STORMWATER MANAGEMENT PLAN

Shady Oak Crossing
Minnetonka, MN

ORIGIN DATE: 04-13-2017

PREPARED FOR:

Campion Engineering Services, Inc.
1800 Pioneer Creek Center
Maple Plain, MN 55359

PREPARED BY:

Civil Methods, Inc.
1551 Livingston Avenue, Ste. 104
West St. Paul, MN 55118

ENGINEER CERTIFICATION:

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly licensed Professional Engineer under the laws of the State of Minnesota.

Name: David Poggi, PE

Signed: 

Date: 04-13-2017

Registration: MN No. 44573

CIVIL METHODS, INC.
PROFESSIONAL ENGINEERS
LAND | WATER | INFRASTRUCTURE

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1. INTRODUCTION

The Shady Oak Crossing commercial development is proposed to be located at 4312 Shady Oak Road, Minnetonka, MN. In addition to the new building, the re-developed site will include a new parking lot with an entrance to Oak Drive Lane, along with the removal of the previous access to Shady Oak Lane. Impervious coverage on the property will be reduced, and a stormwater management system will convey all site runoff to a new basin installed on the adjacent property to the west.

The primary parcel for the project construction is approximately 1.6 acres, while the western parcel is 0.68 acres. The development must meet the stormwater management standards of the City of Minnetonka, the Nine Mile Creek Watershed District (NMCWD), and the MPCA NPDES Permit.

Regulatory Stormwater Requirements:

1) Infiltrate or otherwise retain the volume of 1" of rainfall over all site impervious area.
2) Treat the runoff to the following pollutant reductions: 90% TSS & 60% TP.
3) Match or reduce stormwater discharge rates for the 2-, 10-, and 100-year, Atlas-14 storm events.
4) Include a pretreatment device when underground infiltration methods are employed.
5) Maintain a minimum of 3.0' of separation from the bottom of an infiltration device to the groundwater table elevation.

2. EXISTING SITE CONDITIONS

The existing parcels total approximately 2.28 acres, with the easterly parcel consisting almost entirely of impervious surface associated with existing commercial development, and the smaller westerly parcel including a residence and natural area. The soils present at the site consist primarily of silty sands with moderate to good infiltration capacity, according to soil logs collected at the site (additional soils information included in Appendix A.

The property is covered with 1.22 acres of impervious surface, and primarily drains west into the wetland. Existing drainage patterns on the site are illustrated on Figure 1 (Appendix B).

3. PROPOSED SITE CONDITIONS

3.1 DRAINAGE PATTERNS

The proposed site conditions include 36,000 ft^2 (0.83 ac) of impervious area, a 32% reduction from the existing site condition. The property drainage patterns will remain almost entirely unchanged, with runoff collected by new storm sewer and discharged to a new infiltration basin between the parking lot and offsite wetland to the west. Roof runoff will be directed into the storm sewer system, with only minor areas near the streets draining offsite.

Proposed drainage patterns are illustrated on Figure 1 (Appendix B).

3.2 VOLUME CONTROL AND WATER QUALITY

The proposed infiltration basin will provide a sufficient level of retention to meet the volume control requirements outlined above, including infiltrating 1" of runoff from all impervious area. The relevant volume calculations are as follows:

Infiltration Volume Calculation:

1" x Impervious Area = 1" x (1'/12") x 36,000 sq. ft. = 3,000 cu. ft.

Total Volume Required = 3,000 cu.ft.

Total Volume Provided = 3,822 cu.ft. ✓

As indicated above, the infiltration volume provided (3,822 cu. ft.) exceeds the volume of runoff required to be retained on-site. The provided infiltration volume is stored in the basin between the bottom elevation (915.0) and the outlet elevation (916.5), with no credit assumed for infiltration occurring during rainfall. Although the soils appear sandy, the depth of the basin (bottom to outflow elevation) is limited to 1.5' to ensure timely drawdown.

Treatment is required to reduce site discharge of sediment (TSS) by 90% and phosphorus (TP) by 60%. The entire property drains to the infiltration basin, which is sized to inherently meet these requirements. However, the reductions have been quantified using an acceptable computer model (P8, in this case), as required.

The P8 input parameters and output is included in Appendix C, and the results are summarized here:

Water Quality Results (P8):

Annual TSS Reduction:	97.8% (> 90% ✓)
Annual TP Reduction:	89.8% (> 60% ✓)

3.3 RATE CONTROL

The proposed property *does not* change drainage patterns, but *does* include a significant reduction in impervious coverage; Therefore, the discharge rates leaving the site will be reduced. The proposed condition has been modeled primarily to determine the high water level (HWL) associated with the new basin. The resulting modeled 100-yr, Atlas-14, **HWL = 917.3** (See HydroCAD output in Appendix D).

As indicated, the proposed condition adequately mitigates runoff, so that peak flow rates are maintained or reduced between existing and proposed conditions.

Appendix A – Soils Information

4132 SHADY OAK ROAD	WENCK ASSOCIATES Responsive partner. Exceptional outcomes.	MAY 2016
Sampling Locations		Figure 3

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LOG OF BORING SB-1

Shady Oak Road
Supplemental Soil Investigation
4312 Shady Oak Road
Minnetonka, MN
Project # 3035-0005

Date Started	: 5/12/16	Ground Elevation	: 930 ft. ASL
Date Completed	: 5/12/16	Drilling Company	: NTI
Hole Diameter	: 6"	Driller(s)	: Carl and Dan
Drilling Method	: Hollow Stem Auger	Logged By	: KJJ
Sampling Method	: Split Spoon	Checked By	: MGD

Sample Type: Analytical Soil Sample
Water Levels: ▼ During Drilling

Depth in Feet	Surf. Elev. 930	USCS	GRAPHIC	DESCRIPTION	Water Level	Sample Recovery (%)	PID Result (ppm)	Analytical Sample	REMARKS
0	930	FB		Asphalt					
		SW		CLAYEY SAND, red-brown, with gravel, moist (fill).		100	1.2	■	
						70	0.8		
5	925	SC		SANDY CLAY, dark grey, soft, with gravel, moist.		80	1.0		
		SW		CLAYEY SAND, red-brown, with gravel, moist. Medium stiff.		5	1.3		
10	920					90	0.5		
						60	0.8		
15	915	SC		SANDY CLAY, grey-brown, some gravel, medium stiff, moist.		40	1.0		
20	910	SC		SANDY CLAY, grey, some gravel, stiff, very moist to wet.		10	0.5		
25	905	SW		SILTY SAND, brown, fine to medium grained, wet.	▼	50	0.6		
30		CL		SANDY CLAY, grey, fine grained, medium stiff, wet.		100	0.3		

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LOG OF BORING SB-2

Shady Oak Road
Supplemental Soil Investigation
4312 Shady Oak Road
Minnetonka, MN
Project # 3035-0005

Date Started	: 5/12/16	Ground Elevation	: 930 ft. ASL
Date Completed	: 5/12/16	Drilling Company	: NTI
Hole Diameter	: 6"	Driller(s)	: Carl and Dan
Drilling Method	: Hollow Stem Auger	Logged By	: KJJ
Sampling Method	: Split Spoon	Checked By	: MGD

Sample Type: Analytical Soil Sample
Water Levels: ▼ During Drilling

Depth in Feet	Surf. Elev. 930	USCS	GRAPHIC	DESCRIPTION	Water Level	Sample Recovery (%)	PID Result (ppm)	Analytical Sample	REMARKS
0	930	FB		Asphalt		100	0.3		
		SW		SILTY SAND, dark brown, with gravel, moist (fill).		90	0.5	▨	
5	925	SW		SILTY SAND, red-brown, traces of gravel, moist.		40	0.2		
						0	NA		
10	920	SW		SILTY SAND, red-brown, with coarse gravel to cobble, moist.		30	0.3		
		SW		SILTY SAND, brown, fine to medium grained, with gravel, wet.	▼	50	0.2		
15	915	SW		SILTY SAND, brown, coarse grained some gravel, wet.		60	0.3		
20	910					50	0.3		
25	905	SW		SILTY SAND, brown, coarse grained, some gravel and clay, wet.		90	0.3		
30		SW		SAND, Well Graded, brown, some gravel and clay, wet.		30	0.3		

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LOG OF BORING SB-3

Shady Oak Road
Supplemental Soil Investigation
4312 Shady Oak Road
Minnetonka, MN
Project # 3035-0005

Date Started	: 5/12/16	Ground Elevation	: 930 ft. ASL
Date Completed	: 5/12/16	Drilling Company	: NTI
Hole Diameter	: 6"	Driller(s)	: Carl and Dan
Drilling Method	: Hollow Stem Auger	Logged By	: KJJ
Sampling Method	: Split Spoon	Checked By	: MGD

Sample Type: Analytical Soil Sample
Water Levels: ▼ During Drilling

Depth in Feet	Surf. Elev. 930	USCS	GRAPHIC	DESCRIPTION	Water Level	Sample Recovery (%)	PID Result (ppm)	Analytical Sample	REMARKS
0	930	FB		Asphalt		100	1.5		
		SW		CLAYEY SAND, red-brown, with gravel, moist (fill).					
		SW		SILTY SAND, black, trace of ash, moist (fill).		40	2.8		
5	925					60	3.0		
		SW		SILTY SAND, tan, fine grained, moist.		40	0.2		
				With gravel					
10	920			Fine to medium grained.		40	0.2		
						10	0.3		
15	915	SW		SILTY SAND, brown, coarse grained, with gravel, wet.		80	0.3		
20	910					60	0.2		
25	905					60	0.2		
30				Coarse gravel.		80	0.3		

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LOG OF BORING SB-4

Shady Oak Road
Supplemental Soil Investigation
4312 Shady Oak Road
Minnetonka, MN
Project # 3035-0005

Date Started	: 5/12/16	Ground Elevation	: 930 ft. ASL
Date Completed	: 5/12/16	Drilling Company	: NTI
Hole Diameter	: 6"	Driller(s)	: Carl and Dan
Drilling Method	: Hollow Stem Auger	Logged By	: KJJ
Sampling Method	: Split Spoon	Checked By	: MGD

Sample Type: Analytical Soil Sample
Water Levels: ▼ During Drilling

Depth in Feet	Surf. Elev. 930	USCS	GRAPHIC	DESCRIPTION	Water Level	Sample Recovery (%)	PID Result (ppm)	Analytical Sample	REMARKS
0	930	FB		Asphalt					
		SW		SILTY SAND, black, with gravel, moist (fill).		100	0.2		
		SW		SILTY SAND, dark brown,with gravel, trace concrete, moist (fill).		40	0.3		
5	925	SW		SILTY SAND, light brown, moist.		40	0.3		
				Medium grained with gravel.		20	0.2		
10	920			Medium to coarse grained with gravel.		30	0.3		
				Coarse gravel.	▼	10	0.2		
15	915	SW		SILTY SAND, brown, coarse grained, small pockets of clay, wet.		60	0.2		
20	910			Medium to coarse grained with gravel.		50	0.3		
25	905					60	0.2		
30				Coarse gravel.		100	0.2		

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LOG OF BORING SB-5

Shady Oak Road
Supplemental Soil Investigation
4312 Shady Oak Road
Minnetonka, MN
Project # 3035-0005

Date Started	: 5/12/16	Ground Elevation	: 930 ft. ASL
Date Completed	: 5/12/16	Drilling Company	: NTI
Hole Diameter	: 6"	Driller(s)	: Carl and Dan
Drilling Method	: Hollow Stem Auger	Logged By	: KJJ
Sampling Method	: Split Spoon	Checked By	: MGD

Sample Type: Analytical Soil Sample
Water Levels: ▼ During Drilling

Depth in Feet	Surf. Elev. 930	USCS	GRAPHIC	DESCRIPTION	Water Level	Sample Recovery (%)	PID Result (ppm)	Analytical Sample	REMARKS
0	930	FB		Asphalt					
		SW		CLAYEY SAND, red-brown, traces of gravel, moist (fill).		100	0.2		
		SW		SILTY SAND, brown, medium grained, with gravel, moist.		50	0.1		
5	925	SW		SILTY SAND, dark brown, with gravel, moist.		10	0.4		
		SC		SANDY CLAY, red-brown, fine grained, medium stiff, moist.		90	0.1		
10	920					80	0.1		
				Very moist to wet.		80	0.12		
15	915					80	0.2		
				Wet	▼				
20	910					100	0.2		
25	905	CH		CLAY, grey, stiff, some sand, moist.		90	0.2		
30						80			

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LOG OF BORING SB-6

Shady Oak Road
Supplemental Soil Investigation
4312 Shady Oak Road
Minnetonka, MN
Project # 3035-0005

Date Started	: 5/12/16	Ground Elevation	: 930 ft. ASL
Date Completed	: 5/12/16	Drilling Company	: NTI
Hole Diameter	: 6"	Driller(s)	: Carl and Dan
Drilling Method	: Hollow Stem Auger	Logged By	: KJJ
Sampling Method	: Split Spoon	Checked By	: MGD

Sample Type: Analytical Soil Sample
Water Levels: ▼ During Drilling

Depth in Feet	Surf. Elev. 930	USCS	GRAPHIC	DESCRIPTION	Water Level	Sample Recovery (%)	PID Result (ppm)	Analytical Sample	REMARKS
0	930	FB		Asphalt					
		SW		SILTY SAND, dark brown to black, with gravel, some clay, moist (fill).		100	0.3		
						20	0.2	▨	
5	925	SW		SILTY SAND, brown, medium to coarse grained, with gravel, moist.		5	0.1		
						5	0.3		
10	920	SW		CLAYEY SAND, black, moist, slight organic odor.		20	0.2		
		CL		SANDY CLAY, grey-brown, soft, traces of gravel, moist.		80	0.3		
15	915					90	0.3		
				Medium stiff.					
20	910					60	0.6		
25	905	SW		CLAYEY SAND, brown, with gravel, wet.	▼	60	0.3		
30						40			

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LOG OF BORING SB-7

Shady Oak Road
Supplemental Soil Investigation
4312 Shady Oak Road
Minnetonka, MN
Project # 3035-0005

Date Started	: 5/12/16	Ground Elevation	: 930 ft. ASL
Date Completed	: 5/12/16	Drilling Company	: NTI
Hole Diameter	: 6"	Driller(s)	: Carl and Dan
Drilling Method	: Hollow Stem Auger	Logged By	: KJJ
Sampling Method	: Split Spoon	Checked By	: MGD

Sample Type: Analytical Soil Sample
Water Levels: ▼ During Drilling

Depth in Feet	Surf. Elev. 930	USCS	GRAPHIC	DESCRIPTION	Water Level	Sample Recovery (%)	PID Result (ppm)	Analytical Sample	REMARKS
0	930	FB		Asphalt					
		SW		SILTY SAND, brown, with gravel, some clay, moist (fill).		100	7.6		
		SW		SILTY SAND, dark brown to black, with gravel, trace ash, moist.		50	11.6		
5	925	SW		SILTY SAND, red-brown, with gravel , moist.		50	5.3		
		SC		SANDY CLAY, red-brown, some gravel, medium stiff, moist.		90	1.3		
10	920			Stiff with trace gravel.		30	0.8		
		SC		SANDY CLAY, black, traces of gravel, moist, slight organic odor.		70	0.8		
15	915	SC		SANDY CLAY, dark grey, traces of gravel, medium stiff, moist.		100	0.6		
20	910	SC		SANDY CLAY, red-brown, fine grained, traces of gravel, medium stiff, moist.		100	0.7		
25	905	SW		CLAYEY SAND, brown, fine to coarse grained, some gravel, wet.	▼	70	0.8		
30				Coarse gravel.		50	0.5		

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LOG OF BORING SB-8

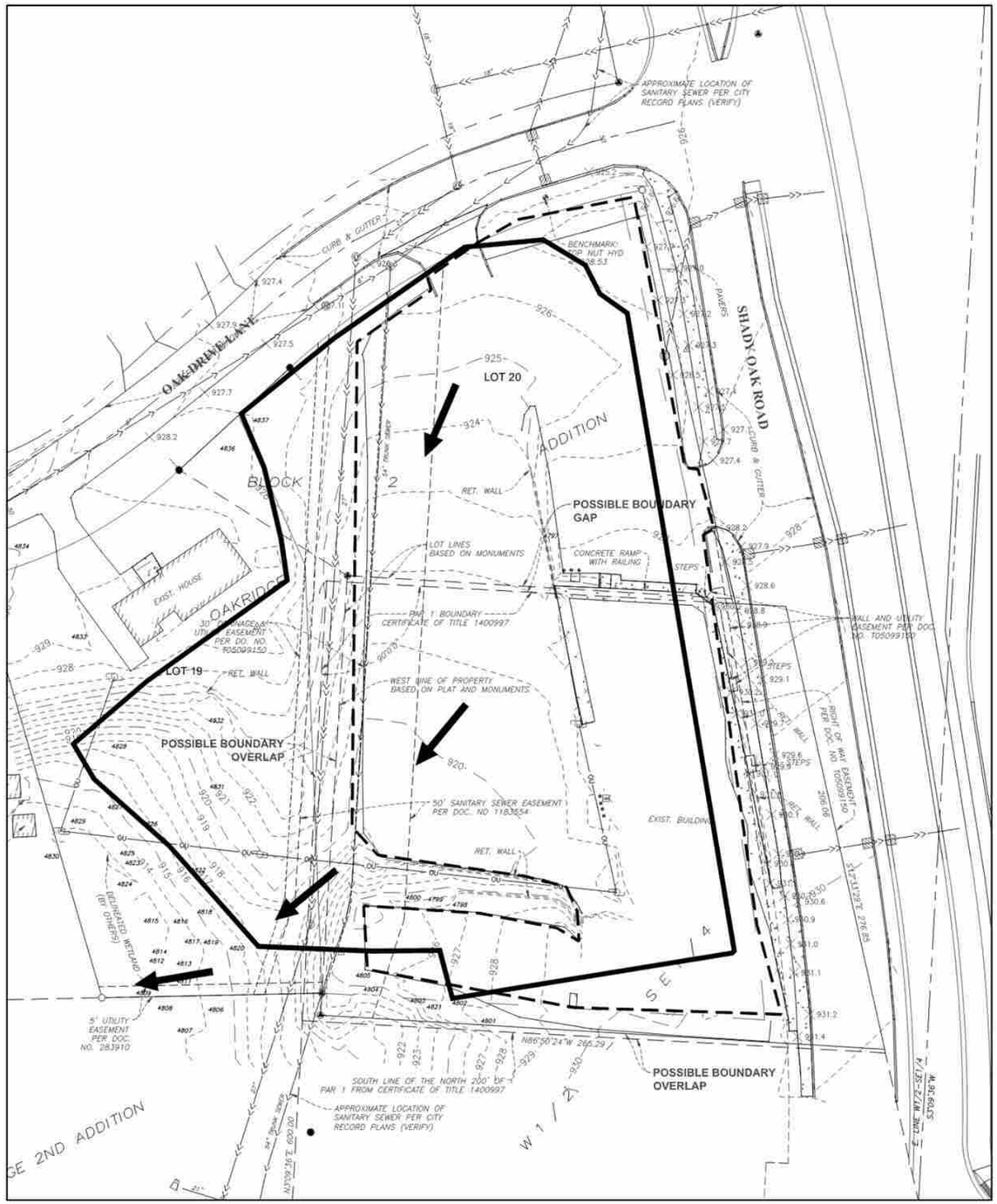
Shady Oak Road
Supplemental Soil Investigation
4312 Shady Oak Road
Minnetonka, MN
Project # 3035-0005

Date Started	: 5/12/16	Ground Elevation	: 930 ft. ASL
Date Completed	: 5/12/16	Drilling Company	: NTI
Hole Diameter	: 6"	Driller(s)	: Carl and Dan
Drilling Method	: Hollow Stem Auger	Logged By	: KJJ
Sampling Method	: Split Spoon	Checked By	: MGD

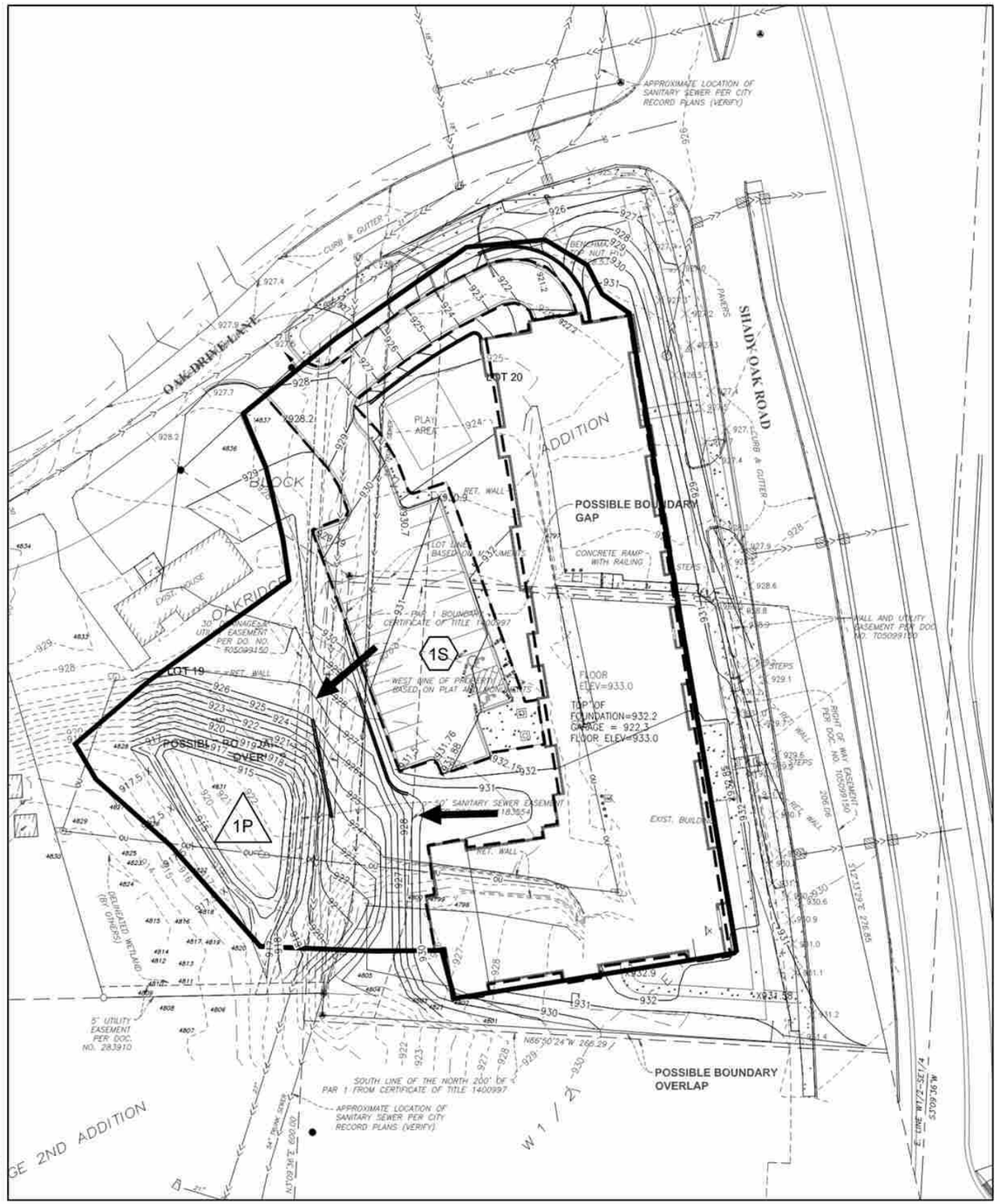
Sample Type: Analytical Soil Sample
Water Levels: ▼ During Drilling

Depth in Feet	Surf. Elev. 930	USCS	GRAPHIC	DESCRIPTION	Water Level	Sample Recovery (%)	PID Result (ppm)	Analytical Sample	REMARKS
0	930	FB		Asphalt		100	0.6		
		SW		SILTY SAND, dark brown, with gravel, moist (fill). Trace Ash		50	0.4		
5	925					60	0.4	▨	
						40	0.4		
10	920			Trace clay.		90	0.3		
		SW		SILTY SAND, light brown, some gravel, moist.					
		SW		CLAYEY SAND, brown, some gravel, moist.		50	0.4		
15	915	SC		SANDY CLAY, brown, traces of gravel, moist. Black lens with organics		90	0.4		
20	910	SC		SANDY CLAY, brown, with gravel, moist. Higher sand content, tan color.		50	0.4		
25	905	SW		SILTY SAND, brown, coarse grained, with gravel, small pockets of clay, wet.	▼	60	0.5		
30		SC		SILTY SAND, tan, fine to medium grained, some gravel, wet.		50	0.3		

Appendix B – Drainage Diagram



EXISTING CONDITIONS



PROPOSED CONDITIONS

CIVIL METHODS, INC.
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SHADY OAK CROSSING
MINNETONKA, MN

DRAINAGE DIAGRAM
STORMWATER MANAGEMENT PLAN

FIG 1

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Appendix C – P8 Output

P8 Urban Catchment Model, Version 3.5				Run Date	04/10/17
Case	ShadyOak1.p8c	FirstDate	10/01/78	Precip(in)	29.5
Title	Shady Oak Proposed	LastDate	09/30/79	Rain(in)	23.22
PrecFile	msp_4989.pcp	Events	64	Snow(in)	6.29
PartFile	nurp50.p8p	TotalHrs	8618	TotalYrs	0.98

Case Title	Shady Oak Proposed
Case Data File	ShadyOak1.p8c
Path	D:\CMI\7. Projects\0301_CES Shady Oak Stormwater Management\06_MODELING AND ANALYSIS\P8
Case Notes:	
Storm Data File	msp_4989.pcp
Particle File	nurp50.p8p
Air Temp File File	msp_4889.tmp

Time Steps Per Hour	10
Minimum Inter-Event Time (hrs)	10
Maximum Continuity Error %	2
Rainfall Breakpoint (inches)	0.8
Precipitation Scale Factor	1
Air Temp Offset (deg-F)	0
Loops Thru Storm File	5
Simulation Dates	
Start	9/1/1978
Keep	10/1/1978
Stop	9/30/1979

Max Snowfall Temperature (deg-f)	32.0
SnowMelt Temperature (deg-f)	32.0
Snowmelt Coef (in/degF-Day)	0.06
Soil Freeze Temp (deg-F)	32.0
Snowmelt Abstraction Factor	1.00
Evapo-Trans. Calibration Factor	1.00
Growing Season Start Month	5
Growing Season End Month	10

5-Day Antecedent Rainfall + Runoff (inches)		
CN Antecedent Moisture Condition	AMC-II	AMC-III
Growing Season	1.40	2.10
NonGrowing Season	0.50	1.10

Watershed Data						
Watershed Name	ToGarden1w					
Runoff to Device	RG1w					
Infiltration to Device						
Watershed Area	1.492					
SCS Curve Number (Pervious)	74					
Scale Factor for Pervious Runoff Load	1					
Indirectly Connected Imperv Fraction	0					
UnSwept Impervious Fraction	0.554					
UnSwept Depression Storage (inches)	0.02					
UnSwept Imperv. Runoff Coefficient	0.95					

UnSwept Scale Factor for Particle Loads	1					
Swept Impervious Fraction	0					
Swept Depression Storage (inches)	0.02					
Swept Imperv. Runoff Coefficient	1					
Swept Scale Factor for Particle Loads	1					
Sweeping Frequency	0					
Sweeping Efficiency	1					
Sweeping Start Date (MMDD)	101					
Sweeping Stop Date (MMDD)	1231					

Device Data						
Device Name	RG1w					
Device Type	INF_BASIN					
Infiltration Outlet						
Normal Outlet						
Spillway Outlet						
Particle Removal Scale Factor	1					
Bottom Elevation (ft)	915					
Bottom Area (acres)	0.03					
Permanent Pool Area (acres)						
Permanent Pool Volume (ac-ft)						
Perm Pool Infilt Rate (in/hr)						
Flood Pool Area (acres)	0.058					
Flood Pool Volume (ac-ft)	0.066					
Flood Pool Infilt Rate (in/hr)	0.2					
Infilt Basin Void Fraction (%)	100					
Detention Pond Outlet Parameters						
Outlet Type						
Outlet Orifice Diameter (in)						
Orifice Discharge Coef						
Outlet Weir Length (ft)						
Weir Discharge Coef						
Perforated Riser Height (ft)						
Number of Holes in Riser						
Holes Diameter						
Flood Pool Drain Time (hrs)						
Swale Parameters						
Length of Flow Path (ft)						
Slope of Flow Path %						
Bottom Width (ft)						
Side Slope (ft-v/ft-h)						
Maximum Depth of Flow (ft)						
Mannings n Constant						
Hydraulic Model						
Pipe, Splitter, Aquifer Parameter						
Hydraulic Res. Time (hrs)						

Particle Data					
Particle File	nurp50.p8p				
Particle Class	P0%	P10%	P30%	P50%	P80%
Filtration Efficiency (%)	90	100	100	100	100
Settling Velocity (ft/hr)	0	0.03	0.3	1.5	15

First Order Decay Rate (1/day)	0	0	0	0	0
2nd Order Decay (1/day-ppm)	0	0	0	0	0
Impervious Runoff Conc (ppm)	1	0	0	0	0
Pervious Runoff Conc (ppm)	1	100	100	100	200
Pervious Conc Exponent	0	1	1	1	1
Accum. Rate (lbs-ac-day)	0	1.75	1.75	1.75	3.5
Particle Removal Rate (1/day)	0	0.25	0.25	0.25	0.25
Washoff Coefficient	0	20	20	20	20
Washoff Exponent	0	2	2	2	2
Sweeper Efficiency	0	0	0	5	15

Water Quality Component Data							
Component Name	TSS	TP	TKN	CU	PB	ZN	HC
Water Quality Criteria (ppm)							
Level 1	5	0.025	2	2	0.02	5	0.1
Level 2	10	0.05	1	0.0048	0.014	0.0362	0.5
Level 3	20	0.1	0.5	0.02	0.15	0.38	1
Content Scale Factor	1	1	1	1	1	1	1
Particle Composition (mg/kg)							
P0%	0	99000	600000	13600	2000	640000	250000
P10%	1000000	3850	15000	340	180	1600	22500
P30%	1000000	3850	15000	340	180	1600	22500
P50%	1000000	3850	15000	340	180	1600	22500
P80%	1000000	0	0	340	180	0	22500

P8 Urban Catchment Model, Version 3.5				Run Date	04/10/17
Case	ShadyOak1.p8c	FirstDate	10/01/78	Precip(in)	29.5
Title	Shady Oak Propo	LastDate	09/30/79	Rain(in)	23.22
PrecFile	msp_4989.pcp	Events	64	Snow(in)	6.29
PartFile	nurp50.p8p	TotalHrs	8618	TotalYrs	0.98

Mass Balances by Device and Variable

Device: RG1w Type: INF_BASIN Variable: P0%

Mass Balance Term	Flow_acft	Flow_cfs	Load_lbs	Load_lbs/yr	Conc_ppm
01 watershed inflows	2.11	0.00	5.7	5.8	1.00
03 infiltrate	1.76	0.00	4.8	4.9	1.00
04 exfiltrate	1.76	0.00	0.5	0.5	0.10
05 filtered	0.00	0.00	4.3	4.4	
07 spillway outlet	0.36	0.00	1.0	1.0	1.00
09 total inflow	2.11	0.00	5.7	5.8	1.00
10 surface outflow	0.36	0.00	1.0	1.0	1.00
11 groundw outflow	1.76	0.00	0.5	0.5	0.10
12 total outflow	2.11	0.00	1.4	1.5	0.25
13 total trapped	0.00	0.00	4.3	4.4	
14 storage increase	0.00	0.00	0.0	0.0	
15 mass balance check	0.00	0.00	0.0	0.0	
Reduction (%)	0.00	0.00	74.8	74.8	

Device: RG1w Type: INF_BASIN Variable: P10%

Mass Balance Term	Flow_acft	Flow_cfs	Load_lbs	Load_lbs/yr	Conc_ppm
01 watershed inflows	2.11	0.00	111.0	112.9	19.32
03 infiltrate	1.76	0.00	36.9	37.6	7.73
04 exfiltrate	1.76	0.00	0.0	0.0	0.00
05 filtered	0.00	0.00	36.9	37.6	
07 spillway outlet	0.36	0.00	7.6	7.7	7.81
08 sedimen + decay	0.00	0.00	66.5	67.7	
09 total inflow	2.11	0.00	111.0	112.9	19.32
10 surface outflow	0.36	0.00	7.6	7.7	7.81
11 groundw outflow	1.76	0.00	0.0	0.0	0.00
12 total outflow	2.11	0.00	7.6	7.7	1.32
13 total trapped	0.00	0.00	103.4	105.2	
14 storage increase	0.00	0.00	0.0	0.0	
15 mass balance check	0.00	0.00	0.0	0.0	
Reduction (%)	0.00	0.00	93.2	93.2	

Device: RG1w Type: INF_BASIN Variable: P30%

Mass Balance Term	Flow_acft	Flow_cfs	Load_lbs	Load_lbs/yr	Conc_ppm

01 watershed inflows	2.11	0.00	111.0	112.9	19.32
03 infiltrate	1.76	0.00	5.7	5.8	1.19
04 exfiltrate	1.76	0.00	0.0	0.0	0.00
05 filtered	0.00	0.00	5.7	5.8	
07 spillway outlet	0.36	0.00	3.3	3.4	3.42
08 sedimen + decay	0.00	0.00	102.0	103.8	
09 total inflow	2.11	0.00	111.0	112.9	19.32
10 surface outflow	0.36	0.00	3.3	3.4	3.42
11 groundw outflow	1.76	0.00	0.0	0.0	0.00
12 total outflow	2.11	0.00	3.3	3.4	0.58
13 total trapped	0.00	0.00	107.7	109.5	
14 storage increase	0.00	0.00	0.0	0.0	
15 mass balance check	0.00	0.00	0.0	0.0	
Reduction (%)	0.00	0.00	97.0	97.0	

Device: RG1w Type: INF_BASIN Variable: P50%

Mass Balance Term	Flow_acft	Flow_cfs	Load_lbs	Load_lbs/yr	Conc_ppm
01 watershed inflows	2.11	0.00	111.0	112.9	19.32
03 infiltrate	1.76	0.00	1.2	1.2	0.25
04 exfiltrate	1.76	0.00	0.0	0.0	0.00
05 filtered	0.00	0.00	1.2	1.2	
07 spillway outlet	0.36	0.00	1.2	1.2	1.19
08 sedimen + decay	0.00	0.00	108.6	110.5	
09 total inflow	2.11	0.00	111.0	112.9	19.32
10 surface outflow	0.36	0.00	1.2	1.2	1.19
11 groundw outflow	1.76	0.00	0.0	0.0	0.00
12 total outflow	2.11	0.00	1.2	1.2	0.20
13 total trapped	0.00	0.00	109.9	111.7	
14 storage increase	0.00	0.00	0.0	0.0	
15 mass balance check	0.00	0.00	0.0	0.0	
Reduction (%)	0.00	0.00	99.0	99.0	

Device: RG1w Type: INF_BASIN Variable: P80%

Mass Balance Term	Flow_acft	Flow_cfs	Load_lbs	Load_lbs/yr	Conc_ppm
01 watershed inflows	2.11	0.00	222.0	225.8	38.64
03 infiltrate	1.76	0.00	0.2	0.3	0.05
04 exfiltrate	1.76	0.00	0.0	0.0	0.00
05 filtered	0.00	0.00	0.2	0.3	
07 spillway outlet	0.36	0.00	0.3	0.3	0.31
08 sedimen + decay	0.00	0.00	221.5	225.3	
09 total inflow	2.11	0.00	222.0	225.8	38.64
10 surface outflow	0.36	0.00	0.3	0.3	0.31
11 groundw outflow	1.76	0.00	0.0	0.0	0.00
12 total outflow	2.11	0.00	0.3	0.3	0.05
13 total trapped	0.00	0.00	221.7	225.5	

14 storage increase	0.00	0.00	0.0	0.0	
15 mass balance check	0.00	0.00	0.0	0.0	
Reduction (%)	0.00	0.00	99.9	99.9	

Device: RG1w Type: INF_BASIN Variable: TSS

Mass Balance Term	Flow_acft	Flow_cfs	Load_lbs	Load_lbs/yr	Conc_ppm
01 watershed inflows	2.11	0.00	555.0	564.6	96.61
03 infiltrate	1.76	0.00	44.1	44.8	9.22
04 exfiltrate	1.76	0.00	0.0	0.0	0.00
05 filtered	0.00	0.00	44.1	44.8	
07 spillway outlet	0.36	0.00	12.3	12.5	12.72
08 sedimen + decay	0.00	0.00	498.7	507.2	
09 total inflow	2.11	0.00	555.0	564.6	96.61
10 surface outflow	0.36	0.00	12.3	12.5	12.72
11 groundw outflow	1.76	0.00	0.0	0.0	0.00
12 total outflow	2.11	0.00	12.3	12.5	2.14
13 total trapped	0.00	0.00	542.7	552.0	
14 storage increase	0.00	0.00	0.0	0.0	
15 mass balance check	0.00	0.00	0.0	0.0	
Reduction (%)	0.00	0.00	97.8	97.8	

Device: RG1w Type: INF_BASIN Variable: TP

Mass Balance Term	Flow_acft	Flow_cfs	Load_lbs	Load_lbs/yr	Conc_ppm
01 watershed inflows	2.11	0.00	1.9	1.9	0.32
03 infiltrate	1.76	0.00	0.6	0.7	0.13
04 exfiltrate	1.76	0.00	0.0	0.0	0.01
05 filtered	0.00	0.00	0.6	0.6	
07 spillway outlet	0.36	0.00	0.1	0.1	0.15
08 sedimen + decay	0.00	0.00	1.1	1.1	
09 total inflow	2.11	0.00	1.9	1.9	0.32
10 surface outflow	0.36	0.00	0.1	0.1	0.15
11 groundw outflow	1.76	0.00	0.0	0.0	0.01
12 total outflow	2.11	0.00	0.2	0.2	0.03
13 total trapped	0.00	0.00	1.7	1.7	
14 storage increase	0.00	0.00	0.0	0.0	
15 mass balance check	0.00	0.00	0.0	0.0	
Reduction (%)	0.00	0.00	89.8	89.8	

Device: RG1w Type: INF_BASIN Variable: TKN

Mass Balance Term	Flow_acft	Flow_cfs	Load_lbs	Load_lbs/yr	Conc_ppm
01 watershed inflows	2.11	0.00	8.4	8.6	1.47
03 infiltrate	1.76	0.00	3.5	3.6	0.74
04 exfiltrate	1.76	0.00	0.3	0.3	0.06
05 filtered	0.00	0.00	3.2	3.3	

07 spillway outlet	0.36	0.00	0.8	0.8	0.79
08 sedimen + decay	0.00	0.00	4.2	4.2	
09 total inflow	2.11	0.00	8.4	8.6	1.47
10 surface outflow	0.36	0.00	0.8	0.8	0.79
11 groundw outflow	1.76	0.00	0.3	0.3	0.06
12 total outflow	2.11	0.00	1.0	1.1	0.18
13 total trapped	0.00	0.00	7.4	7.5	
14 storage increase	0.00	0.00	0.0	0.0	
15 mass balance check	0.00	0.00	0.0	0.0	
Reduction (%)	0.00	0.00	87.6	87.6	

Device: RG1w Type: INF_BASIN Variable: CU

Mass Balance Term	Flow_acft	Flow_cfs	Load_lbs	Load_lbs/yr	Conc_ppm
01 watershed inflows	2.11	0.00	0.3	0.3	0.05
03 infiltrate	1.76	0.00	0.1	0.1	0.02
04 exfiltrate	1.76	0.00	0.0	0.0	0.00
05 filtered	0.00	0.00	0.1	0.1	
07 spillway outlet	0.36	0.00	0.0	0.0	0.02
08 sedimen + decay	0.00	0.00	0.2	0.2	
09 total inflow	2.11	0.00	0.3	0.3	0.05
10 surface outflow	0.36	0.00	0.0	0.0	0.02
11 groundw outflow	1.76	0.00	0.0	0.0	0.00
12 total outflow	2.11	0.00	0.0	0.0	0.00
13 total trapped	0.00	0.00	0.2	0.2	
14 storage increase	0.00	0.00	0.0	0.0	
15 mass balance check	0.00	0.00	0.0	0.0	
Reduction (%)	0.00	0.00	91.1	91.1	

Device: RG1w Type: INF_BASIN Variable: PB

Mass Balance Term	Flow_acft	Flow_cfs	Load_lbs	Load_lbs/yr	Conc_ppm
01 watershed inflows	2.11	0.00	0.1	0.1	0.02
03 infiltrate	1.76	0.00	0.0	0.0	0.00
04 exfiltrate	1.76	0.00	0.0	0.0	0.00
05 filtered	0.00	0.00	0.0	0.0	
07 spillway outlet	0.36	0.00	0.0	0.0	0.00
08 sedimen + decay	0.00	0.00	0.1	0.1	
09 total inflow	2.11	0.00	0.1	0.1	0.02
10 surface outflow	0.36	0.00	0.0	0.0	0.00
11 groundw outflow	1.76	0.00	0.0	0.0	0.00
12 total outflow	2.11	0.00	0.0	0.0	0.00
13 total trapped	0.00	0.00	0.1	0.1	
14 storage increase	0.00	0.00	0.0	0.0	
15 mass balance check	0.00	0.00	0.0	0.0	
Reduction (%)	0.00	0.00	95.4	95.4	

Device: RG1w Type: INF_BASIN Variable: ZN

Mass Balance Term	Flow_acft	Flow_cfs	Load_lbs	Load_lbs/yr	Conc_ppm
01 watershed inflows	2.11	0.00	4.2	4.3	0.73
03 infiltrate	1.76	0.00	3.1	3.2	0.65
04 exfiltrate	1.76	0.00	0.3	0.3	0.06
05 filtered	0.00	0.00	2.8	2.9	
07 spillway outlet	0.36	0.00	0.6	0.6	0.66
08 sedimen + decay	0.00	0.00	0.4	0.5	
09 total inflow	2.11	0.00	4.2	4.3	0.73
10 surface outflow	0.36	0.00	0.6	0.6	0.66
11 groundw outflow	1.76	0.00	0.3	0.3	0.06
12 total outflow	2.11	0.00	0.9	1.0	0.16
13 total trapped	0.00	0.00	3.3	3.3	
14 storage increase	0.00	0.00	0.0	0.0	
15 mass balance check	0.00	0.00	0.0	0.0	
Reduction (%)	0.00	0.00	77.6	77.6	

Device: RG1w Type: INF_BASIN Variable: HC

Mass Balance Term	Flow_acft	Flow_cfs	Load_lbs	Load_lbs/yr	Conc_ppm
01 watershed inflows	2.11	0.00	13.9	14.2	2.42
03 infiltrate	1.76	0.00	2.2	2.2	0.46
04 exfiltrate	1.76	0.00	0.1	0.1	0.03
05 filtered	0.00	0.00	2.1	2.1	
07 spillway outlet	0.36	0.00	0.5	0.5	0.54
08 sedimen + decay	0.00	0.00	11.2	11.4	
09 total inflow	2.11	0.00	13.9	14.2	2.42
10 surface outflow	0.36	0.00	0.5	0.5	0.54
11 groundw outflow	1.76	0.00	0.1	0.1	0.03
12 total outflow	2.11	0.00	0.6	0.6	0.11
13 total trapped	0.00	0.00	13.3	13.5	
14 storage increase	0.00	0.00	0.0	0.0	
15 mass balance check	0.00	0.00	0.0	0.0	
Reduction (%)	0.00	0.00	95.4	95.4	

Appendix D – HydroCAD Output

Proposed Infiltration Basin

Proposed Property to Infiltration Basin

Subcat Reach Pond Link

Routing Diagram for 0301_ShadyOak
Prepared by Civil Methods, Inc., Printed 4/13/2017

Time span=0.00-96.00 hrs, dt=0.01 hrs, 9601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Proposed Property to Runoff Area=65,000 sf 55.38% Impervious Runoff Depth=1.62"
Tc=10.0 min CN=87 Runoff=3.75 cfs 0.201 af

Pond 1P: Proposed Infiltration Basin Peak Elev=916.61' Storage=4,176 cf Inflow=3.75 cfs 0.201 af
Outflow=1.53 cfs 0.113 af

Total Runoff Area = 1.492 ac Runoff Volume = 0.201 af Average Runoff Depth = 1.62"
44.62% Pervious = 0.666 ac 55.38% Impervious = 0.826 ac

Summary for Subcatchment 1S: Proposed Property to Infiltration Basin

Runoff = 3.75 cfs @ 12.18 hrs, Volume= 0.201 af, Depth= 1.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 2-Year Rainfall=2.86"

	Area (sf)	CN	Description
*	36,000	98	Parking & Roof
	29,000	74	>75% Grass cover, Good, HSG C
	65,000	87	Weighted Average
	29,000	74	44.62% Pervious Area
	36,000	98	55.38% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Summary for Pond 1P: Proposed Infiltration Basin

Inflow Area = 1.492 ac, 55.38% Impervious, Inflow Depth = 1.62" for 2-Year event
Inflow = 3.75 cfs @ 12.18 hrs, Volume= 0.201 af
Outflow = 1.53 cfs @ 12.36 hrs, Volume= 0.113 af, Atten= 59%, Lag= 11.1 min
Primary = 1.53 cfs @ 12.36 hrs, Volume= 0.113 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.01 hrs
Peak Elev= 916.61' @ 12.36 hrs Surf.Area= 3,218 sf Storage= 4,176 cf

Plug-Flow detention time= 156.6 min calculated for 0.113 af (56% of inflow)
Center-of-Mass det. time= 74.9 min (879.5 - 804.6)

Volume	Invert	Avail.Storage	Storage Description
#1	915.00'	7,309 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
915.00	2,032	0	0
916.00	2,694	2,363	2,363
916.50	3,140	1,459	3,822
917.50	3,834	3,487	7,309

Device	Routing	Invert	Outlet Devices
#1	Primary	914.50'	**15.0" Round Culvert** L= 20.0' Ke= 0.500 Inlet / Outlet Invert= 914.50' / 914.30' S= 0.0100 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf
#2	Device 1	916.50'	**48.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=1.53 cfs @ 12.36 hrs HW=916.61' (Free Discharge)
↑—**1=Culvert** (Passes 1.53 cfs of 7.20 cfs potential flow)
↑—**2=Orifice/Grate** (Weir Controls 1.53 cfs @ 1.09 fps)

Time span=0.00-96.00 hrs, dt=0.01 hrs, 9601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Proposed Property to Runoff Area=65,000 sf 55.38% Impervious Runoff Depth=2.88"
Tc=10.0 min CN=87 Runoff=6.55 cfs 0.358 af

Pond 1P: Proposed Infiltration Basin Peak Elev=916.78' Storage=4,732 cf Inflow=6.55 cfs 0.358 af
Outflow=6.13 cfs 0.270 af

Total Runoff Area = 1.492 ac Runoff Volume = 0.358 af Average Runoff Depth = 2.88"
44.62% Pervious = 0.666 ac 55.38% Impervious = 0.826 ac

Summary for Subcatchment 1S: Proposed Property to Infiltration Basin

Runoff = 6.55 cfs @ 12.17 hrs, Volume= 0.358 af, Depth= 2.88"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 10-Year Rainfall=4.26"

	Area (sf)	CN	Description
*	36,000	98	Parking & Roof
	29,000	74	>75% Grass cover, Good, HSG C
	65,000	87	Weighted Average
	29,000	74	44.62% Pervious Area
	36,000	98	55.38% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Summary for Pond 1P: Proposed Infiltration Basin

Inflow Area = 1.492 ac, 55.38% Impervious, Inflow Depth = 2.88" for 10-Year event
Inflow = 6.55 cfs @ 12.17 hrs, Volume= 0.358 af
Outflow = 6.13 cfs @ 12.21 hrs, Volume= 0.270 af, Atten= 6%, Lag= 1.9 min
Primary = 6.13 cfs @ 12.21 hrs, Volume= 0.270 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.01 hrs
Peak Elev= 916.78' @ 12.21 hrs Surf.Area= 3,335 sf Storage= 4,732 cf

Plug-Flow detention time= 104.2 min calculated for 0.270 af (75% of inflow)
Center-of-Mass det. time= 38.1 min (831.2 - 793.1)

Volume	Invert	Avail.Storage	Storage Description
#1	915.00'	7,309 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
915.00	2,032	0	0
916.00	2,694	2,363	2,363
916.50	3,140	1,459	3,822
917.50	3,834	3,487	7,309

Device	Routing	Invert	Outlet Devices
#1	Primary	914.50'	**15.0" Round Culvert** L= 20.0' Ke= 0.500 Inlet / Outlet Invert= 914.50' / 914.30' S= 0.0100 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf
#2	Device 1	916.50'	**48.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=6.12 cfs @ 12.21 hrs HW=916.78' (Free Discharge)
↑—**1=Culvert** (Passes 6.12 cfs of 7.60 cfs potential flow)
↑—**2=Orifice/Grate** (Weir Controls 6.12 cfs @ 1.73 fps)

Time span=0.00-96.00 hrs, dt=0.01 hrs, 9601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Proposed Property to Runoff Area=65,000 sf 55.38% Impervious Runoff Depth=5.79"
Tc=10.0 min CN=87 Runoff=12.70 cfs 0.720 af

Pond 1P: Proposed Infiltration Basin Peak Elev=917.32' Storage=6,616 cf Inflow=12.70 cfs 0.720 af
Outflow=8.75 cfs 0.632 af

Total Runoff Area = 1.492 ac Runoff Volume = 0.720 af Average Runoff Depth = 5.79"
44.62% Pervious = 0.666 ac 55.38% Impervious = 0.826 ac

Summary for Subcatchment 1S: Proposed Property to Infiltration Basin

Runoff = 12.70 cfs @ 12.17 hrs, Volume= 0.720 af, Depth= 5.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.01 hrs
MSE 24-hr 3 100-Year Rainfall=7.32"

	Area (sf)	CN	Description
*	36,000	98	Parking & Roof
	29,000	74	>75% Grass cover, Good, HSG C
	65,000	87	Weighted Average
	29,000	74	44.62% Pervious Area
	36,000	98	55.38% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Summary for Pond 1P: Proposed Infiltration Basin

Inflow Area = 1.492 ac, 55.38% Impervious, Inflow Depth = 5.79" for 100-Year event
Inflow = 12.70 cfs @ 12.17 hrs, Volume= 0.720 af
Outflow = 8.75 cfs @ 12.26 hrs, Volume= 0.632 af, Atten= 31%, Lag= 5.2 min
Primary = 8.75 cfs @ 12.26 hrs, Volume= 0.632 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.01 hrs
Peak Elev= 917.32' @ 12.26 hrs Surf.Area= 3,707 sf Storage= 6,616 cf

Plug-Flow detention time= 73.3 min calculated for 0.632 af (88% of inflow)
Center-of-Mass det. time= 26.6 min (805.8 - 779.2)

Volume	Invert	Avail.Storage	Storage Description
#1	915.00'	7,309 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
915.00	2,032	0	0
916.00	2,694	2,363	2,363
916.50	3,140	1,459	3,822
917.50	3,834	3,487	7,309

Device	Routing	Invert	Outlet Devices
#1	Primary	914.50'	**15.0" Round Culvert** L= 20.0' Ke= 0.500 Inlet / Outlet Invert= 914.50' / 914.30' S= 0.0100 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf
#2	Device 1	916.50'	**48.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=8.75 cfs @ 12.26 hrs HW=917.32' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 8.75 cfs @ 7.13 fps)
↑—**2=Orifice/Grate** (Passes 8.75 cfs of 30.30 cfs potential flow)