Water Budget
University Station
University Avenue
Westwood, Massachusetts

Submitted to:
Westwood Marketplace Holdings LLC

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1.0 Introduction

This report summarizes the water budget analysis that has been prepared for the University Station project (the project). The intent of this report is to describe the proposed project, indicate the sources of data used in the water budget and layout the framework of the water budget calculation. In addition to the water budget, a nitrogen loading calculation has been provided based upon the annualized stormwater recharge volumes. This report will show that the University Station project will have a positive impact on the local aquifer and the Neponset River base flow, while not resulting in any significant increases in total nitrogen concentrations within the groundwater aquifer.

1.1 Project Background

The project is a mixed use development located approximately 12 miles southwest of Boston in the Town of Westwood (Figure 1-1) and involves the redevelopment of a significant portion of the University Avenue Business Park. University Station will replace approximately 1.4 million square feet of the former industrial, warehouse, and office uses with a blend of modern residential, retail, restaurant, hotel, office, and public spaces.

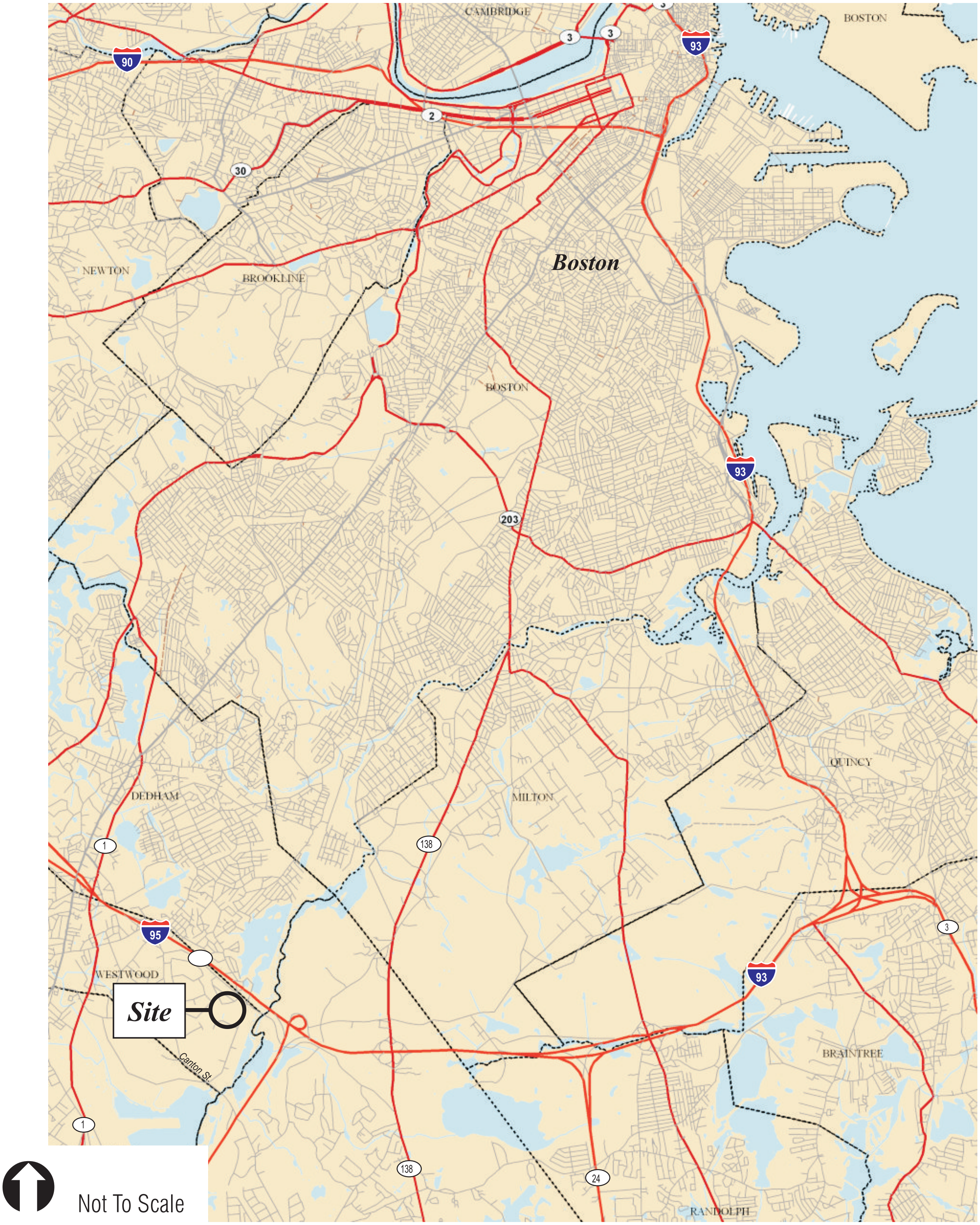
Portions of the former industrial park, associated parking/loading areas, and access driveways have been previously demolished. This analysis utilizes the pre-demolition state of the site as the existing condition in the water budget analysis, as the site work that had been previously conducted is only an interim step in the overall development of the project.

The site is adjacent to the existing University Avenue/Route 128 MBTA Station, and its 2,700 vehicle parking facility. This facility provides a direct transit link to Back Bay and South Station in Downtown Boston. The other land uses adjacent to the project include residential neighborhoods to the west (Town of Westwood), Route 128/95 to the north (Town of Dedham), commercial/industrial uses to the south (Town of Norwood), and the MBTA/Amtrak rail corridor and Neponset River along the eastern boundary (Town of Canton). For further detail, please see Figure 1 – Regional Context Map.

The project site is 130± acres in size. A stormwater management system has been designed that will direct significant portions of the impervious surfaces (building roofs, parking areas and sidewalks) associated with the project site to subsurface infiltration systems that will provide groundwater recharge to the local aquifer. The significant volume of groundwater recharge that will be achieved with the proposed design will provide for a net positive benefit to the local aquifer.

The water budget has been developed considering water consumption, average annual rainfall, infiltration from pervious surfaces (grass and other open spaces), building roofs and parking areas directed to subsurface recharge systems, surface runoff, evapotranspiration and evaporation. Water budgets developed for both the existing and proposed conditions result in balanced water budgets. That is all the volume associated with the annual rainfall is accounted for by way of the parameters identified above.

Further sections provide discussions on the sources of data that were used in developing the water balance, water conserving practices and the net positive benefit to the local aquifer.



TETRA TECH

University Station
Westwood, Massachusetts

Regional Context Map

Figure 1-1

2.0 Data Sources

2.1 Rainfall Data

Daily rainfall data was collected from the Norwood Airport (KOWD Weather Underground) from 2000 to 2009. The rainfall data was compiled and monthly and yearly rainfall averages were determined. Based on the Norwood Airport data, average annual rainfall data was determined to be 44.63 inches. The Norwood Airport rain data was chosen due to the close proximity to the project site. The airport is located just 1.6 miles south of the project and at a similar elevation.

The average annual rainfall data from the Westwood Airport was compared with the long term average recorded at the Great Blue Hill Observatory and to the data used in the previous Westwood Station water budget. The Great Blue Hill Observatory indicates the long term average rainfall for the region is 48.75 inches per year. Using the Norwood data, which predicts approximately 4 inches less rainfall per year, will produce a conservative result that is indicative of recent rainfall trends.

The Norwood Airport annual rainfall data was also compared with the rainfall data utilized in the Westwood Station water budget. The previous data indicated that the average annual rainfall was 44.87 inches. The Norwood Airport data is essentially consistent with the rainfall data used in the previous analysis.

2.2 Temperature Data

Temperature data was obtained from the Norwood Airport for the same 2000 to 2009 time period. The average monthly rainfall data is included in Appendix C. The temperature data is used in estimating monthly evapotranspiration rates and will be applied to both pre-construction and post construction water budgets.

2.3 Existing Water Consumption

Existing water consumption data was gathered from the previously approved Westwood Station water budget. The previous water budget had estimated domestic water consumption at 80,000 gallons per day. This estimate included the 200,000 square foot +/- office building located at 105 Rosemont Road. This building is not part of the University Station project. To account for the reduced water consumption under existing conditions, water consumption was reduced by 15,424 gallons per day (based on Title V flow rates for office uses). This reduction is likely conservative since Title V rates reflect peak demands rather average flow rates. Also, it is assumed that no make-up water is used at 105 Rosemont for evaporative cooling. Therefore, the existing water consumption was estimated to be 64,576 gallons per day.

2.4 Proposed Water Consumption

Proposed water consumption was estimated by using Title V wastewater flow rates and applying the rates to the various uses associated with University Station. A detailed breakdown of the proposed uses along with the associated Title V wastewater flow rates is included in Appendix A.

Similar to the proposed water consumption calculations that were prepared as part of the Westwood Station project, Title V flows have been reduced by 50% to estimate average daily water flows. Title V flows are a useful tool in determined peak rates, which is a necessity in sizing of septic systems, however they over estimate average daily rates.

2.5 Water Conservation

The Neponset River Watershed Association has requested that the project consider using WaterSense water fixtures for showers, faucets, toilets and urinals. The project proponent has committed to utilizing the WaterSense fixtures. In general, any fixture with the WaterSense label will provide 20% efficiency when compared to standard fixtures according to documentation provided by the US EPA. Please see Appendix B for a copy of the US EPA documentation on WaterSense fixtures.

3.0 Water Budget Components

Water budgets have been developed for both the existing condition (pre-demolition) and post construction of the master plan University Station project. The water budgets have been developed utilizing the principal of conservation of mass. That is, all water that falls on the project site must be accounted for, whether it is in the form of surface runoff, infiltration, evapotranspiration or evaporation. This principal is applied to both the existing and proposed water budget calculations. A positive water budget is achieved when water consumption is exceeded by aquifer recharge. In the sections that follow, a discussion of key assumptions and calculation methods has been provided.

3.1 Evapotranspiration

Evapotranspiration is generally defined as the transfer of moisture from the earth to the atmosphere by evaporation of water and transpiration from plants. Evapotranspiration can be estimated by employing methodologies such as the Thornthwaite method. The Thornthwaite estimates evapotranspiration based on factors including temperature and hours of daylight. Evapotranspiration rates can also be affected by soil moisture content. For the purposes of this evaluation, evapotranspiration rates were not adjusted down due to soil moisture. Soil testing conducted to date indicates that the groundwater table is well below the ground surface and it is unlikely that plant roots extend into the water table. Instead, plants rely on soil moisture produced from infiltration and any adjustments would under estimate actual evapotranspiration.

In the water budget calculations, potential evapotranspiration rates have been estimated at 25.56 inches per year. This value has been deducted from the annual average rainfall in order to determine a value for potential recharge.

3.2 Evaporation

Evaporation is generally defined as water transforming from a liquid to a gas or vapor. For the most part, evaporation of water occurs from large bodies of water such as rivers, lakes and oceans. Evaporation from these sources accounts for approximately 90% of all moisture in the atmosphere. The remaining 10% of moisture comes from transpiration. Evaporation rates from building roofs and parking areas should generally be minimal, since both surfaces are designed to drain water efficiently and without depression storage (surfaces are designed and constructed with positive pitch to drain inlets). Typically, rainfall that hits building roofs or paved surfaces will be conveyed into infiltration systems within 5 minutes of falling. However, in order to provide a conservative estimate, it has been assumed that 30% of all rain that falls on impervious surfaces (both building roof areas and paved areas) will evaporate into the atmosphere. This assumption has been applied to both existing and proposed water budget calculations.

3.3 Recharge from Pervious Surfaces

For the purposes of the water budget calculation, it has been assumed that 90% of all rain that falls on pervious surfaces will be infiltrated. Pervious surfaces include lawns, meadows and other open space area. The remaining 10% would run off during larger and less frequent rain events or enter the atmosphere by transpiration. This assumption is consistent with the prior Westwood Station water budget analysis.

3.4 Recharge from Subsurface Infiltration

The proposed University Station project has been designed to provide extensive recharge. As shown on the March 22, 2013 plan submission, 69% of all impervious surfaces will be directed to 6 subsurface recharge systems. Below is a summary of areas tributary to subsurface infiltration system

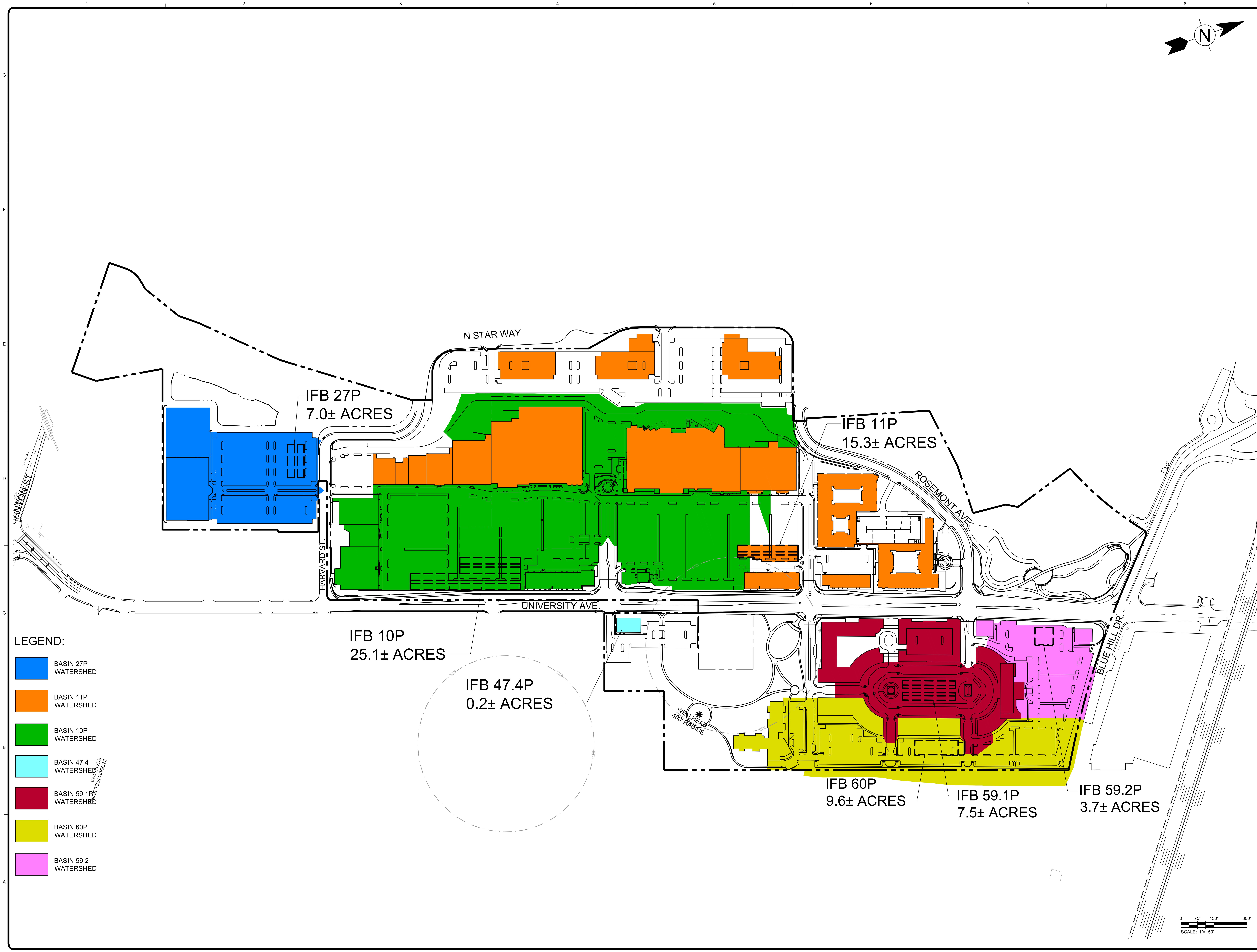
Table 1 – Infiltration Basins Tributary Areas

Basin ID	Overall Tributary Area (acres)	Roof Area (acres)	Paved Area (acres)	Pervious Areas (acres)
IFB 10P	25.1	2.25	20.4	2.4
IFB 11P	15.25	15.25	0	0
IFB 27P	7.0	1.3	5.3	0.4
IFB 47.4P	0.2	0.2	0	0
IFB 59.1P	7.5	2.9	3.7	0.9
IFB 59.2P	3.75	0.25	2.9	0.6
IFB 60P	9.4	1.8	4.55	3.05

For additional information regarding the location of the infiltration systems and the areas tributary to each system, please see Figure 2 – Infiltration Basin Watersheds.

In calculating the volume of rainfall that would reach the infiltration system, contributions from the building roof areas and the paved areas were each considered separately. For the building roof areas, it was assumed that 97% of the rain that fell on the roof would be captured. This approach is consistent with the Westwood Station analysis. However, it was further assumed that 30% of the rain that lands on the building roof areas would evaporate.

The subsurface recharge systems have been designed to store and infiltrate the first 2-inches of rainfall without a discharge. An analysis of the Norwood Airport rainfall data indicates that 98.4% of all rainfall events are less than 2-inches. From this same analysis, it was found that 87.2% of the total rainfall volume was also a result of storms that were less than 2-inches. Based on this analysis, it has been assumed that 85% of the rainfall that lands on impervious surfaces and is tributary to a subsurface recharge system will be infiltrated. Please see Appendix C for a copy of the Norwood Airport rainfall analysis.



3/15/2013 4:09:33 PM - P:\36591\127-3659-12003\DELIVERABLES\2013-03-18 GRAPHICS FOR BETA MEETING\UNIVERSITYSTATION-INFILTRATION_BASIN_WATERSHEDS-031813.DWG - TURNER, AUSTIN

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www.tetratech.com
One Grant Street
Framingham, MA 01701
PHONE: (508) 903-2000 FAX: (508) 903-2001

MARK	DATE	DESCRIPTION	BY
3	03/22/13	Revised Site Development Plans	N.H.C.

Client: Westwood Marketplace Holdings LLC
Proj. Loc.: University Ave, Westwood, MA

University Station - University Avenue Redevelopment

Infiltration Basin Watersheds

Project No.:	127-3659-12003
Designed By:	A.F.T./M.K.D.
Drawn By:	S.V.
Checked By:	N.H.C.

IFB

Bar Measures 1 inch

As noted above, the subsurface recharge systems have been designed to store and infiltrate the first 2-inches of rain. The groundwater recharge calculations that were prepared in support of the March 22, 2013 Stormwater Management Report demonstrates this point. A copy of the recharge calculations are attached in Appendix D. Please note that the calculations are based on a 2.02-inch rainfall and that for each and every basin, there is zero outflow through primary outlets. Instead, all outflow is shown as being discarded. With HydroCAD, discarded flow represents infiltration.

3.5 Surface Runoff

Rainfall that lands on impervious walks, parking areas and roadways and is collected by drainage systems that are not connected to subsurface recharge systems has been accounted for as surface runoff. Although the stormwater is not directed to recharge systems, it is directed to water quality units and/or stormwater treatment basins.

3.6 Irrigation

The planting plan developed for University Station includes a plant list comprised of hardy, drought tolerant native species. Therefore, irrigation needs for the project will be minimal. In fact, most areas will not be irrigated, such as the large Gateway Park and the Meadow Park behind the Dedham-Westwood Water District building. Irrigation will be focused on key areas, such as the residential building and entrance drives to the Core Retail Area. In order to estimate potential irrigation needs it's been assumed that 10% of the pervious areas within University Station would be irrigated. Irrigated areas are assumed to receive one inch of water per week. Further it was assumed that irrigation systems would be in use from the middle of May until the middle of September.

3.7 Evaporative Cooling

Similar to the Westwood Station project, only office buildings have been assumed to use evaporative cooling. As part of the Westwood Station project, evaporative cooling estimates were generated for 1,500,000 square feet of office space. The University Station Office space has been reduced to 325,000 sf or just 22% of the previous project. Therefore the previous evaporative cooling estimates have been reduced to 22% of the Westwood Station estimate. Please note that evaporative cooling estimates have only been applied to the proposed University Station office buildings.

4.0 Water Budget

4.1 Pre-Demolition Water Budget

As requested by the Neponset River Watershed Association and the Dedham-Westwood Water District, the pre-demolition water budget has been recalculated. The land area and water consumption associated with the office building at 105 Rosemont Road has been deleted from the water budget. Norwood Airport rainfall data and evapotranspiration rates were applied for consistency with the post construction water budget. Further, it was assumed that there was no irrigation or evaporative cooling in developing the pre-demolition water budget.

Based on the revised calculations, the pre-demolition water budget for the land associated with University Station yielded a net positive water budget. The water budget calculations indicates that prior to demolition, the local aquifer would realize a surplus of 10.55 million gallons per year. The surplus supports the groundwater base flow of the Neponset River. Please refer to Figure 3 – Pre-Demolition Water Budget for detailed calculations.

4.2 Post Construction Water Budget

A post construction water budget has been developed utilizing the same data as the pre-demolition water budget. Infiltration and water consumption estimates (domestic water use, WaterSense fixtures, irrigation and evaporative cooling) as discussed in prior sections in the report were applied to the water budget. The resulting water budget calculation for the post construction condition also yields a positive water budget. The calculation indicates that the local aquifer would realize a surplus of 26.06 million gallons per year. The calculated surplus exceeds the pre-demolition condition by 15.51 million gallons per year, see Table 2 below. The increased surplus will further enhance the base flow to the Neponset River. Please refer to Figure 4 – Post Construction Water Budget for detailed calculations.

Table 2 – Water Budget Surplus: Pre vs. Post Condition Comparison

	Calculated Water Budget Surplus (Annual)
Pre-Demolition Condition	10.55 MG
Post Construction Condition	26.06 MG
Net Gain in Surplus	**15.51 MG**

Figure 3
University Station Annual Stormwater Budget
Pre-Demolition

Annual Water Budget Summary

				A	B		C	D	G
Month	**Runoff from Impervious Area (MG)**	**EVAPORATION (MG)**	**EVAPOTRANSPIRATION (MG)**	**Stormwater Infiltration (from Pervious Areas) (MG)**	**Parking Area Runoff Directed to Infiltration Systems[2] (MG)**	**Proposed Monthly Consumption Reduced for Average Demands[1] (MG)**	**Proposed Monthly Consumption Demands with Evaporative Cooling**	**Potential Loss to Irrigation (MG)**	**Final Aquifer Recharge[2] A+B+C+D (MG)**
Jan	3.90	(2.15)	0.00	4.30	0.00	(2.00)	(2.00)	0.00	2.29
Feb	3.54	(1.95)	0.00	3.90	0.00	(1.81)	(1.81)	0.00	2.09
Mar	5.36	(2.90)	0.56	5.40	0.00	(2.00)	(2.00)	0.00	3.40
Apr	5.72	(2.89)	2.63	3.94	0.00	(1.94)	(1.94)	0.00	2.00
May	5.48	(2.52)	5.02	1.53	0.00	(2.00)	(2.00)	0.00	-0.48
Jun	5.54	(1.66)	7.50	0.00	0.00	(1.94)	(1.94)	0.00	-1.94
Jul	4.93	0.60	8.76	0.00	0.00	(2.00)	(2.00)	0.00	-2.00
Aug	3.74	1.80	7.98	0.00	0.00	(2.00)	(2.00)	0.00	-2.00
Sep	4.77	(2.11)	5.24	0.54	0.00	(1.94)	(1.94)	0.00	-1.40
Oct	5.67	(2.85)	2.78	3.75	0.00	(2.00)	(2.00)	0.00	1.74
Nov	5.10	(2.69)	1.17	4.57	0.00	(1.94)	(1.94)	0.00	2.63
Dec	5.63	(3.10)	0.00	6.20	0.00	(2.00)	(2.00)	0.00	4.20
Annual	**59.38**	**(22.40)**	**41.64**	**34.12**	**0.00**	**(23.57)**	**(23.57)**	**0.00**	**10.55**

[1]In the approved prior FEIR the origninal water budget noted that Title V estimates represent a maximum daily demand. For average daily demands, Title V estimates were reduced by 50%. After the correction for average daily flows, a further reduction of 15% was assumed for water conserving fixtures, which will be used in the University Station project as required by the MA Plumbing Code.

[2]This analysis indicates that volume of stormwater available to recharge the aquifer and improve groundwater baseflow to the Neponset River. This analysis accounts for all potable and irrigation demands associated with the University Station project.

Figure 3
University Station Annual Stormwater Budget
Pre-Demolition

UNIVERSITY STATION RAINFALL BUDGET - PRE DEMOLITION

	University Station
Impervious Area (ac)	70
Roof Area Recharged (ac)	0
Pervious Area (ac)	60
Total (ac)	**130**

Month	Rainfall (in)	Potential Evapotranspiration (in)	Potential Infiltration (in)	Total Water Budget for Site (MG)
Jan	2.93	0	2.93	10.34
Feb	2.66	0	2.66	9.39
Mar	4.03	0.35	3.69	14.23
Apr	4.30	1.61	2.69	15.17
May	4.12	3.08	1.04	14.54
Jun	4.16	4.60	0.00	14.69
Jul	3.71	5.38	0.00	13.09
Aug	2.81	4.90	0.00	9.92
Sep	3.59	3.22	0.37	12.66
Oct	4.26	1.71	2.56	15.05
Nov	3.83	0.72	3.12	13.53
Dec	4.23	0	4.23	14.93
	44.63	**25.56**	**23.27**	**157.55**

POTENTIAL RECHARGE

Month	Infiltration from Pervious Area (MG)	Recharge from Roofs (MG)	Potential Loss to Irrigation[1] (MG)	Parking Area Runoff Directed to Infiltration Systems[2] (MG)	Total Infiltration (Recharge)[2] (MG)
Jan	4.30	0.00	0.00	0.00	4.30
Feb	3.90	0.00	0.00	0.00	3.90
Mar	5.40	0.00	0.00	0.00	5.40
Apr	3.94	0.00	0.00	0.00	3.94
May	1.53	0.00	0.00	0.00	1.53
Jun	0.00	0.00	0.00	0.00	0.00
Jul	0.00	0.00	0.00	0.00	0.00
Aug	0.00	0.00	0.00	0.00	0.00
Sep	0.54	0.00	0.00	0.00	0.54
Oct	3.75	0.00	0.00	0.00	3.75
Nov	4.57	0.00	0.00	0.00	4.57
Dec	6.20	0.00	0.00	0.00	6.20
	34.12	**0.00**	**0.00**	**0.00**	**34.12**

[1]Assumes the previous industrial park did not provide for infiltration

[2]The industrial park did not provide systems for groundwater recharge. All parking areas and builidngs were hard piped to drainage systems that discharged to the wetlands adjacent to the Neposet River.

POTENTIAL RUNOFF

Month	Runoff from Impervious Area[1] (MG)
Jan	3.90
Feb	3.54
Mar	5.36
Apr	5.72
May	5.48
Jun	5.54
Jul	4.93
Aug	3.74
Sep	4.77
Oct	5.67
Nov	5.10
Dec	5.63
	59.38

1.Accounts for impervious areas, including building roofs.

Month	EVAPORATION (MG)
Jan	2.15
Feb	1.95
Mar	2.90
Apr	2.89
May	2.52
Jun	1.66
Jul	-0.60
Aug	-1.80
Sep	2.11
Oct	2.85
Nov	2.69
Dec	3.10
	22.40

Month	EVAPOTRANSPIRATION (MG)
Jan	0.00
Feb	0.00
Mar	0.56
Apr	2.63
May	5.02
Jun	7.50
Jul	8.76
Aug	7.98
Sep	5.24
Oct	2.78
Nov	1.17
Dec	0.00
	41.64

EVAPOTRANSPIRATION CALCULATION (BASED ON BLUE HILL TEMP DATA)

Month	Temp (d F)	Temp (d C)	i	ET (cm) (unadjusted)	Daylight Factor	ET (cm) (adjusted)	ET (in)
Jan	26.46	-3.1	0	0.00	0	0	0
Feb	28.94	-1.7	0	0.00	0	0	0
Mar	36.49	2.5	0.35	0.85	1.03	0.88	0.35
Apr	47.63	8.7	2.31	3.69	1.11	4.09	1.61
May	56.35	13.5	4.51	6.21	1.26	7.82	3.08
Jun	66.28	19.0	7.57	9.27	1.26	11.69	4.60
Jul	70.63	21.5	9.08	10.67	1.28	13.66	5.38
Aug	70.25	21.3	8.94	10.55	1.18	12.45	4.90
Sep	61.78	16.5	6.12	7.86	1.04	8.18	3.22
Oct	50.58	10.3	3.00	4.52	0.96	4.34	1.71
Nov	42.24	5.7	1.22	2.24	0.81	1.82	0.72
Dec	31.75	-0.1	0	0.00	0	0	0
		I=	**43.09**	**55.87**		**64.92**	**25.56**

ET (in cm)= 1.62*(10T/I)^a   from Hydrology & Hydraulic Systems by Ram S. Gupta © 1989 pg 79-81
a= 1.174185879

Figure 3
University Station Annual Stormwater Budget
Pre-Demolition

UNIVERSITY STATION WATER DEMAND

Month	Days	Proposed Monthly Consumption (64,576 GPD) in MG	Evaporative Cooling Estimated for Office Buildings (MG)*
Jan	31	2.00	0.00
Feb	28	1.81	0.00
Mar	31	2.00	0.00
Apr	30	1.94	0.00
May	31	2.00	0.00
Jun	30	1.94	0.00
Jul	31	2.00	0.00
Aug	31	2.00	0.00
Sep	30	1.94	0.00
Oct	31	2.00	0.00
Nov	30	1.94	0.00
Dec	31	2.00	0.00
Annual	**365**	**23.57**	**0.00**

Figure 4
University Station Annual Stormwater Budget
Post Construction

Annual Water Budget Summary

Month	Runoff from Impervious Area (MG)	EVAPORATION (MG)	EVAPOTRANSPIRATION (MG)	A Stormwater Infiltration (from Roof, Paved and Pervious Areas) (MG)	Parking Area Runoff Directed to Infiltration Systems[2] (MG)	Proposed Monthly Consumption Reduced for Average Demands[1] (MG)	B Proposed Monthly Consumption Demands with Evaporative Cooling (MG)	C Potential Loss to Irrigation (MG)	Final Aquifer Recharge[3] A+B+C (MG)
Jan	1.45	(2.96)	0.00	5.93	1.75	(3.12)	(3.12)	0.00	2.82
Feb	1.31	(2.69)	0.00	5.39	1.59	(2.82)	(2.82)	0.00	2.57
Mar	1.99	(4.03)	0.40	7.80	2.41	(3.12)	(3.12)	0.00	4.68
Apr	2.12	(4.16)	1.88	7.01	2.57	(3.02)	(3.02)	0.00	3.99
May	2.04	(4.04)	3.60	5.11	2.46	(3.12)	(3.37)	(0.23)	1.51
Jun	2.06	(3.67)	5.37	4.05	2.49	(3.02)	(3.59)	(0.47)	-0.01
Jul	1.83	(1.84)	6.28	3.61	2.22	(3.12)	(3.93)	(0.47)	-0.78
Aug	1.39	(0.54)	5.72	2.74	1.68	(3.12)	(3.93)	(0.47)	-1.66
Sep	1.77	(3.49)	3.76	3.88	2.14	(3.02)	(3.59)	(0.23)	0.05
Oct	2.11	(4.11)	1.99	6.84	2.55	(3.12)	(3.37)	0.00	3.47
Nov	1.89	(3.79)	0.84	7.01	2.29	(3.02)	(3.02)	0.00	3.99
Dec	2.09	(4.28)	0.00	8.56	2.53	(3.12)	(3.12)	0.00	5.45
Annual	**22.06**	**(39.60)**	**29.84**	**67.92**	**26.68**	**(36.70)**	**(39.98)**	**-1.87**	**26.08**

[1]In the approved prior FEIR the origninal water budget noted that Title V estimates represent a maximum daily demand. For average daily demands, Title V estimates were reduced by 50%. After the correction for average daily flows, a further reduction of 20% was assumed for WaterSense water conserving fixtures, which have been suggested for use in the University Station project. USEPA indicates the WaterSense fixtures will result in 20% water conservation.

[2]An analysis of the daily rain data (2000 to 2009) from the Norwood Airport indicates that 98.4% of all rain events produce less than 2" of rainfall. From this same data, 87.2% of the total rainfall volume was a result of rain events of less than 2". Review of the onsite infiltration systems indicates that upto 2" of rainfall can be stored and infiltrated prior to any outflow. There are 37 acres of non-roof impervious area being directed to infiltration systems and for the purpose of this analysis, it has been assumed that 85% of the monthly rainfall can be infiltrated. We used the Norwood Airport daily records as the closest station at the same elevation and valley climate condition as the locus and compared that data to the NOAA Great Blue Hill monthly data for evapotranspiration.

[3]This analysis indicates that volume of stormwater available to recharge the aquifer and improve groundwater baseflow to the Neponset River. This analysis accounts for all potable and irrigation demands associated with the University Station project.

Figure 4
University Station Annual Stormwater Budget
Post Construction

UNIVERSITY STATION WATER BUDGET - POST CONSTRUCTION

	University Station
Impervious Area (ac)	63
Roof Area Recharged (ac)	24
Pervious Area (ac)	43
Total (ac)	**130**

Month	Rainfall (in)	Potential Evapotranspiration (in)	Potential Infiltration (in)	Total Water Budget for Site (MG)
Jan	2.93	0	2.93	10.34
Feb	2.66	0	2.66	9.39
Mar	4.03	0.35	3.69	14.23
Apr	4.30	1.61	2.69	15.17
May	4.12	3.08	1.04	14.54
Jun	4.16	4.60	0.00	14.69
Jul	3.71	5.38	0.00	13.09
Aug	2.81	4.90	0.00	9.92
Sep	3.59	3.22	0.37	12.66
Oct	4.26	1.71	2.56	15.05
Nov	3.83	0.72	3.12	13.53
Dec	4.23	0	4.23	14.93
	44.63	**25.56**	**23.27**	**157.55**

POTENTIAL RECHARGE

Month	Infiltration from Pervious Area (MG)	Recharge from Roofs (MG)	Potential Loss to Irrigation[1] (MG)	Parking Area Runoff Directed to Infiltration Systems[2] (MG)	Total Infiltration (Recharge)3 (MG)
Jan	3.08	1.10	0.00	1.75	5.93
Feb	2.80	1.00	0.00	1.59	5.39
Mar	3.87	1.52	0.00	2.41	7.80
Apr	2.82	1.62	0.00	2.57	7.01
May	1.09	1.55	(0.23)	2.46	4.87
Jun	0.00	1.56	(0.47)	2.49	3.59
Jul	0.00	1.39	(0.47)	2.22	3.15
Aug	0.00	1.06	(0.47)	1.68	2.27
Sep	0.39	1.35	(0.23)	2.14	3.65
Oct	2.69	1.60	0.00	2.55	6.84
Nov	3.28	1.44	0.00	2.29	7.01
Dec	4.44	1.59	0.00	2.53	8.56
	24.46	**16.79**	**-1.87**	**26.68**	**66.06**

[1]Assumes that 10% of the pervious area will be irrigated @ 1" per week mid May thru Mid September

[2]An analysis of the daily rain data (2000 to 2009) from the Norwood Airport indicates that 98.4% of all rain events produce less than 2" of rainfall. From this same data, 87.2% of the total rainfall volume was a result of rain events of less than 2". Review of the onsite infiltration systems indicates that upto 2" of rainfall can be stored and infiltrated prior to any outflow. There are 37 acres of non-roof impervious area being directed to infiltration systems and for the purpose of this analysis, it has been assumed that 85% of the monthly rainfall can be infiltrated.

[3]Only considers recharge from roof and pervious surfaces. Potential irrigation volume has been deducted.

POTENTIAL RUNOFF

Month	Runoff from Impervious Area[1] (MG)
Jan	1.45
Feb	1.31
Mar	1.99
Apr	2.12
May	2.04
Jun	2.06
Jul	1.83
Aug	1.39
Sep	1.77
Oct	2.11
Nov	1.89
Dec	2.09
	22.06

1.Accounts for impervious walks and paved area that are not directed to recharge systems.

Month	EVAPORATION (MG)
Jan	2.96
Feb	2.69
Mar	4.03
Apr	4.16
May	4.04
Jun	3.67
Jul	1.84
Aug	0.54
Sep	3.49
Oct	4.11
Nov	3.79
Dec	4.28
	39.60

Month	EVAPOTRANSPIRATION (MG)
Jan	0.00
Feb	0.00
Mar	0.40
Apr	1.88
May	3.60
Jun	5.37
Jul	6.28
Aug	5.72
Sep	3.76
Oct	1.99
Nov	0.84
Dec	0.00
	29.84

EVAPOTRANSPIRATION CALCULATION (BASED ON NORWOOD AIRPORT TEMP DATA 2000-2009)

Month	Temp (d F)	Temp (d C)	i	ET (cm) (unadjusted)	Daylight Factor	ET (cm) (adjusted)	ET (in)
Jan	26.46	-3.1	0	0.00	0	0	0
Feb	28.94	-1.7	0	0.00	0	0	0
Mar	36.49	2.5	0.35	0.85	1.03	0.88	0.35
Apr	47.63	8.7	2.31	3.69	1.11	4.09	1.61
May	56.35	13.5	4.51	6.21	1.26	7.82	3.08
Jun	66.28	19.0	7.57	9.27	1.26	11.69	4.60
Jul	70.63	21.5	9.08	10.67	1.28	13.66	5.38
Aug	70.25	21.3	8.94	10.55	1.18	12.45	4.90
Sep	61.78	16.5	6.12	7.86	1.04	8.18	3.22
Oct	50.58	10.3	3.00	4.52	0.96	4.34	1.71
Nov	42.24	5.7	1.22	2.24	0.81	1.82	0.72
Dec	31.75	-0.1	0	0.00	0	0	0
		I=	**43.09**	**55.87**		**64.92**	**25.56**

ET (in cm)= 1.62*(10T/I)^a   from Hydrology & Hydraulic Systems by Ram S. Gupta © 1989 pg 79-81
a= 1.174185879

Figure 4
University Station Annual Stormwater Budget
Post Construction

UNIVERSITY STATION WATER DEMAND

Month	Days	Proposed Monthly Consumption (251,384 GPD) in MG	Evaporative Cooling Estimated for Office Buildings (MG)*
Jan	31	7.79	0.00
Feb	28	7.04	0.00
Mar	31	7.79	0.00
Apr	30	7.54	0.00
May	31	7.79	0.25
Jun	30	7.54	0.58
Jul	31	7.79	0.81
Aug	31	7.79	0.81
Sep	30	7.54	0.58
Oct	31	7.79	0.25
Nov	30	7.54	0.00
Dec	31	7.79	0.00
Annual	**365**	**91.76**	**3.28**

*As part of the Westwood Station project, evaporative cooling estimates were generated for 1.5 MSF of office space. The University Station Office space has been reduced to 325,000 sf or just 22% of the previous project. Therefore the previous evaporative cooling estimates have been reduced to 22% of the Westwood Station estimate.

5.0 Nitrogen Loading

The Dedham-Westwood Water District has requested that a nitrogen loading estimate be prepared due to the significant volume of groundwater recharge that will be provided relative to the District's groundwater supply wells. The primary source of nitrogen will be the impervious parking surfaces within University Station. Utilizing a study entitled "Stormwater Best Management Practices (BMP) Performance Analysis" prepared for the US EPA Region 1 by Tetra Tech, dated March 2010, total nitrogen loading rates for commercial areas has been estimated at 9.8 pounds of total nitrogen per year per acre of impervious parking surface. It should be noted that this study was conducted in the Boston area. Therefore, the estimates provided in the report are appropriate due to the relatively close proximity of the study.

To develop a total nitrogen loading rate, the overall impervious parking surfaces that are directed to infiltration system were multiplied by 9.8 pounds of nitrogen and then annualized over the predicted recharge volume. As shown in Table 1, 36.8 acres of impervious parking surfaces are directed to subsurface recharge systems. MA DEP estimates that subsurface infiltration systems will reduce nitrogen loading rates by 50%. Overall, the annual total nitrogen loading is estimated to be 181 pounds per year.

As shown in the water budget, the annual groundwater recharge volume is anticipated to be 67.93 million gallons per year. Therefore to estimate the total nitrogen concentration within the infiltrated stormwater, the 181 pounds of total nitrogen is divided by the 67.93 million gallons of infiltrated stormwater. The resulting concentration is 2.66 lbs/MG or 0.32 mg/L. Please see Appendix D for total nitrogen loading calculations.

There is not an EPA drinking water standard for Total Nitrogen but a Nitrate (NO3) limit <1.0 mg/l. This low resulting nitrogen concentration is not the resulting nitrogen level in the groundwater but only the average annual concentration in the stormwater which is collected, treated and infiltrated into the soils on-site. The resulting groundwater concentration from this infiltrated volume would be much less due to the significantly larger volume within the aquifer.

6.0 Summary

Water budget calculations have been developed that show that the University Station project will provide groundwater recharge in a quantity that is not only in excess of the projected water consumption, but also in excess of pre-demolition groundwater recharge. Construction of University Station will enhance groundwater recharge to the local aquifer and will improve base flow to the Neponset River. Also, nitrogen loading calculations have been provided which indicates that increases in total nitrogen concentrations will be minimal.

Appendix A

Title V Wastewater Flow Estimate

University Station Estimated Title V Wastewater Generation

Building	Type	S.F.	Title V Peak Flow (GPD)
Retail A	Retail	36,000	1,800
Retail B	Retail	14,100	705
Retail C	Retail	22,180	1,109
Retail E	Retail	12,300	615
Retail F	Retail	6,000	300
Retail G	Retail	10,530	527
Retail H	Retail	17,300	865
Retail I	Retail	35,740	1,787
Retail J	Retail	139,060	6,953
Retail K	Supermarket	140,000	13,580
Retail L	Retail	50,900	2,545
Retail N	Retail	12,850	643
Retail O	Retail	19,040	952
Retail P	Retail	2,500	125
Retail Q	Retail	23,180	1,159
Retail R - Lifetime Fitness	Retail	112,000	45,000
Retail T	Retail	10,000	500
Retail U	Retail	10,000	500
Office A	Office	95,400	7,155
Office B	Office	122,100	9,158
Office C	Office	122,100	9,158
Office W	Office	60,000	4,500
Office X	Office	75,000	5,625
Restaurant A (200 seats)	Restaurant	8,000	7,000
Restaurant B (150 seats)	Restaurant	6,400	5,250
Restaurant C (125 seats)	Restaurant	4,800	4,375
Residential A1 (205 beds)	Residential	146,778	22,550
Residential A2 (272 beds)	Residential	204,900	29,920
Residential C (188 beds)	Residential	NA	20,680
Residential B (125 beds)	Residential	NA	13,750
Hotel V (160 beds)	Hotel	NA	17,600
Assisted Living (100 units)	Senior	NA	15,000
		Totals	251,384

Notes: 1.The location of all office uses has not yet been determined. For the purposes of the sewer hydraulic analysis office use has been considered in the upper office area as well as the Village Retail area. This table is not meant to suggest that office use will exceed 325,000 square feet. These calculations will be updated as the building program is further refined.

2. Residential bed counts assumes a split of approxiomately 60% one bedroom and 40% two bedrooms over a total of 650 residences.

Appendix B

US EPA WaterSense Documention

The WaterSense® Label

Research has shown that by using water-efficient products and practices, homeowners can help save natural resources and reduce their water consumption and costs. In order to realize these savings, consumers need to be able to identify products and services that use less water while performing as well as or better than conventional models.

WaterSense, a partnership program sponsored by the U.S. Environmental Protection Agency (EPA), is making it easy to find and select water-efficient products with a label backed by independent testing and certification. WaterSense will also recognize professional service programs that incorporate water efficiency.

In order to use the label, a company must sign a WaterSense partnership agreement. Among other things, the partnership agreement defines the roles and responsibilities of EPA and the partnering organization, as well as proper use of the label on products, on packaging, and in marketing and other promotional materials. Products that bear the WaterSense label meet all the criteria in EPA's specifications for water efficiency and performance.

Generally speaking, WaterSense labeled products will be about 20 percent more water efficient than conventional models in the same category. In addition, WaterSense labeled products perform their intended function as well as or better than their less efficient counterparts.

Look for the Label

The WaterSense label first appeared on professional certification programs for landscape irrigation professionals. These WaterSense labeled programs verify professional proficiency in water-efficient irrigation system design, installation/ maintenance, and auditing. The program will allow homeowners to ask for professionals who partner with the WaterSense program.

WaterSense also has made the label available for water-efficient products in the home, beginning with toilets. As defined by EPA's WaterSense specification, high-efficiency toilets (HETs) use less than 1.3 gallons per flush.

Find the most up-to-date list of labeled products and programs on the WaterSense Web registry in mid-2007. Please visit <www.epa.gov/watersense>.

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Appendix C

Norwood Airport Rain Data

2000 PRECIPITATION EVENTS

SOURCE 2000-2009 EVENTS: WEATHER STATION KOWD-WEATHER UNDERGROUND

MONTH	Total # of Rain Events	Average Monthly Rainfall (inches)
January	111	2.93
February	85	2.66
March	116	4.03
April	134	4.30
May	131	4.12
June	142	4.16
July	122	3.71
August	114	2.81
September	112	3.59
October	114	4.26
November	118	3.83
December	118	4.23
TOTAL	1417	44.63

Summary of Annual Rainfall Events
Norword Airport

YEAR	# of Events	Total rainfall	# of events > 2.0 inches	Total rainfall < 2.5 inches
2000	123	38.97	2	34.25
2001	127	37.31	3	29.61
2002	147	44.23	0	44.23
2003	160	47.09	0	47.09
2004	148	45.02	4	35.38
2005	139	51.94	2	44.77
2006	132	47.55	4	38.08
2007	140	38.57	0	38.57
2008	155	50.02	6	33.81
2009	146	45.64	1	43.46
TOTALS	1417	446.34	22	389.25

87.2% of the total rainfall volume during the 10 year period resulted from events that were greater than 2.0 inches

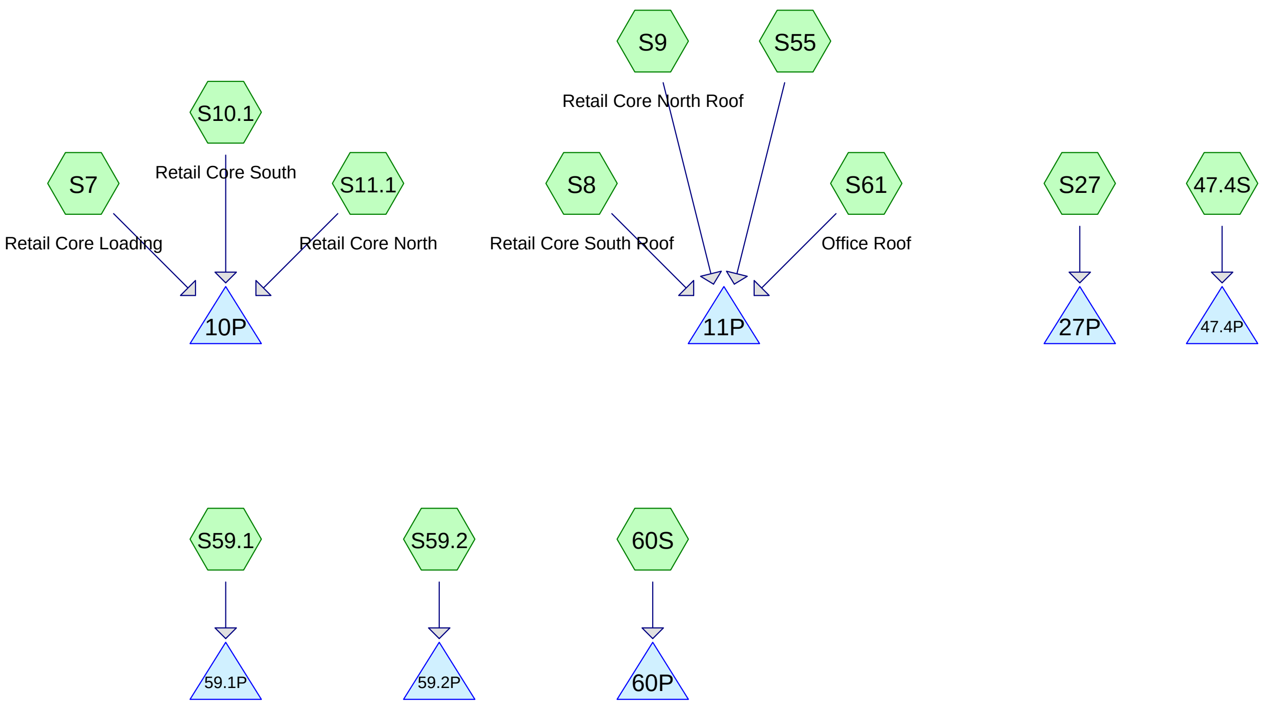
1.6% of the total rainfall events during the 10 year period resulted in events that were greater than 2.0 inches

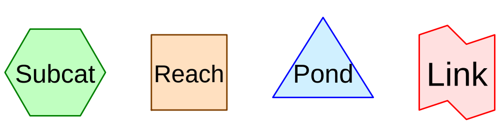
University Station
Water Budget
Norwood Average Temp by Month and Year

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	10-year Avg Temp
Jan	25	25	33	22	19	24	35	31	29	20	26.46
Feb	31	29	33	23	30	27	30	25	31	30	28.94
March	41	34	39	36	37	32	37	37	37	36	36.49
April	46	48	50	44	49	49	47	45	48	49	47.63
May	57	58	56	54	59	52	57	59	54	58	56.35
June	66	68	65	65	64	69	68	67	67	63	66.28
July	67	67	72	72	69	71	75	71	73	68	70.63
August	67	72	71	72	70	73	69	69	67	71	70.25
September	60	62	65	63	62	64	60	63	61	59	61.78
October	50	51	48	49	51	54	50	56	49	49	50.58
November	41	44	40	43	40	43	47	39	40	46	42.24
December	26	36	30	33	32	29	38	29	34	31	31.75

Appendix D

2.02-Inch Recharge Calculation





Routing Diagram for 3659-12003C-Dynamic Field Method-01
Prepared by {enter your company name here}, Printed 3/19/2013
HydroCAD® 10.00 s/n 00983 © 2012 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.168	49	50-75% Grass cover, Fair, HSG A (S7)
7.994	39	>75% Grass cover, Good, HSG A (60S, S10.1, S11.1, S27, S55, S59.1, S59.2, S7)
0.255	61	>75% Grass cover, Good, HSG B (S55)
36.387	98	Paved parking, HSG A (60S, S10.1, S11.1, S27, S59.1, S59.2, S7)
23.898	98	Roofs, HSG A (47.4S, 60S, S10.1, S11.1, S27, S55, S59.1, S59.2, S61, S8, S9)
68.702	**91**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
68.447	HSG A	47.4S, 60S, S10.1, S11.1, S27, S55, S59.1, S59.2, S61, S7, S8, S9
0.255	HSG B	S55
0.000	HSG C	
0.000	HSG D	
0.000	Other	
68.702		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.168	0.000	0.000	0.000	0.000	0.168	50-75% Grass cover, Fair	S7
7.994	0.255	0.000	0.000	0.000	8.249	>75% Grass cover, Good	60S, S10.1, S11.1, S27, S55, S59.1, S59.2, S7
36.387	0.000	0.000	0.000	0.000	36.387	Paved parking	60S, S10.1, S11.1, S27, S59.1, S59.2, S7
23.898	0.000	0.000	0.000	0.000	23.898	Roofs	47.4S, 60S, S10.1, S11.1, S27, S55, S59.1, S59.2, S61, S8, S9
68.447	**0.255**	**0.000**	**0.000**	**0.000**	**68.702**	**TOTAL AREA**	

Time span=6.00-18.00 hrs, dt=0.05 hrs, 241 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 47.4S: Runoff Area=7,150 sf 100.00% Impervious Runoff Depth>1.61"
Tc=5.0 min CN=98 Runoff=0.32 cfs 0.022 af

Subcatchment 60S: Runoff Area=409,177 sf 67.76% Impervious Runoff Depth>0.45"
Tc=5.0 min CN=79 Runoff=5.36 cfs 0.352 af

Subcatchment S10.1: Retail Core South Runoff Area=558,326 sf 95.19% Impervious Runoff Depth>1.36"
Tc=5.0 min CN=95 Runoff=22.11 cfs 1.452 af

Subcatchment S11.1: Retail Core North Runoff Area=280,057 sf 93.60% Impervious Runoff Depth>1.28"
Tc=5.0 min CN=94 Runoff=10.56 cfs 0.684 af

Subcatchment S27: Runoff Area=304,169 sf 94.00% Impervious Runoff Depth>1.28"
Tc=5.0 min CN=94 Runoff=11.47 cfs 0.743 af

Subcatchment S55: Runoff Area=163,904 sf 84.64% Impervious Runoff Depth>0.99"
Tc=5.0 min CN=90 Runoff=4.91 cfs 0.309 af

Subcatchment S59.1: Runoff Area=324,960 sf 87.66% Impervious Runoff Depth>1.05"
Tc=5.0 min CN=91 Runoff=10.33 cfs 0.655 af

Subcatchment S59.2: Runoff Area=163,215 sf 83.18% Impervious Runoff Depth>0.86"
Tc=5.0 min CN=88 Runoff=4.31 cfs 0.270 af

Subcatchment S61: Office Roof Runoff Area=113,278 sf 100.00% Impervious Runoff Depth>1.61"
Tc=5.0 min CN=98 Runoff=5.04 cfs 0.350 af

Subcatchment S7: Retail Core Loading Runoff Area=255,978 sf 69.16% Impervious Runoff Depth>0.49"
Tc=5.0 min CN=80 Runoff=3.67 cfs 0.238 af

Subcatchment S8: Retail Core South Runoff Area=221,180 sf 100.00% Impervious Runoff Depth>1.61"
Tc=5.0 min CN=98 Runoff=9.84 cfs 0.683 af

Subcatchment S9: Retail Core North Runoff Area=191,272 sf 100.00% Impervious Runoff Depth>1.61"
Tc=5.0 min CN=98 Runoff=8.51 cfs 0.591 af

Pond 10P: Peak Elev=47.31' Storage=9,584 cf Inflow=36.28 cfs 2.375 af
Discarded=21.34 cfs 2.372 af Primary=0.00 cfs 0.000 af Outflow=21.34 cfs 2.372 af

Pond 11P: Peak Elev=48.73' Storage=16,830 cf Inflow=28.32 cfs 1.933 af
Discarded=8.21 cfs 1.932 af Primary=0.00 cfs 0.000 af Outflow=8.21 cfs 1.932 af

Pond 27P: Peak Elev=48.62' Storage=9,259 cf Inflow=11.47 cfs 0.743 af
Discarded=2.39 cfs 0.742 af Primary=0.00 cfs 0.000 af Outflow=2.39 cfs 0.742 af

Pond 47.4P: Peak Elev=48.00' Storage=1 cf Inflow=0.32 cfs 0.022 af
Discarded=0.32 cfs 0.022 af Primary=0.00 cfs 0.000 af Outflow=0.32 cfs 0.022 af

Pond 59.1P: Peak Elev=47.87' Storage=10,912 cf Inflow=10.33 cfs 0.655 af
Discarded=1.49 cfs 0.649 af Primary=0.00 cfs 0.000 af Outflow=1.49 cfs 0.649 af

Pond 59.2P: Peak Elev=47.81' Storage=4,271 cf Inflow=4.31 cfs 0.270 af
Discarded=0.60 cfs 0.269 af Primary=0.00 cfs 0.000 af Outflow=0.60 cfs 0.269 af

Pond 60P: Peak Elev=47.79' Storage=5,147 cf Inflow=5.36 cfs 0.352 af
Discarded=0.82 cfs 0.351 af Primary=0.00 cfs 0.000 af Outflow=0.82 cfs 0.351 af

Total Runoff Area = 68.702 ac Runoff Volume = 6.350 af Average Runoff Depth = 1.11"
12.25% Pervious = 8.417 ac 87.75% Impervious = 60.285 ac

Summary for Subcatchment 47.4S:

Runoff = 0.32 cfs @ 12.07 hrs, Volume= 0.022 af, Depth> 1.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Type III 24-hr Infil Rainfall=2.02"

Area (sf)	CN	Description
7,150	98	Roofs, HSG A
7,150		100.00% Impervious Area

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

Summary for Subcatchment 60S:

Runoff = 5.36 cfs @ 12.09 hrs, Volume= 0.352 af, Depth> 0.45"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Type III 24-hr Infil Rainfall=2.02"

Area (sf)	CN	Description
131,912	39	>75% Grass cover, Good, HSG A
197,733	98	Paved parking, HSG A
79,532	98	Roofs, HSG A
409,177	79	Weighted Average
131,912		32.24% Pervious Area
277,265		67.76% Impervious Area

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

Summary for Subcatchment S10.1: Retail Core South

Runoff = 22.11 cfs @ 12.07 hrs, Volume= 1.452 af, Depth> 1.36"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Type III 24-hr Infil Rainfall=2.02"

Area (sf)	CN	Description
26,881	39	>75% Grass cover, Good, HSG A
435,993	98	Paved parking, HSG A
95,452	98	Roofs, HSG A
558,326	95	Weighted Average
26,881		4.81% Pervious Area
531,445		95.19% Impervious Area

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

Summary for Subcatchment S11.1: Retail Core North

Runoff = 10.56 cfs @ 12.07 hrs, Volume= 0.684 af, Depth> 1.28"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Type III 24-hr Infil Rainfall=2.02"

Area (sf)	CN	Description
17,929	39	>75% Grass cover, Good, HSG A
259,625	98	Paved parking, HSG A
2,503	98	Roofs, HSG A
280,057	94	Weighted Average
17,929		6.40% Pervious Area
262,128		93.60% Impervious Area

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

Summary for Subcatchment S27:

Runoff = 11.47 cfs @ 12.07 hrs, Volume= 0.743 af, Depth> 1.28"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Type III 24-hr Infil Rainfall=2.02"

Area (sf)	CN	Description
18,264	39	>75% Grass cover, Good, HSG A
230,041	98	Paved parking, HSG A
55,864	98	Roofs, HSG A
304,169	94	Weighted Average
18,264		6.00% Pervious Area
285,905		94.00% Impervious Area

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

Summary for Subcatchment S55:

Runoff = 4.91 cfs @ 12.08 hrs, Volume= 0.309 af, Depth> 0.99"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Type III 24-hr Infil Rainfall=2.02"

	Area (sf)	CN	Description
	14,073	39	>75% Grass cover, Good, HSG A
	11,103	61	>75% Grass cover, Good, HSG B
*	138,728	98	Roofs, HSG A
	163,904	90	Weighted Average
	25,176		15.36% Pervious Area
	138,728		84.64% Impervious Area

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

Summary for Subcatchment S59.1:

Runoff = 10.33 cfs @ 12.08 hrs, Volume= 0.655 af, Depth> 1.05"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Type III 24-hr Infil Rainfall=2.02"

Area (sf)	CN	Description
40,085	39	>75% Grass cover, Good, HSG A
159,447	98	Paved parking, HSG A
125,428	98	Roofs, HSG A
324,960	91	Weighted Average
40,085		12.34% Pervious Area
284,875		87.66% Impervious Area

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

Summary for Subcatchment S59.2:

Runoff = 4.31 cfs @ 12.08 hrs, Volume= 0.270 af, Depth> 0.86"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Type III 24-hr Infil Rainfall=2.02"

Area (sf)	CN	Description
27,457	39	>75% Grass cover, Good, HSG A
125,158	98	Paved parking, HSG A
10,600	98	Roofs, HSG A
163,215	88	Weighted Average
27,457		16.82% Pervious Area
135,758		83.18% Impervious Area

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

Summary for Subcatchment S61: Office Roof

Runoff = 5.04 cfs @ 12.07 hrs, Volume= 0.350 af, Depth> 1.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Type III 24-hr Infil Rainfall=2.02"

Area (sf)	CN	Description
113,278	98	Roofs, HSG A
113,278		100.00% Impervious Area

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

Summary for Subcatchment S7: Retail Core Loading

Runoff = 3.67 cfs @ 12.09 hrs, Volume= 0.238 af, Depth> 0.49"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Type III 24-hr Infil Rainfall=2.02"

Area (sf)	CN	Description
71,631	39	>75% Grass cover, Good, HSG A
7,309	49	50-75% Grass cover, Fair, HSG A
177,038	98	Paved parking, HSG A
255,978	80	Weighted Average
78,940		30.84% Pervious Area
177,038		69.16% Impervious Area

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

Summary for Subcatchment S8: Retail Core South Roof

Runoff = 9.84 cfs @ 12.07 hrs, Volume= 0.683 af, Depth> 1.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Type III 24-hr Infil Rainfall=2.02"

Area (sf)	CN	Description
221,180	98	Roofs, HSG A
221,180		100.00% Impervious Area

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

Summary for Subcatchment S9: Retail Core North Roof

Runoff = 8.51 cfs @ 12.07 hrs, Volume= 0.591 af, Depth> 1.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Type III 24-hr Infil Rainfall=2.02"

Area (sf)	CN	Description
191,272	98	Roofs, HSG A
191,272		100.00% Impervious Area

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

Summary for Pond 10P:

Inflow Area = 25.123 ac, 88.69% Impervious, Inflow Depth > 1.13" for Infil event
Inflow = 36.28 cfs @ 12.07 hrs, Volume= 2.375 af
Outflow = 21.34 cfs @ 12.19 hrs, Volume= 2.372 af, Atten= 41%, Lag= 6.9 min
Discarded = 21.34 cfs @ 12.19 hrs, Volume= 2.372 af
Primary = 0.00 cfs @ 6.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Peak Elev= 47.31' @ 12.19 hrs Surf.Area= 61,050 sf Storage= 9,584 cf

Plug-Flow detention time= 4.0 min calculated for 2.362 af (99% of inflow)
Center-of-Mass det. time= 3.6 min (760.1 - 756.5)

Volume	Invert	Avail.Storage	Storage Description
#1	47.00'	150,150 cf	**Custom Stage Data (Prismatic)**Listed below Inside #2
#2	47.00'	257,400 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc) 793,650 cf Overall - 150,150 cf Embedded = 643,500 cf x 40.0% Voids
		407,550 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
47.00	11,550	0	0
48.00	11,550	11,550	11,550
49.00	11,550	11,550	23,100
50.00	11,550	11,550	34,650
51.00	11,550	11,550	46,200
52.00	11,550	11,550	57,750
53.00	11,550	11,550	69,300
53.25	11,550	2,888	72,188
60.00	11,550	77,963	150,150

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
47.00	61,050	0	0
48.00	61,050	61,050	61,050
49.00	61,050	61,050	122,100
50.00	61,050	61,050	183,150
51.00	61,050	61,050	244,200
52.00	61,050	61,050	305,250
53.00	61,050	61,050	366,300
53.25	61,050	15,263	381,563
60.00	61,050	412,088	793,650

Device	Routing	Invert	Outlet Devices
#1	Discarded	47.00'	**15.000 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 0.00'
#2	Primary	49.50'	**36.0" Vert. Orifice/Grate** C= 0.600

Discarded OutFlow Max=21.33 cfs @ 12.19 hrs HW=47.30' (Free Discharge)
└─**1=Exfiltration** (Controls 21.33 cfs)

Primary OutFlow Max=0.00 cfs @ 6.00 hrs HW=47.00' (Free Discharge)
└─**2=Orifice/Grate** (Controls 0.00 cfs)

Summary for Pond 11P:

Inflow Area = 15.832 ac, 96.35% Impervious, Inflow Depth > 1.47" for Infil event
Inflow = 28.32 cfs @ 12.07 hrs, Volume= 1.933 af
Outflow = 8.21 cfs @ 12.40 hrs, Volume= 1.932 af, Atten= 71%, Lag= 19.7 min
Discarded = 8.21 cfs @ 12.40 hrs, Volume= 1.932 af
Primary = 0.00 cfs @ 6.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Peak Elev= 48.73' @ 12.40 hrs Surf.Area= 18,500 sf Storage= 16,830 cf

Plug-Flow detention time= 12.0 min calculated for 1.923 af (99% of inflow)
Center-of-Mass det. time= 11.5 min (750.9 - 739.4)

Volume	Invert	Avail.Storage	Storage Description
#1	47.00'	50,050 cf	**Custom Stage Data (Prismatic)**Listed below Inside #2
#2	47.00'	76,180 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc) 240,500 cf Overall - 50,050 cf Embedded = 190,450 cf x 40.0% Voids
		126,230 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
47.00	3,850	0	0
48.00	3,850	3,850	3,850
49.00	3,850	3,850	7,700
50.00	3,850	3,850	11,550
51.00	3,850	3,850	15,400
52.00	3,850	3,850	19,250
53.00	3,850	3,850	23,100
54.00	3,850	3,850	26,950
54.50	3,850	1,925	28,875
60.00	3,850	21,175	50,050

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
47.00	18,500	0	0
48.00	18,500	18,500	18,500
49.00	18,500	18,500	37,000
50.00	18,500	18,500	55,500
51.00	18,500	18,500	74,000
52.00	18,500	18,500	92,500
53.00	18,500	18,500	111,000
54.00	18,500	18,500	129,500
54.50	18,500	9,250	138,750
60.00	18,500	101,750	240,500

Device	Routing	Invert	Outlet Devices
#1	Discarded	47.00'	**18.500 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 0.00'
#2	Primary	49.10'	**36.0" Vert. Orifice/Grate** C= 0.600

Discarded OutFlow Max=8.21 cfs @ 12.40 hrs HW=48.73' (Free Discharge)
└─**1=Exfiltration** (Controls 8.21 cfs)

Primary OutFlow Max=0.00 cfs @ 6.00 hrs HW=47.00' (Free Discharge)
└─**2=Orifice/Grate** (Controls 0.00 cfs)

Summary for Pond 27P:

Inflow Area = 6.983 ac, 94.00% Impervious, Inflow Depth > 1.28" for Infil event
Inflow = 11.47 cfs @ 12.07 hrs, Volume= 0.743 af
Outflow = 2.39 cfs @ 12.50 hrs, Volume= 0.742 af, Atten= 79%, Lag= 25.4 min
Discarded = 2.39 cfs @ 12.50 hrs, Volume= 0.742 af
Primary = 0.00 cfs @ 6.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Peak Elev= 48.62' @ 12.50 hrs Surf.Area= 11,100 sf Storage= 9,259 cf

Plug-Flow detention time= 26.5 min calculated for 0.742 af (100% of inflow)
Center-of-Mass det. time= 25.8 min (780.8 - 755.0)

Volume	Invert	Avail.Storage	Storage Description
#1	47.00'	27,300 cf	**Custom Stage Data (Prismatic)**Listed below Inside #2
#2	47.00'	46,800 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc) 144,300 cf Overall - 27,300 cf Embedded = 117,000 cf x 40.0% Voids
		74,100 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
47.00	2,100	0	0
48.00	2,100	2,100	2,100
49.00	2,100	2,100	4,200
50.00	2,100	2,100	6,300
51.00	2,100	2,100	8,400
52.00	2,100	2,100	10,500
53.00	2,100	2,100	12,600
54.00	2,100	2,100	14,700
60.00	2,100	12,600	27,300

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
47.00	11,100	0	0
48.00	11,100	11,100	11,100
49.00	11,100	11,100	22,200
50.00	11,100	11,100	33,300
51.00	11,100	11,100	44,400
52.00	11,100	11,100	55,500
53.00	11,100	11,100	66,600
54.00	11,100	11,100	77,700
60.00	11,100	66,600	144,300

Device	Routing	Invert	Outlet Devices
#1	Discarded	47.00'	**9.000 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 0.00'
#2	Primary	50.00'	**24.0" Vert. Orifice/Grate X 2.00** C= 0.600

Discarded OutFlow Max=2.39 cfs @ 12.50 hrs HW=48.62' (Free Discharge)
└─**1=Exfiltration** (Controls 2.39 cfs)

Primary OutFlow Max=0.00 cfs @ 6.00 hrs HW=47.00' (Free Discharge)
└─**2=Orifice/Grate** (Controls 0.00 cfs)

Summary for Pond 47.4P:

Inflow Area = 0.164 ac,100.00% Impervious, Inflow Depth > 1.61" for Infil event
Inflow = 0.32 cfs @ 12.07 hrs, Volume= 0.022 af
Outflow = 0.32 cfs @ 12.07 hrs, Volume= 0.022 af, Atten= 0%, Lag= 0.1 min
Discarded = 0.32 cfs @ 12.07 hrs, Volume= 0.022 af
Primary = 0.00 cfs @ 6.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs

Peak Elev= 48.00' @ 12.07 hrs Surf.Area= 368 sf Storage= 1 cf

Plug-Flow detention time= 0.0 min calculated for 0.022 af (100% of inflow)
Center-of-Mass det. time= 0.0 min (733.2 - 733.1)

Volume	Invert	Avail.Storage	Storage Description
#1	48.00'	2,612 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
48.00	366	0	0
49.00	1,265	816	816
50.00	2,328	1,797	2,612

Device	Routing	Invert	Outlet Devices
#1	Discarded	48.00'	**3.00 cfs Exfiltration at all elevations**
#2	Primary	49.25'	**24.0" x 24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=3.00 cfs @ 12.07 hrs HW=48.00' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 3.00 cfs)

Primary OutFlow Max=0.00 cfs @ 6.00 hrs HW=48.00' (Free Discharge)
└─**2=Orifice/Grate** (Controls 0.00 cfs)

Summary for Pond 59.1P:

Inflow Area = 7.460 ac, 87.66% Impervious, Inflow Depth > 1.05" for Infil event
Inflow = 10.33 cfs @ 12.08 hrs, Volume= 0.655 af
Outflow = 1.49 cfs @ 12.61 hrs, Volume= 0.649 af, Atten= 86%, Lag= 32.1 min
Discarded = 1.49 cfs @ 12.61 hrs, Volume= 0.649 af
Primary = 0.00 cfs @ 6.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Peak Elev= 47.87' @ 12.61 hrs Surf.Area= 21,120 sf Storage= 10,912 cf

Plug-Flow detention time= 64.3 min calculated for 0.649 af (99% of inflow)
Center-of-Mass det. time= 61.6 min (829.9 - 768.3)

Volume	Invert	Avail.Storage	Storage Description
#1	47.00'	87,360 cf	**Custom Stage Data (Prismatic)**Listed below x 2 Inside #2
#2	47.00'	74,880 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc) 274,560 cf Overall - 87,360 cf Embedded = 187,200 cf x 40.0% Voids
		162,240 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
47.00	3,360	0	0
48.00	3,360	3,360	3,360
49.00	3,360	3,360	6,720
50.00	3,360	3,360	10,080
51.00	3,360	3,360	13,440
52.00	3,360	3,360	16,800
52.50	3,360	1,680	18,480
60.00	3,360	25,200	43,680

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
47.00	21,120	0	0
48.00	21,120	21,120	21,120
49.00	21,120	21,120	42,240
50.00	21,120	21,120	63,360
51.00	21,120	21,120	84,480
52.00	21,120	21,120	105,600
52.50	21,120	10,560	116,160
60.00	21,120	158,400	274,560

Device	Routing	Invert	Outlet Devices
#1	Discarded	47.00'	**3.000 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 0.00'
#2	Primary	48.50'	**18.0" Round Culvert** L= 356.0' Ke= 0.500 Inlet / Outlet Invert= 48.50' / 41.35' S= 0.0201 '/' Cc= 0.900 n= 0.014, Flow Area= 1.77 sf

Discarded OutFlow Max=1.49 cfs @ 12.61 hrs HW=47.87' (Free Discharge)
└─**1=Exfiltration** (Controls 1.49 cfs)

Primary OutFlow Max=0.00 cfs @ 6.00 hrs HW=47.00' (Free Discharge)
└─**2=Culvert** (Controls 0.00 cfs)

Summary for Pond 59.2P:

Inflow Area = 3.747 ac, 83.18% Impervious, Inflow Depth > 0.86" for Infil event
Inflow = 4.31 cfs @ 12.08 hrs, Volume= 0.270 af
Outflow = 0.60 cfs @ 12.68 hrs, Volume= 0.269 af, Atten= 86%, Lag= 36.2 min
Discarded = 0.60 cfs @ 12.68 hrs, Volume= 0.269 af
Primary = 0.00 cfs @ 6.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Peak Elev= 47.81' @ 12.68 hrs Surf.Area= 9,205 sf Storage= 4,271 cf

Plug-Flow detention time= 61.2 min calculated for 0.268 af (99% of inflow)
Center-of-Mass det. time= 60.4 min (839.1 - 778.7)

Volume	Invert	Avail.Storage	Storage Description
#1A	47.00'	8,080 cf	**125.00'W x 73.64'L x 3.50'H Field A**
			32,218 cf Overall - 12,018 cf Embedded = 20,199 cf x 40.0% Voids
#2A	47.50'	12,018 cf	**StormTech SC-740** x 260 Inside #1
			Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
			Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
			Row Length Adjustment= +0.44' x 6.45 sf x 26 rows
		20,098 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	47.00'	**2.750 in/hr Exfiltration over Surface area**
			Conductivity to Groundwater Elevation = 0.00'
#2	Primary	45.30'	**24.0" Round Culvert** L= 560.0' Ke= 0.500
			Inlet / Outlet Invert= 45.30' / 36.90' S= 0.0150 '/' Cc= 0.900
			n= 0.014, Flow Area= 3.14 sf
#3	Device 2	49.00'	**6.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.60 cfs @ 12.68 hrs HW=47.81' (Free Discharge)
└─**1=Exfiltration** (Controls 0.60 cfs)

Primary OutFlow Max=0.00 cfs @ 6.00 hrs HW=47.00' (Free Discharge)
└─**2=Culvert** (Passes 0.00 cfs of 12.63 cfs potential flow)
  └─**3=Sharp-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 60P:

Inflow Area = 9.393 ac, 67.76% Impervious, Inflow Depth > 0.45" for Infil event
Inflow = 5.36 cfs @ 12.09 hrs, Volume= 0.352 af
Outflow = 0.82 cfs @ 12.84 hrs, Volume= 0.351 af, Atten= 85%, Lag= 45.1 min
Discarded = 0.82 cfs @ 12.84 hrs, Volume= 0.351 af
Primary = 0.00 cfs @ 6.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 6.00-18.00 hrs, dt= 0.05 hrs
Peak Elev= 47.79' @ 12.84 hrs Surf.Area= 11,657 sf Storage= 5,147 cf

Plug-Flow detention time= 58.9 min calculated for 0.350 af (99% of inflow)
Center-of-Mass det. time= 58.0 min (861.5 - 803.5)

Volume	Invert	Avail.Storage	Storage Description
#1A	47.00'	10,246 cf	**196.25'W x 59.40'L x 3.50'H Field A**
			40,800 cf Overall - 15,185 cf Embedded = 25,616 cf x 40.0% Voids
#2A	47.50'	15,185 cf	**StormTech SC-740** x 328 Inside #1
			Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
			Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
			Row Length Adjustment= +0.44' x 6.45 sf x 41 rows
		25,431 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	47.00'	**3.000 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 0.00'
#2	Primary	44.75'	**30.0" Round Culvert** L= 120.0' Ke= 0.500 Inlet / Outlet Invert= 44.75' / 42.35' S= 0.0200 '/' Cc= 0.900 n= 0.014, Flow Area= 4.91 sf
#3	Device 2	48.15'	**6.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.82 cfs @ 12.84 hrs HW=47.79' (Free Discharge)
↑—**1=Exfiltration** (Controls 0.82 cfs)

Primary OutFlow Max=0.00 cfs @ 6.00 hrs HW=47.00' (Free Discharge)
↑—**2=Culvert** (Passes 0.00 cfs of 23.76 cfs potential flow)
  ↑—**3=Sharp-Crested Rectangular Weir** (Controls 0.00 cfs)

Appendix E

Nitrogen Loading Calculation

NITROGEN LOADING CALCULATION

LOADING RATE = 9.8 lbs/YEAR/ACRE TN

FROM TABLE 1: 36.8 ACRES IMPERVIOUS PARKING/ROADS DIRECTED TO RECHARGE SYSTEMS

TOTAL NITROGEN LOADING = 9.8 lb/YR/AC × 36.9 AC

= 362 lb/YR

PER MA DEP, INFILTRATION BASIN WILL REDUCE NITROGEN LOADING BY 50%.

THEREFORE ANNUAL RECHARGE FROM WATER BUDGET

= 67.93 MILLION GALLONS/YEAR

<u>CONCENTRATION</u>

$$\frac{181\ \text{lb/YR}}{67.93\ \text{MG/YR}} = 2.66\ \text{lbs/MG OF TN}$$

$$2.66\ \frac{\text{lbs}}{\text{MG}} \times 0.11983 = \underline{0.32\ \text{mg/L}}$$

TETRA TECH

One Grant Street
Framingham, MA 01701-9005
(508) 903-2000

JOB UNIVERSITY STATION
SHEET NO. 1 OF
CALCULATED BY NHC DATE 4/18/13
CHECKED BY DATE
SCALE

Stormwater Best Management Practices (BMP) Performance Analysis

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Prepared for:
United States Environmental Protection Agency – Region 1
5 Post Office Square, Suite 100
Boston, MA 02109

Prepared by:
Tetra Tech, Inc.
10306 Eaton Place, Suite 340
Fairfax, VA 22030

TETRA TECH

Annual average pollutant loading export rates of these pollutants were obtained from the *Fundamentals of Urban Runoff Management: Technical and Institutional Issues* (Shaver et al. 2007). The pollutant export loading rates for different land uses are shown in Table 3-2. These pollutant loading export rates were selected for this project because they have been reported in several sources of stormwater management literature. Also, use of these TP export rates were applied to the Charles River watershed (310 square miles) and found to closely match (within 1 percent) the measured annual phosphorus load for a 5-year period (1998 to 2002) (MassDEP and US EPA 2007).

Table 3-2. Summary of typical pollutant loading export rates from different land uses

Land cover/Source category	Pollutant loading export rates (lbs/ac-yr)			
	TSS	TP	TN	Zn
Commercial	1,000	1.5	9.8	2.1
Industrial	670	1.3	4.7	0.4
High-Density Residential	420	1.0	6.2	0.7
Medium-Density Residential	250	0.3	3.9	0.1
Low-Density Residential	65	0.04	0.4	0.04

Source: Shaver et al. 2007

3.3. Setup and Calibration of SWMM Water Quality Model

The weather data from the Boston, Massachusetts, station was used to generate runoff volume and pollutant time series in the New England region using the SWMM.

3.3.1. Water Quality Processes in SWMM

In the SWMM, the water quality simulation is divided into two processes: buildup and washoff. The amount of buildup is estimated as a function of the preceding dry-weather days and can be computed using one of three functions: Power, Exponential, and Saturation. The washoff process simulates the pollutant washoff from a given land use and can be computed using one of three functions: Exponential, Rating Curve, and Event Mean Concentration.

The SWMM buildup and washoff routines used to represent these processes provide a more reliable pollutant loading time series as compared to other methods (e.g., event mean concentration). This is because the buildup and washoff routines account for the pollutant mass balance over time. The routines also represent the time between events when pollutants accumulate and the predominance of small rainfall events and the effect of rainfall intensity on washing off pollutant load that has accumulated on impervious surfaces.

In this project, a power function was assumed for the pollutant buildup and an exponential function was assumed for the pollutant washoff. As for the buildup, the pollutant buildup (B) accumulates proportionally to time (t) raised to some power, until a maximum is reached,

$$B = Min\ (C_1,\ C_2 t^{C_3}) \qquad (1)$$

where C_1 = maximum buildup possible (mass per unit of area or curb length), C_2=buildup rate constant (1/days), and C_3=time exponent.

In the exponential washoff function, the washoff load (W) in units of mass per hour is proportional to the product of runoff raised to some power and to the amount of buildup remaining,

$$W = C_1 q^{C_2} B \qquad (2)$$