CARTER ENGINEERING

Hydrology Report

for

White Cap Auto Spa Express Tunnel Car Wash

2000 N. Croatan HWY
Kill Devil Hills, NC 27948

22019SW

Prepared for:

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December 1, 2022
Revised December 22, 2022

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Appendix

1.) Rainfall Data
2.) Basin Overflow
3.) Pond Report
4.) Hydrographs
5.) Operations and Maintenance Plan
6.) Soil and Infiltration Test

INTRODUCTION

Project Description

The scope of this project includes the construction of a 2,448 s.f. conveyorized, tunnel car wash including associated vacuum bays. The study property is located on 2000 North Croatan Highway, Kill Devil Hills, NC 27948, Parcel #029831100. Activities proposed include demolition of existing buildings and hardscape; grading of the site; and installation of concrete pavement, curb and gutter, stormwater management facilities, all associated utilities, and landscaping.

Vicinity Map

Methodology

Stormwater Conveyance system for managing runoff was designed to be in accordance with the "Town of Kill Devil Hills Stormwater Management Plan 2010". Stormwater runoff peaks for the 10-yr, 2-hr storm event of 4.3" in volume were formulated. The appropriate hydrographs were then routed through the Infiltration Basin. The resulting post-developed conditions stormwater runoff peaks, seen below, show the 10-yr, 2-hr storm event of 4.3" in volume to be properly managed and allowed to infiltrate.

Design guidance was provided by the USDA Natural Resources Conservation Service's TR-55, Urban Hydrology for Small Watersheds. Hydrologic analysis of storm water runoff from the proposed development was performed using the Soil Conservation Service (SCS) Unit Hydrograph Method, as represented in the Hydraflow extension of AutoCAD Civil 3D, 2021.

Design Stormwater rainfall depths were obtained from the Kill Devil Hills, NC Stormwater Management Ordinance. The Type II rainfall distribution was used for the analysis with the runoff hydrograph peaking factor set at 484.

The drainage areas and curve numbers for existing conditions were determined from field observation, surveys, existing land cover, soil types and slopes. The same values for the proposed conditions were determined from future land use plans for the site.

PRE-DEVELOPED ANALYSIS

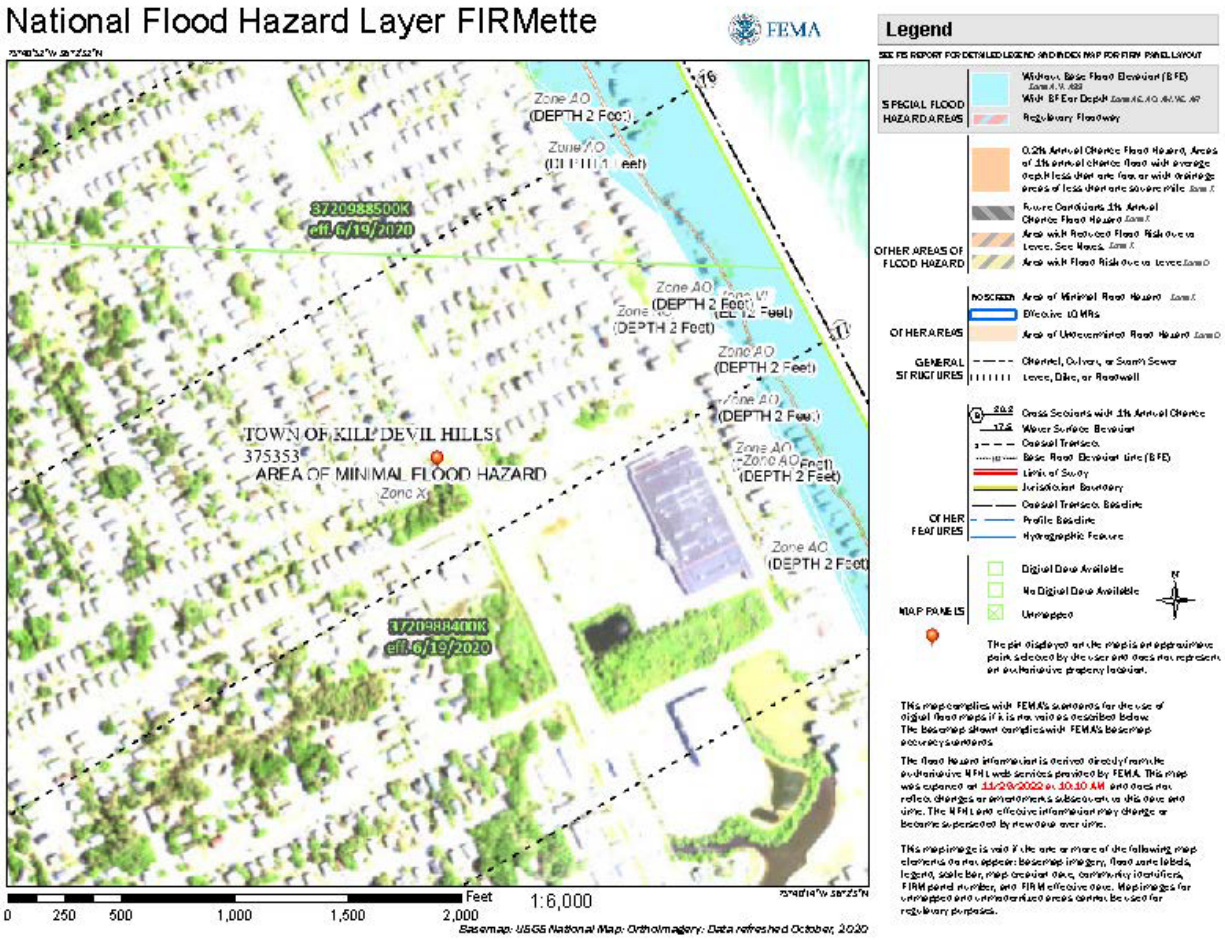
Pre-Developed Land Use

The 0.707-acre project site is currently undeveloped and consists of Class A hydrological soil and found to be in good condition. Currently, the site drains from the west to the east. Curve numbers based on existing site conditions were used to conduct the pre-developed peak flow analysis.

Existing soils on the site, as delineated by the National Cooperative Soil Survey of the U.S. Department of Agriculture and the Natural Resources Conservation Service are shown below.

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
CoB	Corolla fine sand, 0 to 6 percent slopes, rarely flooded	0.7	100.0%
Totals for Area of Interest		**0.7**	**100.0%**

Per FIRM panel 3720988400K, effective date June 19, 2020, the site is not within a flood hazard area. This study examines the existing site condition of the 0.707-acre project area with the proposed site condition to ensure compliance with requirements of the Kill Devil Hills, NC Stormwater Management Ordinance.



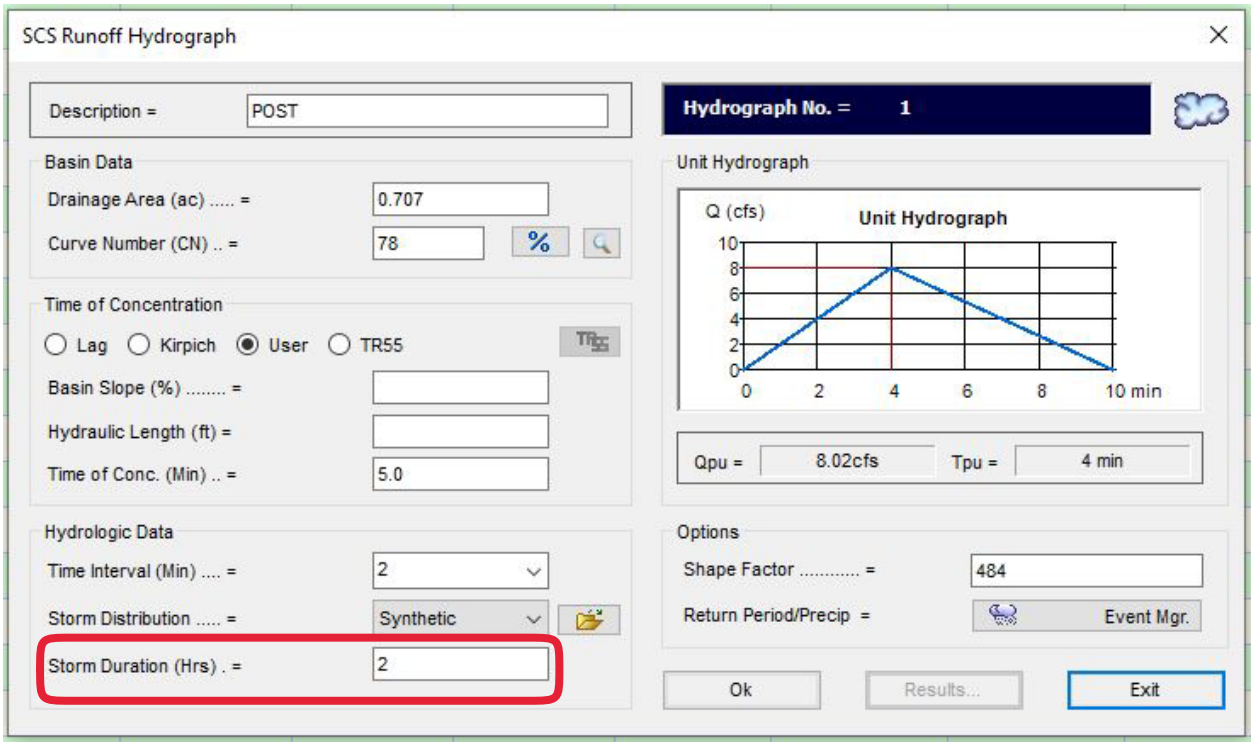
POST-DEVELOPED ANALYSIS

Post-Developed Land Use

Virtually all of the 0.707 acre site will be disturbed. The proposed carwash, drive isles, parking, and concrete curb and gutter will add 0.448 acres of impervious area to the site. Stormwater requirements will be satisfied by the proposed Infiltration Basin.

The increase in stormwater runoff from the site will be detained and infiltrate via the proposed Infiltration Basin. As shown in the Soil and Infiltration Test, see appendix, an infiltration rate of 20-in/hr was used during analysis. Said Infiltration Basin will control the 10-yr 2-hr storm event of 4.3" volume. Additional runoff will exit via the Basin Overflow, see appendix, which will be set at 7.00 feet.

HYDROGRAPH INPUT



RAINFALL TABLE

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.06	3.73	0.00	4.81	0.00	7.08	8.24	9.51
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	4.30	0.00	0.00	0.00

RESULTS

SUMMARY OF BASIN PERFORMANCE			
STORM EVENT	ELEVATION (ft)	MAX. STORAGE (ft^3)	MAX. DISCHARGE (ft^3/sec)
10 YR	6.29	1,324	0.00

POND VOLUME CALCULATIONS

Required Volume = 4.3" x 0.448 acres
= 6,986 cf required

Provided Volume at elevation 7.0' = 6,446 cf provided
Pond Volume =2,412 c.f.
Pond sides @ 33% void ratio =3,766 c.f.
Sock Drains =268 c.f.

- Remainder of volume required provided by dynamic infiltration. See pond model for more information. The infiltration rate is 20 in/hr.

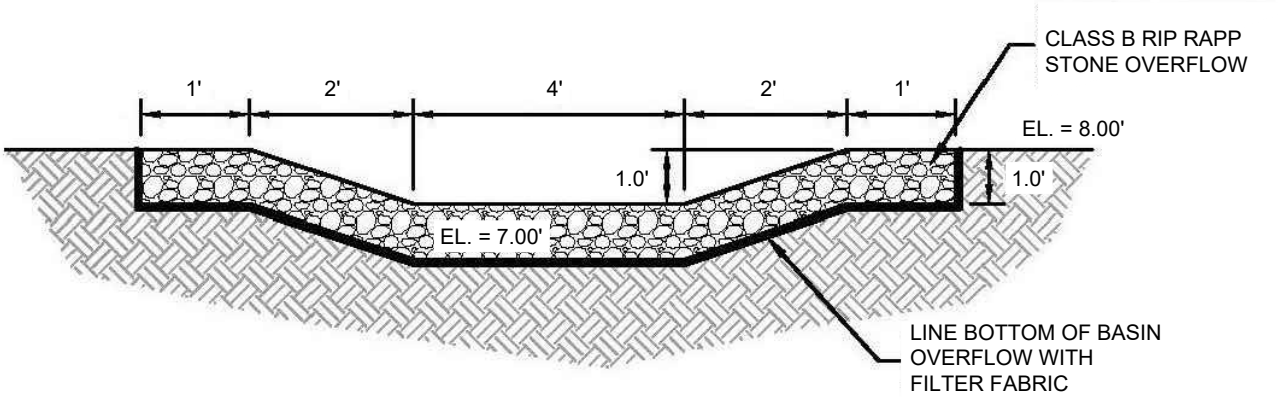
CONCLUSION

The Infiltration Basin will provide effective control so that current peak stormwater runoff from the 10-year 2-hr rainfall event of 4.3" in volume will be detained and allowed to infiltrate. Soil erosion and sediment control measures will be employed on site to ensure no erosive effects will occur, particularly at adjacent downstream properties.

In our opinion, these results satisfy the requirements of an effective stormwater management system.

APPENDIX

1.) Rainfall Data
2.) Basin Overflow
3.) Pond Report
4.) Hydrographs
5.) Operations and Maintenance Plan
6.) Soil and Infiltration Test



BASIN OVERFLOW DETAIL

NOT TO SCALE

Pond Report

Pond No. 1 - BASIN

Pond Data

Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 5.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	5.00	581	0	0
1.00	6.00	1,203	873	873
2.00	7.00	1,902	1,539	2,412
3.00	8.00	2,653	2,267	4,679

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 0.00	0.00	0.00	0.00
Span (in)	= 0.00	0.00	0.00	0.00
No. Barrels	= 0	0	0	0
Invert El. (ft)	= 0.00	0.00	0.00	0.00
Length (ft)	= 0.00	0.00	0.00	0.00
Slope (%)	= 0.00	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	No	No	No

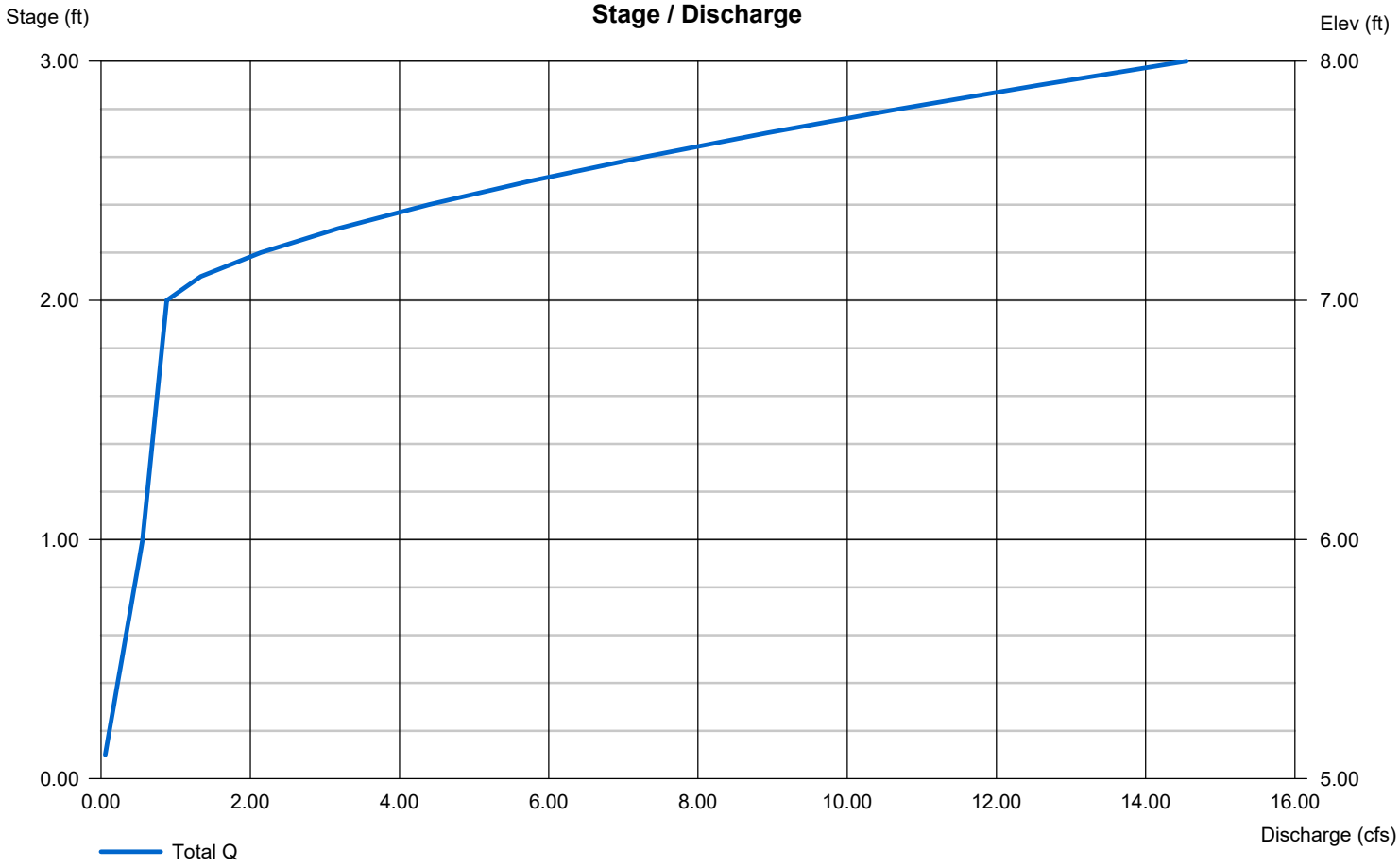
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 4.00	0.00	0.00	0.00
Crest El. (ft)	= 7.00	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= Rect	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 20.000 (by Contour)

TW Elev. (ft) = 0.00

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



Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

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	SCS Runoff	------	--------	--------	--------	--------	2.293	--------	--------	--------	POST
3	Reservoir	1	--------	--------	--------	--------	0.000	--------	--------	--------	ROUTED

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2022

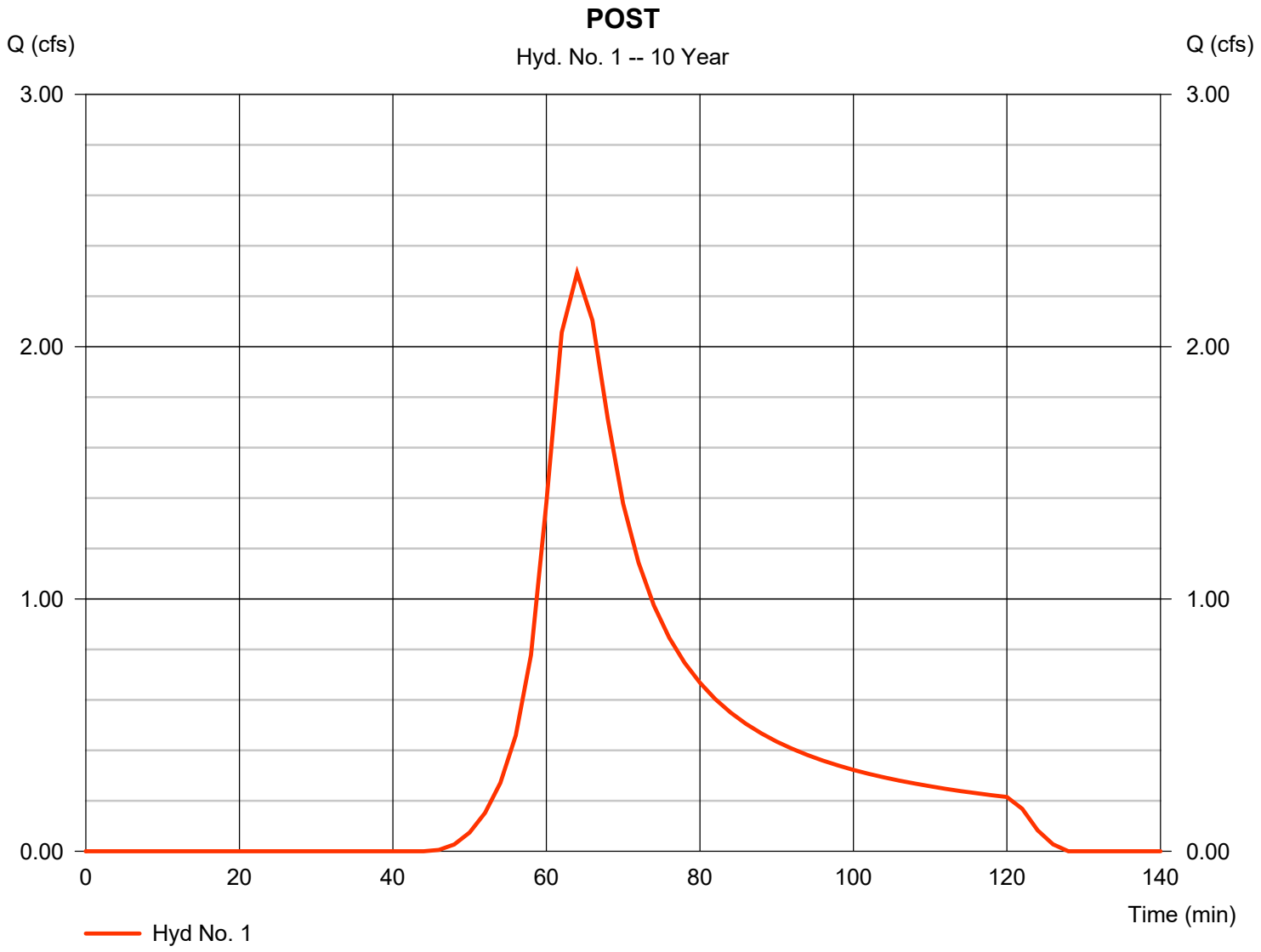
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	2.293	2	64	2,914	------	------	------	POST
3	Reservoir	0.000	2	152	0	1	6.29	1,324	ROUTED

Hydrograph Report

Hyd. No. 1

POST

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.293 cfs
Storm frequency	=	10 yrs	Time to peak	=	64 min
Time interval	=	2 min	Hyd. volume	=	2,914 cuft
Drainage area	=	0.707 ac	Curve number	=	78
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	User	Time of conc. (Tc)	=	5.00 min
Total precip.	=	3.11 in	Distribution	=	Synthetic
Storm duration	=	2.00 hrs	Shape factor	=	484

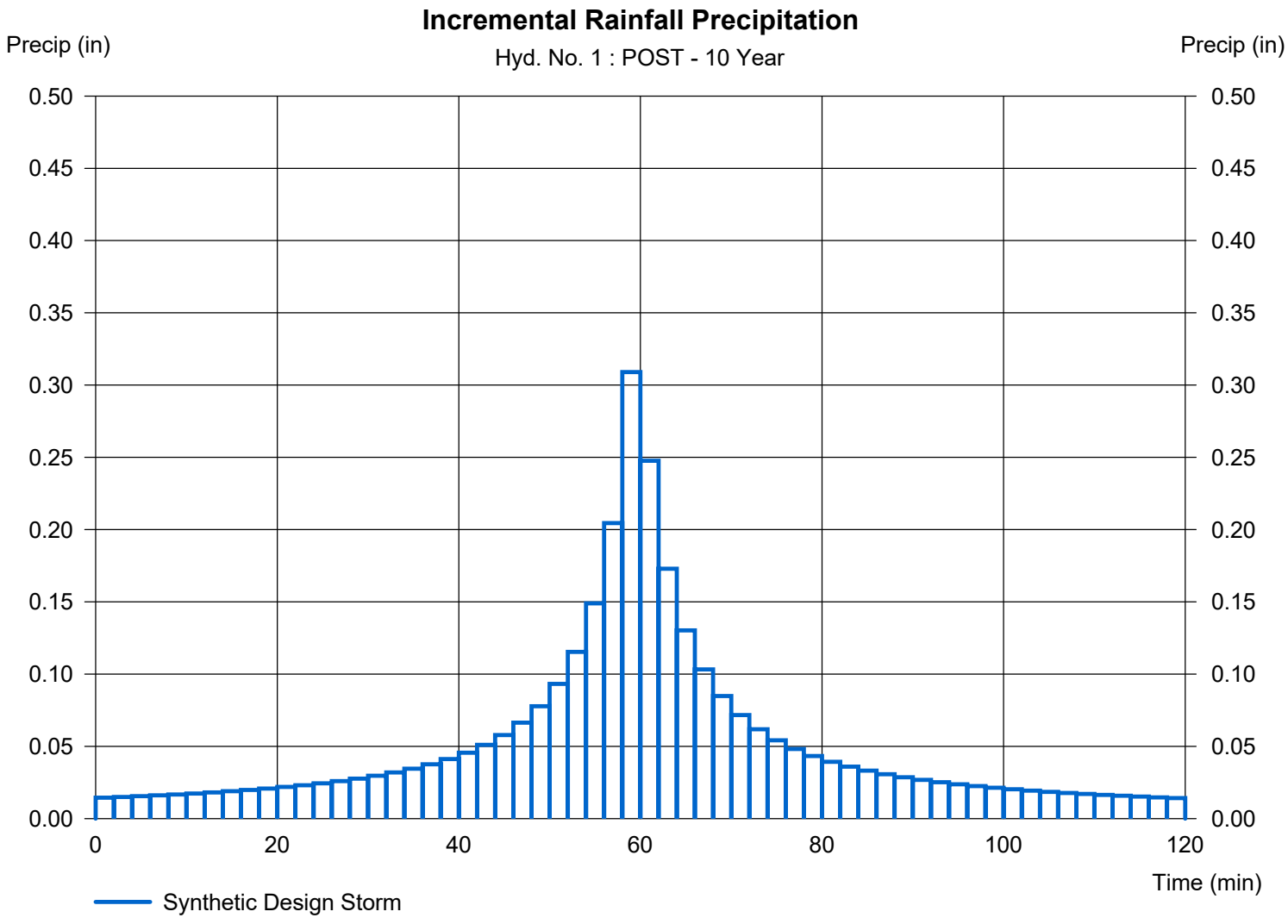


Precipitation Report

Hyd. No. 1

POST

Storm Frequency	= 10 yrs	Time interval	= 2 min
Total precip.	= 3.1144 in	Distribution	= Synthetic
Storm duration	= 2.00 hrs		



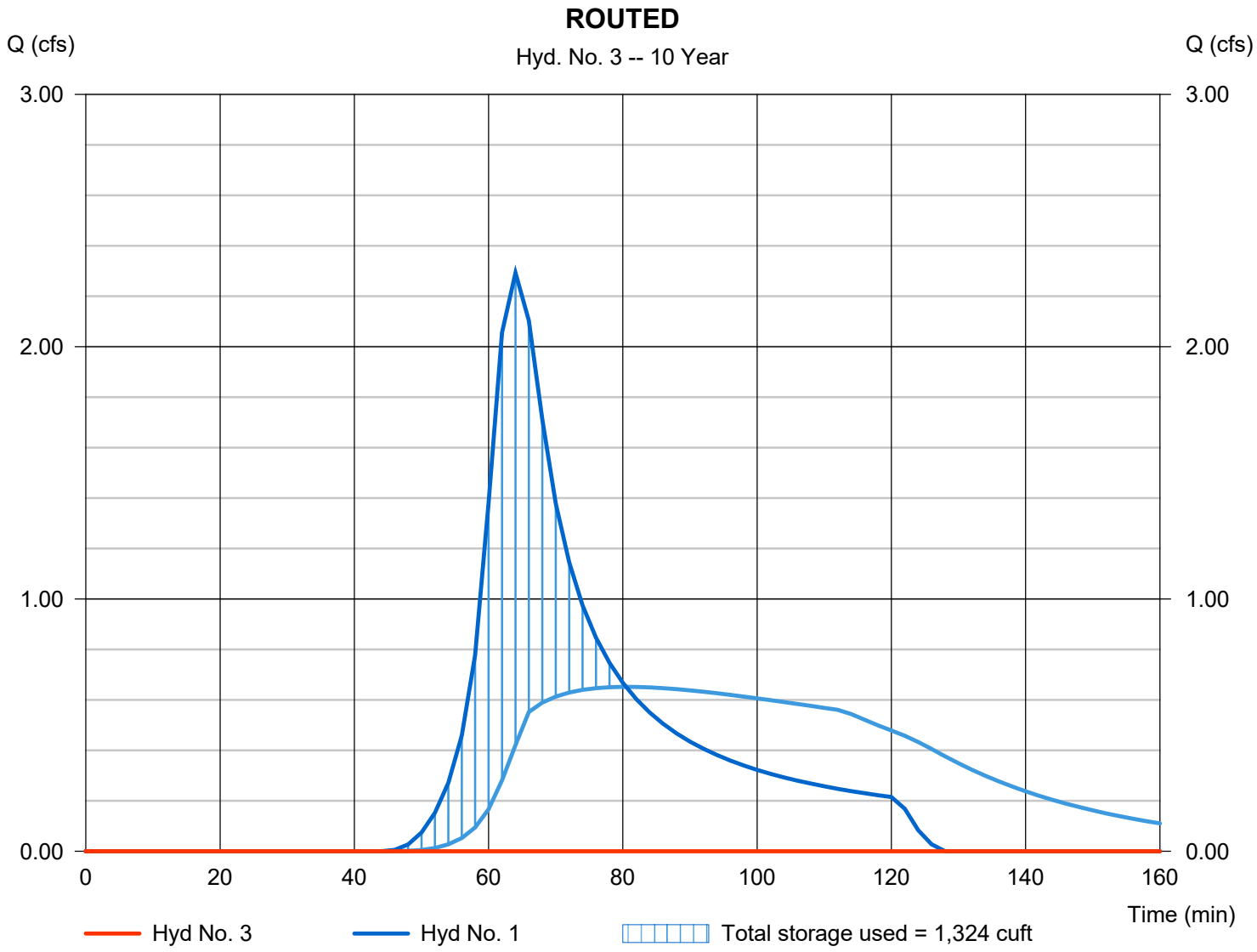
Hydrograph Report

Hyd. No. 3

ROUTED

Hydrograph type	=	Reservoir	Peak discharge	=	0.000 cfs
Storm frequency	=	10 yrs	Time to peak	=	152 min
Time interval	=	2 min	Hyd. volume	=	0 cuft
Inflow hyd. No.	=	1 - POST	Max. Elevation	=	6.29 ft
Reservoir name	=	BASIN	Max. Storage	=	1,324 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	69.0574	12.9000	0.8960	--------
2	80.7636	13.2000	0.8899	--------
3	0.0000	0.0000	0.0000	--------
5	78.9070	12.9000	0.8389	--------
10	79.1337	12.4000	0.8040	--------
25	71.5817	11.2000	0.7453	--------
50	63.6558	9.9000	0.6912	--------
100	59.5240	8.9000	0.6525	--------

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	5.21	4.18	3.50	3.02	2.66	2.38	2.16	1.97	1.82	1.69	1.58	1.48
2	6.11	4.92	4.14	3.58	3.16	2.83	2.57	2.35	2.17	2.02	1.89	1.77
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	7.02	5.71	4.83	4.21	3.74	3.37	3.07	2.83	2.62	2.44	2.29	2.16
10	7.96	6.50	5.53	4.83	4.30	3.89	3.56	3.28	3.05	2.85	2.68	2.53
25	8.98	7.35	6.28	5.51	4.93	4.48	4.11	3.81	3.55	3.34	3.15	2.98
50	9.84	8.05	6.90	6.08	5.46	4.98	4.59	4.27	3.99	3.76	3.56	3.38
100	10.69	8.74	7.50	6.63	5.97	5.46	5.05	4.70	4.41	4.17	3.95	3.76

Tc = time in minutes. Values may exceed 60.

Storm Distribution	Rainfall Precipitation Table (in)							
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SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	4.30	0.00	0.00	0.00

Infiltration Practice

An infiltration practice is a shallow excavation, typically filled with stone or an engineered soil mix, which is designed to temporarily hold stormwater runoff until it infiltrates into the surrounding soils. Infiltration practices are able to reduce stormwater quantity, recharge the groundwater, and reduce pollutant loads.

There are some common problems to be aware of when maintaining infiltration practices. They include, but are not limited to, the following:

- Sediment build-up
- Clogging in the inlet and outlet structure
- Clogging the underdrain (if applicable)
- Mosquitoes breeding in the practice

Routine maintenance should be performed on infiltration practices to ensure that the practice is functioning properly. Infiltration practices should be inspected after a large rainstorm. Keep drainage paths, both to and from the BMP, clean so that the water can properly infiltrate into the ground. Note that it might take longer for the water to infiltrate into the ground during the winter months and early spring.

In order to limit the sediment that enters the infiltration practice, infiltration practices should always be designed with adequate pretreatment (e.g., vegetated filter strip, sediment forebay). Routine maintenance of the pretreatment device, such as removing accumulated sediment, trash, and debris, decreases the amount of maintenance required on the infiltration practice as well as its likelihood of clogging and failing. Infiltration trenches can have either exposed aggregate at the surface of the practice which provides sediment removal and additional pretreatment upstream of the infiltration trench and can be easily removed and replaced when it becomes clogged.

If the infiltration practice is not draining properly, check for clogging of the inflow structure or underdrain. To help ensure that larger storm events are able to safely bypass the infiltration practice a perforated pipe (e.g., underdrain) is sometimes placed near the top of the stone reservoir or planting bed. This provides additional conveyance of stormwater runoff after the infiltration trench or basin has filled. Another consideration is the infiltration rate of the soil media. If the soil is not draining properly, the filter fabric could be clogged or the soil could be clogged or over-compacted. In an infiltration practice, the filter fabric is likely to be clogged along the top and sides of the infiltration practice. If the filter fabric becomes clogged, the practices will need to be dug up, cleaned, and the fabric replaced. The media is likely to become clogged at the upper layer of the soil first. If the media is clogged or over-compacted, then the media should be replaced. Potential sources of excessive sediment that could clog the media include ant mounds and unstable soil upstream of the practice. Possible sources of

compaction are tractors or maintenance vehicles traveling through the practice. If the practice includes an underdrain, a structural repair or cleanout to unclog the underdrain may be necessary.

If designed and maintained correctly, there is no danger of infiltration practices becoming a breeding ground for mosquitoes. A mosquito egg requires 24-48 hours to hatch. In addition, it takes 10-14 more days for the egg to develop and become an adult. By having an infiltration practice that drains properly, it is unlikely that it would provide a habitat that could become a breeding area for mosquitoes. Should the infiltration practices become a breeding ground for mosquitoes, the problem is likely with the soil media or the overflow structure which may need to be addressed.

The table below shows a schedule for when different maintenance activities should be performed on the infiltration practice.

Infiltration Practice Typical Routine Maintenance Activities and Schedule

Maintenance Activity	Schedule
• Inspect to ensure that contributing drainage area and infiltration practice are clear of sediment, trash and debris. Remove any accumulated sediment and debris. • Ensure that the contributing drainage area is stabilized. Plant replacement vegetation as needed. • Check observation well to ensure that infiltration practice is properly dewatering after storm events.	Monthly
• Inspect pretreatment devices for sediment accumulation. Remove accumulated sediment, trash and debris. • Inspect top layer of filter fabric and pea gravel or landscaping for sediment accumulation. Remove and replace if clogged. • Inspect the practice for damage, paying particular attention to inlets, outlets and overflow spillways. Repair or replace any damaged components as needed. • Inspect the practice following rainfall events (specifically large rainfall events). Check observation well to ensure that complete drawdown has occurred within 72 hours after the end of a rainfall event. Failure to drawdown within this timeframe may indicate infiltration practice failure.	Semi-Annually during first year and Annually thereafter
• Remove aggregate and install clean, washed trench aggregate • It may be necessary to replace piping, filter fabric, etc.	Upon Failure

Infiltration Practice					
Maintenance Item	Condition				Comment
	Good	Marginal	Poor	N/A*	
General Inspection					
Access to the site is adequately maintained for inspection and maintenance.					
Area is clean (trash, debris, grass clippings, etc. removed).					
Inlet					
Drainage ways (overland flow or pipes) to the practice are free of trash, debris, large branches, etc. Drainage ways are in good condition.					
Area around the inlet structure is mowed and grass clippings are removed.					
No evidence of gullies, rills, or excessive erosion around the inlet structure.					
Water is going through structure (i.e. no evidence of water going around the structure).					
Diversion structure (high flow bypass structure or underdrain) is free of trash, debris, or sediment. Comment on overall condition of diversion structure and list type.					
Pretreatment (choose one)					
Forebay – area is free of trash, debris, and sediment.					
Forebay – No undesirable vegetation.					
Forebay – No signs of erosion, rills, or gullies. Erosion protection is present on site.					
Forebay – No signs of standing water.					
Filter Strip– area is free of trash debris and sediment. Area has been mowed and grass clippings are removed. No evidence of erosion or sediment accumulation.					
Filter Strip – No signs of unhealthy grass, bare or dying grass. Grass height is maintained to a height of 6 – 15 inches.					
Filter Strip– No signs of erosion, rills, or gullies. Erosion protection is present on site.					
Filter Strip – No undesirable vegetation.					
Filter Strip – No signs of standing water (examples include: stains, odors, mosquito larvae, etc).					

Infiltration Practice					
Maintenance Item	Condition				Comment
	Good	Marginal	Poor	N/A*	
Main Treatment					
Main treatment area is free of trash, debris, and sediment.					
Erosion protection is present on site (i.e. turf reinforcement mats). Comment on types of erosion protection and evaluate condition.					
Structure seems to be working properly. No settling around the structure. Comment on overall condition of structure.					
No signs of ponding water more than 48 hours after a rain storm event (examples include: stains, odors, mosquito larvae, etc).					
No undesirable vegetation growing within the practice.					
Native plants were used in the practice according to the landscaping plan.					
Observation well is capped and locked when not in use					
Flow testing has been performed on infiltration practice to determine if underdrain is clogged.					
Emergency Overflow and Outlet Structure					
Area is free of trash, debris, and sediment.					
No evidence of erosion, scour, or flooding around the structure.					
No signs of sediment accumulation.					
Grass height of 6 – 15 inches is maintained.					
Results					
Overall condition of Infiltration Practice:					
Additional Comments					
Notes: *If a specific maintenance item was not checked, please check N/A and explain why in the appropriate comment box.					

MEMORANDUM

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Fax: (252) 261-1260
Web: www.quible.com

To: **Michael W. Strader, Jr., P.E., Quible & Associates**

From: Brian Rubino, P.G.

Date: October 21, 2022

Re: **P22182 Soil and Groundwater Investigation**

Michael,

On Monday October 17, 2022, representatives from Quible visited the Site to conduct shallow soil borings in the location of potential future stormwater collection basins or infiltration areas. The purpose of our evaluation was to understand lithologic conditions, to determine the depth and elevation of the Static Water Table (WT), Season High Water Table (SHWT), and to measure infiltration rates for a Stormwater Management System design for a car wash facility. We selected two locations (SB-1 and SB-2) for our testing as shown on the accompanying exhibit.

Soils consist of:

SB-1

- 0-1.7' bgs: fine-grained sand (10 YR 5/3)
- 1.7'-2.0' bgs: fine-grained sand (10 YR 4/2)
- 2.0'-3.2' bgs: poorly sorted fine-coarse grained sand (10 YR 4/2)
- 3.2'-4.5' bgs: moderately sorted sand (GLEY1 4/10Y); saturated
- 4.5'-4.7' bgs: fine-grained sand with some decomposed organic material (10 YR 2/1)
- 4.7'-6.0' bgs: fine-grained sand (10 YR 3/1)

SB-2

- 0-2.4' bgs: fine-grained sand (10 YR 5/3)
- 2.4'-3.3' bgs: fine to medium grained sand (10 YR 5/3) with some iron oxidation (10 YR 5/6)
- 3.3-5.0' bgs: fine to very fine-grained sand grained sand (10 YR 4/2)
- 5.0'-5.2' bgs: fine-grained sand with some decomposed organic material (10 YR 2/1)
- 5.2'-6.0' bgs: fine-grained sand (10 YR 6/1)

A summary of elevation data collected and observed is as follows:

Soil Boring	Ground Elevation (ft); (NAVD 88)	Groundwater Elevation (ft); (NAVD 88)	Approx. Elevation of SHWT (ft); (NAVD 88)	Measured infiltration Rates (in/hr.)
SB-1	6.91'	4.39'	4.79'	>20
SB-2	8.24	4.44'	4.80'	>20

Ground elevation data was collected on the date of the soil borings using an RTK GPS system. Temporary piezomters, using a two-inch .010 slot pvc well screen were installed at the boring locations and were allowed to recover for a period of at least 45 minutes before the depth to groundwater was measured using an electronic water level checker.

Infiltration rate field testing of the in-situ soils in the immediate vicinity of the soils boring locations was conducted using a double ringed infiltrometer (12-inch inner diameter and 24-inch outer diameter). This procedure measures the natural downward movement of water to the groundwater table which can be relied upon to design Site stormwater collection, storage and treatment systems in the area tested. The infiltration test was done on in the soil unit at the surface. All soil units encountered at both locations are considered very well drained. Prior to measuring the infiltration rates, water was added to the rings to saturate underlying soils until a constant infiltration rate was obtained. Duplicate 15-minute infiltration tests were conducted and the results were averaged (see table above). The infiltration rate is greater than 20”/hr which can be expected in unconsolidated sand-dominated substrata.

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W. DURHAM STREET
(40' R/W M.B. 1, PG. 106)

10' M.B.S.L.

30' M.B.S.L.

10' M.B.S.L.

10' M.B.S.L.

10' M.B.S.L.

PROPOSED CARWASH EQUIPMENT ROOM F.F.E.= 9.50'

GROUND ELEVATION = 6.91'
APPROX. S.H.W.T. = 4.79'
ACTUAL W.T. 10/17/22 = 4.39'

SB2

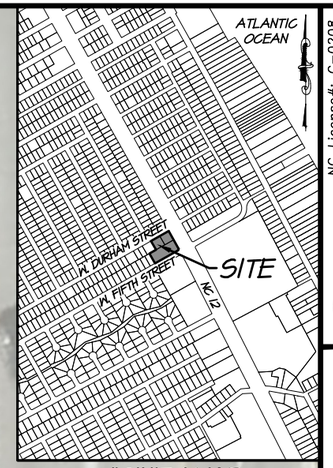
GROUND ELEVATION = 8.24'
APPROX. S.H.W.T. = 4.80'
ACTUAL W.T. 10/17/22 = 4.44'

SB1

W. FIFTH STREET
(50' R/W M.B. 4, PG. 33)

US 158
N. CROATAN HIGHWAY
(150' R/W M.B. 4, PG. 33A)

MAGNETIC



VICINITY MAP
(NTS)

Quible & Associates, P.C.
SINCE 1959
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THIS MAP IS NOT A CERTIFIED SURVEY AND HAS NOT BEEN REVIEWED BY A LOCAL GOVERNMENT AGENCY FOR COMPLIANCE WITH ANY APPLICABLE LAND DEVELOPMENT REGULATIONS.

SOIL BORING EXHIBIT

PARCEL A
WRIGHT'S SHORES

ATLANTIC TOWNSHIP
DARE COUNTY
NORTH CAROLINA

GRAPHIC SCALE IN FEET 1"= 30'
0 30' 60'

PROJECT	DRAWN BY	CHECKED BY	DATE
P22182	JJC	BDR	10/21/22

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