LL = 79<br>PL = 24<br>Fines = 84% | | | |
| 30 | ST5 | 50 | PP = 3.0-4.5+ tsf | | | |
| 35 | ST6 | 60 | PP = 3.0-4.5+ tsf<br>MC = 25%<br>DD = 97 pcf<br>LL = 72<br>PL = 21<br>Fines = 97% | | | |

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# BORING NUMBER B-44



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | ST7 | 100 | PP = 3.0-4.5+ tsf<br>Weathered to Unweathered zone | CL-ML | | (CL-ML) Silty Clay, orange-tan mottled gray, hard, slightly moist, with chalk/limestone deposits in joints and fractures, calcareous<br>No chalk/limestone in fractures 15-25 feet<br>Minor sand and silt in fractures (gray) 15-39.5 feet *(continued)* |
| 39.5 | | | | | | 511.7 |
| 40 | ST8 | 100 | PP = 4.5+ tsf | | | Shaley Clay, dark gray, hard, dry, slightly calcareous, weathered |
| 41.0 | | | | | | 510.2 |
| 45 | ST9 | 90 | PP = 4.5+ tsf | | | Silty Clay Shale, dark gray, hard, dry, calcareous, with limestone intrusions in fractures<br>No limestone intrusions in fractures 55-76 feet<br>Interbedded heavily weathered zones 65-76 feet |
| 50 | ST10 | 100 | PP = 4.5+ tsf<br>LL = 60<br>PL = 25 | | | |
| 55 | | 100 | PP = 4.5+ tsf | | | |
| 60 | ST11 | 100 | PP = 4.5+ tsf | | | |
| 65 | | 100 | PP = 4.5+ tsf | | | |
| 70 | ST12 | 100 | PP = 4.5+ tsf | | | |
| 75 | | | | | | |

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# BORING NUMBER B-44



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 75 | | | | | | |
| | | 100 | | | | 76.0 475.2 |
| | ST13 | | | | | Bottom of borehole at 76.0 feet. |

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# BORING NUMBER B-45



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/31/18 **COMPLETED** 10/31/18
**GROUND ELEVATION** 545.5 ft **HOLE SIZE** 7.25 inches
**DRILLING CONTRACTOR** West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** V. Wooters **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0 | | | | | | |
| | | 100 | PP = 3.0-3.75 tsf | CL-ML | | (CL-ML) Silty Clay, dark brown, medium hard, moist, slightly calcareous, organic |
| | | | | | | 4.0 541.5 |
| 5 | | | | | | (CL-ML) Silty Clay, orange/tan mottled gray hard, slightly moist to dry, slightly calcareous |
| | ST1 | 50 | PP = 0-4.5+ tsf | | | Very dry and weathered zones 5-26 feet |
| 10 | | | | | | |
| | ST2 | 50 | PP = 0-4.5+ tsf | | | |
| 15 | | | | | | |
| | ST3 | 100 | PP = 0-4.5+ tsf | CL-ML | | |
| 20 | | | | | | |
| | ST4 | 100 | PP = 0-4.5+ tsf | | | |
| 25 | | | | | | |
| | ST5 | 100 | Weathered to Unweathered zone<br>PP = 0-4.5+ tsf<br>MC = 21%<br>DD = 107 pcf<br>LL = 66<br>PL = 20<br>Fines = 90% | | | 26.0 519.5 |
| | | | | CL | | (CL) Shaley Clay, dark gray with orange/tan mottling, dry, hard, calcareous, with weathered shale |
| | | | | | | 28.0 517.5 |
| 30 | | | | | | Silty Clay Shale, dark gray, hard, dry, slightly calcareous, unweathered |
| | ST6 | 100 | PP = 4.5+ tsf | | | |
| 35 | | | | | | |

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 10/2/20 13:41 - Z:\GIL\GINT FILES\WACO LANDFILL\SITE 50 WACO REV.GPJ

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SCS ENGINEERS
SCS Engineers
1901 Central Drive, Ste. 550
Bedford, Texas
Telephone: 817-571-2288

# BORING NUMBER B-45



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | | | | | Silty Clay Shale, dark gray, hard, dry, slightly calcareous, unweathered *(continued)* |
| | | 100 | PP = 4.5+ tsf | | | |
| 40 | | | | | | |
| | ST7 | 100 | PP = 4.5+ tsf<br>MC = 15%<br>LL = 58<br>PL = 20<br>Fines = 92% | | | |
| 45 | | | | | | |
| | | 100 | PP = 4.5+ tsf | | | |
| 50 | | | | | | |
| | ST8 | | | | | 51.0 494.5 |

Bottom of borehole at 51.0 feet.

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Bedford, Texas
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# BORING NUMBER B-46



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 11/1/18 **COMPLETED** 11/1/18
**GROUND ELEVATION** 559.25 ft **HOLE SIZE** 8.25 inches
**DRILLING CONTRACTOR** BEST Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** T. Derstine **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0 | | | | MH | | (MH) Clayey Silt, brown, soft to firm, moist, organic, with a trace of gravel and white chalky material — 1.0 — 558.3 |
| 5 | | 58 | PP = 1.0-4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, orange-brown mottled brown, stiff to hard, slightly moist, with some gravel — 5.0 — 554.3 |
| 10 | ST1 | 33/76 | PP = 4.5+ tsf | CL-ML | | (CL-ML) Silty Clay, orange-brown mottled brown, hard, slightly moist, calcareous, with chalk in joints and fossil fragments — 10.0 — 549.3 |
| 15 | ST2 | 29/100 | PP = 4.5+ tsf | | | Silty Shale, orange-brown mottled brown and gray, hard, slightly moist, calcareous, weathered<br>Chalk in joints 10-11.5 feet<br>More moist and softer 25-35 feet |
| 20 | ST3 | 33/100 | PP = 4.5+ tsf | | | Silty lenses and crystalline deposits in interbeds 15-35 feet |
| 25 | ST4 | 33/56 | PP = 4.5+ tsf | | | |
| 30 | ST5 | 33/71 | PP = 3.0 tsf | | | |
| 35 | ST6 | 38/61 | PP = 1.0-4.0 tsf | | | |

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Bedford, Texas
Telephone: 817-571-2288

# BORING NUMBER B-46



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

| DEPTH (ft) | NUMBER | RECOVERY % | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 35 | | | | | | |
| | ST7 | 33 / 71 | PP = 3.0-4.5 tsf | | | |
| 40 | | | | | | 40.0 519.3 |
| | ST8 | 21 / 96 | PP = 4.5+ tsf Weathered to Unweathered zone | | | Silty Shale, gray, hard, slightly moist, calcareous, with silty lenses in interbeds<br>Traces of orange-brown staining 40-65 feet<br>Shell/fossil fragments 45-65 feet |
| 45 | | | | | | |
| | ST9 | 21 / 96 | PP = 4.5+ tsf MC = 13% DD = 110 pcf LL = 62 PL = 21 Fines = 94% | | | |
| 50 | | | | | | |
| | | 74 | PP = 4.5+ tsf | | | |
| 55 | | | | | | |
| | ST10 | 25 / 95 | PP = 4.5+ tsf | | | |
| 60 | | | | | | |
| | | 80 | PP = 4.5+ tsf | | | |
| 65 | | | | | | 65.4 493.9 |
| | ST11 | 17 | | | | Bottom of borehole at 65.0 feet. |

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Bedford, Texas
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# WELL NUMBER B-47 (PZ-47)



**CLIENT** City of Waco
**PROJECT NAME** City of Waco Landfill MSW-2400
**PROJECT NUMBER** 16216088.00
**PROJECT LOCATION** Waco, Texas
**DATE STARTED** 10/11/18 **COMPLETED** 10/12/18
**GROUND ELEVATION** 532.4 ft **HOLE SIZE** 7.25 inches
**DRILLING CONTRACTOR** West Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** Continuous Flight Auger
**AT TIME OF DRILLING** --- No Groundwater
**LOGGED BY** V. Wooters **CHECKED BY** J. Lawrence
**AT END OF DRILLING** --- No Groundwater
**NOTES**
**AFTER DRILLING** --- No Groundwater

| DEPTH (ft) | NUMBER | RECOVERY % | REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|
| 0 | | | | ML | | 0.5 (ML) Silt, dark brown, soft, moist 531.9 | |
| | | | | | | (CL) Clay, light gray, hard, dry, calcareous, with chalk in fractures | |
| 5 | | 100 | | CL | | | |
| | ST1 | 100 | | | | 7.0 525.4 | |
| | | | | | | (CL-ML) Silty Clay, orange-tan mottled gray, hard, dry, calcareous, with chalk in fractures/joints | |
| 10 | | | | | | Trace of sub-angular gravel 1/8" at 7-10 feet | |
| | ST2 | 40 | | | | | |
| 15 | | | | | | | |
| | ST3 | 80 | | CL-ML | | | |
| 20 | | | | | | | |
| | ST4 | 80 | | | | | |
| 25 | | | | | | | |
| | ST5 | 100 | | | | 27.0 505.4 | |
| | | | | | | (CL) Clay, gray with orange-brown mottling, hard, slighty moist to dry, calcareous, with weathered shale, weathered | |
| 30 | | | | CL | | | |
| | | 80 | Weathered to Unweathered zone | | | 33.0 499.4 | |
| 35 | | | | | | | |

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 10/2/20 13:41 - Z:\GIL\GINT FILES\WACO LANDFILL\SITE 50 WACO REV.GPJ

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Telephone: 817-571-2288

# WELL NUMBER B-47 (PZ-47)



**CLIENT** City of Waco **PROJECT NAME** City of Waco Landfill MSW-2400

**PROJECT NUMBER** 16216088.00 **PROJECT LOCATION** Waco, Texas

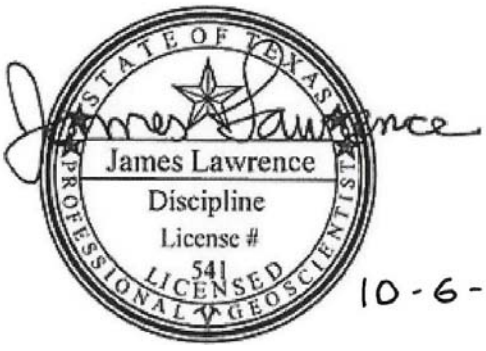
| DEPTH (ft) | NUMBER | RECOVERY % | REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|
| 35 | | | | | | Silty Clay Shale, dark gray, hard, dry, calcareous, unweathered<br><br>Limestone lenses in fractures 38-57 *(continued)* | |
| | | 100 | | | | | |
| 40 | | | | | | | |
| | | 80 | | | | | |
| 45 | | | | | | | |
| | ST6 | 80 | | | | | |
| 50 | | | | | | | |
| | | 80 | | | | | |
| 55 | | | | | | | |
| | ST7 | 100 | | | | 57.0 475.4 | |

Bottom of borehole at 57.5 feet.

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 10/2/20 13:41 - Z:\GIL\GINT FILES\WACO LANDFILL\SITE 50 WACO REV.GPJ

# APPENDIX III-4.F

# GEOTECHNICAL INVESTIGATION REPORTS



October 8, 2020
TEAM Project No. 202030
Report No. 1

SCS Engineers
1901 Central Drive
Suite 550
Bedford, Texas 76021

Attn: James Lawrence, P.E.

Re: Geotechnical Laboratory Testing
Waco Landfill

Dear Mr. Lawrence:

Submitted here is our report of laboratory testing services completed on soil samples received at our materials testing laboratory in Arlington, Texas between September 8 and 24, 2020 for the above referenced project. The laboratory test program was completed in accordance with instructions received September 24, 2020. The laboratory testing program was completed utilizing the following test methodologies:

| | |
|---|---|
| Atterberg Limits | ASTM D-4318 |
| Grain Size Analysis | ASTM D-422 |
| Classification of Soils | ASTM D-2487/2488 |
| Moisture Content | ASTM D-2216 |
| Coefficient of Permeability | ASTM D-2434 / E-1110-2-1906, Appendix VII |

We appreciate the opportunity to be of assistance to you with this project. Should you have any questions, or if we may be of further assistance, please call the undersigned at (817) 467-5500.

Sincerely,
TEAM Consultants, Inc.

Jason Young, GIT
Staff Geologist

## SUMMARY OF LABORATORY TEST RESULTS

**SCS Engineers**
**Waco Landfill**

| Boring Number | Depth (ft) | UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487/2488) | | Material Finer than No. 200 Sieve (ASTM D-722) (% Passing) | ATTERBERG LIMITS (ASTM D-4318) | | COEFFICIENT OF PERMEABILITY (EM 1110-2-1906) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | LIQUID LIMIT | PLASTICITY INDEX | MOISTURE CONTENT (%) | DRY DENSITY (pcf) | HYDRAULIC CONDUCTIVITY $K_H$ (cm/sec) | HYDRAULIC CONDUCTIVITY $K_V$ (cm/sec) |
| B-4 | 1-2 | Dark brown and gray fat clay with sand | CH | 71.2 | 67 | 46 | 24.2 | --- | --- | --- |
| | 10' | Brown and gray fat clay | CH | --- | --- | --- | 9.6 | 115.9 | 3.43E-08 | 8.78E-09 |
| | 20' | Tan and gray fat clay | CH | --- | --- | --- | 18.1 | 113.0 | 8.89E-09 | 2.81E-09 |
| | 35' | Dark gray fat clay with sand | CH | --- | --- | --- | 14.1 | 112.8 | 6.71E-06 | 1.76E-09 |
| B-9 | 1-2 | Dark brown fat clay with sand | CH | 81.9 | 60 | 39 | 22.2 | --- | --- | --- |
| B-16 | 1-2 | Brown fat clay with sand | CH | 84.5 | 75 | 51 | 26.3 | --- | --- | --- |
| B-19 | 1-2 | Brown and tan fat clay with sand | CH | 81.7 | 55 | 35 | 18.5 | --- | --- | --- |
| B-20 | 2' | Tan fat clay with sand | CH | 74.2 | 56 | 38 | 11.7 | 123.1 | 4.54E-09 | 3.82E-09 |
| | 15' | Tan and brown fat clay | CH | --- | --- | --- | 18.0 | 102.9 | 1.27E-07 | 2.93E-09 |
| | 30' | Tan and gray fat clay | CH | 91.1 | 61 | 41 | 18.9 | 108.0 | 3.10E-08 | 2.14E-09 |
| | 50' | Dark gray fat clay with sand | CH | --- | --- | --- | 16.7 | 113.4 | 9.25E-09 | 1.30E-09 |
| B-23 | 1-2 | Brown sandy fat clay | CH | 68.6 | 96 | 66 | 31.7 | 86.8 | 4.36E-09 | 5.01E-09 |
| B-27 | 1-2 | Dark brown and gray sandy fat clay | CH | 64.4 | 59 | 38 | 20.3 | --- | --- | --- |

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill  Project No.: 202030  Date: 9/10/2020

Sample No: B-4 10' Horizontal  Date Sampled: n/a

Material Description: Brown and gray fat clay

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 141.2 | g | Tare No.: | 471 | |
| Ring weight: | 63.1 | g | Wet weight+tare: | 335.4 | g |
| Wet weight of sample: | 78.1 | g | Dry weight+tare: | 318.4 | g |
| Diameter: | 5.08 | cm | Tare weight: | 141.8 | g |
| Area: | 20.27 | $cm^2$ | Dry weight of sample: | 176.6 | g |
| Thickness: | 1.913 | cm | Weight of moisture: | 17.0 | g |
| Unit dry weight: | 114.8 | pcf | Percent moisture: | 9.6 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 9/28/20 02:45 PM | | 63.3 | | | |
| 9/28/20 04:45 PM | 7,200 | | 61.1 | 3.84E-08 | |
| 9/29/20 08:20 AM | 56,100 | | 47.9 | 3.39E-08 | |
| 9/29/20 10:55 AM | 9,300 | | 46.2 | 3.04E-08 | |
| 9/29/20 01:05 PM | 7,800 | | 44.5 | 3.76E-08 | |
| | 80,400 | | | | 3.43E-08 |

Tube No.: 3

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_H$ = 3.43E-08 cm/sec

Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill  Project No.: 202030  Date: 9/25/2020

Sample No: B-4 10' Vertical  Date Sampled: n/a

Material Description: Brown and gray fat clay

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 227.2 | g | Tare No.: | 471 | |
| Ring weight: | 104.5 | g | Wet weight+tare: | 335.4 | g |
| Wet weight of sample: | 122.7 | g | Dry weight+tare: | 318.4 | g |
| Diameter: | 6.35 | cm | Tare weight: | 141.8 | g |
| Area: | 31.67 | $cm^2$ | Dry weight of sample: | 176.6 | g |
| Thickness: | 1.887 | cm | Weight of moisture: | 17.0 | g |
| Unit dry weight: | 116.9 | pcf | Percent moisture: | 9.6 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 9/28/20 09:15 AM | | 72.1 | | | |
| 9/28/20 12:45 PM | 12,600 | | 70.3 | 9.91E-09 | |
| 9/28/20 02:45 PM | 7,200 | | 69.4 | 8.84E-09 | |
| 9/28/20 04:45 PM | 7,200 | | 68.4 | 9.96E-09 | |
| 9/29/20 08:20 AM | 56,100 | | 62.2 | 8.37E-09 | |
| | 83,100 | | | | 8.78E-09 |

Tube No.: 2

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_V$ = 8.78E-09 cm/sec

Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill  Project No.: 202030  Date: 9/10/2020

Sample No: B-4 20' Horizontal  Date Sampled: n/a

Material Description: Tan and gray fat clay

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 141.7 | g | Tare No.: | 104 | |
| Ring weight: | 63.1 | g | Wet weight+tare: | 331.8 | g |
| Wet weight of sample: | 78.6 | g | Dry weight+tare: | 303.5 | g |
| Diameter: | 5.08 | cm | Tare weight: | 147.2 | g |
| Area: | 20.27 | $cm^2$ | Dry weight of sample: | 156.3 | g |
| Thickness: | 1.910 | cm | Weight of moisture: | 28.3 | g |
| Unit dry weight: | 107.3 | pcf | Percent moisture: | 18.1 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 9/28/20 12:45 PM | | 69.6 | | | |
| 9/28/20 02:45 PM | 7,200 | | 69.0 | 9.39E-09 | |
| 9/28/20 04:45 PM | 7,200 | | 68.4 | 9.48E-09 | |
| 9/29/20 08:20 AM | 56,100 | | 64.2 | 8.82E-09 | |
| 9/29/20 01:05 PM | 17,100 | | 63 | 8.62E-09 | |
| | 87,600 | | | | 8.89E-09 |

Tube No.: 5

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_H$ = 8.89E-09 cm/sec

Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill  Project No.: 202030  Date: 9/25/2020

Sample No: B-4 20' Vertical  Date Sampled: n/a

Material Description: Tan and gray fat clay

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 229.4 | g | Tare No.: | 104 | |
| Ring weight: | 104.5 | g | Wet weight+tare: | 331.8 | g |
| Wet weight of sample: | 125.0 | g | Dry weight+tare: | 303.5 | g |
| Diameter: | 6.35 | cm | Tare weight: | 147.2 | g |
| Area: | 31.67 | $cm^2$ | Dry weight of sample: | 156.3 | g |
| Thickness: | 1.890 | cm | Weight of moisture: | 28.3 | g |
| Unit dry weight: | 110.4 | pcf | Percent moisture: | 18.1 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 9/28/20 12:45 PM | | 67.8 | | | |
| 9/28/20 04:45 PM | 14,400 | | 67.2 | 3.05E-09 | |
| 9/29/20 08:20 AM | 56,100 | | 65.1 | 2.80E-09 | |
| 9/29/20 01:05 PM | 17,100 | | 64.5 | 2.68E-09 | |
| 9/29/20 04:55 PM | 13,800 | | 64 | 2.79E-09 | |
| | 101,400 | | | | 2.81E-09 |

Tube No.: 4

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_V$ = 2.81E-09 cm/sec

Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill | Project No.: 202030 | Date: 9/25/2020

Sample No: B-4 35' Horizontal | Date Sampled: n/a

Material Description: Dark gray fat clay with sand

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 141.3 | g | Tare No.: | 684 | |
| Ring weight: | 63.1 | g | Wet weight+tare: | 356.3 | g |
| Wet weight of sample: | 78.2 | g | Dry weight+tare: | 329.7 | g |
| Diameter: | 5.08 | cm | Tare weight: | 141.0 | g |
| Area: | 20.27 | $cm^2$ | Dry weight of sample: | 188.7 | g |
| Thickness: | 1.915 | cm | Weight of moisture: | 26.6 | g |
| Unit dry weight: | 110.2 | pcf | Percent moisture: | 14.1 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 9/30/20 10:25 AM | | 32.3 | | | |
| 9/30/20 10:26 AM | 60 | | 30.6 | 7.06E-06 | |
| 9/30/20 10:27 AM | 60 | | 29.1 | 6.56E-06 | |
| 9/30/20 10:28 AM | 60 | | 27.7 | 6.44E-06 | |
| 9/30/20 10:29 AM | 60 | | 26.3 | 6.77E-06 | |
| | 240 | | | | 6.71E-06 |

Tube No.: 5

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_H$ = 6.71E-06 cm/sec

Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill | Project No.: 202030 | Date: 9/25/2020

Sample No: B-4 35' Vertical | Date Sampled: n/a

Material Description: Dark gray fat clay with sand

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 230.8 | g | Tare No.: | 684 | |
| Ring weight: | 104.5 | g | Wet weight+tare: | 356.3 | g |
| Wet weight of sample: | 126.3 | g | Dry weight+tare: | 329.7 | g |
| Diameter: | 6.35 | cm | Tare weight: | 141.0 | g |
| Area: | 31.67 | $cm^2$ | Dry weight of sample: | 188.7 | g |
| Thickness: | 1.892 | cm | Weight of moisture: | 26.6 | g |
| Unit dry weight: | 115.4 | pcf | Percent moisture: | 14.1 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 9/28/20 09:15 AM | | 68.7 | | | |
| 9/28/20 12:45 PM | 12,600 | | 68.4 | 1.72E-09 | |
| 9/28/20 04:45 PM | 14,400 | | 68.1 | 1.51E-09 | |
| 9/29/20 08:20 AM | 56,100 | | 66.7 | 1.83E-09 | |
| 9/29/20 01:05 PM | 17,100 | | 66.3 | 1.74E-09 | |
| | 100,200 | | | | 1.76E-09 |

Tube No.: 6

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_V$ = 1.76E-09 cm/sec

Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill  Project No.: 202030  Date: 9/29/2020

Sample No: B-20 2' Horizontal  Date Sampled: n/a

Material Description: Tan fat clay with sand

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 147.6 | g | Tare No.: | 110 | |
| Ring weight: | 63.1 | g | Wet weight+tare: | 349.6 | g |
| Wet weight of sample: | 84.5 | g | Dry weight+tare: | 325.2 | g |
| Diameter: | 5.08 | cm | Tare weight: | 117.5 | g |
| Area: | 20.27 | $cm^2$ | Dry weight of sample: | 207.7 | g |
| Thickness: | 1.910 | cm | Weight of moisture: | 24.4 | g |
| Unit dry weight: | 121.9 | pcf | Percent moisture: | 11.7 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 9/30/20 10:05 AM | | 67.7 | | | |
| 9/30/20 01:35 PM | 12,600 | | 67.2 | 4.60E-09 | |
| 9/30/20 04:30 PM | 10,500 | | 66.7 | 5.56E-09 | |
| 10/1/20 08:05 AM | 56,100 | | 64.6 | 4.46E-09 | |
| 10/1/20 11:27 AM | 12,120 | | 64.2 | 4.00E-09 | |
| | 91,320 | | | | 4.54E-09 |

Tube No.: 3

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_H$ = 4.54E-09 cm/sec

Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill  Project No.: 202030  Date: 9/29/2020

Sample No: B-20 2' Vertical  Date Sampled: n/a

Material Description: Tan fat clay with sand

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 237.3 | g | Tare No.: | 110 | |
| Ring weight: | 104.5 | g | Wet weight+tare: | 349.6 | g |
| Wet weight of sample: | 132.8 | g | Dry weight+tare: | 325.2 | g |
| Diameter: | 6.35 | cm | Tare weight: | 117.5 | g |
| Area: | 31.67 | $cm^2$ | Dry weight of sample: | 207.7 | g |
| Thickness: | 1.885 | cm | Weight of moisture: | 24.4 | g |
| Unit dry weight: | 124.3 | pcf | Percent moisture: | 11.7 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 9/30/20 01:35 PM | | 63.5 | | | |
| 9/30/20 04:30 PM | 10,500 | | 62.9 | 4.46E-09 | |
| 10/1/20 08:05 AM | 56,100 | | 60.1 | 4.00E-09 | |
| 10/1/20 11:27 AM | 12,120 | | 59.7 | 2.72E-09 | |
| 10/1/20 01:30 PM | 7,380 | | 59.4 | 3.37E-09 | |
| | 86,100 | | | | 3.82E-09 |

Tube No.: 2

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_H$ = 3.82E-09 cm/sec

Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill  Project No.: 202030  Date: 9/29/2020

Sample No: B-20 15' Horizontal  Date Sampled: n/a

Material Description: Tan and brown fat clay

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 135.9 | g | Tare No.: | 683 | |
| Ring weight: | 63.1 | g | Wet weight+tare: | 398.9 | g |
| Wet weight of sample: | 72.8 | g | Dry weight+tare: | 358.8 | g |
| Diameter: | 5.08 | cm | Tare weight: | 136.1 | g |
| Area: | 20.27 | $cm^2$ | Dry weight of sample: | 222.7 | g |
| Thickness: | 1.913 | cm | Weight of moisture: | 40.1 | g |
| Unit dry weight: | 99.3 | pcf | Percent moisture: | 18.0 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 9/30/20 08:40 AM | | 64.1 | | | |
| 9/30/20 09:20 AM | 2,400 | | 62.0 | 1.09E-07 | |
| 9/30/20 10:45 AM | 5,100 | | 57.3 | 1.21E-07 | |
| 9/30/20 11:35 AM | 3,000 | | 54.3 | 1.40E-07 | |
| 9/30/20 01:35 PM | 7,200 | | 48.1 | 1.32E-07 | |
| | 17,700 | | | | 1.27E-07 |

Tube No.: 3

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_H$ = 1.27E-07 cm/sec

Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill  Project No.: 202030  Date: 9/29/2020

Sample No: B-20 15' Vertical  Date Sampled: n/a

Material Description: Tan and brown fat clay

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 224.7 | g | Tare No.: | 683 | |
| Ring weight: | 104.5 | g | Wet weight+tare: | 398.9 | g |
| Wet weight of sample: | 120.2 | g | Dry weight+tare: | 358.8 | g |
| Diameter: | 6.35 | cm | Tare weight: | 136.1 | g |
| Area: | 31.67 | $cm^2$ | Dry weight of sample: | 222.7 | g |
| Thickness: | 1.887 | cm | Weight of moisture: | 40.1 | g |
| Unit dry weight: | 106.4 | pcf | Percent moisture: | 18.0 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 10/1/20 08:05 AM | | 45.5 | | | |
| 10/1/20 11:28 AM | 12,180 | | 45.2 | 2.68E-09 | |
| 10/1/20 01:30 PM | 7,320 | | 45.0 | 2.99E-09 | |
| 10/2/20 08:05 AM | 66,900 | | 43.2 | 3.01E-09 | |
| 10/2/20 12:45 PM | 16,800 | | 42.8 | 2.74E-09 | |
| | 103,200 | | | | 2.93E-09 |

Tube No.: 5

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_H$ = 2.93E-09 cm/sec

Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill  Project No.: 202030  Date: 10/2/2020

Sample No: B-20 30' Horizontal  Date Sampled: n/a

Material Description: Tan and gray fat clay

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 141.6 | g | Tare No.: | 473 | |
| Ring weight: | 63.1 | g | Wet weight+tare: | 366.2 | g |
| Wet weight of sample: | 78.5 | g | Dry weight+tare: | 330.9 | g |
| Diameter: | 5.08 | cm | Tare weight: | 143.8 | g |
| Area: | 20.27 | $cm^2$ | Dry weight of sample: | 187.1 | g |
| Thickness: | 1.910 | cm | Weight of moisture: | 35.3 | g |
| Unit dry weight: | 106.6 | pcf | Percent moisture: | 18.9 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 10/5/20 08:45 AM | | 70.5 | | | |
| 10/5/20 11:05 AM | 8,400 | | 67.6 | 3.91E-08 | |
| 10/5/20 02:00 PM | 10,500 | | 64.6 | 3.38E-08 | |
| 10/6/20 08:20 AM | 66,000 | | 50.3 | 2.96E-08 | |
| 10/6/20 12:15 PM | 14,100 | | 47.6 | 3.06E-08 | |
| | 99,000 | | | | 3.10E-08 |

Tube No.: 3

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_H$ = 3.10E-08 cm/sec

Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill  Project No.: 202030  Date: 9/29/2020

Sample No: B-20 30' Vertical  Date Sampled: n/a

Material Description: Tan and gray fat clay

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 229.3 | g | Tare No.: | 473 | |
| Ring weight: | 104.5 | g | Wet weight+tare: | 366.2 | g |
| Wet weight of sample: | 124.9 | g | Dry weight+tare: | 330.9 | g |
| Diameter: | 6.35 | cm | Tare weight: | 143.8 | g |
| Area: | 31.67 | $cm^2$ | Dry weight of sample: | 187.1 | g |
| Thickness: | 1.892 | cm | Weight of moisture: | 35.3 | g |
| Unit dry weight: | 109.4 | pcf | Percent moisture: | 18.9 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 10/5/20 11:05 AM | | 61.6 | | | |
| 10/5/20 02:00 PM | 10,500 | | 61.3 | 2.30E-09 | |
| 10/6/20 08:20 AM | 66,000 | | 59.6 | 2.11E-09 | |
| 10/6/20 12:15 PM | 14,100 | | 59.3 | 1.77E-09 | |
| 10/6/20 05:00 PM | 17,100 | | 58.8 | 2.45E-09 | |
| | 107,700 | | | | 2.14E-09 |

Tube No.: 3

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_H$ = 2.14E-09 cm/sec

Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill  Project No.: 202030  Date: 10/2/2020

Sample No: B-20 50' Horizontal  Date Sampled: n/a

Material Description: Dark gray fat clay with sand

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 144.2 | g | Tare No.: | 465 | |
| Ring weight: | 63.1 | g | Wet weight+tare: | 329.0 | g |
| Wet weight of sample: | 81.1 | g | Dry weight+tare: | 303.3 | g |
| Diameter: | 5.08 | cm | Tare weight: | 149.8 | g |
| Area: | 20.27 | $cm^2$ | Dry weight of sample: | 153.5 | g |
| Thickness: | 1.910 | cm | Weight of moisture: | 25.7 | g |
| Unit dry weight: | 112.0 | pcf | Percent moisture: | 16.7 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 10/6/20 08:20 AM | | 63.6 | | | |
| 10/6/20 12:15 PM | 14,100 | | 62.4 | 1.06E-08 | |
| 10/6/20 03:40 PM | 12,300 | | 61.5 | 9.23E-09 | |
| 10/6/20 05:00 PM | 4,800 | | 61.2 | 7.96E-09 | |
| 10/7/20 08:00 AM | 54,000 | | 57.5 | 9.02E-09 | |
| | 85,200 | | | | 9.25E-09 |

Tube No.: 3

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_H$ = 9.25E-09 cm/sec

Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill  Project No.: 202030  Date: 10/2/2020

Sample No: B-20 50' Vertical  Date Sampled: n/a

Material Description: Dark gray fat clay with sand

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 232.9 | g | Tare No.: | 465 | |
| Ring weight: | 104.5 | g | Wet weight+tare: | 329.0 | g |
| Wet weight of sample: | 128.4 | g | Dry weight+tare: | 303.3 | g |
| Diameter: | 6.35 | cm | Tare weight: | 149.8 | g |
| Area: | 31.67 | $cm^2$ | Dry weight of sample: | 153.5 | g |
| Thickness: | 1.890 | cm | Weight of moisture: | 25.7 | g |
| Unit dry weight: | 114.8 | pcf | Percent moisture: | 16.7 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 10/5/20 02:00 PM | | 56.5 | | | |
| 10/6/20 08:20 AM | 66,000 | | 55.4 | 1.47E-09 | |
| 10/6/20 12:15 PM | 14,100 | | 55.2 | 1.27E-09 | |
| 10/6/20 05:00 PM | 17,100 | | 55.0 | 1.05E-09 | |
| 10/7/20 08:00 AM | 54,000 | | 54.3 | 1.17E-09 | |
| | 151,200 | | | | 1.30E-09 |

Tube No.: 3

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_H$ = 1.30E-09 cm/sec

Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill  Project No.: 202030  Date: 9/10/2020

Sample No: B-23 1-2' Horizontal  Date Sampled: n/a

Material Description: Brown sandy fat clay

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 134.4 | g | Tare No.: | 635 | |
| Ring weight: | 63.1 | g | Wet weight+tare: | 256.4 | g |
| Wet weight of sample: | 71.3 | g | Dry weight+tare: | 220.2 | g |
| Diameter: | 5.08 | cm | Tare weight: | 105.7 | g |
| Area: | 20.27 | $cm^2$ | Dry weight of sample: | 114.5 | g |
| Thickness: | 1.913 | cm | Weight of moisture: | 36.2 | g |
| Unit dry weight: | 87.2 | pcf | Percent moisture: | 31.7 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 9/11/20 03:40 PM | | 63.1 | | | |
| 9/12/20 11:00 AM | 69,600 | | 60.5 | 4.73E-09 | |
| 9/13/20 01:30 PM | 95,400 | | 57.6 | 4.03E-09 | |
| 9/14/20 08:00 AM | 66,600 | | 55.8 | 3.73E-09 | |
| 9/14/20 02:50 PM | 24,600 | | 54.7 | 6.33E-09 | |
| | 256,200 | | | | 4.36E-09 |

Tube No.: 3

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_H$ = 4.36E-09 cm/sec

Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

# PERMEABILITY TEST

**(EM 1110-2-1906 30 NOV 70)**

Project: SCS Waco Landfill  Project No.: 202030  Date: 9/10/2020

Sample No: B-23 1-2' Vertical  Date Sampled: n/a

Material Description: Brown sandy fat clay

| SAMPLE MEASUREMENTS | | | MOISTURE CONTENT | | |
|---|---|---|---|---|---|
| Wet weight sample+ring: | 213.3 | g | Tare No.: | 635 | |
| Ring weight: | 104.5 | g | Wet weight+tare: | 256.4 | g |
| Wet weight of sample: | 108.9 | g | Dry weight+tare: | 220.2 | g |
| Diameter: | 6.35 | cm | Tare weight: | 105.7 | g |
| Area: | 31.67 | $cm^2$ | Dry weight of sample: | 114.5 | g |
| Thickness: | 1.887 | cm | Weight of moisture: | 36.2 | g |
| Unit dry weight: | 86.4 | pcf | Percent moisture: | 31.7 | % |

**PERMEABILITY DATA**

| Date & Time | Elapsed Time (t) sec | Burrette Readings ($H_0$) cm | ($H_1$) cm | Permeability (k) Single | Cumulative |
|---|---|---|---|---|---|
| 9/11/20 03:40 PM | | 55.2 | | | |
| 9/12/20 11:00 AM | 69,600 | | 50.2 | 6.74E-09 | |
| 9/13/20 01:30 PM | 95,400 | | 45.1 | 5.55E-09 | |
| 9/14/20 08:00 AM | 66,600 | | 43.1 | 3.36E-09 | |
| 9/15/20 10:00 AM | 93,600 | | 39.7 | 4.34E-09 | |
| | 325,200 | | | | 5.01E-09 |

Tube No.: 2

Area of Tube: 0.0829 $cm^2$

Confining Load: 0.625 tsf

$$K = \left[\frac{axL}{Axt}\right] x \ln\left[\frac{H_0}{H_1}\right] x R_T$$

$K_V$ = 5.01E-09 cm/sec

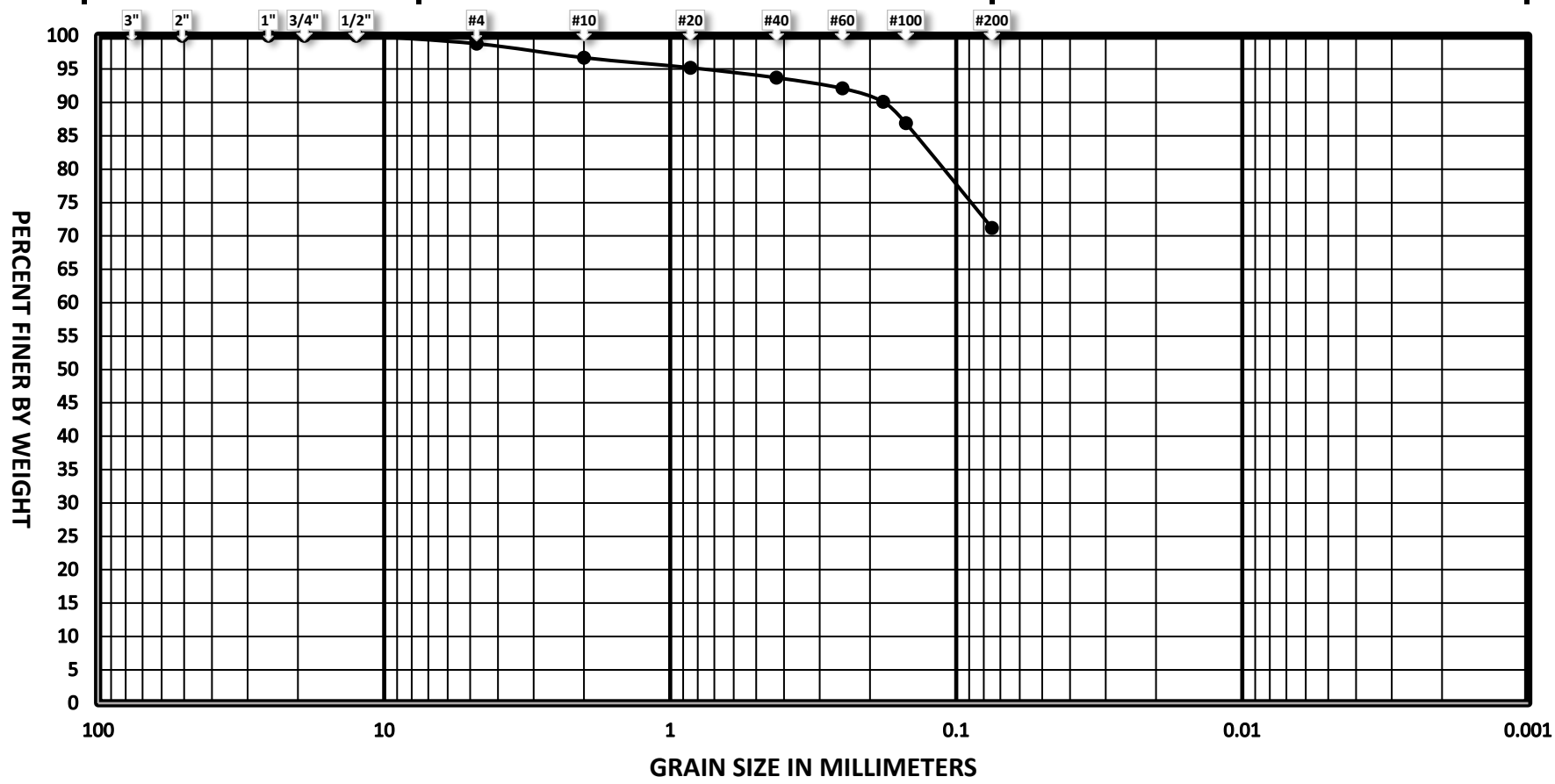
Remarks: A temperature correction factor ($R_T$) of 1.00 is used as this test was performed within a laboratory environment maintained at or slightly above 68°F.

Tested by: Jason Young

Computed by: Jason Young

Checked by: James Hutt

TEAM Consultants, Inc.




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Specimen Data | D90 | D60 | D50 | D30 | D10 | % Gravel | % Sand | % Silt & Clay | $C_C$ | $C_U$ |
|---|---|---|---|---|---|---|---|---|---|---|
| B-4 1-2' | 0.18 | N/A | N/A | N/A | N/A | 1.2 | 27.6 | 71.2 | N/A | N/A |

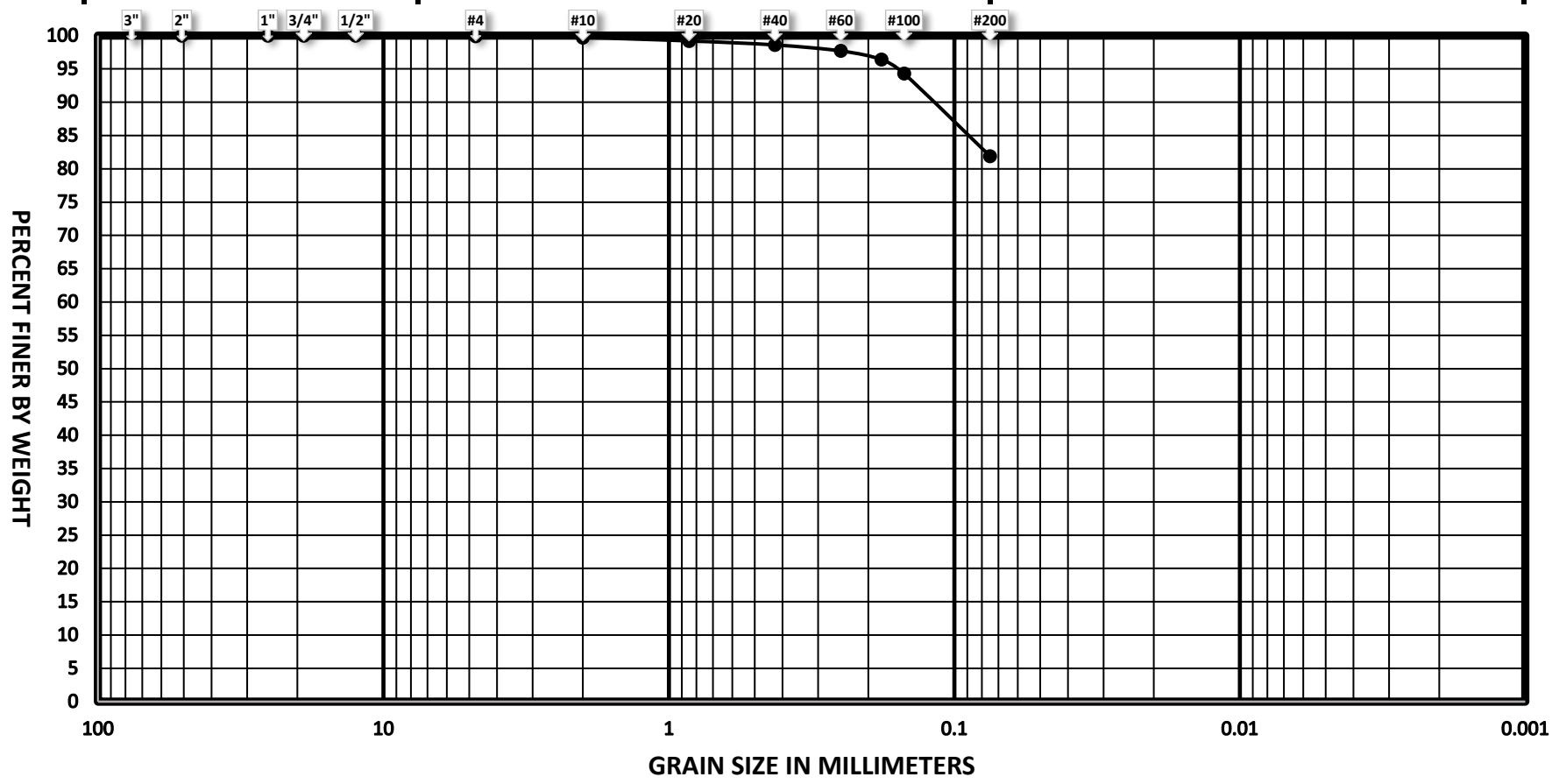
| Unified Soil Classification (ASTM D-2487/2488) | LL | PL | PI |
|---|---|---|---|
| Dark brown and gray fat clay with sand **(CH)** | 67 | 21 | 46 |

## GRAIN SIZE DISTRIBUTION (ASTM D-422)

Client: SCS Engineers
Project: Waco Landfill
Date: 9/29/2020
Performed By: R. Davis
TEAM Project Number: 202030

**TEAM Consultants, Inc.**
3101 Pleasant Valley Ln, Suite 101
Arlington, TX 76015
Telephone: (817) 467-5500
Fax: (817) 468-9920

TEAM Consultants, Inc.




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Specimen Data | D90 | D60 | D50 | D30 | D10 | % Gravel | % Sand | % Silt & Clay | $C_C$ | $C_U$ |
|---|---|---|---|---|---|---|---|---|---|---|
| B-9 1-2' | 0.12 | N/A | N/A | N/A | N/A | 0.1 | 18.0 | 81.9 | N/A | N/A |

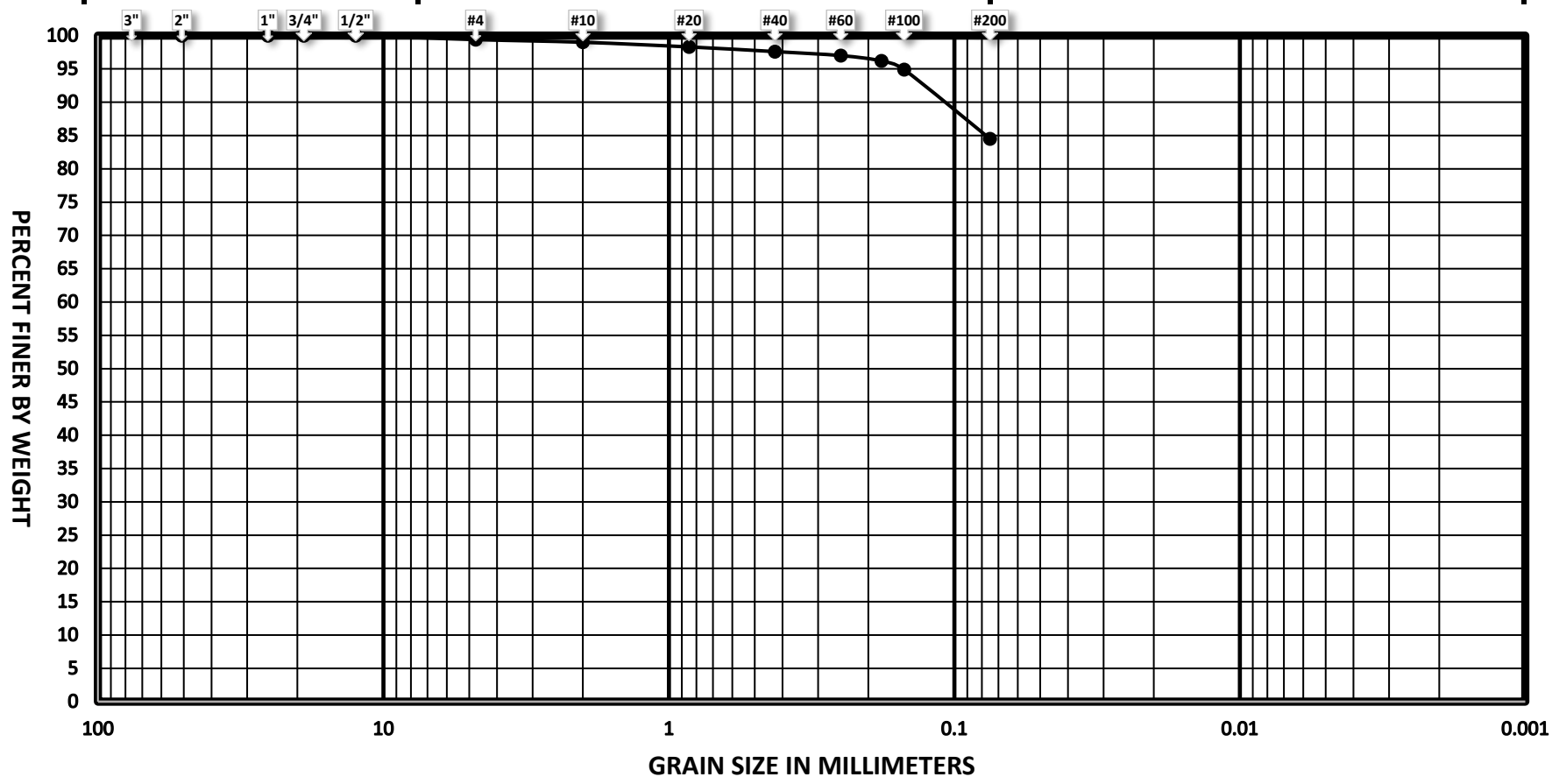
| Unified Soil Classification (ASTM D-2487/2488) | LL | PL | PI |
|---|---|---|---|
| Dark brown fat clay with sand **(CH)** | 60 | 21 | 39 |

## GRAIN SIZE DISTRIBUTION (ASTM D-422)

Client: SCS Engineers
Project: Waco Landfill
Date: 9/29/2020
Performed By: R. Davis
TEAM Project Number: 202030

**TEAM Consultants, Inc.**
3101 Pleasant Valley Ln, Suite 101
Arlington, TX 76015
Telephone: (817) 467-5500
Fax: (817) 468-9920

TEAM Consultants, Inc.




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Specimen Data | D90 | D60 | D50 | D30 | D10 | % Gravel | % Sand | % Silt & Clay | $C_C$ | $C_U$ |
|---|---|---|---|---|---|---|---|---|---|---|
| B-16 1-2' | 0.11 | N/A | N/A | N/A | N/A | 0.6 | 14.9 | 84.5 | N/A | N/A |

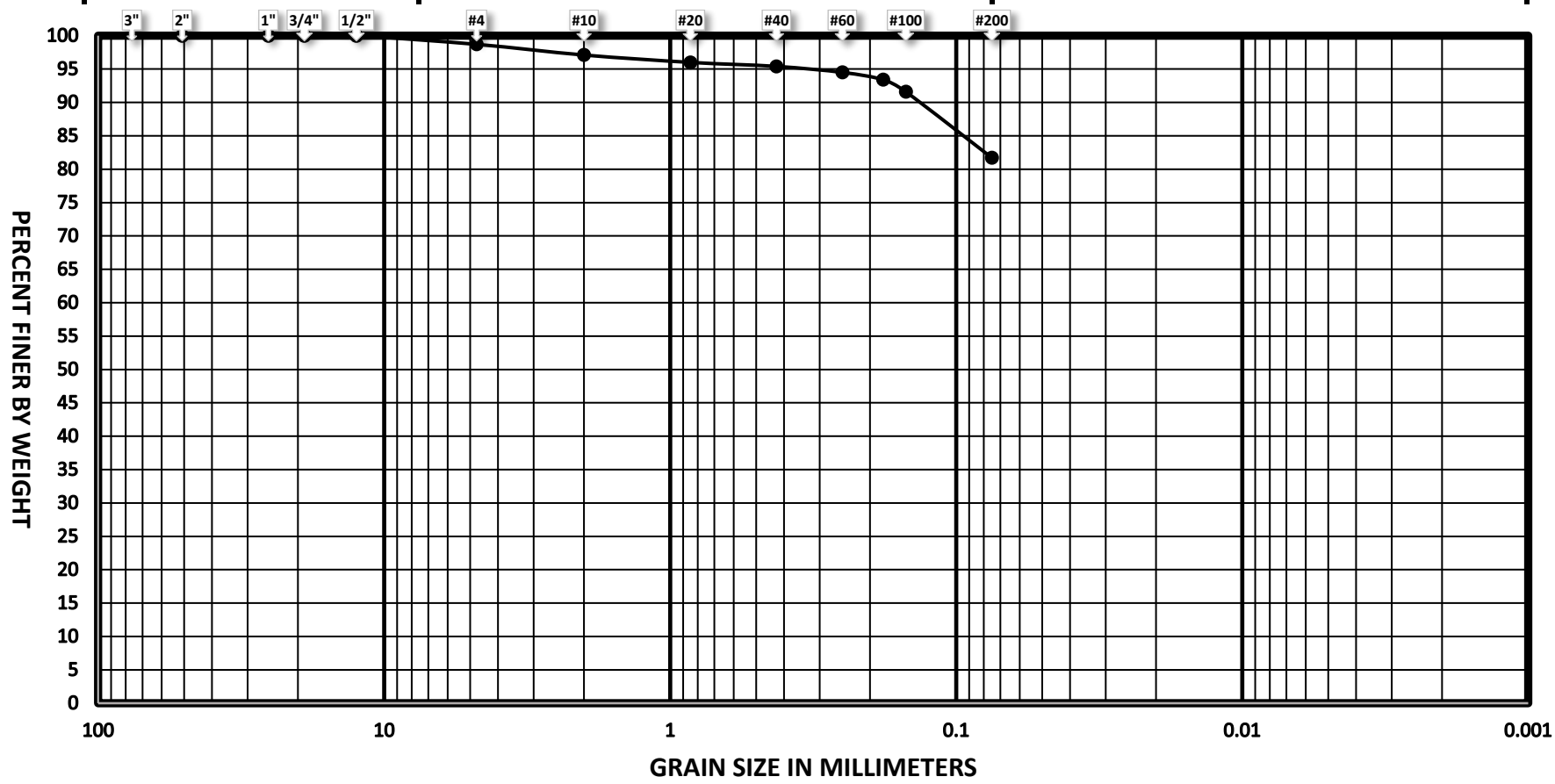
| Unified Soil Classification (ASTM D-2487/2488) | LL | PL | PI |
|---|---|---|---|
| Brown fat clay with sand **(CH)** | 75 | 24 | 51 |

## GRAIN SIZE DISTRIBUTION (ASTM D-422)

Client: SCS Engineers
Project: Waco Landfill
Date: 9/29/2020
Performed By: R. Davis
TEAM Project Number: 202030

**TEAM Consultants, Inc.**
3101 Pleasant Valley Ln, Suite 101
Arlington, TX 76015
Telephone: (817) 467-5500
Fax: (817) 468-9920

TEAM Consultants, Inc.




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Specimen Data | D90 | D60 | D50 | D30 | D10 | % Gravel | % Sand | % Silt & Clay | $C_C$ | $C_U$ |
|---|---|---|---|---|---|---|---|---|---|---|
| B-19 1-2' | 0.14 | N/A | N/A | N/A | N/A | 1.3 | 17.0 | 81.7 | N/A | N/A |

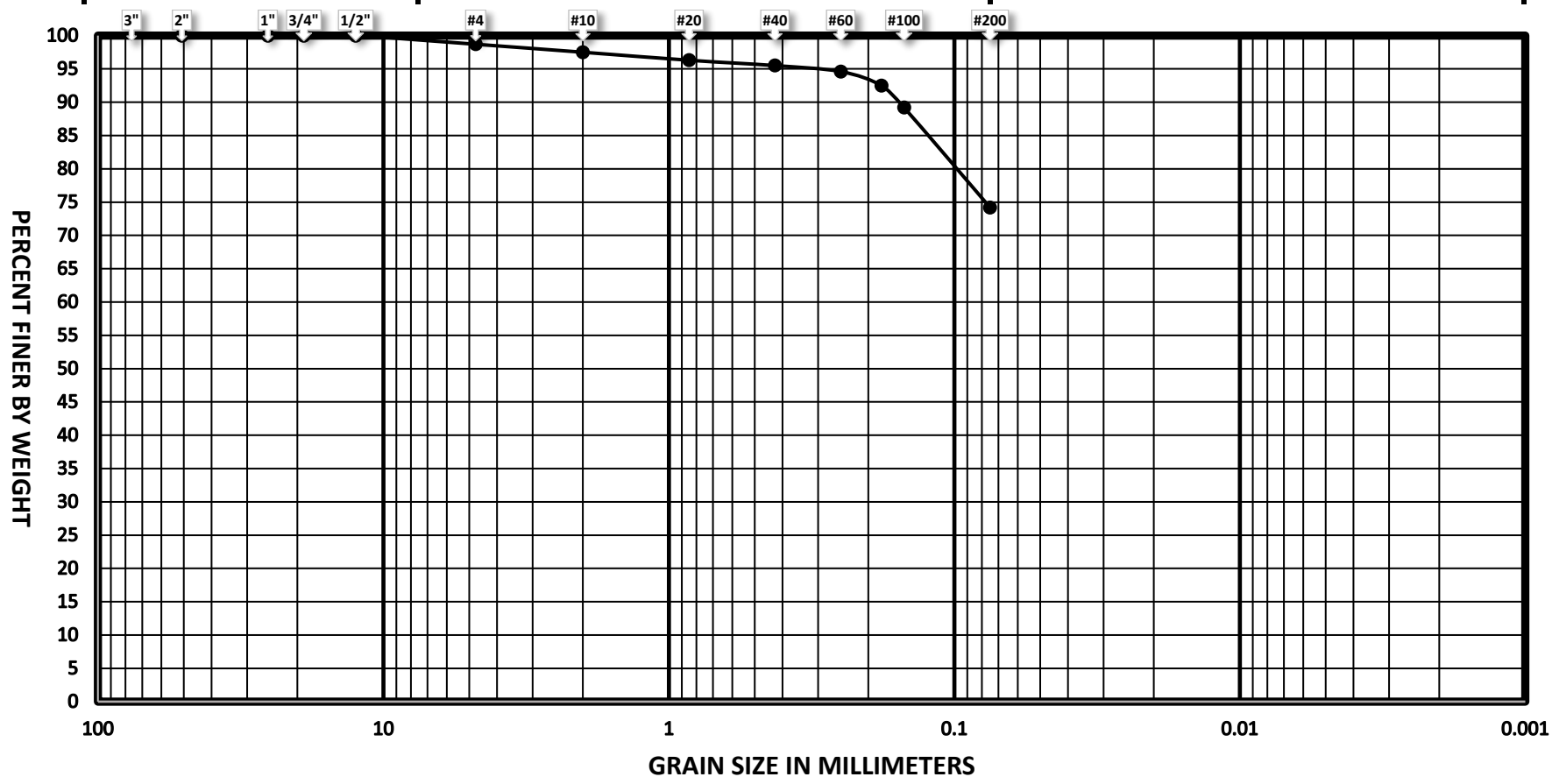
| Unified Soil Classification (ASTM D-2487/2488) | LL | PL | PI |
|---|---|---|---|
| Brown and tan fat clay with sand **(CH)** | 55 | 20 | 35 |

## GRAIN SIZE DISTRIBUTION (ASTM D-422)

Client: SCS Engineers
Project: Waco Landfill
Date: 9/29/2020
Performed By: R. Davis
TEAM Project Number: 202030

**TEAM Consultants, Inc.**
3101 Pleasant Valley Ln, Suite 101
Arlington, TX 76015
Telephone: (817) 467-5500
Fax: (817) 468-9920

TEAM Consultants, Inc.




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Specimen Data | D90 | D60 | D50 | D30 | D10 | % Gravel | % Sand | % Silt & Clay | $C_C$ | $C_U$ |
|---|---|---|---|---|---|---|---|---|---|---|
| B-20 2' | 0.16 | N/A | N/A | N/A | N/A | 1.3 | 24.5 | 74.2 | N/A | N/A |

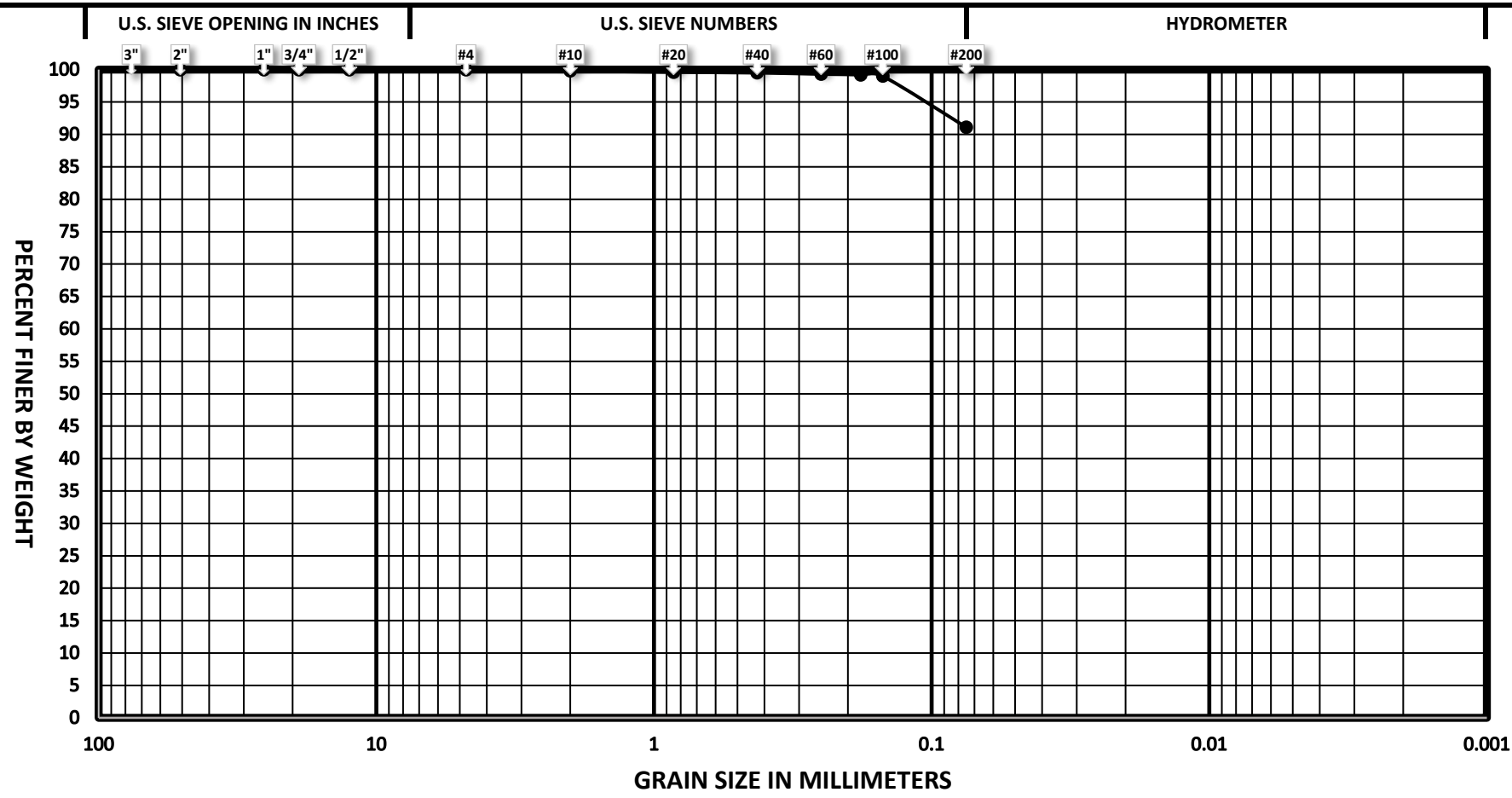
| Unified Soil Classification (ASTM D-2487/2488) | LL | PL | PI |
|---|---|---|---|
| Tan fat clay with sand **(CH)** | 56 | 18 | 38 |

## GRAIN SIZE DISTRIBUTION (ASTM D-422)

Client: SCS Engineers
Project: Waco Landfill
Date: 10/1/2020
Performed By: C. McCauley
TEAM Project Number: 202030

**TEAM Consultants, Inc.**
3101 Pleasant Valley Ln, Suite 101
Arlington, TX 76015
Telephone: (817) 467-5500
Fax: (817) 468-9920

TEAM Consultants, Inc.




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Specimen Data | D90 | D60 | D50 | D30 | D10 | % Gravel | % Sand | % Silt & Clay | $C_C$ | $C_U$ |
|---|---|---|---|---|---|---|---|---|---|---|
| B-20 30' | N/A | N/A | N/A | N/A | N/A | 0.0 | 8.9 | 91.1 | N/A | N/A |

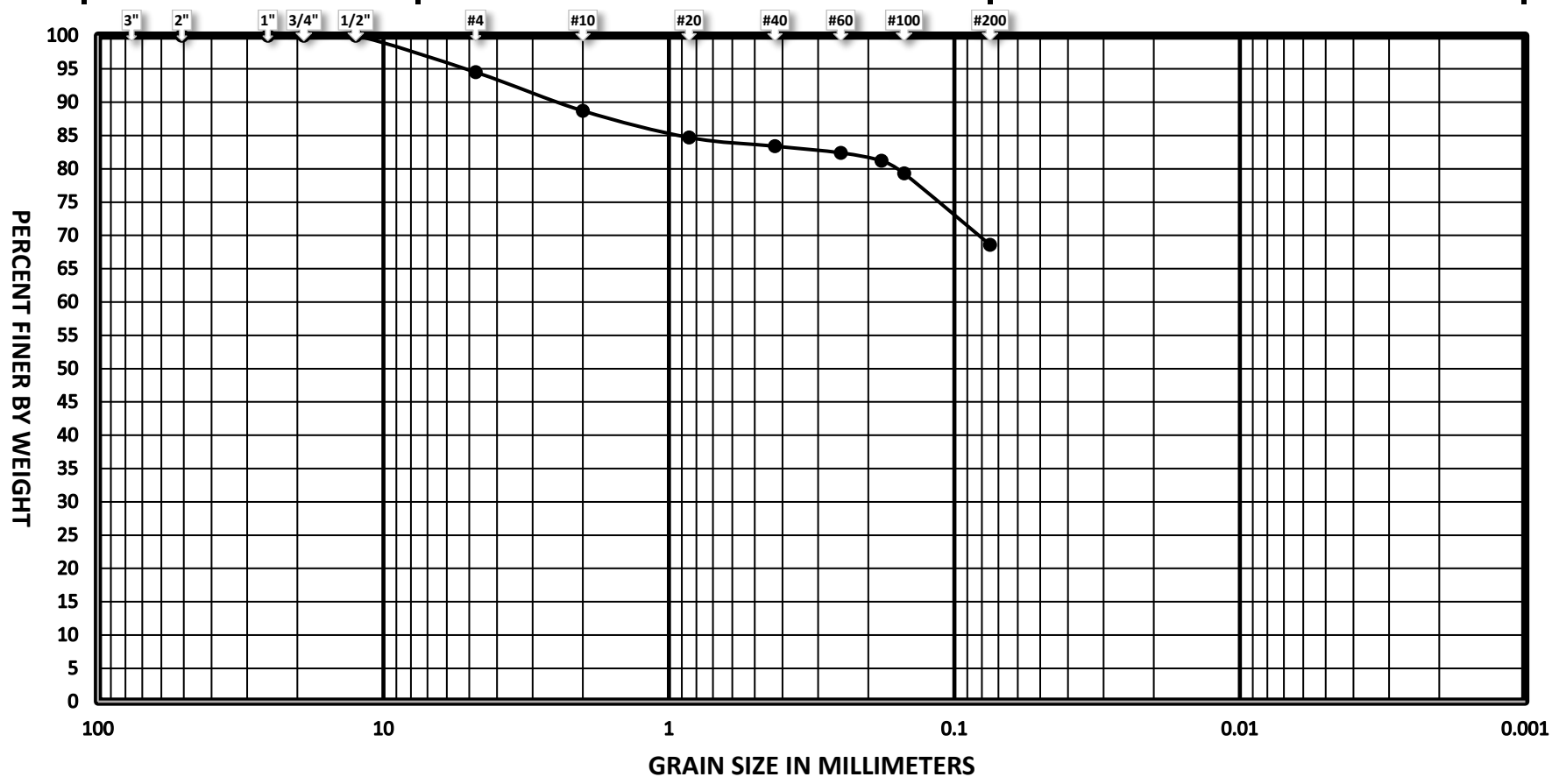
| Unified Soil Classification (ASTM D-2487/2488) | LL | PL | PI |
|---|---|---|---|
| Tan and gray fat clay **(CH)** | 61 | 20 | 41 |

## GRAIN SIZE DISTRIBUTION (ASTM D-422)

Client: SCS Engineers
Project: Waco Landfill
Date: 10/1/2020
Performed By: C. McCauley
TEAM Project Number: 202030

**TEAM Consultants, Inc.**
3101 Pleasant Valley Ln, Suite 101
Arlington, TX 76015
Telephone: (817) 467-5500
Fax: (817) 468-9920

TEAM Consultants, Inc.




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Specimen Data | D90 | D60 | D50 | D30 | D10 | % Gravel | % Sand | % Silt & Clay | $C_C$ | $C_U$ |
|---|---|---|---|---|---|---|---|---|---|---|
| B-23 1-2' | 2.5 | N/A | N/A | N/A | N/A | 5.5 | 25.9 | 68.6 | N/A | N/A |

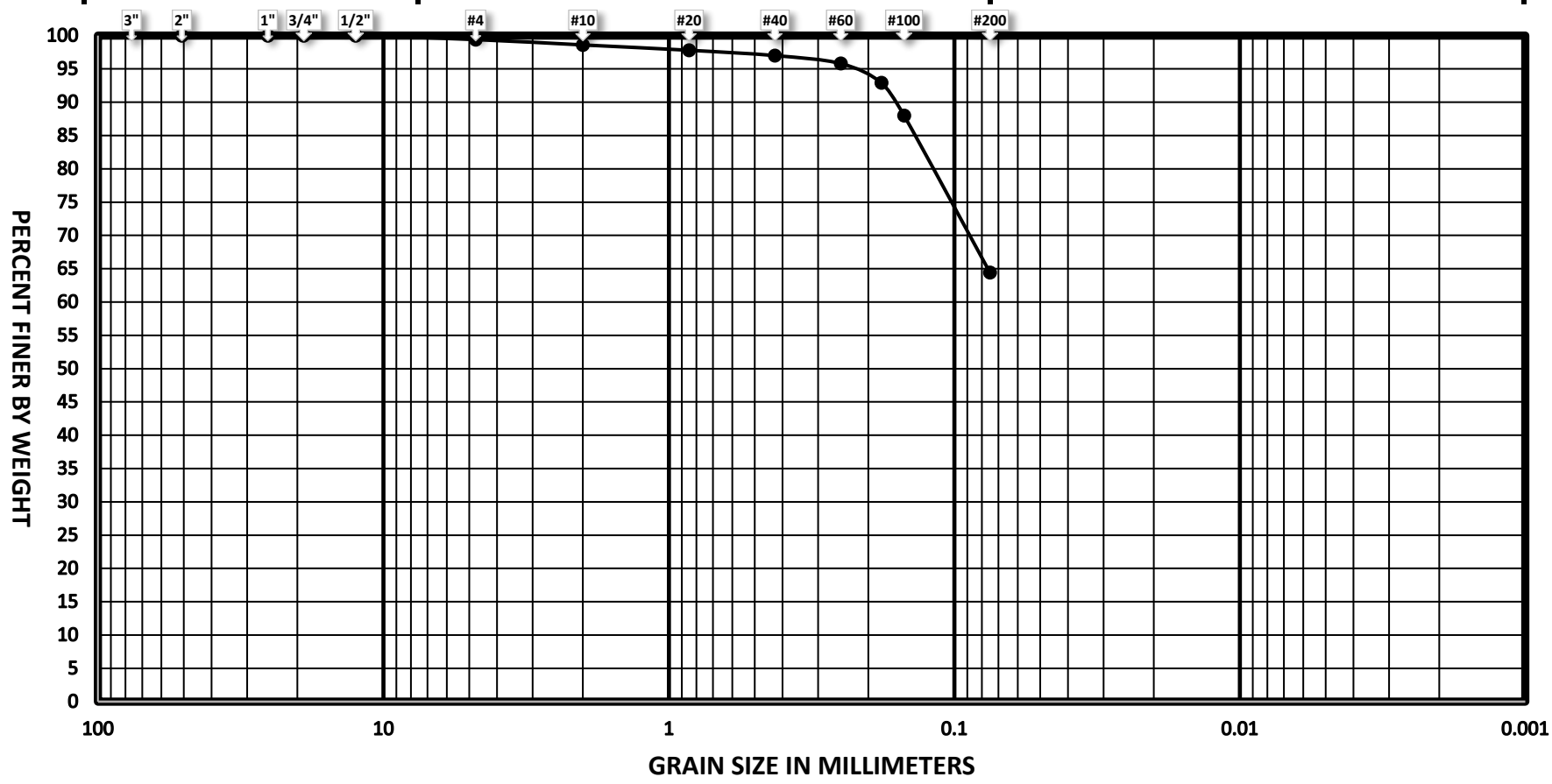
| Unified Soil Classification (ASTM D-2487/2488) | LL | PL | PI |
|---|---|---|---|
| Brown sandy fat clay **(CH)** | 96 | 30 | 66 |

## GRAIN SIZE DISTRIBUTION (ASTM D-422)

Client: SCS Engineers
Project: Waco Landfill
Date: 9/29/2020
Performed By: R. Davis
TEAM Project Number: 202030

**TEAM Consultants, Inc.**
3101 Pleasant Valley Ln, Suite 101
Arlington, TX 76015
Telephone: (817) 467-5500
Fax: (817) 468-9920

TEAM Consultants, Inc.




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Specimen Data | D90 | D60 | D50 | D30 | D10 | % Gravel | % Sand | % Silt & Clay | $C_C$ | $C_U$ |
|---|---|---|---|---|---|---|---|---|---|---|
| B-27 1-2' | 0.16 | N/A | N/A | N/A | N/A | 0.6 | 35.0 | 64.4 | N/A | N/A |

| Unified Soil Classification (ASTM D-2487/2488) | LL | PL | PI |
|---|---|---|---|
| Dark brown and gray sandy fat clay **(CH)** | 59 | 21 | 38 |

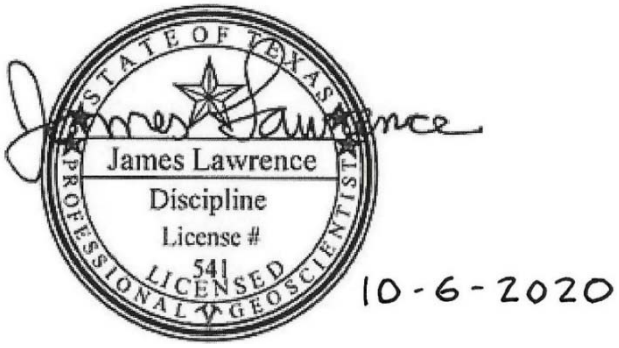
## GRAIN SIZE DISTRIBUTION (ASTM D-422)

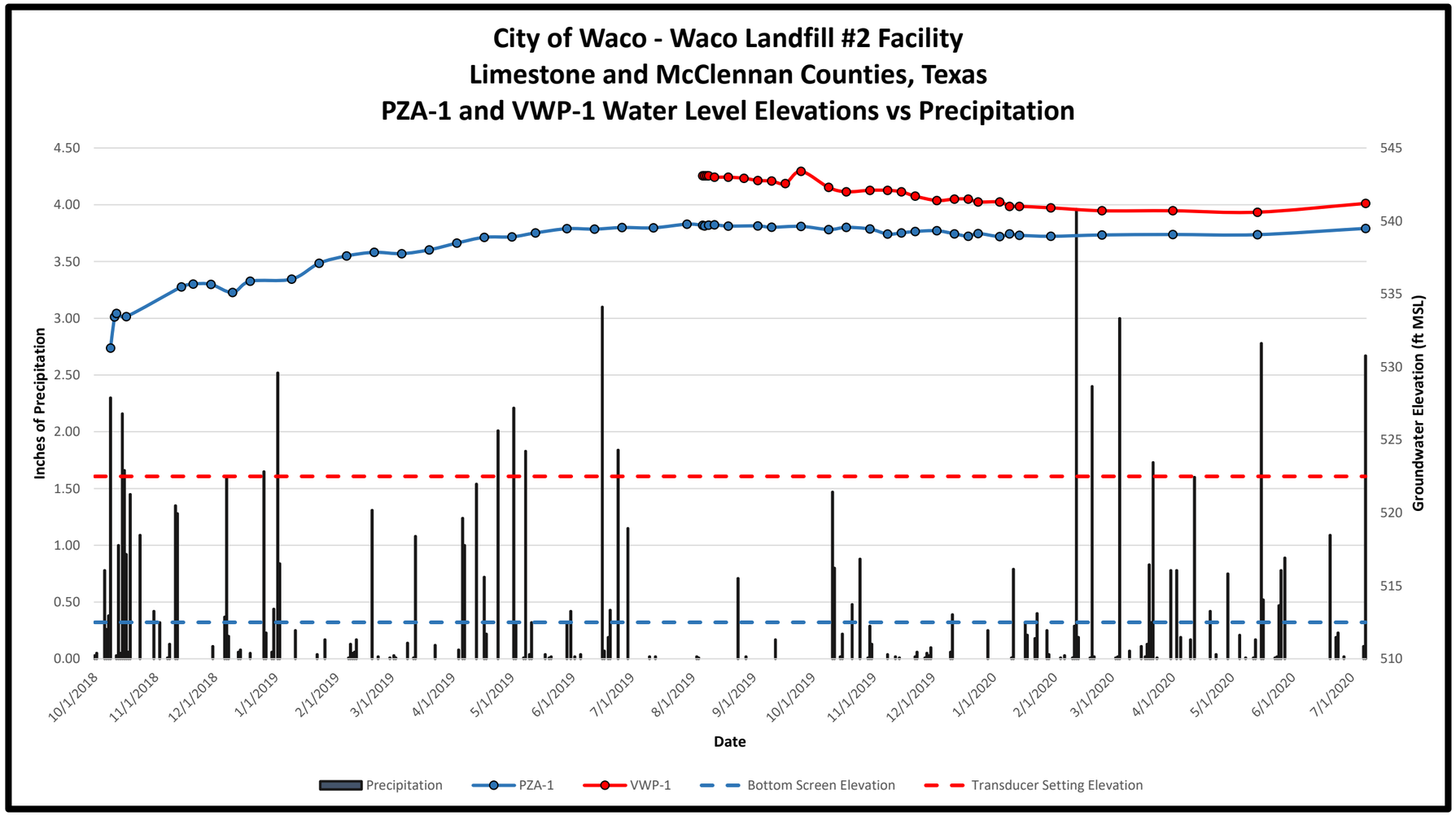
Client: SCS Engineers
Project: Waco Landfill
Date: 9/29/2020
Performed By: R. Davis
TEAM Project Number: 202030

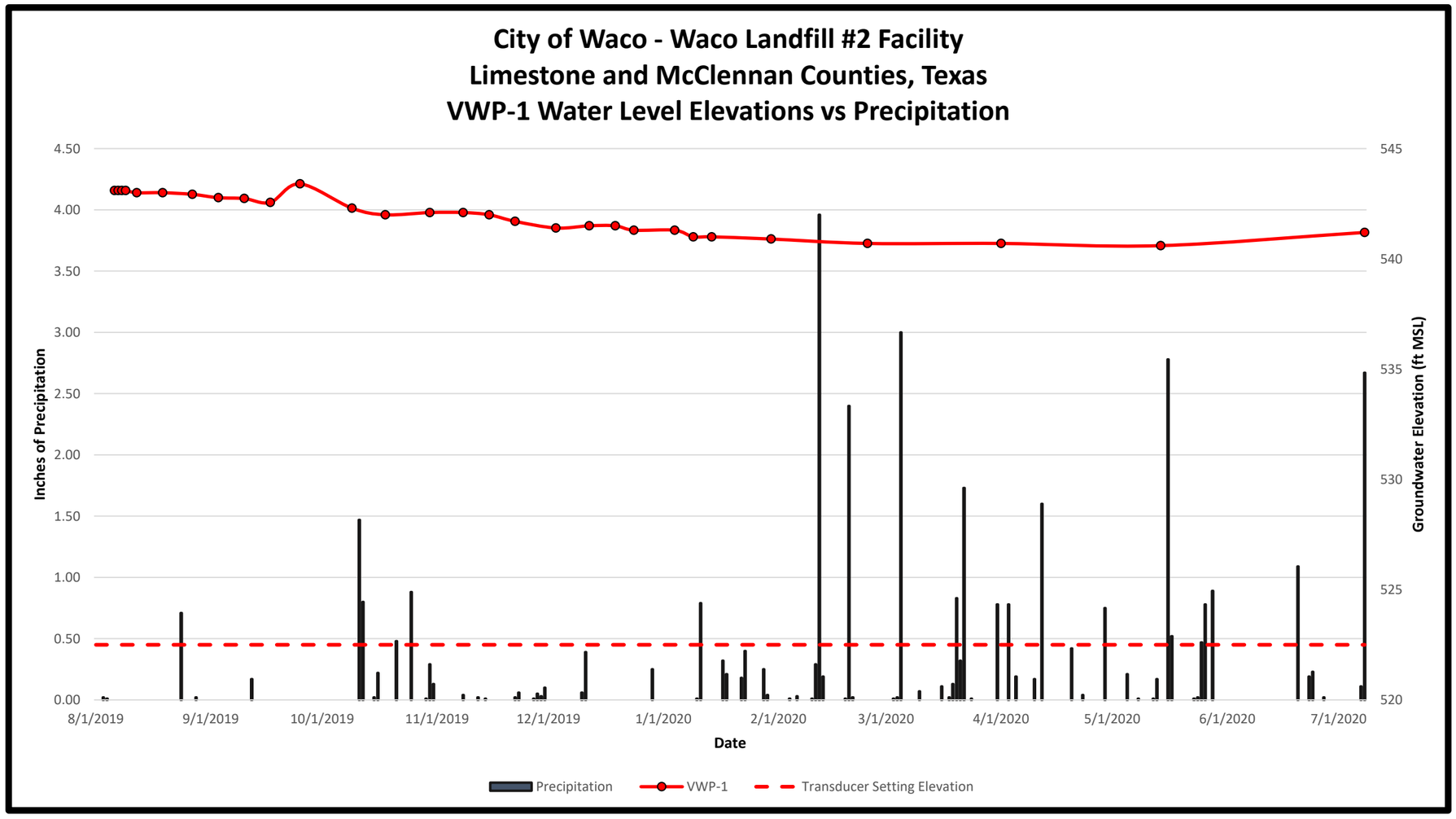
**TEAM Consultants, Inc.**
3101 Pleasant Valley Ln, Suite 101
Arlington, TX 76015
Telephone: (817) 467-5500
Fax: (817) 468-9920

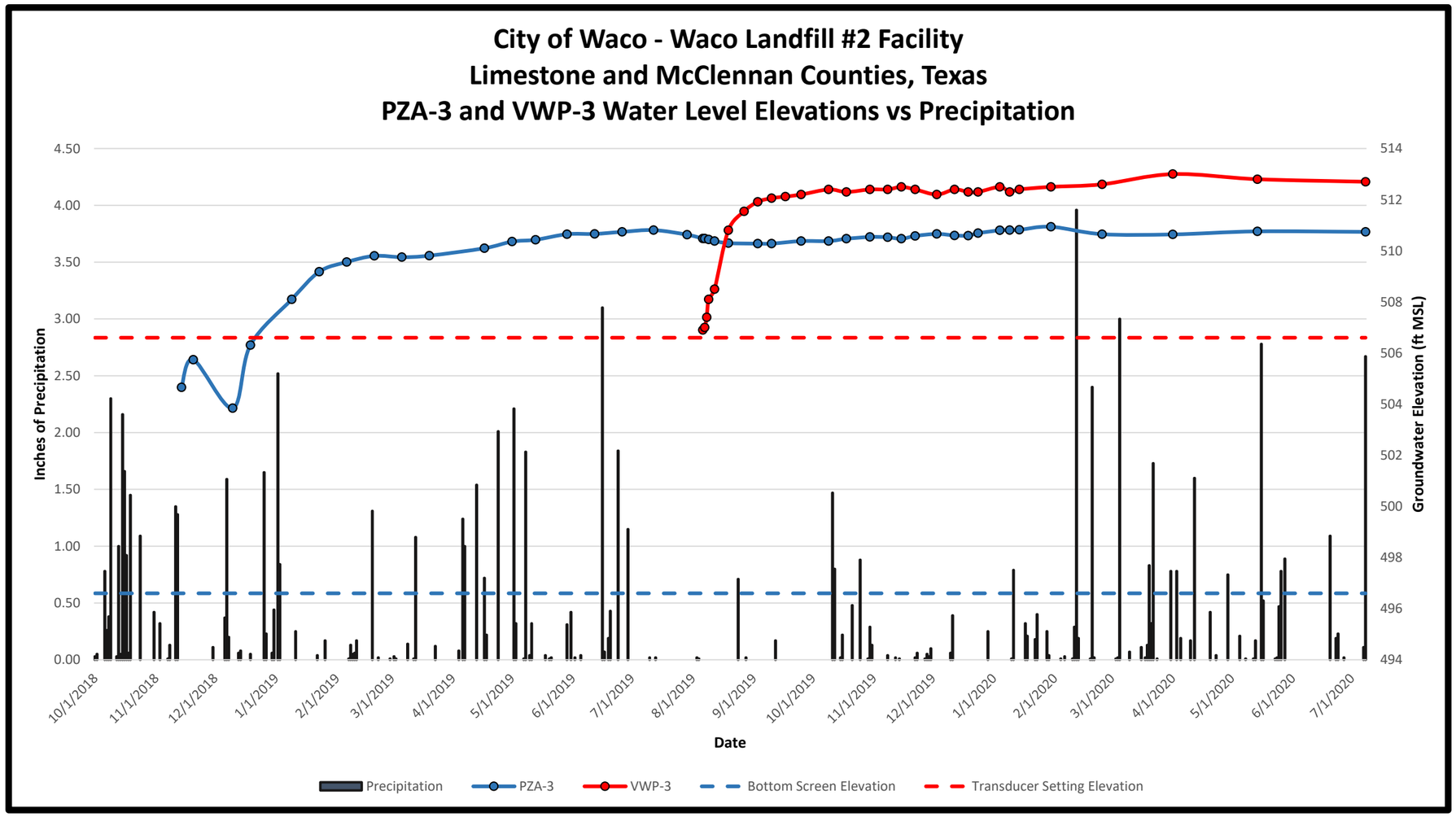
# APPENDIX III-4.J

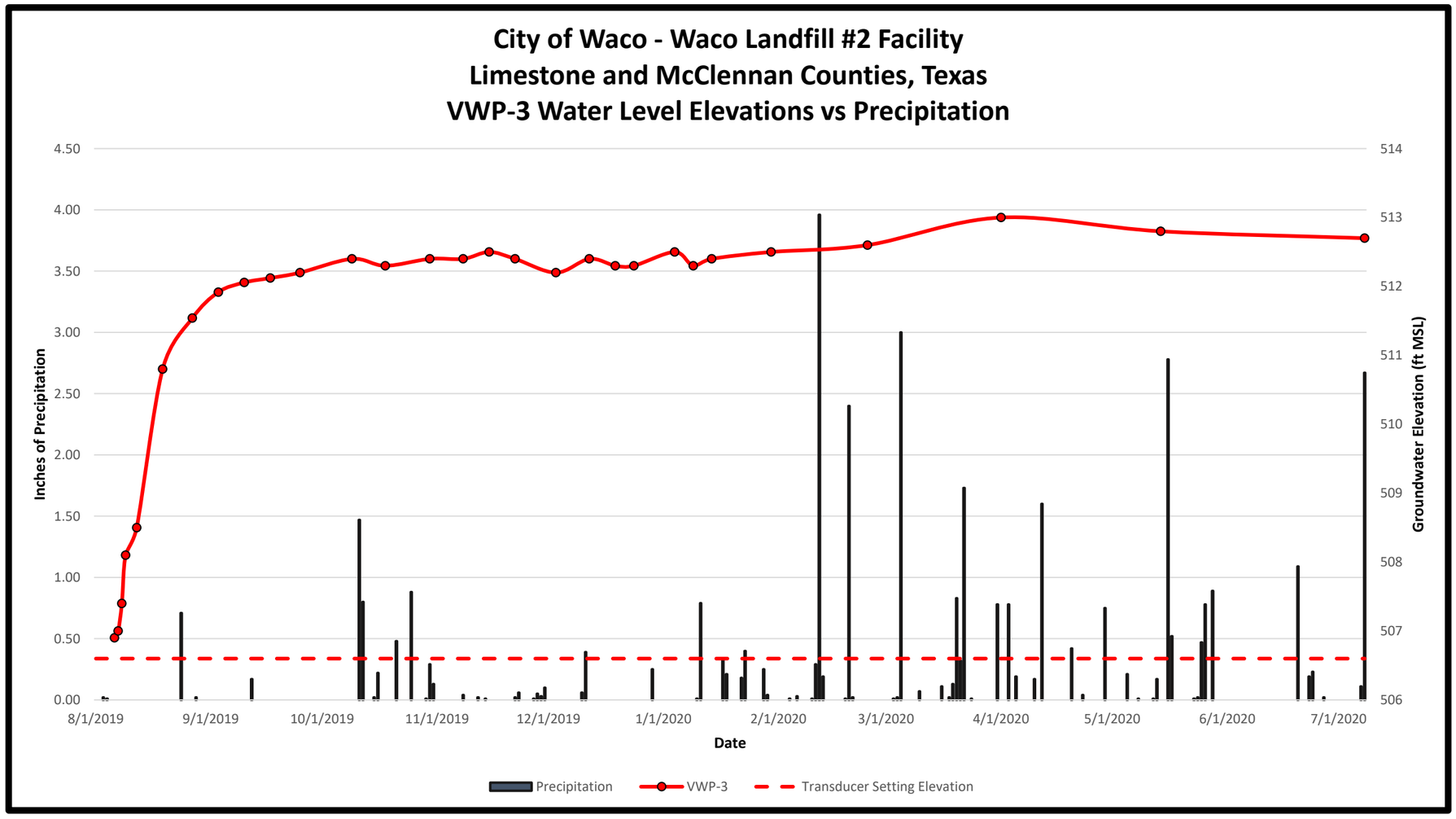
# PRECIPITATION AND GROUNDWATER ELEVATION DATA

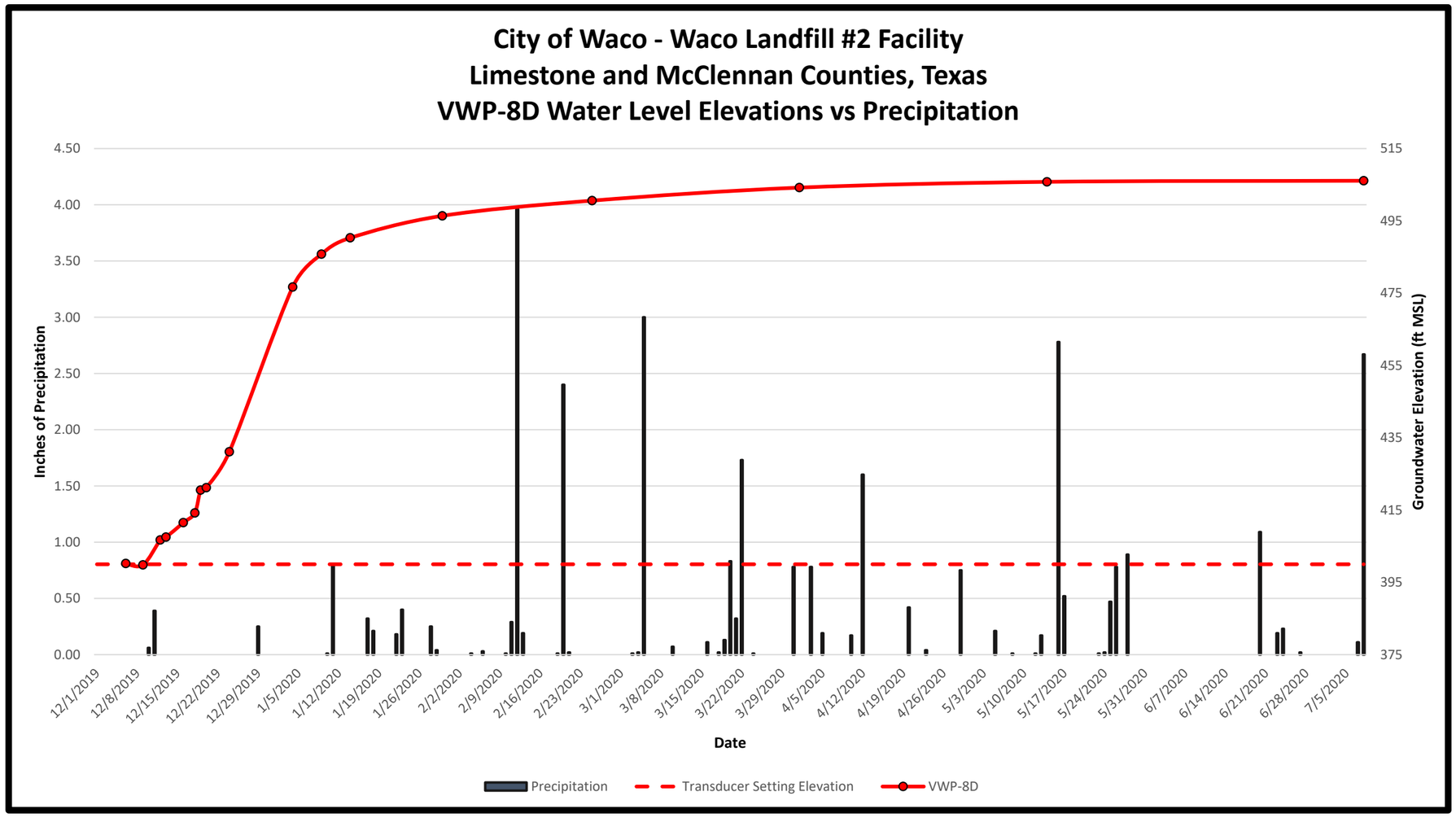


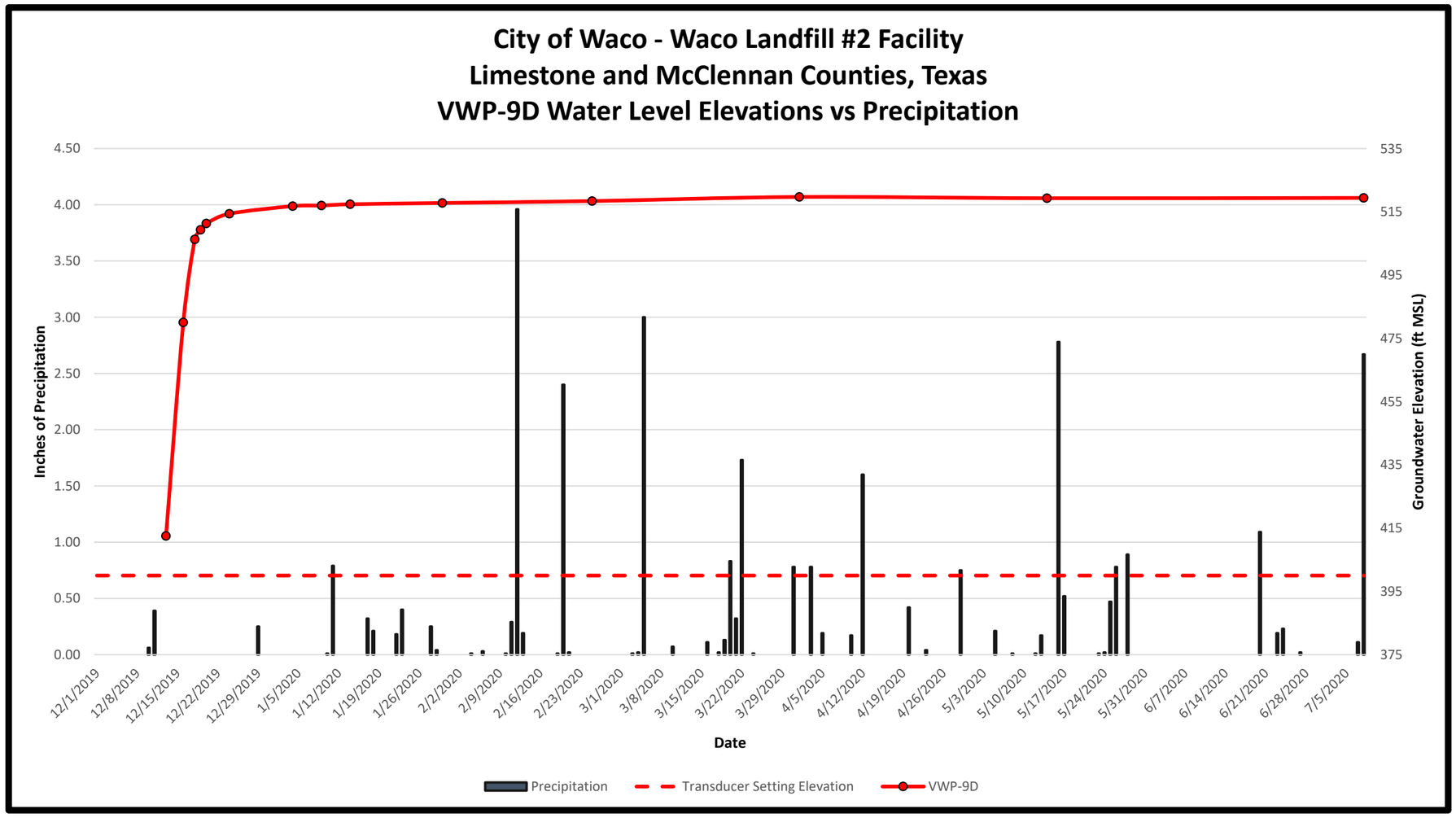

City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
PZA-1 and VWP-1 Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
545
540
535
530
525
520
515
510
10/1/2018
11/1/2018
12/1/2018
1/1/2019
2/1/2019
3/1/2019
4/1/2019
5/1/2019
6/1/2019
7/1/2019
8/1/2019
9/1/2019
10/1/2019
11/1/2019
12/1/2019
1/1/2020
2/1/2020
3/1/2020
4/1/2020
5/1/2020
6/1/2020
7/1/2020
Date
Precipitation
PZA-1
VWP-1
Bottom Screen Elevation
Transducer Setting Elevation

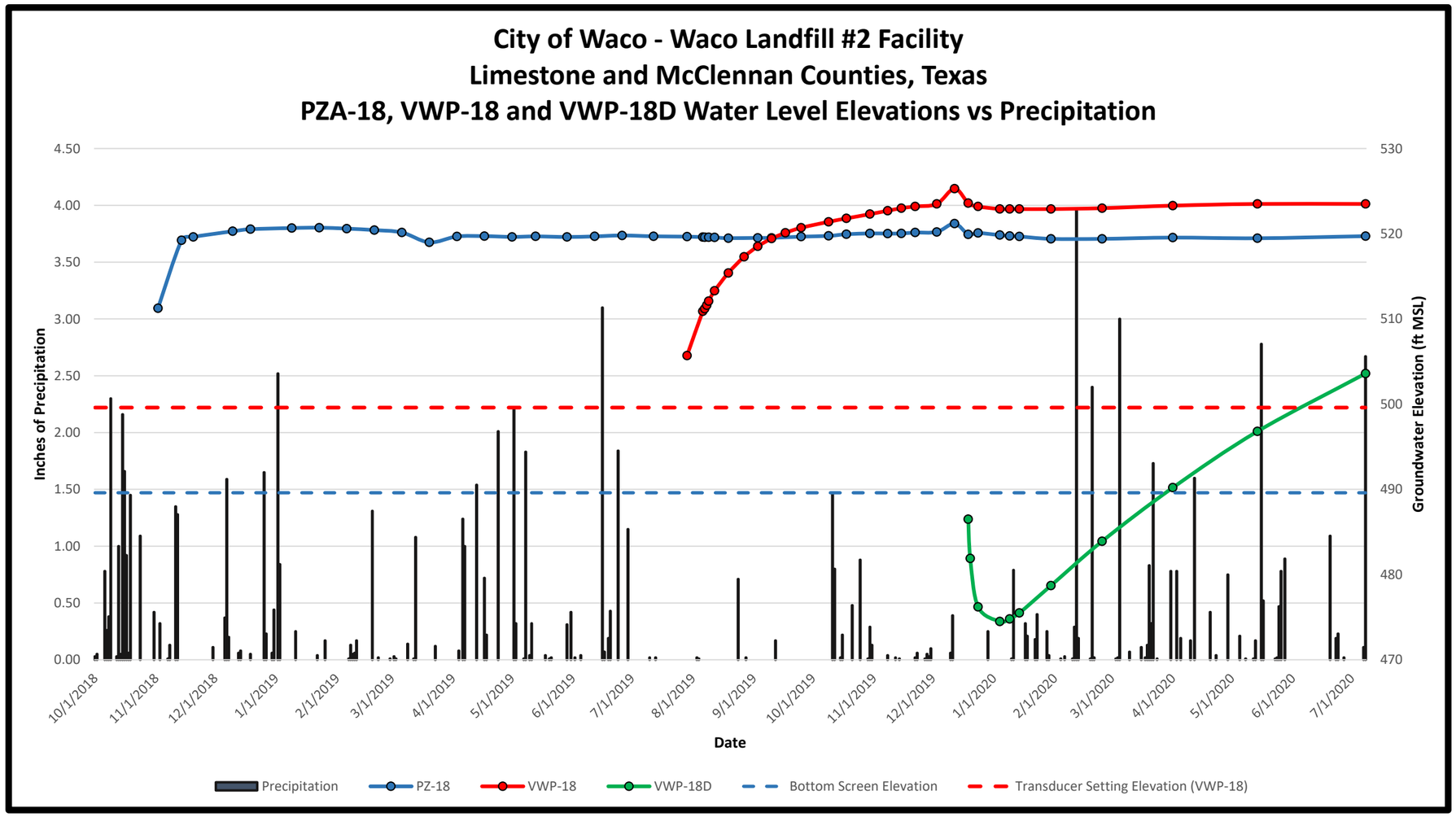

City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
VWP-1 Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
545
540
535
530
525
520
8/1/2019
9/1/2019
10/1/2019
11/1/2019
12/1/2019
1/1/2020
2/1/2020
3/1/2020
4/1/2020
5/1/2020
6/1/2020
7/1/2020
Date
Precipitation
VWP-1
Transducer Setting Elevation

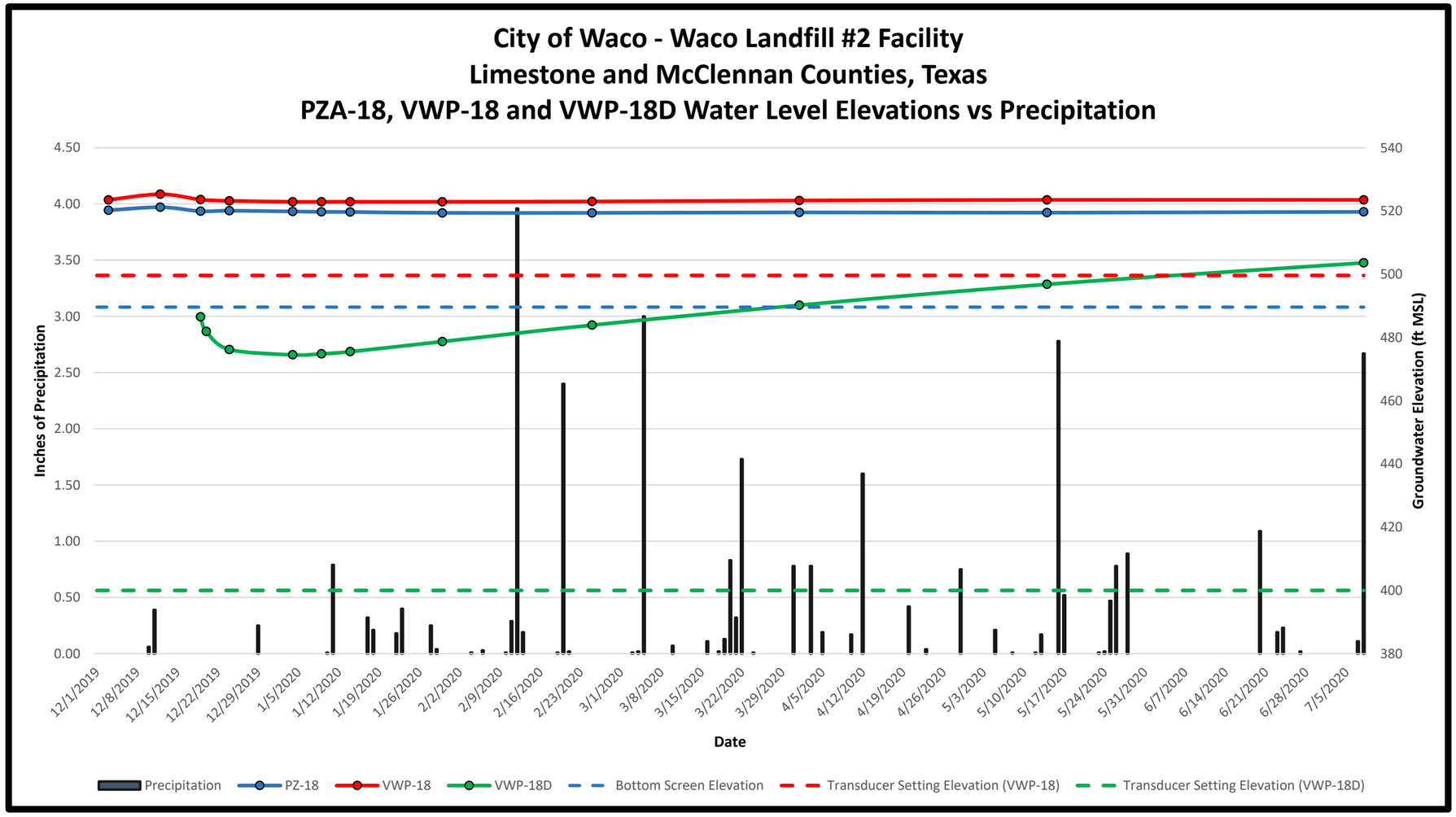

City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
PZA-3 and VWP-3 Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
514
512
510
508
506
504
502
500
498
496
494
10/1/2018
11/1/2018
12/1/2018
1/1/2019
2/1/2019
3/1/2019
4/1/2019
5/1/2019
6/1/2019
7/1/2019
8/1/2019
9/1/2019
10/1/2019
11/1/2019
12/1/2019
1/1/2020
2/1/2020
3/1/2020
4/1/2020
5/1/2020
6/1/2020
7/1/2020
Date
Precipitation
PZA-3
VWP-3
Bottom Screen Elevation
Transducer Setting Elevation

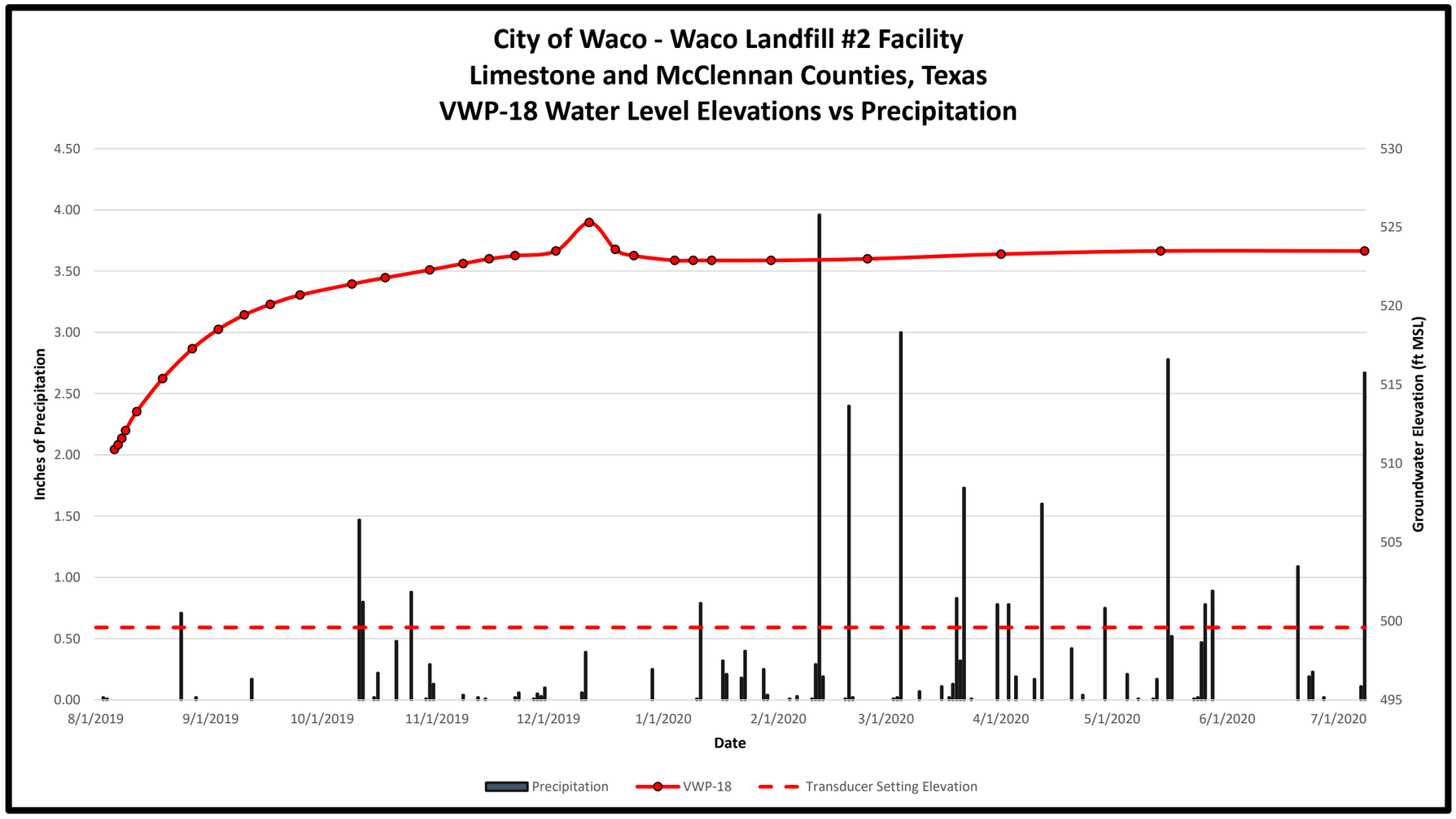

City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
VWP-3 Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
514
513
512
511
510
509
508
507
506
8/1/2019
9/1/2019
10/1/2019
11/1/2019
12/1/2019
1/1/2020
2/1/2020
3/1/2020
4/1/2020
5/1/2020
6/1/2020
7/1/2020
Date
Precipitation
VWP-3
Transducer Setting Elevation

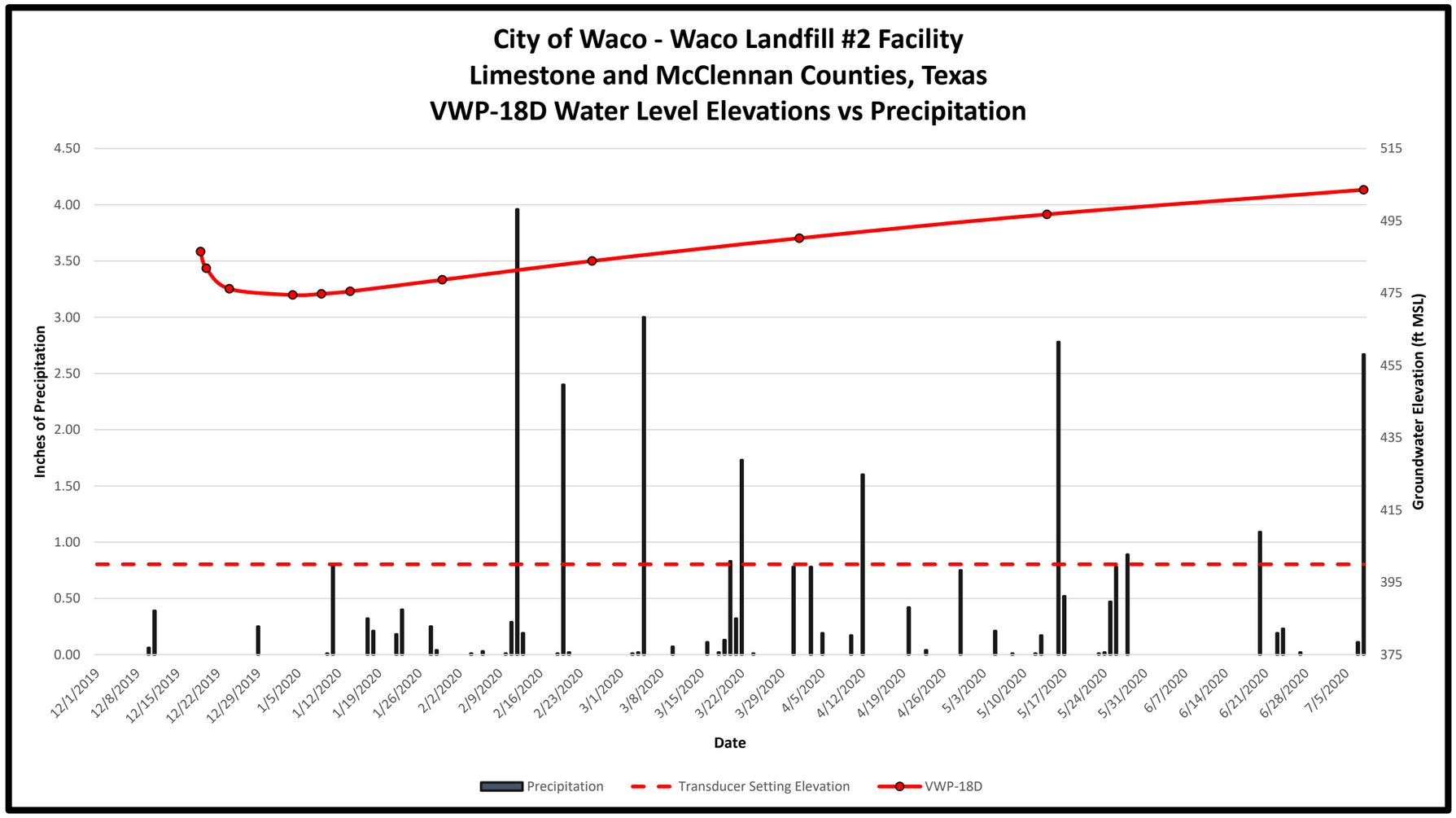

City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
VWP-8D Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
515
495
475
455
435
415
395
375
12/1/2019
12/8/2019
12/15/2019
12/22/2019
12/29/2019
1/5/2020
1/12/2020
1/19/2020
1/26/2020
2/2/2020
2/9/2020
2/16/2020
2/23/2020
3/1/2020
3/8/2020
3/15/2020
3/22/2020
3/29/2020
4/5/2020
4/12/2020
4/19/2020
4/26/2020
5/3/2020
5/10/2020
5/17/2020
5/24/2020
5/31/2020
6/7/2020
6/14/2020
6/21/2020
6/28/2020
7/5/2020
Date
Precipitation
Transducer Setting Elevation
VWP-8D

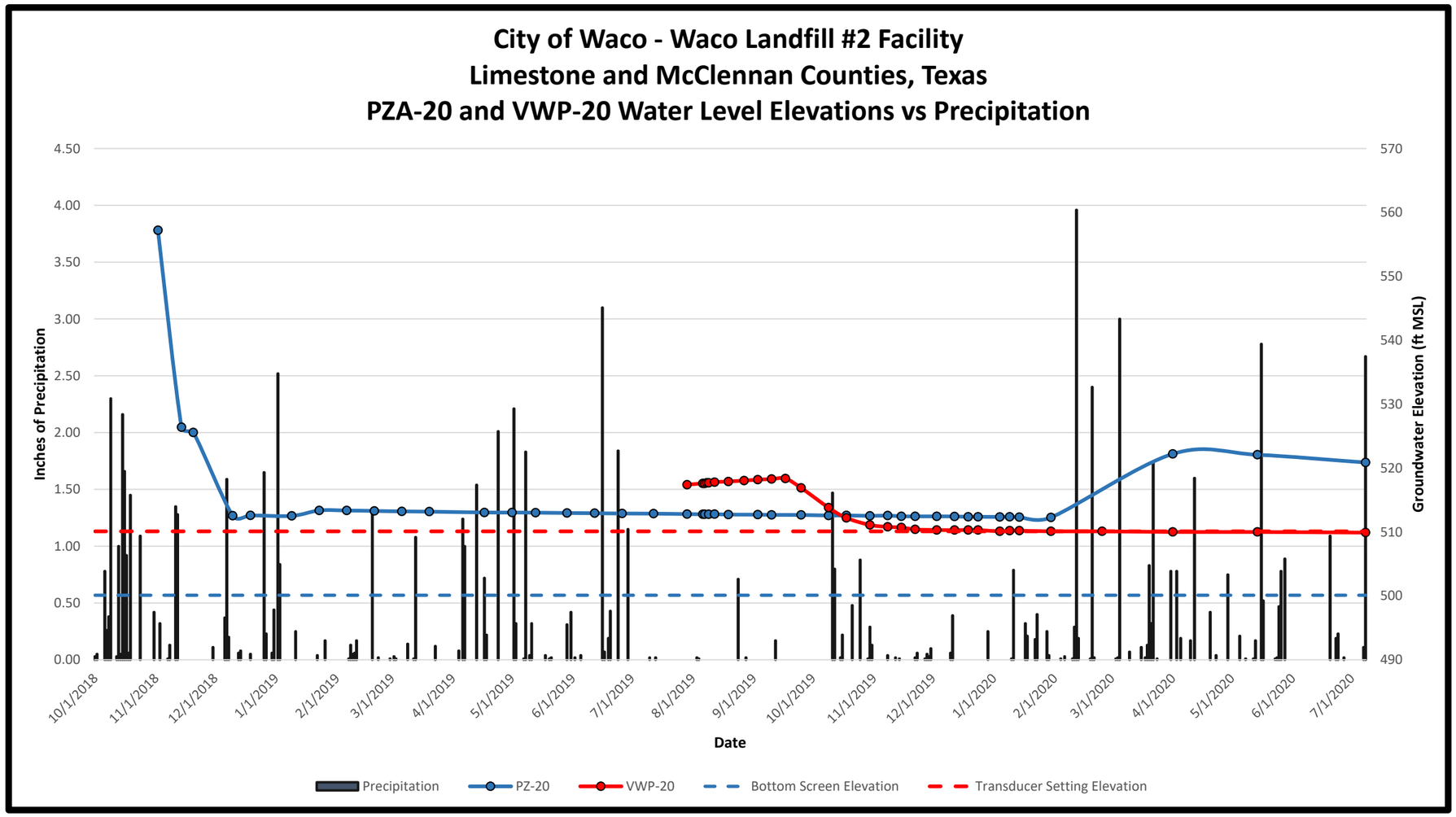

City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
VWP-9D Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
535
515
495
475
455
435
415
395
375
12/1/2019
12/8/2019
12/15/2019
12/22/2019
12/29/2019
1/5/2020
1/12/2020
1/19/2020
1/26/2020
2/2/2020
2/9/2020
2/16/2020
2/23/2020
3/1/2020
3/8/2020
3/15/2020
3/22/2020
3/29/2020
4/5/2020
4/12/2020
4/19/2020
4/26/2020
5/3/2020
5/10/2020
5/17/2020
5/24/2020
5/31/2020
6/7/2020
6/14/2020
6/21/2020
6/28/2020
7/5/2020
Date
Precipitation
Transducer Setting Elevation
VWP-9D

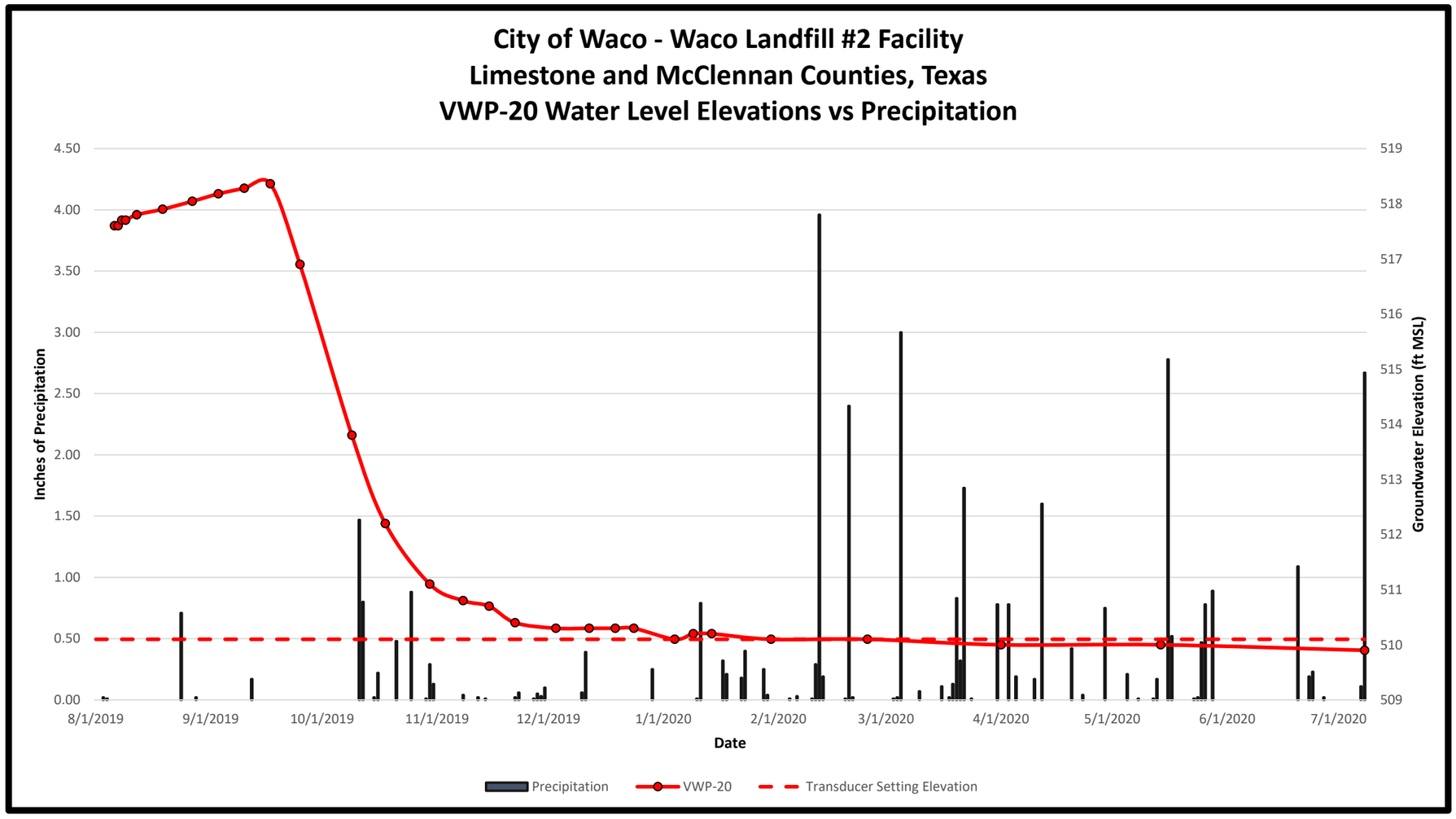

City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
PZA-18, VWP-18 and VWP-18D Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
530
520
510
500
490
480
470
10/1/2018
11/1/2018
12/1/2018
1/1/2019
2/1/2019
3/1/2019
4/1/2019
5/1/2019
6/1/2019
7/1/2019
8/1/2019
9/1/2019
10/1/2019
11/1/2019
12/1/2019
1/1/2020
2/1/2020
3/1/2020
4/1/2020
5/1/2020
6/1/2020
7/1/2020
Date
Precipitation
PZ-18
VWP-18
VWP-18D
Bottom Screen Elevation
Transducer Setting Elevation (VWP-18)

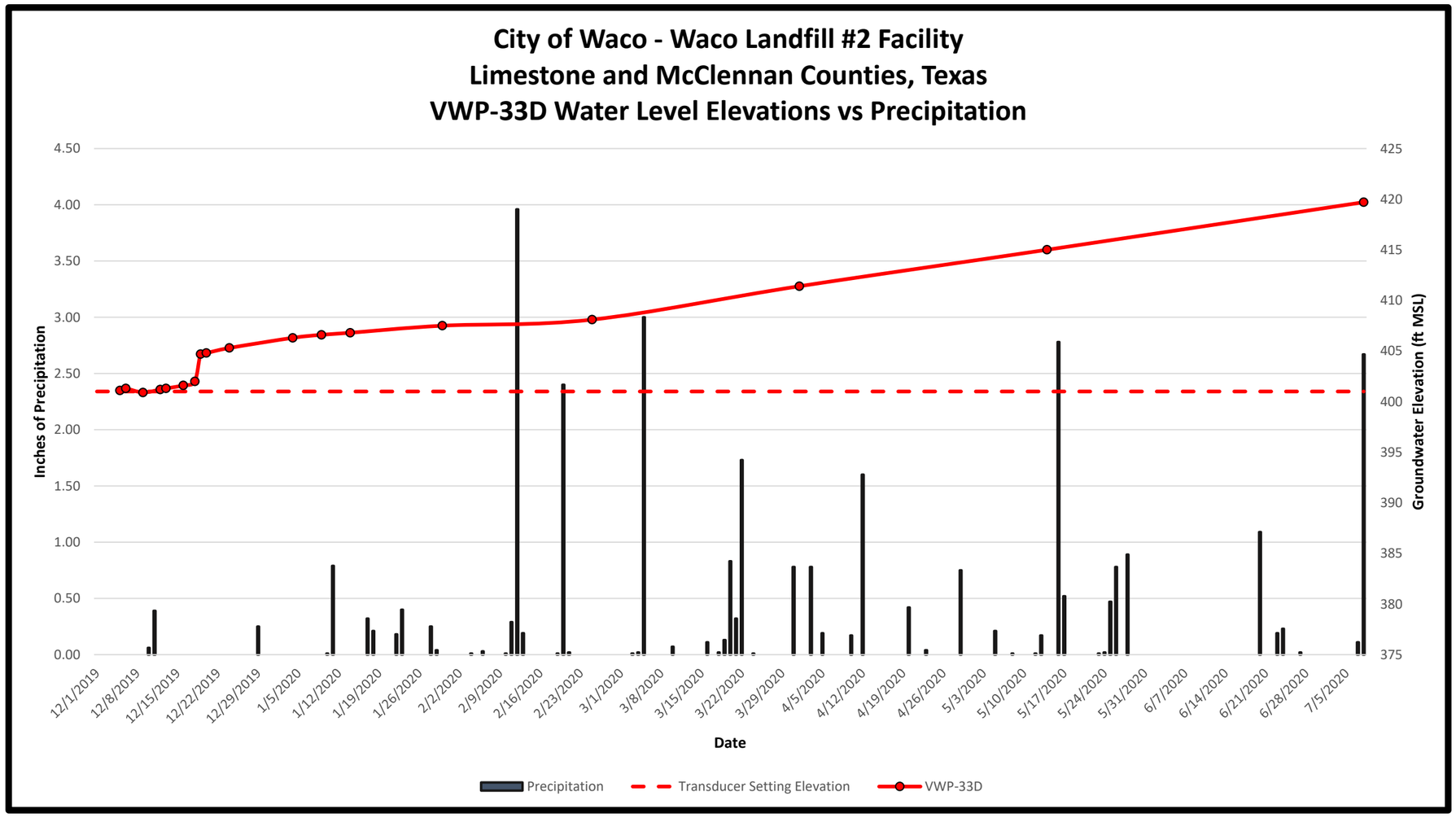

City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
PZA-18, VWP-18 and VWP-18D Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
540
520
500
480
460
440
420
400
380
12/1/2019
12/8/2019
12/15/2019
12/22/2019
12/29/2019
1/5/2020
1/12/2020
1/19/2020
1/26/2020
2/2/2020
2/9/2020
2/16/2020
2/23/2020
3/1/2020
3/8/2020
3/15/2020
3/22/2020
3/29/2020
4/5/2020
4/12/2020
4/19/2020
4/26/2020
5/3/2020
5/10/2020
5/17/2020
5/24/2020
5/31/2020
6/7/2020
6/14/2020
6/21/2020
6/28/2020
7/5/2020
Date
Precipitation
PZ-18
VWP-18
VWP-18D
Bottom Screen Elevation
Transducer Setting Elevation (VWP-18)
Transducer Setting Elevation (VWP-18D)

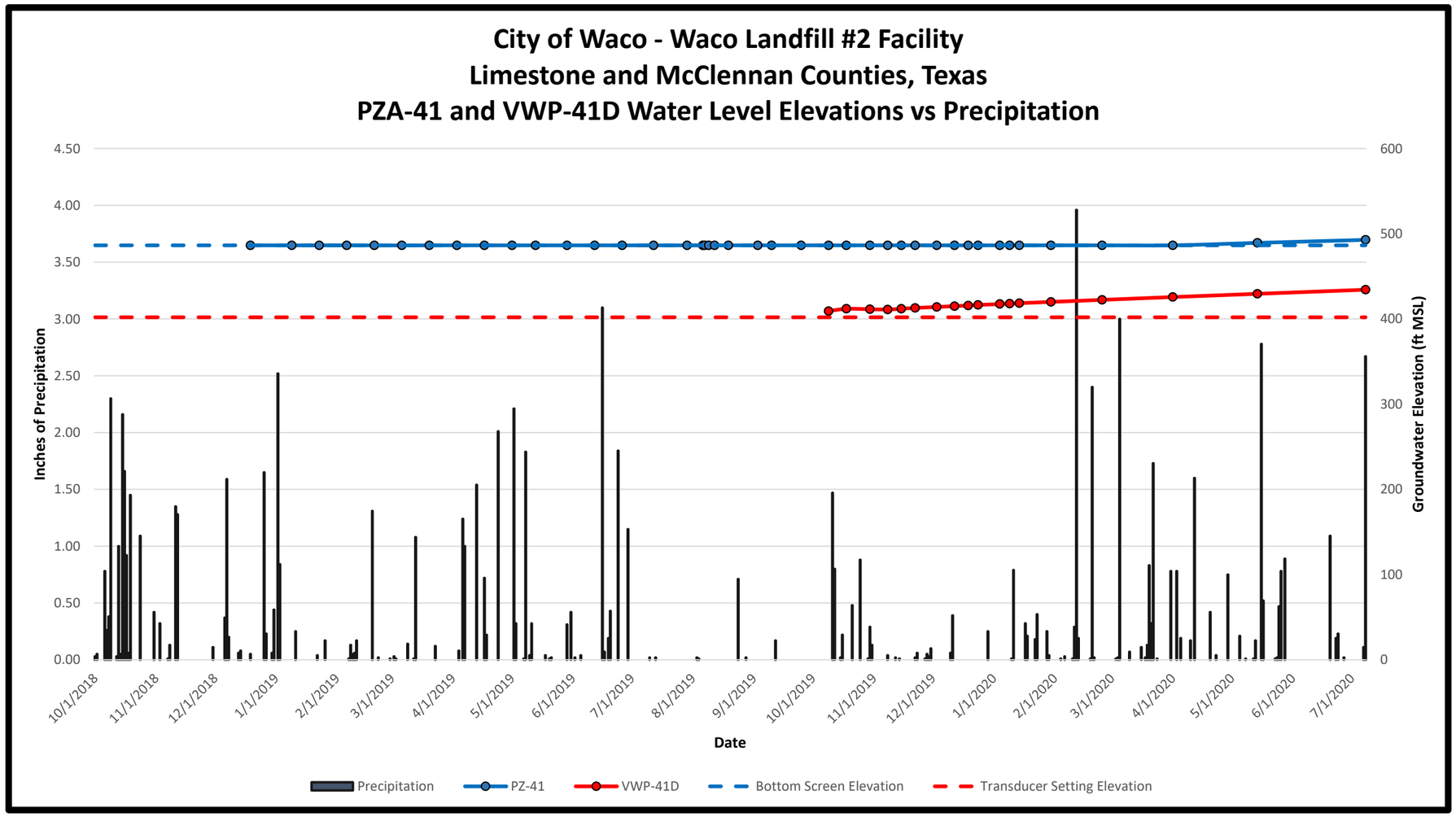

City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
VWP-18 Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
530
525
520
515
510
505
500
495
8/1/2019
9/1/2019
10/1/2019
11/1/2019
12/1/2019
1/1/2020
2/1/2020
3/1/2020
4/1/2020
5/1/2020
6/1/2020
7/1/2020
Date
Precipitation
VWP-18
Transducer Setting Elevation

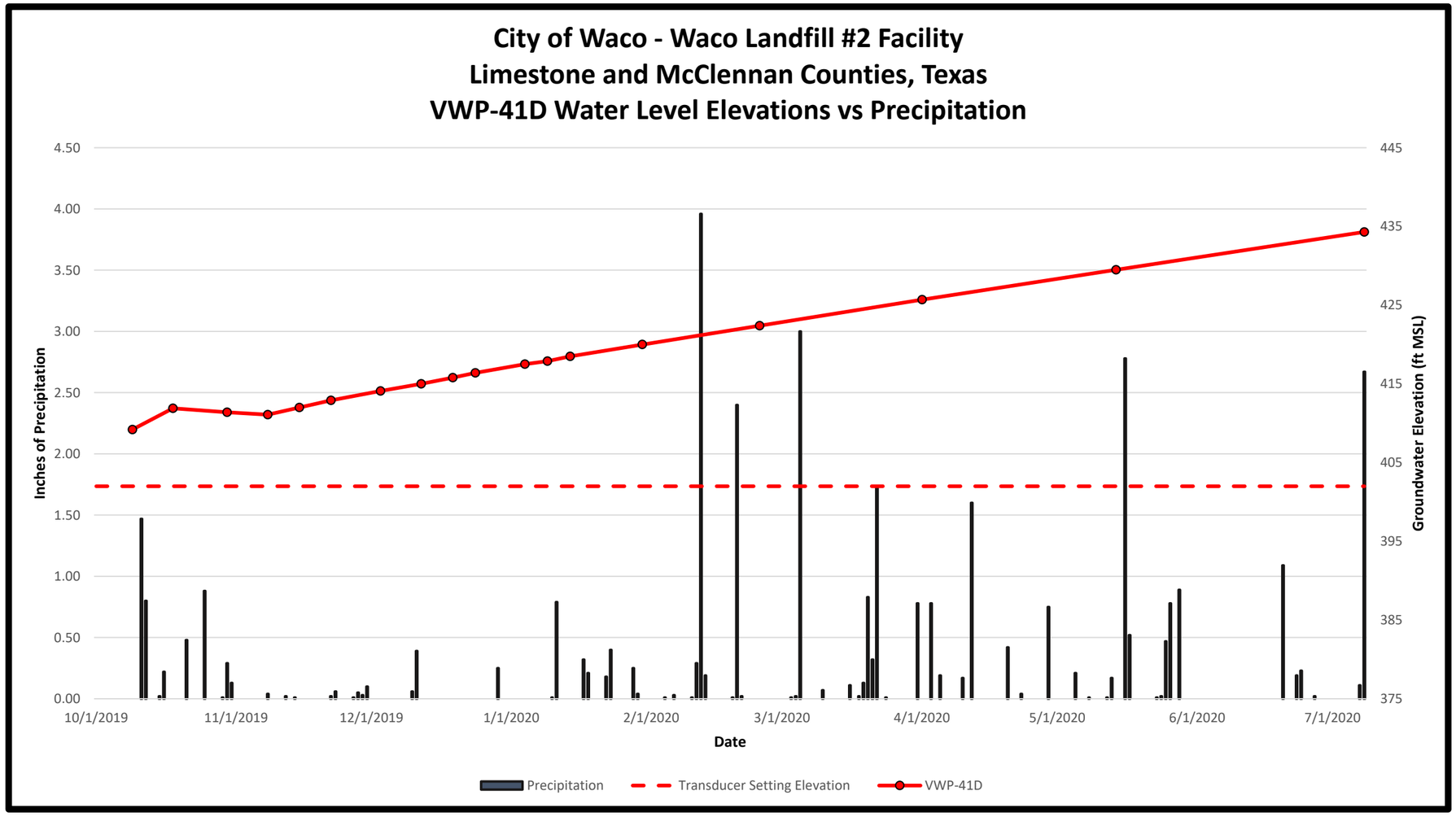

City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
VWP-18D Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
515
495
475
455
435
415
395
375
12/1/2019
12/8/2019
12/15/2019
12/22/2019
12/29/2019
1/5/2020
1/12/2020
1/19/2020
1/26/2020
2/2/2020
2/9/2020
2/16/2020
2/23/2020
3/1/2020
3/8/2020
3/15/2020
3/22/2020
3/29/2020
4/5/2020
4/12/2020
4/19/2020
4/26/2020
5/3/2020
5/10/2020
5/17/2020
5/24/2020
5/31/2020
6/7/2020
6/14/2020
6/21/2020
6/28/2020
7/5/2020
Date
Precipitation
Transducer Setting Elevation
VWP-18D

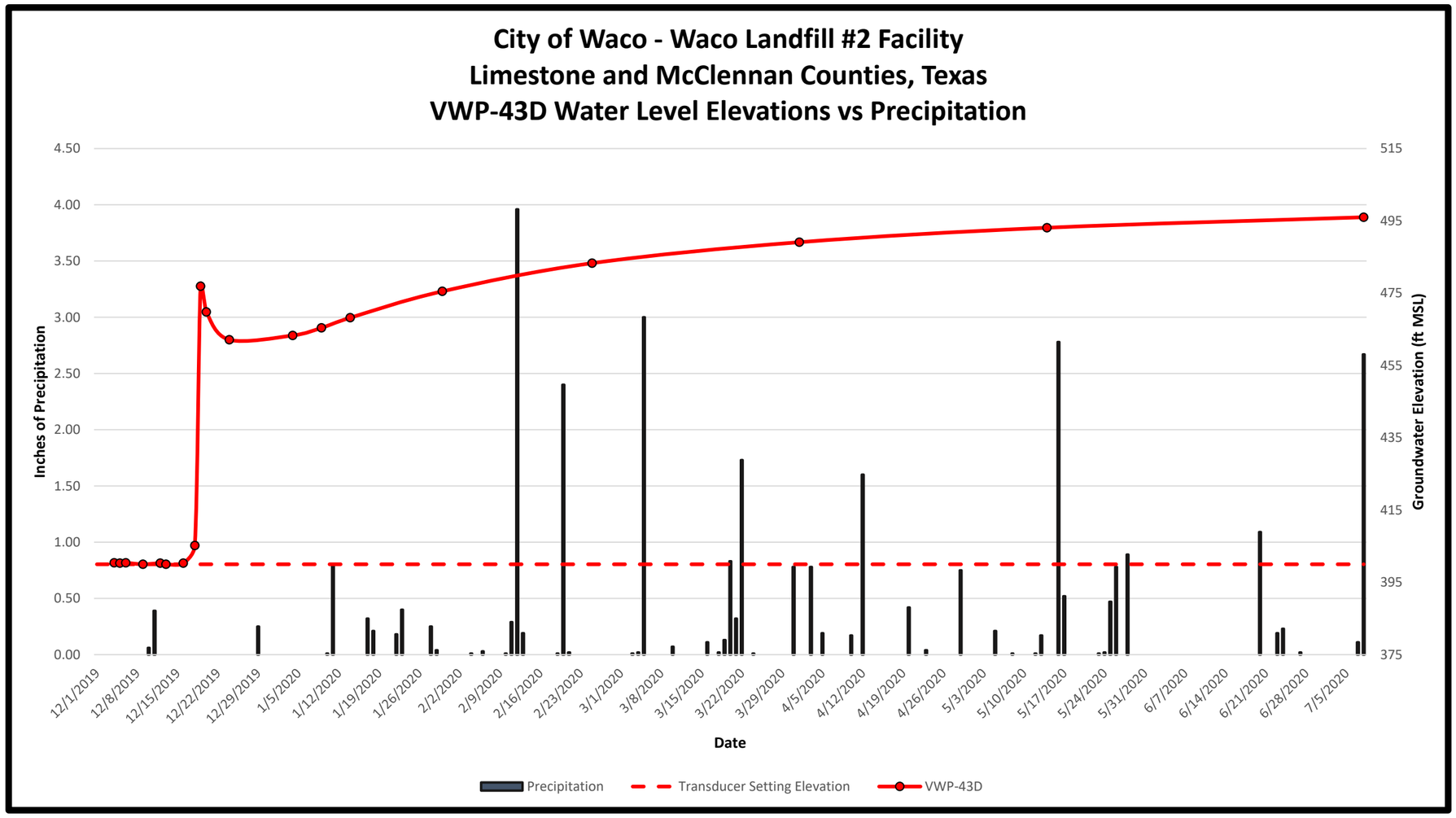

City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
PZA-20 and VWP-20 Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
570
560
550
540
530
520
510
500
490
10/1/2018
11/1/2018
12/1/2018
1/1/2019
2/1/2019
3/1/2019
4/1/2019
5/1/2019
6/1/2019
7/1/2019
8/1/2019
9/1/2019
10/1/2019
11/1/2019
12/1/2019
1/1/2020
2/1/2020
3/1/2020
4/1/2020
5/1/2020
6/1/2020
7/1/2020
Date
Precipitation
PZ-20
VWP-20
Bottom Screen Elevation
Transducer Setting Elevation

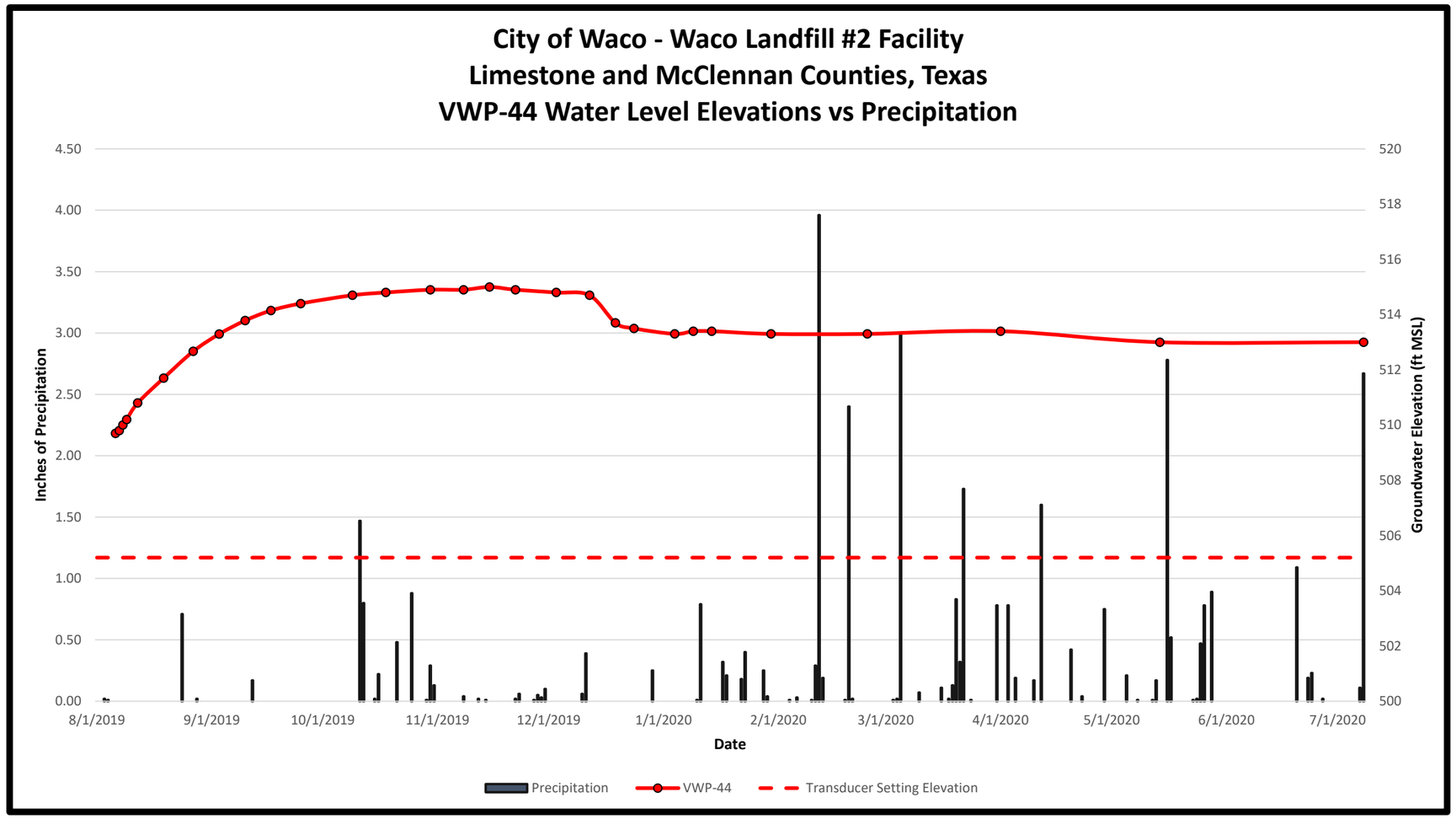

City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
VWP-20 Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
519
518
517
516
515
514
513
512
511
510
509
8/1/2019
9/1/2019
10/1/2019
11/1/2019
12/1/2019
1/1/2020
2/1/2020
3/1/2020
4/1/2020
5/1/2020
6/1/2020
7/1/2020
Date
Precipitation
VWP-20
Transducer Setting Elevation

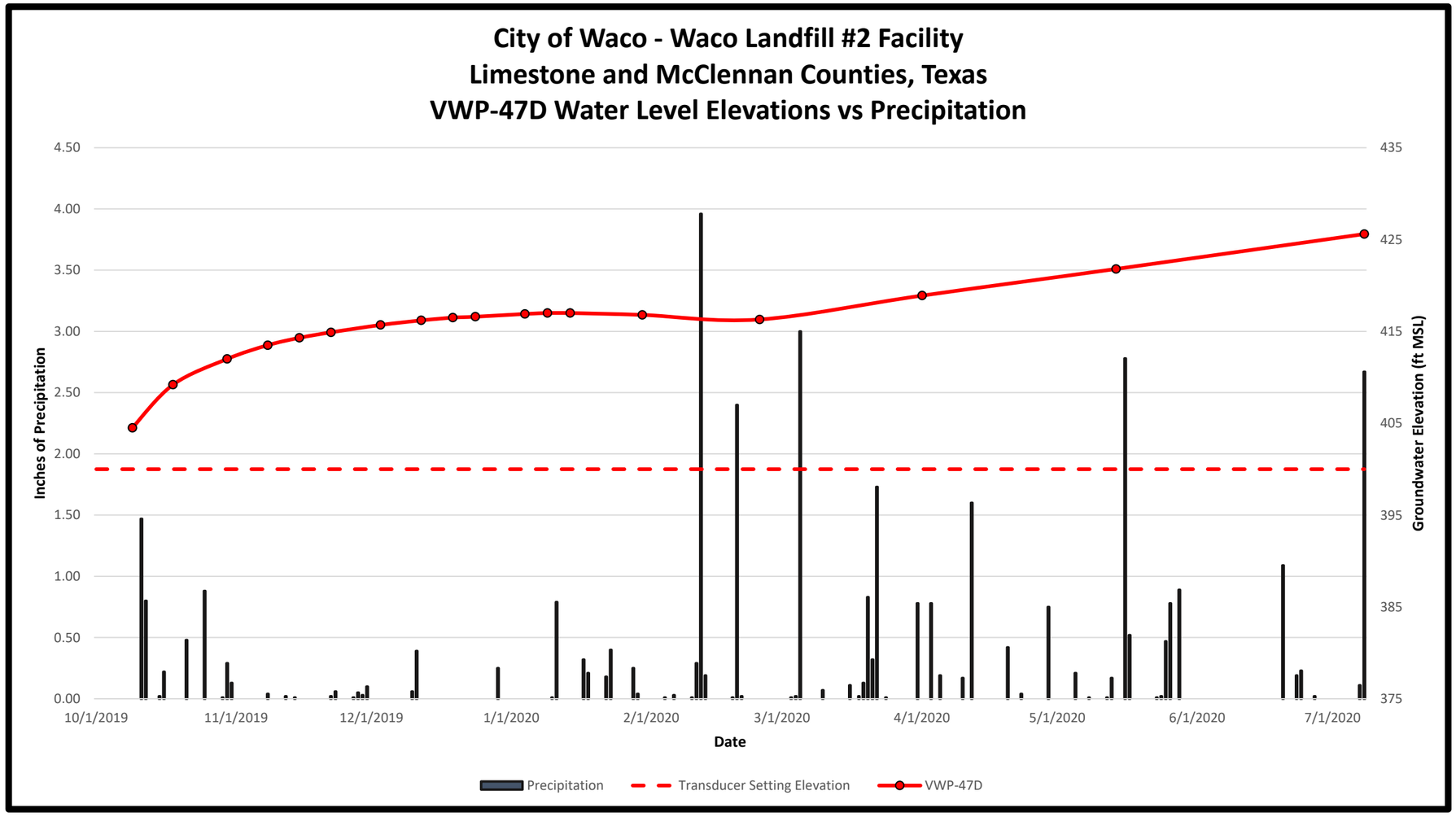

City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
VWP-33D Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
425
420
415
410
405
400
395
390
385
380
375
12/1/2019
12/8/2019
12/15/2019
12/22/2019
12/29/2019
1/5/2020
1/12/2020
1/19/2020
1/26/2020
2/2/2020
2/9/2020
2/16/2020
2/23/2020
3/1/2020
3/8/2020
3/15/2020
3/22/2020
3/29/2020
4/5/2020
4/12/2020
4/19/2020
4/26/2020
5/3/2020
5/10/2020
5/17/2020
5/24/2020
5/31/2020
6/7/2020
6/14/2020
6/21/2020
6/28/2020
7/5/2020
Date
Precipitation
Transducer Setting Elevation
VWP-33D


City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
PZA-41 and VWP-41D Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
600
500
400
300
200
100
0
10/1/2018
11/1/2018
12/1/2018
1/1/2019
2/1/2019
3/1/2019
4/1/2019
5/1/2019
6/1/2019
7/1/2019
8/1/2019
9/1/2019
10/1/2019
11/1/2019
12/1/2019
1/1/2020
2/1/2020
3/1/2020
4/1/2020
5/1/2020
6/1/2020
7/1/2020
Date
Precipitation
PZ-41
VWP-41D
Bottom Screen Elevation
Transducer Setting Elevation


City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
VWP-41D Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
445
435
425
415
405
395
385
375
10/1/2019
11/1/2019
12/1/2019
1/1/2020
2/1/2020
3/1/2020
4/1/2020
5/1/2020
6/1/2020
7/1/2020
Date
Precipitation
Transducer Setting Elevation
VWP-41D

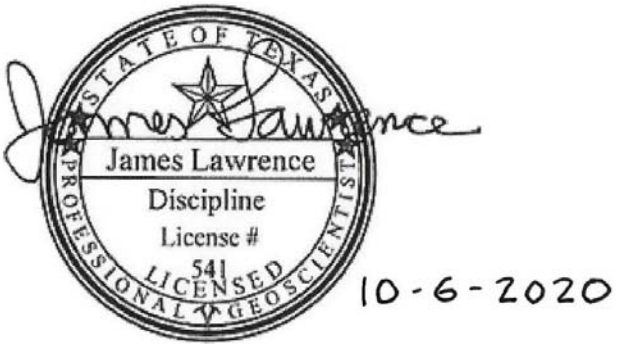

City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
VWP-43D Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
515
495
475
455
435
415
395
375
12/1/2019
12/8/2019
12/15/2019
12/22/2019
12/29/2019
1/5/2020
1/12/2020
1/19/2020
1/26/2020
2/2/2020
2/9/2020
2/16/2020
2/23/2020
3/1/2020
3/8/2020
3/15/2020
3/22/2020
3/29/2020
4/5/2020
4/12/2020
4/19/2020
4/26/2020
5/3/2020
5/10/2020
5/17/2020
5/24/2020
5/31/2020
6/7/2020
6/14/2020
6/21/2020
6/28/2020
7/5/2020
Date
Precipitation
Transducer Setting Elevation
VWP-43D


City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
VWP-44 Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
520
518
516
514
512
510
508
506
504
502
500
8/1/2019
9/1/2019
10/1/2019
11/1/2019
12/1/2019
1/1/2020
2/1/2020
3/1/2020
4/1/2020
5/1/2020
6/1/2020
7/1/2020
Date
Precipitation
VWP-44
Transducer Setting Elevation


City of Waco - Waco Landfill #2 Facility
Limestone and McClennan Counties, Texas
VWP-47D Water Level Elevations vs Precipitation
Inches of Precipitation
Groundwater Elevation (ft MSL)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
435
425
415
405
395
385
375
10/1/2019
11/1/2019
12/1/2019
1/1/2020
2/1/2020
3/1/2020
4/1/2020
5/1/2020
6/1/2020
7/1/2020
Date
Precipitation
Transducer Setting Elevation
VWP-47D

# APPENDIX III-4.K

# STANDPIPE PIEZOMETER HISTORIC WATER LEVEL DATA



## Appendix III-4.K: Standpipe Piezometer Historic Water Level Data

### Depth to water (ft, TOC)

| Well I.D. | 1/23/2019 | 2/6/2019 | 2/20/2019 | 3/6/2019 | 3/20/2019 | 4/3/2019 | 4/17/2019 | 5/1/2019 | 5/13/2019 | 5/29/2019 | 6/12/2019 | 6/26/2019 | 7/12/2019 | 7/29/2019 | 8/6/2019 | 8/7/2019 | 8/9/2019 | 8/12/2019 | 8/19/2019 | 9/3/2019 | 9/10/2019 | 9/25/2019 | 10/9/2019 | 10/18/2019 | 10/30/2019 | 11/8/2019 | 11/15/2019 | 11/22/2019 | 12/3/2019 | 12/12/2019 | 12/19/2019 | 12/24/2019 | 1/4/2020 | 1/9/2020 | 1/14/2020 | 1/30/2020 | 2/25/2020 | 4/1/2020 | 5/14/2020 | 7/8/2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PZ-1 | 18.02 | 17.52 | 17.27 | 17.36 | 17.10 | 16.64 | 16.24 | 16.21 | 15.94 | 15.65 | 15.68 | 15.57 | 15.59 | 15.34 | 15.42 | 15.46 | 15.41 | 15.38 | 15.47 | 15.46 | 15.55 | 15.49 | 15.71 | 15.56 | 15.67 | 16.02 | 15.94 | 15.84 | 15.79 | 16 | 16.17 | 15.98 | 16.19 | 16 | 16.1 | 16.17 | 16.08 | 16.05 | 16.06 | 15.63 |
| PZ-3 | 35.03 | 34.65 | 34.41 | 34.46 | 34.40 | n/a | 34.11 | 33.85 | 33.78 | 33.56 | 33.55 | 33.47 | 33.40 | 33.58 | 33.73 | 33.73 | 33.77 | 33.83 | 33.91 | 33.93 | 33.93 | 33.83 | 33.83 | 33.74 | 33.67 | 33.68 | 33.74 | 33.63 | 33.55 | 33.61 | 33.62 | 33.52 | 33.41 | 33.4 | 33.39 | 33.27 | 33.56 | 33.57 | 33.45 | 33.47 |
| PZ-8 | DRY | 77.17 | 77.19 | 77.56 | 77.57 | DRY | DRY | 77.53 | 77.54 | DRY | 77.55 | 77.54 | 77.57 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | 77.55 | 77.58 | 77.56 | 77.57 | 77.58 | 77.57 | 77.56 | 77.57 | 77.57 | DRY | DRY | DRY | DRY | DRY | DRY |
| PZ-9 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY |
| PZ-18 | 17.09 | 17.20 | 17.37 | 17.65 | 18.81 | 18.12 | 18.08 | 18.17 | 18.11 | 18.18 | 18.11 | 18.00 | 18.10 | 18.14 | 18.20 | 18.21 | 18.21 | 18.23 | 18.32 | 18.28 | 18.28 | 18.14 | 18.05 | 17.86 | 17.76 | 17.78 | 17.76 | 17.66 | 17.59 | 16.61 | 17.88 | 17.71 | 17.96 | 18.07 | 18.12 | 18.4 | 18.4 | 18.25 | 18.33 | 18.08 |
| PZ-20 | 54.40 | 54.41 | 54.48 | 54.55 | 54.59 | n/a | 54.72 | 54.73 | 54.75 | 54.80 | 54.84 | 54.88 | 54.90 | 54.97 | 55.00 | 55.01 | 54.99 | 54.97 | 55.05 | 55.06 | 55.10 | 55.11 | 55.19 | 55.18 | 55.25 | 55.21 | 55.32 | 55.33 | 55.33 | 55.34 | 55.4 | 55.39 | 55.42 | 55.41 | 55.44 | 55.5 | N/A | 45.55 | 45.69 | 46.9 |
| PZ-33 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY |
| PZ-41 | DRY | DRY | 51.64 | 51.75 | DRY | DRY | 51.63 | 51.64 | 51.64 | 51.65 | 51.63 | 51.65 | 51.64 | DRY | DRY | DRY | DRY | DRY | DRY | 51.63 | 51.63 | DRY | DRY | DRY | DRY | 51.63 | DRY | 51.64 | 51.65 | 51.63 | 51.64 | 51.64 | 51.62 | 51.63 | DRY | DRY | DRY | DRY | 48.75 | 45.24 |
| PZ-43 | DRY | 50.41 | 50.41 | 50.44 | DRY | DRY | DRY | DRY | 50.44 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | 50.46 | 50.46 | 50.46 | 50.46 | 50.45 | 50.43 | 50.45 | DRY | DRY | DRY | DRY | DRY | DRY |
| PZ-47 | 33.50 | 33.49 | 33.44 | 33.89 | DRY | DRY | DRY | DRY | 33.93 | DRY | DRY | 33.92 | 33.90 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY |

### Water Level Elevation (ft msl, from T.O.C)

| Well I.D. | 1/23/2019 | 2/6/2019 | 2/20/2019 | 3/6/2019 | 3/20/2019 | 4/3/2019 | 4/17/2019 | 5/1/2019 | 5/13/2019 | 5/29/2019 | 6/12/2019 | 6/26/2019 | 7/12/2019 | 7/29/2019 | 8/6/2019 | 8/7/2019 | 8/9/2019 | 8/12/2019 | 8/19/2019 | 9/3/2019 | 9/10/2019 | 9/25/2019 | 10/9/2019 | 10/18/2019 | 10/30/2019 | 11/8/2019 | 11/15/2019 | 11/22/2019 | 12/3/2019 | 12/12/2019 | 12/19/2019 | 12/24/2019 | 1/4/2020 | 1/9/2020 | 1/14/2020 | 1/30/2020 | 2/25/2020 | 4/1/2020 | 5/14/2020 | 7/8/2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PZ-1 | 537.10 | 537.60 | 537.85 | 537.76 | 538.02 | 538.48 | 538.88 | 538.91 | 539.18 | 539.47 | 539.44 | 539.55 | 539.53 | 539.78 | 539.70 | 539.66 | 539.71 | 539.74 | 539.65 | 539.66 | 539.57 | 539.63 | 539.41 | 539.56 | 539.45 | 539.1 | 539.18 | 539.28 | 539.33 | 539.12 | 538.95 | 539.14 | 538.93 | 539.12 | 539.02 | 538.95 | 539.04 | 539.07 | 539.06 | 539.49 |
| PZ-3 | 509.18 | 509.56 | 509.80 | 509.75 | 509.81 | n/a | 510.10 | 510.36 | 510.43 | 510.65 | 510.66 | 510.74 | 510.81 | 510.63 | 510.48 | 510.48 | 510.44 | 510.38 | 510.30 | 510.28 | 510.28 | 510.38 | 510.38 | 510.47 | 510.54 | 510.53 | 510.47 | 510.58 | 510.66 | 510.60 | 510.59 | 510.69 | 510.80 | 510.81 | 510.82 | 510.94 | 510.65 | 510.64 | 510.76 | 510.74 |
| PZ-8 | DRY | 476.22 | 476.20 | 475.83 | 475.82 | DRY | DRY | 475.86 | 475.85 | DRY | 475.84 | 475.85 | 475.82 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | 475.84 | 475.81 | 475.83 | 475.82 | 475.81 | 475.82 | 475.83 | 475.82 | 475.82 | DRY | DRY | DRY | DRY | DRY | DRY |
| PZ-9 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY |
| PZ-18 | 520.71 | 520.60 | 520.43 | 520.15 | 518.99 | 519.68 | 519.72 | 519.63 | 519.69 | 519.62 | 519.69 | 519.80 | 519.70 | 519.66 | 519.60 | 519.59 | 519.59 | 519.57 | 519.48 | 519.52 | 519.52 | 519.66 | 519.75 | 519.94 | 520.04 | 520.02 | 520.04 | 520.14 | 520.21 | 521.19 | 519.92 | 520.09 | 519.84 | 519.73 | 519.68 | 519.4 | 519.4 | 519.55 | 519.47 | 519.72 |
| PZ-20 | 513.37 | 513.36 | 513.29 | 513.22 | 513.18 | n/a | 513.05 | 513.04 | 513.02 | 512.97 | 512.93 | 512.89 | 512.87 | 512.80 | 512.77 | 512.76 | 512.78 | 512.80 | 512.72 | 512.71 | 512.67 | 512.66 | 512.58 | 512.59 | 512.52 | 512.56 | 512.45 | 512.44 | 512.44 | 512.43 | 512.37 | 512.38 | 512.35 | 512.36 | 512.33 | 512.27 | N/A | 522.22 | 522.08 | 520.87 |
| PZ-33 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY |
| PZ-41 | DRY | DRY | 486.40 | 486.29 | DRY | DRY | 486.41 | 486.40 | 486.40 | 486.39 | 486.41 | 486.39 | 486.40 | DRY | DRY | DRY | DRY | DRY | DRY | 486.41 | 486.41 | DRY | DRY | DRY | DRY | 486.41 | DRY | 486.4 | 486.39 | 486.41 | 486.4 | 486.4 | 486.42 | 486.41 | DRY | DRY | DRY | DRY | 489.29 | 492.8 |
| PZ-43 | DRY | 500.90 | 500.90 | 500.87 | DRY | DRY | DRY | DRY | 500.87 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | 500.85 | 500.85 | 500.85 | 500.85 | 500.86 | 500.88 | 500.86 | DRY | DRY | DRY | DRY | DRY | DRY |
| PZ-47 | 502.66 | 502.67 | 502.72 | 502.27 | DRY | DRY | DRY | DRY | 502.23 | DRY | DRY | 502.24 | 502.26 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY |

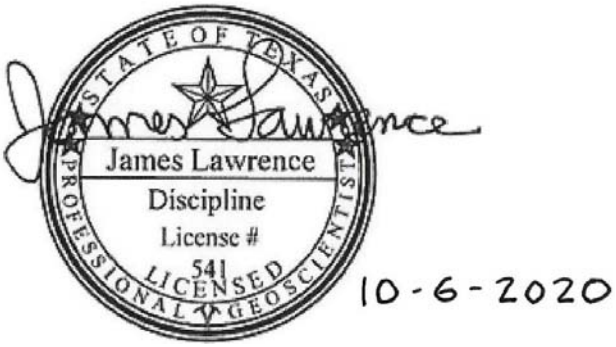
### Height of Water Column (ft)

| Well I.D. | 1/23/2019 | 2/6/2019 | 2/20/2019 | 3/6/2019 | 3/20/2019 | 4/3/2019 | 4/17/2019 | 5/1/2019 | 5/13/2019 | 5/29/2019 | 6/12/2019 | 6/26/2019 | 7/12/2019 | 7/29/2019 | 8/6/2019 | 8/7/2019 | 8/9/2019 | 8/12/2019 | 8/19/2019 | 9/3/2019 | 9/10/2019 | 9/25/2019 | 10/9/2019 | 10/18/2019 | 10/30/2019 | 11/8/2019 | 11/15/2019 | 11/22/2019 | 12/3/2019 | 12/12/2019 | 12/19/2019 | 12/24/2019 | 1/4/2020 | 1/9/2020 | 1/14/2020 | 1/30/2020 | 2/25/2020 | 4/1/2020 | 5/14/2020 | 7/8/2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PZ-1 | 24.92 | 25.42 | 25.67 | 25.58 | 25.84 | 26.30 | 26.70 | 26.73 | 27.00 | 27.29 | 27.26 | 27.37 | 27.35 | 27.60 | 27.52 | 27.48 | 27.53 | 27.56 | 27.47 | 27.48 | 27.39 | 27.45 | 27.23 | 27.38 | 27.27 | 26.92 | 27 | 27.1 | 27.15 | 26.94 | 26.77 | 26.96 | 26.75 | 26.94 | 26.84 | 26.77 | 26.86 | 26.89 | 26.88 | 27.31 |
| PZ-3 | 12.97 | 13.35 | 13.59 | 13.54 | 13.60 | N/A | 13.89 | 14.15 | 14.22 | 14.44 | 14.45 | 14.53 | 14.60 | 14.42 | 14.27 | 14.27 | 14.23 | 14.17 | 14.09 | 14.07 | 14.07 | 14.17 | 14.17 | 14.26 | 14.33 | 14.32 | 14.26 | 14.37 | 34.45 | 14.39 | 14.38 | 14.48 | 14.59 | 14.6 | 14.61 | 14.73 | 14.44 | 14.43 | 14.55 | 14.53 |
| PZ-8 | DRY | 0.59 | 0.57 | 0.20 | 0.19 | DRY | DRY | 0.23 | 0.22 | DRY | 0.21 | 0.22 | 0.19 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | 0.21 | 0.18 | 0.2 | 0.19 | 0.18 | 0.19 | 0.2 | 0.19 | 0.19 | DRY | DRY | DRY | DRY | DRY | DRY |
| PZ-9 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY |
| PZ-18 | 31.72 | 31.61 | 31.44 | 31.16 | 30.00 | 30.69 | 30.73 | 30.64 | 30.70 | 30.63 | 30.70 | 30.81 | 30.71 | 30.67 | 30.61 | 30.60 | 30.60 | 30.58 | 30.49 | 30.53 | 30.53 | 30.67 | 30.76 | 30.95 | 31.05 | 31.03 | 31.05 | 31.15 | 31.22 | 32.23 | 30.93 | 31.1 | 30.85 | 30.74 | 30.69 | 30.41 | 30.41 | 30.56 | 30.48 | 30.73 |
| PZ-20 | 12.64 | 12.63 | 12.56 | 12.49 | 12.45 | DRY | 12.32 | 12.31 | 12.29 | 12.24 | 12.20 | 12.16 | 12.14 | 12.07 | 12.04 | 12.03 | 12.05 | 12.07 | 11.99 | 11.98 | 11.94 | 11.93 | 11.85 | 11.86 | 11.79 | 11.83 | 11.72 | 11.71 | 11.71 | 11.7 | 11.64 | 11.65 | 11.62 | 11.63 | 11.6 | 11.54 | N/A | 21.49 | 21.35 | 20.14 |
| PZ-33 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY |
| PZ-41 | DRY | DRY | 0.16 | 0.05 | DRY | DRY | 0.17 | 0.16 | 0.16 | 0.15 | 0.17 | 0.15 | 0.16 | DRY | DRY | DRY | DRY | DRY | DRY | 0.17 | 0.17 | DRY | DRY | DRY | DRY | 0.17 | DRY | 0.16 | 0.15 | 0.17 | 0.16 | 0.16 | 0.18 | 0.17 | DRY | DRY | DRY | DRY | 3.05 | 6.56 |
| PZ-43 | DRY | 0.16 | 0.16 | 0.13 | DRY | DRY | DRY | DRY | 0.13 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | 0.11 | 0.11 | 0.11 | 0.11 | 0.12 | 0.14 | 0.12 | DRY | DRY | DRY | DRY | DRY | DRY |
| PZ-47 | 0.47 | 0.48 | 0.53 | 0.08 | DRY | DRY | DRY | DRY | 0.04 | DRY | DRY | 0.05 | 0.07 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY |

| Well I.D. | Latitude | Longitude | Ground Surface Elevation (ft msl) | Concrete Slab Elevation (ft msl) | Top of PVC Pipe (ft msl) | Top of Steel Casing Elevation (ft msl) | Total Well Depth (ft below TOC) |
|---|---|---|---|---|---|---|---|
| PZ-1 | 31° 42' 16.86706" N | 96° 55' 59.13570" W | 551.74 | 552.12 | 555.12 | 555.49 | 42.94 |
| PZ-3 | 31° 41' 54.27334" N | 96° 55' 43.84234" W | 541.20 | 541.58 | 544.21 | 545.05 | 48.00 |
| PZ-8 | 31° 42' 11.59335" N | 96° 55' 12.20821" W | 550.34 | 550.89 | 553.39 | 553.74 | 77.76 |
| PZ-9 | 31° 42' 10.45884" N | 96° 55' 37.43147" W | 535.30 | 535.58 | 539.44 | 539.94 | 37.45 |
| PZ-18 | 31° 42' 28.96389" N | 96° 55' 26.98650" W | 534.84 | 535.23 | 537.80 | 538.26 | 48.81 |
| PZ-20 | 31° 42' 34.92848" N | 96° 55' 14.44772" W | 564.68 | 565.05 | 567.77 | 568.35 | 67.04 |
| PZ-33 | 31° 42' 00.00182" N | 96° 55' 14.53975" W | 539.20 | 539.57 | 542.49 | 542.89 | 57.59 |
| PZ-41 | 31° 42' 10.66572" N | 96° 54' 59.07613" W | 534.62 | 535.03 | 538.04 | 538.39 | 51.80 |
| PZ-43 | 31° 42' 20.55019" N | 96° 55' 01.03302" W | 548.86 | 549.20 | 551.31 | 552.07 | 50.57 |
| PZ-47 | 31° 42' 04.14903" N | 96° 55' 28.39274" W | 532.48 | 532.89 | 536.16 | 536.59 | 33.97 |

# APPENDIX III-4.L

# VIBRATING WIRE PIEZOMETER HISTORIC WATER LEVEL DATA



## Appendix III-4.L: Vibrating Wire Piezometer Historic Water Level Data

### Reading (Dg)

| VWP ID | 7/29/2019 | 8/6/2019 | 8/7/2019 | 8/8/2019 | 8/9/2019 | 8/12/2019 | 8/19/2019 | 8/27/2019 | 9/3/2019 | 9/10/2019 | 9/17/2019 | 9/25/2019 | 10/9/2019 | 10/18/2019 | 10/30/2019 | 11/8/2019 | 11/15/2019 | 11/22/2019 | 12/3/2019 | 12/4/2019 | 12/5/2019 | 12/6/2019 | 12/9/2019 | 12/12/2019 | 12/13/2019 | 12/16/2019 | 12/18/2019 | 12/19/2019 | 12/20/2019 | 12/24/2019 | 1/4/2020 | 1/9/2020 | 1/14/2020 | 1/30/2020 | 2/25/2020 | 4/1/2020 | 5/14/2020 | 7/8/2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VWP-1 | —— | 7948.2 | 7948.7 | 7949.2 | 7950.2 | 7952.6 | 7952.7 | 7954.5 | 7959.1 | 7960.2 | 7965.5 | 7941.4 | 7973.3 | 7981.3 | 7980.2 | 7978.7 | 7982.5 | 7990.5 | 7999.3 | —— | —— | —— | —— | 7998.3 | —— | —— | —— | 7996.6 | —— | 8004.3 | 8003.8 | 8011.9 | 8011.7 | 8016.0 | 8020.7 | 8022.2 | 8025.5 | 8007.9 |
| VWP-3 | —— | 8684.3 | 8682.5 | 8673.1 | 8652.7 | 8642.8 | 8583.1 | 8562.5 | 8552.5 | 8548.8 | 8547.2 | 8545.2 | 8539.6 | 8541.9 | 8539.0 | 8540.1 | 8538.3 | 8540.4 | 8543.8 | —— | —— | —— | —— | 8538.7 | —— | —— | —— | 8541.3 | —— | 8542.3 | 8537.1 | 8541.3 | 8539.9 | 8537.6 | 8535.5 | 8524.6 | 8528.2 | 8532.7 |
| VWP-4 | —— | 8716.0 | 8717.2 | 8717.8 | 8718.8 | 8720.7 | 8717.0 | 8718.1 | 8717.5 | 8715.1 | 8718.6 | 8720.3 | 8713.6 | 8723 | 8716.2 | 8708.5 | 8708.8 | 8717 | 8717.5 | —— | —— | —— | —— | 8714.4 | —— | —— | —— | 8708 | —— | 8714.9 | 8709.9 | 8719.1 | 8716.7 | 8716.7 | 8719.3 | 8718.6 | 8725.5 | 8723.1 |
| VWP-8 | —— | 8690.2 | 8691.1 | 8691.3 | 8692.6 | 8694.8 | 8689.9 | 8691.3 | 8690.0 | 8687.3 | 8690.7 | 8693.3 | 8686.8 | 8696.6 | 8688.4 | 8681.2 | 8681.9 | 8689.2 | 8690.4 | —— | —— | —— | —— | 8687.6 | —— | —— | —— | 8681.4 | —— | 8689.1 | 8682.5 | 8693.2 | 8690.1 | 8689.2 | 8692.4 | 8690.8 | 8697.9 | 8695.8 |
| VWP-8D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 8929.3 | 8942.3 | 8762.4 | 8739.4 | 8637 | 8563.8 | 8399.3 | 8380.9 | 8121.1 | 6927.9 | 6688.5 | 6570.0 | 6411.4 | 6299.4 | 6206.3 | 6165.2 | 6155.5 |
| VWP-9 | —— | 8599.6 | 8600.6 | 8601.4 | 8601.7 | 8603.9 | 8600.8 | 8599.5 | 8600.4 | 8598.3 | 8600.9 | 8603.2 | 8597.4 | 8605.5 | 8599.2 | 8591.1 | 8591.9 | 8600.3 | 8600.3 | —— | —— | —— | —— | 8592.7 | —— | —— | —— | 8590.7 | —— | 8598.2 | 8593.2 | 8601.1 | 8599.0 | 8599.5 | 8601.5 | 8600.8 | 8607.7 | 8605.3 |
| VWP-9D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 8712.3 | 6743.6 | 5978.5 | 5890.9 | 5830.6 | 5739.9 | 5669.8 | 5664.2 | 5654.6 | 5642.3 | 5625.6 | 5586.0 | 5597.8 | 5595.9 |
| VWP-18 | 8599.2 | 8467.5 | 8458.0 | 8449.0 | 8435.3 | 8404.8 | 8351.2 | 8303.2 | 8271.7 | 8248.4 | 8231.2 | 8217 | 8199.5 | 8187.3 | 8174.3 | 8163.9 | 8157.1 | 8152.1 | 8144.3 | —— | —— | —— | —— | 8098.2 | —— | —— | —— | 8143.3 | —— | 8151.6 | 8160.2 | 8160.4 | 8160.9 | 8160.2 | 8157.1 | 8150.7 | 8145.8 | 8144.2 |
| VWP-18D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 6433.5 | 6572.6 | 6743.7 | 6796.6 | 6784.6 | 6764.6 | 6669.5 | 6514.2 | 6324.0 | 6128.6 | 5925.0 |
| VWP-19 | 8812.8 | 8814.8 | 8815.0 | 8815.2 | 8815.5 | 8815.8 | 8816.2 | 8816.9 | 8815.5 | 8815.3 | 8814.8 | 8815.8 | 8815.1 | 8815.6 | 8815.6 | 8811.7 | 8809.9 | 8813.7 | 8814 | —— | —— | —— | —— | 8811.1 | —— | —— | —— | 8809.3 | —— | 8812.2 | 8812.2 | 8813.8 | 8813.7 | 8814.2 | 8816.8 | 8816.1 | 8821.2 | 8819.9 |
| VWP-20 | 8576.4 | 8570.1 | 8569.5 | 8568.8 | 8568.2 | 8566.3 | 8561.8 | 8558.6 | 8555.0 | 8552.3 | 8550.1 | 8587.9 | 8672.3 | 8715.2 | 8743.6 | 8751.9 | 8754.9 | 8763.4 | 8766.3 | —— | —— | —— | —— | 8765.3 | —— | —— | —— | 8765.9 | —— | 8764.8 | 8770.7 | 8767.4 | 8768.5 | 8769.5 | 8769.4 | 8773.2 | 8774.1 | 8776.7 |
| VWP-25 | —— | 8766.4 | 8767.7 | 8768.4 | 8768.5 | 8770.5 | 8766.6 | 8765.5 | 8766.7 | 8764.3 | 8767.4 | 8769.5 | 8762.9 | 8771.3 | 8765.0 | 8757.5 | 8758.2 | 8765.6 | 8765.8 | —— | —— | —— | —— | 8758.3 | —— | —— | —— | 8756.2 | —— | 8763.7 | 8758.5 | 8767.6 | 8764.5 | 8764.8 | 8766.6 | 8766.8 | 8772.9 | 8770.2 |
| VWP-26 | 8645.4 | 8648.0 | 8648.4 | 8648.6 | 8649.7 | 8651.7 | 8647.0 | 8648.0 | 8646.8 | 8644.3 | 8646.8 | 8649.4 | 8643.0 | 8652.7 | 8644.4 | 8637.4 | 8637.9 | 8645.1 | 8646 | —— | —— | —— | —— | 8642.8 | —— | —— | —— | 8637.1 | —— | 8644.1 | 8637.8 | 8647.8 | 8644.9 | 8644.6 | 8647.4 | 8645.7 | 8652.7 | 8651.7 |
| VWP-27 | 8618.6 | 8620.8 | 8621.4 | 8622.0 | 8622.6 | 8624.6 | 8619.4 | 8620.7 | 8619.8 | 8617.5 | 8620.5 | 8622.5 | 8616.5 | 8625.7 | 8618.4 | 8610.7 | 8611.2 | 8619.1 | 8619.8 | —— | —— | —— | —— | 8617.2 | —— | —— | —— | 8610.7 | —— | 8617.8 | 8611.6 | 8621.4 | 8618.9 | 8618.8 | 8621.4 | 8620.7 | 8627.8 | 8625.7 |
| VWP-30 | 8779.3 | 8692.9 | 8691.1 | 8690.5 | 8689.6 | 8689.8 | 8689.9 | 8688.8 | 8688.6 | 8686.6 | 8689.5 | 8691.2 | 8684.8 | 8692.9 | 8688.4 | 8679.3 | 8679.8 | 8686.8 | 8687.5 | —— | —— | —— | —— | 8684.6 | —— | —— | —— | 8679.2 | —— | 8686 | 8680.8 | 8689.7 | 8687.5 | 8685.2 | 8599.3 | 8443.6 | 8635.1 | 8688.8 |
| VWP-33 | —— | 8625.2 | 8626.2 | 8627.3 | 8629.9 | 8633.5 | 8630.3 | 8634.2 | 8634.6 | 8633.5 | 8638.6 | 8639.5 | 8620.7 | 8631.7 | 8622.5 | 8614.3 | 8614.6 | 8624.1 | 8624.6 | —— | —— | —— | —— | 8621.6 | —— | —— | —— | 8614.3 | —— | 8622.9 | 8616.4 | 8627.5 | 8624.8 | 8624.3 | 8627.3 | 8625.6 | 8633.6 | 8631.3 |
| VWP-33D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 8958 | 8953.7 | 8965.7 | 8957 | 8955.5 | 8945 | 8935.6 | 8860.3 | 8856.3 | 8844.5 | 8817.3 | 8808.1 | 8801.7 | 8783.2 | 8765.6 | 8674.4 | 8574.5 | 8444.6 |
| VWP-41 | 8628.6 | 8631.7 | 8632.7 | 8632.9 | 8633.8 | 8636.3 | 8631.5 | 8632.6 | 8631.8 | 8629.4 | 8632.9 | 8635.3 | 8629.0 | 8638.4 | 8630.8 | 8623.8 | 8624.3 | 8631.7 | 8632.7 | —— | —— | —— | —— | 8629.5 | —— | —— | —— | 8624.1 | —— | 8630.8 | 8625.6 | 8634.9 | 8632.4 | 8632.1 | 8635.2 | 8633.2 | 8639.8 | 8637.6 |
| VWP-41D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 8788.2 | 8717.3 | 8730.9 | 8739.7 | 8715.6 | 8692.4 | 8660.7 | —— | —— | —— | —— | 8634.7 | —— | —— | —— | 8613.9 | —— | 8599.5 | 8570.7 | 8558.2 | 8544.1 | 8504.1 | 8441.0 | 8354.1 | 8252.6 | 8127.0 |
| VWP-43 | 8641.7 | 8643.8 | 8644.3 | 8645.2 | 8645.4 | 8647.1 | 8643.8 | 8644.0 | 8643.8 | 8641.8 | 8644.6 | 8646.3 | 8640.6 | 8648.4 | 8642.4 | 8634.7 | 8635.4 | 8643.5 | 8644.1 | —— | —— | —— | —— | 8641.1 | —— | —— | —— | 8635.1 | —— | 8642.5 | 8636.3 | 8645.4 | 8643.8 | 8643.3 | 8645.5 | 8644.3 | 8650.8 | 8648.7 |
| VWP-43D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 8871.2 | 8874.3 | 8870.9 | 8881.9 | 8872.7 | 8883.1 | 8874.7 | 8736.7 | 6716.3 | 6916.7 | 7132.4 | 7099.7 | 7039.9 | 6961.8 | 6755.9 | 6534.9 | 6372.5 | 6259.0 | 6179.1 |
| VWP-44 | —— | 8661.3 | 8656.4 | 8652.5 | 8646.3 | 8633.6 | 8609.6 | 8585.6 | 8569.9 | 8557.7 | 8548.5 | 8542.1 | 8535.2 | 8532.3 | 8529.8 | 8528.5 | 8528.4 | 8529 | 8531.6 | —— | —— | —— | —— | 8534.5 | —— | —— | —— | 8560.7 | —— | 8565.9 | 8569.3 | 8566.3 | 8567.1 | 8569.3 | 8568.7 | 8566.6 | 8576.8 | 8577.3 |
| VWP-47 | —— | 8718.1 | 8718.9 | 8719.1 | 8719.9 | 8722.8 | 8718.9 | 8718.8 | 8718.7 | 8716.3 | 8719.2 | 8721.1 | 8715.4 | 8723 | 8716.7 | 8709 | 8709.3 | 8717.2 | 8717.5 | —— | —— | —— | —— | 8709.6 | —— | —— | —— | 8708.2 | —— | 8715.7 | 8710.3 | 8719.4 | 8716.5 | 8717.5 | 8719.6 | 8719.7 | 8726.2 | 8723.8 |
| VWP-47D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 8801.7 | 8673.1 | 8596.5 | 8556.3 | 8534.6 | 8517.5 | 8495.5 | —— | —— | —— | —— | 8482.8 | —— | —— | —— | 8474 | —— | 8470.2 | 8463.2 | 8461.7 | 8461.5 | 8466.1 | 8479.8 | 8409.5 | 8328.2 | 8224.9 |

### Temperature (˚C)

| VWP ID | 7/29/2019 | 8/6/2019 | 8/7/2019 | 8/8/2019 | 8/9/2019 | 8/12/2019 | 8/19/2019 | 8/27/2019 | 9/3/2019 | 9/10/2019 | 9/17/2019 | 9/25/2019 | 10/9/2019 | 10/18/2019 | 10/30/2019 | 11/8/2019 | 11/15/2019 | 11/22/2019 | 12/3/2019 | 12/4/2019 | 12/5/2019 | 12/6/2019 | 12/9/2019 | 12/12/2019 | 12/13/2019 | 12/16/2019 | 12/18/2019 | 12/19/2019 | 12/20/2019 | 12/24/2019 | 1/4/2020 | 1/9/2020 | 1/14/2020 | 1/30/2020 | 2/25/2020 | 4/1/2020 | 5/14/2020 | 7/8/2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VWP-1 | —— | 21.5 | 21.5 | 21.5 | 21.5 | 21.5 | 21.4 | 21.4 | 21.4 | 21.4 | 21.4 | 21.4 | 21.4 | 21.3 | 21.3 | 21.3 | 21.4 | 21.4 | 21.5 | —— | —— | —— | —— | 21.4 | —— | —— | —— | 21.4 | —— | 21.4 | 21.5 | 21.4 | 21.4 | 21.5 | 21.5 | 21.6 | 21.5 | 21.4 |
| VWP-3 | —— | 21.5 | 21.6 | 21.5 | 21.5 | 21.5 | 21.5 | 21.5 | 21.5 | 21.5 | 21.4 | 21.4 | 21.4 | 21.4 | 21.4 | 21.4 | 21.4 | 21.5 | 21.4 | —— | —— | —— | —— | 21.4 | —— | —— | —— | 21.4 | —— | 21.5 | 21.5 | 21.5 | 21.5 | 21.4 | 21.5 | 21.5 | 21.5 | 21.4 |
| VWP-4 | —— | 20.8 | 20.8 | 20.8 | 20.8 | 20.7 | 20.8 | 20.8 | 20.8 | 20.8 | 20.8 | 20.9 | 21.0 | 21 | 21.1 | 21.2 | 21.2 | 21.3 | 21.3 | —— | —— | —— | —— | 21.3 | —— | —— | —— | 21.4 | —— | 21.4 | 21.5 | 21.4 | 21.4 | 21.4 | 21.4 | 21.2 | 20.9 | 20.6 |
| VWP-8 | —— | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20 | 20.0 | 20 | 20.0 | 20 | 20.0 | 20 | 20.0 | —— | —— | —— | —— | 20 | —— | —— | —— | 20 | —— | 20 | 20 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| VWP-8D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 22.7 | 22 | 21.9 | 21.9 | 21.8 | 21.8 | 21.8 | 21.8 | 21.8 | 21.8 | 21.8 | 21.8 | 21.7 | 21.8 | 21.8 | 21.7 | 21.7 |
| VWP-9 | —— | 21.2 | 21.1 | 21.2 | 21.1 | 21.1 | 21.1 | 21.1 | 21.1 | 21.1 | 21.1 | 21.1 | 21.1 | 21.1 | 21.2 | 21.2 | 21.1 | 21.2 | 21.4 | —— | —— | —— | —— | 21.2 | —— | —— | —— | 21.3 | —— | 21.3 | 21.3 | 21.3 | 21.3 | 21.4 | 21.5 | 21.5 | 21.4 | 21.2 |
| VWP-9D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 22.4 | 22.5 | 22.4 | 22.5 | 22.5 | 22.4 | 22.5 | 22.5 | 22.5 | 22.5 | 22.5 | 22.4 | 22.3 | 22.3 |
| VWP-18 | 20.8 | 20.8 | 20.8 | 20.7 | 20.7 | 20.8 | 20.8 | 20.7 | 20.7 | 20.7 | 20.7 | 20.7 | 20.7 | 20.7 | 20.7 | 20.7 | 20.6 | 20.7 | 20.7 | —— | —— | —— | —— | 20.7 | —— | —— | —— | 20.7 | —— | 20.7 | 20.7 | 20.7 | 20.8 | 20.8 | 20.8 | 20.8 | 20.8 | 20.7 |
| VWP-18D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 22.7 | 22.4 | 22.4 | 22.2 | 22.3 | 22.3 | 22.2 | 22.2 | 22.2 | 22.2 | 22.2 |
| VWP-19 | 21.7 | 21.6 | 21.7 | 21.7 | 21.7 | 21.7 | 21.6 | 21.7 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | —— | —— | —— | —— | 21.6 | —— | —— | —— | 21.6 | —— | 21.6 | 21.6 | 21.5 | 21.7 | 21.6 | 21.6 | 21.6 | 21.5 | 21.6 |
| VWP-20 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | —— | —— | —— | —— | 21.8 | —— | —— | —— | 21.7 | —— | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.7 | 21.6 | 21.6 |
| VWP-25 | —— | 19.5 | 19.4 | 19.5 | 19.4 | 19.4 | 19.4 | 19.4 | 19.4 | 19.4 | 19.4 | 19.4 | 19.4 | 19.4 | 19.4 | 19.4 | 19.5 | 19.5 | 19.6 | —— | —— | —— | —— | 19.5 | —— | —— | —— | 19.5 | —— | 19.6 | 19.6 | 20.2 | 19.7 | 19.6 | 19.7 | 19.7 | 19.7 | 19.6 |
| VWP-26 | 19.7 | 19.7 | 19.6 | 19.7 | 19.7 | 19.7 | 19.7 | 19.7 | 19.7 | 19.7 | 19.7 | 19.8 | 19.9 | 20 | 20.0 | 20.1 | 20.1 | 20.1 | 20.2 | —— | —— | —— | —— | 20.3 | —— | —— | —— | 20.3 | —— | 20.3 | 20.4 | 20.4 | 20.5 | 20.5 | 20.5 | 20.4 | 20.2 | 20.0 |
| VWP-27 | 20.8 | 20.8 | 20.8 | 20.8 | 20.8 | 20.7 | 20.8 | 20.7 | 20.8 | 20.8 | 20.8 | 20.8 | 20.8 | 20.9 | 20.9 | 21 | 21.0 | 21.1 | 21.1 | —— | —— | —— | —— | 21.2 | —— | —— | —— | 21.2 | —— | 21.3 | 21.4 | 21.3 | 21.3 | 21.4 | 21.4 | 21.3 | 21.0 | 20.8 |
| VWP-30 | 20.3 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.1 | 20.1 | 20.1 | 20.2 | 20.1 | 20.1 | —— | —— | —— | —— | 20.1 | —— | —— | —— | 20.1 | —— | 20.1 | 20.1 | 20.2 | 20.2 | 20.2 | 20.2 | 20.3 | 20.2 | 20.3 |
| VWP-33 | —— | 21.6 | 21.6 | 21.6 | 21.5 | 21.5 | 21.5 | 21.4 | 21.5 | 21.5 | 21.5 | 21.5 | 21.4 | 21.4 | 21.5 | 21.5 | 21.4 | 21.5 | 21.4 | —— | —— | —— | —— | 21.4 | —— | —— | —— | 21.5 | —— | 21.5 | 21.5 | 21.5 | 21.5 | 21.4 | 21.5 | 21.5 | 21.5 | 21.4 |
| VWP-33D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 23.5 | 22.7 | 22.4 | 22.3 | 22.3 | 22.2 | 22.3 | 22.2 | 22.2 | 22.2 | 22.1 | 22.2 | 22.2 | 22.1 | 22.1 | 22.1 | 22.1 | 22.1 |
| VWP-41 | 19.7 | 19.7 | 19.7 | 19.6 | 19.7 | 19.7 | 19.7 | 19.7 | 19.6 | 19.6 | 19.6 | 19.6 | 19.6 | 19.6 | 19.6 | 19.7 | 19.6 | 19.6 | 19.6 | —— | —— | —— | —— | 19.6 | —— | —— | —— | 19.6 | —— | 19.6 | 19.7 | 19.6 | 19.6 | 19.6 | 19.7 | 19.7 | 19.8 | 19.8 |
| VWP-41D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 21.7 | 21.4 | 21.4 | 21.3 | 21.3 | 21.4 | 21.4 | —— | —— | —— | —— | 21.3 | —— | —— | —— | 21.2 | —— | 21.3 | 21.3 | 21.3 | 21.3 | 21.3 | 21.3 | 21.3 | 21.3 | 21.2 |
| VWP-43 | 20.4 | 20.4 | 20.3 | 20.3 | 20.3 | 20.3 | 20.3 | 20.2 | 20.2 | 20.3 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | 20.2 | —— | —— | —— | —— | 20.2 | —— | —— | —— | 20.2 | —— | 20.2 | 20.2 | 20.2 | 20.2 | 20.3 | 20.3 | 20.4 | 20.4 | 20.4 |
| VWP-43D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 22.4 | 22.1 | 22 | 21.9 | 21.9 | 21.9 | 21.8 | 21.9 | 21.8 | 21.9 | 21.8 | 21.8 | 21.8 | 21.8 | 21.8 | 21.8 | 21.8 | 21.8 | 21.7 |
| VWP-44 | —— | 22.1 | 22.1 | 22.1 | 22.1 | 22.1 | 22.1 | 22.1 | 22.1 | 22.0 | 22.1 | 22.1 | 22.1 | 22.1 | 22.1 | 22 | 22.0 | 22.1 | 22.0 | —— | —— | —— | —— | 22.1 | —— | —— | —— | 22 | —— | 22 | 22 | 22.0 | 22.0 | 22.0 | 22.0 | 22.0 | 22.0 | 22.0 |
| VWP-47 | —— | 19.4 | 19.4 | 19.4 | 19.4 | 19.4 | 19.5 | 19.6 | 19.6 | 19.9 | 20.0 | 20.2 | 20.5 | 20.7 | 20.9 | 21.1 | 21.1 | 21.3 | 21.3 | —— | —— | —— | —— | 21.3 | —— | —— | —— | 21.3 | —— | 21.3 | 21.2 | 21.2 | 21.0 | 20.8 | 20.5 | 20.0 | 19.6 | 19.6 |
| VWP-47D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 22.1 | 21.3 | 21.2 | 21.2 | 21.2 | 21.2 | 21.1 | —— | —— | —— | —— | 21.2 | —— | —— | —— | 21.1 | —— | 21.2 | 21.1 | 21.2 | 21.2 | 21.1 | 21.1 | 21.1 | 21.1 | 21.1 |

### Pressure (PSI)

| VWP ID | 7/29/2019 | 8/6/2019 | 8/7/2019 | 8/8/2019 | 8/9/2019 | 8/12/2019 | 8/19/2019 | 8/27/2019 | 9/3/2019 | 9/10/2019 | 9/17/2019 | 9/25/2019 | 10/9/2019 | 10/18/2019 | 10/30/2019 | 11/8/2019 | 11/15/2019 | 11/22/2019 | 12/3/2019 | 12/4/2019 | 12/5/2019 | 12/6/2019 | 12/9/2019 | 12/12/2019 | 12/13/2019 | 12/16/2019 | 12/18/2019 | 12/19/2019 | 12/20/2019 | 12/24/2019 | 1/4/2020 | 1/9/2020 | 1/14/2020 | 1/30/2020 | 2/25/2020 | 4/1/2020 | 5/14/2020 | 7/8/2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VWP-1 | —— | 8.929532 | 8.922337 | 8.915142 | 8.900752 | 8.866216 | 8.8653932 | 8.8394912 | 8.773297 | 8.7574682 | 8.6812012 | 9.0280002 | 8.5689592 | 8.4544554 | 8.4702844 | 8.4918694 | 8.4365712 | 8.3214512 | 8.194203 | —— | —— | —— | —— | 8.2092092 | —— | —— | —— | 8.2336722 | —— | 8.1228692 | 8.129448 | 8.013505 | 8.0163832 | 7.95389 | 7.886257 | 7.864056 | 7.817185 | 8.0710652 |
| VWP-3 | —— | 0.148887 | 0.176508 | 0.331783 | 0.664915 | 0.826582 | 1.801483 | 2.137881 | 2.301181 | 2.361602 | 2.389503 | 2.422163 | 2.513611 | 2.476052 | 2.523409 | 2.505446 | 2.53484 | 2.498774 | 2.445025 | —— | —— | —— | —— | 2.528308 | —— | —— | —— | 2.48585 | —— | 2.467747 | 2.552663 | 2.484077 | 2.506939 | 2.546271 | 2.578791 | 2.756788 | 2.698 | 2.626288 |
| VWP-4 | —— | -0.033429 | -0.053193 | -0.063075 | -0.079545 | -0.109845 | -0.049899 | -0.068016 | -0.058134 | -0.018606 | -0.076251 | -0.105243 | 0.004113 | -0.150705 | -0.039702 | 0.086124 | 0.081183 | -0.054864 | -0.063099 | —— | —— | —— | —— | -0.012042 | —— | —— | —— | 0.092373 | —— | -0.02127 | 0.060087 | -0.090444 | -0.050916 | -0.050916 | -0.093738 | -0.080223 | -0.190887 | -0.14838 |
| VWP-8 | —— | 0.027982 | 0.013627 | 0.010437 | -0.010298 | -0.045388 | 0.032767 | 0.010437 | 0.031172 | 0.074237 | 0.020007 | -0.021463 | 0.082212 | -0.074098 | 0.056692 | 0.171532 | 0.160367 | 0.043932 | 0.024792 | —— | —— | —— | —— | 0.069452 | —— | —— | —— | 0.168342 | —— | 0.045527 | 0.150797 | -0.019868 | 0.029577 | 0.043932 | -0.007108 | 0.018412 | -0.094833 | -0.061338 |
| VWP-8D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 0.108153 | -0.088872 | 2.883792 | 3.263522 | 4.956661 | 6.165193 | 8.881088 | 9.184872 | 13.47417 | 33.1739 | 37.1264 | 39.082831 | 41.703832 | 43.550437 | 45.08752 | 45.768594 | 45.928741 |
| VWP-9 | —— | -0.017939 | -0.033995 | -0.049025 | -0.052992 | -0.090986 | -0.037449 | -0.014998 | -0.030541 | 0.005726 | -0.039176 | -0.078897 | 0.021269 | -0.118618 | -0.011031 | 0.128856 | 0.116254 | -0.030028 | -0.032456 | —— | —— | —— | —— | 0.101224 | —— | —— | —— | 0.13455 | —— | 0.005025 | 0.091375 | -0.045058 | -0.008791 | -0.01864 | -0.054394 | -0.042305 | -0.160254 | -0.116378 |
| VWP-9D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 5.41438 | 34.627304 | 45.983972 | 47.281372 | 48.176224 | 49.524796 | 50.5625 | 50.6456 | 50.788064 | 50.970596 | 51.218424 | 51.80867 | 51.636144 | 51.66434 |
| VWP-18 | 2.640668 | 4.871666 | 5.032596 | 5.186319 | 5.418397 | 5.933804 | 6.841788 | 7.656171 | 8.189781 | 8.584483 | 8.875851 | 9.116399 | 9.412849 | 9.619517 | 9.839737 | 10.015913 | 10.132368 | 10.215805 | 10.347937 | —— | —— | —— | —— | 11.128871 | —— | —— | —— | 10.364877 | —— | 10.224275 | 10.07859 | 10.0752 | 10.06547 | 10.077328 | 10.129842 | 10.23826 | 10.321264 | 10.349631 |
| VWP-18D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 37.45382 | 35.451316 | 32.978921 | 32.21951 | 32.39041 | 32.679413 | 34.056105 | 36.30019 | 39.04858 | 41.87211 | 44.81413 |
| VWP-19 | -0.39417 | -0.42593 | -0.430932 | -0.434274 | -0.439287 | -0.4443 | -0.449324 | -0.462681 | -0.437627 | -0.434285 | -0.42593 | -0.44264 | -0.430943 | -0.439298 | -0.439298 | -0.374129 | -0.344051 | -0.407549 | -0.412562 | —— | —— | —— | —— | -0.364103 | —— | —— | —— | -0.334025 | —— | -0.382484 | -0.382484 | -0.40756 | -0.409209 | -0.415904 | -0.45935 | -0.447653 | -0.531214 | -0.511151 |
| VWP-20 | 3.149094 | 3.25128 | 3.261012 | 3.272366 | 3.282098 | 3.312916 | 3.385906 | 3.43781 | 3.496202 | 3.539996 | 3.57568 | 2.962564 | 1.593596 | 0.897758 | 0.43711 | 0.302484 | 0.253824 | 0.115954 | 0.068916 | —— | —— | —— | —— | 0.083276 | —— | —— | —— | 0.075404 | —— | 0.093246 | -0.002452 | 0.051074 | 0.033232 | 0.017012 | 0.018634 | -0.043002 | -0.05574 | -0.097912 |
| VWP-25 | | -0.041373 | -0.062892 | -0.075833 | -0.076676 | -0.111136 | -0.043939 | -0.024986 | -0.045662 | -0.00431 | -0.057723 | -0.093906 | 0.019812 | -0.12492 | -0.016371 | 0.112854 | 0.099913 | -0.027589 | -0.031915 | —— | —— | —— | —— | 0.09819 | —— | —— | —— | 0.134373 | —— | 0.004268 | 0.093864 | -0.068209 | -0.010396 | -0.014685 | -0.046579 | -0.050025 | -0.155128 | -0.107727 |
| VWP-26 | -0.0795304 | -0.123938 | -0.130313 | -0.134186 | -0.152974 | -0.1871344 | -0.1068584 | -0.1239384 | -0.103442 | -0.0607424 | -0.1034424 | -0.148308 | -0.0394536 | -0.2055872 | -0.0638232 | 0.0552792 | 0.0467392 | -0.0762368 | -0.0920664 | —— | —— | —— | —— | -0.037868 | —— | —— | —— | 0.059488 | —— | -0.060072 | 0.047074 | -0.123726 | -0.0746512 | -0.0695272 | -0.1173512 | -0.087858 | -0.2065024 | -0.188507 |
| VWP-27 | -0.097272 | -0.133506 | -0.143388 | -0.15327 | -0.163152 | -0.194625 | -0.110448 | -0.130392 | -0.117036 | -0.079155 | -0.128565 | -0.161505 | -0.062685 | -0.215676 | -0.095445 | 0.029907 | 0.021672 | -0.109908 | -0.121437 | —— | —— | —— | —— | -0.080082 | —— | —— | —— | 0.026973 | —— | -0.091431 | 0.009216 | -0.150723 | -0.109548 | -0.109368 | -0.15219 | -0.139194 | -0.25173 | -0.214209 |
| VWP-30 | -1.67265 | -0.162999 | -0.131571 | -0.121095 | -0.105381 | -0.108873 | -0.110619 | -0.091413 | -0.087921 | -0.053001 | -0.103635 | -0.133317 | -0.021573 | -0.161892 | -0.083322 | 0.075564 | 0.065727 | -0.055386 | -0.067608 | —— | —— | —— | —— | -0.016974 | —— | —— | —— | 0.07731 | —— | -0.041418 | 0.049374 | -0.107127 | -0.068715 | -0.028557 | 1.471257 | 4.188672 | 0.846189 | -0.09252 |
| VWP-33 | —— | -0.05623 | -0.07105 | -0.087352 | -0.125089 | -0.1784412 | -0.1310172 | -0.1880208 | -0.194743 | -0.1784412 | -0.2540232 | -0.2673612 | 0.0120492 | -0.1509708 | -0.0154212 | 0.1061028 | 0.1024512 | -0.0391332 | -0.0457488 | —— | —— | —— | —— | -0.0012888 | —— | —— | —— | 0.1061028 | —— | -0.0213492 | 0.074981 | -0.089521 | -0.0495072 | -0.0413028 | -0.0865572 | -0.061363 | -0.1799232 | -0.145043 |
| VWP-33D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 0.063913 | 0.13962 | -0.044481 | 0.092399 | 0.115814 | 0.280792 | 0.426453 | 1.602959 | 1.665399 | 1.849597 | 2.275262 | 2.417801 | 2.517705 | 2.807563 | 3.082299 | 4.505931 | 6.06537 | 8.093109 |
| VWP-41 | 0.087249 | 0.035634 | 0.018984 | 0.017043 | 0.000669 | -0.040956 | 0.038964 | 0.020649 | 0.035358 | 0.075318 | 0.017043 | -0.022917 | 0.081978 | -0.074532 | 0.052008 | 0.167169 | 0.160233 | 0.037023 | 0.020373 | —— | —— | —— | —— | 0.073653 | —— | —— | —— | 0.163563 | —— | 0.052008 | 0.137199 | -0.016257 | 0.025368 | 0.030363 | -0.022641 | 0.010659 | -0.10062 | -0.06399 |
| VWP-41D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 3.121894 | 4.289133 | 4.066093 | 3.923266 | 4.318506 | 4.697493 | 5.217373 | —— | —— | —— | —— | 5.645266 | —— | —— | —— | 5.987879 | —— | 6.222546 | 6.694866 | 6.899866 | 7.131106 | 7.787106 | 8.821946 | 10.24711 | 11.911706 | 13.973039 |
| VWP-43 | -0.001269 | -0.036486 | -0.04332 | -0.058413 | -0.061767 | -0.090276 | -0.034935 | -0.036738 | -0.033384 | -0.001395 | -0.0468 | -0.075309 | 0.02028 | -0.110526 | -0.009906 | 0.119223 | 0.107484 | -0.028353 | -0.038415 | —— | —— | —— | —— | 0.011895 | —— | —— | —— | 0.112515 | —— | -0.011583 | 0.092391 | -0.060216 | -0.033384 | -0.02655 | -0.063444 | -0.044871 | -0.153876 | -0.118659 |
| VWP-43D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 0.15444 | 0.114825 | 0.169716 | 0.003423 | 0.144735 | -0.015009 | 0.116682 | 2.233695 | 33.269706 | 30.188895 | 26.87841 | 27.38068 | 28.29921 | 29.498826 | 32.66145 | 36.05601 | 38.55047 | 40.293834 | 41.523765 |
| VWP-44 | —— | 1.926352 | 2.010877 | 2.078152 | 2.185102 | 2.4041766 | 2.8181766 | 3.2321766 | 3.503002 | 3.7140882 | 3.8721516 | 3.9825516 | 4.1015766 | 4.1516016 | 4.1947266 | 4.2177882 | 4.2195132 | 4.2085266 | 4.1643132 | —— | —— | —— | —— | 4.1136516 | —— | —— | —— | 3.6623382 | —— | 3.5726382 | 3.513988 | 3.565738 | 3.5519382 | 3.5139882 | 3.5243382 | 3.560563 | 3.3846132 | 3.3759882 |
| VWP-47 | —— | -0.017259 | -0.030883 | -0.034289 | -0.047913 | -0.0973 | -0.032353 | -0.03212 | -0.030417 | 0.006045 | -0.044812 | -0.080109 | 0.012552 | -0.119816 | -0.015467 | 0.112724 | 0.107615 | -0.029862 | -0.034971 | —— | —— | —— | —— | 0.099566 | —— | —— | —— | 0.123408 | —— | -0.004317 | 0.089115 | -0.065858 | -0.013531 | -0.027621 | -0.058974 | -0.053327 | -0.158142 | -0.11727 |
| VWP-47D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 1.938147 | 3.987437 | 5.201709 | 5.838075 | 6.181586 | 6.452279 | 6.802233 | —— | —— | —— | —— | 7.00158 | —— | —— | —— | 7.142578 | —— | 7.201038 | 7.313542 | 7.335593 | 7.338759 | 7.267635 | 7.050764 | 8.163613 | 9.450592 | 11.085831 |

### Pressure Head (feet $H_2O$)

| VWP ID | 7/29/2019 | 8/6/2019 | 8/7/2019 | 8/8/2019 | 8/9/2019 | 8/12/2019 | 8/19/2019 | 8/27/2019 | 9/3/2019 | 9/10/2019 | 9/17/2019 | 9/25/2019 | 10/9/2019 | 10/18/2019 | 10/30/2019 | 11/8/2019 | 11/15/2019 | 11/22/2019 | 12/3/2019 | 12/4/2019 | 12/5/2019 | 12/6/2019 | 12/9/2019 | 12/12/2019 | 12/13/2019 | 12/16/2019 | 12/18/2019 | 12/19/2019 | 12/20/2019 | 12/24/2019 | 1/4/2020 | 1/9/2020 | 1/14/2020 | 1/30/2020 | 2/25/2020 | 4/1/2020 | 5/14/2020 | 7/8/2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VWP-1 | —— | 20.63 | 20.62 | 20.60 | 20.57 | 20.49 | 20.49 | 20.43 | 20.27 | 20.24 | 20.06 | 20.86 | 19.80 | 19.54 | 19.57 | 19.62 | 19.50 | 19.23 | 18.94 | —— | —— | —— | —— | 18.97 | —— | —— | —— | 19.03 | —— | 18.77 | 18.79 | 18.52 | 18.52 | 18.38 | 18.22 | 18.17 | 18.06 | 18.65 |
| VWP-3 | —— | 0.34 | 0.41 | 0.77 | 1.54 | 1.91 | 4.16 | 4.94 | 5.32 | 5.46 | 5.52 | 5.60 | 5.81 | 5.72 | 5.83 | 5.79 | 5.86 | 5.77 | 5.65 | —— | —— | —— | —— | 5.84 | —— | —— | —— | 5.74 | —— | 5.70 | 5.90 | 5.74 | 5.79 | 5.88 | 5.96 | 6.37 | 6.23 | 6.07 |
| VWP-4 | —— | -0.08 | -0.12 | -0.15 | -0.18 | -0.25 | -0.12 | -0.16 | -0.13 | -0.04 | -0.18 | -0.24 | 0.01 | -0.35 | -0.09 | 0.20 | 0.19 | -0.13 | -0.15 | —— | —— | —— | —— | -0.03 | —— | —— | —— | 0.21 | —— | -0.05 | 0.14 | -0.21 | -0.12 | -0.12 | -0.22 | -0.19 | -0.44 | -0.34 |
| VWP-8 | —— | 0.06 | 0.03 | 0.02 | -0.02 | -0.10 | 0.08 | 0.02 | 0.07 | 0.17 | 0.05 | -0.05 | 0.19 | -0.17 | 0.13 | 0.40 | 0.37 | 0.10 | 0.06 | —— | —— | —— | —— | 0.16 | —— | —— | —— | 0.39 | —— | 0.11 | 0.35 | -0.05 | 0.07 | 0.10 | -0.02 | 0.04 | -0.22 | -0.14 |
| VWP-8D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 0.25 | -0.21 | 6.66 | 7.54 | 11.45 | 14.25 | 20.52 | 21.22 | 31.14 | 76.66 | 85.79 | 90.31 | 96.37 | 100.64 | 104.19 | 105.76 | 106.13 |
| VWP-9 | —— | -0.04 | -0.08 | -0.11 | -0.12 | -0.21 | -0.09 | -0.03 | -0.07 | 0.01 | -0.09 | -0.18 | 0.05 | -0.27 | -0.03 | 0.30 | 0.27 | -0.07 | -0.07 | —— | —— | —— | —— | 0.23 | —— | —— | —— | 0.31 | —— | 0.01 | 0.21 | -0.10 | -0.02 | -0.04 | -0.13 | -0.10 | -0.37 | -0.27 |
| VWP-9D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 12.51 | 80.02 | 106.26 | 109.26 | 111.33 | 114.44 | 116.84 | 117.03 | 117.36 | 117.78 | 118.36 | 119.72 | 119.32 | 119.39 |
| VWP-18 | 6.10 | 11.26 | 11.63 | 11.98 | 12.52 | 13.71 | 15.81 | 17.69 | 18.92 | 19.84 | 20.51 | 21.07 | 21.75 | 22.23 | 22.74 | 23.14 | 23.41 | 23.61 | 23.91 | —— | —— | —— | —— | 25.72 | —— | —— | —— | 23.95 | —— | 23.63 | 23.29 | 23.28 | 23.26 | 23.29 | 23.41 | 23.66 | 23.85 | 23.92 |
| VWP-18D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 86.55 | 81.92 | 76.21 | 74.45 | 74.85 | 75.52 | 78.70 | 83.88 | 90.23 | 96.76 | 103.56 |
| VWP-19 | -0.91 | -0.98 | -1.00 | -1.00 | -1.02 | -1.03 | -1.04 | -1.07 | -1.01 | -1.00 | -0.98 | -1.02 | -1.00 | -1.02 | -1.02 | -0.86 | -0.80 | -0.94 | -0.95 | —— | —— | —— | —— | -0.84 | —— | —— | —— | -0.77 | —— | -0.88 | -0.88 | -0.94 | -0.95 | -0.96 | -1.06 | -1.03 | -1.23 | -1.18 |
| VWP-20 | 7.28 | 7.51 | 7.54 | 7.56 | 7.58 | 7.66 | 7.82 | 7.94 | 8.08 | 8.18 | 8.26 | 6.85 | 3.68 | 2.07 | 1.01 | 0.70 | 0.59 | 0.27 | 0.16 | —— | —— | —— | —— | 0.19 | —— | —— | —— | 0.17 | —— | 0.22 | -0.01 | 0.12 | 0.08 | 0.04 | 0.04 | -0.10 | -0.13 | -0.23 |
| VWP-25 | —— | -0.10 | -0.15 | -0.18 | -0.18 | -0.26 | -0.10 | -0.06 | -0.11 | -0.01 | -0.13 | -0.22 | 0.05 | -0.29 | -0.04 | 0.26 | 0.23 | -0.06 | -0.07 | —— | —— | —— | —— | 0.23 | —— | —— | —— | 0.31 | —— | 0.01 | 0.22 | -0.16 | -0.02 | -0.03 | -0.11 | -0.12 | -0.36 | -0.25 |
| VWP-26 | -0.18 | -0.29 | -0.30 | -0.31 | -0.35 | -0.43 | -0.25 | -0.29 | -0.24 | -0.14 | -0.24 | -0.34 | -0.09 | -0.48 | -0.15 | 0.13 | 0.11 | -0.18 | -0.21 | —— | —— | —— | —— | -0.09 | —— | —— | —— | 0.14 | —— | -0.14 | 0.11 | -0.29 | -0.17 | -0.16 | -0.27 | -0.20 | -0.48 | -0.44 |
| VWP-27 | -0.22 | -0.31 | -0.33 | -0.35 | -0.38 | -0.45 | -0.26 | -0.30 | -0.27 | -0.18 | -0.30 | -0.37 | -0.14 | -0.50 | -0.22 | 0.07 | 0.05 | -0.25 | -0.28 | —— | —— | —— | —— | -0.19 | —— | —— | —— | 0.06 | —— | -0.21 | 0.02 | -0.35 | -0.25 | -0.25 | -0.35 | -0.32 | -0.58 | -0.49 |
| VWP-30 | -3.87 | -0.38 | -0.30 | -0.28 | -0.24 | -0.25 | -0.26 | -0.21 | -0.20 | -0.12 | -0.24 | -0.31 | -0.05 | -0.37 | -0.19 | 0.17 | 0.15 | -0.13 | -0.16 | —— | —— | —— | —— | -0.04 | —— | —— | —— | 0.18 | —— | -0.10 | 0.11 | -0.25 | -0.16 | -0.07 | 3.40 | 9.68 | 1.96 | -0.21 |
| VWP-33 | —— | -0.13 | -0.16 | -0.20 | -0.29 | -0.41 | -0.30 | -0.43 | -0.45 | -0.41 | -0.59 | -0.62 | 0.03 | -0.35 | -0.04 | 0.25 | 0.24 | -0.09 | -0.11 | —— | —— | —— | —— | 0.00 | —— | —— | —— | 0.25 | —— | -0.05 | 0.17 | -0.21 | -0.11 | -0.10 | -0.20 | -0.14 | -0.42 | -0.34 |
| VWP-33D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 0.15 | 0.32 | -0.10 | 0.21 | 0.27 | 0.65 | 0.99 | 3.70 | 3.85 | 4.27 | 5.26 | 5.59 | 5.82 | 6.49 | 7.12 | 10.41 | 14.02 | 18.70 |
| VWP-41 | 0.20 | 0.08 | 0.04 | 0.04 | 0.00 | -0.09 | 0.09 | 0.05 | 0.08 | 0.17 | 0.04 | -0.05 | 0.19 | -0.17 | 0.12 | 0.39 | 0.37 | 0.09 | 0.05 | —— | —— | —— | —— | 0.17 | —— | —— | —— | 0.38 | —— | 0.12 | 0.32 | -0.04 | 0.06 | 0.07 | -0.05 | 0.02 | -0.23 | -0.15 |
| VWP-41D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 7.21 | 9.91 | 9.40 | 9.07 | 9.98 | 10.85 | 12.06 | —— | —— | —— | —— | 13.05 | —— | —— | —— | 13.84 | —— | 14.38 | 15.47 | 15.94 | 16.48 | 17.99 | 20.39 | 23.68 | 27.53 | 32.29 |
| VWP-43 | 0.00 | -0.08 | -0.10 | -0.13 | -0.14 | -0.21 | -0.08 | -0.08 | -0.08 | 0.00 | -0.11 | -0.17 | 0.05 | -0.26 | -0.02 | 0.28 | 0.25 | -0.07 | -0.09 | —— | —— | —— | —— | 0.03 | —— | —— | —— | 0.26 | —— | -0.03 | 0.21 | -0.14 | -0.08 | -0.06 | -0.15 | -0.10 | -0.36 | -0.27 |
| VWP-43D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 0.36 | 0.27 | 0.39 | 0.01 | 0.33 | -0.03 | 0.27 | 5.16 | 76.88 | 69.76 | 62.11 | 63.27 | 65.39 | 68.17 | 75.47 | 83.32 | 89.08 | 93.11 | 95.95 |
| VWP-44 | —— | 4.45 | 4.65 | 4.80 | 5.05 | 5.56 | 6.51 | 7.47 | 8.09 | 8.58 | 8.95 | 9.20 | 9.48 | 9.59 | 9.69 | 9.75 | 9.75 | 9.73 | 9.62 | —— | —— | —— | —— | 9.51 | —— | —— | —— | 8.46 | —— | 8.26 | 8.12 | 8.24 | 8.21 | 8.12 | 8.14 | 8.23 | 7.82 | 7.80 |
| VWP-47 | —— | -0.04 | -0.07 | -0.08 | -0.11 | -0.22 | -0.07 | -0.07 | -0.07 | 0.01 | -0.10 | -0.19 | 0.03 | -0.28 | -0.04 | 0.26 | 0.25 | -0.07 | -0.08 | —— | —— | —— | —— | 0.23 | —— | —— | —— | 0.29 | —— | -0.01 | 0.21 | -0.15 | -0.03 | -0.06 | -0.14 | -0.12 | -0.37 | -0.27 |
| VWP-47D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 4.48 | 9.21 | 12.02 | 13.49 | 14.28 | 14.91 | 15.72 | —— | —— | —— | —— | 16.18 | —— | —— | —— | 16.51 | —— | 16.64 | 16.90 | 16.95 | 16.96 | 16.79 | 16.29 | 18.86 | 21.84 | 25.62 |

### Inferred Groundwater Elevation (ft MSL)

| VWP ID | 7/29/2019 | 8/6/2019 | 8/7/2019 | 8/8/2019 | 8/9/2019 | 8/12/2019 | 8/19/2019 | 8/27/2019 | 9/3/2019 | 9/10/2019 | 9/17/2019 | 9/25/2019 | 10/9/2019 | 10/18/2019 | 10/30/2019 | 11/8/2019 | 11/15/2019 | 11/22/2019 | 12/3/2019 | 12/4/2019 | 12/5/2019 | 12/6/2019 | 12/9/2019 | 12/12/2019 | 12/13/2019 | 12/16/2019 | 12/18/2019 | 12/19/2019 | 12/20/2019 | 12/24/2019 | 1/4/2020 | 1/9/2020 | 1/14/2020 | 1/30/2020 | 2/25/2020 | 4/1/2020 | 5/14/2020 | 7/8/2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VWP-1 | —— | 543.1 | 543.1 | 543.1 | 543.1 | 543.0 | 543.0 | 542.9 | 542.8 | 542.7 | 542.6 | 543.4 | 542.3 | 542.0 | 542.1 | 542.1 | 542.0 | 541.7 | 541.4 | —— | —— | —— | —— | 541.5 | —— | —— | —— | 541.5 | —— | 541.3 | 541.3 | 541.0 | 541.0 | 540.9 | 540.7 | 540.7 | 540.6 | 541.2 |
| VWP-3 | —— | 506.9 | 507.0 | 507.4 | 508.1 | 508.5 | 510.8 | 511.5 | 511.9 | 512.1 | 512.1 | 512.2 | 512.4 | 512.3 | 512.4 | 512.4 | 512.5 | 512.4 | 512.2 | —— | —— | —— | —— | 512.4 | —— | —— | —— | 512.3 | —— | 512.3 | 512.5 | 512.3 | 512.4 | 512.5 | 512.6 | 513.0 | 512.8 | 512.7 |
| VWP-4 | —— | 526.9 | 526.9 | 526.9 | 526.8 | 526.7 | 526.9 | 526.8 | 526.9 | 527.0 | 526.8 | 526.8 | 527.0 | 526.7 | 526.9 | 527.2 | 527.2 | 526.9 | 526.9 | —— | —— | —— | —— | 527.0 | —— | —— | —— | 527.2 | —— | 527.0 | 527.1 | 526.8 | 526.9 | 526.9 | 526.8 | 526.8 | 526.6 | 526.7 |
| VWP-8 | —— | 486.4 | 486.3 | 486.3 | 486.3 | 486.2 | 486.4 | 486.3 | 486.4 | 486.5 | 486.3 | 486.3 | 486.5 | 486.1 | 486.4 | 486.7 | 486.7 | 486.4 | 486.4 | —— | —— | —— | —— | 486.5 | —— | —— | —— | 486.7 | —— | 486.4 | 486.6 | 486.3 | 486.4 | 486.4 | 486.3 | 486.3 | 486.1 | 486.2 |
| VWP-8D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 400.2 | 399.8 | 406.7 | 407.5 | 411.5 | 414.2 | 420.5 | 421.2 | 431.1 | 476.7 | 485.8 | 490.3 | 496.4 | 500.6 | 504.2 | 505.8 | 506.1 |
| VWP-9 | —— | 506.9 | 506.8 | 506.8 | 506.8 | 506.7 | 506.8 | 506.9 | 506.8 | 506.9 | 506.8 | 506.7 | 506.9 | 506.6 | 506.9 | 507.2 | 507.2 | 506.8 | 506.8 | —— | —— | —— | —— | 507.1 | —— | —— | —— | 507.2 | —— | 506.9 | 507.1 | 506.8 | 506.9 | 506.9 | 506.8 | 506.8 | 506.5 | 506.6 |
| VWP-9D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 412.5 | 480.0 | 506.3 | 509.3 | 511.3 | 514.4 | 516.8 | 517.0 | 517.4 | 517.8 | 518.4 | 519.7 | 519.3 | 519.4 |
| VWP-18 | 505.7 | 510.9 | 511.2 | 511.6 | 512.1 | 513.3 | 515.4 | 517.3 | 518.5 | 519.4 | 520.1 | 520.7 | 521.4 | 521.8 | 522.3 | 522.7 | 523.0 | 523.2 | 523.5 | —— | —— | —— | —— | 525.3 | —— | —— | —— | 523.6 | —— | 523.2 | 522.9 | 522.9 | 522.9 | 522.9 | 523.0 | 523.3 | 523.5 | 523.5 |
| VWP-18D | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | —— | 486.5 | 481.9 | 476.2 | 474.5 | 474.8 | 475.5 | 478.7 | 483.9 | 490.2 | 496.8 | 503.6 |
| VWP-19 | 510.1 | 510.0 | 510.0 | 510.0 | 510.0 | 510.0 | 510.0 | 509.9 | 510.0 | 510.0 | 510.0 | 510.0 | 510.0 | 510.0 | 510.0 | 510.1 | 510.2 | 510.1 | 510.0 | —— | —— | —— | —— | 510.2 | —— | —— | —— | 510.2 | —— | 510.1 | 510.1 | 510.1 | 510.1 | 510.0 | 509.9 | 510.0 | 509.8 | 509.8 |
| VWP-20 | 517.4 | 517.6 | 517.6 | 517.7 | 517.7 | 517.8 | 517.9 | 518.0 | 518.2 | 518.3 | 518.4 | 516.9 | 513.8 | 512.2 | 511.1 | 510.8 | 510.7 | 510.4 | 510.3 | —— | —— | —— | —— | 510.3 | —— | —— | —— | 510.3 | —— | 510.3 | 510.1 | 510.2 | 510.2 | 510.1 | 510.1 | 510.0 | 510.0 | 509.9 |
| VWP-25 | —— | 504.9 | 504.9 | 504.8 | 504.8 | 504.7 | 504.9 | 504.9 | 504.9 | 505.0 | 504.9 | 504.8 | 505.0 | 504.7 | 505.0 | 505.3 | 505.2 | 504.9 | 504.9 | —— | —— | —— | —— | 505.2 | —— | —— | —— | 505.3 | —— | 505.0 | 505.2 | 504.8 | 505.0 | 505.0 | 504.9 | 504.9 | 504.6 | 504.8 |
| VWP-26 | 505.8 | 505.7 | 505.7 | 505.7 | 505.6 | 505.6 | 505.8 | 505.7 | 505.8 | 505.9 | 505.8 | 505.7 | 505.9 | 505.5 | 505.9 | 506.1 | 506.1 | 505.8 | 505.8 | —— | —— | —— | —— | 505.9 | —— | —— | —— | 506.1 | —— | 505.9 | 506.1 | 505.7 | 505.8 | 505.8 | 505.7 | 505.8 | 505.5 | 505.6 |
| VWP-27 | 519.8 | 519.7 | 519.7 | 519.6 | 519.6 | 519.6 | 519.7 | 519.7 | 519.7 | 519.8 | 519.7 | 519.6 | 519.9 | 519.5 | 519.8 | 520.1 | 520.1 | 519.7 | 519.7 | —— | —— | —— | —— | 519.8 | —— | —— | —— | 520.1 | —— | 519.8 | 520.0 | 519.7 | 519.7 | 519.7 | 519.6 | 519.7 | 519.4 | 519.5 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VWP-30 | 502.1 | 505.6 | 505.7 | 505.7 | 505.8 | 505.7 | 505.7 | 505.8 | 505.8 | 505.9 | 505.8 | 505.7 | 506.0 | 505.6 | 505.8 | 506.2 | 506.2 | 505.9 | 505.8 | --- | --- | --- | --- | 506.0 | --- | --- | --- | 506.2 | --- | 505.9 | 506.1 | 505.8 | 505.8 | 505.9 | 509.4 | 515.7 | 508.0 | 505.8 |
| VWP-33 | --- | 494.7 | 494.6 | 494.6 | 494.5 | 494.4 | 494.5 | 494.4 | 494.3 | 494.4 | 494.2 | 494.2 | 494.8 | 494.5 | 494.8 | 495.0 | 495.0 | 494.7 | 494.7 | --- | --- | --- | --- | 494.8 | --- | --- | --- | 495.0 | --- | 494.8 | 495.0 | 494.6 | 494.7 | 494.7 | 494.6 | 494.7 | 494.4 | 494.5 |
| VWP-33D | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 401.1 | 401.3 | 400.9 | 401.2 | 401.3 | 401.6 | 402.0 | 404.7 | 404.8 | 405.3 | 406.3 | 406.6 | 406.8 | 407.5 | 408.1 | 411.4 | 415.0 | 419.7 |
| VWP-41 | 496.6 | 496.5 | 496.4 | 496.4 | 496.4 | 496.3 | 496.5 | 496.4 | 496.5 | 496.6 | 496.4 | 496.3 | 496.6 | 496.2 | 496.5 | 496.8 | 496.8 | 496.5 | 496.4 | --- | --- | --- | --- | 496.6 | --- | --- | --- | 496.8 | --- | 496.5 | 496.7 | 496.4 | 496.5 | 496.5 | 496.3 | 496.4 | 496.2 | 496.3 |
| VWP-41D | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 409.2 | 411.9 | 411.4 | 411.1 | 412.0 | 412.9 | 414.1 | --- | --- | --- | --- | 415.0 | --- | --- | --- | 415.8 | --- | 416.4 | 417.5 | 417.9 | 418.5 | 420.0 | 422.4 | 425.7 | 429.5 | 434.3 |
| VWP-43 | 511.5 | 511.4 | 511.4 | 511.4 | 511.4 | 511.3 | 511.4 | 511.4 | 511.4 | 511.5 | 511.4 | 511.3 | 511.5 | 511.2 | 511.5 | 511.8 | 511.7 | 511.4 | 511.4 | --- | --- | --- | --- | 511.5 | --- | --- | --- | 511.8 | --- | 511.5 | 511.7 | 511.4 | 511.4 | 511.4 | 511.4 | 511.4 | 511.1 | 511.2 |
| VWP-43D | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 400.4 | 400.3 | 400.4 | 400.0 | 400.3 | 400.0 | 400.3 | 405.2 | 476.9 | 469.8 | 462.1 | 463.3 | 465.4 | 468.2 | 475.5 | 483.3 | 489.1 | 493.1 | 496.0 |
| VWP-44 | --- | 509.7 | 509.8 | 510.0 | 510.2 | 510.8 | 511.7 | 512.7 | 513.3 | 513.8 | 514.1 | 514.4 | 514.7 | 514.8 | 514.9 | 514.9 | 515.0 | 514.9 | 514.8 | --- | --- | --- | --- | 514.7 | --- | --- | --- | 513.7 | --- | 513.5 | 513.3 | 513.4 | 513.4 | 513.3 | 513.3 | 513.4 | 513.0 | 513.0 |
| VWP-47 | --- | 512.4 | 512.3 | 512.3 | 512.3 | 512.2 | 512.3 | 512.3 | 512.3 | 512.4 | 512.3 | 512.2 | 512.4 | 512.1 | 512.4 | 512.7 | 512.6 | 512.3 | 512.3 | --- | --- | --- | --- | 512.6 | --- | --- | --- | 512.7 | --- | 512.4 | 512.6 | 512.2 | 512.4 | 512.3 | 512.3 | 512.3 | 512.0 | 512.1 |
| VWP-47D | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 404.5 | 409.2 | 412.0 | 413.5 | 414.3 | 414.9 | 415.7 | --- | --- | --- | --- | 416.2 | --- | --- | --- | 416.5 | --- | 416.6 | 416.9 | 417.0 | 417.0 | 416.8 | 416.3 | 418.9 | 421.8 | 425.6 |

*** Pressure (P, in psi) calculated using the following linear equation provided by Geokon:**

$P = G(R_1 - R_0) + K(T_1 - T_0) \cdot (S_1 - S_0)$

**where:**

**G = Linear Gauge Factor (psi/digit)**

**$R_1$ = Instrument Reading (digits)**

**$R_0$ = Initial Zero Instrument Reading (digits)**

**$T_1$ = Temperature Reading (˚C)**

**$T_0$ = Initial Zero Temperature Reading (˚C)**

**K = Thermal Factor (psi/˚C)**

*$S_1$ = Measured Barometric pressure (psi)*

*$S_0$ = Intiial Zero Barometric pressure (psi)*

*Note: Barometric corrections not performed as VWPs are installed in sealed boreholes, per Geokon Model 4500 Series Instruction Manual, p. 6.*

***Note:** Values in **red** represent a zero pressure head. Elevation values in **red** are associated with the subsurface location of the transducer and should **not** be considered an inferred groundwater elevation.

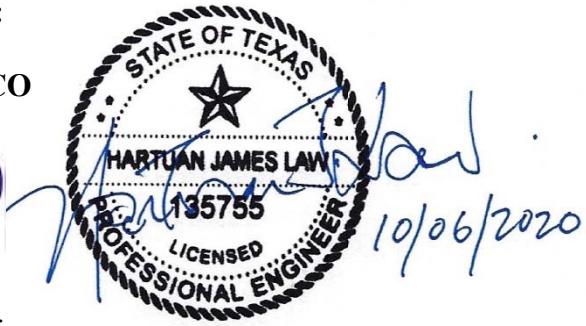
| MSW-2400 Vibrating Wire Piezometer (VWP) Reference Information | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| VWP ID | Surface Elevation (ft MSL) | VWP Elevation (ft MSL) | VWP Depth | Serial Number | Factory Zero Reading (digits) | Factory Zero Temperature (˚C) | Field Zero Reading (digits) | Field Zero Temperature (˚C) | Linear Gauge Factor G (psi/digit) | Thermal Factor K (psi/˚C) |
| VWP-1 | 551.40 | 522.50 | 28.90 | 1921455 | 8572 | 21.2 | 8562.1 | 37.0 | -0.01439 | -0.006162 |
| VWP-3 | 540.90 | 506.60 | 34.30 | 1921444 | 8695 | 22.2 | 8678.0 | 35.7 | -0.01633 | -0.01773 |
| VWP-4 | 549.59 | 527.00 | 22.59 | 1921438 | 8717 | 22.2 | 8707.7 | 31.2 | -0.01647 | -0.00993 |
| VWP-8 | 550.90 | 486.30 | 64.60 | 1921442 | 8691 | 21.9 | 8679.2 | 31.8 | -0.01595 | -0.01724 |
| VWP-8D | 551.00 | 400.00 | 151.00 | 1943860 | 8928 | 21.6 | 8945.6 | 16.3 | -0.01651 | -0.02515 |
| VWP-9 | 535.25 | 506.90 | 28.35 | 1921447 | 8599 | 22.2 | 8593.5 | 28.4 | -0.01727 | -0.01214 |
| VWP-9D | 535.00 | 400.00 | 135.00 | 1943862 | 9086 | 21.9 | 9082.2 | 19.5 | -0.01484 | -0.02584 |
| VWP-18 | 534.60 | 499.60 | 35.00 | 1921452 | 8748 | 21.6 | 8743.9 | 35.8 | -0.01694 | -0.01263 |
| VWP-18D | 535.00 | 400.00 | 135.00 | 1943861 | 9040 | 21.6 | 9034.1 | 17.7 | -0.01445 | -0.02497 |
| VWP-19 | 562.10 | 511.00 | 51.10 | 1921454 | 8816 | 21.7 | 8775.8 | 35.2 | -0.01671 | -0.01660 |
| VWP-20 | 564.55 | 510.10 | 54.45 | 1921440 | 8772 | 21.7 | 8756.1 | 34.3 | -0.01622 | -0.01860 |
| VWP-25 | 533.80 | 505.00 | 28.80 | 1921450 | 8766 | 21.4 | 8759.3 | 28.7 | -0.01723 | -0.00880 |
| VWP-26 | 530.50 | 506.00 | 24.50 | 1921453 | 8649 | 21.5 | 8637.1 | 33.3 | -0.01708 | -0.004576 |
| VWP-27 | 546.70 | 520.00 | 26.70 | 1921446 | 8632 | 22.0 | 8610.2 | 23.6 | -0.01647 | -0.01467 |
| VWP-30 | 544.05 | 506.00 | 38.05 | 1921451 | 8690 | 22.5 | 8676.4 | 31.5 | -0.01746 | -0.01107 |
| VWP-33 | 538.60 | 494.80 | 43.80 | 1921439 | 8627 | 21.9 | 8617.6 | 28.7 | -0.01482 | -0.00794 |
| VWP-33D | 539.00 | 401.00 | 138.00 | 1943866 | 8963 | 21.9 | 8965.6 | 18.4 | -0.01561 | -0.01073 |
| VWP-41 | 534.80 | 496.40 | 38.40 | 1921443 | 8631 | 22.0 | 8627.5 | 27.3 | -0.01665 | -0.01389 |
| VWP-41D | 535.00 | 402.00 | 133.00 | 1933662 | 8996 | 23.2 | 8975.1 | 25.5 | -0.01640 | -0.01493 |
| VWP-43 | 549.50 | 511.50 | 38.00 | 1921441 | 8642 | 21.9 | 8637.0 | 25.4 | -0.01677 | -0.01551 |
| VWP-43D | 549.00 | 400.00 | 149.00 | 1943859 | 8879 | 22.0 | 8888.2 | 18.4 | -0.01536 | -0.02667 |
| VWP-44 | 554.35 | 505.20 | 49.15 | 1921448 | 8781 | 21.4 | 8767.4 | 37.2 | -0.01725 | -0.006366 |
| VWP-47 | 532.60 | 512.40 | 20.20 | 1921449 | 8718 | 21.6 | 8708.8 | 29.0 | -0.01703 | -0.0147 |
| VWP-47D | 532.00 | 400.00 | 132.00 | 1933663 | 8931 | 23.2 | 8923.6 | 22.6 | -0.01583 | -0.01694 |

**CITY OF WACO LANDFILL**
**TCEQ PERMIT NO. MSW-2400**
**McLENNAN AND LIMESTONE COUNTIES, TEXAS**

# PART III - SITE DEVELOPMENT PLAN
# ATTACHMENT 5
# GEOTECHNICAL/STABILITY ANALYSES

**Prepared for:**

**CITY OF WACO**

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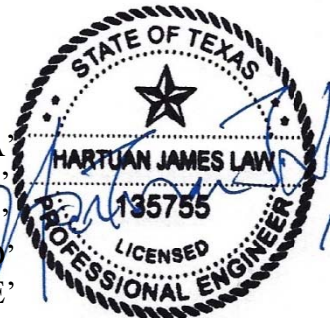


10/06/2020

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## Appendices

5A Slope Stability Analyses
5B Veneer Stability Analyses
5C Settlement Analyses

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# 2 GEOTECHNICAL TESTING

## 2.1 GENERAL

Geotechnical testing was done on soil samples obtained during the site subsurface exploration conducted from October 2018 to January 2019 (see Attachment 4). During this site exploration, 42 borings were advanced between 28 to 80 feet in depth. Soil samples were collected during auger advancement utilizing thick walled Shelby tubes, two-foot split spoons, or five-foot continuous split barrels. Select soil samples from each stratum were used for geotechnical testing. The geotechnical tests were performed to evaluate physical and engineering properties of the different soil strata in accordance with 30 TAC §330.63(e)(5). Two additional borings were drilled in December 2019 (B-9 and B-43) to depths of 135 feet and 150 ft, respectively. The site exploration is discussed in detail in Attachment 4, Section 5. In Attachment 5, for the evaluation of the tests results, soil samples were grouped as West Disposal Area Samples, East Disposal Area Samples, and Other Samples (i.e., samples from borings outside the respective waste footprints).

Test parameters, the ASTM Test Methods, and the location within this report where test results are presented are shown in Table 5-2-1. The test results are summarized on Tables 5-2-2 to 5-2-7 for reference and individual testing results are shown in Attachment 4, Appendix 4.F.

**Table 5-2-1. Laboratory Test Parameters**

| Test Parameter | Test Results | ASTM Test Method |
|---|---|---|
| Standard Proctor | Table 5-2-6<br>Appendix 4.F | D 698 |
| Sieve Analysis (Passing No. 200) | Table 5-2-2 to 5-2-4<br>Appendix 4.F | D 1140 |
| Atterberg Limits<br>(Liquid and Plastic Limit, Plasticity Index) | Table 5-2-2 to 5-2-4<br>Appendix 4.F | D 4318 |
| Moisture Content & Unit Weight | Table 5-2-2 to 5-2-4<br>Appendix 4.F | D 2216 |
| Hydraulic Conductivity<br>(Remolded to 95% Standard Proctor)<br>Hydraulic Conductivity<br>(Undisturbed Sample, $K_H$ and $K_V$) | Table 5-2-6<br>Appendix 4.F<br>Table 5-2-7<br>Appendix 4.F | USACE EM 1110-2-1906, Appendix VII<br>USACE EM 1110-2-1906, Appendix VII |
| Consolidated Undrained Triaxial Test | Table 5-2-5<br>Appendix 4.F | D 4767 |
| Unconfined Compression Test | Table 5-2-8<br>Appendix 4.F | D 2166 |

4, Appendix 4B and 4C, the landfill excavation will typically encounter predominantly high plasticity clays (CH).

As described in Attachment 4, site lithology as determined by the drilling exploration program is quite homogenous both horizontally and vertically. Site lithology has been divided into surficial alluvial (Unit I), upper "weathered" calcareous shale-marl (Unit II) and lower "unweathered" calcareous shale-marl (Unit III) horizons based on field observations. Uppermost Unit 1 soil horizon generally ranges from zero to three feet in thickness. This thin uppermost soil layer (Unit I) will mostly be used as topsoil and, due to its thickness and similarity to other layers, will not be used for landfill development to the extent of the lower layers (Units II and III).

### 2.6.2 Laboratory Test Results

The geotechnical laboratory test results are summarized in the sections below for the West Disposal Area, East Disposal Area, and areas outside the waste footprints. The boring location map and geotechnical laboratory reports are presented in Attachment 4. Laboratory test results including Liquid Limit (LL), Plasticity Index (PI), percent fines, percent sand, percent gravel, water content, dry unit weight, unconfined compressive strength and Unified Soil Classification System (UCSC) classification are presented in Tables 5-2-2 to 5-2-4.

Results of the CU tests are presented in Attachment 4 (Appendix 4.F) and summarized in Table 5-2-5. Results of the hydraulic conductivity tests of the samples remolded at 95% Standard Proctor are presented in Attachment 4 and summarized in Table 5-2-6. Results of the hydraulic conductivity tests in both horizontal and vertical directions of undisturbed samples obtained from each soil unit are presented in Attachment 4 and summarized in Table 5-2-7.

**Table 5-2-2. Summary of Geotechnical Material Property Test Results – West Disposal Area**

| Boring Number | Sample Depth (ft) | Soil Layer | LL | PI[1] | Fines (%) | Sand (%) | Gravel (%) | Water Content (%) | Dry Unit Weight (pcf) | $q_u$ Strength (tsf) | USCS[4] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B-1 | 15-20 | Unit II | 75 | 53 | 93 | 5 | 2 | 23 | | | CH |
| | 35-38 | Unit III | 69 | 45 | 97 | 3 | 0 | 19 | | | CH |
| B-3 | 25-30 | Unit II | 60 | 36 | 93 | 7 | 0 | 18 | | | CH |
| | 40-45 | Unit III | 63 | 43 | 96 | 4 | 0 | 16 | | | CH |
| B-4 | 1-2 | Unit I | 67 | 46 | 71.2 | 27.6 | 1.2 | 24.2 | | | CH |
| B-9 | 1-2 | Unit I | 60 | 39 | 81.9 | 18 | 0.1 | 22.2 | | | CH |
| | 5-7 | Unit II | 53 | 35 | 75 | 23 | 2 | 15 | | | CH |
| | 20-22 | Unit II | 67 | 47 | 91 | 6 | 3 | 20 | 105 | 12.32 | CH |
| | 35-37 | Unit III | 62 | 42 | 89 | 8 | 3 | 15 | 116 | | CH |
| B-16 | 1-2 | Unit I | 75 | 51 | 84.5 | 14.9 | 0.6 | 26.3 | | | CH |
| | 10-12 | Unit II | 78 | 52 | 91 | 9 | 0 | 19 | 105 | | CH |
| | 25-27 | Unit II | 60 | 38 | 77 | 18 | 5 | 15 | 116 | 17.76 | CH |
| | 50-52 | Unit III | 64 | 43 | 94 | 6 | 0 | 17 | 115 | | CH |
| B-17 | 15-17 | Unit II | 66 | 41 | 91 | 9 | 0 | 19 | 106 | 8.09 | CH |
| | 25-27[2] | Unit II | 67 | 44 | | | | | | | CH |
| | 45-47 | Unit III | 60 | 41 | 83 | 17 | 0 | 15 | 120 | 23.36 | CH |
| B-23 | 1-2 | Unit I | 96 | 66 | 68.6 | 25.9 | 5.5 | 31.7 | 86.8 | | CH |
| | 10-12 | Unit II | 73 | 50 | 98 | 2 | 0 | 20 | 108 | | CH |
| | 30-32 | Unit II | 74 | 51 | 85 | 12 | 3 | 18 | 108 | | CH |
| | 35-37 | Unit II | 77 | 55 | 89 | 11 | 0 | 20 | 101 | | CH |
| | 40-42 | Unit III | 70 | 50 | 96 | 4 | 0 | 15 | | | CH |
| B-24 | 5-7 | Unit I | 51 | 33 | 73 | 24 | 3 | 15 | 112 | 14.94 | CH |
| | 15-17 | Unit II | 74 | 52 | 98 | 2 | 0 | 21 | 99 | 7.94 | CH |
| | 25-27 | Unit II | 69 | 44 | 89 | 11 | 0 | 19 | 103 | | CH |
| | 45-47[2] | Unit III | 59 | 33 | | | | | | | CH |
| B-31 | 15-17[2] | Unit II | 66 | 39 | | | | | | | CH |
| | 30-32 | Unit III | 74 | 52 | 90 | 7 | 3 | 18 | 103 | 5.37 | CH |
| | 55-57 | Unit III | 60 | 37 | 96 | 3 | 1 | 14 | | | CH |
| B-44 | 10-12 | Unit II | 71 | 49 | 91 | 6 | 3 | 20 | 108 | | CH |
| | 20-22 | Unit II | 79 | 55 | 84 | 11 | 5 | 21 | 105 | | CH |
| | 30-32 | Unit II | 72 | 51 | 97 | 3 | 0 | 25 | 97 | 4.44 | CH |
| | 50-52 | Unit III | 60 | 35 | | | | | | | CH |

[1] PI = LL – PL
[2] See Table 5-2-5 for CU test results.

**Table 5-2-3. Summary of Geotechnical Material Property Test Results – East Disposal Area**

| Boring Number | Sample Depth (ft) | Soil Layer | LL | PI[1] | Fines (%) | Sand (%) | Gravel (%) | Water Content (%) | Dry Unit Weight (pcf) | $q_u$ Strength (tsf) | USCS[4] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B-15 | 55-57 | Unit III | 57 | 37 | 91 | 7 | 2 | 11 | 116 | 1.61 | CH |
| B-14 | 15-17 | Unit II | 58 | 35 | 65 | 30 | 5 | 19 | 104 | | CH |
| | 35-37 | Unit III | 58 | 39 | 94 | 5 | 1 | 15 | | | CH |
| B-18 | 10-12 | Unit II | 66 | 45 | 92 | 7 | 1 | 19 | 105 | 4.26 | CH |
| | 45-47 | Unit III | 57 | 38 | 90 | 10 | 0 | 13 | 109 | 3.59 | CH |
| B-45 | 25-27 | Unit II | 66 | 46 | 90 | 8 | 2 | 21 | 107 | 6.21 | CH |
| | 40-42 | Unit III | 58 | 38 | 92 | 8 | 0 | 15 | | | CH |
| B-21 | 15-17 | Unit II | 69 | 44 | 97 | 3 | 0 | 19 | | | CH |
| | 35-37 | Unit III | 57 | 39 | 94 | 6 | 0 | 15 | 108 | 10.49 | CH |
| | 40-42 | Unit III | 61 | 40 | 88 | 8 | 4 | 14 | | | CH |
| B-19[2] | 1-2 | Unit I | 55 | 35 | 81.7 | 17 | 1.3 | 18.5 | | | CH |
| | 10-12 | Unit II | 83 | 59 | 92 | | | | | | CH |
| | 50-52 | Unit II | 63 | 44 | 91 | 7 | 2 | 14 | 117 | | CH |
| | 70-72 | Unit III | 57 | 38 | 95 | 5 | 0 | 15 | | | CH |
| B-46 | 45-47 | Unit III | 62 | 41 | 94 | 6 | 0 | 13 | 110 | | CH |
| B-20 | 2 | Unit I | 56 | 38 | 74.2 | 24.5 | 1.3 | 11.7 | 123.1 | | CH |
| | 30 | Unit II | 61 | 41 | 91.1 | 8.9 | 0 | 18.9 | 108 | | CH |
| | 45-47 | Unit II | 59 | 36 | 95 | 5 | 0 | 13 | 116 | 18.68 | CH |
| | 55-57 | Unit III | 58 | 37 | 96 | 3 | 1 | 13 | 118 | 16.82 | CH |
| B-13 | 35-37 | Unit II | 66 | 43 | 94 | 6 | 0 | 20 | | | CH |
| | 45-47 | Unit III | 51 | 33 | 95 | 5 | 0 | 15 | | | CH |
| B-27 | 1-2 | Unit I | 64.4 | 59 | 38 | 35 | 0.6 | 20.3 | | | CH |
| | 25-27 | Unit II | 68 | 47 | 87 | 10 | 3 | 18 | 108 | | CH |
| | 45-47 | Unit III | 61 | 40 | 97 | 3 | 0 | 15 | 118 | | CH |
| B-43 | 10-12 | Unit II | 60 | 40 | 95 | 5 | 0 | 18 | 111 | 7.12 | CH |
| | 25-27 | Unit II | 61 | 42 | 94 | 5 | 1 | 16 | 117 | | CH |
| | 45-47 | Unit III | 63 | 40 | 95 | 5 | 0 | 16 | | | CH |
| B-8 | 10-12 | Unit II | 67 | 50 | 85 | | | | | | CH |
| | 40-42 | Unit II | 58 | 38 | 92 | 8 | 0 | 16 | 106 | 4.02 | CH |
| | 50-52 | Unit III | 58 | 38 | 97 | 2 | 1 | 14 | 116 | | CH |

[1] PI = LL – PL
[2] See Table 5-2-5 for CU test results.

**Table 5-2-3. (cont.) Summary of Geotechnical Material Property Test Results – East Disposal Area**

| Boring Number | Sample Depth (ft) | Soil Layer | LL | PI[1] | Fines (%) | Sand (%) | Gravel (%) | Water Content (%) | Dry Unit Weight (pcf) | $q_u$ Strength (tsf) | USCS[4] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B-35 | 45-47 | Unit III | 54 | 33 | 75 | 17 | 8 | 13 | 109 | | CH |
| B-30 | 15-17 | Unit II | 61 | 41 | 90 | 6 | 4 | 18 | | | CH |
| | 30-32 | Unit II | 62 | 41 | 94 | 6 | 0 | 18 | | | CH |
| B-29 | 25-27 | Unit II | 60 | 39 | 95 | 4 | 1 | 16 | 113 | | CH |
| | 35-37 | Unit III | 51 | 34 | 90 | 10 | 0 | 11 | 114 | | CH |
| B-34 | 10-12 | Unit II | 57 | 38 | 82 | 17 | 1 | 14 | | | CH |
| | 20-22 | Unit II | 63 | 43 | 95 | 5 | 0 | 16 | 111 | | CH |
| B-22 | 30-32 | Unit II | 74 | 47 | 84 | 8 | 1 | 20 | | | CH |
| | 45-47 | Unit III | 64 | 39 | 92 | 7 | 8 | 17 | | | CH |
| B-10 | 10-12 | Unit II | 65 | 41 | 90 | 7 | 3 | 19 | | | CH |
| | 25-27 | Unit II | 54 | 33 | 94 | 6 | 0 | 15 | 108 | | CH |
| | 40-42 | Unit III | 59 | 39 | 92 | 7 | 1 | 14 | | | CH |

[1] PI = LL – PL

**Table 5-2-4. Summary of Geotechnical Material Property Test Results – Other Borings**

| Boring Number | Sample Depth (ft) | Soil Layer | LL | PI[1] | Fines (%) | Sand (%) | Gravel (%) | Water Content (%) | Dry Unit Weight (pcf) | $q_u$ Strength (tsf) | USCS[4] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B-11 | 20-22 | Unit II | 75 | 49 | 89 | 10 | 1 | 21 | 95 | | CH |
| | 45-47 | Unit III | 55 | 33 | 86 | 14 | 0 | 13 | 120 | | CH |
| B-36 | 15-17 | Unit II | 56 | 35 | 91 | 8 | 1 | 18 | | | CH |
| | 30-32 | Unit III | 64 | 38 | 93 | 7 | 0 | 17 | 115 | | CH |

[1] PI = LL – PL

**Table 5-2-5. Summary of Consolidated Undrained (CU) Triaxial Test Results**

| Area | Boring Number | Sample Depth (ft) | Sampled Layer | CU test Results | |
|---|---|---|---|---|---|
| | | | | c′ (psi) | ϕ′ (°) |
| East Disposal Area | B-19 | 50-51 | Unit II | 7.4 | 24.0 |
| West Disposal Area | B-17 | 25-26 | Unit II | 1.6 | 26.2 |
| West Disposal Area | B-31 | 15-16 | Unit II | 5.5 | 25.9 |
| West Disposal Area | B-24 | 45-46 | Unit III | 10.0 | 34.0 |
| West Disposal Area | B-44 | 50-51.5 | Unit III | 1.7 | 19.2 |

**Table 5-2-6. Summary of Standard Proctor & Hydraulic Conductivity Tests – Remolded Samples**

| Area | Boring Number | Sample Depth (ft) | Sampled Layer | Standard Proctor | | Hydraulic Conductivity (Remolded) (cm/s) |
|---|---|---|---|---|---|---|
| | | | | MDD (pcf) | OMC (%) | |
| West Disposal Area | B-16 | 10-12 | Unit II | 97.6 | 24.0 | $1.94 \times 10^{-8}$ |
| West Disposal Area | B-23 | 10-12 | Unit II | 96.0 | 25.1 | $2.69 \times 10^{-8}$ |
| East Disposal Area | B-8 | 10-12 | Unit II | 97.9 | 23.6 | $2.23 \times 10^{-8}$ |
| East Disposal Area | B-19 | 10-12 | Unit II | 93.9 | 26.6 | $2.05 \times 10^{-8}$ |

**Table 5-2-7. Summary of Hydraulic Conductivity Tests – Undisturbed Samples**

| Area | Boring Number | Sample Depth (ft) | Sampled Layer | Hydraulic Conductivity (Undisturbed) (cm/s) | |
|---|---|---|---|---|---|
| | | | | $K_H$ | $K_V$ |
| West Disposal Area | B-23 | 1-2 | Unit I | $4.36 \times 10^{-9}$ | $5.01 \times 10^{-9}$ |
| | B-4 | 10-20’ | Unit II[(1)] | $2.16 \times 10^{-8}$ | $5.80 \times 10^{-9}$ |
| | | 35’ | Unit III | $6.71 \times 10^{-6}$ | $1.76 \times 10^{-9}$ |
| East Disposal Area | B-20 | 1-2 | Unit I | $4.54 \times 10^{-9}$ | $3.82 \times 10^{-9}$ |
| | | 15-30’ | Unit II[(1)] | $7.90 \times 10^{-8}$ | $3.40 \times 10^{-9}$ |
| | | 50’ | Unit III | $9.25 \times 10^{-9}$ | $1.30 \times 10^{-9}$ |

[(1)] Hydraulic Conductivity presented is the average of test results calculated at depth range shown.

### 2.6.3 Material Properties

The geotechnical laboratory test results presented in the previous section are compiled in Table 5-2-8. Test results obtained from areas outside the waste limits are not included in this table since these areas will mostly be undisturbed during landfill construction. The landfill excavation will typically encounter predominantly high plasticity clays (CH) in the West Disposal Area and East Disposal Area, where all samples taken were classified as high plasticity clays (CH).

Site lithology has been divided into a surficial alluvial (Unit I), an upper "weathered" (Unit II) and a lower "unweathered" (Unit III) horizons based on field observations, and the engineering properties of these units confirmed by geotechnical laboratory testing are generally very similar (see Table 5-2-8). In addition to this similarity, engineering properties of soil samples (surficial alluvial, weathered and/or unweathered) from the West Disposal Area are very similar to the samples from the East Disposal Area. Therefore, for slope stability analyses and settlement analyses, foundation soils, which consist of Strata II and III, are modeled as one uniform layer for the landfill (including the West and East Disposal Areas). The engineering properties of this soil layer are estimated by the weighted average of all test results of these two units.

The results of the drained shear strength tests performed on the undisturbed samples are presented in Attachment 4. As seen in Table 5-2-5, similar shear strength properties were obtained for Units II and III. As discussed in Section 4, in addition to these test results, empirical relationships are also used to calculate the shear strength properties.

Table 5-2-6 shows the remolded hydraulic conductivities obtained through laboratory testing. The remolded hydraulic conductivities values for Unit II range between $1.9x10^{-8}$ and $2.7x10^{-8}$ cm/sec (four test results). Table 5-2-7 shows the undisturbed horizontal and vertical hydraulic conductivities obtained through laboratory testing for each of the three units. The horizontal hydraulic conductivities ($K_H$) values for Unit II range between $2.16x10^{-8}$ and $7.90x10^{-8}$ cm/sec. The vertical hydraulic conductivities ($K_V$) values for Unit II range between $3.40x10^{-9}$ and $5.80x10^{-9}$ cm/sec. These results indicated that the undisturbed Unit II below the bottom of the landfill would have in-situ hydraulic conductivity of less than $1.0x10^{-7}$ cm/sec. in either direction. One outlier data point of $K_H$ for the Unit III in the West Disposal Area might be due to disturbance during sample preparation and should be disregarded. Generally, the undisturbed samples exhibit low hydraulic conductivities. Unit II hydraulic conductivity reported for the West Disposal Area and East Disposal Area were very similar, with little variability. The results as shown in Table 5-2-6 and Table 5-2-7 confirm that on-site soils will be suitable for use as liner materials. Although hydraulic conductivity is low enough for liner construction, gravel chimney drains will likely be needed to promote leachate flow through the protective cover. These gravel chimney drains are included in the design (see Attachment 12 – Leachate and Contaminated Water Management Plan).

**Table 5-2-8. Typical Properties of On-Site Materials**

| Laboratory Test | West Disposal Area | | | | | | East Disposal Area | | | | | | Foundation Soils [3] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Surficial Alluvial Unit I | | Weathered Clay Unit II | | Unweathered Clay Unit III | | Surficial Alluvial Unit I | | Weathered Clay Unit II | | Unweathered Clay Unit III | | |
| | Average Value | No. of Tests | Average Value | No. of Tests | Average Value | No. of Tests | Average Value | No. of Tests | Average Value | No. of Tests | Average Value | No. of Tests | |
| Liquid Limit | 75 | 4 | 68 | 18 | 65 | 10 | 57 | 3 | 63 | 21 | 58 | 17 | 63 |
| Plastic Limit | 24 | 4 | 22 | 18 | 22 | 10 | 20 | 3 | 21 | 21 | 20 | 17 | 21 |
| Plasticity Index | 51 | 4 | 46 | 18 | 43 | 10 | 37 | 3 | 42 | 21 | 38 | 17 | 42 |
| Moisture Content | 26.1 | 4 | 19 | 16 | 16 | 10 | 16.8 | 3 | 17 | 19 | 14 | 17 | 16.5 |
| % Passing No. 200 Sieve | 76.6 | 4 | 88 | 16 | 93 | 8 | 73.5 | 3 | 90 | 21 | 92 | 17 | 91 |
| Dry Unit Weight (pcf) | 86.8 | 1 | 105.6 | 13 | 113.5 | 4 | 123.1 | 1 | 110 | 14 | 112 | 10 | 109.4 |
| Unit Weight [2] (pcf) | 109.5 | N/A | 125.6 | N/A | 131.2 | N/A | 143.8 | N/A | 128.7 | N/A | 127.7 | N/A | 127.7 |
| CU Test – Cohesion (c) (psi) | | | 3.55 | 2 | 5.9 | 2 | | | 7.4 | 1 | N/A | N/A | 5.4 |
| CU Test – Friction Angle (ϕ) (°) | | | 26.0 | 2 | 26.6 | 2 | | | 24 | 1 | N/A | N/A | 25.9 |
| $q_u$ Test – Unconfined Compressive Strength (psf) [4] | | | 10.9 | 6 | 14.4 | 2 | | | 8.1 | 5 | 9.8 | 5 | 10,530 |
| Hydraulic Conductivity (remolded) (cm/s) | N/A | N/A | $2.31 \times 10^{-8}$ | 2 | N/A | N/A | N/A | 2 | $2.14 \times 10^{-8}$ | 2 | N/A | N/A | $2.23 \times 10^{-8}$ |
| Hydraulic Conductivity (Undisturbed) (cm/s) | $K_H = 4.36 \times 10^{-9}$ $K_V = 5.01 \times 10^{-9}$ | 1 | $K_H = 2.16 \times 10^{-8}$ $K_V = 5.80 \times 10^{-9}$ | 1 | $K_H = 6.71 \times 10^{-6}$ $K_V = 1.76 \times 10^{-9}$ | 1 | $K_H = 4.54 \times 10^{-9}$ $K_V = 3.82 \times 10^{-9}$ | 1 | $K_H = 7.90 \times 10^{-8}$ $K_V = 3.36 \times 10^{-9}$ | 1 | $K_H = 9.25 \times 10^{-9}$ $K_V = 1.30 \times 10^{-9}$ | 1 | N/A |

Notes:
1. West Disposal Area and East Disposal Area averages are arithmetic.
2. Unit Weight is calculated using the dry unit weight, water content (WC), and the following formula: $\gamma = \gamma_d \times (1 + WC)$
3. For foundation soil properties, weighted averages of Units II and III test results are compiled in this column.
4. Average of 10 lowest $q_u$ values.

Cross sections selected for analyses, input parameters and assumptions, and results of the analyses are presented in the following sections. PCSTABL5M output files of the excavation stability, stability under interim and final conditions are presented in Appendix 5A.

Stability of the proposed liner system during construction is evaluated in the veneer mode. The limit equilibrium method of Koerner and Soong (1998) is used to analyze the stability of the liner system on the 3 Horizontal:1 Vertical (3H:1V) sideslopes. Using Koerner and Soong (1998) method, the minimum required interface friction angle that can achieve a target factor of safety is estimated. The result is presented in Appendix 5B.

Stability of the proposed final cover system is also evaluated using the same method used for liner system stability in veneer mode. The result is also presented in Appendix 5B.

## 4.2 SECTIONS SELECTED FOR ANALYSIS

Slope stability analyses were performed for selected cross-sections of the landfill. The locations of these cross sections were selected based on review of the proposed excavation grades and the final grading plan. A critical slope section is considered to have a maximum waste height, a maximum exterior slope angle, and a shallow perimeter berm. All slope sections except the interim slopes are virtually buttressed by the excavation and the landfill perimeter, including a perimeter berm of various heights.

Please refer to Drawings 5.1 and 5.2 at the end of this attachment (prior to the Appendices) for plan views of the landfill showing where the various sections were cut. Drawings 5.3 through 5.7 show the various sections. Profiles of the sections can also be seen on the model outputs provided in Appendix 5A.

One cross section was selected for excavation stability analysis close to the north corner of the East Disposal Area (Section AA′). This cross section was selected as the most critical because the excavation cut is deepest in this area (including West Disposal Area and East Disposal Area).

Interim fill condition was analyzed using one cross section (Section BB′) with the tallest potential interim waste slope that would be constructed from an intercell berm to the maximum waste height with a slope inclination of 3H:1V.

Slope stability analyses under final conditions (waste stability, foundation soils stability, and liner stability) were performed for three slopes at final grade (Sections CC′, DD′, and EE′). The analyses were performed on cross-sections assuming that the landfill has reached its maximum height.

## 4.3 INPUT PARAMETERS AND ASSUMPTIONS

Table 5-2-8 compiles the results of the geotechnical tests performed on the foundation soils. In addition to the CU tests and unconfined compression strength tests, long-term and short-term shear strength parameters for foundation soils are also estimated using (i) the available empirical relationships in the literature and/or (ii) shear strength properties reported in the literature for CH type soils. These estimations are presented in Appendix 5A.

Based on Table 5-4-3, interface friction angles of 11 degrees and 15 degrees were used in the block-type stability analyses for the cell floor and side slope liner systems, respectively. The unit weight of the soil/geosynthetic and geosynthetic/geosynthetic interface layer is assumed to have a typical value of 100 pcf (Attachment 5, Appendix 5A, Page 5-A-20, table showing Layer 4 or 5). Since this layer is relatively thin and when computing the driving force of each slice column above a failure pane, it has no significant contribution in calculating the factor of safety against slope sliding.

To be conservative, no adhesion value was used in the analysis; however, adhesion is typically considered to determine the effective shear strength of the critical interface.

**Table 5-4-3. Summary of Liner Interface Properties**

| Interface | Peak Friction Angle $\phi_{peak}$ (°) | Residual Friction Angle $\phi_{residual}$ (°) |
|---|---|---|
| Smooth HDPE GM /Compacted Clay Liner (Saturated) | 11 | 11 |
| Smooth HDPE GM /SS Geocomposite (Geonet) | **11** | 9 |
| NW GT/Cohesive Soil | 30 | 21 |
| Textured HDPE GM /Compacted Clay Liner (Saturated) | 18 | 16 |
| Textured HDPE GM /DS Geocomposite | 26 | **15** |
| Geocomposite/ Protective Cover | 18 | 18 |

1. Polyethylene; GM: geomembrane; SS: single-sided; DS: double-sided; NW GT: non-woven geotextile.
2. Interface friction angle for each interface considered is based on 2005 GRI Report #30, "Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces" by G. R. Koerner and D. Narejo (2005).
3. Textured HDPE liner will be used on all sideslopes as well as 5 feet from the toe of the slope.

- The compacted clay liner interface with the HDPE liner was assumed to be in a saturated condition for conservativeness, since the cell excavation extends below the seasonal high groundwater table (see Attachment 10 – Soil and Liner Quality Control Plan for more information).

- According to Federal guidance on the application of Subtitle D regulations, an acceptable factor of safety for long-term global static slope stability analyses is 1.5. For the temporary short-term slope stability condition such as the interim waste slope, a factor of safety of 1.3 is considered acceptable. An acceptable factor of safety for a static veneer stability analysis is 1.5 for the final cover system and 1.3 for the liner system (i.e., interim conditions).

- The ground water table was assumed 1 foot below lowest subgrade elevations for these stability analyses. It is assumed that either the ground water controls will be installed at the time of construction or that sufficient ballast will be in place prior to hydrostatic uplift on the liner in accordance with Attachment 10.

## 4.4 RESULTS OF ANALYSES – EXCAVATION, INTERIM, AND FINAL CONDITIONS

The results of the global static slope stability analyses for the various scenarios considered are presented in Tables 5-4-4 to 5-4-6. The locations of the critical failure surfaces for each cross-section are presented in Appendix 5A, in which detailed computer graphical printouts and output files for each model run are presented.

The calculated FS for excavation stability analysis and interim conditions are greater than the minimum acceptable value of 1.3.

The calculated FS for the global static slope stability analysis (final conditions) are greater than the minimum acceptable value of 1.5. The most critical section of all those considered, Section CC′ yielded a FS of 1.64 under block-type failure mode, with the failure surface located within the bottom liner system.

Interface friction angles used in the block-type failure mode are considered typical and conservative for the existing interfaces. Should there be a different interface present due to selection of materials not considered before, the global slope stability analyses should be reevaluated during construction in order to validate the requirements of the FS values.

Under circular failure surface mode (final conditions), the calculated factors of safety are greater than 2.5 with a failure surface located within the waste mass. From the results of the analysis, it is anticipated that the block-type failure mode is more critical than the circular failure mode.

The results of the stability analyses indicate that the proposed excavation, interim waste fill slopes and the final waste fill slopes are stable under the conditions analyzed.

**Table 5-4-4. Stability Analyses Results – Excavation Stability**

| Cross Section | Output File Name | Slope Stability Analysis | Calculated Factor of Safety | Target Factor of Safety |
|---|---|---|---|---|
| AA′ | Waco XS A - Undrained | Circular | 3.94 | 1.30 |

**Table 5-4-5. Stability Analyses Results – Interim Conditions**

| Cross Section | Output File Name | Slope Stability Analysis | Calculated Factor of Safety | Target Factor of Safety |
|---|---|---|---|---|
| BB′ | Waco XS B - Circular | Circular | 2.11 | 1.30 |
| BB′ | Waco XS B - Block | Block | 1.40 | 1.30 |

As described previously in this section, site lithology has been divided into upper "weathered" and lower "unweathered" horizons based on field observations. For foundation settlement calculations, unweathered soil layer is assumed to be incompressible and weathered soil layer remaining following cell excavation is considered the compressible layer. As shown on the landfill cross-sections, the subgrade is very close to the top of the unweathered soil layer. The thickness of remaining weathered soil layer varies from zero to 14 feet within the West Disposal Area and East Disposal Area cell floors. To be conservative, this remaining weathered foundation soil layer is assumed to be normally consolidated. Due to very low thickness of the compressible soil layer, secondary compression is assumed to be negligible.

Potential heave (rebound) due to excavation of overburden above the excavation base grades was built into the foundation settlement spreadsheet when calculating the initial overburden stress of the soil layers.

Settlement of the foundation soils was calculated using the EXCEL spreadsheets as presented in Appendix 5C. Material property assumptions are also summarized in these spreadsheets. Unit weight of MSW is assumed to be 60 pcf for settlement calculations. Compression index (Cc) was estimated with empirical relationships using average moisture contents and liquid limits of the foundation soils, which are summarized in Table 5-2-8.

Two cross sections (Section 1 and 2) were analyzed for the proposed East Disposal Area and West Disposal Area, respectively. Both of these cross sections were located along the leachate corridor of the cells, which has the flattest slope on the cell floor (i.e., 1%). Leachate corridors with thicker underlying compressible foundation soils (i.e., weathered zone) were selected for settlement analyses. The locations of the cross sections on the excavation and final cover grading plans are presented in Figures 1 to 4 of Appendix 5C. The geometries of the cross sections are presented in Figures 5 and 6 of Appendix 5C.

The minimum calculated post-settlement leachate corridor slope is 0.9%, as compared to the original pre-settlement slope of 1%. Therefore, positive drainage of leachate towards the leachate collection sumps will be maintained. Maximum calculated tensile strain in the liner system is less than 0.1%, which is less than the allowable tensile strain for typical liner system geosynthetic components and compacted clay liners. As shown in Appendix 5C, the liner system will be relaxing (i.e., no tension) and therefore not impacted by settlement.

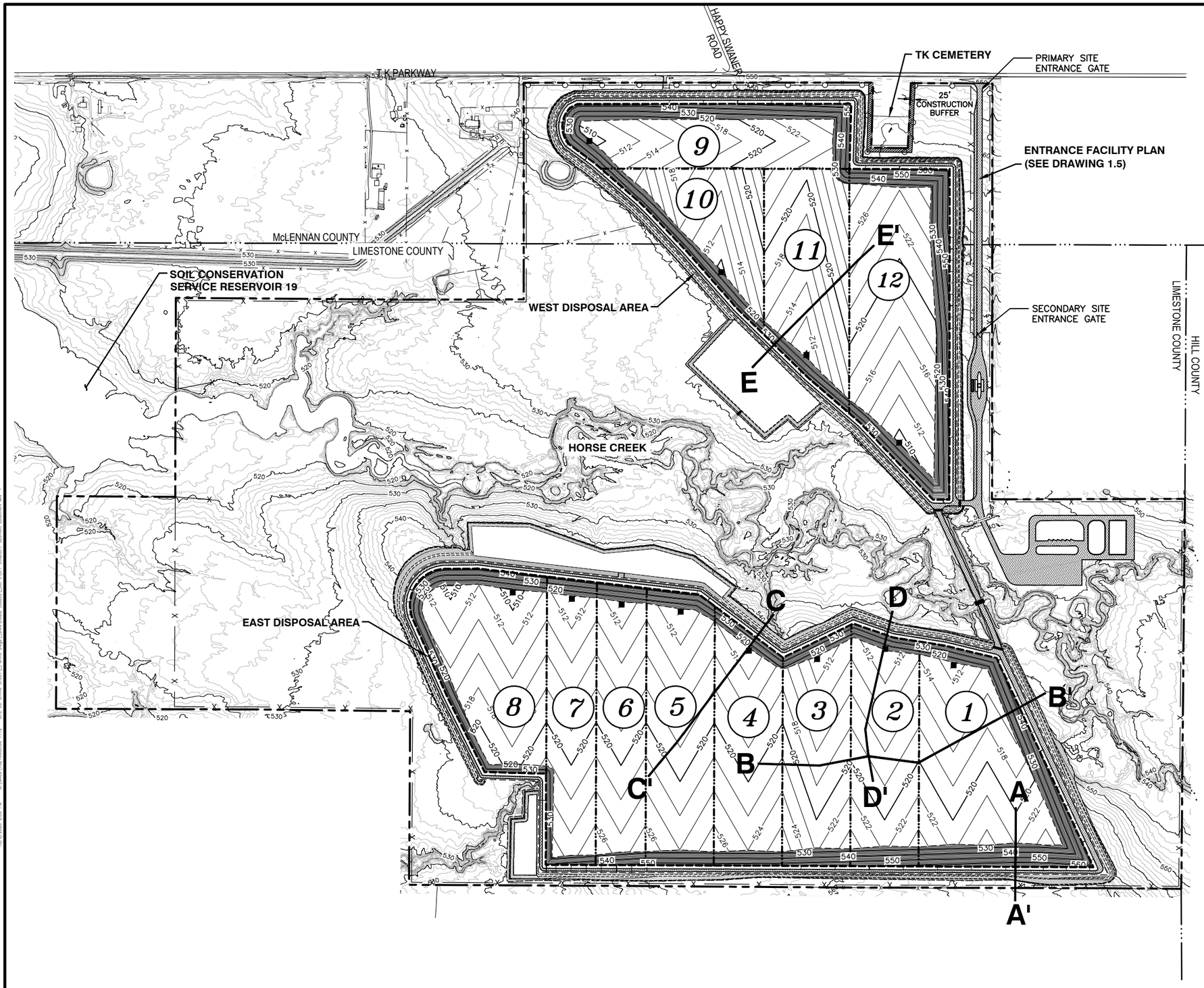
It is therefore concluded that foundation settlement and associated strain will not adversely affect the performance of the bottom liner system.

## 5.3 FINAL COVER SETTLEMENT

Settlement of the final cover system due to consolidation of MSW is evaluated in this section. The final cover system settles due to primary consolidation of MSW with the construction of the final cover system (i.e., increase in vertical stress), and secondary compression due to waste

## DRAWINGS

- Drawing 5.1 Stability Sections Location Map 1
- Drawing 5.2 Stability Sections Location Map 2
- Drawing 5.3 East Disposal Area Stability Cross Section A-AA'
- Drawing 5.4 East Disposal Area Stability Cross Section B-BB'
- Drawing 5.5 East Disposal Area Stability Cross Section C-CC'
- Drawing 5.6 East Disposal Area Stability Cross Section D-DD'
- Drawing 5.7 West Disposal Area Stability Cross Section E-EE'




0 300 600
SCALE IN FEET

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- SECTOR BOUNDARY
- COUNTY LINE
- 560 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- X PROPOSED/EXISTING PERIMETER FENCE (CHAIN LINK OR BARBED WIRE)
- PROPOSED 8' PRIVACY FENCE
- ACCESS ROAD
- 510 EXCAVATION GRADE TOPOGRAPHIC CONTOURS (SEE NOTE 2)
- X SECTOR DESIGNATION
- B - B' STABILITY-SECTION LOCATIONS

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.
2. ELEVATIONS SHOWN ON THIS DRAWING WITHIN WASTE LIMITS ARE EXCAVATION GRADES (BOTTOM OF LINER) ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).

STATE OF TEXAS
HARTUAN JAMES LAW
135755
LICENSED
PROFESSIONAL ENGINEER

10/06/2020

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISION INCLUDES: LIMITS OF WASTE. | HJL |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: STABILITY SECTIONS LOCATION MAP 1

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES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PROJ. NO. 16216088.00 | DSN. BY: BG/RRK | DWN. BY: NR | CHK. BY: BJD | Q/A RVW BY: RRK | APP. BY: RRK

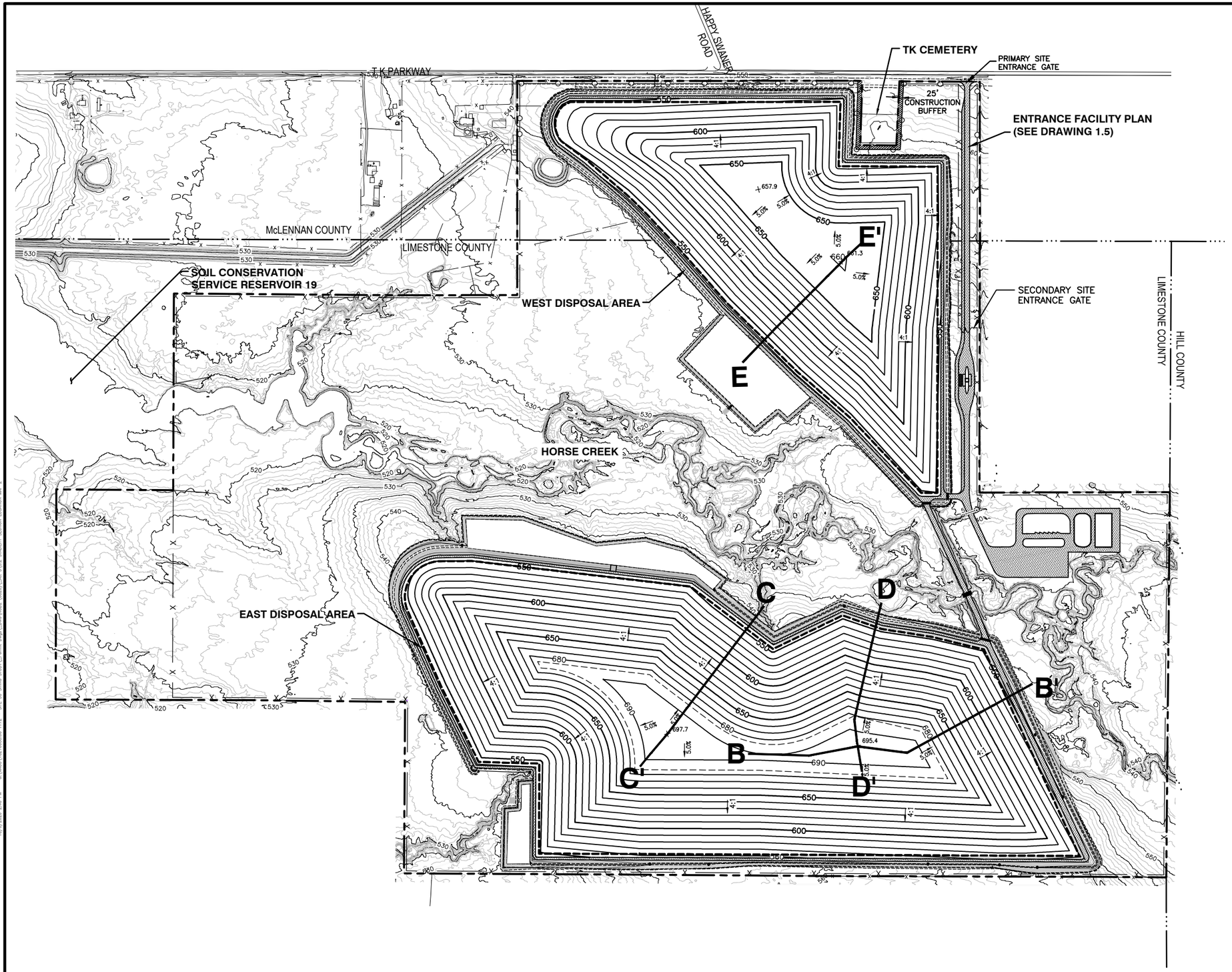
CADD FILE: 5.1 STABILITY SECTION LOCATION MAP

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. 5.1

FOR PERMITTING PURPOSES ONLY

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SCALE IN FEET

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- COUNTY LINE
- 560 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- 650 FINAL COVER TOPOGRAPHIC CONTOURS (SEE NOTE 2)
- X PROPOSED/EXISTING PERIMETER FENCE (CHAIN LINK OR BARBED WIRE)
- PROPOSED 8' PRIVACY FENCE
- ACCESS ROAD
- **B - B'** STABILITY-SECTION LOCATIONS

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.
2. ELEVATIONS SHOWN ON THIS DRAWING WITHIN WASTE LIMITS ARE TOP OF FINAL COVER ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).

STATE OF TEXAS
HARTUAN JAMES LAW
135755
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PROFESSIONAL ENGINEER

10/06/2020

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| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISION INCLUDES: LIMITS OF WASTE. | HJL |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: STABILITY SECTIONS LOCATION MAP 2

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES


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PROJ. NO. 16216088.00 | DSN. BY: BG/RRK | DWN. BY: NR | CHK. BY: BJD | Q/A RVW BY: RRK | APP. BY: RRK

CADD FILE: 5.2 STABILITY SECTION LOCATION MAP 2

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. 5.2

# APPENDIX 5C

# SETTLEMENT ANALYSES

- **Liner System Settlement Analysis**
- **Final Cover Settlement Analysis**

**SCS Engineers**
**TBPE Reg. # F-3407**

**Inclusive of Pages 5-C-1 to 5-C-13(7)**

# LINER SYSTEM

# SETTLEMENT ANALYSIS

# HAND CALCULATION ON PRIMARY SETTLEMENT

Date: April 22, 2019
Project: City of Waco Landfill, McLennan and Limestone Counties, TX
Project No.: 16216088.00

**Spreadsheet to calculate the amount of foundation soils consolidation/settlement**
**East Disposal Area - Cross Section 1**

Hand calcs to check Primary Settlement at Point A5 and strain on Liner between Points A4 and A5

Equation: $S = C_c * [H/(1+e_o)] * \log(P/P_o)$, where Primary Settlement

S = total settlement due to consolidation; feet
$C_c$ = Average compression index; (Cc = w /100), or $C_c$ = 0.007(LL-7), or use previous reported value)
w = Moisture Content; %
H = thickness of the foundation soil layer; feet
$e_o$ = average initial void ratio of the foundation soil layer before surcharge ($e_o$ = (w x S.G.) / 100, or use previous reported value)
P = total pressure acting on mid-height of the foundation soil layer, ($P = P_o + s$);psf.
s = surcharge ($s = (H_s \times g_{MSW}) + (F \times g_{Fill}) - (C \times g_{Foundation\ Soil})$)
$H_s$ = Height of Waste in feet
$P_o$ = present effective overburden pressure at mid-height of the foundation soil layer; psf ($P_o = (H_o \times g_{Foundation\ Soil}) / 2$)

ASSUMPTIONS:

| | |
|---|---|
| 1. Average unit wt. of liner/fnl cvr, $g_{Fill}$ (pcf): | 120 |
| 2. Average unit wt. of MSW, $g_{MSW}$ (pcf): | 60 |
| 3. Unit weight of foundation soil, $g_{Foundation\ Soil}$ (pcf): | 125 |
| 4. Moisture Content (WDA average) (%): | 18 |
| 5. Liquid Limit (WDA average): | 63 |
| 6. $C_c$ (using (Cc = w / 100)): | 0.180 |
| 7. $C_c$ (using (Cc = 0.007(LL-7)): | 0.392 |
| 8. Specific Gravity, S.G. (assumed for clays) | 2.7 |
| 10. Thickness of Final Cover System (ft) | 3.5 |

Ave = 0.286

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location of Consideration Point | EG el. | GWT El. | Top of Bedrock El. | Subgrade El. | Top of Protective Soil Layer | Top of Final Cover | Thickness of Found. Soil to Bedrock H | Existing Ground to Bedrock $H_o$ | Fill F | Cut C | Height of Waste $H_s$ | Natural Moisture Content w | Specific Gravity S.G. | $C_c$ (average) | Surcharge ($\Delta P$) s | $e_o$ | $P'_o$ | $P'$ ($P'_o + \Delta P$) | Settlement S |
| | feet | feet | feet | feet | feet | feet | feet | feet | feet | feet | feet | % | | - | psf | - | psf | psf | feet |
| SECTION 1 | | | | | | | | | | | | | | | | | | | |
| $A_1$ (x=2.7) | 542.5 | 513.7 | 517.0 | 542.5 | 546.5 | 549.9 | 25.5 | 25.5 | 0.0 | 0.0 | 0.0 | 18 | 2.7 | 0.286 | 900 | 0.513 | 1,594 | 2,494 | 0.94 |
| $A_2$ (x=105.45) [1] | 545.9 | 513.7 | 517.0 | 509.8 | 513.8 | 575.0 | 0.0 | 28.9 | 0.0 | 36.0 | 57.6 | 18 | 2.7 | 0.286 | N/A | 0.486 | N/A | N/A | 0.00 |
| $A_3$ (x=300) [1] | 560.0 | 515.2 | 512.0 | 511.8 | 515.8 | 623.0 | 0.0 | 48.0 | 0.0 | 48.2 | 103.7 | 18 | 2.7 | 0.286 | N/A | 0.486 | N/A | N/A | 0.00 |
| $A_4$ (x=560.95) | 561.3 | 517.1 | 509.0 | 514.4 | 518.4 | 687.0 | 5.4 | 52.3 | 0.0 | 46.9 | 165.1 | 18 | 2.7 | 0.286 | 5108 | 0.486 | 5,867 | 10,975 | 0.28 |
| $A_5$ (x=740.1) | 562.2 | 518.4 | 511.0 | 516.2 | 520.2 | 695.8 | 5.2 | 51.2 | 0.0 | 46.0 | 172.1 | 18 | 2.7 | 0.286 | 5611 | 0.486 | 5,777 | 11,387 | 0.29 |
| $A_6$ (x=915.6) | 563.1 | 519.7 | 513.0 | 517.9 | 521.9 | 687.0 | 4.9 | 50.1 | 0.0 | 45.1 | 161.6 | 18 | 2.7 | 0.286 | 5063 | 0.486 | 5,685 | 10,748 | 0.26 |
| $A_7$ (x=1252.5) | 562.0 | 522.2 | 517.0 | 521.3 | 525.3 | 602.8 | 4.3 | 45.0 | 0.0 | 40.6 | 74.0 | 18 | 2.7 | 0.286 | 312 | 0.513 | 5,162 | 5,474 | 0.02 |
| $A_8$ (x=1378) | 561.8 | 523.1 | 517.0 | 563.2 | 567.2 | 571.4 | 46.2 | 45.0 | 1.3 | -1.4 | 0.7 | 18 | 2.7 | 0.286 | 1272 | 0.513 | 2,731 | 4,003 | 1.45 |
| | | | | | | | | | | | | | | | | | Max. Settlement (Cell Floor) | | 0.29 |
| | | | | | | | | | | | | | | | | | Max. Settlement (Side Slope) | | 1.45 |

[1] Thickness of foundation soil remaining following excavation is zero. Therefore, settlement = 0 ft.

hand calcs to check this settlement. Checked ✓

| Analysis Location | Point $A_1$ | Point $A_2$ | Point $A_3$ | Point $A_4$ | Point $A_5$ | Point $A_6$ | Point $A_7$ | Point $A_8$ | |
|---|---|---|---|---|---|---|---|---|---|
| x-Coordinate | 2.7 | 104.4 | 300.0 | 561.0 | 740.1 | 915.6 | 1252.5 | 1378.0 | 1 |
| Pre-settlement Top of Subgrade, ft | 542.5 | 509.8 | 511.8 | 514.4 | 516.2 | 517.9 | 521.3 | 563.2 | 2 |
| Total Settlement, ft | 0.94 | 0.00 | 0.00 | 0.28 | 0.29 | 0.26 | 0.02 | 1.45 | |
| Post-settlement Top of Subgrade, ft | 541.56 | 509.8 | 511.8 | 514.1 | 515.9 | 517.7 | 521.3 | 561.7 | 3 |

| Analysis Location | Point $A_1$ to Point $A_1$ | Point $A_2$ to Point $A_3$ | Point $A_3$ to Point $A_4$ | Point $A_4$ to Point $A_5$ | Point $A_5$ to Point $A_6$ | Point $A_6$ to Point $A_7$ | Point $A_7$ to Point $A_8$ | |
|---|---|---|---|---|---|---|---|---|
| Presettlement Corridor Slope, % | 32.11 | -1.00 | -1.00 | -1.00 | -1.00 | -1.00 | -33.38 | 4 |
| Postsettlement Corridor Slope, % | 31.19 | -1.00 | -0.89 | -0.99 | -1.02 | -1.07 | -32.24 | 5 |
| Initial Length, ft | 106.82 | 195.61 | 260.96 | 179.16 | 175.51 | 336.92 | 132.31 | 6 |
| Final Length, ft | 106.53 | 195.61 | 260.96 | 179.16 | 175.51 | 336.92 | 131.86 | 7 |
| Strain, % (- values=no tension) | -0.265% | 0.000% | -0.001% | 0.000% | 0.000% | 0.001% | -0.337% | 8 |

Strain Calcs. checked ✓

(A) (B)

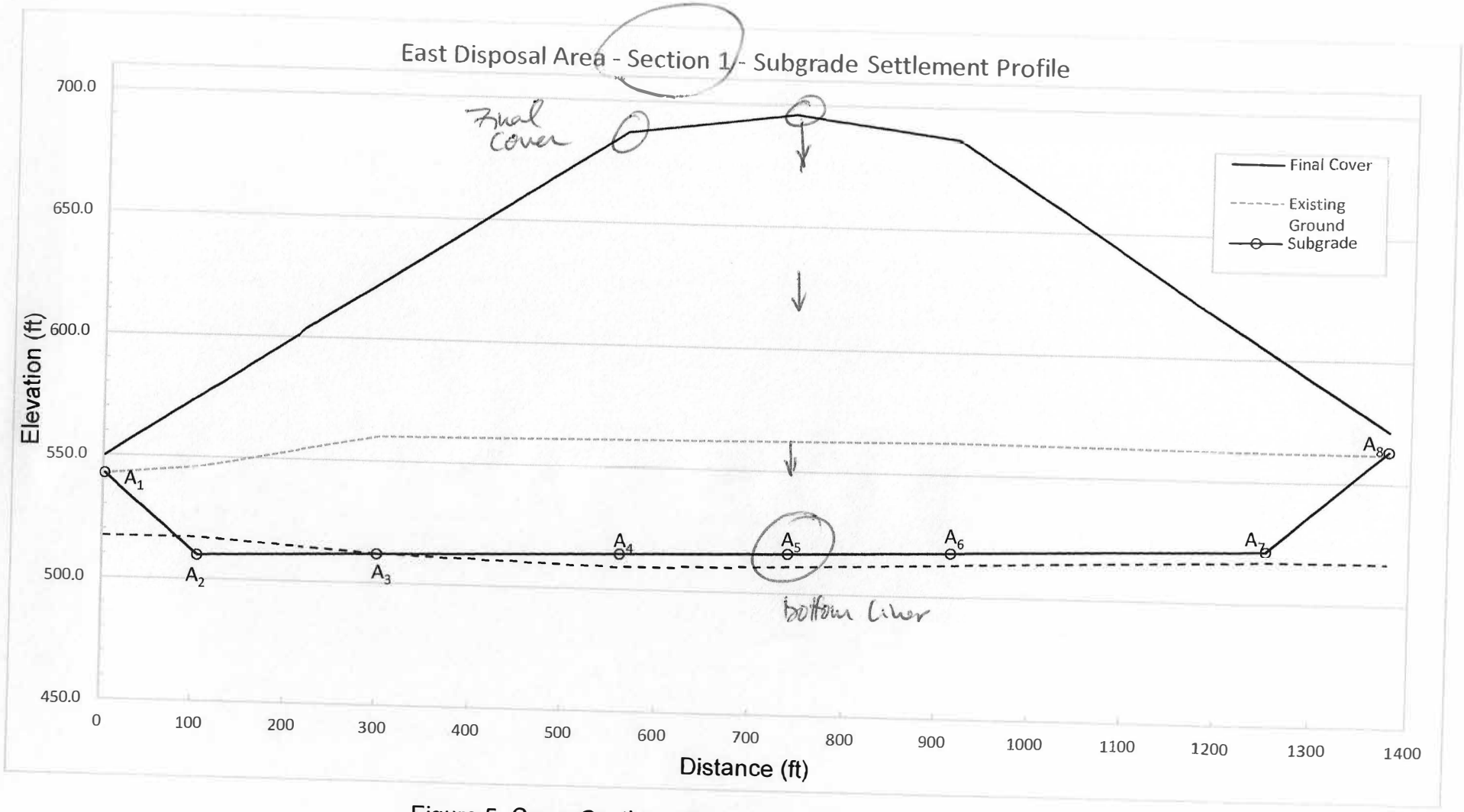


Figure 5. Cross Section 1 Geometry – East Disposal Area

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For column # ref, see attached spreadsheets

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CALCULATED BY ITL DATE 9/30/2020
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SCALE

Settlement - Sample Calculations of one Settlement Point, A5, Section 1, EDA

Page 5-C-3, April 2020

Settlement Point A5 (Primary settlement)

Total of Protective Soil Layer: Col.(6)
= Subgrade Elevation + 4 feet (soil liner + cover soil)
= col(5) + 4
= 516.2' + 4' = 520.2'

Thickness of Foundation Soil to Bedrock: col.(8)
H = subgrade elev. - top of bedrock elev.
= Col.(5) - Col.(4)
= 516.2' - 511.0' = 5.2'

Existing Ground to Bedrock: Col.(9)
Ho = EG - Top of Bedrock
= Col.(2) - Col.(4)
= 562.2' - 511.0'
= 51.2'

Fill: Col.(10)
F = thickness of foundation soil to Bedrock - Existing ground to Bedrock
= Col.(8) - Col.(9)
= 5.2' - 51.2' < 0 ; If < 0, then Fill = 0
= 0'

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Cut : col (11)

C = EG - Subgrade
= col (2) - col (5)
= 562.2' - 516.2' = 46'

Height of Waste : col (12)

$H_s$ = Top of Final Cover - Top of Protective Soil Layer
- Thickness of Final cover
= col (7) - col (6) - Assumption (10)
= 695.8' - 520.2' - 3.5'
= 172.1'

Natural Moisture Content : col (13)
w = ~~Assumption~~ (4) = 18 %

Specific Gravity S.G. : col (14)
S.G. = Assumption (8) = 2.7

Cc : col (15)
= Average between Assumptions (6) & (7)
= (0.150 + 0.392) / 2
= 0.286

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Surcharge : Col. (10)

$\Delta P$ or $S$ = Height of waste $\times \gamma_{waste}$
+
Fill $\times \gamma_{Fill\,(soil)}$
−
Cut $\times \gamma_{cut\,(soil)}$
+
(Soil liner + Protective soil Layer) $\times \gamma_{soil}$
+
Final Cover $\times \gamma_{soil}$
+
Water Column $\times \gamma_w (= 62.4\ pcf)$

= Col (12) × Assumption (2) +
Col (10) × Assumption (1) +
Col (11) × Assumption (3) +
[Col (6) − Col (5)] × Assumption (1) +
Assumption (10) × Assumption (1) +
[Col. (3) − Col. (5)] × 62.4

= (172.1)' × 60 pcf + (0.0) × 120 pcf −
46' × 125 pcf + (520.2' − 516.2') × 120 pcf
+ 3.5' × 120 pcf + (518.4' − 516.2') × 62.4 pcf

= 5,613 psf

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$e_o$, Initial Void Ratio : col (17)
= natural moisture content × S.G / 100
= col. (13) × col. (14) / 100
= 18 × 2.7 / 100 = 0.486

$P_o$, Present overburden Pressure at mid-point of Foundation Layer
: col (18)

= (Existing Ground to Bedrock − thickness of Foundation soil to bedrock/2) *
γ Foundation soil
− (Groundwater table Elev −
(top of Bedrock Elev + (thickness of Foundation soil to bedrock)/2)) *
62.4 pcf

= (col. (9) − col. (8)/2) * Assumption (3) −
(col. (3) − (col. (4) + col. (8)/2)) * ~~Assumption~~ 62.4 pcf

= (5112' + 512'/2) × 125 pcf −
(5118.4' − (5111' + 512'/2)) * 62.4 pcf

= 5,776 psf

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$P_o$, Total pressure acting at mid-point of foundation soil : col. (19)

$= P_o + s$

$=$ col. (18) + Col. (16)

$= 5,776 + 5,613 = 11,389$ psf

Settlement of Point A5 : col. (20)

$$S_{A5} = C_c \frac{H}{1+e_o} \left( \log \frac{P}{P_o} \right)$$

$$= \text{col. (15)} * \frac{\text{col. (8)}}{1 + \text{col. (17)}} \left( \log \frac{\text{col. (19)}}{\text{col. (18)}} \right)$$

$$= (0.286) \frac{5.2}{1+0.486} \log \frac{11,389}{5776}$$

$= 0.29'$ (checked) ✓
col. (20)

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Section 1 in EDA - Strain calcs of geomembrane due to settlement

Page 5-C-3, April 2020, bottom table.

Cell (B)(4): Pre settlement slope between $A_4$ + $A_5$, $S_0$

$$S_0 = \frac{Y_1 - Y_0}{X_1 - X_0} \times 100\%$$

$$= \frac{\text{col. (A)(2)} - \text{(B)(2)}}{\text{col. (B)(1)} - \text{(A)(1)}} \times 100\%$$

$$= \frac{514.4' - 516.2}{740.1 - 561.0} \times 100\%$$

$$= \frac{-1.8'}{179.1} \times 100 = -1.00\%$$

(-1.00% in cell (B)(4) checked ✓)

Cell (B)(5): Post Settlement slope between $A_4$ + $A_5$, $S_1$

$$S_1 = \frac{Y_1 - Y_0}{X_1 - X_0} \times 100\%$$

$$= \frac{\text{col. (A)(3)} - \text{(B)(3)}}{\text{col. (B)(1)} - \text{(A)(1)}} \times 100\%$$

$$= \frac{514.1 - 515.9}{740.1 - 561.0} \times 100\%$$

$$= \frac{-1.8}{179.1} \times 100 = -1.00\%$$

(-0.99% in cell (B)(5) checked ✓ Round up diff.)

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cell (B)(6) Initial Length between A4 + A5, $L_0$

$$L_0 = \sqrt{\left[(X_1 - X_0)^2_{\text{Pre-settlement}} + (Y_1 - Y_0)^2_{\text{Pre-settlement}}\right]}$$

$$= \sqrt{\left[\left(\text{col}(B)(1) - (A)(1)\right)^2 + \left(\text{col}(B)(2) - (A)(2)\right)^2\right]}$$

$$= \sqrt{(740.1 - 561)^2 + (516.2 - 514.4)^2}$$

$$= \sqrt{(179.1^2 + 1.8^2)} = 179.1'$$ (179.16' in cell (B)(6) checked ✓ Roundup diff.)

cell (B)(7) Final Length between A4 + A5, $L_1$

$$L_1 = \sqrt{\left[(X_1 - X_0)^2_{\text{Post-settlement}} + (Y_1 - Y_0)^2_{\text{post settlement}}\right]}$$

$$= \sqrt{\left[\left(\text{col}(B)(1) - (A)(1)\right)^2 + \left(\text{col}(B)(3) - (A)(3)\right)^2\right]}$$

$$= \sqrt{[740.1 - 561]^2 + (515.9 - 514.1)^2}$$

$$= \sqrt{(179.1)^2 + (1.8)^2} = 179.1'$$ (179.16' in cell (B)(7) checked ✓ Roundup diff.)

$\Rightarrow L_0 = L_1 \Rightarrow$ No change in length.

cell (B)(8): Strain in % between A4 + A5

$$\text{Strain} = \frac{L_1 - L_0}{L_0} \times 100\%$$

$$= \frac{179.1 - 179.1}{179.1} = 0\%$$ (No strain on liner)

checked in cell (B)(8) OK

# FINAL COVER SYSTEM

# SETTLEMENT ANALYSIS

# HAND CALCULATION ON PRIMARY AND SECONDARY SETTLEMENT

Date: April 22, 2019
Project: City of Waco Landfill, McLennan and Limestone Counties, TX
Project No.: 16216088.00

**Spreadsheet to calculate the amount of municipal solid waste consolidation/settlement.**

$$S = \underbrace{C_{c\varepsilon} H \log\left(\frac{P}{P_0}\right)_1}_{\text{Primary Consolidation}} + \underbrace{C_\alpha H \log\left(\frac{t_2}{t_1}\right)_2}_{\text{Secondary Compression}}$$

where:

S = total settlement;
$C_{c\varepsilon}$ = modified compression index;
H = initial thickness of compressible layer;
$P_0$ = initial effective overburden stress;
P = final effective overburden pressure. ($P = P_0 + \Delta P$),
$\Delta P$ = final cover thickness x unit weight of final cover soils
$C_\alpha$ = secondary compression index;
$t_1$ = time when secondary compression is assumed to begin (assumed to be 1 year)
$t_2$ = time for when secondary settlements are calculated for (assumed to be 30 years)

$$\varepsilon = \frac{L_0 - L_f}{L_0} \times 100\ (percent)$$

where:

$\varepsilon$ = strain in the final cover system (+ indicated compression, - indicated tension);
$L_f$ = final length between calculation points based on post-settlement elevations; and
$L_i$ = initial length between calculation points based on pre-settlement elevations.

ASSUMPTIONS:

| | |
|---|---|
| 1. Average unit wt. of liner/fnl cvr, $\gamma_{FB}$ (pcf): | 120 |
| 2. Average unit wt. of MSW, $\gamma_{MSW}$ (pcf): | 60 |
| 3. Thickness of Final Cover System (ft): | 3.5 |
| 4. Surcharge ($\Delta P$) ($\gamma_{FB}$ x $Thickness_{Final\ Cvr}$) (psf): | 420 |
| 5. $t_1$ (years): | 1 |
| 6. $t_2$ (years): | 30 |
| 7. $C_{c\varepsilon}$: | 0.205 |
| 8. $C_\alpha$: | 0.050 |

120 x 3.5 = 420

Hand calcs to check Primary and secondary settlement/ consolidation at Point A5 and Strain of Final Cover Liner between Points A4 and A5

| Location of Consideration Point | Top of Final Cover | Top of Waste | Top of Protective Soil Layer | Thickness of Waste |
|---|---|---|---|---|
| | feet | feet | feet | feet |
| SECTION 1 | | | | |
| $A_1$ (x= 162.9) | 542.7 | 539.2 | 538.3 | 0.9 |
| $A_2$ (x= 211.4) | 554.8 | 551.3 | 522.2 | 29.1 |
| $A_3$ (x=741.0) | 687.0 | 683.5 | 521.1 | 162.4 |
| $A_4$ (x= 1643.9) | 697.6 | 694.1 | 522.2 | 171.9 |
| $A_5$ (x= 2285.0) | 689.9 | 686.4 | 526.4 | 160.0 |
| $A_6$ (x= 2795.8) | 695.3 | 691.8 | 521.9 | 169.9 |
| $A_7$ (x= 3089.9) | 694.0 | 690.5 | 524.0 | 166.5 |
| $A_8$ (x= 3230.0) | 687.0 | 683.5 | 521.4 | 162.1 |
| $A_9$ (x=3674.3) | 575.7 | 572.2 | 519.4 | 52.8 |
| $A_{10}$ (x=3764.8) | 553.0 | 549.5 | 549.0 | 0.5 |

Settlement of MSW Layer 1

1 2 3 4 5 6 7 8 9 10 11 12

| Location of Consideration Point | Top of Final Cover | Top of Waste | Waste El. at Midpoint | Thickness of Waste Layer | $C_{c\varepsilon}$ | Surcharge ($\Delta P$) | P'o | P' (P'o + $\Delta P$) | Primary Settlement | Cα | Secondary Settlement | Total Settlement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | feet | feet | feet | feet | - | psf | psf | psf | ft | | ft | ft |
| SECTION 1 | | | | | | | | | | | | |
| $A_1$ (x= 162.9) | 542.7 | 539.2 | 539.1 | 0.2 | 0.205 | 420.0 | 4.5 | 424.5 | 0.06 | 0.050 | 0.01 | 0.07 |
| $A_2$ (x= 211.4) | 554.8 | 551.3 | 548.9 | 4.8 | 0.205 | 420.0 | 145.5 | 565.5 | 0.59 | 0.050 | 0.36 | 0.94 |
| $A_3$ (x= 741.0) | 687.0 | 683.5 | 670.0 | 27.1 | 0.205 | 420.0 | 812.0 | 1232.0 | 1.00 | 0.050 | 2.00 | 3.00 |
| $A_4$ (x= 1643.9) | 697.6 | 694.1 | 679.8 | 28.7 | 0.205 | 420.0 | 859.5 | 1279.5 | 1.01 | 0.050 | 2.12 | 3.13 |
| $A_5$ (x= 2285.0) | 689.9 | 686.4 | 673.1 | 26.7 | 0.205 | 420.0 | 800.0 | 1220.0 | 1.00 | 0.050 | 1.97 | 2.97 |
| $A_6$ (x= 2795.8) | 695.3 | 691.8 | 677.6 | 28.3 | 0.205 | 420.0 | 849.5 | 1269.5 | 1.01 | 0.050 | 2.09 | 3.10 |
| $A_7$ (x= 3089.9) | 694.0 | 690.5 | 676.6 | 27.8 | 0.205 | 420.0 | 832.5 | 1252.5 | 1.01 | 0.050 | 2.05 | 3.06 |
| $A_8$ (x= 3230.0) | 687.0 | 683.5 | 670.0 | 27.0 | 0.205 | 420.0 | 810.5 | 1230.5 | 1.00 | 0.050 | 2.00 | 3.00 |
| $A_9$ (x=3674.3) | 575.7 | 572.2 | 567.8 | 8.8 | 0.205 | 420.0 | 264.0 | 684.0 | 0.75 | 0.050 | 0.65 | 1.40 |
| $A_{10}$ (x=3764.8) | 553.0 | 549.5 | 549.5 | 0.1 | 0.205 | 420.0 | 2.5 | 422.5 | 0.04 | 0.050 | 0.01 | 0.04 |

$A_5$ ---->

check this - calcs by hand. (See attached)

Settlement of MSW Layer 2

| Location of Consideration Point | Top of Final Cover | Top of Waste | Waste El. at Midpoint | Thickness of Waste Layer | $C_{c\varepsilon}$ | Surcharge ($\Delta P$) | P'o | P' (P'o + $\Delta P$) | Primary Settlement | Cα | Secondary Settlement | Total Settlement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | feet | feet | feet | feet | - | psf | psf | psf | ft | | ft | ft |
| SECTION 1 | | | | | | | | | | | | |
| $A_1$ (x= 162.9) | 542.7 | 539.2 | 539.0 | 0.2 | 0.205 | 420.0 | 13.5 | 433.5 | 0.05 | 0.050 | 0.01 | 0.06 |
| $A_2$ (x= 211.4) | 554.8 | 551.3 | 544.0 | 4.8 | 0.205 | 420.0 | 436.5 | 856.5 | 0.29 | 0.050 | 0.36 | 0.65 |
| $A_3$ (x= 741.0) | 687.0 | 683.5 | 642.9 | 27.1 | 0.205 | 420.0 | 2436.0 | 2856.0 | 0.38 | 0.050 | 2.00 | 2.38 |
| $A_4$ (x= 1643.9) | 697.6 | 694.1 | 651.1 | 28.7 | 0.205 | 420.0 | 2578.5 | 2998.5 | 0.38 | 0.050 | 2.12 | 2.50 |
| $A_5$ (x= 2285.0) | 689.9 | 686.4 | 646.4 | 26.7 | 0.205 | 420.0 | 2400.0 | 2820.0 | 0.38 | 0.050 | 1.97 | 2.35 |
| $A_6$ (x= 2795.8) | 695.3 | 691.8 | 649.3 | 28.3 | 0.205 | 420.0 | 2548.5 | 2968.5 | 0.38 | 0.050 | 2.09 | 2.48 |
| $A_7$ (x= 3089.9) | 694.0 | 690.5 | 648.9 | 27.8 | 0.205 | 420.0 | 2497.5 | 2917.5 | 0.38 | 0.050 | 2.05 | 2.43 |
| $A_8$ (x= 3230.0) | 687.0 | 683.5 | 643.0 | 27.0 | 0.205 | 420.0 | 2431.5 | 2851.5 | 0.38 | 0.050 | 2.00 | 2.38 |
| $A_9$ (x=3674.3) | 575.7 | 572.2 | 559.0 | 8.8 | 0.205 | 420.0 | 792.0 | 1212.0 | 0.33 | 0.050 | 0.65 | 0.98 |
| $A_{10}$ (x=3764.8) | 553.0 | 549.5 | 549.4 | 0.1 | 0.205 | 420.0 | 7.5 | 427.5 | 0.03 | 0.050 | 0.01 | 0.04 |

Settlement at A5 Layer 1

Settlement of MSW Layer 3

| Location of Consideration Point | Top of Final Cover | Top of Waste | Waste El. at Midpoint | Thickness of Waste Layer | $C_{c\varepsilon}$ | Surcharge ($\Delta P$) | P'o | P' (P'o + $\Delta P$) | Primary Settlement | Cα | Secondary Settlement | Total Settlement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | feet | feet | feet | feet | - | psf | psf | psf | ft | | ft | ft |
| SECTION 1 | | | | | | | | | | | | |
| $A_1$ (x= 162.9) | 542.7 | 539.2 | 538.8 | 0.2 | 0.205 | 420.0 | 22.5 | 442.5 | 0.04 | 0.050 | 0.01 | 0.05 |
| $A_2$ (x= 211.4) | 554.8 | 551.3 | 539.2 | 4.8 | 0.205 | 420.0 | 727.5 | 1147.5 | 0.20 | 0.050 | 0.36 | 0.55 |
| $A_3$ (x= 741.0) | 687.0 | 683.5 | 615.8 | 27.1 | 0.205 | 420.0 | 4060.0 | 4480.0 | 0.24 | 0.050 | 2.00 | 2.24 |
| $A_4$ (x= 1643.9) | 697.6 | 694.1 | 622.5 | 28.7 | 0.205 | 420.0 | 4297.5 | 4717.5 | 0.24 | 0.050 | 2.12 | 2.35 |
| $A_5$ (x= 2285.0) | 689.9 | 686.4 | 619.7 | 26.7 | 0.205 | 420.0 | 4000.0 | 4420.0 | 0.24 | 0.050 | 1.97 | 2.21 |
| $A_6$ (x= 2795.8) | 695.3 | 691.8 | 621.0 | 28.3 | 0.205 | 420.0 | 4247.5 | 4667.5 | 0.24 | 0.050 | 2.09 | 2.33 |
| $A_7$ (x= 3089.9) | 694.0 | 690.5 | 621.1 | 27.8 | 0.205 | 420.0 | 4162.5 | 4582.5 | 0.24 | 0.050 | 2.05 | 2.29 |
| $A_8$ (x= 3230.0) | 687.0 | 683.5 | 616.0 | 27.0 | 0.205 | 420.0 | 4052.5 | 4472.5 | 0.24 | 0.050 | 2.00 | 2.23 |
| $A_9$ (x=3674.3) | 575.7 | 572.2 | 550.2 | 8.8 | 0.205 | 420.0 | 1320.0 | 1740.0 | 0.22 | 0.050 | 0.65 | 0.87 |
| $A_{10}$ (x=3764.8) | 553.0 | 549.5 | 549.3 | 0.1 | 0.205 | 420.0 | 12.5 | 432.5 | 0.03 | 0.050 | 0.01 | 0.03 |

Settlement of MSW Layer 4

| Location of Consideration Point | Top of Final Cover | Top of Waste | Waste El. at Midpoint | Thickness of Waste Layer | $C_{\alpha e}$ | Surcharge ($\Delta P$) | P'o | P' (P'o + $\Delta P$) | Primary Settlement | Cα | Secondary Settlement | Total Settlement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | feet | feet | feet | feet | - | psf | psf | psf | ft | | ft | ft |
| SECTION 1 | | | | | | | | | | | | |
| $A_1$ (x= 162.9) | 542.7 | 539.2 | 538.7 | 0.2 | 0.205 | 420.0 | 31.5 | 451.5 | 0.04 | 0.050 | 0.01 | 0.05 |
| $A_2$ (x= 211.4) | 554.8 | 551.3 | 534.3 | 4.8 | 0.205 | 420.0 | 1018.5 | 1438.5 | 0.15 | 0.050 | 0.36 | 0.51 |
| $A_3$ (x= 741.0) | 687.0 | 683.5 | 588.8 | 27.1 | 0.205 | 420.0 | 5684.0 | 6104.0 | 0.17 | 0.050 | 2.00 | 2.17 |
| $A_4$ (x= 1643.9) | 697.6 | 694.1 | 593.8 | 28.7 | 0.205 | 420.0 | 6016.5 | 6436.5 | 0.17 | 0.050 | 2.12 | 2.29 |
| $A_5$ (x= 2285.0) | 689.9 | 686.4 | 593.1 | 26.7 | 0.205 | 420.0 | 5600.0 | 6020.0 | 0.17 | 0.050 | 1.97 | 2.14 |
| $A_6$ (x= 2795.8) | 695.3 | 691.8 | 592.7 | 28.3 | 0.205 | 420.0 | 5946.5 | 6366.5 | 0.17 | 0.050 | 2.09 | 2.26 |
| $A_7$ (x= 3089.9) | 694.0 | 690.5 | 593.4 | 27.8 | 0.205 | 420.0 | 5827.5 | 6247.5 | 0.17 | 0.050 | 2.05 | 2.22 |
| $A_8$ (x= 3230.0) | 687.0 | 683.5 | 588.9 | 27.0 | 0.205 | 420.0 | 5673.5 | 6093.5 | 0.17 | 0.050 | 2.00 | 2.17 |
| $A_9$ (x=3674.3) | 575.7 | 572.2 | 541.4 | 8.8 | 0.205 | 420.0 | 1848.0 | 2268.0 | 0.16 | 0.050 | 0.65 | 0.81 |
| $A_{10}$ (x=3764.8) | 553.0 | 549.5 | 549.2 | 0.1 | 0.205 | 420.0 | 17.5 | 437.5 | 0.02 | 0.050 | 0.01 | 0.03 |

Settlement of MSW Layer 5

| Location of Consideration Point | Top of Final Cover | Top of Waste | Waste El. at Midpoint | Thickness of Waste Layer | $C_{\alpha e}$ | Surcharge ($\Delta P$) | P'o | P' (P'o + $\Delta P$) | Primary Settlement | Cα | Secondary Settlement | Total Settlement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | feet | feet | feet | feet | - | psf | psf | psf | ft | | ft | ft |
| SECTION 1 | | | | | | | | | | | | |
| $A_1$ (x= 162.9) | 542.7 | 539.2 | 538.5 | 0.2 | 0.205 | 420.0 | 40.5 | 460.5 | 0.03 | 0.050 | 0.01 | 0.04 |
| $A_2$ (x= 211.4) | 554.8 | 551.3 | 529.5 | 4.8 | 0.205 | 420.0 | 1309.5 | 1729.5 | 0.12 | 0.050 | 0.36 | 0.48 |
| $A_3$ (x= 741.0) | 687.0 | 683.5 | 561.7 | 27.1 | 0.205 | 420.0 | 7308.0 | 7728.0 | 0.13 | 0.050 | 2.00 | 2.13 |
| $A_4$ (x= 1643.9) | 697.6 | 694.1 | 565.2 | 28.7 | 0.205 | 420.0 | 7735.5 | 8155.5 | 0.13 | 0.050 | 2.12 | 2.25 |
| $A_5$ (x= 2285.0) | 689.9 | 686.4 | 566.4 | 26.7 | 0.205 | 420.0 | 7200.0 | 7620.0 | 0.13 | 0.050 | 1.97 | 2.10 |
| $A_6$ (x= 2795.8) | 695.3 | 691.8 | 564.4 | 28.3 | 0.205 | 420.0 | 7645.5 | 8065.5 | 0.13 | 0.050 | 2.09 | 2.23 |
| $A_7$ (x= 3089.9) | 694.0 | 690.5 | 565.6 | 27.8 | 0.205 | 420.0 | 7492.5 | 7912.5 | 0.13 | 0.050 | 2.05 | 2.18 |
| $A_8$ (x= 3230.0) | 687.0 | 683.5 | 561.9 | 27.0 | 0.205 | 420.0 | 7294.5 | 7714.5 | 0.13 | 0.050 | 2.00 | 2.13 |
| $A_9$ (x=3674.3) | 575.7 | 572.2 | 532.6 | 8.8 | 0.205 | 420.0 | 2376.0 | 2796.0 | 0.13 | 0.050 | 0.65 | 0.78 |
| $A_{10}$ (x=3764.8) | 553.0 | 549.5 | 549.1 | 0.1 | 0.205 | 420.0 | 22.5 | 442.5 | 0.02 | 0.050 | 0.01 | 0.03 |

Settlement of MSW Layer 6

| Location of Consideration Point | Top of Final Cover | Top of Waste | Waste El. at Midpoint | Thickness of Waste Layer | $C_c e$ | Surcharge ($\Delta P$) | P'o | P' (P'o + $\Delta P$) | Primary Settlement | Cα | Secondary Settlement | Total Settlement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | feet | feet | feet | feet | - | psf | psf | psf | ft | | ft | ft |
| SECTION 1 | | | | | | | | | | | | |
| $A_1$ (x= 162.9) | 542.7 | 539.2 | 538.4 | 0.2 | 0.205 | 420.0 | 49.5 | 469.5 | 0.03 | 0.050 | 0.01 | 0.04 |
| $A_2$ (x= 211.4) | 554.8 | 551.3 | 524.6 | 4.8 | 0.205 | 420.0 | 1600.5 | 2020.5 | 0.10 | 0.050 | 0.36 | 0.46 |
| $A_3$ (x= 741.0) | 687.0 | 683.5 | 534.6 | 27.1 | 0.205 | 420.0 | 8932.0 | 9352.0 | 0.11 | 0.050 | 2.00 | 2.11 |
| $A_4$ (x= 1643.9) | 697.6 | 694.1 | 536.5 | 28.7 | 0.205 | 420.0 | 9454.5 | 9874.5 | 0.11 | 0.050 | 2.12 | 2.23 |
| $A_5$ (x= 2285.0) | 689.9 | 686.4 | 539.7 | 26.7 | 0.205 | 420.0 | 8800.0 | 9220.0 | 0.11 | 0.050 | 1.97 | 2.08 |
| $A_6$ (x= 2795.8) | 695.3 | 691.8 | 536.1 | 28.3 | 0.205 | 420.0 | 9344.5 | 9764.5 | 0.11 | 0.050 | 2.09 | 2.20 |
| $A_7$ (x= 3089.9) | 694.0 | 690.5 | 537.9 | 27.8 | 0.205 | 420.0 | 9157.5 | 9577.5 | 0.11 | 0.050 | 2.05 | 2.16 |
| $A_8$ (x= 3230.0) | 687.0 | 683.5 | 534.9 | 27.0 | 0.205 | 420.0 | 8915.5 | 9335.5 | 0.11 | 0.050 | 2.00 | 2.11 |
| $A_9$ (x=3674.3) | 575.7 | 572.2 | 523.8 | 8.8 | 0.205 | 420.0 | 2904.0 | 3324.0 | 0.11 | 0.050 | 0.65 | 0.76 |
| $A_{10}$ (x=3764.8) | 553.0 | 549.5 | 549.0 | 0.1 | 0.205 | 420.0 | 27.5 | 447.5 | 0.02 | 0.050 | 0.01 | 0.03 |

| Point Number | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ | $A_6$ | $A_7$ | $A_8$ | $A_9$ | $A_{10}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| X Coordinate | 162.9 | 211.4 | 741.0 | 1643.9 | 2285.0 | 2795.8 | 3089.9 | 3230.0 | 3674.3 | 3764.8 |
| Layer 1 -Total Settlement (ft) | 0.07 | 0.94 | 3.00 | 3.13 | 2.97 | 3.10 | 3.06 | 3.00 | 1.40 | 0.04 |
| Layer 2 -Total Settlement (ft) | 0.06 | 0.65 | 2.38 | 2.50 | 2.35 | 2.48 | 2.43 | 2.38 | 0.98 | 0.04 |
| Layer 3 -Total Settlement (ft) | 0.05 | 0.55 | 2.24 | 2.35 | 2.21 | 2.33 | 2.29 | 2.23 | 0.87 | 0.03 |
| Layer 4 -Total Settlement (ft) | 0.05 | 0.51 | 0.51 | 2.29 | 2.14 | 2.26 | 2.22 | 2.17 | 0.81 | 0.03 |
| Layer 5 -Total Settlement (ft) | 0.00 | 0.48 | 2.13 | 2.25 | 2.10 | 2.23 | 2.18 | 2.13 | 0.78 | 0.03 |
| Layer 6 -TotalSettlement (ft) | 0.04 | 0.46 | 2.11 | 2.23 | 2.08 | 2.20 | 2.16 | 2.11 | 0.76 | 0.03 |
| Total Settlement at Point (ft) | 0.27 | 3.59 | 12.37 | 14.75 | 13.86 | 14.60 | 14.35 | 14.01 | 5.59 | 0.20 |

| X Coordinate | 162.9 | 211.4 | 741.0 | 1643.9 | 2285.0 | 2795.8 | 3089.9 | 3230.0 | 3674.3 | 3764.8 |
|---|---|---|---|---|---|---|---|---|---|---|
| Pre-settlement Top of Final Cover, ft | 542.7 | 554.8 | 687.0 | 697.6 | 689.9 | 695.3 | 694.0 | 687.0 | 575.7 | 553.0 |
| Total Settlement, ft | 0.27 | 3.59 | 12.37 | 14.75 | 13.86 | 14.60 | 14.35 | 14.01 | 5.59 | 0.20 |
| Post-settlement Top of Final Cover, ft | 542.43 | 551.21 | 674.6 | 682.8 | 676.0 | 680.7 | 679.7 | 673.0 | 570.1 | 552.8 |

| Analysis Location | Point $A_1$ to Point $A_2$ | Point $A_2$ to Point $A_3$ | Point $A_3$ to Point $A_4$ | Point $A_4$ to Point $A_5$ | Point $A_5$ to Point $A_6$ | Point $A_6$ to Point $A_7$ | Point $A_7$ to Point $A_8$ | Point $A_8$ to Point $A_9$ | Point $A_9$ to Point $A_{10}$ |
|---|---|---|---|---|---|---|---|---|---|
| Presettlement Final Cover Top Slope, % | -24.95 | -24.96 | -1.17 | 1.20 | -1.06 | 0.44 | 5.00 | 25.05 | 25.08 |
| Postsettlement Final Cover Top Slope, % | -18.09 | -23.30 | -0.91 | 1.06 | -0.91 | 0.36 | 4.76 | 23.15 | 19.13 |
| Initial Length, ft | 49.99 | 545.85 | 902.96 | 641.15 | 510.83 | 294.10 | 140.27 | 458.03 | 93.30 |
| Final Length, ft | 49.29 | 543.79 | 902.94 | 641.14 | 510.82 | 294.10 | 140.26 | 456.05 | 92.14 |
| Strain, % (Tensile Negative) | 1.399% | 0.377% | 0.003% | 0.002% | 0.001% | 0.000% | 0.012% | 0.431% | 1.247% |

1 2 3 4 5 6 7 8

(C) (D)

↑ check this by hand (see attached calcs)

(Strain on Final Cover Liner)

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For Column #, see attached spreadsheets

Sample calculations of the Final Cover System on Primary and Secondary Consolidation and Compression.

Settlement of MSW Layer 1, Section 1, Point A5
Page 5-C-12

Cell Col.(2): Top of Waste El. = Top of Final Cover El. − Final Cover Thickness
= Col.(1) − Assumption(3) = 689.9' − 3.5'
= 686.4'

Col.(3): Waste El. at midpoint
= Top of waste El. − waste layer thickness/2
= Col.(2) − Col.(4)/2
= 686.4' − 26.7/2 = 673.1'

Col.(4): Thickness of Waste Layer,
H = Total thickness / 6 layers
= 160'/6 = 26.7'

Col.(6): surcharge, s = thickness of Final Cover × Unit weight of Cover soil
= 3.5' × 120 pcf
= 420 psf

Col.(7): Initial Effective Overburden Pressure
$P_o$ = (Top of Waste − Waste El. at midpoint) × $\gamma_{waste}$
= (Col.(2) − Col.(3)) × Assumption (2)
= (686.4 − 673.1) × 60 pcf
= 798 psf

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Col(8): Final Effective Overburden Pressure

$P = P_o + S$

= col.(7) + Col.(6)

= 798 + 420 = 1218 psf

Col.(9) Primary settlement

$S_p = C_{cc} \cdot H \log \frac{P}{P_o}$

$= \text{col.(5)} \cdot \text{col.(4)} \log \frac{\text{Col.(8)}}{\text{Col.(7)}}$

$= 0.205 \times 26.7' \log \frac{1218}{798}$

$= 1.00'$

Col.(11) Secondary settlement

$S_s = C_\alpha \cdot H \log \frac{t_2}{t_1}$ where $t_1 = 1$ year, $t_2 = 30$ years

$= \text{col.(10)} \times \text{col.(4)} \cdot \log \frac{30}{1}$

$= 0.050 \times 26.7' \times \log 30$

$= 1.97'$

Col.(12) Total MSW settlement

$S_{total} = S_p + S_s$

$= 1.00' + 1.97' = 2.97'$ (Checked) Col.(12)

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CHECKED BY DATE
SCALE

Strain calcs on Final Cover SagAcm
Page 5-C-13
Section 1 in EDA

Cell (D)(4): Pre-settlement Final Cover between $A_4$ & $A_5$

$$S_0 = \frac{Y_1 - Y_0}{X_1 - X_0} \times 100\%$$

$$= \frac{Col((C)(2) - (D)(2)}{Col((D)(1) - (E)(1)} \times 100\%$$

$$= \frac{697.6 - 689.9}{2285 - 1643.9} \times 100\%$$

$$= \frac{7.7}{641.1} \times 100\% = 1.20\%$$

(1.20% in cell (D)(4) checked ✓)

Cell (D)(5): Post-settlement Final Cover between $A_4$ + $A_5$

$$S_1 = \frac{Y_1 - Y_0}{X_1 - X_0} \times 100\%$$

$$= \frac{Col((C)(3) - (D)(3)}{Col((D)(1) - Col((C)(1)} \times 100\%$$

$$= \frac{682.8 - 676.0}{2285 - 1643.9} \times 100\%$$

$$= \frac{6.8}{641.1} \times 100\% = 1.06\%$$

(1.06% in cell (D)(5) Checked ✓)

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Cell (D)(6) Initial Length between $A_4$ & $A_5$, $L_0$

$$L_0 = \sqrt{\left[(X_1 - X_0)^2_{\text{Pre-settlement}} + (Y_1 - Y_0)^2_{\text{Pre-settlement}}\right]}$$

$$= \sqrt{\left[(\text{col (D)(1)} - \text{(C)(1)})^2 + (\text{col (D)(2)} - \text{(C)(2)})^2\right]}$$

$$= \sqrt{\left[(2285 - 1643.9)^2 + (689.9 - 697.6)^2\right]}$$

$$= \sqrt{\left[(641.1)^2 + (-7.7)^2\right]} = 641.15'$$

(641.15' in cell (D)(6) Checked ✓)

Cell (D)(7) Final length between $A_4$ & $A_5$, $L_1$

$$L_1 = \sqrt{\left[(X_1 - X_0)^2_{\text{Post-settlement}} + (Y_1 - Y_0)^2_{\text{Post-settlement}}\right]}$$

$$= \sqrt{\left[(\text{Col (D)(1)} - \text{Col (C)(1)})^2 + (\text{Col. (D)(3)} - \text{Col. (C)(3)})^2\right]}$$

$$= \sqrt{\left[(2285 - 1643.9)^2 + (676 - 682.8)^2\right]}$$

$$= \sqrt{\left((641.1)^2 + (-6.8)^2\right)} = 641.14'$$

(641.14' in cell (D)(7) checked ✓)

$\Rightarrow$ $L_0 > L_1$ (by 0.01'

Cell (D)(8) Strain in % between $A_4$ & $A_5$

$$\text{Strain} = \frac{L_1 - L_0}{L_0} \times 100\%$$

$$= \frac{641.14 - 641.15}{641.15} \times 100\%$$

$$= -\frac{0.01}{641.15} \times 100 = -0.002\%$$

(-ve value No strain on liner or relax mode)

checked ✓ cell (D)(8) (OK)

**CITY OF WACO LANDFILL**
**TCEQ PERMIT NO. MSW-2400**
**McLENNAN AND LIMESTONE COUNTIES, TEXAS**

# PART III – SITE DEVELOPMENT PLAN
# ATTACHMENT 6A
# SURFACE WATER DRAINAGE PLAN

**Prepared for:**

**CITY OF WACO**

Solid Waste Services
501 Schroeder Drive
Waco, TX 76710

**Prepared by:**

**SCS ENGINEERS**
**Texas Board of Professional Engineers, Reg. No. F-3407**
Dallas/Fort Worth Office
1901 Central Drive, Suite 550
Bedford, Texas 76021
817/571-2288

Revision 0 – April 2020
Revision 1 – October 2020
SCS Project No. 16216088.00

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6A.2 Post-Development Conditions
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6A.9 East Disposal Area (EDA) East Basin Plan
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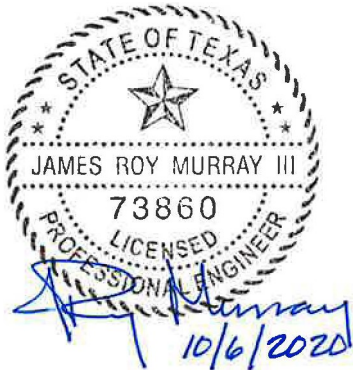


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6A.13 Downchute Details
6A.14 Basin Outlet Details
6A.15 Specifications for Silt Fences and Hay Bales
6A.16 Specifications for Sediment Traps and Check Dams
6A-E.1 Final Cover – Drainage Swale Areas
6A-E.2 Final Cover – Downchute Areas
6A-E.3 Intermediate Cover – Typical Swale/Downchute Layout – I
6A-E.4 Intermediate Cover – Typical Swale/Downchute Layout – II
6A-E.5 Intermediate Cover – Downchute Areas

**(Drawings 6A-E.1 through 6A-E.5 are provided in Appendix 6A-E)**

**Appendices**

6A-A HEC-HMS Input Parameters
6A-B HEC-HMS Pre-Development Output Files
6A-C HEC-HMS Post-Development Input/Output Files
6A-D Discharge Hydrographs
6A-E Hydraulic Analysis
6A-F Soil Loss Analysis
6A-G Erosion and Sedimentation Control Inspection and Maintenance Form

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Pre-development conditions, including on- and off-site drainage areas and subsequent POD locations are depicted on Drawings 6A.1A and 6A.1B. Pre-development PODs and contributing drainage areas are summarized below:

**East PODs (POD-1 through POD-4):**

The following drainage areas convey runoff in a southeasterly direction from the northeastern portion of the property across the east and southeast permit boundaries at the respective PODs:

- PRE-1, PRE-2, PRE-3, and PRE-4 discharge runoff at POD-1, POD-2, POD-3, and POD-4, respectively.

Surface water discharged across the east and southeast property boundaries flow into Packwood Creek, which then discharges into Reservoir 19.

**South PODs (POD-5 through POD-9):**

The following drainage areas convey runoff in a southerly direction from the approximate center of the property across the southern permit boundaries at the respective PODs:

- PRE-5, PRE-6, and PRE-7 discharge at POD-5, POD-6, and POD-7, respectively.
- PRE-8A, PRE-8B, PRE-8C, PRE-8D, OS-1, OS-2, and OS-3 contribute runoff to and discharge at POD-8.
- PRE-9 contributes runoff to and discharges at POD-9.

All surface water runoff discharged across the southern property boundaries ultimately flows into Horse Creek, or directly into Reservoir 19.

**West PODs (POD-10 and POD-11):**

The following drainage areas convey runoff in a southwest direction from the southwestern portion of the property across the southwest permit boundaries at the respective PODs:

- PRE-10A and PRE-10B contribute runoff to and discharge runoff at POD-10.
- PRE-11 discharges at POD-11.

Surface water discharged across the southwest property boundaries flow downstream of the Reservoir 19 dam.

floor. The WDA Basin was modeled using culverts, in HEC-HMS as a wet basin, assuming the basins were over excavated to either contain water, sediment, or a combination of both. Sediment will be removed from the detention basins on a regular basis during inspection and maintenance, as described in Subsection 6.7. The outlet structure of the WDA Basin will be comprised of two 21-inch diameter concrete culverts discharging to POD-8. Additionally, each detention basin has been designed with a minimum 1-foot of freeboard to prevent overtopping during the design storm event.

Elevation-area-discharge relationships for the basins are presented in Appendix 6A-A. HEC-HMS output for the detention basins, including the peak discharge, storage, and pool depth associated with the 25-year, 24-hour storm event is presented in Appendix 6A-C. This information also has been summarized in Table 6A-4-1. Detention basin layout plans are depicted on Drawings 6A.13 through 6A.18.

## 4.3 BASIN OUTLET STRUCTURE DESIGN

Peak discharge rates were calculated for each detention basin outlet structure, as described in Subsection 2.2.4 of this attachment. As described in this section, the standard orifice and weir equations were used for calculation of discharge rates through weep holes and concrete weirs. As previously described, the peak discharge rates were incorporated into the elevation-area-discharge relationships used in the HEC-HMS model, as provided in Appendix 6A-A. Design details for the culvert and concrete weir configurations are shown on Drawing 6A.14. Additionally, Table 6A-4-2 and Table 6A-4-3 describes the respective weir and culvert outlet dimensions/elevations.

**Table 6A-4-1. Detention Basin Peak Storage and Discharge**

| Detention Basin | Discharge Points | Peak Storage (acre-feet) | Peak Pool Depth (ft msl) | Peak Discharge (cfs) |
|---|---|---|---|---|
| EDA East Basin | POD-1 | 4.7 | 537.7 | 106.3 |
| EDA West Basin | POD-8 | 36.3 | 535.9 | 41.8 |
| WDA Basin | POD-8 | 31.1 | 536.5 | 22.5 |

**Table 6A-4-2. Detention Basin Peak Storage and Discharge**

| Detention Basin | Discharge Points | Basin Invert Elevation (ft msl) | Number of Weep Holes | Weir Elevation (ft msl) | Weir Length (ft) |
|---|---|---|---|---|---|
| EDA East Basin | POD-1 | 534.0 | 5 | 535.5 | 10.0 |
| EDA West Basin | POD-8 | 530.0 | 3 | 534.5 | 7.0 |

**Location: POD-4**

| Condition | Peak Discharge Rate (cfs) | Time of Peak Discharge (hours) | Discharge Volume (ac-ft) |
|---|---|---|---|
| Pre-development | 11.2 | 12:20 | 1.4 |
| Post-development | 10.9 | 12:20 | 1.4 |
| Percent Change | -2.7 | N/A | 0.0 |

**Location: POD-5**

| Condition | Peak Discharge Rate (cfs) | Time of Peak Discharge (hours) | Discharge Volume (ac-ft) |
|---|---|---|---|
| Pre-development | 55.0 | 12:40 | 10.6 |
| Post-development | 53.8 | 12:30 | 9.0 |
| Percent Change | -3.3 | N/A | -16.0 |

**Location: POD-6**

| Condition | Peak Discharge Rate (cfs) | Time of Peak Discharge (hours) | Discharge Volume (ac-ft) |
|---|---|---|---|
| Pre-development | 6.9 | 12:30 | 1.1 |
| Post-development | 6.9 | 12:30 | 1.1 |
| Percent Change | 0.0 | N/A | 0.0 |

**Location: POD-7**

| Condition | Peak Discharge Rate (cfs) | Time of Peak Discharge (hours) | Discharge Volume (ac-ft) |
|---|---|---|---|
| Pre-development | 33.9 | 12:40 | 5.9 |
| Post-development | 33.4 | 12:30 | 5.7 |
| Percent Change | -2.7 | N/A | -5.1 |

**Location: POD-8**

| Condition | Peak Discharge Rate (cfs) | Time of Peak Discharge (hours) | Discharge Volume (ac-ft) |
|---|---|---|---|
| Pre-development | 2030.2 | 13:40 | 619.7 |
| Post-development | 2059.8 | 13:20 | 621.1 |
| Percent Change | 1.5 | N/A | 0.3 |

**Location: POD-9**

| Condition | Peak Discharge Rate (cfs) | Time of Peak Discharge (hours) | Discharge Volume (ac-ft) |
|---|---|---|---|
| Pre-development | 4.1 | 12:40 | 0.7 |
| Post-development | 4.1 | 12:40 | 0.7 |
| Percent Change | 0.0 | N/A | 0.0 |

**Location: POD-10**

| Condition | Peak Discharge Rate (cfs) | Time of Peak Discharge (hours) | Discharge Volume (ac-ft) |
|---|---|---|---|
| Pre-development | 36.9 | 12:30 | 6.5 |
| Post-development | 7.8 | 12:40 | 1.3 |
| Percent Change | -78.9 | N/A | -80.0 |

**Location: POD-11**

| Condition | Peak Discharge Rate (cfs) | Time of Peak Discharge (hours) | Discharge Volume (ac-ft) |
|---|---|---|---|
| Pre-development | 21.9 | 12:20 | 3.1 |
| Post-development | 21.0 | 12:40 | 3.0 |
| Percent Change | -4.1 | N/A | -3.2 |

**Notes**

1. Values obtained from HEC-HMS output files (Appendices 6A-B and 6A-C).
2. Time of Peak Discharge in hours from beginning of 24-hour storm period.

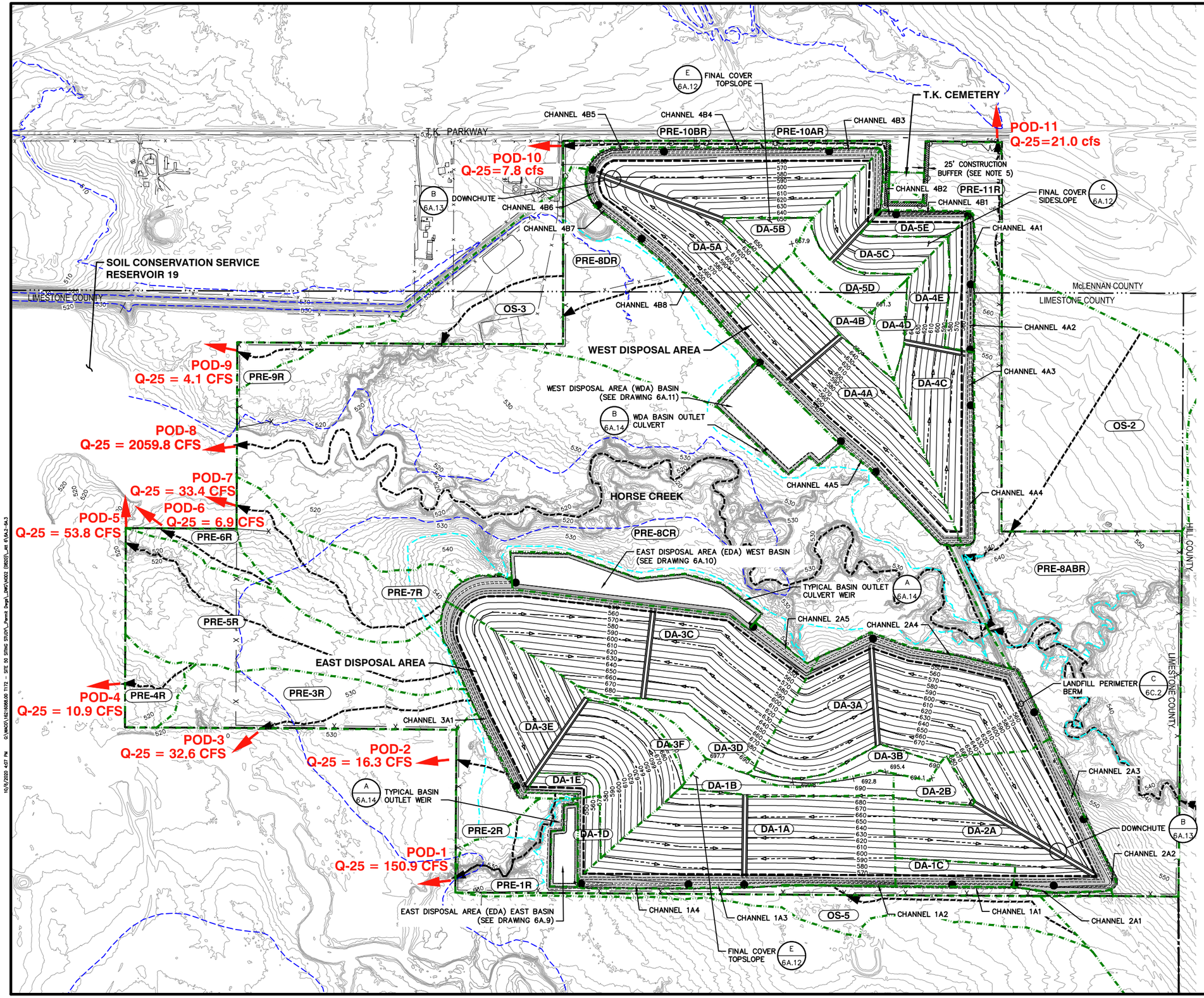
**Table 6A-5-2. Comparison of Reservoir 19 Pre- and Post-Development Conditions Peak Discharge Rate and Volume**

**Location: Reservoir 19**

| Condition | Peak Discharge Rate (cfs) | Discharge Volume (ac-ft) |
|---|---|---|
| Pre-development | 2366.9 | 682.5 |
| Post-development | 2368.7 | 671.6 |
| Percent Change | 0.1 | -1.5 |

# DRAWINGS

## 6A.1A through 6A.16




## LEGEND

- EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- PERMIT BOUNDARY
- LIMITS OF WASTE
- SECTOR BOUNDARY
- COUNTY LINE
- 100-YEAR FLOOD PLAIN (SEE NOTE 2)
- EXISTING FENCE (SCREENED)
- FINAL COVER CONTOURS (SEE NOTE 3)
- PROPOSED/EXISTING PERIMETER FENCE (CHAIN LINK OR BARBED WIRE)
- PROPOSED 8' PRIVACY FENCE
- DRAINAGE SWALES
- DOWNCHUTES
- CHANNEL SECTION
- DRAINAGE AREA BOUNDARY
- POINT-OF-DEMONSTRATION (POD)
- ASSUMED CHANNEL LENGTH
- DA-9B — POST-DEVELOPMENT DRAINAGE AREA
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

NOTE:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPACIAL FROM AERIAL PHOTOGRAPHY FLOWN JULY 03, 2018.
2. 100-YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
3. ELEVATIONS SHOWN ON THIS DRAWING ARE TOP OF FINAL COVER ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).
4. USGS MAP AXTELL, TEXAS (1956) IS SHOWN ON THIS EXHIBIT.
5. IN ACCORDANCE WITH "AN INTENSIVE CULTURAL RESOURCES SURVEY OF THE CITY OF WACO'S PROPOSED SITE 50 LANDFILL PROJECT," PREPARED BY HORIZON ENVIRONMENTAL SERVICES, INC., DATED NOVEMBER 2018 (SEE APPENDIX I/IIA), A 25-FOOT CONSTRUCTION BUFFER WILL BE MAINTAINED AROUND TK CEMETERY TO PROTECT ANY POTENTIAL UNMARKED GRAVES OUTSIDE THE PRESENT MODERN DAY CEMETERY BOUNDARIES AND FENCING.
6. FOR INFORMATION ON DRAINAGE AREA OS-1, SEE DRAWING 6A.1B.

JAMES ROY MURRAY III 73860 LICENSED PROFESSIONAL ENGINEER
10/6/2020

**FOR PERMITTING PURPOSES ONLY**

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOODPLAIN, FLOWAGE EASEMENT, BASIN CALLOUT, LIMITS OF WASTE, NOTES 2 AND 6. | JRM |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: POST-DEVELOPMENT CONDITIONS

PROJECT TITLE: CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO
SOLID WASTE SERVICES


SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188


PROJ. NO. 16216088.00 | DSN. BY: BG/RRK | DWN. BY: NR | CHK. BY: BJD | QA/QC BY: RRK | APP. BY: RRK

CADD FILE: 6A.2-6A.3

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. 6A.2

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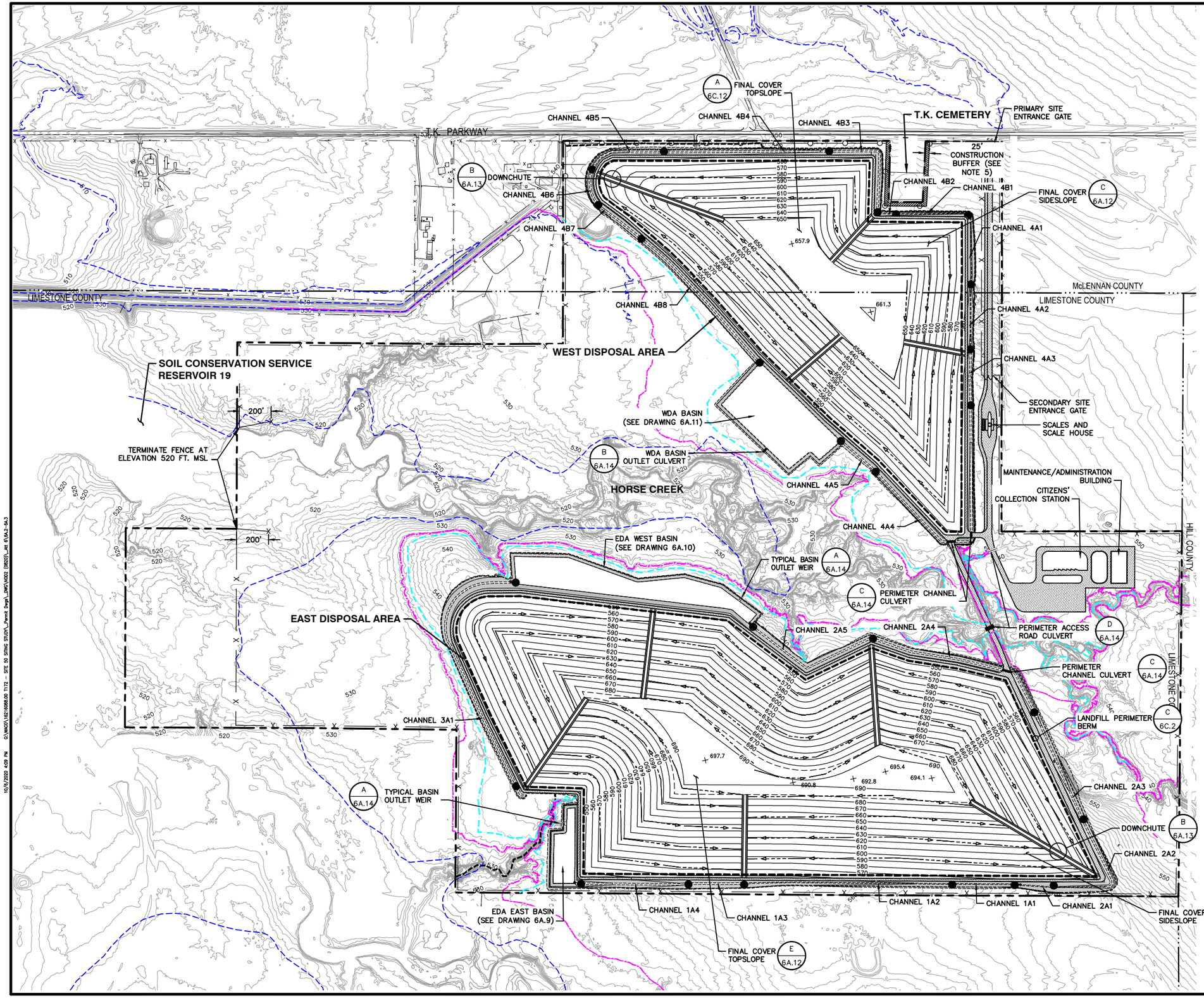


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SCALE IN FEET

## LEGEND

- EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- PERMIT BOUNDARY
- LIMITS OF WASTE
- SECTOR BOUNDARY
- COUNTY LINE
- EXISTING FENCE (SCREENED)
- 100-YEAR FLOOD PLAIN (SEE NOTE 2)
- 100-YEAR STORM EVENT WATER SURFACE (SEE NOTE 6)
- FINAL COVER TOPOGRAPHIC CONTOURS (SEE NOTE 3)
- PROPOSED/EXISTING PERIMETER FENCE (CHAIN LINK OR BARBED WIRE)
- PROPOSED 8' PRIVACY FENCE
- DRAINAGE SWALES
- DOWNCHUTES
- CHANNEL SECTION
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

**NOTE:**

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPACIAL FROM AERIAL PHOTOGRAPHY FLOWN JULY 03, 2018.
2. 100-YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
3. ELEVATIONS SHOWN ON THIS DRAWING ARE TOP OF FINAL COVER ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).
4. USGS MAP AXTELL, TEXAS (1956) IS SHOWN ON THIS EXHIBIT.
5. IN ACCORDANCE WITH "AN INTENSIVE CULTURAL RESOURCES SURVEY OF THE CITY OF WACO'S PROPOSED SITE 50 LANDFILL PROJECT," PREPARED BY HORIZON ENVIRONMENTAL SERVICES, INC., DATED NOVEMBER 2018 (SEE APPENDIX I/IIA), A 25-FOOT CONSTRUCTION BUFFER WILL BE MAINTAINED AROUND TK CEMETERY TO PROTECT ANY POTENTIAL UNMARKED GRAVES OUTSIDE THE PRESENT MODERN DAY CEMETERY BOUNDARIES AND FENCING.
6. 100-YEAR STORM EVENT WATER SURFACE WAS ESTIMATED USING HEC-HMS AND HEC-RAS MODELING AS DISCUSSED IN ATTACHMENT 6B OF THIS PERMIT APPLICATION.

STATE OF TEXAS
JAMES ROY MURRAY III
73860
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

**FOR PERMITTING PURPOSES ONLY**

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOODPLAIN, FLOWAGE EASEMENT, LIMITS OF WASTE, AND NOTE 2. | JRM |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: LANDFILL COMPLETION PLAN

PROJECT TITLE: CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO
SOLID WASTE SERVICES


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1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188


PROJ. NO. 16216088.00 | DSN. BY: BG/RRK | DWN. BY: NR | CHK. BY: BJD | O/A RVW BY: RRK | APP. BY: RRK

CADD FILE: 6A.2-6A.3

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. 6A.3

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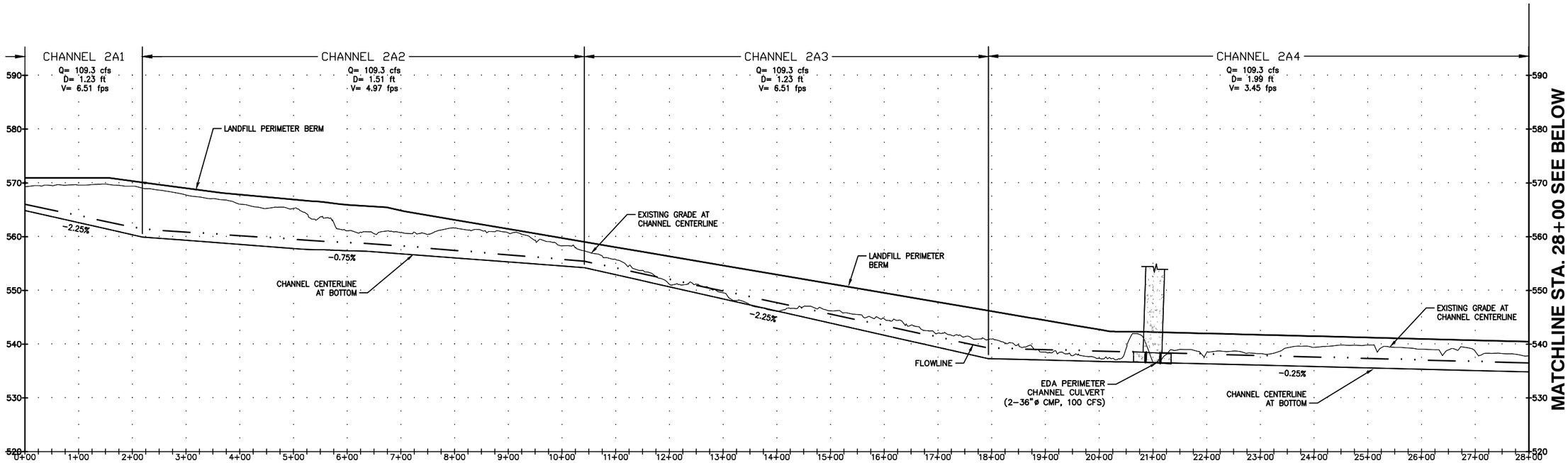
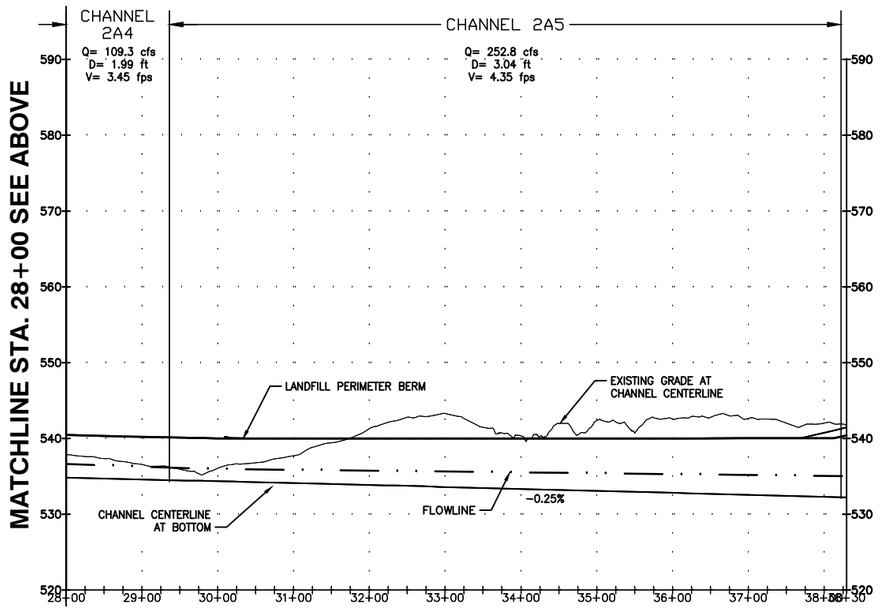



**MATCHLINE STA. 28+00 SEE BELOW**

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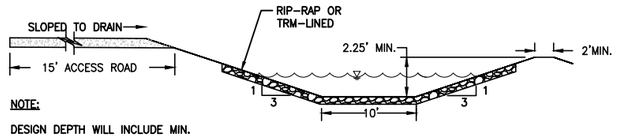
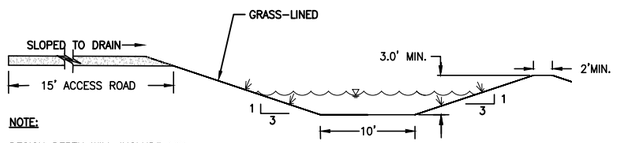



NOTE:

DESIGN DEPTH WILL INCLUDE MIN. 1-FOOT FREEBOARD ABOVE $D_{25}$ (DEPTH AT 25-YEAR, 24-HOUR STORM EVENT).

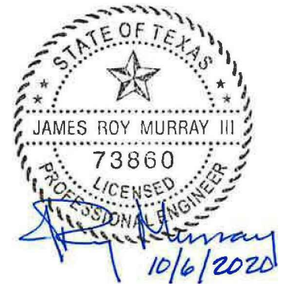
CHANNEL 2A1
TYPICAL CROSS-SECTION
NOT TO SCALE

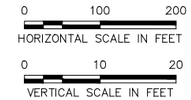



NOTE:

DESIGN DEPTH WILL INCLUDE MIN. 1-FOOT FREEBOARD ABOVE $D_{25}$ (DEPTH AT 25-YEAR, 24-HOUR STORM EVENT).

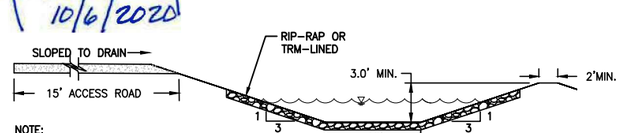
CHANNEL 2A2, AND 2A4
TYPICAL CROSS-SECTION
NOT TO SCALE





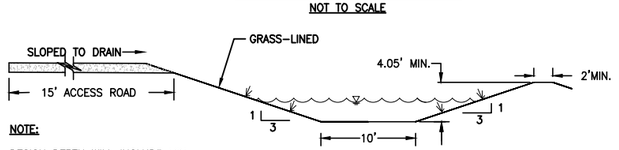





NOTE:

DESIGN DEPTH WILL INCLUDE MIN. 1-FOOT FREEBOARD ABOVE $D_{25}$ (DEPTH AT 25-YEAR, 24-HOUR STORM EVENT).

CHANNEL 2A3
TYPICAL CROSS-SECTION
NOT TO SCALE




NOTE:

DESIGN DEPTH WILL INCLUDE MIN. 1-FOOT FREEBOARD ABOVE $D_{25}$ (DEPTH AT 25-YEAR, 24-HOUR STORM EVENT).

CHANNEL 2A5
TYPICAL CROSS-SECTION
NOT TO SCALE

**FOR PERMITTING PURPOSES ONLY**

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOW, VELOCITY, AND DEPTH UPDATES | |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: CHANNEL PROFILE
CHANNEL 2A1 TO CHANNEL 2A5

PROJECT TITLE: CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO
SOLID WASTE SERVICES


SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188


PROJ. NO. 16216088.00
DSN. BY: BC/RRK
DWN. BY: NR
CHK. BY: BJD
O/A RVW BY: RRK
APP. BY: RRK

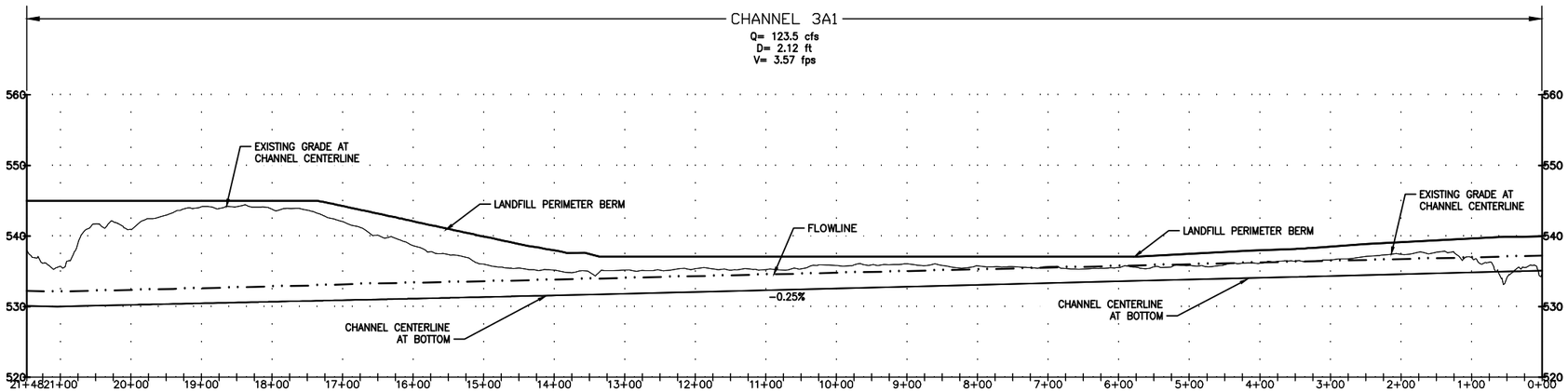
CADD FILE: 6A.A4 - CHANNEL PROFILES

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. **6A.5**

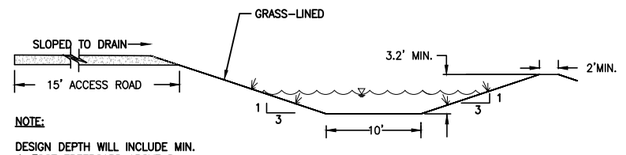

10/6/2020 4:42 PM C:\WACO\16216088.00 TTZ - SITE SO STNG STUDY_Permit Dwgs_DWG\6A02 (2020)_A6 6\6A.A4 - CHANNEL PROFILES




0 100 200
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

STATE OF TEXAS
JAMES ROY MURRAY III
73860
LICENSED
PROFESSIONAL ENGINEER
10/6/2020




CHANNEL 3A1
TYPICAL CROSS-SECTION
NOT TO SCALE

NOTE:
DESIGN DEPTH WILL INCLUDE MIN. 1-FOOT FREEBOARD ABOVE $D_{25}$ (DEPTH AT 25-YEAR, 24-HOUR STORM EVENT).

FOR PERMITTING PURPOSES ONLY

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOW, VELOCITY, AND DEPTH. UPDATES | |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: CHANNEL PROFILE CHANELL 3A1

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188

| | |
|---|---|
| PROJ. NO. | 162160B8.00 |
| DSN. BY: | RG/RRK |
| DWN. BY: | NR |
| CHK. BY: | BJD |
| QA/A. EVA BY: | RRK |
| APP. BY: | RRK |

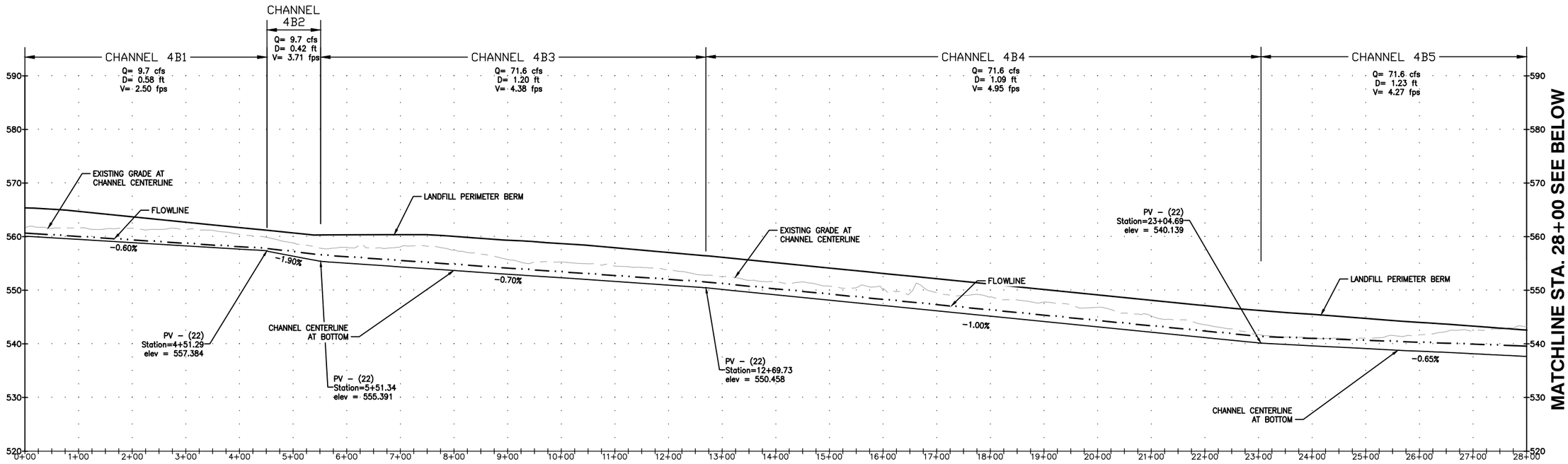
CADD FILE: 6A.A4 - CHANNEL PROFILES

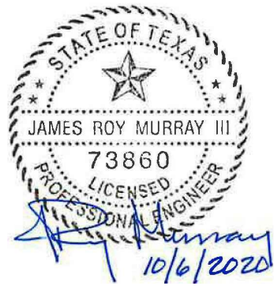
DATE: 04/2020

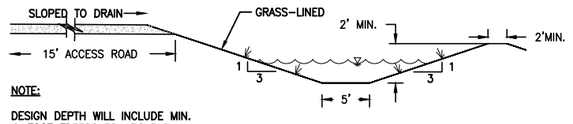
SCALE: AS SHOWN

DRAWING NO. 6A.6

10/6/2020 4:43 PM G:\WACO\162160B8.00 1172 - SITE 50 STING STUDY_Permit Dwgs_DWG\WC02 (6620)_Att 6\6A.A4 - CHANNEL PROFILES



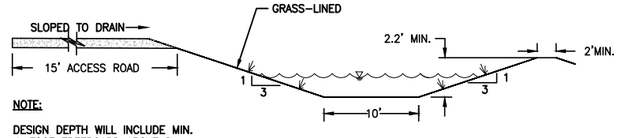




NOTE:

DESIGN DEPTH WILL INCLUDE MIN. 1-FOOT FREEBOARD ABOVE $D_{25}$ (DEPTH AT 25-YEAR, 24-HOUR STORM EVENT).

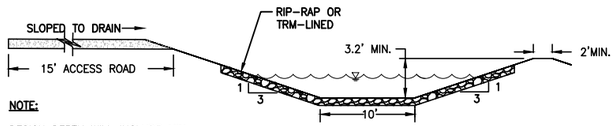
CHANNEL 4B1-4B2
TYPICAL CROSS-SECTION
NOT TO SCALE




NOTE:

DESIGN DEPTH WILL INCLUDE MIN. 1-FOOT FREEBOARD ABOVE $D_{25}$ (DEPTH AT 25-YEAR, 24-HOUR STORM EVENT).

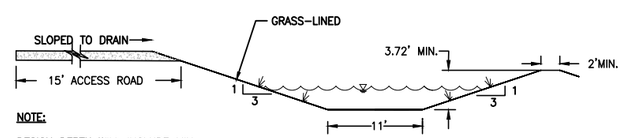
CHANNEL 4B3-4B6
TYPICAL CROSS-SECTION
NOT TO SCALE




NOTE:

DESIGN DEPTH WILL INCLUDE MIN. 1-FOOT FREEBOARD ABOVE $D_{25}$ (DEPTH AT 25-YEAR, 24-HOUR STORM EVENT).

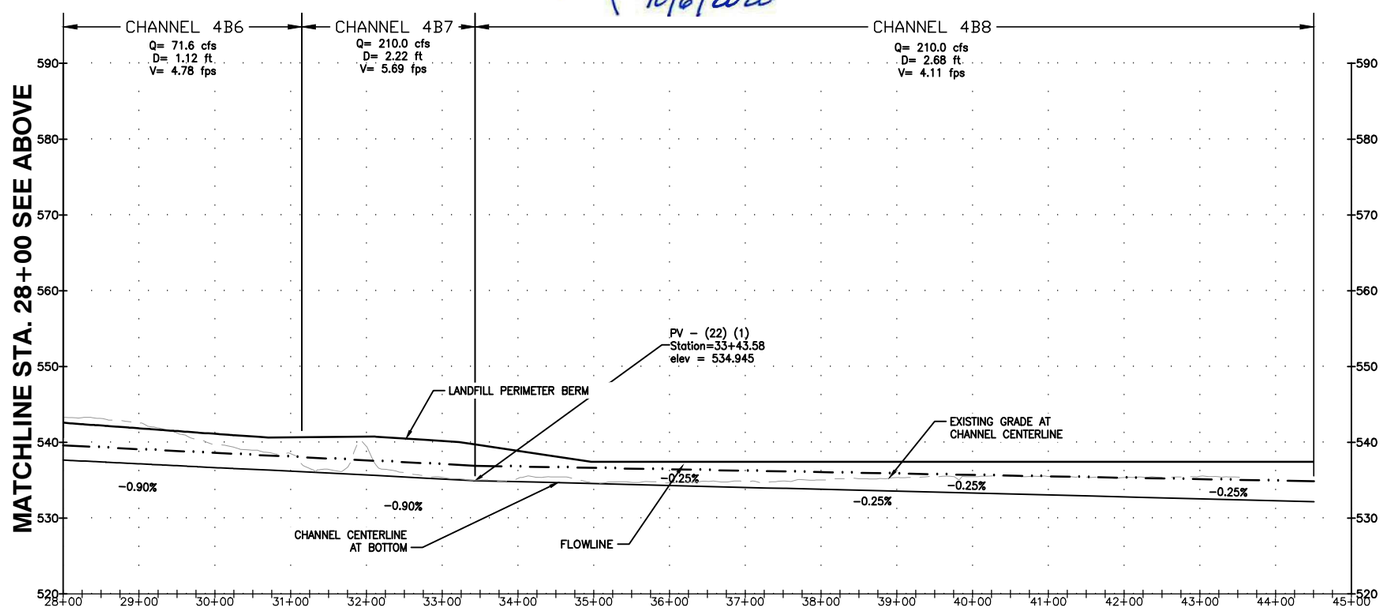
CHANNEL 4B7
TYPICAL CROSS-SECTION
NOT TO SCALE




NOTE:

DESIGN DEPTH WILL INCLUDE MIN. 0.4-FOOT FREEBOARD ABOVE $D_{25}$ (DEPTH AT 25-YEAR, 24-HOUR STORM EVENT).

CHANNEL 4B8
TYPICAL CROSS-SECTION
NOT TO SCALE




FOR PERMITTING PURPOSES ONLY

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: SLOPE, FLOW, VELOCITY, AND DEPTH UPDATES | |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: CHANNEL PROFILE CHANNEL 4B1 TO CHANNEL 4B7

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188

| PROD. NO. | DSN. BY: | DWN. BY: | CHK. BY: | Q/A RVW BY: | APP. BY: |
|---|---|---|---|---|---|
| 162608800 | BG/RRK | NR | BJD | RRK | RRK |

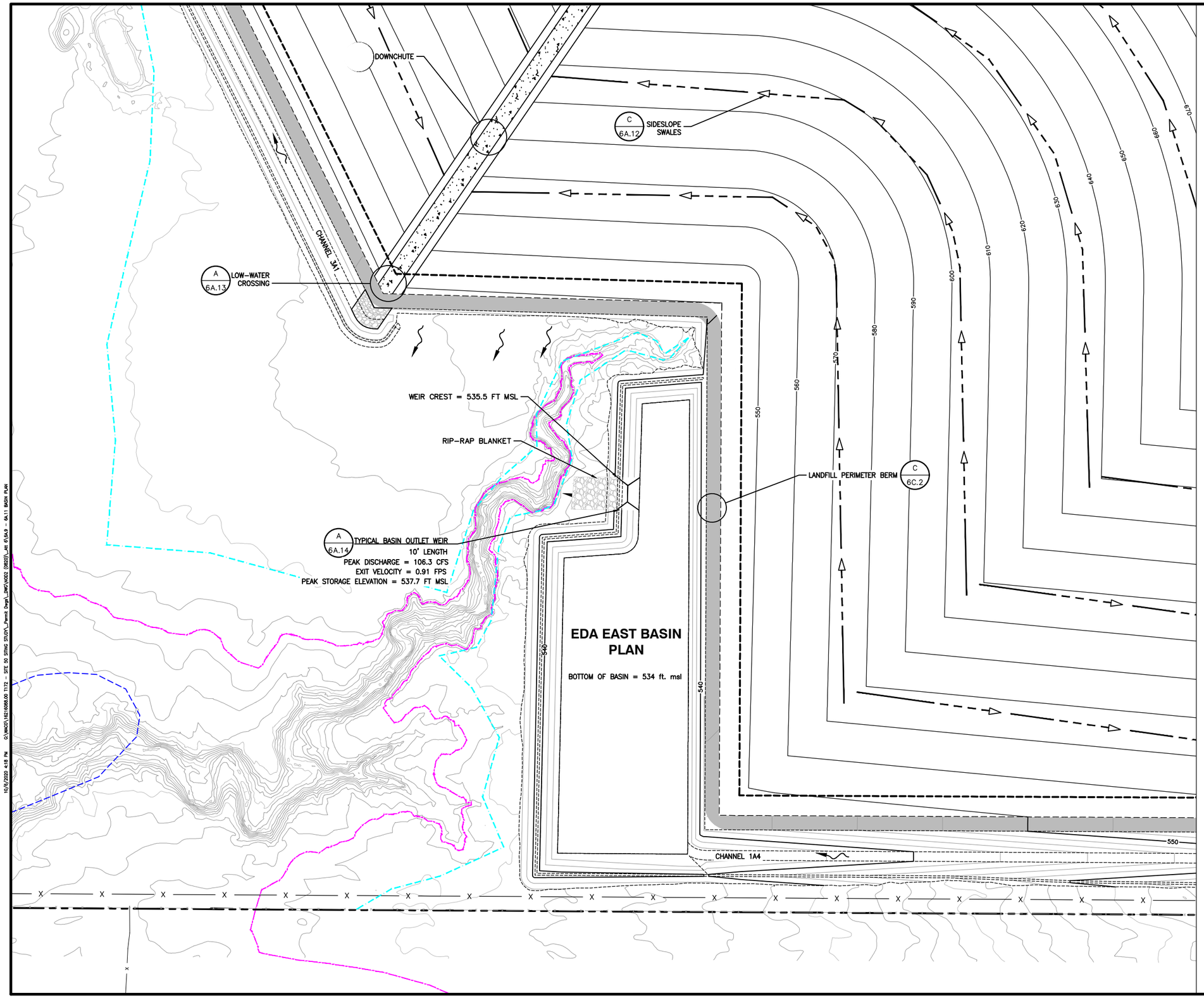
CADD FILE: 6A.4 – CHANNEL PROFILES

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. 6A.8

10/6/2020 7:27 PM G:\WACO\162\608800 1172 – SITE SO SITING STUDY_Permit Dwgs_DWG\A002 (0820)_LAR 6\6A.4 – CHANNEL PROFILES




0 50 100
SCALE IN FEET

## LEGEND

## LEGEND

- 560 — EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- PERMIT BOUNDARY
- LIMITS OF WASTE
- 100-YEAR FLOOD PLAIN (SEE NOTE 2)
- 100-YEAR STORM EVENT WATER SURFACE (SEE NOTE 3)
- 650 — FINAL COVER TOPOGRAPHIC CONTOURS (SEE NOTE 4)
- X — PROPOSED/EXISTING PERIMETER FENCE (BARBED WIRE)
- SWALES
- DOWNCHUTES
- PERIMETER CHANNEL AND SURFACE FLOW DIRECTION
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

NOTE:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPACIAL FROM AERIAL PHOTOGRAPHY FLOWN JULY 03, 2018.
2. 100-YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
3. 100-YEAR STORM EVENT WATER SURFACE WAS ESTIMATED USING HEC-HMS AND HEC-RAS MODELING AS DISCUSSED IN ATTACHMENT 6B OF THIS PERMIT APPLICATION.
4. ELEVATIONS SHOWN ON THIS DRAWING ARE TOP OF FINAL COVER ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).

STATE OF TEXAS
JAMES ROY MURRAY III
73860
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

FOR PERMITTING PURPOSES ONLY

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOODPLAIN, FLOWAGE EASEMENT, LIMITS OF WASTE, EXIT VELOCITY, AND NOTE 2. | JRM |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: EDA EAST BASIN PLAN

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES


SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188


PROJ. NO. 16216088.00 | DSN. BY: BG/RRK | DWN. BY: NR | CHK. BY: BJD | Q/A RVW BY: RRK | APP. BY: RRK

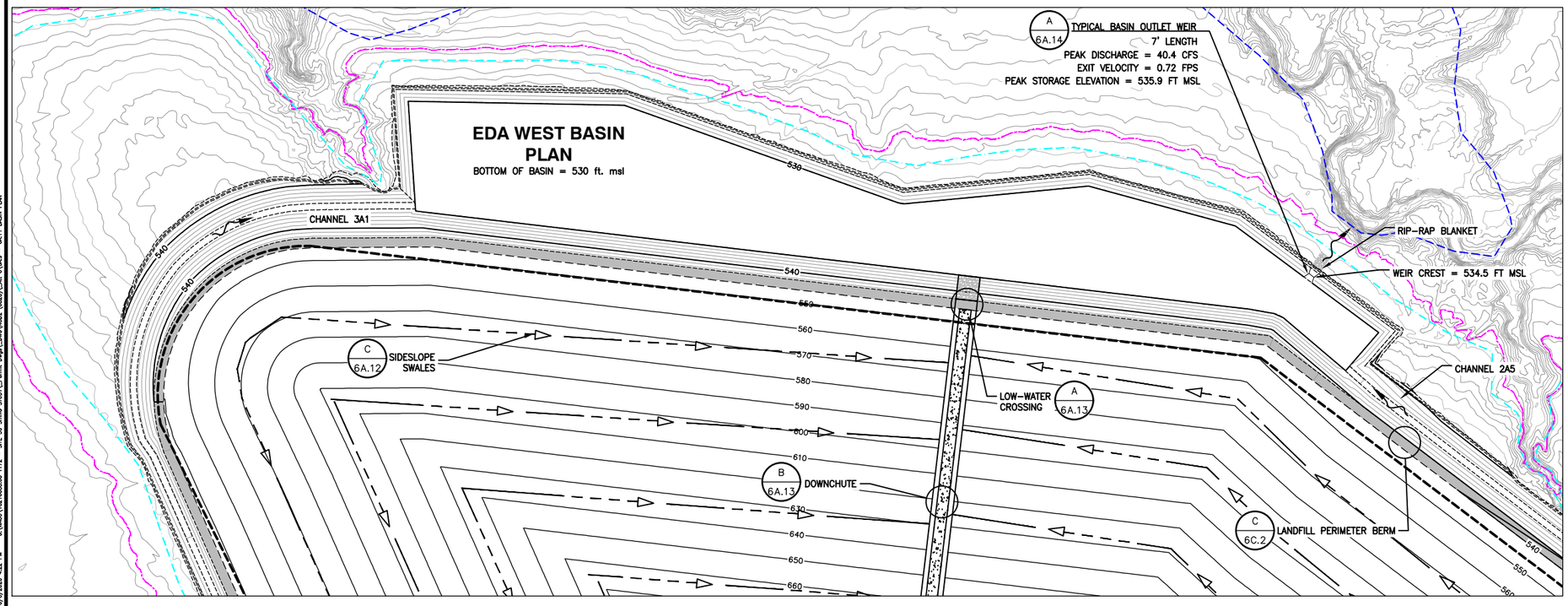
CADD FILE: 6A.9 – 6A.11 BASIN PLAN

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. 6A.9

10/6/2020 4:18 PM G:\WACO\16216088.00 T172 – SITE 50 SITING STUDY_Permit Dwgs_DWG\NO02 (0820)_Att 6\6A.9 – 6A.11 BASIN PLAN




0 100 200
SCALE IN FEET

## LEGEND

- 560 — EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- LIMITS OF WASTE
- 100-YEAR FLOOD PLAIN (SEE NOTE 2)
- 100-YEAR STORM EVENT WATER SURFACE (SEE NOTE 3)
- 650 — FINAL COVER TOPOGRAPHIC CONTOURS (SEE NOTE 4)
- DRAINAGE SWALES
- DOWNCHUTES
- PERIMETER CHANNEL AND SURFACE FLOW DIRECTION
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

NOTE:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPACIAL FROM AERIAL PHOTOGRAPHY FLOWN JULY 03, 2018.
2. 100-YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
3. 100-YEAR STORM EVENT WATER SURFACE WAS ESTIMATED USING HEC-HMS AND HEC-RAS MODELING AS DISCUSSED IN ATTACHMENT 6B OF THIS PERMIT APPLICATION.
4. ELEVATIONS SHOWN ON THIS DRAWING ARE TOP OF FINAL COVER ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).

STATE OF TEXAS
JAMES ROY MURRAY III
73860
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

FOR PERMITTING PURPOSES ONLY

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOODPLAIN, FLOWAGE EASEMENT, LIMITS OF WASTE, EXIT VELOCITY, AND NOTE 2. | JRM |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: EDA WEST BASIN PLAN

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES


SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188


PROJ. NO. 16216088.00 | DSN. BY: BG/RRK | DWN. BY: NR | CHK. BY: BJD | Q/A RVW BY: RRK | APP. BY: RRK

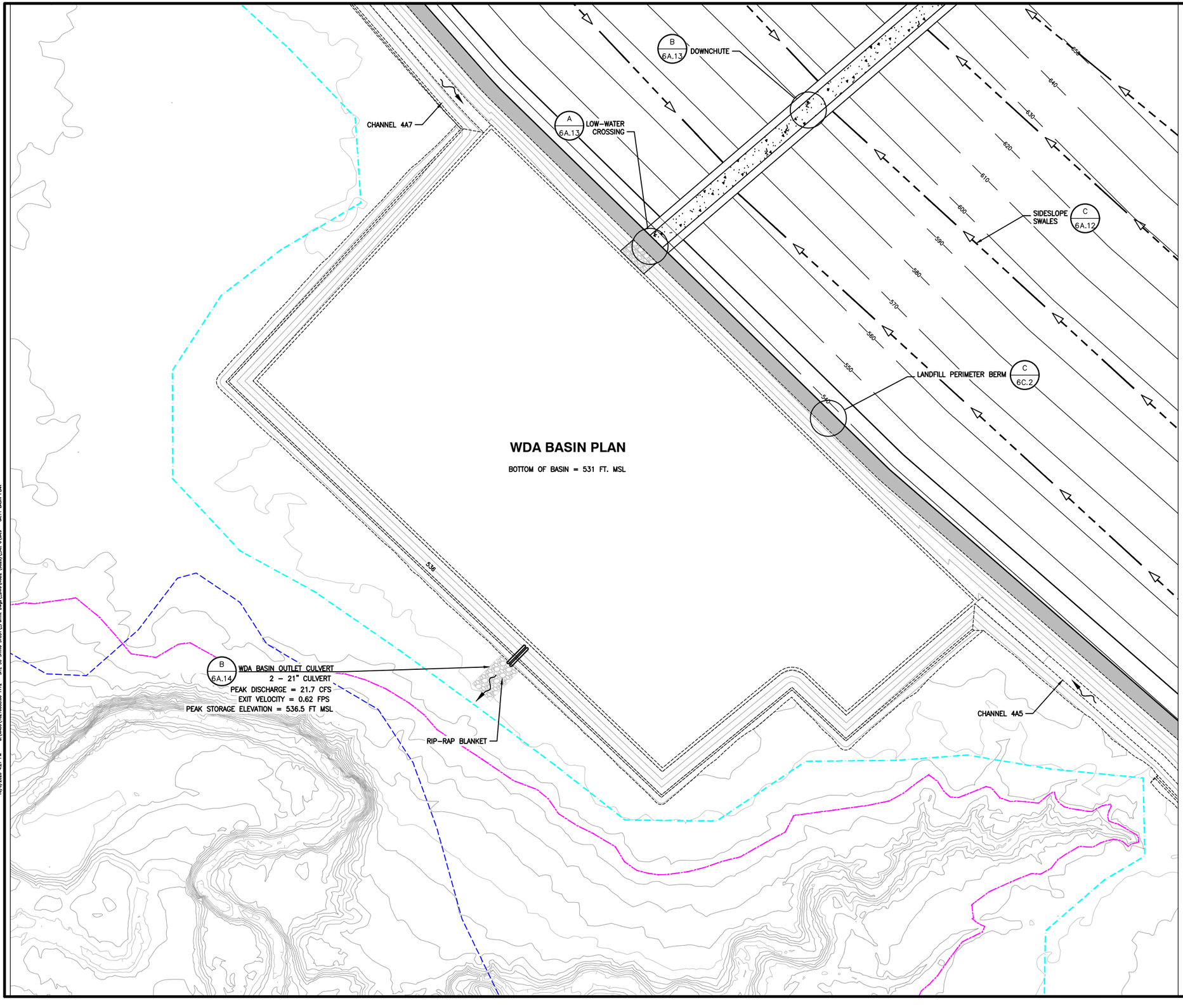
CADD FILE: 6A.9 – 6A.11 BASIN PLAN

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. 6A.10

10/6/2020 4:22 PM G:\WACO\16216088.00 1172 – SITE 50 SITING STUDY_Permit Dwgs_DWG\NOD2 (0820)_Att 6\6A.9 – 6A.11 BASIN PLAN




0 50 100
SCALE IN FEET

## LEGEND

- 560 — EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- PERMIT BOUNDARY
- LIMITS OF WASTE
- 100-YEAR FLOOD PLAIN (SEE NOTE 2)
- 100-YEAR STORM EVENT WATER SURFACE (SEE NOTE 3)
- 650 — FINAL COVER TOPOGRAPHIC CONTOURS (SEE NOTE 4)
- DRAINAGE SWALES
- DOWNCHUTES
- PERIMETER CHANNEL AND SURFACE FLOW DIRECTION
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

NOTE:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPACIAL FROM AERIAL PHOTOGRAPHY FLOWN JULY 03, 2018.
2. 100-YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
3. 100-YEAR STORM EVENT WATER SURFACE WAS ESTIMATED USING HEC-HMS AND HEC-RAS MODELING AS DISCUSSED IN ATTACHMENT 6B OF THIS PERMIT APPLICATION.
4. ELEVATIONS SHOWN ON THIS DRAWING ARE TOP OF FINAL COVER ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).

STATE OF TEXAS
JAMES ROY MURRAY III
73860
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

**FOR PERMITTING PURPOSES ONLY**

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOODPLAIN, FLOWAGE EASEMENT, LIMITS OF WASTE, EXIT VELOCITY, AND NOTE 2. | JRM |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: WDA BASIN PLAN

PROJECT TITLE: CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO
SOLID WASTE SERVICES


**SCS ENGINEERS**
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188


PROJ. NO. 16216088.00 | DSN. BY: BG/RRK | DWN. BY: NR | CHK. BY: BJD | D/A SVR BY: RRK | APP. BY: RRK

CADD FILE: 6A.9 - 6A.11 BASIN PLAN

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. **6A.11**

10/6/2020 4:27 PM G:\WACO\16216088.00 1172 - SITE SO SITING STUDY_Permit Dwgs_DWG\WD02 (2020)_Att 6\6A.9 - 6A.11 BASIN PLAN

# APPENDIX 6A-A

# HEC-HMS INPUT PARAMETERS

- Reservoir 19 (Elevation-Area-Discharge Relationship)
- Pre-development Subbasins
- Post-development Subbasins
- Post-development Perimeter Drainage Channels
- Post-Development Detention Basins (Elevation-Area-Discharge Relationships)
- Precipitation Data
- SCS Curve Numbers
- Manning's Coefficients
- Kinematic Wave Method – Roughness Factors

**SCS Engineers**
**TBPE Reg. # F-3407**

**Inclusive of pages 6A-A-1 to 6A-A-29**

# POST-DEVELOPMENT SUBBASINS

**CITY OF WACO LANDFILL**
**KINEMATIC WAVE INPUT PARAMETERS**
**- POST-DEVELOPMENT CONDITIONS -**

| Discharge Study Point | Contributing Drainage Areas | Drainage Plane | | | Collector | | | | | | | Main Channel | | | | | Area (sq. mi.) | Curve Number (CN) | SCS Method | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Length | Slope | Roughness | Area | No. of Collectors | Length | Slope | Manning's Coefficient | Width | Sideslope | Length | Slope | Manning's Coefficient | Width | Sideslope | | | Stream Length | Slope | Manning n | Sheet Flow $T_c$ | Lag Time |
| | | (ft) | (ft/ft) | | (sq. mil.) | | (ft) | (ft/ft) | | (ft) | xH:1V | (ft) | (ft/ft) | | (ft) | xH:1V | | | (ft) | (ft/ft) | | (min) | (min) |
| **POD-1** | DA-1A | 130 | 0.25 | 0.15 | 0.00395 | 9 | 847 | 0.01 | 0.027 | 0 | 3 | 536 | 0.25 | 0.033 | 15 | 2 | 0.0355 | 85.0 | - | - | - | - | - |
| | DA-1B | 189 | 0.05 | 0.15 | - | - | | - | - | - | - | 906 | 0.01 | 0.027 | 0 | 3 | 0.0055 | 85.0 | - | - | - | - | - |
| | *DA-1C | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.0042 | 85.0 | 179 | 0.0100 | 0.15 | 17.87 | 11 |
| | *DA-1D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.0023 | 85.0 | 138 | 0.0100 | 0.15 | 14.52 | 9 |
| | **DA-1E | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.0019 | 85.0 | 179 | 0.2500 | 0.15 | 4.92 | 5 |
| | | | | | | | | | | | | | | | | | | | | | | | |
| **POD-8** | DA-2A | 130 | 0.25 | 0.15 | 0.00353 | 8 | 757 | 0.01 | 0.027 | 0 | 3 | 950 | 0.25 | 0.033 | 15 | 2 | 0.0282 | 85.0 | - | - | - | - | - |
| | DA-2B | 117 | 0.05 | 0.15 | - | - | - | - | - | - | - | 496 | 0.01 | 0.027 | 0 | 3 | 0.0030 | 85.0 | - | - | - | - | - |
| | DA-3A | 130 | 0.25 | 0.15 | 0.00370 | 10 | 793 | 0.01 | 0.027 | 0 | 3 | 634 | 0.25 | 0.033 | 15 | 2 | 0.0370 | 85.0 | - | - | - | - | - |
| | DA-3B | 179 | 0.05 | 0.15 | - | - | - | - | - | - | - | 808 | 0.01 | 0.027 | 0 | 3 | 0.0040 | 85.0 | - | - | - | - | - |
| | DA-3C | 130 | 0.25 | 0.15 | 0.00417 | 10 | 895 | 0.01 | 0.027 | 0 | 3 | 568 | 0.25 | 0.033 | 15 | 2 | 0.0417 | 85.0 | - | - | - | - | - |
| | DA-3D | 161 | 0.05 | 0.15 | - | - | - | - | - | - | - | 822 | 0.01 | 0.027 | 0 | 3 | 0.0040 | 85.0 | - | - | - | - | - |
| | DA-3E | 130 | 0.25 | 0.15 | 0.00371 | 9 | 796 | 0.01 | 0.027 | 0 | 3 | 693 | 0.25 | 0.033 | 15 | 2 | 0.0334 | 85.0 | - | - | - | - | - |
| | DA-3F | 181 | 0.05 | 0.15 | - | - | - | - | - | - | - | 866 | 0.01 | 0.027 | 0 | 3 | 0.0027 | 85.0 | - | - | - | - | - |
| | DA-4A | 130 | 0.25 | 0.15 | 0.00368 | 8 | 789 | 0.01 | 0.027 | 0 | 3 | 438 | 0.25 | 0.033 | 15 | 2 | 0.0294 | 85.0 | - | - | - | - | - |
| | DA-4B | 236 | 0.05 | 0.15 | - | - | - | - | - | - | - | 566 | 0.01 | 0.027 | 0 | 3 | 0.0050 | 85.0 | - | - | - | - | - |
| | DA-4C | 130 | 0.25 | 0.15 | 0.00324 | 6 | 694 | 0.01 | 0.027 | 0 | 3 | 387 | 0.25 | 0.033 | 15 | 2 | 0.0194 | 85.0 | - | - | - | - | - |
| | DA-4D | 218 | 0.05 | 0.15 | - | - | - | - | - | - | - | 368 | 0.01 | 0.027 | 0 | 3 | 0.0027 | 85.0 | - | - | - | - | - |
| | *DA-4E | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.0047 | 85.0 | 104 | 0.0100 | 0.15 | 11.54 | 7 |
| | DA-5A | 130 | 0.25 | 0.15 | 0.00517 | 7 | 1109 | 0.01 | 0.027 | 0 | 3 | 844 | 0.25 | 0.033 | 15 | 2 | 0.0362 | 85.0 | - | - | - | - | - |
| | DA-5B | 176 | 0.05 | 0.15 | - | - | - | - | - | - | - | 554 | 0.01 | 0.027 | 0 | 3 | 0.0036 | 85.0 | - | - | - | - | - |
| | DA-5C | 130 | 0.25 | 0.15 | 0.00199 | 5 | 427 | 0.01 | 0.027 | 0 | 3 | 370 | 0.25 | 0.033 | 15 | 2 | 0.0099 | 85.0 | - | - | - | - | - |
| | DA-5D | 242 | 0.05 | 0.15 | - | - | - | - | - | - | - | 491 | 0.01 | 0.027 | 0 | 3 | 0.0048 | 85.0 | - | - | - | - | - |
| | *DA-5E | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.0033 | 85.0 | 96 | 0.0100 | 0.15 | 10.87 | 7 |

**Total Area =** **0.32 sq. miles**
**Waste Diposal Total Area =** **205 acres**

**Note:**
1. *, Drainage areas indicated with an asterisk, include areas modeled using the Velocity method, as described in Attachment 6A, Section 2.2.
1. **, Drainage area DA-1E indicated with two asterisks, open channel was included into lag time calculation.

| Open Channel Flow | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Surface Description | Length | Slope (ft/ft) | Manning n | Cross-sectional Area | Wetted Perimeter | Hydraulic Radius | Avg. Velocity | Channel Flow $T_c$ |
| | (feet) | (ft/ft) | | (ft2) | (ft) | (ft) | (ft/s) | (min) |
| Grass | 1006 | 0.013 | 0.027 | 5.8 | 9.0 | 0.6 | 4.6 | 4 |

| | a (ft) | d (ft) | left slope (%) | right slope (%) | Area (ft2) | Wetted P (ft) |
|---|---|---|---|---|---|---|
| DA-1E | 2.85 | 1.0 | 32.0 | 37.0 | 5.8 | 9.0 |

**CITY OF WACO LANDFILL**
**VELOCITY METHOD INPUT PARAMETERS**
**- POST-DEVELOPMENT CONDITIONS -**

2-yr, 24-hr Rainfall Depth = 4.25 imches

| Discharge Study Point | Contributing Drainage Areas | Area (sq. mi.) | Curve Number (CN) | Sheet Flow | | | | Shallow Concentrated Flow | | | | Open Channel Flow | | | | | | | | Time of Concentration (Tc) | | | | Total Lag Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Surface Description | Length | Slope | Manning n | Surface Description | Length | Slope | Avg. Velocity | Surface Description | Length | Slope (ft/ft) | Manning n | Cross-sectional Area | Wetted Perimeter | Hydraulic Radius | Avg. Velocity | Sheet Flow $T_c$ | Shallow Concentrated Flow $T_c$ | Channel Flow $T_c$ | Total $T_c$ | |
| | | | | | (feet) | (ft/ft) | | | (feet) | (ft/ft) | (ft/s) | | (feet) | (ft/ft) | | (ft2) | (ft) | (ft) | (ft/s) | (min) | (min) | (min) | (min) | (min) |
| **POD-1** | PRE-1R | 0.0149 | 74.7 | Grass | 262 | 0.021 | 0.15 | - | - | - | - | Grass | 472 | 0.028 | 0.027 | 5.8 | 9.0 | 0.6 | 6.9 | 18 | - | 1 | 19 | 11 |
| | OS-5 | 0.0131 | 80.0 | Grass | 300 | 0.008 | 0.15 | Grass | 2149 | 0.010 | 0.7 | - | - | - | - | - | - | - | - | 29 | 51 | - | 81 | 48 |
| | EDA East | 0.0030 | 99.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| **POD-2** | PRE-2R | 0.0086 | 73.0 | Grass | 300 | 0.009 | 0.15 | - | - | - | - | - | - | - | - | - | - | - | - | 28 | - | - | 28 | 17 |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| **POD-3 & 4** | PRE-3R | 0.0207 | 73.0 | Grass | 300 | 0.014 | 0.15 | Grass | 1050 | 0.014 | 0.8 | - | - | - | - | - | - | - | - | 24 | 21 | - | 45 | 27 |
| | PRE-4R | 0.0056 | 73.0 | Grass | 300 | 0.013 | 0.15 | Grass | 172 | 0.017 | 0.9 | - | - | - | - | - | - | - | - | 24 | 3 | - | 27 | 16 |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| **POD-5 & 6** | PRE-5R | 0.0356 | 73.0 | Grass | 300 | 0.017 | 0.15 | Grass | 1302 | 0.017 | 0.9 | Grass | 760 | 0.013 | 0.027 | 5.1 | 10.5 | 0.5 | 3.8 | 22 | 24 | 3 | 49 | 29 |
| | PRE-6R | 0.0043 | 73.0 | Grass | 300 | 0.007 | 0.15 | Grass | 458 | 0.009 | 0.7 | - | - | - | - | - | - | - | - | 31 | 12 | - | 43 | 26 |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| **POD-7** | PRE-7R | 0.0226 | 73.0 | Grass | 300 | 0.028 | 0.15 | Grass | 1416 | 0.010 | 0.7 | - | - | - | - | - | - | - | - | 18 | 34 | - | 52 | 31 |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| **POD-8** | PRE-8ABR | 0.0847 | 73.8 | Grass | 300 | 0.005 | 0.15 | Grass | - | - | - | Grass | 3100 | 0.001 | 0.027 | 22.7 | 15.3 | 1.5 | 2.3 | 36 | - | 23 | 59 | 35 |
| | PRE-8CR | 0.1912 | 73.1 | - | - | - | - | Grass | 613 | 0.018 | 0.9 | Grass | 8832 | 0.001 | 0.027 | 40.6 | 24.3 | 1.7 | 2.9 | - | 11 | 51 | 62 | 37 |
| | PRE-8DR | 0.0325 | 73.7 | Grass | 300 | 0.010 | 0.15 | Grass | 1501 | 0.012 | 0.8 | - | - | - | - | - | - | - | - | 27 | 33 | - | 60 | 36 |
| | OS-1 | 1.5800 | 79.7 | Grass | 300 | 0.013 | 0.15 | Grass | 2460 | 0.013 | 0.8 | Grass | 11834 | 0.006 | 0.027 | 137.1 | 110.4 | 1.2 | 5.1 | 24 | 52 | 39 | 115 | 69 |
| | OS-2 | 0.0580 | 80.0 | Grass | 300 | 0.017 | 0.15 | Grass | 1133 | 0.016 | 0.9 | Grass | 920 | 0.011 | 0.027 | 6.8 | 9.3 | 0.7 | 4.6 | 22 | 22 | 3 | 47 | 28 |
| | OS-3 | 0.0233 | 80.0 | Grass | 300 | 0.005 | 0.15 | Grass | 611 | 0.015 | 0.8 | - | - | - | - | - | - | - | - | 37 | 12 | - | 49 | 29 |
| | EDA WEST | 0.0120 | 99.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| | WDA | 0.0100 | 99.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| **POD-9** | PRE-9R | 0.0029 | 73.0 | Grass | 300 | 0.002 | 0.15 | Grass | 164 | 0.004 | 0.5 | - | - | - | - | - | - | - | - | 48 | 6 | - | 54 | 33 |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| **POD-10** | PRE-10AR | 0.0016 | 80.0 | Grass | 300 | 0.014 | 0.15 | Grass | 678 | 0.008 | 0.6 | - | - | - | - | - | - | - | - | 23 | 18 | - | 42 | 25 |
| | PRE-10BR | 0.0032 | 80.0 | Grass | 300 | 0.007 | 0.15 | Grass | 946 | 0.009 | 0.7 | - | - | - | - | - | - | - | - | 32 | 23 | - | 55 | 33 |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| **POD-11** | PRE-11R | 0.0100 | 80.0 | Grass | 300 | 0.015 | 0.15 | Grass | 516 | 0.021 | 1.0 | - | - | - | - | - | - | - | - | 23 | 9 | - | 31 | 19 |

Channel Section:

**Total Area = 2.15 sq. miles**
**Total Area = 1374 acres**
**Permit Property Total Area = 293 acres**

| | a (ft) | d (ft) | left slope (%) | right slope (%) | Area (ft2) | Wetted P (ft) | 2-year, 24 hour | | |
|---|---|---|---|---|---|---|---|---|---|
| PRE-1R Channel Section: | 2.85 | 1.0 | 32.0 | 37.0 | 5.8 | 9.0 | Q2yr : | 16.9 | cfs |
| PRE-5R Channel Section: | 3.19 | 0.8 | 15.5 | 31.0 | 5.1 | 10.5 | Q2yr: | 16.2 | cfs |
| PRE-8ABR Channel Section | 2.75 | 2.5 | 54.0 | 32.0 | 22.7 | 15.3 | Q2 yr: | 44.2 | cfs |
| PRE-8CR Channel Section: | 4.65 | 2.9 | 22.5 | 50.0 | 40.6 | 24.3 | Q2 yr: | 94.5 | cfs |
| OS-1 Channel Section: | 42.00 | 1.8 | 7.7 | 4.0 | 137.1 | 110.4 | Q2 yr: | 710.3 | cfs |
| OS-2 Channel Section: | 0.75 | 1.6 | 27.1 | 85.1 | 6.8 | 9.3 | Q2 yr: | 44.6 | cfs |

**Note:**
1. Drainage Areas Pre-10A, Pre-10B, and Pre-11 were not included in the HEC-HMS Model due to the following: (1) these areas will not be disturbed during development of the landfill; and (2) these areas due not contribute run-on/runoff to the post-development perimeter

**Methodology:**

Reference: United States Department of Agriculture. Hydrology National Engineering Handbook, Part 630 (May 2010). Chapter 15, Time of Concentration.

Sheet Flow $T_c$

$$T_t = \frac{0.007(nl)^{0.8}}{(P_2)^{0.5} S^{0.4}} \quad \text{(eq. 15-8)}$$

where:

$T_t$ = travel time, h
n = Manning's roughness coefficient (0.15, short-grass prairie)
l = sheet flow length, ft
$P_2$ = 2-year, 24-hour rainfall, in (4.25 inches)
S = slope of land surface, ft/ft

Shallow Concentrated Flow $T_c$

$$V = 6.962\ (s)^{0.5}$$

where:

V = Average velocity, ft/s
s = slope of the hydraulic grade line, ft/ft

(Table 15-3 for Short-grass pasture flow type )

Channel Flow $T_c$

$$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n} \quad \text{(eq. 15-10)}$$

where:

V = Average velocity, ft/s
r = hydraulic radius, ft

$$= \frac{a}{P_w}$$

a = cross-sectional flow area, ft2
$P_w$ = Wetted perimeter, ft
s = slope of the hydraulic grade line, ft/ft
n = Manning's n value for open channel flow (0.027, grass)

Lag time

$$V = 0.6\, T_c \quad \text{(eq. 15-3)}$$

where:

L = lag, h
$T_c$ = time of concentration, h

# POST-DEVELOPMENT PERIMETER DRAINAGE CHANNELS

| Channel Name | Receiving Basin | Receiving POD | Channel Length (ft) | Bottom Slope (ft/ft) | Bottom Width (ft) | Sideslope (XH:1V) | Mannings Coefficient | Lining Material |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 1A1 | EDA EAST BASIN | POD 1 | 404 | 0.0100 | 5 | 3 | 0.027 | Grass |
| 1A2 | EDA EAST BASIN | POD 1 | 1,274 | 0.0080 | 5 | 3 | 0.027 | Grass |
| 1A3 | EDA EAST BASIN | POD 1 | 348 | 0.0025 | 10 | 3 | 0.027 | Grass |
| 1A4 | EDA EAST BASIN | POD 1 | 711 | 0.0220 | 10 | 3 | 0.033 | TRM/Rip Rap |
| | | | | | | | | |
| 2A1 | EDA WEST BASIN | POD 8 | 223 | 0.0225 | 10 | 3 | 0.033 | TRM/Rip Rap |
| 2A2 | EDA WEST BASIN | POD 8 | 818 | 0.0070 | 10 | 3 | 0.027 | Grass |
| 2A3 | EDA WEST BASIN | POD 8 | 762 | 0.0225 | 10 | 3 | 0.033 | TRM/Rip Rap |
| 2A4 | EDA WEST BASIN | POD 8 | 1,159 | 0.0025 | 10 | 3 | 0.027 | Grass |
| 2A5 | EDA WEST BASIN | POD 8 | 852 | 0.0025 | 10 | 3 | 0.027 | Grass |
| | | | | | | | | |
| 3A1 | EDA WEST BASIN | POD 8 | 2,037 | 0.0025 | 10 | 3 | 0.027 | Grass |
| | | | | | | | | |
| 4A1 | WDA BASIN | POD 8 | 434 | 0.0025 | 5 | 3 | 0.027 | Grass |
| 4A2 | WDA BASIN | POD 8 | 416 | 0.0300 | 5 | 3 | 0.027 | Grass |
| 4A3 | WDA BASIN | POD 8 | 338 | 0.0150 | 10 | 3 | 0.033 | TRM/Rip Rap |
| 4A4 | WDA BASIN | POD 8 | 1,636 | 0.0060 | 10 | 3 | 0.027 | Grass |
| 4A5 | WDA BASIN | POD 8 | 240 | 0.0025 | 10 | 3 | 0.027 | Grass |
| | | | | | | | | |
| 4B1 | WDA BASIN | POD 8 | 448 | 0.0060 | 5 | 3 | 0.027 | Grass |
| 4B2 | WDA BASIN | POD 8 | 104 | 0.0190 | 5 | 3 | 0.027 | Grass |
| 4B3 | WDA BASIN | POD 8 | 714 | 0.0070 | 10 | 3 | 0.027 | Grass |
| 4B4 | WDA BASIN | POD 8 | 341 | 0.0100 | 10 | 3 | 0.027 | Grass |
| 4B5 | WDA BASIN | POD 8 | 699 | 0.0065 | 10 | 3 | 0.027 | Grass |
| 4B6 | WDA BASIN | POD 8 | 495 | 0.0090 | 10 | 3 | 0.027 | Grass |
| 4B7 | WDA BASIN | POD 8 | 245 | 0.0090 | 10 | 3 | 0.033 | TRM/Rip Rap |
| 4B8 | WDA BASIN | POD 8 | 1,406 | 0.0025 | 11 | 3 | 0.027 | Grass |

Note: TRM = Turf Reinforcing Mat, a permanent reinforcing mat placed below vegetation layer to increase resistance to erosion.

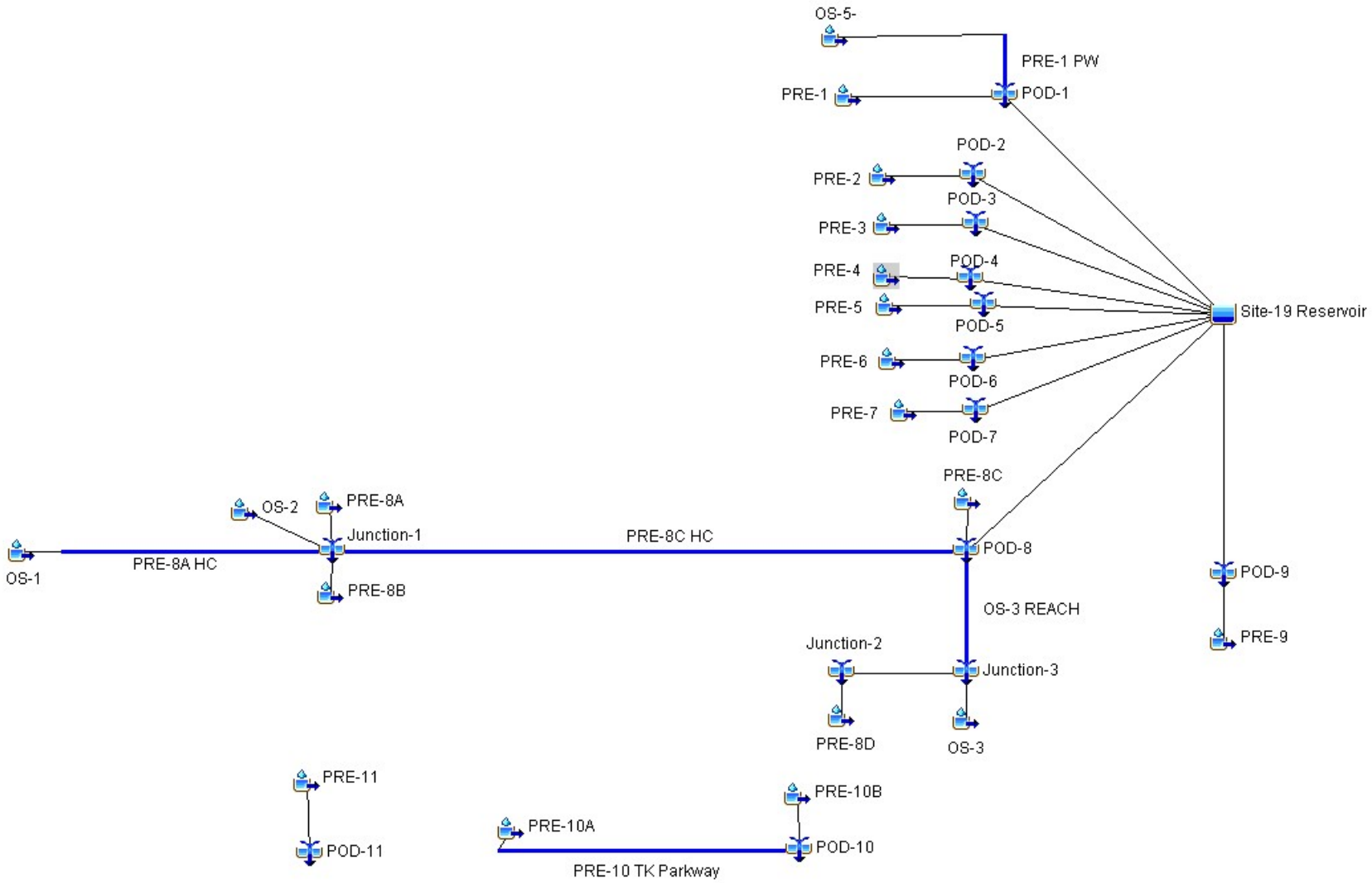
# APPENDIX 6A-B

# HEC-HMS PRE-DEVELOPMENT INPUT/OUTPUT FILES

**SCS Engineers**
**TBPE Reg. # F-3407**

**Inclusive of pages 6A-B-1 to 6A-B-61**

**CITY OF WACO LANDFILL**
**HEC-HMS INPUT SCHEMATIC**
**PRE-DEVELOPMENT CONDITIONS**



# PRE-DEVELOPMENT INPUT FILES

```
Basin: Pre-Development
     Last Modified Date: 29 September 2020
     Last Modified Time: 23:45:09
     Version: 4.0
     Filepath Separator: \
     Unit System: English
     Missing Flow To Zero: No
     Enable Flow Ratio: No
     Compute Local Flow At Junctions: No

     Enable Sediment Routing: No

     Enable Quality Routing: No
End:

Subbasin: OS-1
     Canvas X: -11792.89026275116
     Canvas Y: 46.367851622875605
     Area: 1.58
     Downstream: PRE-8A HC

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 79.7

     Transform: SCS
     Lag: 69
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Reach: PRE-8A HC
     Canvas X: -6537.867078825348
     Canvas Y: -602.782071097372
     From Canvas X: -10494.590417310661
     From Canvas Y: -602.7820710973729
     Label X: -61.0
     Label Y: -12.0
     Downstream: Junction-1

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 3400
     Energy Slope: 0.001
```

```
     Width: 33
     Side Slope: 2.33
     Mannings n: 0.03
     Use Variable Time Step: No
     Channel Loss: None
End:

Subbasin: PRE-8A
     Canvas X: -6461.380716767375
     Canvas Y: 1118.5989395770412
     Area: 0.0873
     Downstream: Junction-1

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73.8

     Transform: SCS
     Lag: 35
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Subbasin: OS-2
     Canvas X: -8404.210453927497
     Canvas Y: -1972.2665513595166
     Area: 0.058
     Downstream: Junction-1

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 80

     Transform: SCS
     Lag: 28
     Unitgraph Type: STANDARD

     Baseflow: None
End:
```

```
Subbasin: PRE-8B
     Canvas X: -6255.323017371606
     Canvas Y: -1942.829737160122
     Area: 0.0510
     Downstream: Junction-1

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 77.4

     Transform: SCS
     Lag: 39
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: Junction-1
     Canvas X: -6537.867078825348
     Canvas Y: -602.782071097372
     Downstream: PRE-8C HC
End:

Reach: PRE-8C HC
     Canvas X: 6012.364760432767
     Canvas Y: -1313.755795981453
     From Canvas X: -6537.867078825348
     From Canvas Y: -602.782071097372
     Label X: -30.0
     Label Y: 9.0
     Downstream: POD-8

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 8902
     Energy Slope: 0.001
     Width: 28.8
     Side Slope: 2.33
     Mannings n: 0.03
     Use Variable Time Step: No
     Channel Loss: None
End:

Subbasin: PRE-8C
```

```
     Canvas X: 6043.276661514687
     Canvas Y: -448.22256568778903
     Label X: -72.0
     Label Y: -4.0
     Area: 0.3085
     Downstream: POD-8

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73.1

     Transform: SCS
     Lag: 60
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Subbasin: PRE-8D
     Canvas X: 3323.0293663060293
     Canvas Y: -6383.307573415765
     Area: 0.0770
     Downstream: Junction-2

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 74.8

     Transform: SCS
     Lag: 34
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: Junction-2
     Canvas X: 3415.7650695517805
     Canvas Y: -4992.27202472952
     Downstream: Junction-3
End:
```

```
Subbasin: OS-3
     Canvas X: 5950.540958268935
     Canvas Y: -6476.043276661514
     Area: 0.024
     Downstream: Junction-3

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 80

     Transform: SCS
     Lag: 29
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: Junction-3
     Canvas X: 5919.6290571870195
     Canvas Y: -4992.27202472952
     Downstream: OS-3 REACH
End:

Reach: OS-3 REACH
     Canvas X: 6012.364760432767
     Canvas Y: -1313.755795981453
     From Canvas X: 5919.6290571870195
     From Canvas Y: -4992.27202472952
     Downstream: POD-8

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 2039
     Energy Slope: 0.0030
     Width: 5
     Side Slope: 10
     Mannings n: 0.03
     Use Variable Time Step: No
     Channel Loss: None
End:

Junction: POD-8
     Canvas X: 6012.364760432767
     Canvas Y: -1313.755795981453
```

```
     Downstream: Site-19 Reservoir
End:

Subbasin: PRE-1
     Canvas X: 3519.037333836861
     Canvas Y: 6583.142084592149
     Area: 0.1022
     Downstream: POD-1

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 75.3

     Transform: SCS
     Lag: 39
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Subbasin: OS-5
     Canvas X: 4241.577318731119
     Canvas Y: 8188.786495468284
     Area: 0.013
     Downstream: PRE-1 PW

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 80

     Transform: SCS
     Lag: 48
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Reach: PRE-1 PW
     Canvas X: 6676.804675226589
     Canvas Y: 6556.38134441088
```

```
     From Canvas X: 6757.086895770395
     From Canvas Y: 7814.136132930518
     Downstream: POD-1

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 2364
     Energy Slope: 0.011
     Width: 38.9
     Side Slope: 4.44
     Mannings n: 0.03
     Use Variable Time Step: No
     Channel Loss: None
End:

Junction: POD-1
     Canvas X: 6676.804675226589
     Canvas Y: 6556.38134441088
     Downstream: Site-19 Reservoir
End:

Subbasin: PRE-5
     Canvas X: 4374.03400309119
     Canvas Y: 2272.0247295208665
     Label X: -69.0
     Label Y: -4.0
     Area: 0.0422
     Downstream: POD-5

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73

     Transform: SCS
     Lag: 39
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-5
     Canvas X: 6136.012364760434
     Canvas Y: 2055.641421947451
     Downstream: Site-19 Reservoir
End:
```

```
Subbasin: PRE-2
     Canvas X: 3252.7679690332334
     Canvas Y: 5445.810626888221
     Label X: -78.0
     Label Y: -5.0
     Area: 0.0248
     Downstream: POD-2

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73

     Transform: SCS
     Lag: 29
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-2
     Canvas X: 6059.654631083202
     Canvas Y: 4976.4521193092605
     Label X: -1.0
     Label Y: -1.0
     Downstream: Site-19 Reservoir
End:

Subbasin: PRE-3
     Canvas X: 4374.03400309119
     Canvas Y: 3879.4435857805265
     Label X: -67.0
     Label Y: 1.0
     Area: 0.0235
     Downstream: POD-3

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73
```

```
     Transform: SCS
     Lag: 31
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-3
     Canvas X: 5888.717156105104
     Canvas Y: 3724.8840803709436
     Downstream: Site-19 Reservoir
End:

Subbasin: PRE-7
     Canvas X: 4404.94590417311
     Canvas Y: 46.367851622875605
     Label X: -68.0
     Label Y: -4.0
     Area: 0.0233
     Downstream: POD-7

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73

     Transform: SCS
     Lag: 31
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-7
     Canvas X: 6012.364760432767
     Canvas Y: 200.92735703245853
     Downstream: Site-19 Reservoir
End:

Subbasin: PRE-4
     Canvas X: 4250.386398763527
     Canvas Y: 2952.086553323031
     Label X: -68.0
     Label Y: 2.0
     Area: 0.0056
     Downstream: POD-4
```

```
     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73

     Transform: SCS
     Lag: 13
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-4
     Canvas X: 5857.805255023184
     Canvas Y: 2982.9984544049466
     Downstream: Site-19 Reservoir
End:

Subbasin: PRE-6
     Canvas X: 4343.122102009274
     Canvas Y: 1406.4914992272043
     Label X: -67.0
     Label Y: -4.0
     Area: 0.0043
     Downstream: POD-6

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73

     Transform: SCS
     Lag: 26
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-6
     Canvas X: 5981.452859350851
     Canvas Y: 1375.5795981452866
```

```
     Downstream: Site-19 Reservoir
End:

Subbasin: PRE-9
     Canvas X: 11112.828438948996
     Canvas Y: -4497.6816074188555
     Area: 0.0029
     Downstream: POD-9

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73

     Transform: SCS
     Lag: 33
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-9
     Canvas X: 11051.004636785165
     Canvas Y: -3013.9103554868616
     Downstream: Site-19 Reservoir
End:

Reservoir: Site-19 Reservoir
     Canvas X: 11078.880026809653
     Canvas Y: 2178.486595174264

     Route: Modified Puls
     Routing Curve: Elevation-Area-Outflow
     Initial Elevation: 520.69
     Elevation-Area Table: Site 19 Reservoir
     Elevation-Outflow Table: Site 19 Reservoir
     Primary Table: Elevation-Outflow
End:

Subbasin: PRE-11
     Canvas X: -7275.352395672336
     Canvas Y: -7176.199381761979
     Label X: -1.0
     Label Y: 1.0
     Area: 0.0104
     Downstream: POD-11
```

```
     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 80

     Transform: SCS
     Lag: 19
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-11
     Canvas X: -7217.928902627511
     Canvas Y: -8639.876352395671
End:

Subbasin: PRE-10B
     Canvas X: 2550.2318392581146
     Canvas Y: -7434.312210200927
     Area: 0.0135
     Downstream: POD-10

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 79.6

     Transform: SCS
     Lag: 35
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Subbasin: PRE-10A
     Canvas X: -3508.500772797526
     Canvas Y: -7743.431221020093
     Area: 0.0085
     Downstream: PRE-10 TK Parkway
```

```
     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 80

     Transform: SCS
     Lag: 10
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Reach: PRE-10 TK Parkway
     Canvas X: 2581.1437403400305
     Canvas Y: -8547.140649149924
     From Canvas X: -3477.5888717156104
     From Canvas Y: -8330.757341576505
     Label X: -69.0
     Label Y: -18.0
     Downstream: POD-10

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 1215.664
     Energy Slope: 0.008
     Width: 17.8
     Side Slope: 0.12
     Mannings n: 0.03
     Use Variable Time Step: No
     Channel Loss: None
End:

Junction: POD-10
     Canvas X: 2581.1437403400305
     Canvas Y: -8547.140649149924
End:

Basin Schematic Properties:
     Last View N: 5000.0
     Last View S: -5000.0
     Last View W: -5000.0
     Last View E: 5000.0
     Maximum View N: 5000.0
     Maximum View S: -5000.0
     Maximum View W: -5000.0
     Maximum View E: 5000.0
```

```
     Extent Method: Elements
     Buffer: 0
     Draw Icons: Yes
     Draw Icon Labels: Name
     Draw Map Objects: No
     Draw Gridlines: No
     Draw Flow Direction: No
     Fix Element Locations: No
     Fix Hydrologic Order: No
End:
```

# PRE-DEVELOPMENT OUTPUT FILES

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (pre)

Start of Run: 02Oct2018, 00:00 Basin Model: Pre-Development
End of Run: 04Oct2018, 00:00 Meteorologic Model: 25-year, 24-hour
Compute Time: 30Sep2020, 10:47:32 Control Specifications: 48-HOUR

| Hydrologic Element | Drainage Area (MI2) | Peak Discharge (CFS) | Time of Peak | Volume (AC-FT) |
|---|---|---|---|---|
| OS-1 | 1.58 | 1709.8 | 02Oct2018, 13:10 | 463.2 |
| PRE-8A HC | 1.58 | 1677.8 | 02Oct2018, 13:20 | 462.5 |
| PRE-8A | 0.0873 | 123.7 | 02Oct2018, 12:40 | 22.4 |
| OS-2 | 0.058 | 104.2 | 02Oct2018, 12:30 | 17.1 |
| PRE-8B | 0.0510 | 73.6 | 02Oct2018, 12:40 | 14.2 |
| Junction-1 | 1.7763 | 1820.9 | 02Oct2018, 13:20 | 516.3 |
| PRE-8C HC | 1.7763 | 1729.7 | 02Oct2018, 13:40 | 514.5 |
| PRE-8CR | 0.3085 | 314.9 | 02Oct2018, 13:10 | 77.9 |
| PRE-8D | 0.0770 | 113.1 | 02Oct2018, 12:40 | 20.2 |
| Junction-2 | 0.0770 | 113.1 | 02Oct2018, 12:40 | 20.2 |
| OS-3 | 0.024 | 42.3 | 02Oct2018, 12:30 | 7.0 |
| Junction-3 | 0.1010 | 153.7 | 02Oct2018, 12:40 | 27.3 |
| OS-3 REACH | 0.1010 | 150.6 | 02Oct2018, 12:50 | 27.4 |
| POD-8 | 2.1858 | 2030.2 | 02Oct2018, 13:40 | 619.7 |
| PRE-1 | 0.1022 | 140.7 | 02Oct2018, 12:40 | 27.2 |
| OS-5- | 0.013 | 17.7 | 02Oct2018, 12:50 | 3.8 |
| PRE-1 PW | 0.013 | 17.4 | 02Oct2018, 13:10 | 3.8 |
| POD-1 | 0.1152 | 153.9 | 02Oct2018, 12:50 | 31.0 |
| PRE-5 | 0.0422 | 55.0 | 02Oct2018, 12:40 | 10.6 |
| POD-5 | 0.0422 | 55.0 | 02Oct2018, 12:40 | 10.6 |
| PRE-2 | 0.0248 | 37.5 | 02Oct2018, 12:30 | 6.2 |
| POD-2 | 0.0248 | 37.5 | 02Oct2018, 12:30 | 6.2 |
| PRE-3 | 0.0235 | 34.2 | 02Oct2018, 12:40 | 5.9 |
| POD-3 | 0.0235 | 34.2 | 02Oct2018, 12:40 | 5.9 |
| PRE-7 | 0.0233 | 33.9 | 02Oct2018, 12:40 | 5.9 |
| POD-7 | 0.0233 | 33.9 | 02Oct2018, 12:40 | 5.9 |
| PRE-4 | 0.0056 | 11.2 | 02Oct2018, 12:20 | 1.4 |
| POD-4 | 0.0056 | 11.2 | 02Oct2018, 12:20 | 1.4 |
| PRE-6 | 0.0043 | 6.9 | 02Oct2018, 12:30 | 1.1 |
| POD-6 | 0.0043 | 6.9 | 02Oct2018, 12:30 | 1.1 |
| PRE-9 | 0.0029 | 4.1 | 02Oct2018, 12:40 | 0.7 |

| Hydrologic Element | Drainage Area (MI2) | Peak Discharge (CFS) | Time of Peak | Volume (AC-FT) |
|---|---|---|---|---|
| POD-9 | 0.0029 | 4.1 | 02Oct2018, 12:40 | 0.7 |
| Site-19 Reservoir | 2.4276 | 66.6 | 03Oct2018, 01:40 | 176.5 |
| PRE-10B | 0.0135 | 21.6 | 02Oct2018, 12:40 | 3.9 |
| PRE-10A | 0.0085 | 21.2 | 02Oct2018, 12:10 | 2.5 |
| PRE-11 TK Parkway | 0.0085 | 20.0 | 02Oct2018, 12:20 | 2.5 |
| POD-10 | 0.0220 | 36.9 | 02Oct2018, 12:30 | 6.5 |
| PRE-11 | 0.0104 | 21.9 | 02Oct2018, 12:20 | 3.1 |
| POD-11 | 0.0104 | 21.9 | 02Oct2018, 12:20 | 3.1 |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (pre)
Reservoir: Site-19 Reservoir

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | Pre-Development |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 12:02:00 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Inflow: | 2169.9 (CFS) | Date/Time of Peak Inflow: | 02Oct2018, 13:30 |
| Peak Discharge: | 66.6 (CFS) | Date/Time of Peak Discharge: | 03Oct2018, 01:40 |
| Inflow Volume: | 682.6 (AC-FT) | Peak Storage: | 615.2 (AC-FT) |
| Discharge Volume: | 176.5 (AC-FT) | Peak Elevation: | 523.2 (FT) |

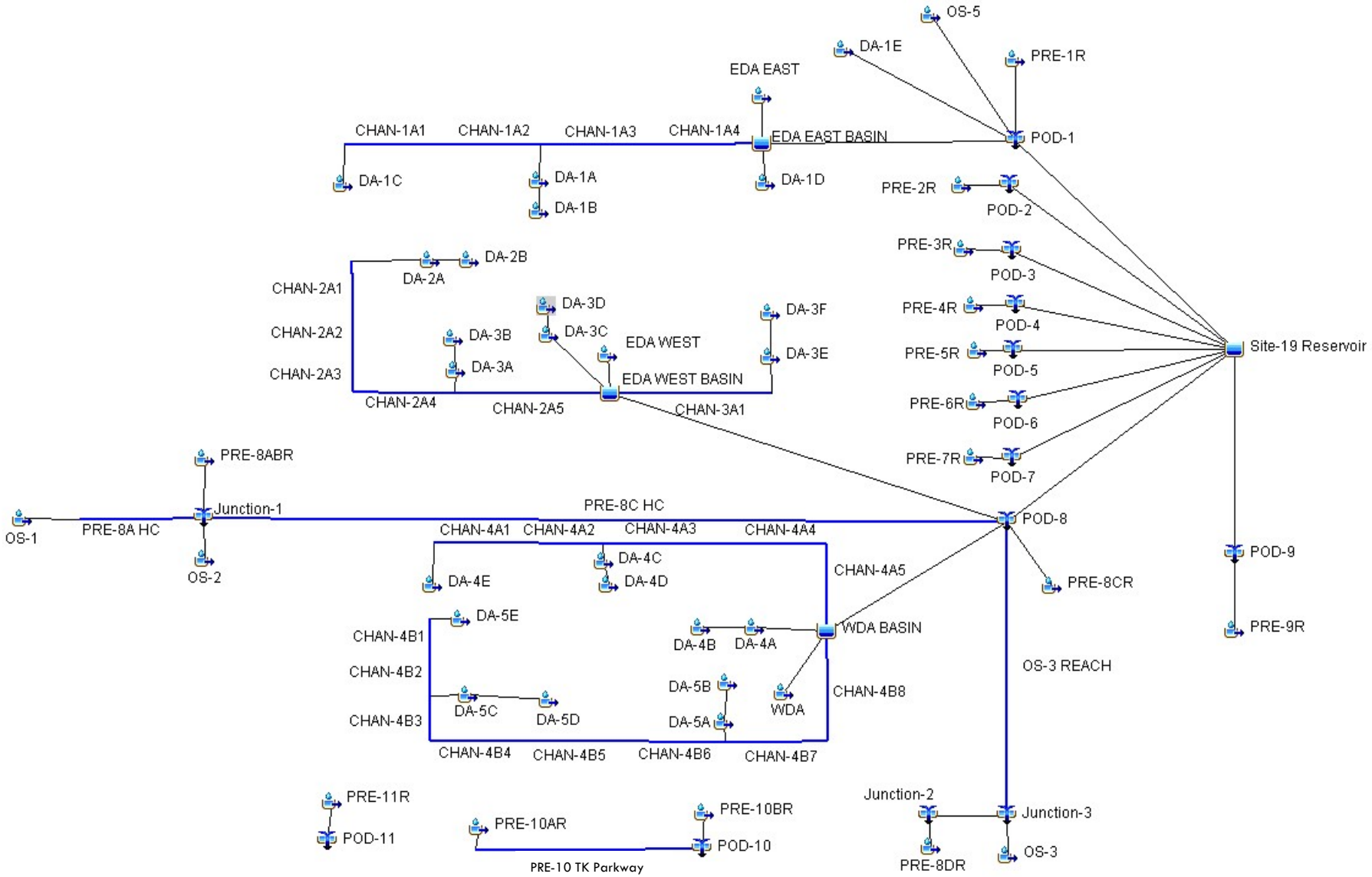
# APPENDX 6A-C

# HEC-HMS POST-DEVELOPMENT INPUT/OUTPUT FILES

**SCS Engineers**
**TBPE Reg. # F-3407**

**Inclusive of pages 6A-C-1 to 6A-C-141**

**CITY OF WACO LANDFILL**
**HEC-HMS INPUT SCHEMATIC**
**PRE-DEVELOPMENT CONDITIONS**



# HEC-HMS POST-DEVELOPMENT INPUT FILES FOR EDA WEST BASIN, EDA EAST BASIN, & WDA BASIN / POD-1, POD-2, POD-3, POD-4, POD-5, POD-6, POD-7, POD-8, POD-9, POD-10, & POD-11

```
Basin: POST DEVELOPMENT
     Last Modified Date: 29 September 2020
     Last Modified Time: 21:39:14
     Version: 4.0
     Filepath Separator: \
     Unit System: English
     Missing Flow To Zero: No
     Enable Flow Ratio: No
     Compute Local Flow At Junctions: No

     Enable Sediment Routing: No

     Enable Quality Routing: No
End:

Subbasin: OS-1
     Canvas X: -15271.903323262839
     Canvas Y: -1933.5347432024173
     Label X: -27.0
     Label Y: -19.0
     Area: 1.57999
     Downstream: PRE-8A HC

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 79.7

     Transform: SCS
     Lag: 69
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Reach: PRE-8A HC
     Canvas X: -11314.199395770393
     Canvas Y: -1933.5347432024173
     From Canvas X: -14029.333619727578
     From Canvas Y: -1962.2986874115732
     Label X: -61.0
     Label Y: -12.0
     Downstream: Junction-1

     Route: Muskingum Cunge
     Channel: Trapezoid
```

```
     Length: 558
     Energy Slope: 0.0912
     Width: 33
     Side Slope: 0.12
     Mannings n: 0.03
     Use Variable Time Step: No
     Channel Loss: None
End:

Subbasin: PRE-8ABR
     Canvas X: -11283.987915407855
     Canvas Y: -634.4410876132933
     Area: 0.0847
     Downstream: Junction-1

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73.8

     Transform: SCS
     Lag: 35
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Subbasin: OS-2
     Canvas X: -11283.987915407855
     Canvas Y: -2839.8791540785514
     Label X: -27.0
     Label Y: -18.0
     Area: 0.058
     Downstream: Junction-1

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 80

     Transform: SCS
     Lag: 28
```

```
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: Junction-1
     Canvas X: -11314.199395770393
     Canvas Y: -1933.5347432024173
     Label X: -4.0
     Label Y: 5.0
     Downstream: PRE-8C HC
End:

Reach: PRE-8C HC
     Canvas X: 6268.882175226587
     Canvas Y: -2024.169184290031
     From Canvas X: -11314.199395770393
     From Canvas Y: -1933.5347432024173
     Label X: -30.0
     Label Y: 9.0
     Downstream: POD-8

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 10612
     Energy Slope: 0.0048
     Width: 28.8
     Side Slope: 0.21
     Mannings n: 0.03
     Use Variable Time Step: No
     Channel Loss: None
End:

Subbasin: PRE-8CR
     Canvas X: 7265.861027190334
     Canvas Y: -3413.8972809667684
     Area: 0.1912
     Downstream: POD-8

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73.1

     Transform: SCS
     Lag: 37
```

```
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Subbasin: DA-3B
     Canvas X: -5845.921450151056
     Canvas Y: 1993.9577039274918
     Area: 0.0040
     Downstream: DA-3A

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 179
     Plane 1 Slope: 0.05
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: Main
     Channel Length: 808
     Channel Slope: 0.01
     Channel Mannings N: 0.027
     Shape: Triangle
     Channel Side Slope: 3
     Channel Number of Steps: 5

     Baseflow: None
End:

Subbasin: DA-3A
     Canvas X: -5785.4984894259815
     Canvas Y: 1299.093655589124
     Area: 0.037
     Downstream: CHAN-2A5

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None
```

```
     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 130
     Plane 1 Slope: 0.25
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: 2
     Collector Length: 793
     Collector Slope: 0.01
     Collector Mannings N: 0.027
     Shape: Triangle
     Collector Side Slope: 3
     Collector Area: 0.00370
     Collector Number of Steps: 5

     Channel: Main
     Channel Length: 634
     Channel Slope: 0.25
     Channel Mannings N: 0.033
     Shape: Trapezoid
     Channel Width: 15
     Channel Side Slope: 2
     Channel Number of Steps: 5
     Route Upstream: Yes

     Baseflow: None
End:

Subbasin: DA-2B
     Canvas X: -5483.383685800603
     Canvas Y: 3716.0120845921447
     Area: 0.0030
     Downstream: DA-2A

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85
```

```
     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 117
     Plane 1 Slope: 0.05
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: Main
     Channel Length: 496
     Channel Slope: 0.01
     Channel Mannings N: 0.027
     Shape: Triangle
     Channel Side Slope: 3
     Channel Number of Steps: 5

     Baseflow: None
End:

Subbasin: DA-2A
     Canvas X: -6359.5166163141985
     Canvas Y: 3716.0120845921447
     Label X: -35.0
     Label Y: -18.0
     Area: 0.0282
     Downstream: CHAN-2A1

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 130
     Plane 1 Slope: 0.25
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: 2
     Collector Length: 757
     Collector Slope: 0.01
```

```
     Collector Mannings N: 0.027
     Shape: Triangle
     Collector Side Slope: 3
     Collector Area: 0.00342
     Collector Number of Steps: 5

     Channel: Main
     Channel Length: 950
     Channel Slope: 0.25
     Channel Mannings N: 0.033
     Shape: Trapezoid
     Channel Width: 15
     Channel Side Slope: 2
     Channel Number of Steps: 5
     Route Upstream: Yes

     Baseflow: None
End:

Reach: CHAN-2A1
     Canvas X: -8055.4539426682295
     Canvas Y: 2585.8946940795768
     From Canvas X: -8074.1556428227905
     From Canvas Y: 3693.612863459985
     Label X: -78.0
     Label Y: -5.0
     Downstream: CHAN-2A2

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 223
     Energy Slope: 0.0225
     Width: 10
     Side Slope: 3
     Mannings n: 0.033
     Use Variable Time Step: No
     Channel Loss: None
End:

Reach: CHAN-2A2
     Canvas X: -8055.453942668231
     Canvas Y: 1681.0211667141384
     From Canvas X: -8055.4539426682295
     From Canvas Y: 2585.8946940795768
     Label X: -80.0
     Label Y: -3.0
     Downstream: CHAN-2A3

     Route: Muskingum Cunge
     Channel: Trapezoid
```

```
     Length: 818
     Energy Slope: 0.0075
     Width: 10
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
End:

Reach: CHAN-2A3
     Canvas X: -8055.4539426682295
     Canvas Y: 813.5374981905788
     From Canvas X: -8055.453942668231
     From Canvas Y: 1681.0211667141384
     Label X: -81.0
     Label Y: -4.0
     Downstream: CHAN-2A4

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 762
     Energy Slope: 0.0225
     Width: 10
     Side Slope: 3
     Mannings n: 0.033
     Use Variable Time Step: No
     Channel Loss: None
End:

Reach: CHAN-2A4
     Canvas X: -5807.27078031538
     Canvas Y: 800.7198784069633
     From Canvas X: -8055.4539426682295
     From Canvas Y: 813.5374981905788
     Label X: -44.0
     Label Y: -11.0
     Downstream: CHAN-2A5

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 1029
     Energy Slope: 0.0025
     Width: 10
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
End:

Reach: CHAN-2A5
```

```
     Canvas X: -2426.2734584450372
     Canvas Y: 804.289544235924
     From Canvas X: -5807.27078031538
     From Canvas Y: 800.7198784069633
     Label X: -45.0
     Label Y: -15.0
     Downstream: EDA WEST BASIN

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 852
     Energy Slope: 0.0025
     Width: 10
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
End:

Subbasin: DA-3D
     Canvas X: -3820.3753351206433
     Canvas Y: 2707.774798927614
     Area: 0.0040
     Downstream: DA-3C

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 161
     Plane 1 Slope: 0.05
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: Main
     Channel Length: 822
     Channel Slope: 0.01
     Channel Mannings N: 0.027
     Shape: Triangle
     Channel Side Slope: 3
     Channel Number of Steps: 5
```

```
     Baseflow: None
End:

Subbasin: DA-3C
     Canvas X: -3761.3293051359506
     Canvas Y: 2084.5921450151054
     Area: 0.0417
     Downstream: EDA WEST BASIN

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 130
     Plane 1 Slope: 0.25
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: 2
     Collector Length: 895
     Collector Slope: 0.01
     Collector Mannings N: 0.027
     Shape: Triangle
     Collector Side Slope: 3
     Collector Area: 0.00417
     Collector Number of Steps: 5

     Channel: Main
     Channel Length: 568
     Channel Slope: 0.25
     Channel Mannings N: 0.033
     Shape: Trapezoid
     Channel Width: 15
     Channel Side Slope: 2
     Channel Number of Steps: 5
     Route Upstream: Yes

     Baseflow: None
End:
```

```
Subbasin: DA-3F
     Canvas X: 1102.7190332326281
     Canvas Y: 2567.9758308157097
     Area: 0.0027
     Downstream: DA-3E

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 181
     Plane 1 Slope: 0.05
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: Main
     Channel Length: 866
     Channel Slope: 0.01
     Channel Mannings N: 0.027
     Shape: Triangle
     Channel Side Slope: 3
     Channel Number of Steps: 5

     Baseflow: None
End:

Subbasin: DA-3E
     Canvas X: 1102.7190332326281
     Canvas Y: 1601.2084592145002
     Area: 0.0333
     Downstream: CHAN-3A1

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85
```

```
     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 130
     Plane 1 Slope: 0.25
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: 2
     Collector Length: 789
     Collector Slope: 0.01
     Collector Mannings N: 0.027
     Shape: Triangle
     Collector Side Slope: 3
     Collector Area: 0.00371
     Collector Number of Steps: 5

     Channel: Main
     Channel Length: 693
     Channel Slope: 0.25
     Channel Mannings N: 0.033
     Shape: Trapezoid
     Channel Width: 15
     Channel Side Slope: 2
     Channel Number of Steps: 5
     Route Upstream: Yes

     Baseflow: None
End:

Reach: CHAN-3A1
     Canvas X: -2426.2734584450372
     Canvas Y: 804.289544235924
     From Canvas X: 1115.5050942093594
     From Canvas Y: 790.6848650286765
     Label X: -26.0
     Label Y: -16.0
     Downstream: EDA WEST BASIN

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 2037
     Energy Slope: 0.0025
     Width: 10
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
End:
```

```
Subbasin: EDA WEST
     Canvas X: -2453.083109919571
     Canvas Y: 1662.1983914209122
     Label X: 2.0
     Label Y: 7.0
     Area: 0.011
     Downstream: EDA WEST BASIN

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 99

     Transform: SCS
     Lag: 1
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Reservoir: EDA WEST BASIN
     Canvas X: -2426.2734584450372
     Canvas Y: 804.289544235924
     Label X: -3.0
     Label Y: 9.0
     Downstream: POD-8

     Route: Modified Puls
     Routing Curve: Elevation-Area-Outflow
     Initial Elevation: 530
     Elevation-Area Table: EDA WEST BASIN
     Elevation-Outflow Table: EDA WEST BASIN
     Primary Table: Elevation-Outflow
End:

Subbasin: DA-5B
     Canvas X: 166.16314199395856
     Canvas Y: -5528.700906344413
     Label X: -61.0
     Label Y: -6.0
     Area: 0.0036
     Downstream: DA-5A

     Canopy 1: None
     Plant Uptake Method: None
```

```
     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 176
     Plane 1 Slope: 0.05
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: Main
     Channel Length: 554
     Channel Slope: 0.01
     Channel Mannings N: 0.027
     Shape: Triangle
     Channel Side Slope: 3
     Channel Number of Steps: 5

     Baseflow: None
End:

Subbasin: DA-5A
     Canvas X: 75.52870090634678
     Canvas Y: -6404.833836858008
     Label X: -58.0
     Label Y: -3.0
     Area: 0.0362
     Downstream: CHAN-4B7

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 130
     Plane 1 Slope: 0.25
     Plane 1 Roughness: 0.15
```

```
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: 2
     Collector Length: 1109
     Collector Slope: 0.01
     Collector Mannings N: 0.027
     Shape: Triangle
     Collector Side Slope: 3
     Collector Area: 0.00517
     Collector Number of Steps: 5

     Channel: Main
     Channel Length: 844
     Channel Slope: 0.25
     Channel Mannings N: 0.033
     Shape: Trapezoid
     Channel Width: 15
     Channel Side Slope: 2
     Channel Number of Steps: 5
     Route Upstream: Yes

     Baseflow: None
End:

Subbasin: DA-5D
     Canvas X: -3761.3293051359506
     Canvas Y: -5921.450151057403
     Label X: -23.0
     Label Y: -19.0
     Area: 0.0048
     Downstream: DA-5C

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 242
     Plane 1 Slope: 0.05
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5
```

```
     Channel: Main
     Channel Length: 491
     Channel Slope: 0.01
     Channel Mannings N: 0.027
     Shape: Triangle
     Channel Side Slope: 3
     Channel Number of Steps: 5

     Baseflow: None
End:

Subbasin: DA-5C
     Canvas X: -5513.595166163141
     Canvas Y: -5800.604229607252
     Label X: -24.0
     Label Y: -16.0
     Area: 0.0099
     Downstream: CHAN-4B3

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 130
     Plane 1 Slope: 0.25
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: 2
     Collector Length: 427
     Collector Slope: 0.01
     Collector Mannings N: 0.027
     Shape: Triangle
     Collector Side Slope: 3
     Collector Area: 0.00199
     Collector Number of Steps: 5

     Channel: Main
     Channel Length: 370
     Channel Slope: 0.25
```

```
     Channel Mannings N: 0.033
     Shape: Trapezoid
     Channel Width: 15
     Channel Side Slope: 2
     Channel Number of Steps: 5
     Route Upstream: Yes

     Baseflow: None
End:

Subbasin: DA-5E
     Canvas X: -5694.864048338368
     Canvas Y: -4138.972809667675
     Area: 0.0033
     Downstream: CHAN-4B1

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: SCS
     Lag: 7
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Reach: CHAN-4B1
     Canvas X: -6341.149871356063
     Canvas Y: -4830.626825179659
     From Canvas X: -6341.149871356061
     From Canvas Y: -4129.597570940945
     Label X: -76.0
     Label Y: -4.0
     Downstream: CHAN-4B2

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 448
     Energy Slope: 0.006
     Width: 5
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
```

```
End:

Reach: CHAN-4B2
     Canvas X: -6341.149871356061
     Canvas Y: -5830.675537105955
     From Canvas X: -6341.149871356063
     From Canvas Y: -4830.626825179659
     Label X: -79.0
     Label Y: -2.0
     Downstream: CHAN-4B3

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 104
     Energy Slope: 0.0190
     Width: 5
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
End:

Reach: CHAN-4B3
     Canvas X: -6341.149871356063
     Canvas Y: -6819.1103302717165
     From Canvas X: -6341.149871356061
     From Canvas Y: -5830.675537105955
     Label X: -79.0
     Label Y: -5.0
     Downstream: CHAN-4B4

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 714
     Energy Slope: 0.007
     Width: 10
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
End:

Reach: CHAN-4B4
     Canvas X: -4339.492031546952
     Canvas Y: -6819.110330271726
     From Canvas X: -6341.149871356063
     From Canvas Y: -6819.1103302717165
     Label X: -43.0
     Label Y: -12.0
     Downstream: CHAN-4B5
```

```
     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 341
     Energy Slope: 0.01
     Width: 10
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
End:

Reach: CHAN-4B5
     Canvas X: -2124.206087123004
     Canvas Y: -6821.211592429854
     From Canvas X: -4339.492031546952
     From Canvas Y: -6819.110330271726
     Label X: -45.0
     Label Y: -14.0
     Downstream: CHAN-4B6

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 699
     Energy Slope: 0.0065
     Width: 10
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
End:

Reach: CHAN-4B6
     Canvas X: 110.6455871159942
     Canvas Y: -6856.145878957961
     From Canvas X: -2124.206087123004
     From Canvas Y: -6821.211592429854
     Label X: -42.0
     Label Y: -13.0
     Downstream: CHAN-4B7

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 495
     Energy Slope: 0.01
     Width: 10
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
```

```
End:

Reach: CHAN-4B7
     Canvas X: 2357.9921692963544
     Canvas Y: -6836.1474759172015
     From Canvas X: 110.6455871159942
     From Canvas Y: -6856.145878957961
     Label X: -39.0
     Label Y: -15.0
     Downstream: CHAN-4B8

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 245
     Energy Slope: 0.01
     Width: 10
     Side Slope: 3
     Mannings n: 0.033
     Use Variable Time Step: No
     Channel Loss: None
End:

Reach: CHAN-4B8
     Canvas X: 2319.03485254692
     Canvas Y: -4396.7828418230565
     From Canvas X: 2357.9921692963544
     From Canvas Y: -6836.1474759172015
     Label X: -8.0
     Label Y: -7.0
     Downstream: WDA BASIN

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 1406
     Energy Slope: 0.0025
     Width: 11
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
End:

Subbasin: DA-4B
     Canvas X: -438.0664652567975
     Canvas Y: -4320.241691842901
     Label X: -35.0
     Label Y: -17.0
     Area: 0.005
     Downstream: DA-4A
```

```
     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 236
     Plane 1 Slope: 0.05
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: Main
     Channel Length: 566
     Channel Slope: 0.01
     Channel Mannings N: 0.027
     Shape: Triangle
     Channel Side Slope: 3
     Channel Number of Steps: 5

     Baseflow: None
End:

Subbasin: DA-4A
     Canvas X: 740.1812688821774
     Canvas Y: -4320.241691842901
     Label X: -29.0
     Label Y: -16.0
     Area: 0.0293
     Downstream: WDA BASIN

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 130
```

```
     Plane 1 Slope: 0.25
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: 2
     Collector Length: 789
     Collector Slope: 0.01
     Collector Mannings N: 0.027
     Shape: Triangle
     Collector Side Slope: 3
     Collector Area: 0.00368
     Collector Number of Steps: 5

     Channel: Main
     Channel Length: 438
     Channel Slope: 0.25
     Channel Mannings N: 0.033
     Shape: Trapezoid
     Channel Width: 15
     Channel Side Slope: 2
     Channel Number of Steps: 5
     Route Upstream: Yes

     Baseflow: None
End:

Subbasin: DA-4D
     Canvas X: -2432.0241691842893
     Canvas Y: -3383.685800604231
     Area: 0.0027
     Downstream: DA-4C

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 218
     Plane 1 Slope: 0.05
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5
```

```
     Channel: Main
     Channel Length: 368
     Channel Slope: 0.01
     Channel Mannings N: 0.027
     Shape: Triangle
     Channel Side Slope: 3
     Channel Number of Steps: 5

     Baseflow: None
End:

Subbasin: DA-4C
     Canvas X: -2552.87009063444
     Canvas Y: -2870.0906344410887
     Label X: -1.0
     Label Y: 0.0
     Area: 0.0194
     Downstream: CHAN-4A3

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 130
     Plane 1 Slope: 0.25
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: 2
     Collector Length: 694
     Collector Slope: 0.01
     Collector Mannings N: 0.027
     Shape: Triangle
     Collector Side Slope: 3
     Collector Area: 0.00324
     Collector Number of Steps: 5

     Channel: Main
     Channel Length: 387
     Channel Slope: 0.25
```

```
     Channel Mannings N: 0.033
     Shape: Trapezoid
     Channel Width: 15
     Channel Side Slope: 2
     Channel Number of Steps: 5
     Route Upstream: Yes

     Baseflow: None
End:

Reach: CHAN-4A2
     Canvas X: -2574.128293728436
     Canvas Y: -2502.8588792334576
     From Canvas X: -4461.13090396298
     From Canvas Y: -2483.4938526408187
     Label X: -43.0
     Label Y: 8.0
     Downstream: CHAN-4A3

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 416
     Energy Slope: 0.030
     Width: 5
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
End:

Reach: CHAN-4A3
     Canvas X: -193.66300891401806
     Canvas Y: -2502.8588792334576
     From Canvas X: -2574.128293728436
     From Canvas Y: -2502.8588792334576
     Label X: -39.0
     Label Y: 10.0
     Downstream: CHAN-4A4

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 338
     Energy Slope: 0.015
     Width: 10
     Side Slope: 3
     Mannings n: 0.033
     Use Variable Time Step: No
     Channel Loss: None
End:
```

```
Reach: CHAN-4A4
     Canvas X: 2327.7806889338244
     Canvas Y: -2502.8588792334613
     From Canvas X: -193.66300891401806
     From Canvas Y: -2502.8588792334576
     Label X: -33.0
     Label Y: 9.0
     Downstream: CHAN-4A5

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 1636
     Energy Slope: 0.006
     Width: 10
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
End:

Reach: CHAN-4A5
     Canvas X: 2319.03485254692
     Canvas Y: -4396.7828418230565
     From Canvas X: 2327.7806889338244
     From Canvas Y: -2502.8588792334613
     Label X: -7.0
     Label Y: 11.0
     Downstream: WDA BASIN

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 240
     Energy Slope: 0.0025
     Width: 10
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
End:

Subbasin: WDA
     Canvas X: 1404.833836858008
     Canvas Y: -5740.181268882176
     Label X: -23.0
     Label Y: -17.0
     Area: 0.010
     Downstream: WDA BASIN

     Canopy: None
     Plant Uptake Method: None
```

```
     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 99

     Transform: SCS
     Lag: 1
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Reservoir: WDA BASIN
     Canvas X: 2319.03485254692
     Canvas Y: -4396.7828418230565
     Downstream: POD-8

     Route: Modified Puls
     Routing Curve: Elevation-Area-Outflow
     Initial Elevation: 531
     Elevation-Area Table: WDA BASIN
     Elevation-Outflow Table: WDA BASIN
     Primary Table: Elevation-Outflow
End:

Subbasin: PRE-8DR
     Canvas X: 4607.250755287012
     Canvas Y: -9123.867069486405
     Label X: -38.0
     Label Y: -18.0
     Area: 0.0325
     Downstream: Junction-2

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73.7

     Transform: SCS
     Lag: 35
     Unitgraph Type: STANDARD

     Baseflow: None
End:
```

```
Junction: Junction-2
     Canvas X: 4546.827794561934
     Canvas Y: -8459.214501510574
     Label X: -65.0
     Label Y: 15.0
     Downstream: Junction-3
End:

Subbasin: OS-3
     Canvas X: 6299.093655589124
     Canvas Y: -9305.135951661632
     Area: 0.02334
     Downstream: Junction-3

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 80

     Transform: SCS
     Lag: 29
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: Junction-3
     Canvas X: 6268.882175226587
     Canvas Y: -8459.214501510574
     Downstream: OS-3 REACH
End:

Reach: OS-3 REACH
     Canvas X: 6268.882175226587
     Canvas Y: -2024.169184290031
     From Canvas X: 6268.882175226587
     From Canvas Y: -8459.214501510574
     Downstream: POD-8

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 2039
     Energy Slope: 0.0030
     Width: 5
     Side Slope: 10
```

```
     Mannings n: 0.03
     Use Variable Time Step: No
     Channel Loss: None
End:

Junction: POD-8
     Canvas X: 6268.882175226587
     Canvas Y: -2024.169184290031
     Downstream: Site-19 Reservoir
End:

Subbasin: DA-1B
     Canvas X: -3972.809667673715
     Canvas Y: 4773.413897280966
     Area: 0.0055
     Downstream: DA-1A

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 189
     Plane 1 Slope: 0.05
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: Main
     Channel Length: 906
     Channel Slope: 0.01
     Channel Mannings N: 0.027
     Shape: Triangle
     Channel Side Slope: 3
     Channel Number of Steps: 5

     Baseflow: None
End:

Subbasin: DA-1A
     Canvas X: -3972.809667673715
     Canvas Y: 5468.277945619335
     Area: 0.0355
```

```
     Downstream: CHAN-1A3

     Canopy 1: None
     Plant Uptake Method: None

     Surface 1: None

     LossRate 1: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: Kinematic Wave

     Plane: 1
     Plane 1 Length: 130
     Plane 1 Slope: 0.25
     Plane 1 Roughness: 0.15
     Plane 1 Percent of Area: 100
     Plane 1 Number of Steps: 5

     Channel: 2
     Collector Length: 847
     Collector Slope: 0.01
     Collector Mannings N: 0.027
     Shape: Triangle
     Collector Side Slope: 3
     Collector Area: 0.00395
     Collector Number of Steps: 5

     Channel: Main
     Channel Length: 536
     Channel Slope: 0.25
     Channel Mannings N: 0.033
     Shape: Trapezoid
     Channel Width: 15
     Channel Side Slope: 2
     Channel Number of Steps: 5
     Route Upstream: Yes

     Baseflow: None
End:

Subbasin: DA-1C
     Canvas X: -8262.839879154079
     Canvas Y: 5377.643504531722
     Area: 0.0042
     Downstream: CHAN-1A1

     Canopy: None
     Plant Uptake Method: None
```

```
     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: SCS
     Lag: 11
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Reach: CHAN-1A1
     Canvas X: -6017.365997842705
     Canvas Y: 6243.663060278207
     From Canvas X: -8236.427072038217
     From Canvas Y: 6228.240659827116
     Label X: -45.0
     Label Y: 9.0
     Downstream: CHAN-1A2

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 404
     Energy Slope: 0.01
     Width: 5
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
End:

Reach: CHAN-1A2
     Canvas X: -3946.771527430814
     Canvas Y: 6230.052017912093
     From Canvas X: -6017.365997842705
     From Canvas Y: 6243.663060278207
     Label X: -41.0
     Label Y: 9.0
     Downstream: CHAN-1A3

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 1274
     Energy Slope: 0.008
     Width: 5
     Side Slope: 3
     Mannings n: 0.027
```

```
     Use Variable Time Step: No
     Channel Loss: None
End:

Reach: CHAN-1A3
     Canvas X: -1410.2888371615236
     Canvas Y: 6237.710973724886
     From Canvas X: -3946.771527430814
     From Canvas Y: 6230.052017912093
     Label X: -40.0
     Label Y: 8.0
     Downstream: CHAN-1A4

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 348
     Energy Slope: 0.0025
     Width: 10
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
End:

Reach: CHAN-1A4
     Canvas X: 921.4501510574046
     Canvas Y: 6253.776435045317
     From Canvas X: -1410.2888371615236
     From Canvas Y: 6237.710973724886
     Label X: -45.0
     Label Y: 8.0
     Downstream: EDA EAST BASIN

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 711
     Energy Slope: 0.022
     Width: 10
     Side Slope: 3
     Mannings n: 0.033
     Use Variable Time Step: No
     Channel Loss: None
End:

Subbasin: EDA EAST
     Canvas X: 921.4501510574046
     Canvas Y: 7311.1782477341385
     Label X: -39.0
     Label Y: 19.0
     Area: 0.003
```

```
     Downstream: EDA EAST BASIN

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 99

     Transform: SCS
     Lag: 1
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Subbasin: DA-1D
     Canvas X: 981.8731117824791
     Canvas Y: 5407.854984894259
     Area: 0.0023
     Downstream: EDA EAST BASIN

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: SCS
     Lag: 9
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Reservoir: EDA EAST BASIN
     Canvas X: 921.4501510574046
     Canvas Y: 6253.776435045317
     Label X: -5.0
     Label Y: 3.0
     Downstream: POD-1

     Route: Modified Puls
     Routing Curve: Elevation-Area-Outflow
     Initial Elevation: 534
```

```
     Elevation-Area Table: EDA EAST BASIN
     Elevation-Outflow Table: EDA EAST BASIN
     Primary Table: Elevation-Outflow
End:

Subbasin: PRE-1R
     Canvas X: 6450.151057401814
     Canvas Y: 8096.676737160121
     Area: 0.0149
     Downstream: POD-1

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 74.7

     Transform: SCS
     Lag: 11
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Subbasin: OS-5
     Canvas X: 4621.329211746524
     Canvas Y: 9072.642967542506
     Area: 0.01309
     Downstream: POD-1

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 80

     Transform: SCS
     Lag: 48
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Subbasin: DA-1E
```

```
     Canvas X: 2704.7913446676976
     Canvas Y: 8330.75734157651
     Area: 0.0019
     Downstream: POD-1

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: SCS
     Lag: 5
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-1
     Canvas X: 6450.151057401814
     Canvas Y: 6314.199395770393
     Downstream: Site-19 Reservoir
End:

Subbasin: PRE-5R
     Canvas X: 5634.441087613293
     Canvas Y: 1722.054380664651
     Label X: -72.0
     Label Y: -5.0
     Area: 0.0356
     Downstream: POD-5

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73

     Transform: SCS
     Lag: 29
     Unitgraph Type: STANDARD

     Baseflow: None
End:
```

```
Junction: POD-5
     Canvas X: 6419.939577039277
     Canvas Y: 1722.054380664651
     Label X: -29.0
     Label Y: -19.0
     Downstream: Site-19 Reservoir
End:

Subbasin: PRE-7R
     Canvas X: 5543.806646525682
     Canvas Y: -604.2296072507561
     Label X: -68.0
     Label Y: -4.0
     Area: 0.0226
     Downstream: POD-7

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73

     Transform: SCS
     Lag: 30
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-7
     Canvas X: 6389.728096676739
     Canvas Y: -634.4410876132933
     Label X: -30.0
     Label Y: -18.0
     Downstream: Site-19 Reservoir
End:

Subbasin: PRE-3R
     Canvas X: 5332.326283987917
     Canvas Y: 3957.7039274924464
     Label X: -67.0
     Label Y: 1.0
     Area: 0.0207
     Downstream: POD-3

     Canopy: None
```

```
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73

     Transform: SCS
     Lag: 27
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-3
     Canvas X: 6389.728096676739
     Canvas Y: 3897.280966767371
     Label X: -30.0
     Label Y: -22.0
     Downstream: Site-19 Reservoir
End:

Subbasin: PRE-2R
     Canvas X: 5271.903323262843
     Canvas Y: 5347.432024169184
     Label X: -78.0
     Label Y: -5.0
     Area: 0.0086
     Downstream: POD-2

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73

     Transform: SCS
     Lag: 17
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-2
     Canvas X: 6329.305135951665
     Canvas Y: 5347.432024169184
```

```
     Label X: -31.0
     Label Y: -23.0
     Downstream: Site-19 Reservoir
End:

Subbasin: PRE-4R
     Canvas X: 5543.806646525682
     Canvas Y: 2719.033232628398
     Label X: -71.0
     Label Y: -5.0
     Area: 0.0056
     Downstream: POD-4

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73

     Transform: SCS
     Lag: 16
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-4
     Canvas X: 6450.151057401814
     Canvas Y: 2719.033232628398
     Label X: -29.0
     Label Y: -19.0
     Downstream: Site-19 Reservoir
End:

Subbasin: PRE-6R
     Canvas X: 5604.229607250756
     Canvas Y: 604.2296072507543
     Label X: -67.0
     Label Y: -4.0
     Area: 0.0043
     Downstream: POD-6

     Canopy: None
     Plant Uptake Method: None

     Surface: None
```

```
     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73

     Transform: SCS
     Lag: 26
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-6
     Canvas X: 6510.574018126888
     Canvas Y: 634.4410876132915
     Label X: -33.0
     Label Y: -21.0
     Downstream: Site-19 Reservoir
End:

Subbasin: PRE-9R
     Canvas X: 11253.776435045318
     Canvas Y: -4380.664652567977
     Area: 0.0029
     Downstream: POD-9

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 73

     Transform: SCS
     Lag: 33
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-9
     Canvas X: 11253.776435045318
     Canvas Y: -2749.244712990938
     Downstream: Site-19 Reservoir
End:

Reservoir: Site-19 Reservoir
     Canvas X: 11246.648793565684
     Canvas Y: 1769.436997319035
```

```
     Route: Modified Puls
     Routing Curve: Elevation-Area-Outflow
     Initial Elevation: 520.69
     Elevation-Area Table: Site 19 Reservoir
     Elevation-Outflow Table: Site 19 Reservoir
     Primary Table: Elevation-Outflow
End:

Subbasin: PRE-11R
     Canvas X: -8504.53172205438
     Canvas Y: -8126.888217522661
     Label X: -1.0
     Label Y: 1.0
     Area: 0.010
     Downstream: POD-11

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 80

     Transform: SCS
     Lag: 19
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Junction: POD-11
     Canvas X: -8595.166163141994
     Canvas Y: -9033.232628398793
End:

Subbasin: DA-4E
     Canvas X: -6313.67292225201
     Canvas Y: -3378.016085790885
     Area: 0.0047
     Downstream: CHAN-4A1

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
```

```
     Percent Impervious Area: 0.0
     Curve Number: 85

     Transform: SCS
     Lag: 7
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Reach: CHAN-4A1
     Canvas X: -4461.130903962981
     Canvas Y: -2483.4938526408205
     From Canvas X: -6276.501614341445
     From Canvas Y: -2476.7606903386677
     Label X: -42.0
     Label Y: 8.0

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 434
     Energy Slope: 0.0025
     Width: 5
     Side Slope: 3
     Mannings n: 0.027
     Use Variable Time Step: No
     Channel Loss: None
End:

Subbasin: PRE-10BR
     Canvas X: -347.4320241691821
     Canvas Y: -8368.580060422963
     Area: 0.0029
     Downstream: POD-10

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 80

     Transform: SCS
     Lag: 33
     Unitgraph Type: STANDARD

     Baseflow: None
End:
```

```
Subbasin: PRE-10AR
     Canvas X: -5271.903323262839
     Canvas Y: -8700.906344410876
     Area: 0.0016
     Downstream: PRE-11 TK Parkway

     Canopy: None
     Plant Uptake Method: None

     Surface: None

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 80

     Transform: SCS
     Lag: 25
     Unitgraph Type: STANDARD

     Baseflow: None
End:

Reach: PRE-11 TK Parkway
     Canvas X: -407.85498489426027
     Canvas Y: -9184.290030211483
     From Canvas X: -5350.700654192953
     From Canvas Y: -9206.8902720901
     Label X: -67.0
     Label Y: -15.0
     Downstream: POD-10

     Route: Muskingum Cunge
     Channel: Trapezoid
     Length: 1215.664
     Energy Slope: 0.008
     Width: 17.8
     Side Slope: 0.12
     Mannings n: 0.033
     Use Variable Time Step: No
     Channel Loss: None
End:

Junction: POD-10
     Canvas X: -407.85498489426027
     Canvas Y: -9184.290030211483
End:

Basin Schematic Properties:
     Last View N: 5000.0
```

```
     Last View S: -5000.0
     Last View W: -5000.0
     Last View E: 5000.0
     Maximum View N: 5000.0
     Maximum View S: -5000.0
     Maximum View W: -5000.0
     Maximum View E: 5000.0
     Extent Method: Elements
     Buffer: 0
     Draw Icons: Yes
     Draw Icon Labels: Name
     Draw Map Objects: No
     Draw Gridlines: No
     Draw Flow Direction: No
     Fix Element Locations: No
     Fix Hydrologic Order: No
End:
```

# HEC-HMS OUTPUT FILES
# FOR
# EDA WEST BASIN, EDA EAST BASIN, & WDA BASIN / POD-1, POD-2, POD-3, POD-4, POD-5, POD-6, POD-7, POD-8, POD-9, POD-10, & POD-11

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Start of Run: 02Oct2018, 00:00 Basin Model: POST DEVELOPMENT
End of Run: 04Oct2018, 00:00 Meteorologic Model: 25-year, 24-hour
Compute Time: 30Sep2020, 11:16:22 Control Specifications: 48-HOUR

| Hydrologic Element | Drainage Area (MI2) | Peak Discharge (CFS) | Time of Peak | Volume (AC-FT) |
|---|---|---|---|---|
| OS-1 | 1.57999 | 1709.8 | 02Oct2018, 13:10 | 463.2 |
| PRE-8A HC | 1.57999 | 1707.8 | 02Oct2018, 13:10 | 463.2 |
| PRE-8ABR | 0.0847 | 120.0 | 02Oct2018, 12:40 | 21.7 |
| OS-2 | 0.058 | 104.2 | 02Oct2018, 12:30 | 17.1 |
| Junction-1 | 1.72269 | 1831.2 | 02Oct2018, 13:10 | 502.0 |
| PRE-8C HC | 1.72269 | 1811.1 | 02Oct2018, 13:20 | 501.9 |
| PRE-8CR | 0.1912 | 258.4 | 02Oct2018, 12:40 | 48.3 |
| DA-3B | 0.0040 | 12.7 | 02Oct2018, 12:10 | 1.3 |
| DA-3A | 0.0410 | 130.8 | 02Oct2018, 12:10 | 13.4 |
| DA-2B | 0.0030 | 9.6 | 02Oct2018, 12:10 | 1.0 |
| DA-2A | 0.0312 | 99.7 | 02Oct2018, 12:10 | 10.2 |
| CHAN-2A1 | 0.0312 | 99.5 | 02Oct2018, 12:10 | 10.2 |
| CHAN-2A2 | 0.0312 | 98.1 | 02Oct2018, 12:10 | 10.2 |
| CHAN-2A3 | 0.0312 | 95.9 | 02Oct2018, 12:10 | 10.2 |
| CHAN-2A4 | 0.0312 | 87.2 | 02Oct2018, 12:10 | 10.3 |
| CHAN-2A5 | 0.0722 | 206.8 | 02Oct2018, 12:10 | 23.7 |
| DA-3D | 0.0040 | 12.7 | 02Oct2018, 12:10 | 1.3 |
| DA-3C | 0.0457 | 145.8 | 02Oct2018, 12:10 | 15.0 |
| DA-3F | 0.0027 | 8.6 | 02Oct2018, 12:10 | 0.9 |
| DA-3E | 0.0360 | 114.9 | 02Oct2018, 12:10 | 11.8 |
| CHAN-3A1 | 0.0360 | 102.8 | 02Oct2018, 12:10 | 11.6 |
| EDA WEST | 0.011 | 37.7 | 02Oct2018, 12:10 | 4.6 |
| EDA WEST BASIN | 0.1649 | 40.4 | 02Oct2018, 14:10 | 34.7 |
| DA-5B | 0.0036 | 11.4 | 02Oct2018, 12:10 | 1.2 |
| DA-5A | 0.0398 | 127.0 | 02Oct2018, 12:10 | 13.0 |
| DA-5D | 0.0048 | 15.2 | 02Oct2018, 12:10 | 1.6 |
| DA-5C | 0.0147 | 46.7 | 02Oct2018, 12:10 | 4.8 |
| DA-5E | 0.0033 | 9.7 | 02Oct2018, 12:10 | 1.1 |
| CHAN-4B1 | 0.0033 | 9.3 | 02Oct2018, 12:10 | 1.1 |
| CHAN-4B2 | 0.0033 | 9.2 | 02Oct2018, 12:10 | 1.1 |
| CHAN-4B3 | 0.0180 | 54.8 | 02Oct2018, 12:10 | 5.9 |

| Hydrologic Element | Drainage Area (MI2) | Peak Discharge (CFS) | Time of Peak | Volume (AC-FT) |
|---|---|---|---|---|
| CHAN-4B4 | 0.0180 | 53.9 | 02Oct2018, 12:10 | 5.9 |
| CHAN-4B5 | 0.0180 | 51.5 | 02Oct2018, 12:10 | 5.9 |
| CHAN-4B6 | 0.0180 | 49.6 | 02Oct2018, 12:10 | 5.9 |
| CHAN-4B7 | 0.0578 | 175.4 | 02Oct2018, 12:10 | 19.0 |
| CHAN-4B8 | 0.0578 | 163.8 | 02Oct2018, 12:10 | 19.0 |
| DA-4B | 0.005 | 15.9 | 02Oct2018, 12:10 | 1.6 |
| DA-4A | 0.0343 | 109.3 | 02Oct2018, 12:10 | 11.2 |
| DA-4D | 0.0027 | 8.6 | 02Oct2018, 12:10 | 0.9 |
| DA-4C | 0.0221 | 70.5 | 02Oct2018, 12:10 | 7.2 |
| DA-4E | 0.0047 | 13.9 | 02Oct2018, 12:10 | 1.5 |
| CHAN-4A1 | 0.0047 | 13.0 | 02Oct2018, 12:10 | 1.5 |
| CHAN-4A2 | 0.0047 | 12.6 | 02Oct2018, 12:10 | 1.5 |
| CHAN-4A3 | 0.0268 | 82.5 | 02Oct2018, 12:10 | 8.8 |
| CHAN-4A4 | 0.0268 | 78.1 | 02Oct2018, 12:10 | 8.8 |
| CHAN-4A5 | 0.0268 | 75.6 | 02Oct2018, 12:10 | 8.8 |
| WDA | 0.010 | 34.3 | 02Oct2018, 12:10 | 4.1 |
| WDA BASIN | 0.1289 | 21.7 | 02Oct2018, 15:30 | 21.0 |
| PRE-8DR | 0.0325 | 45.9 | 02Oct2018, 12:40 | 8.3 |
| Junction-2 | 0.0325 | 45.9 | 02Oct2018, 12:40 | 8.3 |
| OS-3 | 0.02334 | 41.1 | 02Oct2018, 12:30 | 6.9 |
| Junction-3 | 0.05584 | 85.4 | 02Oct2018, 12:40 | 15.2 |
| OS-3 REACH | 0.05584 | 83.4 | 02Oct2018, 12:50 | 15.2 |
| POD-8 | 2.26353 | 2059.8 | 02Oct2018, 13:20 | 621.1 |
| DA-1B | 0.0055 | 17.5 | 02Oct2018, 12:10 | 1.8 |
| DA-1A | 0.0410 | 130.8 | 02Oct2018, 12:10 | 13.4 |
| DA-1C | 0.0042 | 11.0 | 02Oct2018, 12:10 | 1.4 |
| CHAN-1A1 | 0.0042 | 10.4 | 02Oct2018, 12:10 | 1.4 |
| CHAN-1A2 | 0.0042 | 10.4 | 02Oct2018, 12:20 | 1.4 |
| CHAN-1A3 | 0.0452 | 137.0 | 02Oct2018, 12:10 | 14.8 |
| CHAN-1A4 | 0.0452 | 134.9 | 02Oct2018, 12:10 | 14.8 |
| EDA EAST | 0.003 | 10.3 | 02Oct2018, 12:10 | 1.2 |
| DA-1D | 0.0023 | 6.4 | 02Oct2018, 12:10 | 0.8 |
| EDA EAST BASIN | 0.0505 | 106.3 | 02Oct2018, 12:20 | 16.8 |
| PRE-1R | 0.0149 | 31.9 | 02Oct2018, 12:10 | 3.9 |
| OS-5 | 0.01309 | 17.8 | 02Oct2018, 12:50 | 3.9 |

| Hydrologic Element | Drainage Area (MI2) | Peak Discharge (CFS) | Time of Peak | Volume (AC-FT) |
|---|---|---|---|---|
| DA-1E | 0.0019 | 5.8 | 02Oct2018, 12:10 | 0.6 |
| POD-1 | 0.08039 | 150.9 | 02Oct2018, 12:20 | 25.2 |
| PRE-5R | 0.0356 | 53.8 | 02Oct2018, 12:30 | 9.0 |
| POD-5 | 0.0356 | 53.8 | 02Oct2018, 12:30 | 9.0 |
| PRE-7R | 0.0226 | 33.4 | 02Oct2018, 12:30 | 5.7 |
| POD-7 | 0.0226 | 33.4 | 02Oct2018, 12:30 | 5.7 |
| PRE-3R | 0.0207 | 32.6 | 02Oct2018, 12:30 | 5.2 |
| POD-3 | 0.0207 | 32.6 | 02Oct2018, 12:30 | 5.2 |
| PRE-2R | 0.0086 | 16.3 | 02Oct2018, 12:20 | 2.2 |
| POD-2 | 0.0086 | 16.3 | 02Oct2018, 12:20 | 2.2 |
| PRE-4R | 0.0056 | 10.9 | 02Oct2018, 12:20 | 1.4 |
| POD-4 | 0.0056 | 10.9 | 02Oct2018, 12:20 | 1.4 |
| PRE-6R | 0.0043 | 6.9 | 02Oct2018, 12:30 | 1.1 |
| POD-6 | 0.0043 | 6.9 | 02Oct2018, 12:30 | 1.1 |
| PRE-9R | 0.0029 | 4.1 | 02Oct2018, 12:40 | 0.7 |
| POD-9 | 0.0029 | 4.1 | 02Oct2018, 12:40 | 0.7 |
| Site-19 Reservoir | 2.44422 | 64.8 | 03Oct2018, 01:30 | 173.7 |
| PRE-11R | 0.010 | 21.0 | 02Oct2018, 12:20 | 3.0 |
| POD-11 | 0.010 | 21.0 | 02Oct2018, 12:20 | 3.0 |
| PRE-10BR | 0.0029 | 4.8 | 02Oct2018, 12:40 | 0.9 |
| PRE-10AR | 0.0016 | 3.0 | 02Oct2018, 12:30 | 0.5 |
| PRE-10 TK Parkway | 0.0016 | 3.0 | 02Oct2018, 12:40 | 0.5 |
| POD-10 | 0.0045 | 7.8 | 02Oct2018, 12:40 | 1.3 |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Subbasin: PRE-5R

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 12:14:22 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Discharge: | 53.8 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:30 |
| Precipitation Volume: | 15.0 (AC-FT) | Direct Runoff Volume: | 9.0 (AC-FT) |
| Loss Volume: | 6.0 (AC-FT) | Baseflow Volume: | 0.0 (AC-FT) |
| Excess Volume: | 9.0 (AC-FT) | Discharge Volume: | 9.0 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Subbasin: PRE-7R

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 12:14:22 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Discharge: | 33.4 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:30 |
| Precipitation Volume: | 9.5 (AC-FT) | Direct Runoff Volume: | 5.7 (AC-FT) |
| Loss Volume: | 3.8 (AC-FT) | Baseflow Volume: | 0.0 (AC-FT) |
| Excess Volume: | 5.7 (AC-FT) | Discharge Volume: | 5.7 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Subbasin: PRE-8CR

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 12:14:22 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Discharge: | 258.4 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:40 |
| Precipitation Volume: | 80.6 (AC-FT) | Direct Runoff Volume: | 48.3 (AC-FT) |
| Loss Volume: | 32.3 (AC-FT) | Baseflow Volume: | 0.0 (AC-FT) |
| Excess Volume: | 48.3 (AC-FT) | Discharge Volume: | 48.3 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Subbasin: PRE-8DR

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 12:14:22 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Discharge: | 45.9 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:40 |
| Precipitation Volume: | 13.7 (AC-FT) | Direct Runoff Volume: | 8.3 (AC-FT) |
| Loss Volume: | 5.4 (AC-FT) | Baseflow Volume: | 0.0 (AC-FT) |
| Excess Volume: | 8.3 (AC-FT) | Discharge Volume: | 8.3 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Reach: OS-3 REACH

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 12:14:22 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Inflow: | 85.4 (CFS) | Date/Time of Peak Inflow | 02Oct2018, 12:40 |
| Peak Discharge: | 83.4 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:50 |
| Inflow Volume: | 15.2 (AC-FT) | Discharge Volume: | 15.2 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)
Junction: Junction-2

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 12:14:22 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

Peak Discharge: 45.9 (CFS) Date/Time of Peak Discharge: 02Oct2018, 12:40
Volume: 8.3 (AC-FT)

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Junction: Junction-3

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 12:14:22 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

Peak Discharge: 85.4 (CFS) Date/Time of Peak Discharge: 02Oct2018, 12:40

Volume: 15.2 (AC-FT)

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Reach: CHAN-2A5

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 12:14:22 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Inflow: | 218.0 (CFS) | Date/Time of Peak Inflow | 02Oct2018, 12:10 |
| Peak Discharge: | 206.8 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:10 |
| Inflow Volume: | 23.7 (AC-FT) | Discharge Volume: | 23.7 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Reach: CHAN-3A1

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 12:14:22 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Inflow: | 114.9 (CFS) | Date/Time of Peak Inflow | 02Oct2018, 12:10 |
| Peak Discharge: | 102.8 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:10 |
| Inflow Volume: | 11.8 (AC-FT) | Discharge Volume: | 11.6 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Reach: CHAN-4B6

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 12:36:32 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Inflow: | 51.5 (CFS) | Date/Time of Peak Inflow | 02Oct2018, 12:10 |
| Peak Discharge: | 49.5 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:10 |
| Inflow Volume: | 5.9 (AC-FT) | Discharge Volume: | 5.9 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Reach: CHAN-4B7

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 12:36:32 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Inflow: | 176.6 (CFS) | Date/Time of Peak Inflow | 02Oct2018, 12:10 |
| Peak Discharge: | 175.1 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:10 |
| Inflow Volume: | 19.0 (AC-FT) | Discharge Volume: | 19.0 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Reach: CHAN-4B8

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 12:36:32 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Inflow: | 175.1 (CFS) | Date/Time of Peak Inflow | 02Oct2018, 12:10 |
| Peak Discharge: | 163.0 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:10 |
| Inflow Volume: | 19.0 (AC-FT) | Discharge Volume: | 19.0 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Subbasin: DA-3A

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 12:59:43 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Discharge: | 130.8 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:10 |
| Precipitation Volume: | 15.6 (AC-FT) | Direct Runoff Volume: | 13.4 (AC-FT) |
| Loss Volume: | 3.5 (AC-FT) | Baseflow Volume: | 0.0 (AC-FT) |
| Excess Volume: | 12.1 (AC-FT) | Discharge Volume: | 13.4 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Subbasin: DA-3C

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 12:59:43 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Discharge: | 145.8 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:10 |
| Precipitation Volume: | 17.6 (AC-FT) | Direct Runoff Volume: | 15.0 (AC-FT) |
| Loss Volume: | 4.0 (AC-FT) | Baseflow Volume: | 0.0 (AC-FT) |
| Excess Volume: | 13.6 (AC-FT) | Discharge Volume: | 15.0 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Subbasin: DA-3E

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 13:05:01 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Discharge: | 114.9 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:10 |
| Precipitation Volume: | 14.0 (AC-FT) | Direct Runoff Volume: | 11.8 (AC-FT) |
| Loss Volume: | 3.2 (AC-FT) | Baseflow Volume: | 0.0 (AC-FT) |
| Excess Volume: | 10.9 (AC-FT) | Discharge Volume: | 11.8 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Subbasin: DA-4A

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 13:05:01 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Discharge: | 109.3 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:10 |
| Precipitation Volume: | 12.3 (AC-FT) | Direct Runoff Volume: | 11.2 (AC-FT) |
| Loss Volume: | 2.8 (AC-FT) | Baseflow Volume: | 0.0 (AC-FT) |
| Excess Volume: | 9.6 (AC-FT) | Discharge Volume: | 11.2 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)
Subbasin: DA-4C

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 13:05:01 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Discharge: | 70.5 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:10 |
| Precipitation Volume: | 8.2 (AC-FT) | Direct Runoff Volume: | 7.2 (AC-FT) |
| Loss Volume: | 1.8 (AC-FT) | Baseflow Volume: | 0.0 (AC-FT) |
| Excess Volume: | 6.3 (AC-FT) | Discharge Volume: | 7.2 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Subbasin: DA-5A

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 13:05:01 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Discharge: | 127.0 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 12:10 |
| Precipitation Volume: | 15.3 (AC-FT) | Direct Runoff Volume: | 13.0 (AC-FT) |
| Loss Volume: | 3.4 (AC-FT) | Baseflow Volume: | 0.0 (AC-FT) |
| Excess Volume: | 11.8 (AC-FT) | Discharge Volume: | 13.0 (AC-FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Junction: POD-5

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 13:05:01 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

Peak Discharge: 53.8 (CFS) Date/Time of Peak Discharge: 02Oct2018, 12:30

Volume: 9.0 (AC-FT)

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Junction: POD-7

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 13:05:01 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

Peak Discharge: 33.4 (CFS) Date/Time of Peak Discharge: 02Oct2018, 12:30

Volume: 5.7 (AC-FT)

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Junction: POD-8

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 13:11:32 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

Peak Discharge: 2059.8 (CFS) Date/Time of Peak Discharge: 02Oct2018, 13:20

Volume: 621.0 (AC-FT)

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)
Reservoir: EDA WEST BASIN

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 13:11:32 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Inflow: | 493.1 (CFS) | Date/Time of Peak Inflow: | 02Oct2018, 12:10 |
| Peak Discharge: | 40.4 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 14:10 |
| Inflow Volume: | 54.8 (AC-FT) | Peak Storage: | 36.3 (AC-FT) |
| Discharge Volume: | 34.7 (AC-FT) | Peak Elevation: | 535.9 (FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)

Reservoir: WDA BASIN

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 13:11:32 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

## Computed Results

| | | | |
|---|---|---|---|
| Peak Inflow: | 382.3 (CFS) | Date/Time of Peak Inflow: | 02Oct2018, 12:10 |
| Peak Discharge: | 21.7 (CFS) | Date/Time of Peak Discharge: | 02Oct2018, 15:30 |
| Inflow Volume: | 43.1 (AC-FT) | Peak Storage: | 31.1 (AC-FT) |
| Discharge Volume: | 21.0 (AC-FT) | Peak Elevation: | 536.5 (FT) |

Project: City of Waco Landfill 4.0 Simulation Run: 25 yr, 24 hr (post)
Reservoir: Site-19 Reservoir

| | | | |
|---|---|---|---|
| Start of Run: | 02Oct2018, 00:00 | Basin Model: | POST DEVELOPMENT |
| End of Run: | 04Oct2018, 00:00 | Meteorologic Model: | 25-year, 24-hour |
| Compute Time: | 30Sep2020, 13:11:32 | Control Specifications: | 48-HOUR |

Volume Units: AC-FT

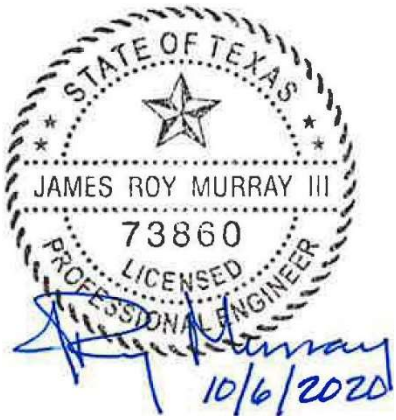
## Computed Results

| | | | |
|---|---|---|---|
| Peak Inflow: | 2164.4 (CFS) | Date/Time of Peak Inflow: | 02Oct2018, 13:20 |
| Peak Discharge: | 64.8 (CFS) | Date/Time of Peak Discharge: | 03Oct2018, 01:30 |
| Inflow Volume: | 671.5 (AC-FT) | Peak Storage: | 594.8 (AC-FT) |
| Discharge Volume: | 173.7 (AC-FT) | Peak Elevation: | 523.1 (FT) |

# APPENDIX 6A-E

# HYDRAULIC ANALYSIS

- **Overland Flow Velocity Analysis**
- **Drainage Swale Flow Analysis**
- **Downchute Flow Analysis**
- **Perimeter Channel Flow Analysis (HydroCalc Output Files)**
- **Hydraulic Analysis References**
- **Hydraulic Analysis Drawings 6A-E.1 through 6A-E.5**




**SCS Engineers**
**TBPE Reg. # F-3407**
**Inclusive of pages 6A-E-1 to 6A-E-77**

# INTERMEDIATE COVER – OVERLAND FLOW VELOCITY

# CITY OF WACO LANDFILL
## INTERMEDIATE COVER - DRAINAGE SWALE FLOW ANALYSIS



**Required:** Calculate the flow velocity and normal depth for sizing drainage swales installed on intermediate cover.

**Method:**

1. Determine peak discharge rate associated with the 25 - year, 24 - hour storm event for the swale contributing drainage areas, as shown on Drawings 6A-E.3 and 6A-E.4, using the Rational Method (see Subsection 2.2 of Attachment 6A).
2. Determine Mannings "n" and runoff coefficient "C" (see Pages 6A-A-25 and 6A-E-71, respectively).
3. Using the specified channel geometry, evaluate the peak velocity and flow depth using HYDROCALC program.
4. Compare the worst case flow velocity with the permissible velocity of 5 fps.

**Solution:** **Rational Method Calculations for Typical Swale Contributing Areas**

| Drainage Area [2] | Runoff Coef. C[3] | Rainfall Int. I, (in/hr)[4] | Area (acres) | Peak Discharge (cfs) |
|---|---|---|---|---|
| SW12 | 0.70 | 8.9 | 4.0 | 25.0 |
| SW13 | 0.35 | 8.9 | 2.1 | 6.5 |
| Example-1[5] | 0.35 | 8.9 | 17.0 | 53.0 |
| SW8 | 0.35 | 8.9 | 6.8 | 21.2 |
| SW11 | 0.70 | 8.9 | 5.2 | 32.7 |
| SW9 | 0.35 | 8.9 | 10.1 | 31.5 |
| SW10 | 0.35 | 8.9 | 2.8 | 8.7 |
| Example-2[5] | 0.70 | 8.9 | 7.3 | 45.5 |
| Example-3[5] | 0.70 | 8.9 | 10.0 | 62.3 |
| | | | | |
| | | | | |
| | | | | |

$$I = \frac{b}{(t_c + d)^e}$$

Where, I = Rainfall intensity, in/hr
b= 103.56

d= 11.0
e= 0.806
$t_c$ = 10 min

(b, d, e are associated with a 25 - year, 24 - hour storm for Limestome Co., see Page 6A-E-73)

**Solution (Con't):** **Typical Swale Summary Calculations for Greatest Peak Discharge into a Topslope and Sideslope Swale[1]**

| Drainage Area [2] | Flow Rate (cfs) | Bottom Slope(ft/ft) | Manning's n[3] | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| SW9 | 31.5 | 0.005 | 0.027 | 2 | 20 | 0.0 | 1.06 | 2.54 |
| Example-1[5] | 53.0 | 0.005 | 0.027 | 2 | 20 | 0.0 | 1.29 | 2.88 |
| SW11 | 32.7 | 0.010 | 0.027 | 2 | 4 | 0.0 | 1.56 | 4.49 |
| Example-2[5] | 45.5 | 0.010 | 0.027 | 2 | 4 | 0.0 | 1.76 | 4.87 |
| Example-3[5] | 62.3 | 0.010 | 0.027 | 2 | 4 | 0.0 | 1.98 | 5.27 |

**Conclusions:**

From above drainage swale summary calculations, grass-lined topslope swales installed on intermediate cover will have peak velocities less than the permissible velocity of 5 fps. Therefore, topslope swales on installed on intermediate cover will be constructed with a minimum depth of 2.0 feet, provided the contributing area is less than or equal to 17 acres, as shown for Example-1.

Drainage swales installed on the intermediate cover sideslopes may exhibit peak velocities greater than 5 fps if the contributing area is greater than 7.3 acres (see Example 2). Therefore, sideslope swales installed on intermediate cover will be grass-lined and contructed with a minimum depth of 2.4 feet, provided the contributing area is less than or equal to 7.3 acres. Additionally, sideslope swales with contributing areas greater than 7.3 acres but less than 10 acres will be rip rap or TRM-lined and constructed with a minimum depth of 2.6 feet. Drainage swales installed on intermediate cover will be constructed with a minimum 0.5-foot of freeboard above calculated peak flow depth. See Drawing 6A.12 for drainage swale details.

**Notes:**

1. Calculations were performed using the HYDROCALC program developed by Dodson and Associates (Version 1.3, 1986).
2. Contributing drainage areas are depicted on Drawings 6A-E.3 and 6A-E.4.
3. Refer to Hydraulic Calculation References for Mannings "n" and runoff coefficient, C, references.
4. Rainfal Intensity (I) calculated for tc = 10 min, using equation for rainfall intensity shown above. Refer to Hydraulic Calculation References for coefficient b,d, and e references.
5. Example 1 represents the largest intermediate cover topslope drainage area to any one drainage swale. Example 2 represents the largest intermediate cover sideslope drainage area to any one grass-lined drainage swale. Exampke 3 represents the largest intermediate cover sideslope drainage area to any one rip rap or TRM lined drainage swale.

# FINAL COVER – DRAINAGE SWALE FLOW

# CITY OF WACO LANDFILL
## FINAL COVER - DRAINAGE SWALE FLOW ANALYSIS



**Required:** Calculate the flow velocity and normal depth for sizing drainage swales installed on final cover.

**Method:**

1. Determine peak discharge rate associated with the 25 - year, 24 - hour storm event for the swale contributing drainage areas, as shown on Drawing 6A-E.1, using the Rational Method (see Subsection 2.2 of Attachment 6A).
2. Determine Mannings "n" and runoff coefficient "C" (see Pages 6A-A-25 and 6A-E-71, respectively).
3. Using the specified channel geometry, evaluate the peak velocity and flow depth using HYDROCALC program.
4. Compare the worst case flow velocity with the permissible velocity of 5 fps.

**Solution:** **Rational Method Calculations for Typical Swale Contributing Areas**

| Drainage Area [2] | Runoff Coef. C[3] | Rainfall Int. I, (in/hr)[4] | Area (acres) | Peak Discharge (cfs) |
|---|---|---|---|---|
| SW1 | 0.70 | 8.9 | 3.7 | 22.8 |
| SW2 | 0.70 | 8.9 | 3.2 | 20.0 |
| SW3 | 0.35 | 8.9 | 2.1 | 6.4 |
| SW4 | 0.70 | 8.9 | 3.0 | 18.7 |
| SW5 | 0.70 | 8.9 | 3.3 | 20.8 |
| SW6 | 0.35 | 8.9 | 2.4 | 7.4 |
| SW7 | 0.35 | 8.9 | 2.1 | 6.4 |

$$I = \frac{b}{(t_c + d)^e}$$

Where, I = Rainfall intensity, in/hr
b= 103.56
d= 11.0
e= 0.806
$t_c$ = 10 min

(b, d, e are associated with a 25 - year, 24 - hour storm for Limestone Co., see Page 6A-E-73)

**Typical Swale Summary Calculations[1]**

| Drainage Area [2] | Flow Rate (cfs) | Bottom Slope(ft/ft) | Manning's n[3] | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| SW1 | 22.8 | 0.01 | 0.027 | 2 | 4 | 0.0 | 1.36 | 4.09 |
| SW2 | 20.0 | 0.01 | 0.027 | 2 | 4 | 0.0 | 1.30 | 3.96 |
| SW3 | 6.4 | 0.005 | 0.027 | 2 | 20 | 0.0 | 1.71 | 0.58 |
| SW4 | 18.7 | 0.01 | 0.027 | 2 | 4 | 0.0 | 1.26 | 3.90 |
| SW5 | 20.8 | 0.01 | 0.027 | 2 | 4 | 0.0 | 1.32 | 4.00 |
| SW6 | 7.4 | 0.005 | 0.027 | 2 | 20 | 0.0 | 0.62 | 1.77 |
| SW7 | 6.4 | 0.005 | 0.027 | 2 | 20 | 0.0 | 0.58 | 1.71 |

**Conclusions:** From above drainage swale summary calculations, the greatest calculated flow velocity in a sideslope swale is 4.09 fps and in a topslope swale is 0.62 fps, which are both less than the permissible velocity of 5 fps. Therefore, drainage swales installed on the final cover topslope and sideslope will be constructed with a minimum depth of 2.1 and 2.5 feet, respectively. Drainage swales will be constructed with a minimum 1-foot of freeboard above calculated peak flow depth. See Drawing 6A.12 for drainage swale details.

**Notes:**

1. Calculations were performed using the HYDROCALC program developed by Dodson and Associates (Version 1.3, 1986).
2. Contributing drainage areas are depicted on Drawing 6A-E.1.
3. Refer to Hydraulic Calculation References for Mannings "n" and runoff coefficient, C, references.
4. Rainfal Intensity (I) calculated for tc = 10 min, using equation for rainfall intensity shown above. Refer to Hydraulic Calculation References for coefficient b,d, and e references.

# DOWNCHUTE FLOW ANALYSIS

# INTERMEDIATE COVER – DOWNCHUTE FLOW

# CITY OF WACO LANDFILL
## INTERMEDIATE COVER - DOWNCHUTE FLOW ANALYSIS



**Required:** Calculate the peak flow depth for sizing downchutes installed on **intermediate cover**.

**Method:**

1. Determine peak discharge rate associated with the 25 - year, 24 - hour storm event for downchute contributing drainage areas using the Rational Method (see Subsection 2.2 of Attachment 6A).
2. Determine Mannings "n" and runoff coefficient "C" (see Page 6A-A-25 and 6A-E-71, respectively).
3. Using the specified channel geometry, evaluate the peak velocity and flow depth using HYDROCALC program.

**Solution:**

$$I = \frac{b}{(t_c + d)^e}$$

Where, I = Rainfall intensity, in/hr
b= 103.56
d= 11.0
e= 0.806
$t_c$ = 10 min

(b, d, e are associated with a 25 - year, 24 - hour storm for Limestone Co., see Page 6A-E-73)

**Rational Method Calculations for Typical Swale Contributing Areas**

| Drainage Area [2] | Runoff Coef. C[3] | Rainfall Int. I, (in/hr)[4] | Area (acres) | Peak Discharge (cfs) |
|---|---|---|---|---|
| DC3 | 0.70 | 8.9 | 9.0 | 56.2 |
| DC4 | 0.70 | 8.9 | 10.5 | 65.2 |
| Example DC[5] | 0.70 | 8.9 | 35.0 | 218.1 |

**Typical Swale Summary Calculations[1]**

| Drainage Area [2] | Flow Rate (cfs) | Bottom Slope(ft/ft) | Manning's n[3] | Sideslope (left) | Sideslope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| DC3 | 56.2 | 0.25 | 0.033 | 2 | 2 | 10.0 | 0.43 | 12.05 |
| DC4 | 65.2 | 0.25 | 0.033 | 2 | 2 | 10.0 | 0.47 | 12.71 |
| Example DC[5] | 218.1 | 0.25 | 0.033 | 2 | 2 | 10.0 | 0.95 | 19.31 |

**Conclusions:**

Based on the greatest contributing drainage area shown on Drawing 6A-E.5, downchutes installed on intermediate cover will be constructed 2 feet deep (assuming 1-foot of freeboard), with a 10-foot bottom width, and 2H:1V sideslopes. Gabions, rip rap, or dissipation blocks will be installed at the toe of the landfill berm with the perimeter channels to dissipate the peak velocity. Typcial details for downchutes are depcited on Drawing 6A.20.

**Notes:**

1. Calculations were performed using the HYDROCALC program developed by Dodson and Associates (Version 1.3, 1986).
2. Contributing drainage areas are depicted on Drawing 6A-E.5.
3. Refer to Hydraulic Calculation References for Mannings "n" and runoff coefficient, C, references.
4. Rainfal Intensity (I) calculated for tc = 10 min, using equation for rainfall intensity shown above. Refer to Hydraulic Calculation References for coefficient b,d, and e references.
5. Example DC represents the largest intermediate cover drainage area to any one downchute.

# Example DC

TRAPEZOIDAL CHANNEL ANALYSIS
NORMAL DEPTH COMPUTATION

September 28, 2020

PROGRAM INPUT DATA

| DESCRIPTION | VALUE |
|---|---|
| Flow Rate (cfs) | 218.1 |
| Channel Bottom Slope (ft/ft) | 0.25 |
| Manning's Roughness Coefficient (n-value) | 0.033 |
| Channel Left Side Slope (horizontal/vertical) | 2.0 |
| Channel Right Side Slope (horizontal/vertical) | 2.0 |
| Channel Bottom Width (ft) | 10.0 |

COMPUTATION RESULTS

| DESCRIPTION | VALUE |
|---|---|
| Normal Depth (ft) | 0.95 |
| Flow Velocity (fps) | 19.31 |
| Froude Number | 3.762 |
| Velocity Head (ft) | 5.79 |
| Energy Head (ft) | 6.74 |
| Cross-Sectional Area of Flow (sq ft) | 11.3 |
| Top Width of Flow (ft) | 13.8 |

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# FINAL COVER – DOWNCHUTE FLOW

# CITY OF WACO LANDFILL
# FINAL COVER - DOWNCHUTE FLOW ANALYSIS



**Required:** Calculate the peak flow depth for sizing downchutes installed on **final cover**.

**Method:**

1. Determine peak discharge rate associated with the 25 - year, 24 - hour storm event for downchute contributing drainage areas using the Rational Method (see Subsection 2.2 of Attachment 6A).
2. Determine Mannings "n" and runoff coefficient "C" (see Page 6A-A-25 and 6A-E-71, respectively).
3. Using the specified channel geometry, evaluate the peak velocity and flow depth using HYDROCALC program.

**Solution:**

$$I = \frac{b}{(t_c + d)^e}$$

Where, I = Rainfall intensity, in/hr

| | |
|---|---|
| b= | 103.56 |
| d= | 11.0 |
| e= | 0.806 |
| $t_c$ = | 10 min |

(b, d, e are associated with a 25 - year, 24 - hour storm for Limestone Co., see Page 6A-E-73)

**Rational Method Calculations for Typical Swale Contributing Areas**

| | Drainage Area [2] | Runoff Coef. C[3] | Rainfall Int. I, (in/hr)[4] | Area (acres) | Peak Discharge (cfs) |
|---|---|---|---|---|---|
| East | DC1 | 0.70 | 8.9 | 21.7 | 135.2 |
| West | DC2 | 0.70 | 8.9 | 15.1 | 93.8 |

**Typical Swale Summary Calculations[1]**

| Drainage Area [2] | Flow Rate (cfs) | Bottom Slope(ft/ft) | Manning's n[3] | Sideslope (left) | Sideslope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| DC1 | 135.2 | 0.25 | 0.033 | 2 | 2 | 15.0 | 0.60 | 15.20 |
| DC2 | 93.8 | 0.25 | 0.033 | 2 | 2 | 15.0 | 0.49 | 13.28 |

**Conclusions:** Based on the greatest contributing drainage areas shown on Drawing 6A-E.2, downchutes installed on final cover will be constructed 2 feet deep (assuming 1-foot of freeboard), with a 15-foot bottom width, and 2H:1V sideslopes. Gabions, rip rap, or dissipation blocks will be installed at the toe of the landfill berm with the perimeter channels to dissipate the peak velocity. Typcial details for downchutes are depcited on Drawing 6A.20.

**Notes:**

1. Calculations were performed using the HYDROCALC program developed by Dodson and Associates (Version 1.3, 1986).
2. Contributing drainage areas are depicted on Drawing 6A-E.2.
3. Refer to Hydraulic Calculation References for Mannings "n" and runoff coefficient, C, references.
4. Rainfal Intensity (I) calculated for tc = 10 min, using equation for rainfall intensity shown above. Refer to Hydraulic Calculation References for coefficient b,d, and e references.

# DETENTION BASIN AND PERIMETER CHANNEL FLOW ANALYSIS (HYDROCALC OUTPUT FILES)

TRAPEZOIDAL CHANNEL ANALYSIS
NORMAL DEPTH COMPUTATION

October 1, 2020

PROGRAM INPUT DATA

| DESCRIPTION | VALUE |
|---|---|
| Flow Rate (cfs) | 106.3 |
| Channel Bottom Slope (ft/ft) | 0.0001 |
| Manning's Roughness Coefficient (n-value) | 0.033 |
| Channel Left Side Slope (horizontal/vertical) | 3.0 |
| Channel Right Side Slope (horizontal/vertical) | 3.0 |
| Channel Bottom Width (ft) | 10.0 |

COMPUTATION RESULTS

| DESCRIPTION | VALUE |
|---|---|
| Normal Depth (ft) | 4.78 |
| Flow Velocity (fps) | 0.91 |
| Froude Number | 0.093 |
| Velocity Head (ft) | 0.01 |
| Energy Head (ft) | 4.79 |
| Cross-Sectional Area of Flow (sq ft) | 116.31 |
| Top Width of Flow (ft) | 38.67 |

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TRAPEZOIDAL CHANNEL ANALYSIS
NORMAL DEPTH COMPUTATION

October 1, 2020

PROGRAM INPUT DATA

| DESCRIPTION | VALUE |
|---|---|
| Flow Rate (cfs) | 40.4 |
| Channel Bottom Slope (ft/ft) | 0.0001 |
| Manning's Roughness Coefficient (n-value) | 0.033 |
| Channel Left Side Slope (horizontal/vertical) | 3.0 |
| Channel Right Side Slope (horizontal/vertical) | 3.0 |
| Channel Bottom Width (ft) | 7.0 |

COMPUTATION RESULTS

| DESCRIPTION | VALUE |
|---|---|
| Normal Depth (ft) | 3.32 |
| Flow Velocity (fps) | 0.72 |
| Froude Number | 0.087 |
| Velocity Head (ft) | 0.01 |
| Energy Head (ft) | 3.33 |
| Cross-Sectional Area of Flow (sq ft) | 56.31 |
| Top Width of Flow (ft) | 26.92 |

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TRAPEZOIDAL CHANNEL ANALYSIS
NORMAL DEPTH COMPUTATION

October 1, 2020

PROGRAM INPUT DATA

| DESCRIPTION | VALUE |
|---|---|
| Flow Rate (cfs) | 21.7 |
| Channel Bottom Slope (ft/ft) | 0.0001 |
| Manning's Roughness Coefficient (n-value) | 0.033 |
| Channel Left Side Slope (horizontal/vertical) | 3.0 |
| Channel Right Side Slope (horizontal/vertical) | 3.0 |
| Channel Bottom Width (ft) | 5.0 |

COMPUTATION RESULTS

| DESCRIPTION | VALUE |
|---|---|
| Normal Depth (ft) | 2.69 |
| Flow Velocity (fps) | 0.62 |
| Froude Number | 0.084 |
| Velocity Head (ft) | 0.01 |
| Energy Head (ft) | 2.7 |
| Cross-Sectional Area of Flow (sq ft) | 35.23 |
| Top Width of Flow (ft) | 21.16 |

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# CHANNEL-2A5

TRAPEZOIDAL CHANNEL ANALYSIS
NORMAL DEPTH COMPUTATION

September 29, 2020

PROGRAM INPUT DATA

| DESCRIPTION | VALUE |
|---|---|
| Flow Rate (cfs) | 252.8 |
| Channel Bottom Slope (ft/ft) | 0.0025 |
| Manning's Roughness Coefficient (n-value) | 0.027 |
| Channel Left Side Slope (horizontal/vertical) | 3.0 |
| Channel Right Side Slope (horizontal/vertical) | 3.0 |
| Channel Bottom Width (ft) | 10.0 |

COMPUTATION RESULTS

| DESCRIPTION | VALUE |
|---|---|
| Normal Depth (ft) | 3.04 |
| Flow Velocity (fps) | 4.35 |
| Froude Number | 0.535 |
| Velocity Head (ft) | 0.29 |
| Energy Head (ft) | 3.33 |
| Cross-Sectional Area of Flow (sq ft) | 58.1 |
| Top Width of Flow (ft) | 28.24 |

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# CHANNEL-3A1

TRAPEZOIDAL CHANNEL ANALYSIS
NORMAL DEPTH COMPUTATION

September 29, 2020

PROGRAM INPUT DATA

| DESCRIPTION | VALUE |
|---|---|
| Flow Rate (cfs) | 123.5 |
| Channel Bottom Slope (ft/ft) | 0.0025 |
| Manning's Roughness Coefficient (n-value) | 0.027 |
| Channel Left Side Slope (horizontal/vertical) | 3.0 |
| Channel Right Side Slope (horizontal/vertical) | 3.0 |
| Channel Bottom Width (ft) | 10.0 |

COMPUTATION RESULTS

| DESCRIPTION | VALUE |
|---|---|
| Normal Depth (ft) | 2.12 |
| Flow Velocity (fps) | 3.57 |
| Froude Number | 0.51 |
| Velocity Head (ft) | 0.2 |
| Energy Head (ft) | 2.31 |
| Cross-Sectional Area of Flow (sq ft) | 34.58 |
| Top Width of Flow (ft) | 22.69 |

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# CHANNEL-4B6

TRAPEZOIDAL CHANNEL ANALYSIS
NORMAL DEPTH COMPUTATION

September 29, 2020

PROGRAM INPUT DATA

| DESCRIPTION | VALUE |
|---|---|
| Flow Rate (cfs) | 71.6 |
| Channel Bottom Slope (ft/ft) | 0.009 |
| Manning's Roughness Coefficient (n-value) | 0.027 |
| Channel Left Side Slope (horizontal/vertical) | 3.0 |
| Channel Right Side Slope (horizontal/vertical) | 3.0 |
| Channel Bottom Width (ft) | 10.0 |

COMPUTATION RESULTS

| DESCRIPTION | VALUE |
|---|---|
| Normal Depth (ft) | 1.12 |
| Flow Velocity (fps) | 4.78 |
| Froude Number | 0.891 |
| Velocity Head (ft) | 0.36 |
| Energy Head (ft) | 1.48 |
| Cross-Sectional Area of Flow (sq ft) | 14.98 |
| Top Width of Flow (ft) | 16.72 |

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# CHANNEL-4B7

TRAPEZOIDAL CHANNEL ANALYSIS
NORMAL DEPTH COMPUTATION

September 29, 2020

PROGRAM INPUT DATA

| DESCRIPTION | VALUE |
|---|---|
| Flow Rate (cfs) | 210.0 |
| Channel Bottom Slope (ft/ft) | 0.009 |
| Manning's Roughness Coefficient (n-value) | 0.033 |
| Channel Left Side Slope (horizontal/vertical) | 3.0 |
| Channel Right Side Slope (horizontal/vertical) | 3.0 |
| Channel Bottom Width (ft) | 10.0 |

COMPUTATION RESULTS

| DESCRIPTION | VALUE |
|---|---|
| Normal Depth (ft) | 2.22 |
| Flow Velocity (fps) | 5.69 |
| Froude Number | 0.797 |
| Velocity Head (ft) | 0.5 |
| Energy Head (ft) | 2.72 |
| Cross-Sectional Area of Flow (sq ft) | 36.92 |
| Top Width of Flow (ft) | 23.3 |

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# CHANNEL-4B8

TRAPEZOIDAL CHANNEL ANALYSIS
NORMAL DEPTH COMPUTATION

September 29, 2020

PROGRAM INPUT DATA

| DESCRIPTION | VALUE |
|---|---|
| Flow Rate (cfs) | 210.0 |
| Channel Bottom Slope (ft/ft) | 0.0025 |
| Manning's Roughness Coefficient (n-value) | 0.027 |
| Channel Left Side Slope (horizontal/vertical) | 3.0 |
| Channel Right Side Slope (horizontal/vertical) | 3.0 |
| Channel Bottom Width (ft) | 11.0 |

COMPUTATION RESULTS

| DESCRIPTION | VALUE |
|---|---|
| Normal Depth (ft) | 2.68 |
| Flow Velocity (fps) | 4.11 |
| Froude Number | 0.528 |
| Velocity Head (ft) | 0.26 |
| Energy Head (ft) | 2.94 |
| Cross-Sectional Area of Flow (sq ft) | 51.07 |
| Top Width of Flow (ft) | 27.09 |

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**CITY OF WACO LANDFILL**
**TCEQ PERMIT NO. MSW-2400**
**McLENNAN AND LIMESTONE COUNTIES, TEXAS**

# PART III
# SITE DEVELOPMENT PLAN
# ATTACHMENT 6B
# FLOODPLAIN EVALUATION

**Prepared for:**

**CITY OF WACO**

Solid Waste Services
501 Schroeder Drive
Waco, TX 76710

**Prepared by:**

**SCS ENGINEERS**
**Texas Board of Professional Engineers, Reg. No. F-3407**
Dallas/Fort Worth Office
1901 Central Drive, Suite 550
Bedford, Texas 76021
817/571-2288

Revision 0 – April 2020
Revision 1 – October 2020
SCS Project No. 16216088.00

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Drawing 6B.2: Flood Study Drainage Areas
Drawing 6B.3: Proposed Limit of 100-year Flood Study

## Appendices

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6B-B HEC-HMS Input File
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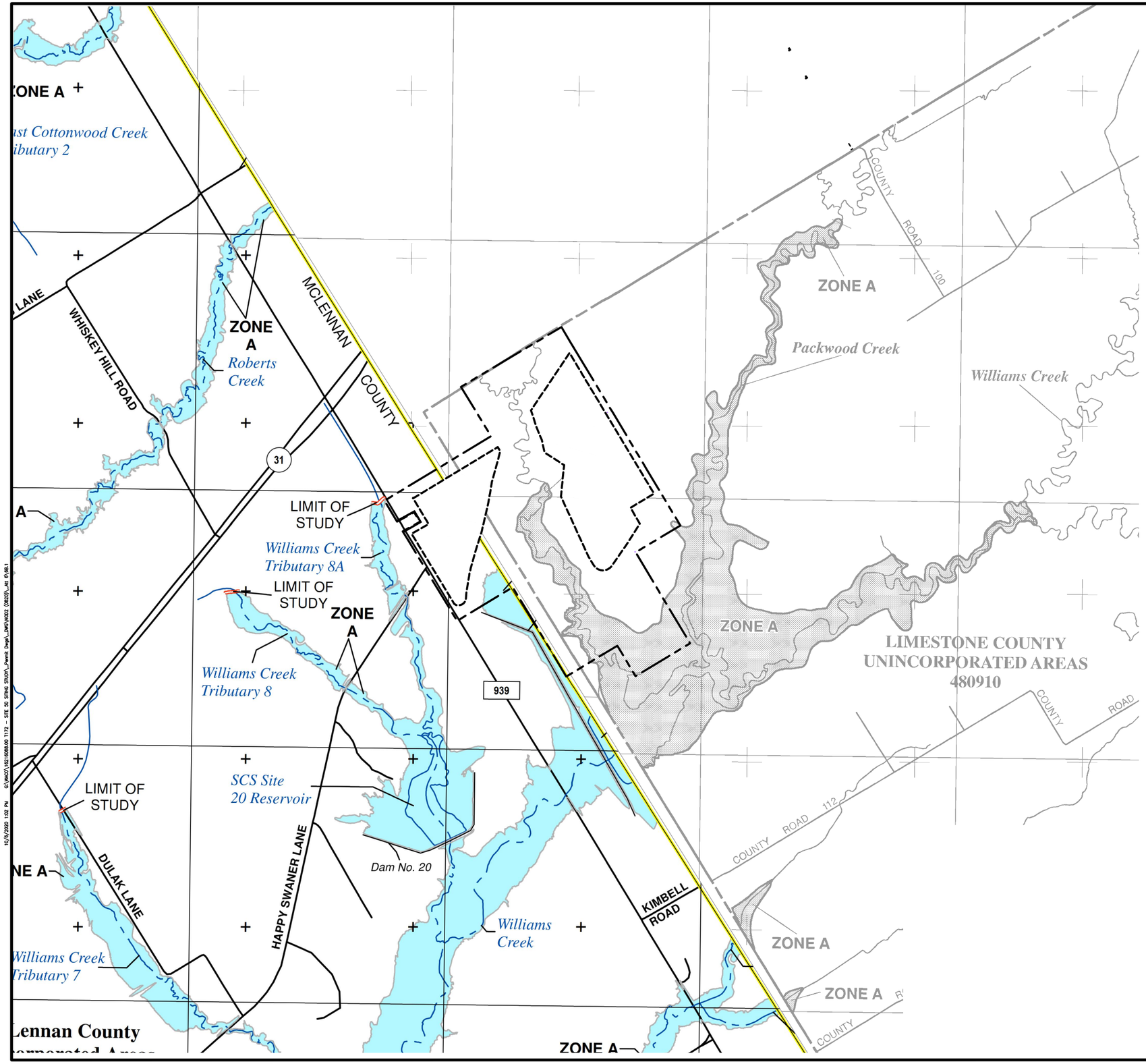
**SCS Engineers**
**TBPE Reg. # F-3407**

## DRAWINGS

- Drawing 6B.1: FEMA Floodplain Map
- Drawing 6B.2: Flood Study Drainage Areas
- Drawing 6B.3: Proposed Limit of 100-year Flood Study




N

0 1000 2000
SCALE IN FEET

## LEGEND

PERMIT BOUNDARY

LIMITS OF WASTE

ZONE A SPECIAL FLOOD HAZARD AREA

OTHER SPECIAL FLOOD HAZARD AREA

## NOTES:

1. THESE MAPS MAY NOT INCLUDE ALL SPECIAL FLOOD HAZARD AREAS IN THE COMMUNITY. AFTER A MORE DETAILED STUDY, THE SPECIAL FLOOD HAZARD AREAS SHOWN ON THESE MAPS MAY BE MODIFIED, AND OTHER AREAS ADDED.
2. ZONE A: AREAS WITH A 1% ANNUAL CHANCE OF FLOODING AND A 26% CHANCE OF FLOODING OVER THE LIFE OF A 30-YEAR MORTGAGE. BECAUSE DETAILED ANALYSES ARE NOT PERFORMED FOR SUCH AREAS; NO DEPTHS OR BASE FLOOD ELEVATIONS ARE SHOWN WITHIN THESE ZONES.
3. ZONE X: AREAS DETERMINED TO BE OUTSIDE THE 0.2% ANNUAL CHANCE FLOODPLAIN.

## BASE MAP SOURCES FIRM

FLOOD INSURANCE RATE MAP LIMESTONE COUNTY, TEXAS INCORPORATED AREA COMMUNITY – PANEL 125 OF 625
MAP NUMBER: 48293C0125C
EFFECTIVE DATE: SEPTEMBER 16, 2011
U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

FLOOD INSURANCE RATE MAP MCLENNAN COUNTY, TEXAS INCORPORATED AREA COMMUNITY – PANEL 250 OF 750
MAP NUMBER: 48309C0250D
EFFECTIVE DATE: DECEMBER 20, 2019
U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

STATE OF TEXAS
JAMES ROY MURRAY III
73860
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

FOR PERMITTING PURPOSES ONLY

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | 2019 UPDATE TO MCLENNAN COUNTY FIRM MAP | JRM |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: FEMA FLOODPLAIN MAP

PROJECT TITLE: CITY OF WACO LANDFILL TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO SOLID WASTE SERVICES


SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
PH (817) 571-2288 FAX NO. (817) 571-2188

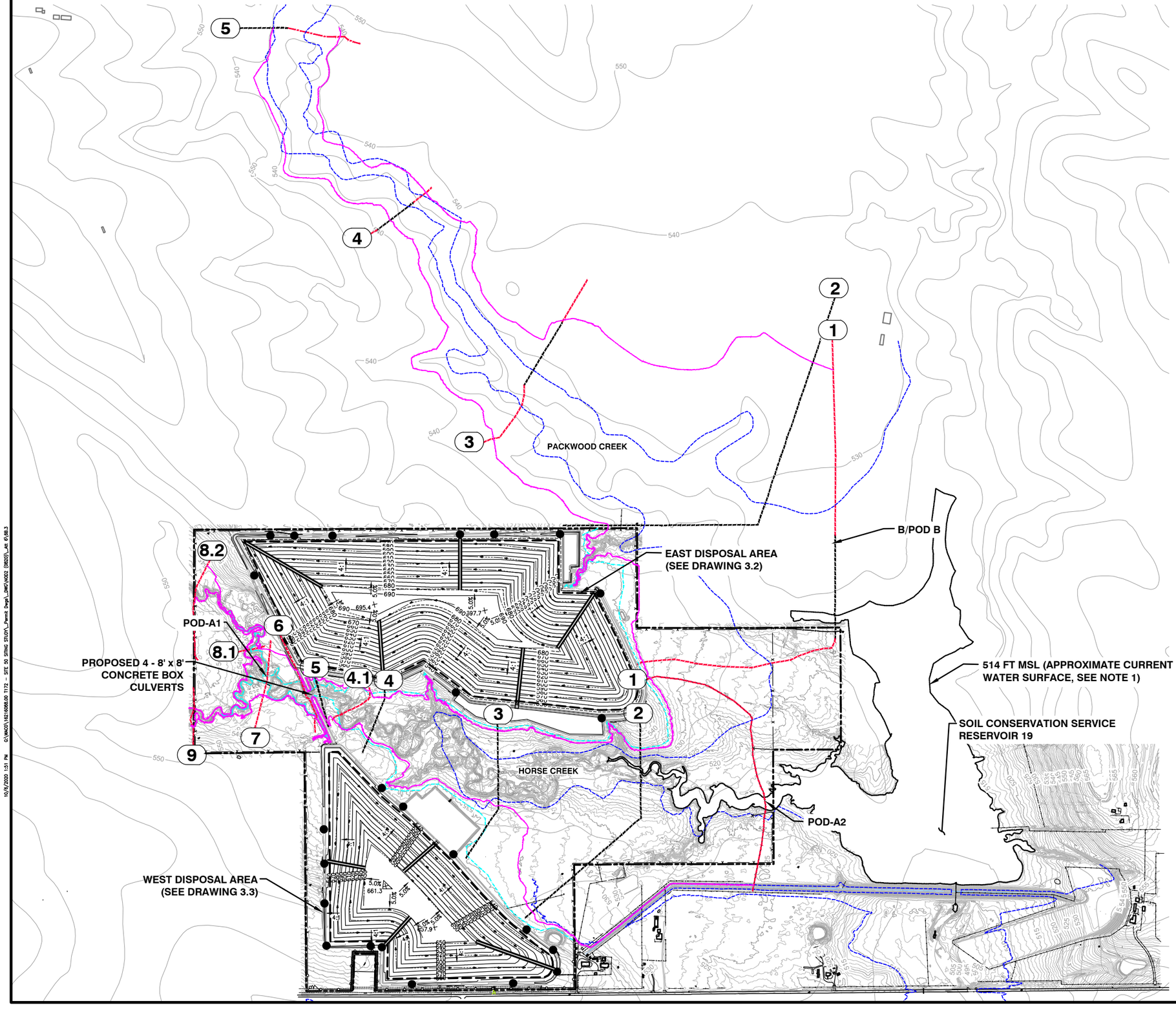

PROJ. NO. 16216088.00 | DSN. BY: RRK | DWN. BY: JLJ | CHK. BY: KDY | Q/A RVW BY: KDY | APP. BY: RRK

CADD FILE: 6B.1

DATE: 10/2020

SCALE: AS SHOWN

DRAWING NO. 6B.1




0 500 1000
SCALE IN FEET

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- 4 SURVEYED CROSS-SECTIONALS
- 7 TOPOGRAPHY CROSS-SECTIONALS
- 100-YEAR FLOOD PLAIN (SEE NOTE 2)
- 100-YEAR STORM EVENT WATER SURFACE
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

NOTE:

1. EXISTING TOPOGRAPHY IS A COMPOSITE OF 2016 AND 2018 SURVEYS.

   2016 TOPOGRAPHIC SURVEY FROM U.S. GEOLOGICAL SURVEY.

   2018 TOPOGRAPHIC SURVEY FROM AERIAL PHOTOGRAPHY PERFORMED BY UNITED GEO TECHNOLOGIES, INC. ON JULY 03, 2018.

2. 100-YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY). FOR ADDITIONAL INFORMATION, SEE DRAWING 6B1.

| HORSE CREEK 100-YEAR STORM EVENT WATER SURFACE ELEVATION (FT) | |
|---|---|
| CROSS SECTION 1 | 533.40 |
| CROSS SECTION 2 | 533.41 |
| CROSS SECTION 3 | 533.44 |
| CROSS SECTION 4 | 533.78 |
| CROSS SECTION 5 | 536.60 |
| CROSS SECTION 6 | 538.43 |
| CROSS SECTION 7 | 540.00 |
| CROSS SECTION 8.1 | 537.46 |
| CROSS SECTION 8.2 | 545.35 |
| CROSS SECTION 9 | 541.87 |

THE 100-YEAR FLOOD STUDY IDENTIFIED THE 100-YEAR FLOOD LEVEL AND 100-YEAR FLOOD LIMITS. FOR ADDITIONAL INFORMATION, SEE APPENDIX 6B-D.

STATE OF TEXAS
JAMES ROY MURRAY III
73860
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

**FOR PERMITTING PURPOSES ONLY**

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOODPLAIN, FLOWAGE EASEMENT, LIMITS OF WASTE, NOTE 2, AND HORSE CREEK 100-YEAR STORM EVENT WATER SURFACE ELEVATION TABLE. | JRM |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: PROPOSED LIMIT OF 100-YEAR FLOOD STUDY

PROJECT TITLE: CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO
SOLID WASTE SERVICES

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
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PH (817) 571-2288 FAX NO. (817) 571-2188

PROJ. NO. 16216088.00
DSN. BY: BG/RRK
DWN. BY: NR
CHK. BY: BJD
QA/QA REVIEW BY: RRK
APP. BY: RRK

CADD FILE: 6B.3
DATE: 04/2020
SCALE: AS SHOWN
DRAWING NO. 6B.3

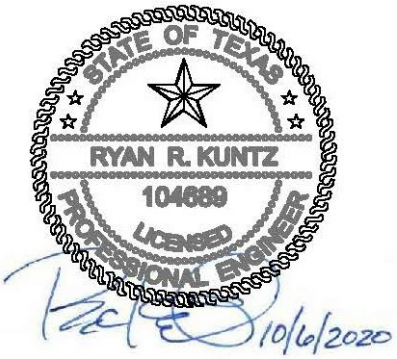
G:\WACO\16216088.00 1172 - SITE 50 SITING STUDY_Permit Dwgs_DWG\WA022 (08/20)_AR 6\6B.3
10/6/2020 1:51 PM

**CITY OF WACO LANDFILL**
**TCEQ PERMIT NO. MSW-2400**
**MCLENNAN AND LIMESTONE COUNTIES, TEXAS**

# PART III - SITE DEVELOPMENT PLAN
# ATTACHMENT 6C
# GROUNDWATER PROTECTION PLAN

**Prepared for:**

**CITY OF WACO**




Solid Waste Services
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**Drawings**

6C.1 Bottom Liner Details
6C.2 Final Cover Details

**SCS Engineers**
**TBPE Reg. # F-3407**

Additional description is provided in Attachment 12. Drawings that depict the layout of the leachate collection system components, as well as selected details of the leachate collection system are also provided in Attachment 12.

The primary collection component of the LCS is the leachate drainage layer, which consists of a geonet-geotextile composite (referred to as geocomposite) placed directly over the geomembrane component of the liner system. The geocomposite will serve to collect and convey leachate to the LCS pipes and sumps. The geocomposite will consist of an HDPE geonet with a non-woven geotextile heat bonded to one or both sides of the geonet. The geocomposite will maintain less than 30 centimeters leachate head above the bottom liner system. Calculations demonstrating the required material properties for the geocomposite are presented in the Attachment 12, Appendix 12B.

A 2-foot thick protective soil cover will be placed over the geocomposite prior to waste placement. Chimney drains, comprised of aggregate wrapped in a non-woven geotextile, will be constructed over the leachate collection piping for both leachate drainage and pipe stability. The bottom liner system of each sector will slope to drain at a minimum 2 percent grade toward a perforated leachate collection pipe located in the center of each sector. The leachate collection piping will be sloped at a minimum 1 percent to drain leachate into leachate collection sumps located at the perimeter of the landfill. Additional discussion and calculations regarding pipe stability to prevent collapse, spacing and size for anticipated leachate flows, and perforations to prevent clogging are presented in Attachment 15, Appendix 12B.

Leachate collected in the sumps will be removed via submersible pumps lowered into the sumps through a riser extending up the sector sideslope. Additional description of the sumps, including sump sizing calculations, is also presented in Attachment 12, Appendix 12B.

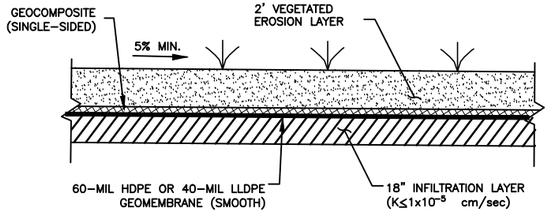
## 2.3 FINAL COVER SYSTEM

As shown on Drawing 6C.2, the final cover system will be a soil-geomembrane composite meeting the requirements of §330.457(a). Beginning from the surface and working down, the final cover system will be comprised of the following components:

- Vegetation (native and/or introduced grasses);
- 24-inch-thick vegetative erosion layer, with the upper 6 inches capable of sustaining vegetation;
- Geocomposite (single-sided on the topslope and double-sided on the sideslopes);
- 60-mil HDPE geomembrane, or 40-mil linear low density polyethylene (LLDPE) geomembrane (smooth on the topslope and textured [both sides] on the sideslopes);
- 18-inch-thick clayey soil infiltration layer ($k \leq 1x10^{-5}$ cm/sec); and

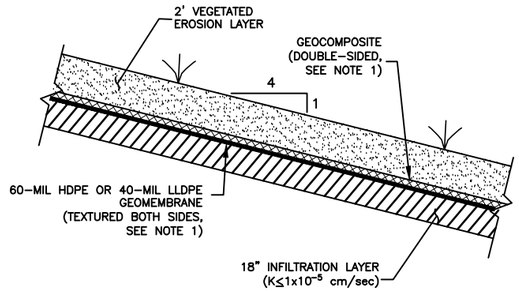
## DRAWINGS

- Drawing 6C.1 Bottom Liner Details
- Drawing 6C.2 Final Cover Details




FINAL COVER – TOPSLOPE (A / 6C.2)

NTS

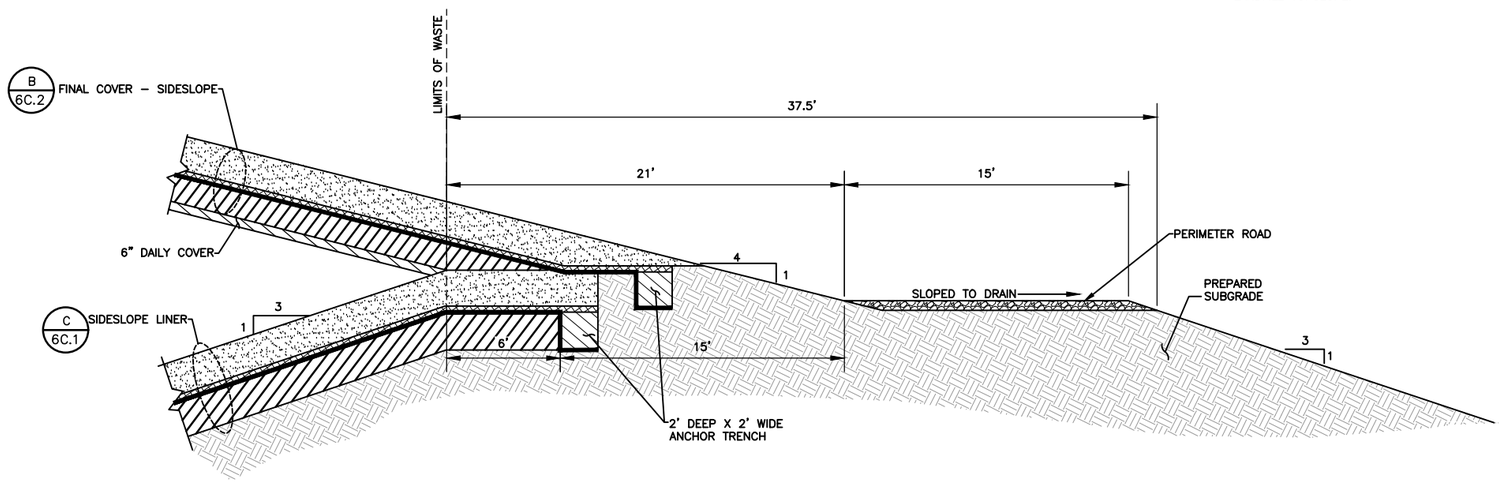



FINAL COVER – SIDESLOPE (B / 6C.2)

NTS

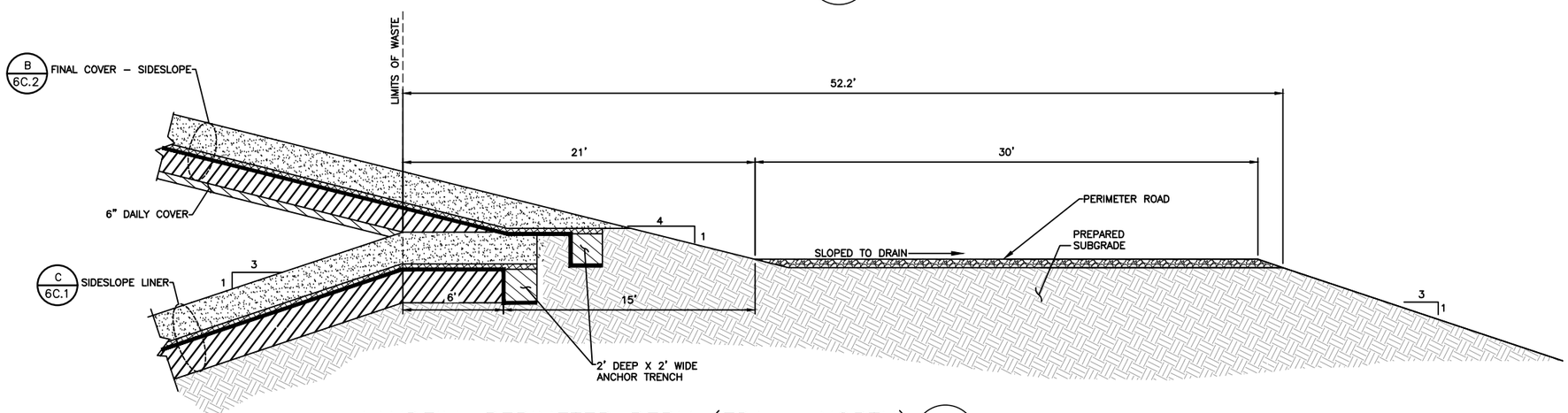
NOTE:

1. TEXTURED GEOMEMBRANE AND DOUBLE-SIDED GEOCOMPOSITE WILL EXTEND A MINIMUM OF 5 FEET ONTO THE LANDFILL TOPSLOPE.




LANDFILL PERIMETER BERM (C / 6C.2)

NTS




LANDFILL PERIMETER BERM (EDA – NORTH) (D / 6C.2)

NTS

**FOR PERMITTING PURPOSES ONLY**

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | ADDED GEOCOMPOSITE ON TOPSLOPE OF FINAL COVER. REVISED NOTE 1 TO CHANGE GEOCOMPOSITE EXTENSION LENGTH TO 5 FEET. ON TOP SLOPE. | |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: **FINAL COVER DETAILS**

PROJECT TITLE: **CITY OF WACO LANDFILL**
**TYPE I MSW - PERMIT APPLICATION**

CLIENT: **CITY OF WACO**
**SOLID WASTE SERVICES**

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PROJ. NO. 16216088.00 | DSN. BY: BG/RRK | DWN. BY: NR | CHK. BY: BJD | D/A R/W BY: RRK | APP. BY: RRK

CADD FILE: 6C2 – FINAL COVER DETAIL-1

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. **6C.2**

10/7/2020 10:18 PM G:\WACO\16216088.00 1172 – SITE SO SITING STUDY_Permit Dwgs_DWG\W002 (2020)_Att 6\6C2 – Final Cover Detail-1

**CITY OF WACO LANDFILL**
**TCEQ PERMIT NO. MSW-2400**
**McLENNAN AND LIMESTONE COUNTIES, TEXAS**

# PART III - SITE DEVELOPMENT PLAN
# ATTACHMENT 7
# GROUNDWATER SAMPLING AND ANALYSIS PLAN

**Prepared for:**

**CITY OF WACO**

Solid Waste Services
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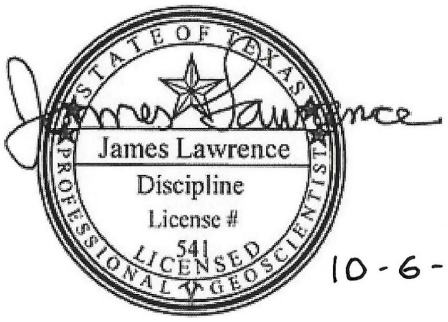
Waco, TX 76710

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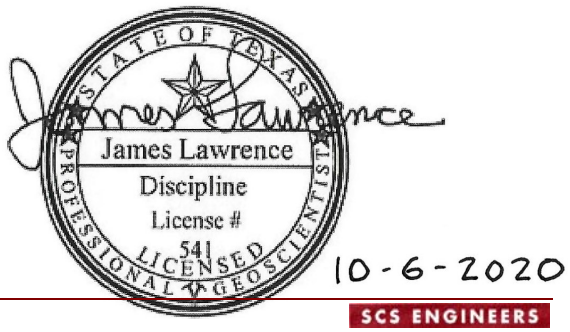


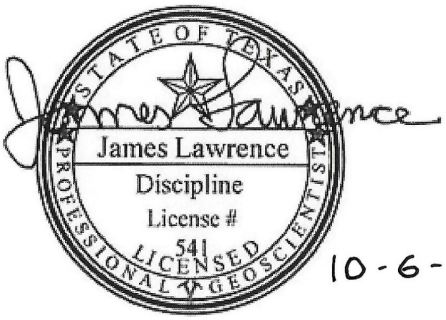
**Tables**

Table 7-2-1. Typical Collecting Frequencies for Blanks

Table 7-3-1. Measurement-Quality Objectives

**Appendices**

Appendix III-7-A List of Constituents for Detection Monitoring




10-6-2020

- Transport off-site or discharge to an authorized wastewater treatment facility, or liquid waste processing facility, if the water quality is acceptable to the receiving facility.

If test results indicate levels of contaminants that cause the water to be classified as hazardous, the water shall be properly transported and disposed of at a hazardous waste facility.

## 2.4 SAMPLE COLLECTION

Physical or chemical changes can occur in groundwater samples if inappropriate or inadequate sampling devices, collection procedures, preservatives, temperature controls, or shipping methods are used. The sampler shall observe the following procedures when collecting samples.

### 2.4.1 Sample Collection Methods

#### 2.4.1.1 Timing and Sequence of Sampling

The elapsed time between purging and sample collection shall be as short as practical, to avoid temporal variations in water levels and water chemistry. Preferably, sampling shall be done within 24 hours of purging. The sampler shall measure the water level in each well again before sampling to determine whether there is enough water for sampling, especially if the well went dry during purging. Where practicable, the water level in a well shall be allowed to recover to 90 percent of the level that existed prior to purging, before collecting a sample. To allow wells that purged dry to recover sufficiently to sample, or suspended sediments to settle, the sampler may have to wait several hours or several days between purging and sampling.

The sampler may allow up to seven days recovery time after purging a well before determining that the well is dry or has not recharged sufficiently to sample. If after seven days a slowly recharging well has not recovered sufficiently for a complete set of samples, the sampler shall collect a partial set of samples in the order specified in this GWSAP, or in another order if warranted by conditions and data needs, until no more samples for the set can be collected. If contamination is known to be present in one or more wells at an MSW landfill, the sampler shall begin the sampling at the well that is known to be the least contaminated and end with the most contaminated well. Where no contamination is known, the order shall generally be from the well with the highest water-level elevation to the one with the lowest elevation (that is, from upgradient to downgradient) for wells screened in the same water-bearing unit.

If low-flow purging is used, then low-flow sampling will also be used. Samples can be collected immediately at a flow rate less than 250 ml/minute, upon parameter and water level stabilization.

#### 2.4.1.2 Cleaning and Decontaminating Field Equipment

If the sampler uses non-dedicated sampling devices, they shall clean and decontaminate them using appropriate procedures before sampling each well. Do not reuse sample bottles, bailer rope, rubber hoses, or disposable gloves. If a bailer is used, a bottom-emptying device is required, because it allows the bailer to be emptied slowly from the bottom, reducing turbulence and aeration, which could alter sample chemistry.

#### 2.4.1.3 Calibrating Field Equipment

Field equipment, including devices for water quality indicator parameters, shall be calibrated in accordance with the manufacturer's instructions prior to sampling.

#### 2.4.1.4 Water Quality Indicator Parameters

Before sample collection begins, the sampler shall measure and record water quality indicator parameters—including pH, specific conductance, dissolved oxygen, oxidation-reduction potential, temperature, and turbidity—in addition to the measurements the sampler made during purging [if low-flow sampling is used].

#### 2.4.1.5 Sample Filtering

Per 30 TAC §330.405(c), the sampler shall not filter any samples in the field.

### 2.4.2 Sample-Collection Procedure

Sampling with a bailer is the collection method of choice at this Facility. If for some reason a bailer is not available for use, a low-flow pump such as a Monsoon pump is an acceptable alternative.

#### 2.4.2.1 Cleanliness

To prevent contamination, the sampler shall keep clean equipment on top of plastic sheeting and not in direct contact with the ground. The sampler shall check the area around the sampling point for possible sources of air contamination, particularly when sampling for VOCs. The sampler shall note any potential impacts in the field log. The sampler shall collect all water samples as close to the wellhead as practical. The sampler shall not allow the sampling device to touch the sampling container, but hold the two as close to each other as possible, to reduce aeration. Water removed during sampling and not utilized shall be handled in the same way as purge water.

#### 2.4.2.2 Sample Volumes and Sampling Containers

The volume of samples and types of sample containers needed depends on the constituents to be analyzed. The sampler shall follow the following EPA recommendations:

- For volatile organic compounds (VOCs), use two [or three] 40 ml glass vials (or lab-specified alternate quantity or size) with special caps with Teflon® septa, pre-preserved by the lab. The septum shall be correctly placed, with the Teflon® side toward the sample (shiny side away from the sample).
- For semivolatile organic compounds (SVOCs), use a one-liter glass container.
- For metals, use laboratory-provided polyethylene or glass containers that already contain the necessary preservatives.
- For other inorganic constituents, use laboratory-provided polyethylene or glass containers (preservatives generally are not used, except for samples to be analyzed for ammonia).

#### 2.4.2.3 Filling Sample Containers

The sampler shall fill sample containers in the following order, according to volatilization sensitivity (from most to least volatile):

- VOCs
- SVOCs
- Metals
- Other Inorganic Constituents

When filling containers for VOC samples, the sampler shall allow the water stream to flow down the inner wall of the vial to minimize formation of air bubbles. The sampler shall overflow the containers slightly so that the vial has a positive meniscus. The sampler shall screw the caps on carefully to avoid leaving any air space in the vials. If an air bubble forms in the bottle, the sampler shall not open the bottle to remove it, but collect an additional, separate sample. If the sampler uses bailers for sampling, the sampler shall discard the first part of the sample to remove any sludge or suspended solids, then fill both VOC vials from a single bailer to minimize differences in the samples.

#### 2.4.2.4 Labeling Sample Containers

All sample containers shall be labeled for identification purposes. The labels shall include information such as sample number (with the well number as part of the sample number), site identification, analysis to be performed, preservatives used, date and time of sample collection, and name of sampler. The sampler shall write the information on the label with permanent ink and, if necessary, cover the label with transparent tape to protect the written data.

### 2.4.3 Quality Control Samples

The sampler is required to use appropriate trip blanks, field blanks, equipment blanks, and field duplicate samples for quality control (QC), as they can help determine whether samples have been contaminated from other sources. Typical collecting frequencies are as follows:

**Table 7-2-1. Typical Collecting Frequencies for Blanks**

| Type of Blank Collection | Frequency |
|---|---|
| Trip Blanks | One for each sampling event |
| Field Blanks | One per day, or one for every 10 wells sampled, whichever is greater |
| Equipment Blanks | One per day or sampling event [if non-dedicated/non-disposable equipment is used] |
| Field Duplicates | One for every 20 wells sampled, with at least one per sampling event |

The various types of QC samples are described below.

- Trip Blanks. A trip blank is a laboratory-prepared sample of reagent-grade or distilled water provided with a set of sample jars that is transported to and from the site in the same manner as the sample containers. The purpose of the trip blank is to determine if any of the sample bottles or collected samples have been contaminated before or during sampling, or if sample shipment, handling, and storage have had an impact on the integrity of the sample.

- Field Blanks. A field blank is prepared in the field by pouring laboratory reagent-grade or distilled water into clean sample containers opened in the field, then returned with the samples to the laboratory for analysis. It is used to check for incorrect sampling procedures or airborne contaminants at the sample-collection point. It is appropriate to collect the field blanks when sampling downgradient wells. If a well is contaminated, a field blank collected close to the contaminated well, in addition to the regular field blank, may help determine if there are other contaminant sources in the area of the well.

- Equipment Blanks. An equipment blank is a sample of laboratory reagent-grade or distilled water run through the well-sampling equipment in the same manner as the actual groundwater sample, to determine the effectiveness of the procedures for equipment decontamination. An equipment blank is not necessary if non-dedicated/non-disposable equipment is used.

- Field Duplicates. Analysis of field duplicate samples provides a check on the precision of the laboratory techniques. Field duplicates are two samples taken at the same time from the same well, and from the same bailer, if bailers are used. Field duplicates are labeled differently so that the laboratory is unaware that the samples are duplicates.

- Field duplicate samples shall be labeled as the sampler would regular samples, but with a sample name such as “Dup-1,” “Dup-2,” and so on, and with the sample time omitted, so there is no way for the laboratory to know which well the duplicate sample is from. The information about which well the duplicate is from shall be recorded in the field log book.

### 2.4.4 Chain-of-Custody Documentation

A suitable chain-of-custody (COC) document shall accompany the samples at every step from field to laboratory and shall be signed by each party (except commercial transporters) handling the samples, from the sampler to the laboratory representative. Usually laboratories provide their own blank COC forms with the empty sample-bottle shipment. Proper COC procedures are essential to ensure sample integrity and to provide legally and technically defensible data.

The person collecting the sample starts the COC procedure and fills in all the required information on the COC document, such as sample name, collection date and time, and requested analyses. Individuals relinquishing and receiving the samples shall sign, date, and note the time of transfer on the COC document. A completed COC document shall be placed inside a sealed plastic bag to prevent the ice or water in the cooler from damaging it. Mailed packages shall have tracking numbers to allow for locating shipments.

### 2.4.5 Sample Storage and Transport

All samples shall be kept cold, ideally at 4° C ± 2°, and transported to the laboratory as soon as possible, preferably within 48 hours of sampling. The samples shall be wrapped, put into resealable plastic bags, and placed in a hard-sided ice chest or other insulated container packed with sufficient ice or refreezable materials to keep them at the ideal temperature. Dry ice is not to be used to chill the samples because the samples could freeze and break their containers.

If the samples are to be shipped, they shall be kept chilled with ice in plastic bags while sampling is occurring. Then, just before shipping, the sampler shall pour out the excess melt water, and add more ice, if necessary. Coolers can also be kept cold with frozen packages of refreezable materials such as "blue ice." The samples, blanks, and COC documents need to be well packed in the insulated cooler, with as little extra air space as possible, utilizing ice bags, foam, or bubble wrap to add padding, then thoroughly sealed with shipping tape. Flimsy, expanded-foam or soft-sided ice chests are not suitable for shipping.

### 2.4.6 Documentation of Sampling

This GWSAP requires that all information related to a sampling event be recorded in a bound, permanent field log book or equivalent. All the entries in the log book shall be legible and made in black, permanent ink. Entry errors shall be crossed out with a single line, dated, and initialed by the person making the corrections. An essential practice is to record sufficient information so that the sampling situation can be reconstructed without relying on the sampler's memory. Location, date, time, weather conditions, name and identity of sampling personnel, all field measurements including numerical values and units, comments about the integrity of the well, and so on shall be recorded. Because the field log book may be the only acceptable record for legal purposes, it shall be protected and kept in a safe place.

During assessment monitoring, the 95% lower confidence limit (LCL) for each constituent is compared against its GWPS to determine if a constituent is present at a statistically significant level above its GWPS. If an LCL exceeds a GWPS, corrective action is triggered, unless it is demonstrated that the statistically significant level resulted from error in sampling, analysis, statistical evaluation, or from natural variation in groundwater quality.

During corrective action monitoring, the 95% upper confidence limit (UCL) for each constituent is compared against its GWPS to determine if a constituent remains at a statistically significant level above its GWPS. A remedy under corrective action is considered complete when the UCLs for all assessment constituents have not exceeded GWPSs for a period of three consecutive years.

#### 5.2.1.1 Alternate Source Demonstration [30 TAC §330.407(b)(3)]

If a statistically significant increase over a background limit of any tested constituent at any monitoring well has occurred and the owner or operator has reasonable cause to think that a source other than the Landfill caused the contamination or that the statistically significant increase resulted from error in sampling, analysis, or statistical evaluation, or from natural variation in groundwater quality, then the owner or operator may submit a report providing documentation to this effect. The report is commonly referred to as an "alternate source demonstration (ASD)," but may be a demonstration of an error or of natural variation, instead of a source other than the Landfill.

In making a demonstration under this paragraph, the owner or operator shall not filter the groundwater sample for constituents addressed by the demonstration prior to laboratory analysis. The executive director may also require the owner or operator to provide analyses of the landfill leachate to support the demonstration per 30 TAC §330.407(b)(3)(C).

The owner or operator pursuing an ASD shall first notify the executive director of the TCEQ (and any local pollution agency with jurisdiction that has requested to be notified) in writing, within 14 days of determining an SSI over a background limit, that the owner or operator intends to make the demonstration. The ASD shall be submitted within 90 days of determining an SSI.

If the ASD is satisfactory to the executive director, the facility may continue detection monitoring. If the ASD is not satisfactory, the Landfill shall proceed with assessment monitoring.

## 5.3 ASSESSMENT MONITORING [30 TAC §330.409]

Assessment monitoring is required if a facility determines there has been an SSI over a background limit for one or more of the constituents. Within 90 days of determining that an SSI has occurred, and not less than annually thereafter, the owner or operator shall sample and analyze each affected well and the two wells adjacent to each affected well for the full set of constituents listed in Appendix II to 40 CFR, Part 258. After sampling for the full set of Appendix II constituents, the executive director may delete any of the Appendix II constituents.

The executive director may specify an appropriate alternative frequency, in accordance with 30 TAC §330.409(c), for repeated sampling and analysis for the full set of 40 CFR Part 258, Appendix II constituents. During alternative frequency for repeated sampling, the following factors shall be considered:

- lithology and hydraulic conductivity of the aquifer and unsaturated zone;
- groundwater flow rates;
- minimum distance of travel from the waste nearest to any point of compliance monitoring well;
- resource value of the uppermost aquifer; and
- nature (fate and transport) of any constituents detected in response to this section.

In accordance with TAC §330.409(d)(2), if any new constituents are detected in the well as a result of the Appendix II analysis, a background limit shall be established for the additional constituents. This background level consists of four statistically independent samples from each background well. Furthermore, groundwater protection standards shall be established for all constituents in point of compliance wells detected (TAC §330.409(d)(3)). The groundwater protection standards shall be established in accordance with TAC §330.409(h) or (i).

In accordance with TAC §330.409(h), the owner or operator shall establish a groundwater protection standard for each 40 CFR Part 258, Appendix II constituent detected in the point of compliance monitoring wells. The groundwater protection standard must be:

- for constituents for which a maximum contaminant level (MCL) has been promulgated under 40 CFR Part 141, Safe Drinking Water Act, the MCL for that constituent;

- for constituents for which MCLs have not been promulgated, the background concentration for the constituent established from wells in accordance with TAC §330.405(d);

- for constituents for which the background level is higher than the MCL promulgated under 40 CFR Part 141, Safe Drinking Water Act or health-based levels identified under TAC §330.409(i), the background concentration.

In accordance with TAC §330.409(i), the executive director may establish an alternative groundwater protection standard for 40 CFR Part 258, Appendix II constituents for which MCLs have not been established. These groundwater protection standards shall be appropriate health-based levels that satisfy either the criteria of paragraphs (1) - (4) of this subsection, inclusive or comply with paragraph (5) of this subsection:

1. the level is derived in a manner consistent with United States Environmental Protection Agency guidelines for assessing the health risks of environmental pollutants

2. the level is based on scientifically valid studies conducted in accordance with the Toxic Substances Control Act Good Laboratory Practice Standards (40 CFR Part 792) or equivalent;

3. for carcinogens, the level represents a concentration associated with an excess lifetime cancer risk level (due to continuous lifetime exposure) with the 1 x 10-4 to 1 x 10 -6 range; and

4. for systemic toxicants, the level represents a concentration to which the human population (including sensitive subgroups) could be exposed to on a daily basis that is likely to be without appreciable risk of deleterious effects during a lifetime. Systemic toxicants include toxic chemicals that cause effects other than cancer or mutation; or

5. the level is developed in accordance with TAC §350 (relating to Texas Risk Reduction Program).

If the concentration of any Appendix II constituent is above its respective background limit, but below its GWPS, the facility shall continue assessment monitoring. If the concentrations of all Appendix II constituents are shown to be at or below background values for two consecutive sampling events, the owner or operator may return the well to detection monitoring status, after notifying the executive director and receiving approval.

No later than 60 days after each sampling event a determination shall be made whether any Appendix II constituents were detected at statistically significant levels above the groundwater protection standard. If any Appendix II constituents were detected at statistically significant levels above the groundwater protection standard, the facility shall notify the executive director and appropriate local government officials within seven days of the determination.

In accordance with 30 TAC §330.409(g)(1), the owner or operator will also need to characterize the nature and extent of the release by installing additional monitoring wells as necessary; install at least one additional monitoring well between the monitoring well with the statistically significant level and the next adjacent wells along the point of compliance before the next sampling event and sample these wells in accordance with 30 TAC §330.409(d)(1); notify in writing all persons that own or occupy the land that directly overlies any part of the plume of contamination; and initiate an assessment of corrective measures within 90 days of the notice to the executive director.

The owner or operator may demonstrate an ASD in accordance with 30 TAC §330.409(g)(2). The executive director shall be notified within 14 days of exceedance determination an intent to submit an ASD. The ASD report shall be submitted within 90 days of exceedance determination. The owner or operator shall not filter the groundwater sample for constituents addressed by the demonstration prior to laboratory analysis. The executive director may also require the owner or operator to provide analyses of the landfill leachate to support the demonstration. The owner or operator shall continue to monitor in accordance with the assessment monitoring program. If a successful demonstration is made, the owner or operator shall continue monitoring in accordance with the assessment monitoring program.

If the owner or operator determines that the assessment monitoring program no longer satisfies the requirements of this section, the owner or operator shall, within 90 days, submit an application for a permit amendment or modification to make any appropriate changes to the program in accordance with 30 TAC §330.409(g)(4).

## 5.4 ASSESSMENT OF CORRECTIVE MEASURES [30 TAC §330.411]

Within 90 days of finding that any of the 40 CFR, Part 258, Appendix II constituents have been detected at a statistically significant level above a GWPS, the owner or operator shall initiate an assessment of corrective measures. This assessment shall be completed within 180 days of initiating the assessment.

The assessment shall analyze the effectiveness of potential corrective measures, including performance, reliability, ease of implementation, and potential impacts. The assessment shall also discuss the control of exposure to residual contamination, time required to begin and complete the

remedy, costs of remedy implementation, and institutional requirements such as state or local permit requirements that may substantially affect implementation of the remedy or remedies.

Prior to selecting a remedy, the owner or operator shall discuss the results of the assessment of corrective measures in a public meeting with interested and affected parties. The owner or operator shall arrange the meeting and provide notice in accordance with the provisions of 30 TAC §39.501(e)(3).

### 5.4.1 Selection of Remedy [30 TAC §330.413]

Within 30 days of completing the assessment of corrective measures, the facility shall select a remedy and submit a report to the TCEQ for review and approval. The report shall describe the remedy or remedies proposed for selection and the way it meets the remedy standards in 30 TAC §330.413(b).

### 5.4.2 Implementation of the Corrective Action [30 TAC §330.415]

The facility shall implement a corrective action groundwater monitoring program following the schedule specified for the selected remedy. The corrective action is considered complete when the concentrations of all constituents are shown to be at or below GWPSs for a period of three consecutive years. The owner or operator shall also take any interim measures necessary to ensure the protection of human health and the environment. Interim measures shall, to the greatest extent practicable, be consistent with the objectives of and contribute to the performance of the approved remedy.

## 5.5 REPORTING REQUIREMENTS

### 5.5.1 Annual Detection Monitoring Report

The results from detection monitoring events shall be submitted to the TCEQ in an annual report within 90 days after the last groundwater monitoring event in a calendar year at the Landfill. The last groundwater monitoring event refers to a second semiannual event. The annual detection monitoring report shall include the following information:

- A discussion regarding SSIs during the calendar year and a summary of the statistical calculations.
- A summary of the groundwater monitoring events with the monitoring status of each well.
- Results of all groundwater monitoring, resampling, and analytical work produced during the sampling events for the year, including all of the following:
- groundwater sampling results on form TCEQ-0312
- background statistical limits and statistical analyses
- a laboratory case narrative and laboratory review checklist

- the chain of custody for the samples
- A contour map of piezometric groundwater levels and groundwater flow direction for each sampling event. The map shall include all background wells and point-of-compliance wells.
- Recommendations for any changes or updates to the background data set or the monitoring program for the facility.
- Any other items requested by the executive director.
- Submit a permit amendment or modification, if the detection monitoring program no longer satisfies 30 TAC §330.407.

The entire laboratory report, which includes the laboratory quality assurance information and quality control data, and laboratory analytical data, shall be provided electronically in a PDF file on a CD or equivalent media acceptable to TCEQ.

### 5.5.2 Semiannual Report

A semiannual report covering the first half of the calendar year shall be submitted within 74 days after the first semiannual event. The annual report shall not duplicate information that was provided in the semiannual report (such as TCEQ-0312, forms, results of statistical evaluations, and laboratory checklist), but shall include a summary of the semiannual report.

### 5.5.3 Assessment Monitoring Report

The results from assessment monitoring events shall be submitted no later than 60 days after each sampling event. In addition, an annual assessment monitoring report shall be submitted within 60 days after the second semiannual groundwater monitoring event at a facility. The report shall include a statement documenting whether any constituent was present at a statistically significant level above a GWPS during the calendar year. The annual detection monitoring report shall also include the following information:

- Results of all groundwater monitoring results, summary of background groundwater quality values, groundwater monitoring analyses, statistical calculations, graphs, and drawings.
- The groundwater flow rate and direction in the upper and lower aquifers based on data from sampling events with supporting documentation.
- A separate contour map of piezometric water levels for both the upper and lower aquifers based, at a minimum, upon concurrent measurement in all monitoring wells. All data or documentation used to establish the contour map should be included in the report.
- Recommendations for any changes.
- Any other items requested by the executive director.

### 5.5.4 Corrective Action Report

If the Landfill is performing corrective action, an annual corrective action report shall be submitted by March 1 of each year.

### 5.5.5 Additional Information about Reporting

Assessment monitoring reports may be combined with detection monitoring reports.

Further information about meeting the reporting requirements for groundwater monitoring [30 TAC §330.405 through §330.409] is provided in the document Guidelines for Groundwater Monitoring Reports, available on the TCEQ website at https://www.tceq.texas.gov/permitting/waste_permits/msw_permits/msw_gwmon_coract.html

# CITY OF WACO LANDFILL
# TCEQ PERMIT NO. MSW-2400
# MCLENNAN AND LIMESTONE COUNTIES, TEXAS

## PART III - SITE DEVELOPMENT PLAN
## ATTACHMENT 8
## CLOSURE AND POST-CLOSURE COST ESTIMATES

**Prepared for:**

**CITY OF WACO**

Solid Waste Services
501 Schroeder Drive
Waco, Texas 76710

**Prepared by:**

**SCS ENGINEERS**
**Texas Board of Professional Engineers, Reg. No. F-3407**
Dallas/Fort Worth Office
1901 Central Drive, Suite 550
Bedford, Texas 76021
817/571-2288

Revision 0 – April 2020
Revision 1 – October 2020
SCS Project No. 16216088.00

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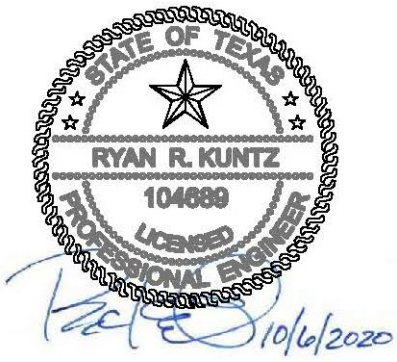
8A Closure Cost Estimate Form for Municipal Solid Waste Type I Landfills
8B Closure Cost Estimate Calculations
8C Post-Closure Care Cost Estimate Form for Municipal Solid Waste Type I Landfills
8D Post-Closure Care Cost Estimate Calculations




**SCS Engineers**
**TBPE Reg. # F-3407**

# APPENDIX 8A

## CLOSURE COST ESTIMATE FORM
## FOR MUNICIPAL SOLID WASTE TYPE I LANDFILLS

**SCS Engineers**
**TBPE Reg. # F-3407**

**Inclusive of pages 8A-1 to 8A-15**

# Texas Commission on Environmental Quality

## Closure Cost Estimate Form for Municipal Solid Waste Type I Landfills

This form is for use by applicants or site operators to provide cost estimates for closure of MSW Type I landfills to meet the requirements in 30 Texas Administrative Code (TAC) Chapter 330, Section 330.63(j) and 30 TAC Chapter 330 Subchapter L. The costs to be provided herein are cost estimates for hiring a third party to close the largest waste fill area that could potentially be open in the year to follow and those areas that have not received final cover. If you need assistance in completing this form, please contact the MSW Permits Section in the Waste Permits Division at (512) 239-2335.

Facility Name: City of Waco Landfill

MSW Permit No.: 2400

Site Operator/Permittee Name and Mailing Address: City of Waco

Total Closure Cost Estimate (2020 Dollar Amount): $2,147,642

### I. Professional Engineer's Statement, Seal, and Signature

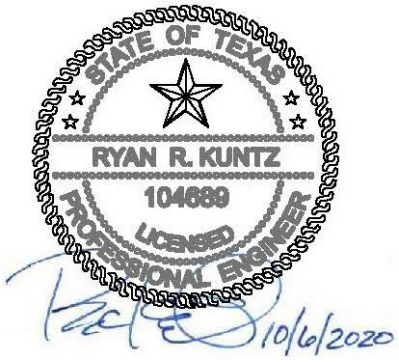
I am a licensed professional engineer in the State of Texas. To the best of my knowledge, this Closure Cost Estimate has been completed in substantial conformance with the facility Closure Plan and, in my professional opinion, is in compliance with Title 30 of the Texas Administrative Code, Chapter 330.

Name: Ryan Kuntz, P.E. Title: Vice President

Date:

Company Name: SCS Engineers Firm Registration Number: F-3407

Professional Engineer's Seal




Professional Engineer's Signature

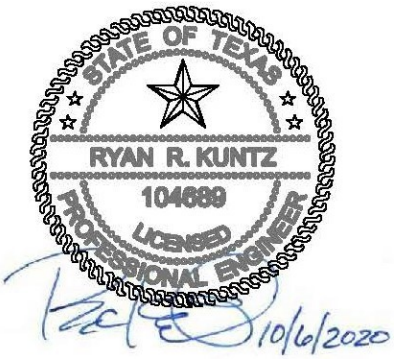
**CITY OF WACO LANDFILL**
**TCEQ PERMIT NO. MSW-2400**
**McLENNAN AND LIMESTONE COUNTIES, TEXAS**

# PART III – SITE DEVELOPMENT PLAN
# ATTACHMENT 9
# FINAL CLOSURE AND POST-CLOSURE PLAN

**Prepared for:**

**CITY OF WACO**

Solid Waste Services
501 Schroeder Drive
Waco, TX 76710




**Prepared by:**

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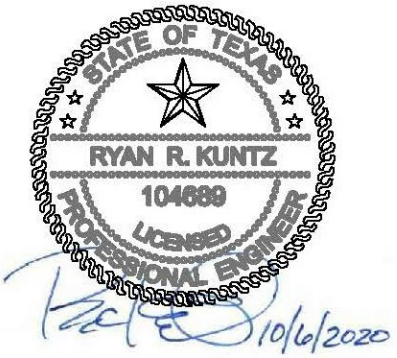
9.1 Final Closure Schedule

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employed by the manufacturer. Each quality control certificate will include roll identification numbers, testing procedures, and results of quality control tests. The quality control tests will be performed in accordance with project-specific testing methods and subject to one test per 100,000 square feet of material or a minimum of one test per resin lot, whichever is greater.

All geomembrane properties must meet the minimum values set forth in the most recent version of Geosynthetic Research Institute (GRI) standard GM-13 for 60-mil HDPE, or GM-17 for LLDPE. The GP will review the test results prior to acceptance of the geomembrane to assure that the certified minimum properties meet specified values.

#### 2.3.2.2 Conformance Testing

Conformance testing shall be performed by a third-party independent laboratory. Conformance testing methods and frequencies will be performed in accordance with Table 9-2-3.

**Table 9-2-3. Geomembrane Conformance Testing**

| TEST | METHOD | MINIMUM FREQUENCY |
|---|---|---|
| Thickness (laboratory) | ASTM D5199 (1) or D5994 | 1 per 100,000 $ft^2$ and every resin lot |
| Thickness (2) (field) | | 1 measurement per 5 feet along leading edge of each geomembrane panel |
| Density | ASTM D1505 or D792 | 1 per 100,000 $ft^2$ and every resin lot |
| Carbon black content | ASTM D1603 | |
| Carbon black dispersion | ASTM D5596 | |
| Tensile properties (3) | ASTM D638 or D6693 | |

1. ASTM D5994 for textured geomembrane, D5199 for smooth.
2. No single measurement will be less than ten percent below the required nominal thickness in order for the panel to be acceptable. A minimum of 5 measurements will be made per panel.
3. 2-inch initial gauge length assumed for elongation at break at 2.0 in/min.

### 2.3.3 Installation Monitoring and Testing

Upon delivery of geosynthetic material, the CQA Monitor will observe that the materials are handled and stored in accordance with manufacturer's recommendations.

Field seaming of the geomembrane will be performed in strict accordance with methods approved by the manufacturer. This usually includes fusion welding or extrusion welding. Tack welds (if used) will use heat only. No double-sided tape, glue, or other method will be permitted when extrusion or fusion welding is used for bonding.

Each day prior to commencing field seaming, trial seams will be made on pieces of geomembrane material to verify that conditions are adequate for production seaming. Each trial test seam will be at least 3 feet long by 1-foot wide. Four adjoining one-inch wide specimens will be die-cut from the test seam sample. Two specimens will be tested in the field for shear and 2 for peel.

The failure criteria are the same as that for destructive seam testing as described below. The test specimens must exhibit a Film Tear Bond (FTB). If one test seam fails, the trial seam will be repeated. If this trial seam fails, then 2 more trial seams must be constructed and tested. This process must continue and no welding can begin for the machine or welder until all test seams are passing. Additional trial seams will be made for all of the following:

- At the beginning of each seaming period for each seaming apparatus used that day (the beginning of each seaming period is considered to be morning, and immediately after a break);
- Each occurrence of significantly different environmental conditions (i.e., temperature, humidity, dust, etc.);
- Any time the machine is turned off for more than 30 minutes; and
- When seaming different geomembranes (i.e. tie-ins and smooth to textured).

Both the welder and the machine must be tested for each new trial seam when extrusion welding. Only the machine needs to be tested for each new trial seam when fusion welding since the machine is not as operator dependent. Each individual seaming will make at least one test seam each day he/she actually performs seaming.

### 2.3.4 Non-Destructive Testing

Continuous, non-destructive testing will be performed on all seams by the installer. Air pressure testing on dual-track fusion welds and vacuum-box testing for extrusion welds are the only acceptable methods. All leaks must be isolated and repaired by the following procedures:

1. Air-Pressure Testing (GRI GM6) - The ends of the air channel of the dual-track fusion weld must be sealed and pressured to approximately 30 psi, if possible. The air pump must then be shut off and the air pressure observed after 5 minutes. A loss of less than 4 psi is acceptable if it is determined that the air channel is not blocked between the sealed ends. A loss of 4 psi or more indicates the presence of a seam leak that must then be isolated and repaired by following the procedures described under "Seam Failure Repairs and Retesting." The GP or his/her qualified representatives must observe and record all pressure gauge readings.

2. Vacuum-Box Testing (ASTM D4437) - A suction value of approximately 3 to 5 inches of gauge vacuum must be applied to all extrusion welded seams that can be tested in this manner. Examples of extrusion welded seams that do not easily lend themselves to vacuum testing would be around boots, appurtenances, etc. The seam must be observed for leaks at least ten seconds while subjected to this vacuum. The GP or his/her qualified representative must observe 100 percent of this testing.

### 2.3.5 Destructive Seam Testing

Destructive seam testing will be performed in accordance with ASTM D6392. Destructive samples will be taken at a minimum of one strategic location for every 1,000 linear feet of seaming

or major fraction thereof. The total footage of individual repairs of leaks of more than 10 feet in seaming length and individual repairs of more than 10 feet in seaming length for failed seams must also be counted and destructively tested using the same frequency of testing described above. At a minimum, a destructive test must be done for each welding machine used for seaming or repairs. A sufficient amount of the seam must be removed in order to conduct field testing, independent laboratory testing, and archiving of enough material in order to retest the seam, if necessary. Field testing will include at least 2 peel test specimens. Destructive seam-testing locations will be cap-stripped and the cap completely seamed by extrusion welding to the geomembrane. Capped sections will be non-destructively tested. Additional destructive test samples may be taken if deemed necessary by the GP or his/her qualified representative.

All field-tested specimens from a destructive-test location must be passing in both shear and peel for the seam to be considered as passing. Field tested specimens, are determined as passing if the specimen tested in peel fails in FTB and all test specimens meet the criteria listed in the Table 9-2-4 The independent laboratory testing must confirm these field results. The minimum passing criteria for independent laboratory testing are all three of the following:

- Five of five specimens tested in the peel mode must fail in FTB.
- Five of five specimens from each peel and shear determination must meet the minimum specified value in Table 9-2-4.
- All 5 specimens for shear determination should meet the minimum percent elongation at break value in Table 9-2-4.

The above criteria apply to both tracks from each dual-track fusion welded seam before it is considered as passing. It should be noted that geomembrane manufacturers may have differing values for their geomembrane sheets and therefore, the specific values are not meant to be minimum or maximum values as construction materials and specifications may vary between manufacturers and throughout the life of the site. Consequently, the manufacturer's sheet-strength values must be provided in order to determine if the test results are passing.

**Table 9-2-4. Geomembrane Seam Strength**

| Property | Qualifier | Unit | Specified Value | | Test |
|---|---|---|---|---|---|
| | | | 60-mil HDPE | 40-mil LLDPE | |
| Shear Strength | Min.<br>Min. | lb/in<br>% | 120<br>50 | 60<br>50 | ASTM D6392 |
| **Peel Strength:**<br>Fusion<br>Extrusion | <br>Min<br>Min. | <br>lb/in<br>lb/in | <br>91<br>78 | <br>50<br>44 | ASTM D6392 |

### 2.3.6 Seam Failure Delineation

In the event failing tests are obtained at a destructive test location, new destructive test samples will be obtained, a minimum of 10 feet in either direction of the failing test. If one, but not both, of the additional tests fail, further additional destructive testing will be required until passing tests are obtained at both ends of the original destructive test location. A cap will be required for the areas subject to destructive testing, and testing of the cap will be placed in accordance with Section 2.3.7. If more than two failing destructive test locations are observed for a single seam, the CQA Monitor will have the alternative of requiring the entire seam be removed, and a new seam welded.

In the event more than one failing destructive test are observed for a single welding apparatus, new (passing) trial welds will be required prior to resuming geomembrane welding or seaming with the apparatus.

### 2.3.7 Seam Failure Repairs and Retesting

Any portion of the geomembrane with a detected flaw, or which fails a nondestructive or destructive test, or where destructive tests were cut, or where nondestructive tests left cuts or holes, must be repaired. The CQA Monitor will locate and record all repairs on the repair log. Repair techniques include the following:

- Patching - used to repair holes, tears, large panel defects, undispersed raw materials, contamination by foreign matter, and destructive sample locations.

- Extrusion - used to repair small defects in the panels and seams. In general, this procedure should be used for defects less than 3/8-inch in the largest dimension.

- Capping - used to repair failed welds or to cover seams where welds or bonded sections cannot be nondestructively tested.

- Removal - used to replace areas with large defects where the preceding methods are not appropriate. Also used to remove excess material (wrinkles, fishmouths, intersections, etc.) from the installed geomembrane. Areas of removal shall be patched or capped.

For any repair method, the following provisions will be satisfied:

- Surfaces of the geomembrane which are to be repaired using extrusion methods will be ground no more than one hour prior to the repair;

- All surface will be clean and dry at the time of repair;

- Patches or caps will extend at least 6 inches beyond the edge of the defect, and all corners of patches will be rounded with a radius of approximately 3 inches or more;

- All repairs will be nondestructively tested as previously described; and

- All seaming equipment, personnel, and operation procedures used in repair work will meet the same requirements as for new seaming operations.

The GP or his/her qualified representative will observe all destructive and non-destructive testing of repairs and will record the number of each repair, type, date and test outcome. Repairs that pass the non-destructive tests will be taken as an indication of an adequate repair. Repairs more than 150 ft long will also be required to have a destructive test performed. Repairs that fail the initial retest will be redone and retested until a passing test results. All work and testing of repairs will be fully documented in a repair log.

### 2.3.8 Geocomposite and Erosion Layer Testing

When placing overlying material on the geomembrane, every effort must be made to minimize wrinkle development and stress imparted to the geomembrane. If possible, cover should be placed during the coolest weather available. Small wrinkles should be isolated and covered as quickly as possible to prevent their growth. In no case will the geomembrane be allowed to fold over on itself.

#### 2.3.8.1 Geocomposite

A single-sided and double-sided geocomposite will be installed over the geomembrane on the landfill topslope and sideslopes, respectively. The geocomposite will conform to the material and performance properties specified by the GP, consistent with project construction plans and technical specifications. The drainage geocomposite manufacturer (or supplier), will conduct quality control testing at a frequency of 1 per 100,000 square feet and certify that all materials delivered comply with project specifications. The material certifications shall be reviewed by the GP and approved for the project prior to acceptance of any of the material.

#### 2.3.8.2 Erosion Layer

The erosion layer will consist of a 24-inch-thick soil layer, with the top 6 inches capable of sustaining vegetation in accordance with §330.457(a)(3). The required thickness of the layer will be verified by settlement plates or survey methods on an established grid system with not less than one verification point per 10,000 square feet of surface area. A minimum of two verification points is required. The selected grid will be the same for both beginning and finished elevations of the erosion layer, so that minimum thickness can be calculated and verified. All elevation calculations necessary for thickness determination will be included as part of the supporting documentation in the FCSER.

The erosion layer does not require compaction control; however, it should be stable for construction and disposal traffic. The erosion layer will be deployed in “fingers” along the geomembrane or geocomposite to control the amount of slack and minimize wrinkles and/or folds. Soil cover will generally be placed in an up-slope direction on sideslopes so that stress imparted to the geocomposite and geomembrane is minimized. Care will be exercised in placement so as not to shift, wrinkle or damage any underlying geosynthetic layers, and the placement methods will be documented.

- Consistent with the closure engineering plans, sections of the landfill that are above-grade will be regraded and reshaped, as needed, to provide the proper slope for positive drainage, consistent with closure engineering plans.

- The final cover system will be constructed in accordance with this attachment and closure engineering plans.

- Following application of final cover, the landfill will be seeded or sodded immediately with appropriate grasses to minimize erosion. The established grasses will provide a minimum of 90 percent coverage of the final cover system.

- Consistent with the closure engineering plans and with Attachment 6A – Surface Water Drainage Plan, a surface water drainage system will be constructed to minimize erosion.

- A closure certification will be prepared by an independent registered professional engineer and submitted to TCEQ for approval.

- All proper notices and documentation will be filed with the appropriate agencies.

### 3.2.1 Estimate of Largest Area Ever Requiring Final Cover

In accordance with §330.457(e)(2), the largest area ever requiring final cover in the year to follow landfill closing is estimated to be approximately 21.3 acres. The estimated largest area requiring final cover is expected to occur when waste is being placed in Sector 1 in the East Disposal Area. At the time of the Owner's annual review of the closure cost estimate, the Owner will also confirm that the estimated largest area ever requiring final cover is accurate. Based on this annual review, adjustments will be made, as appropriate.

In addition, the entire 502.5 acres of the site would also need to be administratively closed. Supporting calculations are presented in Part III, Attachment 8 - Cost Estimate for Closure and Post-Closure Care, Appendix 8A.

### 3.2.2 Estimate of Maximum Inventory of Waste Ever On Site

Consistent with §330.457(e)(3), the estimate of maximum inventory of waste (defined as waste and daily cover) ever on site over the active life of the facility is approximately 24,661,442 cubic yards (based upon volumes computed from top of bottom liner protective cover and top final grade elevations less final cover thicknesses). Supporting calculations are included in Part III, SDP Narrative, Appendix IIIA - Site Life Calculations.

approval of (1) an alternative monitoring frequency, and (2) an alternative list of parameters to be monitored. Such requests will be based on supporting data available at the time of the request.

- Monitor the landfill perimeter LFG monitoring system in accordance with Chapter 330, Subchapter I. In accordance with Subchapter I, the minimum monitoring frequency will be quarterly. However, the Owner reserves the right to request TCEQ approval of an alternate monitoring frequency. Such a request will be based on supporting data available at the time of the request.

- If applicable, maintain and operate the LFG collection and/or control system in accordance with applicable regulations.

## 6.2 DECREASING POST-CLOSURE CARE PERIOD

The Owner may submit a request to decrease the length of the post-closure care maintenance period. This request will include a documented certification signed by an independent registered professional engineer. The certification will include all applicable documentation demonstrating that the reduced period is sufficient to protect human health and the environment. Applicable documentation may include data from monitoring of groundwater, surface water, leachate levels, and landfill gas. The certified documentation must be reviewed and approved by the TCEQ prior to decreasing the length of the post-closure care period.

## 6.3 INCREASING POST-CLOSURE CARE PERIOD

The length of the post-closure care period may be increased by the TCEQ if it is determined that the increased duration is necessary to protect human health and the environment. In accordance with 330.463(b)(2)(B), if there is evidence of a release from landfill activities, the executive director may require an investigation into the nature and extent of the release and an assessment of measures necessary to correct an impact to groundwater. It is understood that the Owner will receive appropriate notification of any such proposed changes prior to the TCEQ's final determination, thereby allowing the Owner to submit appropriate documentation for TCEQ's consideration.

## 6.4 COMPLETION OF POST-CLOSURE CARE PERIOD

Upon completion of the post-closure care period, the Owner will submit to the TCEQ a certification, signed by an independent professional engineer, verifying that Post-Closure care maintenance has been completed in accordance with this Post-Closure Care Plan, in accordance with §330.465(a). The submittal will include all documentation necessary for certification of completion of post-closure care maintenance. The certification will be placed in the Site Operating Record upon approval. Additionally, in accordance with §330.465(b), following completion of the post-closure care period, the Owner will submit to the TCEQ a request for voluntary revocation of the landfill permit.

**CITY OF WACO LANDFILL**
**TCEQ PERMIT NO. MSW-2400**
**McLENNAN AND LIMESTONE COUNTIES, TEXAS**

# PART III - SITE DEVELOPMENT PLAN
# ATTACHMENT 10
# SOILS AND LINER QUALITY CONTROL PLAN

**Prepared for:**

**CITY OF WACO**

Solid Waste Services
501 Schroeder Drive
Waco, TX 76710

**Prepared by:**

**SCS ENGINEERS**
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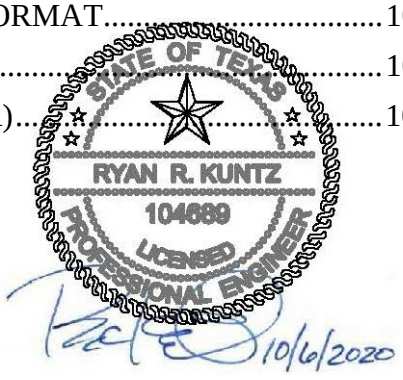



**SCS Engineers**
**TBPE Reg. # F-3407**

# 1 INTRODUCTION

## 1.1 PURPOSE

The following Soil and Liner Quality Control Plan (SLQCP) has been prepared for the City of Waco Landfill (Landfill) in accordance with 30 TAC §330.339. This SLQCP is intended to provide the Owner, Design Engineer, Construction Quality Assurance (CQA) Professional of Record, Contractor, and Geosynthetics Contractor the needed guidance regarding CQA/control during construction of municipal solid waste disposal units at the Landfill. This SLQCP also will provide the CQA Professional of Record the needed guidance for preparing the soil liner and geomembrane liner evaluation reports for each individual cell.

This SLQCP addresses the testing methods and other requirements set forth in the 30 TAC §330.339 of the Texas Commission of Environmental Quality (TCEQ) regulations and current TCEQ guidance document, RG-534 (2017 version). The proposed bottom liner system is comprised of the following components (from top to bottom):

- 2-foot-thick soil protective cover;
- Single-sided geocomposite (non-woven geotextile on the top side only of geonet);
- 60-mil high density polyethylene (HDPE) geomembrane (smooth); and
- 2-foot-thick compacted clay liner ($k \leq 1x10^{-7}$ cm/sec); and
- Prepared subgrade (excavation grade).

On sideslopes the liner section will be as follows (from top to bottom):

- 2-foot-thick soil protective cover;
- Double-sided geocomposite (non-woven geotextile on both sides of geonet);
- 60-mil textured HDPE geomembrane (textured on both sides);
- 2-foot-thick compacted clay liner ($k \leq 1x10^{-7}$ cm/sec); and
- Prepared subgrade (excavation grade).

These bottom and sideslope liner systems are depicted on Drawing 6C.1 (Attachment 6C – Groundwater Protection Plan) as required by 30 TAC §330.339(a)(1) and §330.339(b)(2)(A). The design of the leachate collection system components are described in Attachment 12 – Leachate and Contaminated Water Management Plan. Additional guidance and technical requirements for the liner, leachate collection system, and related construction will also be presented in the construction plans and technical specifications prepared prior to construction of waste disposal cell.

This SLQCP includes the CQA requirements for the following:

- Subgrade and General Fill;
- Low Permeability Soil Liner;
- Geosynthetics (geomembrane, drainage geocomposite, and geotextiles);
- Leachate Collection Piping;
- Drainage Aggregate; and
- Protective Cover.

This SLQCP, which will be followed during liner construction, outlines materials selection and evaluation, laboratory test requirements, field test requirements, and treatment of problems for the components described above. Testing requirements for each component of the liner system are included in the individual sections throughout this SLQCP and summarized in Appendix 10A. This SLQCP also includes reporting requirements for soil liner and geomembrane liner evaluation reports for the CQA of soil liner and geomembrane liner components of the liner system.

## 1.2 DEFINITIONS

Whenever the terms listed below are used, the intent and meaning shall be interpreted as indicated.

### 1.2.1 ASTM

This means the American Society for Testing and Materials.

### 1.2.2 Construction Quality Assurance (CQA)

A planned system of activities that provides the owner and permitting agency assurance that the facility will be constructed as specified in the design (EPA, 1993). CQA includes observations and evaluations of materials and workmanship necessary to assess and document that construction has been performed consistent with the applicable contract and permit documents. CQA refers to measures taken by the CQA geotechnical professional and/or CQA monitor to assess if the bottom and sideslope liner systems construction has been in compliance with the permit drawings and this SLQCP for the site.

### 1.2.3 CQA Geotechnical Professional (GP)

The GP is an authorized representative of the Owner and has overall responsibility for CQA and confirming that the bottom and sideslope liner systems have been constructed in general accordance with the permit application, as approved by the TCEQ, and the construction plans and technical specifications. The GP must be a Professional Engineer licensed in Texas with

experience in either solid waste engineering and/or geotechnical engineering. Alternatively, a GP may be a geologist with experience in geotechnical testing and the evaluation of engineering properties of soils for liner systems which involve in-situ or compacted soil, provided the geologist is acting in compliance with the provisions of the Texas Engineering Practice Act.

The GP must show competency and experience in certifying similar installations and be presently employed by or practicing as a solid waste engineer, geotechnical engineer or as an engineering geologist in a geotechnical/environmental engineering organization. The credentials of the GP must meet or exceed the minimum requirements required by the TCEQ. The GP will be the professional of record, who signs the Soil Liner Evaluation Report (SLER) and Geomembrane Liner Evaluation Report (GLER) for the respective liner system construction.

### 1.2.4 CQA Monitors

These are representatives of the GP who work under direct supervision of the GP. The CQA Monitor is responsible for quality assurance monitoring and performing on-site tests and observations. A qualified Lead CQA Monitor shall have a minimum of two years of directly related experience; or be a graduate engineer or geologist with one year of directly related experience. A junior CQA Monitor may work under the direct supervision of the Lead CQA Monitor or the GP and may have less than one year of directly related experience. The CQA Monitor is onsite full-time during subgrade preparation, liner system construction, and leachate collection system construction and reports directly to the GP. Any references to monitoring, testing, or observations to be performed by the GP should be interpreted to mean the GP or CQA Monitor working under the GP's direction.

### 1.2.5 Construction Quality Control (CQC)

These actions provide a means to measure the characteristics of an item, material, or service to comply with the requirements of the contract or permit documents. CQC actions will be performed by the Contractor or manufacturer of materials. All quality control testing shall be performed prior to or during construction of the liner. In no instance shall quality control field or laboratory testing be undertaken after completion of liner construction.

### 1.2.6 Contract Documents

These are the official set of documents provided by the Owner. The documents include bidding requirements, contract forms, contract conditions, technical specifications, construction plans, addenda, and contract modifications.

### 1.2.7 Technical Specifications (or Specifications)

These are the qualitative requirements for products, materials, and workmanship upon which the construction contract is based.

### 1.2.8 Contractor

This is the person or persons, firm, partnership, corporation, or any combination, who as an independent contractor, has entered into a contract with the Owner.

the formations at the site was also calculated, as summarized in Attachment 4, Table III-4.14. As indicated by this data, the highest recorded groundwater movement at the site is estimated to be approximately 0.039 feet/year, which is consistent with groundwater movement through sediments with very low hydraulic conductivity. Based on this groundwater velocity value, the time for groundwater to travel one foot would be greater than 25 years. Therefore, sufficient ballast will be placed prior to the liner system experiencing any potential hydrostatic uplift.

However, as indicated in Section 2.5.3, a SHWT map has been developed for an assumed potentiometric surface for designing an underdrain system and evaluating ballast, if needed, for short- and long-term groundwater control, respectively. The assumptions and calculations for the ballast evaluation and underdrain design are described in Section 11.5 (see also Appendix 10C) and Appendix 10D, respectively.

### 2.5.3 Seasonal High Groundwater Table

A SHWT map has been developed based on standard standpipe piezometers and vibrating wire piezometers (VWPs) installed at the site during the subsurface and groundwater investigation (see Attachment 4, Section 6). Based on the observations presented in Attachment 4, the shallow occurrences of groundwater do not appear to be uniform across the site and may occur in isolated pockets; there exists a continuously saturated groundwater zone that occurs at deeper elevations below the base of the proposed excavation grades; and the shallow and deep occurrences of groundwater do not appear to be hydraulically connected. However, as a conservative approach to sizing underdrain components for short-term groundwater control and evaluating long-term groundwater control (waste or soil ballast), if needed, the SHWT map was developed with a culmination of high water level readings from both the shallow standpipe piezometers/VWPs and deep VWPs installed at the site during the groundwater investigation. This SHWT map, provided in Appendix 10B, depicts the measurement points, including the seasonal high groundwater table (SHWT) levels, and future excavation grades. As shown on the map, portions of the excavation grades extend below this assumed SHWT.

As noted in this SLQCP, the SHWT map will be reviewed and updated, if necessary, prior to the design of each cell based on the most recent data available at the time of design. If the groundwater elevations at monitoring points has increased since the last cell construction, the SHWT map will be revised upward to reflect those increases. An updated SHWT map will be presented in the SLER and GLER. In addition, observations of the subgrade soil characteristics and indications of groundwater seepage (if any) and potential impacts to the dewatering and ballast calculations will also be documented in the SLER and GLER.

# 3 LOW PERMEABILITY SOIL LINER

## 3.1 INTRODUCTION

Construction of the soil liner will begin after excavation, embankment construction, subgrade preparation, and grading to excavation grades has been completed. For this landfill, the soil liner constructed for all waste disposal cells will be a 2-foot thick compacted soil (clay) liner, as described in Section 1.1.

Soil for the soil liner must achieve an installed permeability of $1x10^{-7}$ cm/s or less; a liquid limit (LL) of 30 or greater; a plasticity index (PI) of 15 or greater; percent passing the No. 200 sieve of 30 percent or greater; and 100 percent passing the 1-inch sieve (i.e., no particles greater than 1 inch in size) with no more than 10 percent rocks by weight. The final lift of the soil liner shall not contain rock or other deleterious materials that can cause damage to the overlying geomembrane.

## 3.2 QUALITY ASSURANCE TESTING

### 3.2.1 Pre-Construction Testing

Pre-construction testing will be performed for each liner material borrow source and for each identifiable change in material from an individual borrow source (i.e., change in color and plasticity or gradation based on visual observation by the GP or CQA Monitor). A change in color only (with same gradation and plasticity characteristics) will not be considered a change of material. Testing will be performed according in the laboratory according to the testing schedule set forth in Table 10-3-1.

For each borrow source, correlations will be developed based on moisture-density tests and permeability tests (performed on soil samples at a calculated density) of representative soil samples demonstrating that the soils will have the required permeability at the specified level of compaction. Soil density test results will be reported as a percentage of the maximum dry density at the corresponding optimum moisture content. Correlation testing will be provided to GP and CQA Monitor for use in the field during soil liner construction.

**Table 10-3-1. Soil Liner Pre-Construction Testing Schedule**

| TEST | METHOD USED | FREQUENCY |
|---|---|---|
| Soil Classifications: USCS | ASTM D2487 | 1 per soil type / minimum 1 per borrow source |
| Sieve Analysis | ASTM D422 or D1140 | |
| Atterberg Limits | ASTM D4318 | |
| Moisture/Density Relationship | ASTM D698 | |
| Hydraulic Conductivity (1) | ASTM D5084 (2)(3) | 1 per Moisture-Density Relationship |

1. Field testing of permeability (in accordance with ASTM D5093) is optional, and may be replaced by laboratory testing.
2. Testing procedures in Appendix VII of the Corps of Engineers Manual EM 1110-2-1906, November 30, 1970, Laboratory Soils Testing, may be used as an alternative method.
3. Permeability tests will be conducted with tap water or 0.05N solution of CaSO4. Distilled water will not be allowed.

### 3.2.2 Construction Testing

Construction quality assurance for the soil liner will consist of both laboratory and field testing. The minimum frequencies and test methods for testing soil liners during construction are presented on Table 10-3-2. The sampling and test methods used during liner construction will follow the latest technical guidelines of the TCEQ. In accordance with 30 TAC §330.339(a)(2), the GP or CQA Monitor will be on-site during all liner construction activities. Laboratory testing will be performed by an independent geotechnical laboratory.

All quality assurance testing of soil liners will be performed during the construction of the liner. In no instance will any quality assurance field or laboratory testing be undertaken after completion of liner construction, except for that testing which is required of the final constructed lift, confirmation of liner thickness, or cover material thickness. All soil testing and evaluation of the soil liner will be complete prior to installing the geomembrane and leachate collection system on the area under evaluation.

**Table 10-3-2. Soil Liner Construction Testing Schedule**

| TEST | METHOD | MINIMUM FREQUENCY |
|---|---|---|
| Field Moisture/Density Test | ASTM D1556, D2167, or D6938 | 1 per 8,000 $ft^2$ per 6-inch lift (1) |
| Sieve Analysis | ASTM D422 or D1140 | 1 per 100,000 $ft^2$ per 6-inch lift (2) |
| Atterberg Limits | ASTM D4318 | |
| Hydraulic Conductivity (3) (4) | ASTM D5084 or CoE EM 1110-2-1906 (5) | |
| Thickness | Survey | 1 per 5,000 $ft^2$ |

1. A minimum of three tests must be conducted for each 6-inch lift, regardless of cover area.
2. A minimum of one test must be conducted for each lift, regardless of cover area.
3. Testing will be conducted on undisturbed samples.
4. Permeability tests will be run using tap water or a 0.05N solution of $CaSO_4$. Distilled water will not be allowed.
5. Field testing of permeability (in accordance with ASTM D5093) is optional, and may be replaced by laboratory testing.

## 3.3 CONSTRUCTION PROCEDURES

### 3.3.1 General Requirements

During placement of the soil liner following guidelines apply:

- The excavation grade surface should be scarified (roughened) prior to placing the first lift of the soil liner, thus providing adequate bonding between the liner and underlying foundation soils.

- Bottom and sideslope soil liners will be constructed in compacted lifts not exceeding 6 inches. The top of each subsequent lift should be scarified (roughened) to a shallow depth prior to the spreading and compaction of successive lifts, thereby providing bonding between the lifts.

- The soil liners will not be compacted with a bulldozer or any track-mobilized equipment unless it is used to pull a pad-footed roller. The soil liner shall be compacted with a pad-footed or prong-footed roller only. The maximum clod size of the compacted liner soils shall be approximately one inch in diameter. In all cases soil clods shall be reduced to the smallest size necessary to achieve the coefficient of permeability reported by the testing laboratory and to destroy any macrostructure evidenced after the compaction of the clods under density-controlled conditions.

- No loose lift should be thicker than the pads of the compactor so that complete bonding with the top of the previous lift is achieved. The soil liner lifts will be compacted by a minimum 3 passes (back and forth) of the compaction equipment.

- At a minimum, soil liners will be compacted to 95 percent of the maximum dry density and at a moisture content of 0 to +4% above optimum, as determined by ASTM D698, in order to achieve a permeability of $1x10^{-7}$ cm/s, as specified in Section 3.1. Clay liner density test results will be reported as a percentage of the maximum dry density at the corresponding moisture content percentage. The CQA Monitor will inspect the adequacy of the scarification and compaction effort in providing good lift bonding (i.e., no smooth interface between lifts) during the initial stages of liner installation.

- Although not anticipated since design grades are not this steep, equipment and safety limitations prohibit finished grades with slopes greater than 3H:1V if the liner is constructed parallel to the surface. Compaction equipment placing sideslope liners on slopes steeper than 3H:1V results in reduced stability of compaction equipment, and reduction in compaction efficiency.

- The top surface of the completed soil liner must be sealed with a smooth-drummed roller prior to final liner thickness surveying and placement of the geomembrane liner.

- The surface of the soil liner will be sealed by smooth drumming when construction is to be shut down for more than 24 hours to mitigate the effects of desiccation and wetting from rainfall events. Additionally, smooth drum rolling to seal the surface will be required on a routine basis during the summer months at the end of each day's liner construction to reduce desiccation.

- Any liner perforations required for obtaining laboratory samples will be repaired by backfilling the hole with bentonite chips or 50/50 powdered/granulated bentonite/soil/sand mixture hand-tamped into place. If the hole is in the upper lift of soil liner, the upper 2 inches will be backfilled by clayey liner soil which will be hand-tamped sufficiently to blend the backfill into the adjacent soil liner lift.

- Soil liner construction shall be conducted in a systematic and timely manner, such that the soil liner is not left exposed for an extended period of time. The Contractor will be required to maintain any exposed soil liner in a condition acceptable to the CQA Monitor through the completion and approval of the soil liner, and during placement of the geomembrane over the soil liner.

### 3.3.2 Liner Tie-ins

The leading 10 to 20 feet of the liner will **not** be covered with waste, but instead will be protected to facilitate tie-in with subsequent cell liners. Liners will not be constructed by "butting" the entire thickness of a new liner segment next to the previously constructed section of liner. Soil liner tie-ins will be performed using the following procedures:

- The edge of the previously installed liner will be uncovered, exposed, and cut back on a slope so that the entire existing liner edge is tied to new construction without superimposed construction joints.
- The surface of the existing liner will be scarified (roughened) prior to subsequent soil placement, to further reduce the possibility of construction joints.
- The length of the tie-in area should be at least 5 feet per foot thickness of liner.

### 3.3.3 Hydrating Liner Soil

Prior to attempting to hydrate (moisture condition by wetting) clayey soils, clod sizes will be reduced by disking, pulverizing, or other method of breaking clods as acceptable to the GP or CQA Monitor. The number of passes required for adequate clod size reduction will be determined in the field between the Contractor and GP, based on soil condition, equipment used, and equipment operation. After applying water, the soil will be mixed and stockpiled, if necessary, to allow adequate time for hydration to occur. The amount of moisture conditioning and time of hydration will be determined in the field by the GP. Water used in hydrating liner soils must be clean and will not have come into contact with waste or any objectionable material.

## 3.4 PROCEDURES FOR ADDRESSING FAILING TESTS

### 3.4.1 Failing Field Density Tests

As described in Table 10-3-2, field density tests will be performed at a frequency of 1 test per 8,000 square feet, per lift. In the event a test indicates field density less than specified, the Contractor will be required to moisture condition (either dry or moisten, if needed) the soil, and then re-compact and retest the soil. The entire 8,000 square foot area represented by the failing test will be required to be reworked.

Alternately, the contractor may perform a minimum of 3 additional field density tests spaced no less than 20 feet in a circular pattern surrounding the original failed test, and, if all tests pass field density, the rework area will be limited to the area inside of the circle formed by the passing tests. If one or more of the additional field tests fail, the entire 8,000 square foot area represented by the failed test will require reworking.

In the event of a second failed field density test, the GP will be immediately notified, and a field decision made by the GP regarding conducting a second rework of the area (as described above) or alternately, requiring that an additional Proctor test be performed on the soils comprising the failed test area. If an additional Proctor test is required, the GP will direct the contractor to either

obtain soil samples from the failed area, or alternately, from the borrow source from which the failing soils were obtained. Reworking and retesting of the soils will not occur until after the additional laboratory testing has been completed, and the new Proctor test information submitted to the GP or CQA Monitor.

The results of both passing and failing tests will be recorded, and reported within the SLER.

### 3.4.2 Failing Gradation or Atterberg Limits Tests

As described in Table 10-3-2, gradation and Atterberg limits tests will be performed at a frequency of 1 test per 100,000 square feet, per lift of soil liner (concurrent with permeability tests). In the event of a failing test, the GP will immediately be notified, and the failing laboratory results provided to the GP. If either the LL or the PI varies by 10 or more points when compared against the appropriate moisture/density curve developed for that borrow source, the soil is considered as a separate soil borrow source and a new test series including moisture/density, compaction relationship, sieve analysis and coefficient of permeability should be determined and these results used for field construction control.

Additional test samples will be obtained at a minimum of 3 locations, spaced no less than 20 feet in a circular pattern surrounding the original failed test. If passing results are obtained for the additional test samples, the area defined by the passing tests will be removed, replaced, and retested. If one or more of the additional tests fail, a new sample will be obtained 30 feet (minimum) from the original failed test (along a line radiating from the original failed test through the failing additional test(s)), and in 10-foot (minimum) increments thereafter, until passing test results are obtained. The area requiring removal and replacement ultimately will be defined by passing test results. After removal and replacement, one additional passing test in the approximate center of the reworked area will be required.

### 3.4.3 Failing Permeability Tests

As described in Table 10-3-2, permeability tests will be performed at a frequency of 1 test per 100,000 square feet, per lift of soil liner (concurrent with gradation and Atterberg limits tests). In the event of a failing permeability test, the GP will immediately be notified, and the failing laboratory results provided to the GP.

Prior to requiring additional permeability sampling and testing, a field density test will be performed at the location of the failed test. If a failing field density test is obtained, the failed area will be defined as described in Section 3.4.1, above, except that additional field density testing will be performed until passing tests are obtained. After reworking and achieving passing field density tests, a new permeability sample will be obtained for testing.

If passing field density tests are obtained at the location of the failed permeability test location, additional Atterberg limits and gradation test samples will be obtained at a minimum of 3 locations, spaced no less than 20 feet in a circular pattern surrounding the original failed test. If passing results are obtained for the additional test samples (Atterberg limits and gradation tests), the area defined by the passing tests will be removed and replaced. If one or more of the additional tests fail, a new sample will be obtained 30 feet (minimum) from the original failed

test (along a line radiating from the original failed test through the failing additional test(s)), and in 10-foot (minimum) increments thereafter, until passing test results are obtained. Passing Atterberg limits and gradation test results will be used to define the area requiring removal and replacement. After removal and replacement, a new permeability sample will be obtained and tested, and a passing test obtained prior to approval of the reworked area.

## 3.5 THICKNESS VERIFICATION

The thickness (minimum 2-foot) of constructed soil liners will be verified by surveying methods. As described in Table 10-3-2, at a minimum, one thickness verification will be performed for every 5,000 square feet of constructed soil liner. Survey locations will be based on pre-established survey grid in accordance with Section 2.3. A minimum of three (3) survey points shall be used for all constructed soil liners regardless of size. All elevation calculations necessary for thickness verification will be included in the SLER submittal.

## 3.6 HYDROSTATIC CONSIDERATIONS – BALLASTING

Hydrostatic considerations for excavation below the seasonal high groundwater table are described in Section 2.5 of this Attachment.

# 4 GEOMEMBRANE

## 4.1 INTRODUCTION

This section describes CQA procedures for the installation of 60-mil high-density polyethylene (HDPE) geomembrane. CQA procedures for drainage geocomposite, geotextiles, and leachate collection piping are discussed in Sections 5 through 8. The overall goal of the CQA procedures is to confirm (1) that proper materials, construction techniques and procedures are used; (2) that the Geosynthetic Contractor implements a quality control plan in accordance with this SLQCP; and (3) that the project is built in accordance with this SLQCP and the project construction plans and technical specifications. The quality assurance program is intended to identify and define problems that may occur during construction and to observe that these problems are avoided and/or corrected before construction is complete.

The GLER, prepared after completion of construction, will document that the constructed facility meets the design intent and technical specifications.

## 4.2 QUALITY CONTROL AND QUALITY ASSURANCE TESTING

CQC during installation of the geomembrane will be performed by the Geosynthetics Contractor. CQA during installation of geomembrane will be performed by the CQA Monitor to assure that the geomembrane is installed in accordance with this SLQCP and the project construction plans and technical specifications. To monitor compliance, a quality assurance program will include the following:

- A review of the geomembrane manufacturer's quality control submittals.
- Material conformance testing.
- CQA testing, both destructive and non-destructive.
- Construction monitoring and documentation.

Conformance testing refers to activities that take place prior to material installation. Construction testing includes activities that occur during geosynthetic installation. All quality control/assurance monitoring and testing will be conducted in accordance with this SLQCP and the project construction plans and technical specifications. The GP or CQA Monitor will be on-site, and observe all geomembrane installation and testing activities.

### 4.2.1 Manufacturer's Quality Control

Prior to the installation of the geomembrane, the manufacturer or installer will provide the GP with quality control certificates signed by a responsible party employed by the manufacturer. Each quality control certificate will include roll identification numbers, testing procedures, and results of quality control tests. The manufacturer's quality control tests will be performed in accordance with the test methods and frequencies provided in the most recent version of

Geosynthetic Research Institute (GRI) standard GM-13. Additionally, testing for the geomembrane resin will be performed in accordance with the following:

- Specific Gravity/Density (ASTM D792 or D1505): 1 per batch and every resin lot; and
- Melt Flow Index (ASTM D1238): 1 per batch and every resin lot.

All geomembrane properties must meet the minimum values set forth in the most recent version of Geosynthetic Research Institute (GRI) standard GM-13. UV Resistance testing not required for HDPE that will be immediately covered. A copy of the current version of GRI-GM13 is included in Appendix 10A.

### 4.2.2 Conformance Testing

Conformance testing refers to testing (by a third-party independent laboratory) performed after manufacture of the geomembrane to verify it meets the required specifications. Conformance testing methods and required frequencies are presented in Table 10-4-1.

**Table 10-4-1. Geomembrane Conformance Testing**

| TEST | METHOD | MINIMUM FREQUENCY |
|---|---|---|
| Thickness (laboratory) | ASTM D5199 (1) or D5994 | 1 per 50,000 ft$^2$ and every resin lot |
| Thickness (2) (field) | | 1 measurement per 5 feet along leading edge of each geomembrane panel. |
| Density | ASTM D1505 or D792 | 1 per 100,000 ft$^2$ and every resin lot |
| Carbon black content | ASTM D1603 | |
| Carbon black dispersion | ASTM D5596 | |
| Tensile properties (3) | ASTM D638 or D6693 | |

1. ASTM D5994 for textured geomembrane, D5199 for smooth.
2. No single measurement will be less than ten percent below the required nominal thickness in order for the panel to be acceptable. A minimum of 5 measurements will be made per panel.
3. 2-inch initial gauge length assumed for elongation at break at 2.0 in/min.

## 4.3 INSTALLATION

### 4.3.1 Delivery

Upon delivery of the geomembrane, the CQA Monitor will observe that:

- The geomembrane is delivered in rolls and is not folded. Any evidence of folding (other than from the manufacturing process) or other shipping damage is cause for rejection of the material.
- Equipment used to unload and store the rolls does not damage the geomembrane.
- The geomembrane is stored in an acceptable location and in accordance with the manufacturer's recommendations and specifications. The geomembrane must not be

stored more than five (5) rolls high. During delivery and storage, the geomembrane must be protected from puncture, dirt, grease, water, mud, mechanical abrasions, excessive heat, or other potentially damaging elements. During storage, the geomembrane shall be raised off the floor/ground to minimize damage.

- All manufacturing documentation required by this SLQCP, as set forth in the technical specifications, has been received and reviewed for compliance with the specifications. This documentation will be included in the GLER.

- The geosynthetics receipt log form has been completed for all materials received.

Damaged geomembrane will be rejected and removed from the site or stored at a location separate from accepted geomembrane. Geomembrane that does not have proper identification or manufacturer's documentation must be stored at a separate location until all documentation has been received, reviewed, and accepted, and will not be incorporated into work until all required documentation is received and reviewed by the CQA Monitor for completeness.

### 4.3.2 Panel Placement

During panel placement, the CQA Monitor must perform the following:

- Record panel and roll numbers and lengths on the panel placement and/or panel seaming log. Develop field notes documenting panel deployment that depicts the locations of panels, seams, destructive test locations and repairs. These field notes will be used to produce a record drawing of the panel placement to be included in the GLER. Alternatively, the panel placement drawing may be developed from field surveying methods.

- Conduct thickness verification tests at 5 foot intervals along the leading edge, at a minimum of 5 locations per panel. No single thickness measurement will be less than 10% below the required normal thickness.

- Observe the geomembrane surface as it is deployed and record all panel defects and repair of the defects (panel rejected, patch installed) on the repair sheet. All repairs will be made in accordance with this SLQCP, supplemental technical specifications, and located on the record drawing of panel placement.

- Observe that heavy vehicular equipment is not allowed on the geomembrane during handling (low ground-pressure support equipment, such as generators, may be allowed with rub sheet protection, as applicable).

- Observe that there are no angular stones greater than 1 inch in size, construction debris, or other deleterious items immediately beneath the geomembrane within the compacted clay soil liner, which could cause damage to the geomembrane.

- Observe that the geomembrane is placed in a manner that provides good contact with the underlying materials, and that no bridging or stretching over surface features occurs. The

subgrade (clay soil liner) under the geomembrane must be smooth-rolled, and maintained in a smooth, uniform, and compacted condition during geomembrane installation. Geomembrane placement methods must be conducted as not to rut or damage underlying clay soil liner.

- Observe that the geomembrane is not dragged across a surface that would damage the material. If the geomembrane is dragged across an unprotected surface, the geomembrane must be inspected for damages and repaired or rejected, as necessary. Record weather conditions including temperature. The geomembrane must not be deployed in the presence of excess moisture (fog, dew, mist, etc.), rain, or high wind. In addition, the geomembrane should not be placed when the air temperature is less than 40°F unless this requirement is waived by the design engineer in writing. Excessive wind is that which can lift and move the geomembrane panels.

- Observe that people working on the geomembrane do not smoke, wear shoes that could damage the geomembrane, or engage in activities that could damage the geomembrane.

- Observe that the method used to deploy the geomembrane minimizes wrinkles and that the geomembrane is anchored to prevent movement by the wind. Wrinkles should be walked-out or removed at the discretion of the CQA personnel. Confirm that the geomembrane is placed in a manner that provides good contact with the underlying soil liner materials, and that no bridging or stretching over surface features occurs.

- Observe that no more panels are deployed than can be seamed on that same day.

- Observe that there are no horizontal seams on sideslopes and that the textured material extends a minimum length beyond the toe of the slope as shown on the construction plans.

The CQA Monitor must inform both the contractor and the GP of any observed variances or unacceptable conditions from above. Note, however, that the CQA Monitor's failure to identify one or more of the above conditions does not relieve the Contractor of responsibility for installing and protecting the geomembrane installation in accordance with the construction plans and technical specifications.

### 4.3.3 Field Seaming

A seam numbering system must be agreed to by the GP and Contractor prior to the start of seaming operations. One procedure is to identify the seam by adjacent panels. For example, the seam located between Panels 306 and 401 would be Seam No. 306/401.

Trial seam testing will be performed for each of the following events:

- At the beginning of each seaming period per workday and for each seaming apparatus, including in the morning and immediately after each extended break throughout the day.

- After any major change in environmental condition, i.e., temperature, humidity, dust, etc.

- Any time the seaming apparatus is turned off for longer than 30 minutes.

- When seaming different geomembranes, i.e., smooth to textured.

Both the welder and the welding apparatus must be tested for extrusion welding. Only the apparatus must be tested according to the above schedule for fusion welding. Each welder or seamer, whether extrusion or fusion welding, must be tested at least once daily.

Each trial seam shall be at least three (3) feet in length, and 1 foot wide. A minimum of four (4) adjoining 1-inch wide coupons will be die-cut from the test seam. Two field samples will be tested for shear, and two samples tested for peel. The apparatus used for field testing must have a current certificate of calibration issued by the appropriate state or federal agency.

If one of the test seams fails, the trial seam will be repeated and testing performed on the trial seam samples. If the second trial seam fails, two additional trial seams will be performed and tested. Trial seaming and retesting will continue until two consecutive passing test series (i.e., two consecutive trial seams) are achieved for the apparatus, and welder, if applicable (extrusion welding only).

The CQA Monitor must observe all trial welding operations, quantitative testing of each trial weld for peel and shear, and recording of the results on the trial weld form. It is important that the trial welds or seams be completed under conditions similar to those under which the panels will be welded.

CQA documentation of trial seam procedures shall include, at a minimum, the following:

- Documentation that trial seams are performed by each welder and welding apparatus prior to commencement of welding and prior to commencement of the second half of the workday, or after extended break periods throughout the day.

- The welder, the welding apparatus number, time, date, ambient air temperature, welding machine temperatures and trial seam number for each trial seam.

During geomembrane welding operations, the CQA Monitor must observe the following:

- The contractor has the number of welding apparatuses and spare parts necessary to perform the work.

- Equipment used for welding will not damage the geomembrane.

- The extrusion welder is purged prior to beginning a weld until all the heat-degraded extrudate is removed.

- Seam grinding has been completed less than one hour before seam welding, and the upper geomembrane is beveled (extrusion welding only).

- The end of welds more than five (5) minutes old are ground to expose new material before restarting a weld (extrusion welding only).

- The ambient temperature, measured six (6) inches above the geomembrane surface, is between 41° and 104° Fahrenheit.

- The contact surfaces of the geomembrane are clean, free of dust, grease, dirt, debris, and moisture prior to welding.

- The seams are overlapped a minimum of three (3) inches for extrusion and hot wedge welding, or in accordance with manufacturer's recommendations, whichever is more stringent. Panels should be overlapped (shingled) in the down-grade direction.

- No solvents or adhesives are present in the seam area.

- The procedure used to temporarily hold the panels together does not damage the panels and does not preclude CQA testing.

- The panels are being welded in accordance with the plans and specifications. Seams should be oriented parallel to the line of maximum slope. In corners and odd-shaped geometric locations, the number of field seams should be minimized.

- There is no free moisture in the weld area.

- Observe that at the end of each day or installation segment, all unseamed panel edges are anchored with sandbags or other approved devices. Penetration anchors shall not be used to secure the geomembrane.

- If seaming operations are carried out at night, adequate illumination shall be provided and must be approved by the GP.

## 4.4 SEAM TESTING

During seam testing, the CQA Monitor will perform the following tasks:

- Review technical specifications regarding test procedures.

- Observe that equipment operators are properly trained and qualified to perform their work.

- Observe that test equipment meets project technical specifications.

- Observe that the entire length of each seam is tested in accordance with the specifications.

- Observe continuity testing and record results on the appropriate test log.

- Observe that all testing is completed in accordance with the technical specifications.
- Identify the failed areas by marking the area with a waterproof marker compatible with the geomembrane, and inform the contractor of any required repairs, then record the repair area on the repair log.
- Observe that all repairs are completed and tested in accordance with the project specifications.
- Record all completed and tested repairs on the repair log.

For destructive samples, the CQA Monitor will select locations where seam samples will be cut for laboratory testing. Sample locations should not be disclosed to the Contractor prior to completion of the seam.

Destructive samples must be shipped to the third-party laboratory for seam testing. Test methods and required frequencies are presented in Section 4.4.1. The third-party laboratory must provide test results within 24 hours, in writing or via telephone, to the GP. Certified test results are to be provided within 5 days. The CQA Monitor must immediately notify the GP in the event of a calibration discrepancy or failed test results.

### 4.4.1 Non-Destructive Testing

Continuous, non-destructive testing will be performed on all seams by the installer. Air pressure testing on dual-track fusion welds and vacuum-box testing for extrusion welds are the only acceptable methods. All leaks must be isolated and repaired by the following procedures:

1. Air-Pressure Testing (GRI GM6) - The ends of the air channel of the dual-track fusion weld must be sealed and pressured to approximately 30 psi, if possible. The air pump must then be shut off and the air pressure observed after five (5) minutes. A loss of less than 4 psi is acceptable if it is determined that the air channel is not blocked between the sealed ends. A loss of 4 psi or more indicates the presence of a seam leak that must then be isolated and repaired by following the procedures described under "Seam Failure Repairs and Retesting." The GP or his/her qualified representatives must observe and record all pressure gauge readings.

2. Vacuum-Box Testing (ASTM D4437) - A suction value of approximately 3 to 5 inches of gauge vacuum must be applied to all extrusion welded seams that can be tested in this manner. Examples of extrusion welded seams that do not easily lend themselves to vacuum testing would be around boots, appurtenances, etc. The seam must be observed for leaks at least ten seconds while subjected to this vacuum. The GP or his/her qualified representative must observe 100 percent of this testing.

### 4.4.2 Destructive Testing

Destructive seam testing will be performed in accordance with ASTM D6392. Destructive samples shall be taken at a minimum of one location for every 500 linear feet of field seam. The

total footage of individual repairs of leaks of more than 10 feet and individual repairs of more than 10 feet for failed seams must also be counted and destructively tested using the same frequency of testing described above. At a minimum, a destructive test must be done for each welding machine used for seaming or repairs. A sufficient amount of the seam must be removed in order to conduct field testing, independent laboratory testing, and archiving of enough material in order to retest the seam when necessary.

Field testing shall include at least two (2) peel test specimens (four (4) when possible for testing both tracks on dual-track fusion welded seams). Independent laboratory testing shall consist of five (5) shear test specimens and five (5) peel test specimens (10 when possible for both tracks of dual-track fusion welded seams). Destructive seam-testing locations shall be cap-stripped and the cap completely seamed by extrusion welding to the parent geomembrane. Capped sections shall be nondestructively tested. Additional destructive test samples may be taken if deemed necessary by the GP or CQA Monitor.

All field-tested specimens from a destructive test location must be passing in both shear and peel for the seam to be considered as passing. Field-tested specimens are determined as passing if the specimen tested in peel fails in film tear bond (FTB) and all test specimens meet the criteria listed in Table 10-4-2. Independent laboratory testing must confirm these field results. The minimum passing criteria for independent laboratory testing are all three of the following:

- 5 of 5 specimens tested in the peel mode must fail in FTB.
- 5 of 5 specimens from each peel and shear determination must meet the minimum specified values in Table 10-4-2.
- All 5 specimens for shear determination should meet the minimum percent elongation at break value in Table 10-4-2.

The above criteria must be met by both tracks from each dual-track fusion welded seam before it is considered as passing.

**Table 10-4-2. Geomembrane Seam Strength**

| Property | Qualifier | Unit | Value |
|---|---|---|---|
| Shear Strength<br>Shear elongation at break | Min.<br>Min. | lb/in<br>% | 120<br>50 |
| **Peel Strength:** | | | |
| Fusion | Min | lb/in | 91 |
| Extrusion | Min. | lb/in | 78 |

### 4.4.3 Seam Failure Delineation

In the event failing tests are obtained at a destructive test location, new destructive test samples will be obtained, a minimum of 10 feet in either direction of the failing test. If one, but not both, of the additional tests fail, further additional destructive testing will be required until passing tests are obtained at both ends of the original destructive test location. A cap will be required for the areas subject to destructive testing, and testing of the cap will be required as set forth in this SLQCP. If more than two failing destructive test locations are observed for a single seam, the CQA Monitor will have the alternative of requiring the entire seam be removed, and a new seam welded.

In the event more than one failing destructive test are observed for a single welding apparatus, new (passing) trial welds will be required prior to resuming geomembrane welding or seaming with the apparatus. All additional testing shall be at the Contractor's expense.

## 4.5 REPAIRS AND RETESTING

All seam leaks and destructive test locations shall be repaired for a distance of at least six (6) inches on each side of the leak or destructive test location. At a minimum, these repairs shall be non-destructively retested in accordance with Section 4.4.1. Destructive testing shall be performed in accordance with Section 4.4.2, or at the discretion of the CQA Monitor.

## 4.6 REPAIRS

Any portion of the geomembrane with a detected flaw, or which fails a non-destructive or destructive test, or where destructive tests were cut, or where non-destructive tests left cuts or holes, must be repaired in accordance with the specifications. The CQA Monitor must locate and record all repairs on the repair sheet. Repair techniques include the following:

- Patching - used to repair holes, tears, large panel defects, undispersed raw materials, contamination by foreign matter, and destructive sample locations.

- Extrusion - used to repair small defects in the panels and seams. In general, this procedure should be used for defects less than 3/8-inch in the largest dimension.

- Topping – used to repair inadequate seam areas, which have an exposed edge, for lengths of seams under five (5) feet. An extruded weld shall be permitted along the outside edge.

- Capping - used to repair failed welds or to cover seams, less than five (5) feet in length, where welds or bonded sections cannot be non-destructively tested. An extrusion weld or fusion weld shall be allowed.

- Spot welding and seaming – used to repair small tears, pinholes, or other minor, localized flaws.

- Removal - used to replace areas with large defects, greater than five (5) feet in length, where the preceding methods are not appropriate. Also used to remove excess material

(wrinkles, fishmouths, intersections, etc.) from the installed geomembrane. Areas of removal shall be patched or capped.

Repair procedures will include the following:

- Abrade geomembrane surfaces to be repaired (extrusion welds only) no more than one hour prior to the repair.
- Clean and dry all surfaces at the time of repair.
- Extend patches or caps at least 6 inches beyond the edge of the defect, and round all corners of patches to a radius of at least 3 inches. Bevel the top edges of patches prior to extrusion welding.
- geomembrane below large caps should be approximately cut to avoid water or gas collection between the two sheets.

### 4.6.1 Wrinkles

During placement of cover materials over the geomembrane, temperature changes or creep can cause wrinkles to develop in the geomembrane. Any wrinkles which can fold over must be repaired either by cutting out the excess material or, if possible, by allowing the liner to contract by temperature reduction. In no case can material be placed over the geomembrane which could result in the membrane folding. The CQA Monitor must monitor the geomembrane for wrinkles and notify the contractor if wrinkles are being covered by soil. The CQA Monitor is then responsible for documenting corrective action to remove the wrinkles.

### 4.6.2 Folded Material

All folded geomembrane must be removed. Remnant folds evident after deployment of the roll which are due to manufacturing process are acceptable.

### 4.6.3 Bridging or Induced Tension

Bridging or Induced Tension: Bridging is defined as areas where the geomembrane is not in contact with the subgrade due to a void in the subgrade or the sheet is pulled in tension so as to span over depressions in the subgrade. Areas likely to promote bridging, i.e. trenches, toe of slopes, etc., shall be loaded with sandbags after deployment and after seaming. Induced tension is stress introduced into the geomembrane during installation or covering. These areas will likely result in bridging. Areas with excessive bridging shall be identified and repaired by either of the following methods:

1. The geomembrane shall be cut, by the Contractor, so the tension is relieved and the geomembrane conforms to the subgrade contours. The cut geomembrane shall be repaired and tested according to the specifications regarding repairs and testing.
2. The geomembrane shall be cut, by the Contractor, and subgrade material shall be added and placed, in accordance with the contract specifications, so as bring the geomembrane

in contact with the subgrade. The cut geomembrane shall be repaired and tested according to the specifications regarding repairs and testing.

### 4.6.4 Anchor Trench

An anchor trench will be constructed around all portions of the geomembrane where the leading edge(s) of the geomembrane will not be needed for future tie-in for expansion into the next lined cell. The anchor trench backfill material will be placed as outlined in the technical specifications. Care will be taken when backfilling and compaction to prevent damage to the underlying geomembrane. Slightly rounded corners will be provided in anchor trenches where the geomembrane enters the trench as to avoid sharp bends in the geomembrane.

The geomembrane anchor trench will be left open until seaming is completed. Expansion and contraction of the geomembrane should be accounted for in the liner placement. The anchor trench will be filled in the morning when temperatures are coolest to reduce bridging of the geomembrane.

The anchor trench backfill material will be placed in uniform lifts compacted to at least 90 percent of standard Proctor (ASTM D 698) density at a moisture content ranging from -2 to +4 percent of optimum. Compaction density and moisture of the anchor trench backfill will be visually verified by the CQA Monitor. Specific density and moisture testing of in-place anchor trench backfill will be at the discretion of the CQA Monitor.

## 4.7 GEOMEMBRANE ACCEPTANCE

The contractor retains all ownership and responsibility for the geomembrane until acceptance by the Owner. In the event the contractor is responsible for placing cover over the geomembrane, the contractor retains all ownership and responsibility for the geomembrane until all required documentation is complete, and the cover material is placed. After panels are placed, seamed, tested successfully, and any repairs are made, the completed installation will be inspected by the Owner's and Contractor's representatives. Any damage or defect found during this inspection will be repaired by the installer. The installation will not be accepted until it meets the requirements of both representatives. In addition, the geomembrane will be accepted by the GP only when the following has been completed:

- The installation is finished.
- All seams have been inspected and verified to be acceptable.
- All required laboratory and field tests have been completed and reviewed.
- All required contractor-supplied documentation has been received and reviewed.
- Record drawings of the panel placement, testing, and repairs have been completed and verified by the GP. The record drawings show the panel dimensions, the location of all panels, seams, destructive tests, and repairs.

- Acceptance of the GLER by TCEQ.

# 5 DRAINAGE GEOCOMPOSITE

## 5.1 INTRODUCTION

This section describes CQA procedures for the installation of drainage geocomposite in the liner. All quality control testing will be conducted in accordance with this SLQCP and the project construction plans and technical specifications. The GP or CQA Monitor will be on-site, and observe all geocomposite installation.

## 5.2 DELIVERY

Upon delivery, the CQA Monitor must observe the following:

- Unloading equipment will not damage the drainage geocomposite rolls.
- Drainage geocomposite rolls are wrapped in impermeable and opaque protection covers.
- Care is used when unloading the rolls.
- All documentation required by the SLQCP and technical specifications has been received and reviewed for compliance.
- Each roll is marked or tagged with the manufacturer's name, lot number, roll number, and roll dimensions.
- Materials are stored in a location that will protect the rolls from precipitation, mud, dirt, dust, puncture, cutting, impact forces, or any other damaging or deleterious conditions.

Any damaged rolls shall be rejected and removed from the site or stored at a location, separate from accepted rolls, designated by the Owner. All rolls which do not have proper manufacturer's documentation shall also be stored at a separate location until all documentation has been received and approved.

## 5.3 QUALITY CONTROL TESTING

The drainage geocomposite manufacturer (or supplier), will conduct quality control testing in accordance with the manufacturer's quality control program and certify that all materials delivered comply with technical specifications. The minimum frequencies and test methods for manufacturer's quality control testing for geocomposites are presented in Table 10-5-1. The material certifications shall be reviewed by the GP and approved for the project prior to acceptance of any of the material.

The geocomposite manufacturer also shall certify that geocomposite transmissivity meets or exceeds the transmissivity requirements set forth in the technical specifications (see Attachment 12 – Leachate and Contaminated Water Management Plan for transmissivity requirements). The manufacturer shall further certify that transmissivity results meet or exceed all requirements for the gradient and confining pressures listed in the technical specifications. If alternate gradient or

confining pressures are used for the certification, the geocomposite manufacturer shall certify that the material meets or exceeds the technical specification requirements. However, even with the manufacturer's certification, the GP reserves the right to reject any materials not meeting the transmissivity requirements, including gradient and confining pressure requirements.

**Table 10-5-1. Manufacturer's Testing Schedule for Geocomposite**

| PRODUCT | TEST | METHOD | MINIMUM FREQUENCY |
|---|---|---|---|
| Resin | Density | ASTM D1505 or D792 | 1 per batch and every resin lot |
| | Melt Flow Index | ASTM D1238 | |
| Geonet | Density | ASTM D1505 or D792 | 1 per 100,000 $ft^2$ and every resin lot |
| | Mass/Area | ASTM D1603 | |
| | Thickness | ASTM D5199 | |
| Geotextile | Mass/Area | ASTM D5261 | 1 per 100,000 $ft^2$ and every resin lot |
| | Grab Tensile Strength | ASTM D4632 | |
| | Trapezoidal Tear Strength | ASTM D4533 | |
| | Apparent Opening Size | ASTM D4751 | |
| | Permittivity | ASTM D4491 | |
| Geocomposite | Transmissivity | ASTM D4716 | One test per product type |

Additionally, conformance testing will be performed for transmissivity (ASTM D4716) and ply adhesion (D413) by an independent third-party laboratory chosen by the GP. Conformance testing for these parameters will be performed at least once per product type and project.

## 5.4 INSTALLATION

### 5.4.1 Surface Preparation

Prior to geocomposite installation, the CQA Monitor must observe the following:

- All lines and grades have been verified by the Contractor.
- All debris, soil, dust and other materials shall be removed from the geomembrane surface being prepared prior to deployment of the overlying geocomposite.
- When placed over a geomembrane, the geomembrane installation, including all required documentation, has been completed.
- The supporting surface does not contain stones that could damage the geocomposite or the geomembrane.

### 5.4.2 Placement

During placement, the CQA Monitor must perform the following:

- Observe the geocomposite as it is deployed and record all defects and disposition of the defects (panel rejected, patch installed, etc.). All repairs are to be made in accordance with the specifications.

- Verify that equipment used to deploy the geocomposite does not damage the geocomposite or underlying geomembrane by handling, trafficking, leakage of hydrocarbons, or by other means.

- Verify that people working on the geocomposite do not smoke, wear shoes that could damage the geocomposite, or engage in activities that could damage the geocomposite or underlying geomembrane.

- Verify that the geocomposite is anchored to prevent movement by the wind (the contractor is responsible for any damage resulting to or from wind blown geocomposite. Use sandbags, or equivalent, to prevent bridging).

- Verify that the geocomposite remains free of contaminants such as soil, grease, fuel, etc.

- Observe that the geocomposite is laid smooth and free of tension, stress, folds, wrinkles, or creases.

- Observe that on slopes the geocomposite is secured in the anchor trench and then rolled or lowered down the slope in a controlled fashion.

- Observe that adjacent rolls of geocomposite are overlapped, tied, and seamed in accordance with the manufacturer's recommendations and the specifications.

- Observe that the geonet components are tied at the specified interval with plastic fasteners. In the absence of other specifications, the adjoining geonet panels will be tied approximately every 5 feet along the roll length (edges) and every 1 foot along the roll width (ends).

- Observe that geotextile component is overlapped and either thermal bonded or sewn together.

- All seams should run parallel to the line of the slope. Seams shall be overlapped a minimum of four (4) inches. Typing material shall be white or yellow for easy inspection. Metallic material shall not be allowed. The geotextile shall then be overlapped and sewn.

## 5.5 REPAIRS

Repair procedures include the following:

- Holes or tears in the drainage geocomposite will be repaired by placing a geocomposite patch extending 2 feet beyond the edges of the hole or tear.

- Secure patch to the originally installed geocomposite by tying every 6 inches.

- Where the hole or tear width across the roll is more than 50 percent of the roll width, the damaged area will be removed and replaced across the entire roll width.

# 6 GEOTEXTILES

## 6.1 INTRODUCTION

This section describes CQA procedures for the installation of geotextiles for liner construction. All quality control testing will be conducted in accordance with this SLQCP and the project construction plans and technical specifications. The GP or CQA Monitor will be on-site, and observe all geotextile installation.

## 6.2 DELIVERY

During delivery the CQA Monitor must observe the following:

- Unloading equipment will not damage the geotextile rolls.
- Geotextile rolls are wrapped in impermeable and opaque protection covers.
- Care is used when unloading the rolls.
- All documentation required by the SLQCP and technical specifications has been received and reviewed for compliance.
- Each roll is marked or tagged with the manufacturer's name, lot number, roll number, and roll dimensions.
- Materials are stored in a location that will protect the rolls from precipitation, mud, dirt, dust, puncture, cutting, impact forces, or any other damaging or deleterious conditions.

Any damaged rolls must be rejected and removed from the site or stored at a location separate from accepted rolls, designated by the Owner. All rolls which do not have proper manufacturer's documentation must also be stored at a separate location until all documentation has been received and approved.

## 6.3 QUALITY CONTROL TESTING

The geotextile manufacturer (or supplier), will conduct quality control testing in accordance with the manufacturer’s quality control program and certify that all materials delivered comply with technical specifications. The minimum frequencies and test methods for manufacturer’s quality control testing for geotextiles are presented in Table 10-6-1. The material certifications shall be reviewed by the GP and approved for the project prior to acceptance of any of the material.

**Table 10-6-1. Manufacturer's Testing Schedule for Geotextile**

| TEST | METHOD | MINIMUM FREQUENCY |
|---|---|---|
| Mass/Area | ASTM D5261 | 1 per 100,000 $ft^2$ and every resin lot |
| Grab Tensile Strength | ASTM D4632 | |
| Trapezoidal Tear Strength | ASTM D4533 | |
| Apparent Opening Size | ASTM D4751 | |
| Permittivity | ASTM D4491 | |

## 6.4 INSTALLATION

### 6.4.1 Surface Preparation

Prior to geotextile installation, the CQA Monitor must observe the following:

- All lines and grades have been verified by the Contractor.
- Except where a geotextile is used as wrap around gravel (such as around chimney drains), all debris, soil, dust and other materials shall be removed from the surface being prepared for geotextile deployment.
- When placed over a geomembrane or geocomposite, the underlying material installation, including all required documentation, has been completed.

### 6.4.2 Placement

During placement, the CQA Monitor must observe the following:

- Observe the geotextile as it is deployed, and record all defects and disposition of the defects (panel rejected, patch installed, etc.). All repairs are to be made in accordance with the specifications.
- Observe that equipment used does not damage the geotextile by handling, equipment transit, leakage of hydrocarbons, or other means.
- Observe that people working on the geotextile do not smoke, wear shoes that could damage the material, or engage in activities that could damage the material.
- Observe that the geotextile is securely anchored as applicable.
- Observe that the geotextiles are temporarily anchored as necessary to prevent movement by the wind.
- Observe that the panels are overlapped in accordance with the construction plans, technical specifications and manufacturer's recommendations.

- Examine the geotextile after installation to confirm that no potentially harmful foreign objects are present.

- Observe that seams (where required) are continuously sewn or thermal bonded in accordance with the manufacturer's recommendations and project specifications.

The CQA Monitor must inform both the Contractor and GP if the above conditions are not met.

## 6.5 REPAIRS

Repair procedures include the following:

- Patching - used to repair holes, tears and large defects.

- Removal - used to replace areas with large defects where the preceding method is not appropriate.

Holes, tears, and defects must be repaired in the following manner. Soil or other material which may have penetrated the defect must be removed completely prior to repair. If located on a slope, the defect must be patched using the same type of material. On a sideslope, should any tear, hole, or defect exceed 10 percent of the width of the panel, the panel must be removed and replaced. If the defect is not located on a slope, the patch must be made using the same type of material and placed with a minimum of 24 inches overlap in all directions. All geotextile patches should be thermal bonded in place.

# APPENDIX 10A

# MATERIAL TESTING SCHEDULES

- **Geosynthetic Research Institute, Test Method GM13 (GRI-GM13)**

- **Liner Component Testing Schedules**
  - Testing Schedule for Compacted Clay Liner
  - Testing Schedule for Geomembrane
  - Testing Schedule for Geocomposite
  - Testing Schedule for Non-Woven Geotextile

# GEOSYNTHETIC RESEARCH INSTITUTE
# TEST METHOD GM13 (GRI-GM13)

# LINER COMPONENT TESTING SCHEDULES

## Table 10A-1. Testing Schedule for Compacted Clay Liner

| TEST CATEGORY | TEST | METHOD USED | FREQUENCY |
|---|---|---|---|
| Borrow Source Materials | Soil Classifications: USCS | ASTM D2487 | 1 per soil type / minimum 1 per borrow source |
| | Sieve Analysis | ASTM D422 or D1140 | |
| | Atterberg Limits | ASTM D4318 | |
| | Moisture/Density Relationship | ASTM D698 | |
| | Hydraulic Conductivity (1) | ASTM D5084 (2)(3) | 1 per Moisture-Density Relationship |
| Constructed Liners | Field Moisture/Density Test | ASTM D1556, D2167, or D6938 | 1 per 8,000 $ft^2$ per 6-inch lift (4) |
| | Sieve Analysis | ASTM D422 or D1140 | 1 per 100,000 $ft^2$ per 6-inch lift (5) |
| | Atterberg Limits | ASTM D4318 | |
| | Hydraulic Conductivity (6) (7) | ASTM D5084 or CoE EM 1110-2-1906 (8) | |
| | Thickness | Survey | 1 per 5,000 $ft^2$ |

1. Field testing of permeability (in accordance with ASTM D5093) is optional, and may be replaced by laboratory testing.
2. Testing procedures in Appendix VII of the Corps of Engineers Manual EM 1110-2-1906, November 30, 1970, Laboratory Soils Testing, may be used as an alternative method.
3. Permeability tests will be conducted with tap water or 0.05N solution of CaSO4. Distilled water will not be allowed.
4. A minimum of three tests must be conducted for each 6-inch lift, regardless of area.
5. A minimum of one test must be conducted for each lift, regardless of cover area.
6. Testing will be conducted on undisturbed samples.
7. Permeability tests will be run using tap water or a 0.05N solution of CaSO4. Distilled water will not be allowed.
8. Field testing of permeability (in accordance with ASTM D5093) is optional, and may be replaced by laboratory testing.

**Table 10A-2. Testing Schedule for Geomembrane**

| TEST CATEGORY | TEST | METHOD | MINIMUM FREQUENCY |
|---|---|---|---|
| Resin | Specific Gravity/Density | ASTM D792 or D1505 | One per batch and every resin lot |
| | Melt Flow Index | ASTM D1238 | |
| Geomembrane Manufacturer | Manufacturer Quality Control (MQC) | Testing per GRI Test Method GM13 | Testing per GRI Test Method GM13 |
| Conformance Testing by Third-Party Independent Laboratory | Thickness | ASTM D5199 [1] or D5994 | 1 per 50,000 $ft^2$ and every resin lot |
| | Thickness [2] (field) | | 1 measurement per 5 feet along leading edge of each geomembrane panel. |
| | Density | ASTM D1505 or D792 | 1 per 100,000 $ft^2$ and every resin lot |
| | Carbon black content | ASTM D1603 | |
| | Carbon black dispersion | ASTM D5596 | |
| | Tensile properties [3] | ASTM D638, Type IV | |
| Destructive Seam Field Testing | Shear | ASTM DD4437 or D6392 | One per 500 linear feet of field seam |
| | Peel | ASTM D4437 | |
| Non-destructive Seam Field Testing | Air Pressure | GRI GM-6 or ASTM D5820 | All dual-track fusion |
| | Vacuum | ASTM D4437 or D5641 | All non-air-pressure tested seams when possible |

1. ASTM D5994 for textured geomembrane, D5199 for smooth.
2. No single measurement will be less than ten percent below the required nominal thickness in order for the panel to be acceptable. A minimum of 5 measurements will be made per panel.
3. 2-inch initial gauge length assumed for elongation at break at 2.0 in/min.

**Table 10A-3. Testing Schedule for Geocomposite**

| TEST CATEGORY | TEST | METHOD | MINIMUM FREQUENCY |
|---|---|---|---|
| Manufacturer (Resin) | Density | ASTM D1505 or D792 | 1 per 100,000 $ft^2$ and every resin lot |
| | Melt Flow Index | ASTM D1238 | |
| Manufacturer (Geonet) | Density | ASTM D1505 or D792 | 1 per 100,000 $ft^2$ and every resin lot |
| | Mass/Area | ASTM D1603 | |
| Manufacturer (Geotextile) | Mass/Area | ASTM D5261 | 1 per 100,000 $ft^2$ and every resin lot |
| | Grab Tensile Strength | ASTM D4632 | |
| | Trapezoidal Tear Strength | ASTM D4533 | |
| | Apparent Opening Size | ASTM D4751 | |
| | Permittivity | ASTM D4491 | |
| Manufacturer (Geocomposite) | Transmissivity | ASTM D4716 | One test per product type |
| Conformance Testing by Third-Party Independent Laboratory | Transmissivity | ASTM D4716 | One test per product type |
| | Ply Adhesion | ASTM D413 | One test per project |

**Table 10A-4. Testing Schedule for Non-woven Geotextile**

| TEST CATEGORY | TEST | METHOD | MINIMUM FREQUENCY |
|---|---|---|---|
| Manufacturer | Mass/Area | ASTM D5261 | 1 per 100,000 $ft^2$ and every resin lot |
| | Grab Tensile Strength | ASTM D4632 | |
| | Trapezoidal Tear Strength | ASTM D4533 | |
| | Apparent Opening Size | ASTM D4751 | |
| | Permittivity | ASTM D4491 | |

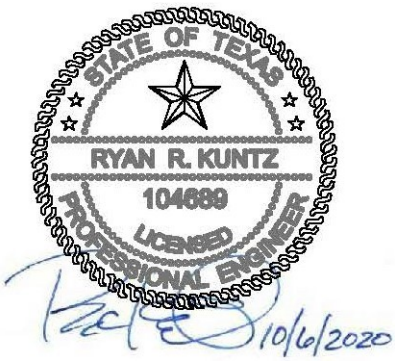
**CITY OF WACO LANDFILL**
**TCEQ PERMIT NO. MSW-2400**
**MCLENNAN AND LIMESTONE COUNTIES, TEXAS**

# PART III - SITE DEVELOPMENT PLAN
# ATTACHMENT 11
# LANDFILL GAS MANAGEMENT PLAN

**Prepared for:**

CITY OF WACO

Solid Waste Services
501 Schroeder Drive
Waco, Texas 76710




**Prepared by:**

**SCS ENGINEERS**
**Texas Board of Professional Engineers, Reg. No. F-3407**
Dallas/Fort Worth Office
1901 Central Drive, Suite 550
Bedford, Texas 76021
817/571-2288

Revision 0 – April 2020
Revision 1 – October 2020
SCS Project No. 16216088.00

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## Drawings

11.1 Gas Monitoring Plan
11.2 Typical Gas Monitoring and Vent Details

## Appendices

11A Methane Monitoring and Recording Form

**SCS Engineers**
**TBPE Reg. # F-3407**

If used, continuous methane monitors/alarms will be tested in accordance with the manufacturer's testing specifications and recommended frequency.

## 3.3 RECORDKEEPING AND REPORTING

Field monitoring data records for GMPs, on-site structures, and utility vents will be maintained for the methane monitoring and kept on-site as part of the Site Operating Record. Field data will be recorded on the Methane Monitoring and Recording Form (Appendix 11A) or similar form. Methane monitoring will be performed quarterly in accordance with 30 TAC §330.371(b)(2) during the following periods:

Methane Monitoring Quarters

**First Quarter:** January – March
**Second Quarter:** April - June
**Third Quarter:** July - September
**Fourth Quarter:** October – December

In accordance with §330.371(e), the methane monitoring and control program will continue for a period of 30 years after the certification of final closure or until the owner or operator receives written authorization from the TCEQ to revise or discontinue the program. Authorization to reduce gas monitoring and control shall be based on a demonstration that there is no potential for gas migration beyond the property boundary or into on-site structures. Demonstration of this proposal shall be supported by data collected and additional studies as required.

## 3.4 BACKUP PLAN FOR GMPS/UTILITY VENTS AND CONTINUOUS METHANE MONITORS

In accordance with 30 TAC §330.371(g)(3), the following is a backup plan to be used if stationary GMPs/utility trench vents or continuous methane monitors become unusable or inoperative.

### 3.4.1 Stationary GMPs/Utility Vents

1. Unusable or inoperative GMPs/utility vents will be repaired or replaced within 60 days of discovery of being unusable or in-operative.

2. Upon completion of a replacement GMP/utility vent, an installation report including boring logs and/or construction details will be maintained in the landfill Site Operating Record.

3. Should a monitoring event occur prior to the 60-day replacement of a damaged GMP/utility vent, barhole probing will be implemented next to the damaged probe using a portable gas monitor.

### 3.4.2 Stationary Continuous Methane Monitor/Alarm

1. Damaged or inoperative stationary continuous methane monitors/alarms will be repaired or replaced upon discovery of damage or malfunction.

2. Alternatively a portable combustible gas indicator calibrated to detect 1.25 percent methane by volume will be used during monitoring events.

# 4 ACTION PLAN

## 4.1 INITIAL RESPONSE MEASURES

This action plan has been prepared for the protection of human health in the event concentrations of methane exceed regulatory limits either at the permit boundary or within on-site structures. The appropriate emergency response is different for each situation; therefore, the plan will address the situations for structures and permit boundaries separately.

This action plan also recognizes that a single-event exceedance of allowable limits on a combustible gas indicator or continuous methane alarm does not necessarily mean that the concentration of methane has actually exceeded allowable levels. Therefore, a procedure, as described below, will be implemented to verify the validity of a single-event exceedance on a combustible gas indicator or continuous methane alarm.

### 4.1.1 Immediate Emergency Action

The initial action in the event methane is detected at levels above regulatory limits is to protect human health. Therefore, immediately following an exceedance, the TCEQ Austin Office, TCEQ regional office, local and county officials, emergency officials, and the public ( defined as adjacent landowners within 1,000 feet of the exceedance) will be notified that a potential exceedance has occurred and that verification procedures are being implemented. The Landfill Manager will advise the landowner to consider evacuating any structure within 1,000 feet of the exceedance while further assessment of the potential for off-site migration is underway, as described in Section 4.1.2. Additionally, the following specific responses will also be implemented depending on the circumstances described below.

#### 4.1.1.1 On-Site Structures

If an on-site structure is found to have methane concentrations that exceed 1.25 percent methane by volume, the structure is to be evacuated of all personnel immediately and the Landfill Manager will be notified. Personnel (except for qualified monitoring personnel) will not be allowed to re-enter the affected structure until additional measures have been taken, as described in Section 4.1.2 of this attachment.

#### 4.1.1.2 Permit Boundary

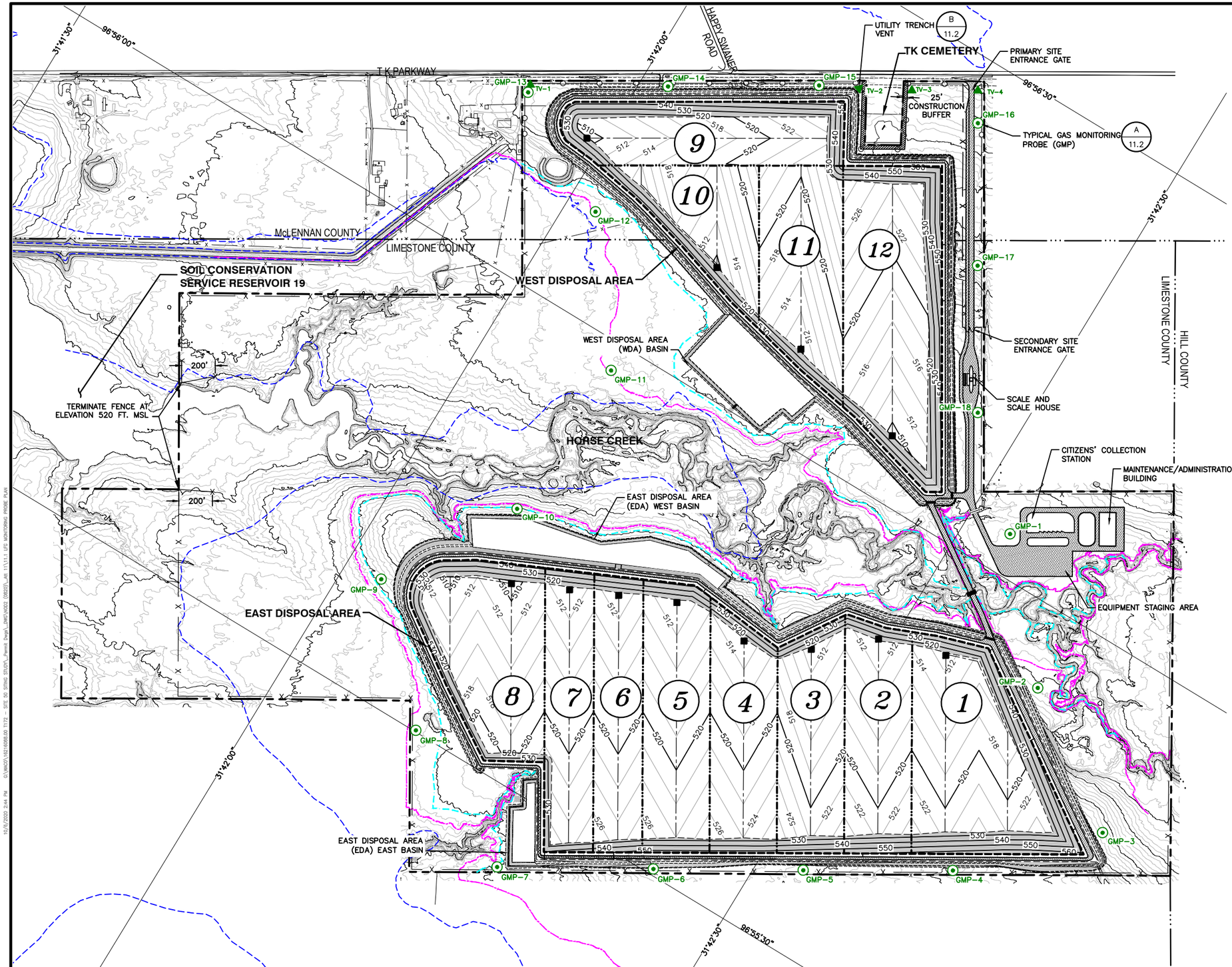
If methane concentration levels that exceed 5 percent methane by volume, are detected at the permit boundary in one of the GMPs or utility trench vents, the Landfill Manager will be notified.

### 4.1.2 Verification Procedures

Once immediate emergency measures have been taken to protect human health, the Landfill Manager will instruct monitoring personnel to begin verification procedures. Such procedures are intended to determine if the methane levels detected are accurate, or if erroneous levels have been detected due to equipment malfunction or other reasons.

## DRAWINGS

- **Drawing 11.1 Gas Monitoring Plan**
- **Drawing 11.2 Typical Gas Monitoring and Vent Details**

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## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- SECTOR BOUNDARY
- COUNTY LINE
- 560 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- 100-YEAR FLOOD PLAIN (SEE NOTE 2)
- 100-YEAR STORM EVENT WATER SURFACE (SEE NOTE 5)
- EXISTING UNDERGROUND WATER LINE
- X PROPOSED/EXISTING PERIMETER FENCE (CHAIN LINK OR BARBED WIRE)
- PROPOSED 8' PRIVACY FENCE
- ACCESS ROAD
- 510 EXCAVATION GRADE TOPOGRAPHIC CONTOURS (SEE NOTE 3)
- 96°55'30" LATITUDE/LONGITUDE LINES
- TOE/TOP OF SLOPE
- LEACHATE COLLECTION TRENCH
- TV-1 PROPOSED UTILITY TRENCH VENTS
- GMP-13 PROPOSED LANDFILL GAS MONITOR PROBE (SEE NOTE 4)
- X SECTOR DESIGNATION
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.
2. 100-YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
3. ELEVATIONS SHOWN ON THIS DRAWING ARE EXCAVATION GRADES OR BOTTOM OF LINER ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).
4. LANDFILL GAS MONITORING PROBES WILL BE INSTALLED CONSISTENT WITH ATTACHMENT 11, SECTION 3.
5. 100-YEAR STORM EVENT WATER SURFACE WAS ESTIMATED USING HEC-HMS AND HEC-RAS MODELING DISCUSSED IN ATTACHMENT 6B OF THIS PERMIT APPLICATION.

STATE OF TEXAS
RYAN R. KUNTZ
104689
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

FOR PERMITTING PURPOSES ONLY

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOODPLAIN, FLOWAGE EASEMENT, BASIN CALLOUT, LIMITS OF WASTE, AND NOTE 2. | RRK |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE
GAS MONITORING PLAN

PROJECT TITLE
CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT
CITY OF WACO
SOLID WASTE SERVICES


SCS ENGINEERS
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CONSULTING ENGINEERS
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PROJ. NO. 16216088.00 | DSN. BY: BG/RRK | DWN. BY: NR | CHK. BY: BJD | Q/A RVW BY: RRK | APP. BY: RRK

CADD FILE: 11.1 LFG MONITORING PROBE PLAN

DATE: 04/2020

SCALE: AS SHOWN

DRAWING NO. 11.1

**CITY OF WACO LANDFILL**
**TCEQ PERMIT NO. MSW-2400**
**McLENNAN AND LIMESTONE COUNTIES, TEXAS**

# PART III
# SITE DEVELOPMENT PLAN -ATTACHMENT 12
# LEACHATE AND CONTAMINATED WATER MANAGEMENT PLAN

**Prepared for:**

**CITY OF WACO**

Solid Waste Services
501 Schroeder Drive
Waco, TX 76710

**Prepared by:**

**SCS ENGINEERS**
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1901 Central Drive, Suite 550
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817/571-2288

Revision 0 – April 2020
Revision 1 – October 2020
SCS Project No. 16216088.00

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12.2 West Disposal Area - Leachate Collection System Layout Plan
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12.4 Leachate Collection System Details

## Appendices

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12B Leachate Collection System Design Calculations
12C Containment Berm and Diversion Berm Calculations
12D HDPE Pipe Corrosion Durability Literature

**SCS Engineers**
**TBPE Reg. # F-3407**

# 4 LEACHATE AND CONTAMINATED WATER STORAGE

As discussed in Section 3.5, leachate storage will be provided in the leachate collection sumps and above-ground leachate storage tank(s). Initial leachate storage will be provided in the leachate collection sumps. Each sump will provide approximately between 7,000 and 11,900 gallons of leachate storage, depending on sump size, which includes at least one day of storage time, assuming an average leachate generation rate. Sump volume calculations are provided in Appendix 12B. Leachate will be removed from the sumps by submersible pumps located within the sump riser pipes. The sump pumps will discharge leachate into above-ground leachate storage tank(s), as described below.

Additionally, contaminated water (surface water contacting waste) will be contained at the working face using containment berms, as described in Section 2.3 of this attachment. Water that infiltrates into the underlying waste will be managed as leachate. Through routine landfill operations contaminated water contained at the working face will be removed by the end of each working day, and discharged to an above-grade leachate storage tank.

Leachate and contaminated water will be stored in the storage tank(s) until it is hauled off for disposal at a local wastewater treatment plant (WWTP) or recirculated back into the landfill, as described in Section 5.

Actual leachate generation and recirculation rates will govern the ultimate number and capacity of above-ground leachate storage tank(s) required at the landfill. As the landfill is developed and leachate generation decreases/increases, the number and size of leachate storage tanks will also be decreased/increased. Storage of leachate and contaminated water will be conducted in one or a combination of the following two ways:

- Option 1 – Temporary leachate storage tanks will be located adjacent to the perimeter haul road and adjacent to one of the sector's leachate collection sump risers. There may be up to twelve (12) temporary leachate storage tanks corresponding to one per sector, with a minimum capacity of 2,500 gallons and maximum capacity of 10,000 gallons for each storage tank. At a minimum, the leachate storage tanks will be located in an area that is optimal for collection of leachate from multiple sectors and that is easily accessible to tanker or vacuum trucks for removal of leachate. Foundations will be compacted earth, gravel, concrete, or similar. The anchoring system will be in accordance with manufacturer's recommendations.

- Option 2 – Permanent leachate storage tank(s) will be located within the landfill permit boundary at the location depicted on Drawings 12.1 and 12.2. There may be up to four (4) permanent leachate storage tank(s), with a maximum aggregate capacity of no greater than 400,000 gallons; with a minimum capacity of 50,000 gallons and maximum capacity of 200,000 gallons for each tank. Leachate generated will be transported to the leachate storage tank(s) via a leachate forcemain serving both disposal areas. The permanent leachate storage tank(s) also will be installed to allow for easy access to tanker or vacuum trucks for removal of leachate. Foundations will be gravel, concrete, or similar and anchored in accordance with manufacture's recommendations.

Storage tanks will be either single or double-contained. In either event, the storage tanks used at the landfill will either be fabricated from steel, polyethylene, or fiberglass. Therefore, the storage tanks installed will be fabricated consistent with one of the following standards (i.e., depending on the material that the tank was fabricated from):

- AWWA D100 for welded carbon steel tanks;
- ASTM D1998 for upright polyethylene storage tanks; and
- ASTM D3299 for filament wound glass-fiber-reinforced thermoset resin chemical-resistant tanks (i.e., fiberglass).

If single-contained, secondary containment will be provided by construction of either geomembrane-lined or concrete-lined containment. The area encompassed and height of the containment will provide sufficient capacity to detain the capacity of the single largest tank and 7.9 inches of precipitation (i.e., 25-year, 24-hour storm event) while maintaining one-foot of freeboard over the detained volume. Secondary containment for double-contained tanks will be provided by a double wall of the same material, geosynthetic liner and/or bladder, or similar system. Double-contained tanks will also include an inspection port, site glass, or similar for monitoring the interior tank integrity for leaks. Additionally, each storage tank (single- and double-contained) will be equipped with level or tank float sensor(s) that communicates with each pump control panel when the tank is full and shuts down the pumps until sufficient leachate volume has been removed from the tank. Furthermore, each storage tank will be equipped with quick connects or control valves (size and type recommended by the manufacturer of the tank) that will allow tanker or vacuum trucks to connect to the tank without spilling leachate during transfer operations.

Landfill personnel will inspect leachate tanks, secondary containment system by visual inspection, related piping, and connections on a weekly basis. During these inspections, landfill personnel will also verify that a spill has not occurred. Records of these inspections and any maintenance as a result of the inspections will be maintained in the Site Operating Record.

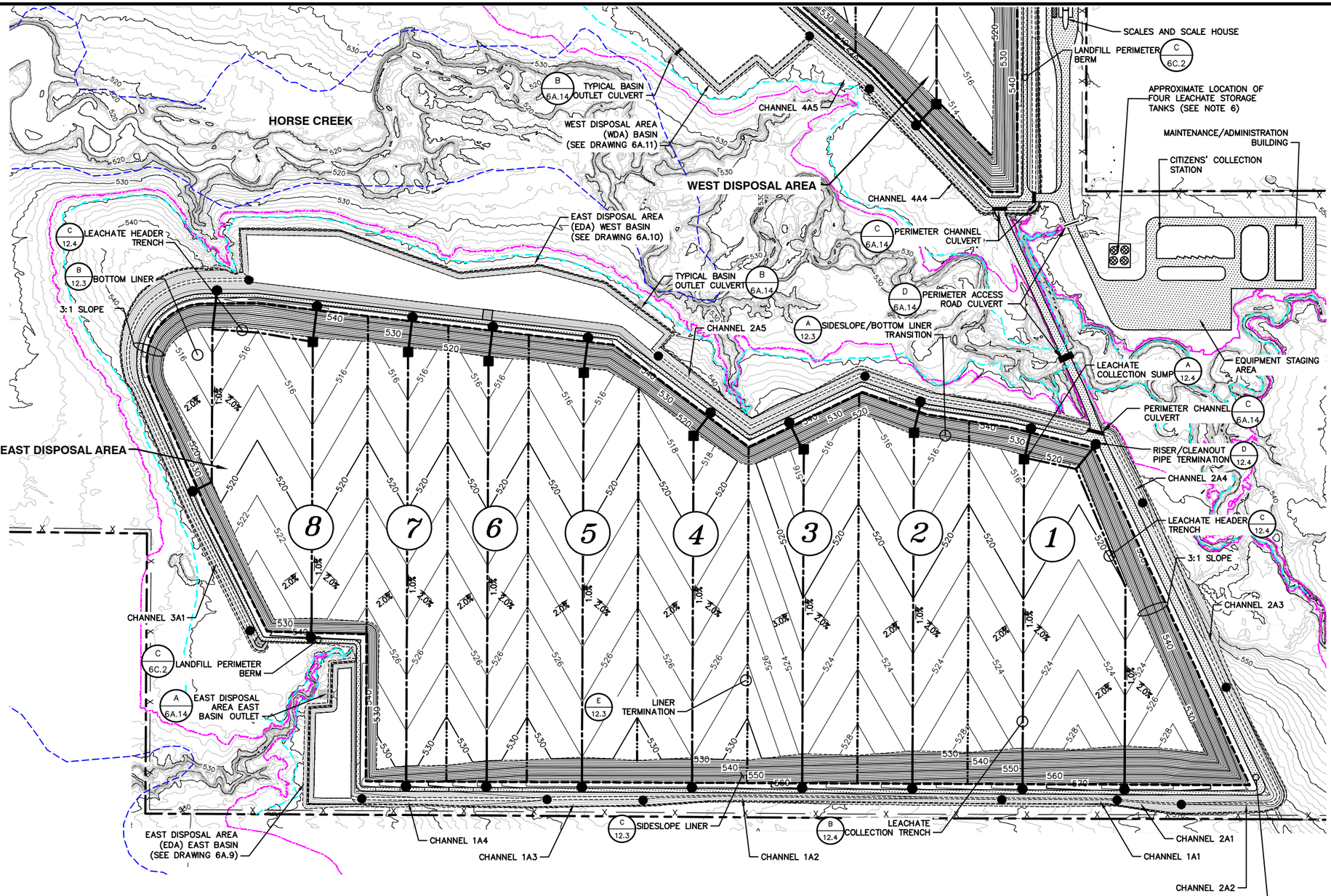
In the event a leachate or contaminated water spill occurs, these liquids will be treated as contaminated water and contained by either the tank secondary containment, construction of earthen berms, or placement of sorbent pads/socks, etc. surrounding the spill, and landfill personnel will implement the following spill response procedures:

1. Immediately remove the leachate or contaminated water upon detection of the spill or leak by pumping the leachate or contaminated water to a secured tank.
2. The area subjected to the spill or leak will also be cleaned up by removing all soil or material showing any sign of contamination and disposed of at the working face of the landfill.
3. The resulting clean-up procedures will be documented in the Site Operating Record.

Additionally, potential spills and spill response efforts and cleanup, reporting, and recordkeeping related to the above-ground leachate storage tanks or any component of the leachate collection system will also be addressed in the Stormwater Pollution Prevention Plan (SWP3), which will be prepared and implemented prior to commencement of landfill operations. The SWP3 will be prepared consistent with the Texas Pollutant Discharge Elimination System (TPDES) General Permit TXR050000, including spill prevention and response measures, as required by Part III, Section A.4(e) 12D of the TPDES General Permit.

## DRAWINGS

- Drawing 12.1: East Disposal Area - Leachate Collection System Layout Plan
- Drawing 12.2: West Disposal Area - Leachate Collection System Layout Plan
- Drawing 12.3: Bottom Liner Details
- Drawing 12.4: Leachate Collection System Details

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## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- SECTOR BOUNDARY
- 560 EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- 100–YEAR FLOOD PLAIN (SEE NOTE 2)
- 100–YEAR STORM EVENT WATER SURFACE (SEE NOTE 5)
- X PROPOSED/EXISTING PERIMETER FENCE (CHAIN LINK OR BARBED WIRE)
- ACCESS ROAD
- 520 TOP OF PROTECTIVE COVER TOPOGRAPHIC CONTOURS (SEE NOTE 3)
- LEACHATE COLLECTION SUMP
- LEACHATE COLLECTION PIPE
- TOE/TOP OF SLOPE
- CLEANOUT/SUMP RISER
- CHANNEL SECTION
- X SECTOR DESIGNATION (SEE NOTE 4)
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.
2. 100–YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
3. ELEVATIONS SHOWN ON THIS DRAWING WITHIN WASTE LIMITS ARE TOP OF PROTECTIVE COVER ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).
4. SECTOR DEVELOPMENT SEQUENCE REPRESENTED BY NUMBERING. SECTORS MAY BE DEVELOPED IN SMALLER INCREMENTS (AKA SUBSECTORS OR CELLS) WITH LINER CERTIFICATIONS SUBMITTED SEPARATELY TO TCEQ FOR REVIEW. IF SECTORS ARE DEVELOPED AS SMALLER CELLS, THE DOWN–GRADIENT CELLS WITH LEACHATE COLLECTION SUMP WILL BE DEVELOPED FIRST.
5. 100–YEAR STORM EVENT WATER SURFACE WAS ESTIMATED USING HEC–HMS AND HEC–RAS MODELING AS DISCUSSED IN ATTACHMENT 6B OF THIS PERMIT APPLICATION.
6. APPROXIMATE LOCATION OF THE LEACHATE STORAGE TANKS DEPICTED REPRESENTS THE PERMANENT LEACHATE STORAGE TANKS LOCATION (OPTION 2). REQUIREMENTS RELATED TO THESE TANKS ARE DESCRIBED IN ATTACHMENT 12, SECTION 4. LOCATION OF LEACHATE STORAGE TANKS (OPTION 2) WILL BE MAINTAINED WITH A MINIMUM 125–FOOT BUFFER FROM THE PERMIT BOUNDARY.

KEY MAP

STATE OF TEXAS
RYAN R. KUNTZ
104689
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

FOR PERMITTING PURPOSES ONLY

| REV. | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOODPLAIN, FLOWAGE EASEMENT, BASIN CALLOUT, LIMITS OF WASTE, LEACHATE COLLECTION TANKS, NOTES 2 AND 6. | RRK |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: EAST DISPOSAL AREA
LECAHTE COLLECTION SYSTEM LAYOUT PLAN

PROJECT TITLE: CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO
SOLID WASTE SERVICES


SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
1901 CENTRAL DRIVE, SUITE 550, BEDFORD, TX 76021
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PROJ. NO. 16216088.00
DSN. BY: BG/RRK
DWN. BY: NR
CHK. BY: BJD
QA/QC BY: RRK
APP. BY: RRK

CADD FILE: 12.1 – LECHATE COLLECTION LAYOUT – EAST
DATE: 04/2020
SCALE: AS SHOWN
DRAWING NO. 12.1


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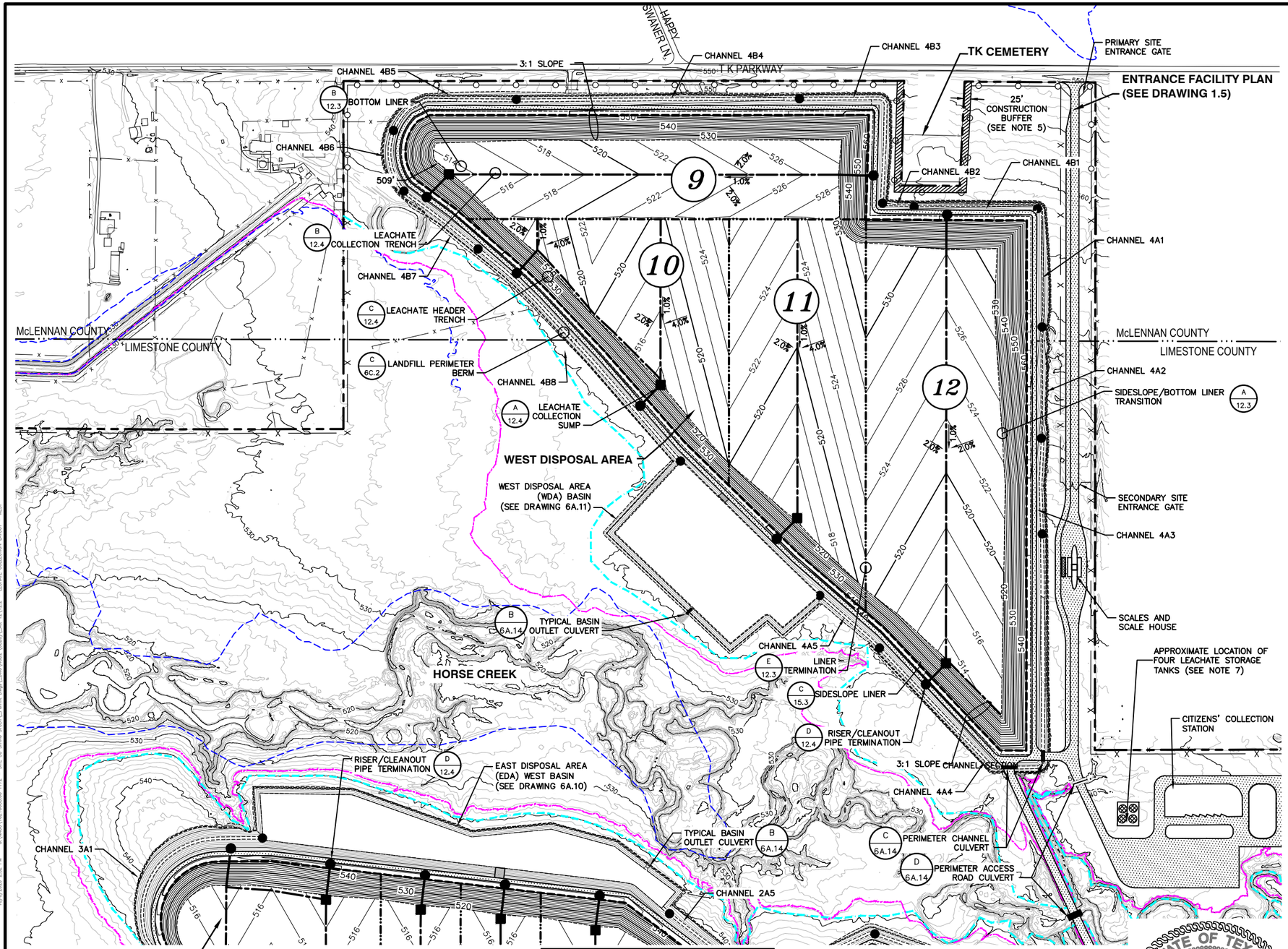


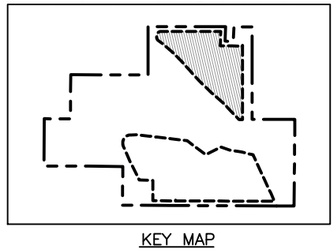

KEY MAP

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## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- SECTOR BOUNDARY
- COUNTY LINE
- 560 — EXISTING TOPOGRAPHIC CONTOURS (SEE NOTE 1)
- 100–YEAR FLOOD PLAIN (SEE NOTE 2)
- 100–YEAR STORM EVENT WATER SURFACE (SEE NOTE 6)
- PROPOSED PERIMETER FENCE (CHAIN LINK)
- PROPOSED 8' PRIVACY FENCE
- ACCESS ROAD
- 520 — TOP OF PROTECTIVE COVER TOPOGRAPHIC CONTOURS (SEE NOTE 3)
- LEACHATE COLLECTION SUMP
- LEACHATE COLLECTION PIPE
- TOE/TOP OF SLOPE
- CLEANOUT/SUMP RISER
- CHANNEL SECTION
- X — SECTOR DESIGNATION (SEE NOTE 4)
- SURVEYED FLOWAGE EASEMENT (534.5' NGVD 29 CONTOUR)

NOTES:

1. THE EXISTING TOPOGRAPHY SHOWN ON THIS PLAN WAS DEVELOPED BY DAS GEOSPATIAL FLOWN ON JULY 03, 2018.
2. 100–YEAR FLOOD PLAIN IS DESIGNATED AS ZONE A, BASED ON FIRM PANEL 48293C0125C, DATED 09/16/11 (LIMESTONE COUNTY), AND FIRM PANEL 48309C0250D, DATED 12/20/19 (MCLENNAN COUNTY).
3. ELEVATIONS SHOWN ON THIS DRAWING WITHIN WASTE LIMITS ARE TOP OF PROTECTIVE COVER ELEVATIONS IN FEET MEAN SEA LEVEL (FT MSL).
4. SECTOR DEVELOPMENT SEQUENCE REPRESENTED BY NUMBERING. SECTORS MAY BE DEVELOPED IN SMALLER INCREMENTS (AKA SUBSECTORS OR CELLS) WITH LINER CERTIFICATIONS SUBMITTED SEPARATELY TO TCEQ FOR REVIEW. IF SECTORS ARE DEVELOPED AS SMALLER CELLS, THE DOWN–GRADIENT CELLS WITH LEACHATE COLLECTION SUMP WILL BE DEVELOPED FIRST.
5. IN ACCORDANCE WITH "AN INTENSIVE CULTURAL RESOURCES SURVEY OF THE CITY OF WACO'S PROPOSED SITE 50 LANDFILL PROJECT," PREPARED BY HORIZON ENVIRONMENTAL SERVICES, INC., DATED NOVEMBER 2018 (SEE APPENDIX I/IIA), A 25–FOOT CONSTRUCTION BUFFER WILL BE MAINTAINED AROUND TK CEMETERY TO PROTECT ANY POTENTIAL UNMARKED GRAVES OUTSIDE THE PRESENT MODERN DAY CEMETERY BOUNDARIES AND FENCING.
6. 100–YEAR STORM EVENT WATER SURFACE WAS ESTIMATED USING HEC–HMS AND HEC–RAS MODELING AS DISCUSSED IN ATTACHMENT 6B OF THIS PERMIT APPLICATION.
7. APPROXIMATE LOCATION OF THE LEACHATE STORAGE TANKS DEPICTED REPRESENTS THE PERMANENT LEACHATE STORAGE TANKS LOCATION (OPTION 2). REQUIREMENTS RELATED TO THESE TANKS ARE DESCRIBED IN ATTACHMENT 12, SECTION 4. LOCATION OF LEACHATE STORAGE TANKS (OPTION 2) WILL BE MAINTAINED WITH A MINIMUM 125–FOOT BUFFER FROM THE PERMIT BOUNDARY.

STATE OF TEXAS
RYAN R. KUNTZ
104689
LICENSED
PROFESSIONAL ENGINEER
10/6/2020

FOR PERMITTING PURPOSES ONLY

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/2020 | REVISIONS INCLUDE: FLOODPLAIN, FLOWAGE EASEMENT, BASIN CALLOUT, LIMITS OF WASTE, LEACHATE COLLECTION TANKS, NOTES 2 AND 7. | RRK |

TEXAS BOARD OF PROFESSIONAL ENGINEERS REG. NO. F-3407

DRAWING TITLE: WEST DISPOSAL AREA
LECAHTE COLLECTION SYSTEM LAYOUT PLAN

PROJECT TITLE: CITY OF WACO LANDFILL
TYPE I MSW - PERMIT APPLICATION

CLIENT: CITY OF WACO
SOLID WASTE SERVICES

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
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PROJ. NO. 162160B8.00
DSN. BY: BG/RRK
DWN. BY: NR
CHK. BY: BJD
Q/A ROM BY:
APP. BY: RRK

CADD FILE: 12.2 – LECHATE COLLECTION LAYOUT – WEST
DATE: 04/2020
SCALE: AS SHOWN
DRAWING NO. 12.2

# APPENDIX 12A

## LEACHATE GENERATION MODEL (HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE (HELP) OUTPUT FILES)

- Leachate Generation Model Narrative
- Climatological Data
- Help Model Summary Sheets
- HELP Output Files (Without Leachate Recirculation)
- HELP Output Files (With Leachate Recirculation)

# HELP MODEL SUMMARY SHEETS

**SCS Engineers**
**TBPE Reg. # F-3407**
**Inclusive of pages 12A-14 to 12A-18**

**CITY OF WACO LANDFILL**
**HELP MODEL SUMMARY SHEET**
**(WITHOUT LEACHATE RECIRCULATION)**

| HELP MODEL INPUT PARAMETERS | | ACTIVE (10' WASTE) | INTERIM (60' WASTE) | INTERIM (130' WASTE) | INTERIM (170' WASTE) | CLOSED (170' WASTE) |
|---|---|---|---|---|---|---|
| | | CASE 1 | CASE 2 | CASE 3 | CASE 4 | CASE 5 |
| PROTECTIVE | Thickness (in) | 24 | 24 | 24 | 24 | 24 |
| COVER | Porosity (vol/vol) | 0.4750 | 0.4750 | 0.4750 | 0.4750 | 0.4750 |
| (Texture = 15) | Field Capacity (vol/vol) | 0.3780 | 0.3780 | 0.3780 | 0.3780 | 0.3780 |
| | Wilting Point (vol/vol) | 0.2650 | 0.2650 | 0.2650 | 0.2650 | 0.2650 |
| | Hyd. Conductivity (cm/s) | 1.7E-05 | 1.7E-05 | 1.7E-05 | 1.7E-05 | 1.7E-05 |
| LEACHATE | Thickness (in) | 0.24 | 0.22 | 0.20 | 0.19 | 0.19 |
| COLLECTION | Porosity (vol/vol) | 0.8500 | 0.8500 | 0.8500 | 0.8500 | 0.8500 |
| (Texture = 0) | Field Capacity (vol/vol) | 0.0100 | 0.0100 | 0.0100 | 0.0100 | 0.0100 |
| | Wilting Point (vol/vol) | 0.0050 | 0.0050 | 0.0050 | 0.0050 | 0.0050 |
| | Hyd. Conductivity (cm/s) | 10.00 | 7.80 | 4.80 | 3.00 | 3.00 |
| | Slope (%) | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| | Slope Length (ft) | 340 | 340 | 340 | 340 | 340 |
| FLEXIBLE | Thickness (in) | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| MEMBRANE | Hyd. Conductivity (cm/s) | 2.0E-13 | 2.0E-13 | 2.0E-13 | 2.0E-13 | 2.0E-13 |
| LINER | Pinhole Density (holes/acre) | 1 | 1 | 1 | 1 | 1 |
| (Texture = 35) | Install. Defects (holes/acre) | 4 | 4 | 4 | 4 | 4 |
| | Placement Quality | GOOD | GOOD | GOOD | GOOD | GOOD |
| COMPACTED | Thickness (in) | 24 | 24 | 24 | 24 | 24 |
| CLAY LINER | Porosity (vol/vol) | 0.4270 | 0.4270 | 0.4270 | 0.4270 | 0.4270 |
| (Texture =16) | Field Capacity (vol/vol) | 0.4180 | 0.4180 | 0.4180 | 0.4180 | 0.4180 |
| | Wilting Point (vol/vol) | 0.3670 | 0.3670 | 0.3670 | 0.3670 | 0.3670 |
| | Hyd. Conductivity (cm/s) | 1.0E-07 | 1.0E-07 | 1.0E-07 | 1.0E-07 | 1.0E-07 |
| PRECIPITATION | Average Annual (in) | 30.95 | 31.90 | 31.90 | 31.90 | 31.90 |
| RUNOFF | Average Annual (in) | 0.00 | 7.15 | 6.46 | 4.10 | 4.87 |
| EVAPOTRANSPIRATION | Average Annual (in) | 19.18 | 22.43 | 22.87 | 23.67 | 26.89 |
| LATERAL DRAINAGE (LCS) | Average Annual (cf/year) | 43,183 | 8,419 | 9,306 | 15,085 | 538 |
| LATERAL DRAINAGE (LCS) | Average Annual (cf/day) | 118.3 | 23.1 | 25.5 | 41.3 | 1.5 |
| LATERAL DRAINAGE (LCS) | Peak daily (cf/day) | 844 | 583 | 304 | 289 | 6 |
| HEAD ON LINER | Average daily (in) | 0.070 | 0.062 | 0.052 | 0.080 | 0.002 |
| HEAD ON LINER | Peak daily (in) | 0.138 | 0.123 | 0.105 | 0.159 | 0.014 |

**CITY OF WACO LANDFILL**
**HELP MODEL SUMMARY SHEET**
**(WITH LEACHATE RECIRCULATION)**

| HELP MODEL INPUT PARAMETERS | | ACTIVE (10' WASTE) | INTERIM (60' WASTE) | INTERIM (130' WASTE) | INTERIM (170' WASTE) |
|---|---|---|---|---|---|
| | | CASE 1- RECIRCULATION | CASE 2- RECIRCULATION | CASE 3- RECIRCULATION | CASE 4- RECIRCULATION |
| FLEXIBLE | Thickness (in) | 0.06 | 0.06 | 0.06 | 0.06 |
| MEMBRANE | Hyd. Conductivity (cm/s) | 2.0E-13 | 2.0E-13 | 2.0E-13 | 2.0E-13 |
| LINER | Pinhole Density (holes/acre) | 1 | 1 | 1 | 1 |
| (Texture = 35) | Install. Defects (holes/acre) | 4 | 4 | 4 | 4 |
| | Placement Quality | GOOD | GOOD | GOOD | GOOD |
| COMPACTED | Thickness (in) | 24 | 24 | 24 | 24 |
| CLAY LINER | Porosity (vol/vol) | 0.4270 | 0.4270 | 0.4270 | 0.4270 |
| (Texture =16) | Field Capacity (vol/vol) | 0.4180 | 0.4180 | 0.4180 | 0.4180 |
| | Init. Moisture Content (vol/vol) | 0.4270 | 0.4270 | 0.4270 | 0.4270 |
| | Hyd. Conductivity (cm/s) | 1.0E-07 | 1.0E-07 | 1.0E-07 | 1.0E-07 |
| PRECIPITATION | Average Annual (in) | 30.95 | 31.90 | 31.90 | 31.90 |
| RUNOFF | Average Annual (in) | 0.00 | 7.15 | 6.46 | 4.10 |
| EVAPOTRANSPIRATION | Average Annual (in) | 19.18 | 22.43 | 22.87 | 23.67 |
| LATERAL DRAINAGE (LCS) | Average Annual (cf/year) | 43,189 | 7,738 | 8,340 | 14,373 |
| LATERAL DRAINAGE (LCS) | Average Annual (cf/day) | 118.3 | 21.2 | 22.8 | 39.4 |
| LATERAL DRAINAGE (LCS) | Peak daily (cf/day) | 461 | 60 | 64 | 122 |
| LEACHATE RECIRCULATION | Average Annual (cf/day) | 80,207 | 69,639 | 47,259 | 26,692 |
| LEACHATE RECIRCULATION | Peak daily (cf/day) | 856 | 540 | 365 | 226 |
| HEAD ON LINER | Average daily (in) | 0.109 | 0.064 | 0.074 | 0.096 |
| HEAD ON LINER | Peak daily (in) | 0.215 | 0.126 | 0.147 | 0.189 |

**CITY OF WACO LANDFILL**
**TCEQ PERMIT NO. MSW-2400**
**McLENNAN AND LIMESTONE COUNTIES, TEXAS**

# PART IV
# SITE OPERATING PLAN

**Prepared for:**

**CITY OF WACO**

Solid Waste Services
501 Schroeder Drive
Waco, TX 76710

**Prepared by:**

**SCS ENGINEERS**
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Revision 0 - April 2020
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will be located as close as practical to the active area to control windblown waste and litter.

- Perimeter fencing, as described in Section 4.1.1.

- As part of the overall site maintenance program, facility personnel will collect daily the windblown waste materials that may have accumulated throughout the entire site, including but not limited to, fences and gates, onsite access roads and drainage channels throughout the site on days when the facility is in operation.

- Facility personnel will inspect public-access roads within two miles in either direction from the landfill entrance for waste spilled in route to the landfill on each day of operation, as described in Section 4.8 of this SOP.

All collected litter will be taken daily to the working face of the landfill for disposal.

## 4.6 EASEMENTS AND BUFFER ZONES (30 TAC §330.141)

### 4.6.1 Easements

In accordance with 30 TAC §330.141, solid waste unloading, storage, disposal, or facility operations will not occur within any easement or right-of-way that crosses the site. All easements will be clearly marked as specified in Section 4.7 of this SOP. At the time of landfill development or cell construction, the waste disposal footprint will be located at least 25-feet from the centerline of any utility and pipeline easement, but no closer than the easement boundary, consistent with 30 TAC §330.543(a). All pipeline and utility easements shall be clearly marked with posts that extend at least six feet above ground level, spaced at intervals no greater than 300 feet. No solid waste unloading, storage, disposal, or processing operations will occur within any easement or right-of-way that crosses the facility, unless and until the easement has been abandoned or relocated.

There are three (3) known easements on the landfill property, including a flowage, waterline, and electric line easement, as described in Parts I/II, Section 3 and shown on the metes and bound survey in Parts I/II, Section 14 of permit application.

### 4.6.2 Buffer Zones

The buffer zone for the waste disposal areas is generally located between the permit boundary and the limits of waste. No solid waste unloading, storage, disposal, or processing operations will occur within the buffer zone. However, perimeter drainage channels, detention basins, and onsite access roads may be installed within the buffer zone between the permit boundary and the limits of waste. Buffer zones may vary around the perimeter of the landfill, but in no case are they less than 125 feet in width. Access roads will be constructed within the buffer zones to allow the safe passage of fire-fighting and other emergency equipment.

Additionally, in accordance with "An Intensive Cultural Resources Survey of the City of Waco's Proposed Site 50 Landfill Property," prepared by Horizon Environmental Services, Inc., dated

November 2018 (see Appendix I/IIA), a 25-foot construction buffer will be maintained around TK Cemetery to protect any potential unmarked graves outside the present modern day cemetery boundaries and fencing. This construction buffer is depicted on Drawing I/II-5 and other site layout drawings contained in Part III – Site Development Plan.

Buffer zones will be clearly marked as specified in Section 4.7 of this SOP.

## 4.7 LANDFILL MARKERS AND BENCHMARK (30 TAC §330.143)

Landfill markers will be installed to clearly mark significant features as described in 30 TAC §330.143(b). The Owner acknowledges that the executive director may modify specific marker requirements to accommodate unique site-specific conditions. The Owner will maintain visibility of all required landfill markers and benchmark prior to closure of the landfill.

The markers will be steel or wooden posts (or other TCEQ approved material) and will extend at least six feet above the ground surface. The markers will not be obscured by vegetation and will be placed in sufficient numbers to clearly show the required boundaries. Landfill markers will be inspected monthly and will be maintained and repaired as necessary. Markers that are removed, destroyed, or otherwise fail to meet regulatory requirements will be replaced within 15 days of discovering their deficiency. Refer to Table 4.1 of this SOP for site inspection and maintenance schedule. Documentation of inspections and maintenance will be maintained in the Site Operating Record of the landfill. Markers will be repainted as needed to retain visibility. Guidelines for type, placement, and color coding of markers are outlined below.

- Site Boundary - Site boundary markers will be painted black. The markers will be placed at each corner of the site and along each boundary line at intervals no greater than 300 feet. Fencing may be placed between these markers as required. In areas where the fence is located on the permit boundary, the fence posts may be painted black and used as site boundary markers.

- Buffer Zone - Buffer zone markers will be painted yellow. The markers will be placed along each buffer zone boundary at intervals of 300 feet. The buffer zones will be a minimum of 125 feet wide from the landfill permit boundary.

- Easements and Rights-of-Way - Easement and right-of-way markers will be painted green. The markers will be placed along the centerline of an easement and along the boundary of a right-of-way, at each corner within the site, and at the intersection of the permit boundary. Where it is impractical to place a marker, the marker will be offset from the easement right-of-way and the offset distance will be clearly painted on the marker.

- Landfill Grid System - Grid markers will be painted white. Markers will be spaced no greater than 100 feet apart measured along perpendicular lines. Where feasible, intermediate markers will be installed where markers cannot be seen from opposite boundaries. At a minimum, grid markers will delineate the area expected to receive

waste within the next 3 years. The grid markers will be maintained during the active life of the site, and throughout the post-closure period, as necessary.

- SLER/GLER Area – Soil liner evaluation report/geomembrane liner evaluation report (SLER/GLER) markers will be painted red. The markers will be placed so that all areas for which a SLER/GLER has been submitted are readily determinable. Such markers are to provide site workers immediate knowledge of the extent of approved disposal areas. These markers will be located and protected so that they are not destroyed during operations until operations extend into the next SLER/GLER area. The location of these markers will be tied into the landfill grid system and will be reported on each SLER/GLER submitted. SLER/GLER markers will not be placed inside the constructed areas.

- 100-Year Floodplain –100-Year floodplain protection markers will be painted blue. The markers will be installed for any area within the 100-year floodplain as delineated by FEMA. The area subject to flooding, including the 100-year storm event water surface boundary as defined in Attachment 6B, will be clearly marked by means of permanent post not more than 300 feet apart or closer if necessary to retain visual continuity.

The site will maintain at least one permanent benchmark at the site in an area readily accessible and will not be used for disposal. The benchmark(s) will be a bronze survey marker, stamped with the elevation and survey date and set in concrete. The benchmark elevation will be surveyed from a known US Coast and Geodetic survey benchmark or other reliable source.

## 4.8 CONTROL OF WASTE SPILLED EN ROUTE TO THE SITE (30 TAC §330.145)

The Landfill Manager or designee will take steps to assure that vehicles hauling waste to the site are enclosed or provided with a tarpaulin, net, or other means to effectively secure the load. The steps taken by the Owner will include, as necessary, the posting of signs requiring the loads to be covered, refusing acceptance of uncovered loads, reporting offenders to the police, adding disposal surcharges, or other necessary means.

On a daily basis when the landfill is in operation, landfill personnel will inspect SH 31 and FM 939 for spilled waste for a distance of two miles in either direction from the landfill entrance used for the delivery of waste to the landfill. If spilled waste is found on these public-access roads within 2 miles from the landfill, such waste will be cleaned up by landfill personnel and delivered to the landfill, assuming such waste is suitable for disposal at the landfill. The Landfill Manager or designee will consult with Texas Department of Transportation (TxDOT) officials and McLennan and Limestone Counties concerning cleanup of these public-access roads consistent with 30 TAC §330.145. Cleanup of these public-access roads will include cleanup of the respective rights-of-way as well.

## 4.9 DISPOSAL OF LARGE ITEMS (30 TAC §330.147)

A large item/white goods storage area will be provided at the CCS or other alternative location designated as the "large item salvage area." Alternatively, large item/white goods will be

diverted from the waste stream at the active working face, and routinely relocated to the storage area. Items that can be classified as large, heavy or bulky can include, but are not limited to, white goods (household appliances), air conditioner units, metal tanks, large metal pieces and automobiles. These items will be recycled as demand warrants but will not be stored in excess of 180 days. Large items that are not recycled will be disposed of at the working face. Care will be taken during disposal of large items such that: (1) large items are excluded from the initial 5 feet of waste over the liner protective cover, (2) large items are placed such that they do not interfere with continued waste filling, and (3) other, smaller municipal solid waste is placed and compacted around them.

The Owner will properly manage chlorinated fluorocarbon (CFC) refrigerant from refrigerators, freezers, air conditioning units, or other items in accordance with 40 CFR §82.156(f). CFCs will be evacuated from refrigerators, freezers, or air conditioners by a third-party vendor, or landfill personnel certified to perform this activity, prior to landfilling or recycling the units at an offsite facility. Electrical equipment, which contain PCBs, will not be accepted, as provided in Section 5.

## 4.10 AIR QUALITY CONTROL AND ODOR MANAGEMENT PLAN (30 TAC §330.149)

### 4.10.1 Air Quality

Municipal solid waste landfills are subject to TCEQ regulations concerning burning and air pollution control. The following procedures will be implemented at the landfill for control of air pollution:

- Open burning of waste will not be permitted at the facility.
- Control of dust emissions (i.e. particulate matter control) from onsite access roads, as described in Section 4.12.
- Obtaining coverage under and complying with either the Standard Air Permit in 30 TAC Subchapter U or an individual air permit.
- For the mulching operation obtaining coverage under and complying with the air quality standard permit in 30 TAC §332.8. In accordance with §332.8(b), mulching operations will be performed as follows in order to comply with the air quality standard permit:
    - The setback distance from the property boundary for brush, untreated wood waste, yard waste, or mulch will 50 feet.
    - Except for initial start-up and shut-down, the receiving chamber on all grinders will be adequately filled prior to commencement of grinding. The receiving chambers will also remain full during grinding operations to minimize emissions from the grinder or wood chipper. In addition, the Owner will have portable watering equipment available during the grinding operations.

- All conveyors which off-load materials from grinders will have available a water or mechanical dust suppression system.
- These controls will be utilized, as necessary, for maximum control of dust when stockpiling ground material.

- Implementation of an Odor Management Plan.
- Investigation of visible air emissions and implementation of controls as necessary.

### 4.10.2 Odor Management Plan

An Odor Management Plan will be implemented at the landfill and will include, but is not limited to, the following procedures:

- Incoming waste will be promptly landfilled.
- Identification of waste that require special attention, including septage, grease trap waste, dead animals, and leachate, and immediately cover and compact with daily cover or other waste.
- Identification of loads with significant odors by the Gate Attendant, and notification to the working face personnel. In the event waste is identified at the CCS with significant odors, landfill personnel will remove the roll-off from the CCS, and dispose of said waste at the working face.
- Freshly landfilled waste will be promptly covered with daily cover at the end of each operating day.
- Keeping the size of the working face to a minimum so waste can be covered quickly.
- Ponded water at the site will be controlled as detailed in Section 4.19 of this SOP.
- Damage or erosion of daily, intermediate, or final cover will be repaired within 5 days of detection (weather permitting) consistent with Section 4.18.5.
- Regular inspection of vapor-tight gaskets on leachate riser end caps. Damaged or deficient gaskets will be repaired, as soon as practicable following the inspection.
- Leachate will be disposed and handled as described in Attachment 12 – Leachate and Contaminated Water Plan.
- Control of landfill gas emissions as detailed in the Landfill Gas Management Plan.
- Clean up spills of odorous materials as soon as possible.

- Accidental fires will be controlled as outlined in Section 6 of this SOP.

## 4.11 DISEASE VECTOR CONTROL (30 TAC §330.151)

The need for vector control (control of rodents, flies, mosquitoes, etc.) will be minimized through proper daily site operations, which include the application of daily and intermediate cover. The extent of the working face will also be minimized, as described in Section 4.2.1. Landfill personnel will make weekly checks for insects and rodents and will report problems to the Landfill Manager or designee. Based on the results of the inspections, a licensed professional may apply pesticides or rodenticides to enhance vector control. Care will be taken to ensure that proper chemicals are used and that they are properly applied.

In addition, if birds become a nuisance at the landfill, pyrotechnics or other similar techniques may be used to manage the bird population at the landfill.

## 4.12 MAINTENANCE OF SITE ACCESS ROADS (30 TAC §330.153)

The site entrance road will be an asphalt or concrete paved roadway, or other suitable material that transitions into onsite access roads, including perimeter and interior haul roads. The landfill access roads (i.e., perimeter and other constructed interior haul roads) will be constructed of crushed stone, gravel, caliche, concrete paving, asphalt paving, or other suitable material and maintained in a clean and safe condition. All-weather landfill access roads will be maintained for access from the public roadway to the waste disposal area(s) and CCS during wet-weather operation. In addition to the all-weather roads, some portions of the onsite roads will be maintained for use during dry weather only.

The all-weather entrance road will be maintained in a manner to limit tracking of mud and associated debris onto FM 939. If mud and/or associated debris is tracked onto FM 939 at the landfill entrance, it will be removed at least once per day on days when mud and associated debris are being tracked onto FM 939. Mud and associated debris that has accumulated at the landfill entrance and this section of FM 939 will removed using a motor grader or other suitable equipment capable of removing the mud and debris accumulations.

Dust will be controlled on the onsite access roads by periodic spraying from a water truck or other means as-needed during periods of significantly dry weather. Dust from onsite access roads will not become a nuisance to surrounding areas. A water source and necessary equipment or other means of dust control approved by the TCEQ will be provided.

Grading equipment will be used, as necessary, to control or remove mud accumulations on onsite access roads. All onsite access roads will be inspected for damage due to traffic or erosion following significant rainfall events. In any instance, the minimum inspection frequency of the site access roads will be monthly. Crushed stone, concrete rubble, masonry demolition debris, or other similar material will be delivered to the site on an as-needed basis for use in maintaining passable onsite access roads during wet weather. All onsite access roads will be maintained in a clean and safe condition. Site access roads will be regraded on an as-needed basis, to minimize depressions, ruts and potholes. Refer to Table 4.1 of this SOP for the site inspection and maintenance schedule.

The date of detection of erosion and date of completion of repairs, including justification of delays, will be documented in the Cover Application Log. Cover inspections will be conducted throughout the operational life of the landfill and post-closure care period.

### 4.18.6 Cover Application Log

Throughout the landfill operation, a cover application log will be maintained and be readily available for inspection in accordance with 30 TAC §330.165(h). For daily cover and intermediate cover, the log will specify the area covered (by use of the grid system), how it was placed, and when it was completed. For final cover, the log will show the final cover area and refer to the final cover certification report for each area. Each entry will be certified by the signature of the Landfill Manager or designee that the work was accomplished as stated in the log. Repairs will be documented in the appropriate cover log, including inspections for erosion, the findings, and the action taken.

## 4.19 PREVENTION OF PONDED WATER (30 TAC §330.167)

The prevention of ponding water is necessary to control infiltration of water into the waste. Additionally, ponded water can be a source of odor and breeding grounds for vectors. This ponding water prevention plan to be implemented at the facility includes, but is not limited to, the following procedures:

**Preventative Actions:**

- Inspections of the landfill cover, consist with Section 4.18 of this SOP, following periods of wet weather, to identify potential ponding locations.

- Routine site grading and maintenance to provide drainage and minimize the ponding of water over areas containing waste.

**Corrective Actions:**

- Should ponding occur, the water will be removed and the depressions filled within seven days of detection.

- If the ponded water has come into contact with waste, leachate, or waste-contaminated soils, it will be treated as contaminated water and handled in accordance with Attachment 12 - Leachate and Contaminated Water Management Plan.

## 4.20 DISPOSAL OF SPECIAL WASTES (30 TAC §330.171)

Acceptance of special wastes, as defined in 30 TAC §330.3(148), will be performed in accordance with 30 TAC §330.171. The acceptance of a special waste not specifically identified in 30 TAC §330.171(c) and 30 TAC §330.171(d) requires prior written approval from the TCEQ. In accordance with §330.171(b), the following applies for special waste acceptance and disposal:

- Approvals will be waste-specific and/or site-specific and will be granted only to appropriate facilities operating in compliance with 30 TAC §330.

- Requests for approval to accept special wastes must be submitted by the generator to the executive director or to a facility with an approved acceptance plan and must include, but are not limited to, the following:

    - A complete description of the chemical and physical characteristics of each waste, a statement as to whether or not each waste is a Class 1 industrial waste as defined in §330.3 of this title, and the quantity and rate at which each waste is produced and/or the expected frequency of disposal;

    - An operational plan containing the proposed procedures for handling each waste and listing required protective equipment for operating personnel and on-site emergency equipment; and

    - A contingency plan outlining responsibility for containment and cleanup of any accidental spills occurring during the delivery and/or disposal operation.

- The executive director may authorize the receipt of special waste with a written concurrence from the Owner or Operator; however, the facility operator is not required to accept the waste.

- The executive director may revoke an authorization to accept special waste if the Owner or Operator does not maintain compliance with these rules or conditions imposed in the authorization to accept special waste.

The special wastes that will be accepted at the site are discussed in the following subsections.

### 4.20.1 Dead Animals and Slaughterhouse Waste

Dead animals and slaughterhouse wastes will be accepted at the landfill (including, but not limited to, hatchery waste, turkey eggs, chicken eggs, etc.) that are delivered to the site independent of other wastes. Dead animals and slaughterhouse wastes will be buried and covered with a minimum of 3 feet of other solid waste or a minimum of 2 feet of earthen material immediately upon receipt.

### 4.20.2 Regulated asbestos-containing material (RACM)

RACM as defined in 40 Code of Federal Regulations §61 may be accepted at the landfill. Prior to the receipt of RACM, the Landfill Manager or designee will dedicate a specific area or areas of the landfill that will receive RACM and will provide written notification to the TCEQ of the area or areas to be designated for receipt of RACM. After the initial authorization to receive RACM is issued, additional areas may be designated by providing written notice to the TCEQ of the location of the additional areas. The Landfill Manager will maintain the following records in the Site Operation Record related to disposal of RACM:

- The location of the area(s) designated to receive RACM must be surveyed and marked by a registered professional land surveyor and identified on a current site diagram. A copy of the current site diagram identifying the RACM area(s) will be submitted to the TCEQ immediately upon completion of the diagram.

- Each load of RACM that arrives on landfill will be documented. This documentation will include the volume of material, and the location and depth of its disposal.

- Delivery of RACM will be coordinated with the Landfill manager or his designee so that the RACM will arrive during times that it can be properly managed by landfill personnel.

- RACM will only be accepted at the landfill in tightly closed and unruptured containers or bags or will be wrapped with at least six-mil polyethylene.

- At a minimum, RACM will only be placed 20 feet or more inside (below) the final sideslope grades, and 10 feet or more below the topslope final grades.

- Bags of RACM will be carefully unloaded and placed in the disposal location. The bags will be promptly covered with 12 inches of clean soil or 3 feet of MSW containing no asbestos. Care will be taken that the bags are not ruptured.

- Upon closure of the landfill, a notation indicating that the landfill accepted RACM will be placed in the deed record. This notation will indicate where the RACM was disposed of on the property by showing its location on a site diagram. A copy of this documentation will be provided to the TCEQ.

- In the event RACM is spilled prior to proper disposal, the following procedures will be followed by the landfill personnel:

    - The Landfill Manager or his designee will immediately be notified of the spill.

    - The manifested owner of the RACM will be notified of the spill, and a request for trained personnel from the RACM owner will be made to assist in the cleanup, if appropriate.

    - A landfill employee trained in asbestos handling and disposal processes will lead the cleanup of the spilled RACM.

    - The RACM will be sprayed with water or other appropriate dust suppressant so that dust or windblown RACM is not generated. Spraying will be sufficient to control dust, without washing the spilled RACM away from the cleanup area.

    - Once dust has been suppressed, the RACM will be collected by shovel or scrapped into a front-end loader and transported to the disposal area. Care will be taken that all of the RACM is removed from the spill area.

- If the quantity of spilled RACM is too large for landfill personnel to address, landfill personnel will immediately contact a licensed RACM abatement company, so that the RACM can be contained by persons trained in RACM cleanup.

### 4.20.3 Nonregulated asbestos-containing material (non-RACM)

Nonregulated asbestos-containing materials (non-RACM) may be accepted for disposal at this landfill provided the wastes are placed on the active working face and covered in accordance with 30 TAC 330.171(c)(4). Under no circumstances may any material containing non-RACM be placed on any surface or roadway that is subject to vehicular traffic or disposed of by any other means by which the material could be crumbled into a friable state.

### 4.20.4 Empty Containers

Empty containers which have been used for pesticides, herbicides, fungicides, or rodenticides will be disposed at the site in accordance with the following:

- The containers are tripled rinsed prior to receipt at the landfill.
- The containers are rendered unusable prior to or upon receipt at the landfill.
- The containers are covered by the end of the same working day they are received.

Containers for which triple-rinsing is not feasible or practical (e.g., paper bags, cardboard containers) may be disposed at the landfill consistent with the provisions of Section 4.20.5.

### 4.20.5 Municipal Hazardous Waste from Conditionally Exempt Generators

Municipal hazardous waste from a conditionally exempt small quantity generator (CESQG) may be accepted at the landfill without further approval from the TCEQ provided the amount of waste does not exceed 220 pounds per month per generator, and provided the landfill owner or operator authorizes acceptance of the waste.

### 4.20.6 Sludge, Grease Trap, Grit Trap, or Municipal Liquid Wastes

Sludge, grease trap waste, grit trap waste, or liquid wastes from municipal sources will be accepted at the landfill for disposal only if the waste has been treated or processed and the treated/processed material has been tested, in accordance with Test Method 9095 (Paint Filter Liquids Test), as described in "Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods" (EPA Publication Number SW 846), as amended, and is certified to contain no free liquids.

### 4.20.7 Used Oil Filters

Used oil filters (to include filters that have been crushed and/or processed to remove free-flowing used oil) from non-household generators will not be accepted at the landfill. However, used oil

filters from internal combustion engines from household generators may be accepted at the landfill if the filter has been:

- Crushed to less than 20% of its original volume to remove all free-flowing used oil.
- Processed by a method other than crushing to remove all free-flowing used oil. A filter is considered to have been processed if:

  (i) the filter has been separated into component parts and the free-flowing used oil has been removed from the filter element by some means of compression in order to remove free-flowing used oil;

  (ii) the used filter element of a filter consisting of a replaceable filtration element in a reusable or permanent housing has been removed from the housing and pressed to remove free-flowing used oil; or

  (iii) the housing is punctured and the filter is drained for at least 24 hours.

## 4.21 VISUAL SCREENING OF DEPOSITED WASTE (30 TAC §330.175)

Methods for visually screening the working face and deposited waste include, but are not limited to, the following items consistent with 30 TAC §330.175:

- Orienting the working face away from FM 939, as feasible, and confining the working face to a minimum area, as described Section 4.2.1.
- Covering the working face daily with daily cover, and applying intermediate and final cover to the landfill, including applying vegetation to intermediate and final cover, as described in Section 4.18.
- Developing the aerial fill portion of the landfill from the exterior to the interior when warranted (i.e., by constructing landfill sideslopes prior to filling operations in the interior of the landfill).
- Providing an 8-foot privacy fence along the western permit boundary adjacent and parallel to FM 939, as depicted in Part III, Drawing 1.2.
- Maintaining existing trees and other vegetation near the landfill permit boundary that are adjacent to FM 939 to the extent practical for landfill development.

## 4.22 LEACHATE AND GAS CONDENSATE RECIRCULATION (30 TAC §330.177)

The Landfill Manager may recirculate leachate or gas condensate derived from the landfill into the areas of the landfill that have a leachate collection system and composite liner, as defined in 30 TAC §330.331(a)(2).

As described in Attachment 12 – Leachate and Contaminated Water Management Plan, leachate and/or gas condensate will be either recirculated back to the landfill or disposed at a local wastewater treatment plant (WWTP) permitted by the TCEQ. Recirculation may be performed by either injecting through vertical or horizontal pipes in the waste, or spraying leachate or gas condensate water onto the working face at the allowable annual rates per acre, as described in Attachment 12. Procedures for recirculating leachate or gas condensate are described in Attachment 12, Section 5. Consistent with §330.125(b)(4), the Landfill Manager will maintain records of the date, time, volume, and location (i.e., landfill unit or sector) that leachate or gas condensate is recirculated back into the landfill.

## Table 4.1 Site Inspection and Maintenance Schedule

| ITEM | TASK | SCHEDULE |
|---|---|---|
| Fence/Gates | Inspect perimeter fence and gates for damage, gaps, intrusions and the like. Make temporary repairs within 24-hours of detection (weather permitting) and permanent repairs within the timeframe approved by the TCEQ region office. | Monthly |
| Windblown Waste | Inspect working fence area, wind fences, access roads, entrance area, and perimeter fence for loose trash. Clean up upon detection. | Daily |
| Waste Spilled en Route to the Site | Inspect portions of SH 31 and FM 939 which are used for waste delivery at least two miles in either direction of the landfill entrance. Clean up upon detection. | Daily |
| Landfill Markers | Inspect all landfill markers for damage, color coding, and general location. Correct or replace damaged markers within 15 days of detection. | Monthly |
| Landfill Access Roads | Inspect landfill access roads for damage from vehicle traffic and erosion. Repair onsite access roads, as needed, based on inspections.<br><br>Inspect FM 939 and landfill entrance for excessive mud and/or debris accumulation. Remove mud/debris accumulations daily using grading equipment or other road cleaning equipment. | Monthly<br><br>Daily<br>(Wet Weather)<br>Weekly (Otherwise) |
| Daily Cover | Inspect for proper placement thickness, and compaction. Remedy deficiencies as needed. | Daily (Active)<br><br>Weekly (Inactive) |
| Intermediate Cover | Inspect for proper placement, thickness, erosion, vegetation, compaction and for presence of waste or other contamination. Remedy deficiencies as needed within 5 days of detection, weather permitting. | Weekly |
| Final Cover | Inspect for proper placement, thickness, compaction, slope, settlement, vegetation, and erosion. Maintenance will be ongoing throughout post-closure care period. Remedy deficiencies as needed within 5 days of detection, weather permitting. | Monthly |

**Table 4.1 (Continued)**

| ITEM | TASK | SCHEDULE |
|---|---|---|
| Erosion Control | Inspect the intermediate and final cover for signs of erosion. Damaged areas will be repaired within 5 days (weather permitting) of detection by restoring cover material, grading, compaction, and/or seeding or sodding. | Weekly (Interim), Monthly (Final), and following wet weather. |
| Disease Vector Control | Inspect landfill facility for insects and rodent populations and report them to the Landfill Manager. | Weekly |
| Ponding Water | Inspect landfill cover for potential ponding water locations. Grade and compact potential areas within 7 days of detection, weather permitting. | Weekly<br><br>(Following Wet Weather) |
| CCS Containers | Inspect the containers for spills and leaks, and repair or replace containers, if necessary, as a result of these inspections. | Daily |

address of the hauling company and driver, the type of vehicle, the size and source of the load, contents of the load, indicators of unauthorized waste, and results of the inspection.

The TCEQ and local pollution agency with jurisdiction that has requested to be notified, will be notified whenever regulated hazardous or PCB waste is detected. Records of the notification will be kept in the Site Operating Record and will include the date and time of notification, the individual contacted, and the information reported.

Personnel training records will be maintained in the Site Operating Record and will include evidence of successful completion of the training, type of training received, and the name of the instructor.

## 5.4 TRAINING

Maintenance Workers, Equipment Operators, and Customer Service Representatives will maintain an understanding of this SOP and will be trained in the following areas:

- Load inspection procedures.
- Identification of unauthorized wastes, including regulated hazardous and PCB waste.
- Waste handling procedures.

The Landfill Manager or designee will maintain an understanding of this SOP and will be trained in the above areas as well as customer notification and recordkeeping. Documentation of training will be placed in the Site Operating Record.

## 5.5 MANAGING UNAUTHORIZED WASTES

Unknown wastes undergoing analysis must be properly segregated and protected against the elements, secured against unauthorized removal or accidental burial, and isolated from other wastes and activities. An effort will be made to identify the entity that deposited the suspected unauthorized waste and to have this entity return to the site and assume full responsibility for proper disposal of the waste.

Known unauthorized wastes detected during unloading of waste or an inspection will be returned immediately to the hauler. Unauthorized waste that is not discovered by landfill employees until after it is unloaded shall be returned to the vehicle that delivered the waste. If the hauler is not available or has left the site, the waste will be safely stored until provisions for removal by the hauler and/or disposal at an authorized facility can be arranged.

If regulated hazardous or PCB wastes are detected, the TCEQ Region office and local pollution agency with jurisdiction, will be notified via telephone within 24 hours and the TCEQ Austin Office MSW Section will be notified in writing with a copy to the TCEQ Region Office within 14 days. As soon as is practical, the hauler will be required to remove the hazardous waste from the site. Prior to removal, the hauler must demonstrate that he has an EPA identification number,

package the waste in accordance with TxDOT regulations, and properly manifest the waste designating a permitted facility to treat, store, or dispose of the hazardous waste.