Run-on And Run-off Control System Plan
Jeffrey Energy Center
Flue Gas Desulfurization (FGD) Landfill

Prepared for:
Westar Energy
Jeffrey Energy Center
St. Marys, Kansas

Prepared by:
CB&I Environmental & Infrastructure, Inc.

October 2016
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<tr>
<td>§257.81(a)(1) stipulates:</td>
<td>Sections 4.3.1</td>
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<td>(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain: (1) A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm;</td>
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<td>§257.81(a)(2) stipulates:</td>
<td>Sections 4.3.2</td>
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<td>(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain: … (2) A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm.</td>
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<td>§257.81(b) stipulates:</td>
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<td>(b) Run-off from the active portion of the CCR unit must be handled in accordance with the surface water requirements under §257.3-3.</td>
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<tr>
<td>USEPA CCR Rule Criteria 40 CFR§257.81</td>
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<td>§257.81(c)(1) stipulates:</td>
<td>Section 5.1</td>
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<td>(c) Run-on and run-off control system plan—(1) Content of the plan. The owner or operator must prepare initial and periodic run-on and run-off control system plans for the CCR unit according to the timeframes specified in paragraphs (c)(3) and (4) of this section. These plans must document how the run-on and run-off control systems have been designed and constructed to meet the applicable requirements of this section. Each plan must be supported by appropriate engineering calculations. The owner or operator has completed the initial run-on and run-off control system plan when the plan has been placed in the facility's operating record as required by §257.105(g)(3).</td>
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<td>§257.81(c)(2) stipulates:</td>
<td>Sections 2.0 &amp; 5.3</td>
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<td>(2) Amendment of the plan. The owner or operator may amend the written run-on and run-off control system plan at any time provided the revised plan is placed in the facility's operating record as required by §257.105(g)(3). The owner or operator must amend the written run-on and run-off control system plan whenever there is a change in conditions that would substantially affect the written plan in effect.</td>
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| **USEPA CCR Rule Criteria**  
| 40 CFR§257.81 | **Jeffrey Energy Center (JEC)**  
| **Run-on and Run-off Control System Plan** |
| --- | --- |
| §257.81(c)(3) stipulates:  
(3) Timeframes for preparing the initial plan—(i) Existing CCR landfills. The owner or operator of the CCR unit must prepare the initial run-on and run-off control system plan no later than October 17, 2016. | Section 1.0 |
| §257.81(c)(4) stipulates:  
(4) Frequency for revising the plan. The owner or operator of the CCR unit must prepare periodic run-on and run-off control system plans required by paragraph (c)(1) of this section every five years. The date of completing the initial plan is the basis for establishing the deadline to complete the first subsequent plan. The owner or operator may complete any required plan prior to the required deadline provided the owner or operator places the completed plan into the facility’s operating record within a reasonable amount of time. In all cases, the deadline for completing a subsequent plan is based on the date of completing the previous plan. For purposes of this paragraph (c)(4), the owner or operator has completed a periodic run-on and run-off control system plan when the plan has been placed in the facility’s operating record as required by §257.105(g)(3). | Section 5.3 |
| §257.81(c)(5) stipulates:  
(5) The owner or operator must obtain a certification from a qualified professional engineer stating that the initial and periodic run-on and run-off control system plans meet the requirements of this section. | Section 6.0 |
<table>
<thead>
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<tr>
<td>§257.81(d) stipulates:</td>
<td>Sections 5.1 &amp; 5.2</td>
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<td><em>(d) The owner or operator of the CCR unit must comply with the recordkeeping requirements specified in §257.105(g), the notification requirements specified in §257.106(g), and the internet requirements specified in §257.107(g).</em></td>
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1.0 INTRODUCTION

CB&I Environmental and Infrastructure, Inc. (CB&I) has prepared the following Run-On and Run-Off Control System Plan (Plan) at the request of Westar Energy (Westar) for the Flue Gas Desulfurization (FGD) Landfill located at the Jeffrey Energy Center (JEC) in St. Marys, Kansas. JEC is a coal-fired and natural gas fired power plant that has been in operation since 1980. The FGD Landfill has been deemed to be a regulated coal combustion residual (CCR) unit by the United States Environmental Protection Agency (USEPA), through the Disposal of Coal Combustion Residuals from Electric Utilities Final Rule (CCR Rule) 40 CFR §257 and §261.

CCR regulations set forth within Title 40 Code of Federal Regulations (CFR) Part §257.81, provide guidelines for stormwater management controls (run-on and run-off controls) to ensure that regulated CCR units are designed to safely manage storm events up to the 25-year, 24-hour storm. Specifically, §257.81 stipulates:

§257.81: “(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain: (1) A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm; and (2) A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm.”

As demonstrated in this Plan, the stormwater run-on and run-off controls have been designed for the 25-year, 24-hour storm and are in compliance with 40 CFR Part §257.81. This document provides discussion of CB&I’s professional judgement/opinion regarding specific aspects of the Rule as they pertain to the FGD Landfill which has been deemed as a regulated CCR unit at Westar’s Jeffrey Energy Center. This Plan will be placed in the Facility Operating Record prior to October 17, 2016, per 40 CFR Part §257.81(c)(3).

2.0 REGULATORY OVERVIEW OF RUN-ON AND RUN-OFF CONTROL REQUIREMENTS

On April 17, 2015, the USEPA published the CCR Rule under Subtitle D of the Resource Conservation and Recovery Act (RCRA) as 40 CFR Parts §257 and §261. The purpose of the CCR Rule is to regulate the management of coal combustion residuals in regulated units for landfill and surface impoundments. The FGD Landfill has been deemed to be a regulated CCR unit at JEC.

This Plan marks the initial analysis of the facility run-on and run-off control features based on the permitted facility conditions. Construction activities may occur at the facility that will subsequently modify the current conditions as described within this Plan. This Plan will be amended in accordance with §257.81(c)(2), which stipulates:

§257.81(c)(2): “(c)(2)The owner or operator may amend the written run-on and run-off control system plan at any time provided the revised plan is placed in the facility’s operating record as required by §257.105(g)(3). The owner or operator must amend the written run-on and run-off control system plan whenever there is a change in conditions that would substantially affect the written plan in effect.”

This Plan will be amended to accurately analyze the run-on and run-off control features associated with the permitted facility conditions. Amendments to this Plan will be
3.0 JEC LANDFILL OVERVIEW

3.1 Site Location and Topography

Westar owns and operates the industrial landfills at JEC in St. Marys, Pottawatomie County, Kansas. JEC is located approximately 4.5 miles north of Belvue, Kansas and approximately 4.5 miles west of Highway 63 and resides in Sections 1, 2, 11, and 12, Township 9 South, Range 11 East and Sections 6 and 7, Township 9 South, Range 12 East. The location of the FGD Landfill is depicted in Figure 1.

The FGD Landfill is located due south of the Bottom Ash Pond. The FGD Landfill consists of four phases. Phases I through III extend laterally and Phase IV extends vertically on top of Phases I through III. Phase I is currently being filled and has an area of approximately 56.0 acres. Phase II and Phase III are not yet operational, and have an area of approximately 44.5 acres and 47.5 acres, respectively. Phase IV will be the landfilling required to achieve permitted final elevations.

The permitted FGD Landfill boundary currently consists of ravines which are being filled with flue gas desulfurization gypsum and stockpiles of FGD gypsum. The topography varies across the FGD Landfill between approximate elevation 1,173 - 1,291 ft. mean sea level (MSL). Once FGD disposal and final cover installation/closure is complete, the FGD Landfill will peak at an approximate elevation of 1358 ft. MSL. The top plateau of the landfill will have a 2% slope draining towards the landfill side slopes set at a 4H:1V slope. Existing and permitted site topography is depicted in Figure 2 and Figure 3, respectively.

Tower Hill Lake was developed in 1978 through the construction of the Tower Hill Dam. The lake was developed to provide make-up water for JEC processes, as well to manage all stormwater associated with the facility, including the FGD Landfill, in accordance with Industrial Landfill Permit No. 0359. Tower Hill Lake has been designed to accept all clean, non-contact stormwater and discharge off-site, in accordance with National Pollutant Discharge Elimination System (NPDES) Permit No. I-KS67-PO06 and 40 CFR Part §257.81(b). Tower Hill Lake is located northwest of the FGD Landfill as detailed on Figure 2.

3.2 Existing Regulatory Permits and Consents

Westar has been granted an Industrial Landfill Permit at JEC by the Kansas Department of Health and Environment – Bureau of Waste Management (KDHE-BWM) Permit No. 0359, in accordance with Kansas Statutes Annotated (K.S.A.) 65-3407. KDHE modified the solid waste permit, per K.A.R. 28-29-6a, in response to the CCR Rule to include CCR waste management units on-site as disposal areas to be covered by the existing solid waste permit. This Permit enables the site to continue safe disposal of the CCR generated on-site at JEC to be properly disposed of within the Industrial Landfill Permit boundary, including the FGD Landfill.
Westar has also been granted a Kansas Water Pollution Control Permit and Authorization to Discharge under the NPDES Permit No. I-KS67-PO06 from the KDHE-BWM. The NPDES Permit covers different outfall locations at JEC and allows the discharge of water into the Kansas River in accordance with effluent limitations and monitoring requirements. Non-contact stormwater within the Industrial Landfill Permit boundary discharges from the Tower Hill Lake system, which is covered under the NPDES Permit.

3.3 Stormwater Management System Overview

The existing stormwater management system includes a perimeter drainage channel which includes check dams, intermediate swales constructed along the facility boundary, and vegetated berm on the southwest and western area of the FGD Landfill as detailed on Figure 4. Stormwater run-on from the south that overland flows across the haul road will be conveyed around the active portions of the landfill via the perimeter drainage channels.

The FGD Landfill currently diverts non-contact stormwater run-on from the active Phase I of the FGD Landfill directly into Tower Hill Lake. Stormwater run-on and run-off from the proposed, not operational areas of, Phase II and III portions of the FGD Landfill currently flow to a natural pond that collects stormwater until it evaporates. Once FGD disposal and final cover installation/closure is complete, all non-contact stormwater run-off will flow into the perimeter drainage channels through overland flow or the terrace berm and letdown structure system. The perimeter drainage channels have been designed and constructed to convey stormwater run-on and run-off into Tower Hill Lake as detailed in Figure 5.

Tower Hill Lake and the Tower Hill Dam have been designed and constructed to manage non-contact stormwater run-on and run-off within a regional subcatchment that includes the Industrial Landfill Permit boundary, including the FGD Landfill, as well as adjacent areas outside of the Industrial Landfill Permit boundary. Direct precipitation and non-contact stormwater run-off the regional subcatchment flow to and are managed by Tower Hill Lake. The regional subcatchment that drains into Tower Hill Lake is depicted in Figure 6.

3.3.1 FGD Landfill Run-On

Stormwater controls are currently used to direct “uphill” or “upstream” stormwater from entering the operational areas of the FGD Landfill. Potential run-on stormwater comes from subcatchments (also called watersheds, or watershed areas) that are directly adjacent to the landfill boundary. A perimeter drainage channel has been constructed to direct non-contact stormwater run-on away from the active portions of the landfill in a controlled manner. A vegetated temporary perimeter berm structure has been constructed around active landfill along the southwestern and western perimeter of the landfill to provide an additional stormwater run-on control measures during the operational phase. Areas contributing to stormwater run-on into the perimeter drainage channel are depicted in Figure 5.

3.3.2 FGD Landfill Stormwater Management Controls

Stormwater management controls at the FGD Landfill will include stormwater features that will minimize stormwater flow onto active portions of the landfill and stormwater conveyance features that are designed to control stormwater flowing away from the landfill. Direct precipitation and stormwater run-off from the active portions of the FGD Landfill have historically been managed by a combination of intermediate and permanent drainage channels flowing to the Bottom Ash Pond adjacent to the site and FGD Pond within the site,
which ultimately flows to the Bottom Ash Pond as detailed in Figure 4. CCR solids are settled using containments and check dams within the Landfill. Treated water will then drain into Tower Hill Lake. As landfilling operations continue, intermediate drainage channels, terrace berms, and letdown structures will be utilized to direct non-contact stormwater run-off into the perimeter drainage channel. Terrace berms and letdown structures will be constructed as final landfill elevations are achieved. Once FGD landfilling has been completed, gentle landfill slopes will convey stormwater to terrace berms and letdown structures that will flow to the perimeter drainage channel and Tower Hill Lake.

3.3.3 FGD Landfill Stormwater Run-Off Location

Prior to final cover installation and closure, all non-contact stormwater from the FGD Landfill will flow into Tower Hill Lake via intermediate and permanent stormwater conveyance features. Contact water is managed using containments and check dams within the Landfill. Treated water will then drain into Tower Hill Lake. Tower Hill Lake eventually drains into a tributary of the Kansas River. The outfall location at Tower Hill Lake is monitored to ensure that effluent limits meet the standards set by the NPDES Permit No. I-KS67-PO06 and 40 CFR Part §257.81(b).

3.4 Stormwater Management Operations and Maintenance

3.4.1 Routine Operations and Maintenance

Westar is currently recycling a portion of the JEC FGD material, the continued demand may affect the projected infill and phasing for the unit. The FGD Landfill will be constructed in four phases, Phase I through IV. Phases I through III will extend laterally while Phase IV will extend vertically on top of Phases I through III to achieve final elevations. Initially, topsoil removal, minor grading, and deep ravine filling will be completed to prepare each development area to receive FGD gypsum. The FGD gypsum will be placed in a controlled manner, compacted, and graded. After Phases I through III have been completed according to current permits, Phase IV will be completed to permitted final grades. The final cover will be placed contemporaneously with the completion of each active landfilling area.

3.4.2 Previous Inspection review of Run-on / Run-off controls

Weekly (7-day) and annual inspections occur at the Landfill in line with inspection requirements outlined in 40 CFR §257.84. A review of the weekly inspection reports noted that in October 2015, a stormwater conveyance pipe was clogged with debris. This issue was resolved within a few weeks and has not reoccurred. There were no other erosion repairs required for the FGD Landfill.

A review of the annual inspection report conducted in October 2015 confirms that there were no significant slope failures or sloughing on the exterior landfill berms or outside slopes. Stormwater from the exterior berms and slopes are conveyed to perimeter stormwater channels and into Tower Hill Lake. Trees and other woody vegetation are continuously monitored and removed from the vegetated berms when necessary. It was concluded that the landfill procedures have not deviated from the facilities Operational Plan for the landfill and that the layout and grading processes for the FGD Landfill are consistent with the permitted construction drawings.
3.4.3 Corrective Actions and Documentation

A review of both the annual and weekly FGD Landfill inspection reports show that no corrective actions were necessary at the FGD Landfill.

4.0 HYDROLOGIC ANALYSES

4.1 Methodology Overview

In order to determine compliance with 40 CFR Part §257.81 regarding the management of stormwater run-on and run-off at the FGD Landfill, existing site topography, permitted final grades, and permitted stormwater drainage features were modeled using the computer model software HydroCAD. This computer model is used to develop discharge rates and volumes for the 25-year, 24-hour storm event for each stormwater control feature to be utilized at the FGD Landfill to manage stormwater run-on and run-off.

4.1.1 Landfill Run-on and Run-off Analysis

The purpose of the run-on and run-off analysis is to demonstrate that the run-on control system will safely convey stormwater around the permitted FGD Landfill boundary and that the run-off control system is designed to collect and control stormwater run-off from the 25-year, 24-hour storm event. The run-on and run-off analysis will determine stormwater peak discharge rates and volumes associated with the 25-year, 24-hour storm event for both run-on and run-off. The run-on and run-off analysis will demonstrate that all stormwater conveyance features such as the perimeter drainage channel, box culverts, and piping networks will not overtop. The run-on and run-off subcatchments for the FGD Landfill analysis are depicted in Figure 5.

4.1.2 Regional Run-off Analysis

Due to the fact that Tower Hill Lake was established to serve as the primary stormwater control for the entire JEC, a regional run-off analysis has been modeled to demonstrate that Tower Hill Lake is appropriately sized to accommodate the stormwater run-off associated with the 25-year, 24-hour storm event for all contributing areas, of which the FGD Landfill is a small proportion. The run-off analysis analyzes the peak discharge rate and volume from the regional watershed. The regional watershed is modeled to show that Tower Hill Lake has the available capacity to accept the stormwater run-off from the regional watershed. The regional watershed contributing to the overall stormwater flow into Tower Hill Lake is depicted in Figure 6.

4.1.3 Terrace Berm and Letdown Structure Analysis

After closure of the landfill is complete, the FGD Landfill has been designed to convey stormwater from the landfill side slopes to terrace berm structures. Terrace berms are designed to slow the discharge of stormwater and provide additional storage as it moves through the stormwater management system. The terrace berms convey stormwater directly into the perimeter drainage channels or to letdown structures that connect to these channels. During storm events, these features will decrease the peak discharge rates for each subcatchment on the landfill side slopes. For the purpose of the run-on and run-off model, it is assumed that the terrace berms and letdown structures are not part of the stormwater management system. This is conservative because each subcatchment will
yield a larger peak discharge than will be observed during the 25-year, 24-hour storm event.

A HydroCAD analysis was used to evaluate the capacity of the terrace berms and letdown structures. The purpose of the analysis was to determine if the terrace berm structures and letdown pipes were sized appropriately to convey the 25-year, 24-hour storm event without overtopping or backing up. The largest subcatchment was modeled to provide the highest potential peak discharge rate and volume that will flow into any terrace berm and letdown structure. The analysis of the terrace berms and letdown structures is provided in Appendix E.

4.2 Model Input Parameters

To ensure that all stormwater run-on and run-off control features comply with 40 CFR Part §257.81, all elements were computer modeled with numerous conservative assumptions. AutoCAD Civil3D 2014 (AutoCAD) was utilized to delineate key features and the computer model HydroCAD was used to develop discharge rates and volumes for the 25-year, 24-hour storm event to evaluate regulatory compliance with 40 CFR Part §257.81 at JEC. HydroCAD is a computer aided design program used to model hydrology and hydraulics of stormwater using either TR-20 or TR-55 procedures developed by the Soil Conservation Services (now the Natural Resource Conservation Service).

The stormwater modeling methodology used the following analysis methods, as further describe in subsequent text:

- **Runoff Calculation Method:** SCS TR-20
- **Reach Routing Method:** Dynamic Storage Indication plus Translation Method
- **Pond Routing Method:** Storage Indication Method (Modified-Puls)
- **Storm Distribution:** Rainfall Intensity Table for Kansas Counties - 1997
- **Unit Hydrograph:** SCS
- **Antecedent Moisture Condition:** 2

The Soil Conservation Service (SCS), now renamed the Natural Resources Conservation Service (NRCS) developed methods TR-20 and TR-55 as standardized stormwater modeling. Both provide similar results; the main differentiation in methodology is based on the use of chart-based solutions vs. computer modeling. TR-55, frequently called the “tabular method” was developed prior to the widespread use or computer modeling. As such it was developed to utilize chart based solutions to use the SCS runoff equation. TR-20 is a computer based modeling approach that is more complex and generally considered slightly more accurate than TR-55.

4.2.1 Rainfall Totals and Distributions

Rainfall intensities and distribution patterns for both analyses were determined using *Rainfall Intensity Tables for Kansas Counties - 1997*, developed for the Kansas Department of Transportation and authored by University of Kansas professor Bruce M. McEnroe. Rainfall depths for the modeled scenario was selected from this report and entered into HydroCAD. It is noted that TR-55 outlines that an NRCS Type II 24-hour storm distribution is appropriate within this region of Kansas. These distribution patterns may be selected from a drop-down list in HydroCAD. The rainfall totals and distributions table utilized in both analyses can be found in Appendix A.
4.2.2 Subcatchment Boundaries

Subcatchment areas (also known as watersheds) were delineated using AutoCAD based on topographic breaks within the areas to be analyzed. For the landfill run-on and run-off analysis, all areas contributing to stormwater run-on and run-off for the FGD Landfill are delineated and imported into HydroCAD. Subcatchment boundaries are depicted in Figure 5.

For the run-off analysis, the Industrial Landfill watershed was delineated using the United States Geological Survey (USGS) 7.5 minute topographic quadrangle for Emmett and Laclede, Kansas from 2015. Subcatchment boundaries are depicted in Figure 6.

4.2.3 Runoff Coefficient Variables

Curve numbers are used to identify the runoff characteristics of an area. Curve numbers consider both the land cover that will be encountered by surface water (such as grass, road, standing water, etc.) as well as the type of soil that underlies the land cover. The underlying soil is important because soil matrix has a large impact on whether water infiltrates the soil or is shed.

The SCS (NRCS) technical resource TR-55 provides lookup tables of curve numbers for combinations of various landcovers and the underlying surficial soils. As further described below, CB&I developed assumptions of surficial soil types and delineated various landcovers to develop a weighted average for each modeled subcatchment area. Using values specified in TR-55.

Surficial Soil Type

According to the KDHE-BWM Industrial Landfill Permit No. 0359 application (Permit application) for JEC, the site is covered with mostly silty clay loam as well as CCR material. The Permit application defines the surficial soil type as Hydrologic Soil Group D (HSG-D) based on the high run-off potential of both the native soils and CCR material. Surficial soil type within the HydroCAD model was conservatively assumed to be HSG-D in all areas within the Industrial Landfill Permit boundary and the regional subcatchment.

Land Covers

The land covers were determined based on a review of aerial photography and the topographic survey for the Industrial Landfill boundary.

For the landfill run-on and run-off analysis modelled worse case, restored conditions to final permitted elevations with the Bottom Ash Pond at full capacity stormwater run-on and run-off from grassland areas were conservatively assumed to be good grass cover. The TR-55 manual designates good grass cover as grassland with greater than 75% vegetative density. For the purpose of the model, all landfill subcatchments and run-on subcatchments were defined as good grass cover in accordance with the TR-55 manual. The proposed gravel haul roads along the east, south, and west borders of the FGD Landfill were conservatively defined as gravel surfaces. For the purpose of the run-on and run-off model, these areas were designated as gravel surfaces in accordance with the TR-55 manual.
For the Regional run-off analysis, land covers within the regional subcatchment were defined to accurately portray permitted facility conditions.

The Bottom Ash Pond that conveys stormwater to Tower Hill Lake was conservatively assumed to be at full capacity. This area was designated to have a land cover defined as “water surface” according to the TR-55 manual.

Based on permitted final conditions within the Industrial Landfill Permit boundary, all areas are defined to have good grass cover. The TR-55 manual designates good grass cover as grassland with greater than 75% vegetative density. For the purposes of the model, all landfill areas were defined as good grass cover in accordance with the TR-55 manual.

4.2.4 Time of Concentration

The time of concentration, defined as the longest amount of time a waterdrop would take to travel from the headwater of a subcatchment area to its downstream edge (i.e. prior to being managed by a downstream element) was delineated in AutoCAD and manually entered in HydroCAD.

For the Landfill run-on and run-off model, terrace berms and letdown structures were not included within the time of concentration flow path calculation. This approach is conservative because it allows for larger flows to be directed into the perimeter drainage channels, whereas terrace berms and letdown structures control the rate in which stormwater flows into the perimeter drainage ditch from the landfill side slopes. The following assumptions were made in the time of concentration calculations:

- For each watershed the time of concentration, \( T_c \), is the sum of the travel times, \( T_t \), of various consecutive flow segments. There are three types of flow: sheet flow, shallow concentrated flow, and open channel flow.

- Sheet flow is assumed to become shallow concentrated flow at 100 feet, which is conservative in comparison to 300 feet, but subsequent research has generally shown 100 feet to be more accurate.

- The Manning’s coefficient “n” for sheet flow was assumed to be 0.15, indicative of short-grass prairie vegetative cover. This number is appropriate for the grass covered run-on subcatchments and is the HydroCAD default.

- The Manning’s coefficient “n” for sheet flow on gravel surfaces was assumed to be 0.01, indicative of smooth surfaces. This number is appropriate for the run-on subcatchments that are graveled surfaces and is the HydroCAD default.

- An average flow velocity of 7 ft/sec was assumed in shallow concentrated flow calculations for the watershed, which is the HydroCAD default for “short grass pasture”, which is considered most indicative of the grass type that exists in these areas.

The time of concentration flow paths are depicted in Figure 5.

For the Regional run-off model, the following assumptions were made in the calculations:

- For each subcatchment the time of concentration, \( T_c \), is the sum of the travel times,
Sheet flow is assumed to become shallow concentrated flow at 100 feet. It is noted that TR-20 and TR-55 methods specify 300 feet, but subsequent research has generally shown 100 feet to be more accurate.

The Manning’s coefficient “n” for sheet flow was assumed to be 0.15, indicative of short-grass prairie vegetative cover. This number is appropriate for the grass covered run-on subcatchments and is the HydroCAD default.

An average flow velocity of 7 ft/sec was assumed in shallow concentrated flow calculations for the subcatchment, which is the HydroCAD default for “short grass pasture”, which is considered most indicative of the grass type that exists in these areas.

The Manning’s coefficient “n” for channel flow was assumed to be 0.03, indicative of natural steams that are clean and straight. This number is appropriate for the natural drainage channel that conveys stormwater into the Tower Hill Lake and is the HydroCAD default.

The time of concentration flow paths are depicted in Figure 6.

4.2.5 Stormwater Conveyance Features

Non-contact stormwater run-on and run-off for restored conditions is conveyed around the perimeter of the FGD Landfill and into Tower Hill Lake through the use of perimeter drainage channels, concrete box culverts, and drainage pipes. Dimensions and invert/outlet elevations for these structures were found within the KDHE-BWM Industrial Permit No. 0359 application drawing set. These features were manually imported into HydroCAD. Perimeter drainage channel sections, concrete box culverts, and drainage pipes are depicted in Figure 5.

4.2.6 Basin Elements

A transitional pond denoted West Pond on Figure 4, transfers non-contact stormwater from the west portion of the perimeter drainage channel to Tower Hill Lake was modeled to determine if the pond overtops the lowest berm elevation. The transitional pond was modeled by entering the area at each minor and major contour interval into HydroCAD to determine incremental detention volumes. Inlet and outlet channels were manually imported into HydroCAD to provide accurate stormwater volumes and flow velocities into and out of the transitional pond.

Tower Hill Lake was modeled by entering the area at each minor and major contour interval to determine incremental detention volumes. The volume of the normal water elevation was also specified. Tower Hill Lake was modeled as a closed system without an outlet structure. This model parameter will provide the total available capacity without any water leaving the basin, which is conservative for this system. Site topography for the Jeffrey Energy Center was provided by Professional Engineering Consultants (PEC), was utilized to determine the available capacity for Tower Hill Lake.

Both basin elements are depicted in Figure 4.
4.3 Model Findings

The HydroCAD results for the 25-year, 24-hour storm duration were analyzed to evaluate run-on and run-off controls at the FGD Landfill. Results of the Landfill run-on and run-off analysis indicate that the perimeter drainage channels used to prevent flow onto the active portion of the CCR unit during the peak discharge are sized appropriately for the 25-year, 24-hour storm event per 40 CFR Part §257.81.

A review of the stormwater conveyance features downstream of the perimeter drainage channels may be anticipated to overtop and erode due to stormwater volumes and flow velocities exceeding 5 ft/sec. Recommendations for modifications to specific stormwater conveyance features are detailed in the following sections to ensure compliance with 40 CFR Part §257.81.

Results of the terrace berm and letdown structure analysis indicate that these features have been sized to properly convey stormwater discharge rates and volumes associated with the 25-year, 24-hour storm event.

4.3.1 Landfill Run-on and Run-off Analysis (§257.81(a) & §257.81(b))

The run-on and run-off analysis for the FGD Landfill was completed to determine if the run-on control system complies with 40 CFR Part §257.81(a), which states,

“(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain: (1) A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm; (2) A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm.”

Results from this run-on and run-off hydrologic analysis can be found in Appendix C.

Peak run-on rates were determined using HydroCAD. Areas contributing to run-on for the FGD Landfill have a total discharge rate of 130.4 cfs. At the present time, run-on is collected within the south perimeter drainage channel. Based on the model findings, the south perimeter drainage channel properly conveys stormwater from the southern landfillside slopes and the contributing run-on areas without overtopping. It was also demonstrated that all perimeter drainage channel segments properly convey stormwater without overtopping.

The perimeter channel flow velocity has been reviewed to determine whether scour or erosion is anticipated to occur. Erosion or scour may be anticipated to occur at flow velocities exceeding 5 ft/sec for drainage channels lined with vegetation. Based on observed flow velocities, CB&I ultimately modeled the perimeter channel flow as a ditch lined with an erosion control material (such as rip-rap, concrete armor, or other appropriate erosion control measure). This modeling was selected by utilizing a Manning’s coefficient of 0.035, indicative of a rip-rap liner. It is recommended that regular inspections occur at the perimeter drainage channels to monitor and provide repairs to the erosion control material.

Based on a review of the model, the drainage pipe and downstream drainage channel in the northwest corner of the FGD Landfill have an approximate outlet flow velocity exceeding
25 ft/sec. CB&I recommends that an erosion control apron such as rip-rap or other appropriate erosion control measure be placed at the outlet structure of the drainage pipes in order to decrease the flow velocities and minimize erosion as stormwater leaves the pipes. The erosion control apron is not required to be installed until final closure of the FGD Landfill. The weekly (7-day) and annual inspections will identify if the erosion control apron is functioning properly to accommodate the associated flow velocities.

The Landfill run-on and run-off model indicate that the north box culvert is anticipated to overtop during the 25-year, 24-hour storm event when the site achieves final closure. It was determined that an additional box culvert with the same dimensions will properly convey the stormwater volume associated with the 25-year, 24-hour storm event. A HydroCAD model has been provided in Appendix D to demonstrate that the additional box culvert will provide the necessary capacity.

4.3.2 Regional Run-off Analysis (§257.81(a)(2) & (§257.81(b))

The run-off analysis for Tower Hill Lake was completed to determine if the run-off control system complies with 40 CFR Part §257.81(a)(2), which states,

“(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain: ...(2) A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm.”

Tower Hill Lake is designed to serve as the final stormwater run-off management system for the regional watershed including the FGD Landfill. Tower Hill Lake was analyzed to determine if it has been designed to collect and control stormwater run-off from the regional subcatchment for a 25-year, 24-hour storm event.

For the 25-year, 24-hour storm event within the regional subcatchment, it was determined that the subcatchment contributes 327.2 acre-feet of run-off into Tower Hill Lake.

Tower Hill Lake was modeled by entering the area at each minor and major contour interval to determine incremental detention volumes. The available stormwater capacity for the Tower Hill Lake is approximately 2,805 acre-feet. Based on the model, Tower Hill Lake will not overtop from the stormwater discharge volume of the regional subcatchment. It is also noted that a freeboard of 17 feet will be achieved after the discharge volume from the 25-year, 24-hour storm event flows into the Tower Hill Lake.

Results from the Regional run-off hydrologic analysis can be found in Appendix C.

4.3.3 Terrace Berm and Letdown Structure Analysis

The terrace berm and letdown structure model demonstrates that the terrace berm structures and letdown pipes are sized appropriately to convey the 25-year, 24-hour storm event without overtopping or backing up. The largest subcatchment was modeled to provide the highest potential peak discharge rate and volume that is anticipated to flow into any terrace berm and letdown structure. Based on model findings, the terrace berms and letdown structures at the FGD Landfill have been sized to properly convey stormwater associated with the 25-year, 24-hour storm event without overtopping or backing up.

Results from this analysis can be found in Appendix D.
4.4 Engineering Evaluation of Findings

4.4.1 Design Appropriateness Based on Model Findings

Landfill Run-on

The purpose of the run-on control system is to safely convey stormwater around the permitted FGD Landfill boundary. Based on model findings, the FGD Landfill perimeter drainage channel safely conveys stormwater run-on associated with the 25-year, 24-hour storm event away from the FGD Landfill.

Landfill Run-off

The purpose of the run-off control system is to collect and control stormwater volumes associated with the 25-year, 24-hour storm event. Based on model findings, an additional north box culvert is recommended to be constructed in order to safely convey stormwater volumes associated with the 25-year, 24-hour storm event at final closure. It is also recommended that an erosion control apron such as rip-rap or other appropriate erosion control measure be placed at the outlet structure of the northwest drainage pipes in order to decrease the flow velocities and minimize erosion as stormwater leaves the pipes at final closure. Additional model analyses demonstrate that the recommended modifications will comply with 40 CFR Part §257.81 at final closure.

Regional Run-off

Tower Hill Lake has been designed and constructed to manage stormwater from a regional subcatchment which includes FGD Landfill. Based on model findings, it was determined that Tower Hill Lake has the available capacity to accept the stormwater run-off from the regional subcatchment, including the FGD Landfill.

4.4.2 Operations and Maintenance Considerations

Weekly (7-day) and annual inspections of the landfill and stormwater conveyance structures are undertaken to ensure the structures will be clear from debris, identify repairs required for erosion, and monitor any erosion controls.

Operations and maintenance of the Tower Hill Lake basin are recommended to continue as completed previously.
5.0 RECORDS RETENTION AND MAINTENANCE

5.1 Incorporation of Plan into Operating Record

§257.105(g) of 40 CFR Part §257 provides record keeping requirements to ensure that this Plan will be placed in the facility’s operating record. Specifically, §257.105(g) stipulates:

§257.105(g): (g) Operating criteria. The owner or operator of a CCR unit subject to this subpart must place the following information, as it becomes available, in the facility’s operating record: (3) The initial and periodic run-on and run-off control system plans as required by §257.81(c).

This Report will be placed within the Facility Operating Record upon Westar’s review and approval.

5.2 Notification Requirements (§257.81(d))

§257.106(g) of 40 CFR Part §257 provides guidelines for the notification of the availability of the initial and periodic plan. Specifically, §257.106(g) stipulates:

§257.106(g): (g) Operating criteria. The owner or operator of a CCR unit subject to this subpart must notify the State Director and/or appropriate Tribal authority when information has been placed in the operating record and on the owner or operator’s publicly accessible internet site. The owner or operator must: (3) Provide notification of the availability of the initial and periodic run-on and run-off control system plans specified under §257.105(g)(3).

The State Director and appropriate Tribal Authority will be notified upon placement of this Plan in the Facility Operating Record.

§257.107(g) of 40 CFR Part §257 provides publicly accessible Internet site requirements to ensure that this Plan is accessible through the Westar Energy webpage. Specifically, §257.107(g) stipulates:

§257.107(g): (g) Operating criteria. The owner or operator of a CCR unit subject to this subpart must place the following information on the owner or operator’s CCR Web site: (3) The initial and periodic run-on and run-off control system plans specified under §257.105(g)(3).

This Plan will be uploaded to Westar Energy’s CCR Compliance reporting Web site upon Westar’s review and approval.
5.3 Plan Amendments §257.81(c)(3) & §257.81(c)(4))

This Plan has been completed in accordance with §257.81(c)(3) to provide an initial analysis of the run-on and run-off control systems. This Plan will continue to undergo review as the FGD Landfill continues phased construction activities.

This Run-on and Run-off Control System Plan will continue to undergo review as the FGD Landfill continues phased construction activities. Westar Energy is required to prepare periodic run-on and run-off control system plans every five (5) years, as required by §257.81(c)(4) of the Rule. The amended Plan will be reviewed and recertified by a registered professional engineer and will be placed in JEC’s facility operating record as required per §257.105(g)(3). The amended Plan will supersede and replace any prior versions. Availability of the amended Plan will be noticed to the State Director per §257.106(g)(3) and posted to the publicly accessible internet site per §257.107(g)(3).

A record of Plan reviews/assessments is provided on the first page of this document, immediately following the Table of Contents.
6.0 PROFESSIONAL ENGINEER CERTIFICATION (§257.81(c)(5))

The undersigned registered professional engineer is familiar with the requirements of the CCR Rule and has visited and examined the Jeffrey Energy Center or has supervised examination of the Jeffrey Energy Center by appropriately qualified personnel. The undersigned registered professional engineer attests that this CCR Run-on and Run-off Control System Plan has been prepared in accordance with good engineering practice, including consideration of applicable industry standards and meets the requirements of 40 CFR Part §257.81, and that this Plan is adequate for JEC facility. This certification was prepared as required by 40 CFR Part §257.81(c)(5).

Name of Professional Engineer: Richard Southorn

Company: CB&I

Signature:

Date: 10/4/16

PE Registration State: Kansas

PE Registration Number: PE25201

Professional Engineer Seal: [Image of professional engineer seal]
FIGURES

Figure 1 - FGD Landfill, Site Location Plan
Figure 2 - FGD Landfill, Existing Site Topography
Figure 3 - FGD Landfill, Permitted Final Landform
Figure 4 - FGD Landfill, Existing Site Stormwater Management Features
Figure 5 - FGD Landfill, Run-on / Run-off Subcatchments
Figure 6 - FGD Landfill, Regional Subcatchments
Figure 7 - FGD Landfill, Proposed Stormwater Features
1. AERIAL TOPO OBTAINED FROM USGS 7.5-MINUTE SERIES, EMMETT AND LACLEDE QUADRANGLE, KANSAS, 2014.

2. ALL BOUNDARIES ARE APPROXIMATE.
1. EXISTING CONTOURS DEVELOPED BY PROFESSIONAL ENGINEERING CONSULTANTS IN APRIL 2016.
2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.
3. CCR UNIT BOUNDARY IS APPROX. 148.0 ACRES.
4. ALL BOUNDARIES ARE APPROXIMATE.
1. Existing contours developed by professional engineering consultants in April 2016.
2. For clarity, not all site features may be shown.
3. Final grades were taken from KDHE-BWM industrial landfill permit no. 0359.
4. Phase I approx. area = 56.0 AC
5. Phase II approx. area = 44.5 AC
6. Phase III approx. area = 47.5 AC
7. Phase IV approx. area (Elev. 1209' MSL) = 84.0 AC
8. All boundaries are approximate.
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**LEGEND**

- **CCR UNIT BOUNDARY**
- **APPROXIMATE LOCATION OF EXISTING STORMWATER RUN-ON FEATURES**

**NOTES**

1. **EXISTING CONTOURS DEVELOPED BY PROFESSIONAL ENGINEERING CONSULTANTS IN APRIL 2016.**
2. **FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.**
3. **CCR UNIT BOUNDARY IS APPROX. 148.1 ACRES.**
4. **ALL BOUNDARIES ARE APPROXIMATE.**
1. EXISTING CONTOURS DEVELOPED BY PROFESSIONAL ENGINEERING CONSULTANTS IN APRIL 2016.
2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.
3. ALL BOUNDARIES ARE APPROXIMATE.
1. Figure adapted from USGS 7.5 minute topographic quadrangle from Emmett and Leclede, KS (2015).
2. For clarity, not all site features may be shown.
3. All boundaries are approximate.
1. EXISTING CONTOURS DEVELOPED BY PROFESSIONAL ENGINEERING CONSULTANTS IN APRIL 2016.

2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.

3. ALL BOUNDARIES AND PROPOSED STORMWATER FEATURE LOCATIONS ARE APPROXIMATE.
APPENDICES
APPENDIX A

Rainfall Intensity Tables for Kansas Counties
RAINFALL INTENSITY TABLES

FOR KANSAS COUNTIES

Developed for

Kansas Department of Transportation

by

Bruce M. McEnroe

Department of Civil and Environmental Engineering
University of Kansas
Lawrence, Kansas

June, 1997
### Rainfall Intensity Table

**Pottawatomie County, Kansas**

This table contains average rainfall intensities in inches per hour.

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RAINFALL INTENSITY TABLE
POTTAWATOMIE COUNTY KANSAS

THIS TABLE CONTAINS AVERAGE RAINFALL INTENSITIES
IN INCHES PER HOUR.

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## Rainfall Intensity Table

**Pottawatomie County, Kansas**

This table contains average rainfall intensities in inches per hour.

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<td>0.28</td>
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</table>
APPENDIX B

Run-on and Run-off HydroCAD Output Files
### Area Listing (all nodes)

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<th>Area (acres)</th>
<th>CN</th>
<th>Description</th>
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<tr>
<td>2.925</td>
<td>96</td>
<td>Gravel surface, HSG D (NR, WR)</td>
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</table>
Summary for Subcatchment NL1: North Landfill 1

Runoff = 237.75 cfs @ 12.12 hrs, Volume = 17.707 af, Depth = 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs
Type II 24-hr  25-yr, 24-hr Rainfall = 6.00"

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<th>Description</th>
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<td>Pervious Area</td>
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<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
</tr>
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<td></td>
<td></td>
<td></td>
<td>n = 0.150  P2 = 3.36&quot;</td>
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<td></td>
<td>Short Grass Pasture  Kv = 7.0 fps</td>
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<td></td>
<td>Total</td>
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</table>

Subcatchment NL1: North Landfill 1

Type II 24-hr  25-yr, 24-hr Rainfall = 6.00"
Runoff Area = 56.193 ac
Runoff Volume = 17.707 af
Runoff Depth = 3.78"
Flow Length = 1,253'
Tc = 19.5 min
CN = 80
Summary for Subcatchment NL2: North Landfill 2

Runoff = 102.28 cfs @ 12.10 hrs, Volume= 7.296 af, Depth= 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

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<table>
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<tr>
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<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
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Subcatchment NL2: North Landfill 2

Type II 24-hr 25-yr
24-hr Rainfall=6.00"
Runoff Area=23.155 ac
Runoff Volume=7.296 af
Runoff Depth=3.78"
Flow Length=908'
Tc=18.0 min
CN=80
Summary for Subcatchment NR: North Run-on

Runoff = 13.90 cfs @ 11.89 hrs, Volume = 0.672 af, Depth = 5.53"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

<table>
<thead>
<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.458</td>
<td>96</td>
<td>Gravel surface, HSG D</td>
</tr>
<tr>
<td>1.458</td>
<td>100.00%</td>
<td>Pervious Area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>35</td>
<td>0.2500</td>
<td>3.14</td>
<td></td>
<td>Sheet Flow, Smooth surfaces n = 0.011 P2 = 3.36&quot;</td>
</tr>
</tbody>
</table>

Subcatchment NR: North Run-on

Hydrograph

Type II 24-hr 25-yr
24-hr Rainfall=6.00"
Runoff Area=1.458 ac
Runoff Volume=0.672 af
Runoff Depth=5.53"
Flow Length=35'
Slope=0.2500 '/'
Tc=0.2 min
CN=96
Summary for Subcatchment SL1: South Landfill 1

Runoff = 157.54 cfs @ 12.10 hrs, Volume= 11.080 af, Depth= 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

<table>
<thead>
<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>35.163</td>
<td>80</td>
<td>&gt;75% Grass cover, Good, HSG D</td>
</tr>
<tr>
<td>35.163</td>
<td>100</td>
<td>100.00% Pervious Area</td>
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</table>

<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.6</td>
<td>100</td>
<td>0.0200</td>
<td>0.17</td>
<td></td>
<td>Sheet Flow, Grass: Short n= 0.150 P2= 3.36&quot;</td>
</tr>
<tr>
<td>6.0</td>
<td>355</td>
<td>0.0200</td>
<td>0.99</td>
<td></td>
<td>Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps</td>
</tr>
<tr>
<td>1.9</td>
<td>399</td>
<td>0.2500</td>
<td>3.50</td>
<td></td>
<td>Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps</td>
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</table>

17.5 854 Total

Subcatchment SL1: South Landfill 1

Hydrograph

Type II 24-hr 25-yr
24-hr Rainfall=6.00"
Runoff Area=35.163 ac
Runoff Volume=11.080 af
Runoff Depth=3.78"
Flow Length=854'
Tc=17.5 min
CN=80
Summary for Subcatchment SL2: South Landfill 2

Runoff = 100.01 cfs @ 12.02 hrs, Volume= 5.696 af, Depth= 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs

<table>
<thead>
<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>18.076</td>
<td>80</td>
<td>&gt;75% Grass cover, Good, HSG D</td>
</tr>
<tr>
<td>18.076</td>
<td>100.00%</td>
<td>Pervious Area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tc  (min)</th>
<th>Length  (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
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<tbody>
<tr>
<td>6.6</td>
<td>63</td>
<td>0.0200</td>
<td>0.16</td>
<td></td>
<td><strong>Sheet Flow,</strong> Grass: Short n= 0.150 P2= 3.36&quot;</td>
</tr>
<tr>
<td>1.6</td>
<td>37</td>
<td>0.2500</td>
<td>0.39</td>
<td></td>
<td><strong>Sheet Flow,</strong> Grass: Short n= 0.150 P2= 3.36&quot;</td>
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<tr>
<td>2.4</td>
<td>512</td>
<td>0.2500</td>
<td>3.50</td>
<td></td>
<td><strong>Shallow Concentrated Flow,</strong> Short Grass Paste</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>r Kv= 7.0 fps</td>
</tr>
</tbody>
</table>

10.6  612  Total

Subcatchment SL2: South Landfill 2

Hydrograph

Type II 24-hr 25-yr 24-hr Rainfall=6.00"

Runoff Area=18.076 ac
Runoff Volume=5.696 af
Runoff Depth=3.78"
Flow Length=612'
Tc=10.6 min
CN=80
**Summary for Subcatchment SR1: South Run-on 1**

Runoff = 53.07 cfs @ 12.02 hrs, Volume = 2.978 af, Depth = 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs

Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

<table>
<thead>
<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.452</td>
<td>80</td>
<td>&gt;75% Grass cover, Good, HSG D</td>
</tr>
<tr>
<td>9.452</td>
<td>100</td>
<td>100.00% Pervious Area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
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<tbody>
<tr>
<td>5.5</td>
<td>100</td>
<td>0.0800</td>
<td>0.30</td>
<td></td>
<td>Sheet Flow, Grass: Short n = 0.150 P2 = 3.36&quot;</td>
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<tr>
<td>4.7</td>
<td>554</td>
<td>0.0800</td>
<td>1.98</td>
<td></td>
<td>Shallow Concentrated Flow, Short Grass Pasture Kv = 7.0 fps</td>
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</tbody>
</table>

10.2 654 Total

**Subcatchment SR1: South Run-on 1**

Hydrograph

Type II 24-hr 25-yr
24-hr Rainfall=6.00"
Runoff Area=9.452 ac
Runoff Volume=2.978 af
Runoff Depth=3.78"
Flow Length=654'
Slope=0.0800 '/'
Tc=10.2 min
CN=80
**Summary for Subcatchment SR2: South Run-on 2**

Runoff = 77.33 cfs @ 12.07 hrs, Volume = 5.132 af, Depth = 3.78”

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs

Type II 24-hr 25-yr, 24-hr Rainfall = 6.00”

<table>
<thead>
<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>16.286</td>
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<td>&gt;75% Grass cover, Good, HSG D</td>
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<tr>
<td>16.286</td>
<td>100</td>
<td>100.00% Pervious Area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2</td>
<td>100</td>
<td>0.0400</td>
<td>0.23</td>
<td></td>
<td>Sheet Flow, Grass: Short n = 0.150 P2 = 3.36”</td>
</tr>
<tr>
<td>8.3</td>
<td>784</td>
<td>0.0500</td>
<td>1.57</td>
<td></td>
<td>Shallow Concentrated Flow, Short Grass Pasture Kv = 7.0 fps</td>
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</table>

15.5 884 Total

**Subcatchment SR2: South Run-on 2**

Hydrograph

- Type II 24-hr 25-yr
- 24-hr Rainfall = 6.00”
- Runoff Area = 16.286 ac
- Runoff Volume = 5.132 af
- Runoff Depth = 3.78”
- Flow Length = 884’
- Tc = 15.5 min
- CN = 80
Summary for Subcatchment WL1: West Landfill 1

Runoff = 83.79 cfs @ 12.03 hrs, Volume= 4.899 af, Depth= 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

<table>
<thead>
<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>15.548</td>
<td>80</td>
<td>&gt;75% Grass cover, Good, HSG D</td>
</tr>
<tr>
<td>15.548</td>
<td>100</td>
<td>Pervious Area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>7.1</td>
<td>69</td>
<td>0.0200</td>
<td>0.16</td>
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<td>Sheet Flow, Grass: Short n= 0.150 P2= 3.36&quot;</td>
</tr>
<tr>
<td>1.4</td>
<td>32</td>
<td>0.2500</td>
<td>0.38</td>
<td></td>
<td>Sheet Flow, Grass: Short n= 0.150 P2= 3.36&quot;</td>
</tr>
<tr>
<td>3.0</td>
<td>639</td>
<td>0.2500</td>
<td>3.50</td>
<td></td>
<td>Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps</td>
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</tbody>
</table>

11.5 740 Total

Subcatchment WL1: West Landfill 1

Type II 24-hr 25-yr
24-hr Rainfall=6.00"
Runoff Area=15.548 ac
Runoff Volume=4.899 af
Runoff Depth=3.78"
Flow Length=740'
Tc=11.5 min
CN=80
FGD Landfill run-on
Prepared by Chicago Bridge and Iron Company
Printed 6/23/2016
HydroCAD® 10.00-15 s/n 04891 © 2015 HydroCAD Software Solutions LLC

Summary for Subcatchment WR: West Run-on

Runoff = 13.98 cfs @ 11.89 hrs, Volume= 0.676 af, Depth= 5.53"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr  25-yr, 24-hr Rainfall=6.00"

<table>
<thead>
<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.467</td>
<td>96</td>
<td>Gravel surface, HSG D</td>
</tr>
<tr>
<td>1.467</td>
<td>100.00%</td>
<td>Pervious Area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>35</td>
<td>0.2500</td>
<td>3.14</td>
<td></td>
<td>Sheet Flow, Smooth surfaces</td>
</tr>
</tbody>
</table>

n= 0.011  P2= 3.36"

Subcatchment WR: West Run-on

Hydrograph

Type II 24-hr
25-yr
24-hr Rainfall=6.00"
Runoff Area=1.467 ac
Runoff Volume=0.676 af
Runoff Depth=5.53"
Flow Length=35'
Slope=0.2500 '/'
Tc=0.2 min
CN=96
Summary for Reach N1: North Channel 1

Inflow Area = 24.613 ac, 0.00% Impervious, Inflow Depth = 3.88" for 25-yr, 24-hr event
Inflow = 103.84 cfs @ 12.10 hrs, Volume= 7.968 af
Outflow = 95.06 cfs @ 12.24 hrs, Volume= 7.968 af, Atten= 8%, Lag= 8.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.28 fps, Min. Travel Time= 5.1 min
Avg. Velocity = 1.71 fps, Avg. Travel Time= 21.9 min

Peak Storage= 29,609 cf @ 12.16 hrs
Average Depth at Peak Storage= 1.32'
Bank-Full Depth= 3.00' Flow Area= 45.0 sf, Capacity= 513.75 cfs

6.00' x 3.00' deep channel, n= 0.035
Side Slope Z-value= 3.0 '/' Top Width= 24.00'
Length= 2,244.0'  Slope= 0.0330 '/'
Inlet Invert= 1,274.00', Outlet Invert= 1,200.00'

Reach N1: North Channel 1

Inflow Area=24.613 ac
Avg. Flow Depth=1.32'
Max Vel=7.28 fps
n=0.035
L=2,244.0'
S=0.0330 '/'
Capacity=513.75 cfs
Summary for Reach NBC: North Box Culvert

Inflow Area = 24.613 ac, 0.00% Impervious, Inflow Depth = 3.88" for 25-yr, 24-hr event
Inflow = 95.06 cfs @ 12.24 hrs, Volume= 7.968 af
Outflow = 65.37 cfs @ 12.10 hrs, Volume= 7.968 af, Atten= 31%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 11.82 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.76 fps, Avg. Travel Time= 0.2 min

Peak Storage= 234 cf @ 12.15 hrs
Average Depth at Peak Storage= 1.50'
Bank-Full Depth= 1.50' Flow Area= 6.0 sf, Capacity= 54.11 cfs

48.0" W x 18.0" H Box Pipe
n= 0.011 Concrete pipe, straight & clean
Length= 39.0' Slope= 0.0100 '/'
Inlet Invert= 1,200.00', Outlet Invert= 1,199.61'

Reach NBC: North Box Culvert

Inflow Area=24.613 ac
Avg. Flow Depth=1.50'
Max Vel=11.82 fps
48.0" x 18.0" Box Pipe
n=0.011
L=39.0'
S=0.0100 '/'
Capacity=54.11 cfs
Summary for Reach S1: South Channel 1

Inflow Area = 44.615 ac, 0.00% Impervious, Inflow Depth = 3.78" for 25-yr, 24-hr event
Inflow = 200.23 cfs @ 12.07 hrs, Volume= 14.058 af
Outflow = 180.12 cfs @ 12.22 hrs, Volume= 14.058 af, Atten= 10%, Lag= 9.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.49 fps, Min. Travel Time= 5.4 min
Avg. Velocity = 2.01 fps, Avg. Travel Time= 20.2 min

Peak Storage= 58,825 cf @ 12.13 hrs
Average Depth at Peak Storage= 1.80'
Bank-Full Depth= 6.00' Flow Area= 156.0 sf, Capacity= 2,283.11 cfs

8.00' x 6.00' deep channel, n= 0.035
Side Slope Z-value= 3.0 '/' Top Width= 44.00'
Length= 2,435.0' Slope= 0.0233 '/'
Inlet Invert= 1,287.00', Outlet Invert= 1,230.30'

Reach S1: South Channel 1

Hydrograph

Inflow Area=44.615 ac
Avg. Flow Depth=1.80'
Max Vel=7.49 fps
n=0.035
L=2,435.0'
S=0.0233 '/'
Capacity=2,283.11 cfs
Summary for Reach S2: South Channel 2

Inflow Area = 78.977 ac, 0.00% Impervious, Inflow Depth = 3.78” for 25-yr, 24-hr event
Inflow = 272.60 cfs @ 12.11 hrs, Volume= 24.886 af
Outflow = 262.07 cfs @ 12.26 hrs, Volume= 24.886 af, Atten= 4%, Lag= 8.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.63 fps, Min. Travel Time= 4.5 min
Avg. Velocity = 1.55 fps, Avg. Travel Time= 16.3 min

Peak Storage= 70,870 cf @ 12.18 hrs
Average Depth at Peak Storage= 2.83'
Bank-Full Depth= 6.00' Flow Area= 156.0 sf, Capacity= 1,338.23 cfs

8.00' x 6.00' deep channel, n= 0.035
Side Slope Z-value= 3.0 '/' Top Width= 44.00'
Length= 1,515.0' Slope= 0.0080 '/'
Inlet Invert= 1,229.46', Outlet Invert= 1,217.34'

Inflow Area=78.977 ac
Avg. Flow Depth=2.83'
Max Vel=5.63 fps
n=0.035
L=1,515.0'
S=0.0080 '/'
Capacity=1,338.23 cfs
Summary for Reach SBC: South Box Culvert

Inflow Area = 44.615 ac, 0.00% Impervious, Inflow Depth = 3.78" for 25-yr, 24-hr event
Inflow = 180.12 cfs @ 12.22 hrs, Volume = 14.058 af
Outflow = 179.10 cfs @ 12.23 hrs, Volume = 14.058 af, Atten = 1%, Lag = 0.3 min

Routing by Stor-Ind+Trans method, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs
Max. Velocity = 12.29 fps, Min. Travel Time = 0.2 min
Avg. Velocity = 2.86 fps, Avg. Travel Time = 0.8 min

Peak Storage = 1,985 cf @ 12.22 hrs
Average Depth at Peak Storage = 1.82'
Bank-Full Depth = 4.00' Flow Area = 32.0 sf, Capacity = 411.57 cfs

96.0" W x 48.0" H Box Pipe
n = 0.011 Concrete pipe, straight & clean
Length = 136.0' Slope = 0.0062 '/'
Inlet Invert = 1,230.30', Outlet Invert = 1,229.46'

Reach SBC: South Box Culvert

Hydrograph

Inflow Area = 44.615 ac
Avg. Flow Depth = 1.82'
Max Vel = 12.29 fps
96.0" x 48.0"
Box Pipe
n = 0.011
L = 136.0'
S = 0.0062 '/'
Capacity = 411.57 cfs
Summary for Reach W1: West Channel 1

Inflow Area = 95.992 ac, 0.00% Impervious, Inflow Depth = 3.81" for 25-yr, 24-hr event
Inflow = 287.03 cfs @ 12.23 hrs, Volume= 30.461 af
Outflow = 284.20 cfs @ 12.32 hrs, Volume= 30.461 af, Atten= 1%, Lag= 5.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.88 fps, Min. Travel Time= 3.1 min
Avg. Velocity = 1.91 fps, Avg. Travel Time= 12.9 min

Peak Storage= 53,065 cf @ 12.27 hrs
Average Depth at Peak Storage= 2.38'
Bank-Full Depth= 4.00' Flow Area= 80.0 sf, Capacity= 840.32 cfs

8.00' x 4.00' deep channel, n= 0.035
Side Slope Z-value= 3.0 '/' Top Width= 32.00'
Length= 1,472.0' Slope= 0.0190 '/'
Inlet Invert= 1,220.00', Outlet Invert= 1,192.00'

Reach W1: West Channel 1

Hydrograph

Inflow Area=95.992 ac
Avg. Flow Depth=2.38'
Max Vel=7.88 fps
n=0.035
L=1,472.0'
S=0.0190 '/'
Capacity=840.32 cfs
Summary for Reach W2: West Channel 2

Inflow Area = 95.992 ac, 0.00% Impervious, Inflow Depth = 3.81" for 25-yr, 24-hr event
Inflow = 284.17 cfs @ 12.32 hrs, Volume= 30.461 af
Outflow = 283.35 cfs @ 12.33 hrs, Volume= 30.461 af, Atten= 0%, Lag= 0.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 10.43 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 2.40 fps, Avg. Travel Time= 2.2 min

Peak Storage= 8,437 cf @ 12.32 hrs
Average Depth at Peak Storage= 1.62'
Bank-Full Depth= 4.00' Flow Area= 96.0 sf, Capacity= 1,644.11 cfs

12.00' x 4.00' deep channel, n= 0.035
Side Slope Z-value= 3.0 '/' Top Width= 36.00'
Length= 310.0' Slope= 0.0461 '/'
Inlet Invert= 1,182.30', Outlet Invert= 1,168.00'

Reach W2: West Channel 2

Hydrograph

Inflow Area=95.992 ac
Avg. Flow Depth=1.62'
Max Vel=10.43 fps
n=0.035
L=310.0'
S=0.0461 '/'
Capacity=1,644.11 cfs
Summary for Reach WP1: West Pipe 1

Inflow Area = 95.992 ac, 0.00% Impervious, Inflow Depth = 3.81" for 25-yr, 24-hr event
Inflow = 284.20 cfs @ 12.32 hrs, Volume= 30.461 af
Outflow = 284.17 cfs @ 12.32 hrs, Volume= 30.461 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 26.81 fps, Min. Travel Time= 0.0 min
Avg. Velocity = 7.08 fps, Avg. Travel Time= 0.1 min

Peak Storage= 403 cf @ 12.32 hrs
Average Depth at Peak Storage= 1.50'
Bank-Full Depth= 3.00' Flow Area= 21.2 sf, Capacity= 568.99 cfs

A factor of 3.00 has been applied to the storage and discharge capacity
36.0" Round Pipe
n= 0.011 Concrete pipe, straight & clean
Length= 38.0' Slope= 0.0579 '/'
Inlet Invert= 1,184.50', Outlet Invert= 1,182.30'

Reach WP1: West Pipe 1

Hydrograph

Inflow Area=95.992 ac
Avg. Flow Depth=1.50'
Max Vel=26.81 fps
36.0"
Round Pipe x 3.00
n=0.011
L=38.0'
S=0.0579 '/'
Capacity=568.99 cfs
Summary for Pond P1: West Pond

Inflow Area = 95.992 ac, 0.00% Impervious, Inflow Depth = 3.81" for 25-yr, 24-hr event
Inflow = 283.35 cfs @ 12.33 hrs, Volume= 30.461 af
Outflow = 193.69 cfs @ 12.59 hrs, Volume= 28.222 af, Atten= 32%, Lag= 15.1 min
Primary = 193.69 cfs @ 12.59 hrs, Volume= 28.222 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 1,168.38' @ 12.59 hrs   Surf.Area= 136,196 sf   Storage= 391,673 cf

Plug-Flow detention time= 100.0 min calculated for 28.222 af (93% of inflow)
Center-of-Mass det. time= 58.4 min ( 904.3 - 845.8 )

Volume Invert Avail.Storage Storage Description
#1 1,161.00' 635,015 cf Custom Stage Data (Prismatic) Listed below (Recalc)

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<tbody>
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<td>0</td>
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<tr>
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<td>1,421</td>
<td>711</td>
<td>711</td>
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<tr>
<td>1,163.00</td>
<td>2,910</td>
<td>2,166</td>
<td>2,876</td>
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<td>1,164.00</td>
<td>5,545</td>
<td>4,228</td>
<td>7,104</td>
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<td>1,165.00</td>
<td>30,760</td>
<td>18,153</td>
<td>25,256</td>
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<td>1,166.00</td>
<td>113,772</td>
<td>72,266</td>
<td>97,522</td>
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<td>1,168.00</td>
<td>129,318</td>
<td>243,090</td>
<td>340,612</td>
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<td>1,170.00</td>
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<td>294,403</td>
<td>635,015</td>
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Device Routing Invert Outlet Devices
#1 Primary 1,166.00' 20.0' long x 267.0' breadth Broad-Crested Rectangular Weir
Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=193.27 cfs @ 12.59 hrs   HW=1,168.38' (Free Discharge)

1=Broad-Crested Rectangular Weir (Weir Controls 193.27 cfs @ 4.06 fps)
Pond P1: West Pond

Inflow Area=95.992 ac
Peak Elev=1,168.38'
Storage=391,673 cf

Hydrograph

Flow (cfs)

Time (hours)
Summary for Pond THL: Tower Hill Lake

Inflow Area = 176.798 ac, 0.00% Impervious, Inflow Depth = 3.66" for 25-yr, 24-hr event
Inflow = 336.60 cfs @ 12.14 hrs, Volume = 53.896 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume = 0.000 af, Atten = 100%, Lag = 0.0 min

Routing by Stor-Ind method, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs
Peak Elev = 1,146.46' @ 48.00 hrs  Surf.Area = 5,161,549 sf  Storage = 2,347,219 cf

Plug-Flow detention time = (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time = (not calculated: no outflow)

<table>
<thead>
<tr>
<th>Volume</th>
<th>Invert</th>
<th>Avail.Storage</th>
<th>Storage Description</th>
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</thead>
<tbody>
<tr>
<td>#1</td>
<td>1,146.00'</td>
<td>122,166,852 cf</td>
<td><strong>Custom Stage Data (Prismatic)</strong> Listed below (Recalc)</td>
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<tbody>
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<td>0</td>
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<td>1,148.00</td>
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<td>1,156.00</td>
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<td>11,924,811</td>
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<td>1,166.00</td>
<td>7,276,829</td>
<td>14,252,789</td>
<td>122,166,852</td>
</tr>
</tbody>
</table>
Pond THL: Tower Hill Lake

Hydrograph

Inflow Area=176.798 ac
Peak Elev=1,146.46'
Storage=2,347,219 cf
APPENDIX C

Run-on and Run-off with Box Culvert HydroCAD Output Files
<table>
<thead>
<tr>
<th>Area</th>
<th>CN</th>
<th>Description</th>
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<tbody>
<tr>
<td>173.873</td>
<td>80</td>
<td>&gt;75% Grass cover, Good, HSG D (NL1, NL2, SL1, SL2, SR1, SR2, WL1)</td>
</tr>
<tr>
<td>2.925</td>
<td>96</td>
<td>Gravel surface, HSG D (NR, WR)</td>
</tr>
</tbody>
</table>
Summary for Subcatchment NL1: North Landfill 1

Runoff = 237.75 cfs @ 12.12 hrs, Volume= 17.707 af, Depth= 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

<table>
<thead>
<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>56.193</td>
<td>80</td>
<td>&gt;75% Grass cover, Good, HSG D</td>
</tr>
<tr>
<td>56.193</td>
<td>100.00%</td>
<td>Pervious Area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.6</td>
<td>100</td>
<td>0.0200</td>
<td>0.17</td>
<td></td>
<td>Sheet Flow, Grass: Short n= 0.150 P2= 3.36&quot;</td>
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<tr>
<td>6.1</td>
<td>362</td>
<td>0.0200</td>
<td>0.99</td>
<td></td>
<td>Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps</td>
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<tr>
<td>3.8</td>
<td>791</td>
<td>0.2500</td>
<td>3.50</td>
<td></td>
<td>Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps</td>
</tr>
</tbody>
</table>

19.5 1,253 Total

Subcatchment NL1: North Landfill 1

Hydrograph

Type II 24-hr 25-yr
24-hr Rainfall=6.00"
Runoff Area=56.193 ac
Runoff Volume=17.707 af
Runoff Depth=3.78"
Flow Length=1,253'
Tc=19.5 min
CN=80
Summary for Subcatchment NL2: North Landfill 2

Runoff = 102.28 cfs @ 12.10 hrs, Volume= 7.296 af, Depth= 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

<table>
<thead>
<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>23.155</td>
<td>80</td>
<td>&gt;75% Grass cover, Good, HSG D</td>
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<tr>
<td>23.155</td>
<td>100</td>
<td>100.00% Pervious Area</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.6</td>
<td>100</td>
<td>0.0200</td>
<td>0.17</td>
<td></td>
<td>Sheet Flow, Grass: Short n= 0.150 P2= 3.36&quot;</td>
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<tr>
<td>6.4</td>
<td>382</td>
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<td>0.99</td>
<td></td>
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<tr>
<td>2.0</td>
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<td>3.50</td>
<td></td>
<td>Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps</td>
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</table>

18.0 908 Total

Subcatchment NL2: North Landfill 2

Hydrograph

Type II 24-hr 25-yr
24-hr Rainfall=6.00"
Runoff Area=23.155 ac
Runoff Volume=7.296 af
Runoff Depth=3.78"
Flow Length=908'
Tc=18.0 min
CN=80
Summary for Subcatchment NR: North Run-on

Runoff = 13.90 cfs @ 11.89 hrs, Volume = 0.672 af, Depth = 5.53"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

<table>
<thead>
<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.458</td>
<td>96</td>
<td>Gravel surface, HSG D</td>
</tr>
<tr>
<td>1.458</td>
<td>100.00%</td>
<td>Pervious Area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
</tr>
</thead>
</table>
| 0.2      | 35            | 0.2500        | 3.14              |                | Sheet Flow, Smooth surfaces n = 0.011 P2 = 3.36"

Subcatchment NR: North Run-on

Hydrograph

Type II 24-hr 25-yr
24-hr Rainfall=6.00"
Runoff Area=1.458 ac
Runoff Volume=0.672 af
Runoff Depth=5.53"
Flow Length=35'
Slope=0.2500 '/'
Tc=0.2 min
CN=96
Summary for Subcatchment SL1: South Landfill 1

Runoff = 157.54 cfs @ 12.10 hrs, Volume= 11.080 af, Depth= 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

<table>
<thead>
<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
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<tbody>
<tr>
<td>35.163</td>
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<td>&gt;75% Grass cover, Good, HSG D</td>
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<td>35.163</td>
<td>100.00%</td>
<td>Pervious Area</td>
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</table>

<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.6</td>
<td>100</td>
<td>0.0200</td>
<td>0.17</td>
<td></td>
<td><strong>Sheet Flow,</strong> Grass: Short   n= 0.150   P2= 3.36&quot;</td>
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<tr>
<td>6.0</td>
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<td>0.99</td>
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<td><strong>Shallow Concentrated Flow,</strong> Short Grass Pasture  Kv= 7.0 fps</td>
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<tr>
<td>1.9</td>
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<td><strong>Shallow Concentrated Flow,</strong> Short Grass Pasture  Kv= 7.0 fps</td>
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</tbody>
</table>

17.5 854 Total

Subcatchment SL1: South Landfill 1

Hydrograph

Type II 24-hr 25-yr
24-hr Rainfall=6.00"
Runoff Area=35.163 ac
Runoff Volume=11.080 af
Runoff Depth=3.78"
Flow Length=854'
Tc=17.5 min
CN=80
Summary for Subcatchment SL2: South Landfill 2

Runoff = 100.01 cfs @ 12.02 hrs, Volume= 5.696 af, Depth= 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

<table>
<thead>
<tr>
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<th>CN</th>
<th>Description</th>
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<tbody>
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<tr>
<td>18.076</td>
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<table>
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<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
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<th>Description</th>
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<tr>
<td>2.4</td>
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<td>0.2500</td>
<td>3.50</td>
<td></td>
<td>Shallow Concentrated Flow, Short Grass Pasture  Kv= 7.0 fps</td>
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</table>

Subcatchment SL2: South Landfill 2

Hydrograph

Type II 24-hr
25-yr
24-hr Rainfall=6.00"
Runoff Area=18.076 ac
Runoff Volume=5.696 af
Runoff Depth=3.78"
Flow Length=612'
Tc=10.6 min
CN=80
Summary for Subcatchment SR1: South Run-on 1

Runoff = 53.07 cfs @ 12.02 hrs, Volume= 2.978 af, Depth= 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

<table>
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<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
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<tr>
<td>9.452</td>
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<td>Pervious Area</td>
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</table>

<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
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</table>

10.2 654 Total

Subcatchment SR1: South Run-on 1

Hydrograph

Type II 24-hr 25-yr
24-hr Rainfall=6.00"
Runoff Area=9.452 ac
Runoff Volume=2.978 af
Runoff Depth=3.78"
Flow Length=654'
Slope=0.0800 '/'
Tc=10.2 min
CN=80
Summary for Subcatchment SR2: South Run-on 2

Runoff = 77.33 cfs @ 12.07 hrs, Volume= 5.132 af, Depth= 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

<table>
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<th>Description</th>
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<tr>
<td>16.286</td>
<td>100</td>
<td>100.00% Pervious Area</td>
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<table>
<thead>
<tr>
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<th>Length</th>
<th>Slope</th>
<th>Velocity</th>
<th>Capacity</th>
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<td>1.57</td>
<td></td>
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15.5  884  Total

Subcatchment SR2: South Run-on 2

Hydrograph

Type II 24-hr 25-yr
24-hr Rainfall=6.00"
Runoff Area=16.286 ac
Runoff Volume=5.132 af
Runoff Depth=3.78"
Flow Length=884'
Tc=15.5 min
CN=80
Summary for Subcatchment WL1: West Landfill 1

Runoff = 83.79 cfs @ 12.03 hrs, Volume= 4.899 af, Depth= 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

<table>
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<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
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<tr>
<td>15.548</td>
<td>100.00% Pervious Area</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
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<td>3.50</td>
<td></td>
<td>Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps</td>
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</table>

11.5 740 Total

Subcatchment WL1: West Landfill 1

Hydrograph

Type II 24-hr 25-yr 24-hr Rainfall=6.00"
Runoff Area=15.548 ac
Runoff Volume=4.899 af
Runoff Depth=3.78"
Flow Length=740'
Tc=11.5 min
CN=80
Summary for Subcatchment WR: West Run-on

Runoff  =  13.98 cfs @ 11.89 hrs, Volume= 0.676 af, Depth= 5.53"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr  25-yr, 24-hr Rainfall=6.00"

<table>
<thead>
<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>1.467</td>
<td>96</td>
<td>Gravel surface, HSG D</td>
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<tr>
<td>1.467</td>
<td>100.00%</td>
<td>Pervious Area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tc</th>
<th>Length</th>
<th>Slope</th>
<th>Velocity</th>
<th>Capacity</th>
<th>Description</th>
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<td>0.2</td>
<td>35</td>
<td>0.2500</td>
<td>3.14</td>
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<td>Sheet Flow, Smooth surfaces n= 0.011 P2= 3.36&quot;</td>
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</table>

Subcatchment WR: West Run-on

Flow Length=35'
Slope=0.2500 '/'
Tc=0.2 min
CN=96
Summary for Reach N1: North Channel 1

Inflow Area = 24.613 ac, 0.00% Impervious, Inflow Depth = 3.88" for 25-yr, 24-hr event
Inflow = 103.84 cfs @ 12.10 hrs, Volume= 7.968 af
Outflow = 95.06 cfs @ 12.24 hrs, Volume= 7.968 af, Atten= 8%, Lag= 8.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.28 fps, Min. Travel Time= 5.1 min
Avg. Velocity = 1.71 fps, Avg. Travel Time= 21.9 min

Peak Storage= 29,609 cf @ 12.16 hrs
Average Depth at Peak Storage= 1.32'
Bank-Full Depth= 3.00' Flow Area= 45.0 sf, Capacity= 513.75 cfs

6.00' x 3.00' deep channel, n= 0.035
Side Slope Z-value= 3.0 '/' Top Width= 24.00'
Length= 2,244.0' Slope= 0.0330 '/'
Inlet Invert= 1,274.00', Outlet Invert= 1,200.00'

Reach N1: North Channel 1

Inflow Area=24.613 ac
Avg. Flow Depth=1.32'
Max Vel=7.28 fps
n=0.035
L=2,244.0'
S=0.0330 '/'
Capacity=513.75 cfs
Summary for Reach NBC: North Box Culvert

Inflow Area = 24.613 ac, 0.00% Impervious, Inflow Depth = 3.88" for 25-yr, 24-hr event
Inflow = 95.06 cfs @ 12.24 hrs, Volume= 7.968 af
Outflow = 94.98 cfs @ 12.25 hrs, Volume= 7.968 af, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 10.76 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.21 fps, Avg. Travel Time= 0.3 min

Peak Storage= 344 cf @ 12.25 hrs
Average Depth at Peak Storage= 1.10'
Bank-Full Depth= 1.50' Flow Area= 12.0 sf, Capacity= 108.22 cfs

A factor of 2.00 has been applied to the storage and discharge capacity
48.0" W x 18.0" H Box Pipe
n= 0.011 Concrete pipe, straight & clean
Length= 39.0' Slope= 0.0100 '/'
Inlet Invert= 1,200.00', Outlet Invert= 1,199.61'

Reach NBC: North Box Culvert

Hydrograph

- Inflow Area=24.613 ac
- Avg. Flow Depth=1.10'
- Max Vel=10.76 fps
- 48.0" x 18.0" Box Pipe x 2.00
- n=0.011
- L=39.0'
- S=0.0100 '/'
- Capacity=108.22 cfs
Summary for Reach S1: South Channel 1

Inflow Area = 44.615 ac, 0.00% Impervious, Inflow Depth = 3.78" for 25-yr, 24-hr event
Inflow = 200.23 cfs @ 12.07 hrs, Volume= 14.058 af
Outflow = 180.12 cfs @ 12.22 hrs, Volume= 14.058 af, Attenuation= 10%, Lag= 9.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.49 fps, Min. Travel Time= 5.4 min
Avg. Velocity = 2.01 fps, Avg. Travel Time= 20.2 min

Peak Storage= 58,825 cf @ 12.13 hrs
Average Depth at Peak Storage= 1.80'
Bank-Full Depth= 6.00' Flow Area= 156.0 sf, Capacity= 2,283.11 cfs

8.00' x 6.00' deep channel, n= 0.035
Side Slope Z-value= 3.0 '/' Top Width= 44.00'
Length= 2,435.0' Slope= 0.0233 '/'
Inlet Invert= 1,287.00', Outlet Invert= 1,230.30'

Reach S1: South Channel 1

Hydrograph

Inflow Area=44.615 ac
Avg. Flow Depth=1.80'
Max Vel=7.49 fps
n=0.035
L=2,435.0'
S=0.0233 '/'
Capacity=2,283.11 cfs
Summary for Reach S2: South Channel 2

Inflow Area = 78.977 ac, 0.00% Impervious, Inflow Depth = 3.78" for 25-yr, 24-hr event
Inflow = 272.60 cfs @ 12.11 hrs, Volume = 24.886 af
Outflow = 262.07 cfs @ 12.26 hrs, Volume = 24.886 af, Atten = 4%, Lag = 8.8 min

Routing by Stor-Ind+Trans method, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs
Max. Velocity = 5.63 fps, Min. Travel Time = 4.5 min
Avg. Velocity = 1.55 fps, Avg. Travel Time = 16.3 min

Peak Storage = 70,870 cf @ 12.18 hrs
Average Depth at Peak Storage = 2.83'
Bank-Full Depth = 6.00' Flow Area = 156.0 sf, Capacity = 1,338.23 cfs

8.00' x 6.00' deep channel, n = 0.035
Side Slope Z-value = 3.0 '/' Top Width = 44.00'
Length = 1,515.0' Slope = 0.0080 '/'
Inlet Invert = 1,229.46', Outlet Invert = 1,217.34'

Reach S2: South Channel 2

Hydrograph

Inflow Area = 78.977 ac
Avg. Flow Depth = 2.83'
Max Vel = 5.63 fps
n = 0.035
L = 1,515.0'
S = 0.0080 '/'
Capacity = 1,338.23 cfs
### Summary for Reach SBC: South Box Culvert

- **Inflow Area:** 44.615 ac, 0.00% Impervious, **Inflow Depth:** 3.78" for 25-yr, 24-hr event
- **Inflow:** 180.12 cfs @ 12.22 hrs, **Volume:** 14.058 af
- **Outflow:** 179.10 cfs @ 12.23 hrs, **Volume:** 14.058 af, **Atten:** 1%, **Lag:** 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
- **Max. Velocity:** 12.29 fps, **Min. Travel Time:** 0.2 min
- **Avg. Velocity:** 2.86 fps, **Avg. Travel Time:** 0.8 min

- **Peak Storage:** 1,985 cf @ 12.22 hrs
- **Average Depth at Peak Storage:** 1.82'
- **Bank-Full Depth:** 4.00' **Flow Area:** 32.0 sf, **Capacity:** 411.57 cfs

96.0" W x 48.0" H Box Pipe
- **n:** 0.011 Concrete pipe, straight & clean
- **Length:** 136.0' **Slope:** 0.0062 '/'
- **Inlet Invert:** 1,230.30', **Outlet Invert:** 1,229.46'

---

**Reach SBC: South Box Culvert**

**Hydrograph**

- **Inflow Area=44.615 ac**
- **Avg. Flow Depth=1.82'**
- **Max Vel=12.29 fps**
- **96.0" x 48.0"**
- **Box Pipe**
  - **n=0.011**
  - **L=136.0'**
  - **S=0.0062 '/'**
- **Capacity=411.57 cfs**
Summary for Reach W1: West Channel 1

Inflow Area = 95.992 ac, 0.00% Impervious, Inflow Depth = 3.81" for 25-yr, 24-hr event
Inflow = 287.03 cfs @ 12.23 hrs, Volume= 30.461 af
Outflow = 284.20 cfs @ 12.32 hrs, Volume= 30.461 af, Atten= 1%, Lag= 5.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.88 fps, Min. Travel Time= 3.1 min
Avg. Velocity = 1.91 fps, Avg. Travel Time= 12.9 min

Peak Storage= 53,065 cf @ 12.27 hrs
Average Depth at Peak Storage= 2.38'
Bank-Full Depth= 4.00' Flow Area= 80.0 sf, Capacity= 840.32 cfs

8.00' x 4.00' deep channel, n= 0.035
Side Slope Z-value= 3.0 '/' Top Width= 32.00'
Length= 1,472.0' Slope= 0.0190 '/'
Inlet Invert= 1,220.00', Outlet Invert= 1,192.00'

Reach W1: West Channel 1

Hydrograph

Inflow Area=95.992 ac
Avg. Flow Depth=2.38'
Max Vel=7.88 fps
n=0.035
L=1,472.0'
S=0.0190 '/'
Capacity=840.32 cfs
Summary for Reach W2: West Channel 2

Inflow Area = 95.992 ac, 0.00% Impervious, Inflow Depth = 3.81" for 25-yr, 24-hr event
Inflow = 284.17 cfs @ 12.32 hrs, Volume= 30.461 af
Outflow = 283.35 cfs @ 12.33 hrs, Volume= 30.461 af, Attenu= 0%, Lag= 0.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 10.43 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 2.40 fps, Avg. Travel Time= 2.2 min

Peak Storage= 8,437 cf @ 12.32 hrs
Average Depth at Peak Storage= 1.62'
Bank-Full Depth= 4.00' Flow Area= 96.0 sf, Capacity= 1,644.11 cfs

12.00' x 4.00' deep channel, n= 0.035
Side Slope Z-value= 3.0 '/' Top Width= 36.00'
Length= 310.0' Slope= 0.0461 '/'
Inlet Invert= 1,182.30', Outlet Invert= 1,168.00'

Reach W2: West Channel 2

HydroGraph

Inflow Area=95.992 ac
Avg. Flow Depth=1.62'
Max Vel=10.43 fps
n=0.035
L=310.0'
S=0.0461 '/'
Capacity=1,644.11 cfs
Summary for Reach WP1: West Pipe 1

Inflow Area = 95.992 ac, 0.00% Impervious, Inflow Depth = 3.81” for 25-yr, 24-hr event
Inflow = 284.20 cfs @ 12.32 hrs, Volume = 30.461 af
Outflow = 284.17 cfs @ 12.32 hrs, Volume = 30.461 af, Atten = 0%, Lag = 0.0 min

Routing by Stor-Ind+Trans method, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs
Max. Velocity = 26.81 fps, Min. Travel Time = 0.0 min
Avg. Velocity = 7.08 fps, Avg. Travel Time = 0.1 min

Peak Storage = 403 cf @ 12.32 hrs
Average Depth at Peak Storage = 1.50'
Bank-Full Depth = 3.00' Flow Area = 21.2 sf, Capacity = 568.99 cfs

A factor of 3.00 has been applied to the storage and discharge capacity
36.0" Round Pipe
n = 0.011 Concrete pipe, straight & clean
Length = 38.0' Slope = 0.0579 '/'
Inlet Invert = 1,184.50', Outlet Invert = 1,182.30'

Reach WP1: West Pipe 1

Hydrograph

Inflow Area = 95.992 ac
Avg. Flow Depth = 1.50'
Max Vel = 26.81 fps
36.0" Round Pipe x 3.00
n = 0.011
L = 38.0'
S = 0.0579 '/'
Capacity = 568.99 cfs
Summary for Pond P1: West Pond

Inflow Area = 95.992 ac, 0.00% Impervious, Inflow Depth = 3.81” for 25-yr, 24-hr event
Inflow = 283.35 cfs @ 12.33 hrs, Volume= 30.461 af
Outflow = 193.69 cfs @ 12.59 hrs, Volume= 28.222 af, Atten= 32%, Lag= 15.1 min
Primary = 193.69 cfs @ 12.59 hrs, Volume= 28.222 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 1,168.38’ @ 12.59 hrs  Surf.Area= 136,196 sf  Storage= 391,673 cf

Plug-Flow detention time= 100.0 min calculated for 28.222 af (93% of inflow)
Center-of-Mass det. time= 58.4 min (904.3 - 845.8 )

Volume Invert Avail.Storage Storage Description
#1 1,161.00’ 635,015 cf Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation Surf.Area Inc.Store Cum.Store
(feet) (sq-ft) (cubic-feet) (cubic-feet)
1,161.00 0 0 0
1,162.00 1,421 711 711
1,163.00 2,910 2,166 2,876
1,164.00 5,545 4,228 7,104
1,165.00 30,760 18,153 25,256
1,166.00 113,772 72,266 97,522
1,168.00 129,318 243,090 340,612
1,170.00 165,085 294,403 635,015

Device Routing Invert Outlet Devices
#1 Primary 1,166.00’ 20.0’ long x 267.0’ breadth Broad-Crested Rectangular Weir
Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=193.27 cfs @ 12.59 hrs  HW=1,168.38’ (Free Discharge)
1=Broad-Crested Rectangular Weir (Weir Controls 193.27 cfs @ 4.06 fps)
Pond P1: West Pond

Inflow Area = 95.992 ac
Peak Elev = 1,168.38'
Storage = 391,673 cf

Hydrograph
Summary for Pond THL: Tower Hill Lake

Inflow Area = 176.798 ac, 0.00% Impervious, Inflow Depth = 3.66" for 25-yr, 24-hr event
Inflow = 367.39 cfs @ 12.19 hrs, Volume= 53.896 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Attenuation= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 1,146.46' @ 48.00 hrs Surf.Area= 5,161,549 sf Storage= 2,347,219 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

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<td>122,166,852</td>
<td>Custom Stage Data (Prismatic) Listed below (Recalculated)</td>
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Pond THL: Tower Hill Lake

Hydrograph

Inflow Area=176.798 ac
Peak Elev=1,146.46'
Storage=2,347,219 cf
APPENDIX D

Terrace Berm and Letdown Structures HydroCAD Output Files
Routing Diagram for FGD Landfill Terrace Berms and Letdown Structures
HydroCAD® 10.00-15 s/n 04891 © 2015 HydroCAD Software Solutions LLC

FGD Landfill Subcatchment → Terrace Berm → Letdown Structure
### Area Listing (all nodes)

<table>
<thead>
<tr>
<th>Area (acres)</th>
<th>CN</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.081</td>
<td>80</td>
<td>&gt;75% Grass cover, Good, HSG D (FGD)</td>
</tr>
</tbody>
</table>
Summary for Subcatchment FGD: FGD Landfill Subcatchment

Runoff  =  42.68 cfs @  12.08 hrs,  Volume=  2.861 af,  Depth=  3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr  25-yr, 24-hr Rainfall=6.00"

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<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.081</td>
<td>80</td>
<td>&gt;75% Grass cover, Good, HSG D</td>
</tr>
<tr>
<td>9.081</td>
<td>100.00%</td>
<td>Pervious Area</td>
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</table>

<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
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<tbody>
<tr>
<td>9.6</td>
<td>100</td>
<td>0.0200</td>
<td>0.17</td>
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<td><strong>Sheet Flow,</strong> Grass: Short n= 0.150  P2= 3.36&quot;</td>
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<tr>
<td>6.2</td>
<td>371</td>
<td>0.0200</td>
<td>0.99</td>
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<td><strong>Shallow Concentrated Flow,</strong> Short Grass Pasture  Kv= 7.0 fps</td>
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<tr>
<td>15.8</td>
<td>471</td>
<td>Total</td>
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Subcatchment FGD: FGD Landfill Subcatchment

Type II 24-hr  25-yr Rainfall=6.00"

- Runoff Area=9.081 ac
- Runoff Volume=2.861 af
- Runoff Depth=3.78"
- Flow Length=471'
- Slope=0.0200 '/'
- Tc=15.8 min
- CN=80
Summary for Reach 1R: Letdown Structure

Inflow Area = 9.081 ac, 0.00% Impervious, Inflow Depth = 3.78" for 25-yr, 24-hr event
Inflow = 40.15 cfs @ 12.18 hrs, Volume= 2.861 af
Outflow = 39.56 cfs @ 12.20 hrs, Volume= 2.861 af, Atten= 1%, Lag= 1.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.33 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 2.05 fps, Avg. Travel Time= 4.3 min

Peak Storage= 2,262 cf @ 12.19 hrs
Average Depth at Peak Storage= 0.38'
Bank-Full Depth= 0.75' Flow Area= 9.2 sf, Capacity= 127.27 cfs

10.00' x 0.75' deep channel, n= 0.035
Side Slope Z-value= 3.0 '/' Top Width= 14.50'
Length= 527.0' Slope= 0.2000 '/'
Inlet Invert= 0.00', Outlet Invert= -105.40'

Reach 1R: Letdown Structure

Hydrograph

Inflow Area=9.081 ac
Avg. Flow Depth=0.38'
Max Vel=9.33 fps
n=0.035
L=527.0'
S=0.2000 '/'
Capacity=127.27 cfs
Summary for Reach TB: Terrace Berm

Inflow Area = 9.081 ac, 0.00% Impervious, Inflow Depth = 3.78" for 25-yr, 24-hr event
Inflow = 42.68 cfs @ 12.08 hrs, Volume= 2.861 af
Outflow = 40.15 cfs @ 12.18 hrs, Volume= 2.861 af, Atten= 6%, Lag= 5.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.36 fps, Min. Travel Time= 3.4 min
Avg. Velocity = 1.39 fps, Avg. Travel Time= 10.7 min

Peak Storage= 8,221 cf @ 12.12 hrs
Average Depth at Peak Storage= 1.76'
Bank-Full Depth= 2.00' Flow Area= 12.0 sf, Capacity= 57.18 cfs

0.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 2.0 4.0 '/' Top Width= 12.00'
Length= 886.0' Slope= 0.0100 '/'
Inlet Invert= 1,340.00', Outlet Invert= 1,331.14'

Reach TB: Terrace Berm

Hydrograph

Inflow Area=9.081 ac
Avg. Flow Depth=1.76'
Max Vel=4.36 fps
n=0.030
L=886.0'
S=0.0100 '/'
Capacity=57.18 cfs
APPENDIX E

Regional Run-off HydroCAD Output Files
### Area Listing (all nodes)

<table>
<thead>
<tr>
<th>Area</th>
<th>CN</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>934.496</td>
<td>80</td>
<td>&gt;75% Grass cover, Good, HSG D (WC)</td>
</tr>
<tr>
<td>76.350</td>
<td>98</td>
<td>Water Surface, HSG D (WC)</td>
</tr>
</tbody>
</table>
Summary for Subcatchment WC: Watershed Capacity

Runoff = 963.68 cfs @ 13.99 hrs, Volume = 327.155 af, Depth = 3.88"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span = 0.00-40.00 hrs, dt = 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall = 6.00"

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<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
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<tr>
<td>934.496</td>
<td>80</td>
<td>&gt;75% Grass cover, Good, HSG D</td>
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<tr>
<td>76.350</td>
<td>98</td>
<td>Water Surface, HSG D</td>
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</table>

<table>
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<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
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<td>1,010.846</td>
<td>81</td>
<td>Weighted Average</td>
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<tr>
<td>934.496</td>
<td>92.45% Pervious Area</td>
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<tr>
<td>76.350</td>
<td>7.55% Impervious Area</td>
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<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
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<td>7.2</td>
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<td>0.23</td>
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<td><strong>Sheet Flow</strong>, Grass: Short</td>
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<td>n = 0.150  P2 = 3.36&quot;</td>
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<td>13.5</td>
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<td>0.0400</td>
<td>1.40</td>
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<td><strong>Shallow Concentrated Flow</strong>,</td>
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<td>Short Grass Pasture</td>
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<td>Kv = 7.0 fps</td>
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<td>147.2</td>
<td>4,737</td>
<td>0.1000</td>
<td>0.54</td>
<td>16.09</td>
<td><strong>Channel Flow</strong>, Area= 30.0 sf</td>
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<tr>
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<td></td>
<td></td>
<td>Perim= 4,737.0' r= 0.01'</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>n = 0.030  Stream, clean &amp; straight</td>
</tr>
</tbody>
</table>

167.9 5,975 Total

Subcatchment WC: Watershed Capacity

Type II 24-hr 25-yr
24-hr Rainfall = 6.00"
Runoff Area = 1,010.846 ac
Runoff Volume = 327.155 af
Runoff Depth = 3.88"
Flow Length = 5,975'
Tc = 167.9 min
CN = 81
Summary for Pond THL: Tower Hill Lake

Inflow Area = 1,010.846 ac, 7.55% Impervious, Inflow Depth = 3.88" for 25-yr, 24-hr event
Inflow = 963.68 cfs @ 13.99 hrs, Volume= 327.155 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
Peak Elev= 1,148.70' @ 33.65 hrs Surf.Area= 5,408,743 sf Storage= 14,250,505 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

<table>
<thead>
<tr>
<th>Volume</th>
<th>Invert</th>
<th>Avail.Storage</th>
<th>Storage Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>1,146.00'</td>
<td>122,166,852 cf</td>
<td>Custom Stage Data (Prismatic) Listed below (Recalc)</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1,146.00</td>
<td>5,104,361</td>
<td>0</td>
<td>0</td>
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<tr>
<td>1,148.00</td>
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<td>10,458,843</td>
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<td>1,164.00</td>
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<td>13,692,041</td>
<td>107,914,063</td>
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<tr>
<td>1,166.00</td>
<td>7,276,829</td>
<td>14,252,789</td>
<td>122,166,852</td>
</tr>
</tbody>
</table>
Pond THL: Tower Hill Lake

Inflow Area=1,010.846 ac
Peak Elev=1,148.70'
Storage=14,250,505 cf