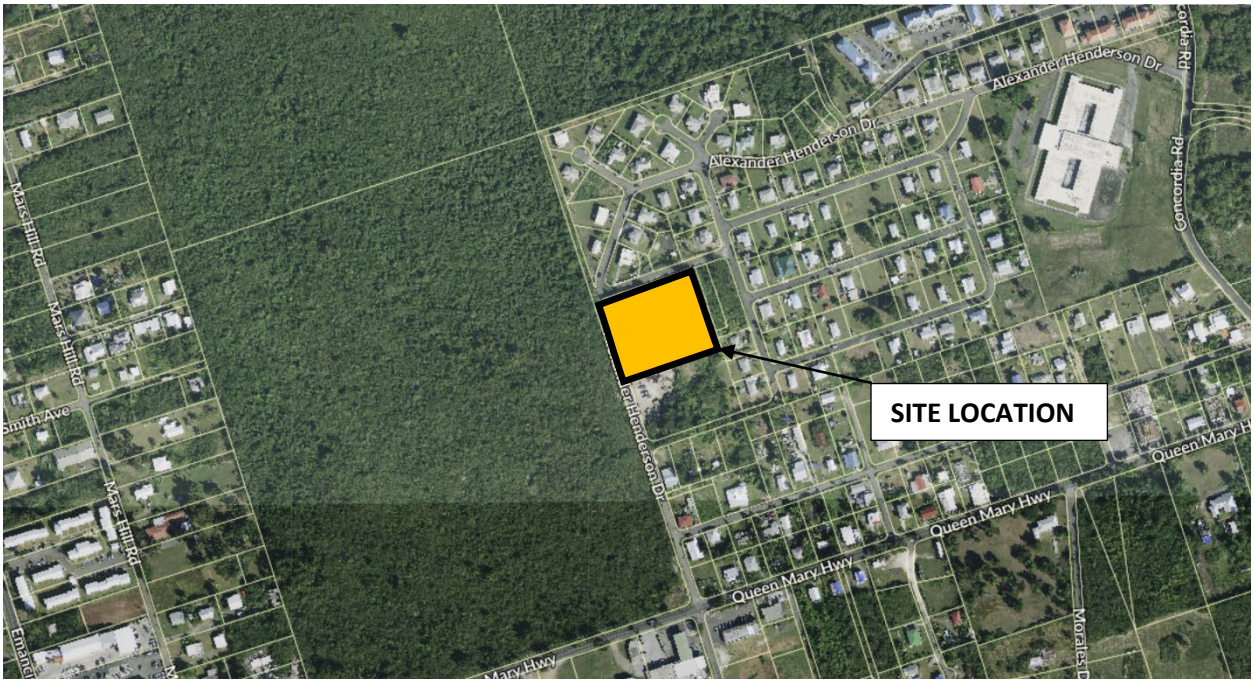
HYDROLOGY STUDY REPORT

PROJECT SITE:

V.I. DEPARTMENT OF PUBLIC WORKS (DPW)
PLOT 73-B
ESTATE CONCORDIA
FREDERIKSTED, ST. CROIX, USVI 00840



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INTRODUCTION

This site is currently developed with two main building structures and three smaller utility structures. Hurricanes Irma and Maria in 2017 rendered extensive damage leaving the facility uninhabitable in its aftermath. Since then, the site has been abandoned.

The proposed improvements will result in the demolition of the three small utility structures and the main administrative building with adjoining equipment bays. A new approximately 4,150 SF administrative building will be constructed towards the entrance to the site and a new approximately 1,780 SF heavy equipment parking structure will be constructed at the rear, within the same footprint as the main structure being demolished.

This hydrology study will focus on a pre-development vs. a post-development analysis to ensure that the proposed improvements do not adversely impact stormwater quality and quantity beyond the pre-existing condition. Any additional impacts will be quantified and properly mitigated in accordance with the Department of Planning and Natural Resources (DPNR) requirements.

SOILS CLASSIFICATION

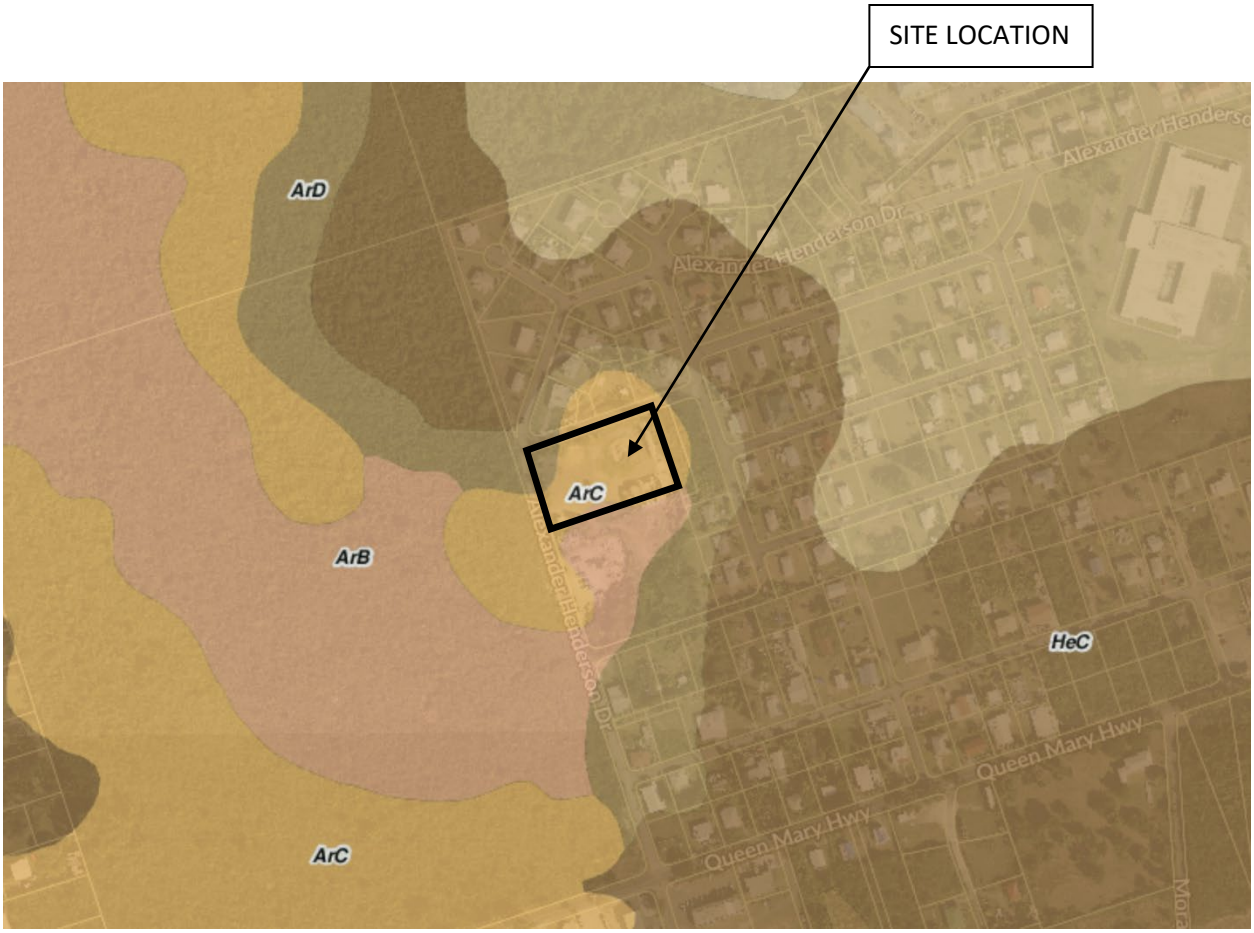
For Curve Number (CN) determination, there are four (4) main types of Hydrologic Soils Classification which are as follows:

Group A – Soils that have low runoff potential when thoroughly wet. These soils typically have less than 10% clays and more than 90% sand or gravel.

Group B – Soils that have moderately low runoff potential when thoroughly wet. These soils typically have between 10% - 20% clays and 50% - 90% sand.

Group C – Soils that have moderately high runoff potential when thoroughly wet. These soils typically have between 20% - 40% clays and less than 50% sand.

Group D – Soils that have high runoff potential when thoroughly wet. These soils typically have greater than 40% clays and less than 50% sand.



St. Croix Hydrologic Soils Classification (Source: *https://usvi.mapgeo.io*)

Based on the above, the Hydrologic Soils Classification for the Site is ***Group C***.

CURVE NUMBER (CN) CLASSIFICATION

The curve number classification is determined based on land use type and hydrologic soil type. The table below indicates CN values for various land uses and hydrologic soil types.

Table 3-6. Typical Curve Number Values for Urban Areas (SCS 1986)

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1] Average runoff condition, and $I_a = 0.2S$.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Based on the above, the site falls into three (3) distinct classifications listed as follows:

Poor Condition (grass cover < 50%) – this accounts for the grass cover within the property.

Gravel (including right-of-way) – this accounts for the gravel ground cover within the property.

Paved; open ditches (including right-of-way) – this accounts for the paved surfaces within the property.

Commercial and business – this accounts for the buildings within the property.

BASIN CHARACTERISTICS

The disturbed area of the site is approximately 1.68 acres broken down into four (4) major ground cover types. The table below shows the breakdown along with a Weighted Curve Number for each category and ultimately for the entire site.

- **PRE-DEVELOPMENT**

TABLE 1 - PRE-DEVELOPMENT BASIN CHARACTERISTICS			
DESCRIPTION	**AREA**	**UNITS**	**WEIGHTED CURVE NUMBER (CN)**
BUILDINGS	0.12	AC	94
PAVEMENT & SIDEWALK	0.13	AC	92
GRASS COVER	0.9	AC	86
ASPHALT PAVEMENT	0.05	AC	92
GRAVEL	0.48	AC	89

TOTAL AREA	1.68	AC

WEIGHTED CN VALUE	**88**

- **POST-DEVELOPMENT**

TABLE 2 - POST-DEVELOPMENT BASIN CHARACTERISTICS			
DESCRIPTION	**AREA**	**UNITS**	**WEIGHTED CURVE NUMBER (CN)**
BUILDINGS	0.16	AC	94
CONCRETE PAVEMENT & SIDEWALK	0.34	AC	92
GRASS COVER	0.85	AC	86
ASPHALT PAVEMENT	0.05	AC	92
GRAVEL	0.28	AC	89

TOTAL AREA	1.68	AC

WEIGHTED CN VALUE	**89**

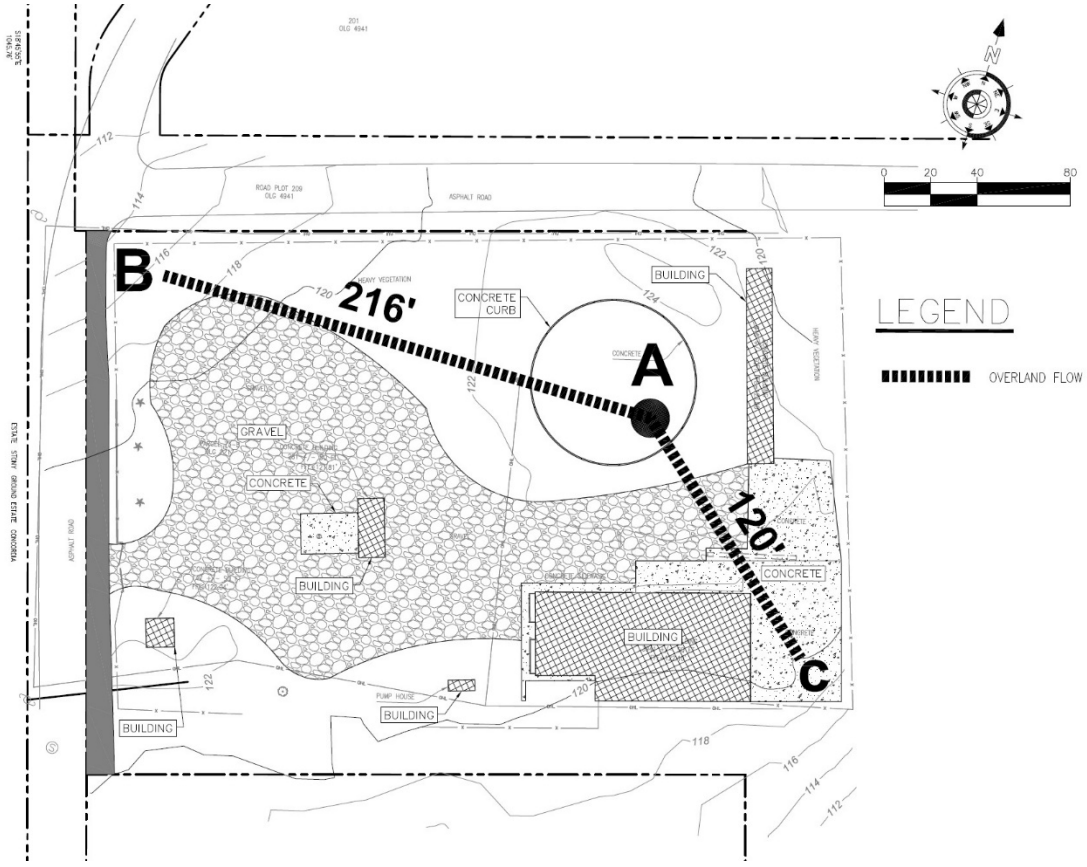
TIME OF CONCENTRATION (Tc)

The time of concentration is necessary to estimate peak discharge and is dependent upon the watershed characteristics. To accurately determine Tc, the hydraulics of each part of the flow path must be considered separately.

- **PRE-DEVELOPMENT**

In the pre-development, the site has two distinct flow paths which are all **overland** flow as follows:

- A-B (Overland Flow) – 216 ft. travel distance @ average slope of 3.2%
- A-C (Overland Flow) – 120 ft. travel distance @ average slope of 4.2%



Both flow patterns will be evaluated to determine which one produces the most critical (longest) Time of Concentration (Tc) which will be used to determine the stormwater water runoff volume.

P_{24} = 4 IN (2yr_24 HOUR CUMMULATIVE RAINFALL AMOUNT)

$$T_t = \frac{(.007)(nL)^{.8}}{(P)^{.5}(S)^{.4}}$$

(OVERLAND FLOW)

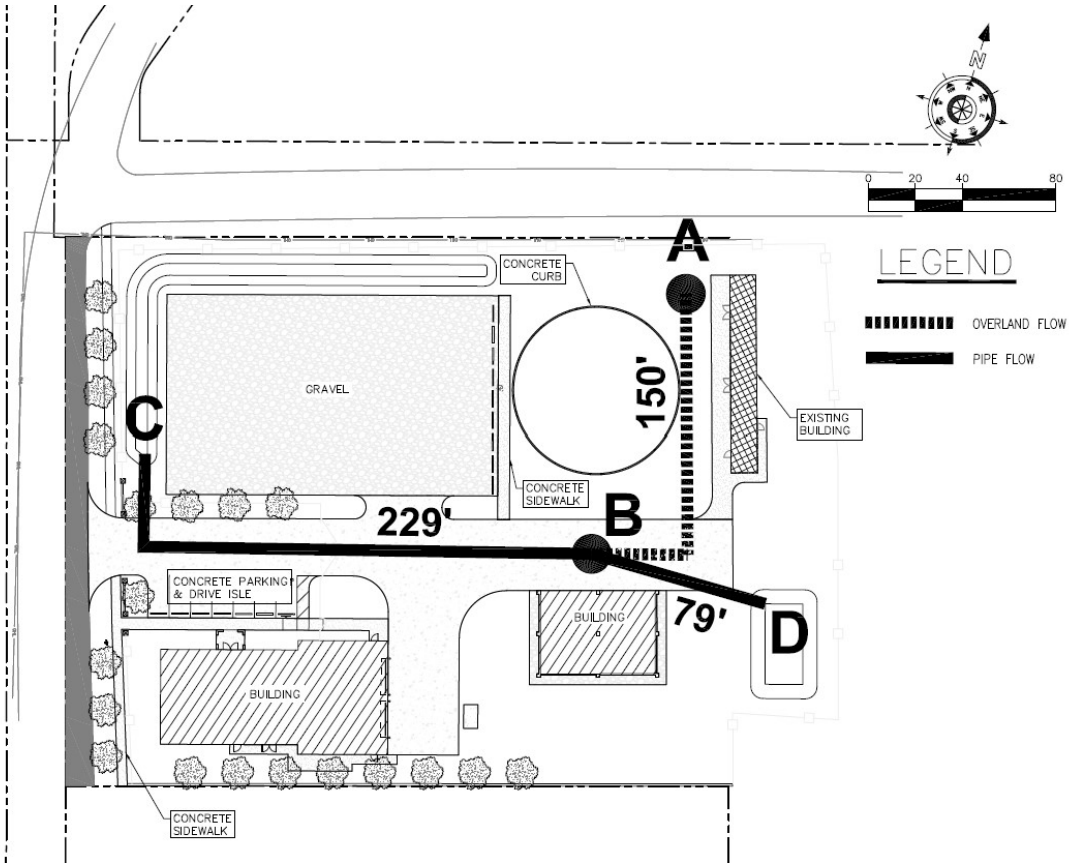
TABLE 3 - PRE-DEVELOPMENT TIME OF CONCENTRATION Tc (2yr - 24 HOUR STORM)					
SEGMENT DESCRIPTION	SLOPE (S)	LENGTH (L)	MANNING'S COEF. (n)	Tt (hrs)	
A-B (OVERLAND FLOW)	0.032	216	0.03	0.062	CONTROLS!
A-C (OVERLAND FLOW)	0.042	120	0.03	0.035	

Tc = ∑Tt = 0.062 hrs (2YR - 24HR STORM)

➢ POST-DEVELOPMENT

In the post-development, the site has two distinct flow paths as follows:

- A-B-C (Overland Flow & Pipe Flow) – 150 ft. **overland** travel distance @ average slope of 1.33% & 229 ft. of 15" ø **pipe** @ 0.25% slope
- A-B-D (Overland Flow & Pipe Flow) – 150 ft. **overland** travel distance @ average slope of 1.33% & 79 ft. of 15" ø **pipe** @ 0.00% slope



All three flow patterns will be evaluated to determine which one produces the most critical (longest) Time of Concentration (Tc) which will be used to determine the stormwater water runoff volume.

P_{24} = 4 IN (2yr_24 HOUR CUMMULATIVE RAINFALL AMOUNT)

$$T_t = \frac{(.007)(nL)^{.8}}{(P)^{.5}(S)^{.4}}$$ (OVERLAND FLOW)

$$T_t = \frac{L}{v}$$ (PIPE FLOW)

$$v = \frac{1.49}{n}(D/4)^{2/3} s^{1/2}$$

v= 2.29 fps

v= 0.46 fps

TABLE 4 - POST-DEVELOPMENT TIME OF CONCENTRATION Tc (2yr - 24 HOUR STORM)								
SEGMENT DESCRIPTION		SLOPE (S)	LENGTH (L)	PIPE DIA (FT.)	MANNING'S COEF. (n)	Individual Tt (hrs)	Cummulative Tt (hrs)	
A-B-C (OVERLAND & PIPE FLOW)	A-B (OVERLAND)	0.0133	150	N/A	0.03	0.066	0.093	
	B-C (PIPE)	0.0025	229	1.25	0.015	0.028		
A-B-D (OVERLAND & PIPE FLOW)	A-B (OVERLAND)	0.0133	150	N/A	0.03	0.066	0.114	CONTROLS!
	B-D (PIPE)	0.00	79	1.25	0.015	0.048		

Tc = ∑Tt = 0.114 hrs (2YR - 24HR STORM)

RUNOFF (Q) AND STORAGE VOLUME (V)

DPNR Runoff Onsite Storage Requirements as per the ***Territorial Pollutant Discharge Elimination System - General Permit Number VIGSA0000*** is as follows:

1) 3600 cubic feet per acre (1" over 1 acre) or,
2) 2yr – 24 hours storm; which is greater

➢ PRE-DEVELOPMENT

PRE-DEVELOPMENT - RUNOFF (Q) AND TOTAL VOLUME (V)

Runoff equation

$$Q = \frac{\left[P - 0.2\left(\frac{1000}{CN} - 10\right)\right]^2}{P + 0.8\left(\frac{1000}{CN} - 10\right)}$$

where:
Q = runoff (in)
P = rainfall (in)
CN = runoff curve number

Volume Equation

$$V = QA$$

where:

Q = runoff (ft)

A = Area (ac)

DPNR Runoff Onsite Storage Requirements
(Territorial Pollutant Discharge Elimination System - General Permit Number VIGSA0000)

1) 3600 cubic feet per acre (1" over 1 acre), or

2) 2 yr - 24 hour storm; whichever is greater

1) 3600 CUBIC FEET PER ACRE
Disturbed Site Acreage = 1.68
ac

V= 0.14 ac-ft

2) 2 YR - 24 HOUR STORM

STORM EVENT	P (in)	CN	Q (in)	Area (ac)	V (ac-ft)	
2 - YEAR	4	88	2.73	1.68	0.38	CONTROLS!

As can be noted from the above calculations, the 2yr – 24 hr. storm event generates the most runoff in the pre-development/ current site condition.

➢ POST-DEVELOPMENT

POST-DEVELOPMENT - RUNOFF (Q) AND TOTAL VOLUME (V)

Runoff equation

$$Q = \frac{\left[P - 0.2\left(\frac{1000}{CN} - 10\right)\right]^2}{P + 0.8\left(\frac{1000}{CN} - 10\right)}$$

where:
Q = runoff (in)
P = rainfall (in)
CN = runoff curve number

Volume Equation

$$V = QA$$

where:

Q = runoff (ft)

A = Area (ac)

DPNR Runoff Onsite Storage Requirements
(Territorial Pollutant Discharge Elimination System - General Permit Number VIGSA0000)

1) 3600 cubic feet per acre (1" over 1 acre), or

2) 2 yr - 24 hour storm; whichever is greater

1) 3600 CUBIC FEET PER ACRE

Disturbed Site Acreage = 1.68 ac

V= 0.14 ac-ft

2) 2 YR - 24 HOUR STORM

STORM EVENT	P (in)	CN	Q (in)	Area (ac)	V (ac-ft)	
2 - YEAR	4	89	2.82	1.68	0.40	CONTROLS!

As can be noted from the above calculations, the 2yr – 24 hr. storm event generates the most runoff in the post-development.

CONCLUSION

Given that the proposed improvements do not significantly increase the building and impervious areas over the existing condition, the additional runoff generated is only a negligible **0.02 ac-ft**. However, rather than simply provide the required amount to offset this minimal impact, a decision was taken to further improve the existing condition by providing enough storage to cover at least 1-inch of runoff over the entire disturbed site which equates to **0.14 ac-ft**.

Stormwater Retention Pond Calculations

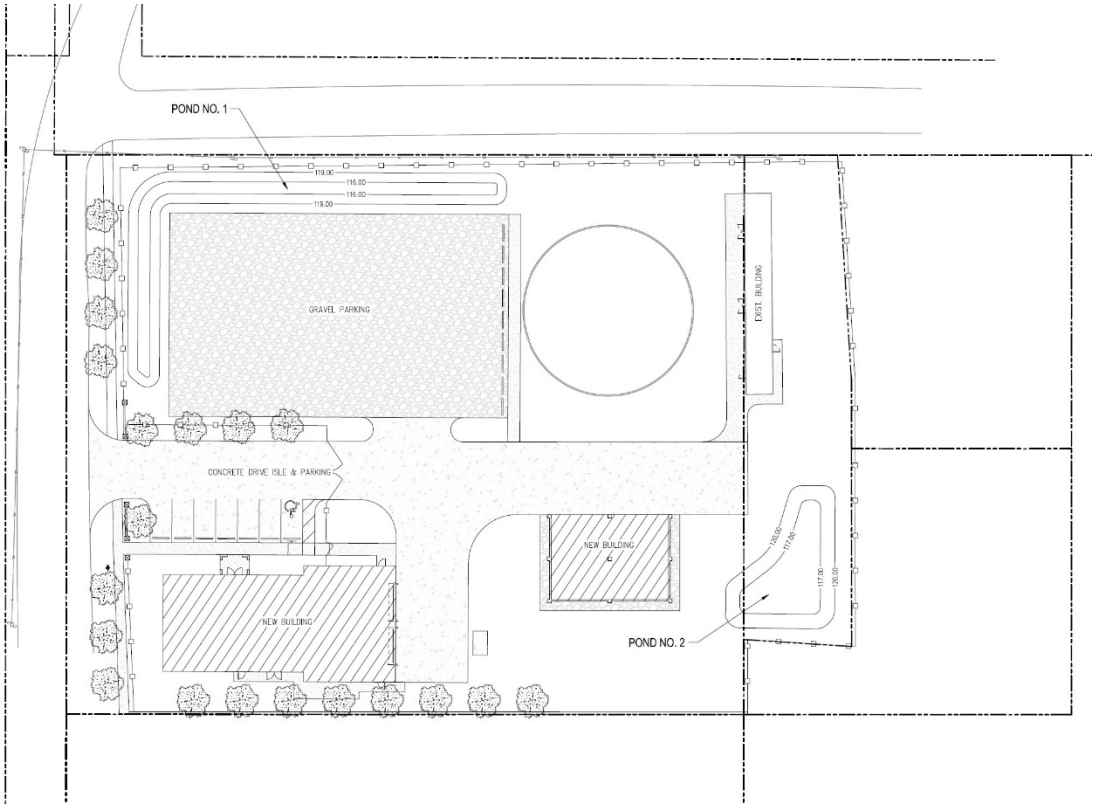
POND No. 1

Stage	Area	Area	Average Area	Incremental Volume	Cumulative Pond Volume
(ft)	(Sq. Ft)	(Acres)	(Acres)	(Ac-ft)	(Ac-ft)
116.0	1,089	0.025			
119.0	2,918	0.067	0.05	0.14	0.14

POND No. 2

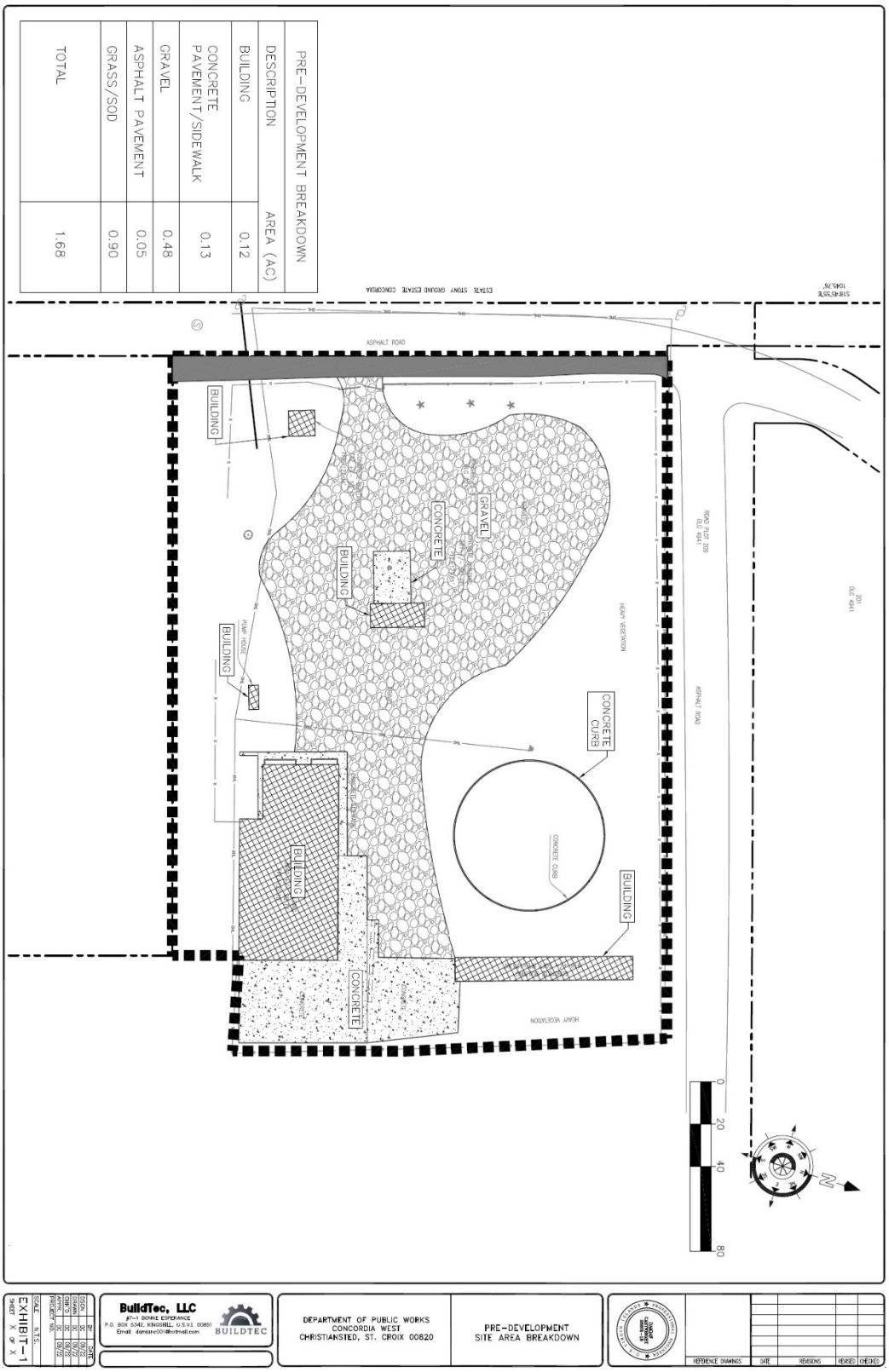
Stage	Area	Area	Average Area	Incremental Volume	Cumulative Pond Volume
(ft)	(Sq. Ft)	(Acres)	(Acres)	(Ac-ft)	(Ac-ft)
117.0	907	0.021			
120.0	1,889	0.043	0.03	0.10	0.10

Proposed Cumulative Pond Storage of 0.24 Ac-ft >> Required Storage of 0.02 Ac-ft

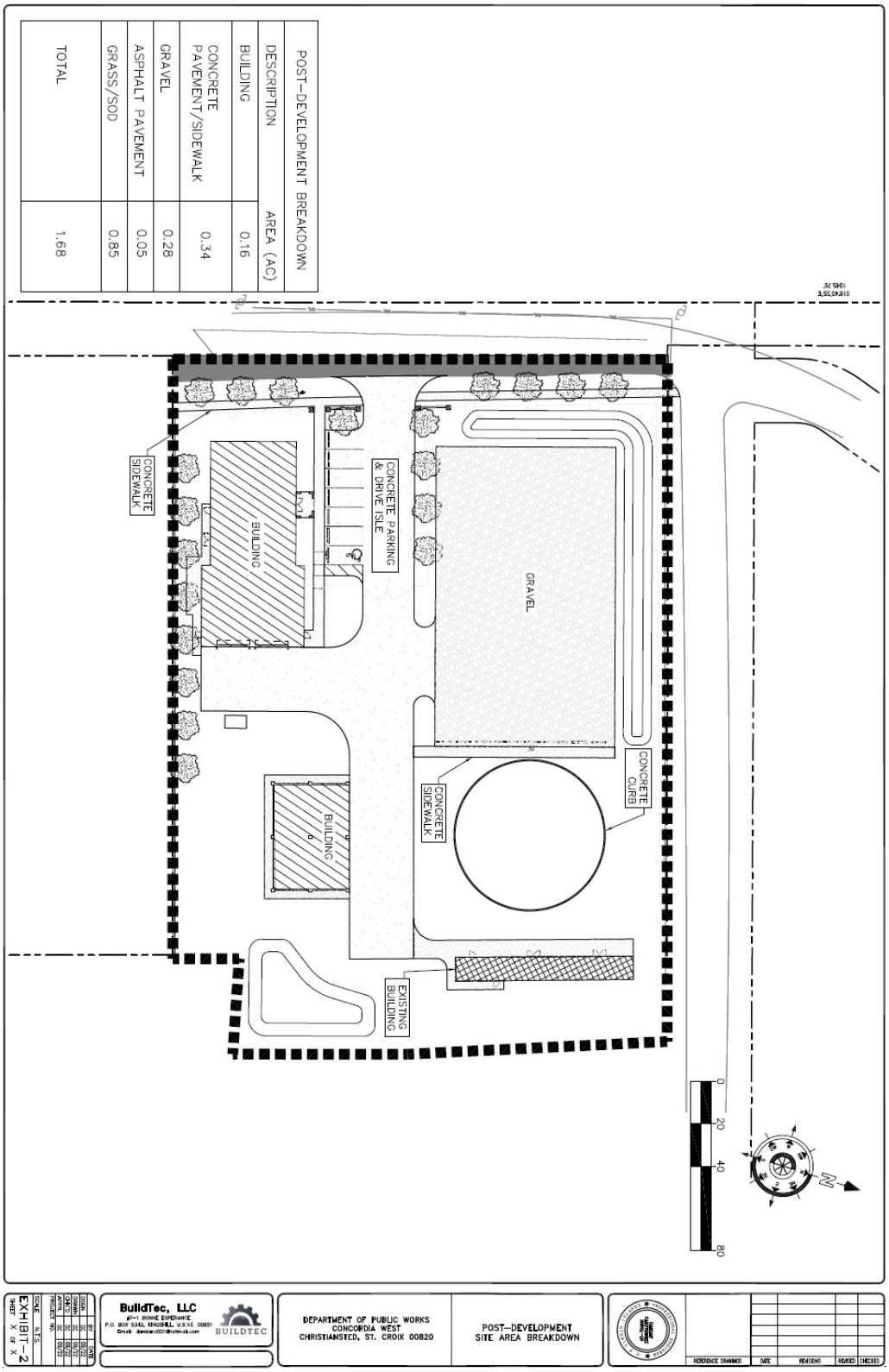


STORAGE POND LAYOUT FOR A TOTAL VOLUME OF 0.24 AC-FT

APPENDICES



PRE-DEVELOPMENT SITE AREA BREAKDOWN



POST-DEVELOPMENT SITE AREA BREAKDOWN