# PART III

# SITE DEVELOPMENT PLAN

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# SITE DEVELOPMENT PLAN

## LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
## WACO, McLENNAN COUNTY, TEXAS
## PERMIT AMENDMENT APPLICATION
## MSW PERMIT NO. 1646B

*Physical Site Address:*
677 Selby Lane
Waco, TX 76705
(254) 799-9353

*Prepared for:*

**City of Lacy Lakeview**
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and

**Waste Management of Texas, Inc.**
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Prepared by:

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October 2022

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10/21/2022

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# PART III

# SITE DEVELOPMENT PLAN NARRATIVE REPORT

## LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
## WACO, McLENNAN COUNTY, TEXAS
## PERMIT AMENDMENT APPLICATION
## MSW PERMIT NO. 1646B

*Prepared for:*

**City of Lacy Lakeview**

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Prepared by:

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**TABLE**



**ATTACHMENTS**

# 1. INTRODUCTION

## 1.1 Terms of Reference

This permit amendment application is for an expansion of the existing Lacy Lakeview Recycling and Disposal Facility (RDF), a Type I municipal solid waste (MSW) facility (landfill) located in an unincorporated area of McLennan County, Texas (within the extra-territorial jurisdiction of the City of Waco).

The complete permit amendment application is divided into Parts I through IV as required by 30 TAC §330.57. Part I of the permit amendment application presents site and applicant information. Part II presents an existing conditions summary and information on the character of the facility and surrounding area. Part III presents facility design information, detailed investigative reports, schematic designs of the facility, and required plans. Part IV presents the Site Operating Plan (SOP) which describes the general procedures for conducting day-to-day operations at the facility.

This report and accompanying attachments comprise Part III of the permit amendment application for MSW Permit No. 1646B. Part III addresses the items required by 30 TAC §330.63 by discussing the criteria used in the selection and design of this facility for safeguarding the health, welfare, and physical property of the public and the environment. This Part III narrative report includes discussion of the geology, soil conditions, drainage, land use, zoning, adequacy of access roads and highways, and other considerations specific to this facility.

In this report, where cross-references are made to various other Part I through Part IV reports, plans, attachments/appendices, and drawings; they refer to the latest versions of these items contained in Parts I through IV of the permit amendment application for MSW Permit No. 1646B (and as updated via any approved amendments, corrections, or modifications issued by the Texas Commission on Environmental Quality (TCEQ) for this permit).

## 1.2 Existing Conditions

The Lacy Lakeview Recycling and Disposal Facility is an existing Type I MSW facility located in McLennan County, Texas, approximately 5 miles northeast of downtown Waco. The facility is located approximately 2.7 miles east of the intersection of Interstate Highway (IH)-35 and TX-340 Loop/N Loop 340, and just southeast of the City of Bellmead. The physical address of the site is 677 Selby Lane, Waco, TX 76705.

The initial landfill facility MSW Permit No. 1646 was issued by the Texas Department of Health, and disposal operations began, in roughly the 1983 timeframe. The permit was amended in

November 1992 (through issuance by the Texas Water Commission of MSW Permit No. 1646-A) to upgrade the landfill from what was known at that time as a "Type II" classification, to a Type I classification. In the 1994 timeframe, the facility design and associated permit documents underwent a Subtitle D upgrade. The facility is currently operating with TCEQ authorization under MSW Permit No. 1646A. As currently permitted, the site permit boundary area consists of approximately 95.22 acres, with the landfill waste footprint occupying about 64.0 acres.

The existing facility is composed of "pre-Subtitle D" areas known as Phase 1 and Phase 2A that have a combined area of approximately 19.6 acres. Construction of these areas pre-dated the RCRA Subtitle D regulations promulgated in the early 1990s, and as such, they are built with a liner system that has a compacted clay liner without an overlying geomembrane to form a composite liner. The remaining existing areas of the landfill, totaling approximately 44.4 acres, are known as Cells 2-1 through 3-5 – each of which have a Subtitle D-compliant liner system (with composite liner and leachate collection and recovery system).

The current facility buffer distances from the permit boundary to the limit of waste disposal vary depending on location. Along the east and north boundaries, buffer zones of 90 and 100 feet, respectively, are maintained. The south side of the existing landfill has a variable buffer zone that is at least 195-ft wide (minimum). The west side of the existing site is permitted with a 60-ft wide buffer zone from the current Permit 1646A boundary (which will be replaced by the enlarged permit boundary further to the west that will have a buffer zone ≥125-ft to the new limit of waste disposal).

Current ancillary features located outside the permitted waste disposal area include the entrance facilities (entrance/exit road, scale and office/scalehouse area), maintenance shop, perimeter access roads, surface water drainage features, leachate management features, groundwater monitoring wells, landfill gas monitoring and control systems, etc.. Also, activities conducted at the facility to support operation of the landfill include:

- storage of leachate, gas condensate, and contaminated water in on-site storage tanks (prior to disposal at an authorized facility) and/or in an on-site lined evaporation pond; and

- landfill gas collection and control (including an on-site flare station).

## 1.3 Proposed Expansion

A facility layout plan showing the extent of the existing and proposed landfill footprint and designations of the disposal cells is presented in Part III, Attachment 3A, Drawing 3A-1. As shown, the proposed landfill expansion area is to the west of the existing landfill area. The permit boundary is also being changed accordingly to also extend westward to encompass this expansion area. Table III-1, presented below, summarizes the current permit conditions and the proposed changes.

**TABLE III-1**
**SUMMARY OF CURRENT PERMIT AND PROPOSED EXPANSION**
**LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY**

| Item | Units | Current Condition (Permit 1646A) | Increase due to Expansion | New Condition (Permit 1646B) |
|---|---|---|---|---|
| Permit Boundary Area | (acres) | 95.22 | 64.49 | 159.71 |
| Waste Disposal Footprint Area | (acres) | 64.0 | 39.9 | 103.9 |
| Buffer/Other Area | (acres) | 31.2 | 24.6 | 55.8 |
| Total Waste Disposal Capacity | (cubic yards) | 6,162,000 | 10,452,700 | 16,652,700 |
| Remaining Capacity as of 2/1/22 aerial flyover survey) | (cubic yards) | 200,000 | 10,452,700 | 10,652,700 |
| Projected (Approximate) Remaining Site Life (from 2/1/22 aerial flyover) | (years) | 1.5 | 34.5 | 36.1 |
| Maximum Elevation of Final Cover | (ft, MSL) | 485 | 65 | 550 |
| Elevation of Deepest Excavation | (ft, MSL) | 372 | 30’ deeper | 342 |

Table III-1 indicates that of the approximately 159.7-acre new permit boundary, the waste footprint of the proposed expanded landfill will occupy approximately 103.9 acres. The remaining area of about 55.8 acres will be used as buffers and other site features (e.g., unused areas, perimeter access road, ditches, main access road with scales and scale-house, etc.). Buffer zones (i.e., a zone free of municipal solid waste processing and disposal activities within and adjacent to the facility boundary on property owned or controlled by the owner or operator) will be maintained at the minimum distances called-out on Drawing 3A-1. Specific details of the buffer zones around each side of the site (including addressing new waste for the expansion) were presented in Section 15.1.2 of the Part I/II Report.

For MSW Permit No. 1646B the filling pattern will start by continuing to fill existing active areas of the current landfill, followed by construction and subsequent waste filling in new areas (starting with Cell 4-1). Phased development plans indicating the filling sequence is presented on a series of drawings in Part I/II, Appendix IIA (see Drawings I/IIA-25 to 28).

Ancillary site features located outside the permitted waste disposal areas (e.g., entrance/exit road, scale, and office/scalehouse area), perimeter access roads, surface water drainage features, leachate management features, groundwater monitoring wells, landfill gas monitoring and control systems, etc.), will remain consistent with the existing features, but in some cases are updated as needed to accommodate the expanded landfill layout – as described and shown in the various Site Development Plan attachments. In addition to waste disposal, waste processing and storage activities will occur, as described subsequently in Section 2.3, and their operations are discussed in Part IV (the SOP).

## 1.4 Land Use and Zoning

An analysis of land use and zoning, and potential impact on the area surrounding the facility, was previously presented in Section 6 of the Part I/II Report. In brief, the facility is on land that is not zoned, and the facility is a compatible land use based on the data and rationale presented in the Part I/II Report.

## 1.5 Adequacy of Access Roads and Highways

A Transportation Study evaluating the adequacy of roads and highways and related traffic was performed for this facility and its proposed expansion. The Transportation Study and related data on roads and traffic and documentation of coordination with the Texas Department of Transportation (TxDOT) and other agencies are provided in Part I/II, Appendix I/IIH.

The site is accessed by Selby Lane, approximately 0.6 miles south of US 84. Access to the site from the west is primarily by roads such as IH-35 that feed to US 84 to Selby Lane or roads that feed to TX-340 Loop/N Loop 340 to Selby Lane. Access to the site from the east is primarily by US 84 to Selby Lane. The site may also be accessed from the south using roads that feed to Old Mexia Road, to Selby Lane. There are no known weight restrictions on these roads in one mile proximity to the facility, other than the maximum legal weight limit of 80,000 pounds.

A facility layout plan showing the facility access point is presented on Drawing 3A-1. As shown on this drawing, access will be provided to the landfill at the existing site entrance/exit on Selby Lane in the northwest corner of the facility. There are no proposed public roadway improvements associated with this proposed expansion (e.g., no public roadway improvements at the site entrance/exit location).

## 1.6 Organization of Part III (Site Development Plan)

The remainder of this report is organized as follows:

- the general facility design is presented in Section 2;
- the facility surface water drainage design is discussed in Section 3;

- the waste management unit design is discussed in Section 4;
- geology and soils topics are addressed Section 5;
- groundwater topics are addressed in Section 6;
- the landfill gas management plan is discussed in Section 7;
- the facility closure plan is discussed in Section 8;
- the facility post-closure plan is discussed in Section 9; and
- cost estimates for closure and post-closure care are discussed in Section 10.

The attachments to the Site Development Plan are organized as follows:

- Attachment 1 provides drawings that present additional information on the general facility design (related to waste movement and access) and the on-site waste storage/processing areas and the landfill disposal areas;
- Attachment 2 is the Facility Surface Water Drainage Report, with related drawings and calculations;
- Attachment 3 provides the Waste Management Unit Design and related drawings, plans, and calculations for the landfill;
- Attachment 4 is the Geology Report;
- Attachment 5 is the Groundwater Monitoring Plan;
- Attachment 6 is the Landfill Gas Management Plan;
- Attachment 7 is the Closure Plan;
- Attachment 8 is the Post-Closure Plan; and
- Attachment 9 is the Cost Estimates for Closure and Post-Closure Care.

# 2. GENERAL FACILITY DESIGN

## 2.1 Introduction

Section 2 of this report has been prepared to address the general facility design topics required by 30 TAC §330.63(b).

## 2.2 Facility Access Control

This section describes how access will be controlled for the facility, pursuant to 30 TAC §330.63(b)(1). The access controls described below are designed to prevent the entry of livestock, protect the public from exposure to potential health and safety hazards, and to discourage unauthorized entry or uncontrolled disposal of solid waste or hazardous materials. Refer to Section 7 of Part IV (the SOP), for operating requirements related to access control, including the required inspection, maintenance, and notification procedures, as required by 30 TAC §330.131.

Access control to prevent unauthorized access, unauthorized dumping, and public exposure to the facility is provided by: (i) fencing; (ii) control features at the main entrance/exit gate; (iii) locked gates at any other secondary site access point(s) around the facility perimeter (if any); (iv) natural barriers; and (v) site personnel awareness and observations for maintaining access control. Drawing 3A-1 provides a cross-reference to a map of facility access control features; this map is provided in Part I/II, Appendix I/IIA, Drawing I/IIA-21.

Fencing, gates, and natural barriers will serve as the primary landfill access controls. To discourage unauthorized entry into the landfill facility, the majority of the perimeter property around the facility will be protected by fencing (see Drawing I/IIA-21). The southeastern portion of the property has a wooded area adjacent to Tehuacana Creek; these trees and shrubs (along with the creek itself) will serve as a natural barrier to control access. Also, at the western portion of the proposed facility along Selby Lane there is currently a natural barrier of trees and shrubs that will initially provide access control, until replaced with fencing as described on Drawing I/IIA-21. Where fencing is used, it will be composed of (at minimum) barbed wire, woven wire, wooden fencing, plastic fencing, pipe fencing, field fence, or other fence materials.

The site is accessed through a lockable entry gate at the main entrance. Secondary access gates along the perimeter fencing, if present, will be kept locked except when in use. Entry to the landfill is restricted to only personnel whose entry is authorized by site management (e.g., the facility employees and contractors, authorized waste haulers/customers, TCEQ personnel, properly identified visitors, etc.). Visitors entering the site are directed to the office location for check-in.

The Gate Attendant(s) will direct waste transport drivers to the proper disposal area. There, the drivers will be directed to a specific unloading area. The Gate Attendant(s) or other site personnel will also direct drivers needing access to other portions of the facility (e.g., construction contractors, haulers of material going to storage/processing areas). Additionally, when appropriate, signs with directional arrows and/or barricades may be placed along site roads to direct traffic and control interior access.

During normal operating hours, facility personnel will be on duty at the scale house and in the vicinity of landfill operations to control access and disposal operations. When the site is closed, the entry gate will be closed to prevent site access, and locked when no personnel are present on-site.

## 2.3 Waste Movement

### 2.3.1 Flow Diagram and Schematic Layout

The facility is a Type I MSW Facility. A detailed description of the allowable and prohibited waste streams is included in the Waste Acceptance Plan (Part I/II, Appendix I/IIG).

Storage, processing, and disposal activities that are allowed to take place at the facility are:

- waste disposal in the landfill;
- recycling-related storage and/or processing, as follows:
    - staging/storage of large/heavy/bulky items such as white goods (household appliances;
    - storage and processing of uncontaminated wood materials via brush collection and grinding/chipping/mulching (hereafter, "wood recycling");
    - storage and sorting of potentially-recyclable C&D materials received/salvaged (hereafter "C&D material recycling"); and
    - tire management.
- liquid waste solidification; and
- storage of leachate, gas condensate, and contaminated water generated by this facility in evaporation ponds and/or tanks.

The allowable and prohibited wastes indicated in the facility's Waste Acceptance Plan apply to all activities at the facility (storage/processing areas, and disposal in the landfill).

A flow diagram indicating the storage, processing, and disposal sequence is presented on Attachment 1, Drawing 1-1.

A schematic layout of the facility, showing the areas dedicated for waste disposal and identifying the storage and processing activities and describing their allowable locations, is presented on Attachment 1, Drawing 1-2.

### 2.3.2 Solid Waste Disposal Facility (Landfill)

Drawing 1-2 in Attachment 1 presents an overview schematic plan drawing of the site layout and identifies the areas dedicated for waste disposal (i.e., the landfill). The landfill is designed, and will be constructed and operated, to meet all applicable TCEQ requirements for Type I landfills. Section 4 of this report describes the "Waste Management Unit Design", including the liner and final cover system, and related construction details, specifications, and engineering analyses. Additional engineering plans, drawings, specifications, and calculations for the waste management unit design are also referenced in Section 4 and provided as various attachments to Part III. Operational requirements for the landfill are described in Part IV (the SOP). In terms of ventilation, the landfill has and will continue to install and operate an active landfill gas collection and control system as described in Attachment 6 (Landfill Gas Management Plan). Odor control measures that will be implemented during landfill operations are as described in Section 16.2 of the SOP.

### 2.3.3 Recycling-Related Storage/Processing Areas

Large/Heavy/Bulky Item Area. An area to unload, collect, stage/sort, and store received/salvaged large/heavy/bulky items such as white goods (household appliances) will be maintained at the site. The area is allowed to be located either on properly-covered waste within the current landfill footprint, or is allowed to be located in areas within the future landfill footprint. Alternately, the facility may designate an area outside of the current or future landfill footprint, provided that it is greater than 50-feet from the permit boundary and does not interfere with site operations. This area will have a size not larger than 100 feet by 100 feet. This storage area is allowed to move from time to time based on landfill operational needs. The materials allowed in this area are only those large/bulky items that have been received/salvaged from the authorized waste streams that are allowed to be accepted at this facility. The items being collected and staged in this area are not expected to be combustible. The items will be removed often enough to prevent them from becoming a nuisance, to preclude the discharge of any pollutants from the area, and to prevent an excessive accumulation of the material at the site. Operational requirements that pertain to this area are described in Part IV (the SOP).

Wood Recycling Area. An area to unload, segregate, and stockpile/store uncontaminated wood materials (e.g., trees, stumps, shrubs, brush, leaves, grass clippings, sawdust, pallets, other wood materials); to perform processing by grinding/chipping/mulching; and to store processed wood materials, is allowed to be maintained at the site. The wood recycling area is allowed to be located either on properly-covered waste within the current landfill footprint, or is allowed to be located in areas within the future landfill footprint. This area will have a size not larger than two (2) acres. This area is allowed to move from time to time based on landfill operational needs. The materials allowed in this area are only the uncontaminated wood materials that have been received from the authorized waste streams that are allowed to be accepted at this facility. The materials will be removed often enough to prevent them from becoming a nuisance, to preclude the discharge of any pollutants from the area, and to prevent an excessive accumulation of the material at the site. The collected materials will be removed from the site for recycling within 180 days or less, or disposed of at the working face within 180 days of acceptance at the facility. Processed wood materials may be reused by the facility. Operational requirements that pertain to this area are described in Part IV (the SOP).

C& D Material Recycling Area. An area to unload, stage/sort/process, and store potentially-recyclable C&D materials received/salvaged at the facility is allowed to be maintained at the site, either located on properly-covered waste within the current landfill footprint, or in areas within the future landfill footprint. This area will have a size not larger than one (1) acre. Examples of potentially-recyclable C&D materials include but are not limited to metal, plastic, concrete, bricks, drywall, cardboard, shingles, or other inert materials. The stockpile sizes of these materials may vary, depending on the amount of materials received at a given time. The items being collected and staged in this area are not expected to be combustible. The items will be removed often enough to prevent them from becoming a nuisance, to preclude the discharge of any pollutants from the area, and to prevent an excessive accumulation of the material at the site. The collected materials will be removed from the site for recycling within 180 days or less, or disposed of at the working face within 180 days of acceptance at the facility. Inert C&D materials may be reused by the facility. Operational requirements that pertain to this area are described in Part IV (the SOP).

Tire Management Area. The Waste Acceptance Plan (Part I/II, Appendix I/IIG) prohibits disposal of whole tires, and only allows disposal of certain specified tire pieces. With respect to tire management storage and processing activities, whole tires or tire pieces are allowed to be unloaded, collected, stored, and/or processed (i.e., size-reduced) in an area not larger than 100 feet by 100 feet in size that is allowed to be either located on properly-covered waste within the current landfill footprint, or is allowed to be located in areas within the future landfill footprint. This area is allowed to move from time to time based on landfill operational needs. Tires will be removed from the site often enough to prevent the items from becoming a nuisance, to preclude the discharge of pollutants from the area, and to prevent excessive accumulation of material at the site. In general, the tires may be stored on-site for a period not to exceed 180 days. Operational requirements and storage requirements that pertain to this area are described in Part IV (the SOP).

Ventilation and Odor Control Measures for On-Site Recycling-Related Storage/Processing Areas. The above recycling-related areas involve recyclable materials that are essentially inert, minimally degradable, or otherwise do not experience rapid decomposition. Thus, these areas are considered to have very low potential for needing ventilation or producing odors. The recyclable materials in these areas will generally be kept in stockpiles on the ground surface and will not have appreciable infrastructure constructed (e.g., there are no floors, walls, structures, sump drains, etc.). Thus, these areas will be ventilated naturally (by their outdoor ambient-air conditions). In the unlikely event that operation of the recycling-related areas produces objectionable odors, the odor control measures described in Section 16.2 of the SOP will be implemented, as appropriate.

### 2.3.3 Liquid Waste Solidification Area

Solidification of liquid wastes is allowed to occur on-site at a "portable/moveable" liquid waste solidification area. This area will be located on waste (over Subtitle D-lined areas), where solidification basins recessed into the waste will be used to receive liquid waste and process it via mixing with solidification agents. The layout/location, design, and operational requirements of this liquid waste solidification area are presented in the Liquid Waste Solidification Plan in Appendix IV-C of the SOP. This plan addresses the ventilation/odor control measures that will be implemented for these activities.

### 2.3.4 Leachate Evaporation Ponds and Storage Tanks

Leachate removed from the landfill will be transferred to on-site leachate evaporation ponds or to on-site leachate storage tanks. The locations of these features are shown on Drawing 1-2 in Attachment 1. Gas condensate and contaminated water generated by this facility will also be managed in these areas. The layout/location, design, and operational requirements associated with these leachate storage areas are presented in the Leachate and Contaminated Water Management Plan in Part III, Attachment 3E. This plan addresses the ventilation/odor control measures that will be implemented for these activities.

## 2.4 Sanitation and Water Pollution Control at Storage/Processing Areas

### 2.4.1 Recycling-Related Storage/Processing Areas

The recycling-related storage/processing areas are associated with materials that are basically inert, minimally soluble or degradable, not having waste particles or residues, not having free liquids or be of a nature that could cause a spill, and which are not expected to result in the need for washing or other cleaning operations (other than general housekeeping for tidiness, fire prevention, and control of storm water runon and runoff). As such, the materials that will be stored and processed in these areas are expected to have a low potential for the generation of contaminated water. Also, the materials in these areas will be kept in stockpiles on the ground surface, so there will be no appreciable infrastructure constructed (e.g., there are no floors, walls, structures, sump drains, etc.). Accordingly, during the normal course of operations of these recycling areas, stormwater contacting these areas will not be considered contaminated water. Nevertheless, best management practices will be implemented for proper sanitation and water pollution control. See below for further discussion, including those actions that will be taken in the event contaminated water generation is suspected or confirmed.

Each of these areas is designed to control surface water drainage in the vicinity of the areas, to prevent runoff onto and off of these areas, and will be operated and maintained to manage runon and runoff during peak discharge from the 25-year, 24-hour storm event and to prevent the off-site discharge of waste and contaminated water. This will be accomplished through the following measures:

- Installation of runon diversion berms up-gradient from the recycling areas. This will divert stormwater around the recycling areas to prevent excessive storm water from passing through the area and potentially causing any washouts of the areas, or otherwise leading to potential contaminated water generation. These runon diversion berms will be sized in accordance with Part III, Attachment 2E.

- The facility will implement necessary steps to control and prevent the discharge of contaminated water in accordance with the Leachate and Contaminated Water Management Plan in Part III, Attachment 3E. In particular, although not expected due to the aforementioned nature of the materials kept in the recycling areas, if contaminated water generation is suspected or confirmed at recycling areas, contaminated water management measures will be implemented in a similar manner as those for the active working face. Namely, this would involve constructing containment berms sized in accordance with Part III, Attachment 2E, and implemented as required by the Leachate and

Contaminated Water Management Plan for active working face contaminated water controls.

Operational requirements for these recycling areas are described in Part IV (the SOP), including additional discussion of surface water controls, fire protection, and contaminated water management. No discharge of contaminated water shall occur without obtaining specific written authorization from the TCEQ prior to the discharge. The landfill will be operated consistent with §330.15(h) regarding discharge of solid wastes or pollutants into waters of the United States.

#### 2.4.2 Liquid Waste Solidification Area

Sanitation and water pollution control measures that will be implemented at the liquid waste solidification area are presented in the Liquid Waste Solidification Plan in Appendix IV-C of the SOP.

#### 2.4.3 Leachate Evaporation Ponds and Storage Tanks

Sanitation and water pollution control measures that will be implemented at the leachate storage areas are presented in the Leachate and Contaminated Water Management Plan in Part III, Attachment 3E.

### 2.5 Endangered Species Protection

Pursuant to 30 TAC §330.61(n) and §330.551, site-specific endangered and threatened species assessments were conducted by qualified biologists for this project. Geosyntec's assessment and related correspondence with the Texas Parks and Wildlife Department (TPWD) and the United States Fish and Wildlife Service (USFWS), are provided in Part I/II, Appendix I/IIM. In summary, no federally-listed or state-listed endangered or threatened species, or any critical habitats for such species, were found at the site. The findings show that ongoing facility development and operation is not expected to cause or result in the destruction or adverse modification of critical habitats or contribute to the taking or harming of any endangered or threatened species.

# 3. FACILITY SURFACE WATER DRAINAGE REPORT

Pursuant to 30 TAC §330.63(c), a Facility Surface Water Drainage Report is included with Part III. This Report is provided in Part III, Attachment 2. The resulting facility design complies with the requirements of 30 TAC §330.303. The Facility Surface Water Drainage Report in Attachment 2 has been prepared to satisfy the applicable requirements of 30 TAC Chapter 330, Subchapter G; and include the information required by 30 TAC §330.63(c). The Report includes a narrative description of the drainage conditions and features at the site under pre-development and post-development conditions and addresses flood protection; and is accompanied by engineering design drawings and supporting hydrology calculations and hydraulic structural design calculations for the site drainage features.

# 4. WASTE MANAGEMENT UNIT DESIGN

## 4.1 Introduction

Section 4 of this report presents waste management unit design information, pursuant to 30 TAC §330.63(d)(4). The general facility design was previously addressed in Section 2. Attachment 3 of this SDP provides the supporting engineering drawings, plans, specifications, and calculations for the design of the landfill unit.

Sections 4.2 through 4.13 address the waste management unit design of the landfill. Sections 4.14 and 4.15 address waste management unit design for the liquid waste solidification area, and the leachate evaporation ponds, respectively.

## 4.2 Drawings

A series of engineering drawings presenting details of the landfill waste management unit design are included in Attachment 3A.

## 4.3 Provisions for All-Weather Operation

All-weather roadways will be used to provide access during wet weather from the site entrance along Selby Lane (public roadway) to the waste unloading area being used during wet weather. An all-weather road will also be provided around the landfill perimeter. These all-weather roads have a gravel surface. The layout of the existing entrance facilities and related access roads is shown on Attachment 3A, Drawing 3A-2. The landfill perimeter access road around the final landfill configuration is shown on Attachment 3A, Drawing 3A-5.

Additional interior access roads needed to access waste unloading areas will be established by the facility to provide waste vehicle access and facilitate site operations as waste filling progresses. These interior access roads will lead from the facility entrance road and will continue on to the active working face; accordingly their locations will vary as development progresses. Interior roads that will be used by waste vehicles and landfill operations vehicles during wet weather conditions will be maintained so that continuous access to waste disposal areas is provided during both wet and dry weather.

The rough gravel road surfacing on the internal roads used to access the active working face will reduce the amount of mud tracked from the disposal area by shaking and pulling mud off the vehicle tires as they exit the disposal area. Similarly, the gravel entrance road will further minimize tracking of mud from the site onto public roads.

Access road maintenance requirements, including specific provisions addressing control of mud tracking, dust control, and general road cleaning and safety, are provided as required in Part IV (the SOP).

## 4.4 Proposed Landfill Method

The facility currently operates, and proposes to continue operating, as a multi-level, modified aerial fill landfill, with above and below-grade filling. The general site layout plan is shown in Attachment 3A on Drawing 3A-1. Attachment 3A, Drawings 3A-3 through 3A-5 show the liner system base grades and final cover system grades. Phased development plans indicating the filling sequence is presented on a series of drawings in Part I/II, Appendix I/IIA (see Drawings I/IIA-25 to 28

For all proposed landfill cell construction, the liner sideslopes are configured at 3H:1V down to a cell floor sloped at 2% towards a central corridor inclined at 1% towards the cell low point (i.e. sump). The final aerial fill side slopes (i.e., above-grade final slopes) will be configured at 4H:1V slopes (i.e., a 25% grade) up to a landfill top deck area. The top deck area is inclined at a 5% slope from a central ridge as shown on Drawing 3A-5. The final cover side slopes will incorporate drainage control features (diversion drainage terraces and downdrains) as discussed in the Drainage Report (Part III, Attachment 2) and shown on the Drainage Report drawings (Part III, Attachment 2A). Also, the landfill slopes (and landfill as a whole) has been evaluated for stability and calculations demonstrate adequate factors of safety, as discussed subsequently in Section 4.11 of this report. Portions of the landfill have received final cover, and the remaining areas will have final cover system installed incrementally with the landfill development progression as fill areas reach their maximum final waste grade elevations or following the active life of the landfill.

## 4.5 Landfill Depth and Height Statistics

The elevation of deepest excavation is 342 feet above mean sea level (ft, MSL). This will occur at low points (sumps) of new proposed Cells 4-3, 4-4 and 4-5, the layout of which is illustrated on the Overall Base Grading Plan (Attachment 3A, Drawing 3A-3). The maximum elevation of the final cover is 550 ft, MSL. The maximum elevation of waste is 546.9 ft, MSL (which is calculated based on using the possible 3.1-ft thick alternative water-balance final cover system which, if used, would result in the highest possible elevation of waste – see Section 4.12 of this report for a discussion on final cover thickness). The maximum waste and final cover elevations are illustrated on the Overall Final Cover Grading Plan (Attachment 3A, Drawing 3A-5).

## 4.6 Estimated Rate of Solid Waste Deposition and Site Life

The landfill volume, estimated rate of solid waste deposition, and the resulting site life estimate is presented in Attachment 3B. For reference, a description of the waste characteristics, anticipated facility service area and population served, and a five-year projection of the estimated maximum annual waste acceptance rate is presented in the Waste Acceptance Plan in Part II of the permit amendment application, as required by 30 TAC §330.61(b) [see Part I/II, Appendix I/IIG].

## 4.7 Landfill Cross Sections

A series of landfill cross sections are provided in Attachment 3A (see Drawings 3A-6 through 3A-11). These cross sections have been selected to pass through key site features so as to accurately depict the existing and proposed depths of all fill areas within the site. The sections show the top of the perimeter berm; top of the proposed fill (top of the final cover); maximum elevation of proposed waste fill; top of the waste; existing ground; bottom of the excavations; side slopes of sectors and fill areas; groundwater monitoring wells, plus the initial and static levels of any water encountered. Landfill gas monitoring probes are shown on the cross sections if they are near the section location. The cross-sections also show the logs of soil borings that pass near the profile. The 100-year flood elevations (i.e., the Base Flood Elevations (BFEs)) of Tehuacana Creek adjacent to the southern side of the site are identified on applicable sections taken adjacent to the floodplain.

## 4.8 Landfill Construction Design Details

Landfill construction design details are also presented in Attachment 3A (see Drawings 3A-12 through 3A-16), to accompany the previously mentioned cross sections. The aforementioned landfill cross sections call-out the design details (e.g., liner system, final cover system, perimeter berm and tie-ins), which are then presented on the construction design details drawings.

## 4.9 Liner System Design and Liner Quality Control Plan

### 4.9.1 Proposed Liner System

This Site Development Plan is for a lateral and vertical expansion of the existing Type I landfill. There are two landfill liner system types proposed – one for the lateral expansion area (i.e., new disposal cells), and one for the "overlay area" (i.e., the portion of the existing landfill that will be vertically expanded onto a "pre-Subtitle D" area). A drawing that depicts cross-sectional views of the construction details of each proposed liner system is presented on Drawing 3A-12. Also, the location and layout of the lateral expansion (new cell) areas and overlay area are depicted on

Drawings 3A-1, 3A-3, and 3A-4, and overall landfill cross sections are included on Drawings 3A-6 through 11. The components of the proposed liner systems are described below.

New Disposal Cells – Floor and Sideslope Liner System (components from top to bottom):

- 2-ft (min) thick protective cover soil;
- double-sided geocomposite drainage layer (geonet with nonwoven geotextiles bonded on both the top and bottom sides);
- 60-mil thick high-density polyethylene (HDPE) textured geomembrane liner; and
- compacted clay liner having a hydraulic conductivity of no more than $1 \times 10^{-7}$ centimeters per second (i.e., $k \leq 1 \times 10^{-7}$ cm/sec), placed on a prepared subgrade.

Overlay Area – Liner System (components from top to bottom):

- 2-ft (min) thick protective cover soil;
- double-sided geocomposite drainage layer (geonet with nonwoven geotextiles bonded on both the top and bottom sides);
- 60-mil thick HDPE textured geomembrane liner;
- compacted clay liner having a hydraulic conductivity of no more than $1 \times 10^{-7}$ centimeters per second (i.e., $k \leq 1 \times 10^{-7}$ cm/sec); and
- 1-ft (min) thick base leveling layer of soil above the existing waste.

From the above description of the liner components, both of the proposed liner systems will include a composite liner formed by the geomembrane installed above (in direct and uniform contact with) the compacted clay liner. Both liner systems also will include a leachate collection system that is designed and constructed to maintain less than a 30-centimeter depth of leachate over the liner (discussed subsequently), of which the double-sided geocomposite drainage layer is a part. Also the liner types in the existing landfill areas was described previously in Section 1.2 of this narrative report.

The proposed liner systems described above have been designed and will be constructed to meet the design criteria of 30 TAC §330.331(a)(2) and (b). With the existing Subtitle D landfill cells also meeting this design criteria, and the overlay liner system also meeting this criteria placed over a pre-Subtitle D area, this will result in all vertical expansion areas (as well as the lateral expansion areas) meeting the cited design criteria.

### 4.9.2 Liner Quality Control Plan

Pursuant to 30 TAC §330.63(d)(4)(G), a Liner Quality Control Plan (LQCP) for this facility has been prepared to meet the applicable requirements of 30 TAC Subchapter H. The LQCP is presented in Attachment 3C.

## 4.10 Leachate Collection System

A leachate collection system has been designed to drain, collect, and allow leachate removal from the landfill during the active life, scheduled closure, and the post-closure period of the landfill. As described above, the proposed liner system includes a geocomposite drainage layer above the composite liner for leachate collection. Leachate percolating through the waste will be collected in the drainage layer and will flow by gravity towards leachate collection corridors or sideslope chimney drains, which in turn conveys leachate to collection sumps at the low points of the liner system floor grades of each cell. Submersible pumps in each sump will be used to remove collected leachate from the landfill, which will then be conveyed to leachate evaporation ponds or storage tanks.

The leachate collection system is designed and will be constructed to maintain less than a 30-centimeter depth of leachate over the liner. Attachment 3E presents a Leachate and Contaminated Water Plan and associated design drawings and calculations demonstrating how the leachate management collection and removal systems are designed to meet the criteria for depth of leachate on the liner and the other criteria in 30 TAC §330.333. Construction requirements or the leachate collection system are presented in the LQCP.

## 4.11 Geotechnical Analyses of Landfill Design

Geotechnical engineering analyses of the landfill design have been conducted to evaluate the structural integrity of the landfill and underlying foundation. These analyses are as follows (with their location within Attachment 3D noted in parentheses):

- Geotechnical Report (Attachment 3D.1), presenting the soils data collected during site investigations, the results of geotechnical laboratory testing, describing the findings on the suitability of soil conditions, and describing the selection of relevant geotechnical parameters. This attachment has been prepared to include, among other things, the geotechnical information required by 30 TAC §330.63(e)(5).

- Slope Stability (Attachment 3D.2), analyzing the ability of the landfill features and foundation materials to resist driving forces which could have the potential to induce sliding of slopes at the site, and the calculated factors of safety against these events.

- Settlement (Attachment 3D.3), analyzing the ability of the landfill liner and leachate collection features to withstand predicted load-induced settlements of the foundation and (for the overlay area) waste.

- Liner Uplift and Ballast Evaluation (Attachment 3D.4), evaluating the conditions that could lead to special liner design constraints related to uplift/ballast, whether the design can resist calculated uplift forces and/or needs ballast, and noting any other special features that may be needed.

## 4.12 Final Cover System Design and Quality Control Plan

Three types of final cover systems are proposed for areas not yet closed: one for the pre-Subtitle D area that is unaffected by this expansion; and two options for the Subtitle D areas of the landfill. A drawing that depicts cross-sectional views of the construction details of each proposed final cover system is presented on Drawing 3A-14. The components of the proposed final cover systems are described below.

Pre-Subtitle D Final Cover System (at Phase 1 only) (components from top to bottom):

- an erosion layer of earthen material composed of a 6-inch (min) thick topsoil layer capable of sustaining native plant growth, and seeded or sodded immediately following the application of final cover in order to minimize erosion; and

- 1.5-ft (min) thick compacted soil layer composed of clayey earthen material and having a coefficient of permeability (i.e., a hydraulic conductivity) no greater than $1 \times 10^{-5}$ cm/sec (i.e., $k \leq 1 \times 10^{-5}$cm/sec).

Standard Subtitle D Final Cover System Option (components from top to bottom):

- 2-ft (min) thick erosion layer, subdivided into:
    - a 6-inch (min) thick topsoil layer on the top surface, capable of sustaining native plant growth, and seeded or sodded immediately following the application of final cover in order to minimize erosion; and
    - underlying the topsoil, an 18-inch (min) thick cover soil layer;

- geocomposite drainage layer (double-sided on sideslopes, using geonet with nonwoven geotextiles bonded on both the top and bottom sides; single-sided on the 5% top-deck areas using geonet with a nonwoven geotextile bonded on the top side);

- 40-mil thick linear low-density polyethylene (LLDPE) geomembrane (textured on sideslopes, smooth or textured on the 5% top-deck areas); and

- 1.5-ft (min) thick compacted soil infiltration layer composed of clayey earthen material and having a coefficient of permeability (i.e., a hydraulic conductivity) no greater than $1 \times 10^{-5}$ cm/sec (i.e., $k \leq 1 \times 10^{-5}$cm/sec).

<u>Alternate Subtitle D Final Cover System Option Using Water-Balance (WB) Soil-Only Cover</u> (components from top to bottom):

- an erosion layer of earthen material composed of a 6-inch or 12-inch thick topsoil layer(1) capable of sustaining native plant growth, and seeded or sodded immediately following the application of final cover; and

- 2.6-ft (min) thick compacted soil storage layer composed of clayey earthen material and having a coefficient of permeability (i.e., a hydraulic conductivity) no greater than $5 \times 10^{-8}$ cm/sec (i.e., $k \leq 5 \times 10^{-8}$cm/sec).

(1)If the underlying compacted soil layer is classified by the unified soil classification system as SC (clayey sand) or CL (lean clay), the minimum topsoil thickness is 6-inches. If the underlying compacted soil layer is classified as CH (fat clay), the minimum topsoil thickness is 12-inches.

With respect to the alternate Subtitle D final cover system using a WB-type cover, the design was selected based on TCEQ Publication RG-494, *Guidance for Requesting a Water Balance (WB) Alternative Final Cover for a Municipal Solid Waste Landfill*, TCEQ Waste Permits Division, March 2017. Using this approach for an “Option 1” WB cover, the statewide design table was used to determine that this site is in Geoclimatic Region 4 (Austin). The storage layer thickness was then selected accordingly, adopting the specified as-built hydraulic conductivity indicated above based on the properties of on-site low permeability borrow soils available that are judged likely candidates to be used for constructing this layer.

A Final Cover Quality Control Plan (FCQCP) has been prepared and is included in Attachment 7 (Closure Plan), providing the design and specifications for the final cover, to meet the applicable requirements of 30 TAC §330.457.

## 4.13 Final Cover Erosion Protection

The final cover system has been designed to minimize soil loss from erosion. The surface of the final cover system will be vegetated. Drainage terraces are specified as part of the surface water management system (see Attachment 2A, Drawing 2A-1) to intercept surface water runoff and limit the length of overland sheet flow. The terraces will direct the runoff into downdrains which will convey the runoff into the perimeter ditch/pond system. These surface water conveyance features are designed to handle the calculated design flow rates, velocities, and tractive stresses (design details and calculations are presented in the Facility Surface Water Drainage Report in Attachment 2).

Also, a calculation of the predicted soil erosion loss on the final cover system, with results demonstrating that the final cover is designed with adequate resistance to erosion, is presented in Attachment 3E.

The final cover will be periodically inspected for signs of erosion and ponding of water, and maintained/repaired as necessary during the active life and post-closure care period of the site, as described in Part IV (the SOP) and Part III, Attachment 8 (Post-Closure Plan), respectively.

## 4.14 Waste Management Unit Design – Liquid Waste Solidification Area

The waste management unit design of the liquid waste solidification area is presented in the Liquid Waste Solidification Plan in Appendix IV-C of the SOP; this plan also addresses related operational requirements.

## 4.15 Waste Management Unit Design – Leachate Evaporation Ponds

The waste management unit design of the leachate evaporation ponds is presented in the Leachate and Contaminated Water Management Plan in Part III, Attachment 3E; this plan also addresses related operational requirements.

## 5. GEOLOGY REPORT

A Geology Report is presented in Part III, Attachment 4. This Geology Report was prepared by the professional geoscientist (P.G.)-of-record for the application. The Geology Report addresses the information required in 30 TAC §330.63(e) with the exception of the geotechnical data required by 30 TAC §330.63(e)(5)(A) and (B), which was prepared by Geosyntec's geotechnical engineer and is presented in Part III, Attachment 3D.1.

In summary, the Geology Report includes descriptions of the regional geology and hydrogeology, geologic processes, regional aquifers, subsurface investigations, and addresses geologic faults and seismicity.

The Geotechnical Report prepared by Geosyntec and presented in Part III, Attachment 3D.1 includes data on the geotechnical properties of the subsurface soil materials and a discussion on the suitability of the soils and strata for the uses for which they are intended.

## 6. GROUNDWATER MONITORING PLAN

A Groundwater Monitoring Plan [that includes a Groundwater Sampling and Analysis Plan (GWSAP)] is presented in Part III, Attachment 5. This Plan was prepared by the P.G.-of-record for the application. The Groundwater Monitoring Plan and GWSAP addresses the information required in 30 TAC §330.63(f) and the applicable requirements of 30 TAC §330.401 through §330.421 for Type I Landfills. The Plan includes identification of the point of compliance; details of the required groundwater monitoring program; and the GWSAP.

## 7. LANDFILL GAS MANAGEMENT PLAN

Pursuant to 30 TAC §330.63(g), a facility Landfill Gas Management Plan is included with Part III. This Plan is provided in Part III, Attachment 6. The Landfill Gas Management Plan has been prepared to meet the requirements of 30 TAC §330.371 for Type I Landfills. This includes the requirements for landfill gas monitoring at the perimeter permit boundary and in on-site structures, and procedures to be followed if excessive methane gas levels are measured.

## 8. CLOSURE PLAN

Pursuant to 30 TAC §330.63(h), a facility Closure Plan is included with Part III. This Plan is provided in Part III, Attachment 7. The Closure Plan has been prepared to meet the requirements of 30 TAC §330.457 (closure requirements for MSW landfill units that receive waste on or after October 9, 1993). This includes a description of the final cover system, a discussion of closure activities, drawings and sections, and closure specifications for the construction of the landfill final cover.

## 9. POST-CLOSURE PLAN

Pursuant to 30 TAC §330.63(i), a facility Post-Closure Plan is included with Part III. This Plan is provided in Part III, Attachment 8. The Post-Closure Plan has been prepared to meet the requirements of 30 TAC §330.463. This includes information on post-closure care activities to maintain the facility following closure, persons responsible for the activities, and planned post-closure use of the facility.

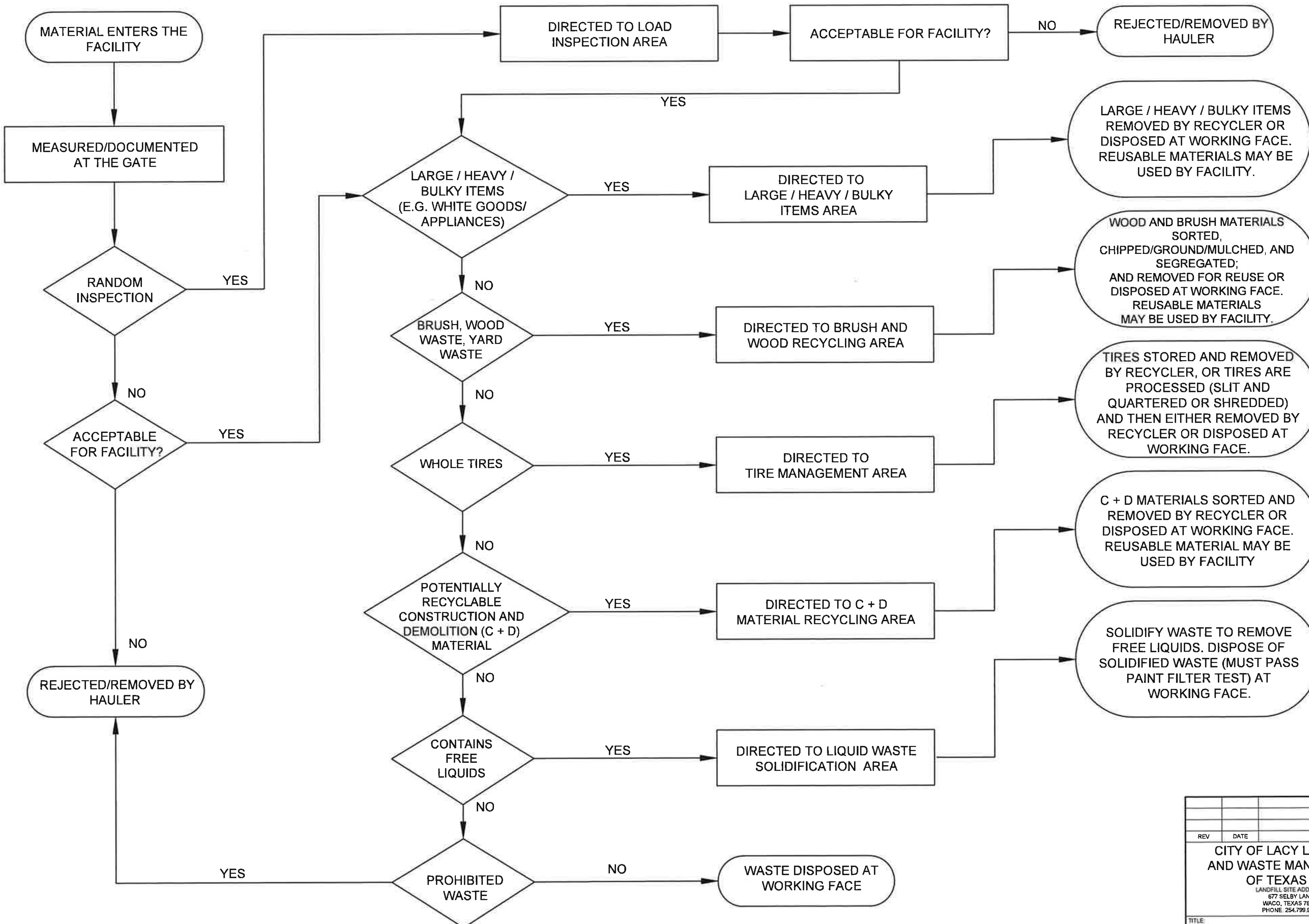
## 10. COST ESTIMATES FOR CLOSURE AND POST-CLOSURE CARE

Pursuant to 30 TAC §330.63(j), cost estimates for closure and post-closure care are included with Part III. This information is provided in Part III, Attachment 9. The closure cost estimate has been prepared to meet the requirements of 30 TAC §330.503, and the post-closure care cost estimate has been prepared to meet the requirements of 30 TAC §330.507. Documentation on financial assurance is included with Attachment 9.

# ATTACHMENT 1

# GENERAL FACILITY DESIGN

| LIST OF DRAWINGS | | |
|---|---|---|
| Drawing No. | Title | Drawing Date (latest revision) |
| 1-1 | Flow Diagram | October 2022 |
| 1-2 | Schematic Plan of General Facility Design | October 2022 |




STATE OF TEXAS
SCOTT M. GRAVES
86557
LICENSED
PROFESSIONAL ENGINEER

10/21/2022

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CITY OF LACY LAKEVIEW
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AUSTIN, TEXAS 78757
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TITLE:

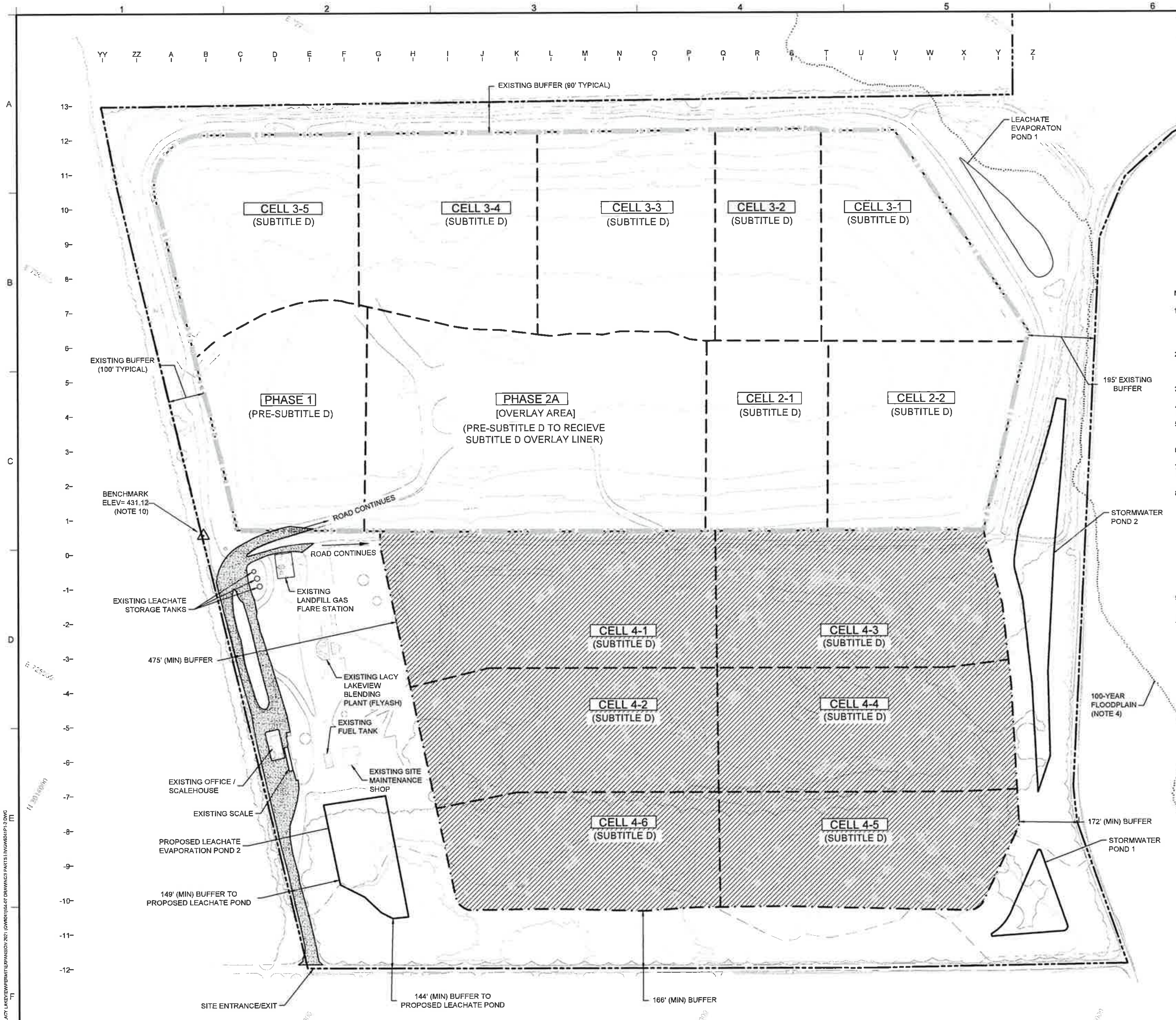
# FLOW DIAGRAM

PROJECT:

LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

PERMIT DRAWING

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PROJECT NO.: | GW8041 | DESIGN BY: | SMG | REVIEWED BY: | YB | PART NO.: | DRAWING | |
| FILE: | GW8041P1-1 | DRAWN BY: | JJV / KH | APPROVED BY: | SMG | III | 1-1 | |




## LEGEND

- EXISTING GROUND ELEVATION CONTOUR (FT, MSL) (NOTES 1, 2)
- EXISTING ROAD
- EXISTING VEGETAION / TREE
- EXISTING FENCE
- EXISTING BUILDING
- EXISTING WATER LINE
- COORDINATE GRID (NOTE 2)
- 13– SITE GRID
- PERMIT BOUNDARY (PERMIT 1646B)(NOTE 3)
- CURRENT LIMIT OF WASTE (PERMIT 1646A)
- PROPOSED LIMIT OF WASTE (PERMIT 1646B)
- CELL BOUNDARY
- EXPANSION AREA
- MAIN LANDFILL ACCESS ROAD
- 100-YEAR FLOODPLAIN (NOTE 4)

NOTES:

1. TOPOGRAPHIC BASE MAP OF EXISTING SITE CONDITIONS WAS GENERATED BY PHOTOGRAMMETRIC METHODS BASED ON AN AERIAL SURVEY FLOWN ON 01 FEBRUARY 2022 BY HYDREX ENVIRONMENTAL. EXISTING TOPOGRAPHY IN OBSCURED AREAS AND / OR OUTSIDE OF PROPERTY WHERE SHOWN SUPPLEMENTED WITH THE UNITED STATES GEOLOGIC SURVEY (USGS) 3DEP PROGRAM, 3 METER RESOLUTION LIDAR FLOWN IN 2011.
2. ELEVATIONS ARE IN FEET ABOVE MEAN SEA LEVEL (FT, MSL), AS DEFINED BY THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988. COORDINATE GRID OF NORTHINGS AND EASTINGS IS A LOCAL COORDINATE GRID BASED ON A TRANSLATION FROM STATE PLANE COORDINATES, THAT HAS BEEN USED FOR HISTORICAL SURVEY ACTIVITIES AT THE SITE.
3. PERMIT BOUNDARY AND PROPERTY BOUNDARY COINCIDE.
4. 100-YEAR FLOODPLAIN LIMITS FROM CURRENT FEMA MAP PRESENTED ON DRAWING I/IIA-18.
5. MAIN LANDFILL ACCESS ROAD, AS WELL AS INTERIOR SITE ACCESS ROADS USED TO ACCESS FILL AREAS, ARE ALL-WEATHER (E.G., GRAVEL).
6. REFER TO DRAWING I/IIA-21 FOR A FACILITY ACCESS CONTROL FEATURES DRAWING AND INFORMATION.
7. BESIDES THE BUFFERS SHOWN ON THIS DRAWING, THERE ARE NO SPECIAL PROVISIONS FOR THE MAINTENANCE OF NATURAL WINDBREAKS OR PLANS FOR SCREENING THE FACILITY FROM PUBLIC VIEW.
8. IN ADDITION TO THE WASTE DISPOSAL UNIT (LIMIT OF WASTE OF THE LANDFILL AND LEACHATE STORAGE AREAS) SHOWN ON THIS DRAWING, THE FACILITY MAY CONDUCT WASTE STORAGE / PROCESSING AT THE SITE AT THE FOLLOWING RECYCLING-RELATED AREAS:
   - LARGE / HEAVY / BULKY ITEM
   - WOOD RECYCLING AREA
   - TIRE MANAGEMENT AREA

   THESE RECYCLING-RELATED AREAS WILL MOVE AS LANDFILLING PROGRESSES, BUT WILL ALWAYS BE LOCATED WITHIN THE LIMITS OF THE PROPOSED LANDFILL FOOTPRINT (LIMIT OF WASTE) SHOWN ON THIS DRAWING. ALLOWABLE SIZE REQUIREMENTS FOR THESE AREAS ARE GIVEN IN SECTION 8 OF THE SITE OPERATING PLAN (SOP).
9. LIQUID WASTE SOLIDIFICATION IS ALLOWED TO BE CONDUCTED IN A MOVEABLE AREA THAT MUST BE LOCATED ABOVE SUBTITLE D - LINED AREAS AND IN ACCORDANCE WITH OTHER DESIGN AND OPERATIONAL REQUIREMENTS GIVEN IN APPENDIX IV-C OF THE SOP.
10. BENCHMARK IS A BRONZE SURVEY MARKER SET IN CONCRETE WITH THE BENCHMARK ELEVATION AND SURVEY DATE STAMPED ON IT. THE BENCHMARK ELEVATION WAS SURVEYED-IN FROM U.S. COAST AND GEODETIC SURVEY MONUMENT ID NO. BZ1079. BENCHMARK COORDINATES ARE TABULATED BELOW:

| GLOBAL COORDINATES | | LOCAL COORDINATES | | TEXAS STATE PLANE COORDINATES (NAD83, TEXAS CENTRAL ZONE) | |
|---|---|---|---|---|---|
| LAT | N031° 36' 19.13" | NORTHING | 3013964.569 | NORTHING | 10562603.920 |
| LONG | W097° 03' 29.95" | EASTING | 725591.307 | EASTING | 3316004.953 |

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10/21/2022

0 150' 300'
SCALE IN FEET

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TITLE: SCHEMATIC PLAN OF GENERAL FACILITIES DESIGN

PROJECT: LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

PERMIT DRAWING

| | | | | | |
|---|---|---|---|---|---|
| PROJECT NO.: GW8041 | DESIGN BY: SMG | REVIEWED BY: YB | PART NO.: III | DRAWING 1-2 |
| FILE: GW8041P1-2 | DRAWN BY: JJV / KH | APPROVED BY: SMG | | |

# ATTACHMENT 2

# FACILITY SURFACE WATER DRAINAGE REPORT

# PART III – ATTACHMENT 2
# FACILITY SURFACE WATER DRAINAGE REPORT

## LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
## WACO, McLENNAN COUNTY, TEXAS
## PERMIT AMENDMENT APPLICATION
## MSW PERMIT NO. 1646B

*Prepared for:*

**City of Lacy Lakeview**

and

**Waste Management of Texas, Inc.**

Prepared by:

Geosyntec consultants

10/21/2022

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October 2022

# TABLE OF CONTENTS
# FACILITY SURFACE WATER DRAINAGE REPORT



10/21/2022

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GEOSYNTEC CONSULTANTS, INC.
TEXAS ENG. FIRM
REGISTRATION NO. F-1182

# TABLE OF CONTENTS (CONTINUED)



## ATTACHMENTS



10/21/2022

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GEOSYNTEC CONSULTANTS, INC.
TEXAS ENG. FIRM
REGISTRATION NO. F-1182

# 1. INTRODUCTION

## 1.1 Purpose

Pursuant to 30 TAC §330.63(c), this Facility Surface Water Drainage Report (Drainage Report) has been developed as part of the permit amendment application (PAA) for the proposed lateral and vertical expansion of the Lacy Lakeview Recycling and Disposal Facility. The resulting facility design complies with the requirements of 30 TAC §330.303. This Drainage Report has been prepared to satisfy the applicable requirements of 30 TAC Chapter 330, Subchapter G; and includes the information required by 30 TAC §330.63(c). This Drainage Report and the analyses and computations referenced herein were prepared in a manner consistent with guidance provided in the Texas Commission on Environmental Quality (TCEQ) *Surface Water Drainage and Erosional Stability Guidelines for a Municipal Solid Waste Landfill,* Regulatory Guidance (RG)-417 (TCEQ, 2018).

The Drainage Report includes a narrative description of the drainage conditions and features at the site under pre-development and post-development conditions, and is accompanied by engineering design drawings and supporting hydrology and hydraulic structural design calculations for the site's drainage features. Specific objectives of this Drainage Report are to:

- present an overview of the project, site watershed setting, and information on the site in relation to the 100-year floodplain;
- describe the currently permitted (MSW Permit No. 1646A) site conditions and establish the pre-development drainage conditions accordingly;
- summarize the proposed post-development surface water management system design and describe the drainage features and components within the facility area;
- describe the post-development drainage conditions;
- describe the hydrologic method and design parameters applied to estimate peak flow rates, times of concentration, and runoff volumes for both the pre-development and post-development drainage conditions;
- compare pre-development versus post-development discharges from the site and provide analyses and discussion to demonstrate that the existing pre-development drainage patterns will not be adversely altered as a result of the proposed landfill expansion;
- describe the hydraulic methods and design parameters applied to analyze and design the features and components of the surface water management system, and present the structural design of these items;

- present the erosion and sediment control measures, including requirements for surface water inspections and maintenance;
- address protection from 100-year frequency flooding; and
- present overall conclusions that summarize the results of the surface water drainage analysis and design.

## 1.2 Project Overview

The Lacy Lakeview Recycling and Disposal Facility is an existing Type I municipal solid waste (MSW) facility (landfill) located in McLennan County, Texas, approximately 5 miles northeast of downtown Waco. The facility is located approximately 2.7 miles east of the intersection of Interstate Highway (IH)-35 and TX-340 Loop/N Loop 340, and just southeast of the City of Bellmead. Location maps are presented elsewhere in the PAA (e.g., Part I/II, Appendix I/IIA). The currently permitted facility has a permit boundary encompassing approximately 95.22 acres and the waste disposal footprint area of the current permitted design is 64.0 acres.

A lateral and vertical expansion of the facility is proposed in this PAA (MSW Permit No. 1646B). As a part of this lateral expansion, the permit boundary is proposed to increase to approximately 159.71 acres and the waste disposal footprint is proposed to increase to approximately 103.9 acres.

A series of engineering drawings are presented in Attachment 2A of this Drainage Report to present the proposed surface water management system design and associated drainage features. Drawing 2A-1 in Attachment 2A introduces the proposed facility drainage design, by presenting the "Facility Surface Water Management Plan," and shows the location of the landfill and the associated drainage facilities and features.

## 1.3 Site Setting and Watershed Information

The United States Geological Survey (USGS) developed a system of Hydrologic Unit Codes (HUC) which are arranged or nested within each other from the largest geographic area (regions) to the smallest geographic area (cataloging units) to identify watersheds; these designations are used to identify the site setting. Regionally, the site is in east-central McLennan County, within the Tehuacana Creek watershed of the Middle Brazos Basin (HUC-1206). The entire site is within the Little Tehuacana Creek sub-watershed (HUC-12 No. 120602020706), an approximately 27,000-acre sub-watershed that is part of the overall 196,500-acre Tehuacana Creek Watershed (HUC-10 No. 1206020207).

Tehuacana Creek is located on the southeastern portion of the site (see Drawing 2A-4) and flows in a south-southeasterly direction as it passes the site. Natural ground elevations at the site range from approximately elevation 398 ft, MSL at Tehuacana Creek, to about 434 ft, MSL at the northwest corner of the property near Selby Lane. Natural terrain conditions at the site are relatively flat – with topography sloped towards the south at approximately 1 to 2 percent. In general, water leaving the eastern roughly one-half of the site drains to the southeast and makes its way into the main body of Tehuacana Creek. Runoff from the western roughly one-half of the site drains southward and eventually leaves the southwestern part of the site, where it passes under Old Mexia Road, where a portion of the flow continues overland, and a portion of the flow joins an unnamed tributary of Tehuacana Creek, and all of which ultimately reaches Tehuacana Creek roughly 0.4 miles south of the site.

The main body of Tehuacana Creek originates northeast of the site and generally flows in a south by southwest direction where it passes the southeast boundary of the site, and where it continues flowing to the south-southeast until it enters the Brazos River at a point approximately 5.5 miles south of the site and 5 miles east of Waco. Tehuacana Creek receives surface water from and drains areas in north and northeast portions of McLennan County, southern portions of Hill County, and the western corner of Limestone County, as well as portions of the cities of Lacy Lakeview, Bellmead, and Waco.

Clean (uncontaminated) surface water runoff from the existing facility is managed through drainage terraces, downdrain channels, and perimeter channels which route surface water towards Tehuacana Creek. The proposed landfill conditions will have similar surface water management features routing uncontaminated surface water runoff in the same general manner off the covered landfill slopes and through perimeter drainage channels as described further herein.

## 1.4 100-Year Floodplain Information

TCEQ rules for the siting of landfills include a location restriction in 30 TAC §330.547, which indicates that no solid waste disposal operations shall be permitted in Federal Emergency Management Agency (FEMA)-defined 100-year floodways; and that new municipal solid waste management units, existing municipal solid waste units, and lateral expansions that are located in 100-year floodplains must meet certain additional requirements. Herein, references to the "100-year floodplain" refer to the floodplain for a 1% annual chance flood (i.e., a 100-year flood event). A demonstration of compliance with this location restriction is provided in Part I/II of the PAA (see Part I/II Narrative Report, Section 11.1), as required by 30 TAC §330.61(m)(1). An overview of this information for the landfill and its lateral expansion is presented below.

With respect to FEMA-mapped floodplains and the FEMA-designated floodway, the site and vicinity are part of FEMA Flood Insurance Rate Map (FIRM) Number 48309C0400D (December 20, 2019), Panel 400 of 750. A copy of the current FEMA map is included in Part I/II, Appendix I/IIA (see Drawing I/II-18). Inspection of the FEMA map reveals that:

- There is a FEMA-defined 100-year floodway associated with Tehuacana Creek in the extreme southeastern portion of the site. However, the landfill waste disposal limits are not within a 100-year floodway (and in fact, are set-back at least approximately 300-ft from the floodway).

- The entire landfill, including the proposed lateral expansion (this project) waste disposal footprint, is located entirely outside the limits of the FEMA-mapped 100-year floodplain. No construction is proposed to occur in a floodplain.

Additional information on protection of the facility from flooding (including addressing flood protection freeboard at the landfill perimeter) is discussed in Section 7 of this Drainage Report, after details of the proposed design and supporting analyses are presented.

## 2. DESCRIPTION OF THE PRE-DEVELOPMENT CONDITION

Under current MSW Permit No. 1646A, the eastern portion of the site where the existing landfill is situated has been largely developed, changing from the previously undeveloped conditions that used to exist many decades ago (pre-landfill) within the current permit boundary, to be those permitted as the landfill facility. Accordingly, the pre-development condition includes drainage areas that encompass the current as-permitted final closure landfill conditions at the facility, as well as existing conditions of adjacent and off-site drainage areas that contribute runoff to and within the site. This will allow a proper comparison to post-development conditions at the common points-of-interest (i.e., outfalls where surface water exits the site). Specifically, the pre-development conditions are defined as follows:

- Within the permit boundary, the pre-development conditions are the current as-permitted (MSW-1646A) final landfill condition (generally situated on the eastern side of the overall site) along with existing topography of on-site conditions in the expansion area (generally situated on the western side of the overall site); and

- Other off-site areas that contribute run-on to the site are delineated using the existing topography of those conditions.

The pre-development conditions and resulting drainage areas are delineated on Drawing 2A-2 (with off-site pre-development contributing areas shown on Drawing 2A-4), presented in Attachment 2A of this Drainage Report. Overall, the pre-development drainage area is 305.9 acres, and there are three (3) outfalls. These outfalls, and the pre-development condition, are described below.

- "Outfall A" is located at the southeastern portion of the site, where runoff ultimately makes its way into the main body of Tehuacana Creek. Under the as-permitted final closure landfill conditions of the existing landfill under MSW Permit No. 1646A, runoff from all of the existing landfill final grades and surface water management features (as well as from some adjacent on-site and off-site areas) discharges at Outfall A. Accordingly, the current-permitted landfill final closure conditions, along with existing conditions of adjacent areas, were incorporated into the pre-development condition associated with drainage areas contributing to Outfall A.

- "Outfall B" is located in the south-southwestern portion of the site. This outfall receives and discharges runoff originating from on-site areas (but none associated with the existing landfill) and from adjacent off-site areas. The contributing drainage areas associated with Outfall B are relatively undisturbed/undeveloped. Under pre-development conditions, there is also a natural drainage path in the western portion of the site (see Drawing 2A-2) that, from site-specific topographic maps and USGS maps, appears to flow into a low area that has the potential to temporarily hold and detain water before it reachs Outfall B (depending on the magnitude of the storm event). These existing conditions were incorporated into the pre-development condition associated with drainage areas contributing to Outfall B.

- "Outfall C" is located in the extreme southwest corner of the site. This outfall receives and discharges flow generated by runoff from a small contributing drainage area.

Drawing 2A-2 indicates the calculated peak flow rate and the volume of runoff discharged from the site at each of the three outfalls due to a 24-year, 24-hour rainfall event under pre-development conditions. A description of the selected hydrologic method and design parameters is presented subsequently in this Drainage Report.

# 3. PROPOSED SURFACE WATER MANAGEMENT SYSTEM

## 3.1 General

This section summarizes the proposed surface water management system design and describes the drainage features and components within the landfill facility. The landfill facility will have above- and below-grade waste filling over lined areas. A series of drawings presenting the liner base (excavation) grades, the site configuration during phased development and waste filling, and the landfill completion plan, are presented in Part I/II of the PAA (see Drawings I/IIA-23 through I/IIA-28 in Appendix I/IIA). As described below, certain permanent components of the overall site surface water management system will be constructed at points during the development sequence, while other components will be installed as portions of the landfill reach final grade or at the time of closure.

Specific to this Drainage Report, a series of engineering drawings are presented in Attachment 2A to present the surface water management system design and associated drainage features. Drawing 2A-1 in Attachment 2A of this Drainage Report presents the final configuration of the landfill and the related surface water management system features. As shown, the landfill will have final cover sideslopes inclined at 4 horizontal to 1 vertical (4H:1V) (i.e., 25%) slopes. At the crest of the final cover sideslopes, the final cover grades then continue up at a shallower top-deck grade of five percent (5%), up to a peak (ridgeline) elevation. In this Drainage Report, final cover slope areas with grades of 5% are designated as “top deck areas,” and final cover slopes with overall grades of 4H:1V are designated as “sideslope areas.”

## 3.2 Surface Water Management System Components

Various surface water management system components collect and convey surface water from the final cover system to the discharge points (i.e., outfalls) from the site, as described below. The sizing and hydraulic design of these features is described later in this Drainage Report, in Section 5 (which references detailed calculation packages presented as attachments included with this Drainage Report).

Drainage Terraces, Let-Down Channel, and Downdrains. Sideslope drainage terraces installed as “tack-on” berms on the final cover sideslope will intercept surface water runoff (i.e., sheet flow) along the up-gradient sideslope areas of the final cover, and convey runoff to downdrain pipes. Similar drainage terraces will also be constructed at the crest of the landfill sideslope, or the toe of the top deck of the final cover, to collect and convey sheet flow runoff from the 5% slope top deck surfaces to the downdrain pipes. In addition, in one instance, a rip-rap lined let-down channel will be constructed along a drainage fold (valley) on the top deck to to minimize long-term potential erosion and route runoff to a downdrain pipe. Closed conduit downdrain pipes oriented perpendicularly to the landfill slopes (i.e., down-slope) will collect the runoff from low points of the drainage terraces and let-down channel, and convey the surface water to the landfill perimeter channels along the toe of the cover system sideslopes. For reference, this design approach is consistent with the current permit (MSW Permit No. 1646A), and portions of the southeast part of the landfill have already been closed (i.e., final capped) with an existing network of similar sideslope terraces and HDPE downdrains. Some of these existing features will be unaffected by the landfill expansion and will remain in-service, as identified on Drawing 2A-1 of Attachment 2A as the area of existing surface water management system features.

<u>Perimeter Drainage Channels and Culverts</u>. A series of perimeter drainage channels will be positioned around the expanded landfill to convey runoff from drainage terraces and downdrains, and any contributing sheet flow from adjacent areas, to the downstream terminations of these channels (in some cases into stormwater ponds, discussed subsequently). The layout and designations of the proposed expanded perimeter drainage channel network are identified on Drawing 2A-6 of Attachment 2A. A portion of the currently permitted perimeter drainage network will remain in-service (referred to as the North Channel and East Channel). The expansion area will also have perimeter drainage channels situated around its perimeter (referred to as the West Channel and South Channel).

Also, on the west perimeter of the expanded landfill, a Diversion Channel will be constructed to replace the natural drainage path that crosses the site under pre-development conditions (see Drawings 2A-6 and 2A-2 for the Diversion Channel layout and pre-development drainage path, respectively). The Diversion Channel is essentially a re-routed alignment for the former natural drainage path that will eventually be affected by landfill development, and as such, the purpose of this Diversion Channel is to convey contributing stormwater from landfill and adjacent areas (including some off-site run-on flows) around the west side of the landfill, to the south, and ultimately into an on-site stormwater pond (described subsequently).

In various locations around the perimeter, culvert pipes exist; in other locations, culvert pipes will be installed. Drawing 2A-6 shows the locations and designations of these culverts.

<u>Stormwater Ponds</u>. To accommodate the post-development conditions of the overall landfill with the proposed expansion, two (2) stormwater ponds will be constructed on the south side of the landfill. The location and designation of these ponds are shown on Drawing 2A-1 (with enlarged-scale plan views provided on Drawing 2A-5). As shown, Stormwater Pond 1 will be located in the southwest corner of the site, where its outlet will release stormwater at a controlled rate to Outfall B. Stormwater Pond 2 will be located in the middle-southern portion of the site, where it will release stormwater at a controlled rate to the South Channel, which ultimately conveys flow to Outfall A. The geometry and appurtenances of each of these stormwater ponds have been designed to provide a storage/detention function (controlling the rate of stormwater release from the site to their respective downstream conveyances, and, ultimately, their site outfalls, to be at rates equal to or less than the pre-development discharge rates from the site, as demonstrated later

in this Drainage Report). By accomplishing storage and detention, these ponds are also expected to provide a sediment control/water quality function. Each pond will outlet via a primary (i.e., "principal") spillway pipe and inlet riser system, along with an secondary spillway channel. The ponds are designed to function as "dry ponds" – that is, to completely empty within a relatively short period of time after each storm event.

It is also noted that the currently-permitted surface water management system under MSW Permit No. 1646A does not include stormwater ponds for detention of runoff. Instead, runoff is rounted around the existing landfill and ultimately to Outfall A. From review of existing topography, there appears to be a shallow, low area in the southeast corner of the site (just upstream from Outfall A). This appears to be a small depression fitted with an overflow pipe that would have a minor (but beneficial) effect on water quality (acting as a temporary silt trap – a type of best management practice (BMP)). This existing feature will remain as-is in the post-development condition. Since this feature provides essentially no storage/retention (particularly for the relatively large 25-year, 24-hour storm), and is not required by current MSW Permit No. 1646A, it was conservatively ignored under both pre- and post-development conditions.

Active-Area Surface Water Controls. During ongoing landfill development and prior to final cover installation and closure, the site will utilize temporary diversion berms and contaminated water holding areas to maintain the separation of clean runoff from potentially-contaminated water. Temporary diversion berms will be placed up-gradient from active waste areas (i.e., the working face) to intercept clean runoff and route it around active areas to the surface water management system. Also, containment berms will be used to create holding areas down-gradient from the working face to hold any contaminated water that is generated and prevent its runoff and discharge from the site. The requirements regarding active-area surface water controls are presented in the Leachate and Contaminated Water Management Plan (Part III, Attachment 3E). Calculations for sizing of the active-area surface water controls are presented in this Drainage Report, in Attachment 2E.

Interim Erosion and Sediment Control Measures. Erosion and sediment control is addressed in Section 6 of this Drainage Report. In addition, an Intermediate Cover Erosion and Sediment Control Plan (ICESCP) is provided in Attachment 2F to this Drainage Report and includes a description of the measures to be utilized during interim conditions at the site.

# 4. DESCRIPTION OF THE POST-DEVELOPMENT CONDITION

The post-development drainage areas will include the proposed permit boundary, as well as off-site drainage areas that contribute run-on to the site, as follows:

- Within the permit boundary, the post-development conditions are the final conditions proposed in this PAA that incorporate the expanded landfill and the surface water management features described in Section 3.

- Other off-site areas that contribute run-on to the site under post-development conditions are the same as for pre-development conditions, as described in Section 2.

The post-development conditions and resulting drainage areas are delineated on Drawing 2A-3 (with off-site post-development contributing areas shown on Drawing 2A-4), presented in Attachment 2A of this Drainage Report. The post-development surface water management features at the site and the routing of surface water were discussed in Section 3. Inspection of Drawing 2-3 shows that the post-development drainage area is 305.9 acres (the same as the pre-development drainage area). Also, the three site outfalls (A, B, and C) are at the same locations as those used to model pre-development conditions because the drainage patterns where runoff leaves the site are not being changed from pre-development conditions.

Drawing 2A-3 also provides the calculated peak flow rate and the volume of runoff discharged from the site for the 25-year, 24-hour rainfall event under post-development conditions. A description of the hydrologic method and design parameters is presented subsequently in this Drainage Report. Also, in Section 5.5.1, comparisons of the pre-development and post-development conditions are discussed.

# 5. DRAINAGE CALCULATIONS

## 5.1 General

In accordance with 30 TAC §330.303(a), the surface water management system has been designed to be capable of conveying the peak discharges from the 25-year, 24-hour rainfall event. Design and analysis calculations are made to demonstrate that post-development peak discharges exiting the facility are less than pre-development flows exiting the facility from the 25-year, 24-hour rainfall event. Calculations have been performed to size the drainage features and to demonstrate that flow velocities and tractive stresses in conveyance components will not cause erosion of the drainage terraces, downdrains, perimeter channels, culvert outlets, etc. The calculations related to the site surface water management features are presented as additional attachments to the Drainage Report, and are as follows:

- Hydrology calculations (i.e., calculations of peak runoff rates, times of concentration, and total runoff volumes for the pre-development and post-development conditions) are presented in Attachment 2B. This attachment also includes the storm routing design through the on-site stormwater ponds and the resulting hydrology computations associated with their detention capabilities and performance.

- Hydraulic calculations for the sizing and the design of the drainage terraces and downdrain channels are presented in Attachment 2C.

- Hydraulic calculations for the sizing and the design of the proposed perimeter drainage channels and culverts are presented in Attachment 2D.

- Hydrology and hydraulics calculations for active-area surface water controls are presented in Attachment 2E.

It is also noted that an additional calculation package for predicting soil loss and sizing of interim erosion and sediment controls is presented in Attachment 2F.

## 5.2 Design Rainfall Event

As indicated above and pursuant to 30 TAC §330.63(c)(1)(D)(i), the 25-year, 24-hour rainfall depth was utilized as the design rainfall event for the surface water management system design. The rainfall depth-duration frequency relationships selected for design used the National Oceanic and Atmospheric Administration's (NOAA's) Atlas 14 Precipitation-Frequency analysis for Texas (NOAA, 2018). Using the online NOAA estimate tool for the site location, the site-specific 24-hour, 25-year rainfall depth is 7.35 inches, and this value was selected for design of the proposed facility surface water management system and for the pre- vs. post-development analyses and comparisons. The design rainfall depths in the hydrologic model were selected consistent with the Texas Department of Transportation's (TxDOT's) Hydraulic Design Manual (TxDOT, 2019) methods and procedures. Additional information concerning the design storm parameters and methods is presented in Attachment 2B to this Drainage Report.

## 5.3 Hydrologic Model

The U.S. Army Corps of Engineers Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) computer program was used to model the pre-development and post-development conditions. HEC-HMS is the successor to and replacement for the HEC-1 program. Modeling was used to calculate surface water runoff volumes, peak flow rates, routing of rainfall event hydrographs through perimeter channels, and runoff discharge quantities. Attachment 2B of this Drainage Report presents detailed drainage calculations, including a detailed discussion of the parameters used in the analyses and the results of the hydrologic modeling efforts.

## 5.4 Hydraulics

Principles of open channel flow using Manning's equation (Chow, 1959) were used to size the perimeter drainage channels, top deck drainage terraces, sideslope drainage terraces, and downdrain pipes based on the peak flows derived from the HEC-HMS hydrologic modeling. Manning's Equation in its general form is expressed as:

$$Q = \frac{1.49}{n} A\, R^{2/3}\, {S_o}^{2/3}$$

where:

$Q$ = discharge (cfs);

$n$ = Manning's roughness coefficient;

$A$ = area of cross-section of flow ($ft^2$);

$P$ = wetted perimeter (ft);

$R$ = hydraulic radius (ft) = $A/P$; and

$S_0$ = longitudinal slope (ft/ft).

Tractive stresses, as well as flow velocities resulting from peak flows, were calculated to select the type of channel lining that would be necessary to prevent erosion of the drainage features. The average tractive stress for a given depth of flow in a channel is calculated by:

$$\tau_o = \gamma_w RS$$

where: $\tau_o$ = average tractive stress ($lb/ft^2$);

$\gamma_w$ = unit weight of water ($lb/ft^3$);

$R$ = hydraulic radius (ft); and

$S$ = channel slope (ft/ft).

As an additional design step, inlets of the downdrain pipes were evaluated using the orifice equation based on the peak flows derived from the HEC-HMS hydrologic modeling. The orifice equation in its general form is expressed as:

$$Q = CA\sqrt{2gH}$$

where: $Q$ = discharge (cfs);

$C$ = discharge coefficient;

$A$ = area of cross-section of flow ($ft^2$);

$g$ = acceleration from gravity ($ft/s^2$); and

$H$ = depth from headwater to center of pipe.

Culverts located along the landfill perimeter and pond network were analyzed based on the peak flows derived from the HEC-HMS hydrologic modeling within the HY-8 Culvert Analysis Program v.7.5 (HY-8) developed by the Federal Highway Administration (FHWA).

Finally, elevation-area relationships (also known as stage-storage relationships) were developed for the proposed stormwater ponds, and subsequently inputted into the HEC-HMS model of post-development conditions. The elevation-area relationship is calculated based on the size, depth, and shape of the pond, while the elevation-outflow relationship is calculated based on the configuration of the outflow control structures. The elevation-area relationship describes the volume of storage provided by the pond at different water level stages.

As mentioned, the computations for sizing surface water management system components are found in the following attachments to this Drainage Report:

- Attachment 2B – Hydrology;
- Attachment 2C – Drainage Terraces and Downdrains; and
- Attachment 2D – Culverts and Perimeter Drainage Channels.

## 5.5 Calculation Results Summary

### 5.5.1 Discharge Comparisons

Table 5.5.1-1 summarizes the pre- and post-development peak discharge, total discharge volume, peak velocity, time to the peak discharge rate, and total runoff area. The pre- and post-development nodal network diagrams are included in Attachment 2B, to present the delineation of drainage areas and how they are linked/connected to route flows to each site outfall.

**TABLE 5.5.1-1**

**SUMMARY OF PEAK DISCHARGE CONDITIONS AT SITE OUTFALLS (PRE- VS. POST-DEVELOPMENT COMPARISON)**

| LOCATION | OUTPUT PARAMETER | PRE-DEVELOPMENT CONDITIONS (25-YEAR EVENT) | POST-DEVELOPMENT CONDITIONS (25-YEAR EVENT) |
|---|---|---|---|
| OUTFALL A | PEAK DISCHARGE (CFS) | 481 | 435 |
| | TOTAL RUNOFF VOLUME (AC-FT) | 75.8 | 73.3 |
| | TIME TO PEAK DISCHARGE (MIN) | 10 | 11 |
| | TOTAL RUNOFF AREA (AC) | 166.7 | 160.7 |
| | PEAK VELOCITY (FPS) | 3.9 | 3.9 |
| OUTFALL B | PEAK DISCHARGE (CFS) | 250 | 222 |
| | TOTAL RUNOFF VOLUME (AC-FT) | 65.0 | 69.1 |
| | TIME TO PEAK DISCHARGE (MIN) | 18 | 31 |
| | TOTAL RUNOFF AREA (AC) | 138.5 | 144.5 |
| | PEAK VELOCITY (FPS) | 5.1 | 4.2 |
| OUTFALL C | PEAK DISCHARGE (CFS) | 4 | 4 |
| | TOTAL RUNOFF VOLUME (AC-FT) | 0.3 | 0.3 |
| | TIME TO PEAK DISCHARGE (MIN) | 5 | 5 |
| | TOTAL RUNOFF AREA (AC) | 0.7 | 0.7 |
| | PEAK VELOCITY (FPS) | 2.6 | 2.6 |

Examination of the calculation results shown above indicates that the predicted peak post-development discharge rates and velocities are similar, but in all cases less than or equal to the peak pre-development discharge rates at each site outfall. The computed runoff volumes are similar (within 6%) for pre-development and post-development conditions at the site outfalls. Additionally, times to peak discharge are similar for the pre-development and post-development conditions at Outfalls A and C; while there is a somewhat increased time to peak discharge at Outfall B for the post-development condition due to the addition of Stormwater Pond 1 and its detention of flows as runoff passes through the pond.

Channel outlets and pond outlets under post-development conditions will be equipped with energy dissipators (riprap apron or equivalently-effective concrete dissipation device) to reduce peak velocities to low, non-erodible levels before reaching the site outfalls. The peak velocities are generally similar between pre- and post-development conditions at all three outfalls. The evaluation of selected outlet protection systems and calculation of peak velocity is presented in Attachment 2D.

In summary, the proposed outfalls will be in the same locations as the existing outfalls, and surface water runoff under proposed post-development conditions is generally routed towards each outfall in a similar/consistent manner to pre-development conditions. The proposed drainage areas and patterns of runoff will be similar to the existing permitted pre-development drainage patterns. The reduced peak discharge rates under post-development conditions are beneficial given the watershed-wide importance of reducing peak runoff rates during storm events. This information demonstrates that the existing pre-development drainage patterns will not be adversely affected by the proposed lateral expansion.

### 5.5.2 Stormwater Ponds

Stormwater Ponds 1 and 2 were designed to adequately detain and pass the 25-year, 24-hour rainfall event while maintaining at least 0.5 feet of freeboard, and to hold/pass the 100-year, 24-hour rainfall event without overtopping the berm crest. The HEC-HMS model was used to calculate surface water runoff volumes, peak flow rates, peak water surface elevations, and routing of rainfall event hydrographs through the North Surface Water Pond and its series of sub-ponds. The results of this analysis are summarized below in Table 5.5.2-1.

**TABLE 5.5.2-1**

**STORMWATER POND WATER LEVELS AND DETENTION CAPACITY**

| Parameter | 25-Year Event | | 100-Year Event | |
|---|---|---|---|---|
| | Pond 1 | Pond 2 | Pond 1 | Pond 2 |
| Peak Water Surface Elevation (ft, MSL) | 415.0 | 409.2 | 415.9 | 410.0 |
| Available Freeboard to Pond Crest (ft) | 1.0 | 0.8 | 0.1 | 0.0 |
| Peak Storage per Pond (ac-ft) | 5.6 | 5.3 | 6.6 | 6.3 |

As shown in the above table, adequate freeboard is provided for the 25-year, 24-hour rainfall event in the ponds. Additionally, the water surface elevation in each pond during the 100-year, 24-hour rainfall event is at or below the berm crest elevations (i.e., no overtopping).

### 5.5.3 Perimeter Drainage Channels

Perimeter channels have been designed to convey the peak flows from the 25-year, 24-hour rainfall event while maintaining at least 0.5 feet of freeboard. Additionally, perimeter channels were designed with the capacity to convey the 100-year, 24-hour rainfall event without overtopping. Tractive stresses and velocities for peak flows during the 25-year, 24-hour rainfall event have been computed and channel linings have been selected to withstand the predicted tractive stresses. Also, the existing perimeter channel reaches (North Channel 1, all East Channels, and South Channel 2) that will continue to be used were analyzed and found to meet the established criteria.

Drawing 2A-6 of Attachment 2A shows the designation and layout of the perimeter drainage channels. Drawings 2A-7 through 2A-9 present the perimeter drainage channel profiles. A table summarizing channel widths, depths, and slopes is provided on Drawing 2A-13, and calculations pertaining to the perimeter drainage channel design and analysis are presented in Attachment 2D to this Drainage Report. Table 5.5.3-1 summarizes the peak 25-year, 24-hour and peak 100-year, 24-hour rainfall event design and analysis values in the proposed perimeter channels.

**TABLE 5.5.3-1**
**PERIMETER DRAINAGE CHANNEL RESULTS**

| Channel Segment Designation | 25-Yr Peak Flow Rate ($ft^3/s$) | 25-Yr Peak Flow Depth (ft) | 25-Yr Peak Flow Velocity (ft/s) | 25-Yr Peak Tractive Stress ($lb/ft^2$) | 25-Yr Freeboard (ft) | 100-Yr Freeboard (ft) | Proposed Channel Lining Material |
|---|---|---|---|---|---|---|---|
| North Channel 1 | 47 | 1.16 | 4.3 | 0.40 | 0.8 | 0.6 | Grass |
| East Channel 1 | 133 | 2.21 | 5.7 | 0.60 | 2.1 | 1.7 | Grass |
| East Channel 2 | 210 | 2.84 | 5.9 | 0.61 | 1.4 | 0.9 | Grass |
| East Channel 3 | 246 | 3.04 | 6.1 | 0.64 | 0.9 | 0.3 | Grass |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| West Channel 1 | 157 | 2.48 | 5.1 | 0.47 | 0.5 | 0.1 | Grass |
| West Channel 2 (0.5%) | 82 | 1.83 | 4.3 | 0.36 | 1.2 | 0.9 | Grass |
| West Channel 2 (1.0%) | 82 | 1.54 | 5.5 | 0.63 | 1.5 | 1.2 | Grass |
| West Channel 3 | 26 | 1.01 | 3.2 | 0.24 | 2.0 | 1.8 | Grass |
| South Channel 1 | 15 | 0.50 | 4.4 | 0.53 | 2.5 | 2.4 | Grass |
| South Channel 2 | 161 | 2.66 | 5.0 | 0.45 | 1.3 | 0.7 | Grass |
| Diversion Channel U | 103 | 1.73 | 7.8 | 1.19 | 2.3 | 1.9 | Turf reinforcement matrix (TRM) |
| Diversion Channel D | 264 | 3.78 | 6.5 | 0.68 | 1.2 | 0.5 | Grass |

### 5.5.4 Drainage Terraces

The top deck and sideslope drainage terrace layout is presented on the Facility Surface Water Management Plan, Drawing 2A-1. Details of both the top deck and sideslope drainage terraces are presented on Drawing 2A-10, and calculations pertaining to the design of these structures are presented in Attachment 2D to this Drainage Report. Drainage terraces have been designed to convey the peak flows from the 25-year, 24-hour rainfall event, while maintaining a minimum of 0.5 feet of freeboard. Additionally, the drainage terraces have been designed with the capacity to convey the 100-year, 24-hour rainfall event without overtopping. Based on the calculated peak tractive stresses, grass lining was selected as the lining of the channels in order to resist erosion of the channel during a 25-year rainfall event. Sideslope drainage terraces were designed for a 2.0% typical, 1.0% minimum, and 3.0% maximum longitudinal slope based on the maximum peak flow rate calculated for an individual segment of sideslope terrace. Top deck terraces were designed for a 1.1% typical, 1.1% minimum, and 1.5% maximum longitudinal slope based on the maximum peak flow rate calculated for an individual segment of top deck terrace. Table 5.5.4-1 summarizes the peak 25-year, 24-hour and peak 100-year, 24-hour design values for each drainage terrace.

**TABLE 5.5.4-1**
**TOP DECK AND SIDESLOPE DRAINAGE TERRACES**

| Terrace Designation | 25-Yr Peak Flow Rate ($ft^3/s$) | 25-Yr Peak Flow Depth (ft) | 25-Yr Peak Flow Velocity (ft/s) | 25-Yr Peak Tractive Stress ($lb/ft^2$) | 25-Yr Freeboard (ft) | 100-Yr Freeboard (ft) | Proposed Channel Lining Material |
|---|---|---|---|---|---|---|---|
| Top Deck (1.1%) | 57 | 1.1 | 3.9 | 0.38 | 0.9 | 0.7 | Grass |
| Top Deck (1.5%) | 57 | 1.1 | 4.4 | 0.49 | 0.9 | 0.8 | Grass |
| Sideslope (1.0%) | 17 | 1.2 | 3.8 | 0.36 | 0.8 | 0.6 | Grass |
| Sideslope (3.0%) | 17 | 1.0 | 5.7 | 0.87 | 1.0 | 0.9 | Grass |

### 5.5.5 Downdrains

Downdrains have been designed to convey the peak flows from the 25-year, 24-hour rainfall event at the pipe inlet, as well as to convey peak flows from the more stringent 100-year, 24-hour rainfall event at the pipe outlet, based on the surface water management system layout presented on the Facility Surface Water Management Plan, Drawing 2A-1. Additionally, both existing downdrains (A and B-L) were re-analyzed and determined to meet the established criteria. Details of the downdrains are presented on Drawings 2A-11 and 2A-12, and calculations pertaining to the downdrain design and analysis are presented in Attachment 2D to this Drainage Report. All existing and proposed downdrain locations utilize 24-inch smooth-interior high-density polyethylene (HDPE) closed-conduit downdrain pipes inclined on a 0.25 ft/ft slope (i.e., the 4H:1V landfill sideslopes). Table 5.5.5-1 summarizes the peak 25-year, 24-hour analysis values for the most critical case of an individual pipe (i.e., the condition associated with the highest peak flow). The results show that the highest calculated peak flow condition can be adequately conveyed through the downdrain pipe while maintaining freeboard. Erosion control at the downstream outlet of the downdrains typically consists of downdrain energy dissipators, as described in Attachment 2D and shown on Drawing 2A-14.

**TABLE 5.5.5-1**

**INDIVIDUAL DOWNDRAIN PIPE SIZING**

| TYPICAL 4H:1V PIPE CONFIGURATION AND FLOWRATES | | |
|---|---|---|
| 25-year Peak Flow : | 69 | cfs |
| 100-year Peak Flow : | 97 | cfs |
| 25-year Depth of Flow: | 13 | inches |
| 100-year Depth of Flow: | 16 | inches |
| PIPE INLET ON TOP DECK | | |
| 25-year Peak Flow: | 21 | cfs |
| 25-year Freeboard: | 0.6 | ft [1] |
| PIPE INLET ON SIDESLOPE | | |
| 25-year Peak Flow: | 17 | cfs |
| 25-year Freeboard: | 0.8 | ft [1] |

Note [1]: Berms are 3.5-ft tall at the top deck inlet area and 3.0-ft tall at the sideslope inlet area

### 5.5.6 Culverts

Culverts were designed to convey the peak flows from the 25-year, 24-hour rainfall event while maintaining at least 1 foot of freeboard. Additionally, culverts were designed with the capacity to convey the 100-year, 24-hour rainfall event without overtopping. Culverts were analyzed by utilizing the HY-8 Culvert Analysis Program v.7.5 (HY-8) developed by the FHWA. The performance of each culvert is modeled and assessed based on boundary conditions of the structure, culvert configuration, peak flow criteria, and tailwater levels. The tailwater levels were selected based on the computed water depth in the downstream perimeter channel predicted at the time each culvert is predicted to experience peak flows for the 100-year, 24-hour rainfall events. Existing culverts (NC-2, EC-1, EC-2, and EC-3) were also analyzed and found to meet the established criteria. Finally, riprap aprons were design for applicable existing and proposed culverts following criteria from the FHWA. The analysis results for evaluation of the permitted culvert, including discharge rates, are provided in Attachment 2D.

Note that as part of the facility design, there are control structures (outlet pipes) at each stormwater pond. These pipes have been adequately sized as part of the hydrologic computations in Attachment 2B, but are not assigned the term "culverts." This is because the design of the stormwater ponds and resulting discharge rates are influenced by the outlet pipe in each pond. Therefore, the sizing of the outlet pipes was done as part of the stormwater pond performance modeling (discharge flows, pond elevations, etc.), rather than as a stand-alone "culvert design" package.

# 6. EROSION AND SEDIMENT CONTROL

## 6.1 General

The facility has been designed to minimize soil erosion losses, thereby providing effective erosional stability to top deck surfaces and external embankment sideslopes during all phases of landfill operation, closure, and post-closure care. The surface water management system design described in this Drainage Report accomplishes this by utilizing properly-sized and designed drainage terraces, downdrains, perimeter drainage channels, culverts, and stormwater ponds. These features provide for positive drainage of runoff from the final cover system and surrounding site areas and within acceptable tolerances for stresses that could cause erosion.

Additionally, temporary grassing/stabilization, diversions, and other BMPs will be used to minimize soil erosion and sedimentation during intermediate conditions. These BMPs, along with other measures utilized while landfill slopes have intermediate cover, are discussed in the Intermediate Cover Erosion and Sediment Control Plan (ICESCP), which is provided in Attachment 2F to this Drainage Report. The rainfall intensity determination method utilized in calculations for the design of the intermediate cover features is consistent with the TxDOT Hydraulic Design Manual (2019) methods and procedures. As areas of the landfill reach final grade, the final cover system will be installed, including vegetation and other final long-term surface water management system components located on the sideslopes and the top deck areas.

## 6.2 Soil Loss Minimization

The long-term effects of erosion have been evaluated using the Revised Universal Soil Loss Equation (RUSLE) for the intermediate and final cover surfaces. These analyses are more thoroughly discussed for the intermediate cover and final cover surfaces in Appendix 2F-1 of Attachment 2F and in Attachment 3F of the Site Development Plan, respectfully. When landfill slopes are surfaced with intermediate cover prior to receiving final cover, measures will be taken to minimize soil erosion and loss. These measures are discussed in the ICESCP in Attachment 2F of this Drainage Report. Surface water conveyance structures have been designed for landfill areas with both intermediate and final cover systems. Flow velocities have been estimated for these conveyance structures to evaluate if erosion controls, other than grassing, are required (e.g., concrete lining, geomembranes, geosynthetic erosion control materials, riprap lining materials, etc.).

## 6.3 Seeding and Stabilization Activities

Temporary and permanent stabilization will be used during the construction and operation of the facility to minimize soil erosion and sedimentation. Temporary stabilization will be performed as described in the ICESCP (see Attachment 2F).

Permanent stabilization will be performed in conjunction with final cover system construction (for the landfill) and final closure of the facility (for other disturbed areas), as described in the Closure Plan (Part III, Attachment 7). In particular, refer to Section 6.4 of the Final Cover Quality Control Plan (FCQCP) in Part III, Attachment 7B for a description of the permanent stabilization specifications and installation procedures.

## 6.4. Surface Water Maintenance Plan

### 6.4.1 General

During site construction activities and site operations, inspection and maintenance of disturbed areas and their surface water management system features will be conducted in accordance with the facility's Texas Pollutant Discharge Elimination System (TPDES) Multi-Sector General Storm Water Permit. Written records of these inspections and maintenance activities will be maintained as required, as further discussed in Part IV – Site Operating Plan (SOP), Section 24.

During the post-closure care period for the facility, inspections will be performed as indicated in the Post-Closure Plan located in Attachment 8 to the SDP.

### 6.4.2 Site Maintenance Activities

In general, the following procedures will be followed when deemed necessary by the inspections performed in accordance with the TPDES permit and Section 24 of the SOP, to maintain and ensure functionality of the surface water management system and erosion and sedimentation controls:

- Eroded areas or areas with ponding water will be regraded to their original slopes and reseeded or covered with an erosion resistant material. Upgrades to the original design specifications can be considered at this remedial stage depending upon the severity of systems degradation.

- Additional temporary erosion protection and sediment control measures using established BMPs will be implemented (seeding, temporary berms, ditches, silt fences, erosion mat, check dams, silt traps, etc.), as necessary, during operation to minimize the amount of erosion and sedimentation. These measures can be removed once the erosion has been stopped and long-term vegetation is established and permanent conveyance structures are in place.

- Piped structures (i.e., culverts) will be kept free of debris to allow flows to achieve the design.

- Vegetated water conveyance areas will be mowed periodically to encourage healthy growth and to maintain design flow capacities and erosion resistance.

- Temporary diversion berms will be constructed up-gradient of the active working face to limit surface water run-on to waste operations. The temporary containment berms downslope of working areas, interphase berms, or temporary cell berms in interim areas (as appropriate) will also serve to contain surface water runoff down-gradient of active working areas. Any surface water that comes in contact with waste will be handled as contaminated water and kept separate from clean runoff.

- Erosion control structures and drainage features will be cleaned periodically (removal of debris and sediment) in order to maintain design capacity. The excavated material will be transported to designated areas of the site for spreading and drying (must be surrounded by adequate temporary erosion controls).

- Areas of distressed vegetation will be identified and re-vegetated.

- Damaged or eroded drainage terraces, downdrain pipes, perimeter channels, and culverts will be repaired.

- Excess silt, weeds and other debris accumulated in drainage channels and other conveyances will be removed to restore the design configuration, followed by re-vegetating the disturbed areas as appropriate.

Whether maintenance or repairs of site surface water features are needed, and the timing on implementing any remedies, will be determined based on the severity of the erosion or damage compared to the disturbance that will be caused by the repair and seasonal factors (weather patterns, growing season, etc.).

# 7. PROTECTION FROM FLOODING

The location of the FEMA-delineated 100-year floodplain of Tehuacana Creek is presented on Drawing 2A-1 of this Drainage Report (also shown at a broader scale on Drawing 2A-4). A description of how the entire landfill (including the proposed lateral expansion waste disposal footprint) is located entirely outside the limits of the FEMA-mapped 100-year floodway and 100-year floodplain was provided previously in Section 1.4 of this Drainage Report.

With respect to protection from a 100-year frequency flood, in addition to the landfill being set-back horizontally from the 100-year floodway and floodplain as a means of protection, a comparison of the base flood elevations (BFEs) (i.e., elevations of the 100-year flood event) of Tehuacana Creek to the landfill perimeter berms that surround the limits of waste disposal can be made. The BFEs of the Tehuacana Creek 100-year frequency flood are shown on the published FEMA map (included in Appendix I/IIA of Part I/II, Drawing I/IIA-18). The FEMA map shows that, in areas to the southeast of the landfill beyond the limits of disposal and limits of disturbance of this project, BFEs range from approximately elevation 401 ft, MSL to elevation 398.7 ft, MSL. In comparison, the existing landfill perimeter road adjacent to these areas ranges from approximately elevations 406 ft, MSL to 408 ft, MSL, and is in an area where that part of the landfill is now closed with a final cap (i.e., has approved final cover in place, stabilized with vegetation, and will remain as such). There is at least 5 feet of freeboard between the crest of the perimeter road and the 100-year flood elevations.

Also note that a landfill cross-section passing through the portion of the site where the waste disposal limits are at their lowest elevation (and representative of where the landfill is closest to the 100-year floodplain) is presented in Part III, Attachment 3A (see Drawing 3A-7). This Landfill Cross-Section A-A' on Drawing 3A-7 illustrates the 100-year flood level of Tehuacana Creek in relation to the perimeter berm/waste limits (demonstrating freeboard levels).

Based on these conditions, there is both a horizontal set-back and vertical freeboard provided between the landfill perimeter berm and the 100-year frequency flood. The landfill is adequately protected from flooding.

Finally, it is noted that there are no existing levees or other improvements at the site that were subject to approval of the Commission under Texas Water Code, §16.236, nor are such features proposed as part of the landfill expansion and related site development activities proposed in this PAA. As documented herein, no portions of the landfill footprint or its associated development are or will be located within a 100-year floodway. Therefore, the requirements of 30 TAC Chapter 301, Subchapter C, 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.

## 8. DRAINAGE FEATURE INSTALLATION SCHEDULE

The phased landfill development configurations are illustrated in Part I/II of the PAA. Specifically, Part I/II, Appendix I/IIA, Drawing IIA-24 presents a tabulated overview of the stages of landfill expansion development, and Drawings I/IIA-25 through I/IIA-28 show the stages of development and layout of the related features.

Overall, as the landfill is developed, the landfill will have temporary grassing/stabilization, diversions, and other BMPs installed on top deck and external-facing slopes in accordance with the ICESCP provided in Attachment 2F. When the facility is ready for final closure (or incrementally in phases as areas have achieved final waste grades, if the facility elects to install final cover incrementally), the final cover system will be installed and the final landfill drainage features (i.e., final cover with topsoil and vegetation, drainage terraces, and downdrains) required for those areas being capped will be installed in conjunction with the final cover installation.

With respect to perimeter surface water management system features (perimeter drainage channels and stormwater ponds), those final features will be installed prior to when runoff generated by the landfill areas (i.e., above-grade filling) contributes flow towards those perimeter features. More specifically, from the information presented in Part I/II of the PAA, it is expected that the main components of the final perimeter drainage features will be installed according to the following approximate schedule:

- When Cell 4-2 is constructed, the Diversion Channel on the west side of the site will be constructed, as will Stormwater Pond 1. Also, the West Channel on the north side of Cell 4-2 will be constructed.

- When Cell 4-3 is constructed, Stormwater Pond 2 will be constructed, along with the South Channel. Also, perimeter drainage channel segments adjacent to Cell 4-3 will be constructed.

- As the remaining cells are constructed, the perimeter drainage channels adjacent to those cells will be constructed, along with the necessary conveyances to the downstream features.

# 9. CONCLUSIONS

This Drainage Report presents the proposed facility drainage design in compliance with the applicable requirements of 30 TAC Chapter 330, Subchapter G, and §§330.63(c) and 330.303. The Drainage Report is accompanied by engineering design drawings, supporting hydrology calculations, and hydraulic structural design calculations for the site drainage features. The following conclusions summarize the results of the drainage analysis and design:

- The drainage design criteria selected meet the requirements of 30 TAC Chapter 330, Subchapter G.
- The surface water management system drainage structures (terraces, downdrains, ditches, and culverts) are designed to convey peak flows from the 25-year rainfall event.
- The stormwater pond capacities and outlet structures are designed to manage the 25-year rainfall event and with erosion protection to attenuate the velocity and dissipate the energy at each outfall.
- Erosion will be minimized through the interim and permanent design features and BMPs described herein.
- The post-development discharge rates from the site are less than the pre-development discharge rates, and the discharge volumes, velocities, and time-to-peak discharge for the pre- and post-development conditions are similar.
- The landfill is not within the 100-year floodway or 100-year floodplain. As such, no waste filling will occur in the 100-year floodplain as a part of the expansion of the landfill. The landfill is protected from the 100-year frequency flood event.

The post-development drainage patterns will be similar to the existing pre-development permitted drainage patterns and will direct surface water runoff to the same outfall locations. The existing pre-development drainage patterns will not be adversely altered.

## 10. REFERENCES

Chow, V.T (1959). *Open Channel-Hydraulics,* McGraw-Hill.

NOAA (2018). Point Precipitation Frequency Estimates, National Oceanic and Atmospheric Administration, Atlas 14, Volume 11, Version 2.0. Available online: https://hdsc.nws.noaa.gov/hdsc/pfds/.

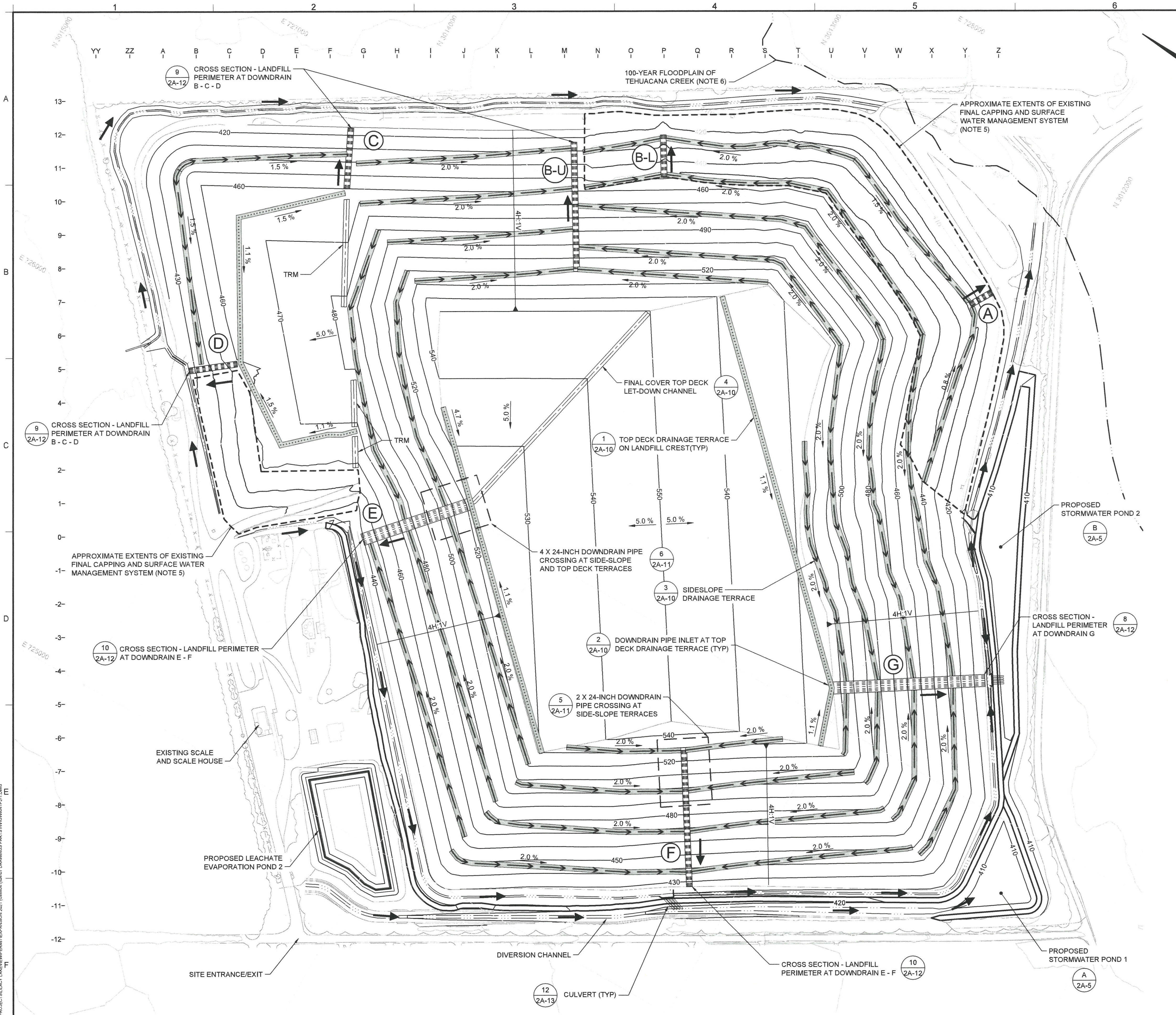
TCEQ (2018). *Surface Water Drainage and Erosional Stability Guidelines for a Municipal Solid Waste Landfill,* Regulatory Guidance 417 (RG-417), Texas Commission on Environmental Quality, Waste Permits Division, Revised May 2018.

TxDOT (2019). *Hydraulic Design Manual*, Texas Department of Transportation, revised September 2019.

# ATTACHMENT 2A

# SURFACE WATER MANAGEMENT SYSTEM DRAWINGS

| LIST OF DRAWINGS | | |
|---|---|---|
| Drawing No. | Title | Drawing Date (latest revision) |
| 2A-1 | Facility Surface Water Management Plan | October 2022 |
| 2A-2 | Pre-Development Plan with Drainage Patterns | October 2022 |
| 2A-3 | Post-Development Plan with Drainage Patterns | October 2022 |
| 2A-4 | Overall Drainage Areas | October 2022 |
| 2A-5 | Stormwater Ponds | October 2022 |
| 2A-6 | Perimeter Drainage Channel Plan with Stationing | October 2022 |
| 2A-7 | Storm Water Channel North and East (Existing) Profile | October 2022 |
| 2A-8 | Perimeter Storm Water Channel Profile (West and South) | October 2022 |
| 2A-9 | Diversion Channel Profile | October 2022 |
| 2A-10 | Surface Water Management System Details I | October 2022 |
| 2A-11 | Surface Water Management System Details II | October 2022 |
| 2A-12 | Surface Water Management System Details III | October 2022 |
| 2A-13 | Surface Water Management System Details IV | October 2022 |
| 2A-14 | Surface Water Management System Details V | October 2022 |




PERMIT DRAWING

## LEGEND

- EXISTING GROUND ELEVATION CONTOUR (FT, MSL) (NOTES 1, 2)
- EXISTING ROAD
- EXISTING VEGETAION / TREE
- EXISTING FENCE
- EXISTING BUILDING
- EXISTING WATER LINE
- COORDINATE GRID (NOTE 2)
- SITE GRID
- PERMIT BOUNDARY
- 400 — PROPOSED GROUND ELEVATION (FT, MSL) (NOTE 3)
- SIDESLOPE DRAINAGE TERRACE
- TYPICAL DOWNDRAIN (PROPOSED 2 X 24" HDPE OR EXISTING 1 X 24" HDPE) (NOTE 5)
- 4 X 24" HDPE DOWNDRAIN
- (A) DOWNDRAIN DESIGNATION
- TOP DECK DRAINAGE TERRACE
- RIDGE LINE PROTECTION ( LET-DOWN CHANNEL OR TRM)
- SURFACE WATER FLOW DIRECTION
- 2.0 % BENCH FLOW DIRECTION AND LONGITUDINAL SLOPE INDICATOR.
- PERIMETER DRAINAGE CHANNEL

NOTES:

1. TOPOGRAPHIC BASE MAP OF EXISTING SITE CONDITIONS WAS GENERATED BY PHOTOGRAMMETRIC METHODS BASED ON AN AERIAL SURVEY FLOWN ON 01 FEBRUARY 2022 BY HYDREX ENVIRONMENTAL. EXISTING TOPOGRAPHY IN OBSCURED AREAS AND / OR OUTSIDE OF PROPERTY WHERE SHOWN SUPPLEMENTED WITH THE UNITED STATES GEOLOGIC SURVEY (USGS) 3DEP PROGRAM, 3 METER RESOLUTION LIDAR FLOWN IN 2011.
2. ELEVATIONS ARE IN FEET ABOVE MEAN SEA LEVEL (FT, MSL), AS DEFINED BY THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988. COORDINATE GRID OF NORTHINGS AND EASTINGS IS A LOCAL COORDINATE GRID BASED ON A TRANSLATION FROM STATE PLANE COORDINATES, THAT HAS BEEN USED FOR HISTORICAL SURVEY ACTIVITIES AT THE SITE.
3. PROPOSED GROUND WITHIN THE LIMIT OF FINAL COVER REFERS TO TOP OF FINAL COVER SYSTEM (TOP OF THE TOPSOIL COMPONENT OF THE FINAL COVER SYSTEM). OUTSIDE OF THE LIMIT OF FINAL COVER, THE PROPOSED CONTOURS REFER TO FINISHED GRADE.
4. REFER TO DRAWING 2A-5 FOR STORMWATER MANAGEMENT FEATURES ASSOCIATED WITH STORMWATER PONDS AND DRAWING 2A-6 FOR DESIGNATIONS OF CULVERTS AND PERIMETER DRAINAGE CHANNELS (NOT SHOWN ON THIS DRAWING FOR CLARITY).
5. DOWNDRAIN A, DOWNDRAIN B-L, AND ALL TERRACES WITHIN THE EXTENTS SHOWN EXIST AS PART OF MSW PERMIT NO. 1646A AT AREAS THAT HAVE BEEN FINAL CAPPED, AND WILL REMAIN IN-SERVICE.
6. 100-YEAR FLOODPLAIN IS TAKEN FROM FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA) FLOOD INSURANCE RATE MAP NUMBER 48309C0400D (PANEL 400) REVISED 20 DECEMBER 2019, AS SHOWN ON DRAWING I IIA-18.

0 150' 300'
SCALE IN FEET

STATE OF TEXAS
SCOTT M. GRAVES
86557
LICENSED PROFESSIONAL ENGINEER

6/21/2022

FOR PERMIT PURPOSES ONLY

| REV | DATE | DESCRIPTION | DRN | APP |
|---|---|---|---|---|

CITY OF LACY LAKEVIEW AND WASTE MANAGEMENT OF TEXAS INC.
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TEXAS ENG. FIRM REGISTRATION NUMBER 1182
8217 SHOAL CREEK BLVD, SUITE 200
AUSTIN, TEXAS 78757
PHONE: 512.451.4003

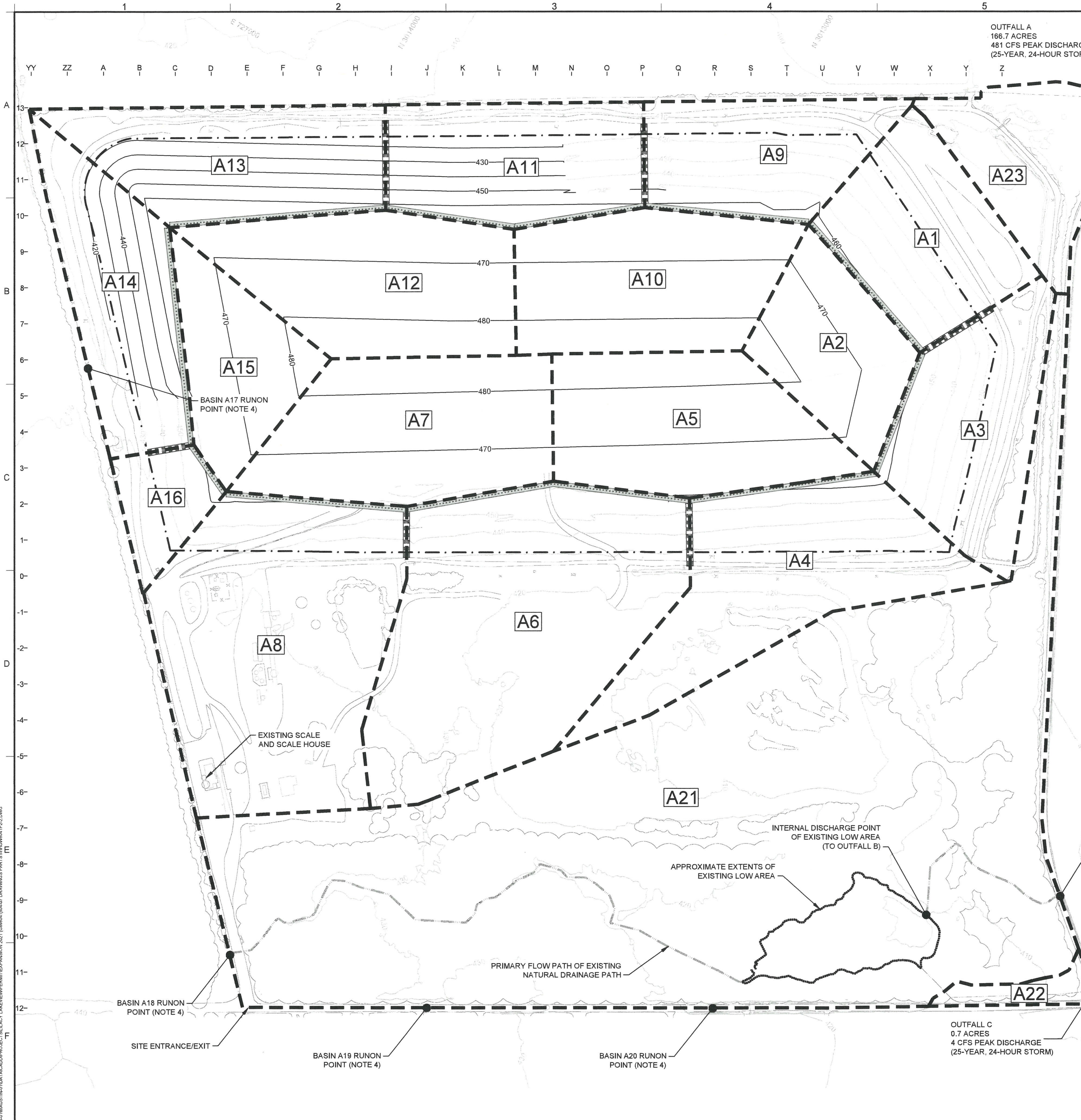
TITLE:

# FACILITY SURFACE WATER MANAGEMENT PLAN

PROJECT:

LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

| PROJECT NO.: GW8041 | DESIGN BY: SMG | REVIEWED BY: YB | PART NO.: III | DRAWING: 2A-1 |
|---|---|---|---|---|
| FILE: GW8041P2-1 | DRAWN BY: JJV / KH | APPROVED BY: SMG | | |




PRE-DEVELOPMENT SUMMARY (NOTE 6)

| BASIN ID | BASIN AREA (ACRES) | 25-YEAR PEAK DISCHARGE (CFS) | TIME OF CONCENTRATION, Tc (MINUTES) |
|---|---|---|---|
| A1 | 5.15 | 30 | 6.0 |
| A2 | 3.90 | 21 | 8.8 |
| A3 | 5.57 | 32 | 6.0 |
| A4 | 7.93 | 30 | 30.3 |
| A5 | 6.30 | 35 | 8.5 |
| A6 | 12.99 | 51 | 26.8 |
| A7 | 6.82 | 37 | 8.8 |
| A8 | 11.81 | 50 | 22.8 |
| A9 | 4.56 | 26 | 6.0 |
| A10 | 6.29 | 34 | 8.6 |
| A11 | 5.33 | 31 | 6.0 |
| A12 | 6.61 | 36 | 8.6 |
| A13 | 5.79 | 33 | 6.0 |
| A14 | 5.27 | 30 | 6.0 |
| A15 | 3.61 | 20 | 8.6 |
| A16 | 1.69 | 10 | 6.0 |
| A17 | 62.91 | 154 | 78.1 |
| A18 | 19.21 | 41 | 96.1 |
| A19 | 47.26 | 70 | 158.2 |
| A20 | 26.69 | 65 | 74.7 |
| A21 | 45.37 | 202 | 16.7 |
| A22 | 0.71 | 4 | 6.0 |
| A23 | 4.16 | 22 | 11.5 |

## LEGEND

- EXISTING GROUND ELEVATION CONTOUR (FT, MSL) (NOTES 1, 2)
- EXISTING ROAD
- EXISTING VEGETAION / TREE
- EXISTING FENCE
- EXISTING BUILDING
- EXISTING WATER LINE
- COORDINATE GRID (NOTE 2)
- SITE GRID
- PERMIT BOUNDARY
- LIMIT OF WASTE
- PROPOSED GROUND ELEVATION (FT, MSL) (NOTE 3)
- TYPICAL DOWNDRAIN
- TOP DECK DRAINAGE TERRACE
- DRAINAGE AREA
- A3 DRAINAGE AREA DESIGNATION

NOTES:

1. TOPOGRAPHIC BASE MAP OF EXISTING SITE CONDITIONS WAS GENERATED BY PHOTOGRAMMETRIC METHODS BASED ON AN AERIAL SURVEY FLOWN ON 01 FEBRUARY 2022 BY HYDREX ENVIRONMENTAL. EXISTING TOPOGRAPHY IN OBSCURED AREAS AND / OR OUTSIDE OF PROPERTY WHERE SHOWN SUPPLEMENTED WITH THE UNITED STATES GEOLOGIC SURVEY (USGS) 3DEP PROGRAM, 3 METER RESOLUTION LIDAR FLOWN IN 2011.
2. ELEVATIONS ARE IN FEET ABOVE MEAN SEA LEVEL (FT, MSL), AS DEFINED BY THE NORTH AMERICAN VERTICAL DATUM OF 1988. COORDINATE GRID REPRESENTS SITE COORDINATES BASED ON TEXAS CENTRAL ZONE (4203) COORDINATE SYSTEM, NORTH AMERICAN DATUM OF 1983 (NAD-83).
3. PROPOSED GROUND WITHIN THE LIMIT OF FINAL COVER OF THE EXISTING LADFILL REFERS TO TOP OF FINAL COVER SYSTEM (TOP OF THE TOPSOIL COMPONENT OF THE FINAL COVER SYSTEM).
4. BASINS A17 TO A20 ARE OFF-SITE DRAINAGE AREAS AND ARE SHOWN ON DRAWING 2A-4.
5. BASINS A1 TO A16, A21, AND A23 ARE BASED ON THE LANDFILL COMPLETION PLAN DRAWING (ATTACHMENT NO 9-A, DATED JANUARY 1994) AND ONSITE DRAINAGE AREA MAP (ATTACHMENT NO. 8-B, DATED AUGUST 1986) OF MSW PERMIT NO. 1646A.
6. CALCULATIONS FOR PRE-DEVELOPMENT HYDROLOGY ARE PRESENTED IN PART III, ATTACHMENT 2B.

0 150' 300'
SCALE IN FEET

STATE OF TEXAS
SCOTT M. GRAVES
86557
LICENSED PROFESSIONAL ENGINEER

12/21/2022

FOR PERMIT PURPOSES ONLY

| REV | DATE | DESCRIPTION | DRN | APP |
|---|---|---|---|---|

CITY OF LACY LAKEVIEW AND WASTE MANAGEMENT OF TEXAS INC.
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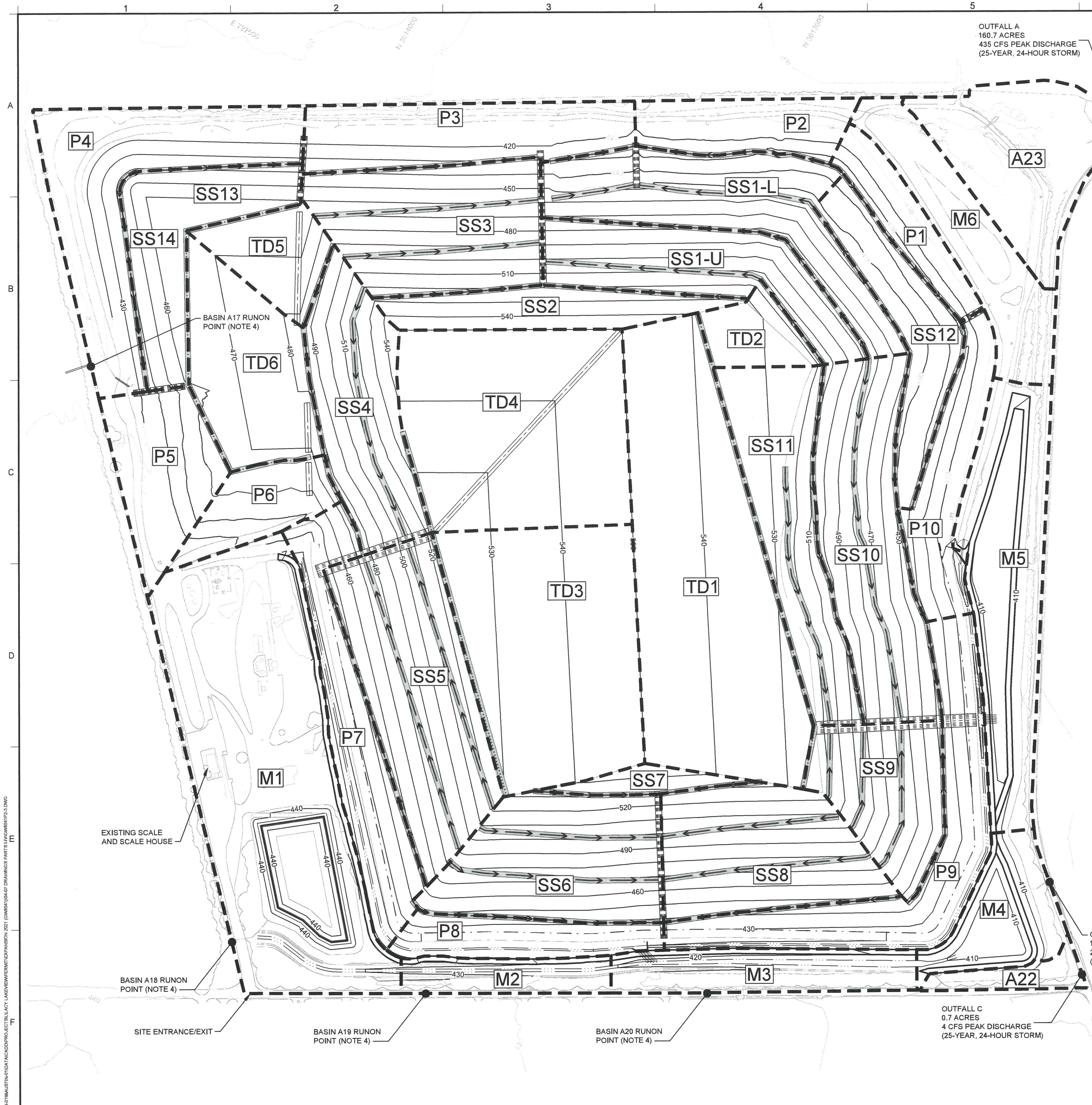
TITLE:
PRE-DEVELOPMENT PLAN WITH DRAINAGE PATTERNS

PROJECT:
LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

PERMIT DRAWING

| PROJECT NO.: GW8041 | DESIGN BY: SMG | REVIEWED BY: YB | PART NO.: III | DRAWING: 2A-2 |
|---|---|---|---|---|
| FILE: GW8041P2-2 | DRAWN BY: JJV / KH | APPROVED BY: SMG | | |




| POST-DEVELOPMENT SUMMARY (NOTE 5) | | | |
|---|---|---|---|
| BASIN ID | BASIN AREA (ACRES) | 25-YEAR PEAK DISCHARGE (CFS) | TME OF CONCENTRATION, Tc (MINUTES) |
| TD1 | 10.75 | 57 | 10.8 |
| TD2 | 1.18 | 6 | 10.1 |
| TD3 | 8.07 | 42 | 11.5 |
| TD4 | 8.00 | 42 | 11.1 |
| TD5 | 1.71 | 9 | 8.8 |
| TD6 | 3.82 | 21 | 8.6 |
| SS1-L | 4.89 | 28 | 6.0 |
| SS1-U | 3.77 | 22 | 6.0 |
| SS2 | 2.19 | 13 | 6.0 |
| SS3 | 4.96 | 28 | 6.0 |
| SS4 | 4.01 | 23 | 6.0 |
| SS5 | 5.97 | 34 | 6.0 |
| SS6 | 4.74 | 27 | 6.0 |
| SS7 | 0.65 | 4 | 6.0 |
| SS8 | 4.48 | 26 | 6.0 |
| SS9 | 3.12 | 18 | 6.0 |
| SS10 | 5.53 | 32 | 6.0 |
| SS11 | 4.37 | 23 | 10.3 |
| SS12 | 2.81 | 16 | 6.0 |
| SS13 | 1.47 | 8 | 6.0 |
| SS14 | 1.81 | 10 | 6.0 |
| P1 | 1.60 | 9 | 6.0 |
| P2 | 2.11 | 12 | 6.0 |
| P3 | 3.62 | 21 | 6.0 |
| P4 | 5.49 | 32 | 6.0 |
| P5 | 2.82 | 16 | 6.0 |
| P6 | 1.73 | 10 | 6.0 |
| P7 | 3.64 | 21 | 6.0 |
| P8 | 1.85 | 11 | 6.0 |
| P9 | 4.66 | 26 | 6.6 |
| P10 | 2.53 | 15 | 6.0 |
| M1 | 12.11 | 45 | 29.7 |
| M2 | 1.37 | 8 | 6.0 |
| M3 | 2.38 | 14 | 6.0 |
| M4 | 2.23 | 14 | 6.0 |
| M5 | 5.26 | 32 | 6.0 |
| M6 | 3.27 | 19 | 6.0 |
| A17 | 62.91 | 154 | 78.1 |
| A18 | 19.21 | 41 | 96.1 |
| A19 | 47.26 | 70 | 158.2 |
| A20 | 26.69 | 65 | 74.7 |
| A22 | 0.71 | 4 | 6.0 |
| A23 | 4.16 | 22 | 11.5 |

0 150' 300'
SCALE IN FEET

## LEGEND

- EXISTING GROUND ELEVATION CONTOUR (FT, MSL) (NOTES 1, 2)
- EXISTING ROAD
- EXISTING VEGETAION / TREE
- EXISTING BUILDING
- EXISTING WATER LINE
- COORDINATE GRID (NOTE 2)
- PERMIT BOUNDARY
- 400 — PROPOSED GROUND ELEVATION (FT, MSL) (NOTE 3)
- SIDESLOPE DRAINAGE TERRACE
- TYPICAL DOWNDRAIN (PROPOSED 2 X 24" HDPE OR EXISTING 1 X 24" HDPE)
- 4 X 24" HDPE DOWNDRAIN
- TOP DECK DRAINAGE TERRACE
- RIDGE LINE PROTECTION (LET-DOWN CHANNEL OR TRM)
- DRAINAGE AREA
- A3 — DRAINAGE AREA DESIGNATION

NOTES:

1. TOPOGRAPHIC BASE MAP OF EXISTING SITE CONDITIONS WAS GENERATED BY PHOTOGRAMMETRIC METHODS BASED ON AN AERIAL SURVEY FLOWN ON 01 FEBRUARY 2022 BY HYDREX ENVIRONMENTAL. EXISTING TOPOGRAPHY IN OBSCURED AREAS AND / OR OUTSIDE OF PROPERTY WHERE SHOWN SUPPLEMENTED WITH THE UNITED STATES GEOLOGIC SURVEY (USGS) 3DEP PROGRAM, 3 METER RESOLUTION LIDAR FLOWN IN 2011.
2. ELEVATIONS ARE IN FEET ABOVE MEAN SEA LEVEL (FT, MSL), AS DEFINED BY THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988. COORDINATE GRID OF NORTHINGS AND EASTINGS IS A LOCAL COORDINATE GRID BASED ON A TRANSLATION FROM STATE PLANE COORDINATES, THAT HAS BEEN USED FOR HISTORICAL SURVEY ACTIVITIES AT THE SITE.
3. PROPOSED GROUND WITHIN THE LIMIT OF FINAL COVER REFERS TO TOP OF FINAL COVER SYSTEM (TOP OF THE TOPSOIL COMPONENT OF THE FINAL COVER SYSTEM). OUTSIDE OF THE LIMIT OF FINAL COVER, THE PROPOSED CONTOURS REFER TO FINISHED GRADE.
4. BASINS A17 TO A20 ARE OFF-SITE DRAINAGE AREAS AND ARE SHOWN ON DRAWING 2A-4.
5. CALCULATIONS FOR THE POST-DEVELOPMENT HYDROLOGY ARE PRESENTED IN PART III, ATTACHMENT 2B.

STATE OF TEXAS
SCOTT M. GRAVES
86557
LICENSED
PROFESSIONAL ENGINEER

10/21/2022

FOR PERMIT PURPOSES ONLY

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

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8217 SHOAL CREEK BLVD, SUITE 200
AUSTIN, TEXAS 78757
PHONE: 512.451.4003

TITLE:
# POST-DEVELOPMENT PLAN WITH DRAINAGE PATTERNS

PROJECT:
LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

PERMIT DRAWING

| PROJECT NO.: GW8041 | DESIGN BY: SMG | REVIEWED BY: YB | PART NO.: III | DRAWING: 2A-3 |
|---|---|---|---|---|
| FILE: GW8041P2-3 | DRAWN BY: JJV / KH | APPROVED BY: SMG | | |


## LEGEND

- EXISTING GROUND ELEVATION CONTOUR (FT, MSL) (NOTES 1, 2)
- EXISTING ROAD
- EXISTING BUILDING
- EXISTING WATER LINE
- PERMIT BOUNDARY
- FLOW PATH FOR TIME OF CONCENTRATION, TC, CALCULATION
- DRAINAGE AREA

NOTES:

1. TOPOGRAPHIC BASE MAP OF EXISTING SITE CONDITIONS WAS GENERATED BY PHOTOGRAMMETRIC METHODS BASED ON AN AERIAL SURVEY FLOWN ON 01 FEBRUARY 2022 BY HYDREX ENVIRONMENTAL. EXISTING TOPOGRAPHY IN OBSCURED AREAS AND / OR OUTSIDE OF PROPERTY WHERE SHOWN SUPPLEMENTED WITH THE UNITED STATES GEOLOGIC SURVEY (USGS) LIDAR PROGRAMS,0.5- 3 METER RESOLUTION LIDAR FLOWN IN 2011-2020.
2. ELEVATIONS ARE IN FEET ABOVE MEAN SEA LEVEL (FT, MSL), AS DEFINED BY THE NORTH AMERICAN VERTICAL DATUM OF 1988.
3. 100-YEAR FLOODPLAIN IS TAKEN FROM FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA) FLOOD INSURANCE RATE MAP NUMBER 48309C0400D (PANEL 400) REVISED 20 DECEMBER 2019, AS SHOWN ON DRAWING I IIA-18.
4. SUBDIVIDED DRAINAGE AREAS WITHIN THE SHARED SITE BASIN BOUNDARY ARE SHOWN ON DRAWING 2A-2 FOR THE PRE-DEVELOPMENT CONDITION AND ON DRAWING 2A-3 FOR THE PRE-DEVELOPMENT CONDITION.
5. CALCULATIONS FOR THE OFF-SITE HYDROLOGY ARE PRESENTED IN PART III, ATTACHMENT 2B.

OFF-SITE HYDROLOGY SUMMARY (NOTE 5)

| BASIN ID | BASIN AREA (ACRES) | 25-YEAR PEAK DISCHARGE (CFS) | TME OF CONCENTRATION, Tc (MINUTES) |
|---|---|---|---|
| A17 | 62.91 | 154 | 78.1 |
| A18 | 19.21 | 41 | 96.1 |
| A19 | 47.26 | 70 | 158.2 |
| A20 | 26.69 | 65 | 44.8 |

STATE OF TEXAS
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86557
LICENSED
PROFESSIONAL ENGINEER
10/21/2022

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| 0 | | ---- | JJV / KH | SMG |

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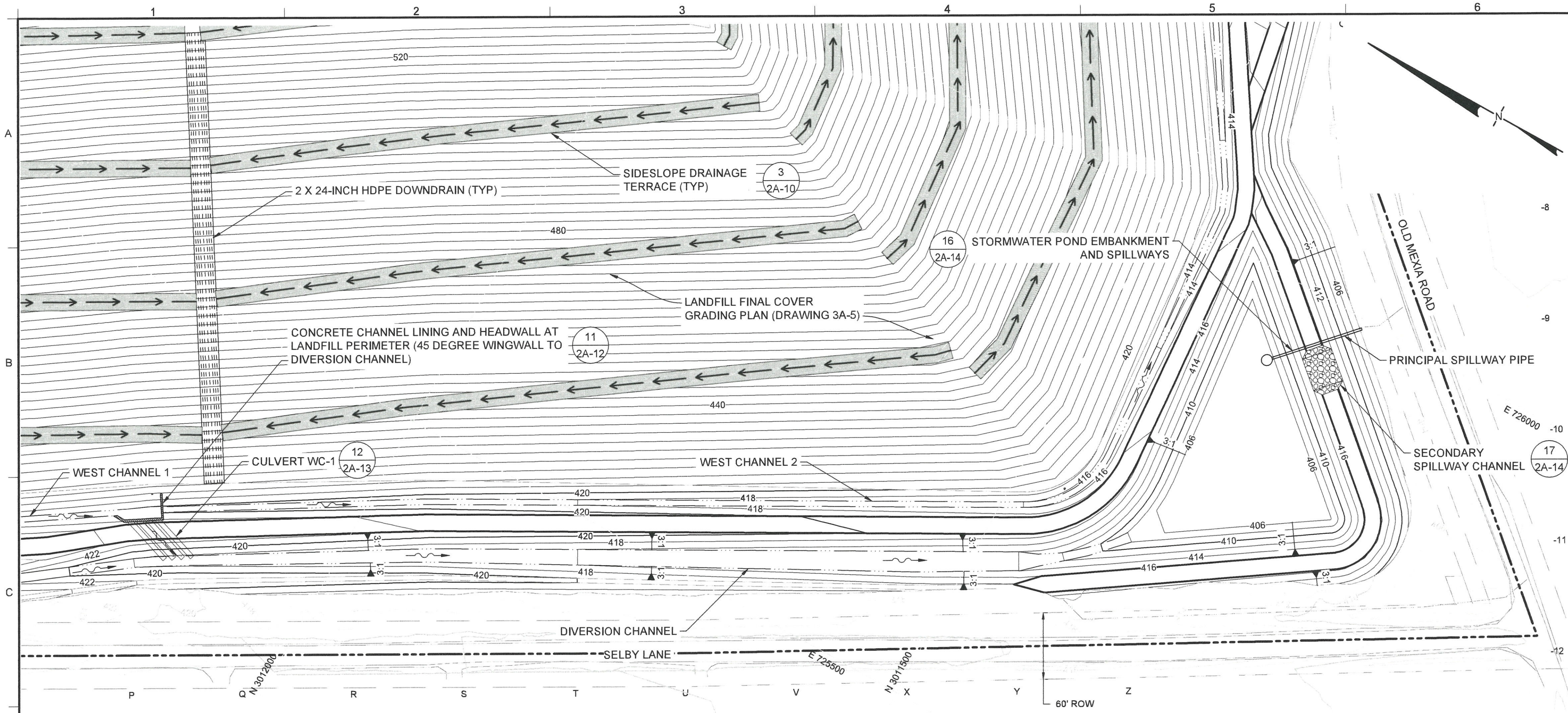
AUSTIN, TEXAS 78757
PHONE: 512.451.4003

TITLE:
OVERALL DRAINAGE AREAS

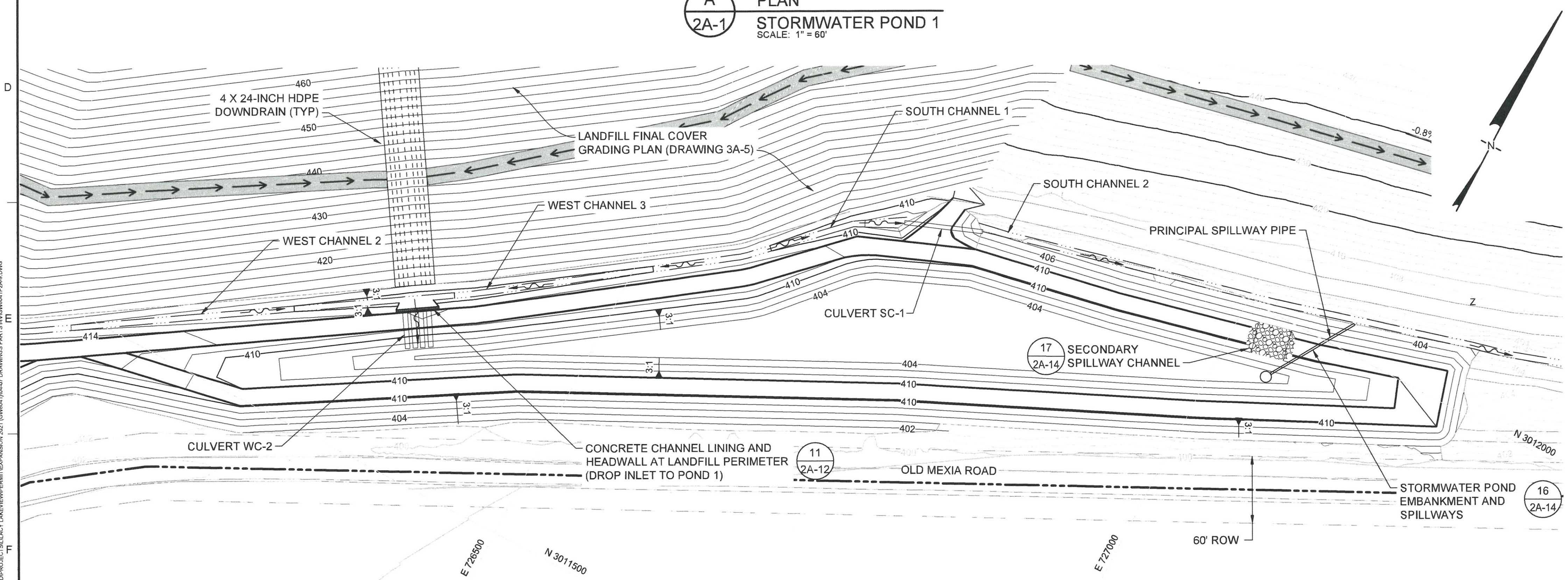
PROJECT:
LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

| PROJECT NO.: GW8041 | DESIGN BY: SMG | REVIEWED BY: YB | PART NO.: III | DRAWING: 2A-4 |
|---|---|---|---|---|
| FILE: GW8041P2-4 | DRAWN BY: JJV / KH | APPROVED BY: SMG | | |

PERMIT DRAWING




A 2A-1 PLAN
STORMWATER POND 1
SCALE: 1" = 60'




B 2A-1 PLAN
STORMWATER POND 2
SCALE: 1" = 60'

## LEGEND

| | |
|---|---|
| 420 | EXISTING GROUND ELEVATION CONTOUR (FT, MSL) (NOTES 1, 2) |
| | EXISTING ROAD |
| | EXISTING WATER LINE |
| | EXISTING EASEMENT OR RIGHT-OF-WAY |
| N 3014000 E 728000 | COORDINATE GRID (NOTE 2) |
| A 13 | SITE GRID |
| | PERMIT BOUNDARY |
| | PROPOSED LIMIT OF COVER |
| 400 | PROPOSED GROUND ELEVATION (FT, MSL) (NOTE 3) |
| | SURFACE WATER FLOW DIRECTION |
| | PERIMETER DRAINAGE CHANNEL |

NOTES:

1. TOPOGRAPHIC BASE MAP OF EXISTING SITE CONDITIONS WAS GENERATED BY PHOTOGRAMMETRIC METHODS BASED ON AN AERIAL SURVEY FLOWN ON 01 FEBRUARY 2022 BY HYDREX ENVIRONMENTAL. EXISTING TOPOGRAPHY IN OBSCURED AREAS AND / OR OUTSIDE OF PROPERTY WHERE SHOWN SUPPLEMENTED WITH THE UNITED STATES GEOLOGIC SURVEY (USGS) 3DEP PROGRAM, 3 METER RESOLUTION LIDAR FLOWN IN 2011.
2. ELEVATIONS ARE IN FEET ABOVE MEAN SEA LEVEL (FT, MSL), AS DEFINED BY THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988. COORDINATE GRID OF NORTHINGS AND EASTINGS IS A LOCAL COORDINATE GRID BASED ON A TRANSLATION FROM STATE PLANE COORDINATES, THAT HAS BEEN USED FOR HISTORICAL SURVEY ACTIVITIES AT THE SITE.
3. PROPOSED FINISHED GRADE WITHIN THE LIMIT OF FINAL COVER REFERS TO TOP OF FINAL COVER SYSTEM (TOP OF THE TOPSOIL COMPONENT OF THE FINAL COVER SYSTEM). OUTSIDE OF THE LIMIT OF FINAL COVER, THE PROPOSED CONTOURS REFER TO FINISHED GRADE.

0 60' 120'
SCALE IN FEET

STATE OF TEXAS
SCOTT M. GRAVES
86557
LICENSED PROFESSIONAL ENGINEER
10/21/2022

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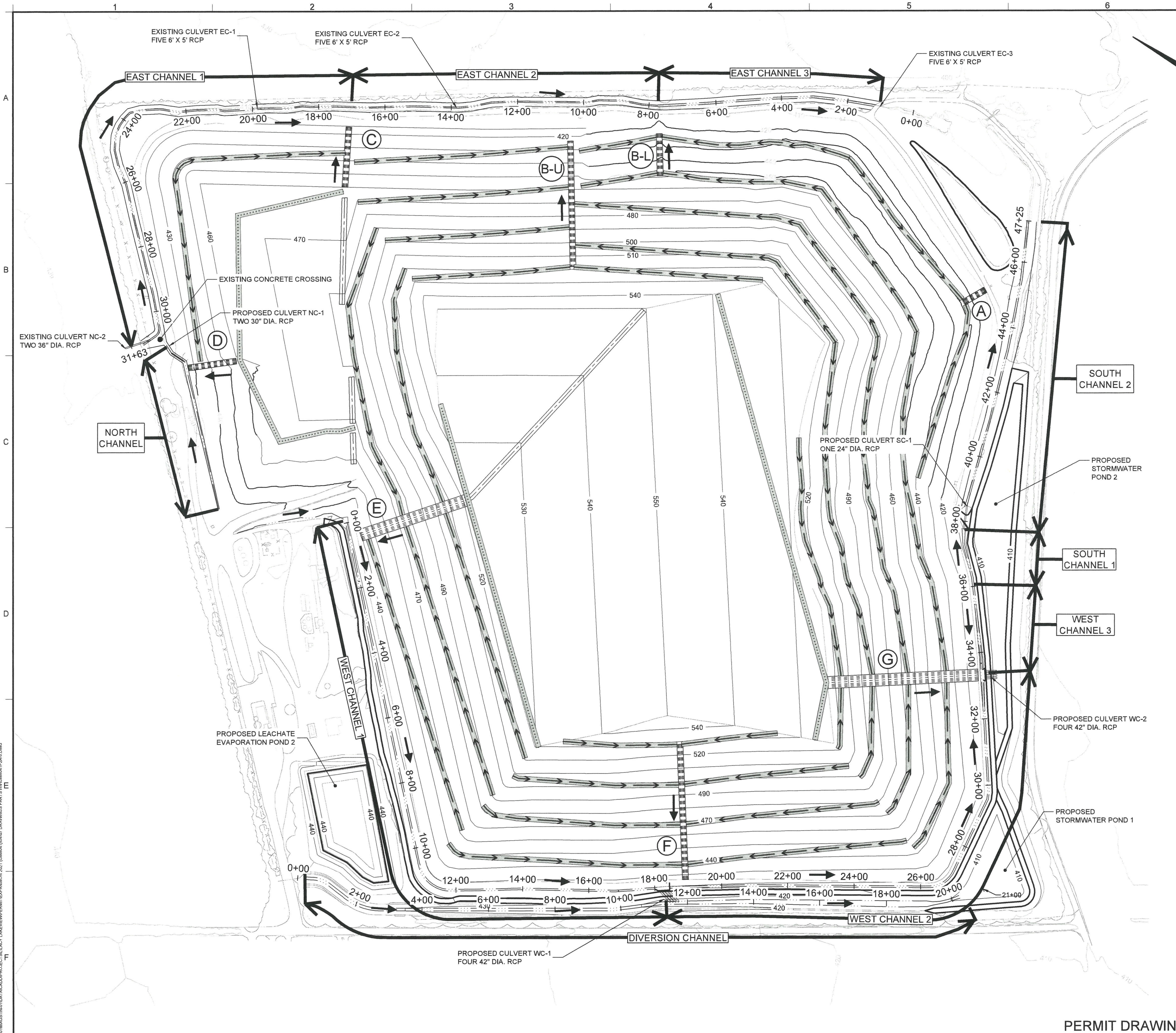
PHONE: 512.451.4003

TITLE: STORMWATER PONDS

PROJECT: LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| PROJECT NO.: | GW8041 | DESIGN BY: | SMG | REVIEWED BY: | YB | PART NO.: III | DRAWING: 2A-5 |
| FILE: | GW8041P2A-9 | DRAWN BY: | JJV / KH | APPROVED BY: | SMG | | |

PERMIT DRAWING




## LEGEND

- EXISTING GROUND ELEVATION CONTOUR (FT, MSL) (NOTES 1, 2)
- EXISTING ROAD
- EXISTING VEGETAION / TREE
- EXISTING FENCE
- EXISTING BUILDING
- EXISTING WATER LINE
- SITE GRID
- PERMIT BOUNDARY
- PROPOSED GROUND ELEVATION (FT, MSL) (NOTE 3)
- SIDESLOPE DRAINAGE TERRACE
- DOWNCHUTE DRAINAGE CHANNEL
- TOP DECK DRAINAGE TERRACE
- RIPRAP/TRM LINED EMBEDDED TOP DECK CHANNEL
- DOWNDRAIN DESIGNATION
- CHANNEL REACH DESIGNATION
- SURFACE WATER FLOW DIRECTION
- PERIMETER DRAINAGE CHANNEL AND ALIGNMENT STATIONING

NOTES:

1. TOPOGRAPHIC BASE MAP OF EXISTING SITE CONDITIONS WAS GENERATED BY PHOTOGRAMMETRIC METHODS BASED ON AN AERIAL SURVEY FLOWN ON 01 FEBRUARY 2022 BY HYDREX ENVIRONMENTAL. EXISTING TOPOGRAPHY IN OBSCURED AREAS AND / OR OUTSIDE OF PROPERTY WHERE SHOWN SUPPLEMENTED WITH THE UNITED STATES GEOLOGIC SURVEY (USGS) 3DEP PROGRAM, 3 METER RESOLUTION LIDAR FLOWN IN 2011.
2. ELEVATIONS ARE IN FEET ABOVE MEAN SEA LEVEL (FT, MSL), AS DEFINED BY THE NORTH AMERICAN VERTICAL DATUM OF 1988.
3. PROPOSED GROUND WITHIN THE LIMIT OF FINAL COVER REFERS TO TOP OF FINAL COVER SYSTEM (TOP OF THE TOPSOIL COMPONENT OF THE FINAL COVER SYSTEM). OUTSIDE OF THE LIMIT OF FINAL COVER, THE PROPOSED CONTOURS REFER TO FINISHED GRADE.
4. REFER TO DRAWING 2A-1 FOR ADDITIONAL SURFACE WATER MANAGEMENT FEATURES ON THE FINAL COVER SYSTEM (NOT SHOWN ON THIS DRAWING FOR CLARITY).
5. REFER TO DETAIL 12 ON DRAWING 2A-13 FOR THE CONFIGURATION OF INDIVIDUAL CULVERTS DESIGNATED ON THIS DRAWING.
6. REFER TO DETAIL 13 ON DRAWING 2A-13 FOR THE CONFIGURATION OF INDIVIDUAL PERIMETER DRAINAGE CHANNEL REACHES DESIGNATED ON THIS DRAWING.

0 150' 300'
SCALE IN FEET

STATE OF TEXAS
SCOTT M. GRAVES
86557
LICENSED PROFESSIONAL ENGINEER
10/21/2022

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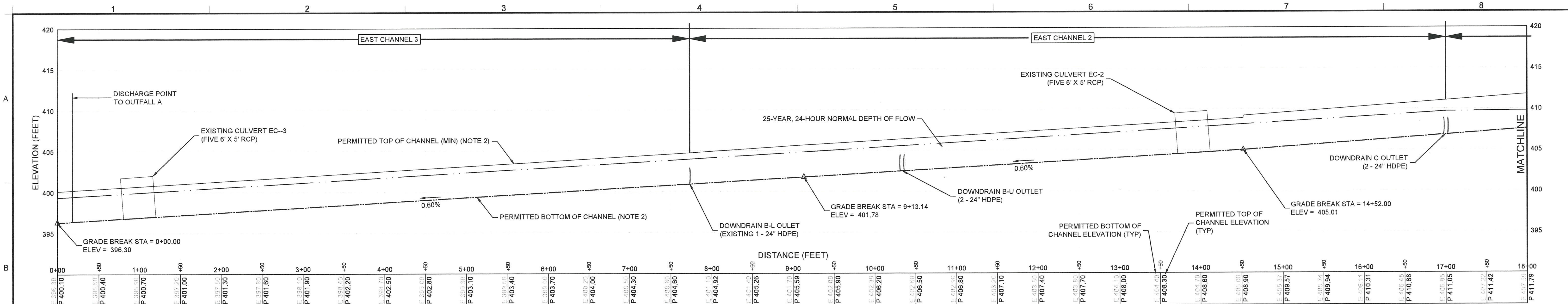
AUSTIN, TEXAS 78757
PHONE: 512.451.4003

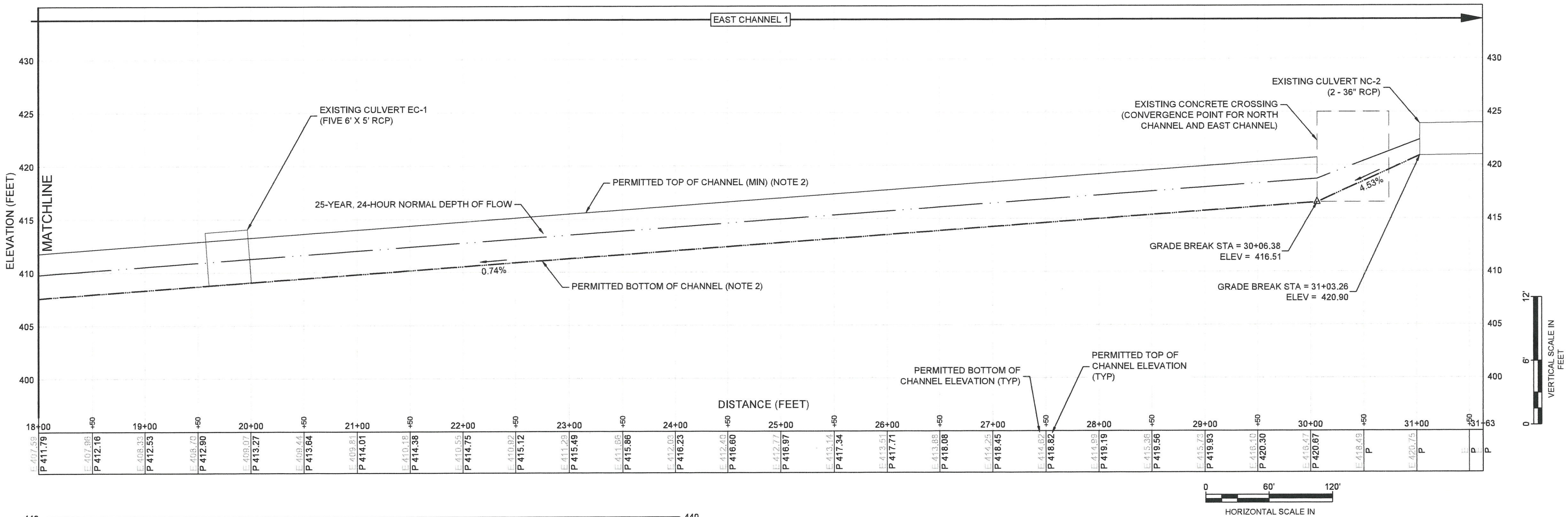
TITLE: PERIMETER DRAINAGE CHANNEL PLAN WITH STATIONING

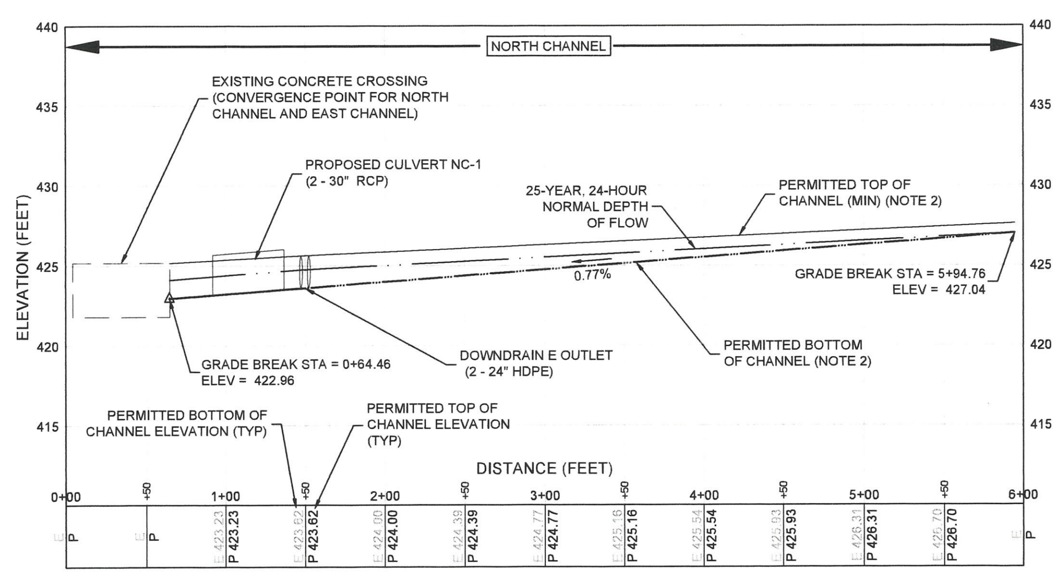
PROJECT: LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

PERMIT DRAWING

| PROJECT NO.: GW8041 | DESIGN BY: SMG | REVIEWED BY: YB | PART NO.: III | DRAWING: 2A-6 |
|---|---|---|---|---|
| FILE: GW8041P2A-5 | DRAWN BY: JJV / KH | APPROVED BY: SMG | | |




NOTES:
1. WATER SURFACE LINE REPRESENTS THE 25-YEAR, 24-HOUR NORMAL DEPTH OF FLOW.
2. BOTTOM OF CHANNEL AND PERMITTED MINIMUM TOP OF CHANNEL GRADES FOR THE NORTH AND EAST CHANNELS ARE BASED ON THE ATTACHMENT NO. 8 DRAINAGE DRAWINGS OF MSW PERMIT NO. 1646A (DATED AUGUST 1986).

STATE OF TEXAS
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LICENSED PROFESSIONAL ENGINEER
10/21/2022

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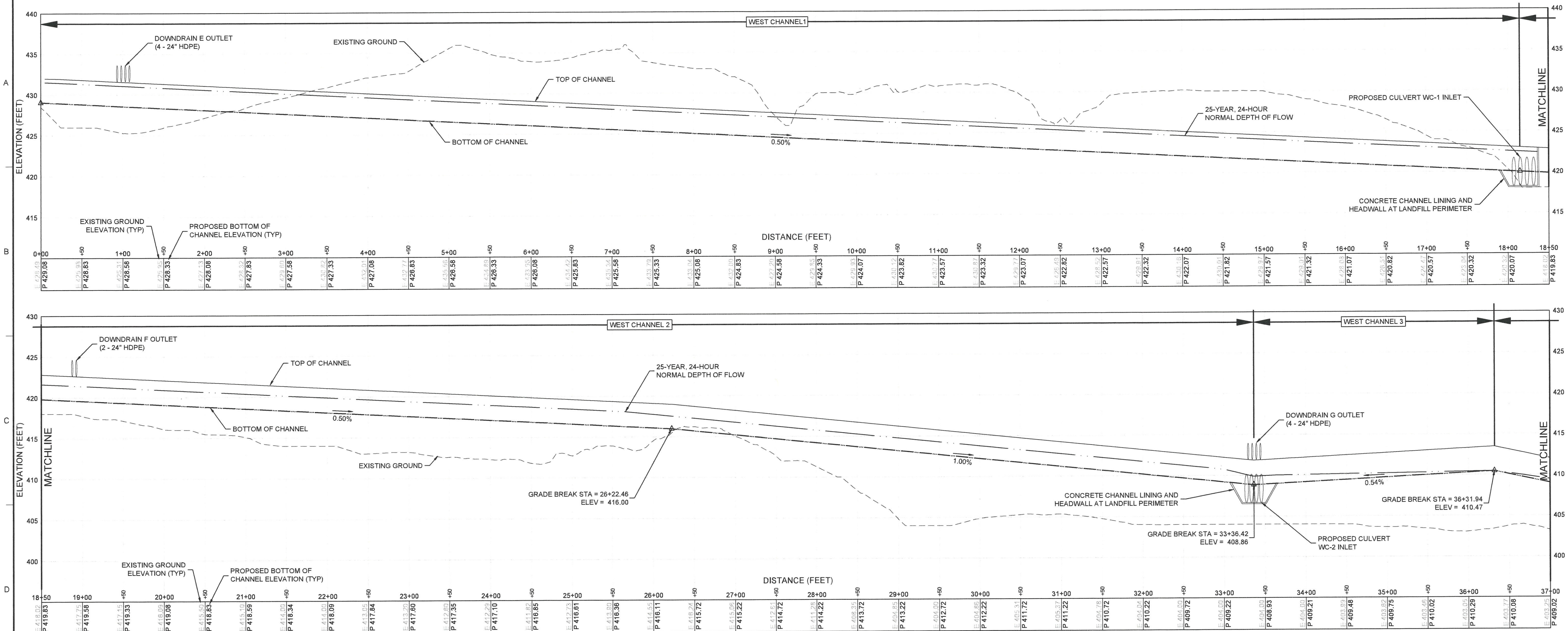
PHONE: 512.451.4003

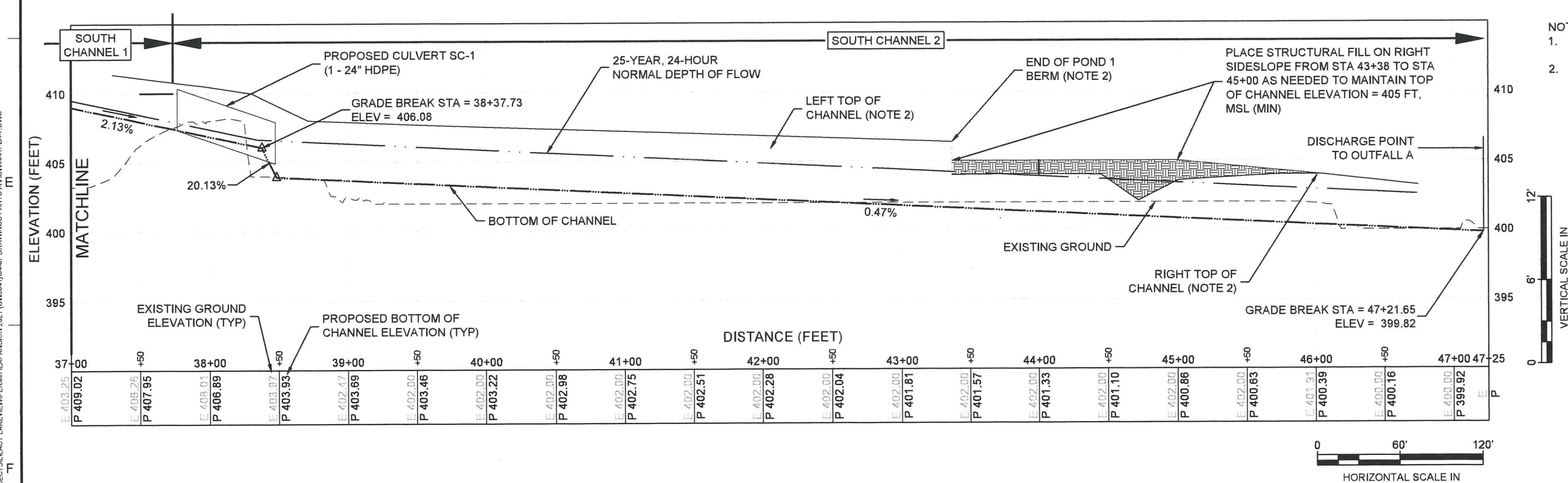
TITLE: STORM WATER CHANNEL NORTH AND EAST (EXISTING) PROFILE

PROJECT: LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

PERMIT DRAWING

| PROJECT NO.: GW8041 | DESIGN BY: SMG | REVIEWED BY: YB | PART NO.: III | DRAWING: 2A-7 |
|---|---|---|---|---|
| FILE: GW8041P2A-6 | DRAWN BY: JJV / KH | APPROVED BY: SMG | | |




NOTES:

1. WATER SURFACE LINE REPRESENTS THE 25-YEAR, 24-HOUR NORMAL DEPTH OF FLOW.
2. THE MINIMUM DEPTH OF CHANNEL 2 IS CONTROLLED BY THE LEFT SIDESLOPE FROM STA. 37+70 TO STA. 43+40 AND THE RIGHT SIDESLOPE FROM STA.43+40 TO THE END OF ALIGNMENT. THIS TRANSITION AT STA 43+40 CORRESPONDS APPROXIMATELY WITH THE END POINT OF THE NORTH FACING EXTERIOR BERM FOR POND 1, WHICH IS PROPOSED TO FUNCTION AS THE RIGHT SIDESLOPE OF CHANNEL 2 FROM STA. 37+70 TO STA. 43+40.

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10/21/2022

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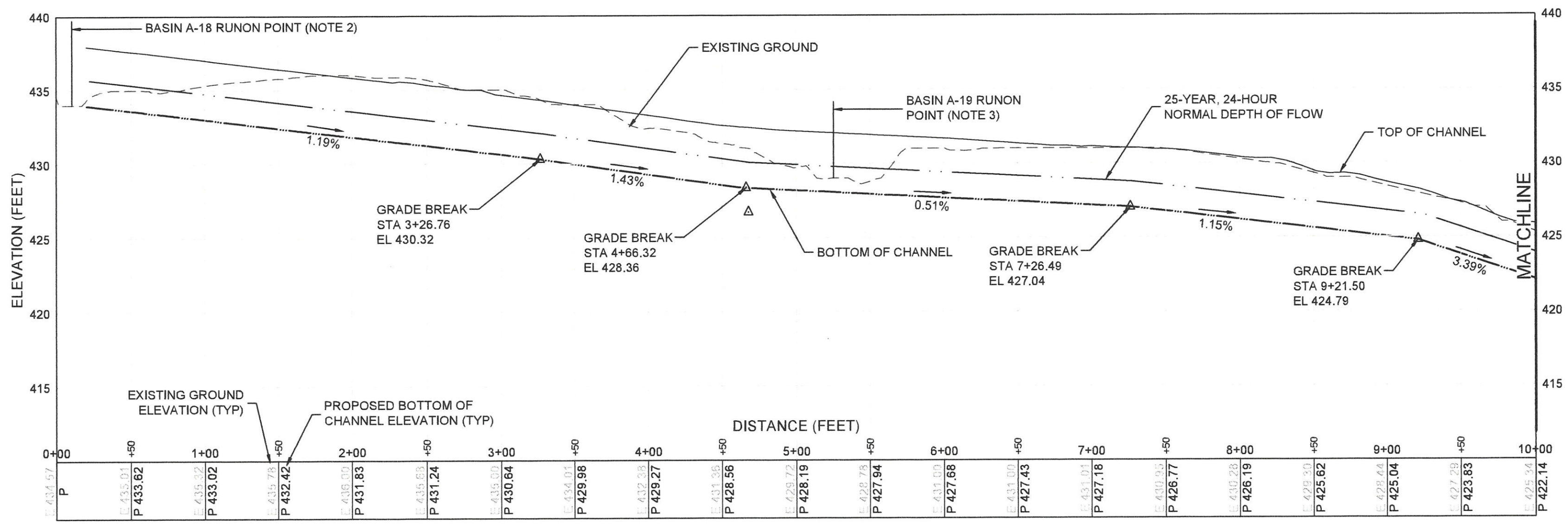
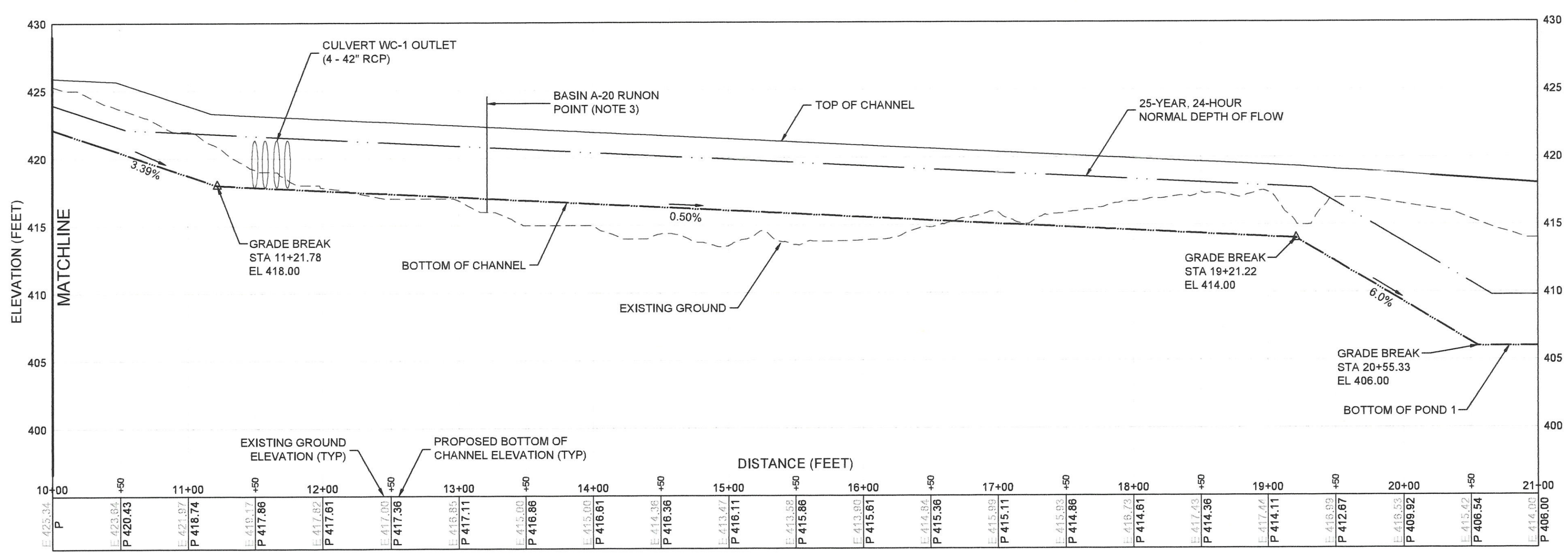
TITLE: PERIMETER STORM WATER CHANNEL PROFILE (WEST AND SOUTH)

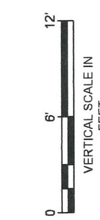
PROJECT: LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

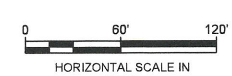
PERMIT DRAWING

| PROJECT NO.: GW8041 | DESIGN BY: SMG | REVIEWED BY: YB | PART NO.: III | DRAWING: 2A-8 |
|---|---|---|---|---|
| FILE: GW8041P2A-7 | DRAWN BY: JJV / KH | APPROVED BY: SMG | | |




NOTES:

1. WATER SURFACE LINE REPRESENTS THE 25-YEAR, 24-HOUR NORMAL DEPTH OF FLOW.
2. REFER TO DRAWING 2A-4 FOR BASIN DELINEATIONS ASSOCIATED WITH RUNON POINTS INTERCEPTED BY THE DIVERSION CHANNEL.

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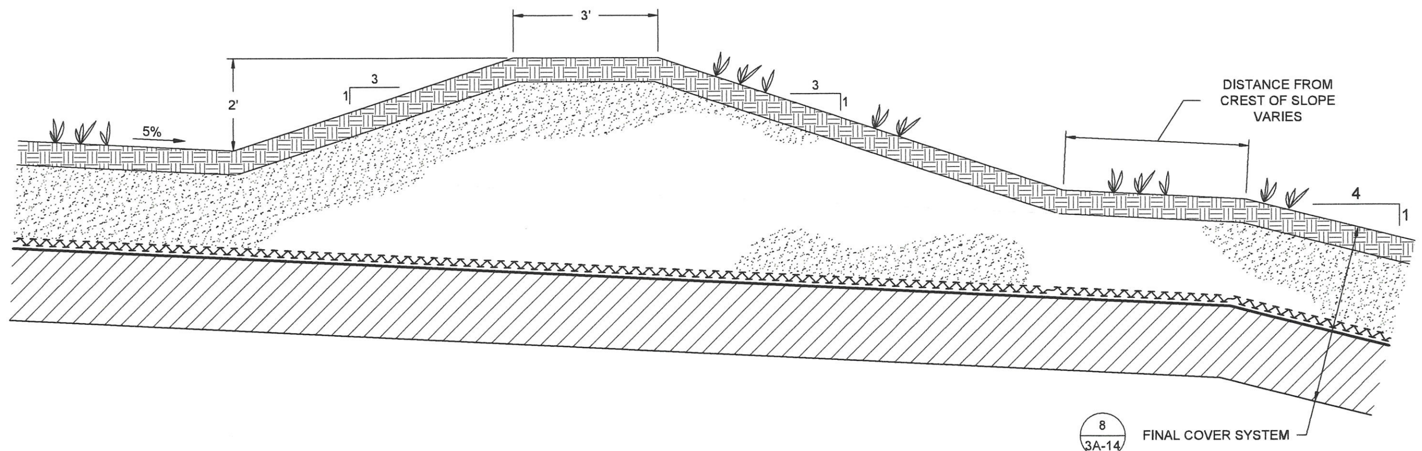
AUSTIN, TEXAS 78757
PHONE: 512.451.4003

TITLE:
# DIVERSION CHANNEL PROFILE

PROJECT:
LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

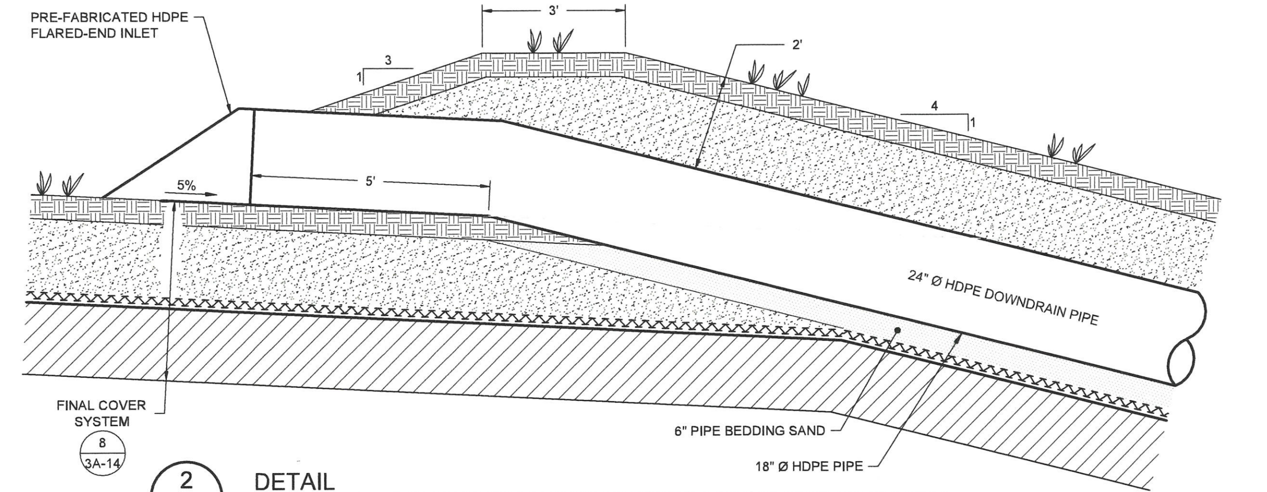
PERMIT DRAWING

| PROJECT NO.: GW8041 | DESIGN BY: SMG | REVIEWED BY: YB | PART NO.: III | DRAWING: 2A-9 |
|---|---|---|---|---|
| FILE: GW8041P2A-8 | DRAWN BY: JJV / KH | APPROVED BY: SMG | | |



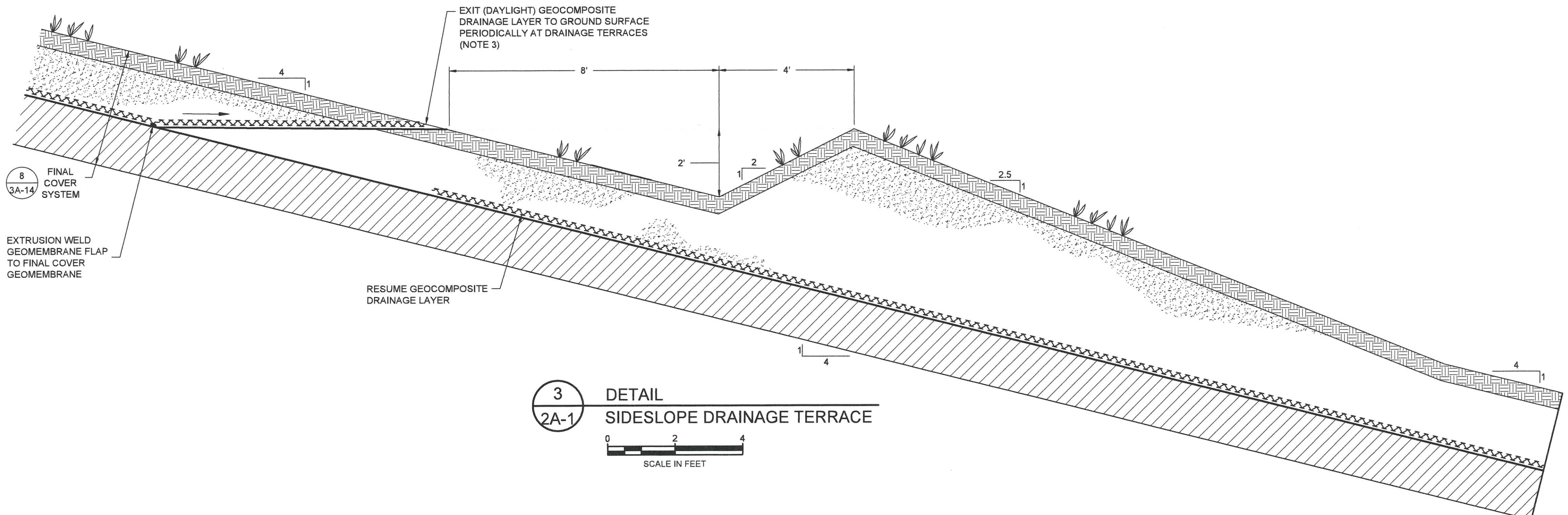

1
2A-1
DETAIL
TOP DECK DRAINAGE TERRACE ON LANDFILL CREST

0 2 4
SCALE IN FEET




2
2A-1
DETAIL
DOWNDRAIN PIPE INLET AT TOP DECK DRAINAGE TERRACE

0 2 4
SCALE IN FEET




3
2A-1
DETAIL
SIDESLOPE DRAINAGE TERRACE

0 2 4
SCALE IN FEET

NOTES:

1. DETAILS ARE SHOWN TO SCALE AS NOTED EXCEPT FOR THE GEOSYNTHETICS WHICH ARE SHOWN AT AN EXAGGERATED SCALE FOR CLARITY.
2. DETAILS ARE DRAWN SHOWING THE "STANDARD SUBTITLE D" COVER SYSTEM. IF THE ALTERNATIVE COVER SYSTEM IS USED, MAINTAIN CONSISTENCY WITH THE CONCEPTS SHOWN ON THESE DETAILS.
3. REFER TO PART III, ATTACHMENT 3G FOR MAXIMUM DRAINAGE LENGTH BETWEEN GEOCOMPOSITE DAYLIGHT POINTS. INSTALL GEOCOMPOSITE EXITS ACCORDINGLY, SO AS NOT TO EXCEED REQUIRED MAXIMUM DRAINAGE LENGTH.

STATE OF TEXAS
SCOTT M. GRAVES
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LICENSED PROFESSIONAL ENGINEER
10/21/2022

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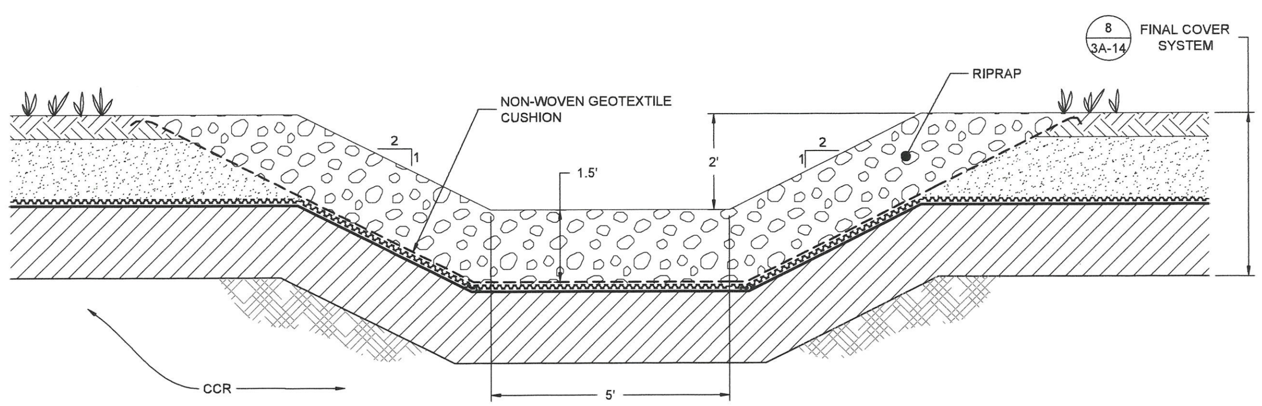


4
2A-1
DETAIL
FINAL COVER TOP DECK LET-DOWN CHANNEL

0 2 4
SCALE IN FEET

PERMIT DRAWING

| REV | DATE | DESCRIPTION | DRN | APP |
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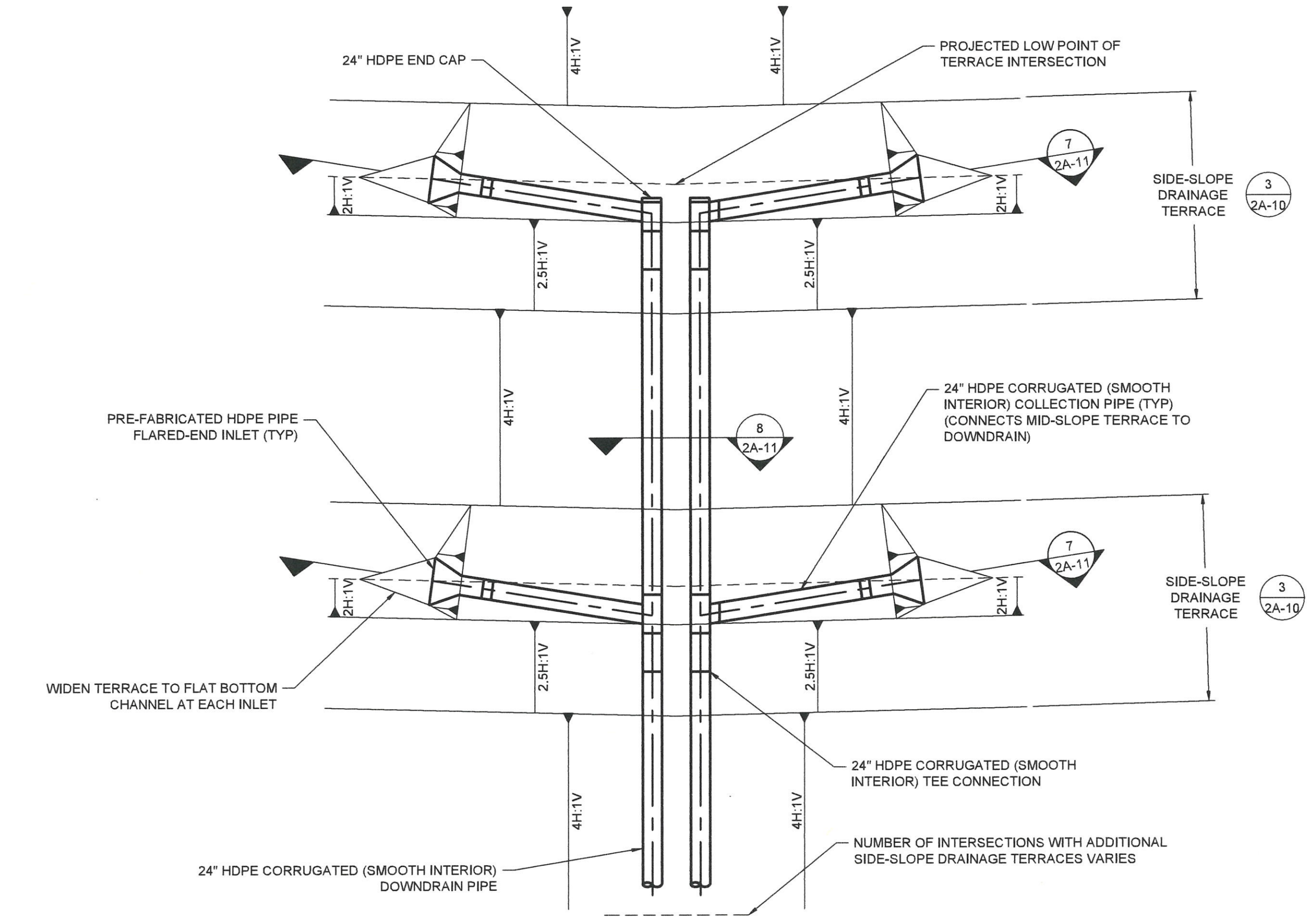
TITLE:
SURFACE WATER MANAGEMENT SYSTEM DETAILS I

PROJECT:
LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

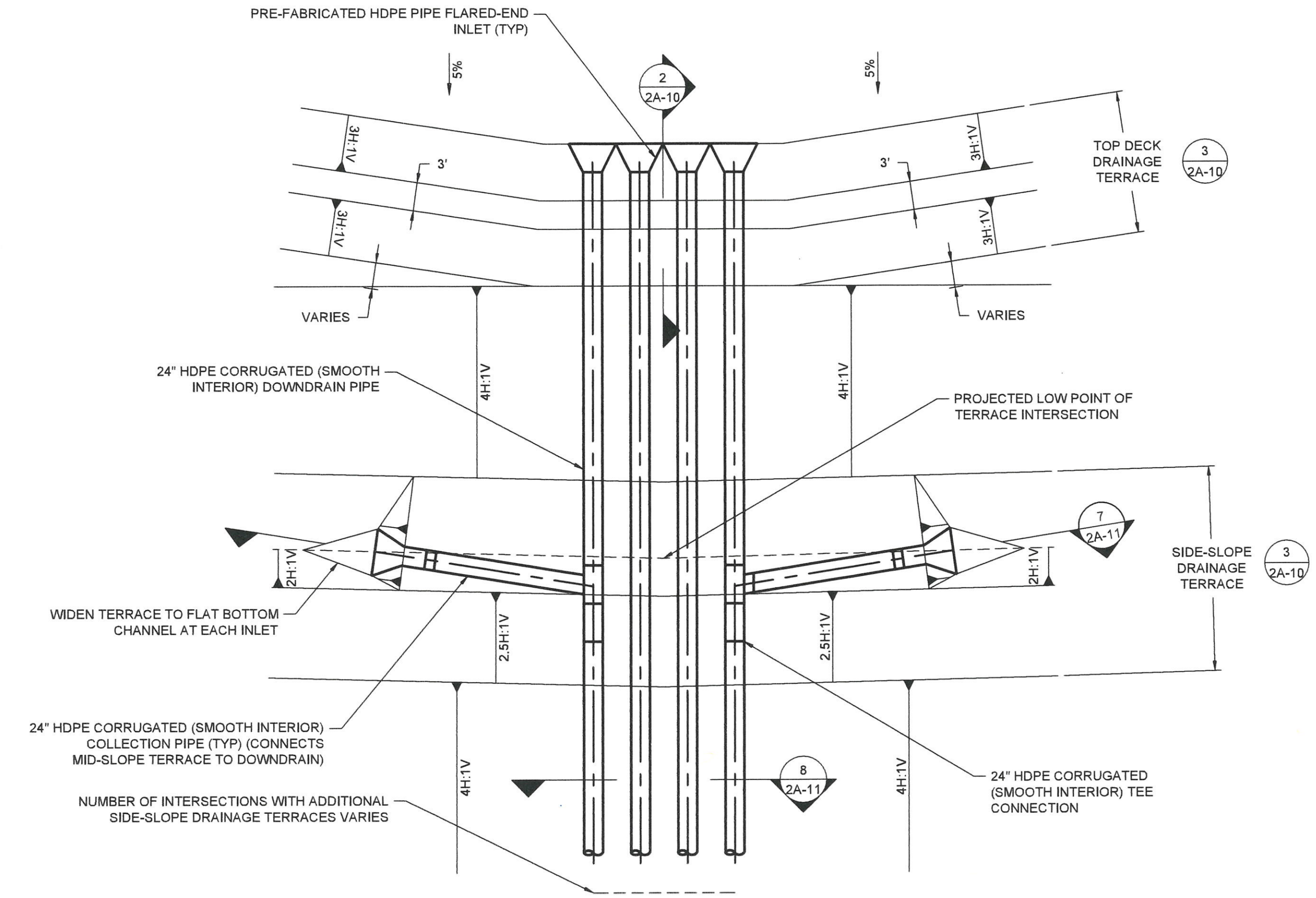
| | | | | | | |
|---|---|---|---|---|---|---|
| PROJECT NO.: GW8041 | DESIGN BY: SMG | REVIEWED BY: YB | PART NO.: | DRAWING: |
| FILE: GW8041P2-9 | DRAWN BY: JJV / KH | APPROVED BY: SMG | III | 2A-10 |




5 / 2A-1 **DETAIL**

**2 X 24-INCH DOWNDRAIN PIPE CROSSING AT SIDE-SLOPE TERRACES**

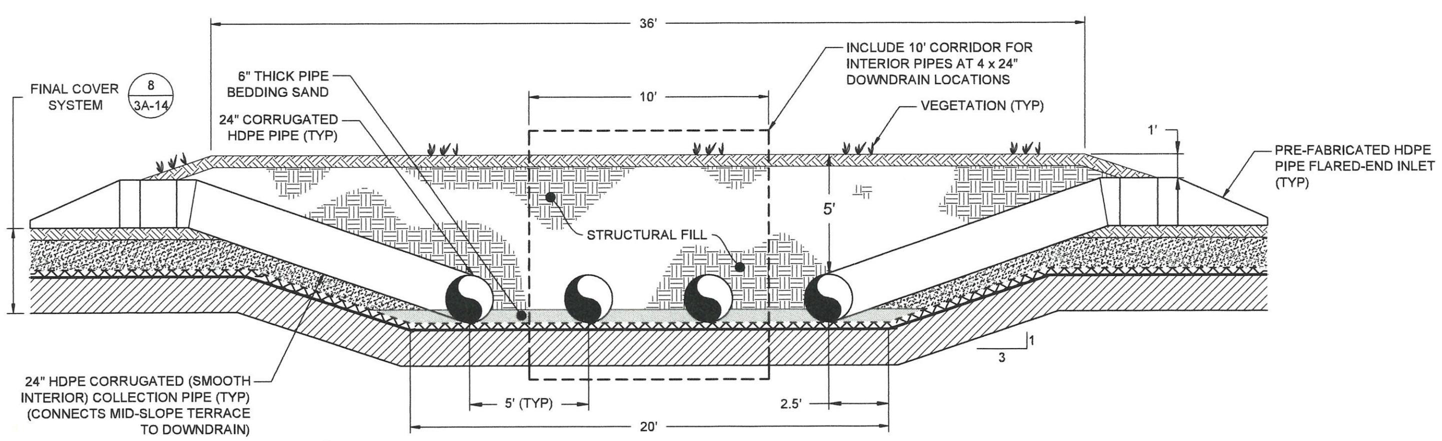
SCALE: NOT TO SCALE




6 / 2A-1 **DETAIL**

**4 X 24-INCH DOWNDRAIN PIPE CROSSING AT SIDE-SLOPE AND TOP DECK TERRACES**

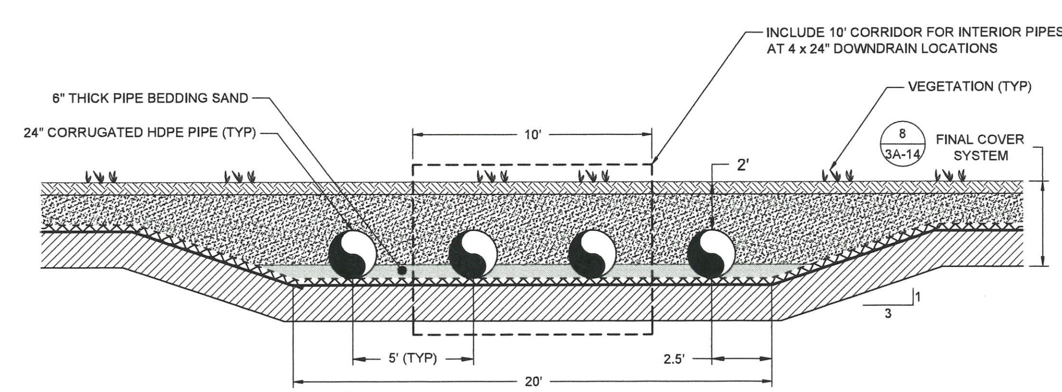
SCALE: NOT TO SCALE




7 / 2A-1 **DETAIL**

**TYPICAL DOWNDRAIN LAYOUT AT SIDE-SLOPE DRAINAGE TERRACE CROSSING**

SCALE: 1" = 4'




8 / 2A-10 **DETAIL**

**TYPICAL DOWNDRAIN LAYOUT**

SCALE: 1" = 4'

NOTES:

1. DETAILS ARE SHOWN TO SCALE AS NOTED EXCEPT FOR THE GEOSYNTHETICS WHICH ARE SHOWN AT AN EXAGGERATED SCALE FOR CLARITY.
2. DETAILS ARE DRAWN SHOWING THE "STANDARD SUBTITLE D" COVER SYSTEM. IF THE ALTERNATIVE COVER SYSTEM IS USED, MAINTAIN CONSISTENCY WITH THE CONCEPTS SHOWN ON THESE DETAILS.

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SCOTT M. GRAVES
86557
LICENSED
PROFESSIONAL ENGINEER

10/21/2022

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

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TITLE: SURFACE WATER MANAGEMENT SYSTEM DETAILS II

PROJECT: LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

| PROJECT NO.: | GW8041 | DESIGN BY: | SMG | REVIEWED BY: | YB | PART NO.: | DRAWING: |
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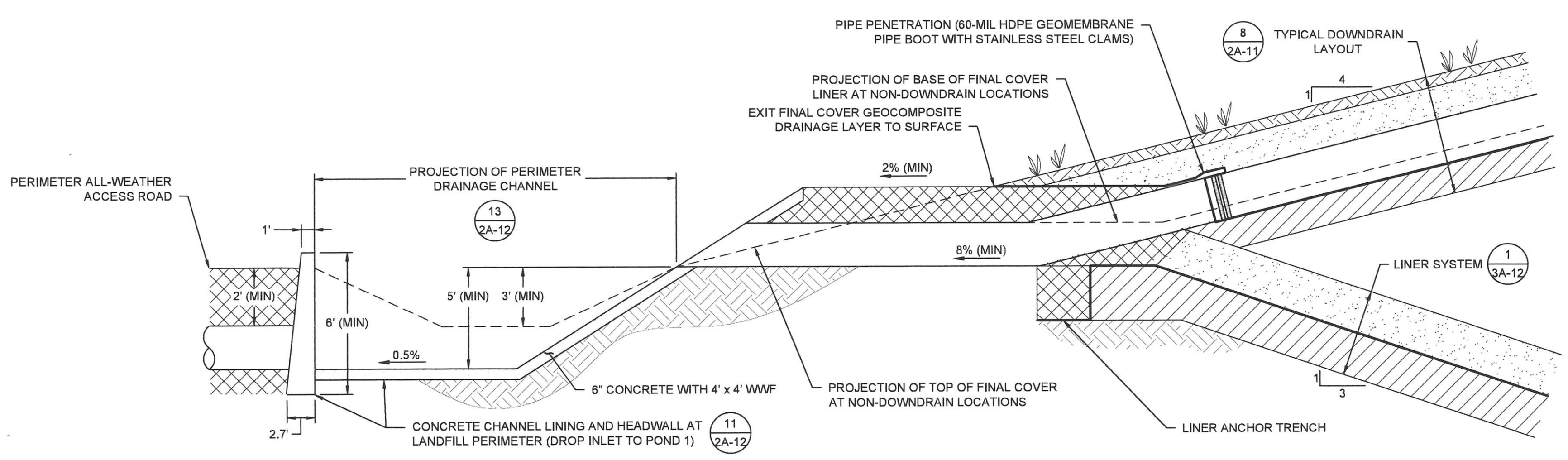
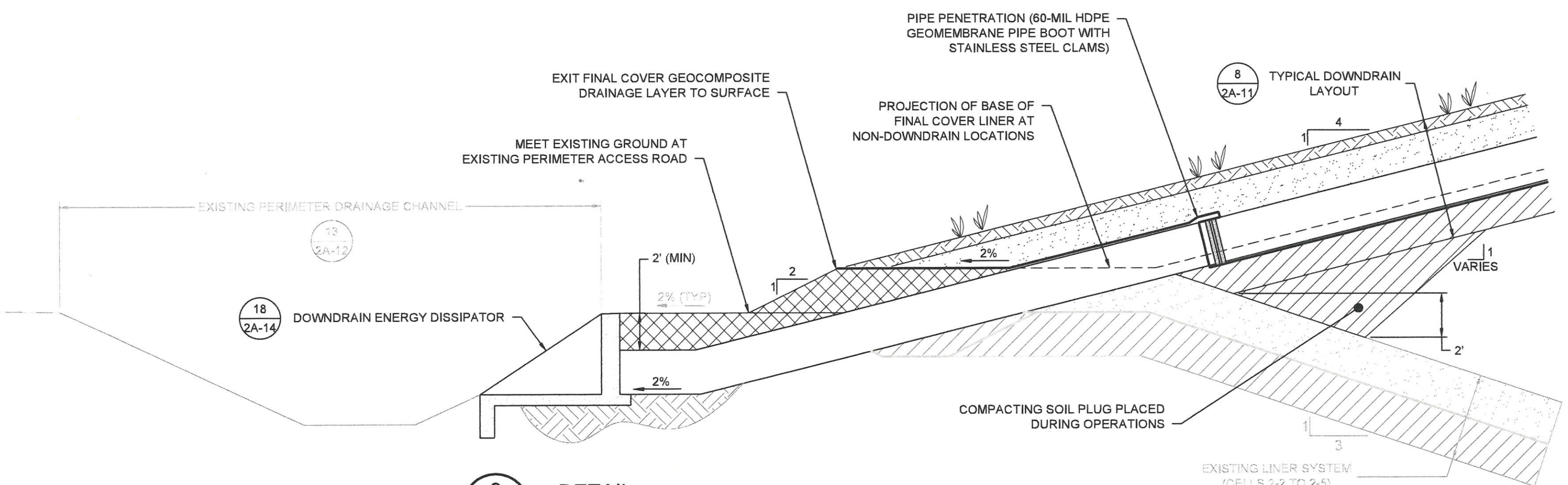
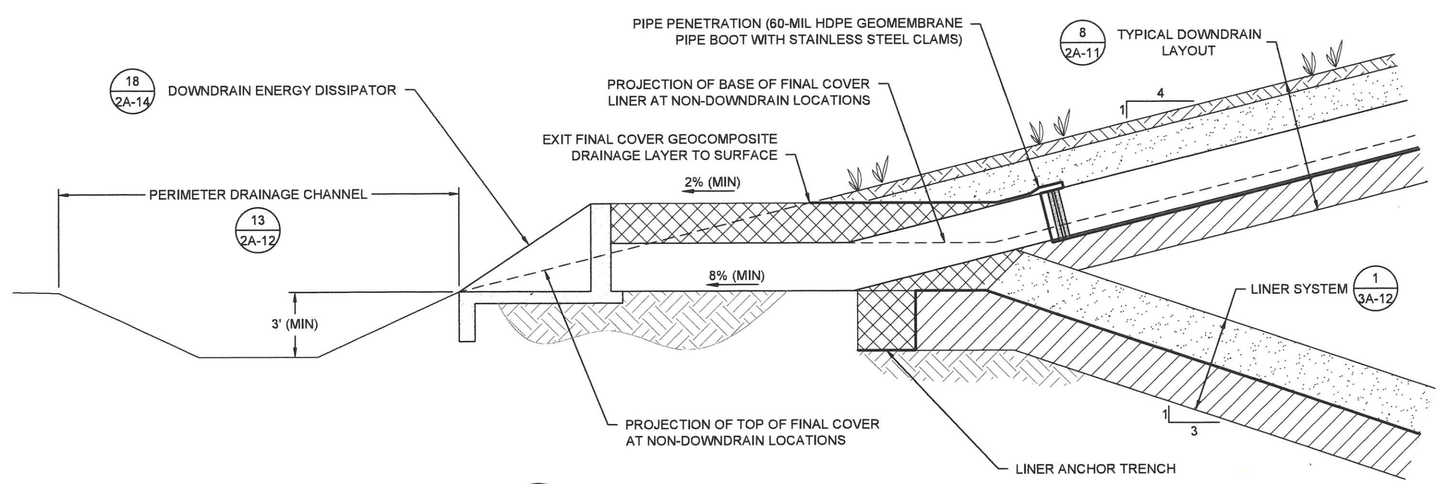
| FILE: | GW8041P2-10 | DRAWN BY: | JJV / KH | APPROVED BY: | SMG | III | 2A-11 |



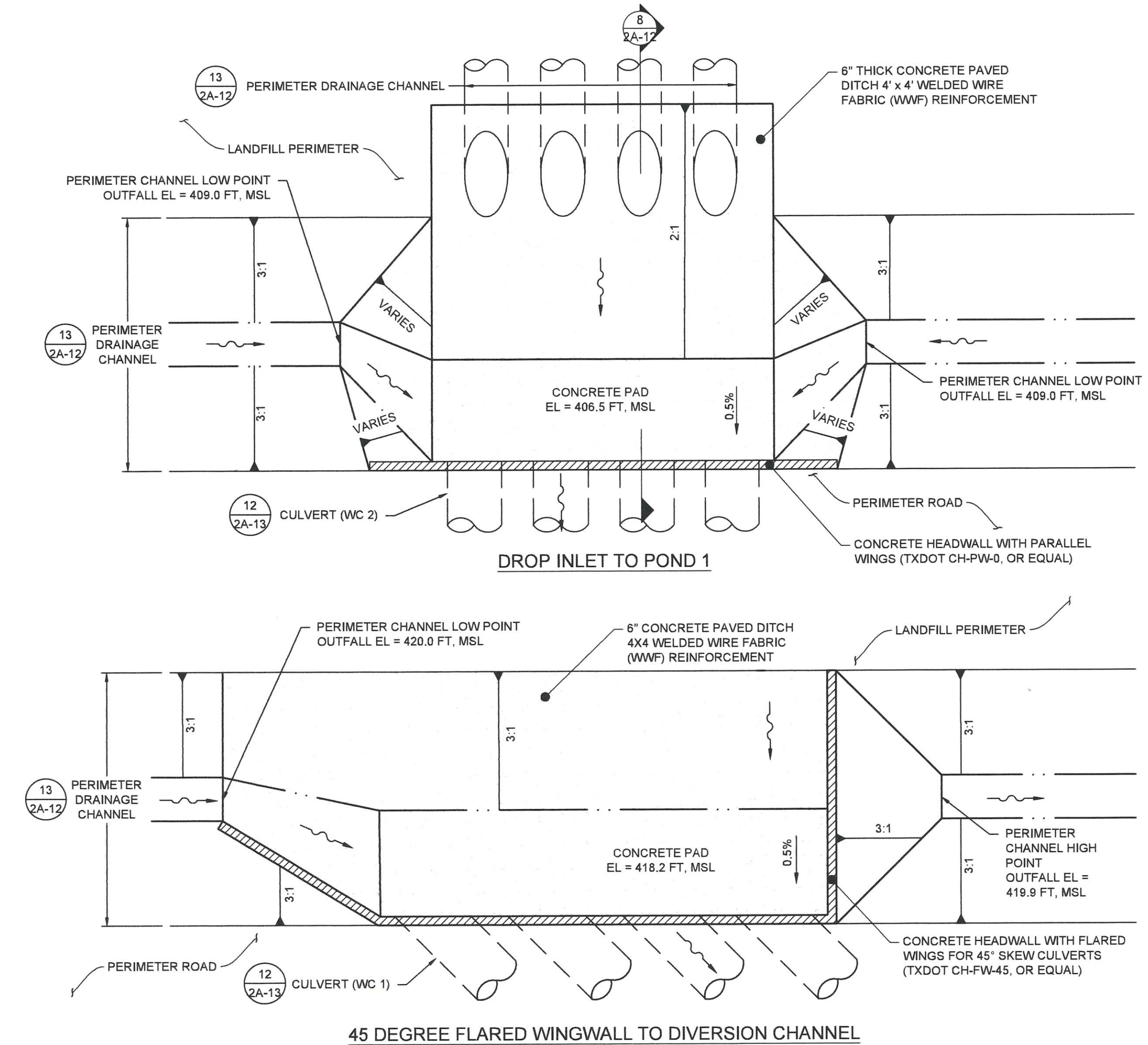

8 2A-1 DETAIL
CROSS SECTION - LANDFILL PERIMETER AT DOWNDRAIN G




9 2A-1 DETAIL
CROSS SECTION - LANDFILL PERIMETER AT DOWNDRAIN B - C - D




10 2A-1 DETAIL
CROSS SECTION - LANDFILL PERIMETER AT DOWNDRAIN E - F




11 2A-1 DETAIL
CONCRETE CHANNEL LINING AND HEADWALL AT LANDFILL PERIMETER
SCALE: NOT TO SCALE

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10/21/2022

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2. DETAILS ARE DRAWN SHOWING THE "STANDARD SUBTITLE D" COVER SYSTEM. IF THE ALTERNATIVE COVER SYSTEM IS USED, MAINTAIN CONSISTENCY WITH THE CONCEPTS SHOWN ON THESE DETAILS.

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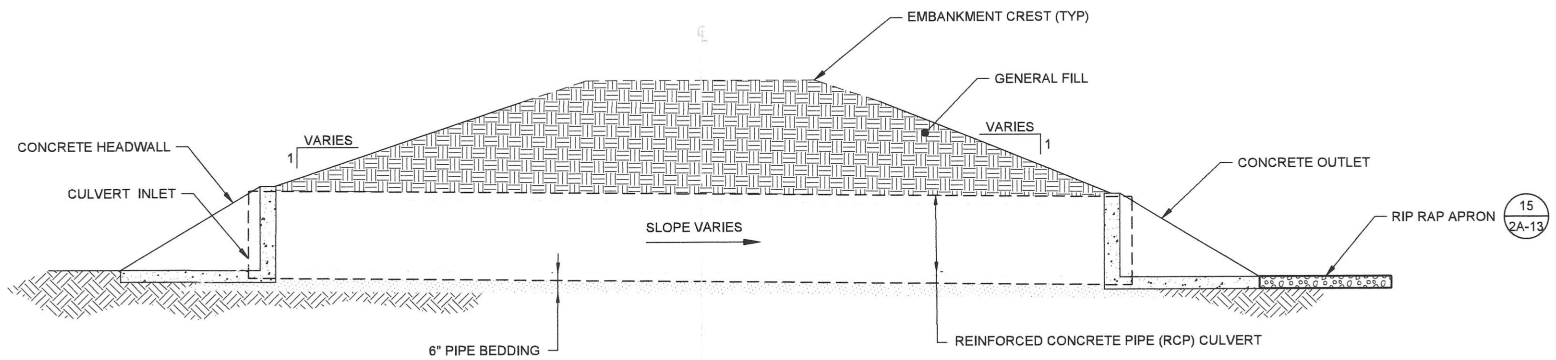
TITLE: SURFACE WATER MANAGEMENT SYSTEM DETAILS III

PROJECT: LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

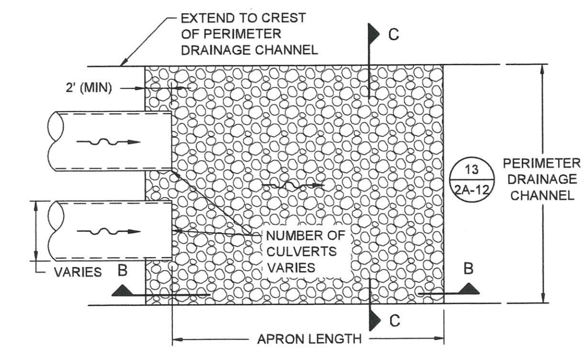
PERMIT DRAWING

| PROJECT NO.: GW8041 | DESIGN BY: SMG | REVIEWED BY: YB | PART NO.: III | DRAWING: 2A-12 |
|---|---|---|---|---|
| FILE: GW8041P2-12 | DRAWN BY: JJV / KH | APPROVED BY: SMG | | |

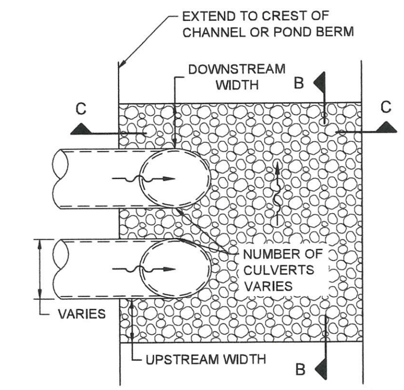



| CULVERT DESIGNATION | APPROX. LENGTH (FT) | SLOPE (%) | (NUMBER OF PIPES) - CULVERT TYPE | INLET ELEVATION (FT) | OUTLET ELEVATION (FT) | ROADWAY ELEVATION (FT) | INLET LOCATION | INLET TYPE | OUTLET LOCATION | OUTLET TYPE |
|---|---|---|---|---|---|---|---|---|---|---|
| WC-1 | 40 | 0.50 | (4) - 42" DIA RCP | 418.20 | 418.00 | 423.20 | WEST CHANNEL 1 | REFER TO DETAIL DETAIL 11 OF DRAWING 2A-12 | DIVERSION CHANNEL | PREFABRICATED CONCRETE FLARED END |
| WC-2 | 35 | 0.57 | (4) - 42" DIA RCP | 406.5 | 406.3 | 412.00 | WEST CHANNEL 2 AND WEST CHANNEL 3 INTERSECTION | | POND 1 | |
| SC-1 | 70 | 3.50 | (1) - 24" DIA RCP | 407.38 | 404.93 | 410.00 | SOUTH CHANNEL 1 | STRAIGHT HEADWALL (TXDOT CH-PW-0, OR EQUAL) | SOUTH CHANNEL 2 | |
| NC-1 | 50 | 0.78 | (2) - 30" DIA RCP | 423.35 | 422.96 | 427.10 | NORTH CHANNEL | EXISTING CONCRETE HEADWALL | EXISTING CONCRETE CROSSING | |
| NC-2 | 75 | 0.10 | (2) - 36" DIA RCP | 421.00 | 420.90 | 425.40 | NORTH PROPERTY BOUNDARY | | EXISTING CONCRETE CROSSING | |
| EC-1 | 40 | 0.60 | (5) - 6' X 5' RCP | 409.07 | 408.83 | 414.07 | EAST CHANNEL 1 | | EAST CHANNEL 1 | EXISTING CONCRETE WINGWALL |
| EC-2 | 40 | 0.60 | (5) - 6' X 5' RCP | 404.70 | 404.46 | 410.20 | EAST CHANNEL 2 | | EAST CHANNEL 2 | |
| EC-3 | 40 | 0.60 | (5) - 6' X 5' RCP | 397.04 | 396.81 | 405.70 | EAST CHANNEL 3 | | SOUTHEAST CORNER OF PROPERTY BOUNDARY | |

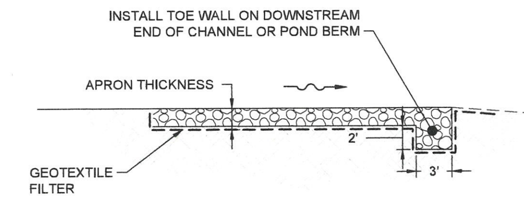
12
3A-12
DETAIL
CULVERT
SCALE: NOT TO SCALE



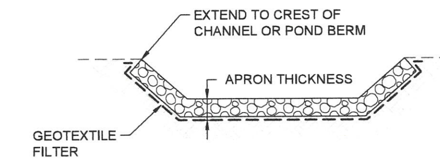

PLAN (PARALLEL FLOW)




PLAN (PERPENDICULAR FLOW)



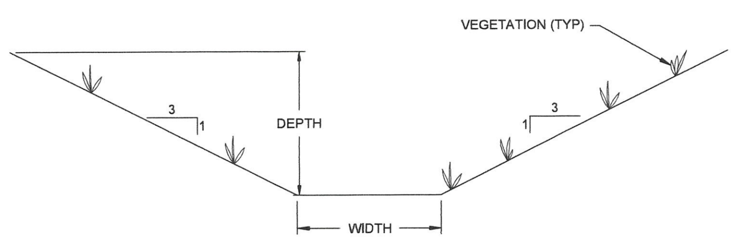

SECTION B




SECTION C

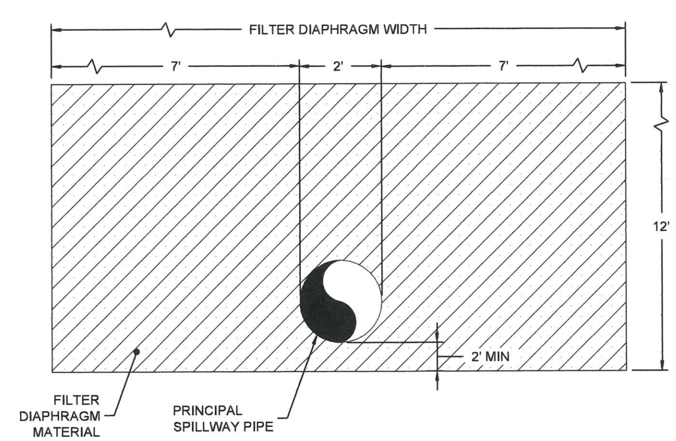
| RIPRAP APRON FEATURE | FLOW CONFIGURATION | TXDOT RIPRAP CLASS (MIN) | APRON THICKNESS (FT) (MIN) | APRON LENGTH (FT) | DOWNSTREAM WIDTH (FT) | UPSTREAM WIDTH (FT) |
|---|---|---|---|---|---|---|
| WC-1, WC-2 | PERPENDICULAR | 3 | 1.5 | - | 18 | 9 |
| SC-1 | PARALLEL | 2 | 1.5 | 8 | - | - |
| EC-1, EC-2, EC-3 | PARALLEL | 1 | 1.0 | 20 | - | - |

15
2A-13
DETAIL
RIPRAP APRON
SCALE: NOT TO SCALE




| PERIMETER CHANNEL | LENGTH (FT) | LONGITUDINAL CHANNEL SLOPE (%) | BOTTOM WIDTH (FT) | DEPTH (FT) | CONDITION |
|---|---|---|---|---|---|
| NORTH CHANNEL 1 | 600 | 0.77 | 6 | 2.0 | EXISTING (MSW 1646A) |
| EAST CHANNEL 1 | 106 | 0.74 | 4 | 4.3 | EXISTING (MSW 1646A) |
| EAST CHANNEL 2 | 927 | 0.60 | 4 | 4.2 | EXISTING (MSW 1646A) |
| EAST CHANNEL 3 | 773 | 0.60 | 4 | 3.9 | EXISTING (MSW 1646A) |
| WEST CHANNEL 1 | 1815 | 0.50 | 5 | 3.0 | PROPOSED |
| WEST CHANNEL 2 | 1521 | 0.50 - 1.00 | 5 | 3.0 | PROPOSED |
| WEST CHANNEL 3 | 296 | 0.54 | 5 | 3.0 | PROPOSED |
| SOUTH CHANNEL 1 | 143 | 2.13 | 5 | 3.0 | PROPOSED |
| SOUTH CHANNEL 2 | 950 | 0.47 | 4 | 4.0 | EXISTING (MSW 1646A) |
| DIVERSION CHANNEL, UPPER | 1111 | 0.51 - 3.39 | 5 | 4.0 | PROPOSED |
| DIVERSION CHANNEL, LOWER | 933 | 0.50 | 5 | 5.0 | PROPOSED |

13
3A-14
DETAIL
PERIMETER DRAINAGE CHANNEL
SCALE: NOT TO SCALE




14
2A-13
DETAIL
FILTER DIAPHGRAM
SCALE: NOT TO SCALE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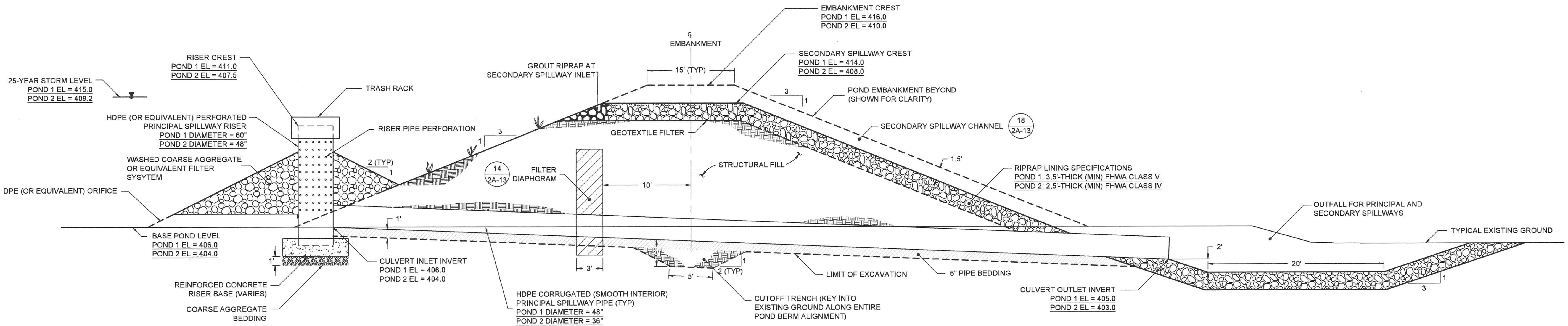
TITLE: SURFACE WATER MANAGEMENT SYSTEM DETAILS IV

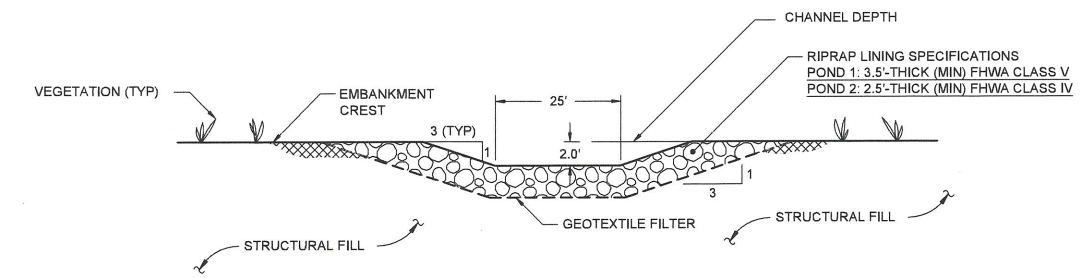
PROJECT: LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

PERMIT DRAWING

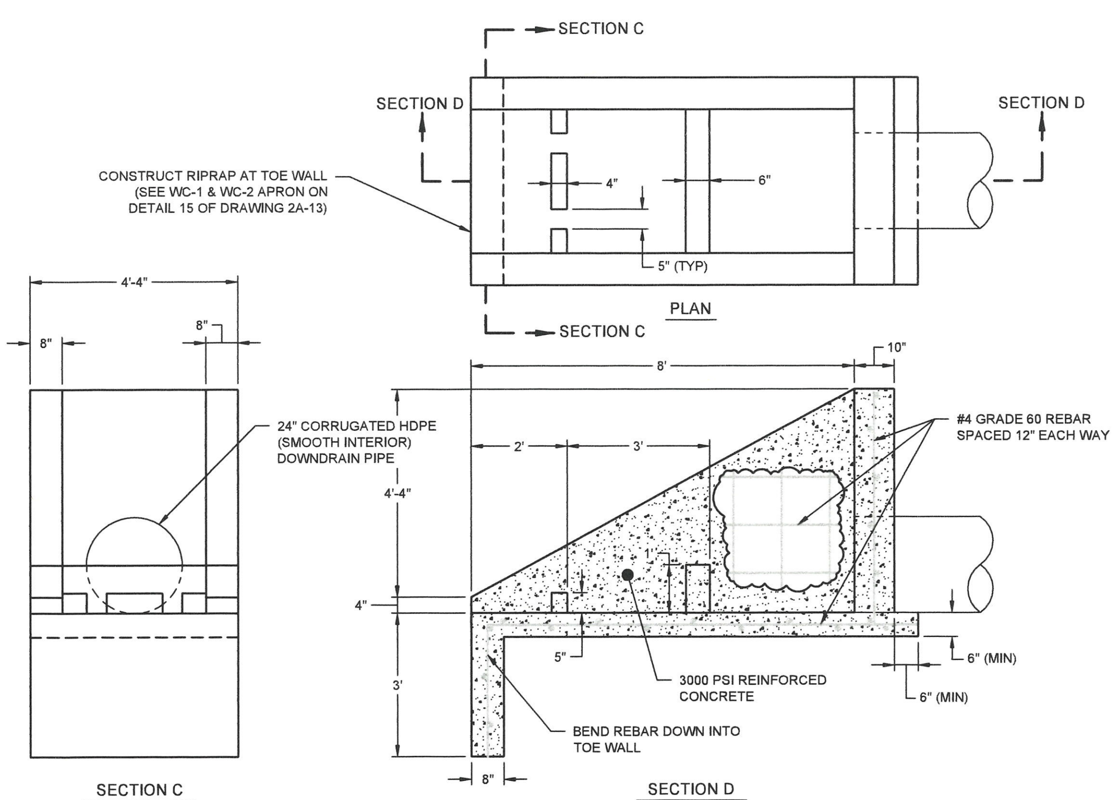
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PROJECT NO.: | GW8041 | DESIGN BY: | SMG | REVIEWED BY: | YB | PART NO.: | III | DRAWING: 2A-13 |
| FILE: | GW8041P2-13 | DRAWN BY: | JJV / KH | APPROVED BY: | SMG | | | |




16
2A-14
DETAIL
STORMWATER POND EMBANKMENT AND SPILLWAYS
SCALE: NTS




17
2A-14
DETAIL
SECONDARY SPILLWAY CHANNEL
SCALE: NTS




18
2A-11
DETAIL
DOWNDRAIN ENERGY DISSIPATOR
SCALE: NTS

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10/21/2022

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| REV | DATE | DESCRIPTION | DRN | APP |
|---|---|---|---|---|

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TITLE: SURFACE WATER MANAGEMENT SYSTEM DETAILS V

PROJECT: LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION - MSW PERMIT NO. 1646B

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| PROJECT NO.: | GW8041 | DESIGN BY: | SMG | REVIEWED BY: | YB | PART NO.: III | DRAWING: 2A-14 |
| FILE: | GW8041P2-14 | DRAWN BY: | JJV / KH | APPROVED BY: | SMG | | |

# ATTACHMENT 2B

# ON-SITE DRAINAGE ANALYSIS – HYDROLOGY

Written by: A. Brewster Date: 10/7/2022 Reviewed by: S. Graves Date: 10/21/2022

Client: WMTX Project: Lacy Lakeview RDF Project No.: GW8041 Phase No.: 05

# ON-SITE DRAINAGE ANALYSIS – HYDROLOGY
# LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY

10/21/2022

STATE OF TEXAS
SCOTT M. GRAVES
86557
LICENSED
PROFESSIONAL ENGINEER

SEALED FOR PERMITTING PURPOSES;
CALCULATION PAGES 1 TO 65

GEOSYNTEC CONSULTANTS
TX ENG FIRM REGISTRATION NO. F-1182

## 1. PURPOSE

The purpose of this calculation package is to present the hydrology analysis for the estimation of surface water runoff as a part of the permit amendment application for the proposed expansion of the Lacy Lakeview Recycling and Disposal Facility. The specific objective of the hydrologic analysis includes calculating peak discharges, times of concentration, and total runoff volumes from the site for the (i) pre-development conditions, and (ii) post-development conditions. Computed values for the post-development case are compared against those computed from the pre-development conditions to demonstrate that the proposed expansion does not adversely alter, to any significant degree, the drainage patterns of the watershed in the vicinity of the site.

The following definitions pertain to the two conditions analyzed in this package:

- Pre-Development Conditions – represent the currently permitted drainage conditions of the landfill facility. The currently permitted surface water management system is analyzed, while incorporating additional off-site run-on drainage areas (including areas located between the property boundary and current permit boundary).
- Post-Development Conditions – represent conditions of the site once the expansion design and overall landfill/facility has been fully developed (MSW Permit No. 1646B), with the final cover and permanent surface water management system installed, while incorporating additional off-site run-on drainage areas (including areas located between the property boundary and proposed permit boundary).

# 2. METHODOLOGY

## 2.1 HEC-HMS Computer Model

Surface water discharges for the pre-development and post-development conditions are estimated using the Hydrologic Modeling System (HEC-HMS) computer program developed through the Hydraulic Engineering Center (HEC) of the United States Army Corps of Engineers (USACE). The program simulates natural and controlled precipitation-runoff and routing processes of a watershed. HEC-HMS is the successor to and replacement for the HEC-1 program (USACE, 2000). For precipitation-runoff-routing simulation, HEC-HMS provides the following components:

- Precipitation-specification options can describe a historical precipitation event, a frequency-based hypothetical precipitation event (i.e., design rainfall or storm event), or an event that represents the upper limit of precipitation possible at a given location. For this analysis, the 25-year (4% annual chance), 24-hour duration hypothetical precipitation event (herein referred to as the 25-year, 24-hour event) and the 100-year (1% annual chance), 24-hour duration hypothetical precipitation event (herein referred to as the 100-year, 24-hour event) were used to compare pre-development and post-development conditions.

- Water loss models can estimate the volume of runoff given the precipitation and properties of the watershed. For this analysis, the Soil Conservation Service (SCS) Curve Number Loss Model was used (USDA, 1986).

- Direct runoff transform models can account for overland flow, storage, and energy losses as surface water runs off a watershed and into the drainage channels. For this analysis, the SCS Unit Hydrograph Model was selected.

- Hydraulic routing models account for storage and energy flux as surface water flows through drainage channels. The Kinematic Wave Model was selected for these analyses.

HEC-HMS models for the pre-development and post-development conditions developed to estimate surface water runoff volumes, peak flow rates, time at which a peak flow rate occurs, and flow characteristics for the perimeter channels.

## 2.2 Pre-Development Condition

Drawing 2A-2 in Attachment 2A of the Facility Surface Water Drainage Report (Drainage Report) presents the final configuration of the currently permitted landfill and surface water management system design, including the natural conditions for the off-site areas adjacent to the landfill. Existing topographic information around the site and in adjacent areas contributing runoff was compiled from photogrammetric methods based on recent site-specific aerial photography surveys, supplemented by published mapping data beyond the extent of the aerials. The topographic information for the general site vicinity was used to model the natural conditions adjacent to the currently permitted landfill boundary. The pre-development drainage area of 305.9 acres includes the currently permitted surface water management system within the approximately 95.2-acre facility permit boundary area, as well as off-site areas which drain onto the permitted area. The consideration of off-site areas for the pre-development condition allows for direct comparison between the pre-development and post-development analysis since the total drainage areas are equivalent. The currently permitted surface water management system design utilizes drainage terraces on the top deck of the landfill, downdrains, culverts, and perimeter channels to control surface water runoff from the site.

The currently permitted surface water management system maintains similar drainage patterns to the natural (or undeveloped) conditions and discharges surface water off the site at three locations (Outfalls A, B, and C). As described in the Part III, Attachment 2 Drainage Report, Outfall A is located at the at the southeastern portion of the site and receives flow from approximately 166.7 acres, Outfall B is located in the south-southwestern portion of the site and receives flow from approximately 138.5 acres, and Outfall C is located in the extreme southwest corner and receives flow from approximately 0.7 acres.

## 2.3 Post-Development Condition

Drawing 2A-1 in Attachment 2A shows the final configuration of the expansion and the proposed surface water management system design. New stormwater management measures are proposed, including (i) two stormwater ponds on the south side of the landfill, which will collect and detain runoff from the landfill perimeter drainage system, and (ii) drainage terraces located on the landfill sideslopes in addition to the landfill top deck. Otherwise, the proposed surface water management system utilizes drainage features to control surface water runoff from the site in a manner similar to the currently permitted facility. The location and designation of these ponds and sideslope terraces are shown on Drawing 2A-1 (with enlarged-scale plan views of each pond provided on Drawing 2A-5).

The facility permit-boundary area associated with the proposed expansion is approximately 159.71 acres. The drainage areas flowing to each of the drainage features are delineated on Drawing 2A-3 in Attachment 2A. As shown, the drainage basin delineations for the pre-development and post-development are generally divided similarly between individual drainage terraces, downdrains, and perimeter channel reaches.

The proposed surface water management system will maintain similar drainage patterns to the pre-development condition, discharging at the outfalls described in the pre-development condition section above. The three site outfalls used for evaluation of the post-development conditions coincide with the 305.9-acre drainage area for pre-development conditions. Specifically, Outfall A receives flow from approximately 160.7 acres, Outfall B receives flow from approximately 144.5 acres, and Outfall C receives flow from approximately 0.7 acres.

## 3. DESIGN PARAMETERS

The following data and assumptions were utilized in selecting engineering parameters to estimate surface water runoff.

### 3.1 Rainfall Return Periods, Durations, and Depths

The site is entirely within the Tehuacana Creek watershed, and outflow from the site ultimately drains to Tehuacana Creek through the three outfalls (Outfalls A, B, and C) identified on Drawings 2A-2 through 2A-4 of Attachment 2A. The surface water management system for the both the currently permitted and proposed facility were designed using rainfall depths represented as 7.35 inches for the 24-hour, 25-year event and 9.81 inches for the 24-hour, 100-year event. The values were selected for design using the online NOAA point precipitation frequency estimate tool (NOAA, 2018) and are presented in Table 2B-1. The design storm hydrograph is defined using a SCS Type III rainfall distribution, which is selected based on Figure 2B-1 (USDA, 1986).

### 3.2 Drainage Subbasins and Reaches

Each subbasin is assigned a curve number subbasin area as a function of soil group, a curve number, and an SCS Unit Hydrograph lag time input parameter. These values are summarized in Table 2B-2 and described as follows.

Drainage Areas – The SCS Curve Number Loss Model was used to estimate the volume of runoff from a given subbasin. Contributing watershed areas for each basin (drainage area) or reach (perimeter channel) in the pre-development and post-development models are divided into multiple subbasins (subareas). Subbasins are modeled for the pre- and post-development to include: (i) top deck surfaces draining to the top deck drainage into top deck terraces and downdrains, (ii) downdrains, sideslope surfaces, and other adjacent and upland areas located outside the landfill perimeter draining into perimeter channels, (iii) perimeter channels draining into other perimeter channels, and (iv) off-site run-on areas. For reference, this design approach is consistent with the current permit. Thus, pre-development drainage areas defined within the permit boundary for this study coincide with those defined in the current permit. For the post-development case, drainage areas are further subdivided to account for the proposed drainage terraces on the sideslopes.

Hydrologic Soil Groups (HSGs) – Figure 2B-2 shows the soil map from the Web Soil Survey tool operated by the USDA Natural Resources Conservation Service (NRCS, 2022) for McLennan County within the approximate location of the proposed permit boundary. The associated Hydrologic Soil Ground type classifications from the Web Soil Survey are presented in Table 2B-3. The predominant soil type at the site and off-site areas contributing run-on to the site is the Wilson clay loam formation, which is classified under the Hydrologic Soil Ground (HSG) type D.

Curve Number (CN) – Individual CNs are obtained from TR-55 (USDA, 1986) and are based on the predominant HSG type D for all land uses within the drainage area. For drainage areas with multiple land uses, weighted CNs were calculated as the sum of all sub-drainage areas (as a percentage of the total drainage area) times their respective CNs. Proposed final cover of the landfill is generally assumed to be open space with fair grass cover conditions and no more than 10% of the area occupied by gravel or dirt access roads (weighted CN = 84.6), which is within the range of CN = 80 to CN = 85 recommended by TCEQ RG-417 for final cover landfill surfaces. Based on the historic site imagery shown in Attachment I/IIA, Drawings I/IIA-4 through I/IIA-8, off-site natural conditions consist of row crops, grassland, farmsteads, and paved streets, with weighted CNs ranging from 79 to 89. A summary of the selected CNs used in the hydrology model is presented in Table 2B-4.

SCS Unit Hydrograph – The SCS Unit Hydrograph Model was used to estimate the direct runoff flow rates from each subbasin using peak rate factor (constant 484) unit hydrographs as a function of lag time (calculated as 60% of the time of concentration [Tc]). Tc was estimated using the NRCS (1986) method and is the summation of (i) sheet flow travel time, calculated with Manning's Kinematic Solution, (ii) shallow concentrated flow travel time, calculated with the Upland Method, and (iii) channel flow travel time, calculated with Manning's equation. Based on the land usage assumptions described above for CN selection, Tc is computed with roughness values corresponding to short grass surfaces for the majority of runoff in this study. Tc is also computed to reflect flow paths down the typical slopes and topography of the delineated features described above for individual drainage areas. Travel times specific to sheet flow and shallow concentrated flow are shown in Table 2B-5. Specific to calculating channel flow travel time, typical cross sections for the existing and proposed grass-lined drainage terraces and perimeter channels were considered, and representative cross sections were selected for the existing natural channels within the offsite basin north of the site (Basin A17) and within the undeveloped west half of the site for the predevelopment case (Basin A21). Travel times specific to channel flow and Tc values are shown in Table 2B-6.

Reaches – Reaches in the HEC-HMS program represent channels, pipes and other conduits that route surface water from upstream subbasins into other reaches, junctions, or reservoirs. The Kinematic Wave Model is used to model the surface water flow in each of the reaches in the HEC-HMS program. Kinematic wave routing accounts for storage and energy flux as surface water moves through stream channels. Assumptions and parameter selections made for calculating channel flow travel time are generally identical the input used for the kinematic wave routing considered in this analysis. Specifically, reaches in this analysis were modeled based on the typical slopes, roughness values, and cross sections of grass-lined perimeter channels, natural channels, HDPE downdrain pipes, and reinforced concrete pipe (RPC) culverts.

## 3.3 Reservoirs

Proposed detention ponds and existing localized low points were modeled as reservoirs based on elevation-area relationships defined from conceptual and existing topographic information around the site and in adjacent areas. The elevation-area relationship describes the volume of storage provided by the pond at different water level stages as a function of depth and shape of the pond. Existing and proposed outlet structures (including engineered spillways, culverts, and other existing topographical features that function as spillways) were defined for each reservoir to establish elevation-outflow relationships over the range of water surface elevations for a given feature. The HEC-HMS model then calculates surface water runoff volumes, peak flow rates, peak water surface elevations, and routing of rainfall event hydrographs through each reservoir feature. Elevation-area and elevation-discharge relationships are presented in Table 2B-7 and were modeled to reflect the following:

- An on-site low point within Basin A21 for the pre-development condition was approximated based on topographic data from the existing terrain in the western roughly one-half of the site. This containment area has a base elevation of 408 ft, MSL, crest elevation of 414 ft, MSL and associated storage capacity of 4.74 acre-feet. As depicted on Drawing 2A-4 of Attachment 2A, the detention area has a well-defined roughly 16-ft opening near the base 408 ft, MSL elevation that generally aligns with the flow path of the natural stream routing to Outfall B. At the defined 414 ft, MSL crest alignment, two potential flow paths were identified for any overtopping runoff, including (i) a 150-ft wide spillway that would also overflow into Outfall B and (ii) a 19-ft wide spillway that would overflow into Outfall C. All three openings were modeled as broad-crested spillway outlets. However, it is noted that only the 16-ft wide opening at the base 408 ft, MSL elevation is engaged during the design storms considered in this evaluation.

- A detention area exists at the inlet of the two existing reinforced concrete pipe (RCP) culverts that route runoff from Basin 17 onto the side. As depicted on Drawing 2A-4 of Attachment 2A, these pipes have an invert elevation of 424 ft, MSL. This detention area is modeled for the pre- and post-development conditions with a base elevation of 424 ft, MSL, crest elevation of 427 ft, MSL, and storage capacity of 0.10 acre-feet based on topographic data from the existing off-site terrain. Beyond the 427 ft, MSL storage elevation, three openings were identified that would serve as overtopping points for larger storm events (including two openings that route any overtopping runoff to an off-site area and a third that routes a small portion of the overtopping flow onto the site). These depressions were modeled as a series of three broad-crested spillways.

- Stormwater Ponds 1 and 2 were designed to adequately detain and pass the 25-year, 24-hour rainfall event while maintaining at least 0.5 feet of freeboard, and to hold the 100-year, 24-hour rainfall event without overtopping the berm crest. The proposed outlet system is shown on Drawing 2A-14 of Attachment 2A and includes a smooth-interior high-density polyethylene (HDPE) outlet pipe at the base pond elevation and a riprap-lined 25-ft wide trapezoidal spillway at an elevation located two feet below the pond crest.

### 3.4 Nodal Network Diagrams

Nodal network diagrams used in HEC-HMS for the pre-development and post-development analyses are provided and correspond to the output files included in Appendix 2B-1.

- Pre-Development Nodal Network – Figure 2A-3 presents the nodal network drawing for the pre-development conditions. The pre-development nodal network diagram shows the subbasins, reaches, reservoirs, and discharge locations. The nodal network diagram represents the existing permitted surface water management system and discharge points shown on Drawing 2A-2 in Attachment 2A.

- Post-Development Nodal Network – Figure 2B-4 presents the nodal network drawing for the post-development conditions. The post-development nodal network diagram shows the subbasins, reaches, reservoirs, and discharge locations. The nodal network diagram represents the proposed surface water management system and discharge points shown on Drawing 2A-3 in Attachment 2A.

## 4. RESULTS

Precipitation event runoff hydrographs for Outfalls A, B, and C are summarized in Figure 2B-5 for the 25-year, 24-hour precipitation event and in Figure 2B-6 for the 100-year, 24-hour precipitation event. A summary of results from the HEC-HMS model is provided in Table 2B-8 and indicates that the predicted peak post-development discharge rates and velocities are less than the peak pre-development discharge rates at each site outfall. The computed runoff volumes are similar (within 6%) for pre-development and post-development conditions at the site outfalls. Additionally, times to peak discharge are similar for the pre-development and post-development conditions at Outfalls A and C, noting that the increased time to peak discharge at Outfall B for the post-development condition is primarily a function of runoff being detained in Pond 1. A summary of results for Ponds 1 and 2 is provided in Table 2B-9 and demonstrates that both ponds can adequately detain and pass the 25-year, 24-hour rainfall event while maintaining at least 0.5 feet of freeboard, and hold the 100-year, 24-hour rainfall event without overtopping the berm crest. Thus, the proposed expansion post-development condition is not anticipated to adversely affect or significantly alter the drainage patterns in the vicinity of the site compared to the as-permitted (pre-development) condition.

## 5. REFERENCES

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# TABLES

# Table 2B-1. Site Specific Point Precipitation Estimates (from NOAA, 2018)

NOAA Atlas 14, Volume 11, Version 2
Location name: Waco, Texas, USA*
Latitude: 31.6028°, Longitude: -97.0557°
Elevation: 464.84 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

## PF tabular

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

| Duration | Average recurrence interval (years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | 0.427 (0.323-0.564) | 0.502 (0.382-0.655) | 0.623 (0.474-0.817) | 0.724 (0.544-0.965) | 0.866 (0.629-1.19) | 0.975 (0.690-1.38) | 1.09 (0.751-1.58) | 1.21 (0.812-1.80) | 1.37 (0.892-2.11) | 1.50 (0.951-2.37) |
| 10-min | 0.681 (0.516-0.899) | 0.801 (0.611-1.05) | 0.995 (0.758-1.31) | 1.16 (0.869-1.54) | 1.39 (1.01-1.90) | 1.56 (1.11-2.21) | 1.75 (1.20-2.53) | 1.93 (1.30-2.87) | 2.18 (1.42-3.36) | 2.38 (1.50-3.75) |
| 15-min | 0.863 (0.653-1.14) | 1.01 (0.770-1.32) | 1.25 (0.949-1.64) | 1.45 (1.09-1.93) | 1.73 (1.25-2.37) | 1.94 (1.37-2.74) | 2.16 (1.49-3.13) | 2.40 (1.61-3.57) | 2.72 (1.77-4.19) | 2.98 (1.88-4.69) |
| 30-min | 1.21 (0.912-1.59) | 1.41 (1.08-1.84) | 1.74 (1.33-2.29) | 2.02 (1.51-2.69) | 2.40 (1.74-3.29) | 2.69 (1.90-3.80) | 3.00 (2.07-4.34) | 3.33 (2.24-4.94) | 3.78 (2.46-5.82) | 4.14 (2.62-6.54) |
| 60-min | 1.55 (1.18-2.05) | 1.83 (1.39-2.38) | 2.27 (1.73-2.98) | 2.64 (1.98-3.51) | 3.15 (2.29-4.32) | 3.55 (2.51-5.00) | 3.96 (2.73-5.74) | 4.41 (2.97-6.56) | 5.05 (3.28-7.77) | 5.56 (3.52-8.77) |
| 2-hr | 1.88 (1.43-2.47) | 2.24 (1.71-2.88) | 2.80 (2.14-3.64) | 3.29 (2.48-4.34) | 3.98 (2.91-5.42) | 4.54 (3.23-6.34) | 5.13 (3.56-7.35) | 5.77 (3.90-8.49) | 6.68 (4.36-10.2) | 7.41 (4.71-11.5) |
| 3-hr | 2.07 (1.58-2.70) | 2.48 (1.90-3.17) | 3.12 (2.39-4.03) | 3.68 (2.79-4.84) | 4.50 (3.31-6.10) | 5.17 (3.70-7.20) | 5.89 (4.10-8.40) | 6.67 (4.51-9.74) | 7.78 (5.08-11.7) | 8.67 (5.52-13.4) |
| 6-hr | 2.39 (1.84-3.10) | 2.91 (2.23-3.66) | 3.68 (2.84-4.72) | 4.38 (3.34-5.72) | 5.41 (4.01-7.28) | 6.27 (4.51-8.65) | 7.21 (5.04-10.2) | 8.23 (5.59-11.9) | 9.69 (6.35-14.4) | 10.9 (6.95-16.6) |
| 12-hr | 2.72 (2.11-3.50) | 3.34 (2.58-4.17) | 4.27 (3.32-5.44) | 5.11 (3.93-6.62) | 6.35 (4.72-8.45) | 7.37 (5.32-10.1) | 8.49 (5.96-11.9) | 9.75 (6.66-13.9) | 11.6 (7.63-17.1) | 13.1 (8.40-19.8) |
| 24-hr | 3.07 (2.40-3.92) | 3.80 (2.95-4.72) | 4.91 (3.85-6.20) | 5.90 (4.56-7.58) | 7.35 (5.48-9.67) | 8.52 (6.18-11.5) | 9.81 (6.92-13.5) | 11.3 (7.75-16.0) | 13.5 (8.93-19.7) | 15.3 (9.87-22.8) |
| 2-day | 3.43 (2.69-4.33) | 4.28 (3.37-5.30) | 5.63 (4.44-7.06) | 6.79 (5.28-8.65) | 8.46 (6.34-11.0) | 9.77 (7.11-13.0) | 11.2 (7.95-15.3) | 12.9 (8.88-18.0) | 15.4 (10.2-22.1) | 17.5 (11.3-25.6) |
| 3-day | 3.70 (2.92-4.65) | 4.63 (3.67-5.72) | 6.10 (4.84-7.62) | 7.36 (5.75-9.33) | 9.15 (6.87-11.8) | 10.5 (7.69-14.0) | 12.0 (8.56-16.3) | 13.8 (9.54-19.1) | 16.4 (10.9-23.4) | 18.6 (12.0-27.0) |
| 4-day | 3.96 (3.13-4.97) | 4.93 (3.92-6.08) | 6.47 (5.14-8.05) | 7.78 (6.09-9.82) | 9.63 (7.25-12.4) | 11.1 (8.09-14.6) | 12.6 (8.98-17.0) | 14.4 (9.97-19.9) | 17.0 (11.4-24.2) | 19.2 (12.5-27.8) |
| 7-day | 4.65 (3.70-5.79) | 5.66 (4.53-6.95) | 7.27 (5.81-9.00) | 8.64 (6.80-10.8) | 10.6 (8.01-13.5) | 12.1 (8.89-15.8) | 13.7 (9.80-18.3) | 15.5 (10.8-21.2) | 18.1 (12.2-25.5) | 20.3 (13.2-29.1) |
| 10-day | 5.21 (4.16-6.46) | 6.26 (5.02-7.66) | 7.93 (6.36-9.78) | 9.35 (7.39-11.7) | 11.4 (8.64-14.5) | 12.9 (9.53-16.8) | 14.6 (10.5-19.4) | 16.4 (11.4-22.3) | 19.0 (12.8-26.6) | 21.2 (13.8-30.1) |
| 20-day | 6.78 (5.44-8.34) | 7.96 (6.46-9.73) | 9.90 (8.01-12.1) | 11.5 (9.14-14.2) | 13.7 (10.5-17.3) | 15.4 (11.4-19.8) | 17.1 (12.3-22.5) | 18.9 (13.2-25.4) | 21.4 (14.4-29.5) | 23.4 (15.3-32.8) |
| 30-day | 8.08 (6.52-9.89) | 9.37 (7.66-11.4) | 11.5 (9.37-14.1) | 13.3 (10.6-16.3) | 15.6 (12.0-19.6) | 17.4 (12.9-22.2) | 19.1 (13.8-25.0) | 20.9 (14.7-27.9) | 23.3 (15.8-31.9) | 25.2 (16.5-35.1) |
| 45-day | 9.99 (8.09-12.2) | 11.4 (9.40-13.9) | 13.8 (11.3-16.9) | 15.8 (12.6-19.3) | 18.3 (14.1-22.8) | 20.1 (15.0-25.6) | 21.9 (15.9-28.4) | 23.7 (16.7-31.4) | 26.1 (17.7-35.3) | 27.9 (18.3-38.4) |
| 60-day | 11.7 (9.52-14.2) | 13.3 (11.0-16.2) | 15.9 (13.1-19.3) | 18.0 (14.5-22.0) | 20.7 (15.9-25.7) | 22.6 (16.9-28.6) | 24.4 (17.7-31.5) | 26.2 (18.5-34.5) | 28.5 (19.3-38.4) | 30.2 (19.9-41.5) |

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

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

Please refer to NOAA Atlas 14 document for more information.

Written by: **A. Brewster** Date: **10/7/2022** Reviewed by: **S. Graves** Date: **10/21/2022**

Client: **WMTX** Project: **Lacy Lakeview RDF** Project No.: **GW8041** Phase No.: **05**

## Table 2B-2. Summary of Watershed Characteristics

**Pre-Development Watershed Characterization**

| Basin ID | Area (acres) | Initial Abstraction (in) | CN | Imperv. Cover (%) | SCS Lag Time (min) |
|---|---|---|---|---|---|
| A1 | 5.15 | 0.36 | 84.6 | 0.0 | 3.6 |
| A2 | 3.90 | 0.36 | 84.6 | 0.0 | 5.3 |
| A3 | 5.57 | 0.36 | 84.6 | 0.0 | 3.6 |
| A4 | 7.93 | 0.36 | 84.6 | 0.0 | 18.2 |
| A5 | 6.30 | 0.36 | 84.6 | 0.0 | 5.1 |
| A6 | 12.99 | 0.36 | 84.6 | 0.0 | 16.1 |
| A7 | 6.82 | 0.36 | 84.6 | 0.0 | 5.3 |
| A8 | 11.81 | 0.36 | 84.6 | 0.0 | 13.7 |
| A9 | 4.56 | 0.36 | 84.6 | 0.0 | 3.6 |
| A10 | 6.29 | 0.36 | 84.6 | 0.0 | 5.2 |
| A11 | 5.33 | 0.36 | 84.6 | 0.0 | 3.6 |
| A12 | 6.61 | 0.36 | 84.6 | 0.0 | 5.2 |
| A13 | 5.79 | 0.36 | 84.6 | 0.0 | 3.6 |
| A14 | 5.27 | 0.36 | 84.6 | 0.0 | 3.6 |
| A15 | 3.61 | 0.36 | 84.6 | 0.0 | 5.2 |
| A16 | 1.69 | 0.36 | 84.6 | 0.0 | 3.6 |
| A17 | 62.91 | 0.25 | 89.0 | 0.0 | 46.8 |
| A18 | 19.21 | 0.25 | 89.0 | 0.0 | 57.7 |
| A19 | 47.26 | 0.31 | 86.6 | 0.0 | 94.9 |
| A20 | 26.69 | 0.31 | 86.6 | 0.0 | 44.8 |
| A21 | 45.37 | 0.44 | 81.8 | 0.0 | 10.0 |
| A22 | 0.71 | 0.53 | 79.0 | 0.0 | 3.6 |
| A23 | 4.16 | 0.36 | 84.6 | 0.0 | 6.9 |
| **Total:** | **305.9** | | | | |

**Post-Development Watershed Characterization**

| Basin ID | Area (acres) | Initial Abstraction (in) | CN | Imperv. Cover (%) | SCS Lag Time (min) |
|---|---|---|---|---|---|
| TD1 | 10.75 | 0.36 | 84.6 | 0.00 | 6.5 |
| TD2 | 1.18 | 0.36 | 84.6 | 0.00 | 6.0 |
| TD3 | 8.07 | 0.36 | 84.6 | 0.00 | 6.9 |
| TD4 | 8.00 | 0.36 | 84.6 | 0.00 | 6.7 |
| TD5 | 1.71 | 0.36 | 84.6 | 0.00 | 5.3 |
| TD6 | 3.82 | 0.36 | 84.6 | 0.00 | 5.2 |
| SS1-L | 4.89 | 0.36 | 84.6 | 0.00 | 3.6 |
| SS1-U | 3.77 | 0.36 | 84.6 | 0.00 | 3.6 |
| SS2 | 2.19 | 0.36 | 84.6 | 0.00 | 3.6 |
| SS3 | 4.96 | 0.36 | 84.6 | 0.00 | 3.6 |
| SS4 | 4.01 | 0.36 | 84.6 | 0.00 | 3.6 |
| SS5 | 5.97 | 0.36 | 84.6 | 0.00 | 3.6 |
| SS6 | 4.74 | 0.36 | 84.6 | 0.00 | 3.6 |
| SS7 | 0.65 | 0.36 | 84.6 | 0.00 | 3.6 |
| SS8 | 4.48 | 0.36 | 84.6 | 0.00 | 3.6 |
| SS9 | 3.12 | 0.36 | 84.6 | 0.00 | 3.6 |
| SS10 | 5.53 | 0.36 | 84.6 | 0.00 | 3.6 |
| SS11 | 4.37 | 0.36 | 84.6 | 0.00 | 6.2 |
| SS12 | 2.81 | 0.36 | 84.6 | 0.00 | 3.6 |
| SS13 | 1.47 | 0.36 | 84.6 | 0.00 | 3.6 |
| SS14 | 1.81 | 0.36 | 84.6 | 0.00 | 3.6 |
| P1 | 1.60 | 0.36 | 84.6 | 0.00 | 3.6 |
| P2 | 2.11 | 0.36 | 84.6 | 0.00 | 3.6 |
| P3 | 3.62 | 0.36 | 84.6 | 0.00 | 3.6 |
| P4 | 5.49 | 0.36 | 84.6 | 0.00 | 3.6 |
| P5 | 2.82 | 0.36 | 84.6 | 0.00 | 3.6 |
| P6 | 1.73 | 0.36 | 84.6 | 0.00 | 3.6 |
| P7 | 3.64 | 0.36 | 84.6 | 0.00 | 3.6 |
| P8 | 1.85 | 0.36 | 84.6 | 0.00 | 3.6 |
| P9 | 4.66 | 0.36 | 84.6 | 0.00 | 4.0 |
| P10 | 2.53 | 0.36 | 84.6 | 0.00 | 3.6 |
| A17 | 62.91 | 0.25 | 89.0 | 0.00 | 46.8 |
| A18 | 19.21 | 0.25 | 89.0 | 0.00 | 57.7 |
| A19 | 47.26 | 0.31 | 86.6 | 0.00 | 94.9 |
| A20 | 26.69 | 0.31 | 86.6 | 0.00 | 44.8 |
| A22 | 0.71 | 0.53 | 79.0 | 0.00 | 3.6 |
| A23 | 4.16 | 0.36 | 84.6 | 0.00 | 6.9 |
| M1 | 12.11 | 0.36 | 84.6 | 0.00 | 17.8 |
| M2 | 1.37 | 0.36 | 84.6 | 0.00 | 3.6 |
| M3 | 2.38 | 0.36 | 84.6 | 0.00 | 3.6 |
| M4 | 2.23 | 0.18 | 91.7 | 0.00 | 3.6 |
| M5 | 5.26 | 0.26 | 88.5 | 0.00 | 3.6 |
| M6 | 3.27 | 0.31 | 86.7 | 0.00 | 3.6 |
| **Total:** | **305.9** | | | | |

## Table 2B-3. Hydrologic Soil Groups for On-Site Soils (from NRCS, 2022)

| RUSLE2 Related Attributes–McLennan County, Texas | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Map symbol and soil name | Pct. of map unit | Slope length (ft) | Hydrologic group | Kf | T factor | Representative value | | |
| | | | | | | % Sand | % Silt | % Clay |
| BrB—Bremond loam, 0 to 2 percent slopes | 85 | 200 | D | 0.49 | 5 | 44.8 | 41.2 | 14.0 |
| CrB—Crockett loam, 3 to 5 percent slopes | 85 | 180 | D | 0.55 | 5 | 40.0 | 46.0 | 14.0 |
| Go—Gowen clay loam, frequently flooded | 85 | 98 | B | 0.28 | 5 | 34.2 | 37.3 | 28.5 |
| To—Tinn clay, 0 to 1 percent slopes, frequently flooded | 85 | 98 | D | 0.24 | 5 | 22.0 | 28.0 | 50.0 |
| WnA—Wilson clay loam, 0 to 2 percent slopes | 85 | 200 | D | 0.37 | 5 | 35.0 | 34.0 | 31.0 |

## Table 2B-4. Summary of Curve Numbers used in Analysis (from USDA, 1986)

| Basin Designation | Basin Areas by Land Use Type (Percent), assuming Hydrologic Soil Group Type D | | | | | | Weighted Curve Number |
|---|---|---|---|---|---|---|---|
| | Urban Areas (Table 2-2a) | | Cultivated Agricultural Lands (Table 2-2b) | | | Other Agricultural Lands (Table 2-2c) | |
| | Streets and Roads; Gravel or Dirt | Impervious Surfaces (Includes Paved Streets and Roads) | Straight Row Crops, Good Condition | Pasture, Grassland, or Range | Woods, Fair Condition | Farmsteads - Buildings, Lanes, Driveways, and Surrounding Lots | |
| | CN = 90 | CN = 98 | CN = 89 | CN = 84 | CN = 79 | CN = 86 | |
| Final Cover and Perimeter Landfill | 10% | | | 90% | | | 84.6 |
| A17 - A18 | | | 100% | | | | 89.0 |
| A19 - A20 | | 5% | | | | 95% | 86.6 |
| A22 | | | | | 100% | | 79.0 |
| A21 (Pre-Dev only) | 5% | 1% | | 42% | 2% | | 83.4 |
| M4 (Post-Dev Only) | 5% | 53% | | 42% | | | 91.7 |
| M5 (Post-Dev Only) | 7% | 29% | | 64% | | | 88.5 |
| M6 (Post-Dev Only) | 8% | 15% | | 76% | | | 86.7 |

Notes:

1. "Final Cover and Perimeter Landfill" areas include Basins A1 - A16 for the Pre-Development condition and Basins P1 - P9, SS1 - SS14, TD1 - TD6, and M1 - M3 for the Post-Development condition. The proposed final cover is generally assumed to be open space with fair grass coverage and have no more than 10% of the area occupied by gravel or dirt access roads.
2. Basins A17 - A18 are within the property north by northwest of the site and are predominantly straight row crops.
3. Basins A19 - A20 are within the properties west and southwest of the site and have less than 5% of the area occupied by Selby Ln. Other land usage varies, but was conservatively assumed to be farmsteads.
4. A region near the southwest border of the site with dense tree coverage is assumed to represent woods in fair condition and encompasses the entirety of Basin A22 (i.e., 0.4 acres) and a portion of Basin A21 (23.5 acres of the total 45.4 acre area).
5. Impervious surface area associated with basins A21, M4, M5, and M6 is based on the 25-year, 24-hour peak storage elevation of the onsite detention area, Pond 2, Pond 3, and the east leachate evaporation pond, respectively.
6. Other areas within Basins A21 and M4 – M6 are assumed to be open space with fair grass coverage and have no more than 10% of the area occupied by gravel or dirt access roads.

## Table 2B-5a. Travel Times (Sheet Flow, Shallow Concentrated Flow)

| Post-Development Conditions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Basin ID** | **Travel Time, Sheet Flow** | | | | **Travel Time, Shallow Concentrated Flow** | | | | |
| | Flow Length, L (ft) | Manning's n | Slope, S (ft/ft) | Time, $T_t$ (min) | Flow Length, L (ft) | Velocity Factor (ft/s) | Slope, S (ft/ft) | Average Velocity (ft/s) | Time, $T_t$ (min) |
| TD1 | 100 | 0.15 | 0.050 | 6.2 | 118 | 7.00 | 0.050 | 1.57 | 1.3 |
| TD2 | 100 | 0.15 | 0.050 | 6.2 | 173 | 7.00 | 0.050 | 1.57 | 1.8 |
| TD3 | 100 | 0.15 | 0.050 | 6.2 | 311 | 7.00 | 0.050 | 1.57 | 3.3 |
| TD4 | 100 | 0.15 | 0.050 | 6.2 | 457 | 7.00 | 0.050 | 1.57 | 4.9 |
| TD5 | 100 | 0.15 | 0.050 | 6.2 | 237 | 7.00 | 0.050 | 1.57 | 2.5 |
| TD6 | 100 | 0.15 | 0.050 | 6.2 | 222 | 7.00 | 0.050 | 1.57 | 2.4 |
| SS1-L | 100 | 0.15 | 0.250 | 3.3 | 22 | 8.00 | 0.250 | 4.00 | 0.1 |
| SS1-U | 100 | 0.15 | 0.250 | 3.3 | 26 | 9.00 | 0.250 | 4.50 | 0.1 |
| SS2 | 100 | 0.15 | 0.250 | 3.3 | 32 | 7.00 | 0.250 | 3.50 | 0.2 |
| SS3 | 100 | 0.15 | 0.250 | 3.3 | 18 | 7.00 | 0.250 | 3.50 | 0.1 |
| SS4 | 100 | 0.15 | 0.250 | 3.3 | 27 | 7.00 | 0.250 | 3.50 | 0.1 |
| SS5 | 100 | 0.15 | 0.250 | 3.3 | 24 | 7.00 | 0.250 | 3.50 | 0.1 |
| SS6 | 100 | 0.15 | 0.250 | 3.3 | 29 | 7.00 | 0.250 | 3.50 | 0.1 |
| SS7 | 79 | 0.15 | 0.250 | 2.7 | | | | | |
| SS8 | 100 | 0.15 | 0.250 | 3.3 | 118 | 7.00 | 0.250 | 3.50 | 0.6 |
| SS9 | 100 | 0.15 | 0.250 | 3.3 | 26 | 7.00 | 0.250 | 3.50 | 0.1 |
| SS10 | 100 | 0.15 | 0.250 | 3.3 | 24 | 7.00 | 0.250 | 3.50 | 0.1 |
| SS11 | 100 | 0.15 | 0.050 | 6.2 | 170 | 7.00 | 0.050 | 1.57 | 1.8 |
| SS12 | 100 | 0.15 | 0.250 | 3.3 | 57 | 7.00 | 0.250 | 3.50 | 0.3 |
| SS13 | 100 | 0.15 | 0.176 | 3.8 | 62 | 7.00 | 0.250 | 3.50 | 0.3 |
| SS14 | 100 | 0.15 | 0.159 | 3.9 | 65 | 7.00 | 0.250 | 3.50 | 0.3 |
| P1 | 100 | 0.15 | 0.250 | 3.3 | 20 | 7.00 | 0.250 | 3.50 | 0.1 |
| P2 | 91 | 0.15 | 0.250 | 3.0 | | | | | |
| P3 | 100 | 0.15 | 0.250 | 3.3 | 59 | 7.00 | 0.250 | 3.50 | 0.3 |
| P4 | 100 | 0.15 | 0.250 | 3.3 | | | | | |
| P5 | 100 | 0.15 | 0.250 | 3.3 | 109 | 7.00 | 0.250 | 3.50 | 0.5 |
| P6 | 100 | 0.15 | 0.080 | 5.2 | 83 | 7.00 | 0.080 | 1.98 | 0.7 |
| P7 | 51 | 0.15 | 0.250 | 1.9 | | | | | |
| P8 | 100 | 0.15 | 0.250 | 3.3 | | | | | |
| P9 | 100 | 0.15 | 0.250 | 3.3 | | | | | |
| P10 | 100 | 0.15 | 0.250 | 3.3 | 54 | 7.00 | 0.250 | 3.50 | 0.3 |
| A17 | 100 | 0.15 | 0.002 | 21.1 | 1062 | 7.00 | 0.002 | 0.34 | 52.0 |
| A18 | 100 | 0.15 | 0.002 | 20.9 | 1553 | 7.00 | 0.002 | 0.34 | 75.2 |
| A19 | 100 | 0.15 | 0.001 | 26.6 | 1399<br>1200 | 7.00<br>7.00 | 0.0013<br>0.0050 | 0.26<br>0.49 | 91.2<br>40.4 |
| A20 | 100 | 0.15 | 0.004 | 17.7 | 995<br>1000 | 7.00<br>7.00 | 0.0037<br>0.0180 | 0.42<br>0.94 | 39.2<br>17.7 |
| A22 | 23 | 0.15 | 0.087 | 1.5 | | | | | |
| A23 | 100 | 0.15 | 0.100 | 4.7 | 173 | 7.00 | 0.004 | 0.42 | 6.8 |
| M1 | 100 | 0.15 | 0.005 | 15.7 | 756 | 7.00 | 0.016 | 0.90 | 14.1 |
| M2 | 71 | 0.15 | 0.05 | 4.7 | | | | | |
| M3 | 65 | 0.15 | 0.05 | 4.4 | | | | | |
| M4–M6 | *Basins contain detention ponds – assume minimum lag time of 3.6 minutes.* | | | | | | | | |

Written by: A. Brewster Date: 10/7/2022 Reviewed by: S. Graves Date: 10/21/2022

Client: WMTX Project: Lacy Lakeview RDF Project No.: GW8041 Phase No.: 05

## Table 2B-5b. Travel Times (Sheet Flow, Shallow Concentrated Flow) (cont.)

| Pre-Development Conditions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Travel Time, Sheet Flow | | | | Travel Time, Shallow Concentrated Flow | | | | |
| Basin ID | Flow Length, L (ft) | Manning's n | Slope, S (ft/ft) | Time, $T_t$ (min) | Flow Length, L (ft) | Velocity Factor (ft/s) | Slope, S (ft/ft) | Average Velocity (ft/s) | Time, $T_t$ (min) |
| A1 | 100 | 0.15 | 0.25 | 3.27 | 190 | 7.0 | 0.25 | 3.50 | 0.9 |
| A2 | 100 | 0.15 | 0.07 | 5.55 | 279 | 7.0 | 0.07 | 1.81 | 2.6 |
| A3 | 100 | 0.15 | 0.25 | 3.27 | 140 | 7.0 | 0.25 | 3.50 | 0.7 |
| A4 | 100 | 0.15 | 0.02 | 9.0 | 1267 | 7.0 | 0.02 | 0.99 | 21.3 |
| A5 | 100 | 0.15 | 0.07 | 5.6 | 282 | 7.0 | 0.07 | 1.81 | 2.6 |
| A6 | 100 | 0.15 | 0.02 | 9.0 | 1057 | 7.0 | 0.02 | 0.99 | 17.8 |
| A7 | 100 | 0.15 | 0.07 | 5.6 | 255 | 7.0 | 0.07 | 1.81 | 2.4 |
| A8 | 100 | 0.15 | 0.02 | 9.0 | 818 | 7.0 | 0.02 | 0.99 | 13.8 |
| A9 | 100 | 0.15 | 0.25 | 3.3 | 150 | 7.0 | 0.25 | 3.50 | 0.7 |
| A10 | 100 | 0.15 | 0.07 | 5.6 | 250 | 7.0 | 0.07 | 1.81 | 2.3 |
| A11 | 100 | 0.15 | 0.25 | 3.3 | 220 | 7.0 | 0.25 | 3.50 | 1.0 |
| A12 | 100 | 0.15 | 0.07 | 5.6 | 250 | 7.0 | 0.07 | 1.81 | 2.3 |
| A13 | 100 | 0.15 | 0.25 | 3.3 | 199 | 7.0 | 0.25 | 3.50 | 0.9 |
| A14 | 100 | 0.15 | 0.25 | 3.3 | 162 | 7.0 | 0.25 | 3.50 | 0.8 |
| A15 | 100 | 0.15 | 0.07 | 5.6 | 290 | 7.0 | 0.07 | 1.81 | 2.7 |
| A16 | 100 | 0.15 | 0.25 | 3.3 | 83 | 7.0 | 0.25 | 3.50 | 0.4 |
| A17 | 100 | 0.15 | 0.0024 | 21.1 | 1062 | 7.0 | 0.0024 | 0.34 | 52.0 |
| A18 | 100 | 0.15 | 0.0024 | 20.9 | 1553 | 7.0 | 0.0024 | 0.34 | 75.2 |
| A19 | 100 | 0.15 | 0.0013 | 26.6 | 1399<br>1200 | 7.0<br>7.0 | 0.0013<br>0.0050 | 0.26<br>0.49 | 91.2<br>40.4 |
| A20 | 100 | 0.15 | 0.0037 | 17.7 | 995<br>1000 | 7.0<br>7.0 | 0.0037<br>0.0180 | 0.42<br>0.94 | 39.2<br>17.7 |
| A21 | 100 | 0.15 | 0.0245 | 8.3 | 552 | 7.0 | 0.0245 | 1.10 | 8.4 |
| A22 | 23 | 0.15 | 0.0870 | 1.5 | | | | | |
| A23 | 100 | 0.15 | 0.1000 | 4.7 | 173 | 7.0 | 0.0037 | 0.42 | 6.8 |

Notes:

1. The maximum length before sheet flow transitions to shallow concentrated flow is limited to 100 ft based on recommendations from TxDOT (2019)
2. An overland flow roughness coefficient of n = 0.15 was selected for all surfaces, based on sheet flow over short grass prairie (TxDOT, 2019).
3. A 2-year, 24-hour rainfall depth of 3.80 inches is selected based on the NOAA (2022) report.
4. Travel Time ($T_t$) is calculated for sheet flow using Manning's kinematic solution (USDA, 1986):
$$T_t = 0.007(nL)^{0.8} / [(P_{2\text{-}24})^{0.5}S^{0.4}]$$
5. Travel time is calculated for shallow concentrated flow as the square root of the slope (ft/ft) times a velocity factor. A velocity factor of 7.0 ft/s was selected, which corresponds to short grass pasture as reported in the HydroCAD v.8 Owner's Manual.

## Table 2B-6a. Travel Times (Channel Flow) and Times of Concentration

| Post-Development Conditions | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Basin ID | Travel Time, Sheet Flow Travel Time, Shallow Concentrated Flow | | | | | | | | | Design Tc (min) |
| | Flow Length, L (ft) | Depth, d (ft) | Area, A ($ft^2$) | Wetted P (ft) | Hydraulic Radius (ft) | Manning's n | Slope, S (ft/ft) | Average Velocity (ft/s) | Time, $T_t$ (min) | |
| TD1 | 1146 | 2.0 | 46.00 | 46.37 | 0.99 | 0.027 | 0.011 | 5.76 | 3.32 | 10.8 |
| TD2 | 899 | 2.0 | 12.00 | 12.72 | 0.94 | 0.027 | 0.020 | 7.51 | 2.00 | 10.1 |
| TD3 | 678 | 2.0 | 46.00 | 46.37 | 0.99 | 0.027 | 0.011 | 5.76 | 1.96 | 11.5 |
| TD4 | | | | | | | | | | 11.1 |
| TD5 | | | | | | | | | | 8.8 |
| TD6 | | | | | | | | | | 8.6 |
| SS1-L | 966 | 2.0 | 12.00 | 12.72 | 0.94 | 0.027 | 0.020 | 7.51 | 2.14 | 6.0 |
| SS1-U | 1050 | 2.0 | 12.00 | 12.72 | 0.94 | 0.027 | 0.020 | 7.51 | 2.33 | 6.0 |
| SS2 | | | | | | | | | | 6.0 |
| SS3 | 630 | 2.0 | 12.00 | 12.72 | 0.94 | 0.027 | 0.020 | 7.51 | 1.40 | 6.0 |
| SS4 | 850 | 2.0 | 12.00 | 12.72 | 0.94 | 0.027 | 0.020 | 7.51 | 1.89 | 6.0 |
| SS5 | 812 | 2.0 | 12.00 | 12.72 | 0.94 | 0.027 | 0.020 | 7.51 | 1.80 | 6.0 |
| SS6 | 576 | 2.0 | 12.00 | 12.72 | 0.94 | 0.027 | 0.020 | 7.51 | 1.28 | 6.0 |
| SS7 | | | | | | | | | | 6.0 |
| SS8 | 559 | 2.0 | 12.00 | 12.72 | 0.94 | 0.027 | 0.020 | 7.51 | 1.24 | 6.0 |
| SS9 | 534 | 2.0 | 12.00 | 12.72 | 0.94 | 0.027 | 0.020 | 7.51 | 1.19 | 6.0 |
| SS10 | 1033 | 2.0 | 12.00 | 12.72 | 0.94 | 0.027 | 0.020 | 7.51 | 2.29 | 6.0 |
| SS11 | 996 | 2.0 | 12.00 | 12.72 | 0.94 | 0.027 | 0.020 | 7.51 | 2.21 | 10.3 |
| SS12 | | | | | | | | | | 6.0 |
| SS13 | 324 | 2.0 | 12.00 | 12.72 | 0.94 | 0.027 | 0.020 | 7.51 | 0.72 | 6.0 |
| SS14 | 439 | 2.0 | 12.00 | 12.72 | 0.94 | 0.027 | 0.020 | 7.51 | 0.97 | 6.0 |
| P1 | 615 | 4.0 | 64.00 | 29.30 | 2.18 | 0.027 | 0.006 | 7.20 | 1.42 | 6.0 |
| P2 | 616 | 4.0 | 64.00 | 29.30 | 2.18 | 0.027 | 0.006 | 7.20 | 1.43 | 6.0 |
| P3 | 924 | 4.0 | 64.00 | 29.30 | 2.18 | 0.027 | 0.006 | 7.20 | 2.14 | 6.0 |
| P4 | 998 | 4.0 | 64.00 | 29.30 | 2.18 | 0.027 | 0.006 | 7.20 | 2.31 | 6.0 |
| P5 | 251 | 4.0 | 72.00 | 31.30 | 2.30 | 0.027 | 0.006 | 7.45 | 0.56 | 6.0 |
| P6 | | | | | | | | | | 6.0 |
| P7 | 1051 | 3.0 | 42.00 | 23.97 | 1.75 | 0.027 | 0.005 | 5.67 | 3.09 | 6.0 |
| P8 | 739 | 3.0 | 42.00 | 23.97 | 1.75 | 0.027 | 0.005 | 5.67 | 2.17 | 6.0 |
| P9 | 1137 | 3.0 | 42.00 | 23.97 | 1.75 | 0.027 | 0.005 | 5.67 | 3.34 | 6.6 |
| P10 | 617 | 3.0 | 42.00 | 23.97 | 1.75 | 0.027 | 0.005 | 5.67 | 1.81 | 6.0 |
| A17 | 1143 | 1.0 | 70.00 | 110.02 | 0.64 | 0.027 | 0.0087 | 3.82 | 4.99 | 78.1 |
| A18 | | | | | | | | | | 96.1 |
| A19 | | | | | | | | | | 158.2 |
| A20 | | | | | | | | | | 74.7 |
| A22 | 380 | 2.0 | 46.00 | 46.37 | 0.99 | 0.027 | 0.0263 | 8.90 | 0.71 | 6.0 |
| A23 | | | | | | | | | | 11.5 |
| M1 | | | | | | | | | | 29.7 |
| M2 | 562 | 3.0 | 28.50 | 15.82 | 1.80 | 0.027 | 0.010 | 8.33 | 1.12 | 6.0 |
| M3 | 772 | 3.0 | 28.50 | 15.82 | 1.80 | 0.027 | 0.010 | 8.33 | 1.54 | 6.0 |
| M4–M6 | *Basins contain detention ponds – assume minimum lag time of 3.6 minutes.* | | | | | | | | | 6.0 |

## Table 2B-6b. Travel Times (Channel Flow) and Times of Concentration (cont.)

| Pre-Development Conditions | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Basin ID** | Travel Time, Sheet Flow Travel Time, Shallow Concentrated Flow | | | | | | | | | **Design Tc (min)** |
| | Flow Length, L (ft) | Depth, d (ft) | Area, A ($ft^2$) | Wetted P (ft) | Hydraulic Radius (ft) | Manning's n | Slope, S (ft/ft) | Average Velocity (ft/s) | Time, $T_t$ (min) | |
| A1 | | | | | | | | | | 6.0 |
| A2 | 315 | 2.0 | 46.0 | 46.4 | 0.99 | 0.027 | 0.020 | 7.76 | 0.68 | 8.8 |
| A3 | 479 | 2.0 | 46.0 | 46.4 | 0.99 | 0.027 | 0.020 | 7.76 | 1.03 | 6.0 |
| A4 | | | | | | | | | | 30.3 |
| A5 | 153 | 2.0 | 46.0 | 46.4 | 0.99 | 0.027 | 0.020 | 7.76 | 0.33 | 8.5 |
| A6 | | | | | | | | | | 26.8 |
| A7 | 410 | 2.0 | 46.0 | 46.4 | 0.99 | 0.027 | 0.020 | 7.76 | 0.88 | 8.8 |
| A8 | | 4.0 | 64.0 | 29.3 | 2.18 | 0.027 | 0.006 | 7.20 | 0.00 | 22.8 |
| A9 | 703 | 4.0 | 64.0 | 29.3 | 2.18 | 0.027 | 0.006 | 7.20 | 1.63 | 6.0 |
| A10 | 363 | 2.0 | 46.0 | 46.4 | 0.99 | 0.027 | 0.020 | 7.76 | 0.78 | 8.6 |
| A11 | 361 | 4.0 | 64.0 | 29.3 | 2.18 | 0.027 | 0.006 | 7.20 | 0.84 | 6.0 |
| A12 | 357 | 2.0 | 46.0 | 46.4 | 0.99 | 0.027 | 0.020 | 7.76 | 0.77 | 8.6 |
| A13 | 603 | 4.0 | 64.0 | 29.3 | 2.18 | 0.027 | 0.006 | 7.20 | 1.40 | 6.0 |
| A14 | 305 | 4.0 | 72.0 | 31.3 | 2.30 | 0.027 | 0.006 | 7.45 | 0.68 | 6.0 |
| A15 | 186 | 2.0 | 46.0 | 46.4 | 0.99 | 0.027 | 0.020 | 7.76 | 0.40 | 8.6 |
| A16 | 135 | 4.0 | 64.0 | 29.3 | 2.18 | 0.027 | 0.006 | 7.20 | 0.31 | 6.0 |
| A17 | 1143 | 1.0 | 70.0 | 110.0 | 0.64 | 0.027 | 0.009 | 3.82 | 4.99 | 78.1 |
| A18 | | | | | | | | | | 96.1 |
| A19 | | | | | | | | | | 158.2 |
| A20 | | | | | | | | | | 74.7 |
| A21 | | | | | | | | | | 16.7 |
| A22 | 380 | 2.0 | 46.00 | 46.37 | 0.99 | 0.027 | 0.0263 | 8.90 | 0.71 | 6.0 |
| A23 | | | | | | | | | | 11.5 |

| Typical Channel Characteristics | | | | | |
|---|---|---|---|---|---|
| Name | Base Width (ft) | Left Slope (xH:1V) | Right Slope (xH:1V) | Manning's n | Typical Slope |
| North & East Perimeter Channel | 4 | 3 | 3 | 0.027 | 0.006 |
| West Perimeter Channel | 5 | 3 | 3 | 0.027 | 0.005 |
| Top Deck Drainage Terrace | 0 | 20 | 3 | 0.027 | 0.011 |
| Side-Slope Drainage Terrace | 0 | 4 | 2 | 0.027 | 0.020 |
| Diversion Channel / On-Site Stream | 5 | 1.5 | 1.5 | 0.027 | 0.010 |
| Natural Channel, Basin A17 | 30 | 40 | 40 | 0.027 | 0.018 |

Notes:

1. A manning's roughness coefficient of n = 0.27 was selected for all open channel flow. Table 4-7 in TxDOT (2019) recommends a 0.022 - 0.033 range for earthen channels (excavated or dedged channels; Earth, straight and uniform; with short grass, few weeds) and a range 0.025 - 0.033 for natural streams (Minor streams; clean, straight, full, no rifts or deep pools).

2. Open channel flow velocity is calculated using Manning's equation (Chow, 1959):
$V = (1.49r^{2/3}S^{1/2}) / n$ where: r = hydraulic radius (ft), and is equal to A/P [area ($ft^2$)/wetted perimeter (ft)]

3. Design time of concentration (Tc) is equal to the total travel time for channel flow (as reported in this table), shallow concentrated flow (see Table 2B-2), and sheet flow (see Table 2B-2) within a given subbasin.

## Table 2B-7. Reservoir Elevation-Area and Elevation-Discharge Relationships

| Elevation (ft, MSL) | Elevation-Area Relationship Input | | Elevation-Discharge Relationship Input | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Broad-Crested Spillway Discharge Parameters | | Culvert Discharge Parameters | | | |
| | Contour Area (acres) | Storage (acre-feet) | Length (ft) | Discharge Location | Type | Length (ft) | Outlet Elevation (ft, MSL) | Discharge Location |
| POND 1 (Post-Dev) | | | | | | | | |
| 404 | 0.65 | | | | 48" Dia HDPE | 85 | 405 | Outfall B |
| 406 | 0.90 | 1.55 | | | | | | |
| 408 | 1.19 | 3.65 | 25 | Outfall B | | | | |
| 410 | 1.52 | 6.36 | | | | | | |
| POND 2 (Post-Dev) | | | | | | | | |
| 406 | 0.38 | | | | 36" Dia. HDPE | 85 | 404 | South Channel 2 |
| 408 | 0.48 | 0.86 | | | | | | |
| 410 | 0.58 | 1.92 | | | | | | |
| 412 | 0.70 | 3.20 | | | | | | |
| 414 | 0.84 | 4.74 | 25 | South Channel 2 | | | | |
| 416 | 1.18 | 6.75 | | | | | | |
| Existing A21 Low Spot (Pre-Dev) | | | | | | | | |
| 408 | 0.00 | | 16 | Outfall B | | | | |
| 410 | 0.24 | 0.31 | | | | | | |
| 412 | 0.97 | 1.40 | | | | | | |
| 414 | 2.08 | 4.31 | 150<br>19 | Outfall B<br>Outfall C | | | | |
| 415 | 2.50 | 6.60 | | | | | | |
| Existing A17 Low Spot (Pre-Dev and Post-Dev) | | | | | | | | |
| 424 | 0.00 | | | | 2 x 36" Dia. RCP | 20 | 422 | East Channel 1 |
| 425 | 0.01 | 0.01 | | | | | | |
| 426 | 0.04 | 0.03 | | | | | | |
| 427 | 0.10 | 0.10 | 24 | Off-Site | | | | |
| 428 | 0.38 | 0.34 | 143<br>104 | Off-Site<br>East Channel 1 | | | | |
| 429 | 0.77 | 0.92 | | | | | | |

Notes:

1. Broad-crested spillways were modeled with a 2.63 ft/S coefficient based on recommendations from USACE (2022).
2. Culverts were modeled with an n value of 0.012, which is representative for both HDPE and concrete culverts based on recommendations from TxDOT (2019).
3. Culverts were modeled with an a square edge headwall, entrance coefficient of 0.5, and exit coefficient of 1 based on recommendation sfrom USACE (2022).
4. Spillway base elevation corresponds to the indicated elevation and is assumed to extend vertically to the maximum elevation of a given elevation-area relationship (i.e., the crest elevation).
5. Culvert invert elevation corresponds to the indicated elevation and is assumed to extend vertically to the maximum elevation of a given elevation-area relationship (i.e., the crest elevation).

## Table 2B-8. Summary of Peak Discharge, Total Runoff Volume, and Time to Peak Discharge at Site Outfalls

| Location | Output parameter | 25-Year, 24-Hour Design Event | | 100-Year, 24-Hour Design Event | |
|---|---|---|---|---|---|
| | | Pre-Dev | Post-Dev | Pre-Dev | Post-Dev |
| Outfall A | Peak Discharg (cfs) | 481 | 435 | 683 | 676 |
| | Total Runoff Volume (ac-ft) | 75.8 | 73.3 | 105.4 | 101.7 |
| | Time to Peak Discharge (min) | 10 | 11 | 9 | 10 |
| | Total Runoff Area (acres) | 166.7 | 160.7 | 166.7 | 160.7 |
| Outfall B | Peak Discharge (cfs) | 250 | 222 | 351 | 338 |
| | Total Runoff Volume (ac-ft) | 65.0 | 69.1 | 92.5 | 97.9 |
| | Time to Peak Discharge (min) | 18 | 31 | 19 | 20 |
| | Total Runoff Area (AC) | 138.5 | 144.5 | 138.5 | 144.5 |
| Outfall C | Peak Discharge (cfs) | 4 | 4 | 5 | 5 |
| | Total Runoff Volume (ac-ft) | 0.3 | 0.3 | 0.4 | 0.4 |
| | Time to Peak Discharge (min) | 5 | 5 | 5 | 5 |
| | Total Runoff Area (acres) | 0.7 | 0.7 | 0.7 | 0.7 |

## Table 2B-9. Summary of Pond Design Output

| Parameter | 25-Year Event | | 100-Year Event | |
|---|---|---|---|---|
| | Pond 1 | Pond 2 | Pond 1 | Pond 2 |
| Peak Water Surface Elevation (ft, MSL) | 415.0 | 409.2 | 415.9 | 410.0 |
| Available Freeboard to Pond Crest (ft) | 1.0 | 0.8 | 0.1 | 0.0 |
| Peak Storage per Pond (ac-ft) | 5.6 | 5.3 | 6.6 | 6.3 |

# FIGURES

Written by: A. Brewster Date: 10/7/2022 Reviewed by: S. Graves Date: 10/21/2022

Client: WMTX Project: Lacy Lakeview RDF Project No.: GW8041 Phase No.: 05

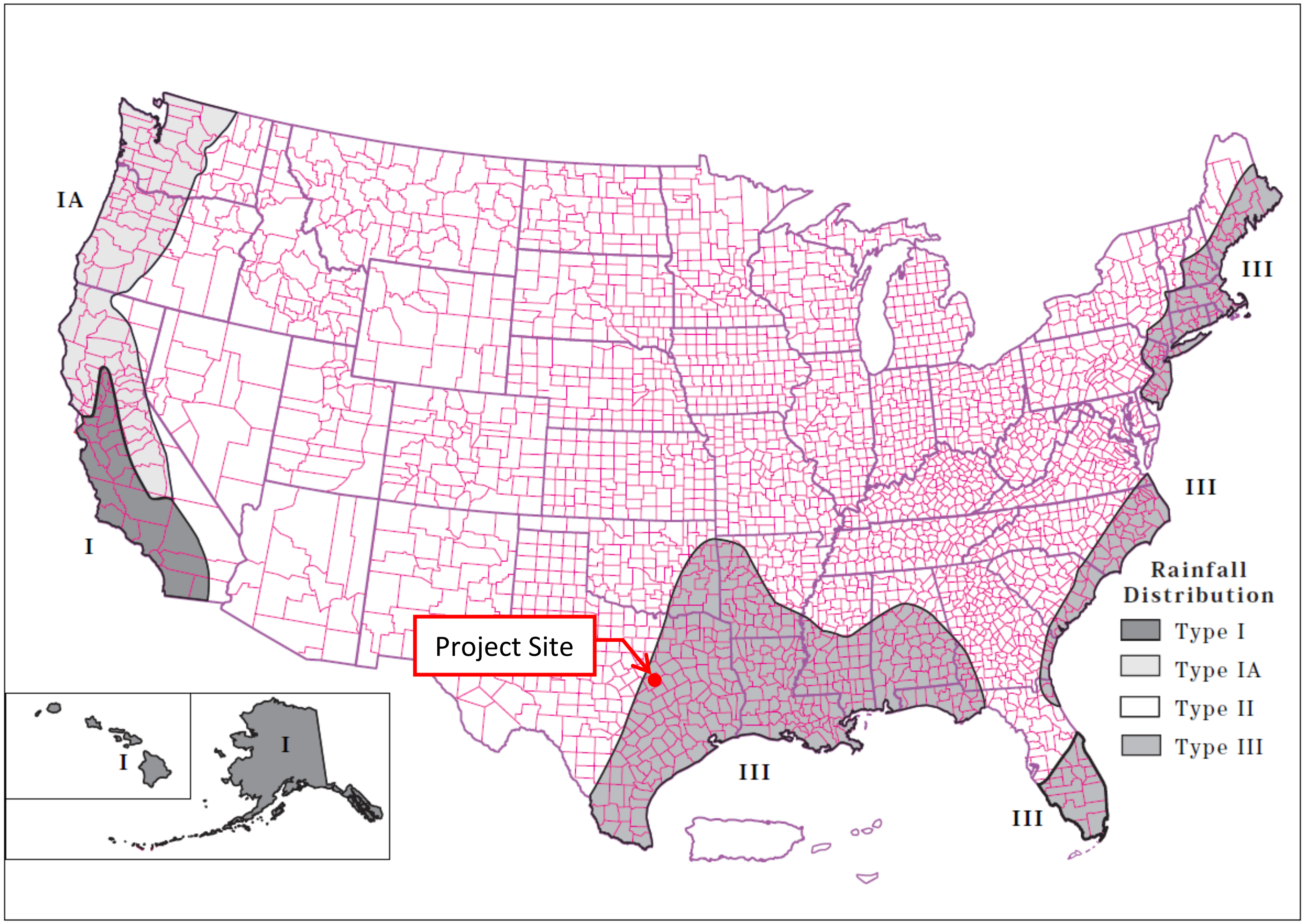
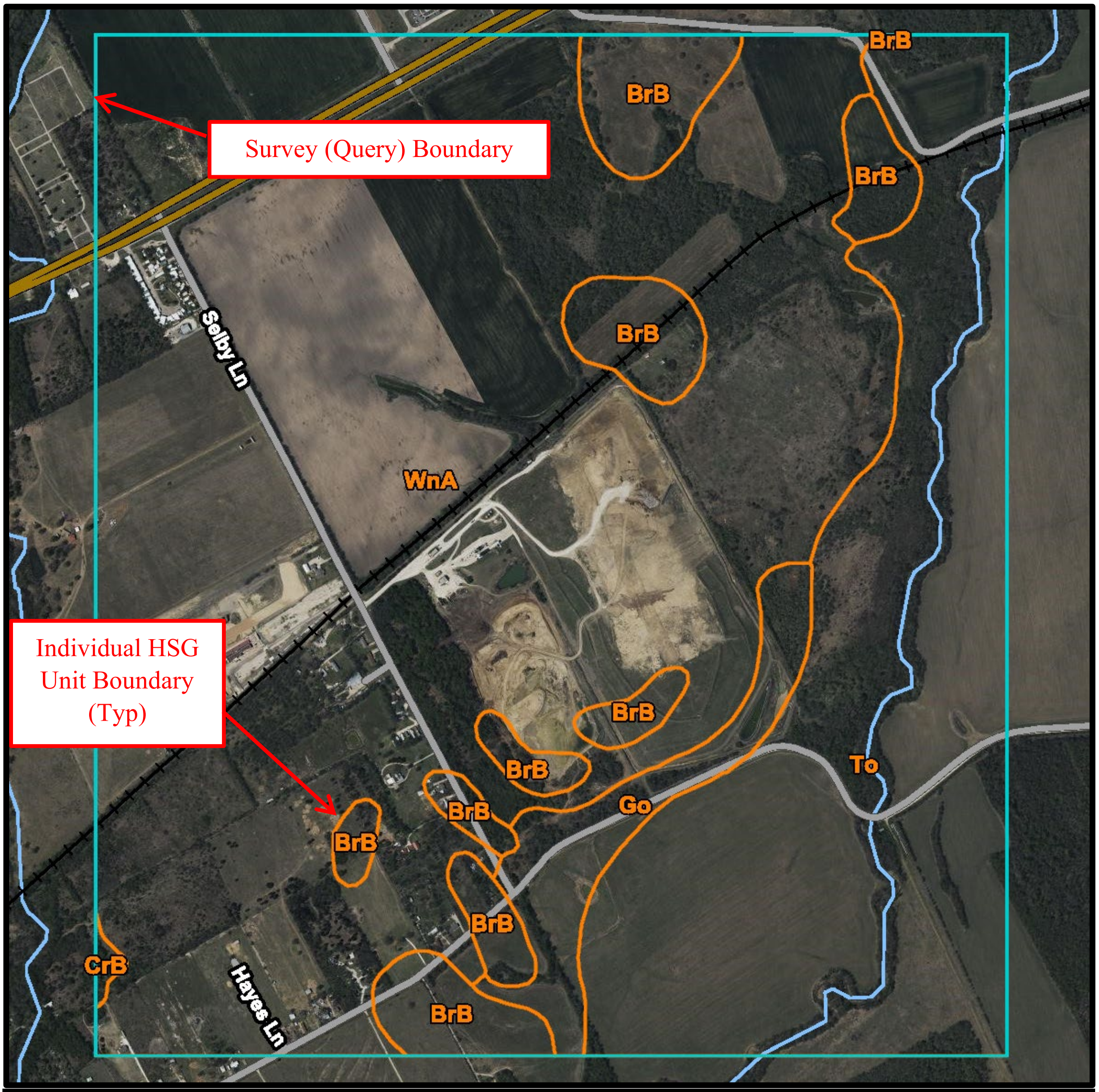



**Figure 2B-1. SCS Rainfall Distributions (from USDA, 1986)**




| Map Unit Symbol | Map Unit Name | Acres in Survey Boundary | Percent in Survey Boundary |
|---|---|---|---|
| BrB | Bremond loam, 0 to 2 percent slopes | 88.3 | 7.8% |
| CrB | Crockett loam, 3 to 5 percent slopes | 1.6 | 0.1% |
| Go | Gowen clay loam, frequently flooded | 39.1 | 3.5% |
| To | Tinn clay, 0 to 1 percent slopes, frequently flooded | 274.3 | 24.3% |
| WnA | Wilson clay loam, 0 to 2 percent slopes | 727.4 | 64.3% |
| | **Totals for Area of Interest** | **1,130.8** | 100.0% |

**Figure 2B-2. USDA Soil Survey for the Site (from NRCS, 2022)**

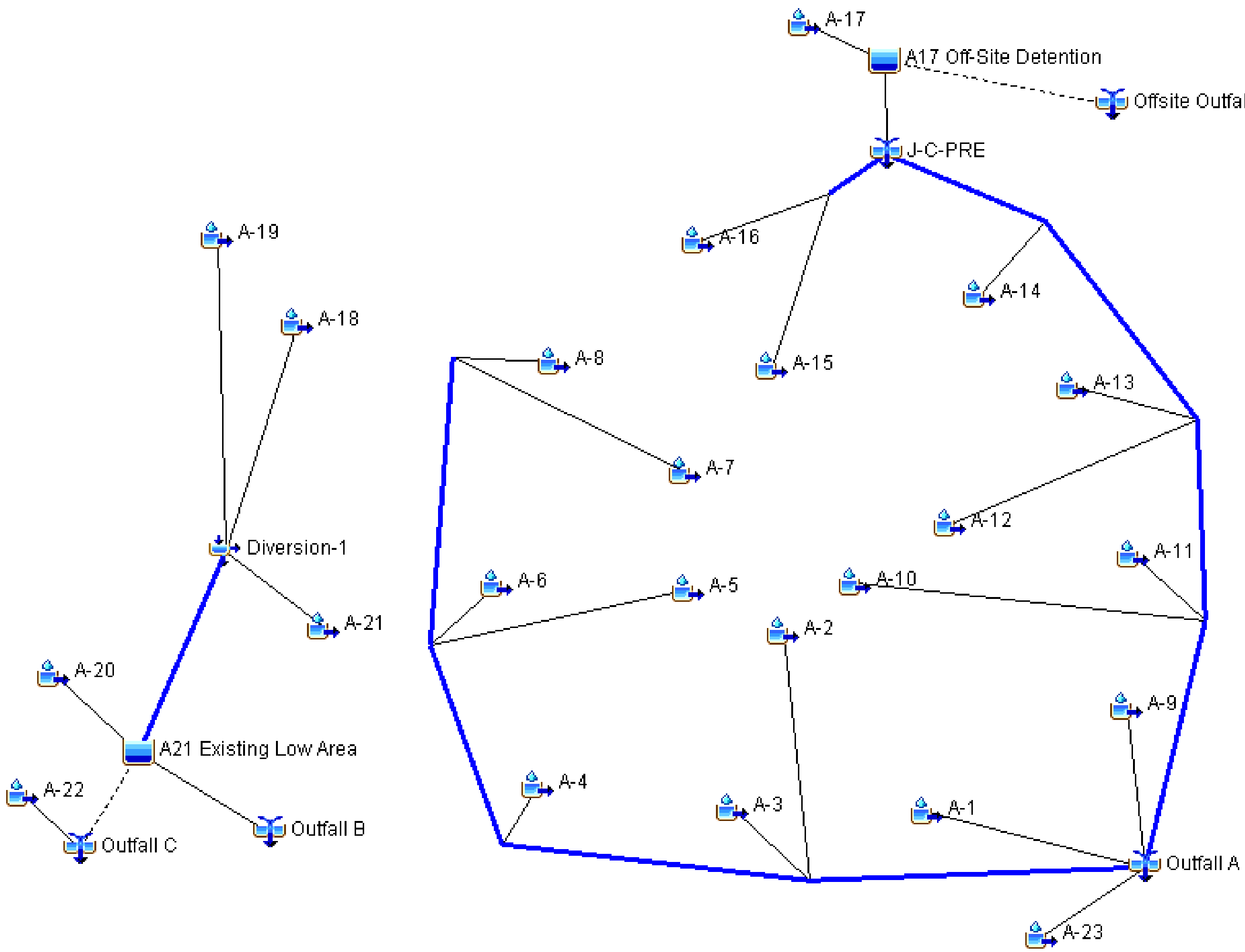



**Figure 2B-3. Pre-Development HEC-HMS Nodal Network**

Written by: A. Brewster Date: 10/7/2022 Reviewed by: S. Graves Date: 10/21/2022

Client: WMTX Project: Lacy Lakeview RDF Project No.: GW8041 Phase No.: 05

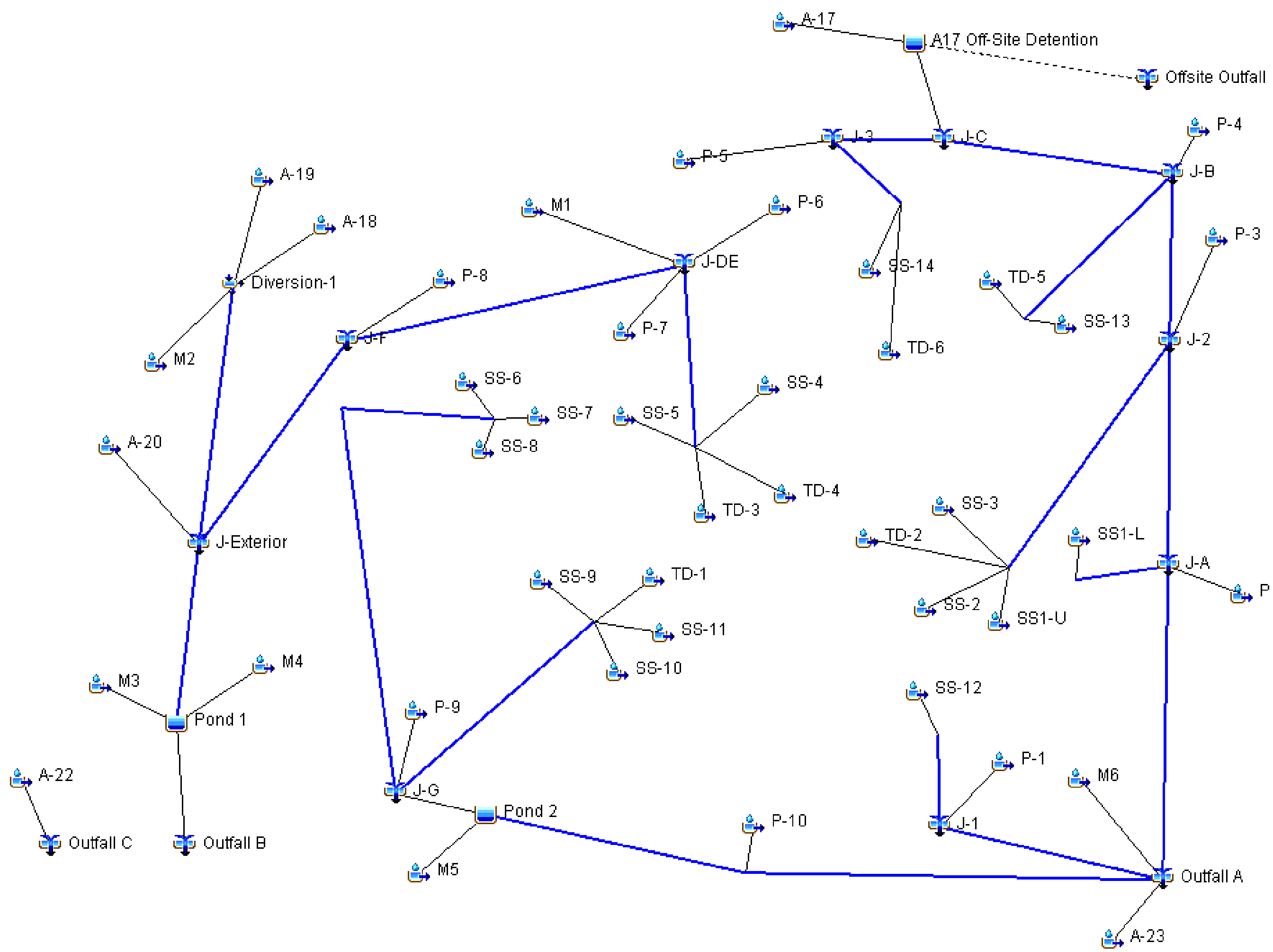



**Figure 2B-4. Post-Development HEC-HMS Nodal Network**

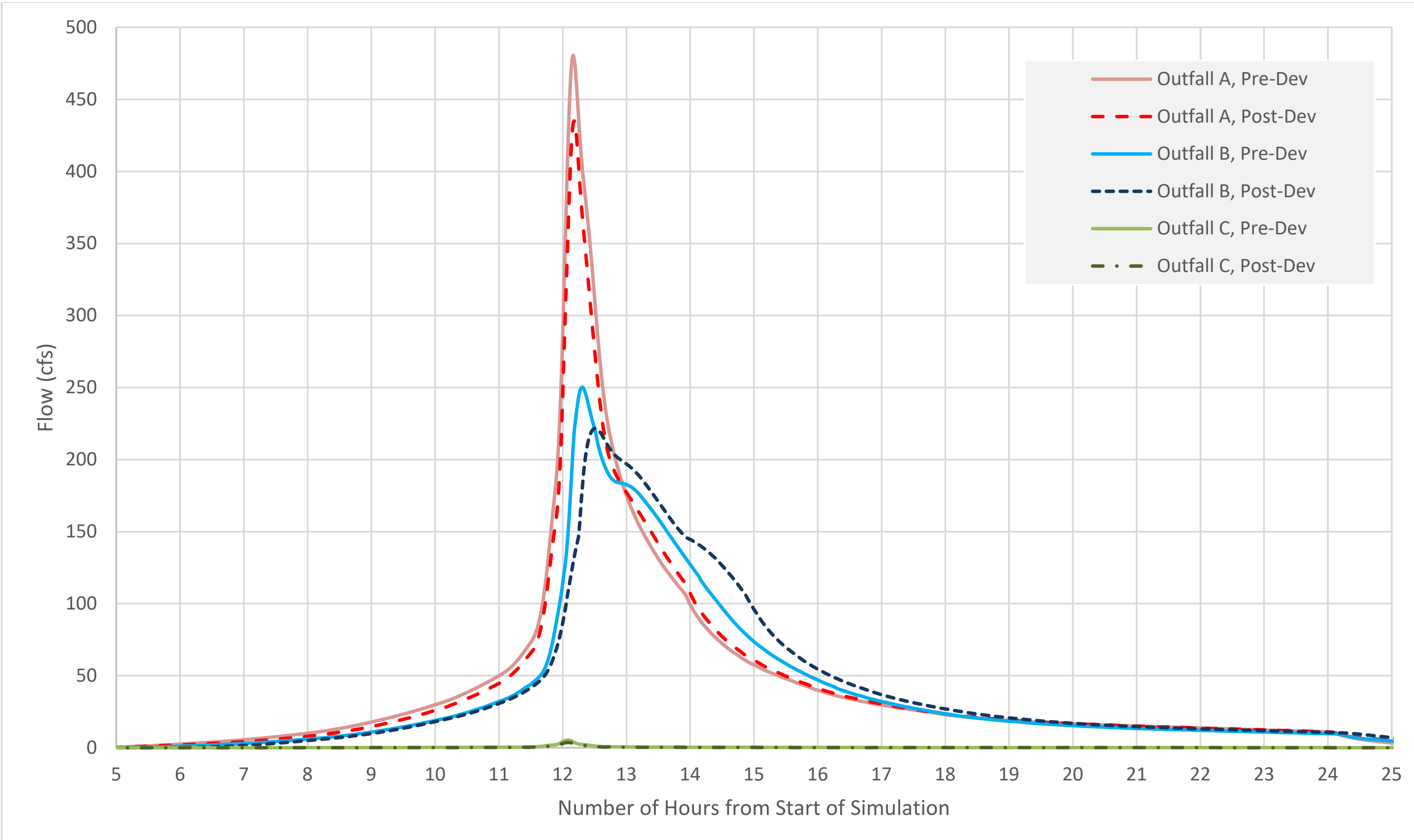



**Figure 2B-5. 25-yr, 24-hr HEC-HMS Precipitation Event Runoff Outfall Hydrographs**

Written by: A. Brewster Date: 10/7/2022 Reviewed by: S. Graves Date: 10/21/2022

Client: WMTX Project: Lacy Lakeview RDF Project No.: GW8041 Phase No.: 05

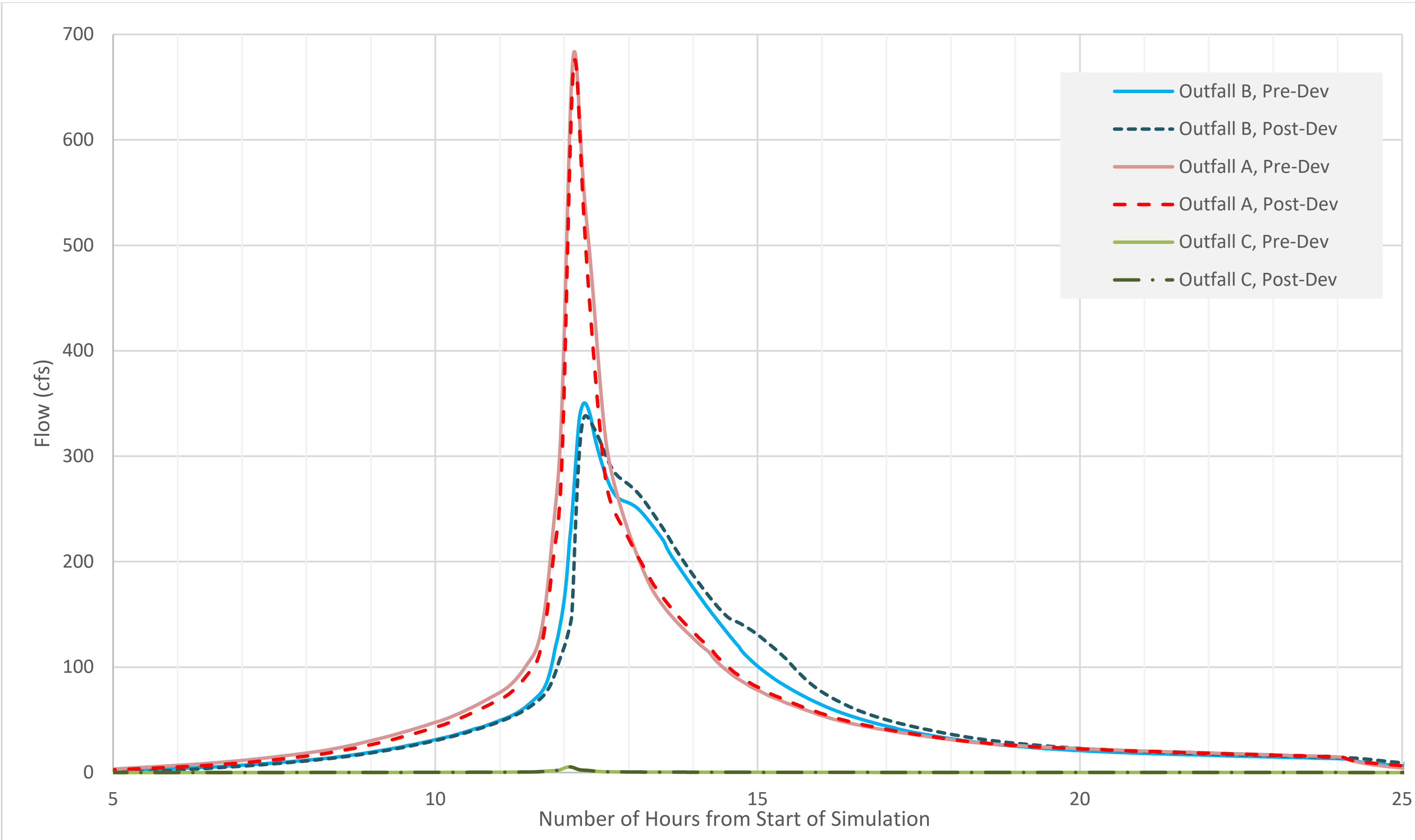



**Figure 2B-6. 100-yr, 24-hr HEC-HMS Precipitation Event Runoff Outfall Hydrographs**

# APPENDIX 2B-1

# HEC-HMS HYDROLOGIC MODEL PARAMETERS

## Table 2B-1-1a. Pre-Development Precipitation Event Nodal Areas, Peak Flow Rates, and Runoff Volumes

| Hydrologic Element | Area (acre) | Pre-Development 25-Year, 24-Hour Event | | | Pre-Development 25-Year 24-Hour Event | | |
|---|---|---|---|---|---|---|---|
| | | Peak Flow Rate (cfs) | Time of Peak (hr:mm) | Volume (ac-ft) | Peak Flow Rate (cfs) | Time of Peak (hr:mm) | Volume (ac-ft) |
| A-1 | 5.1526 | 29.6 | 12:05 | 2.4 | 41.4 | 12:05 | 3.4 |
| A-10 | 6.2861 | 34.4 | 12:07 | 2.9 | 48.2 | 12:06 | 4.1 |
| A-11 | 5.3293 | 30.6 | 12:05 | 2.5 | 42.9 | 12:05 | 3.5 |
| A-12 | 6.6131 | 36.2 | 12:07 | 3.1 | 50.7 | 12:06 | 4.4 |
| A-13 | 5.7939 | 33.3 | 12:05 | 2.7 | 46.6 | 12:05 | 3.8 |
| A-14 | 5.2659 | 30.2 | 12:05 | 2.4 | 42.4 | 12:05 | 3.5 |
| A-15 | 3.6115 | 19.8 | 12:07 | 1.7 | 27.7 | 12:06 | 2.4 |
| A-16 | 1.6877 | 9.7 | 12:05 | 0.8 | 13.6 | 12:05 | 1.1 |
| A-17 | 62.9133 | 153.6 | 12:50 | 31.7 | 211.7 | 12:49 | 44.4 |
| A-17 Inlet | 62.9133 | 96.8 | 12:51 | 27.9 | 122.1 | 12:50 | 36.9 |
| A-18 | 19.2122 | 41.2 | 13:01 | 9.7 | 56.8 | 13:01 | 13.6 |
| A-19 | 47.2589 | 70.1 | 13:40 | 22.7 | 98.0 | 13:39 | 32.2 |
| A-2 | 3.9046 | 21.3 | 12:07 | 1.8 | 29.8 | 12:07 | 2.6 |
| A-20 | 26.6938 | 64.6 | 12:48 | 12.8 | 90.1 | 12:48 | 18.2 |
| A-21 | 45.3696 | 202.0 | 12:11 | 19.7 | 288.3 | 12:11 | 28.6 |
| A-22 | 0.7085 | 3.7 | 12:05 | 0.3 | 5.3 | 12:05 | 0.4 |
| A-23 | 4.1594 | 21.5 | 12:08 | 1.9 | 30.2 | 12:08 | 2.7 |
| A-3 | 5.5667 | 32.0 | 12:05 | 2.6 | 44.8 | 12:05 | 3.7 |
| A-4 | 7.9341 | 29.5 | 12:20 | 3.7 | 41.5 | 12:20 | 5.2 |
| A-5 | 6.2957 | 34.5 | 12:06 | 2.9 | 48.4 | 12:06 | 4.2 |
| A-6 | 12.9869 | 50.9 | 12:18 | 6 | 71.6 | 12:18 | 8.6 |
| A-7 | 6.8154 | 37.2 | 12:07 | 3.1 | 52.1 | 12:07 | 4.5 |
| A-8 | 11.8118 | 49.5 | 12:15 | 5.5 | 69.5 | 12:15 | 7.8 |
| A-9 | 4.5606 | 26.2 | 12:05 | 2.1 | 36.7 | 12:05 | 3.0 |

**Table 2B-1-1b. Pre-Development Precipitation Event Nodal Areas, Peak Flow Rates, and Runoff Volumes (Cont.)**

| Hydrologic Element | Area (acre) | Pre-Development 25-Year, 24-Hour Event | | | Pre-Development 25-Year 24-Hour Event | | |
|---|---|---|---|---|---|---|---|
| | | Peak Flow Rate (cfs) | Time of Peak (hr:mm) | Volume (ac-ft) | Peak Flow Rate (cfs) | Time of Peak (hr:mm) | Volume (ac-ft) |
| Diversion-1 | 111.8406 | 234.1 | 12:12 | 52.2 | 334.4 | 12:12 | 74.3 |
| East Channel 1 D | 73.4784 | 103.8 | 12:52 | 32.8 | 144.1 | 12:09 | 43.9 |
| East Channel 1 U | 68.2125 | 100.4 | 12:51 | 30.3 | 127.1 | 12:51 | 40.4 |
| East Channel 2 | 85.8854 | 165.2 | 12:09 | 38.5 | 234.2 | 12:09 | 52.1 |
| East Channel 3 | 97.5008 | 224.4 | 12:09 | 43.9 | 318.4 | 12:09 | 59.8 |
| Existing Natural Channel | 111.8406 | 233.7 | 12:14 | 52.2 | 333.8 | 12:13 | 74.3 |
| Existing On-Site Detention | 138.5344 | 250.2 | 12:18 | 65 | 350.5 | 12:19 | 92.5 |
| J-C-PRE | 68.2125 | 100.4 | 12:50 | 30.3 | 127.1 | 12:50 | 40.4 |
| North Channel | 5.2992 | 29.2 | 12:06 | 2.4 | 40.9 | 12:06 | 3.5 |
| Offsite Outfall | 0.0000 | 56.7 | 12:51 | 3.8 | 89.5 | 12:50 | 7.5 |
| Outfall A | 166.6886 | 480.5 | 12:10 | 75.8 | 683.4 | 12:09 | 105.4 |
| Outfall B | 138.5344 | 250.2 | 12:18 | 65 | 350.5 | 12:19 | 92.5 |
| Outfall C | 0.7085 | 3.7 | 12:05 | 0.3 | 5.3 | 12:05 | 0.4 |
| South Channel 1 | 45.8438 | 176.4 | 12:16 | 21.2 | 248.0 | 12:15 | 30.3 |
| South Channel 2 | 55.3152 | 205.2 | 12:15 | 25.5 | 290.4 | 12:14 | 36.5 |
| West Channel 1 | 18.6272 | 77.9 | 12:12 | 8.6 | 109.5 | 12:12 | 12.3 |
| West Channel 2 | 37.9098 | 150.1 | 12:13 | 17.5 | 211.2 | 12:13 | 25.0 |

## Table 2B-1-2a. Post-Development Precipitation Event Nodal Areas, Peak Flow Rates, and Runoff Volumes

| Hydrologic Element | Area (acre) | Post-Development 25-Year, 24-Hour Event | | | Post-Development 25-Year 24-Hour Event | | |
|---|---|---|---|---|---|---|---|
| | | Peak Flow Rate (cfs) | Time of Peak (hr:mm) | Volume (ac-ft) | Peak Flow Rate (cfs) | Time of Peak (hr:mm) | Volume (ac-ft) |
| A-17 | 62.9133 | 153.7 | 12:50 | 31.7 | 211.7 | 12:49 | 44.4 |
| A-17 Inlet | 62.9133 | 96.8 | 12:51 | 27.9 | 122.1 | 12:50 | 36.9 |
| A-18 | 19.2122 | 41.2 | 13:01 | 9.7 | 56.8 | 13:01 | 13.6 |
| A-19 | 47.2589 | 70.1 | 13:40 | 22.7 | 98.0 | 13:39 | 32.2 |
| A-20 | 26.6938 | 64.6 | 12:48 | 12.8 | 90.1 | 12:48 | 18.2 |
| A-22 | 0.7085 | 3.7 | 12:05 | 0.3 | 5.3 | 12:05 | 0.4 |
| A-23 | 4.1594 | 21.5 | 12:08 | 1.9 | 30.2 | 12:08 | 2.7 |
| Culvert WC-1 | 45.3754 | 202.6 | 12:11 | 20.9 | 284.8 | 12:10 | 29.9 |
| Diversion Channel D | 139.9059 | 264.0 | 12:13 | 66.8 | 373.0 | 12:12 | 94.7 |
| Diversion Channel U | 67.8368 | 103.2 | 13:22 | 33.1 | 143.9 | 13:21 | 46.6 |
| Diversion 1 | 67.8368 | 103.2 | 13:20 | 33.1 | 143.9 | 13:20 | 46.6 |
| DS-A | 2.8134 | 16.1 | 12:05 | 1.3 | 22.6 | 12:05 | 1.9 |
| DS-B-L | 4.8915 | 28.1 | 12:05 | 2.3 | 39.3 | 12:05 | 3.2 |
| DS-B-U | 12.0992 | 68.6 | 12:05 | 5.6 | 96.2 | 12:05 | 8.0 |
| DS-C | 3.1859 | 17.7 | 12:06 | 1.5 | 24.8 | 12:06 | 2.1 |
| DS-D | 5.6256 | 31.1 | 12:06 | 2.6 | 43.6 | 12:06 | 3.7 |
| DS-E | 26.0480 | 137.5 | 12:07 | 12 | 192.7 | 12:07 | 17.2 |
| DS-F | 9.8739 | 56.6 | 12:05 | 4.6 | 79.4 | 12:05 | 6.5 |
| DS-G | 23.7702 | 126.8 | 12:07 | 11 | 177.7 | 12:07 | 15.7 |
| East Channel 1 | 71.3632 | 102.5 | 12:53 | 31.8 | 130.5 | 12:10 | 42.5 |
| East Channel 2 | 80.0346 | 133.2 | 12:11 | 35.8 | 188.9 | 12:10 | 48.2 |
| East Channel 3 D | 102.7622 | 245.6 | 12:09 | 46.3 | 349.5 | 12:09 | 63.2 |
| East Channel 3 U | 95.7568 | 209.1 | 12:08 | 43.1 | 298.4 | 12:08 | 58.6 |
| J-A | 102.7622 | 245.7 | 12:08 | 46.3 | 349.9 | 12:07 | 63.2 |
| J-B | 80.0346 | 133.3 | 12:09 | 35.8 | 189.3 | 12:08 | 48.2 |
| J-C | 71.3632 | 102.6 | 12:49 | 31.8 | 130.8 | 12:07 | 42.5 |
| J-DE | 43.5238 | 196.1 | 12:07 | 20.1 | 275.6 | 12:07 | 28.7 |
| J-Exterior | 139.9059 | 264.2 | 12:11 | 66.8 | 373.3 | 12:11 | 94.7 |
| J-F | 45.3754 | 202.7 | 12:11 | 20.9 | 285.2 | 12:10 | 29.9 |
| J-G | 38.3021 | 203.6 | 12:07 | 17.7 | 288.1 | 12:07 | 25.3 |
| J-1 | 4.4173 | 25.4 | 12:05 | 2 | 35.5 | 12:05 | 2.9 |
| J-2 | 95.7568 | 209.7 | 12:08 | 43.1 | 298.5 | 12:08 | 58.6 |
| J-3 | 8.4499 | 47.1 | 12:06 | 3.9 | 66.0 | 12:06 | 5.6 |

## Table 2B-1-2b. Post-Development Precipitation Event Nodal Areas, Peak Flow Rates, and Runoff Volumes (cont.)

| Hydrologic Element | Area (acre) | Post-Development 25-Year, 24-Hour Event | | | Post-Development 25-Year 24-Hour Event | | |
|---|---|---|---|---|---|---|---|
| | | Peak Flow Rate (cfs) | Time of Peak (hr:mm) | Volume (ac-ft) | Peak Flow Rate (cfs) | Time of Peak (hr:mm) | Volume (ac-ft) |
| M1 | 12.1082 | 45.4 | 12:20 | 5.6 | 63.8 | 12:19 | 8.0 |
| M2 | 1.3658 | 7.8 | 12:05 | 0.6 | 11.0 | 12:05 | 0.9 |
| M3 | 2.3770 | 13.6 | 12:05 | 1.1 | 19.1 | 12:05 | 1.6 |
| M4 | 2.2342 | 14.0 | 12:05 | 1.2 | 19.1 | 12:05 | 1.6 |
| M5 | 5.2595 | 31.9 | 12:05 | 2.6 | 43.9 | 12:05 | 3.7 |
| M6 | 3.2717 | 19.4 | 12:05 | 1.6 | 26.9 | 12:05 | 2.2 |
| North Channel 1 | 8.4499 | 47.1 | 12:06 | 3.9 | 66.0 | 12:06 | 5.6 |
| Offsite Outfall | 0.0000 | 56.7 | 12:51 | 3.8 | 89.5 | 12:50 | 7.5 |
| Outfall A | 160.7072 | 435.0 | 12:11 | 73.3 | 676.0 | 12:10 | 101.7 |
| Outfall B | 144.5171 | 221.7 | 12:31 | 69.1 | 338.4 | 12:20 | 97.9 |
| Outfall C | 0.7085 | 3.7 | 12:05 | 0.3 | 5.3 | 12:05 | 0.4 |
| Pond 1 | 43.5616 | 154.0 | 12:15 | 20.3 | 254.1 | 12:13 | 28.9 |
| Pond 2 | 144.5171 | 221.7 | 12:31 | 69.1 | 338.4 | 12:20 | 97.9 |
| P-1 | 1.6038 | 9.2 | 12:05 | 0.7 | 12.9 | 12:05 | 1.1 |
| P-10 | 2.5350 | 14.6 | 12:05 | 1.2 | 20.4 | 12:05 | 1.7 |
| P-2 | 2.1139 | 12.1 | 12:05 | 1 | 17.0 | 12:05 | 1.4 |
| P-3 | 3.6230 | 20.8 | 12:05 | 1.7 | 29.1 | 12:05 | 2.4 |
| P-4 | 5.4854 | 31.5 | 12:05 | 2.5 | 44.1 | 12:05 | 3.6 |
| P-5 | 2.8243 | 16.2 | 12:05 | 1.3 | 22.7 | 12:05 | 1.9 |
| P-6 | 1.7261 | 9.9 | 12:05 | 0.8 | 13.9 | 12:05 | 1.1 |
| P-7 | 3.6416 | 20.9 | 12:05 | 1.7 | 29.3 | 12:05 | 2.4 |
| P-8 | 1.8515 | 10.6 | 12:05 | 0.9 | 14.9 | 12:05 | 1.2 |
| P-9 | 4.6579 | 26.4 | 12:05 | 2.2 | 37.1 | 12:05 | 3.1 |
| South Channel 1 D | 46.0966 | 160.5 | 12:16 | 21.5 | 265.1 | 12:13 | 30.6 |
| South Channel 1 U | 43.5616 | 153.7 | 12:15 | 20.3 | 254.0 | 12:13 | 28.9 |
| South Channel 2 (Interior) | 4.4173 | 25.3 | 12:08 | 2 | 35.4 | 12:07 | 2.9 |
| SS-10 | 5.5270 | 31.7 | 12:05 | 2.6 | 44.5 | 12:05 | 3.6 |
| SS-11 | 4.3738 | 23.2 | 12:08 | 2 | 32.5 | 12:07 | 2.9 |
| SS-12 | 2.8134 | 16.2 | 12:05 | 1.3 | 22.6 | 12:05 | 1.9 |
| SS-13 | 1.4714 | 8.4 | 12:05 | 0.7 | 11.8 | 12:05 | 1.0 |
| SS-14 | 1.8067 | 10.4 | 12:05 | 0.8 | 14.5 | 12:05 | 1.2 |
| SS-2 | 2.1946 | 12.6 | 12:05 | 1 | 17.7 | 12:05 | 1.4 |
| SS-3 | 4.9549 | 28.4 | 12:05 | 2.3 | 39.9 | 12:05 | 3.3 |

## Table 2B-1-2c. Post-Development 100-year, 24-hour Precipitation Event Nodal Areas, Peak Flow Rates, and Runoff Volumes

| Hydrologic Element | Area (acre) | Post-Development 25-Year, 24-Hour Event | | | Post-Development 25-Year 24-Hour Event | | |
|---|---|---|---|---|---|---|---|
| | | Peak Flow Rate (cfs) | Time of Peak (hr:mm) | Volume (ac-ft) | Peak Flow Rate (cfs) | Time of Peak (hr:mm) | Volume (ac-ft) |
| SS-4 | 4.0070 | 23.0 | 12:05 | 1.9 | 32.2 | 12:05 | 2.6 |
| SS-5 | 5.9693 | 34.3 | 12:05 | 2.8 | 48.0 | 12:05 | 3.9 |
| SS-6 | 4.7405 | 27.2 | 12:05 | 2.2 | 38.1 | 12:05 | 3.1 |
| SS-7 | 0.6490 | 3.7 | 12:05 | 0.3 | 5.2 | 12:05 | 0.4 |
| SS-8 | 4.4845 | 25.7 | 12:05 | 2.1 | 36.1 | 12:05 | 3.0 |
| SS-9 | 3.1162 | 17.9 | 12:05 | 1.4 | 25.1 | 12:05 | 2.1 |
| SS1-L | 4.8915 | 28.1 | 12:05 | 2.3 | 39.3 | 12:05 | 3.2 |
| SS1-U | 3.7696 | 21.6 | 12:05 | 1.7 | 30.3 | 12:05 | 2.5 |
| TD-1 | 10.7533 | 56.5 | 12:08 | 5 | 79.2 | 12:08 | 7.1 |
| TD-2 | 1.1802 | 6.3 | 12:07 | 0.5 | 8.8 | 12:07 | 0.8 |
| TD-3 | 8.0730 | 41.8 | 12:08 | 3.7 | 58.6 | 12:08 | 5.3 |
| TD-4 | 7.9987 | 41.8 | 12:08 | 3.7 | 58.6 | 12:08 | 5.3 |
| TD-5 | 1.7146 | 9.4 | 12:07 | 0.8 | 13.1 | 12:07 | 1.1 |
| TD-6 | 3.8189 | 20.9 | 12:07 | 1.8 | 29.3 | 12:06 | 2.5 |
| West Channel 1 | 43.5238 | 195.4 | 12:11 | 20.1 | 274.2 | 12:11 | 28.7 |
| West Channel 2 | 9.8739 | 56.0 | 12:10 | 4.6 | 78.8 | 12:09 | 6.5 |

# Table 2B-1-3. Meteorological Input Parameters

| Meteorology: 25yr_24hr | Meteorology: 25yr_24hr |
|---|---|
| Meteorology: 25yr-24hr<br>Last Modified Date: 22 April 2022<br>Last Modified Time: 20:50:59<br>Version: 4.9<br>Unit System: English<br>Set Missing Data to Default: No<br>Precipitation Method: Hypothetical Storm<br>Air Temperature Method: None<br>Atmospheric Pressure Method: None<br>Dew Point Method: None<br>Wind Speed Method: None<br>Shortwave Radiation Method: None<br>Longwave Radiation Method: None<br>Snowmelt Method: None<br>Evapotranspiration Method: No Evapotranspiration<br>Use Basin Model: Pre-Dev<br>Use Basin Model: Post-Dev<br>End:<br><br>Precip Method Parameters: Hypothetical Storm<br>Last Modified Date: 28 July 2021<br>Last Modified Time: 14:28:30<br>Precipitation Method: Point Depth<br>Storm Depth: 7.35<br>Storm Type: SCS Type III<br>Depth-Area Reduction Method: No Reduction<br>End: | Meteorology: 100yr-24hr<br>Last Modified Date: 22 April 2022<br>Last Modified Time: 20:51:09<br>Version: 4.9<br>Unit System: English<br>Set Missing Data to Default: No<br>Precipitation Method: Hypothetical Storm<br>Air Temperature Method: None<br>Atmospheric Pressure Method: None<br>Dew Point Method: None<br>Wind Speed Method: None<br>Shortwave Radiation Method: None<br>Longwave Radiation Method: None<br>Snowmelt Method: None<br>Evapotranspiration Method: No Evapotranspiration<br>Use Basin Model: Post-Dev<br>Use Basin Model: Pre-Dev<br>End:<br><br>Precip Method Parameters: Hypothetical Storm<br>Last Modified Date: 28 July 2021<br>Last Modified Time: 14:30:29<br>Precipitation Method: Point Depth<br>Storm Depth: 9.81<br>Storm Type: SCS Type III<br>Depth-Area Reduction Method: No Reduction<br>End: |

# HEC-HMS PRE-DEVELOPMENT HYDROLOGIC MODEL INPUT PARAMETERS

**Basin: Pre-Dev**

Basin: Pre-Dev
Last Modified Date: 22 October 2022
Last Modified Time: 16:41:12
Version: 4.9
Filepath Separator: \
Unit System: English
Missing Flow To Zero: No
Enable Flow Ratio: No
Compute Local Flow At Junctions: No
Unregulated Output Required: No

Enable Sediment Routing: No

Enable Quality Routing: No
End:

Subbasin: A-8
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: -1304.5419675666662
Canvas Y: 4633.513000428082
From Canvas X: -1013.5363790186111
From Canvas Y: 5423.0118443316405
Area: 0.018456
Downstream: West Channel 1

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 13.658
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: A-7
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: -163.2332326372507
Canvas Y: 3685.6847679038483
From Canvas X: 593.9086294416247
From Canvas Y: 3984.7715736040604
Area: 0.010649
Downstream: West Channel 1

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 5.272
Unitgraph Type: STANDARD

Baseflow: None
End:

Reach: West Channel 1
Last Modified Date: 12 October 2022
Last Modified Time: 17:34:39
Canvas X: -2367.657718037742
Canvas Y: 2194.1695498764857
From Canvas X: -2175.441180080338
From Canvas Y: 4680.205732060085
Downstream: West Channel 2

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 794
Energy Slope: 0.006
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 4
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: A-6
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: -1794.103701582887
Canvas Y: 2706.7071816021007
From Canvas X: -1521.1505922165816
From Canvas Y: 4052.4534686971233
Area: 0.020292
Downstream: West Channel 2

Discretization: None

File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 16.072
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: A-5
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: -145.60787458770392
Canvas Y: 2663.4140010302144
From Canvas X: 35.532994923858496
From Canvas Y: 2664.97461928934
Area: 0.009837
Downstream: West Channel 2

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 5.090
Unitgraph Type: STANDARD

Baseflow: None
End:

Reach: West Channel 2
Last Modified Date: 12 October 2022
Last Modified Time: 17:34:39
Canvas X: -1753.7546036375315
Canvas Y: 457.4677000548436
From Canvas X: -2367.657718037742
From Canvas Y: 2194.1695498764857
Downstream: South Channel 1

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 791
Energy Slope: 0.01
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 4
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: A-4
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: -1440.2086701532958
Canvas Y: 973.8418552916874
From Canvas X: -1216.5820642977997
From Canvas Y: 1785.1099830795256
Area: 0.012397
Downstream: South Channel 1

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 18.193
Unitgraph Type: STANDARD

Baseflow: None
End:

Reach: South Channel 1
Last Modified Date: 12 October 2022
Last Modified Time: 17:34:39
Canvas X: 909.2022135068974
Canvas Y: 153.55491288009307
From Canvas X: -1753.7546036375315
From Canvas Y: 457.4677000548436
Downstream: South Channel 2

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 748
Energy Slope: 0.006
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 4
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: A-3
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: 237.914677463903
Canvas Y: 775.8592675215159
From Canvas X: -1351.9458544839254
From Canvas Y: 2868.0203045685275
Area: 0.008698
Downstream: South Channel 2

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: A-2
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: 682.0078940808962
Canvas Y: 2304.7522425146817
From Canvas X: -421.31979695431437
From Canvas Y: 1598.9847715736041
Area: 0.006101
Downstream: South Channel 2

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 5.282
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: A-15
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: 577.0318054436575
Canvas Y: 4584.578028430664
From Canvas X: 915.3976311336719
From Canvas Y: 4983.079526226734
Area: 0.005643
Downstream: North Channel

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 5.177
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: A-16
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: -57.481084339977315
Canvas Y: 5677.35022750248

From Canvas X: 725.8007493053192
From Canvas Y: 5959.804985560009
Area: 0.002637
Downstream: North Channel

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: A-17
Last Modified Date: 20 October 2022
Last Modified Time: 01:17:44
Canvas X: 863.4140377903295
Canvas Y: 7556.856627072033
From Canvas X: -8541.270417497135
From Canvas Y: 283.33695761085255
Area: 0.098302
Downstream: A17 Off-Site Detention

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 89.0
Initial Abstraction: 0.2472

Transform: SCS
Lag: 46.846
Unitgraph Type: STANDARD

Baseflow: None
End:

Reservoir: A17 Off-Site Detention
Last Modified Date: 22 October 2022
Last Modified Time: 16:40:42
Canvas X: 1554.2556599093787
Canvas Y: 7235.727011086953
From Canvas X: 531.3502777092253
From Canvas Y: 7101.400913589543
Downstream: J-C-PRE
Auxiliary Flow To: Offsite Outfall

Route: Controlled Outflow
Routing Curve: Elevation-Area
Initial Elevation: 424
Elevation-Area Table: A-17 Inlet
Adaptive Control: On
Main Tailwater Condition: None
Auxiliary Tailwater Condition: None

Conduit: Culvert
Conduit Outlet: Main
Culvert Shape: Circular
Chart Number: 1
Scale Number: 1
Solution Control: Automatic
Diameter: 3
Number Barrels: 2
Culvert Length: 20
Entrance Loss Coefficient: 0.5
Exit Loss Coefficient: 1
Top Manning's n: 0.012
Inlet Invert Elevation: 424
Outlet Invert Elevation: 422
End Conduit:

Spillway: Broad-Crested Spillway
Spillway Outlet: Auxiliary
Spillway Crest Length: 24
Spillway Crest Elevation: 427
Spillway Coefficient: 2.63
End Spillway:

Spillway: Broad-Crested Spillway
Spillway Outlet: Auxiliary
Spillway Crest Length: 104
Spillway Crest Elevation: 428
Spillway Coefficient: 2.63
End Spillway:

Spillway: Broad-Crested Spillway
Spillway Outlet: Main
Spillway Crest Length: 143
Spillway Crest Elevation: 428
Spillway Coefficient: 2.63
End Spillway:

Evaporation Method: Zero Evaporation
End Evaporation:

End:

Reach: North Channel
Last Modified Date: 12 October 2022
Last Modified Time: 17:34:39
Canvas X: 1562.8724822825789
Canvas Y: 6420.822750804119
From Canvas X: 1080.8798694350626
From Canvas Y: 6084.640872359974
Downstream: J-C-PRE

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 147
Energy Slope: 0.0077
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 6
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Junction: J-C-PRE
Last Modified Date: 12 October 2022
Last Modified Time: 15:55:05
Canvas X: 1562.8724822825789
Canvas Y: 6420.822750804119
From Canvas X: 2238.142415479988
From Canvas Y: 6195.0086201936865
Downstream: East Channel 1 U
End:

Reach: East Channel 1 U
Last Modified Date: 12 October 2022
Last Modified Time: 17:34:39
Canvas X: 2945.0161819220402
Canvas Y: 5850.750475338558
From Canvas X: 1562.8724822825789
From Canvas Y: 6420.822750804119
Downstream: East Channel 1 D

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 607
Energy Slope: 0.006
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 4
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: A-14
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: 2378.5559956419966
Canvas Y: 5214.861671871502
From Canvas X: 1829.1032148900176
From Canvas Y: 5473.773265651438
Area: 0.008228
Downstream: East Channel 1 D

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Reach: East Channel 1 D
Last Modified Date: 12 October 2022
Last Modified Time: 17:34:39
Canvas X: 4258.325398030925
Canvas Y: 4130.648094833046
From Canvas X: 2945.0161819220402
From Canvas Y: 5850.750475338558
Downstream: East Channel 2

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 878
Energy Slope: 0.006
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 4
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: A-12
Last Modified Date: 18 October 2022
Last Modified Time: 18:50:17
Canvas X: 2116.0638609625785
Canvas Y: 3229.137710974801
From Canvas X: 1795.2622673434853
From Canvas Y: 3747.8849407783414
Area: 0.010333
Downstream: East Channel 2

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 5.176
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: A-13
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: 3184.5730806849333
Canvas Y: 4424.572165285159
From Canvas X: 3402.707275803723
From Canvas Y: 4678.510998307953
Area: 0.009053
Downstream: East Channel 2

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Reach: East Channel 2
Last Modified Date: 12 October 2022
Last Modified Time: 17:34:39
Canvas X: 4325.1987577740965
Canvas Y: 2402.5927611247384
From Canvas X: 4258.325398030925
From Canvas Y: 4130.648094833046
Downstream: East Channel 3

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 721
Energy Slope: 0.006
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 4
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: A-10
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: 1303.0320354119094
Canvas Y: 2729.7313160508556
From Canvas X: 1304.568527918782
From Canvas Y: 2072.7580372250422
Area: 0.009822
Downstream: East Channel 3

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 5.184
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: A-11
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: 3699.807089691647
Canvas Y: 2967.1959683804553
From Canvas X: 2658.2064297800353
From Canvas Y: 2732.6565143824023
Area: 0.008327
Downstream: East Channel 3

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Reach: East Channel 3
Last Modified Date: 20 October 2022
Last Modified Time: 01:31:37
Canvas X: 3800.6694332602565
Canvas Y: 262.5854744948974
From Canvas X: 4325.1987577740965
From Canvas Y: 2402.5927611247384
Downstream: Outfall A

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 607
Energy Slope: 0.006
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 6
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Reach: South Channel 2
Last Modified Date: 20 October 2022
Last Modified Time: 01:31:37
Canvas X: 3800.6694332602565
Canvas Y: 262.5854744948974
From Canvas X: 909.2022135068974
From Canvas Y: 153.55491288009307
Downstream: Outfall A

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 637
Energy Slope: 0.006
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 4
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: A-1
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: 1918.5695156970087
Canvas Y: 744.3292438086346
From Canvas X: -404.3993231810489
From Canvas Y: 1573.6040609137056
Area: 0.008051
Downstream: Outfall A

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: A-9
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: 3640.9232029480227
Canvas Y: 1657.0294883348133
From Canvas X: 2218.2741116751276
From Canvas Y: 702.1996615905246
Area: 0.007126
Downstream: Outfall A

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: A-23
Description: additional area - West
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: 2905.9167209095867
Canvas Y: -333.0518766930509
From Canvas X: -5711.539781931401
From Canvas Y: 2185.3634173815717
Area: 0.006499
Downstream: Outfall A

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.3641

Transform: SCS
Lag: 6.917
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: Outfall A
Last Modified Date: 20 October 2022
Last Modified Time: 01:31:37
Canvas X: 3800.6694332602565
Canvas Y: 262.5854744948974
From Canvas X: 3755.032713920915
From Canvas Y: 73.44422640733501
End:

Junction: Outfall B
Last Modified Date: 18 October 2022
Last Modified Time: 17:48:07
Canvas X: -3761.2256232278087
Canvas Y: 555.9695687843059
From Canvas X: -4765.774646993845
From Canvas Y: -524.2156629031597
End:

Subbasin: A-19
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: -4214.87360776682
Canvas Y: 5715.092174916669
From Canvas X: -2765.824776109159
From Canvas Y: 6302.42931710296
Area: 0.073842
Downstream: Diversion-1

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 86.6
Initial Abstraction: 0.3095

Transform: SCS
Lag: 94.891
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: A-21
Last Modified Date: 18 October 2022

Last Modified Time: 18:06:49
Canvas X: -3291.930484780083
Canvas Y: 2341.5626191153697
From Canvas X: -5123.591254137264
From Canvas Y: 4837.759069988941
Area: 0.070890
Downstream: Diversion-1

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.00
Curve Number: 81.8
Initial Abstraction: 0.4439

Transform: SCS
Lag: 10.005
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: A-18
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: -3512.6656823855465
Canvas Y: 4971.302391957566
From Canvas X: -3253.409432866285
From Canvas Y: 2096.745904462916
Area: 0.030019
Downstream: Diversion-1

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 89.0
Initial Abstraction: 0.2472

Transform: SCS
Lag: 57.657
Unitgraph Type: STANDARD

Baseflow: None
End:

Diversion: Diversion-1
Last Modified Date: 12 October 2022
Last Modified Time: 16:01:32
Canvas X: -4133.745270909581
Canvas Y: 2997.292890199123
From Canvas X: -5711.396843722101
From Canvas Y: 2475.8590029178695
Downstream: Existing Natural Channel

Diverter: None
End Diverter:
End:

Reach: Existing Natural Channel
Last Modified Date: 18 October 2022
Last Modified Time: 17:47:57
Canvas X: -4894.882892520148
Canvas Y: 1260.21120576894
From Canvas X: -4133.745270909581
From Canvas Y: 2997.292890199123
Downstream: A21 Existing Low Area

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 1201
Energy Slope: 0.008326
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 5
Side Slope: 1.5
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: A-20
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: -5625.945047471481
Canvas Y: 1933.9151548206828
From Canvas X: -3392.044977646353
From Canvas Y: 1117.5588199755503
Area: 0.041709
Downstream: A21 Existing Low Area

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 86.6
Initial Abstraction: 0.3095

Transform: SCS
Lag: 44.815
Unitgraph Type: STANDARD

Baseflow: None
End:

Reservoir: A21 Existing Low Area
Last Modified Date: 22 October 2022
Last Modified Time: 16:41:12
Canvas X: -4894.882892520148
Canvas Y: 1260.21120576894
From Canvas X: -5266.544409581922
From Canvas Y: -950.0132286805765
Downstream: Outfall B
Auxiliary Flow To: Outfall C

Route: Controlled Outflow
Routing Curve: Elevation-Area
Initial Elevation: 408
Elevation-Area Table: On-Site Detention Area
Adaptive Control: On
Main Tailwater Condition: None
Auxiliary Tailwater Condition: None

Spillway: Broad-Crested Spillway
Spillway Outlet: Main
Spillway Crest Length: 16
Spillway Crest Elevation: 408
Spillway Coefficient: 2.63
End Spillway:

Spillway: Broad-Crested Spillway
Spillway Outlet: Main
Spillway Crest Length: 150
Spillway Crest Elevation: 414
Spillway Coefficient: 2.63
End Spillway:

Spillway: Broad-Crested Spillway
Spillway Outlet: Auxiliary
Spillway Crest Length: 19
Spillway Crest Elevation: 414
Spillway Coefficient: 2.63
End Spillway:

Evaporation Method: Zero Evaporation
End Evaporation:
End:

Subbasin: A-22
Description: additional area - West
Last Modified Date: 18 October 2022
Last Modified Time: 18:06:49
Canvas X: -5891.127159474022
Canvas Y: 899.502074630469
From Canvas X: 498.52772588620337
From Canvas Y: 1331.6269916871315
Area: 0.001107
Downstream: Outfall C

Discretization: None
File: Pre_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 79.0
Initial Abstraction: 0.5316

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: Outfall C
Last Modified Date: 18 October 2022
Last Modified Time: 17:48:03
Canvas X: -5393.005025997085
Canvas Y: 418.55656644583996
From Canvas X: -5847.389153707862
From Canvas Y: -511.6387500343917
End:

Junction: Offsite Outfall
Last Modified Date: 22 October 2022
Last Modified Time: 18:38:20
Canvas X: 3519.409329411288
Canvas Y: 6850.721935638359
From Canvas X: 3198.4118470384055
From Canvas Y: 6799.126798885736
End:

Basin Layer Properties:
Element Layer:
Name: Icons
Layer shown: Yes
End Layer:
End:

Basin Spatial Properties:
End:

Basin Schematic Properties:
  Last View N: 6870.916660764849
  Last View S: -457.20445952035516
  Last View W: -5881.369170027667
  Last View E: 4325.1987577740965
  Maximum View N: 6978.516452371004
  Maximum View S: 73.44422640733501
  Maximum View W: -6031.800910077087
  Maximum View E: 4325.1987577740965
  Extent Method: Elements
  Buffer: 0
  Draw Icons: Yes
  Draw Icon Labels: Name
  Draw Map Objects: No
  Draw Gridlines: No
  Draw Flow Direction: No
  Draw HillShade Layer: Yes
  Draw Elevation Layer: Yes
  Elevation Layer Color Palette: Default
  Ignore Elevation Color Ramp Scale: No
  Use Interpolated Color Ramp for Elevation Layer: Yes
  Color Ramp Opacity Level for Elevation Layer: 33.0
  Fix Element Locations: No
  Fix Hydrologic Order: No
End:

# HEC-HMS POST-DEVELOPMENT HYDROLOGIC MODEL INPUT PARAMETERS

**Basin: Post-Dev**

Basin: Post-Dev
Last Modified Date: 21 October 2022
Last Modified Time: 21:45:58
Version: 4.9
Filepath Separator: \
Unit System: English
Missing Flow To Zero: No
Enable Flow Ratio: No
Compute Local Flow At Junctions: No
Unregulated Output Required: No

Enable Sediment Routing: No

Enable Quality Routing: No
End:

Subbasin: TD-6
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 10851.53377417764
Canvas Y: 8275.104095116061
From Canvas X: 12539.437315549272
From Canvas Y: 11829.935625344264
Area: 0.005967
Downstream: DS-D

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 5.158
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: SS-14
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 10500.233655224518
Canvas Y: 9779.99338652148
From Canvas X: 2608.355480514215
From Canvas Y: 3423.931727042377
Area: 0.002823
Downstream: DS-D

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Reach: DS-D
Description: downspout D
Last Modified Date: 12 October 2022
Last Modified Time: 16:56:09
Canvas X: 9821.294287843772
Canvas Y: 12123.838076053962
From Canvas X: 11073.300717868504
From Canvas Y: 10997.06534293681
Downstream: J-3

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 130
Energy Slope: 0.25
Mannings n: 0.011
Shape: Circular
Number of Subreaches: 2
Width: 2
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: P-5
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 7113.3673774920935
Canvas Y: 11766.748813150443
From Canvas X: 10104.060167265581
From Canvas Y: 10037.7888035877
Area: 0.004413
Downstream: J-3

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6

Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: J-3
Last Modified Date: 12 October 2022
Last Modified Time: 16:52:53
Canvas X: 9821.294287843772
Canvas Y: 12123.838076053962
From Canvas X: 8188.606190428438
From Canvas Y: 12124.624733164215
Downstream: North Channel
End:

Subbasin: A-17
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 8936.267258565178
Canvas Y: 14281.490133359453
From Canvas X: 3167.9594387268316
From Canvas Y: 7228.381735862475
Area: 0.098302
Downstream: A17 Off-Site Detention

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 89.0
Initial Abstraction: 0.247

Transform: SCS
Lag: 46.846
Unitgraph Type: STANDARD

Baseflow: None
End:

Reservoir: A17 Off-Site Detention
Last Modified Date: 22 October 2022
Last Modified Time: 16:40:08
Canvas X: 11320.084926625756
Canvas Y: 13900.76299458529
From Canvas X: 12240.580133933192
From Canvas Y: 14046.445691841165
Downstream: J-C
Auxiliary Flow To: Offsite Outfall

Route: Controlled Outflow
Routing Curve: Elevation-Area
Initial Elevation: 424
Elevation-Area Table: A-17 Inlet
Adaptive Control: On
Main Tailwater Condition: None
Auxiliary Tailwater Condition: None

Conduit: Culvert
Conduit Outlet: Main
Culvert Shape: Circular
Chart Number: 1
Scale Number: 1
Solution Control: Automatic
Diameter: 3
Number Barrels: 2
Culvert Length: 20
Entrance Loss Coefficient: 0.5
Exit Loss Coefficient: 1
Top Manning's n: 0.012
Inlet Invert Elevation: 424
Outlet Invert Elevation: 422
End Conduit:

Spillway: Broad-Crested Spillway
Spillway Outlet: Auxiliary
Spillway Crest Length: 24
Spillway Crest Elevation: 427
Spillway Coefficient: 2.63
End Spillway:

Spillway: Broad-Crested Spillway
Spillway Outlet: Auxiliary
Spillway Crest Length: 104
Spillway Crest Elevation: 428
Spillway Coefficient: 2.63
End Spillway:

Spillway: Broad-Crested Spillway
Spillway Outlet: Main
Spillway Crest Length: 143
Spillway Crest Elevation: 428
Spillway Coefficient: 2.63
End Spillway:

Evaporation Method: Zero Evaporation
End Evaporation:
End:

Reach: North Channel
Last Modified Date: 12 October 2022
Last Modified Time: 17:52:52
Canvas X: 11849.62436692738
Canvas Y: 12124.624733164215
From Canvas X: 9821.294287843772
From Canvas Y: 12123.838076053962
Downstream: J-C

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 147
Energy Slope: 0.0077
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 6

Written by: A. Brewster Date: 10/7/2022 Reviewed by: S. Graves Date: 10/21/2022

Client: WMTX Project: Lacy Lakeview RDF Project No.: GW8041 Phase No.: 05

Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Junction: J-C
Last Modified Date: 12 October 2022
Last Modified Time: 16:53:41
Canvas X: 11849.62436692738
Canvas Y: 12124.624733164215
From Canvas X: 11849.62436692738
From Canvas Y: 12124.624733164215
Downstream: East Channel 1
End:

Reach: East Channel 1
Last Modified Date: 12 October 2022
Last Modified Time: 16:55:07
Canvas X: 16024.4696559174
Canvas Y: 11503.750305570828
From Canvas X: 11849.62436692738
From Canvas Y: 12124.624733164215
Downstream: J-B

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 1485
Energy Slope: 0.006
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 4
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: TD-5
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 12720.200689911208
Canvas Y: 9578.052581728665
From Canvas X: 785.3481103719241
From Canvas Y: 10234.395130264942
Area: 0.002679
Downstream: DS-C

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 5.253
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: SS-13
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 14078.62123447667
Canvas Y: 8762.211636293272
From Canvas X: 4179.146536193729
From Canvas Y: 5077.395996178708
Area: 0.002299
Downstream: DS-C

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: P-4
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 16505.763430091414
Canvas Y: 12371.543860487185
From Canvas X: 16469.897603440455
From Canvas Y: 8797.690601735452
Area: 0.008571
Downstream: J-B

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Reach: DS-C
Description: downspout C
Last Modified Date: 28 July 2022
Last Modified Time: 20:35:52
Canvas X: 16024.4696559174
Canvas Y: 11503.750305570828
From Canvas X: 13321.110222124797
From Canvas Y: 8872.637043912713
Downstream: J-B

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 190
Energy Slope: 0.25
Mannings n: 0.011
Shape: Circular
Number of Subreaches: 2
Width: 2
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Junction: J-B
Last Modified Date: 12 October 2022
Last Modified Time: 16:56:23
Canvas X: 16024.4696559174
Canvas Y: 11503.750305570828
From Canvas X: 15232.31952416032
From Canvas Y: 12081.805807123292
Downstream: East Channel 2
End:

Reach: East Channel 2
Last Modified Date: 12 October 2022
Last Modified Time: 16:58:30
Canvas X: 15981.650729876477
Canvas Y: 8420.787630624349
From Canvas X: 16024.4696559174
From Canvas Y: 11503.750305570828
Downstream: J-2

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 924
Energy Slope: 0.006
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 4
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: SS-3
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 11853.584514828415
Canvas Y: 5451.128343664286
From Canvas X: 1761.8501883517965
From Canvas Y: 3622.8505191687223
Area: 0.007742
Downstream: DS-B-U

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: SS1-U
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 12855.869128889077
Canvas Y: 3325.335431754478
From Canvas X: 3297.7119365223716
From Canvas Y: 5022.503747116631
Area: 0.005890
Downstream: DS-B-U

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None

End:

Subbasin: SS-2
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 11528.482421620456
Canvas Y: 3582.2489880000176
From Canvas X: 3228.688493402022
From Canvas Y: 4442.706824905699
Area: 0.003429
Downstream: DS-B-U

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: TD-2
Last Modified Date: 18 October 2022
Last Modified Time: 18:51:31
Canvas X: 10459.00675456897
Canvas Y: 4854.682920101217
From Canvas X: -401.94461472833245
From Canvas Y: 4994.894369868491
Area: 0.001844
Downstream: DS-B-U

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 6.042
Unitgraph Type: STANDARD

Baseflow: None
End:

Reach: DS-B-U
Description: downspout B-Upper
Last Modified Date: 9 August 2022
Last Modified Time: 15:45:53
Canvas X: 15981.650729876477
Canvas Y: 8420.787630624349
From Canvas X: 13048.554296073233
From Canvas Y: 4331.580193716176
Downstream: J-2

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 378
Energy Slope: 0.25
Mannings n: 0.011
Shape: Circular
Number of Subreaches: 2
Width: 2
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: P-3
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 16833.020219984362
Canvas Y: 10364.368882477112
From Canvas X: 3749.456927733333
From Canvas Y: 3959.4613379349503
Area: 0.005661
Downstream: J-2

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: J-2
Last Modified Date: 12 October 2022
Last Modified Time: 16:56:23
Canvas X: 15981.650729876477
Canvas Y: 8420.787630624349
From Canvas X: 16152.926434040171
From Canvas Y: 8249.511926460656

Downstream: East Channel 3 U
End:

Reach: East Channel 3 U
Last Modified Date: 12 October 2022
Last Modified Time: 16:59:51
Canvas X: 15961.83542624542
Canvas Y: 4351.231938997562
From Canvas X: 15981.650729876477
From Canvas Y: 8420.787630624349
Downstream: J-A

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 266
Energy Slope: 0.006
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 4
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: SS1-L
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 14329.977378721525
Canvas Y: 4883.148540120459
From Canvas X: 3157.080081960694
From Canvas Y: 4612.7655723663665
Area: 0.007643
Downstream: DS-B-L

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Reach: DS-B-L
Description: downspout B Lower
Last Modified Date: 12 October 2022
Last Modified Time: 17:00:22
Canvas X: 15961.83542624542
Canvas Y: 4351.231938997562
From Canvas X: 14262.197350999395
From Canvas Y: 4092.381550028941
Downstream: J-A

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 120
Energy Slope: 0.25
Mannings n: 0.011
Shape: Circular
Number of Subreaches: 2
Width: 2
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: P-2
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 17312.29859849525
Canvas Y: 3843.8547817144636
From Canvas X: 3653.282408085838
From Canvas Y: 2853.4543619887727
Area: 0.003303
Downstream: J-A

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: J-A
Last Modified Date: 9 August 2022
Last Modified Time: 15:40:13
Canvas X: 15961.83542624542
Canvas Y: 4351.231938997562
From Canvas X: 15981.650729876477
From Canvas Y: 4352.989656736638
Downstream: East Channel 3 D
End:

Reach: East Channel 3 D
Description: Consider discharging this channel straight to OF-3 if combining Pond 1+2

Last Modified Date: 20 October 2022
Last Modified Time: 01:33:04
Canvas X: 15856.251322322745
Canvas Y: -1379.067693658233
From Canvas X: 15961.83542624542
From Canvas Y: 4351.231938997562
Downstream: Outfall A

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 616
Energy Slope: 0.006
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 4
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: SS-12
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 11359.854518384356
Canvas Y: 2061.944105741508
From Canvas X: 7570.409491130856
From Canvas Y: 6153.271257740234
Area: 0.004396
Downstream: DS-A

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Reach: DS-A
Description: downspout A
Last Modified Date: 28 July 2022
Last Modified Time: 20:35:45
Canvas X: 11785.395977865994
Canvas Y: -421.32059682631007
From Canvas X: 11751.594843294286
From Canvas Y: 1251.9777467314889
Downstream: J-1

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 80
Energy Slope: 0.25
Mannings n: 0.011
Shape: Circular
Number of Subreaches: 2
Width: 2
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: P-1
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 12932.936944153504
Canvas Y: 772.5925463828207
From Canvas X: 2467.129999100084
From Canvas Y: 1442.8947404921992
Area: 0.002506
Downstream: J-1

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: J-1
Last Modified Date: 13 October 2022
Last Modified Time: 00:38:59
Canvas X: 11785.395977865994
Canvas Y: -421.32059682631007
From Canvas X: 13112.782685134614
From Canvas Y: -378.5016707853865
Downstream: South Channel 2 (Interior)
End:

Subbasin: SS-6
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 3136.9749357689766
Canvas Y: 7713.022027566736
From Canvas X: 2280.2484603123094
From Canvas Y: 4989.52939521329

Area: 0.007407
Downstream: DS-F

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: SS-8
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 3438.747030088226
Canvas Y: 6492.216736911591
From Canvas X: 2244.7718239905553
From Canvas Y: 5399.987706239645
Area: 0.007007
Downstream: DS-F

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: SS-7
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 4453.798620071155
Canvas Y: 7095.76092555009
From Canvas X: 2277.662626686949
From Canvas Y: 6069.474557660506
Area: 0.001014
Downstream: DS-F

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Reach: DS-F
Description: downspout F
Last Modified Date: 28 July 2022
Last Modified Time: 20:36:39
Canvas X: 855.3376310541826
Canvas Y: 7251.40921591219
From Canvas X: 3630.783817382294
From Canvas Y: 7040.893272037499
Downstream: West Channel 2

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 290
Energy Slope: 0.25
Mannings n: 0.011
Shape: Circular
Number of Subreaches: 2
Width: 2
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: TD-1
Last Modified Date: 18 October 2022
Last Modified Time: 18:51:47
Canvas X: 6555.624213108087
Canvas Y: 4140.0327480892265
From Canvas X: -747.061830330078
From Canvas Y: 5671.32411244791
Area: 0.016802
Downstream: DS-G

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 6.484
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: SS-10
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 5890.686807907403
Canvas Y: 2428.680627017746
From Canvas X: 11729.966698582974
From Canvas Y: 2790.1037572067835
Area: 0.008636
Downstream: DS-G

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: SS-11
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 6726.805684199063
Canvas Y: 3136.629762513344
From Canvas X: 4509.839390020996
From Canvas Y: 6923.764430047611
Area: 0.006834
Downstream: DS-G

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 6.153
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: SS-9
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 4499.598409920731
Canvas Y: 4084.122471018578
From Canvas X: 9938.713740351948
From Canvas Y: 3258.585300128744
Area: 0.004869
Downstream: DS-G

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Reach: DS-G
Description: downspout G
Last Modified Date: 28 July 2022
Last Modified Time: 20:36:44
Canvas X: 1843.5192832747962
Canvas Y: 199.66842708178592
From Canvas X: 5456.525657858374
From Canvas Y: 3336.4721225748062
Downstream: J-G

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 560
Energy Slope: 0.25
Mannings n: 0.011
Shape: Circular
Number of Subreaches: 2
Width: 2

Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Reach: West Channel 2
Last Modified Date: 12 October 2022
Last Modified Time: 17:09:39
Canvas X: 1843.5192832747962
Canvas Y: 199.66842708178592
From Canvas X: 855.3376310541826
From Canvas Y: 7251.40921591219
Downstream: J-G

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 1521.3
Energy Slope: 0.005
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 5
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: P-9
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 2229.4261860302295
Canvas Y: 1720.3787228665387
From Canvas X: 7899.4411417504725
From Canvas Y: 1798.0251957249839
Area: 0.007278
Downstream: J-G

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.969
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: J-G
Last Modified Date: 12 October 2022
Last Modified Time: 17:09:39
Canvas X: 1843.5192832747962
Canvas Y: 199.66842708178592
From Canvas X: 4912.958348297801
From Canvas Y: -742.462542133233
Downstream: Pond 2
End:

Subbasin: M5
Description: Pond 2 area
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 2271.6403610494835
Canvas Y: -1246.817032756313
From Canvas X: -229.15615012172202
From Canvas Y: 1940.715791134864
Area: 0.008218
Downstream: Pond 2

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 88.5
Initial Abstraction: 0.261

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Reservoir: Pond 2
Last Modified Date: 21 October 2022
Last Modified Time: 21:50:27
Canvas X: 3480.515078613227
Canvas Y: -182.34880474702913
From Canvas X: 3301.761237589364
From Canvas Y: 485.55112386383007
Downstream: South Channel 1 U

Route: Controlled Outflow
Routing Curve: Elevation-Area
Initial Elevation: 404
Elevation-Area Table: Pond 1
Adaptive Control: On
Main Tailwater Condition: None
Auxiliary Tailwater Condition: None

Conduit: Culvert
Conduit Outlet: Main
Culvert Shape: Circular
Chart Number: 1
Scale Number: 1
Solution Control: Automatic

Diameter: 3
Number Barrels: 1
Culvert Length: 85
Entrance Loss Coefficient: 0.5
Exit Loss Coefficient: 1
Top Manning's n: 0.012
Inlet Invert Elevation: 404
Outlet Invert Elevation: 403
End Conduit:

Spillway: Broad-Crested Spillway
Spillway Outlet: Main
Spillway Crest Length: 25
Spillway Crest Elevation: 408
Spillway Coefficient: 2.63
End Spillway:

Evaporation Method: Zero Evaporation
End Evaporation:
End:

Reach: South Channel 1 U
Last Modified Date: 21 October 2022
Last Modified Time: 21:50:27
Canvas X: 8218.233048395557
Canvas Y: -1261.173191444097
From Canvas X: 3480.515078613227
From Canvas Y: -182.34880474702913
Downstream: South Channel 1 D

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 192
Energy Slope: 0.005
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 4
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: P-10
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 8372.4512508599
Canvas Y: -361.56701040209373
From Canvas X: 11068.58099092844
From Canvas Y: 1908.2561470007386
Area: 0.003961
Downstream: South Channel 1 D

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Reach: South Channel 1 D
Last Modified Date: 20 October 2022
Last Modified Time: 01:33:04
Canvas X: 15856.251322322745
Canvas Y: -1379.067693658233
From Canvas X: 8218.233048395557
From Canvas Y: -1261.173191444097
Downstream: Outfall A

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 272
Energy Slope: 0.005
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 4
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Reach: South Channel 2 (Interior)
Last Modified Date: 20 October 2022
Last Modified Time: 01:33:04
Canvas X: 15856.251322322745
Canvas Y: -1379.067693658233
From Canvas X: 11785.395977865994
From Canvas Y: -421.32059682631007
Downstream: Outfall A

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 668
Energy Slope: 0.0047
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 4
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: A-23
Description: additional area - West

Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 14950.091677516208
Canvas Y: -2466.1128476059457
From Canvas X: 6332.63517467522
From Canvas Y: 52.30244646867686
Area: 0.006499
Downstream: Outfall A

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 6.917
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: M6
Description: Pond 1 area
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 14333.745627187203
Canvas Y: 462.1364163413873
From Canvas X: 14333.745627187203
From Canvas Y: 462.1364163413873
Area: 0.005112
Downstream: Outfall A

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 86.7
Initial Abstraction: 0.308

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: Outfall A
Last Modified Date: 20 October 2022
Last Modified Time: 01:33:04
Canvas X: 15856.251322322745
Canvas Y: -1379.067693658233
From Canvas X: 3755.032713920915
From Canvas Y: 73.44422640733501
End:

Junction: Outfall B
Last Modified Date: 12 October 2022
Last Modified Time: 21:35:48
Canvas X: -2028.413799697133
Canvas Y: -769.357573737032
From Canvas X: -4765.774646993845
From Canvas Y: -524.2156629031597
End:

Subbasin: TD-3
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 7494.9023859419085
Canvas Y: 5310.420264265662
From Canvas X: 136.438241610389
From Canvas Y: 4235.636495544652
Area: 0.012614
Downstream: DS-E

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 6.904
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: TD-4
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 8965.569142824621
Canvas Y: 5658.736075106304
From Canvas X: 9240.661697207688
From Canvas Y: 10220.062676562586
Area: 0.012498
Downstream: DS-E

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No

Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 6.659
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: SS-5
Last Modified Date: 18 October 2022
Last Modified Time: 18:51:25
Canvas X: 6015.35447587524
Canvas Y: 7090.660818297427
From Canvas X: 2290.810046413012
From Canvas Y: 4664.741148683235
Area: 0.009327
Downstream: DS-E

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: SS-4
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 8667.643443929861
Canvas Y: 7645.2834712407885
From Canvas X: 12170.890503685994
From Canvas Y: 8494.555485727125
Area: 0.006261
Downstream: DS-E

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Reach: DS-E
Description: downspout E
Last Modified Date: 28 July 2022
Last Modified Time: 20:36:35
Canvas X: 7107.127864587077
Canvas Y: 9847.690951596396
From Canvas X: 7313.207596178829
From Canvas Y: 6521.12788077923
Downstream: J-DE

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 175
Energy Slope: 0.25
Mannings n: 0.011
Shape: Circular
Number of Subreaches: 2
Width: 2
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: M1
Description: additional area - NW
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 4334.418477311299
Canvas Y: 10887.979585621624
From Canvas X: -7570.307844073879
From Canvas Y: 9190.812832976566
Area: 0.018919
Downstream: J-DE

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 17.838
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: P-7
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 6015.463054199947
Canvas Y: 8625.639220463072
From Canvas X: 3021.7215477982954
From Canvas Y: 7502.476924245324
Area: 0.005690
Downstream: J-DE

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: P-6
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 8864.046258828079
Canvas Y: 10935.691622727405
From Canvas X: 5805.053067511121
From Canvas Y: 9348.84535811423
Area: 0.002697
Downstream: J-DE

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: J-DE
Last Modified Date: 13 October 2022
Last Modified Time: 00:23:29
Canvas X: 7107.127864587077
Canvas Y: 9847.690951596396
From Canvas X: 7207.048594368038
From Canvas Y: 9228.182426954425
Downstream: West Channel 1
End:

Reach: West Channel 1
Last Modified Date: 12 October 2022
Last Modified Time: 17:10:02
Canvas X: 956.4431713641006
Canvas Y: 8456.210390138489
From Canvas X: 7107.127864587077
From Canvas Y: 9847.690951596396
Downstream: J-F

Route: Kinematic Wave
Channel: Kinematic Wave
Length: 1740
Energy Slope: 0.005
Mannings n: 0.027
Shape: Trapezoid
Number of Subreaches: 2
Width: 5
Side Slope: 3
Initial Variable: Combined Inflow
Index Parameter Type: Index Flow
Index Flow: 100
Channel Loss: None
End:

Subbasin: P-8
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 2714.9548762280483
Canvas Y: 9608.338748497627
From Canvas X: 3131.952499074051
From Canvas Y: 1605.1210309924118
Area: 0.002893
Downstream: J-F

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6

Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: J-F
Last Modified Date: 12 October 2022
Last Modified Time: 17:10:02
Canvas X: 956.4431713641006
Canvas Y: 8456.210390138489
From Canvas X: -401.0132020720557
From Canvas Y: 4362.5615106264595
Downstream: Culvert WC-1
End:

Subbasin: A-19
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: -589.4054805841224
Canvas Y: 11441.94382287257
From Canvas X: -2765.824776109159
From Canvas Y: 6302.42931710296
Area: 0.073842
Downstream: Diversion-1

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 86.6
Initial Abstraction: 0.309

Transform: SCS
Lag: 94.891
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: A-18
Last Modified Date: 18 October 2022
Last Modified Time: 18:13:27
Canvas X: 549.9235008319865
Canvas Y: 10594.420949953117
From Canvas X: -3253.409432866285
From Canvas Y: 2096.745904462916
Area: 0.030019
Downstream: Diversion-1

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 89.0
Initial Abstraction: 0.247

Transform: SCS
Lag: 57.657
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: M2
Description: additional area - West
Last Modified Date: 18 October 2022
Last Modified Time: 18:52:09
Canvas X: -2552.481213096158
Canvas Y: 8064.764723808308
From Canvas X: -7732.241219017125
From Canvas Y: 8324.556125996147
Area: 0.002134
Downstream: Diversion-1

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Diversion: Diversion-1
Last Modified Date: 13 October 2022
Last Modified Time: 00:23:29
Canvas X: -1121.1893662278808
Canvas Y: 9466.622990818974
From Canvas X: -5711.396843722101
From Canvas Y: 2475.8590029178695
Downstream: Diversion Channel U

Diverter: None
End Diverter:
End:

Reach: Diversion Channel U
    Description: Proposed diversion channel stream relocation
    Last Modified Date: 12 October 2022
    Last Modified Time: 19:30:16
    Canvas X: -1754.884499791062
    Canvas Y: 4734.823694317214
    From Canvas X: -1121.1893662278808
    From Canvas Y: 9466.622990818974
    Downstream: J-Exterior

    Route: Kinematic Wave
    Channel: Kinematic Wave
    Length: 707
    Energy Slope: 0.0152
    Mannings n: 0.027
    Shape: Trapezoid
    Number of Subreaches: 2
    Width: 5
    Side Slope: 1.5
    Initial Variable: Combined Inflow
    Index Parameter Type: Index Flow
    Index Flow: 100
    Channel Loss: None
End:

Reach: Culvert WC-1
    Description: Proposed culverts from LF permiter to diversion channel stream relocation
    Last Modified Date: 18 October 2022
    Last Modified Time: 23:08:52
    Canvas X: -1754.884499791062
    Canvas Y: 4734.823694317214
    From Canvas X: 956.4431713641006
    From Canvas Y: 8456.210390138489
    Downstream: J-Exterior

    Route: Kinematic Wave
    Channel: Kinematic Wave
    Length: 100
    Energy Slope: 0.005
    Mannings n: 0.013
    Shape: Circular
    Number of Subreaches: 3
    Width: 3.5
    Initial Variable: Combined Inflow
    Index Parameter Type: Index Flow
    Index Flow: 100
    Channel Loss: None
End:

Subbasin: A-20
    Last Modified Date: 18 October 2022
    Last Modified Time: 18:13:27
    Canvas X: -3383.1410055526294
    Canvas Y: 6567.557268969989
    From Canvas X: -3392.044977646353
    From Canvas Y: 1117.5588199755503
    Area: 0.041709
    Downstream: J-Exterior

    Discretization: None
    File: Post_Dev.sqlite

    Canopy: None
    Allow Simultaneous Precip Et: No
    Plant Uptake Method: None

    Surface: None

    LossRate: SCS
    Percent Impervious Area: 0.0
    Curve Number: 86.6
    Initial Abstraction: 0.309

    Transform: SCS
    Lag: 44.815
    Unitgraph Type: STANDARD

    Baseflow: None
End:

Junction: J-Exterior
    Last Modified Date: 18 July 2022
    Last Modified Time: 18:25:24
    Canvas X: -1754.884499791062
    Canvas Y: 4734.823694317214
    From Canvas X: -3205.1025687695746
    From Canvas Y: 4074.20013664378
    Downstream: Diversion Channel D
End:

Reach: Diversion Channel D
    Last Modified Date: 24 October 2022
    Last Modified Time: 12:53:44
    Canvas X: -1986.6776300490328
    Canvas Y: 1547.7754701460908
    From Canvas X: -1754.884499791062
    From Canvas Y: 4734.823694317214
    Downstream: Pond 1

    Route: Kinematic Wave
    Channel: Kinematic Wave
    Length: 860
    Energy Slope: 0.008326
    Mannings n: 0.027
    Shape: Trapezoid
    Number of Subreaches: 2
    Width: 5
    Side Slope: 1.5
    Initial Variable: Combined Inflow
    Index Parameter Type: Index Flow
    Index Flow: 100
    Channel Loss: None
End:

Subbasin: M3
    Description: additional area - West
    Last Modified Date: 18 October 2022
    Last Modified Time: 18:52:20
    Canvas X: -3560.0431522053404
    Canvas Y: 2187.3200790047413
    From Canvas X: -7276.25262366989
    From Canvas Y: 7163.857883294095
    Area: 0.003714
    Downstream: Pond 1

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 84.6
Initial Abstraction: 0.364

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: M4
Description: Pond 3 area
Last Modified Date: 18 October 2022
Last Modified Time: 18:52:17
Canvas X: -561.3469048565821
Canvas Y: 2547.1636286865923
From Canvas X: -6903.171045658517
From Canvas Y: 3515.9491205162194
Area: 0.003491
Downstream: Pond 1

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 91.7
Initial Abstraction: 0.181

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: A-22
Description: additional area - West
Last Modified Date: 18 October 2022
Last Modified Time: 18:52:22
Canvas X: -4999.417350932745
Canvas Y: 460.07104053185685
Area: 0.001107
Downstream: Outfall C

Discretization: None
File: Post_Dev.sqlite

Canopy: None
Allow Simultaneous Precip Et: No
Plant Uptake Method: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 79.0
Initial Abstraction: 0.532

Transform: SCS
Lag: 3.600
Unitgraph Type: STANDARD

Baseflow: None
End:

Reservoir: Pond 1
Last Modified Date: 24 October 2022
Last Modified Time: 12:53:44
Canvas X: -1986.6776300490328
Canvas Y: 1547.7754701460908
From Canvas X: -4143.244509357473
From Canvas Y: -1192.0612655629284
Downstream: Outfall B

Route: Controlled Outflow
Routing Curve: Elevation-Area
Initial Elevation: 406
Elevation-Area Table: Pond 2
Adaptive Control: On
Main Tailwater Condition: None
Auxiliary Tailwater Condition: None

Conduit: Culvert
Conduit Outlet: Main
Culvert Shape: Circular
Chart Number: 1
Scale Number: 1
Solution Control: Automatic
Diameter: 4
Number Barrels: 1
Culvert Length: 85
Entrance Loss Coefficient: 0.5
Exit Loss Coefficient: 1
Top Manning's n: 0.012
Inlet Invert Elevation: 406
Outlet Invert Elevation: 405
End Conduit:

Spillway: Broad-Crested Spillway
Spillway Outlet: Main
Spillway Crest Length: 25
Spillway Crest Elevation: 414
Spillway Coefficient: 2.63
End Spillway:

Evaporation Method: Zero Evaporation
End Evaporation:

End:

Junction: Outfall C
Last Modified Date: 18 October 2022
Last Modified Time: 18:52:24
Canvas X: -4471.646811399363
Canvas Y: -763.3970283864364
From Canvas X: -9571.505001845962
From Canvas Y: -360.33219559905774
End:

Junction: Offsite Outfall
Last Modified Date: 29 June 2022
Last Modified Time: 20:18:20
Canvas X: 15576.563573421738
Canvas Y: 13225.471038986827
From Canvas X: 14907.641703262372
From Canvas Y: 13744.171577137358
End:

Basin Layer Properties:
Element Layer:
Name: Icons
Layer shown: Yes
End Layer:
End:

Basin Spatial Properties:
End:

Basin Schematic Properties:
Last View N: 14343.96141577225
Last View S: 14005.218578047004
Last View W: 640.9918146167995
Last View E: 791.116481335943
Maximum View N: 14281.490133359453
Maximum View S: -2466.1128476059457
Maximum View W: -7732.241219017125
Maximum View E: 16024.4696559174
Extent Method: Elements
Buffer: 0
Draw Icons: Yes
Draw Icon Labels: Name
Draw Map Objects: No
Draw Gridlines: No
Draw Flow Direction: No
Draw HillShade Layer: Yes
Draw Elevation Layer: Yes
Elevation Layer Color Palette: Default
Ignore Elevation Color Ramp Scale: No
Use Interpolated Color Ramp for Elevation Layer: Yes
Color Ramp Opacity Level for Elevation Layer: 33.0
Fix Element Locations: No
Fix Hydrologic Order: No
End:

# ATTACHMENT 2C

# ON-SITE ANALYSIS AND DESIGN
# DRAINAGE TERRACES AND DOWNDRAINS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Written by: | A. Brewster | Date: | 10/7/2022 | Reviewed by: | S. Graves | Date: | 10/21/2022 |
| Client: | WMTX | Project: | Lacy Lakeview RDF | Project No.: | GW8041 | Phase No.: | 05 |

# ON-SITE ANALYSIS AND DESIGN
# DRAINAGE TERRACES AND DOWNDRAINS
# LACY LAKEVIEW RECYCLING AND DISPOSAL FACILITY

STATE OF TEXAS
SCOTT M. GRAVES
86557
LICENSED
PROFESSIONAL ENGINEER

10/21/2022

SEALED FOR PERMITTING PURPOSES,
CALCULATION PAGES 1 TO 22

GEOSYNTEC CONSULTANTS, INC.
TX ENG. FIRM REGISTRATION NO. F-1182

## 1. PURPOSE

The purpose of this calculation package is to present the design of surface water management features constructed on the final cover of the Lacy Lakeview Recycling and Disposal Facility. Specifically, sideslope drainage terraces installed as "tack-on" berms on the final cover sideslope are designed to intercept surface water runoff (i.e., sheet flow) along the up-gradient sideslope areas of the final cover and convey runoff to downdrain pipes. Similar drainage terraces will also be constructed at the crest of the landfill sideslope, or the toe of the top deck of the final cover, to collect and convey sheet flow runoff from the 5% slope top deck surfaces to the downdrain pipes. In addition, in one instance, a rip-rap lined let-down channel will be constructed along a drainage fold (valley) on the top deck to minimize long-term potential erosion and route runoff to a downdrain pipe. Closed-conduit downdrain pipes oriented perpendicularly to the landfill slopes (i.e., down-slope) will collect the runoff from low points of the drainage terraces and let-down channel, and convey the surface water to the landfill perimeter channels along the toe of the cover system sideslopes. This design approach is consistent with the current permit (under Permit 1646A), and portions of the southeast part of the landfill have already been closed (i.e., final capped) with an existing network of similar sideslope terraces and HDPE downdrains. Some of these existing features will be unaffected by the landfill expansion and are also evaluated as part of this calculation package.

Design of the perimeter channels is presented in Attachment 2D. The Facility Surface Water Management Plan shows the layout of each of these features and can be found in Drawing

2A-1 of Attachment 2A of the Drainage Report.

# 2. METHODOLOGY

## 2.1 Terraces and Let-Down Channel

Terraces were evaluated and designed with grass lining and sized to convey runoff from the 25-year, 24-hour design rainfall event with 0.5 feet (ft) of freeboard and to convey the 100-year, 24-hour design rainfall event without overtopping. The let-down channel was designed with riprap lining to meet the same hydraulic capacity requirements. The capacity of these features is calculated by solving Manning's equation for the depth of flow within each terrace or channel. Manning's equation (Chow, 1959) is expressed as:

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2} \tag{1}$$

where:

$Q$ = discharge (cfs),

$n$ = Manning's roughness coefficient,

$A$ = area of cross-section of flow (ft$^2$),

$P$ = wetted perimeter (ft),

$R$ = hydraulic radius = $A/P$ (ft), and

$S$ = longitudinal slope (ft/ft).

Calculations were also performed to demonstrate that tractive stresses within the terraces and let-down channel during the 25-year, 24-hour design rainfall event will not cause erosion. The average tractive stress in open channels was estimated by Equation (2) (Chow, 1959) and compared to permissible tractive stresses established for each lining component in the following section.

$$\tau_o = \gamma_w R S \tag{2}$$

where:

$\tau_o$ = average tractive stress (lb/ft$^2$),

$\gamma_w$ = unit weight of water (lb/ft$^3$),

$R$ = hydraulic radius = $A/P$ (ft), and

$S$ = channel slope (ft/ft).

## 2.2 Downdrains

Downdrains are evaluated and designed as 24-inch smooth-interior high-density polyethylene (HDPE) closed-conduit pipes in the following configurations.

Typical 4H:1V Configuration: Most segments of downdrain will be constructed at a 0.25 ft/ft slope (i.e., 25%; the 4H:1V landfill sideslopes). Downdrains were sized by solving Manning's equation for the depth of flow, such that runoff from the 25-year, 24-hour design rainfall event can be conveyed with 0.5 ft of freeboard (i.e., the pipe diameter minus the depth of flow) and runoff from the 100-year, 24-hour design rainfall event can be conveyed without the pipe flowing full. The velocity associated with the 25-year, 24-hour design condition is also reported to establish a performance criterion for the downdrain outlets.

Outlet Locations: As shown on drawing 2A-12 of Attachment 2A, the downdrain slope will reduce (flatten) at the toe-of-slope immediately prior to discharging at the perimeter of the landfill (and in slightly different configurations depending on whether a downdrain will drain into the existing or expansion areas). Two additional design cases were considered by solving Equation (1) assuming a full-flowing pipe (i.e., depth of flow equal to pipe diameter) to determine the minimum slope required to fully convey the 25-year peak discharge at each outlet location under gravity flow. It is noted that this method is generally conservative, as it ignores any headwater elevation increases that would occur within the 4H:1V segment of the downdrain if the shallower pipe segment created a bottleneck.

Inlet Locations: The inlets of each downdrain pipe were designed to convey runoff from the 25-year, 24-hour design rainfall event while maintaining a minimum of 0.5 ft of freeboard. As shown on Drawing 2A-10 of Attachment 2A, the berm constructed over the top deck downdrain inlets is approximately 3.5-ft tall. Similarly, as shown on Drawing 2A-11, the berm constructed over the sideslope downdrain inlets is 3.0-ft tall. The capacity of each downdrain inlet area is calculated by solving the orifice equation for the depth of headwater required to convey the 25-year, 24-hour peak discharge. The orifice equation is expressed in its general form as:

$$Q = CA\sqrt{2gH} \tag{3}$$

where:

$Q$ = discharge (cfs);

$C$ = discharge coefficient, assumed to be 0.6;

$A$ = area of cross-section of flow ($ft^2$);

$G$ = acceleration from gravity ($ft/s^2$); and

$H$ = depth from headwater to center of pipe.

## 3. DESIGN PARAMETERS

A summary of the parameters selected for design is provided for the drainage terraces and let-down channel as Table 2C-1 and is provided for the downdrains as Table 2C-2. Permissible shear stress and roughness coefficients were selected following TxDOT (2019) recommendations (as summarized in Tables 2C-3 and 2C-4, respectively).

### 3.1 Terraces and Let-Down Channel

The top deck and sideslope drainage terraces are designed as v-shaped channels (i.e., trapezoidal channels with bottom width equal to zero) that are grass-lined with native vegetation. Sideslope drainage terraces are spaced a maximum of 30-feet apart vertically on the 4H:1V final cover sideslopes (in accordance with Attachment 3E – Soil Cover Loss Erosion Analysis) and were designed for a 2.0% typical, 0.8% minimum, and 3.0% maximum longitudinal slope. Top deck terraces are positioned near the toe of the top deck and were designed for a 1.1% typical, 1.1% minimum, and 1.5% maximum longitudinal slope. The final cover top deck let-down channel is designed as a riprap-lined trapezoidal channel with a 5-ft base and is positioned along the 3.4% slope of the drainage fold (valley) on the top deck. Typical cross sections of these features are shown on Drawing 2A-10 of Attachment 2A.

Retardation Class C (which includes Bermuda and Crab grasses among others) is selected for all drainage terraces (as shown in Table 2C-5) and has a maximum permissible tractive stress of 1.0 psf. Federal Highway Administration (FHWA) Class 2 riprap ($D_{50}$ = 6 inches) is selected for the let-down channel and has a maximum permissible tractive stress of 2.50 psf. A roughness value of *n* = 0.027 was selected for the grass and riprap channel lining based on ranges recommended by TxDOT (2019).

Top deck and sideslope drainage areas are modeled as separate subbasins in the HEC-HMS model discussed in Attachment 2B. The hydraulic performance of the top deck drainage terraces was evaluated based on the hydrograph for subbasin TD1, as shown on Drawing 2-3 of Attachment 2A, which corresponds to the maximum peak discharge within a top deck drainage terrace. In conjunction with Equations (1) and (2), the peak discharge is used to calculate depth of flow and tractive stress. Using the same method, the hydraulic performance of the sideslope drainage terraces was evaluated based on the hydrograph from subbasin SS11. Specifically, the downgradient bench of the two within drainage area SS11 is associated with highest peak discharge at a sideslope inlet area. The peak discharge considered is equal to the peak discharge of the SS-11 subbasin hydrograph times 72% (i.e., the lower bench receives 72% of the total drainage area). Hydraulic performance of the top deck let-down channel is evaluated with the hydrograph for TD4, which has a drainage boundary that encompasses the let-down channel.

## 3.2 Downdrains

All existing and proposed downdrains utilize 24-inch pipes in varying numbers, including a single pipe for existing locations (Downdrains A and B-L), four pipes for locations that collect flow from the expansion area top deck (Downdrains E, and G), and two pipes for all other locations. The two interior pipes of the 4 x 24” HDPE configurations for Downdrains E and G are designed to collect flow exclusively from the top deck area, and any peak discharges associated with the top deck inlet areas is assumed to be distributed evenly among all four pipes. Excluding the two interior pipes at Downdrains E and G, pipes collect flow from multiple inlets constructed along the typical 4H:1V pipe segment, and each inlet ultimately receives flow from a single drainage terrace. Refer to Drawing 2A-11 of Attachment 2A for the typical proposed 2 x 24” HDPE and 4 x 24” HDPE systems.

A roughness value of n = 0.012 was selected based on the range of Manning’s roughness coefficients selected from TxDOT (2019) for smooth-interior polyethylene pipes. The downdrain outlets are proposed to be pre-formed concrete baffles (shown on Drawing 2A-14 of Attachment 2A) and fitted with the same riprap apron used for the concrete drop structure outlet culverts described in Attachment 2D (i.e., Culverts WC1 and WC2, as shown on Drawing 2A-13 of Attachment 2A). An outlet velocity threshold of 50 fps is selected for design based on recommendations by FHWA (2006) for similar energy dissipation structures. Alternatives to the proposed outlet configuration and liner system may be selected if they can meet the maximum outlet velocity performance requirement established in the following section.

Hydraulic performance of downdrains was evaluated based on the maximum peak discharge associated with an individual pipe at its typical slope, inlet area, and outlet area. The typical 4H:1V configuration of all pipes was evaluated based on the rightmost pipe of four at Downdrain G (corresponding to the summation of peak discharges from hydrographs for SS11, SS10, and one-fourth of TD1). Outlet locations along the proposed perimeter is also evaluated based on the rightmost pipe at Downdrain G, and outlet locations along the existing perimeter were evaluated based on the right pipe (of two) at Downdrain B-L (corresponding to the summation of peak discharges from hydrographs for TD2, SS1-U, and SS2 divided by two). The sideslope inlet locations were evaluated based on the rightmost pipe at Downdrain G, which corresponds to the same design point used to evaluate the sideslope terraces (i.e., the area that drains to the lower of the two drainage terraces within subbasin SS11). Finally, the top deck inlet locations were evaluated based on the Downdrain E inlet area (corresponding to the one-fourth of the summation of peak discharges from hydrographs for TD3 and TD4).

## 4. RESULTS

Equation (1) was used to calculate (i) depth of flow and velocity for the sideslope drainage terraces, top deck drainage terraces, top deck let-down channel, and typical 4H:1V downdrain configuration, and (ii) minimum required slope for the downdrain outlets. Equation (2) was used to calculate tractive stress within the sideslope drainage terraces, top deck drainage terraces, and top deck let-down channel. Equation (3) was used to calculate headwater depth at the downdrain inlets. The calculations performed are provided as Appendix 2C-1.

Calculations are summarized in Table 2C-6 for terraces and top deck let-down channel and summarized in Table 2C-7 for downdrains. Drawing 2A-1 of Appendix 2A provides the location and layout of each drainage structure discussed within this calculation package. The results of the drainage terrace and downchute analysis and design are summarized as follows:

- Each drainage terrace, 4H:1V downdrain pipe, and the let-down channel were calculated to adequately convey the 25-year, 24-hour peak discharge with 0.5 feet of freeboard and convey the 100-year, 24-hour peak discharge without overtopping.
- Each downdrain inlet was calculated to adequately convey the 25-year, 24-hour peak discharge with 0.5 feet of freeboard.
- The minimum slope required for the downdrain pipe outlet to convey the 25-year, 24-hour peak discharge was calculated as 0.08 ft/ft along the proposed perimeter and 0.02 ft/ft along the existing perimeter. Drawing 2A-12 of Attachment 2A shows the outlet pipe locations in relation to these minimum slopes.
- The average tractive stress during the 25-year, 24-hour design rainfall event was calculated to remain below 1.0 for all drainage terraces and calculated to remain below 2.5 for the let-down channel. for each drainage terrace was calculated to remain below 1.0 psf. The selected lining materials can adequately resist these tractive stresses.
- Erosion control at the downdrain outlets will consist of baffles constructed in accordance with Drawings 2A-13 and 2A-14 of Attachment 2A. The maximum velocity within the downdrains was calculated to be 40 fps (below the 50 fps design threshold recommended by FHWA (2006) for similar energy dissipation structures).

## 5. REFERENCES

Chow, V.T. (1959). *Open Channel-Hydraulics,* McGraw-Hill.

FHWA (2006). *Hydraulic Design of Energy Dissipators for Culverts and Channels*, Circular Number 14 (HEC-14), Department of Transportation, Third Edition. Revised October 2021.

TxDOT (2019). *Hydraulic Design Manual*, Texas Department of Transportation, revised September 2019.

USDA (1986). *Urban Hydrology for Small Watersheds*, Technical Release 55 (TR-55), United States Department of Agriculture, Science and Education Administration, Agriculture Handbook Number 537.

# TABLES

| Written by: | A. Brewster | Date: | 10/7/2022 | Reviewed by: | S. Graves | Date: | 10/21/2022 |
|---|---|---|---|---|---|---|---|
| Client: | WMTX | Project: | Lacy Lakeview RDF | Project No.: | GW8041 | Phase No.: | 05 |

## Table 2C-1. Design Parameter Summary for the Top Deck Let-Down Channel and Representative Drainage Terraces

| Final Cover Open Channel Design Case | Channel Shape | Design Longitudinal Channel Slope (%) | Manning's n | Depth (ft) | Left Side Slope (H:V) | Right Side Slope (H:V) | 25-yr, 24-hr Design Storm (cfs) | 100-yr, 24-hr Design Storm (cfs) |
|---|---|---|---|---|---|---|---|---|
| Top Deck Terrace (1.1%) | Trapezoid | 1.1 | 0.027 | 5 | 20 | 2 | 57 | 79 |
| Top Deck Terrace (1.5%) | V-shaped | 1.5 | 0.027 | 0 | 20 | 2 | 57 | 79 |
| Sideslope Terrace (0.8%) | V-shaped | 0.8 | 0.027 | 0 | 4 | 2 | 17 | 23 |
| Sideslope Terrace (3.0%) | V-shaped | 3.0 | 0.027 | 0 | 4 | 2 | 17 | 23 |
| Top Deck Let-Down Channel | V-shaped | 3.4 | 0.027 | 5 | 2 | 2 | 47 | 65 |

## Table 2C-2. Design Parameter Summary for 24" HDPE Downdrains

| Downchute Channel Segment | Number of Pipes | Typical Slope (%) (Note 2) | Minimum Slope at Outlet (%) (Note 3) | Number of Inlets | | | Manning's n |
|---|---|---|---|---|---|---|---|
| | | | | Top Deck Area (Note 4) | Sideslope Area (leftmost pipe) (Note 5) | Sideslope Area (rightmost pipe) (Note 5) | |
| Downdrain A | 1 | 25 | 2 | 0 | 1 | 1 | 0.012 |
| Downdrain B-L | 1 | 25 | 2 | 0 | 2 | 2 | 0.012 |
| Downdrain B-U | 2 | 25 | 2 | 0 | 3 | 4 | 0.012 |
| Downdrain C | 2 | 25 | 2 | 2 | 1 | 2 | 0.012 |
| Downdrain D | 2 | 25 | 2 | 2 | 1 | 0 | 0.012 |
| Downdrain E | 4 | 25 | 8 | 4 | 2 | 3 | 0.012 |
| Downdrain F | 2 | 25 | 8 | 2 | 4 | 4 | 0.012 |
| Downdrain G | 4 | 25 | 8 | 4 | 4 | 4 | 0.012 |

Notes:

1. Downdrains were evaluated based on the maximum peak discharge associated with an individual pipe at their respective typical slope, inlet area, or outlet area.
2. Pipes at the typical 4H:1V configuration were evaluated for a 25-yr, 24-hr maximum peak discharge of 69 cfs with 0.5 ft of freeboard and a 100-yr, 24-hr maximum peak discharge of 97 cfs.
3. Outlet areas were evaluated for a 25-yr, 24-hr maximum peak discharge of 69 cfs (for the proposed perimeter outlet pipes at 8%) and 35 cfs (for the existing perimeter outlet pipes at 2%).
4. Top deck inlets were evaluated for a 25-yr, 24-hr maximum peak discharge of 21 cfs with 0.5 ft of freeboard.
5. Sideslope inlets were evaluated for a 25-yr, 24-hr maximum peak discharge of 17 cfs with 0.5 ft of freeboard.

**Table 2C-3. Permissible Shear Stresses for Various Linings (from TxDOT, 2019)**

| Lining Material Type | Permissible Shear Stress Design Value |
|---|---|
| Retardance Class C Vegetation | 1.00 psf (Chapter 7, Section 3) |
| Riprap ($D_{50}$ = 6 inches) | 2.50 psf (Chapter 7, Section 3) |

**Table 2C-4. Manning's Roughness Coefficients (from TxDOT, 2019)**

| Material Type | Manning's n Cited Range | Selected Design Value |
|---|---|---|
| Excavated or dredged channels; Earth, straight and uniform (with short grass, few weeds) | 0.022-0.033 (Table 4-7) | 0.027 |
| Riprap-lined Channels (n-value depends on rock size) | 0.020-0.035 (Table 4-7) | 0.027 |
| Corrugated Polyethylene Closed-Conduit (smooth interior) | 0.009-0.015 (Table 4-9) | 0.012 |

Written by: **A. Brewster** Date: **10/7/2022** Reviewed by: **S. Graves** Date: **10/21/2022**

Client: **WMTX** Project: **Lacy Lakeview RDF** Project No.: **GW8041** Phase No.: **05**

## Table 2C-5. Retardation Class for Lining Materials (from TxDOT, 2019)

| Retardance Class | Cover | Condition |
|---|---|---|
| A | Weeping Lovegrass | Excellent stand, tall (average 30 in. or 760 mm) |
| | Yellow Bluestem Ischaemum | Excellent stand, tall (average 36 in. or 915 mm) |
| B | Kudzu | Very dense growth, uncut |
| | Bermuda grass | Good stand, tall (average 12 in. or 305 mm) |
| | Native grass mixture<br>little bluestem, bluestem, blue gamma, other short and long stem midwest grasses | Good stand, unmowed |
| | Weeping lovegrass | Good Stand, tall (average 24 in. or 610 mm) |
| | Lespedeza sericea | Good stand, not woody, tall (average 19 in. or 480 mm) |
| | Alfalfa | Good stand, uncut (average 11 in or 280 mm) |
| | Weeping lovegrass | Good stand, unmowed (average 13 in. or 330 mm) |
| | Kudzu | Dense growth, uncut |
| | Blue gamma | Good stand, uncut (average 13 in. or 330 mm) |
| C | Crabgrass | Fair stand, uncut (10-to-48 in. or 55-to-1220 mm) |
| | Bermuda grass | Good stand, mowed (average 6 in. or 150 mm) |
| | Common lespedeza | Good stand, uncut (average 11 in. or 280 mm) |
| | Grass-legume mixture: summer (orchard grass redtop, Italian ryegrass, and common lespedeza) | Good stand, uncut (6-8 in. or 150-200 mm) |
| | Centipedegrass | Very dense cover (average 6 in. or 150 mm) |
| | Kentucky bluegrass | Good stand, headed (6-12 in. or 150-305 mm) |
| D | Bermuda grass | Good stand, cut to 2.5 in. or 65 mm |
| | Common lespedeza | Excellent stand, uncut (average 4.5 in. or 115 mm) |
| | Buffalo grass | Good stand, uncut (3-6 in. or 75-150 mm) |
| | Grass-legume mixture:<br>fall, spring (orchard grass Italian ryegrass, and common lespedeza | Good Stand, uncut (4-5 in. or 100-125 mm) |
| | Lespedeza sericea | After cutting to 2 in. or 50 mm (very good before cutting) |
| E | Bermuda grass | Good stand, cut to 1.5 in. or 40 mm |
| | Bermuda grass | Burned stubble |

## Table 2C6. Summary of Calculated Results for Top Deck Let-Down Channel and Drainage Terraces

| Drainage Terrace Designation | 25-Year Design Storm Event | | | | 100-Year Design Storm Event | | | |
|---|---|---|---|---|---|---|---|---|
| | Peak Flow Rate $Q_{25}$ (cfs) | Peak Depth of Flow (ft) | Peak Average Velocity (ft/s) | Peak Average Tractive Stress (psf) | Peak Flow Rate $Q_{100}$ (cfs) | Peak Depth of Flow (ft) | Peak Average Velocity (ft/s) | Peak Average Tractive Stress (psf) |
| Top Deck Terrace (1.1%) | 57 | 1.1 | 3.9 | 0.38 | 79 | 1.27 | 4.25 | 0.43 |
| Top Deck Terrace (1.5%) | 57 | 1.1 | 4.4 | 0.49 | 79 | 1.20 | 4.78 | 0.56 |
| Sideslope Terrace (0.8%) | 17 | 1.3 | 3.5 | 0.30 | 23 | 1.43 | 3.79 | 0.34 |
| Sideslope Terrace (3.0%) | 17 | 1.0 | 5.7 | 0.87 | 23 | 1.12 | 6.23 | 0.98 |
| Top Deck Let-Down Channel | 47 | 1.4 | 7.8 | 1.41 | 65 | 1.06 | 8.60 | 1.65 |

| Written by: | A. Brewster | Date: | 10/7/2022 | Reviewed by: | S. Graves | Date: | 10/21/2022 |
|---|---|---|---|---|---|---|---|
| Client: | WMTX | Project: | Lacy Lakeview RDF | Project No.: | GW8041 | Phase No.: | 05 |

## Table 2C-7. Summary of Calculated Results for Individual 24" HDPE Downdrain Pipes

| | | |
|---|---|---|
| **TYPICAL 4H:1V PIPE CONFIGURATION AND FLOWRATES** | | |
| 25-year Peak Flow : | 69 | cfs |
| 100-year Peak Flow : | 97 | cfs |
| 25-year Freeboard: | 0.9 | ft |
| 100-year Freeboard: | 0.7 | ft |
| 25-year Average Velocity: | 40 | fps |
| **INLET: TOP DECK** | | |
| 25-year Peak Flow: | 21 | cfs |
| 25-year Freeboard: | 0.6 | ft [note 1] |
| **INLET: SIDESLOPE** | | |
| 25-year Peak Flow: | 17 | cfs |
| 25-year Freeboard: | 0.8 | ft [note 1] |
| **OUTLET: AT EXISTING PERIMETER AT** | | |
| 25-year Peak Flow: | 35 | cfs |
| Minimum Required Slope: | 0.02 | ft/ft |
| **OUTLET: AT PROPOSED PERIMETER** | | |
| 25-year Peak Flow: | 69 | cfs |
| Minimum Required Slope: | 0.08 | ft/ft |

Notes:

1. Berms are 3.5-ft tall at the top deck inlet area and 3.0-ft tall at the sideslope inlet area.

# Appendix 2C-1

# Drainage Feature Calculations

Written by: **A. Brewster** Date: **10/7/2022** Reviewed by: **S. Graves** Date: **10/21/2022**

Client: **WMTX** Project: **Lacy Lakeview RDF** Project No.: **GW8041** Phase No.: **05**

# Design/Check: Trapezoidal/Triangular Channel

Methodology: Manning's Equation

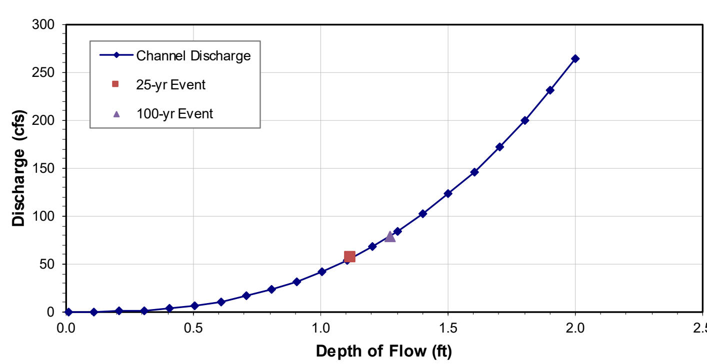
Project: LACY LAKEVIEW LF

Ditch ID: **Top-Deck Terrace (1.1%)**

| | | |
|---|---|---|
| Peak Discharge, $Q_{25}$ = | 57 | cfs (25-yr Event) |
| Peak Discharge, $Q_{100}$ = | 79 | cfs (100-yr Event) |
| Bottom Width, B = | 0 | ft |
| Left Side Slope, $Z_1$ = | 20.0 | horizontal :1 vertical |
| Right Side Slope, $Z_2$ = | 3.0 | horizontal :1 vertical |
| Channel Depth, Y = | 2.0 | ft |
| Top Width, T = | 46 | ft |
| Manning's Roughness Coeff., n = | 0.027 | grass-lined channel |
| Longitudinal Channel Slope, $S_o$ = | 0.011 | ft/ft |

| Depth of Flow Y ft | Area of Flow A $ft^2$ | Wetted Perimeter P ft | Hydraulic Radius R=A/P ft | Average Velocity V ft/s | Discharge (Flow Rate) Q=AV $ft^3/s$ | Avg. Tractive Stress $\tau_0$ $lb/ft^2$ | Comments |
|---|---|---|---|---|---|---|---|
| 0.01 | 0.00 | 0.23 | 0.00 | 0.17 | 0.0 | 0.00 | |
| 0.11 | 0.14 | 2.54 | 0.05 | 0.83 | 0.1 | 0.04 | |
| 0.21 | 0.50 | 4.85 | 0.10 | 1.28 | 0.6 | 0.07 | |
| 0.31 | 1.09 | 7.15 | 0.15 | 1.65 | 1.8 | 0.11 | |
| 0.41 | 1.91 | 9.46 | 0.20 | 1.99 | 3.8 | 0.14 | |
| 0.51 | 2.96 | 11.77 | 0.25 | 2.31 | 6.8 | 0.17 | |
| 0.61 | 4.24 | 14.07 | 0.30 | 2.60 | 11.0 | 0.21 | |
| 0.71 | 5.74 | 16.38 | 0.35 | 2.88 | 16.5 | 0.24 | |
| 0.81 | 7.47 | 18.69 | 0.40 | 3.14 | 23.5 | 0.27 | |
| 0.91 | 9.43 | 21.00 | 0.45 | 3.39 | 32.0 | 0.31 | |
| 1.01 | 11.62 | 23.30 | 0.50 | 3.64 | 42.3 | 0.34 | |
| 1.10 | 14.03 | 25.61 | 0.55 | 3.87 | 54.4 | 0.38 | |
| 1.20 | 16.67 | 27.92 | 0.60 | 4.10 | 68.4 | 0.41 | |
| 1.30 | 19.54 | 30.22 | 0.65 | 4.33 | 84.5 | 0.44 | |
| 1.40 | 22.64 | 32.53 | 0.70 | 4.54 | 102.9 | 0.48 | |
| 1.50 | 25.96 | 34.84 | 0.75 | 4.76 | 123.5 | 0.51 | |
| 1.60 | 29.51 | 37.15 | 0.79 | 4.96 | 146.5 | 0.55 | |
| 1.70 | 33.29 | 39.45 | 0.84 | 5.17 | 172.1 | 0.58 | |
| 1.80 | 37.30 | 41.76 | 0.89 | 5.37 | 200.2 | 0.61 | |
| 1.90 | 41.54 | 44.07 | 0.94 | 5.56 | 231.1 | 0.65 | |
| 2.00 | 46.00 | 46.37 | 0.99 | 5.76 | 264.8 | 0.68 | |
| 1.12 | 14.42 | 25.96 | 0.56 | 3.91 | 56.37 | 0.38 | Q (25-yr Event) |
| 1.27 | 18.56 | 29.46 | 0.63 | 4.25 | 78.96 | 0.43 | Q (100-yr Event) |

***Discharge versus Depth Relationship***



Written by: **A. Brewster** Date: **10/7/2022** Reviewed by: **S. Graves** Date: **10/21/2022**

Client: **WMTX** Project: **Lacy Lakeview RDF** Project No.: **GW8041** Phase No.: **05**

# Design/Check: Trapezoidal/Triangular Channel

Methodology: Manning's Equation

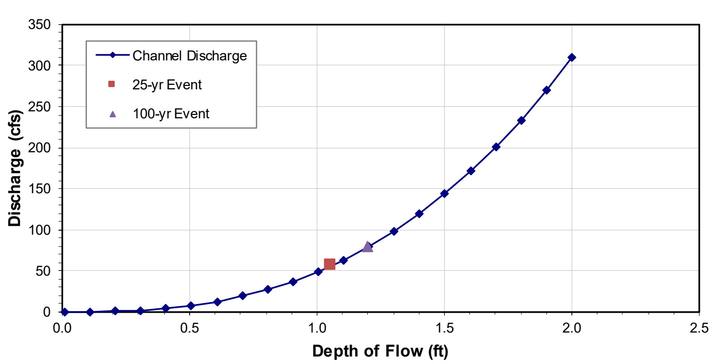
Project: LACY LAKEVIEW LF

Ditch ID: **Top-Deck Terrace (1.5%)**

| | | |
|---|---|---|
| Peak Discharge, $Q_{25}$ = | 57 | cfs (25-yr Event) |
| Peak Discharge, $Q_{100}$ = | 79 | cfs (100-yr Event) |
| Bottom Width, B = | 0 | ft |
| Left Side Slope, $Z_1$ = | 20.0 | horizontal :1 vertical |
| Right Side Slope, $Z_2$ = | 3.0 | horizontal :1 vertical |
| Channel Depth, Y = | 2.0 | ft |
| Top Width, T = | 46 | ft |
| Manning's Roughness Coeff., n = | 0.027 | grass-lined channel |
| Longitudinal Channel Slope, $S_o$ = | 0.015 | ft/ft |

| Depth of Flow Y ft | Area of Flow A $ft^2$ | Wetted Perimeter P ft | Hydraulic Radius R=A/P ft | Average Velocity V ft/s | Discharge (Flow Rate) Q=AV $ft^3/s$ | Avg. Tractive Stress $\tau_0$ $lb/ft^2$ | Comments |
|---|---|---|---|---|---|---|---|
| 0.01 | 0.00 | 0.23 | 0.00 | 0.20 | 0.0 | 0.00 | |
| 0.11 | 0.14 | 2.54 | 0.05 | 0.97 | 0.1 | 0.05 | |
| 0.21 | 0.50 | 4.85 | 0.10 | 1.49 | 0.7 | 0.10 | |
| 0.31 | 1.09 | 7.15 | 0.15 | 1.93 | 2.1 | 0.14 | |
| 0.41 | 1.91 | 9.46 | 0.20 | 2.33 | 4.5 | 0.19 | |
| 0.51 | 2.96 | 11.77 | 0.25 | 2.69 | 8.0 | 0.24 | |
| 0.61 | 4.24 | 14.07 | 0.30 | 3.03 | 12.9 | 0.28 | |
| 0.71 | 5.74 | 16.38 | 0.35 | 3.36 | 19.3 | 0.33 | |
| 0.81 | 7.47 | 18.69 | 0.40 | 3.67 | 27.4 | 0.37 | |
| 0.91 | 9.43 | 21.00 | 0.45 | 3.96 | 37.4 | 0.42 | |
| 1.01 | 11.62 | 23.30 | 0.50 | 4.25 | 49.3 | 0.47 | |
| 1.10 | 14.03 | 25.61 | 0.55 | 4.52 | 63.5 | 0.51 | |
| 1.20 | 16.67 | 27.92 | 0.60 | 4.79 | 79.9 | 0.56 | |
| 1.30 | 19.54 | 30.22 | 0.65 | 5.05 | 98.7 | 0.61 | |
| 1.40 | 22.64 | 32.53 | 0.70 | 5.31 | 120.1 | 0.65 | |
| 1.50 | 25.96 | 34.84 | 0.75 | 5.55 | 144.2 | 0.70 | |
| 1.60 | 29.51 | 37.15 | 0.79 | 5.80 | 171.1 | 0.74 | |
| 1.70 | 33.29 | 39.45 | 0.84 | 6.04 | 200.9 | 0.79 | |
| 1.80 | 37.30 | 41.76 | 0.89 | 6.27 | 233.8 | 0.84 | |
| 1.90 | 41.54 | 44.07 | 0.94 | 6.50 | 269.9 | 0.88 | |
| 2.00 | 46.00 | 46.37 | 0.99 | 6.72 | 309.2 | 0.93 | |
| 1.06 | 12.81 | 24.47 | 0.52 | 4.39 | 56.22 | 0.49 | Q (25-yr Event) |
| 1.20 | 16.56 | 27.82 | 0.60 | 4.78 | 79.15 | 0.56 | Q (100-yr Event) |

***Discharge versus Depth Relationship***



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Client: **WMTX** Project: **Lacy Lakeview RDF** Project No.: **GW8041** Phase No.: **05**

# Design/Check: Trapezoidal/Triangular Channel

Methodology: Manning's Equation

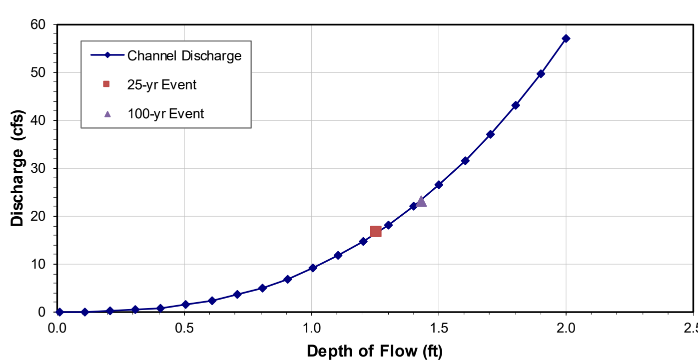
Project: LACY LAKEVIEW LF

Ditch ID: **Sideslope Terrace (0.8%)**

| | | |
|---|---|---|
| Peak Discharge, $Q_{25}$ = | 17 | cfs (25-yr Event) |
| Peak Discharge, $Q_{100}$ = | 23 | cfs (100-yr Event) |
| Bottom Width, B = | 0 | ft |
| Left Side Slope, $Z_1$ = | 4.0 | horizontal :1 vertical |
| Right Side Slope, $Z_2$ = | 2.0 | horizontal :1 vertical |
| Channel Depth, Y = | 2.0 | ft |
| Top Width, T = | 12 | ft |
| Manning's Roughness Coeff., n = | 0.027 | grass-lined channel |
| Longitudinal Channel Slope, $S_o$ = | 0.008 | ft/ft |

| Depth of Flow Y ft | Area of Flow A $ft^2$ | Wetted Perimeter P ft | Hydraulic Radius R=A/P ft | Average Velocity V ft/s | Discharge (Flow Rate) Q=AV $ft^3/s$ | Avg. Tractive Stress $\tau_0$ $lb/ft^2$ | Comments |
|---|---|---|---|---|---|---|---|
| 0.01 | 0.00 | 0.06 | 0.00 | 0.14 | 0.0 | 0.00 | |
| 0.11 | 0.04 | 0.70 | 0.05 | 0.68 | 0.0 | 0.03 | |
| 0.21 | 0.13 | 1.33 | 0.10 | 1.05 | 0.1 | 0.05 | |
| 0.31 | 0.29 | 1.96 | 0.15 | 1.36 | 0.4 | 0.07 | |
| 0.41 | 0.50 | 2.59 | 0.19 | 1.64 | 0.8 | 0.10 | |
| 0.51 | 0.77 | 3.23 | 0.24 | 1.90 | 1.5 | 0.12 | |
| 0.61 | 1.11 | 3.86 | 0.29 | 2.14 | 2.4 | 0.14 | |
| 0.71 | 1.50 | 4.49 | 0.33 | 2.37 | 3.6 | 0.17 | |
| 0.81 | 1.95 | 5.13 | 0.38 | 2.59 | 5.0 | 0.19 | |
| 0.91 | 2.46 | 5.76 | 0.43 | 2.80 | 6.9 | 0.21 | |
| 1.01 | 3.03 | 6.39 | 0.47 | 3.00 | 9.1 | 0.24 | |
| 1.10 | 3.66 | 7.02 | 0.52 | 3.20 | 11.7 | 0.26 | |
| 1.20 | 4.35 | 7.66 | 0.57 | 3.38 | 14.7 | 0.28 | |
| 1.30 | 5.10 | 8.29 | 0.61 | 3.57 | 18.2 | 0.31 | |
| 1.40 | 5.91 | 8.92 | 0.66 | 3.75 | 22.1 | 0.33 | |
| 1.50 | 6.77 | 9.55 | 0.71 | 3.92 | 26.6 | 0.35 | |
| 1.60 | 7.70 | 10.19 | 0.76 | 4.09 | 31.5 | 0.38 | |
| 1.70 | 8.69 | 10.82 | 0.80 | 4.26 | 37.0 | 0.40 | |
| 1.80 | 9.73 | 11.45 | 0.85 | 4.43 | 43.1 | 0.42 | |
| 1.90 | 10.84 | 12.09 | 0.90 | 4.59 | 49.7 | 0.45 | |
| 2.00 | 12.00 | 12.72 | 0.94 | 4.75 | 57.0 | 0.47 | |
| 1.26 | 4.75 | 8.00 | 0.59 | 3.49 | 16.56 | 0.30 | Q (25-yr Event) |
| 1.43 | 6.12 | 9.09 | 0.67 | 3.79 | 23.23 | 0.34 | Q (100-yr Event) |

***Discharge versus Depth Relationship***



Written by: **A. Brewster** Date: **10/7/2022** Reviewed by: **S. Graves** Date: **10/21/2022**

Client: **WMTX** Project: **Lacy Lakeview RDF** Project No.: **GW8041** Phase No.: **05**

# Design/Check: Trapezoidal/Triangular Channel

Methodology: Manning's Equation

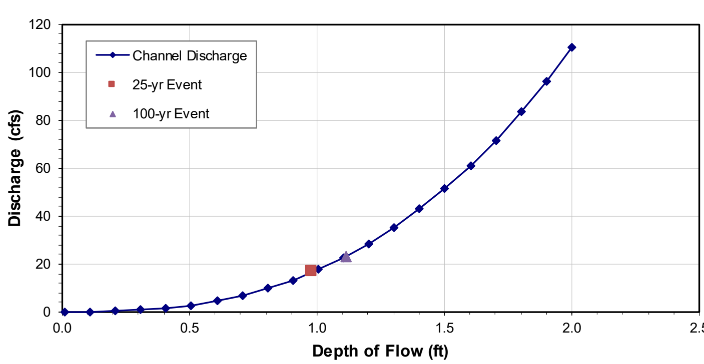
Project: LACY LAKEVIEW LF

Ditch ID: **Sideslope Terrace (3.0%)**

| | | |
|---|---|---|
| Peak Discharge, $Q_{25}$ = | 17 | cfs (25-yr Event) |
| Peak Discharge, $Q_{100}$ = | 23 | cfs (100-yr Event) |
| Bottom Width, B = | 0 | ft |
| Left Side Slope, $Z_1$ = | 4.0 | horizontal :1 vertical |
| Right Side Slope, $Z_2$ = | 2.0 | horizontal :1 vertical |
| Channel Depth, Y = | 2.0 | ft |
| Top Width, T = | 12 | ft |
| Manning's Roughness Coeff., n = | 0.027 | grass-lined channel |
| Longitudinal Channel Slope, $S_o$ = | 0.030 | ft/ft |

| Depth of Flow Y ft | Area of Flow A $ft^2$ | Wetted Perimeter P ft | Hydraulic Radius R=A/P ft | Average Velocity V ft/s | Discharge (Flow Rate) Q=AV $ft^3/s$ | Avg. Tractive Stress $\tau_0$ $lb/ft^2$ | Comments |
|---|---|---|---|---|---|---|---|
| 0.01 | 0.00 | 0.06 | 0.00 | 0.27 | 0.0 | 0.01 | |
| 0.11 | 0.04 | 0.70 | 0.05 | 1.32 | 0.0 | 0.10 | |
| 0.21 | 0.13 | 1.33 | 0.10 | 2.04 | 0.3 | 0.18 | |
| 0.31 | 0.29 | 1.96 | 0.15 | 2.64 | 0.8 | 0.27 | |
| 0.41 | 0.50 | 2.59 | 0.19 | 3.18 | 1.6 | 0.36 | |
| 0.51 | 0.77 | 3.23 | 0.24 | 3.68 | 2.8 | 0.45 | |
| 0.61 | 1.11 | 3.86 | 0.29 | 4.15 | 4.6 | 0.54 | |
| 0.71 | 1.50 | 4.49 | 0.33 | 4.59 | 6.9 | 0.62 | |
| 0.81 | 1.95 | 5.13 | 0.38 | 5.02 | 9.8 | 0.71 | |
| 0.91 | 2.46 | 5.76 | 0.43 | 5.42 | 13.3 | 0.80 | |
| 1.01 | 3.03 | 6.39 | 0.47 | 5.81 | 17.6 | 0.89 | |
| 1.10 | 3.66 | 7.02 | 0.52 | 6.19 | 22.6 | 0.98 | |
| 1.20 | 4.35 | 7.66 | 0.57 | 6.55 | 28.5 | 1.06 | |
| 1.30 | 5.10 | 8.29 | 0.61 | 6.91 | 35.2 | 1.15 | |
| 1.40 | 5.91 | 8.92 | 0.66 | 7.26 | 42.9 | 1.24 | |
| 1.50 | 6.77 | 9.55 | 0.71 | 7.60 | 51.5 | 1.33 | |
| 1.60 | 7.70 | 10.19 | 0.76 | 7.93 | 61.1 | 1.41 | |
| 1.70 | 8.69 | 10.82 | 0.80 | 8.26 | 71.7 | 1.50 | |
| 1.80 | 9.73 | 11.45 | 0.85 | 8.57 | 83.4 | 1.59 | |
| 1.90 | 10.84 | 12.09 | 0.90 | 8.89 | 96.3 | 1.68 | |
| 2.00 | 12.00 | 12.72 | 0.94 | 9.19 | 110.3 | 1.77 | |
| 0.98 | 2.89 | 6.24 | 0.46 | 5.72 | 16.55 | 0.87 | Q (25-yr Event) |
| 1.12 | 3.73 | 7.09 | 0.53 | 6.23 | 23.24 | 0.98 | Q (100-yr Event) |

***Discharge versus Depth Relationship***



Written by: **A. Brewster** Date: **10/7/2022** Reviewed by: **S. Graves** Date: **10/21/2022**

Client: **WMTX** Project: **Lacy Lakeview RDF** Project No.: **GW8041** Phase No.: **05**

# Design/Check: Trapezoidal/Triangular Channel

Methodology: Manning's Equation

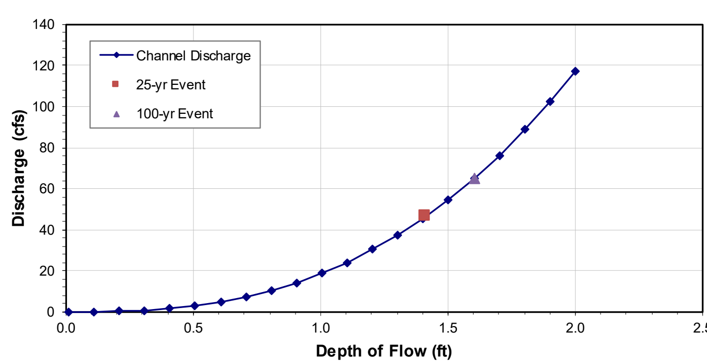
Project: LACY LAKEVIEW LF

Ditch ID: **Top Deck Let-Down Channel**

| | | |
|---|---|---|
| Peak Discharge, $Q_{25}$ = | 47 | cfs (25-yr Event) |
| Peak Discharge, $Q_{100}$ = | 65 | cfs (100-yr Event) |
| Bottom Width, B = | 0 | ft |
| Left Side Slope, $Z_1$ = | 4.0 | horizontal :1 vertical |
| Right Side Slope, $Z_2$ = | 2.0 | horizontal :1 vertical |
| Channel Depth, Y = | 2.0 | ft |
| Top Width, T = | 12 | ft |
| Manning's Roughness Coeff., n = | 0.027 | grass-lined channel |
| Longitudinal Channel Slope, $S_o$ = | 0.034 | ft/ft |

| Depth of Flow Y ft | Area of Flow A $ft^2$ | Wetted Perimeter P ft | Hydraulic Radius R=A/P ft | Average Velocity V ft/s | Discharge (Flow Rate) Q=AV $ft^3/s$ | Avg. Tractive Stress $\tau_0$ $lb/ft^2$ | Comments |
|---|---|---|---|---|---|---|---|
| 0.01 | 0.00 | 0.06 | 0.00 | 0.29 | 0.0 | 0.01 | |
| 0.11 | 0.04 | 0.70 | 0.05 | 1.41 | 0.1 | 0.11 | |
| 0.21 | 0.13 | 1.33 | 0.10 | 2.17 | 0.3 | 0.21 | |
| 0.31 | 0.29 | 1.96 | 0.15 | 2.81 | 0.8 | 0.31 | |
| 0.41 | 0.50 | 2.59 | 0.19 | 3.39 | 1.7 | 0.41 | |
| 0.51 | 0.77 | 3.23 | 0.24 | 3.92 | 3.0 | 0.51 | |
| 0.61 | 1.11 | 3.86 | 0.29 | 4.42 | 4.9 | 0.61 | |
| 0.71 | 1.50 | 4.49 | 0.33 | 4.89 | 7.3 | 0.71 | |
| 0.81 | 1.95 | 5.13 | 0.38 | 5.34 | 10.4 | 0.81 | |
| 0.91 | 2.46 | 5.76 | 0.43 | 5.77 | 14.2 | 0.91 | |
| 1.01 | 3.03 | 6.39 | 0.47 | 6.19 | 18.7 | 1.01 | |
| 1.10 | 3.66 | 7.02 | 0.52 | 6.59 | 24.1 | 1.11 | |
| 1.20 | 4.35 | 7.66 | 0.57 | 6.98 | 30.3 | 1.21 | |
| 1.30 | 5.10 | 8.29 | 0.61 | 7.36 | 37.5 | 1.30 | |
| 1.40 | 5.91 | 8.92 | 0.66 | 7.73 | 45.6 | 1.40 | |
| 1.50 | 6.77 | 9.55 | 0.71 | 8.09 | 54.8 | 1.50 | |
| 1.60 | 7.70 | 10.19 | 0.76 | 8.44 | 65.0 | 1.60 | |
| 1.70 | 8.69 | 10.82 | 0.80 | 8.79 | 76.3 | 1.70 | |
| 1.80 | 9.73 | 11.45 | 0.85 | 9.13 | 88.8 | 1.80 | |
| 1.90 | 10.84 | 12.09 | 0.90 | 9.46 | 102.5 | 1.90 | |
| 2.00 | 12.00 | 12.72 | 0.94 | 9.79 | 117.5 | 2.00 | |
| 1.41 | 5.99 | 8.98 | 0.67 | 7.76 | 46.49 | 1.41 | Q (25-yr Event) |
| 1.60 | 7.72 | 10.20 | 0.76 | 8.45 | 65.23 | 1.61 | Q (100-yr Event) |

***Discharge versus Depth Relationship***



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Client: **WMTX** Project: **Lacy Lakeview RDF** Project No.: **GW8041** Phase No.: **05**

# Downdrain G (Rightmost Pipe)
# Flow Through Circular Pipe

| | | |
|---|---|---|
| Number of Pipes, N= | 1 | |
| Diameter of pipe, D= | 24 | inches |
| Longitudinal Slope, So= | 0.250 | ft/ft |
| Manning's n= | 0.012 | |
| Density of flowing liquid, rho= | 1.94 | slugs/ft^3 |
| Peak Discharge, $Q_{25}$ = | 69.0 | cfs |
| Peak Discharge, $Q_{100}$ = | 96.8 | cfs |

| Theta radians | Theta degrees | Depth of Flow y inches | Area of Flow A ft^2 | Wetted Perimeter P ft | Hydraulic Radius R ft | Average Velocity V ft/s | Discharge Q=A*V cfs | Force F lbf |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 0.00 | 0 | 0.0 | 0.000 | 0.00 | | 0.0 | 0.00 | 0.0 |
| 0.25 | 14 | 0.1 | 0.001 | 0.25 | 0.01 | 1.9 | 0.00 | 0.0 |
| 0.50 | 29 | 0.4 | 0.010 | 0.50 | 0.02 | 4.7 | 0.05 | 0.4 |
| 0.75 | 43 | 0.8 | 0.034 | 0.75 | 0.05 | 7.9 | 0.27 | 4.2 |
| 1.00 | 57 | 1.5 | 0.079 | 1.00 | 0.08 | 11.4 | 0.91 | 20.1 |
| 1.25 | 72 | 2.3 | 0.151 | 1.25 | 0.12 | 15.1 | 2.28 | 66.8 |
| 1.50 | 86 | 3.2 | 0.251 | 1.50 | 0.17 | 18.9 | 4.74 | 173.3 |
| 1.75 | 100 | 4.3 | 0.383 | 1.75 | 0.22 | 22.5 | 8.63 | 377.3 |
| 2.00 | 115 | 5.5 | 0.545 | 2.00 | 0.27 | 26.1 | 14.23 | 720.4 |
| 2.25 | 129 | 6.8 | 0.736 | 2.25 | 0.33 | 29.5 | 21.68 | 1239.3 |
| 2.50 | 143 | 8.2 | 0.951 | 2.50 | 0.38 | 32.6 | 30.97 | 1957.6 |
| 2.75 | 158 | 9.7 | 1.184 | 2.75 | 0.43 | 35.4 | 41.91 | 2877.6 |
| 3.00 | 172 | 11.2 | 1.429 | 3.00 | 0.48 | 37.9 | 54.12 | 3975.8 |
| 3.25 | 186 | 12.7 | 1.679 | 3.25 | 0.52 | 40.0 | 67.10 | 5202.7 |
| 3.50 | 201 | 14.1 | 1.925 | 3.50 | 0.55 | 41.7 | 80.24 | 6486.8 |
| 3.75 | 215 | 15.6 | 2.161 | 3.75 | 0.58 | 43.0 | 92.87 | 7744.2 |
| 4.00 | 229 | 17.0 | 2.378 | 4.00 | 0.59 | 43.9 | 104.39 | 8889.0 |
| 4.25 | 244 | 18.3 | 2.572 | 4.25 | 0.61 | 44.4 | 114.26 | 9845.7 |
| 4.50 | 258 | 19.5 | 2.739 | 4.50 | 0.61 | 44.6 | 122.09 | 10558.9 |
| 4.75 | 272 | 20.6 | 2.875 | 4.75 | 0.61 | 44.4 | 127.67 | 10999.6 |
| 5.00 | 286 | 21.6 | 2.979 | 5.00 | 0.60 | 44.0 | 130.96 | 11167.7 |
| 5.25 | 301 | 22.4 | 3.054 | 5.25 | 0.58 | 43.3 | 132.13 | 11089.2 |
| 5.50 | 315 | 23.1 | 3.103 | 5.50 | 0.56 | 42.4 | 131.49 | 10810.6 |
| 5.75 | 329 | 23.6 | 3.129 | 5.75 | 0.54 | 41.4 | 129.46 | 10391.5 |
| 6.00 | 344 | 23.9 | 3.140 | 6.00 | 0.52 | 40.3 | 126.55 | 9895.5 |
| 6.25 | 358 | 24.0 | 3.142 | 6.25 | 0.50 | 39.2 | 123.27 | 9384.1 |
| | | | | | | | | |
| 3.29 | 188 | 12.9 | 1.716 | 3.29 | 0.52 | 40.2 | 69.05 | 5391.2 |
| 3.84 | 220 | 16.1 | 2.237 | 3.84 | 0.58 | 43.3 | 96.97 | 8154.1 |

Written by: **A. Brewster** Date: **10/7/2022** Reviewed by: **S. Graves** Date: **10/21/2022**

Client: **WMTX** Project: **Lacy Lakeview RDF** Project No.: **GW8041** Phase No.: **05**

# Minimum Slope Calculation at Outlet Area
# Flow Through Circular Pipe

| | | |
|---|---|---|
| Diameter of pipe, D= | 24 | inches |
| Peak Discharge (existing perimeter), $Q_{25}$ = | 35 | cfs |
| Peak Discharge (expansion area), $Q_{25}$ = | 69 | cfs |
| Manning's n= | 0.012 | |
| Density of flowing liquid, rho= | 1.94 | slugs/ft^3 |

| Theta radians | Theta degrees | Depth of Flow y inches | Area of Flow A ft^2 | Wetted Perimeter P ft | Hydraulic Radius R ft | Average Velocity V ft/s | Discharge Q=A*V cfs | Force F lbf | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 6.25 | 358 | 24 | 3.142 | 6.25 | 0.50 | 11.0 | 35 | 743.6 | Existing Perimeter |
| 6.25 | 358 | 24 | 3.142 | 6.25 | 0.50 | 22.0 | 69 | 2942.2 | Proposed Perimeter |

| | | |
|---|---|---|
| Minimum Slope (existing perimeter), So= | 0.020 | ft/ft |
| Minimum Slope (expansion area), So= | 0.078 | ft/ft |

# Inlet Evaluation with Orifice Equation

$$Q = CA\sqrt{2gH}$$

| | | |
|---|---|---|
| Diameter of pipe, D= | 24 | inches |
| Peak Discharge (sideslope inlet), $Q_{25}$ = | 17 | cfs |
| Peak Discharge (top deck inlet), $Q_{25}$ = | 21 | cfs |
| Manning's n= | 0.012 | |
| Density of flowing liquid, rho= | 1.94 | slugs/ft^3 |

| Discharge Coefficient C | Area of Flow A ft^2 | Acceleration Due to Gravity g ($ft^2/s$) | Headwater Depth H ft | Notes |
|---|---|---|---|---|
| 0.60 | 3.14 | 32.17 | 2.21 | sideslope inlet |
| 0.60 | 3.14 | 32.17 | 2.60 | top deck inlet |