ZCS ENGINEERING ARCHITECTURE

Gaffney Lane Elementary School

Safety and Security Upgrades

A Project for:

Oregon City School District

Location:
13521 S Gaffney Lane
Oregon City, Oregon 97045

STORM DRAINAGE REPORT

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March 2020

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1.0 Project Overview

ZCS Engineering and Architecture (ZCS), and BRIC Architecture are working with the Oregon City School District (OCSD) to renovate Gaffney Lane Elementary School (Gaffney Lane) in Clackamas County, Oregon. The school is within the city limits of Oregon City and development is subject to the Oregon City Stormwater and Grading Design Standards. Gaffney Lane is located at 13521 S Gaffney Lane on T03S-R02E-S08BD Tax Lot 4200. See Figure 1 for a vicinity map and location of the school. Gaffney Lane is located on a ±9.70 acre lot zoned as 'Urban Low Density Residential'.

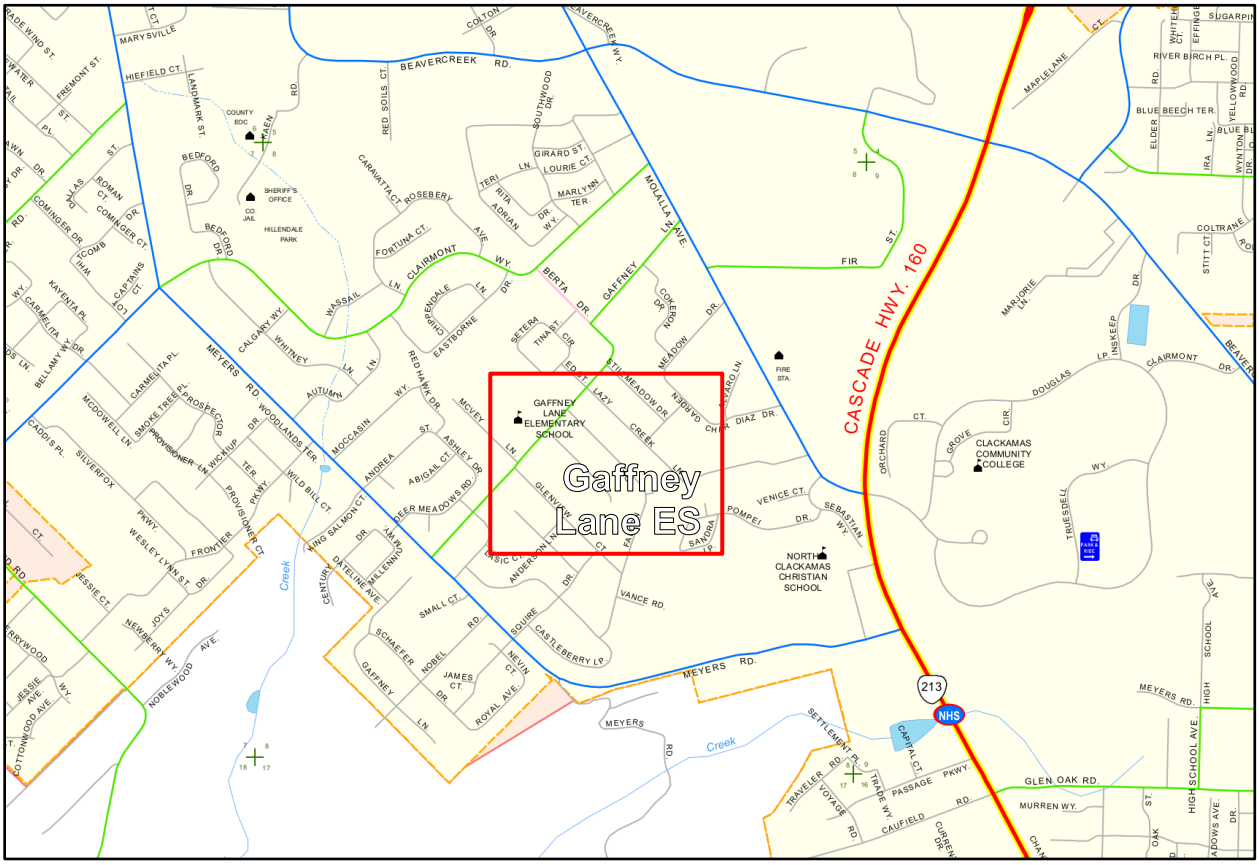


Figure 1 – Vicinity Map

1.1 Existing Site Conditions

The current development of Gaffney Lane includes a ±57,500 SF school building, a ±2,000 SF paved interior courtyard, a ±1,850 SF modular classroom building, and a ±4,525 SF open-air covered play structure with underlying asphalt pavement. An asphalt paved parking and maneuvering area (±68,400) is situated east of the school with additional asphalt paving south of the school for play surface (±22,200 SF). Runoff from buildings and paved surfaces drains to the public stormwater pipe network in Gaffney Lane by way of downspouts and catch-basins on site. The north portion of the

parking lot drains to a subsurface detention system located therein before draining to the public system. In general, developed areas drain southeast at slopes ranging from 2% to 5%. Grass ball fields on the remaining lot drain northwest to the public storm network in Moccasin Way at slopes ranging from 2% to 10%.

1.2 Proposed Site Conditions

Proposed redevelopment includes a ±623 SF addition to the existing school building with no other changes to existing structures on site. The north portion of the existing parking lot will be reconfigured to create a bus drop-off loop with concrete sidewalks providing connection to the school. The entry plaza and delivery area west of the school will be repaved to accommodate changes to the covered entry and expanded trash facilities. A portion of the existing school roof will be redirected to a new stormwater treatment and detention swale located in the northwestern corner of the tax lot. The swale will discharge to the existing public storm system in Moccasin Way. This will reduce discharge to the public system in Gaffney Lane where the school currently drains. No other changes to paved surfaces are proposed.

Overall, new and modified impervious concrete and asphalt surfaces at Gaffney Lane total ±15,080 SF. An area of the existing roof totaling ±17,750 SF will be treated in a vegetated swale in exchange for the developed impervious surface as it is not feasible to capture and treat the impacted impervious surfaces in the parking lot without extensive and cost prohibitive reconfiguration. See Table 1 below for a summary of impervious conditions. See Sheets A-1 and A-2 in Appendix 'A' for an illustration of impervious surfaces and treatment facilities.

Table 1 – Post-Developed Impervious Area Summary

Gaffney Lane Elementary School	**sqft**	**acres**
New Impervious Surface	6,420	0.15
Modified Impervious Surface	8,660	0.20
Total Developed Impervious Surface	**15,080**	**0.35**
Treatment Area (Roof Drainage)	**17,750**	**0.41**

2.0 Stormwater Management Requirements

This stormwater management plan has been prepared in accordance with the Oregon City Stormwater and Grading Design Standards (OCSGDS). Per OCSGDS 1.2.1, any development or redevelopment with new or modified impervious surfaces totaling more than 5,000 SF is subject to the requirements of the standards.

Per OCSGDS 4.2, facilities installed in soil with infiltration rates less than 0.5 inches per hour will require an underdrain connected to an outlet with a flow control structure. Per OCSGDS Appendix D, infiltration tests for developments with more than 10,000 SF of new or redeveloped impervious area should be conducted by a qualified professional. One test is required for every 100 LF or 1,000 SF of proposed infiltration facility, and test should be conducted in the immediate vicinity of the facility.

Per OCSGDS 4.2, water quality facilities should treat a design storm of 1.0 inch in 24 hours. Flow control facilities shall be designed so the duration of peak flow rates from post-development conditions shall be less than or equal to the duration of peak flow rates from pre-developed conditions for all peak flows between 42% of the 2-year peak flow rate up to the 10-year peak flow rate.

Per OCSGDS 5.2.4, an analysis shall be conducted to determine downstream deficiencies beyond the approved discharge point. When deficiency occurs within 1,500 feet or before the point where the developed site contributes less than 15% of the cumulative tributary drainage area (whichever is greater), additional onsite detention will be required.

Per OCSGDS 5.3.4, hydrologic analysis may be performed using the Santabarbara Urban Hydrograph method based on a 24 hour duration storm event with NRCS Type 1A rainfall distribution.

3.0 Stormwater Management Plan

Infiltration testing performed by Geotech Solutions Inc. in accordance with OCSGDS indicates inadequate infiltration on site to meet the requirements described in Section 2.0 of this report (OCSGDS Section 4.2). Infiltration facilities are not recommended; instead, existing topography and site conditions enable the creation of a vegetated swale to provide required treatment and flow control.

Table 2, below, provides a summary of infiltration testing results. The full geotechnical report and infiltration testing addendum can be found in Appendix ‘D’ of this report.

Table 2 - Infiltration Testing Results Summary

Infiltration Test	Depth of Test (feet)	Soil Classification	Field Measured Infiltration Rate (inches/hour)	Corrected Infiltration Rate with FS=2 (inches/hour)
Minimum	4	Volcanic Silt	0.04	Not Recommended
Maximum	4	Volcanic Silt	0.08	Not Recommended
Median	4	Volcanic Silt	0.05	Not Recommended

Per the USDA Soil Survey, the soils at Gaffney Lane belong predominantly to groups 45B (Jory Silty Clay Loam) and 8B (Bornstedt Silt Lome). Both these soils belong to Hydrologic Soil Group (HSG) 'C'; however, testing performed at the site indicates less infiltration potential than typical for soils of this group. Per the Natural Resources Conservation Service Part 630 Hydrology National Engineering Handbook, an HSG 'C' rating indicates soils with moderately high runoff potential.

Based on the impermeable native soil conditions, adequate on-site infiltration at Gaffney Lane cannot be achieved. As a result, a stormwater facility was designed based on the minimum treatment requirements output by the Best Management Practice Sizing Tool (BMP Tool) developed for Water Environmental Services (WES) by Brown and Caldwell using a continuous rainfall model. A vegetated filtration swale designed according to the BMP Tool was considered as a starting point to satisfy minimum water quality control requirements. The size of the filtration swale was then increased to accommodate the necessary flow control described above in Section 2.0 of this report. See Section 3.2, below, for additional information regarding proposed treatment and flow control. See Sheets A-1 through A-3, and Sheet A-12 for the BMP Tool output and an illustrations of the final vegetated swale.

3.1 BMP Tool Sizing Criteria

The BMP tool provides minimum requirements for stormwater treatment facilities based on their input runoff areas and the infiltration rate of their associated soils. Using this tool, areas which are impervious in both pre and post-developed conditions must be treated and in some cases must be flow controlled for treatment based on a continuous rainfall model developed by Brown and Caldwell and WES. Areas which will be impervious but were previously pervious must be treated and must be flow controlled via an allowable facility sized using the BMP Tool. Table 3, on the following page, provides a summary of the existing and proposed impervious surfaces at Gaffney Lane used in the BMP Tool to determine minimum treatment and flow control requirements.

Given site constraints, it was not possible to direct all areas of new impervious surfaces to a surface facility; therefore, a more than equivalent area of existing school building roof drainage has been substituted to provide treatment and flow control that demonstrates compliance with the stated intents of the OCSGDS.

Table 3- Existing vs. Proposed Impervious Areas

Existing Condition	Proposed Condition	Area, sqft	Requirements
Impervious	Impervious	8,660	Treatment Only
Pervious	Impervious	6,420	Treatment & Flow Control
Impervious	Pervious	440	None
Pervious	Pervious	13,940	None
Total Required Treatment Area**		15,080	
Total Impacted Area***		29,460	

**Treatment required for all new and modified impervious surfaces
***Total impacted area is the sum total of all areas

3.2 Proposed Treatment & Flow Control Facilities

The new stormwater facility is adequately sized to provide equivalent treatment for the ±15,080 SF of new and modified impervious surface developed at Gaffney Lane. The final size of the facility has been designed based on treatment for ±17,750 SF of roof runoff from the existing school building. See Sheets A-1 and A-2 in Appendix 'A' for an illustration of the impervious surfaces being developed and the area of school roof being treated at Gaffney Lane.

New stormwater facilities on site are limited to one vegetated filtration swale. The vegetated swale will be located at the west corner of the lot near an existing ball field. The minimum size of the vegetated swale for treatment has been determined by the BMP tool, and the final size of the swale for flow control has been determined using the Hydraflow Hydrographs Extension for Civil 3d 2019 (version 2020). Refer to Sheet A-3 in Appendix 'A' for output from the BMP Tool. Refer to Sheet A-5 in Appendix 'A' for the size and characteristics of the final facility. Table 4, below, provides a summary of proposed treatment.

Table 4- Treatment and Flow Control Summary

Treatment Method	Treatment/Flow Control	Area, sqft
Treatment and Flow Control	Required for New Impervious	256.8
	Required for Roof	710.0
	Provided	2,040
Treatment Only	Required for Modified Impervious	129.9
	Provided	2,040

4.0 Downstream Analysis

Per OCSGDS, a downstream analysis was conducted to determine the capacity of the public stormwater system 1,500 feet downstream of Gaffney Lane Elementary School along Moccasin Way during the projected peak flows from a 25-year storm event.

The study point for this analysis is located along Mud Creek approximately 115' beyond the exit to the culvert beneath Myers Road. This point serves as the discharge for approximately 197 acres of the Mud Creek Drainage Basin. Roughly 80% of this area is comprised of roadways and urban development north of Mud Creek. Gaffney Lane Elementary School is located on the remaining drainage basin south of Mud Creek along with the Deer Meadows, Bay Meadows, and Dell's Addition subdivisions. Downstream analysis was conducted using Autodesk Storm and Sanitary Analysis 2020. Data for the analysis was collected from the Oregon City GIS 'OCWebMaps', and from as-built information on file for the Deer Meadows, Bay Meadows, and Dell's Addition subdivisions.

During construction of the Deer Meadows Subdivision southwest of Gaffney Lane Elementary School, a public storm system and detention pond were constructed along Moccasin Way. Subsequently as part of construction of the Bay Meadows Subdivision, additional storm pipe was added to Moccasin Way, the public storm pond was expanded, a treatment swale was added to the storm pond, and a storm drain manhole was provided at the end of Moccasin Way for future connection to the system. This manhole will serve as the public connection point for the new control facility at Gaffney Lane. All water entering the system will pass through the existing public detention pond and will be discharged through a culvert beneath Meyers Road to Mud Creek. Downstream deficiencies in the storm system through Deer Meadows and Bay Meadows Subdivisions should manifest as on or more of the following:

- Surcharging of existing storm pipes
- Overtopping of the rims of existing manholes
- Overtopping of the existing treatment swale and/or detention pond
- Overtopping of the banks of deer creek
- Surcharging of the Myers Road Culvert

Downstream analysis indicates surcharged conditions in the storm pipes along Moccasin Way, in two of the storm pipes discharging to the public detention pond, and in the final storm pipe discharging from Deer Meadows Subdivision into Mud Creek (See Sheet B-2 in Appendix 'B'). Surcharging did not occur in the Meyers

Road Culvert. Overtopping conditions did not occur for Mud Creek, for the existing swale or storm detention pond, or for any of the existing manholes. These results indicate a surcharged storm system with limited downstream capacity, but do not indicate an elevated risk of surface flooding.

Based on these downstream capacity issues, proposed stormwater improvements at Gaffney Lane will provide detention as follows:

- Post-developed 2-year discharge will be reduced to ½ of the existing 2-year 24-hour runoff rate
- Post-developed 25-year discharge will be reduced to the existing 2-year 24-hour runoff rate

Refer to Appendix 'A' for additional information related to on-site detention. Refer to Appendix 'B' for downstream analysis figures and calculations.

5.0 Over Detention Facilities

Based on these downstream capacity issues, the proposed improvements at Gaffney Lane will be detained as follows: the post-developed 2 year discharge rate will be reduced to ½ of the existing 2 year, 24 hour runoff rate, and the post-developed 25 year discharge rate will be reduced to the existing 2 year, 24 hour runoff rate. To achieve this detention, a 2,040 SF vegetated swale with a 1.25"Ø detention orifice will be provided in place of the 710 SF swale with 1.5"Ø orifice suggested by the WES BMP Tool (See Table 4 3 and Sheet A-3).

Detention calculations were carried out in Hydraflow Hydrographs Extension for Civil 3d 2019 (version 2020) using the Santa Barbara Urban Hydrograph method with precipitation data for Oregon City described in Table 5. See Appendix 'A' for an Outflow Summary, Hydrographs, and a Pond Report.

Table 5 – 24 Hour Rainfall Depths in Oregon City

Recurrence Interval (Years)	24-Hour Depth (Inches)
2	2.8
10	3.5
25	4.0
50	4.4
100	4.5

6.0 Erosion and Sediment Control Plan

An Erosion Control plan has been prepared for this project. The information contained within the plan set is considered a minimum and shall be modified by the Contractor or Inspector as required to contain all sediment on site. Special

attention shall be taken at all existing storm drain catch basins and channels to eliminate any sediment transfer into the existing storm drain system. An all-weather rock surface shall be provided at the construction site entrance. All construction will be maintained within the development limits of this phase. It will be the responsibility of the Contractor to ensure compliance with the referenced plans and County requirements.

7.0 Operation and Maintenance of Stormwater Facilities

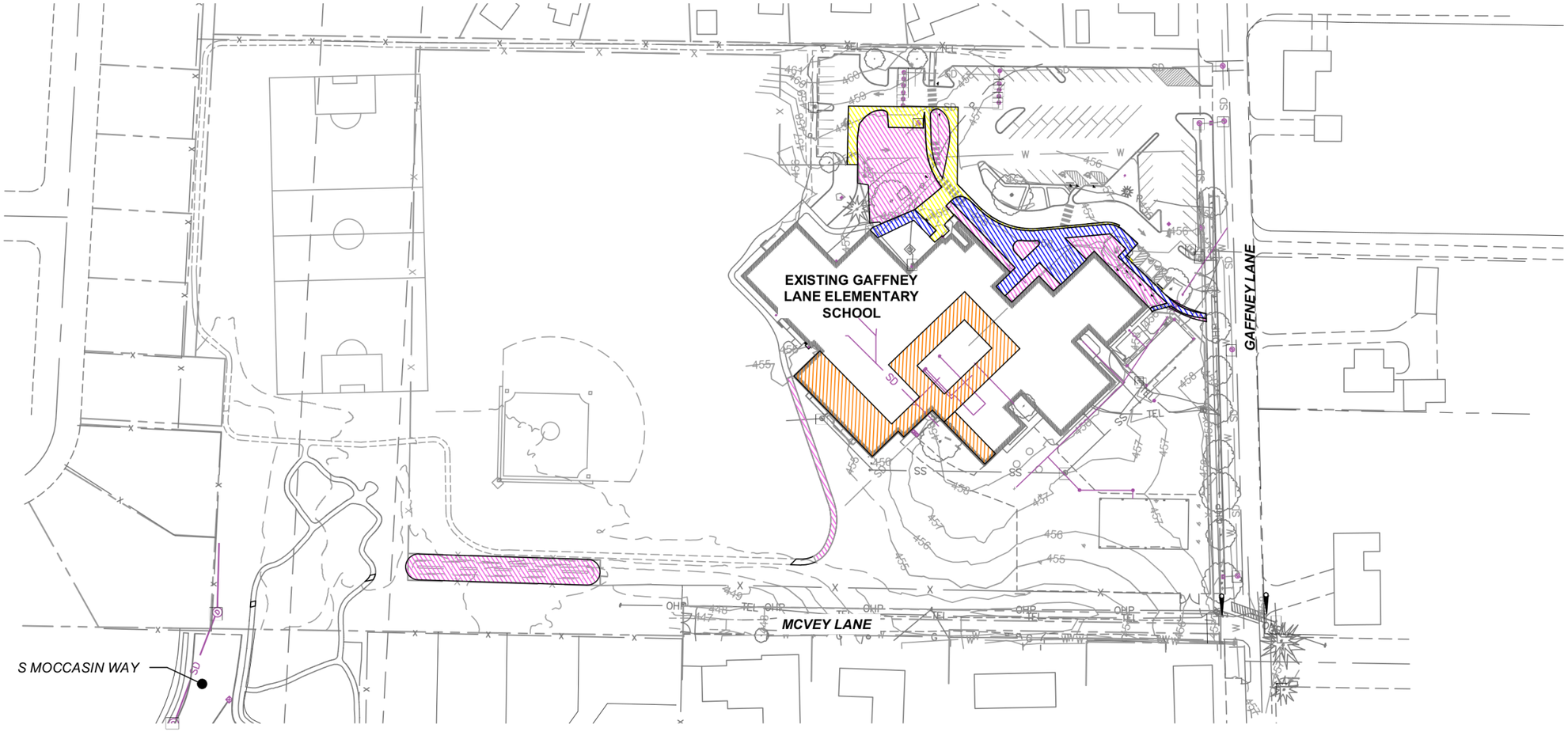
This document has been prepared to guide the owner of the proposed facility (or active operation and maintenance supervisor) in the cleaning, repairing, and general operation and maintenance of the stormwater system. The below requirements shall be considered a minimum.

This document has been prepared to address the overall primary operation and maintenance of the facility. It shall be the responsibility of the owner to adjust specific Operation & Maintenance (O&M) measures in the field as required to maintain a fully functional storm conveyance system. The owner shall implement, at a minimum, the following inspection and maintenance program to be performed twice annually, April and October. The following items shall be incorporated into the program:

- Paved Parking & Maneuvering Areas – Prior to cleaning the pipe network, all paved parking and maneuvering areas shall be swept or washed clean
- Area Inlets – Inspect and clean each inlet grate and sump, clean and repair as needed
- Stormwater Pipe Network – Inspect conveyance pipes for sediment buildup. If sediment is present, high pressure wash each pipe into adjacent downstream catch basin/manhole, taking care not to allow material to wash downstream. All sediment shall be extracted from structures/pipes and disposed of at an approved location
- Stormwater Filtration Swales – Inspect and clean swale. Remove any accumulated garbage/debris. Inspect swale for any signs of erosion; repair any found defects. Review condition of plantings; any plantings that are found to be dead or dying shall be replaced. Remove discharge structure grate to wash and vacuum sump. Do not allow sediment material to wash downstream from this point. All sediment to be extracted from structures and disposed of at an approved location. Examine orifice, remove any blockages to allow for proper operation and drainage.

Appendix 'A' – Treatment and Flow Control Calculations

A-1 Existing Conditions



GAFFNEY LANE PRE-DEVELOPED CONDITIONS EXHIBIT

NTS

PRE-DEVELOPED LEGEND & SUMMARY:

ASPHALT PAVEMENT - EXISTING
AREA = ±0.03 ACRES
CURVE NUMBER = 98
MANNING'S NUMBER = 0.011

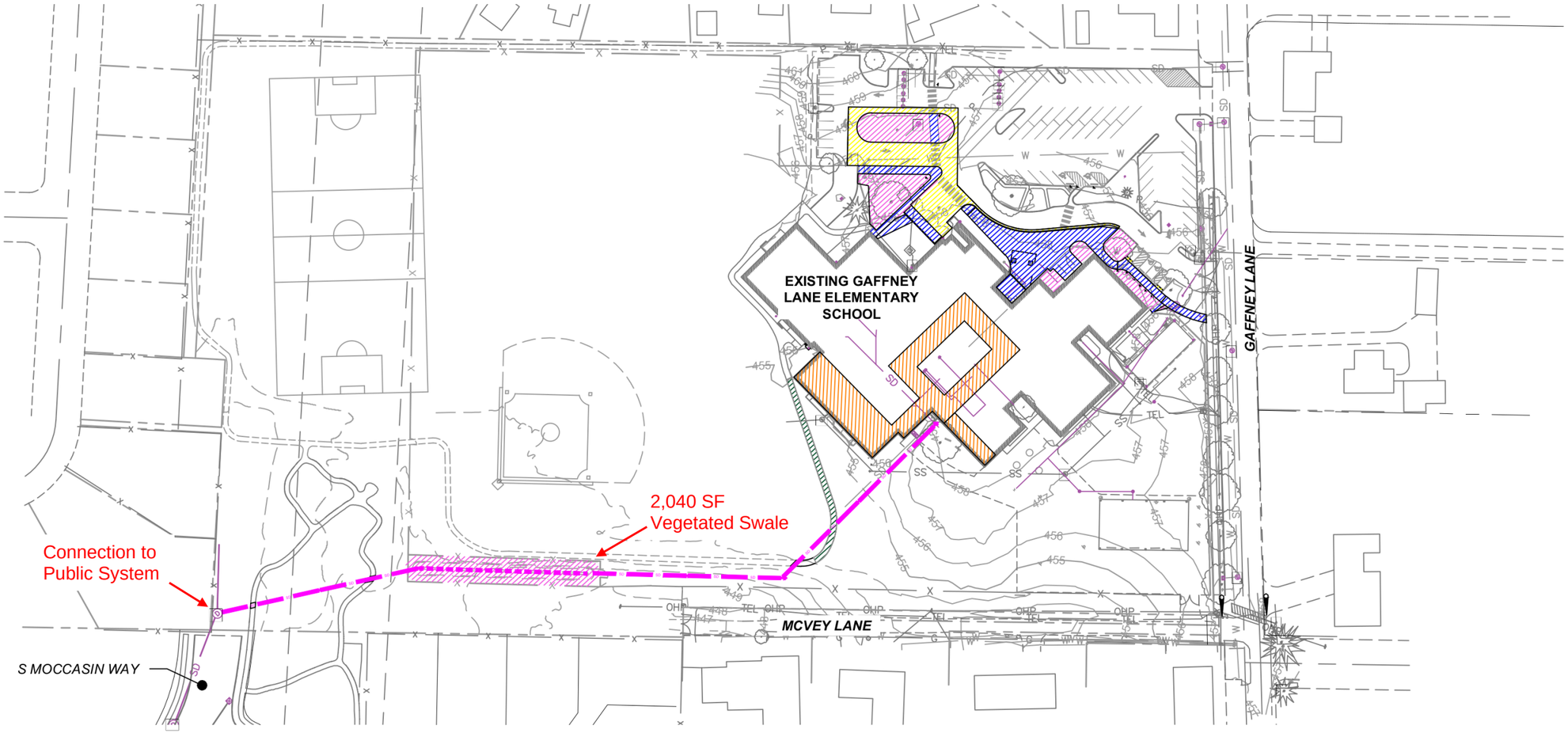
CONCRETE PAVEMENT - EXISTING
AREA = ±0.004 ACRES
CURVE NUMBER = 98
MANNING'S NUMBER = 0.011

LANDSCAPING - EXISTING
AREA = ±0.40 ACRES
CURVE NUMBER = 61
MANNING'S NUMBER = 0.15

TREATED ROOF
AREA = ±0.41 ACRES
CURVE NUMBER = 98
MANNING'S NUMBER = 0.011

TOTAL POST-DEVELOPED:	±0.65 ACRES
IMPERVIOUS AREA	±0.33 ACRES
TREATED AREA (ROOF)	±0.41 ACRES

A-2 Proposed Conditions



GAFFNEY LANE POST-DEVELOPED CONDITIONS EXHIBIT

NTS

POST-DEVELOPED LEGEND & SUMMARY:

ASPHALT PAVEMENT - PROPOSED
AREA = ±0.02 ACRES
CURVE NUMBER = 98
MANNING'S NUMBER = 0.011

CONCRETE PAVEMENT - PROPOSED
AREA = ±0.04 ACRES
CURVE NUMBER = 98
MANNING'S NUMBER = 0.011

NEW STORM DRAIN CONNECTION
LENGTH = ±800 LF
MANNING'S NUMBER = 0.013

LANDSCAPING - PROPOSED
AREA = ±0.12 ACRES
CURVE NUMBER = 61
MANNING'S NUMBER = 0.15

DECOMOPOSED GRANITE - PROPOSED
AREA = .04 ACRES
CURVE NUMBER = 61
MANNING'S NUMBER = 0.15

TOTAL POST-DEVELOPED:	±0.65 ACRES
IMPERVIOUS AREA	±0.33 ACRES
TREATED AREA (ROOF)	±0.41 ACRES

A-3 WES BMP Tool Output (Minimum Treatment Requirements)

WES BMP Sizing Software Version 1.6.0.2, May 2018

WES BMP Sizing Report

Project Information

Project Name	Gaffney Elementary School
Project Type	Addition
Location	13521 S Gaffney Lane
Stormwater Management Area	17750
Project Applicant	Oregon City School District
Jurisdiction	TriCitySD

Drainage Management Area

Name	Area (sq-ft)	Pre-Project Cover	Post-Project Cover	DMA Soil Type	BMP
School Roof	17,750	Grass	Roofs	D	From School Roof
Modified Impervious	8,660	Grass	ConventionalConcrete	D	From Modified Impervious
New Impervious	6,420	Grass	ConventionalConcrete	D	From New Impervious

LID Facility Sizing Details

LID ID	Design Criteria	BMP Type	Facility Soil Type	Minimum Area (sq-ft)	Planned Areas (sq-ft)	Orifice Diameter (in)
From School Roof	FlowControlAndTreatment	Vegetated Swale - Filtration	D1	710.0	2,040.0	1.5
From Modified Impervious	WaterQuality	Vegetated Swale - Filtration	D1	129.9	2,040.0	0.5
From New Impervious	FlowControlAndTreatment	Vegetated Swale - Filtration	D1	256.8	2,040.0	0.9

Pond Sizing Details

1. FCWQT = Flow control and water quality treatment, WQT = Water quality treatment only
2. Depth is measured from the bottom of the facility and includes the three feet of media (drain rock, separation layer and growing media).
3. Maximum volume of the facility. Includes the volume occupied by the media at the bottom of the facility.

A-4 Outflow Summary

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SBUH Runoff	------	-------	0.143	-------	-------	-------	0.246	-------	-------	Target Conditions
2	SBUH Runoff	------	-------	0.266	-------	-------	-------	0.385	-------	-------	Existing Gaffney Roof
3	Reservoir	2	-------	0.072	-------	-------	-------	0.079	-------	-------	Vegetated Swale

1/2 of 2-yr Storm

< 2-yr Storm

Proj. file: P2452 Hydraflow 2.gpw	Friday, 04 / 3 / 2020

A-5 Vegetated Swale Summary

Pond Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 — Thursday, 04 / 9 / 2020

Pond No. 1 - Vegetated Swale

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 448.58 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	448.58	03	0	0
2.72	451.30	03	9	9
2.75	451.33	320	4	12
4.09	452.67	1,687	1,225	1,237
4.42	453.00	2,040	614	1,851

Maximum Available Storage Beneath 4" Free-Board

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 12.00	1.25	0.00	0.00
Span (in)	= 12.00	1.25	0.00	0.00
No. Barrels	= 1	1	0	0
Invert El. (ft)	= 448.58	448.60	0.00	0.00
Length (ft)	= 100.00	0.00	0.00	0.00
Slope (%)	= 0.50	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	Yes	No	No

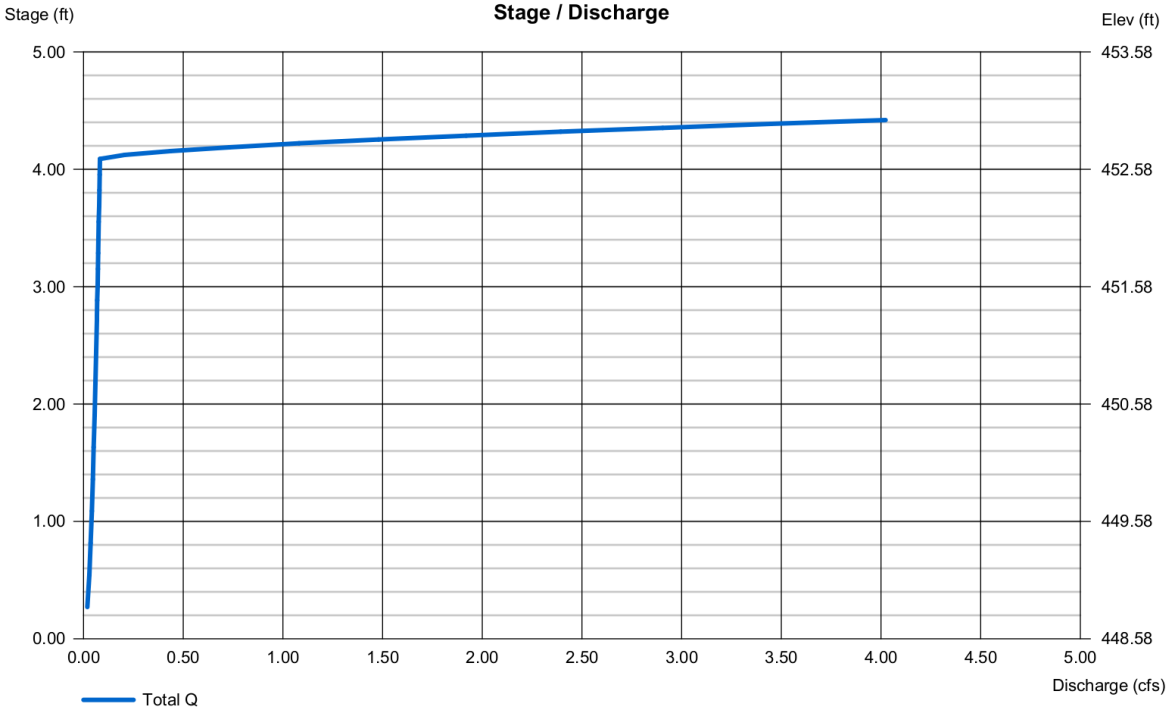
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 6.28	0.00	0.00	0.00
Crest El. (ft)	= 452.67	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= 1	---	---	---
Multi-Stage	= Yes	No	No	No
Exfil.(in/hr)	= 0.000 (by Contour)			
TW Elev. (ft)	= 0.00			

24" Diameter Overflow Riser Rim at 452.67'

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).

1.25" Diameter Control Orifice at 448.58'



A-6 Existing Conditions – 2 Year Storm

Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 — Friday, 04 / 3 / 2020

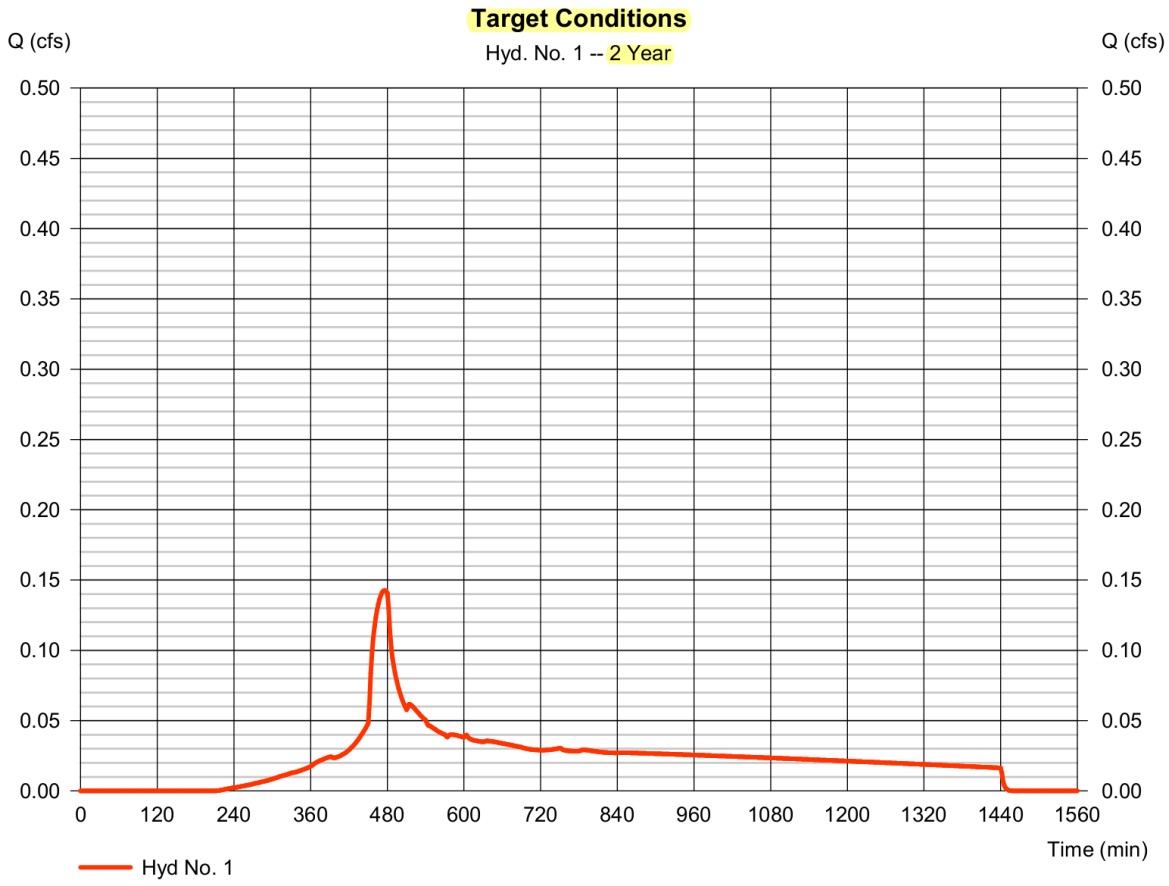
Hyd. No. 1

1/2 of 2 Year Storm = 0.72 cfs

Target Conditions

Hydrograph type	= SBUH Runoff	Peak discharge	= 0.143 cfs
Storm frequency	= 2 yrs	Time to peak	= 476 min
Time interval	= 2 min	Hyd. volume	= 2,086 cuft
Drainage area	= 0.350 ac	Curve number	= 88*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 3.30 min
Total precip.	= 2.80 in	Distribution	= Type IA
Storm duration	= 24 hrs	Shape factor	= n/a

* Composite (Area/CN) = [(0.200 x 98) + (0.150 x 74)] / 0.350



A-7 Unrestricted Roof Runoff – 2 Year Storm

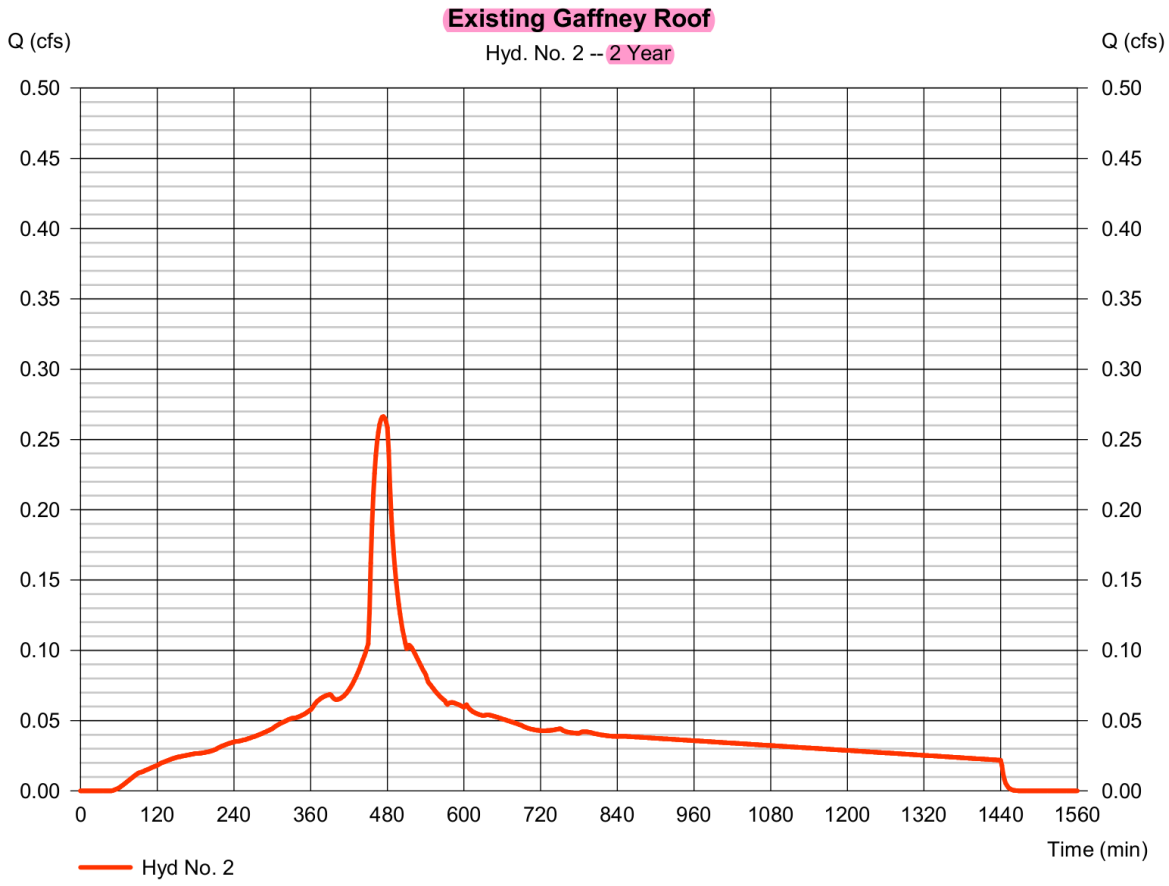
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 — Friday, 04 / 3 / 2020

Hyd. No. 2

Existing Gaffney Roof

Hydrograph type	= SBUH Runoff	Peak discharge	= 0.266 cfs
Storm frequency	= 2 yrs	Time to peak	= 474 min
Time interval	= 2 min	Hyd. volume	= 3,824 cuft
Drainage area	= 0.410 ac	Curve number	= 98
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 2.80 in	Distribution	= Type IA
Storm duration	= 24 hrs	Shape factor	= n/a



A-8 Vegetated Swale – 2 Year Storm

Hydrograph Report

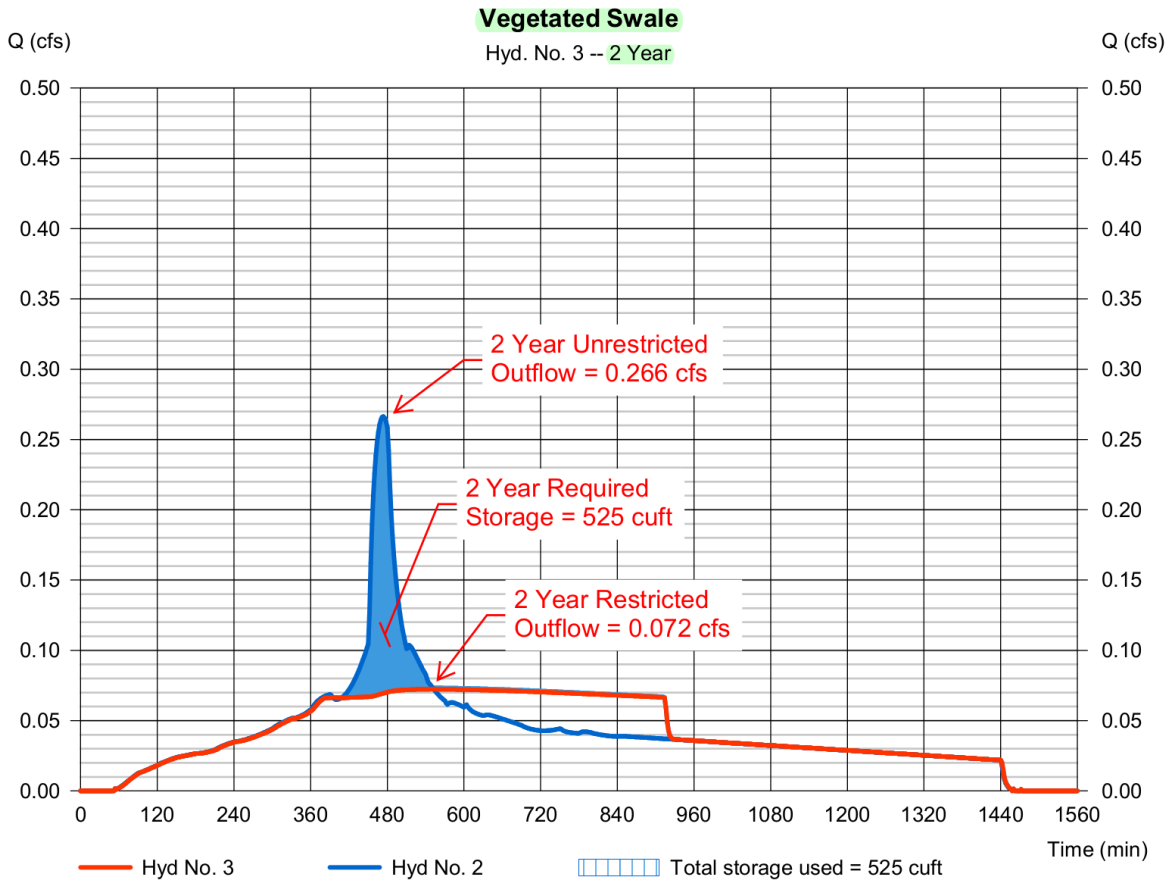
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 — Friday, 04 / 3 / 2020

Hyd. No. 3

Vegetated Swale

Hydrograph type	= Reservoir	Peak discharge	= 0.072 cfs
Storm frequency	= 2 yrs	Time to peak	= 552 min
Time interval	= 2 min	Hyd. volume	= 3,803 cuft
Inflow hyd. No.	= 2 - Existing Gaffney Roof	Max. Elevation	= 451.82 ft
Reservoir name	= Vegetated Swale	Max. Storage	= 525 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



A-9 Existing Conditions – 25 Year Storm

Hydrograph Report

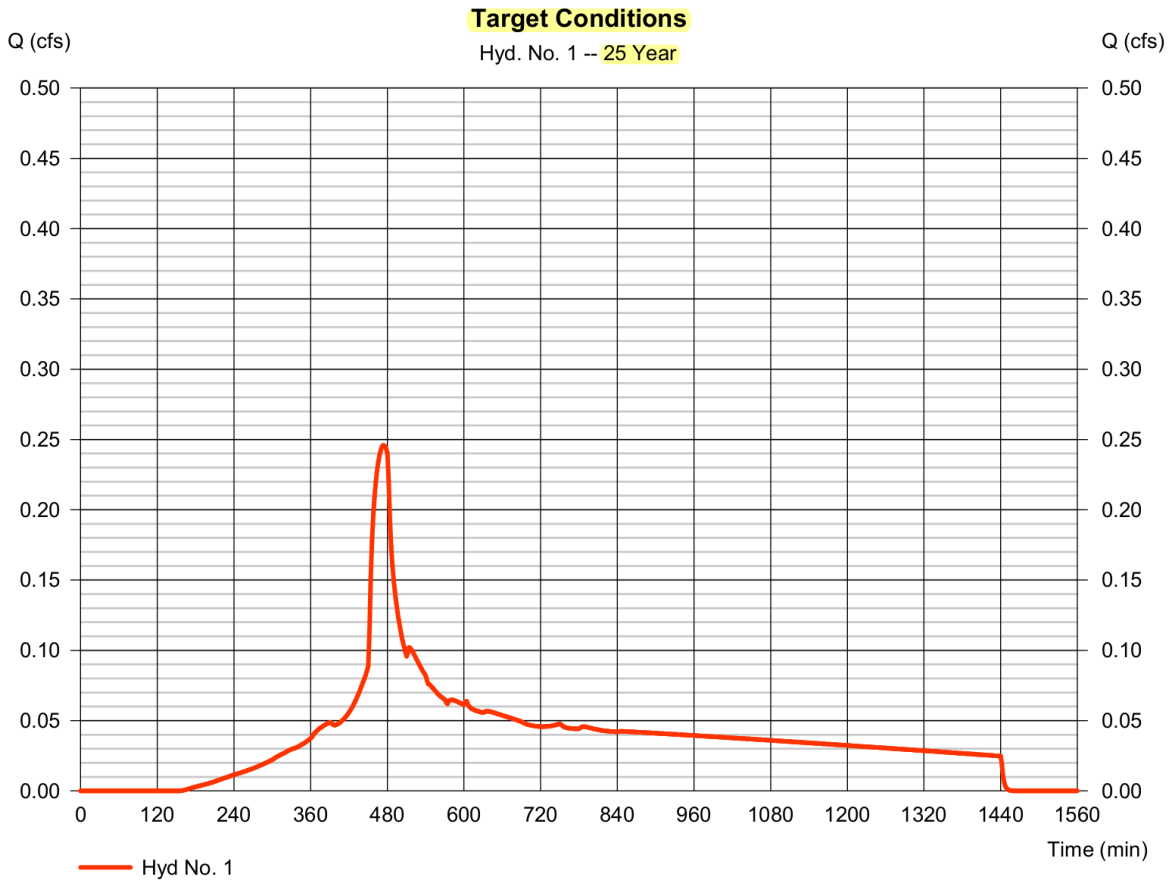
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 — Friday, 04 / 3 / 2020

Hyd. No. 1

Target Conditions

Hydrograph type	= SBUH Runoff	Peak discharge	= 0.246 cfs
Storm frequency	= 25 yrs	Time to peak	= 474 min
Time interval	= 2 min	Hyd. volume	= 3,467 cuft
Drainage area	= 0.350 ac	Curve number	= 88*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 3.30 min
Total precip.	= 4.00 in	Distribution	= Type IA
Storm duration	= 24 hrs	Shape factor	= n/a

* Composite (Area/CN) = [(0.200 x 98) + (0.150 x 74)] / 0.350



A-10 Unrestricted Roof Runoff – 25 Year Storm

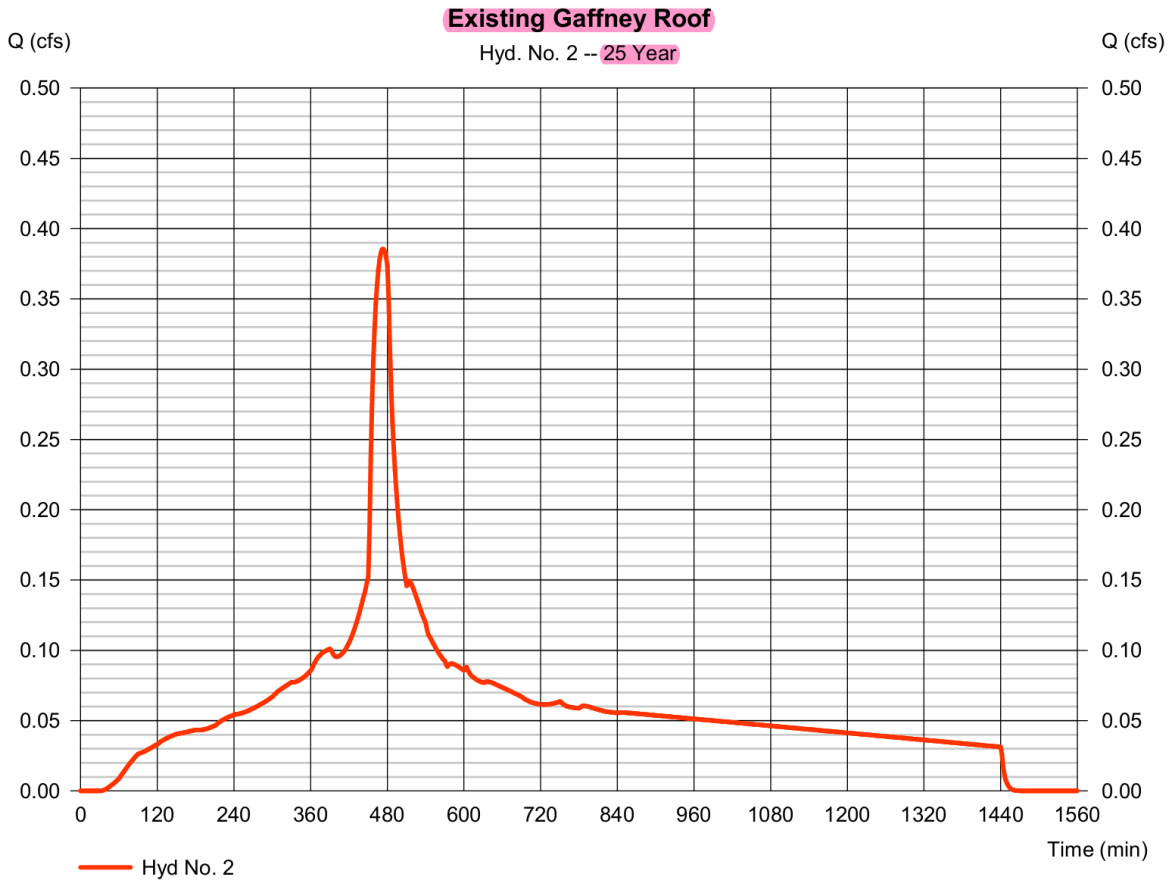
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 — Friday, 04 / 3 / 2020

Hyd. No. 2

Existing Gaffney Roof

Hydrograph type	= SBUH Runoff	Peak discharge	= 0.385 cfs
Storm frequency	= 25 yrs	Time to peak	= 474 min
Time interval	= 2 min	Hyd. volume	= 5,604 cuft
Drainage area	= 0.410 ac	Curve number	= 98
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 4.00 in	Distribution	= Type IA
Storm duration	= 24 hrs	Shape factor	= n/a



A-11 Vegetated Swale – 25 Year Storm

Hydrograph Report

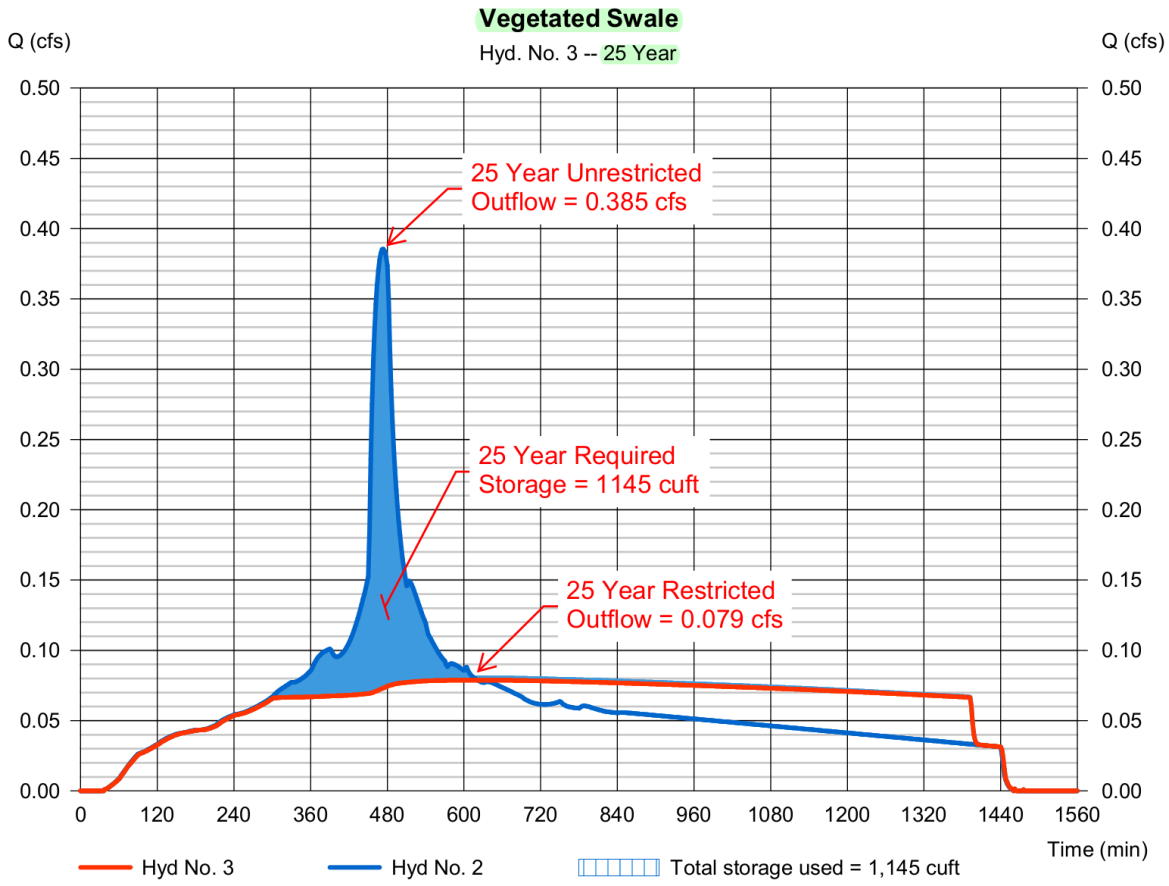
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 — Friday, 04 / 3 / 2020

Hyd. No. 3

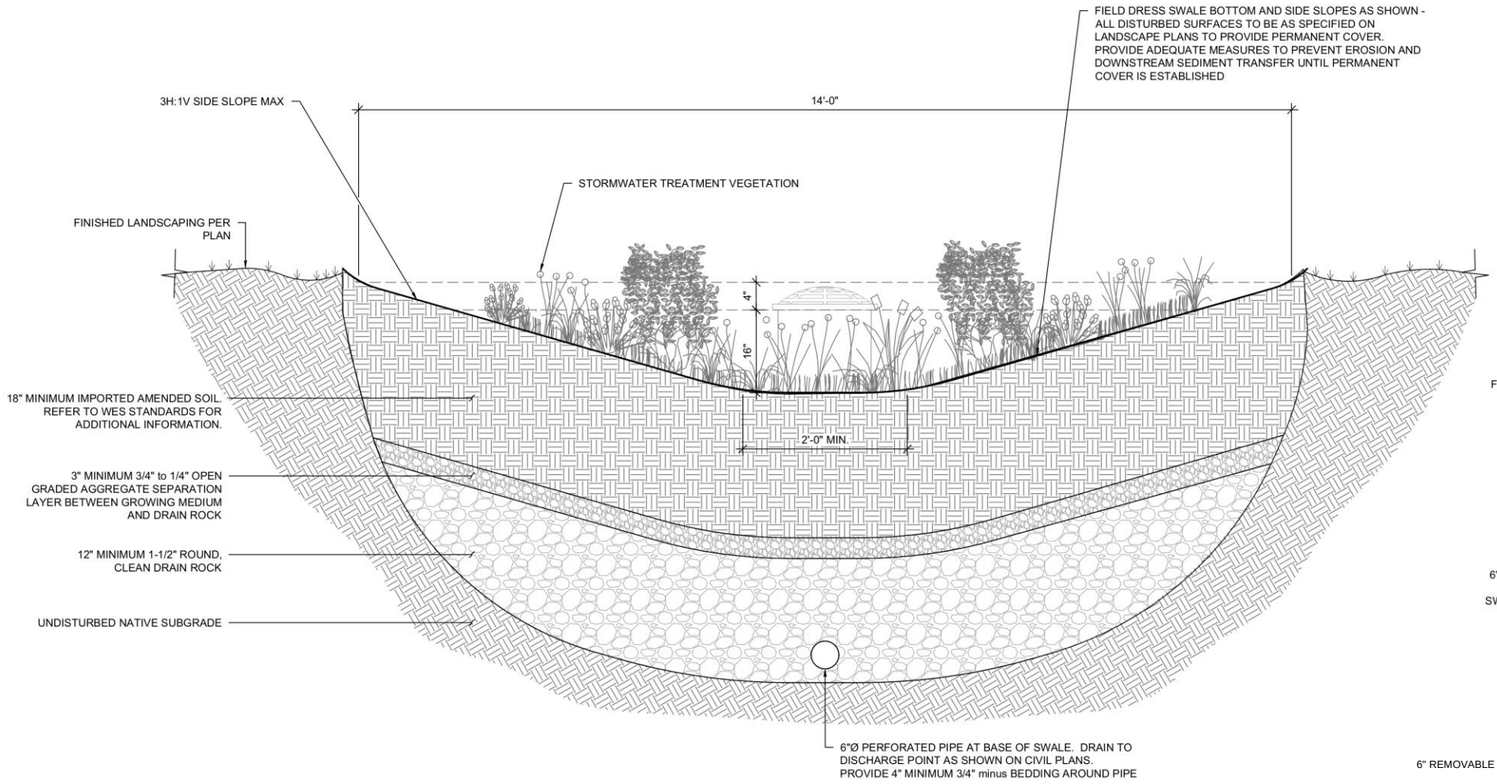
Vegetated Swale

Hydrograph type	= Reservoir	Peak discharge	= 0.079 cfs
Storm frequency	= 25 yrs	Time to peak	= 616 min
Time interval	= 2 min	Hyd. volume	= 5,534 cuft
Inflow hyd. No.	= 2 - Existing Gaffney Roof	Max. Elevation	= 452.40 ft
Reservoir name	= Vegetated Swale	Max. Storage	= 1,145 cuft

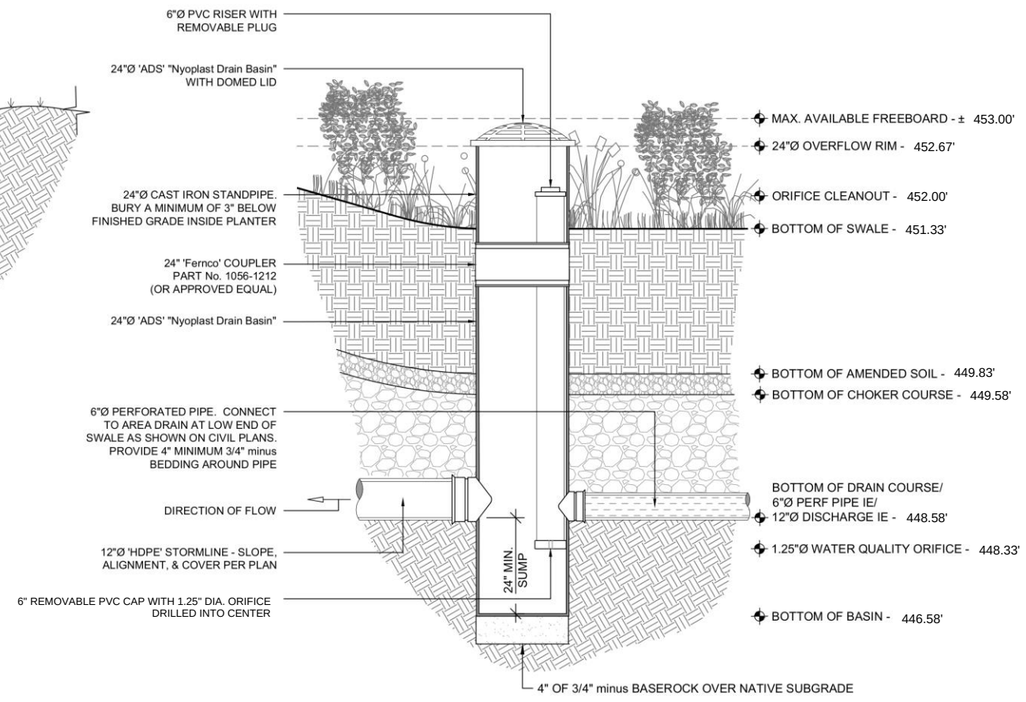
Storage Indication method used. Exfiltration extracted from Outflow.



A-12 Vegetated Swale – Cross Section Detail



TYPICAL INTERIOR SWALE SECTION



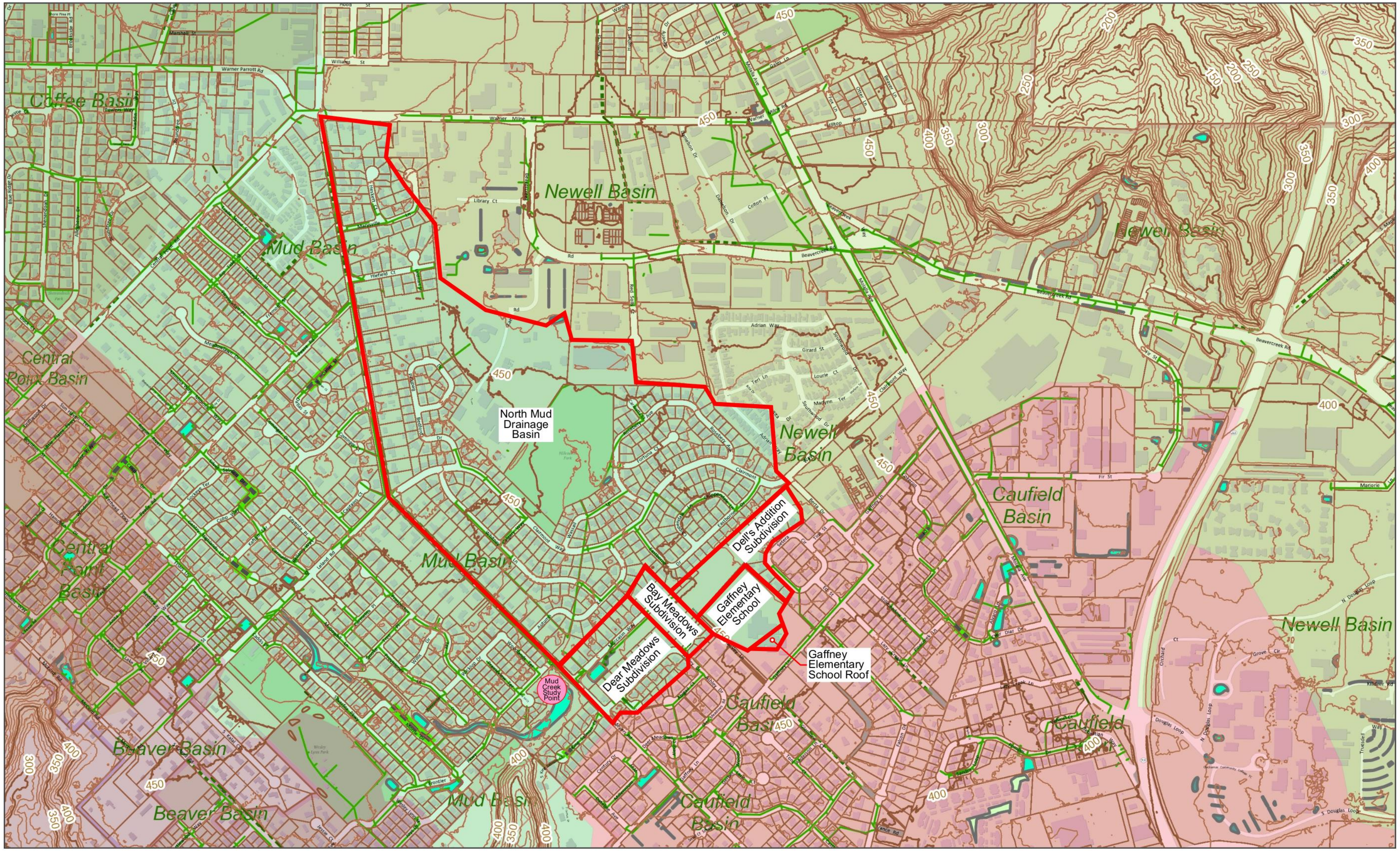
DISCHARGE CONTROL STRUCTURE

SUBMIT SHOP DRAWINGS FOR ENGINEER APPROVAL PRIOR TO CONSTRUCTION

Appendix 'B' – Downstream Analysis

B-1 Drainage Basin Overview

Mud Basin Downstream Analysis



Legend

Street Names

Contours (10ft) - 1:3,600 to 1:12,000

- 50 foot
- 10 foot

Taxlots

Taxlots Outside UGB

Unimproved ROW

Storm Conduits (City Owned)

- Pipe
- Culvert
- Ditch
- Detention Tank

Storm Ponds

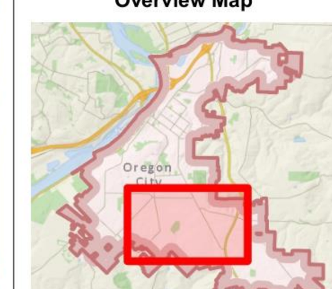
- Pond
- Swale
- Man-Made Wetland
- Infiltration
- Rain Garden
- Pervious Pavement
- Roadside Planter

Drainage Basins

- Abernethy Basin
- Alan Court Basin

Notes

Overview Map



The City of Oregon City makes no representations, express or implied, as to the accuracy, completeness and timeliness of the information displayed. This map is not suitable for legal, engineering, surveying or navigation purposes. Notification of any errors is appreciated.

Map created 4/3/2020

N

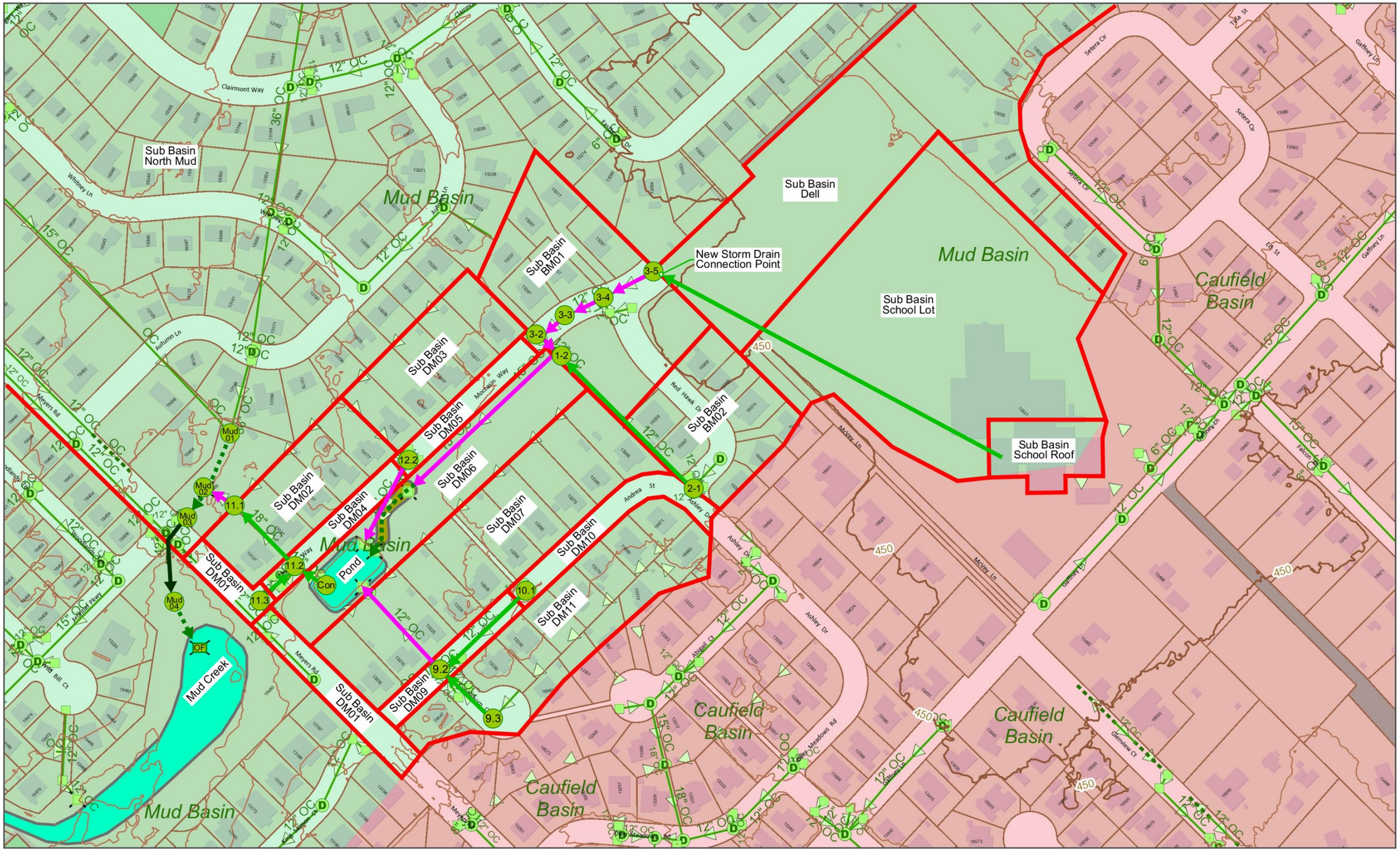
0 1,600 3,200 Feet

1: 9,600

City of Oregon City
PO Box 3040
625 Center St
Oregon City
OR 97045
(503) 657-0891
www.orcity.org

B-2 Sub Basin Overview

Mud Basin Downstream Analysis

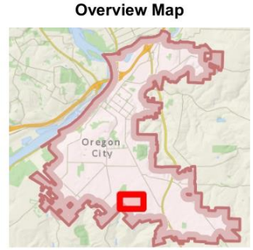


Legend

- Street Names
- Contours (10ft) - 1:3,600 and closer
  - 50 foot
  - 10 foot
- Taxlots
- Taxlots Outside UGB
- Unimproved ROW
- Storm Structures (City Owned)
  - Manhole
  - Inlet
  - Outlet
- Storm Conduits (City Owned)
  - Pipe
  - Surcharged Pipe
  - Culvert
  - Ditch
  - Detention Tank
- Flow Arrows
- Storm Ponds
  - Pond
  - Swale
  - Man-Made Wetland
  - Infiltration
  - Rain Garden

Notes

Overview Map



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Map created 4/3/2020

N

0 400 800 Feet

1: 2,400

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B-3 Rainfall and Sub Basin Report

Rainfall

Element ID	Description	Data Source	Data Source	Rainfall Type	Rain Units	State	County	Return Period	Rainfall Depth	Rainfall Distribution
								(years)	(inches)	
Rain Gage-01		Time Series	Clackamas 25yr	Cumulative	inches	Oregon	Clackamas	25	4	SCS Type IA 24-hr

Sub Basins

Element ID	Description	Area	Drainage Node ID	Impervious Area Curve Number	Pervious Area Curve Number	Impervious Area	Rain Gage ID	Total Precipitation	Total Runoff	Peak Runoff	Time of Concentration
		(acres)				(%)		(inches)	(inches)	(cfs)	(days hh:mm:ss)
BM01	Sub Basin	2.73	MH_3-4	80.00	76.00	100.00	Rain Gage-01	3.99	1.99	0.75	0 00:44:39
BM02	Sub Basin	1.91	MH_2-1	98.00	76.00	25.00	Rain Gage-01	3.99	2.22	0.81	0 00:18:10
DM01	Sub Basin	0.32	Mud03	98.00	80.00	100.00	Rain Gage-01	3.99	3.76	0.30	0 00:05:00
DM02	Sub Basin	1.42	MH11.1	98.00	80.00	0.00	Rain Gage-01	3.99	2.02	0.59	0 00:13:19
DM03	Sub Basin	1.39	MH12.2	98.00	80.00	0.00	Rain Gage-01	3.99	1.99	0.39	0 00:43:42
DM04	Sub Basin	0.49	MH11.2	98.00	80.00	100.00	Rain Gage-01	3.99	3.76	0.46	0 00:05:00
DM05	Sub Basin	0.42	MH12.2	98.00	80.00	100.00	Rain Gage-01	3.99	3.76	0.39	0 00:05:00
DM06	Sub Basin	1.96	MH9.1	98.00	80.00	0.00	Rain Gage-01	3.99	2.00	0.60	0 00:35:33
DM07	Sub Basin	3.33	MH9.1	98.00	80.00	0.00	Rain Gage-01	3.99	1.98	0.87	0 00:50:40
DM08	Sub Basin	0.53	MH11.3	98.00	80.00	100.00	Rain Gage-01	3.99	3.76	0.50	0 00:05:00
DM09	Sub Basin	0.44	MH9.2	98.00	80.00	100.00	Rain Gage-01	3.99	3.76	0.41	0 00:05:00
DM10	Sub Basin	0.54	MH10.1	98.00	80.00	100.00	Rain Gage-01	3.99	3.76	0.51	0 00:05:17
DM11	Sub Basin	2.52	MH9.3	98.00	80.00	0.00	Rain Gage-01	3.99	1.96	0.56	0 01:11:53
Dell	Sub Basin	8.63	MH_3-5	80.00	76.00	100.00	Rain Gage-01	3.99	1.98	2.21	0 00:52:57
North Mud	Sub Basin	162.83	Mud01	80.00	79.00	86.00	Rain Gage-01	3.99	1.96	39.37	0 00:58:36
School Lot	Sub Basin	5.72	MH_3-5	98.00	74.00	0.00	Rain Gage-01	3.99	1.53	0.91	0 01:03:01
School Roof	Sub Basin	1.36	MH_3-5	98.00	76.00	100.00	Rain Gage-01	3.99	3.76	1.28	0 00:05:00

B-4 Junction and Node Report

Junctions

Element ID	Description	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Ground/Rim (Max) Offset (ft)	Surcharge Elevation (ft)	Minimum Pipe Cover (inches)	Peak Inflow (cfs)	Maximum HGL Elevation (ft)	Maximum HGL Depth (ft)	Minimum Freeboard Attained (ft)	Average HGL Elevation (ft)	Average HGL Depth (ft)	Time of Maximum HGL (days hh:mm)	Total Time Flooded (minutes)
Control-IN	Control	424.60	430.66	6.06	430.66	0.00	4.00	430.40	5.80	1.26	429.22	4.62	0 09:31	0.00
Control-OUT	Control	424.60	430.66	6.06	430.66	0.00	4.00	426.53	1.93	5.13	426.38	1.78	0 09:31	0.00
MH1-2	Manhole	433.13	444.35	11.22	444.35	119.64	5.60	435.77	2.64	8.58	433.75	0.62	0 08:06	0.00
MH2-1	Manhole	436.46	441.82	5.36	441.82	52.32	0.81	436.80	0.34	5.02	436.63	0.17	0 08:06	0.00
MH3-2	Manhole	434.15	442.88	8.73	442.88	90.36	4.79	436.76	2.61	6.12	434.63	0.48	0 08:06	0.00
MH3-3	Manhole	434.95	444.30	9.35	444.30	97.80	4.79	438.41	3.46	5.89	435.59	0.64	0 08:06	0.00
MH3-4	Manhole	436.09	446.46	10.37	446.46	110.04	4.80	440.60	4.51	5.86	436.74	0.65	0 08:06	0.00
MH3-5	Manhole	440.62	447.10	6.48	447.10	65.76	4.05	442.53	1.91	4.57	440.96	0.34	0 08:06	0.00
MH10.1	Manhole	434.08	440.16	6.08	440.16	60.96	0.51	434.34	0.26	5.82	434.19	0.11	0 07:55	0.00
MH11.1	Manhole	413.07	420.56	7.49	420.56	41.04	6.27	417.43	4.36	3.13	416.38	3.31	0 09:23	0.00
MH11.2	Manhole	417.77	422.89	5.12	422.89	32.64	6.05	418.54	0.77	4.35	418.31	0.54	0 09:31	0.00
MH11.3	Manhole	419.32	423.44	4.12	423.44	37.44	0.50	419.58	0.26	3.86	419.42	0.10	0 07:54	0.00
MH12.2	Manhole	424.20	435.04	10.84	435.04	76.80	0.75	431.08	6.88	3.96	429.80	5.60	0 09:30	0.00
MH9.1	Manhole	426.82	436.38	9.56	436.38	65.16	2.76	431.21	4.39	5.17	430.53	3.71	0 09:24	0.00
MH9.2	Manhole	431.13	437.18	6.05	437.18	51.72	1.38	431.65	0.52	5.53	431.40	0.27	0 08:00	0.00
MH9.3	Manhole	432.81	437.41	4.60	437.41	43.20	0.56	433.12	0.31	4.29	433.00	0.19	0 08:24	0.00
Mud01	Creek	416.10	420.00	3.90	420.00	0.00	39.37	417.38	1.28	2.72	416.68	0.58	0 08:24	0.00
Mud02	Creek	414.90	418.90	4.00	418.90	0.00	43.25	417.19	2.29	1.71	416.04	1.14	0 08:24	0.00
Mud03	Culvert-IN	414.15	420.00	5.85	420.00	22.20	43.30	417.15	3.00	2.85	415.95	1.80	0 08:24	0.00
Mud04	Culvert-OUT	413.15	420.00	6.85	420.00	34.20	43.28	414.23	1.08	5.77	413.78	0.63	0 08:24	0.00
Swale-IN	Swale	431.15	433.15	2.00	433.15	0.24	5.60	432.48	1.33	0.67	431.89	0.74	0 08:07	0.00

Outfall

Element ID	Invert Elevation (ft)	Boundary Type	Peak Inflow (cfs)	Maximum HGL Depth Attained (ft)	Maximum HGL Elevation Attained (ft)
Outfall	412.00	NORMAL	43.28	1.05	413.05

Pond

Element ID	Invert Elevation (ft)	Max (Rim) Elevation (ft)	Max (Rim) Offset (ft)	Initial Water Depth (ft)	Ponded Area (ft^2)	Peak Inflow (cfs)	Peak Outflow (cfs)	Peak Exfiltration Flow (cfm)	Maximum HGL Elevation (ft)	Maximum HGL Depth (ft)	Average HGL Elevation (ft)	Average HGL Depth (ft)	Time of Maximum HGL (days hh:mm)	Total Time Flooded (minutes)
Pond	425.60	432.60	7.00	0.00	8870.57	9.02	5.82	0.00	431.05	5.45	429.67	4.07	0 09:31	0.00

B-5 Pipe and Channel Report

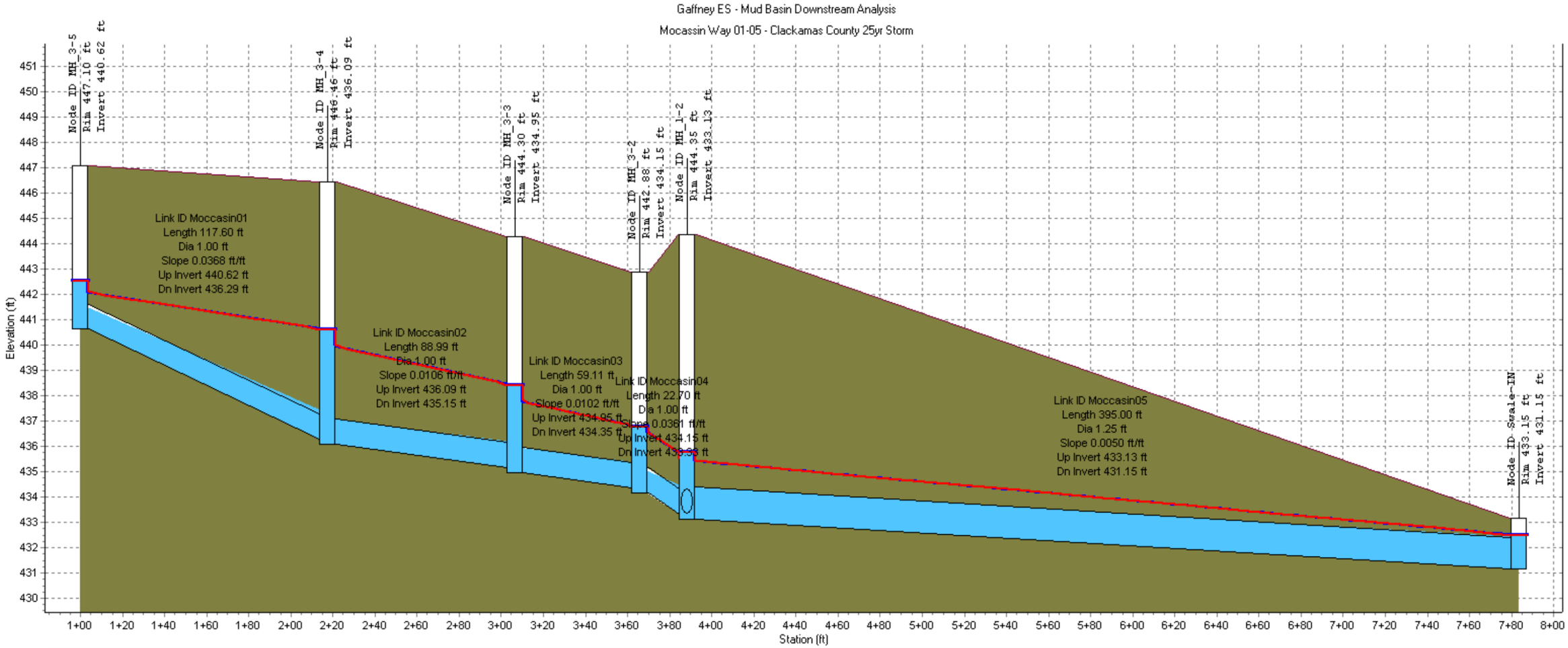
Pipes

Element ID	Desc	Inlet Node	Outlet Node	Length (ft)	Inlet Invert (ft)	Outlet Invert (ft)	Total Drop (ft)	Slope (%)	Pipe Ø (in)	Manning Number	Ent / Exit Losses	Peak Flow (cfs)	Time of Peak Flow (d hh:mm)	Max Flow Velocity (ft/sec)	Travel Time (min)	Design Flow (cfs)	Max/ Design Flow Ratio	Max/ Total Depth Ratio	Total Time Surcharge (min)	Max Flow Depth (ft)	Reported Condition
Andrea01	Pipe	MH10.1	MH9.2	231.00	434.08	431.87	2.21	0.96	12	0.0130	0.5	0.50	0 07:55	3.11	1.24	3.48	0.14	0.26	0.00	0.26	Calculated
Andrea02	Pipe	MH9.3	MH9.2	140.58	432.81	431.87	0.94	0.67	12	0.0130	0.5	0.56	0 08:24	2.78	0.84	2.91	0.19	0.30	0.00	0.30	Calculated
Andrea03	Pipe	MH9.2	MH9.1	222.41	431.13	429.95	1.18	0.53	12	0.0130	0.5	1.38	0 08:00	2.29	1.62	2.60	0.53	0.75	0.00	0.75	Calculated
Andrea04	Pipe	MH9.1	Pond	31.96	429.95	429.73	0.22	0.69	12	0.0130	0.5	2.75	0 08:06	3.88	0.14	2.96	0.93	1.00	194.00	1.00	SURCHARGED
Control-IN	Pipe	Pond	Control-IN	20.00	426.60	426.10	0.50	2.50	12	0.0130	0.5	4.00	0 09:30	5.09	0.07	5.63	0.71	1.00	1000.00	1.00	SURCHARGED
Control-OUT	Pipe	Control-OUT	MH11.2	54.40	426.10	418.67	7.43	13.66	12	0.0130	0.5	4.00	0 09:31	13.37	0.07	13.17	0.30	0.41	0.00	0.41	Calculated
DMout01	Pipe	MH11.2	MH11.1	173.72	417.77	415.64	2.13	1.23	18	0.0130	0.5	6.05	0 09:31	4.92	0.59	11.63	0.52	0.76	0.00	1.13	Calculated
DMout02	Pipe	MH11.1	Mud02	73.64	415.64	414.90	0.74	1.00	18	0.0130	0.5	6.27	0 09:31	4.37	0.28	10.53	0.60	1.00	124.00	1.50	SURCHARGED
MeyersCulvert	Pipe	Mud03	Mud04	100.00	414.15	413.15	1.00	1.00	42	0.0110	0.5	43.28	0 08:24	7.90	0.21	118.90	0.36	0.58	0.00	2.04	Calculated
Mocasin07	Pipe	MH11.3	MH11.2	102.49	419.32	418.17	1.15	1.12	12	0.0130	0.5	0.50	0 07:54	3.23	0.53	3.77	0.13	0.25	0.00	0.25	Calculated
Mocassin06	Pipe	MH12.2	Pond	190.60	427.64	426.73	0.91	0.48	12	0.0130	0.5	0.74	0 08:00	1.61	1.97	2.46	0.30	1.00	965.00	1.00	SURCHARGED
Moccasin01	Pipe	MH_3-5	MH_3-4	117.60	440.62	436.29	4.33	3.68	12	0.0130	0.5	4.05	0 08:06	6.57	0.30	6.84	0.59	1.00	15.00	1.00	SURCHARGED
Moccasin02	Pipe	MH_3-4	MH_3-3	88.99	436.09	435.15	0.94	1.06	12	0.0130	0.5	4.79	0 08:06	6.10	0.24	3.66	1.31	1.00	86.00	1.00	SURCHARGED
Moccasin03	Pipe	MH_3-3	MH_3-2	59.11	434.95	434.35	0.60	1.02	12	0.0130	0.5	4.79	0 08:06	6.10	0.16	3.59	1.34	1.00	46.00	1.00	SURCHARGED
Moccasin04	Pipe	MH_3-2	MH_1-2	22.70	434.15	433.33	0.82	3.61	12	0.0130	0.5	4.79	0 08:06	6.10	0.06	6.77	0.71	1.00	54.00	1.00	SURCHARGED
Moccasin05	Pipe	MH_1-2	Swale-IN	395.00	433.13	431.15	1.98	0.50	15	0.0130	0.5	5.60	0 08:06	4.56	1.44	4.57	1.22	1.00	37.00	1.25	SURCHARGED
OverFlow	Pipe	Pond	MH11.2	48.40	430.85	418.67	12.18	25.17	18	0.0130	0.5	1.82	0 09:31	13.23	0.06	52.70	0.03	0.13	0.00	0.20	Calculated
RedHawk01	Pipe	MH_2-1	MH_1-2	390.71	436.46	433.33	3.13	0.80	12	0.0130	0.5	0.81	0 08:06	1.92	3.39	3.19	0.25	0.67	0.00	0.67	Calculated

Channels

Element ID	Desc	Inlet Node	Outlet Node	Length (ft)	Inlet Invert (ft)	Outlet Invert (ft)	Total Drop (ft)	Slope (%)	Channel Height (ft)	Channel Width (ft)	Manning Number	Ent / Exit	Peak Flow (cfs)	Time of Peak Flow (d hh:mm)	Max Flow Velocity (ft/sec)	Travel Time (min)	Design Flow (cfs)	Max/ Design Flow Ratio	Max/ Total Depth Ratio	Total Time Surcharge (min)	Max Flow Depth (ft)
MoccasinSwale	Channel	Swale-IN	Pond	150.00	431.13	430.13	1.00	0.67	2.00	10.00	0.070	0.5	5.57	0 08:07	1.56	1.60	22.34	0.25	0.46	0.00	0.93
MudCreek01	Channel	Mud01	Mud02	120.00	416.10	414.90	1.20	1.00	4.00	20.00	0.070	0.5	39.31	0 08:18	1.21	1.65	341.95	0.11	0.45	0.00	1.78
MudCreek02	Channel	Mud02	Mud03	75.00	414.90	414.15	0.75	1.00	4.00	20.00	0.070	0.5	43.15	0 08:24	0.83	1.51	341.95	0.13	0.66	0.00	2.64
MudCreek03	Channel	Mud04	Outfall	115.00	413.15	412.00	1.15	1.00	4.00	20.00	0.070	0.5	43.28	0 08:24	2.03	0.94	341.95	0.13	0.27	0.00	1.07

B-6 Moccasin Way 01-05 Profile

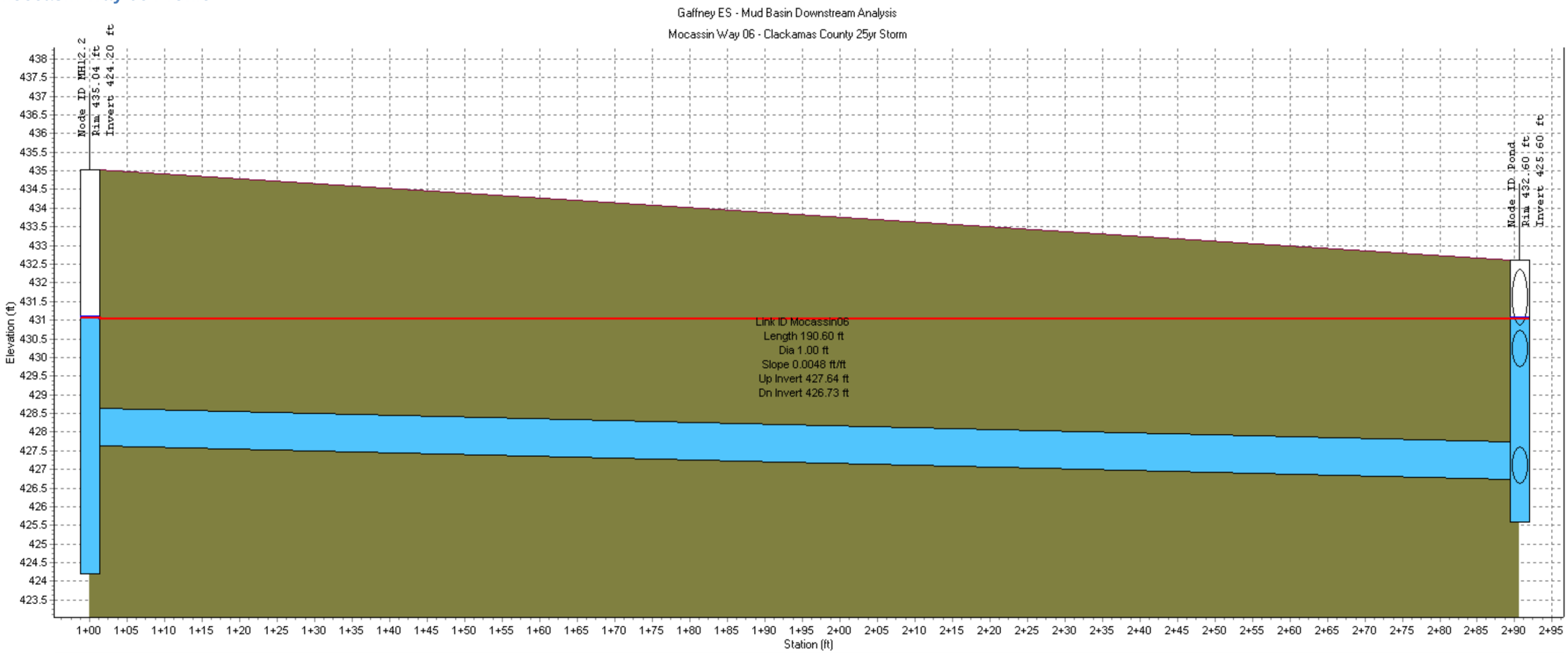


Node ID:	MH_3-5	MH_3-4	MH_3-3	MH_3-2	MH_1-2	Swale-IN
Rim (ft):	447.10	446.46	444.30	442.88	444.35	433.15
Invert (ft):	440.62	436.09	434.95	434.15	433.13	431.15
Min Pipe Cover (ft):	5.48	9.17	8.15	7.53	9.97	0.02
Max HGL (ft):	442.53	440.60	438.41	436.76	435.77	432.48

Link ID:	Moccasin01	Moccasin02	Moccasin03	Moccasin04	Moccasin05
Length (ft):	117.60	88.99	59.11	22.70	395.00
Dia (ft):	1.00	1.00	1.00	1.00	1.25
Slope (ft/ft):	0.0368	0.0106	0.0102	0.0361	0.0050
Up Invert (ft):	440.62	436.09	434.95	434.15	433.13
Dn Invert (ft):	436.29	435.15	434.35	433.33	431.15
Max Q (cfs):	4.05	4.79	4.79	4.79	5.60
Max Vel (ft/s):	6.57	6.10	6.10	6.10	4.56
Max Depth (ft):	1.00	1.00	1.00	1.00	1.25

Autodesk Storm and Sanitary Analysis

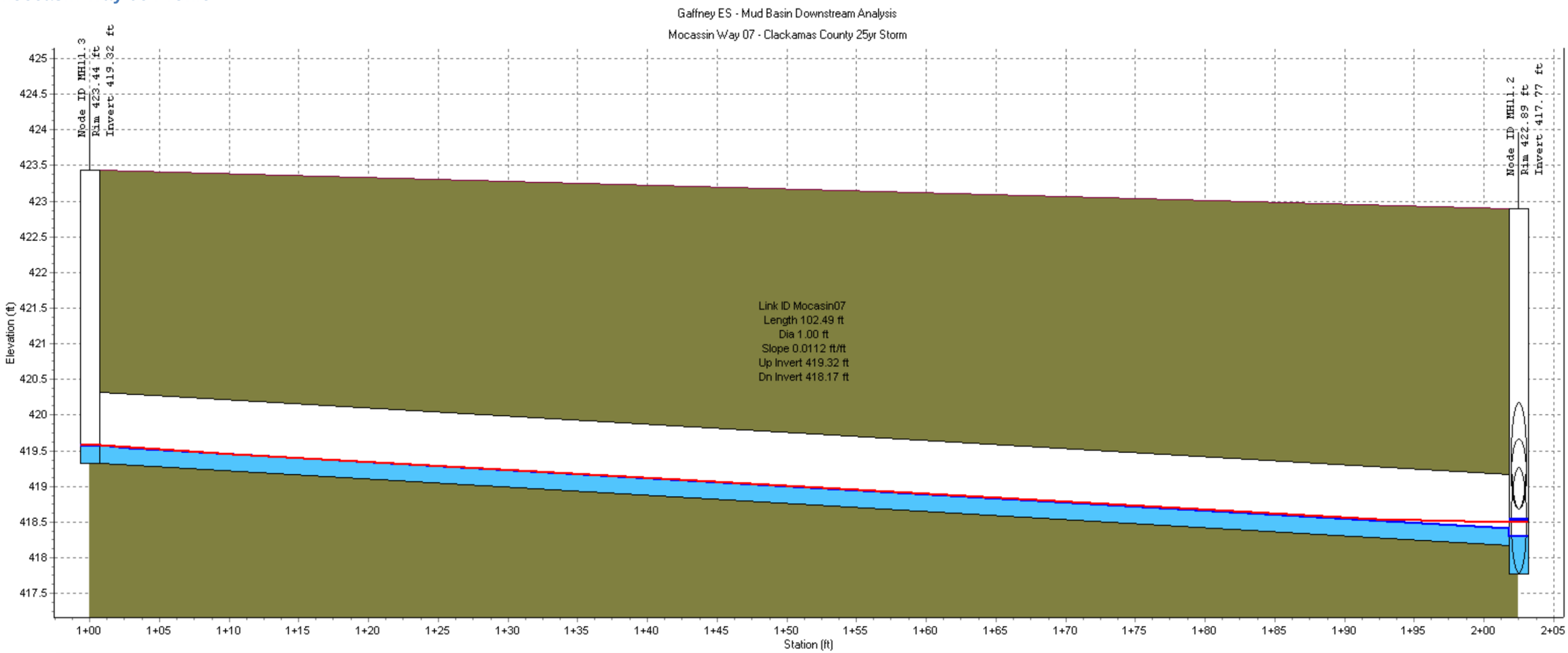
B-7 Moccasin Way 06 Profile



Node ID:	MH12.2		Pond
Rim (ft):	435.04		432.60
Invert (ft):	424.20		425.60
Min Pipe Cover (ft):	6.40		
Max HGL (ft):	431.08		431.05
Link ID:		Mocassin06	
Length (ft):		190.60	
Dia (ft):		1.00	
Slope (ft/ft):		0.0048	
Up Invert (ft):		427.64	
Dn Invert (ft):		426.73	
Max Q (cfs):		0.74	
Max Vel (ft/s):		1.61	
Max Depth (ft):		1.00	

Autodesk Storm and Sanitary Analysis

B-8 Moccasin Way 06 Profile

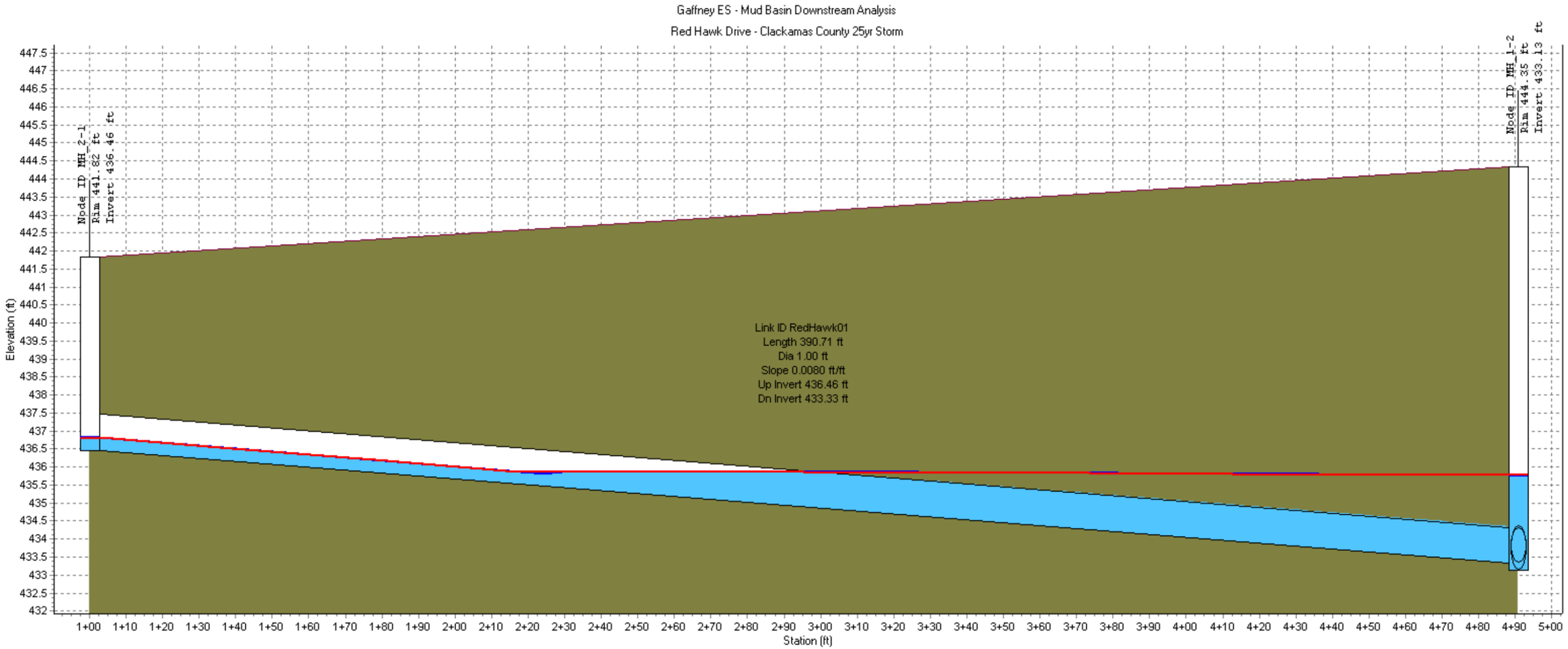


Node ID:	MH11.3	MH11.2
Rim (ft):	423.44	422.89
Invert (ft):	419.32	417.77
Min Pipe Cover (ft):	3.12	2.72
Max HGL (ft):	419.58	418.54

Link ID:	Mocasin07
Length (ft):	102.49
Dia (ft):	1.00
Slope (ft/ft):	0.0112
Up Invert (ft):	419.32
Dn Invert (ft):	418.17
Max Q (cfs):	0.50
Max Vel (ft/s):	3.23
Max Depth (ft):	0.25

Autodesk Storm and Sanitary Analysis

B-9 Red Hawk Drive Profile

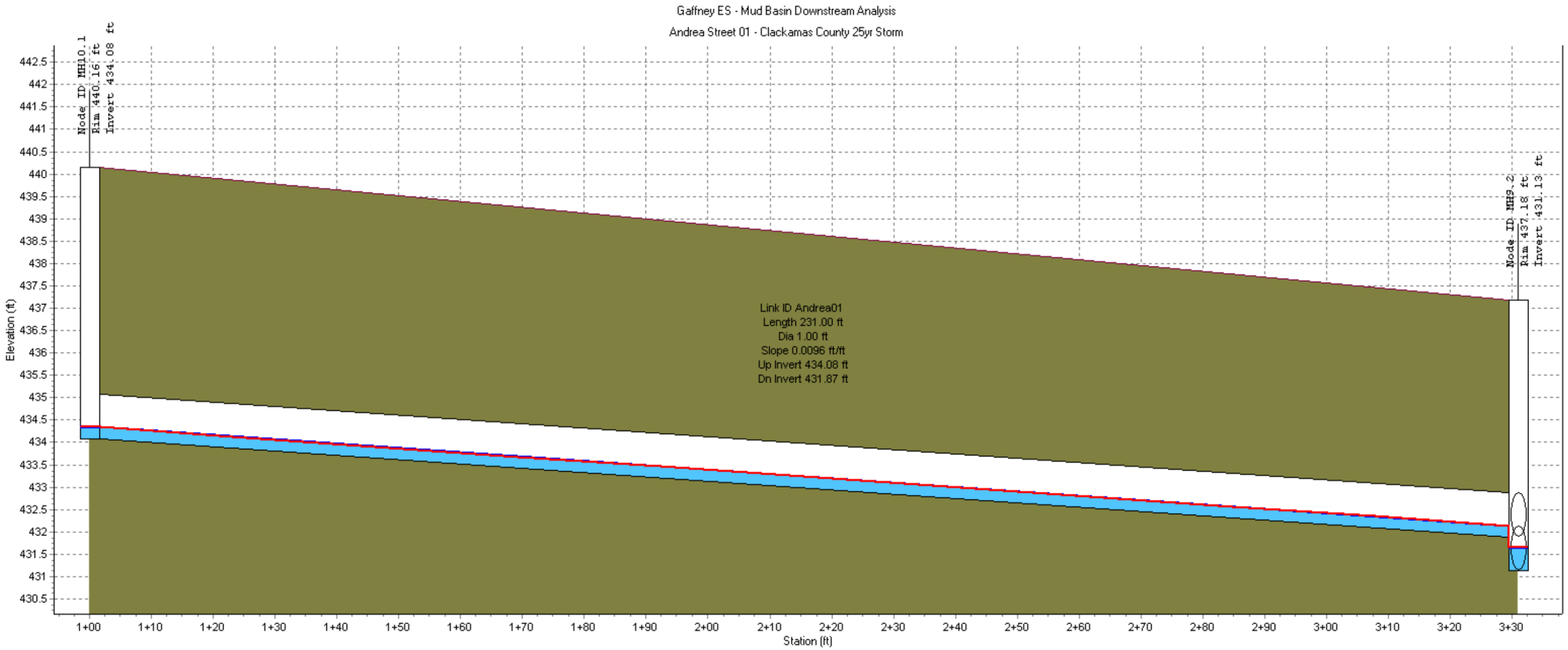


Node ID:	MH_2-1	MH_1-2
Rim (ft):	441.82	444.35
Invert (ft):	436.46	433.13
Min Pipe Cover (ft):	4.36	9.97
Max HGL (ft):	436.80	435.77

Link ID:	RedHawk01
Length (ft):	390.71
Dia (ft):	1.00
Slope (ft/ft):	0.0080
Up Invert (ft):	436.46
Dn Invert (ft):	433.33
Max Q (cfs):	0.81
Max Vel (ft/s):	1.92
Max Depth (ft):	0.67

Autodesk Storm and Sanitary Analysis

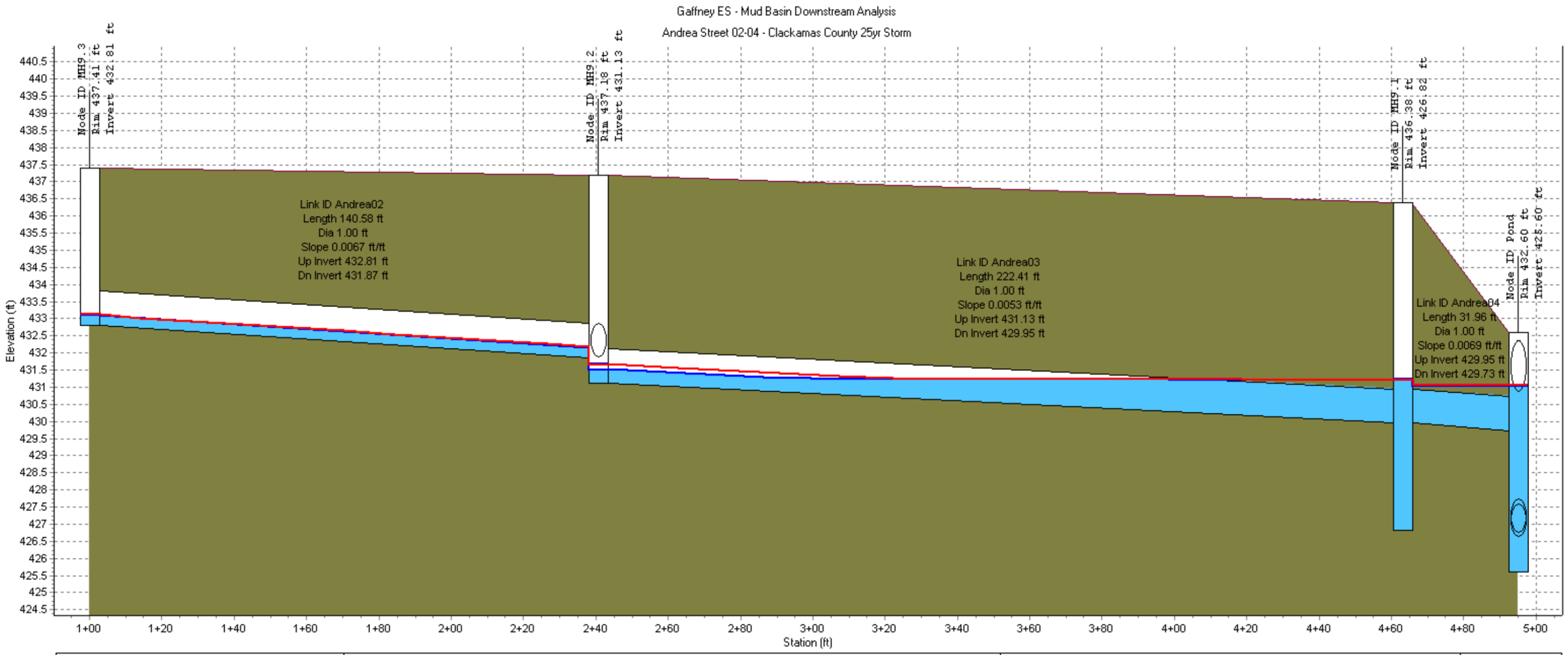
B-10 Andrea Street 01 Profile



Node ID:	MH10.1		MH9.2
Rim (ft):	440.16		437.18
Invert (ft):	434.08		431.13
Min Pipe Cover (ft):	5.08		4.31
Max HGL (ft):	434.34		431.65
Link ID:		Andrea01	
Length (ft):		231.00	
Dia (ft):		1.00	
Slope (ft/ft):		0.0096	
Up Invert (ft):		434.08	
Dn Invert (ft):		431.87	
Max Q (cfs):		0.50	
Max Vel (ft/s):		3.11	
Max Depth (ft):		0.26	

Autodesk Storm and Sanitary Analysis

B-11 Andrea Street 02-04 Profile

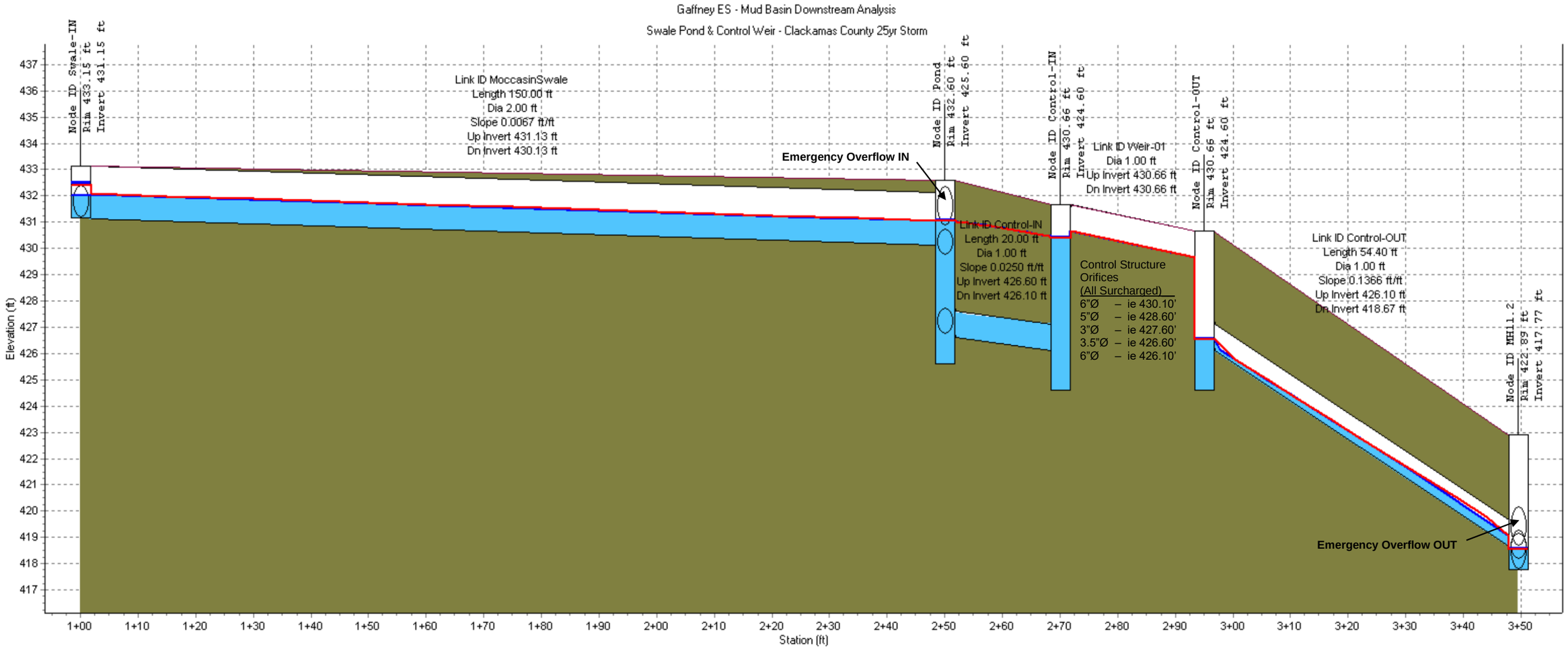


Node ID:	MH9.3	MH9.2	MH9.1	Pond
Rim (ft):	437.41	437.18	436.38	432.60
Invert (ft):	432.81	431.13	426.82	425.60
Min Pipe Cover (ft):	3.60	4.31	5.43	
Max HGL (ft):	433.12	431.65	431.21	431.05

Link ID:	Andrea02	Andrea03	Andrea04
Length (ft):	140.58	222.41	31.96
Dia (ft):	1.00	1.00	1.00
Slope (ft/ft):	0.0067	0.0053	0.0069
Up Invert (ft):	432.81	431.13	429.95
Dn Invert (ft):	431.87	429.95	429.73
Max Q (cfs):	0.56	1.38	2.75
Max Vel (ft/s):	2.78	2.29	3.88
Max Depth (ft):	0.30	0.75	1.00

Autodesk Storm and Sanitary Analysis

B-12 Swale Pond & Control Weir Profile

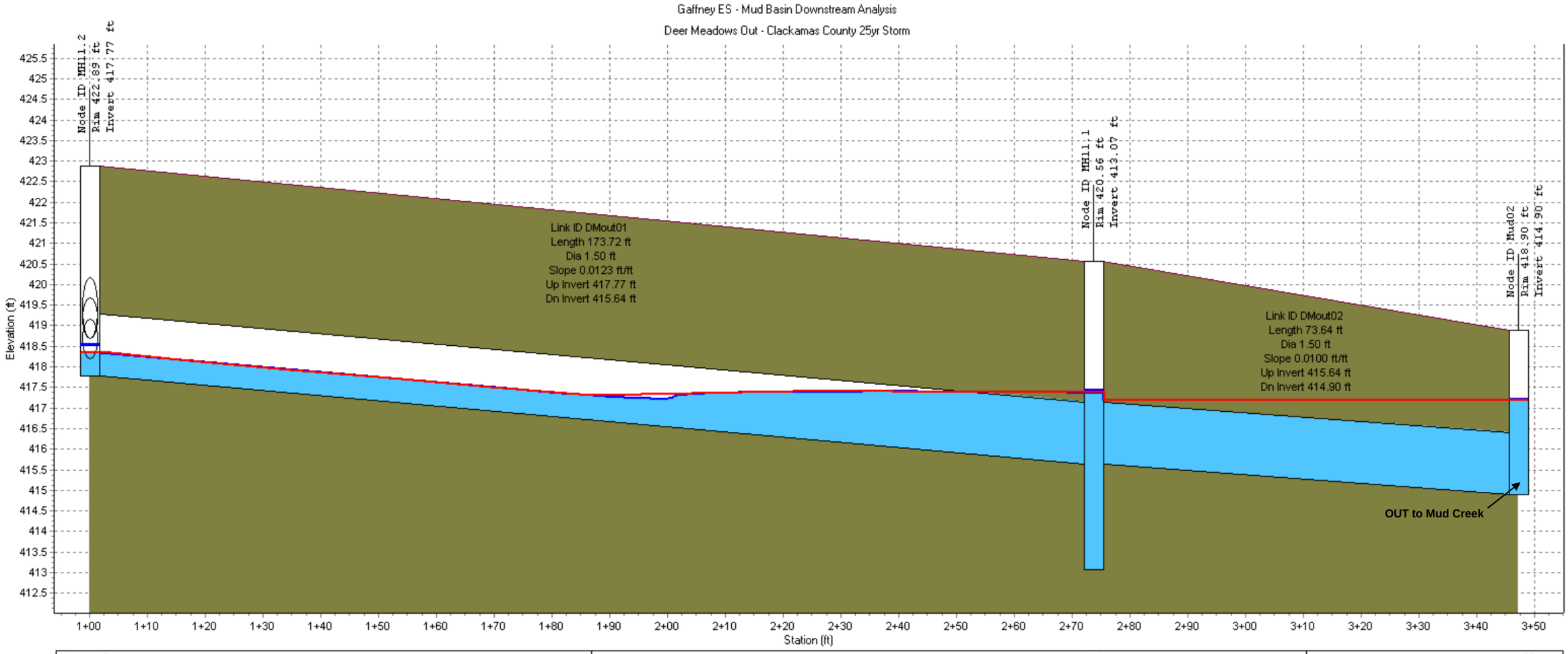


Node ID:	Swale-IN		Pond	Control-IN	Control-OUT	MH11.2
Rim (ft):	433.15		432.60	430.66	430.66	422.89
Invert (ft):	431.15		425.60	424.60	424.60	417.77
Min Pipe Cover (ft):	0.02			0.00	0.00	2.72
Max HGL (ft):	432.48		431.05	430.40	426.53	418.54

Link ID:	MoccasinSwale	Control-IN	Weir-01	Control-OUT
Length (ft):	150.00	20.00		54.40
Dia (ft):	2.00	1.00	1.00	1.00
Slope (ft/ft):	0.0067	0.0250		0.1366
Up Invert (ft):	431.13	426.60	430.66	426.10
Dn Invert (ft):	430.13	426.10	430.66	418.67
Max Q (cfs):	5.57	4.00	0.00	4.00
Max Vel (ft/s):	1.56	5.09	0.00	13.37
Max Depth (ft):	0.93	1.00	0.00	0.41

Autodesk Storm and Sanitary Analysis

B-13 Deer Meadows Subdivision Outflow to Mud Creek

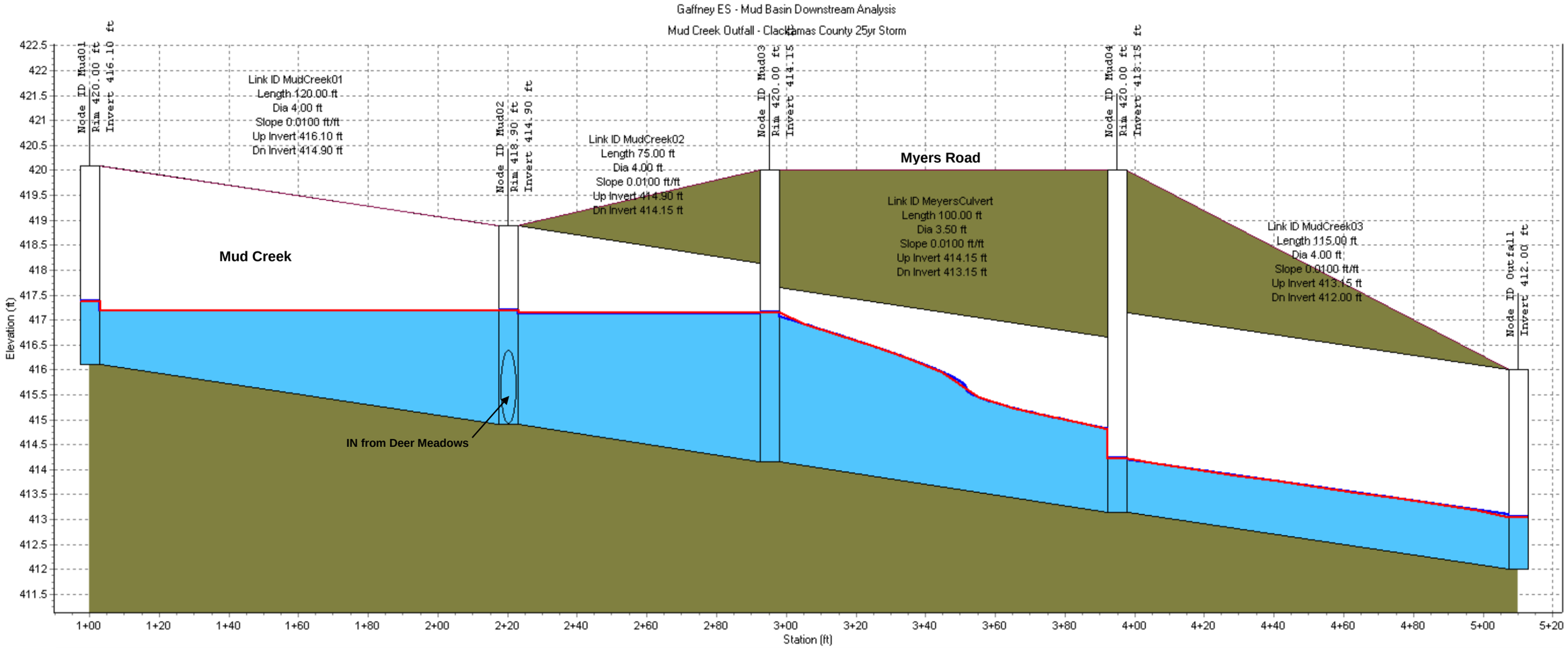


Node ID:	MH11.2	MH11.1	Mud02
Rim (ft):	422.89	420.56	418.90
Invert (ft):	417.77	413.07	414.90
Min Pipe Cover (ft):	2.72	3.42	0.00
Max HGL (ft):	418.54	417.43	417.19

Link ID:	DMout01	DMout02
Length (ft):	173.72	73.64
Dia (ft):	1.50	1.50
Slope (ft/ft):	0.0123	0.0100
Up Invert (ft):	417.77	415.64
Dn Invert (ft):	415.64	414.90
Max Q (cfs):	6.05	6.27
Max Vel (ft/s):	4.92	4.37
Max Depth (ft):	1.13	1.50

Autodesk Storm and Sanitary Analysis

B-14 Mud Creek Profile



Node ID:	Mud01	Mud02	Mud03	Mud04	Outfall
Rim (ft):	420.00	418.90	420.00	420.00	
Invert (ft):	416.10	414.90	414.15	413.15	412.00
Min Pipe Cover (ft):	0.00	0.00	1.85	2.85	
Max HGL (ft):	417.38	417.19	417.15	414.23	413.05

Link ID:	MudCreek01	MudCreek02	MeyersCulvert	MudCreek03
Length (ft):	120.00	75.00	100.00	115.00
Dia (ft):	4.00	4.00	3.50	4.00
Slope (ft/ft):	0.0100	0.0100	0.0100	0.0100
Up Invert (ft):	416.10	414.90	414.15	413.15
Dn Invert (ft):	414.90	414.15	413.15	412.00
Max Q (cfs):	39.31	43.15	43.28	43.28
Max Vel (ft/s):	1.21	0.83	7.90	2.03
Max Depth (ft):	1.78	2.64	2.04	1.07

Autodesk Storm and Sanitary Analysis

Appendix 'C' – USGS Soil Survey

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 Clackamas County Area, Oregon

North Mud Drainage Basin Soils

April 1, 2020

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 (https://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.

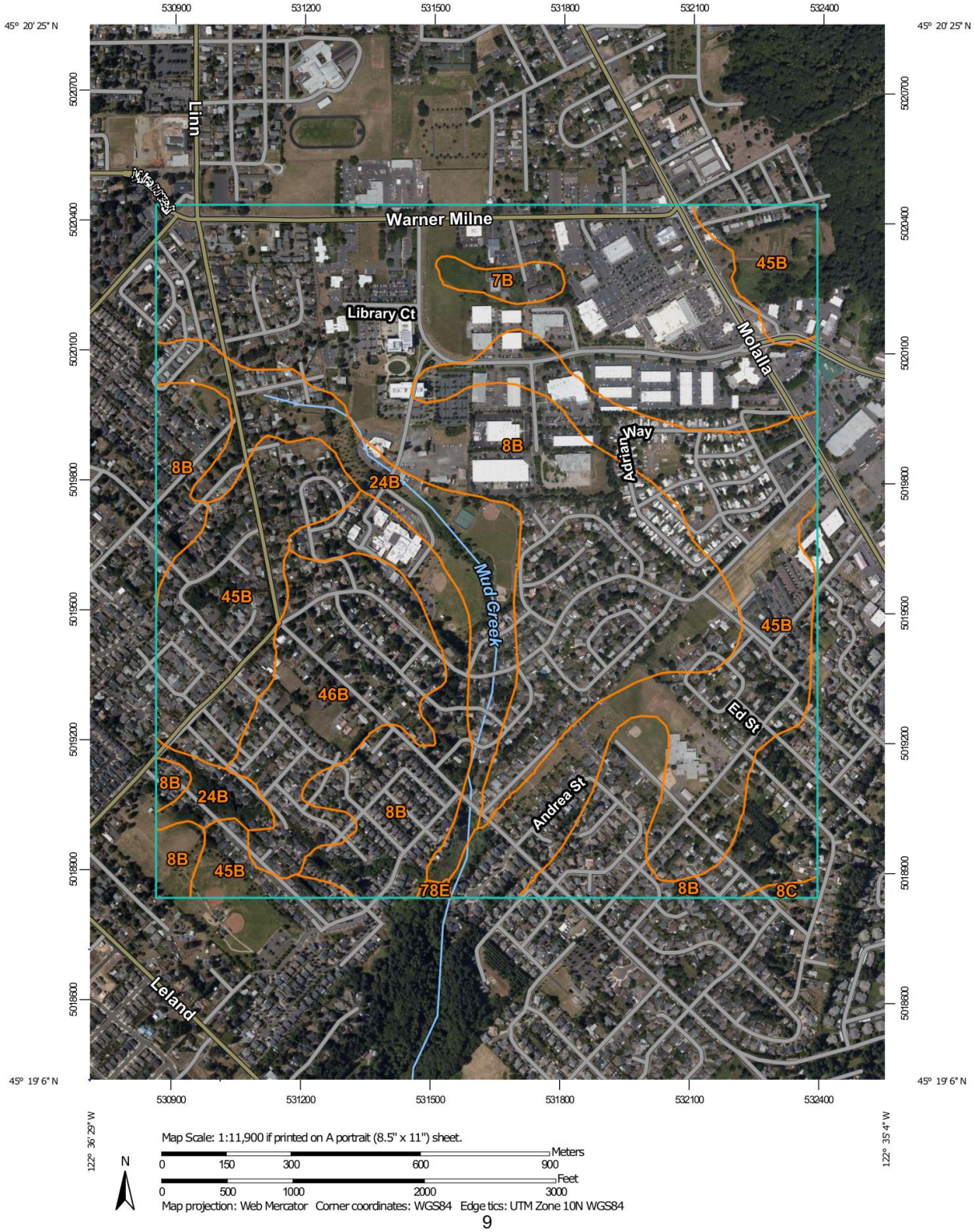
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

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.

Custom Soil Resource Report
Soil Map



9

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 1:20,000.

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
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: Clackamas County Area, Oregon
Survey Area Data: Version 15, Sep 10, 2019

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

Date(s) aerial images were photographed: Jun 13, 2019—Jul 25, 2019

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

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
7B	Borges silty clay loam, 0 to 8 percent slopes	5.2	0.9%
8B	Bornstedt silt loam, 0 to 8 percent slopes	327.1	53.8%
8C	Bornstedt silt loam, 8 to 15 percent slopes	1.2	0.2%
24B	Cottrell silty clay loam, 2 to 8 percent slopes	53.4	8.8%
45B	Jory silty clay loam, 2 to 8 percent slopes	169.9	27.9%
46B	Jory stony silt loam, 3 to 8 percent slopes	50.5	8.3%
78E	Saum silt loam, 30 to 60 percent slopes	0.6	0.1%
Totals for Area of Interest		**607.9**	**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.

Clackamas County Area, Oregon

7B—Borges silty clay loam, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2277
Elevation: 250 to 1,400 feet
Mean annual precipitation: 48 to 65 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 140 to 210 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Borges and similar soils: 80 percent
Minor components: 6 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Borges

Setting

Landform: Depressions on terraces, hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Clayey alluvium

Typical profile

H1 - 0 to 18 inches: silty clay loam
H2 - 18 to 45 inches: silty clay
H3 - 45 to 60 inches: clay loam

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: D
Forage suitability group: Poorly Drained (G002XY006OR)
Hydric soil rating: Yes

Minor Components

Delena

Percent of map unit: 6 percent
Landform: Terraces, hillslopes
Landform position (two-dimensional): Footslope

Landform position (three-dimensional): Interfluve, riser
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

8B—Bornstedt silt loam, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: 227t
Elevation: 300 to 650 feet
Mean annual precipitation: 48 to 65 inches
Mean annual air temperature: 50 to 52 degrees F
Frost-free period: 140 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Bornstedt and similar soils: 85 percent
Minor components: 6 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bornstedt

Setting

Landform: Hillslopes, terraces
Landform position (two-dimensional): Summit, footslope
Landform position (three-dimensional): Interfluve, tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed old alluvium

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 33 inches: silty clay loam
H3 - 33 to 71 inches: silty clay

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 24 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Forage suitability group: Moderately Well Drained < 15% Slopes (G002XY004OR)

Hydric soil rating: No

Minor Components

Borges

Percent of map unit: 5 percent
Landform: Depressions on terraces, hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Aquults

Percent of map unit: 1 percent
Landform: Depressions
Hydric soil rating: Yes

8C—Bornstedt silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 227v
Elevation: 300 to 650 feet
Mean annual precipitation: 48 to 65 inches
Mean annual air temperature: 50 to 52 degrees F
Frost-free period: 140 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Bornstedt and similar soils: 80 percent
Minor components: 8 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bornstedt

Setting

Landform: Hillslopes, terraces
Landform position (two-dimensional): Footslope, summit
Landform position (three-dimensional): Interfluve, riser
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed old alluvium

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 33 inches: silty clay loam
H3 - 33 to 71 inches: silty clay

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: More than 80 inches

Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 24 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.8 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Forage suitability group: Moderately Well Drained < 15% Slopes (G002XY004OR)
Hydric soil rating: No

Minor Components

Borges
Percent of map unit: 6 percent
Landform: Depressions on terraces, hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Aquults
Percent of map unit: 2 percent
Landform: Depressions
Hydric soil rating: Yes

24B—Cottrell silty clay loam, 2 to 8 percent slopes

Map Unit Setting
National map unit symbol: 223v
Elevation: 300 to 900 feet
Mean annual precipitation: 45 to 80 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 140 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition
Cottrell and similar soils: 90 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cottrell

Setting
Landform: Hillslopes, terraces
Landform position (two-dimensional): Footslope

Landform position (three-dimensional): Base slope, interfluve, tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Old alluvium

Typical profile
H1 - 0 to 24 inches: silty clay loam
H2 - 24 to 55 inches: silty clay
H3 - 55 to 86 inches: silty clay loam

Properties and qualities
Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 24 to 35 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.6 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C
Forage suitability group: Moderately Well Drained < 15% Slopes (G002XY004OR)
Hydric soil rating: No

Minor Components

Borges
Percent of map unit: 4 percent
Landform: Depressions on terraces, hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Aquults
Percent of map unit: 1 percent
Landform: Depressions
Hydric soil rating: Yes

45B—Jory silty clay loam, 2 to 8 percent slopes

Map Unit Setting
National map unit symbol: 224x
Elevation: 250 to 1,200 feet
Mean annual precipitation: 50 to 60 inches
Mean annual air temperature: 50 to 54 degrees F

Frost-free period: 165 to 210 days
Farmland classification: All areas are prime farmland

Map Unit Composition
Jory and similar soils: 90 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Jory

Setting
Landform: Hillslopes
Landform position (two-dimensional): Summit, footslope
Landform position (three-dimensional): Base slope, interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium

Typical profile
H1 - 0 to 13 inches: silty clay loam
H2 - 13 to 60 inches: silty clay

Properties and qualities
Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.1 inches)

Interpretive groups
Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Forage suitability group: Well drained < 15% Slopes (G002XY002OR)
Hydric soil rating: No

46B—Jory stony silt loam, 3 to 8 percent slopes

Map Unit Setting
National map unit symbol: 2251
Elevation: 250 to 1,200 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 52 to 54 degrees F
Frost-free period: 165 to 210 days
Farmland classification: Farmland of statewide importance

Map Unit Composition
Jory and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Jory

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit, footslope
Landform position (three-dimensional): Base slope, interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium

Typical profile

H1 - 0 to 8 inches: stony silt loam
H2 - 8 to 48 inches: stony silty clay
H3 - 48 to 60 inches: stony silty clay

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.0 inches)

Interpretive groups

Land capability classification (irrigated): 4s
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: C
Forage suitability group: Well drained < 15% Slopes (G002XY002OR)
Hydric soil rating: No

78E—Saum silt loam, 30 to 60 percent slopes

Map Unit Setting

National map unit symbol: 2274
Elevation: 250 to 800 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 52 to 54 degrees F
Frost-free period: 165 to 210 days
Farmland classification: Not prime farmland

Map Unit Composition

Saum and similar soils: 80 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Saum

Setting

Landform: Hillslopes
Landform position (two-dimensional): Footslope, backslope

Landform position (three-dimensional): Head slope, side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Material silty and colluvium

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 26 inches: silty clay loam
H3 - 26 to 50 inches: gravelly silty clay loam
H4 - 50 to 54 inches: unweathered bedrock

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: 40 to 60 inches to lithic bedrock
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Hydric soil rating: No

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Appendix 'D' – Geotechnical Report

Geotech Solutions Inc.

March 29, 2020 *ocschoools-20-1-gi*

ZCS Engineering
zachs@zcsea.com
shawns@zcsea.com

GEOTECHNICAL ENGINEERING
Gaffney Lane and Jennings Lodge Elementary, Shallow infiltration testing
Oregon City and Gladstone, Oregon

As authorized this letter summarizes our geotechnical engineering services for the proposed shallow infiltration swales for storm water improvements at the Gaffney Lane and Jennings lodge elementary schools in Oregon City and Gladstone, Oregon. The purpose of our work is to evaluate shallow soils near the provided locations and provide an infiltration rate for use in design by ZCS. Specifically, our scope of work included the following:

- Provide principal level project management including management of field and subcontracted services, report writing, analyses, and invoicing.
- Review previous reports, geologic maps and vicinity geotechnical information as indicators of subsurface conditions.
- Complete a site reconnaissance to observe surface features relevant to geotechnical issues, such as topography, vegetation, presence and condition of springs, exposed soils and rock, and evidence of previous grading.
- Explore site subsurface conditions by completing one hand auger at Jennings lodge, and three at Gaffney lane, in or near the proposed locations to depths of up to 4 feet.
- Complete same day open hole falling head infiltration testing in the augers.
- Provide an infiltration rate and strata, and the suitability of the swale relative to seasonal ground water issues.
- Provide a PE/GE stamped letter summarizing our findings.

SITE OBSERVATIONS AND CONDITIONS

Surface Conditions

The sites are relatively flat, and at exploration locations the surface consisted of short grass. HA-1 at Gaffney Lane was lower than the ball diamond.

Subsurface Conditions

The sites were explored on March 26, 2020 by excavating 3 hand augers at Gaffney Lane, and one at Jennings Lodge, each to a depth of 4 feet. Approximate exploration locations are shown on the attached ***Site Plan.***

In general, subsurface conditions at the sites consisted of silt. The silt at Gaffney Lane was generally medium stiff in the top 1-2 feet, then stiff with trace clay below that. This soil is derived in place from severe weathering of Boring Lava. Shallow fill was present in HA-1. The native silt at Jennings Lodge

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was present at 2 feet below silt fill and was soft and contained trace fine sand. This silt is alluvial in origin (consistent with DOGAMI 2004 mapping as "fine grained").

Groundwater – The Geologic Hazard Map of the Canby and Oregon City Quadrangles (Bulletin 99, DOGAMI) indicates that the Gaffney Lane site is adjacent to an area of high ground water (and perhaps the HA-1 location is within it) where the ground water is as shallow as 1.5 feet in the wet season. We did not encounter any seepage in our test pits which were excavated in the wet season. Seasonal high ground water at Jennings Lodge is mapped (USGS 2007) at 40-60 feet below the ground surface. Moisture contents of site soils were 26-28% at Gaffney Lane in three samples tested, and 33% for the one sample from Jennings Lodge.

CONCLUSIONS AND RECOMMENDATIONS

Infiltration

Design - Based on the results of our testing and analyses, infiltration rates in the silt at both sites are very low, likely decrease with depth at Gaffney Lane, and may preclude infiltration. Infiltration is not recommended at Gaffney Lane due to potentially high seasonal perched ground water. It is possible that soils with higher rates are present at depth at the Jennings Lodge location, although mapping indicates fine grained soils. We completed open hole, prewetted, falling head infiltration testing at depths of roughly 1-4 feet in each test pit (3 feet of total head). Raw tested rates included a median of 0.05 $in^3/hr/in^2$ at Gaffney Lane (ranging from 0.04 to 0.08) and 0.11 at Jennings Lodge. If infiltration systems are planned at Jennings Lodge, based on this testing, and our vicinity experience, we recommend using a reduction factor of 2 on the sides of infiltration systems in the silt, and also at the base if systems are protected from sedimentation.

Confirmation Testing and Maintenance - Actual subsurface conditions and infiltration rates can vary widely. Flexibility for adaptation and expansion of infiltration systems must be incorporated into the design and construction, with contingencies included in the project budget and schedule. Infiltration systems need to be maintained free of debris and silt in order to function properly

LIMITATIONS AND OBSERVATION DURING CONSTRUCTION

We have prepared this report for use by ZCS Engineering and their design and construction teams for this project only. The information herein could be used for bidding or estimating purposes but should not be construed as a warranty of subsurface conditions. We have made observations only at the aforementioned locations and only to the stated depths. These observations do not reflect soil types, strata thicknesses, water levels or seepage that may exist between observations. We should be consulted to observe all foundation bearing surfaces, installation of structural fill, and subsurface drainage. We should be consulted to review final design and specifications in order to see that our recommendations are suitably followed. If any changes are made to the anticipated locations, loads, configurations, or construction timing, our recommendations may not be applicable, and we should be consulted. The preceding recommendations should be considered preliminary, as actual soil conditions may vary. For our recommendations to be final, we must be retained to observe actual subsurface conditions encountered. Our observations will allow us to interpret actual conditions and adapt our recommendations if needed.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with the generally accepted practices in this area at the time this report was prepared. No warranty, expressed or implied, is given.

We appreciate the opportunity to work with you on this project and look forward to our continued involvement. If you have any questions, please contact us.

Sincerely,

Don Rondema, MS, PE, GE
Principal

REGISTERED PROFESSIONAL ENGINEER
OREGON
JULY 21, 1995
DON RONDEMA
Expires 12/31/20

Attachments – Site Plan, Soil Classification, Exploration Logs, Moisture Contents.

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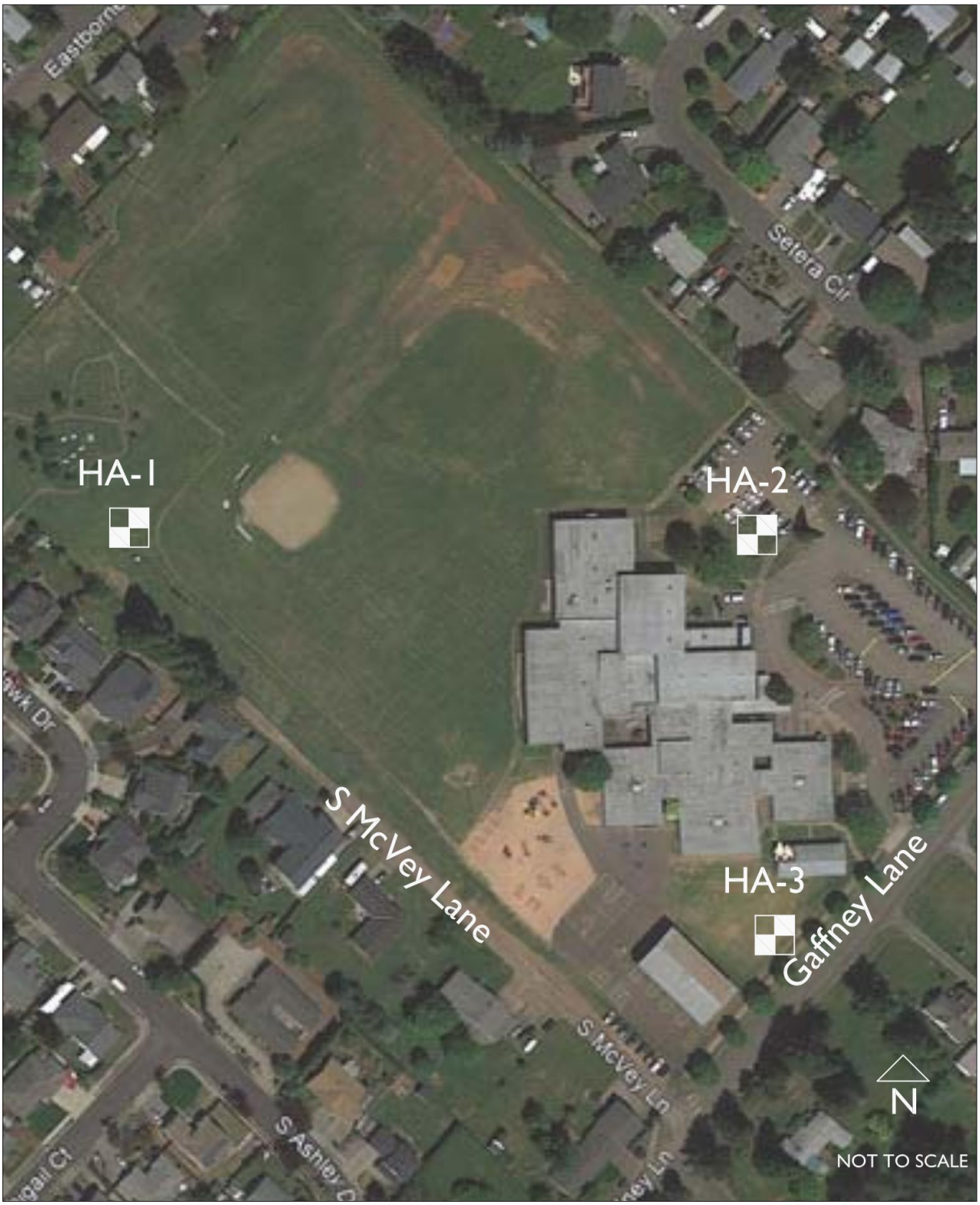

BASE FROM GOOGLE EARTH 2019 AERIAL

Geotech Solutions Inc.

SITE PLAN - Gaffney Lane

ocschools-20-1

GUIDELINES FOR CLASSIFICATION OF SOIL

Description of Relative Density for Granular Soil	
Relative Density	**Standard Penetration Resistance (N-values) blows per foot**
very loose	0 - 4
loose	4 - 10
medium dense	10 - 30
dense	30 - 50
very dense	over 50

Description of Consistency for Fine-Grained (Cohesive) Soils		
Consistency	**Standard Penetration Resistance (N-values) blows per foot**	**Torvane Undrained Shear Strength, tsf**
very soft	0 - 2	less than 0.125
soft	2 - 4	0.125 - 0.25
medium stiff	4 - 8	0.25 - 0.50
stiff	8 - 15	0.50 - 1.0
very stiff	15 - 30	1.0 - 2.0
hard	over 30	over 2.0

Grain-Size Classification	
Description	**Size**
Boulders	12 - 36 in.
Cobbles	3 - 12 in.
Gravel	¼ - ¾ in. (fine)
	¾ - 3 in. (coarse)
Sand	No. 200 - No. 40 Sieve (fine)
	No. 40 - No. 10 sieve (medium)
	No. 10 - No. 4 sieve (coarse)
Silt/Clay	Pass No. 200 sieve

Modifier for Subclassification	
Adjective	**Percentage of Other Material In Total Sample**
Clean/Occasional	0 - 2
Trace	2 - 10
Some	10 - 30
Sandy, Silty, Clayey, etc.	30 - 50

Test Pit #	Depth (ft)	Soil Description

Explorations completed on March 26, 2020, with a hand auger.

Gaffney Lane

HA-1

Location: NW portion of site below ball diamond.
Surface conditions: Short grass.

0 – 2	Stiff, brown SILT FILL with trace gravel; moist.
2 – 4	Medium stiff, brown SILT, with trace clay; moist.

No caving. No seepage.

HA-2

Location: N portion of site in grass area near school.
Surface conditions: Short grass soil.

0 – 1	Medium stiff, brown SILT; moist.
1 – 4	Stiff, brown/black SILT/WEATHRED BORING LAVA, with trace clay; moist.

No caving. No seepage.

HA-3

Location: SE portion of site in grass area near Gaffney Lane.
Surface conditions: Short grass.

0 – 2	Medium stiff, brown SILT; moist.
2 – 4	Stiff, brown/black SILT/WEATHRED BORING LAVA, with trace clay; moist.

No caving. No seepage.

Jennings Lodge

HA-1-Jen

Location: Central portion of site by covered area.
Surface conditions: Short grass, exposed soil.

0 – 2	Medium stiff, brown SILT FILL; moist.
2 – 4	Soft, brown SILT, with trace fine sand; moist.

No caving. No seepage.

Exploration	Depth, ft	Moisture Content
HA-1	4.0	28%
HA-2	4.0	26%
HA-3	4.0	26%
HA-1-Jen	4.0	33%

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MOISTURE CONTENTS
ocschools-20-1-gi