Run-On And Run-Off Control System Plan
NRG Indian River Generating Station
Indian River Landfill Phase I & II

Prepared for:

Indian River Power LLC; a subsidiary of NRG

Indian River Landfill

Dagsboro, Delaware

Prepared by:

CB&I Environmental & Infrastructure, Inc.

October 2016

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LIST OF FIGURES AND APPENDICES

FIGURES

APPENDICES

Plan Review/Amendment Log §257.81(c)(2)

Date of Review	Reviewer Name	Sections Amended and Reason	Version

CCR Regulatory Requirements

USEPA CCR Rule Criteria 40 CFR 257.81	**Indian River Landfill (IRLF) Run-on and Run-off Control System Plan**
§257.81(a)(1) stipulates: *(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;*	Sections 4.3.1
§257.81(a)(2) stipulates: *(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.*	Sections 4.3.1
§257.81(b) stipulates: *(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.*	Section 3.3

USEPA CCR Rule Criteria 40 CFR 257.81	**Indian River Landfill (IRLF) Run-on and Run-off Control System Plan**
§257.81(c)(1) stipulates: *(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).*	Section 5.1
§257.81(c)(2) stipulates: *(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.*	Sections 2.0 & 5.3

USEPA CCR Rule Criteria 40 CFR 257.81	Indian River Landfill (IRLF) 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

USEPA CCR Rule Criteria 40 CFR 257.81	Indian River Landfill (IRLF) Run-on and Run-off Control System Plan
§257.81(d) stipulates: *(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).*	Sections 5.1 & 5.2

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 Indian River Power LLC (Indian River, a subsidiary of NRG Energy, Inc. [NRG]) for the Indian River Landfill (Landfill) located in Dagsboro, Delaware. The 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 Landfill. 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. As previously noted, the Landfill has been deemed to be a regulated CCR unit at the Indian River Generating Station.

This Plan marks the initial analysis of the facility run-on and run-off control features based on the permitted facility conditions to date. Construction activities may occur at the facility that will subsequently modify the permitted facility conditions described within this Plan. This Plan will be amended as necessary 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 documented within the Plan Review/Amendment Log immediately following the Table of Contents.

This Plan also details Indian River Generating Station's compliance with the recordkeeping requirements specified in **Section 5.0**.

3.0 LANDFILL OVERVIEW

3.1 Site Location and Topography

Indian River Power LLC owns and operates an industrial landfill at the Indian River Generating Station in Sussex County, Delaware. The Landfill is bound by the Indian River power generation station to the north and densely vegetated areas in the east, south, and west. The location of the Landfill is depicted in **Figure 1.**

The Landfill is divided into two Phases, Phase I and Phase II. Phase I was certified as closed on October 20, 2014, prior to the establishment of the CCR Rule. Phase II is currently operational and accepting CCR material. Phase II is a vertical and horizontal expansion of Phase I. Phase I and Phase II are constructed on approximately 46 acres and 28 acres, respectively. Stormwater controls for both Phases work in conjunction with each other, and are therefore discussed in this report. The Phase boundaries are depicted in **Figure 2.**

The western portion of Phase II is currently operational and actively accepting CCR material. Phased construction within Phase II will continue at the Landfill until final CCR grades are achieved and the Landfill is closed in accordance with current CCR regulations.

Once CCR disposal and final cover installation/closure is complete, the Landfill will generally have a 3.5% slope on the plateau to a 3H:1V side slope with a peak elevation of approximately 100 ft. MSL. The permitted final landform is depicted in **Figure 3.**

3.2 Existing Regulatory Permits and Consents

The Indian River Generating Station has been granted an Industrial Landfill Permit by the State of Delaware, Department of Natural Resources and Environmental Control (DNREC) Permit SW-12/01, in accordance with 7 Del. Code, Section 6003, Section 4.1.1.1, and 6.0 of the *Delaware Regulations Governing Solid Waste* (DRGSW). This Permit enables the Indian River Generating Station to continue safe disposal of CCR generated on-site at the power plant to be properly disposed of within the permitted Landfill boundary.

The Indian River Generating Station has also been granted a National Pollutant Discharge Elimination System (NPDES) Permit No. DE0050580. The NPDES Permit covers various outfall locations at the Indian River Generating Station (including one associated with the Landfill) and allows the discharge of non-contact stormwater into the Indian River in accordance with effluent limitations and monitoring requirements.

3.3 Stormwater Management System Overview

Stormwater at Phase I and Phase II are managed by separate and shared stormwater conveyance features. Although Phase I was capped and closed prior to the CCR Rule, it will be included within this analysis to ensure that all stormwater conveyance features are sized appropriately.

The Landfill has been designed with controls to effectively manage both stormwater run-on and run-off. A perimeter berm currently bounds active landfilling operations to restrict the flow of stormwater run-on onto these active landfilling areas. Stormwater run-off controls at the Landfill include terrace berms, letdown pipes, perimeter drainage channels, and detention basins that collect and control non-contact stormwater from the Landfill. Stormwater run-off from vegetated portions of the facility flow to detention basins where stormwater is able to infiltrate into the soil or discharge off-site through an NPDES approved outfall. Direct precipitation that falls onto active portions of the Landfill is collected and managed by the existing leachate collection system. The locations of the existing stormwater features are shown on **Figure 4.**

3.3.1 Landfill Run-On

The permitted Landfill is bound by a perimeter berm structure that is approximately 8 to 20 feet in height. The perimeter berm structure has been constructed to prevent stormwater run-on onto active and closed portions of the Landfill.

3.3.2 Landfill Stormwater Management Controls

Stormwater falling on the Landfill is managed by terrace benches, letdown pipes, perimeter drainage ditches, and detention basins. Terrace benches have been designed to intercept runoff from the final landform in order to prevent erosion and reduce the drainage length of runoff. The terrace benches are generally spaced every 20 vertical feet, or every 60 slope feet. Terrace benches intercepting flow from the plateau section of the Indian River Landfill are trapezoidal channels with a 0.5 foot depth, 7 foot bottom width, 3H:1V and 10H:1V side slopes, and a 1.5% channel slope. All side slope terrace benches are v-notch channels with a 1.0 foot depth, 3H:1V and 10H:1V side slopes, and a channel slope of 1.5%. All terrace benches on the Landfill are lined with vegetation.

Terrace benches direct stormwater towards letdown pipes that convey stormwater to the perimeter drainage ditches. Letdown pipes are 24” diameter, smooth-walled plastic pipes that are sloped at 3H:1V.

Stormwater that passes through the letdown pipes flows into the perimeter drainage ditches. The perimeter drainage ditches vary in size but are generally 1 to 2 feet deep with a bottom width ranging from 2 to 8 feet and a channel slope of 1.0%. Design parameters for each perimeter drainage ditch have been provided in **Appendix F.**

Stormwater that falls onto all closed portions of the Landfill are directed to the Northeast and South Detention Basins. The detention basins at the Landfill are comprised of Soil Group A soils. These soils have a low run-off potential and infiltrate stormwater rapidly. Design parameters for each detention basin have been provided in **Appendix H.**

Stormwater that collects in landfilling operational areas is defined as leachate. Leachate is properly managed by the existing leachate collection system at the Landfill. The leachate collection system is designed and constructed to manage leachate beyond the completion of the Landfill final cover installation.

3.3.3 Stormwater Run-Off Location

The Landfill maintains positive drainage towards the Northeast and South Detention Basins. Historically, stormwater has not discharged from either detention basin, with the noted exception of a discharge during Superstorm Sandy. An outfall is located within the South Detention Basin and is permitted under the NPDES Permit No. DE0050580. This outfall conveys stormwater into Island Creek, running along the western border of the Landfill. Outfalls are routinely monitored to ensure that the stormwater flowing offsite is free of silt and sediment, discoloration, or floating debris or non-aqueous substances in order to meet the standards set by the NPDES Permit No DE0050580 and 40 CFR Part §257.81(b).

3.4 Stormwater Management Operations and Maintenance

3.4.1 Routine Operations and Maintenance

Stormwater run-on and run-off controls are maintained as part of routine operations and maintenance. In part, the site maintains the controls through the following measures:

- ❑ mowing of vegetation as necessary
- ❑ filling and/or repairing identified erosion pathways
- ❑ clearing debris from pipe inlets and outlets
- ❑ removing accumulated sediment from the detention basin forebays.

Weekly (7-day) and annual inspections occur at the Landfill in line with inspection requirements outlined in 40 CFR §257.84. These inspections are used to identify and document necessary repairs such that the facility is operated and maintained in accordance with the design.

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. The weekly inspection reports were reviewed dating back to October 2015, and note minor corrective actions that were completed for cover and erosion repairs. The findings of the weekly reports are summarized in the Annual Inspection Report.

The Annual Inspection Report completed in December 2015 notes that all operation and maintenance procedures were properly implemented. There were no deficiencies or remedial actions noted at that time.

3.4.3 Corrective Actions and Documentation

Documentation of remedial actions are placed in the Facility Operating Record.

4.0 HYDROLOGIC ANALYSES

4.1 Methodology Overview

A stormwater model has been developed for the Landfill using the computer modelling software HydroCAD in order to determine whether the stormwater controls comply with 40 CFR Part §257.81. This regulation requires that stormwater conveyance features be appropriately sized to safely convey the 25-year, 24-hour storm. The features that have been analyzed include the terrace benches, letdown pipes, perimeter drainage ditches, and detention basins.

The HydroCAD model conservatively utilizes the permitted final landform of the Landfill to determine the largest discharge rates and volumes (e.g. all areas of the landfill contribute to run-off rather than portions being treated as leachate). The model results for each feature have been reviewed to ensure that they do not overtop during the modeled storm event and that conditions are not created that will result in erosion or scour. Erosion or scour can negatively impact the long-term function of the design and should be mitigated as necessary when modeling or observed conditions indicate the potential exists. Erosion or scour can be mitigated through the selection of appropriate surface lining material or changes in design configurations that slows stormwater flow velocities.

As further described in subsequent text, the model demonstrates that the stormwater conveyance features are appropriately designed to safely route stormwater off of the Landfill to the detention basins and ultimate facility discharge location.

4.2 Model Input Parameters

All stormwater conveyance features have been 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. 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:	SCS Type II 24-hour storm
Unit Hydrograph:	SCS
Antecedent Moisture Condition:	2

The Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service (SCS), 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 of computer modeling. As such it was developed to utilize chart based solutions to use the SCS runoff equation. TR-20 is a computer based hydrograph modeling approach that is more complex and generally considered more accurate than TR-55.

4.2.1 Rainfall Totals and Distributions

The rainfall depth and distribution pattern for the run-on and run-off analysis was determined using the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 point precipitation frequency tool for Delaware provided by the National Weather Service (NWS). The rainfall depth for the modeled scenario was selected from this report and entered into HydroCAD. TR-55 outlines that an NRCS Type II 24-hour storm distribution is appropriate within this region of Delaware. The distribution pattern may be selected from a drop-down list in HydroCAD. The rainfall total from the NOAA-NWS is can be found in **Appendix A.**

4.2.2 Subcatchment Boundaries

Subcatchment areas (also known as watersheds) were delineated using AutoCAD using topographic divides and stormwater conveyance features within Phase I and II. All subcatchment boundaries are delineated and imported into HydroCAD. A summary of the Subcatchment boundaries are depicted in **Figure 3.** Subcatchment delineation and discharge rates are provided in **Appendix B** and **Appendix E**, respectively.

4.2.3 Run-off 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 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 Types

The NRCS was used to delineate surficial soils at the facility in Phase I and II. Based on the NRCS Soil Survey for Sussex County, the entire site is comprised of Soil Group A Soils. The description of each soil is provided in the Soil Survey of Sussex County. A map of the soil boundaries and a copy of the NRCS soil survey is provided in **Appendix C.**

Land Covers

The land covers were delineated for the permitted conditions based on a review of aerial topography and the topographic survey. Vegetated final cover conditions are considered appropriate for use in modeling due to the fact that the landfill will be constructed in phases and final cover will be installed upon achieving final grades. The land cover for the permitted landfill final cover was conservatively assumed to be grassland that is periodically mowed. The TR-55 manual designates this land cover type as “pasture, grassland, or range”.

The TR-55 manual provides lookup tables of curve numbers for combinations of various land covers and the underlying surficial soils. The TR-55 lookup tables for curve numbers are provided within HydroCAD and can be designated for each subcatchment.

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 (ie. prior to being managed by a downstream element) was delineated in AutoCAD and manually entered in HydroCAD.

For the run-on model, the following assumptions were made in the 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 four types of flow: sheet flow, shallow concentrated flow, open channel flow, and pipe flow.
- ❑ Sheet flow is assumed to become shallow concentrated flow at 100 feet, which is conservative in comparison to 300 feet, which is designated in the TR-55 Manual. Additionally, the Sussex County Conservation District and 7 Del.C. Ch.60, *SSWR* require a maximum length of sheet flow of 100 feet for vegetated surfaces and 150 feet for paved surfaces..
- ❑ The Manning's coefficient "n" for sheet flow for the permitted conditions at the landfill is assumed to be 0.24, indicative of dense-grass vegetative cover. This number is a HydroCAD default for "grass: dense" and is considered most indicative of the anticipated grass type that will be used for the landfill final vegetative cover.
- ❑ For permitted conditions, an average flow velocity of 7 ft/sec was assumed in shallow concentrated flow calculations for the landfill, which is the HydroCAD default for "short grass pasture", which is considered most indicative of the anticipated grass type that will be used for the landfill final vegetative cover.
- ❑ Stormwater flowing from each watershed collects in terrace benches situated on the permitted landfill side slopes. In the time of concentration calculation for each subcatchment, the terrace berms were modeled as v-notch channels. Each terrace bench was modeled to reflect permitted design specifications.
- ❑ For stormwater flow through the terrace benches, a Manning's coefficient of 0.035 was assumed in the channel flow calculations for the landfill, which is the HydroCAD default for "earth lined channel, dense weeds", which is considered most indicative of the anticipated grass type within the terrace benches.
- ❑ A number of letdown pipes are installed throughout Phases I and II where terrace benches converge. These letdown pipes were incorporated in the calculation of the total time of concentration within each watershed. Each letdown pipe was modeled as a 24-inch, corrugated plastic pipe, as reflected in permitted design specifications.
- ❑ The Manning's coefficient "n" for pipe flow for the permitted conditions letdown pipes is assumed to be 0.13, indicative of corrugated poly-ethylene pipe.

A summary of the time of concentration calculations for each subcatchment are provided in **Appendix D.** The time of concentration flow paths are depicted in **Figure 3.**

4.2.5 Stormwater Conveyance Features

Stormwater run-off is managed by a series of stormwater conveyance features. Terrace berms, letdown pipes, perimeter drainage ditches, and detention basins are utilized to manage stormwater at the Landfill. Key design parameters, dimensions, and inlet/outlet elevations for these structures were provided in the Indian River Landfill Industrial Permit SW12/01. These features were manually imported into HydroCAD. A summary of the stormwater conveyance feature design parameters are provided in **Appendix F** and **Appendix G.** These features are depicted in **Figure 4.**

4.2.6 Basin Elements

The Northeast and South Detention Basins were modeled by entering the area at each minor and major contour interval to determine incremental detention volumes. The elevation of the normal water elevation was assumed to be the bottom of each basin. Both basins were modeled to incorporate infiltration of stormwater as an outlet system. These modeled parameters can be found in **Appendix H**. 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-off controls at the Landfill. Results of the run-off analysis indicate that stormwater features that collect and convey stormwater from the Landfill are appropriately sized to manage stormwater volumes and peak discharge rates associated with the 25-year, 24-hour storm event per 40 CFR Part §257.81.

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

The run-on and run-off analysis for the 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."*

The perimeter berm structure has been adequately sized to properly prevent stormwater flow onto active portions of the landfill and is in compliance with 40 CFR Part §257.81(a)(1). It is noted that due to the significant size of the perimeter berm used to prevent run-on (8 to 20 feet in height), it was the opinion of the certifying engineer that this feature was not required to be modeled to demonstrate adequacy.

Results of the run-on and run-off analysis indicate that stormwater features that collect and convey stormwater from the Landfill are appropriately sized to manage stormwater flow volumes and peak discharge rates associated with the 25-year, 24-hour storm event. The results indicate that none of the features are anticipated to overtop during the 25-year, 24-hour storm event. Additionally, all stormwater features are designed with the appropriate lining material to minimize the potential for erosion or scour based on the anticipated flow velocities within each stormwater feature.

Results from this run-on and run-off hydrologic analysis can be found in the **Appendices E through I.**

4.4 Engineering Evaluation of Findings

4.4.1 Design Appropriateness Based on Model Findings

Based on the HydroCAD model findings, it is the opinion of CB&I that the stormwater control system is appropriately designed to collect and control the water volume resulting from the 25-year, 24-hour storm event.

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. Records indicate that these inspections are routinely completed and remedial actions are appropriately taken based on observations. Therefore, it is the opinion of CB&I that operations and maintenance activities are appropriate to ensure the continued function of the stormwater control system.

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.

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. This Landfill does not have a Tribal authority.

§257.107(g) of 40 CFR Part §257 provides publicly accessible Internet site requirements to ensure that this Plan is accessible through the Indian River Power 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 the Indian River Power CCR compliance reporting website upon the review and approval by Indian River Power.

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 Run-on and Run-off Control System Plan will continue to undergo review as the Landfill continues phased construction activities. Indian River Power 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 Indian River Generating Station'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))

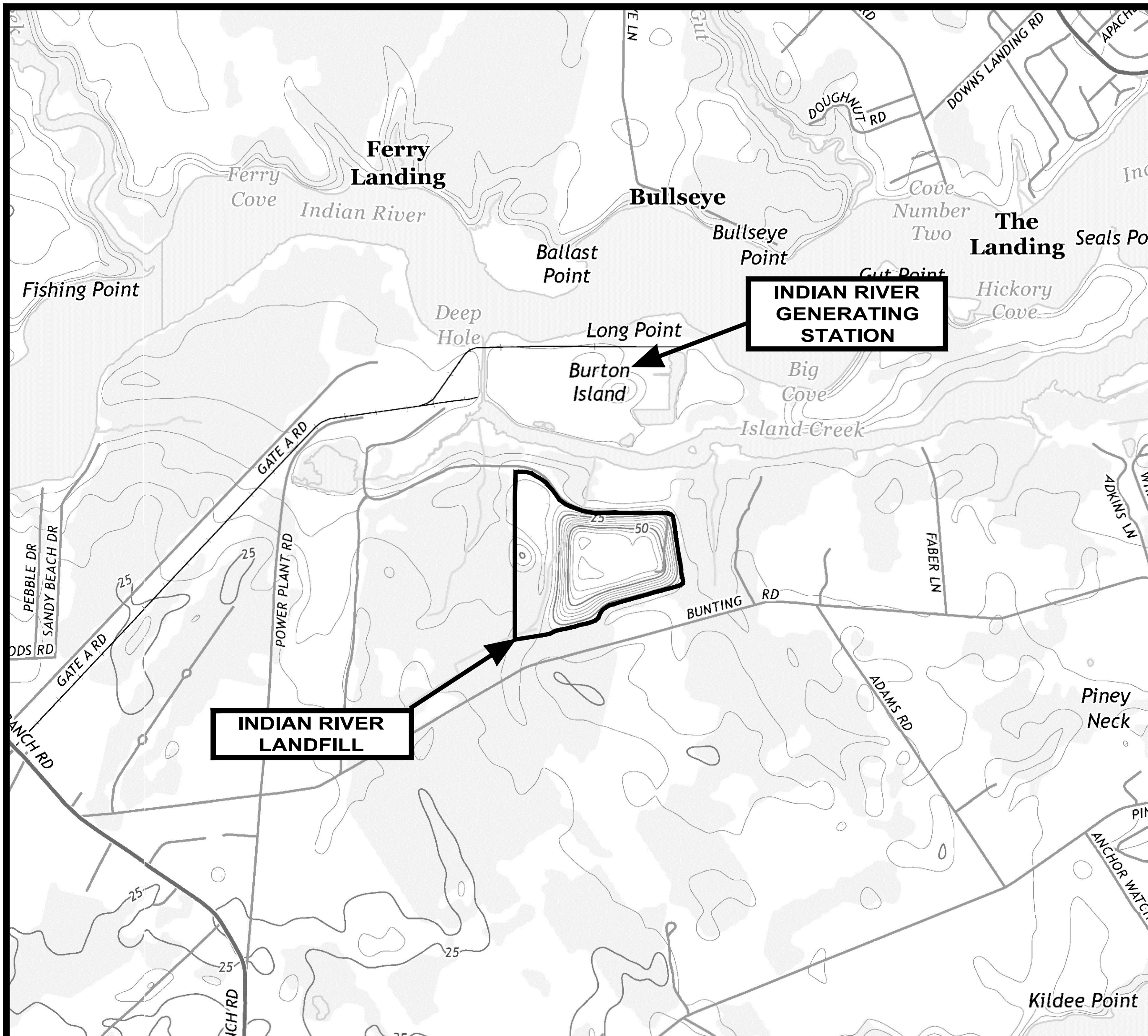
The undersigned registered professional engineer is familiar with the requirements of Title 40 CFR Part §257.81 and has visited and examined the Indian River Generating Station or has supervised examination of the Indian River Generating Station by appropriately qualified personnel. The undersigned registered 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 §257.81, and that this Plan is adequate for the Indian River Generating Station facility. This certification was prepared as required by §257.81(c)(5)

Name of Professional Engineer:	Richard Southorn
Company:	CB&I
Signature:	
Date:	OCT 12, 2016
PE Registration State:	Delaware
PE Registration Number:	20894

Professional Engineer Seal:

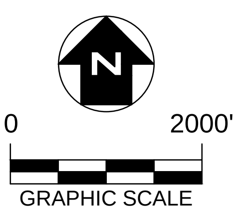
RICHARD DAVID SOUTHORN
LICENSE
No. 20894
DELAWARE
PROFESSIONAL ENGINEER

FIGURES



LEGEND

INDIAN RIVER LANDFILL FACILITY BOUNDARY



NOTES

1. AERIAL TOPO OBTAINED FROM USGS 7.5 - MINUTE SERIES (TOPOGRAPHIC) QUADRANGLE MAP: FRANKFORD, DELAWARE - SUSSEX CO. (2014), MILLSBORO, DELAWARE - SUSSEX CO. (2014).

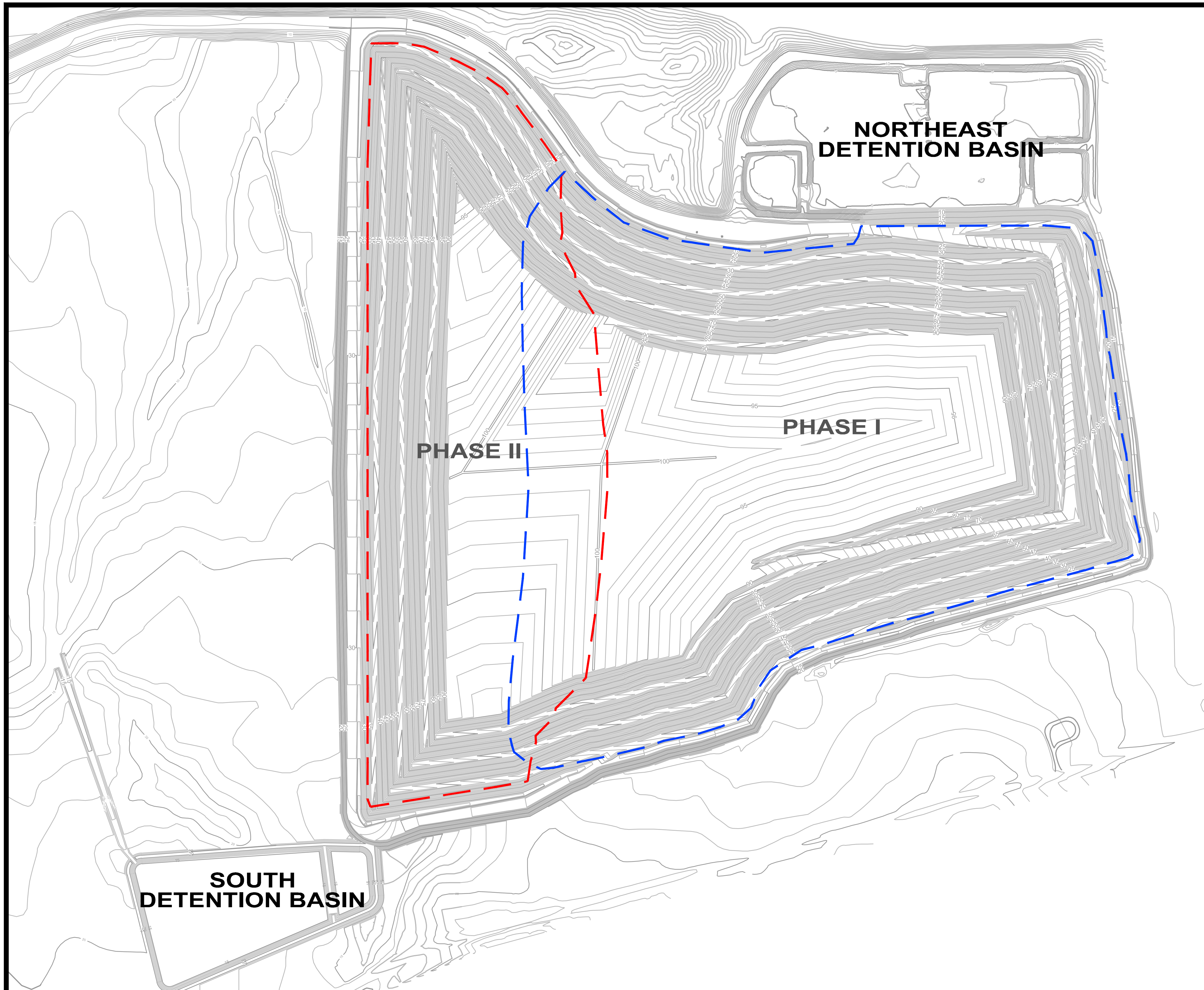
2. ALL BOUNDARIES ARE APPROXIMATE.

CB&I Environmental & Infrastructure, Inc.

NRG INDIAN RIVER LANDFILL
RUN-ON/RUN-OFF CONTROL PLAN

FIGURE 1
INDIAN RIVER LANDFILL
SITE LOCATION PLAN

APPROVED BY: RDS	PROJ. NO.: 6312142841	DATE: OCTOBER 2016



N
0 300'
GRAPHIC SCALE

LEGEND

- Blue dashed line: LANDFILL PHASE BOUNDARY (PHASE I)
- Red dashed line: LANDFILL PHASE BOUNDARY (PHASE II)

NOTES

1. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.
2. ALL BOUNDARIES ARE APPROXIMATE.

REV. NO.	DATE	DESCRIPTION

nrg SM

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NRG INDIAN RIVER LANDFILL RUN-ON/RUN-OFF CONTROL PLAN

FIGURE 2 PERMITTED FINAL LANDFORM

DRAWN BY: SJL	APPROVED BY: RDS	PROJ. NO.: 631214281	DATE: OCTOBER 2016

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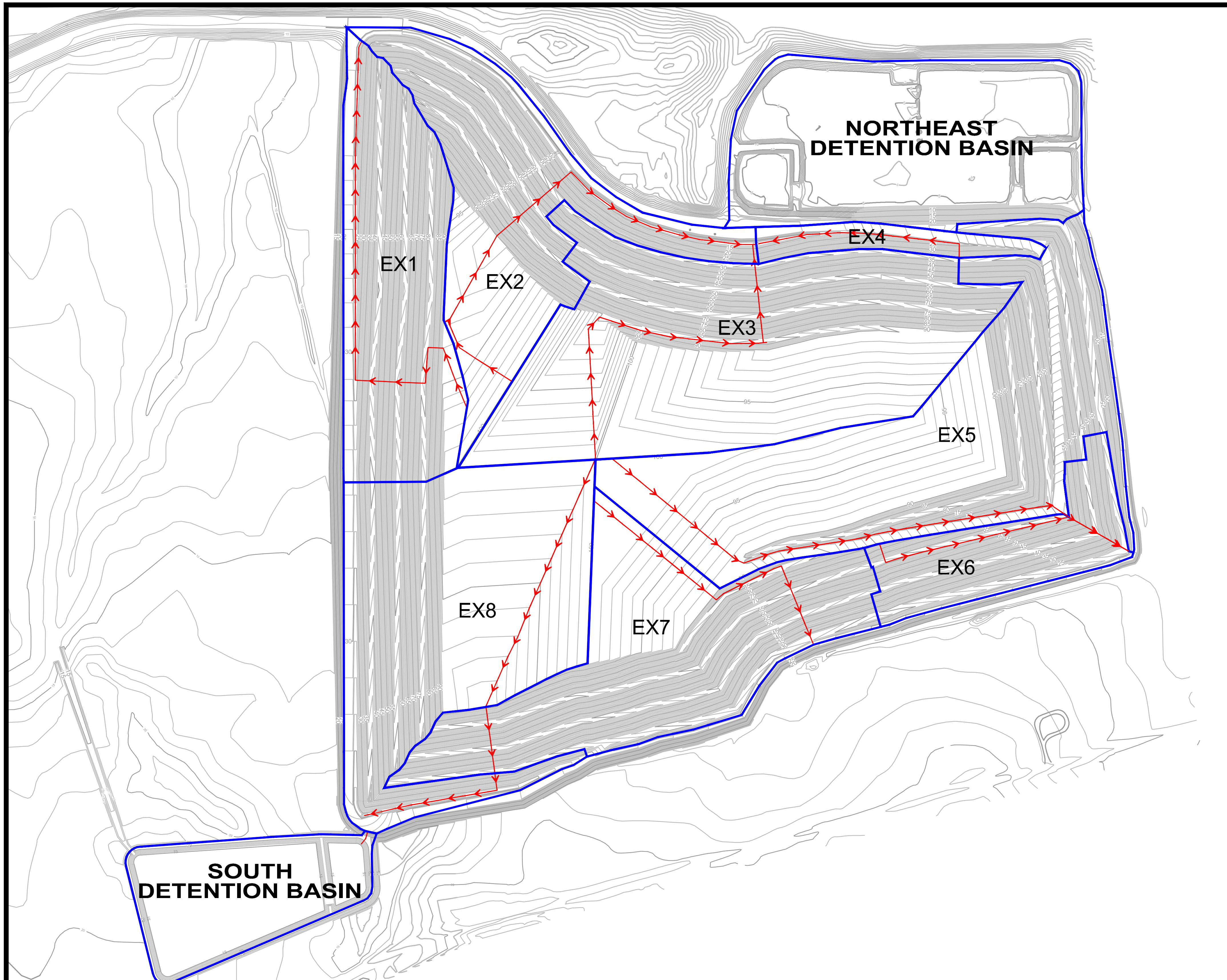

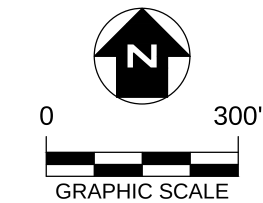

LEGEND

SUBCATCHMENT BOUNDARIES

TIME OF CONCENTRATION FLOWPATHS

NOTES

1. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.
2. ALL BOUNDARIES ARE APPROXIMATE.

REV. NO.	DATE	DESCRIPTION

nrg SM

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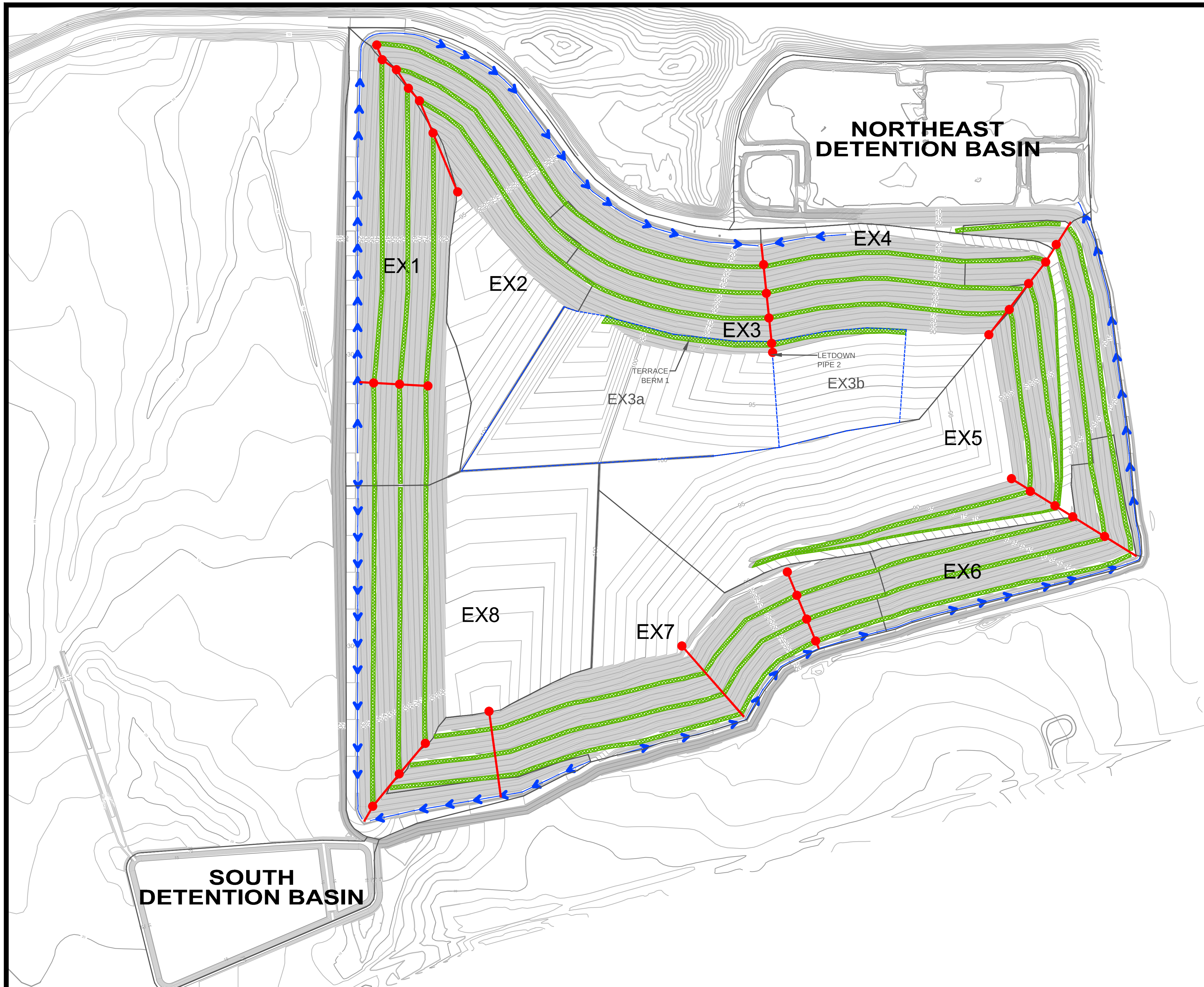
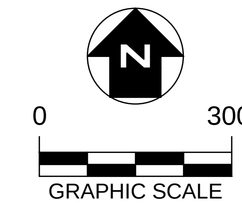
NRG INDIAN RIVER LANDFILL
RUN-ON/RUN-OFF CONTROL PLAN

FIGURE 3
SUBCATCHMENT AREAS

DRAWN BY: SJL	APPROVED BY: RDS	PROJ. NO.: 631214281	DATE: OCTOBER 2016





LEGEND

Black line	LANDFILL SUBCATCHMENT BOUNDARY
Blue dashed line	STORMWATER ANALYSIS SUBCATCHMENT
Green band	PERMITTED TERRACE BERM
Blue line with arrows	PERMITTED DRAINAGE DITCH
Red line	PERMITTED LETDOWN PIPE
Red dot	PERMITTED INLET TO LETDOWN PIPE

NOTES

1. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.
2. ALL BOUNDARIES ARE APPROXIMATE.
3. THE IDENTIFIED TERRACE BENCH AND LETDOWN PIPE WERE SELECTED FOR MODELING DUE TO ACCEPTING STORMWATER FROM THE LARGEST CONTRIBUTING AREAS, AS FURTHER NOTED IN APPENDIX G.

REV. NO.	DATE	DESCRIPTION

nrg SM

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NRG INDIAN RIVER LANDFILL
RUN-ON/RUN-OFF CONTROL PLAN

FIGURE 4
STORMWATER CONVEYANCE FEATURES

DRAWN BY: SJL	APPROVED BY: RDS	PROJ. NO.: 631214281	DATE: OCTOBER 2016

APPENDICES

APPENDIX A

Rainfall Distribution Calculation

Client:	NRG Indian River Power, LLC
Project:	Indian River Landfill CCR Compliance
Project #:	631214281
Calculated By: SJL	Date: 09/22/16
Checked by: RDS	Date: 09/27/16

TITLE: RAINFALL TOTALS AND DISTRIBUTIONS

Problem Statement

Determine the rainfall total and distribution for the 25-year, 24-hour storm frequency, in accordance with Title 40 Code of Federal Regulations Part 257.81(a). The rainfall total and distribution is used in the HydroCAD computer model to determine rainfall runoff quantities.

Given

- Technical Release 55 (TR-55), Urban Hydrology for Small Watersheds, published by the Soil Conservation Service.
- Rainfall data was obtained from the NOAA National Weather Service, Hydrometeorological Design Studies Center, Precipitation Frequency Data Server website, http://hdsc.nws.noaa.gov/hdsc/pfds/, Point Precipitation Frequency Estimates from NOAA Atlas 14 (see attached reference).

Results

The SCS Type II-24 hour synthetic rainfall distribution (cumulative rainfall vs. time) was chosen for the site based on its geographical location (see attached map of storm distribution areas).

A total rainfall depth of 6.65 inches was selecated for the 25-year, 24-hour storm event based on point precipitation frequency estimates from the NOAA for the geographical location of the site (see attached table).

PF tabular | PF graphical | Supplementary information

Print page

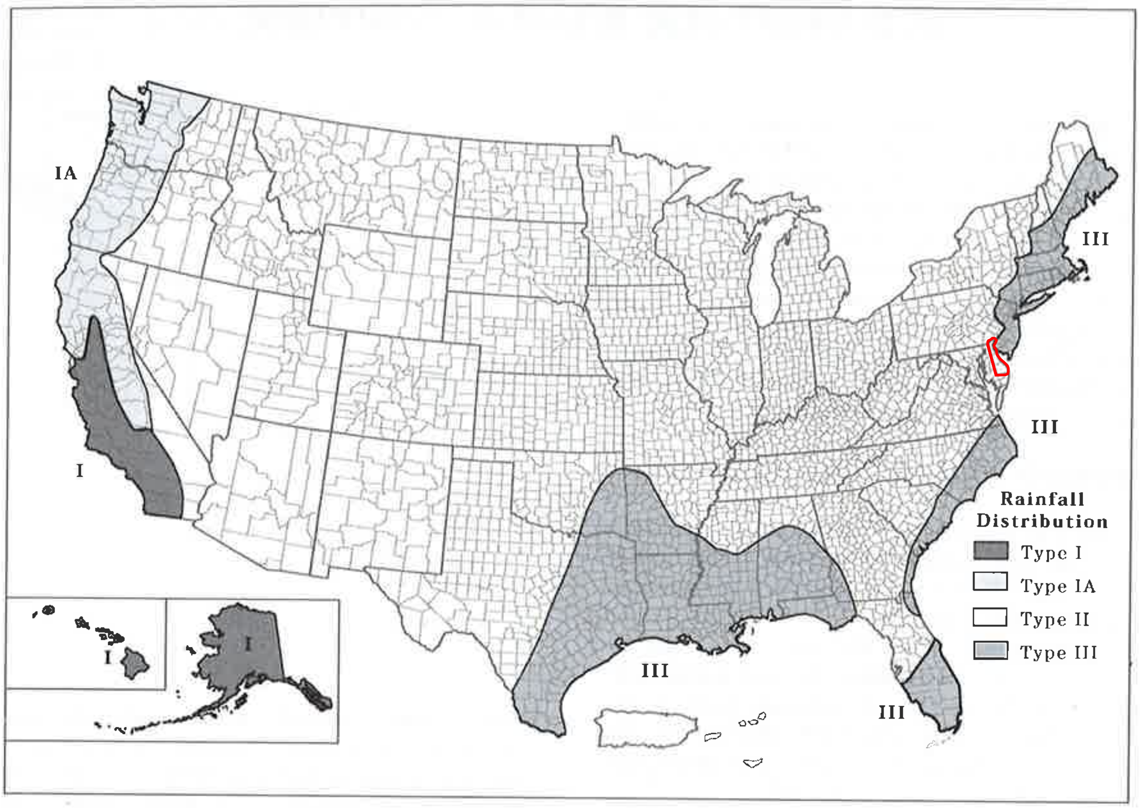
PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.353** (0.317-0.392)	**0.419** (0.377-0.464)	**0.494** (0.444-0.547)	**0.555** (0.498-0.615)	**0.628** (0.561-0.697)	**0.684** (0.609-0.759)	**0.739** (0.654-0.821)	**0.789** (0.694-0.881)	**0.851** (0.740-0.956)	**0.904** (0.779-1.02)
10-min	**0.564** (0.507-0.627)	**0.671** (0.602-0.743)	**0.791** (0.710-0.875)	**0.888** (0.796-0.983)	**1.00** (0.895-1.11)	**1.09** (0.970-1.21)	**1.17** (1.04-1.30)	**1.25** (1.10-1.40)	**1.35** (1.17-1.51)	**1.42** (1.23-1.61)
15-min	**0.706** (0.634-0.783)	**0.843** (0.757-0.934)	**1.00** (0.899-1.11)	**1.12** (1.01-1.24)	**1.27** (1.13-1.41)	**1.38** (1.23-1.53)	**1.48** (1.31-1.65)	**1.58** (1.39-1.76)	**1.70** (1.47-1.90)	**1.79** (1.54-2.02)
30-min	**0.967** (0.869-1.07)	**1.16** (1.05-1.29)	**1.42** (1.28-1.57)	**1.63** (1.46-1.80)	**1.88** (1.68-2.08)	**2.08** (1.85-2.31)	**2.27** (2.01-2.53)	**2.46** (2.16-2.74)	**2.70** (2.35-3.03)	**2.89** (2.50-3.27)
60-min	**1.21** (1.08-1.34)	**1.46** (1.31-1.62)	**1.82** (1.64-2.02)	**2.12** (1.90-2.35)	**2.50** (2.24-2.78)	**2.82** (2.51-3.13)	**3.13** (2.77-3.48)	**3.45** (3.03-3.85)	**3.87** (3.37-4.35)	**4.22** (3.64-4.78)
2-hr	**1.49** (1.33-1.67)	**1.81** (1.62-2.03)	**2.28** (2.03-2.55)	**2.68** (2.38-2.99)	**3.19** (2.82-3.57)	**3.62** (3.18-4.05)	**4.05** (3.55-4.55)	**4.50** (3.91-5.08)	**5.12** (4.39-5.82)	**5.64** (4.79-6.44)
3-hr	**1.63** (1.47-1.83)	**1.99** (1.78-2.22)	**2.50** (2.24-2.80)	**2.95** (2.63-3.29)	**3.54** (3.13-3.95)	**4.05** (3.55-4.51)	**4.57** (3.98-5.10)	**5.11** (4.42-5.74)	**5.87** (5.00-6.63)	**6.51** (5.48-7.40)
6-hr	**2.00** (1.80-2.25)	**2.43** (2.17-2.72)	**3.04** (2.72-3.41)	**3.60** (3.20-4.03)	**4.37** (3.86-4.89)	**5.04** (4.41-5.64)	**5.75** (4.98-6.45)	**6.50** (5.58-7.33)	**7.59** (6.40-8.63)	**8.55** (7.09-9.79)
12-hr	**2.38** (2.13-2.69)	**2.87** (2.57-3.24)	**3.62** (3.23-4.07)	**4.33** (3.84-4.87)	**5.34** (4.70-5.99)	**6.25** (5.44-7.02)	**7.24** (6.23-8.17)	**8.33** (7.06-9.44)	**9.95** (8.25-11.4)	**11.4** (9.28-13.1)
24-hr	**2.79** (2.58-3.05)	**3.40** (3.15-3.71)	**4.42** (4.08-4.82)	**5.30** (4.88-5.77)	**6.65** (6.08-7.21)	**7.83** (7.11-8.45)	**9.16** (8.23-9.87)	**10.7** (9.49-11.5)	**12.9** (11.3-13.9)	**14.9** (12.9-16.0)
2-day	**3.23** (2.98-3.52)	**3.93** (3.63-4.29)	**5.11** (4.71-5.57)	**6.13** (5.63-6.66)	**7.66** (6.99-8.31)	**9.00** (8.16-9.74)	**10.5** (9.44-11.4)	**12.2** (10.9-13.2)	**14.7** (13.0-15.9)	**17.0** (14.7-18.3)
3-day	**3.43** (3.17-3.74)	**4.17** (3.86-4.55)	**5.40** (4.99-5.88)	**6.45** (5.93-7.00)	**8.02** (7.33-8.70)	**9.39** (8.53-10.2)	**10.9** (9.84-11.8)	**12.6** (11.3-13.6)	**15.2** (13.4-16.4)	**17.4** (15.2-18.8)
4-day	**3.63** (3.36-3.96)	**4.42** (4.09-4.81)	**5.69** (5.26-6.19)	**6.77** (6.24-7.35)	**8.38** (7.68-9.08)	**9.78** (8.91-10.6)	**11.3** (10.2-12.2)	**13.0** (11.7-14.1)	**15.6** (13.8-16.9)	**17.8** (15.6-19.3)
7-day	**4.19** (3.91-4.54)	**5.06** (4.71-5.47)	**6.41** (5.96-6.92)	**7.55** (7.00-8.15)	**9.24** (8.52-9.95)	**10.7** (9.80-11.5)	**12.3** (11.2-13.2)	**14.0** (12.7-15.1)	**16.6** (14.8-17.9)	**18.8** (16.6-20.2)
10-day	**4.73** (4.44-5.07)	**5.68** (5.33-6.08)	**7.08** (6.63-7.58)	**8.24** (7.69-8.81)	**9.91** (9.21-10.6)	**11.3** (10.5-12.1)	**12.8** (11.8-13.7)	**14.4** (13.2-15.4)	**16.9** (15.3-18.0)	**19.0** (17.0-20.4)
20-day	**6.30** (5.94-6.68)	**7.49** (7.07-7.95)	**9.06** (8.55-9.61)	**10.3** (9.73-11.0)	**12.1** (11.4-12.8)	**13.5** (12.7-14.3)	**15.0** (14.0-15.9)	**16.6** (15.4-17.6)	**18.7** (17.2-19.8)	**20.5** (18.7-21.7)
30-day	**7.86** (7.45-8.31)	**9.31** (8.82-9.84)	**11.1** (10.5-11.7)	**12.5** (11.8-13.2)	**14.4** (13.6-15.3)	**16.0** (15.0-16.9)	**17.5** (16.4-18.5)	**19.1** (17.8-20.2)	**21.3** (19.7-22.5)	**22.9** (21.2-24.3)
45-day	**9.87** (9.38-10.4)	**11.6** (11.1-12.3)	**13.6** (13.0-14.4)	**15.2** (14.4-16.0)	**17.2** (16.3-18.1)	**18.7** (17.7-19.7)	**20.2** (19.1-21.3)	**21.7** (20.4-22.9)	**23.6** (22.1-24.9)	**25.0** (23.3-26.4)
60-day	**11.8** (11.3-12.4)	**13.9** (13.2-14.6)	**16.1** (15.3-16.9)	**17.7** (16.8-18.6)	**19.8** (18.8-20.7)	**21.3** (20.2-22.4)	**22.8** (21.5-23.9)	**24.1** (22.8-25.4)	**25.9** (24.4-27.2)	**27.1** (25.5-28.6)

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

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

Please refer to NOAA Atlas 14 document for more information.



Rainfall data sources

This section lists the most current 24-hour rainfall data published by the National Weather Service (NWS) for various parts of the country. Because NWS Technical Paper 40 (TP-40) is out of print, the 24-hour rainfall maps for areas east of the 105th meridian are included here as figures B-3 through B-8. For the area generally west of the 105th meridian, TP-40 has been superseded by NOAA Atlas 2, the Precipitation-Frequency Atlas of the Western United States, published by the National Ocean and Atmospheric Administration.

East of 105th meridian

Hershfield, D.M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 155 p.

West of 105th meridian

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-frequency atlas of the Western United States. Vol. I Montana; Vol. II, Wyoming; Vol III, Colorado; Vol. IV, New Mexico; Vol V, Idaho; Vol. VI, Utah; Vol. VII, Nevada; Vol. VIII, Arizona; Vol. IX, Washington; Vol. X, Oregon; Vol. XI, California. U.S. Dept. of Commerce, National Weather Service, NOAA Atlas 2. Silver Spring, MD.

Alaska

Miller, John F. 1963. Probable maximum precipitation and rainfall-frequency data for Alaska for areas to 400 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. of Commerce, Weather Bur. Tech. Pap. No. 47. Washington, DC. 69 p.

Hawaii

Weather Bureau. 1962. Rainfall-frequency atlas of the Hawaiian Islands for areas to 200 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 43. Washington, DC. 60 p.

Puerto Rico and Virgin Islands

Weather Bureau. 1961. Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands for areas to 400 square miles, durations to 24 hours, and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 42. Washington, DC. 94 P.

This appendix reprinted from S.C.S. TR-55, revised 1986.

APPENDIX B

Subcatchment Delineation

Client:	**NRG Indian River Power, LLC**
Project:	**Indian River Landfill CCR Compliance**
Project #:	**631214281**
Calculated By: SJL	**Date:** 9/23/16
Checked by: RDS	**Date:** 9/27/16

TITLE: SUBCATCHMENT DELINEATION

Problem Statement

Delineate the subcatchment areas (watersheds) for permitted conditions for the Indian River Landfill (Phase I & II). For the purpose of this analysis, the permitted conditions set forth within the Indian River Landfill Industrial Permit SW12/01 are utilized to demonstrate compliance with Title 40 Code of Federal Regulations Part 257.81(a).

Given

Stormwater Run-off Subcatchments

Subcatchment areas were delineated based on topographic divides and stormwater conveyance features within Phase I and II. The permitted landfill consists of terrace berms and letdown pipes that convey stormwater from the surface of the landfill to two different locations, the Northeast Detention Basin and the South Detention Basin.

Stormwater Run-on Subcatchments

Based on permitted site topography, it was determined that stormwater run-on flowing towards the landfill is prevented by a perimeter berm that is approximately 8 to 20 feet high. The perimeter berm structure surrounds Phase I and II in order to adequately prevent run-on from adjacent areas.

The subcatchment areas for the permitted conditions are shown on **Figure 3.**

Results

Delineations of the permitted stormwater subcatchments areas for the Indian River Landfill area shown on **Figure 3.** The approximate acreage of all subcatchment areas for the permitted conditions and ultimate discharge locations for each area are summarized in **Table B-1**.

Client: NRG Indian River Power, LLC

Project: Indian River Landfill CCR Compliance

Project #: 631214281

Calculated By: SJL Date: 9/23/16

Checked by: RDS Date: 9/27/16

TITLE: SUBCATCHMENT DELINEATION

Table B-1 Subcatchment Delineation Permitted Conditions		
Subcatchment	**Area (ft^2)**	**Area (acre)**
Areas Managed Onsite		
Ultimate Discharge Location : Northeast Basin		
EX1	323,639	7.4
EX2	357,966	8.2
EX3	633,173	14.5
EX4	54,498	1.3
EX5	591,348	13.6
EX6	153,981	3.5
EX7	411,099	9.4
Northeast Basin	429,247	9.9
Northeast Basin Subtotal:	**2,954,951**	**68**
Ultimate Discharge Location : Southwest Basin		
EX8	512,471	11.8
Southwest Basin	186,745	4.3
Southwest Basin Subtotal:	**699,216**	**16**
Onsite Subtotal:	**3,654,167**	**84**

APPENDIX C

Curve Number Determination

Client: NRG Indian River Power, LLC

Project: Indian River Landfill CCR Compliance

Project #: 631214281

Calculated By: SJL Date: 09/23/16

Checked by: RDS Date: 09/27/16

TITLE: DETERMINATION OF CURVE NUMBER

Problem Statement

Determine the weighted curve numbers (CN) for the permitted conditions of the Indian River Landfill. The CN is used to determine stormwater runoff.

Given

The curve number was determined using the maps and information provided by:

- Custom Soil Resource Report for Sussex County, Delaware, Indian River Landfill (Web Survey). obtained from the United States Department of Agriculture - Natural Resources Conservation Service website (http://websoilsurvey.sc.egov.usda.gov);

- Technical Release 55 (TR-55), Urban Hydrology for Small Watersheds, published by the Soil Conservation Service.

Assumptions

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, 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.

HydroCAD utilizes curve number table values that are published by the SCS (NRCS) in technical resource TR-55. The tables provide typical curve numbers for each land cover and soil group pairing.

TR-55 describes the various hydrologic soil groups as follows:

Group A: Soils with low runoff potential; typically more than 90 percent sand or gravel.

Group B: Moderately low runoff potential with water transmission through the soil unimpeded. Group B soils typically have between 10 and 20 percent clay and 50 to 90 percent sand and have loamy sand or sandy loam textures.

Group C: Moderately high runoff potential. Typically have between 20 and 40 percent clay and less than 50 percent sand, and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures.

Group D: High runoff potential. Typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures.

Client: NRG Indian River Power, LLC

Project: Indian River Landfill CCR Compliance

Project #: 631214281

Calculated By: SJL Date: 09/23/16

Checked by: RDS Date: 09/27/16

TITLE: DETERMINATION OF CURVE NUMBER

The NRCS publishes surficial soil surveys for most areas of the United States. Their *Soil Survey of Sussex County, Delaware* was consulted to identify surficial soils at the facility. For each surficial soil, a name, general description, and Soil Group is provided. This document, in addition to the known landcovers and boundaries of various features, is used to determine the weighted runoff curve number for each subcatchment area.

Selection of Modeled Conditions

The permitted conditions are modeled in the final configuration to ensure that all downstream elements are appropriately sized. Final cover conditions are selected to be the most appropriate, as this reflects long term conditions.

Calculation Method

Surficial Soils

The NRCS was used to delineate surficial soils at the facility in Phase I and II. Based on the NRCS Soil Survey for Sussex County, the entire site is comprised of Soil Group A Soils. The description of each soil is provided in the Soil Survey of Sussex County (refer to attachments).

Land Cover

The land covers were delineated for the permitted conditions based on a review of aerial topography and the topographic survey. Vegetated final cover conditions are considered appropriate for use in modeling due to the fact that the landfill will be constructed in phases and final cover will be installed upon achieving final grades. The land cover for the permitted landfill final cover was conservatively assumed to be grassland that is periodically mowed. The TR-55 manual designates this land cover type as “pasture, grassland, or range”.

The TR-55 manual provides lookup tables of curve numbers for combinations of various land covers and the underlying surficial soils. The TR-55 lookup tables for curve numbers are provided within HydroCAD and can be designated for each subcatchment.

Results

Based on a review of the surficial soil types and land covers, it was determined that the surficial soils and land covers were the same for each subcatchment. Each subcatchment within the stormwater model was designated to consist of Soil Group A Soils and “pasture, grassland, or range” land covers. The run-off curve number associated with these parameters is estimated to be 49, based on the TR-55 manual.

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Sussex County, Delaware

Indian River Landfill

September 27, 2016

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map

Map Scale: 1:7,570 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0, 100, 200, 400, 600

Feet: 0, 350, 700, 1400, 2100

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Sussex County, Delaware
Survey Area Data: Version 14, Sep 29, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 17, 2010—Jul 4, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Sussex County, Delaware (DE005)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
FhA	Fort Mott-Henlopen complex, 0 to 2 percent slopes	64.5	31.3%
FhB	Fort Mott-Henlopen complex, 2 to 5 percent slopes	71.8	34.9%
HpA	Henlopen loamy sand, 0 to 2 percent slopes	0.6	0.3%
HpB	Henlopen loamy sand, 2 to 5 percent slopes	14.9	7.2%
KsA	Klej loamy sand, 0 to 2 percent slopes	0.1	0.1%
Ma	Manahawkin muck, frequently flooded	0.0	0.0%
Pa	Pawcatuck mucky peat, very frequently flooded, tidal	2.5	1.2%
RoA	Rosedale loamy sand, 0 to 2 percent slopes	0.3	0.2%
RuA	Runclint loamy sand, 0 to 2 percent slopes	3.5	1.7%
UzC	Udorthents, 0 to 10 percent slopes	47.0	22.8%
W	Water	0.8	0.4%
Totals for Area of Interest		**206.0**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Sussex County, Delaware

FhA—Fort Mott-Henlopen complex, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 1qtgh
Elevation: 20 to 70 feet
Mean annual precipitation: 42 to 48 inches
Mean annual air temperature: 52 to 58 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Fort mott and similar soils: 45 percent
Henlopen and similar soils: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Fort Mott

Setting

Landform: Flats, fluviomarine terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy eolian deposits over fluviomarine sediments

Typical profile

Ap - 0 to 10 inches: loamy sand
E - 10 to 24 inches: loamy sand
Bt - 24 to 36 inches: sandy loam
C - 36 to 80 inches: loamy sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (1.28 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.3 inches)

Interpretive groups

Land capability classification (irrigated): 2s
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: A
Hydric soil rating: No

Description of Henlopen

Setting

Landform: Marine terraces, dunes
Down-slope shape: Convex
Across-slope shape: Linear

Parent material: Sandy eolian deposits and loamy fluviomarine sediments

Typical profile

Ap - 0 to 10 inches: loamy sand
E - 10 to 46 inches: loamy sand
Bt - 46 to 62 inches: sandy loam
C - 62 to 80 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): 2s
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Ingleside

Percent of map unit: 5 percent
Landform: Flats
Hydric soil rating: No

Runclint

Percent of map unit: 5 percent
Landform: Dunes, knolls, flats
Hydric soil rating: No

Rosedale

Percent of map unit: 5 percent
Landform: Flats, knolls
Hydric soil rating: No

Downer

Percent of map unit: 5 percent
Landform: Flats
Hydric soil rating: No

FhB—Fort Mott-Henlopen complex, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: 1qtgj
Elevation: 20 to 70 feet
Mean annual precipitation: 42 to 48 inches
Mean annual air temperature: 52 to 58 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Fort mott and similar soils: 45 percent
Henlopen and similar soils: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Fort Mott

Setting

Landform: Flats, knolls, fluviomarine terraces
Landform position (three-dimensional): Rise
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Parent material: Sandy eolian deposits over fluviomarine sediments

Typical profile

Ap - 0 to 10 inches: loamy sand
E - 10 to 24 inches: loamy sand
Bt - 24 to 36 inches: sandy loam
C - 36 to 80 inches: loamy sand

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (1.28 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.3 inches)

Interpretive groups

Land capability classification (irrigated): 2s
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: A
Hydric soil rating: No

Description of Henlopen

Setting

Landform: Marine terraces, dunes
Down-slope shape: Linear, convex
Across-slope shape: Linear
Parent material: Sandy eolian deposits and loamy fluviomarine sediments

Typical profile

Ap - 0 to 10 inches: loamy sand
E - 10 to 46 inches: loamy sand
Bt - 46 to 62 inches: sandy loam
C - 62 to 80 inches: sand

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): 2s
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Ingleside

Percent of map unit: 5 percent
Landform: Flats
Hydric soil rating: No

Runclint

Percent of map unit: 5 percent
Landform: Dunes, knolls, flats
Hydric soil rating: No

Rosedale

Percent of map unit: 5 percent
Landform: Flats, knolls
Hydric soil rating: No

Downer

Percent of map unit: 5 percent
Landform: Flats
Hydric soil rating: No

HpA—Henlopen loamy sand, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 1qth3
Elevation: 20 to 70 feet
Mean annual precipitation: 42 to 48 inches
Mean annual air temperature: 52 to 58 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Henlopen and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Henlopen

Setting

Landform: Marine terraces, dunes
Down-slope shape: Linear, convex
Across-slope shape: Linear
Parent material: Sandy eolian deposits and loamy fluviomarine sediments

Typical profile

Ap - 0 to 10 inches: loamy sand
E - 10 to 46 inches: loamy sand
Bt - 46 to 62 inches: sandy loam
C - 62 to 80 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): 2s
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Ingleside

Percent of map unit: 5 percent
Landform: Flats
Hydric soil rating: No

Runclint

Percent of map unit: 5 percent
Landform: Dunes, knolls, flats
Hydric soil rating: No

Rosedale

Percent of map unit: 5 percent
Landform: Flats, knolls
Hydric soil rating: No

Fort mott

Percent of map unit: 5 percent
Landform: Flats
Hydric soil rating: No

HpB—Henlopen loamy sand, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: 1qth4
Elevation: 20 to 70 feet
Mean annual precipitation: 42 to 48 inches
Mean annual air temperature: 52 to 58 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Henlopen and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Henlopen

Setting

Landform: Marine terraces, dunes
Down-slope shape: Linear, convex
Across-slope shape: Linear
Parent material: Sandy eolian deposits and loamy fluviomarine sediments

Typical profile

Ap - 0 to 10 inches: loamy sand
E - 10 to 46 inches: loamy sand
Bt - 46 to 62 inches: sandy loam
C - 62 to 80 inches: sand

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): 2s
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Fort mott

Percent of map unit: 5 percent
Landform: Flats
Hydric soil rating: No

Ingleside

Percent of map unit: 5 percent
Landform: Flats
Hydric soil rating: No

Runclint

Percent of map unit: 5 percent
Landform: Dunes, knolls, flats
Hydric soil rating: No

Rosedale

Percent of map unit: 5 percent
Landform: Flats, knolls
Hydric soil rating: No

KsA—Klej loamy sand, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 1qthw
Elevation: 0 to 200 feet
Mean annual precipitation: 42 to 48 inches
Mean annual air temperature: 52 to 58 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Klej and similar soils: 70 percent
Minor components: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Klej

Setting

Landform: Flats, depressions
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Parent material: Sandy eolian deposits and/or fluviomarine sediments

Typical profile

A - 0 to 7 inches: loamy sand
E - 7 to 14 inches: loamy sand
Bw - 14 to 20 inches: loamy sand
C - 20 to 62 inches: loamy sand
Cg - 62 to 80 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (0.57 to 19.98 in/hr)
Depth to water table: About 10 to 20 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.4 inches)

Interpretive groups

Land capability classification (irrigated): 3w
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: A/D
Hydric soil rating: No

Minor Components

Galloway

Percent of map unit: 10 percent
Landform: Depressions, flats
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear
Hydric soil rating: No

Runclint

Percent of map unit: 5 percent
Landform: Flats, fluviomarine terraces, dunes, knolls
Landform position (three-dimensional): Rise
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Hydric soil rating: No

Hammonton

Percent of map unit: 5 percent

Landform: Flats, depressions, drainageways
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Hydric soil rating: No

Berryland, drained

Percent of map unit: 5 percent
Landform: Depressions, flats, swales
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Hurlock, drained

Percent of map unit: 5 percent
Landform: Depressions, flats, swales
Landform position (three-dimensional): Dip
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear
Hydric soil rating: Yes

Ma—Manahawkin muck, frequently flooded

Map Unit Setting

National map unit symbol: 1qtj3
Elevation: 0 to 100 feet
Mean annual precipitation: 42 to 48 inches
Mean annual air temperature: 52 to 58 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Manahawkin and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Manahawkin

Setting

Landform: Swamps, flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Organic, woody material over sandy alluvium

Typical profile

Oa1 - 0 to 8 inches: muck
Oa2 - 8 to 40 inches: muck
Cg - 40 to 80 inches: sand

Properties and qualities

Slope: 0 to 1 percent

Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.28 to 19.98 in/hr)
Depth to water table: About 0 to 5 inches
Frequency of flooding: Frequent
Frequency of ponding: Frequent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very high (about 17.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7w
Hydrologic Soil Group: A/D
Hydric soil rating: Yes

Minor Components

Puckum

Percent of map unit: 10 percent
Landform: Flood plains, swamps, depressions
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Hydric soil rating: Yes

Indiantown

Percent of map unit: 5 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Pa—Pawcatuck mucky peat, very frequently flooded, tidal

Map Unit Setting

National map unit symbol: 1qtjf
Mean annual precipitation: 42 to 48 inches
Mean annual air temperature: 52 to 58 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Pawcatuck, very frequently flooded, and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pawcatuck, Very Frequently Flooded

Setting

Landform: Tidal flats

Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Herbaceous organic material over sandy marine deposits

Typical profile

Oe1 - 0 to 14 inches: mucky peat
Oe2 - 14 to 45 inches: mucky peat
Cg1 - 45 to 50 inches: loamy sand
Cg2 - 50 to 90 inches: sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (0.57 to 19.98 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: Very frequent
Frequency of ponding: Frequent
Salinity, maximum in profile: Very slightly saline to strongly saline (2.0 to 32.0 mmhos/cm)
Available water storage in profile: Very high (about 13.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydrologic Soil Group: A/D
Hydric soil rating: Yes

Minor Components

Transquaking

Percent of map unit: 10 percent
Landform: Tidal marshes
Hydric soil rating: Yes

Mispillion

Percent of map unit: 5 percent
Landform: Tidal marshes, flood plains
Hydric soil rating: Yes

Sunken

Percent of map unit: 5 percent
Landform: Submerged upland tidal marshes
Hydric soil rating: Yes

RoA—Rosedale loamy sand, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 1qtjx
Elevation: 0 to 120 feet

Mean annual precipitation: 42 to 48 inches
Mean annual air temperature: 52 to 58 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Rosedale and similar soils: 75 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rosedale

Setting

Landform: Flats
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy eolian deposits over fluviomarine sediments

Typical profile

A - 0 to 9 inches: loamy sand
E - 9 to 25 inches: loamy sand
Bt - 25 to 38 inches: sandy loam
C - 38 to 68 inches: loamy sand
2Cg - 68 to 80 inches: sandy clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 5.95 in/hr)
Depth to water table: About 40 to 72 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.3 inches)

Interpretive groups

Land capability classification (irrigated): 2s
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Evesboro

Percent of map unit: 10 percent
Landform: Flats
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Hambrook

Percent of map unit: 5 percent
Landform: Fluviomarine terraces, flats, depressions
Down-slope shape: Linear, concave

Across-slope shape: Linear, concave
Hydric soil rating: No

Galloway

Percent of map unit: 5 percent
Landform: Depressions, flats
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear
Hydric soil rating: No

Klej

Percent of map unit: 5 percent
Landform: Flats, depressions
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Hydric soil rating: No

RuA—Runclint loamy sand, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 1qtjz
Elevation: 0 to 120 feet
Mean annual precipitation: 42 to 48 inches
Mean annual air temperature: 52 to 58 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Runclint and similar soils: 75 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Runclint

Setting

Landform: Flats, fluviomarine terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy eolian deposits and/or fluviomarine sediments

Typical profile

Ap - 0 to 9 inches: loamy sand
E - 9 to 22 inches: sand
Bw - 22 to 39 inches: sand
BC - 39 to 59 inches: sand
2C - 59 to 80 inches: loamy coarse sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained

Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (0.57 to 19.98 in/hr)
Depth to water table: About 40 to 72 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.5 inches)

Interpretive groups

Land capability classification (irrigated): 3s
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Evesboro

Percent of map unit: 10 percent
Landform: Flats
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Galloway

Percent of map unit: 5 percent
Landform: Depressions, flats
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear
Hydric soil rating: No

Hurlock, drained

Percent of map unit: 5 percent
Landform: Swales, depressions, flats
Landform position (three-dimensional): Dip
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: Yes

Klej

Percent of map unit: 5 percent
Landform: Flats, depressions
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Hydric soil rating: No

UzC—Udorthents, 0 to 10 percent slopes

Map Unit Setting

National map unit symbol: 1qtkv
Elevation: 10 to 200 feet

Mean annual precipitation: 42 to 48 inches
Mean annual air temperature: 52 to 58 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Udorthents, loamy, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udorthents, Loamy

Setting

Landform: Knolls, flats
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Fluviomarine sediments

Typical profile

C1 - 0 to 4 inches: sandy loam
C2 - 4 to 80 inches: sandy loam

Properties and qualities

Slope: 0 to 10 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 40 to 72 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Urban land

Percent of map unit: 10 percent
Landform: Flats, knolls
Hydric soil rating: No

W—Water

Map Unit Setting

National map unit symbol: 1qtkx
Mean annual precipitation: 42 to 48 inches

Mean annual air temperature: 52 to 58 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

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APPENDIX D

Time of Concentration Calculation

Client: NRG Indian River Power, LLC

Project: Indian River Landfill CCR Compliance

Project #: 631214281

Calculated By: SJL Date: 09/23/16

Checked by: RDS Date: 09/27/16

TITLE: TIME OF CONCENTRATION CALCULATION

Problem Statement

Summarize the input parameters for HydroCAD related to time of concentration determination for the permitted conditions at the Indian River Landfill. These parameters are used to describe how stormwater runoff is distributed over time. The time of concentration is defined as the longest amount of time a waterdrop would take to travel from the headwater of a subcatchment area to its downstream edge (ie. prior to being managed by a downstream element). HydroCAD automatically calculates the time of concentration based on the input values summarized in this document.

Given

- ❑ Stormwater falling on the Landfill will be directed using a system of terrace berms and letdown pipes.
- ❑ The time of concentration flow paths for the permitted conditions are shown on **Figure 3.**
- ❑ The methodology that HydroCAD uses to calculate the SCS lag time is based on Technical Release 55 (TR-55), Urban Hydrology for Small Watersheds, published by the Soil Conservation Service.
- ❑ Sheet flow is assumed to become shallow concentrated flow at 100 feet, which is conservative in comparison to 300 feet, which is designated in the TR-55 Manual. Additionally, the Sussex County Conservation District and 7 Del.C. Ch.60, *SSWR* require a maximum length of sheet flow of 100 feet for vegetated surfaces and 150 feet for paved surfaces. Please see the following attachment from the HydroCAD Technical Reference for a summary table of velocity factors for shallow concentrated flow determinations.

Assumptions

The following assumptions were made in the 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 four types of flow: sheet flow, shallow concentrated flow, open channel flow, and pipe flow.
- ❑ Sheet flow is assumed to become shallow concentrated flow at 100 feet, which is conservative in comparison to 300 feet, which is designated in the TR-55 Manual. Additionally, the Sussex County Conservation District and 7 Del.C. Ch.60, *SSWR* require a maximum length of sheet flow of 100 feet for vegetated surfaces and 150 feet for paved surfaces..
- ❑ The Manning's coefficient "n" for sheet flow for the permitted conditions at the landfill is assumed to be 0.24, indicative of dense-grass vegetative cover. This number is a HydroCAD default for "grass: dense" and is considered most indicative of the anticipated

grass type that will be used for the landfill final vegetative cover.

- For permitted conditions, an average flow velocity of 7 ft/sec was assumed in shallow concentrated flow calculations for the landfill, which is the HydroCAD default for "short grass pasture", which is considered most indicative of the anticipated grass type that will be used for the landfill final vegetative cover.

- Stormwater flowing from each watershed collects in terrace benches situated on the permitted landfill side slopes. In the time of concentration calculation for each subcatchment, the terrace berms were modeled as v-notch channels. Each terrace bench was modeled to reflect permitted design specifications.

- For stormwater flow through the terrace benches, a Manning's coefficient of 0.035 was assumed in the channel flow calculations for the landfill, which is the HydroCAD default for "earth lined channel, dense weeds", which is considered most indicative of the anticipated grass type within the terrace benches.

- A number of letdown pipes are installed throughout Phases I and II where terrace benches converge. These letdown pipes were incorporated in the calculation of the total time of concentration within each watershed. Each letdown pipe was modeled as a 24-inch, corrugated plastic pipe, as reflected in permitted design specifications.

- The Manning's coefficient "n" for pipe flow for the permitted conditions letdown pipes is assumed to be 0.13, indicative of corrugated poly-ethylene pipe.

Calculations

The following formulas are used by HydroCAD to determine lag times:

Sheet Flow:

Sheet flow is flow over plane surfaces and is calculated by HydroCAD using the following equation.

$$T_t = \frac{(0.007(nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

Where:

T_t =	Travel time (hours)
P_2 =	2-year, 24-hour rainfall
S =	Land slope along flow path (ft/ft)
L =	Flow Length (ft)
n =	Manning's coefficient

Shallow Concentrated Flow:

Average velocity is calculated by HydroCAD using the following equation.

$$T_t = \frac{L}{3,600V}$$

Where:

T_t =	Travel time (hours)
L =	Flow Length, ft
V =	Average velocity, ft/sec
3,600 =	Conversion factor from seconds to hours

Client: NRG Indian River Power, LLC
Project: Indian River Landfill CCR Compliance
Project #: 631214281
Calculated By: SJL Date: 09/23/16
Checked by: RDS Date: 09/27/16

TITLE: TIME OF CONCENTRATION CALCULATION

Channel Flow/Pipe Flow:

Channel flow and pipe flow within the terrace benches and letdown pipes are calculated by HydroCAD using the following equation:

$$T_t = \frac{L}{3,600V}$$

Where:

T_t =		Travel time (hours)
L	=	Flow Length, ft
V	=	Average velocity, ft/sec
3,600	=	Conversion factor from seconds to hours

Channel flow and pipe flow utilize the Manning's equation to solve for the average velocity. HydroCAD calculates the average velocity using the following equation:

$$V = (1.49/n)\, R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where:

V	=	Average velocity, ft/sec
n	=	Manning's coefficient
R	=	Hydraulic radius, ft
S	=	Channel slope, ft/ft

Results

The time of concentration flow paths for the permitted conditions are represented in **Figure 4**. A summary of the flow lengths and slopes used to calculate the lag time for each subcatchment area is provided in **Table D-1**. The table also includes the Time of Concentration calculated by HydroCAD for each subcatchment area.

TABLE D-1															
Indian River Landfill Run-on/Run-off Control Plan															
Time of Concentration Summary															
Subcatchment Name	Area (Acres)	Curve Number	Sheet Flow		Shallow Concentrated		Shallow Concentrated Flow 2		Channel Flow 1		Channel Flow 2		Pipe Flow		Time of Concen.
			Length (ft)	Slope (ft/ft)	Length (ft)	Slope (ft/ft)	Length (ft)	Slope (ft/ft)	Length (ft)	Slope (ft/ft)	Length (ft)	Slope (ft/ft)	Length (ft)	Slope (ft/ft)	(Min)
Existing Conditions															
EX1	7.4	49	100	0.018	77	0.018	42	0.33	97	0.015			191	0.262	16.6
EX2	8.2	49	100	0.043	427	0.015							261	0.284	18.6
EX3	14.5	49	100	0.015	303	0.015			467	0.012			273	0.33	24.2
EX4	1.3	49	38	0.33					289	0.04					2.7
EX5	13.6	49	100	0.015	361	0.015			843	0.045	617	0.015	243	0.33	27.4
EX6	3.5	49	52	0.33					516	0.015			199	0.33	5.5
EX7	9.4	49	100	0.015	318	0.015	12	0.33	70	0.0142			229	0.33	22.2
EX8	11.8	49	100	0.015	635	0.015			370	0.016			231	0.33	29.0
Northeast Basin	9.7	49	54	0.33											2.7
South Basin	4.3	49	40	0.02											6.6

Appendix G: Velocity Factors

The Shallow Concentrated Flow procedure (a.k.a. Upland Method) uses a *velocity factor*, K_V, as listed below. The first two surfaces (paved and unpaved) are the basis for TR-55 Figure 3-1, and the factors were originally obtained from TR-55 Appendix F. The remaining surfaces were taken from NEH-4 Figure 15.2, with the factors derived from that chart. Subsequent revisions to NEH Part 630 provide *numerical* K_V values which are in good agreement with the original chart, except for “Grassed Waterways”, which appears to have changed from 15.0 to 16.13, making it the same as the TR-55 “Unpaved” condition. For compatibility with previous calculations, the HydroCAD lookup table continues to supply the original K_V values as listed below. If different values are required for any reason, HydroCAD allows direct K_V entry instead of using the lookup table. See page 55 for further details on Shallow Concentrated Flow.

Surface Description	K_V [ft/sec]	K_V [m/sec]
Paved	20.33	6.2
Unpaved	16.13	4.92
Grassed Waterway	15.0	4.57
Nearly Bare & Untilled	10.0	3.05
Cultivated Straight Rows	9.0	2.74
Short Grass Pasture	7.0	2.13
Woodland	5.0	1.52
Forest w/Heavy Litter	2.5	0.76

Some descriptions have been abbreviated. Velocity factors have the same units as a velocity, and may be converted between English and metric as described on page 43.

APPENDIX E

Subcatchment Discharge Rates

Client:	NRG Indian River Power, LLC.
Project:	Indian River Landfill CCR Compliance
Project #:	631214281
Calculated By: SJL	Date: 09/26/16
Checked by: RDS	Date: 09/27/16

TITLE: SUBCATCHMENT DISCHARGE RATES

Problem Statement

Determine the stormwater runoff rates for the 25-year, 24-hour storm event at the permitted conditions for the Indian River Landfill. Stormwater discharge rates from the various subcatchment areas are used to determine the adequacy of terrace berms, letdown pipes, perimeter ditches and detention basins in accordance with Title 40 Code of Federal Regulations 257.81.

Given

The stormwater runoff was calculated using HydroCAD. Various parameters, such as rainfall, drainage area, flow lengths within subcatchment areas, and discharge and storage volume of the stormwater detention basins are entered into the program. This calculation provides a summary of these input values and the model results. Equations to determine these parameters are described in previous portions of this appendix.

Storm Model Setup

The stormwater methodology and base information was defined as follows:

Runoff Calculation Method:	SCS TR-20
Reach Routing Method:	Storage Indication + Translation Method
Pond Routing Method:	Storage Indication Method (Modified-Puls)
Storm Distribution:	SCS Type II 24-hour storm
Unit Hydrograph:	SCS
Antecedent Moisture Condition:	2

Model Calculations and Results

The stormwater model was analyzed for the 25-year, 24-hour storm event. Subcatchment areas for the permitted conditions were modeled. **Table E-1** summarizes the peak discharge rates for the 25-year, 24-hour storm event. Please see **Appendix I** for the HydroCAD Output Files.

Client: NRG Indian River Power, LLC.

Project: Indian River Landfill CCR Compliance

Project #: 631214281

Calculated By: SJL Date: 09/26/16

Checked by: RDS Date: 09/27/16

TITLE: SUBCATCHMENT DISCHARGE RATES

TABLE E-1 Indian River Landfill Run-on/Run-off Control Plan Subcatchment Discharge Rate Summary	
Subcatchment Name	**25-year, 24-hour storm event**
Existing Conditions (cfs)	
EX1	10.75
EX2	11.03
EX3	16.40
EX4	3.23
EX5	14.03
EX6	7.97
EX7	11.27
EX8	11.73
Northeast Basin	25.44
South Basin	9.43

APPENDIX F

Perimeter Ditch Sizing

Client:	**NRG Indian River Power, LLC**		
Project:	**Indian River Landfill CCR Compliance**		
Project #:	**631214281**		
Calculated By:	**SJL**	**Date:**	**09/26/16**
Checked by:	**RDS**	**Date:**	**09/27/16**

TITLE: PERIMETER DITCH SIZING

Problem Statement

Determine whether the stormwater ditches are sized to handle the peak flow velocities and depths associated with the 25-year, 24-hour storm even, in accordance with Title 40 Code of Federal Regulations 257.81. The ditches around the perimeter of the waste footprint are considered.

Assumptions

- ❑ Ditches were modeled assuming that the landfill is fully developed and closed in accordance with the permitted conditions.

- ❑ A Manning's coefficient of 0.030 was modeled in HydroCAD to represent grass-lined perimeter ditches. This value is used to calculate the critical velocity for the perimeter ditches. The lower value in the analysis results in a higher velocity and is used to determine if the ditch is adequately lined to minimize scour and erosion.

- ❑ Perimeter ditches at the Landfill range in depth, channel slope, side slope, and bottom width. Dimensions for each perimeter ditch segment have been provided in **Table F-1**.

- ❑ Perimeter ditches shall convey run-off from the 25-year, 24-hour storm event without overtopping.

- ❑ Flow velocities observed during the 25-year, 24-hour storm event within perimeter ditches shall not exceed 5 feet per second (fps), based on the design perimeter ditch liner. Erosion or scour may be anticipated to occur at flow velocities exceeding 5 fps for grass-lined channels. Erosion control measures such as riprap, turf reinforcement mat, or other appropriate erosion control material may be utilized in perimeter ditches with flow velocities that exceed 5 fps.

Client: NRG Indian River Power, LLC

Project: Indian River Landfill CCR Compliance

Project #: 631214281

Calculated By: SJL Date: 09/26/16

Checked by: RDS Date: 09/27/16

TITLE: PERIMETER DITCH SIZING

Calculations

Calculations were performed using the computer program, HydroCAD. The program uses Manning's equation.

$$V = (1.49/n)\, R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where:

V = mean velocity, ft/sec
n = Manning's roughness coefficient
R = hydraulic radius, ft
S = slope, ft/ft

Manning's n, peak flow, sideslope, and channel slope were entered into HydroCAD. HydroCAD is able to calculate peak flow depth and velocity.

The locations of the perimeter ditches are shown in **Figure 4**. Design parameters of each stormwater ditch, including sideslopes, slope, depth, and base width can be found in **Table F-1**.

Results

All perimeter ditches have been designed to appropriately convey the 25-year, 24-hour storm event without overtopping. Flow velocities within the perimeter ditches do not exceed 5 fps, which indicates that erosion or scour is not anticipated to occur. Peak depth and flow velocity within each perimeter ditch can be found in **Table F-1**.

Conclusions

All perimeter ditches are appropriately sized to convey the 25-year, 24-hour storm event without overtopping or eroding. The HydroCAD results for design parameters are summarized in **Table F-1**.

TABLE F-1 Indian River Landfill Run-on/Run-off Control Plan Perimeter Ditch Design Summary										
Ditch Name	**Design Parameters**					**Model Results: 25-year, 24-hour Storm**				
	Sideslopes (H:V)		**Slope (ft/ft)**	**Depth (ft)**	**Base Width (ft)**	**Peak Velocity (ft/s)**	**Erosion/Scour Anticipated?[2] YES/NO**	**Peak Depth (ft)**	**Design Depth > Peak Depth? YES/NO**
	Left	**Right**							
PC-2	1:1	1:1	0.0100	1	8	2.86	NO	0.44	YES
PC-3	1:1	1:1	0.0100	1	8	2.81	NO	0.47	YES
PC-4	1:1	1:1	0.0100	2	6	4.09	NO	0.79	YES
PC-5	2:1	3:1	0.0185	2	2	2.79	NO	0.37	YES
PC-6	2:1	3:1	0.0052	2	6	2.50	NO	0.74	YES
PC-9	2:1	3:1	0.0108	2	6	3.14	NO	0.74	YES

Note:

1. Peak flow depths and velocities are based on a Manning's coefficient of 0.030, which is typical for well-maintained vegetation.

2. Peak flow velocities that exceed 5 feet per second (fps) in vegetative-lined ditches are anticipated to have erosion or scour.

APPENDIX G

Terrace Berm and Letdown Pipe Sizing

Client:	**NRG Indian River Power, LLC**		
Project:	**Indian River Landfill CCR Compliance**		
Project #:	**631214281**		
Calculated By:	**SJL**	**Date:**	**09/26/16**
Checked by:	**RDS**	**Date:**	**09/27/16**

TITLE: TERRACE BENCH AND LETDOWN PIPE SIZING

Problem Statement

Determine whether the terrace benches and downslope ditches are sized to handle the peak flow velocities and depths anticipated for the 25-year, 24-hour storm event, in accordance with Title 40 Code of Federal Regulations 257.81.

Given

- The locations of the terrace benches and downslope ditches are shown in **Figure 4.**
- The peak discharge rates for each subcatchment area for the Landfill are provided in **Appendix E**. The supporting HydroCAD model results are provided in **Appendix I**.

Assumptions

Terrace benches and letdown pipes at the Indian River Landfill are design and constructed to have identical depths, channels slopes, and side slopes. The largest subcatchment area that contributes stormwater flow into the terrace bench and letdown pipe system was modeled to determine whether these features are sized to handle the peak flow velocity and depth anticipated for the 25-year, 24-hour storm. Terrace benches and letdown pipes are sized appropriately at the Indian River Landfill if they can properly convey the stormwater volume from the largest subcatchment without overtopping or eroding.

Based on the permitted conditions at the Indian River landfill, it was determined that the largest subcatchment area contributing stormwater flow into the terrace benches and letdown pipes is the plateau section within EX3. Approximately 6 acres of the plateau section within subcatchment EX3 flow into the terrace bench denoted TB 1 in **Figure 4.** Approximately 9 acres of the plateau section within subcatchment EX3 flow into the letdown pipe denoted DP2. These contributing areas have been manually entered into HydroCAD.

Client:	NRG Indian River Power, LLC
Project:	Indian River Landfill CCR Compliance
Project #:	631214281
Calculated By: SJL	Date: 09/26/16
Checked by: RDS	Date: 09/27/16

TITLE: TERRACE BENCH AND LETDOWN PIPE SIZING

Terrace Benches

Terrace benches have been designed to intercept runoff from the final landform in order to prevent erosion and reduce the drainage length of runoff. These benches drain toward letdown pipes that discharge into the perimeter drainage ditches. The terrace benches are generally spaced every 20 vertical feet, or every 60 slope feet.

- ❑ All terrace benches are be constructed with the following design specifications:
  - o Terrace benches intercepting flow from the plateau section of the Indian River Landfill are trapezoidal channels with a 0.5 foot depth, 7 foot bottom width, 3H:1V and 10H:1V side slopes, and a 1.5% channel slope.
  - o All side slope terrace benches are v-notch channels with a 1.0 foot depth, 3H:1V and 10H:1V side slopes, and a channel slope of 1.5%.
- ❑ All terrace benches are lined with vegetation.

Letdown Pipes

- ❑ Letdown pipes are 24” diameter smooth-walled plastic pipe sloped at 3H:1V. These pipes convey stormwater from the terrace benches to the perimeter drainage channels.

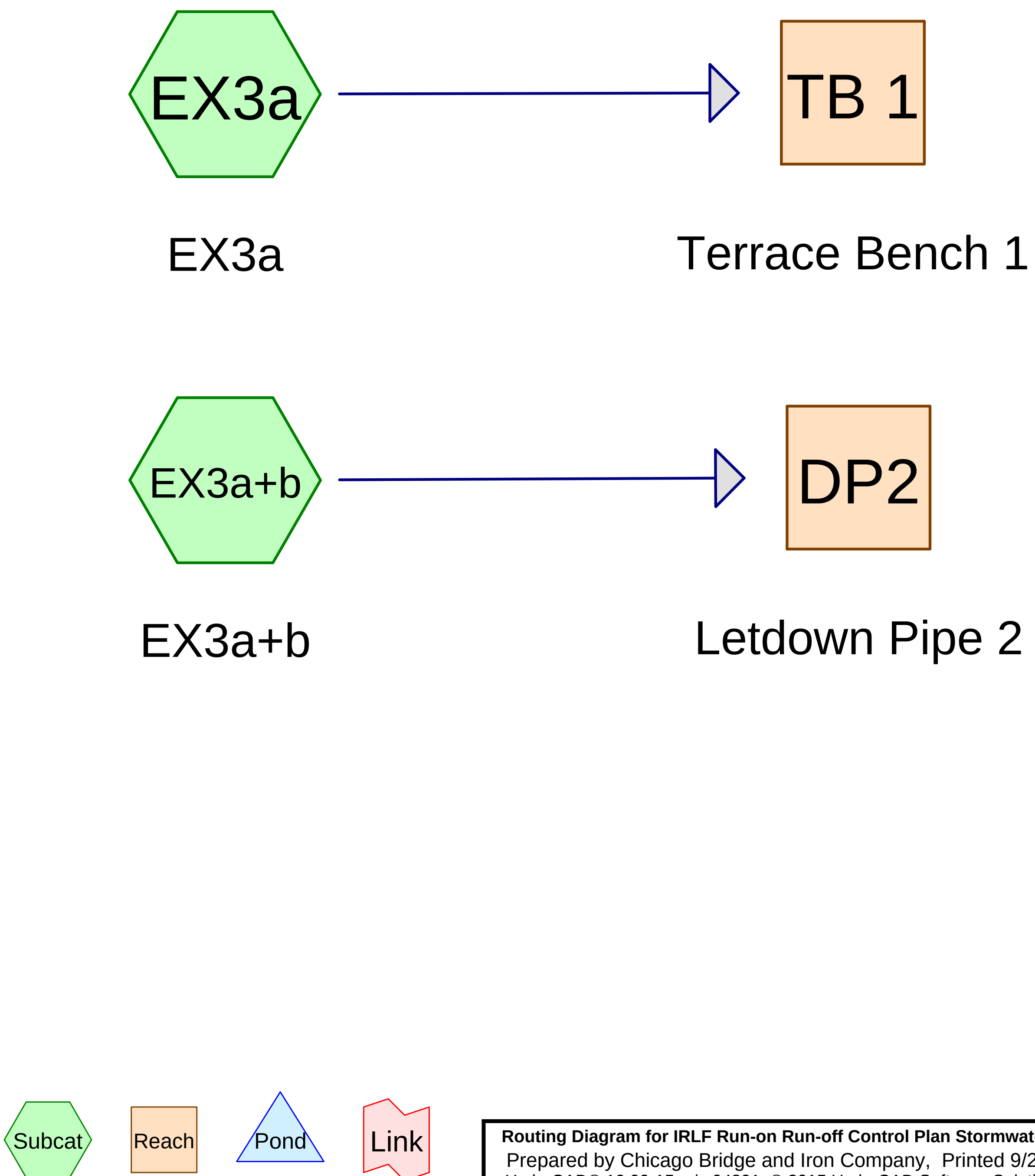
Manning’s Coefficients

- ❑ A Manning’s coefficient of 0.030 was modeled in HydroCAD to represent grass-lined terrace benches. This value is used to calculate the critical velocity for the perimeter ditches. The lower value in the analysis results in a higher velocity and is used to determine if the ditch is adequately lined to minimize scour and erosion.
- ❑ A Manning’s coefficient of 0.013 was assumed for the letdown pipes and is typical of smooth walled plastic pipe.

Results

The peak velocity and depth was analyzed for the terrace bench and letdown pipe that receives the largest amount of stormwater during the 25-year, 24-hour storm event. Based on model findings, the terrace benches and letdown pipes at the Indian River Landfill are appropriately sized to handle peak velocities and depths associated with the 25-year, 24-hour storm event from the largest contributing subcatchment area.

The HydroCAD results for the terrace bench and letdown pipe analysis are attached.



Routing Diagram for IRLF Run-on Run-off Control Plan Stormwater Features
Prepared by Chicago Bridge and Iron Company, Printed 9/27/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
15.037	49	Pasture/grassland/range, Fair, HSG A (EX3a, EX3a+b)

Summary for Subcatchment EX3a: EX3a

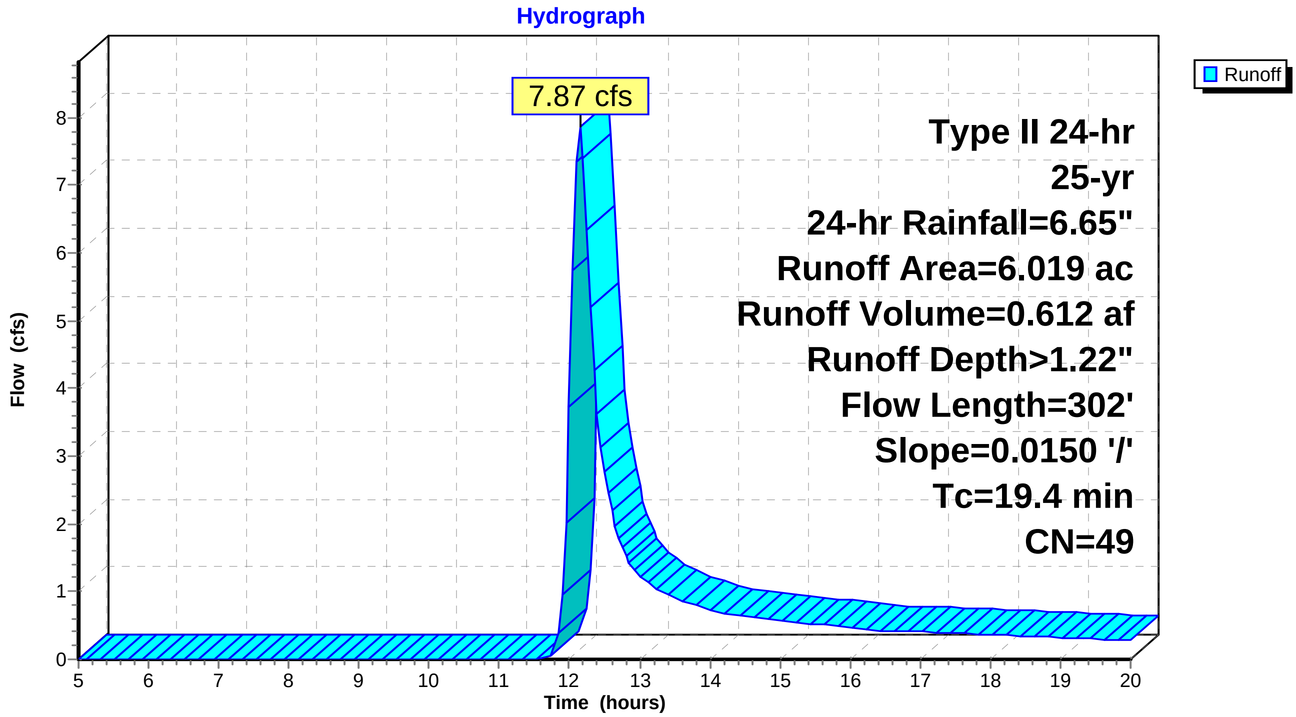
Runoff = 7.87 cfs @ 12.15 hrs, Volume= 0.612 af, Depth> 1.22"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.65"

Area (ac)	CN	Description
6.019	49	Pasture/grassland/range, Fair, HSG A
6.019		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.5	100	0.0150	0.11		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.42"
3.9	202	0.0150	0.86		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
19.4	302	Total			

Subcatchment EX3a: EX3a



Summary for Subcatchment EX3a+b: EX3a+b

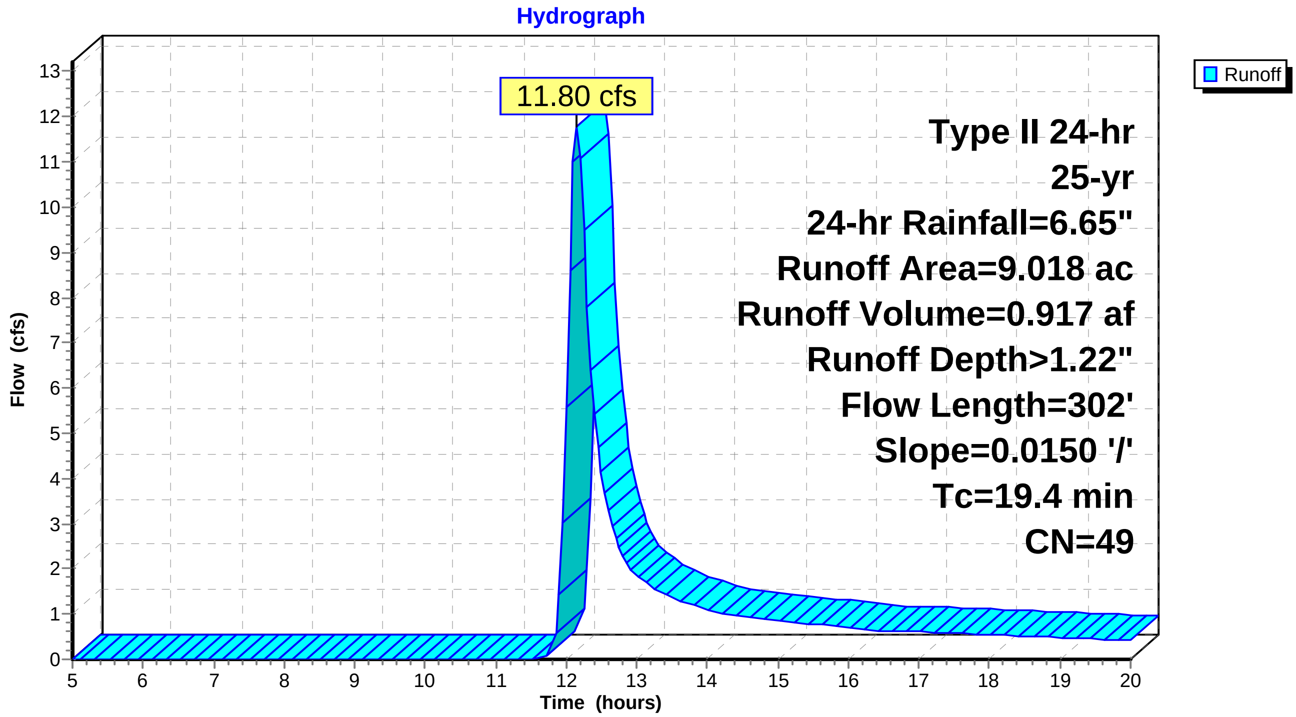
Runoff = 11.80 cfs @ 12.15 hrs, Volume= 0.917 af, Depth> 1.22"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.65"

Area (ac)	CN	Description
9.018	49	Pasture/grassland/range, Fair, HSG A
9.018		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.5	100	0.0150	0.11		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.42"
3.9	202	0.0150	0.86		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
19.4	302	Total			

Subcatchment EX3a+b: EX3a+b



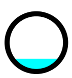
Summary for Reach DP2: Letdown Pipe 2

Inflow Area = 9.018 ac, 0.00% Impervious, Inflow Depth > 1.22" for 25-yr, 24-hr event
Inflow = 11.80 cfs @ 12.15 hrs, Volume= 0.917 af
Outflow = 11.75 cfs @ 12.16 hrs, Volume= 0.916 af, Atten= 0%, Lag= 0.3 min

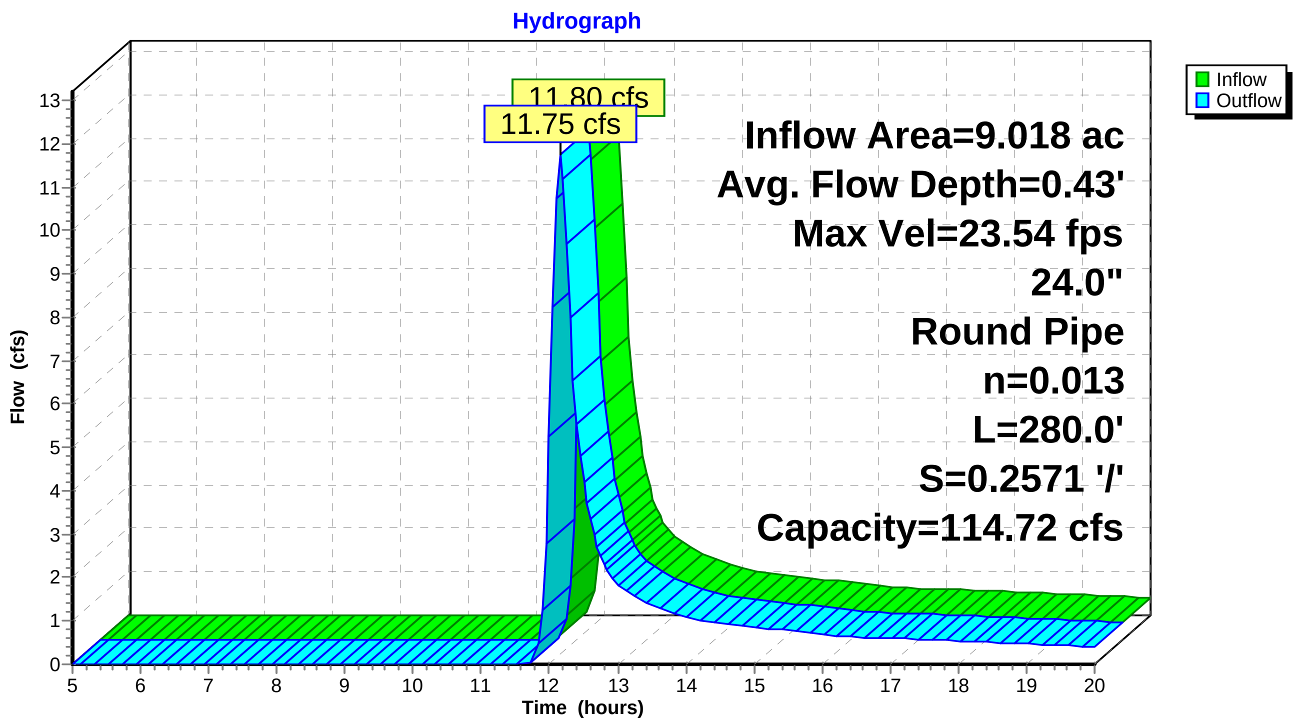
Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 23.54 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 11.08 fps, Avg. Travel Time= 0.4 min

Peak Storage= 140 cf @ 12.15 hrs
Average Depth at Peak Storage= 0.43'
Bank-Full Depth= 2.00' Flow Area= 3.1 sf, Capacity= 114.72 cfs

24.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 280.0' Slope= 0.2571 '/'
Inlet Invert= 84.00', Outlet Invert= 12.00'



Reach DP2: Letdown Pipe 2



Summary for Reach TB 1: Terrace Bench 1

Inflow Area = 6.019 ac, 0.00% Impervious, Inflow Depth > 1.22" for 25-yr, 24-hr event
Inflow = 7.87 cfs @ 12.15 hrs, Volume= 0.612 af
Outflow = 7.57 cfs @ 12.24 hrs, Volume= 0.607 af, Atten= 4%, Lag= 5.5 min

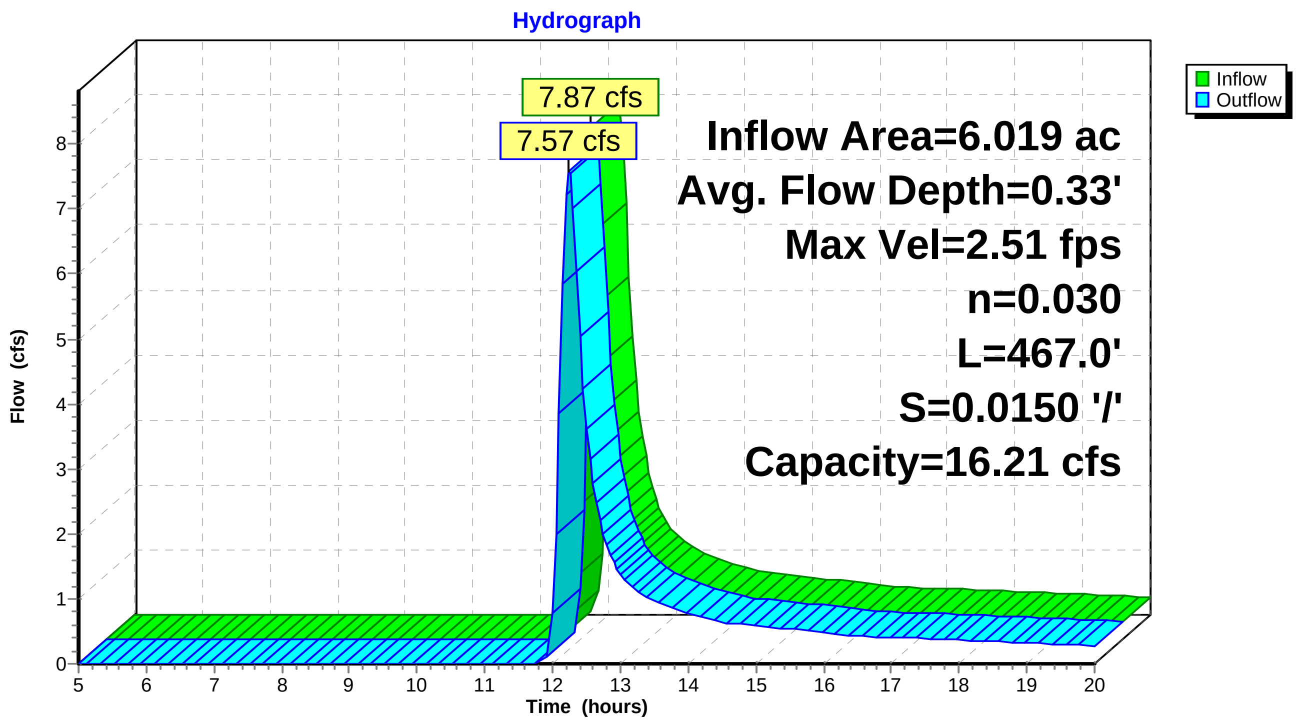
Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.51 fps, Min. Travel Time= 3.1 min
Avg. Velocity = 1.06 fps, Avg. Travel Time= 7.3 min

Peak Storage= 1,412 cf @ 12.19 hrs
Average Depth at Peak Storage= 0.33'
Bank-Full Depth= 0.50' Flow Area= 5.1 sf, Capacity= 16.21 cfs

7.00' x 0.50' deep channel, n= 0.030
Side Slope Z-value= 3.0 10.0 '/' Top Width= 13.50'
Length= 467.0' Slope= 0.0150 '/'
Inlet Invert= 91.00', Outlet Invert= 84.00'

‡

Reach TB 1: Terrace Bench 1



APPENDIX H

Detention Basin Sizing

Client:	**NRG Indian River Power, LLC**		
Project:	**Indian River Landfill CCR Compliance**		
Project #:	**631214281**		
Calculated By:	**SJL**	**Date:**	**09/26/16**
Checked by:	**RDS**	**Date:**	**09/27/16**

TITLE: DETENTION BASIN SIZING

Problem Statement

Determine whether the detention basins that detain stormwater for the Indian River Landfill are adequately sized to detain the 25-year, 24-hour storm event without overtopping, in accordance with Title 40 Code of Federal Regulations 257.81. Additionally, the detention basins are analyzed to determine whether a one-foot freeboard is maintained during the 25-year, 24-hour storm event. The Indian River Landfill currently maintains two detention basins, denoted the Northeast Detention Basin and the South Detention Basin.

Given

- HydroCAD Stormwater Modeling System Owner's Manual (Manual), HydroCAD Software Solutions, LLC, 2006.

- Elevation-area storage summaries for the existing and proposed stormwater detention basins are provided in **Table H-1**.

- The rate of infiltration for the soils in the area of the infiltration basin is listed as 5.95 inches per hour in the Custom Soil Resource Report for Sussex County, Delaware, Indian River Landfill (Soil Survey)(please refer to **Appendix C.**). This infiltration rate is for the soil type of "Fort Mott-Henlopen Complex" and "Udorthents". In accordance with the Sussex Conservation District guidelines, a rate of one-half the posted rate was used for design purposes; therefore, the modeled rate was 2.97 in/hr. The Northeast and South Detention Basins in the permitted condition were modeled using infiltration.

Assumptions

- The Northeast and South Detention Basins were modeled to discharge via infiltration.

Calculations

HydroCAD was used to model the peak storage volume of each detention basin. The storage volume considers both the inflow (which generally includes stormwater collection from the landfill and surrounding area), elevation-storage relationships of the detention basin, and outflow from the basin.

The detention basins were evaluated to ensure that they did not overtop for the 25-year, 24-hour storm event, in accordance with Title 40 Code of Federal Regulations 257.81, and maintain a one-foot freeboard.

Please refer to **Appendix I** for the HydroCAD output files that supplement the tables provided within this analysis.

Client: NRG Indian River Power, LLC

Project: Indian River Landfill CCR Compliance

Project #: 631214281

Calculated By: SJL Date: 09/26/16

Checked by: RDS Date: 09/27/16

TITLE: DETENTION BASIN SIZING

Results

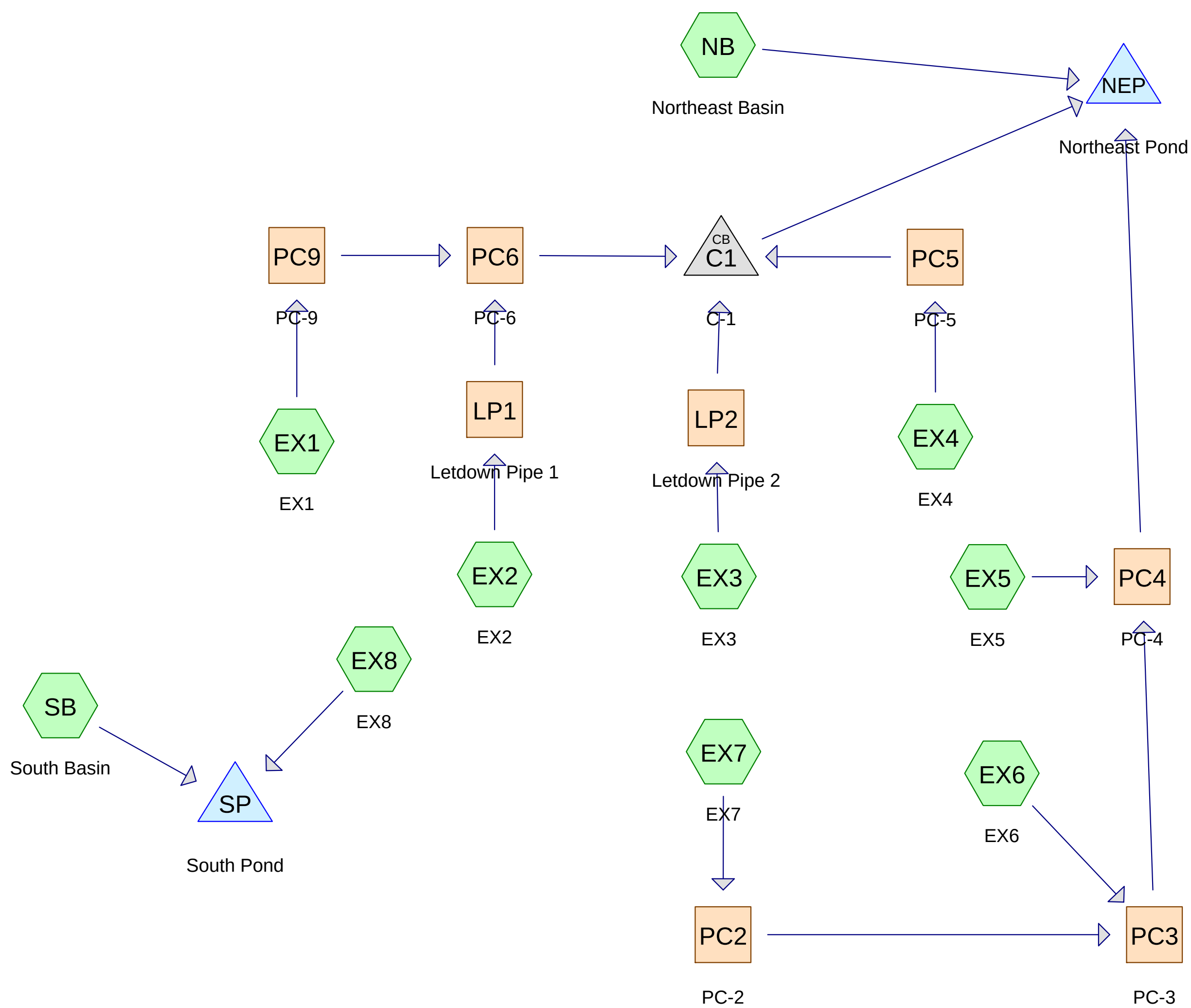
Based on the peak elevation results, all stormwater basins are appropriately sized to detain the 25-year, 24-hour storm event, as they do not overtop and maintain a one-foot freeboard. Inflow/outflow discharge rates and peak elevations for each detention basin have been provided in **Table H-2**.

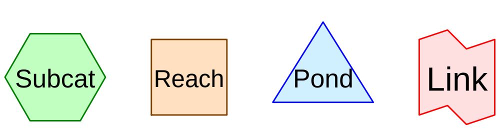
TABLE H-1 Indian River Landfill Run-on/Run-off Control Plan Basin Elevation-Storage Summary				
Elevation (ft MSL)	**Surface Area (ft^2)**	**Incremental Storage (ft^3)**	**Cumulative Storage (ft^3)**	**Cumulative Storage (acre-ft)**
Northeast Detention Basin				
5.00	272,367	0	0	0
6.00	304,740	288,402	288,402	6.6
7.00	317,804	311,249	599,651	13.8
8.00	333,619	325,679	925,331	21.2
9.00	344,815	339,202	1,264,532	29.0
South Detention Basin				
14.00	0	0	0	0.0
15.00	143,408	47,803	47,803	1.1
16.00	149,728	146,557	194,359	4.5
17.00	156,581	153,142	347,501	8.0
18.00	162,684	159,623	507,124	11.6
19.00	168,868	165,766	672,890	15.4
20.00	175,458	172,152	845,043	19.4

Table H-2 Indian River Landfill Run-on/Run-off Control Plan Detention Basin Peak Elevation Summary			
Basin Parameter		**Detention Basin**	
		Northeast	**South**
Drainage Area (acre)		67.8	16.1
NWL (ft. MSL)		5.0	15.0
Detention Basin Crest (ft. MSL)		10.0	20.0
Spillway elevation (ft. MSL)		7.4	17.0
Storm Event Peak Elevation (ft MSL))	**25-year, 24-hour storm event**	5.3	15.0
Basin Maintains 1 ft. freeboard?		**YES**	**YES**
Maximum inflow (cfs)		48.0	13.4
Maximum outflow (cfs)		18.7	9.9

APPENDIX I

HydroCAD Output Files





Routing Diagram for IRLF Run-on Run-off Control Plan, Revised 10-25-2015
Prepared by Chicago Bridge and Iron Company, Printed 9/27/2016
HydroCAD® 10.00-15 s/n 04891 © 2015 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
83.888	49	Pasture/grassland/range, Fair, HSG A (EX1, EX2, EX3, EX4, EX5, EX6, EX7, EX8, NB, SB)

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
83.888	HSG A	EX1, EX2, EX3, EX4, EX5, EX6, EX7, EX8, NB, SB
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
83.888	0.000	0.000	0.000	0.000	83.888	Pasture/grassland/range, Fair	EX1, EX2, EX3, EX4, EX5, EX6, EX7, EX8, NB, SB

Summary for Subcatchment EX1: EX1

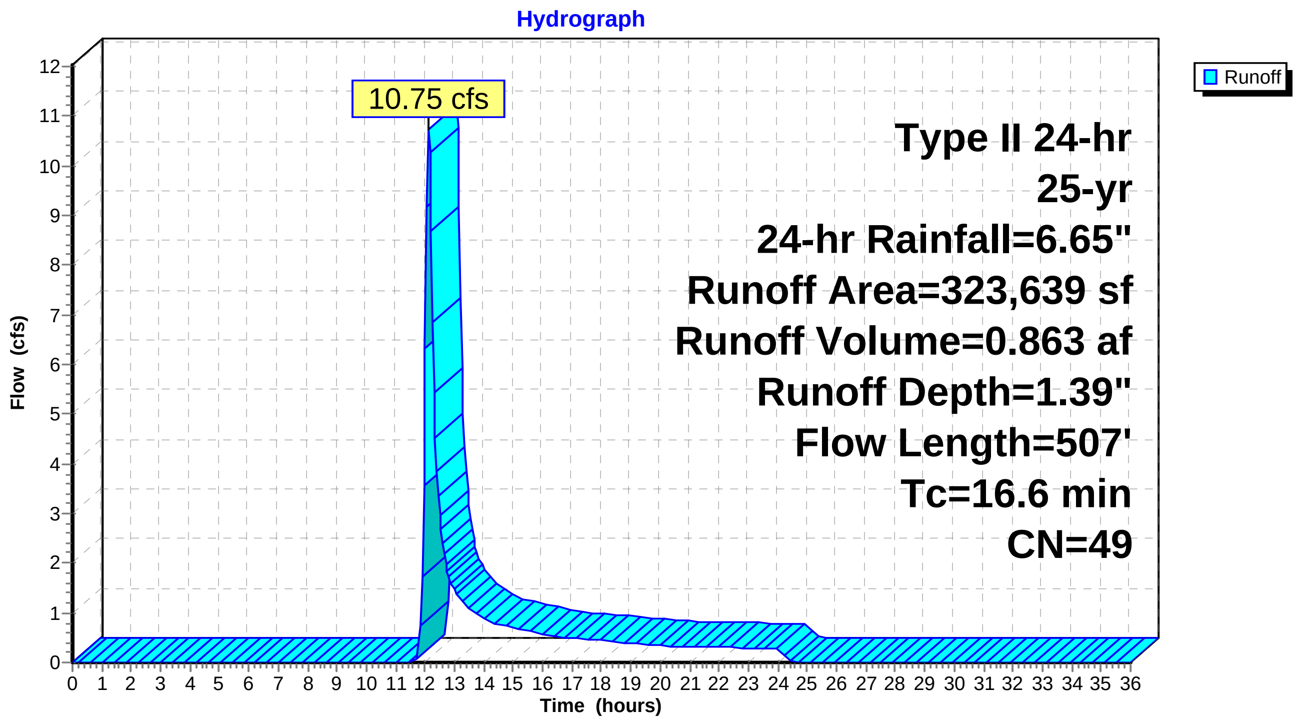
Runoff = 10.75 cfs @ 12.11 hrs, Volume= 0.863 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.65"

Area (sf)	CN	Description
323,639	49	Pasture/grassland/range, Fair, HSG A
323,639		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.4	100	0.0180	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.42"
1.4	77	0.0180	0.94		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.2	42	0.3300	4.02		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.5	97	0.0150	3.24	21.06	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.00' Z= 10.0 & 3.0 '/' Top.W=13.00' n= 0.035
0.1	191	0.2620	36.86	115.79	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Corrugated PE, smooth interior
16.6	507	Total			

Subcatchment EX1: EX1



Summary for Subcatchment EX2: EX2

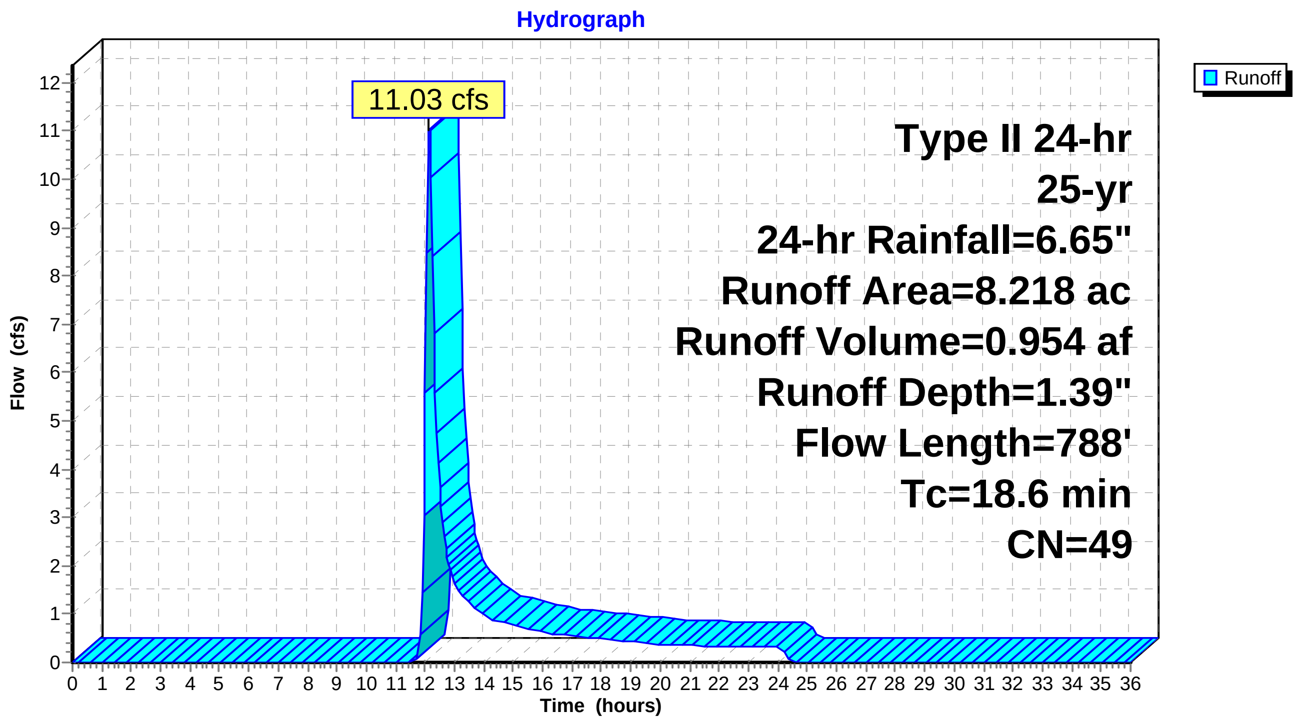
Runoff = 11.03 cfs @ 12.14 hrs, Volume= 0.954 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.65"

Area (ac)	CN	Description
8.218	49	Pasture/grassland/range, Fair, HSG A
8.218		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.2	100	0.0430	0.16		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.42"
8.3	427	0.0150	0.86		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.1	261	0.2840	38.37	120.56	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013
18.6	788	Total			

Subcatchment EX2: EX2



Summary for Subcatchment EX3: EX3

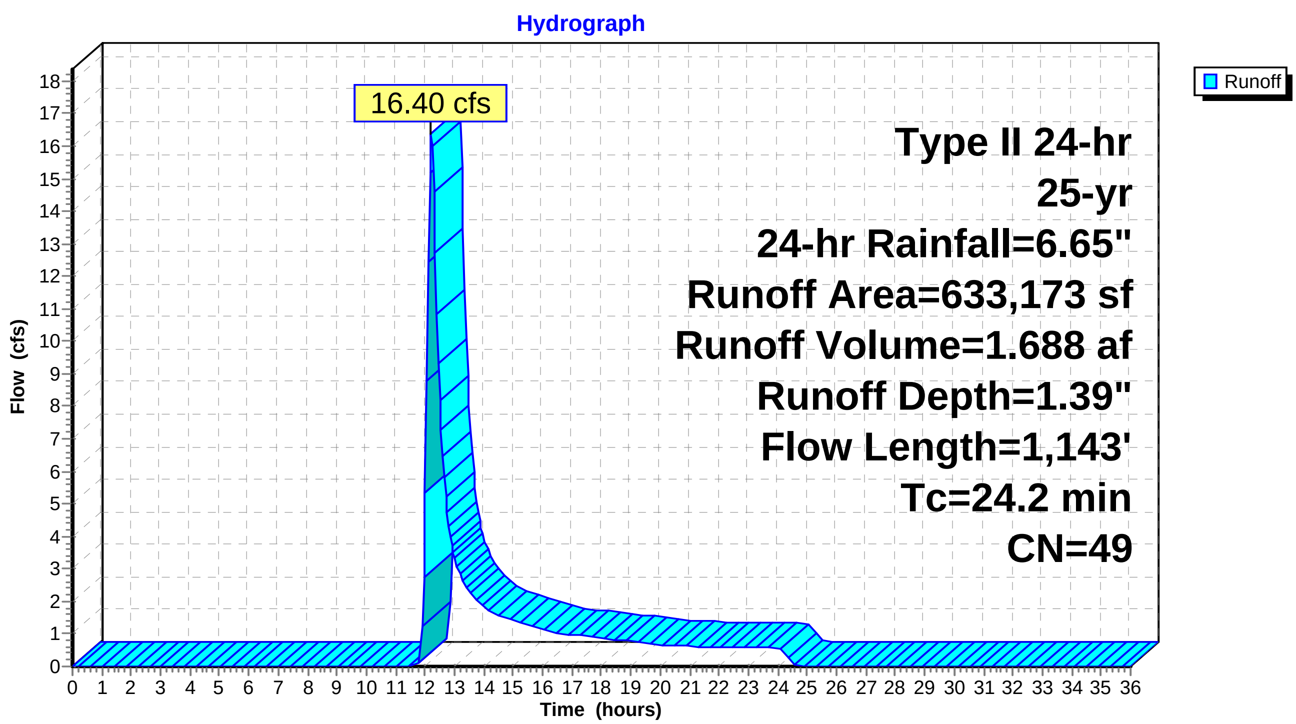
Runoff = 16.40 cfs @ 12.21 hrs, Volume= 1.688 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.65"

Area (sf)	CN	Description
633,173	49	Pasture/grassland/range, Fair, HSG A
633,173		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.5	100	0.0150	0.11		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.42"
5.9	303	0.0150	0.86		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
2.7	467	0.0120	2.90	18.84	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.00' Z= 10.0 & 3.0 '/' Top.W=13.00' n= 0.035 Earth, dense weeds
0.1	273	0.3300	41.37	129.96	**Pipe Channel, Downpipe** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Corrugated PE, smooth interior
24.2	1,143	Total			

Subcatchment EX3: EX3



Summary for Subcatchment EX4: EX4

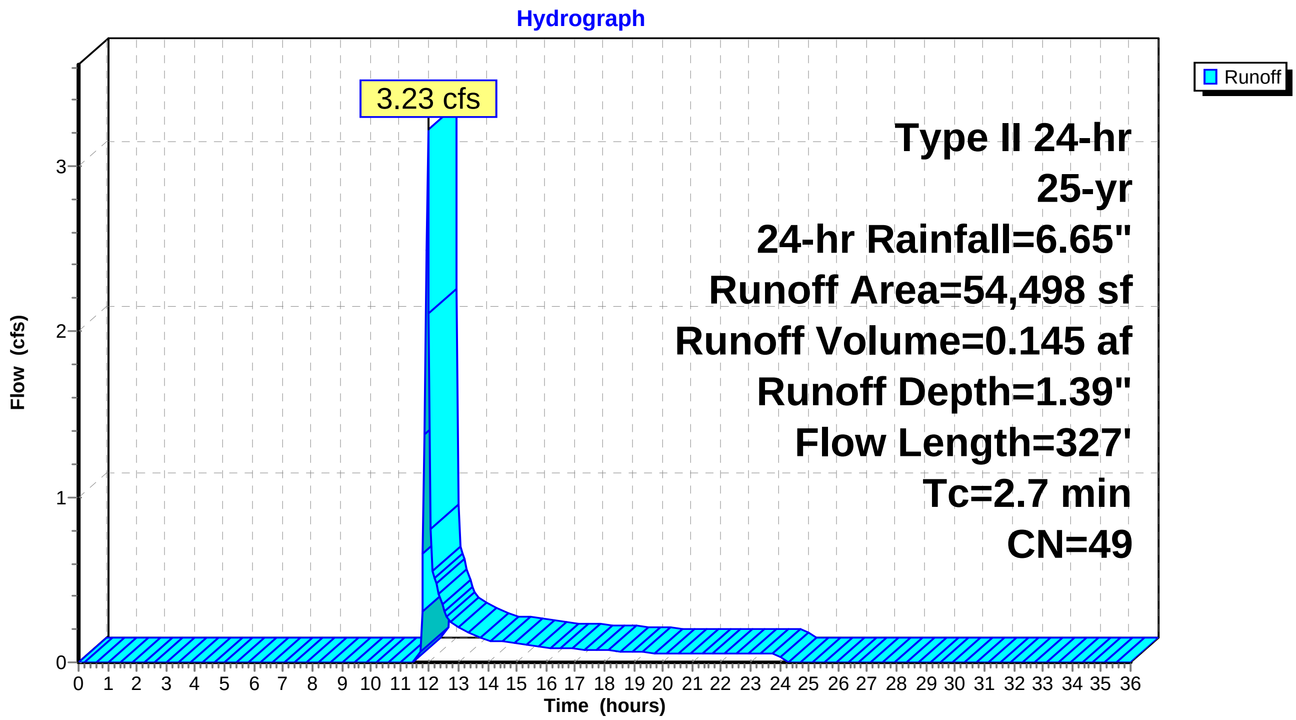
Runoff = 3.23 cfs @ 11.94 hrs, Volume= 0.145 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.65"

Area (sf)	CN	Description
54,498	49	Pasture/grassland/range, Fair, HSG A
54,498		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1	38	0.3300	0.31		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.42"
0.6	289	0.0400	8.07	80.68	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 2.0 & 3.0 '/' Top.W=10.00' n= 0.035 Earth, dense weeds
2.7	327	Total			

Subcatchment EX4: EX4



Summary for Subcatchment EX5: EX5

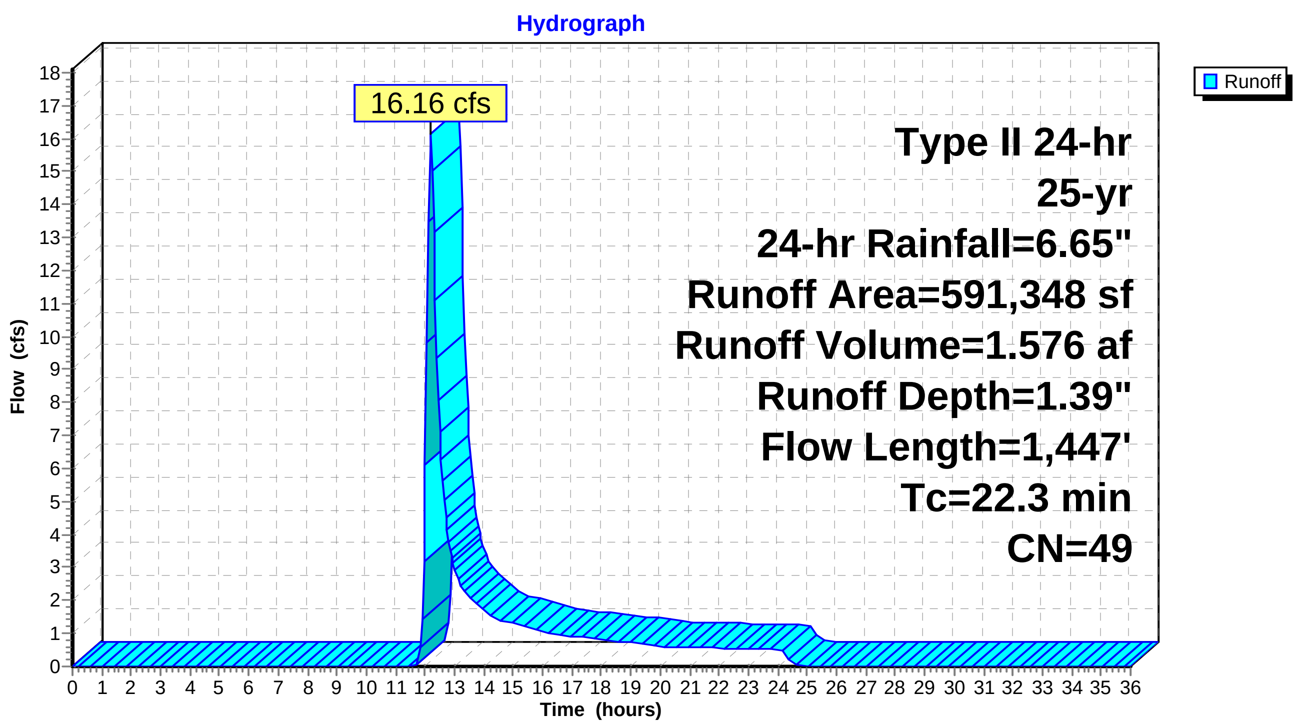
Runoff = 16.16 cfs @ 12.19 hrs, Volume= 1.576 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.65"

Area (sf)	CN	Description
591,348	49	Pasture/grassland/range, Fair, HSG A
591,348		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.5	100	0.0150	0.11		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.42"
5.1	261	0.0150	0.86		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.6	843	0.0450	8.56	85.58	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=2.00' Z= 2.0 & 3.0 '/' Top.W=10.00' n= 0.035 Earth, dense weeds
0.1	243	0.3300	41.37	129.96	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Corrugated PE, smooth interior
22.3	1,447	Total			

Subcatchment EX5: EX5



Summary for Subcatchment EX6: EX6

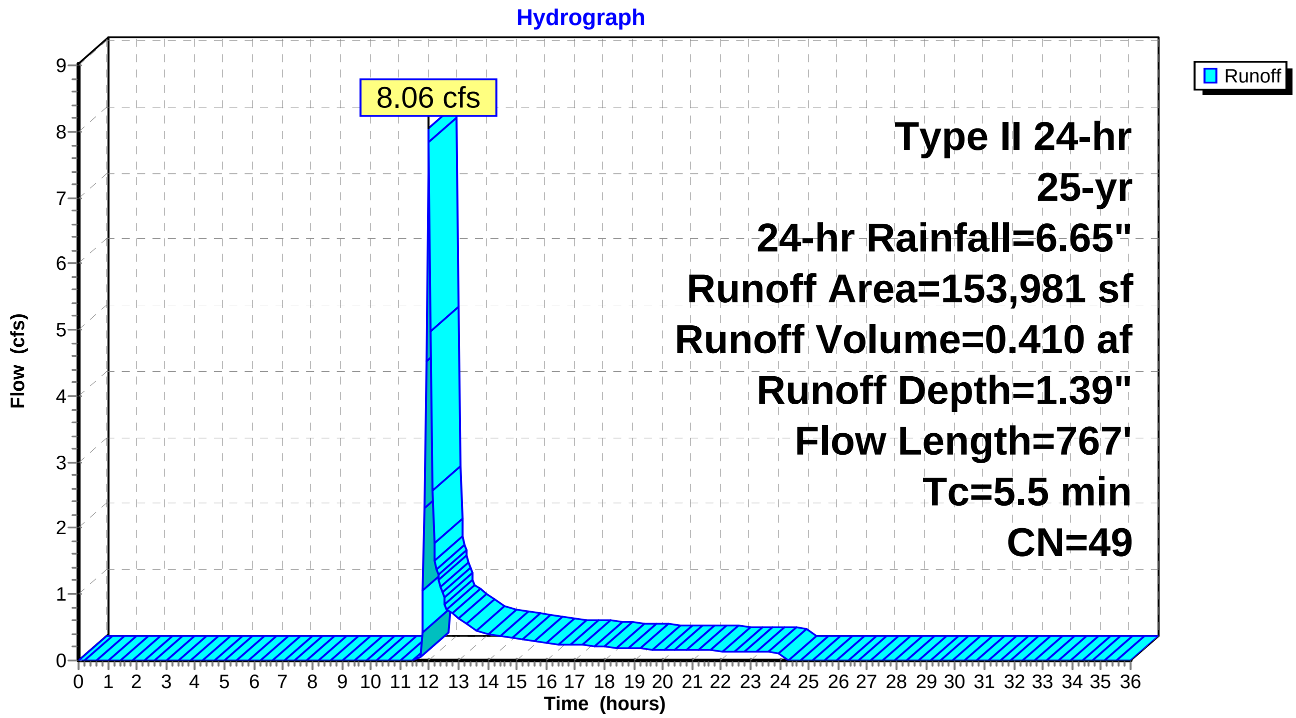
Runoff = 8.06 cfs @ 11.98 hrs, Volume= 0.410 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.65"

Area (sf)	CN	Description
153,981	49	Pasture/grassland/range, Fair, HSG A
153,981		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.7	52	0.3300	0.33		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.42"
2.7	516	0.0150	3.24	21.06	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.00' Z= 10.0 & 3.0 '/' Top.W=13.00' n= 0.035 Earth, dense weeds
0.1	199	0.3300	41.37	129.96	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Corrugated PE, smooth interior
5.5	767	Total			

Subcatchment EX6: EX6



Summary for Subcatchment EX7: EX7

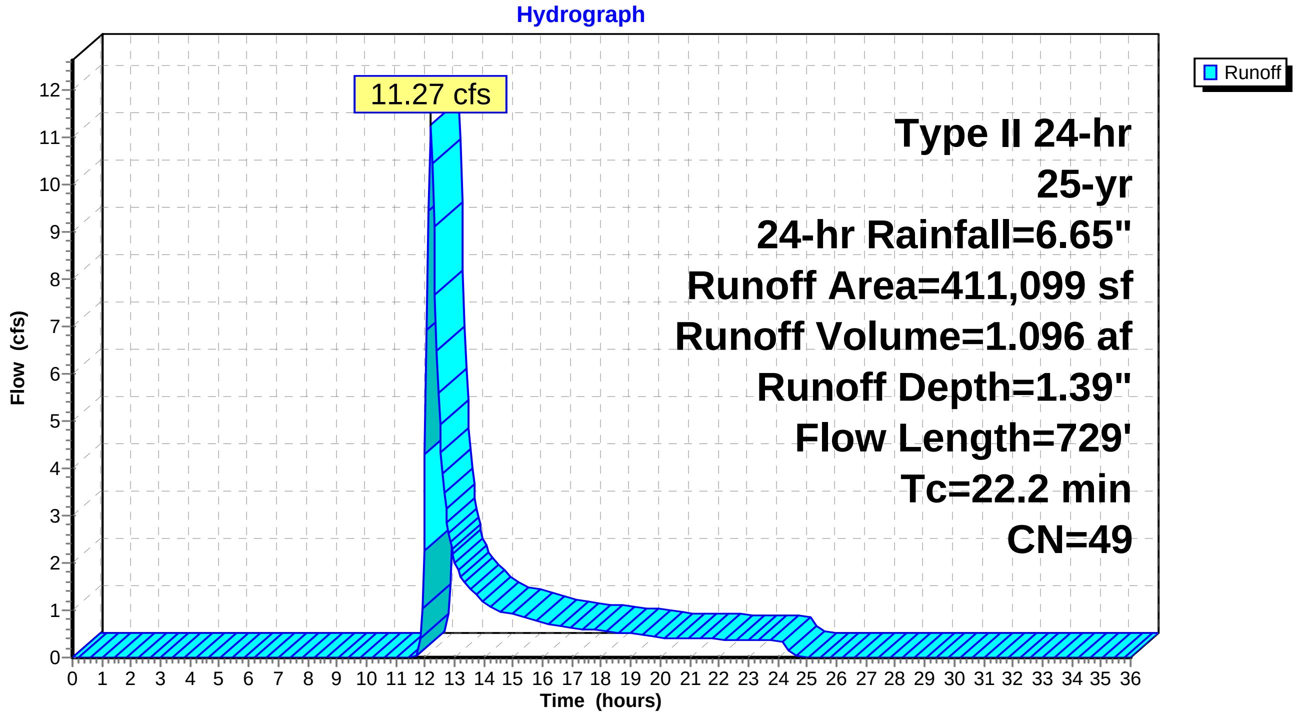
Runoff = 11.27 cfs @ 12.19 hrs, Volume= 1.096 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.65"

Area (sf)	CN	Description
411,099	49	Pasture/grassland/range, Fair, HSG A
411,099		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.5	100	0.0150	0.11		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.42"
6.2	318	0.0150	0.86		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.0	12	0.3300	4.02		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.4	70	0.0142	3.15	20.49	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=1.00' Z= 10.0 & 3.0 '/' Top.W=13.00' n= 0.035 Earth, dense weeds
0.1	229	0.3300	41.37	129.96	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Corrugated PE, smooth interior
22.2	729	Total			

Subcatchment EX7: EX7



Summary for Subcatchment EX8: EX8

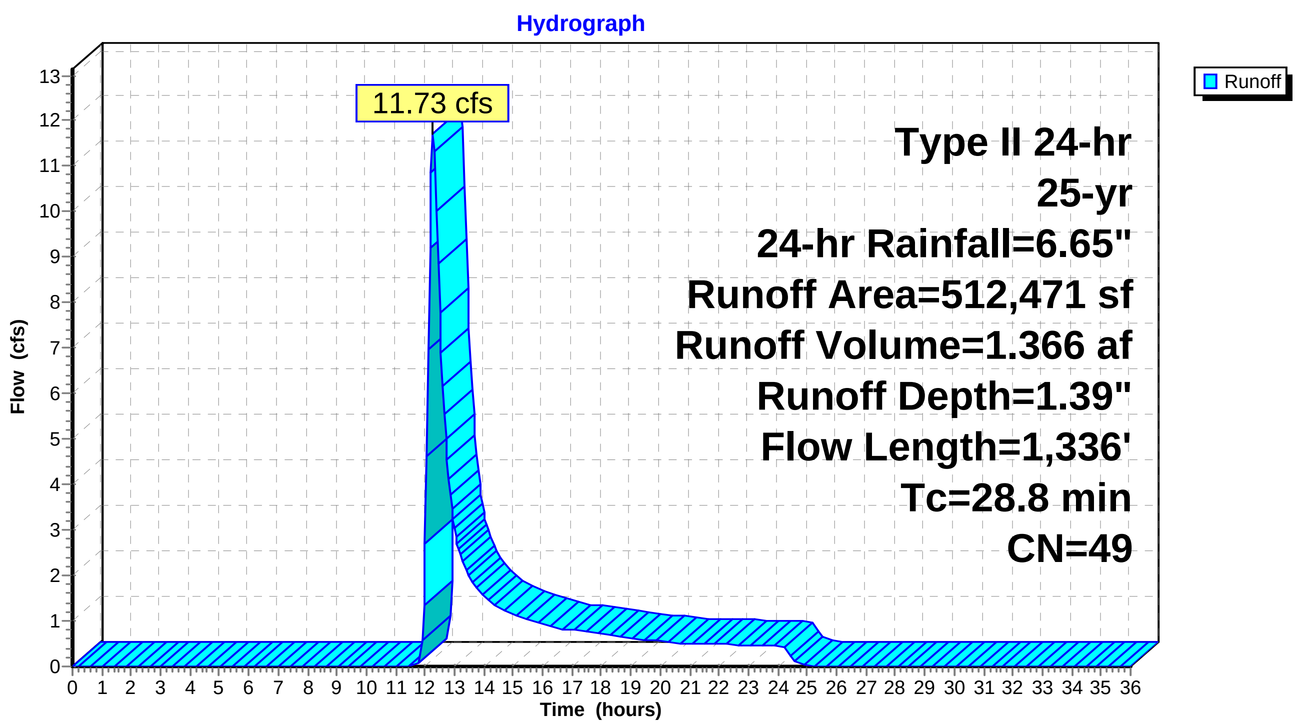
Runoff = 11.73 cfs @ 12.27 hrs, Volume= 1.366 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.65"

Area (sf)	CN	Description
512,471	49	Pasture/grassland/range, Fair, HSG A
512,471		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.5	100	0.0150	0.11		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.42"
12.3	635	0.0150	0.86		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.2	231	0.3300	16.42	3.22	**Pipe Channel,** 6.0" Round Area= 0.2 sf Perim= 1.6' r= 0.13' n= 0.013 Corrugated PE, smooth interior
0.8	370	0.0160	7.50	165.01	**Trap/Vee/Rect Channel Flow,** Bot.W=6.00' D=2.00' Z= 3.0 & 2.0 '/' Top.W=16.00' n= 0.030
28.8	1,336	Total			

Subcatchment EX8: EX8



Summary for Subcatchment NB: Northeast Basin

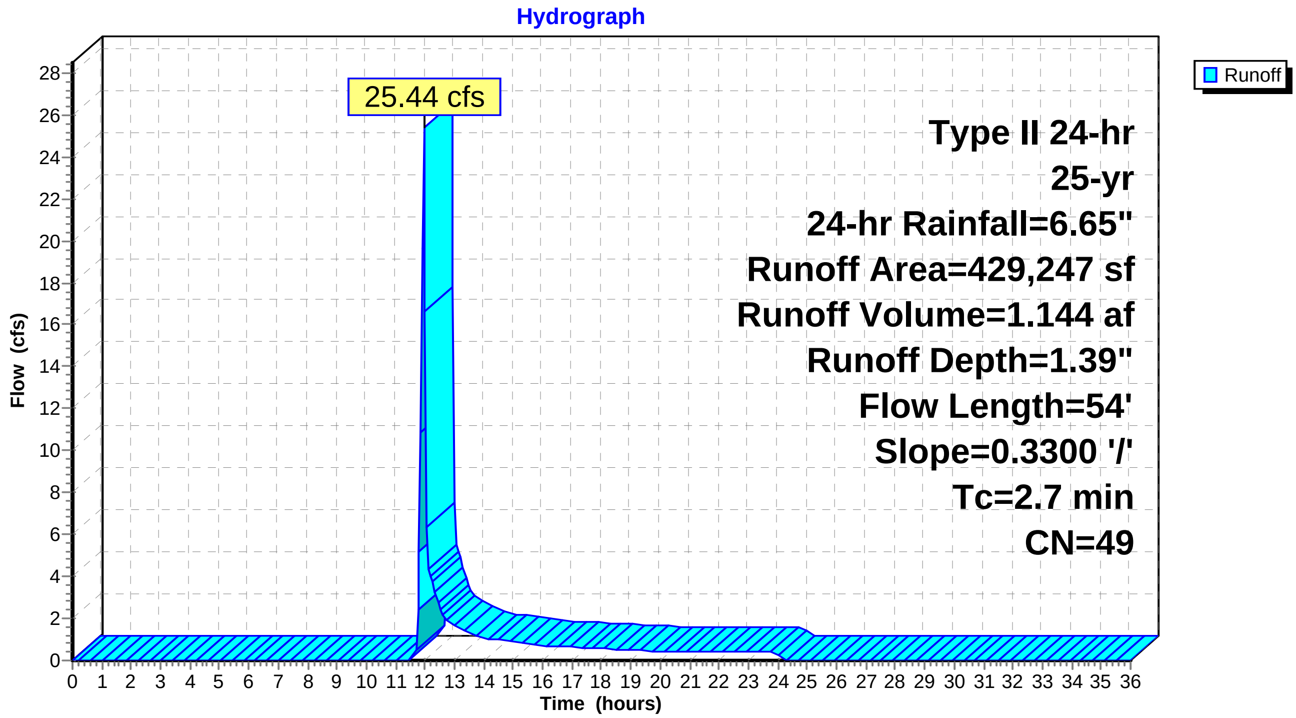
Runoff = 25.44 cfs @ 11.94 hrs, Volume= 1.144 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.65"

Area (sf)	CN	Description
429,247	49	Pasture/grassland/range, Fair, HSG A
429,247		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.7	54	0.3300	0.33		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.42"

Subcatchment NB: Northeast Basin



Summary for Subcatchment SB: South Basin

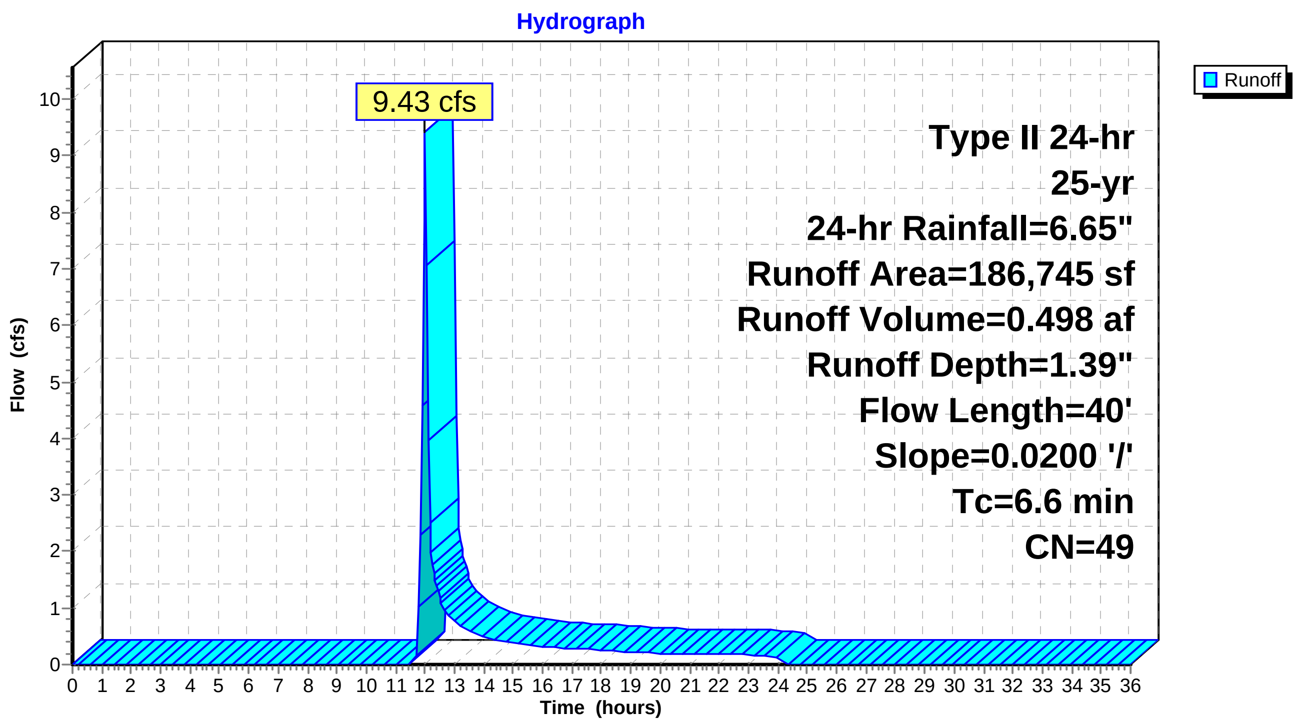
Runoff = 9.43 cfs @ 11.99 hrs, Volume= 0.498 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.65"

Area (sf)	CN	Description
186,745	49	Pasture/grassland/range, Fair, HSG A
186,745		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	40	0.0200	0.10		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.42"

Subcatchment SB: South Basin



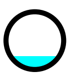
Summary for Reach LP1: Letdown Pipe 1

Inflow Area = 8.218 ac, 0.00% Impervious, Inflow Depth = 1.39" for 25-yr, 24-hr event
Inflow = 11.03 cfs @ 12.14 hrs, Volume= 0.954 af
Outflow = 10.98 cfs @ 12.15 hrs, Volume= 0.954 af, Atten= 0%, Lag= 0.5 min

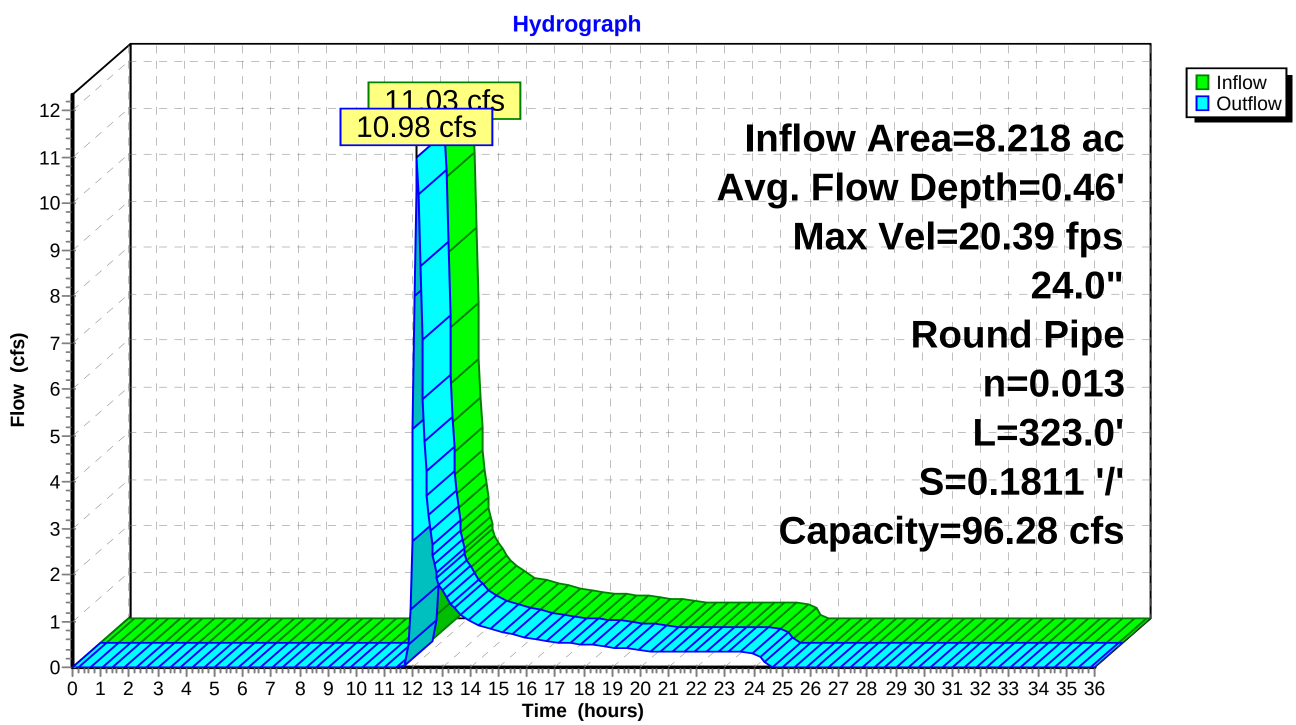
Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 20.39 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 8.45 fps, Avg. Travel Time= 0.6 min

Peak Storage= 175 cf @ 12.14 hrs
Average Depth at Peak Storage= 0.46'
Bank-Full Depth= 2.00' Flow Area= 3.1 sf, Capacity= 96.28 cfs

24.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 323.0' Slope= 0.1811 '/'
Inlet Invert= 77.00', Outlet Invert= 18.50'



Reach LP1: Letdown Pipe 1



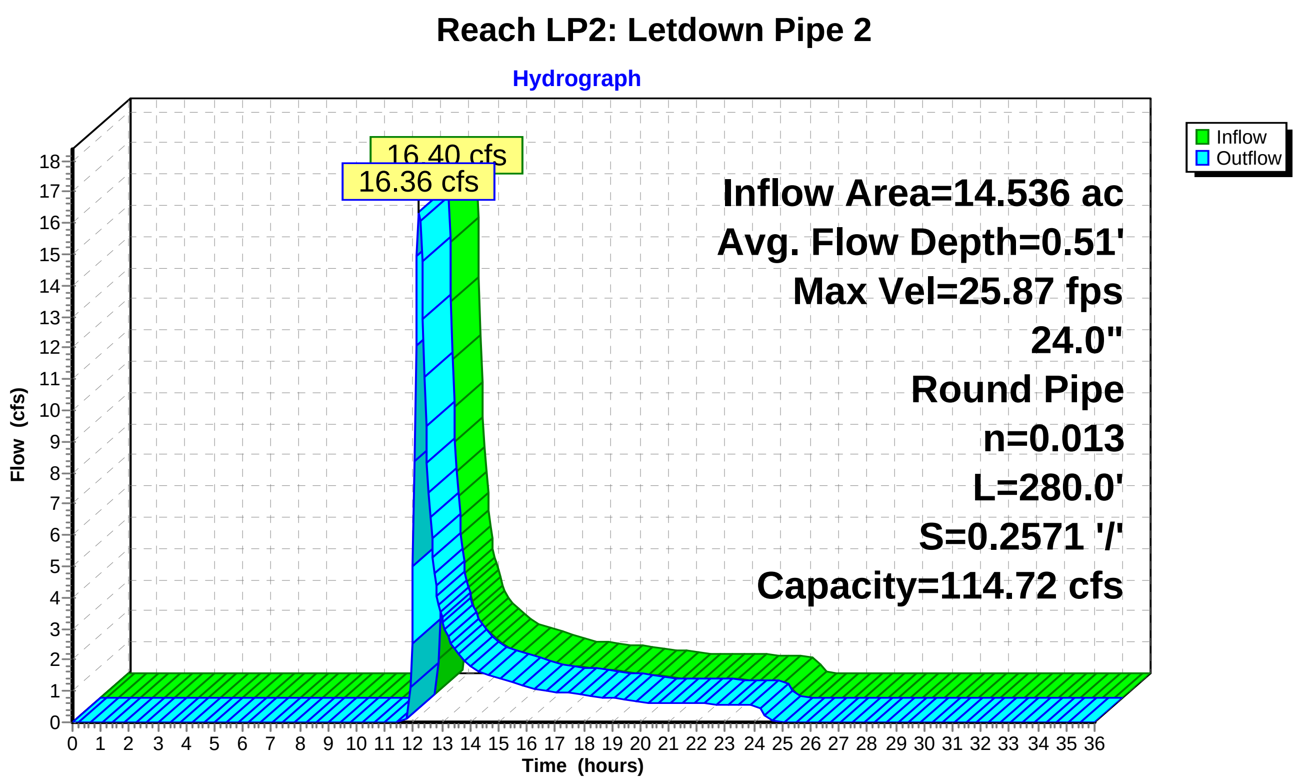
Summary for Reach LP2: Letdown Pipe 2

Inflow Area = 14.536 ac, 0.00% Impervious, Inflow Depth = 1.39" for 25-yr, 24-hr event
Inflow = 16.40 cfs @ 12.21 hrs, Volume= 1.688 af
Outflow = 16.36 cfs @ 12.22 hrs, Volume= 1.688 af, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 25.87 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 11.21 fps, Avg. Travel Time= 0.4 min

Peak Storage= 177 cf @ 12.22 hrs
Average Depth at Peak Storage= 0.51'
Bank-Full Depth= 2.00' Flow Area= 3.1 sf, Capacity= 114.72 cfs

24.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 280.0' Slope= 0.2571 '/'
Inlet Invert= 84.00', Outlet Invert= 12.00'



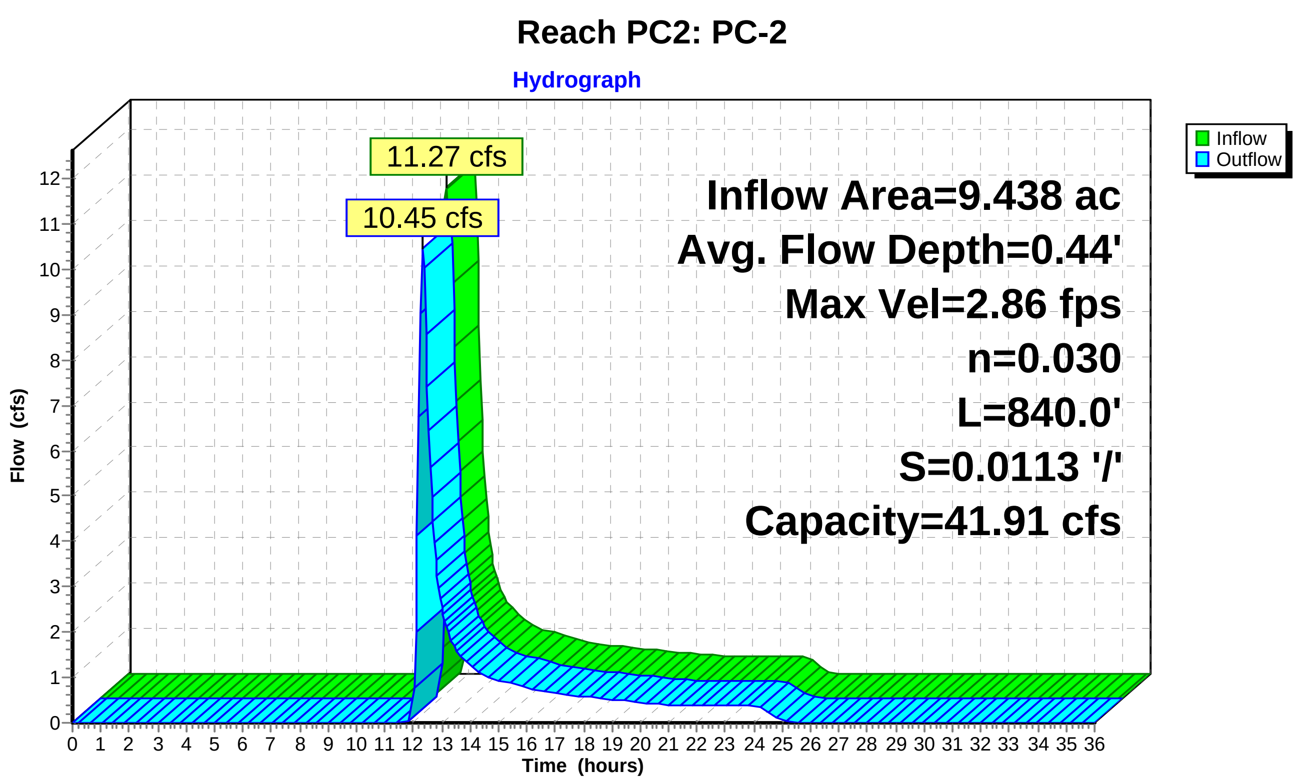
Summary for Reach PC2: PC-2

Inflow Area = 9.438 ac, 0.00% Impervious, Inflow Depth = 1.39" for 25-yr, 24-hr event
Inflow = 11.27 cfs @ 12.19 hrs, Volume= 1.096 af
Outflow = 10.45 cfs @ 12.33 hrs, Volume= 1.096 af, Atten= 7%, Lag= 8.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.86 fps, Min. Travel Time= 4.9 min
Avg. Velocity = 0.76 fps, Avg. Travel Time= 18.5 min

Peak Storage= 3,107 cf @ 12.25 hrs
Average Depth at Peak Storage= 0.44'
Bank-Full Depth= 1.00' Flow Area= 9.0 sf, Capacity= 41.91 cfs

8.00' x 1.00' deep channel, n= 0.030
Side Slope Z-value= 1.0 '/' Top Width= 10.00'
Length= 840.0' Slope= 0.0113 '/'
Inlet Invert= 34.00', Outlet Invert= 24.50'



Summary for Reach PC3: PC-3

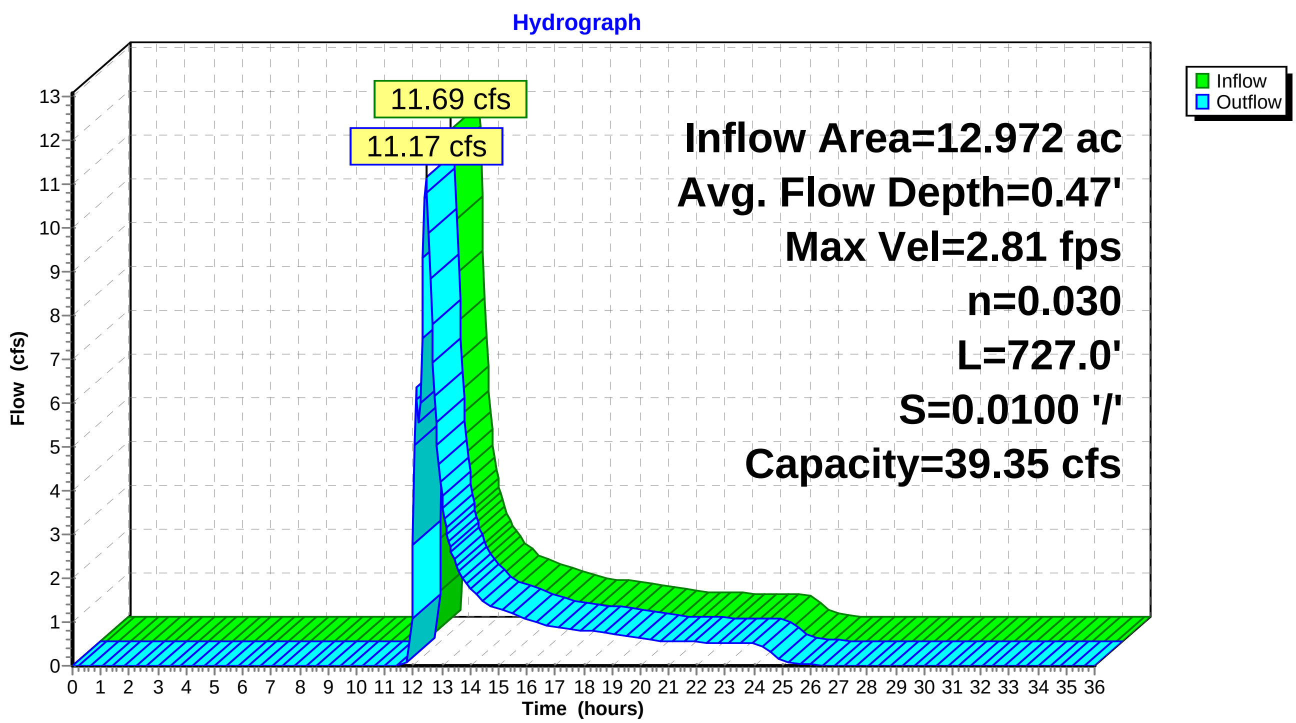
Inflow Area = 12.972 ac, 0.00% Impervious, Inflow Depth = 1.39" for 25-yr, 24-hr event
Inflow = 11.69 cfs @ 12.33 hrs, Volume= 1.506 af
Outflow = 11.17 cfs @ 12.45 hrs, Volume= 1.506 af, Atten= 4%, Lag= 7.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.81 fps, Min. Travel Time= 4.3 min
Avg. Velocity = 0.77 fps, Avg. Travel Time= 15.7 min

Peak Storage= 2,910 cf @ 12.38 hrs
Average Depth at Peak Storage= 0.47'
Bank-Full Depth= 1.00' Flow Area= 9.0 sf, Capacity= 39.35 cfs

8.00' x 1.00' deep channel, n= 0.030
Side Slope Z-value= 1.0 '/' Top Width= 10.00'
Length= 727.0' Slope= 0.0100 '/'
Inlet Invert= 25.25', Outlet Invert= 18.00'

Reach PC3: PC-3



Summary for Reach PC4: PC-4

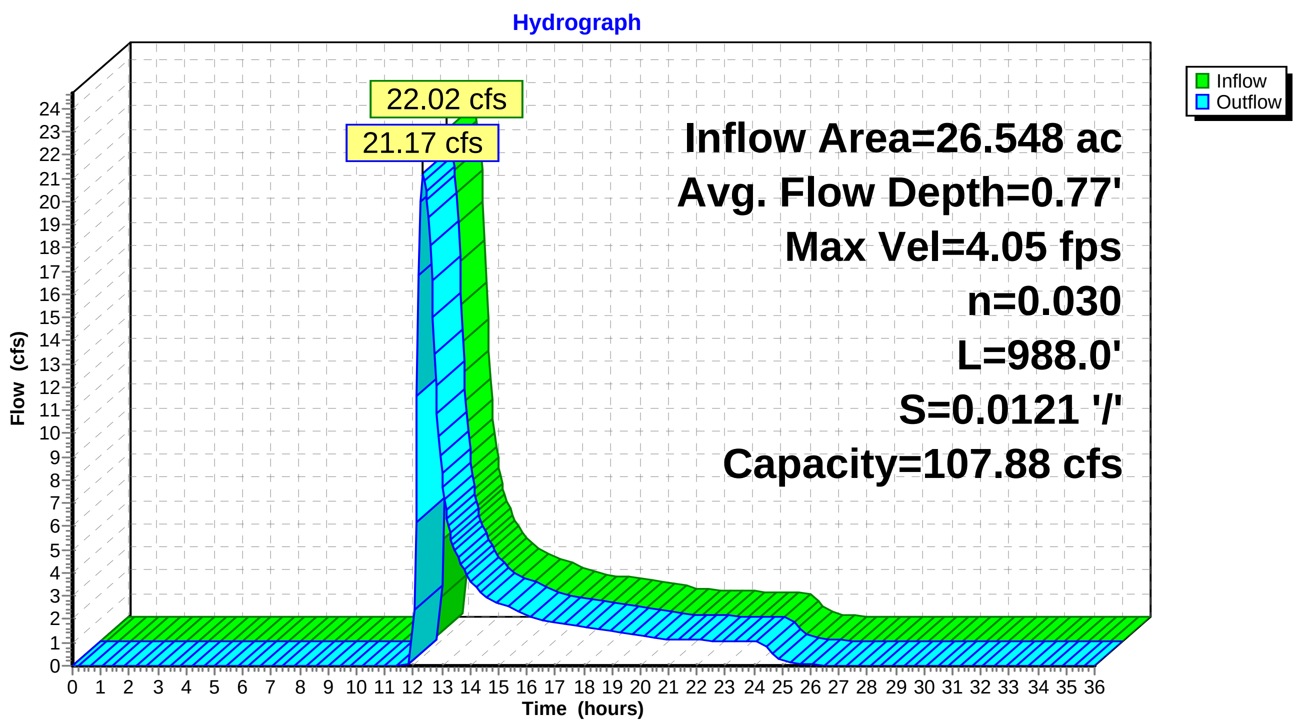
Inflow Area = 26.548 ac, 0.00% Impervious, Inflow Depth = 1.39" for 25-yr, 24-hr event
Inflow = 22.02 cfs @ 12.17 hrs, Volume= 3.083 af
Outflow = 21.17 cfs @ 12.32 hrs, Volume= 3.083 af, Atten= 4%, Lag= 9.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.05 fps, Min. Travel Time= 4.1 min
Avg. Velocity = 1.19 fps, Avg. Travel Time= 13.9 min

Peak Storage= 5,169 cf @ 12.26 hrs
Average Depth at Peak Storage= 0.77'
Bank-Full Depth= 2.00' Flow Area= 16.0 sf, Capacity= 107.88 cfs

6.00' x 2.00' deep channel, n= 0.030
Side Slope Z-value= 1.0 '/' Top Width= 10.00'
Length= 988.0' Slope= 0.0121 '/'
Inlet Invert= 18.00', Outlet Invert= 6.00'

Reach PC4: PC-4



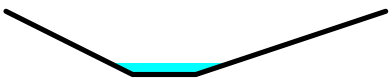
Summary for Reach PC5: PC-5

Inflow Area = 1.251 ac, 0.00% Impervious, Inflow Depth = 1.39" for 25-yr, 24-hr event
Inflow = 3.23 cfs @ 11.94 hrs, Volume= 0.145 af
Outflow = 2.82 cfs @ 11.99 hrs, Volume= 0.145 af, Atten= 13%, Lag= 2.8 min

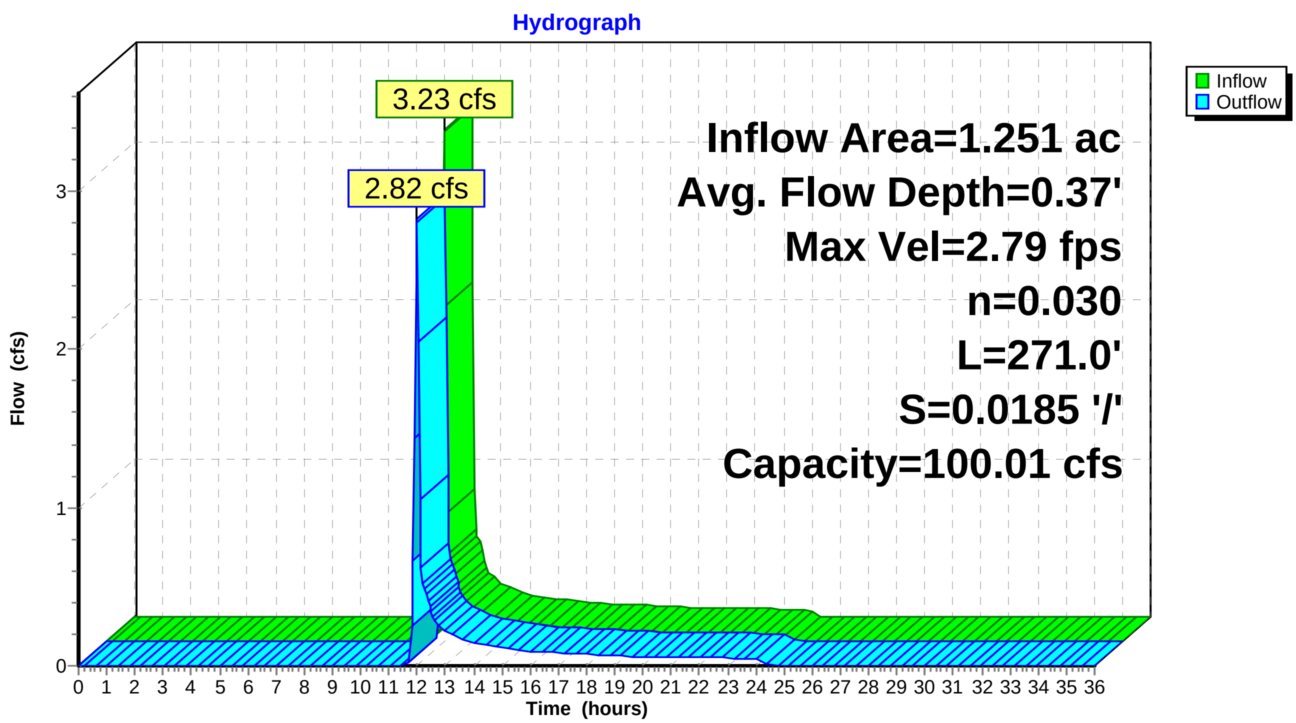
Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.79 fps, Min. Travel Time= 1.6 min
Avg. Velocity = 0.87 fps, Avg. Travel Time= 5.2 min

Peak Storage= 290 cf @ 11.96 hrs
Average Depth at Peak Storage= 0.37'
Bank-Full Depth= 2.00' Flow Area= 14.0 sf, Capacity= 100.01 cfs

2.00' x 2.00' deep channel, n= 0.030
Side Slope Z-value= 2.0 3.0 '/' Top Width= 12.00'
Length= 271.0' Slope= 0.0185 '/'
Inlet Invert= 17.00', Outlet Invert= 12.00'



Reach PC5: PC-5



Summary for Reach PC6: PC-6

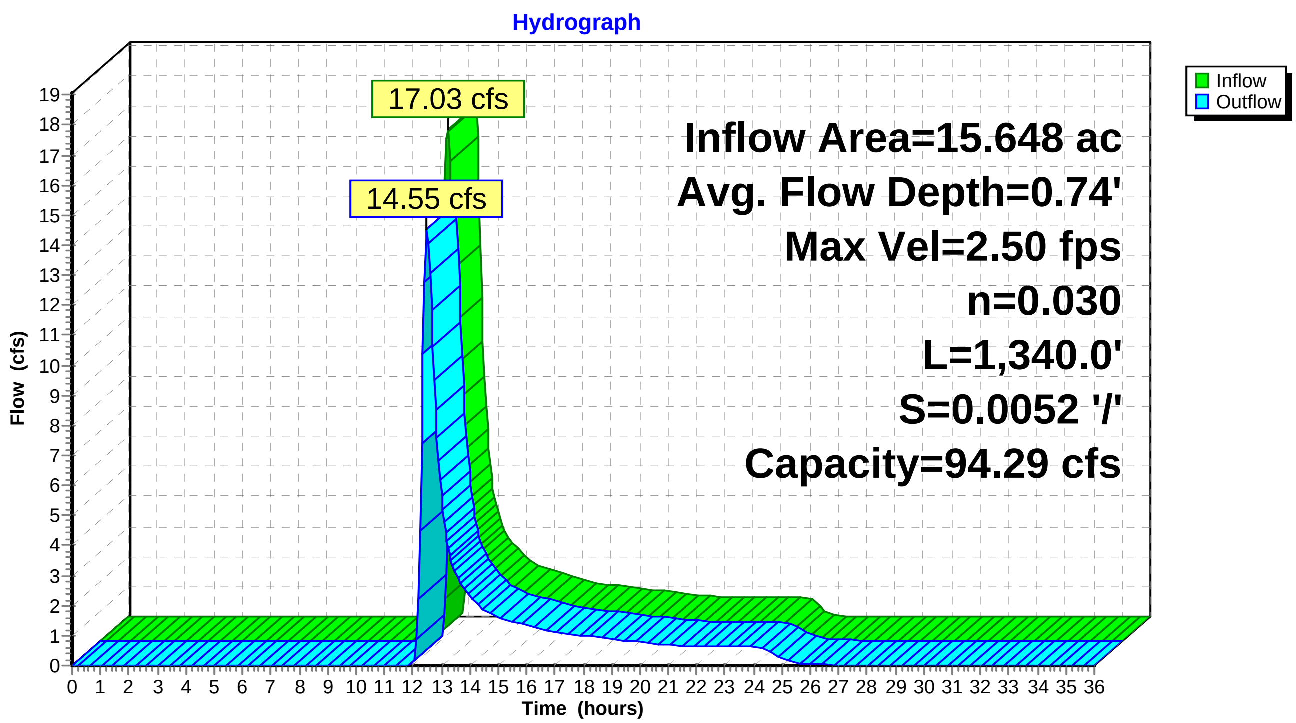
Inflow Area = 15.648 ac, 0.00% Impervious, Inflow Depth = 1.39" for 25-yr, 24-hr event
Inflow = 17.03 cfs @ 12.24 hrs, Volume= 1.817 af
Outflow = 14.55 cfs @ 12.50 hrs, Volume= 1.817 af, Atten= 15%, Lag= 15.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.50 fps, Min. Travel Time= 8.9 min
Avg. Velocity = 0.70 fps, Avg. Travel Time= 31.8 min

Peak Storage= 7,810 cf @ 12.35 hrs
Average Depth at Peak Storage= 0.74'
Bank-Full Depth= 2.00' Flow Area= 22.0 sf, Capacity= 94.29 cfs

6.00' x 2.00' deep channel, n= 0.030
Side Slope Z-value= 2.0 3.0 '/' Top Width= 16.00'
Length= 1,340.0' Slope= 0.0052 '/'
Inlet Invert= 19.00', Outlet Invert= 12.00'

Reach PC6: PC-6



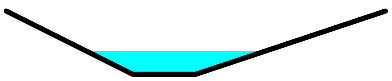
Summary for Reach PC9: PC-9

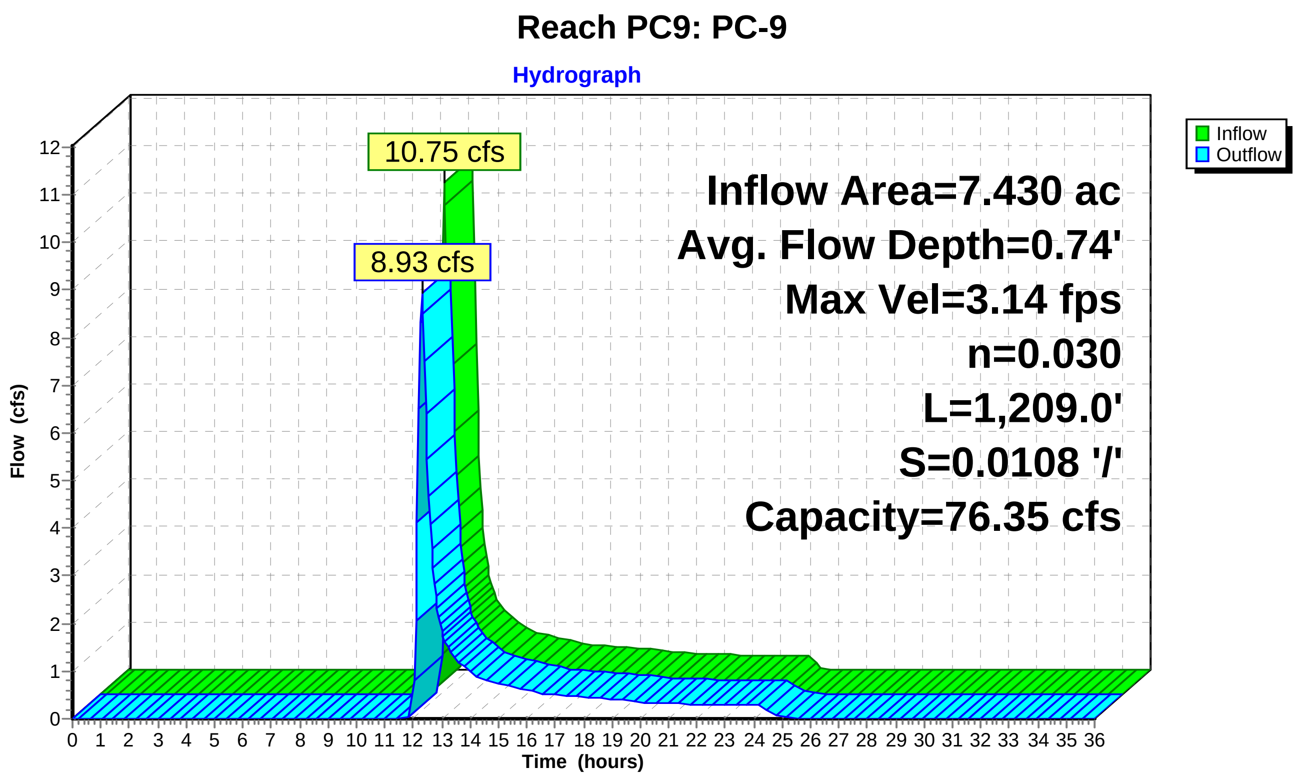
Inflow Area = 7.430 ac, 0.00% Impervious, Inflow Depth = 1.39" for 25-yr, 24-hr event
Inflow = 10.75 cfs @ 12.11 hrs, Volume= 0.863 af
Outflow = 8.93 cfs @ 12.30 hrs, Volume= 0.863 af, Atten= 17%, Lag= 11.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.14 fps, Min. Travel Time= 6.4 min
Avg. Velocity = 1.06 fps, Avg. Travel Time= 19.0 min

Peak Storage= 3,468 cf @ 12.20 hrs
Average Depth at Peak Storage= 0.74'
Bank-Full Depth= 2.00' Flow Area= 14.0 sf, Capacity= 76.35 cfs

2.00' x 2.00' deep channel, n= 0.030
Side Slope Z-value= 2.0 3.0 '/' Top Width= 12.00'
Length= 1,209.0' Slope= 0.0108 '/'
Inlet Invert= 32.00', Outlet Invert= 19.00'





Summary for Pond C1: C-1

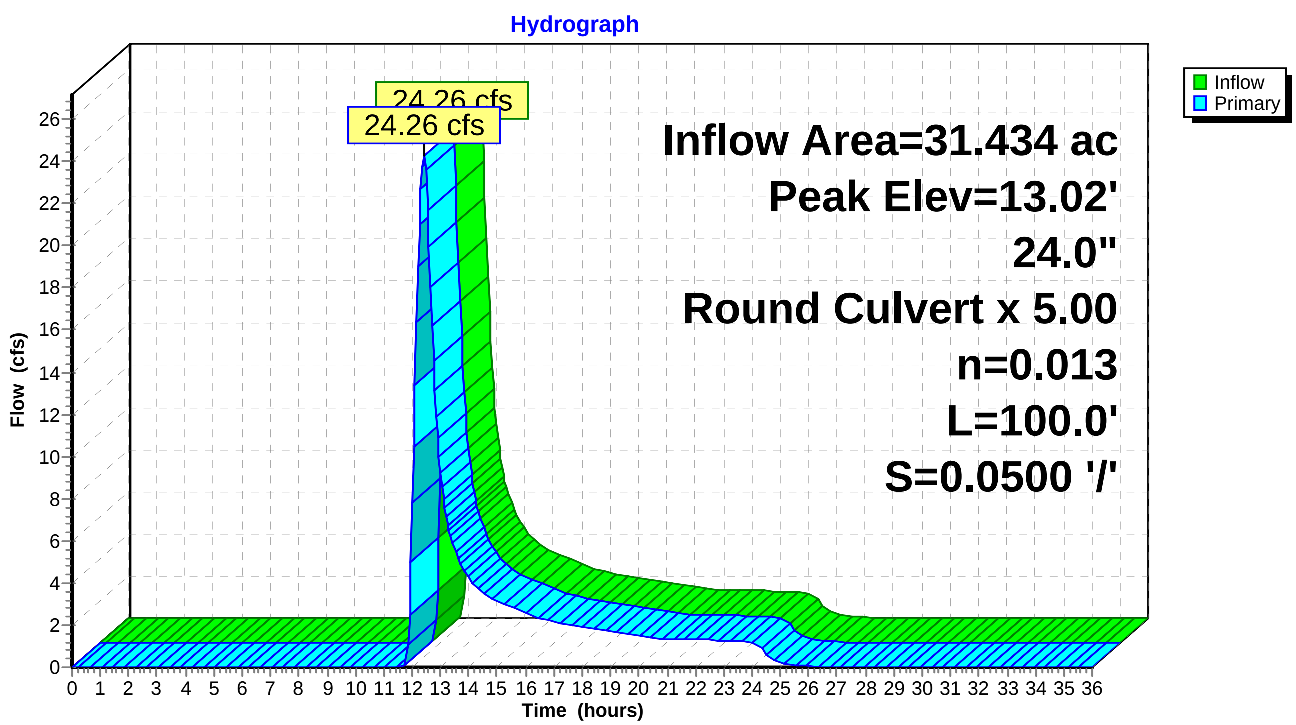
Inflow Area =	31.434 ac,	0.00% Impervious, Inflow Depth =	1.39"	for 25-yr, 24-hr event
Inflow =	24.26 cfs @	12.41 hrs, Volume=	3.650 af	
Outflow =	24.26 cfs @	12.41 hrs, Volume=	3.650 af,	Atten= 0%, Lag= 0.0 min
Primary =	24.26 cfs @	12.41 hrs, Volume=	3.650 af	

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 13.02' @ 12.41 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	12.00'	**24.0" Round Culvert X 5.00** L= 100.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 12.00' / 7.00' S= 0.0500 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf

Primary OutFlow Max=24.20 cfs @ 12.41 hrs HW=13.01' (Free Discharge)
└─**1=Culvert** (Inlet Controls 24.20 cfs @ 3.03 fps)

Pond C1: C-1



Summary for Pond NEP: Northeast Pond

Inflow Area = 67.837 ac, 0.00% Impervious, Inflow Depth = 1.39" for 25-yr, 24-hr event
Inflow = 48.03 cfs @ 12.37 hrs, Volume= 7.878 af
Outflow = 18.73 cfs @ 12.10 hrs, Volume= 7.878 af, Atten= 61%, Lag= 0.0 min
Discarded = 18.73 cfs @ 12.10 hrs, Volume= 7.878 af

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 5.24' @ 13.02 hrs Surf.Area= 280,130 sf Storage= 67,674 cf

Plug-Flow detention time= 26.3 min calculated for 7.867 af (100% of inflow)
Center-of-Mass det. time= 26.2 min (940.3 - 914.1)

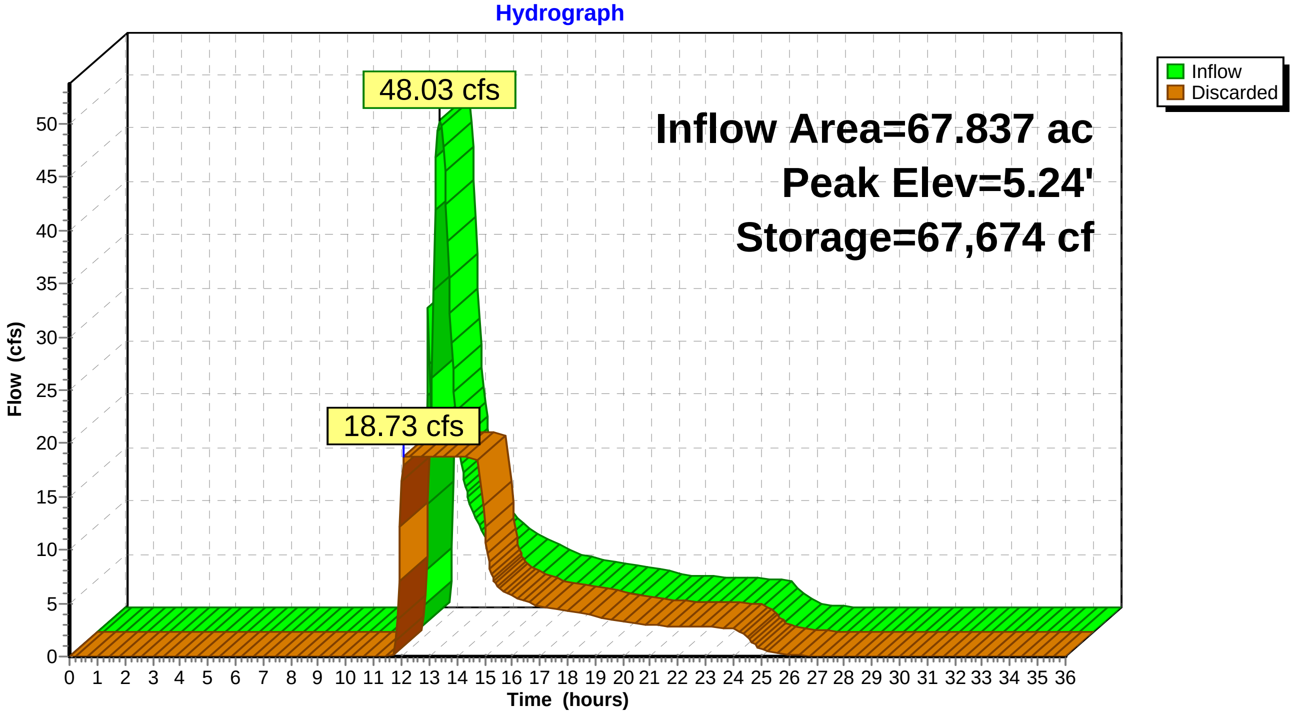
Volume	Invert	Avail.Storage	Storage Description
#1	5.00'	1,264,532 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
5.00	272,367	0	0	272,367
6.00	304,740	288,402	288,402	304,811
7.00	317,804	311,249	599,651	318,064
8.00	333,619	325,679	925,331	334,043
9.00	344,815	339,202	1,264,532	345,479

Device	Routing	Invert	Outlet Devices
#1	Discarded	5.00'	**18.73 cfs Exfiltration at all elevations**

Discarded OutFlow Max=18.73 cfs @ 12.10 hrs HW=5.04' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 18.73 cfs)

Pond NEP: Northeast Pond



Summary for Pond SP: South Pond

Inflow Area = 16.052 ac, 0.00% Impervious, Inflow Depth = 1.39" for 25-yr, 24-hr event
Inflow = 13.41 cfs @ 12.26 hrs, Volume= 1.864 af
Outflow = 9.88 cfs @ 12.10 hrs, Volume= 1.864 af, Atten= 26%, Lag= 0.0 min
Discarded = 9.88 cfs @ 12.10 hrs, Volume= 1.864 af

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Starting Elev= 15.00' Surf.Area= 143,408 sf Storage= 47,803 cf
Peak Elev= 15.04' @ 12.46 hrs Surf.Area= 143,671 sf Storage= 53,832 cf (6,030 cf above start)

Plug-Flow detention time= 373.4 min calculated for 0.767 af (41% of inflow)
Center-of-Mass det. time= 5.8 min (907.3 - 901.5)

Volume	Invert	Avail.Storage	Storage Description
#1	14.00'	845,043 cf	**Custom Stage Data (Pyramidal)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
14.00	0	0	0	0
15.00	143,408	47,803	47,803	143,410
16.00	149,728	146,557	194,359	149,913
17.00	156,581	153,142	347,501	156,942
18.00	162,684	159,623	507,124	163,251
19.00	168,868	165,766	672,890	169,646
20.00	175,458	172,152	845,043	176,442

Device	Routing	Invert	Outlet Devices
#1	Discarded	15.00'	**9.88 cfs Exfiltration when above 15.00'**

Discarded OutFlow Max=9.88 cfs @ 12.10 hrs HW=15.02' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 9.88 cfs)

Pond SP: South Pond