Master Plan

Stormwater Site Plan

For

Mount Vernon Schools

Madison Elementary

Master Plan

Owner:
Mount Vernon Schools
124 East Lawrence Street
Mount Vernon, WA, 98273

February 2018

ReidMiddleton

Master Plan Stormwater Site Plan

Madison Elementary School
Master Plan

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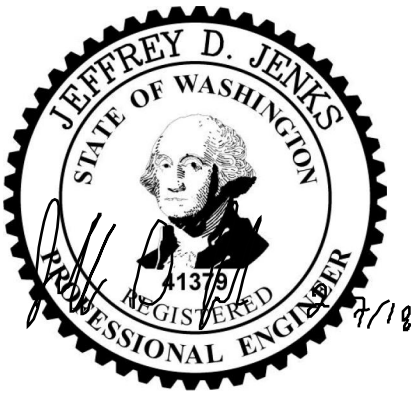
The engineering material and data contained in this report were prepared under the supervision and direction of the undersigned, whose seal as a registered professional engineer is affixed below.



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PROJECT OVERVIEW

This preliminary stormwater site plan report summarizes the storm drainage analysis and design for Madison Elementary School in Mount Vernon, Washington. The project is currently in the design and master planning phase.

The project consists of a new elementary school at the site of the existing Madison Elementary School. Site preparation work will include demolition of the existing school building and portable buildings, demolition of asphalt and concrete pavements and site features, and demolition of existing utilities. The new facility will be a multi-story school building with asphalt paved parking lots, asphalt paved bus and parent drop-off areas with queue lanes, and concrete pedestrian pavements. Site features will include hard- and soft-surface play areas and a grass playfield.

The project includes frontage improvements on 9th Street, along the west edge of the site. Frontage improvements will include curb and gutter with a 6-foot-wide sidewalk connecting to the existing sidewalk on Fir Street.

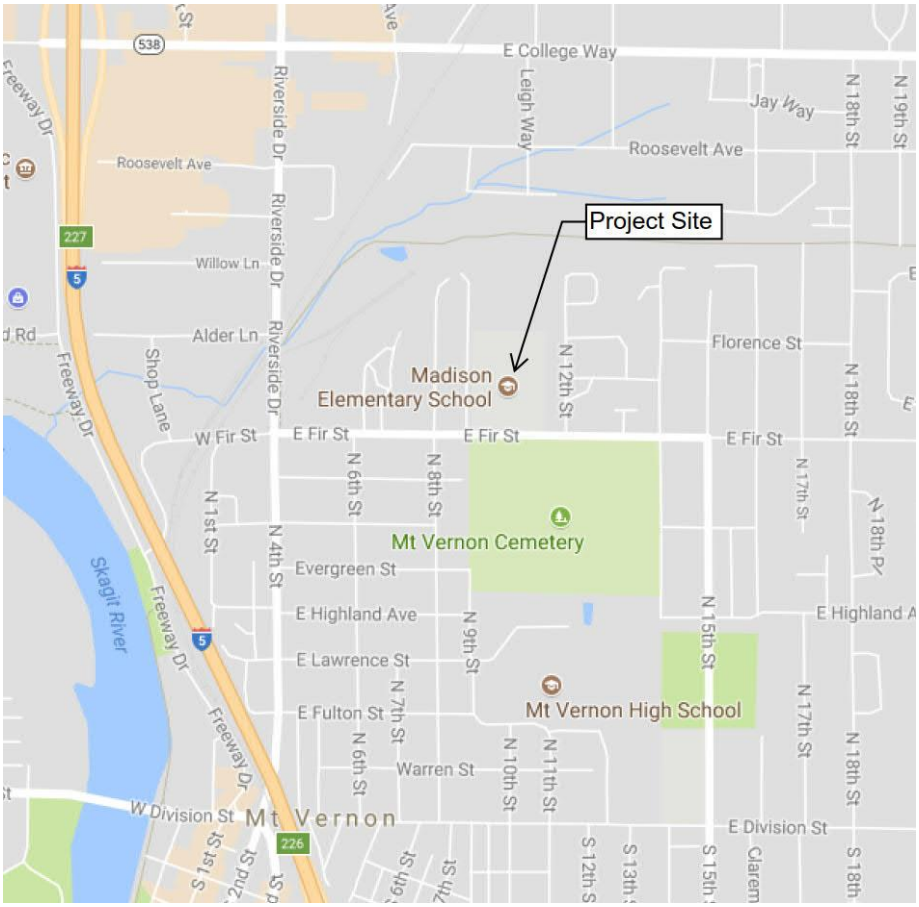


Figure 1. Vicinity Map.

METHODOLOGY

Drainage design for the project is based on Mount Vernon Municipal Code (MVMC) Drainage Code 13.33, supplemented by the Critical Areas Ordinance 15.40.

The MVMC refers to the Washington State Department of Ecology's (DOE) *Stormwater Management Manual for Western Washington* (*Stormwater Manual*) for the stormwater technical manual.

Western Washington Hydrology Model (WWHM 2012) is used for runoff and stormwater management modelling.

This project is a redevelopment project replacing more than 5,000 square feet of hard surface area and is subject to Minimum Requirements #1- #10 in the *Stormwater Manual*.

Minimum Requirement #6 Flow Control seeks to match stormwater flow rates and durations to a forested (undeveloped) condition. Minimum Requirement #8 Wetland Protection seeks to limit the change in runoff timing and volume reaching the wetland from the existing (current) condition.

The Madison Elementary School project site is currently developed with approximately 35 percent existing hard-surface coverage. Given that the existing site is highly developed, it is not possible to control flow rates and durations to match a forested predeveloped condition while maintaining the current runoff timing and volumes reaching the wetlands.

Protection of wetlands is governed by the Mount Vernon Municipal Code Critical Areas Ordinance 15.40, which supplements the drainage code. Clarification on how to apply opposing flow control and wetland protection standards was requested, and the city clarified that the intent of the ordinance is, "…*to ensure that with development, the existing wetland receives the quality and quantity of water in timing that mimics extant conditions or which improves the situation for the wetland.*" This email communication is included in Appendix C. At a meeting with the City on September 19, 2017, City staff confirmed that the target condition for flow control is the existing condition.

Stormwater management design for this project matches the timing and volume of runoff reaching the wetlands to existing (current) conditions within the limits of the wetland protection standard. Flow control provided by Low Impact Development features reduce peak flow rates and durations for most storm return intervals.

Minimum Requirement #5, On-Site Stormwater Management, will be applied to the extent possible without violating the Wetland Protection standard.

MINIMUM REQUIREMENT #1 STORMWATER SITE PLANS

Existing Conditions Summary

The project site is currently occupied by the existing Madison Elementary School. The existing site ground cover consists of building roofs, asphalt and concrete pavements, gravel pavements, and lawn. There are two existing drainage basins on the site. The basins drain to two wetlands (Wetland A and Wetland B) in the forested north parcel of the site. See Figure A-1 in Appendix A for the existing conditions and location of the wetlands and existing basins.

The basin draining to Wetland A is approximately 6.75 acres and is located on the east side of the site. This basin currently collects water from the roof of the main building, a plaza area to the south of the school, the parent parking lot, and a paved play area using roof drains, catch basins, and conveyance pipes. The drainage from these areas that is collected in pipes is discharged into the woods north of the school through an existing 10-inch PVC pipe where it outfalls directly into the woods and then flows over land to Wetland A. The portions of the existing lawn playfield and mulched playground that drain to Wetland A flow over land north into the woods and directly to the wetland.

The second basin currently drains to Wetland B and is approximately 3.5 acres along the west edge of the site, including the east half of 9th Street. The runoff from the west side of the existing school parking lot and bus loop is collected in a series of catch basins and conveyance pipes. An existing 6-inch pipe discharges to a drainage ditch that is located along the east side of 9th Street. The roof drains from the existing portables located at the northwest part of the site daylight on the west side of the portables and discharge to this ditch. The runoff from the existing gravel parking lot is collected in catch basins. The roof drain from the portable next to the gravel lot is connected to a catch basin in the gravel lot. This runoff is discharged to the drainage ditch along 9th Street by an 8-inch PVC pipe. The portions of the play field in this basin flow over land to the north towards Wetland B. Directly north of the property line, between the two parcels, the existing ditch along 9th Street turns east and continues until it discharges directly to Wetland B. This is a defined channel at its outlet to the wetland.

The soils on the site are dense silty glacial till soils with some existing fill soils placed during construction of the existing school. The existing site soils are moisture sensitive and not suitable for infiltration.

EXISTING BASINS

Tributary to Wetland A

Lawn: 4.3 acres
Roof: 1.08 acres
Pavement: 1.32 acres

Tributary to Wetland B

Lawn: 2.18 acres
Roof: 0.19 acres
Pavement: 1.14 acres

EXSITING RUNOFF

Existing flow frequency rates from WWHM 2012:

Tributary to Wetland A

2yr	1.4 cfs
10yr	2.2 cfs
50yr	4.6 cfs
100yr	5.5 cfs

Tributary to Wetland B

2yr	0.75 cfs
10yr	1.2 cfs
50yr	2.4 cfs
100yr	2.9 cfs

Downstream Analysis

The project site drains north to wetlands within a forested parcel. The wetlands drain north through a series of ditches, culverts, and wetlands along the Kulshan Trail, ultimately discharging to Kulshan Creek about 800 feet north of the site. Kulshan Creek flows west and discharges to the Skagit River.

Site Soils

A geotechnical report for this site was prepared by Geotest in 2006. The existing site soils are dense silty sand (glacial till), and fill soils overtop glacial till. The on-site soils are moisture sensitive and not suitable for infiltration systems.

Proposed Conditions Summary

The project will construct a multistory elementary school with asphalt parking lots, asphalt bus and parent drop-off areas and queue lanes, and concrete pedestrian pavements. Site features will include hard- and soft-surface play areas and a grass playfield.

Storm drainage for the site will be split into two basins tributary to Wetland A and Wetland B. The Wetland B basin includes runoff from 9th Street. The Wetland A basin includes the east portion of the school site and about 50 percent of the roof area of the new building. The Wetland B basin includes the west side of the school site and the east half of 9th Street. See Figure A-2 in Appendix A for proposed drainage basins.

Drainage is captured in a traditional pipe and catch basin system, with separate drainage systems for each basin discharging to the respective wetlands. Proposed stormwater management is discussed in the minimum requirements sections below.

PROPOSED BASINS:

Tributary to Wetland A

Lawn: 0.83 acres

Pasture (LID Soil Quality): 2.99 acres
Roof: 0.50 acres
Pavement: 2.27 acres

Tributary to Wetland B

Lawn: 1.44 acres
Pasture (LID Soil Quality): 0.98 acres
Roof: 0.46 acres
Pavement: 0.61 acres

PROPOSED RUNOFF

Proposed flow frequency rates from WWHM 2012:

Tributary to Wetland A

2yr	1.24 cfs
10yr	2.24 cfs
50yr	3.38 cfs
100yr	3.95 cfs

Tributary to Wetland B

2yr	0.60 cfs
10yr	1.19 cfs
50yr	1.88 cfs
100yr	2.24 cfs

MINIMUM REQUIREMENT #2 SWPPP

A full Stormwater Pollution Prevention Plan (SWPPP) will be prepared for the project and submitted as part of the construction permit. The SWPPP will provide guidance for the construction contractor to meet the requirements of the DOE's Construction Stormwater General Permit. A summary of Best Management Practices (BMPs) is listed below.

Element #1: Mark Clearing Limits

Silt fence will be installed along the low side of the project limits. Project limits will be marked by temporary chain link fence or plastic orange protective fence.

Element #2: Establish Construction Access

Construction entrances will be provided from Fir Street and 9th Street and will be constructed according to BMP C105 of the *Stormwater Manual*.

Element #3: Control Flow Rates

Temporary sediment ponds and sediment traps will be used to control flow rates.

Element #4: Install Sediment Controls

Sediment will be controlled using BMPs from the *Stormwater Manual*, including construction entrances and wheel washes, temporary seeding and mulching, dust control, storm drain structure inlet and outlet protection, silt fence, and sediment ponds.

Element #5: Stabilize Soils

The reconstructed slopes will be hydroseeded with an appropriate seed mix outlined in BMP C120. Mulch, blankets, or plastic sheeting will be used to stabilize soils as needed.

Element #6: Protect Slopes

Steep slopes will be protected using seeding, mulching, and blankets.

Element #7: Protect Drain Inlets

Existing and proposed catch basins at or near the project site will be equipped with inlet protection.

Element #8: Stabilize Channels and Outlets

Outlets to ditches or vegetated areas will be protected with quarry spalls or erosion blankets.

Element #9: Control Pollutants

Demolition debris will be transported off site to an approved disposal site. Materials used on the job site will be properly stored and contained, and concrete will be handled per the guidelines in the *Stormwater Manual*.

Element #10: Control De-Watering

Dewatering water will be handled the same as stormwater runoff.

Element #11: Maintain BMPs

Temporary and permanent erosion and sediment control best management practices (BMPs) shall be maintained and repaired as needed to ensure continued performance of their intended function. Maintenance and repair shall be conducted in accordance with BMP specifications.

Element #12: Manage the Project

Clearing and grading activities shall be permitted only if conducted pursuant to an approved site development plan that establishes permitted areas of grading, cutting, and filling. The contractor will be required to have a Certified Erosion Control Lead (CESCL) on site during the work.

MINIMUM REQUIREMENT #3 POLLUTION SOURCE CONTROL

Pollution Source Control BMPs will be implemented during construction to prevent pollution. Proposed BMPs will be per the requirements of the *Stormwater Manual* and will include but are not limited to the following:

BMP C101, Preserving Natural Vegetation
BMP C103, High Visibility Fence
BMP C105, Construction Entrance
BMP C106, Wheel Wash
BMP C107, Construction Road/Parking Area Stabilization
BMP C120, Temporary and Permanent Seeding
BMP C121, Mulching
BMP C123, Plastic Covering
BMP C125, Topsoiling/Composting
BMP C130, Surface Roughening
BMP C140, Dust Control
BMP C150, Materials on Hand
BMP C151, Concrete Handling
BMP C152, Sawcutting and Surfacing Pollution Prevention
BMP C153, Material Delivery, Storage, and Containment
BMP C154, Concrete Washout Area
BMP C160, Certified Erosion and Sediment Control Lead (CESCL)
BMP C200, Interceptor Dike and Swale
BMP C201, Grass-Lined Channels
BMP C207, Checkdams
BMP C209, Outlet Protection
BMP C220, Storm Inlet Protection
BMP C233, Silt Fence
BMP C241, Temporary Sediment Pond

MINIMUM REQUIREMENT #4: PRESERVATION OF NATURAL DRAINAGE

The project side is currently developed and drains to two wetlands on the forested parcel north of the site. No work is planned within the wetlands or wetlands buffers to protect the wetlands and preserve the natural drainage characteristics. Stormwater design for the site will match the existing volumes and timing of runoff to each wetland within the Wetland Protection standards of the *Stormwater Manual*.

MINIMUM REQUIREMENT #5: ON-SITE STORMWATER MANAGEMENT

This project is a redevelopment project that replaces more than 5,000 square feet of hard surfaces, and Minimum Requirement #5 applies. Low Impact Development (LID) features from List #2 are proposed for this project.

Due to existing site soils and topography, permeable pavements are not suitable for this site.

Bio-retention areas will be provided for pavement and roof areas. Lawn and landscape areas will utilize Post Construction Quality and Depth (BMP T5.13).

Per Minimum Requirement #5, bio-retention area should be provided for 5 percent of the pavement and roof area. The existing site is currently developed with a significant amount of existing hard surface that drains to the wetlands. Applying bio-retention to 5 percent of the proposed hard surface modifies the volume and timing of water reaching the existing wetlands and violates the Wetlands Protection standard (Minimum Requirement #8). As such, bio-retention areas are proposed up to the amount possible without violating the Wetland Protection standard but will not equal 5 percent of the proposed hard surfaces.

MINIMUM REQUIREMENT #6: RUNOFF TREATMENT

This project includes more than 5,000 square feet of pollution-generating surface and requires stormwater quality treatment per Minimum Requirement #6. This site does not require oil control as it does not cross the threshold of 100 vehicles per day per 1,000 square feet of building.

Enhanced treatment is required as this is a commercial project (school) that discharges to wetlands that outfall to a fresh water stream.

Water quality treatment will be provided meeting the requirements of the *Stormwater Manual*. For the Master Plan, water quality treatment is assumed to be provided by Modular Wetland filter vaults approved by the DOE for General Use to provide enhanced treatment. Three treatment vaults are proposed for the project. The vaults will be sized to treat the 91 percent water quality flow rate calculated by WWHM.

Modular Wetland Vault #1 will treat runoff tributary to Wetland A on the east side of the site.

Modular Wetland Vault #2 will treat runoff from the school site tributary to Wetland B on the west side of the site.

Modular Wetland Vault #3 will treat runoff from 9th Street tributary to Wetland B on the west side of the site.

Figures 2 through 4 below show sizing calculations for the Modular Wetlands.

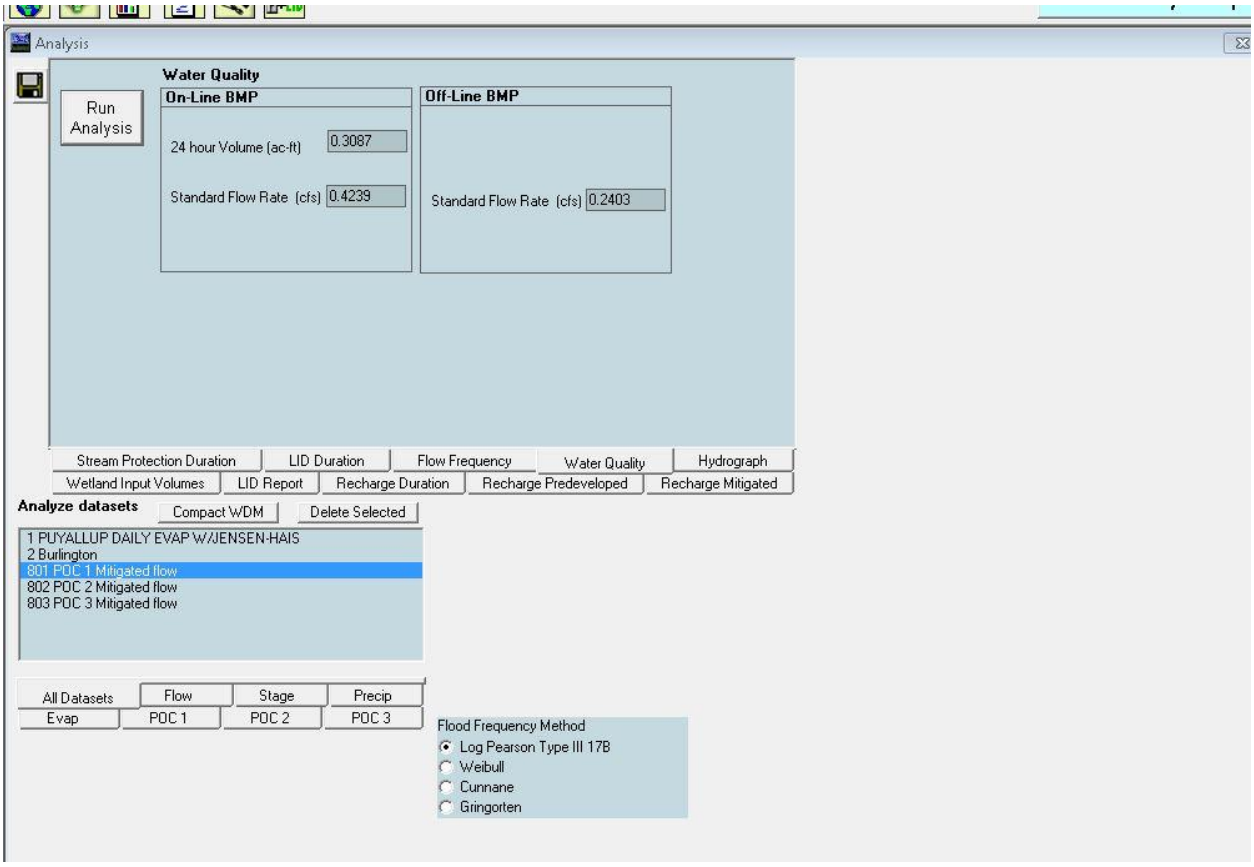


Figure 2. Water Quality Flow for Modular Wetland Vault #1.

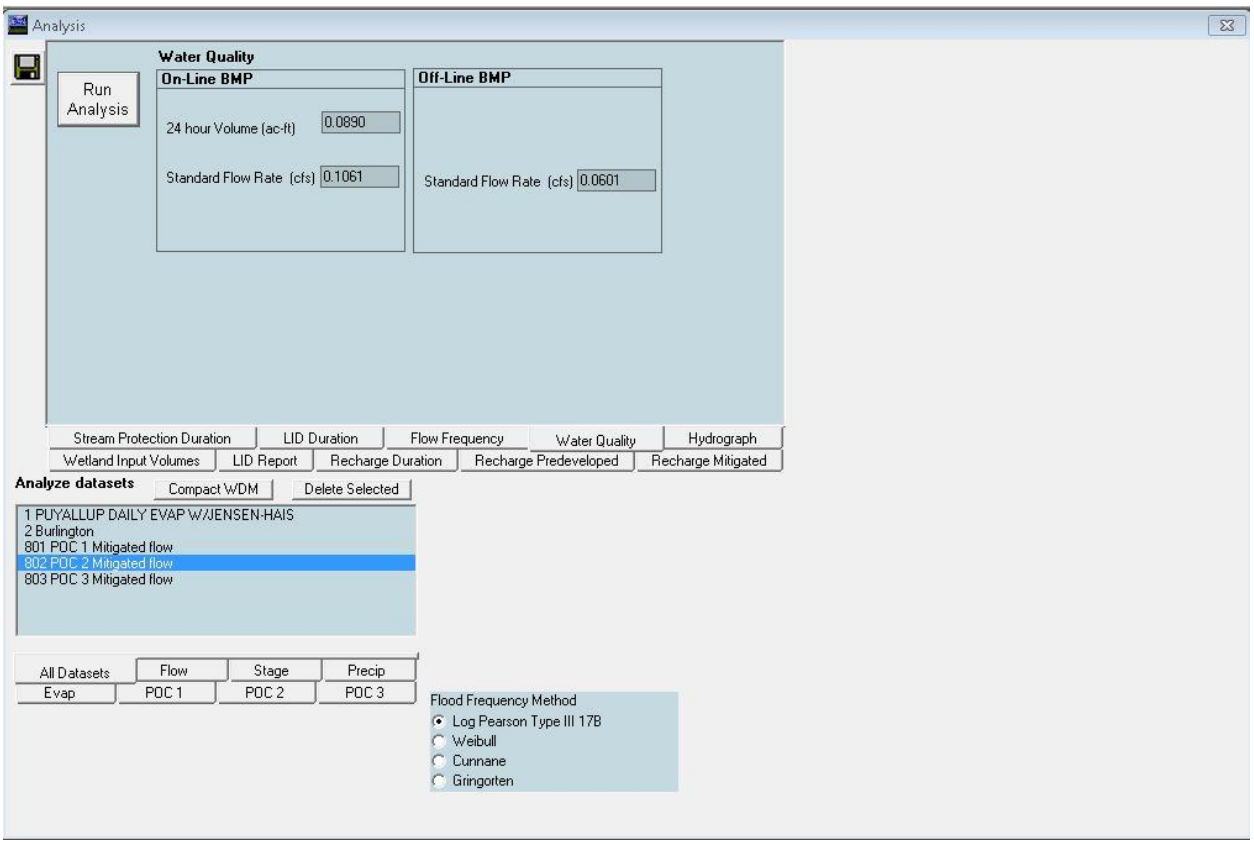


Figure 3. Water Quality Flow for Modular Wetland Vault #2.

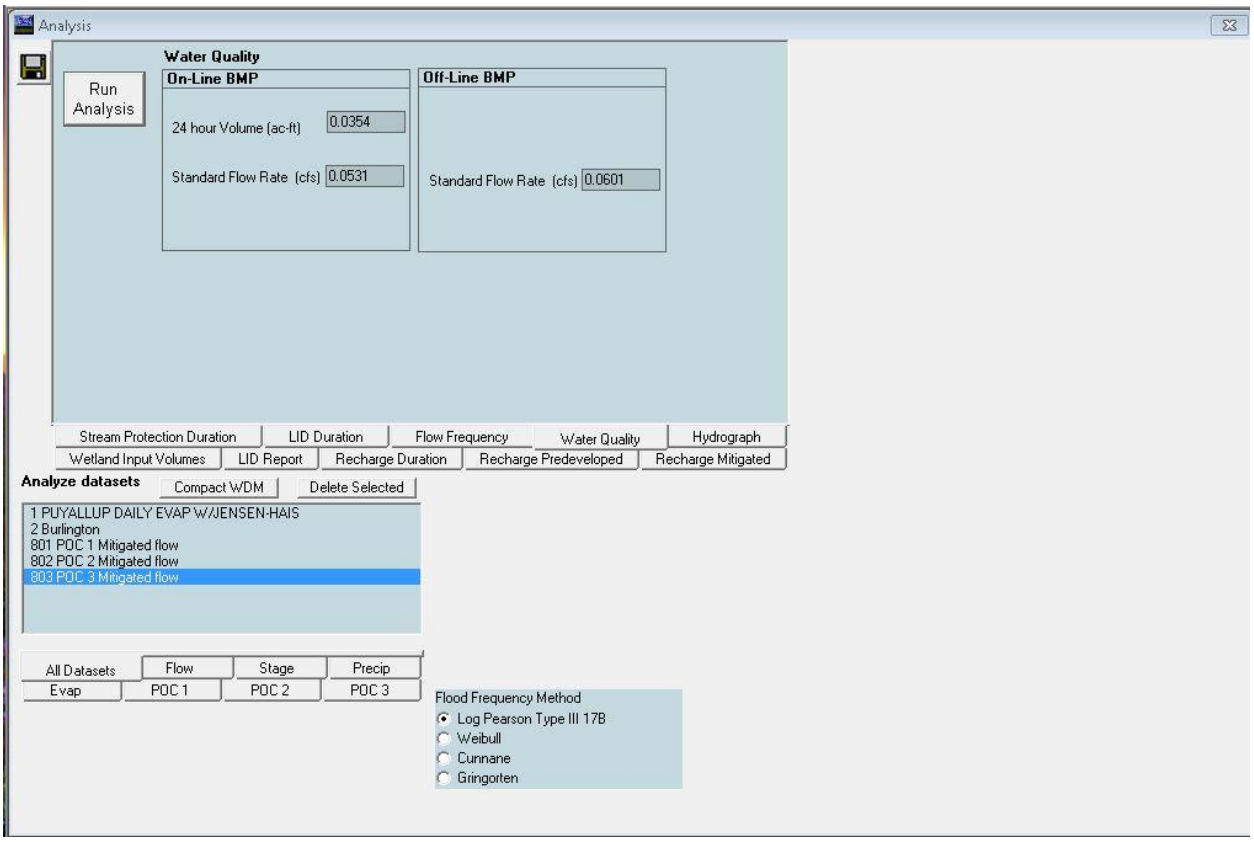


Figure 4. Water Quality Flow to Modular Wetland #3.

Modular Wetland #1 will be an 8-foot by 8-foot vault treating 0.24 cfs.

Modular Wetland #2 and #3 will be 4-foot by 6-foot vaults treating 0.06 cfs.

DOE General Use Designation for the Modular Wetland system is included in Appendix B.

As the project advances through design to construction documents, the selected water quality system may change. Final water quality system details meeting the requirements of the *Stormwater Manual* will be submitted with the building permit submittal.

The bioretention cell located upstream of the Modular Wetland Vault #1 will provide supplementary treatment but is not counted in the water quality vault sizing calculations.

MINIMUM REQUIREMENT #7: FLOW CONTROL

This project includes more than 5,000 square feet of replaced hard surfaces and is subject to Minimum Requirement #7. Flow control (detention) to match a forested condition is not proposed for this project in order to comply with the Wetland Protection standard as described in the Methodology section above.

While the project is not proposing detention, post-project runoff frequencies and durations will both be reduced from the existing (current) condition while meeting the Wetland Protection standard. This is due to the use of bio-retention cells and Post Construction Quality and Depth topsoil for landscape areas. Figures 5 through 8 below show the reduced flow frequency and durations for both Wetland A and Wetland B basins.

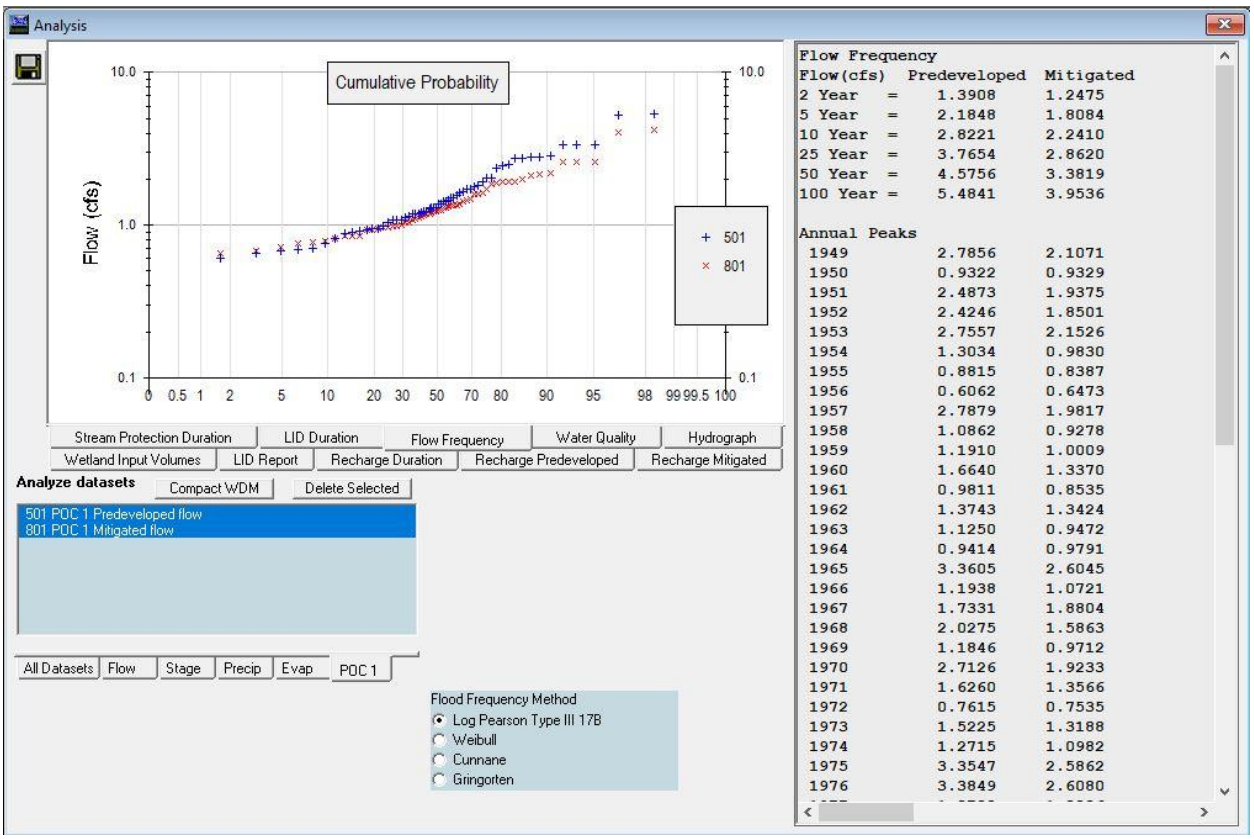
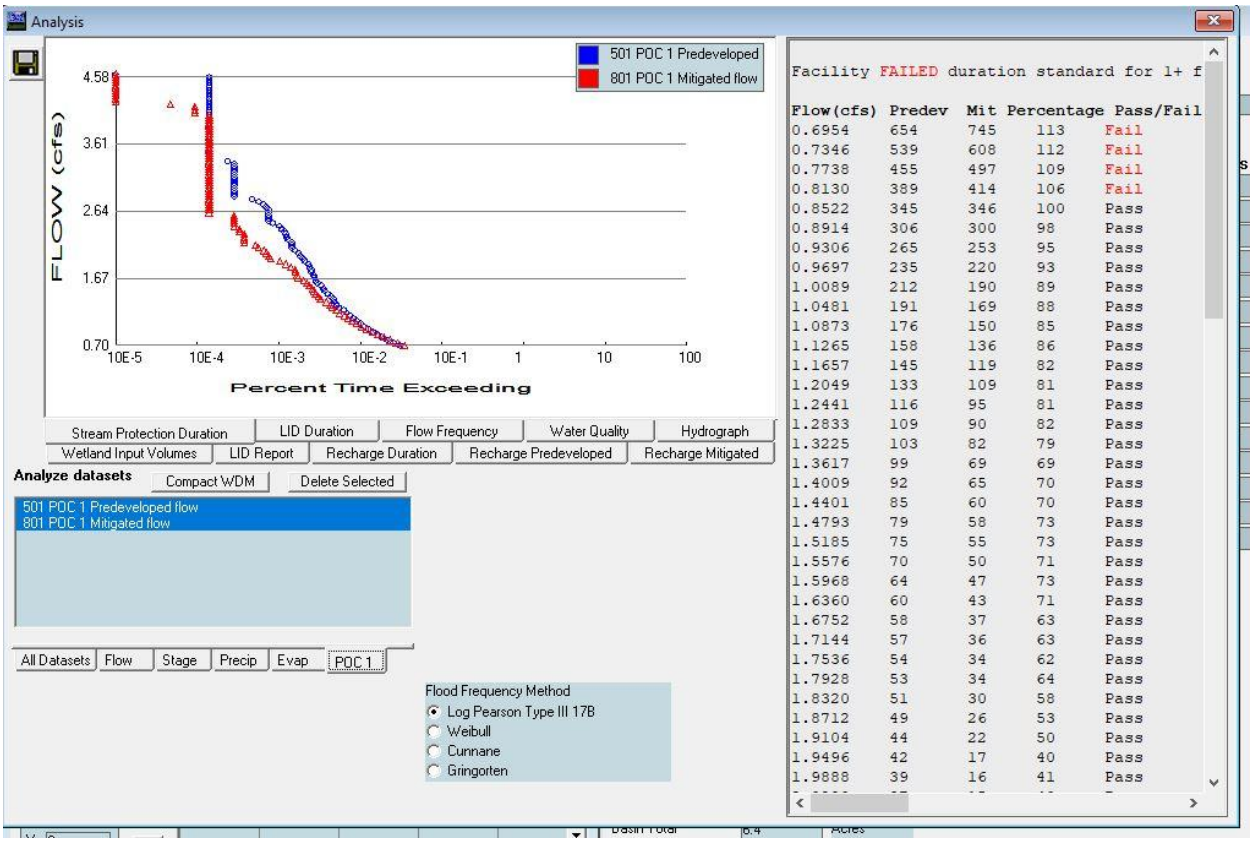


Figure 5. Proposed Reduction in Flow Frequency for Wetland A Basin.



Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.6954	654	745	113	Fail
0.7346	539	608	112	Fail
0.7738	455	497	109	Fail
0.8130	389	414	106	Fail
0.8522	345	346	100	Pass
0.8914	306	300	98	Pass
0.9306	265	253	95	Pass
0.9697	235	220	93	Pass
1.0089	212	190	89	Pass
1.0481	191	169	88	Pass
1.0873	176	150	85	Pass
1.1265	158	136	86	Pass
1.1657	145	119	82	Pass
1.2049	133	109	81	Pass
1.2441	116	95	81	Pass
1.2833	109	90	82	Pass
1.3225	103	82	79	Pass
1.3617	99	69	69	Pass
1.4009	92	65	70	Pass
1.4401	85	60	70	Pass
1.4793	79	58	73	Pass
1.5185	75	55	73	Pass
1.5576	70	50	71	Pass
1.5968	64	47	73	Pass
1.6360	60	43	71	Pass
1.6752	58	37	63	Pass
1.7144	57	36	63	Pass
1.7536	54	34	62	Pass
1.7928	53	34	64	Pass
1.8320	51	30	58	Pass
1.8712	49	26	53	Pass
1.9104	44	22	50	Pass
1.9496	42	17	40	Pass
1.9888	39	16	41	Pass

Figure 6. Proposed Reduction in Runoff Flow Durations in Wetland A Basin.

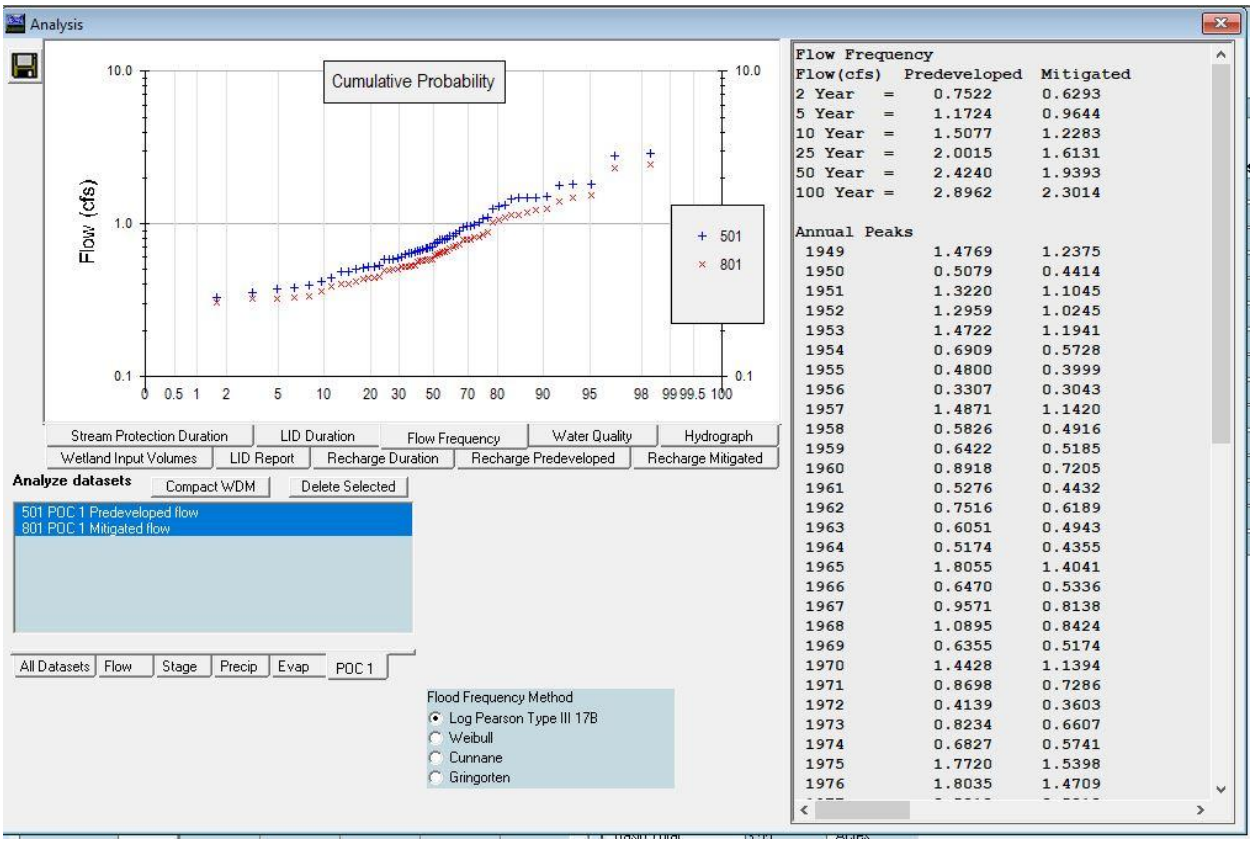


Figure 7. Proposed Reduction in Flow Frequency for Wetland B Basin.

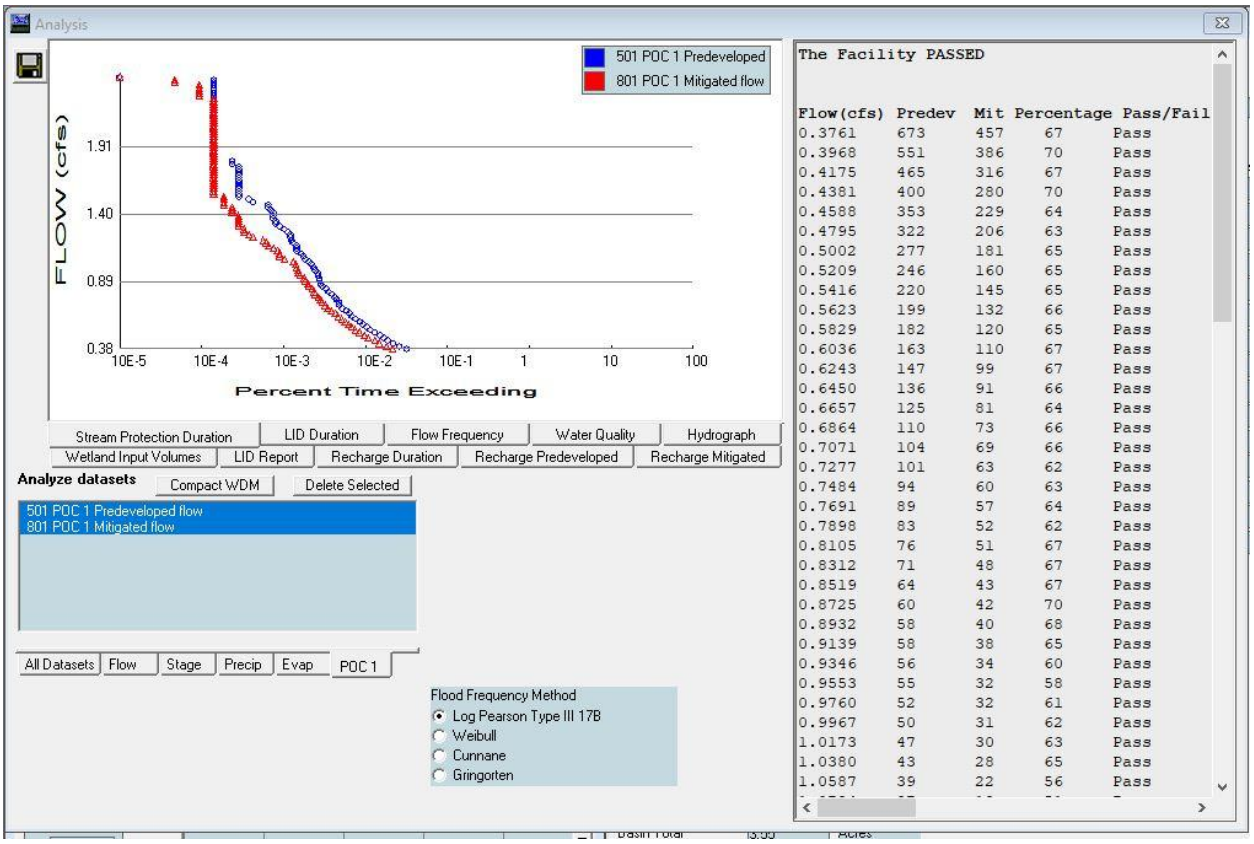


Figure 8. Proposed Reduction in Runoff Flow Durations in Wetland B Basin.

MINIMUM REQUIREMENT #8: WETLANDS PROTECTION

The project site drains to two wetlands on Parcel 2 to the north. The wetlands are designated Wetland A and Wetland B. As discussed in the Methodology section above, the intent of the Wetlands Protection standard is that the post-project condition mimics the pre-project runoff volume and timing to the wetlands.

Per the *Stormwater Manual* Appendix 1-D, the WWHM was used to model the existing and post-project runoff volumes to the wetlands on a daily and monthly basis. The Wetland Protection Standard is that the volumes to the wetland do not change by more than 20 percent for any given day and 15 percent for any given month.

Figure 9 and Figure 10 below show modelling results depicting that the post-project runoff meets the wetland protection standard for both Wetland A and Wetland B.

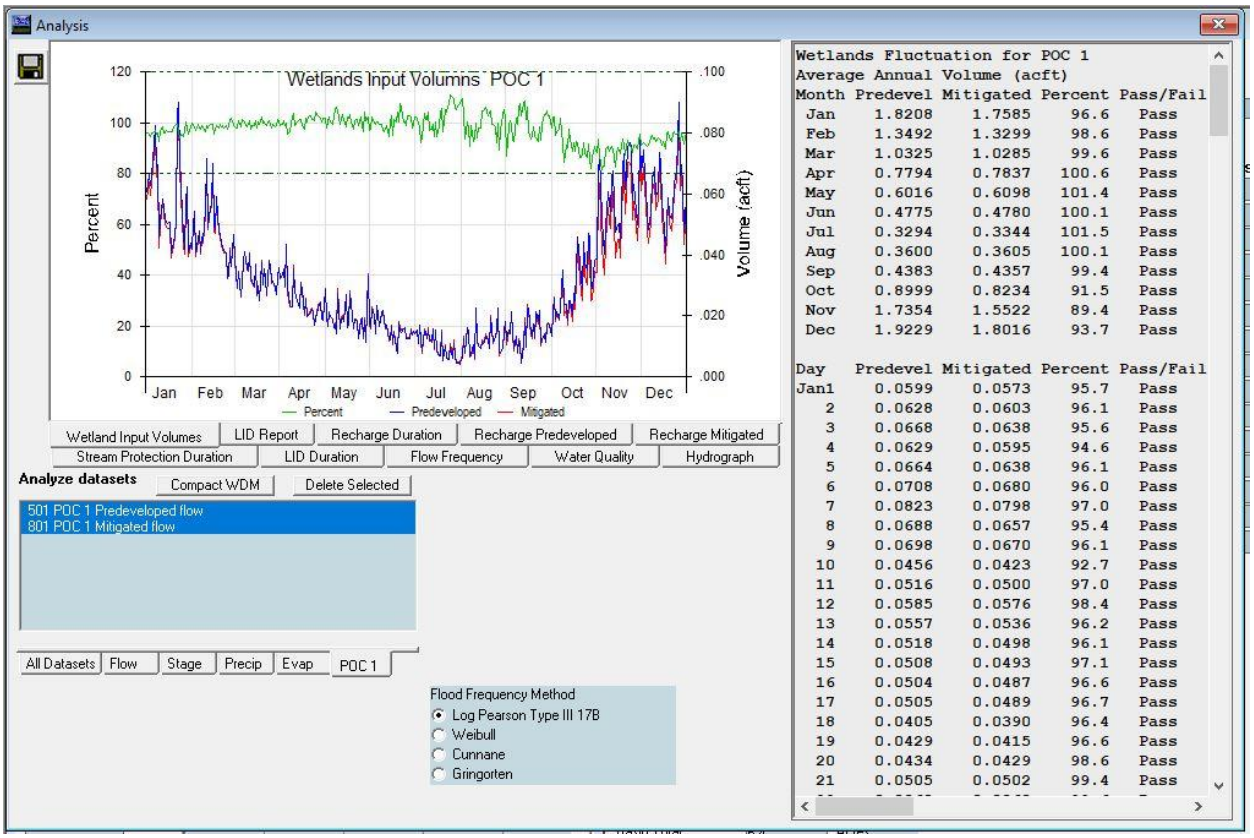
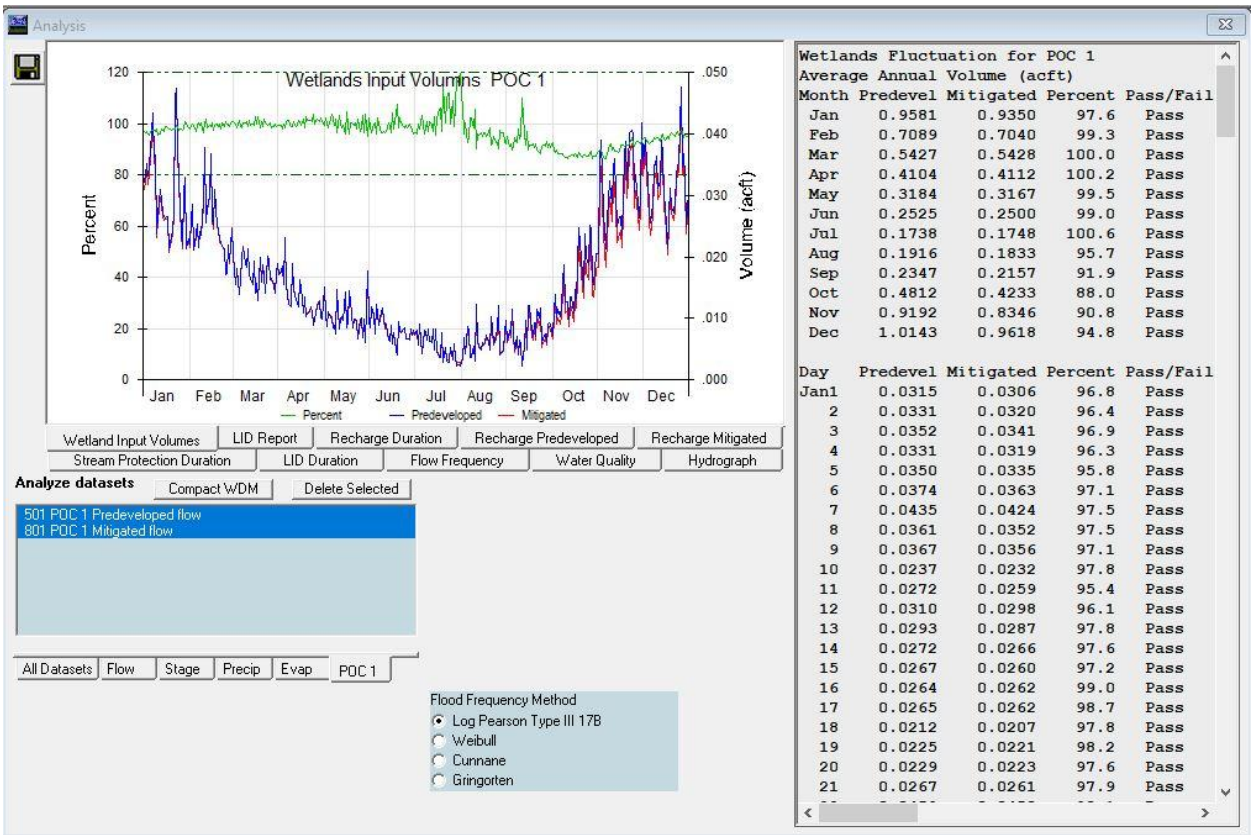


Figure 9. Pre and Post Project Runoff Volumes to Wetland A.



Wetlands Fluctuation for POC 1
Average Annual Volume (acft)

Month	Predevel	Mitigated	Percent	Pass/Fail
Jan	0.9581	0.9350	97.6	Pass
Feb	0.7089	0.7040	99.3	Pass
Mar	0.5427	0.5428	100.0	Pass
Apr	0.4104	0.4112	100.2	Pass
May	0.3184	0.3167	99.5	Pass
Jun	0.2525	0.2500	99.0	Pass
Jul	0.1738	0.1748	100.6	Pass
Aug	0.1916	0.1833	95.7	Pass
Sep	0.2347	0.2157	91.9	Pass
Oct	0.4812	0.4233	88.0	Pass
Nov	0.9192	0.8346	90.8	Pass
Dec	1.0143	0.9618	94.8	Pass

Day	Predevel	Mitigated	Percent	Pass/Fail
Jan1	0.0315	0.0306	96.8	Pass
2	0.0331	0.0320	96.4	Pass
3	0.0352	0.0341	96.9	Pass
4	0.0331	0.0319	96.3	Pass
5	0.0350	0.0335	95.8	Pass
6	0.0374	0.0363	97.1	Pass
7	0.0435	0.0424	97.5	Pass
8	0.0361	0.0352	97.5	Pass
9	0.0367	0.0356	97.1	Pass
10	0.0237	0.0232	97.8	Pass
11	0.0272	0.0259	95.4	Pass
12	0.0310	0.0298	96.1	Pass
13	0.0293	0.0287	97.8	Pass
14	0.0272	0.0266	97.6	Pass
15	0.0267	0.0260	97.2	Pass
16	0.0264	0.0262	99.0	Pass
17	0.0265	0.0262	98.7	Pass
18	0.0212	0.0207	97.8	Pass
19	0.0225	0.0221	98.2	Pass
20	0.0229	0.0223	97.6	Pass
21	0.0267	0.0261	97.9	Pass

Figure 10. Pre- and Post-Runoff Volumes to Wetland B.

No work is planned within the wetlands or their buffers.

MINIMUM REQUIREMENT #9 BASIN PLANNING

No basin planning is required for this project beyond the *Stormwater Manual*.

MINIMUM REQUIREMENT #10: OPERATION AND MAINTENANCE

Operation and maintenance will be determined by the requirements of the *Stormwater Manual* and by the manufacturers of the selected water quality devices. Detail on specific maintenance and operations practices and procedures will be provided with the construction permit application.

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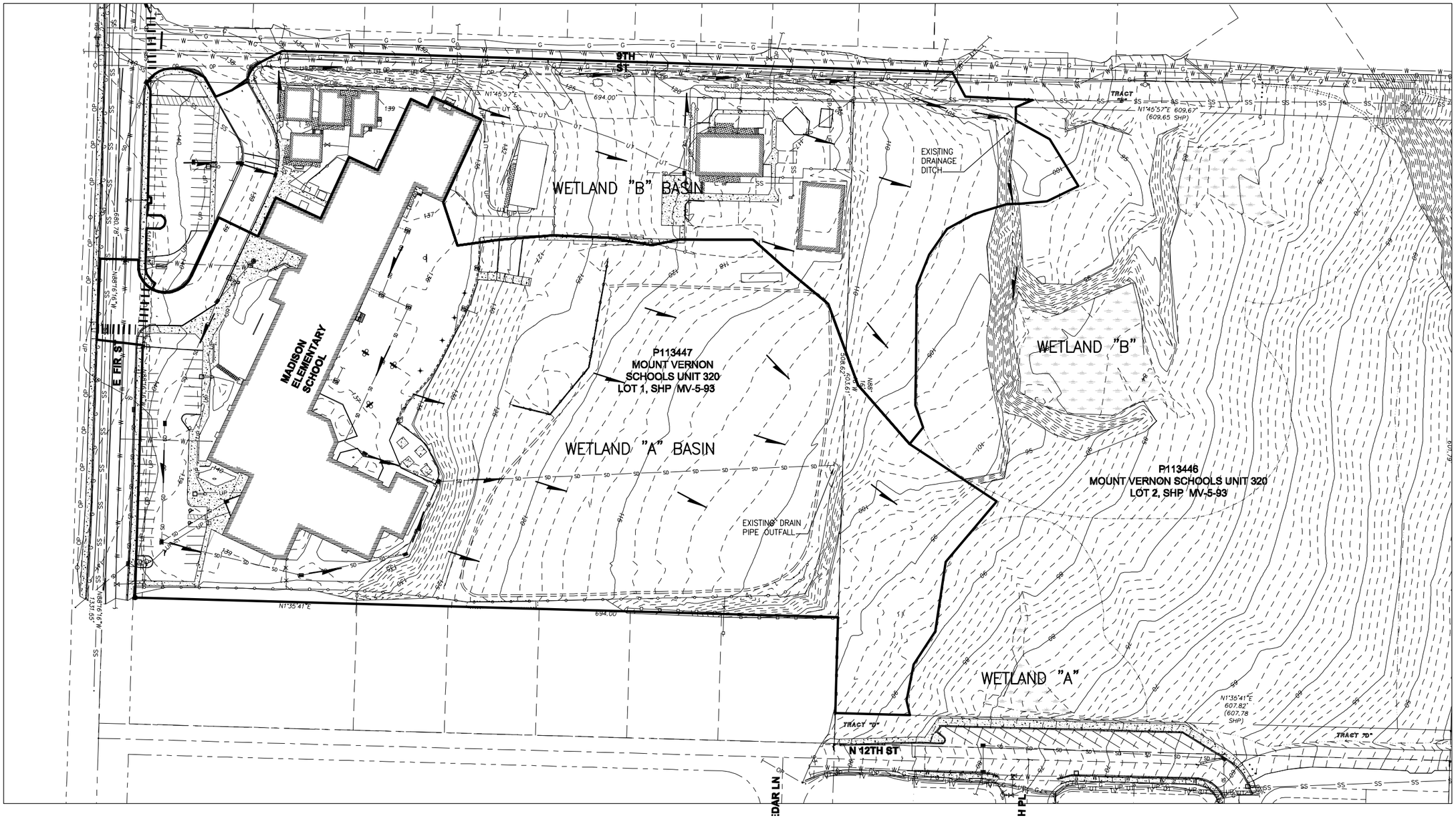
Appendix A
Drawings

EXISTING DRAINAGE BASINS			
WETLAND A		WETLAND B	
LAND COVER	AREA (ACRES)	LAND COVER	AREA (ACRES)
LAWN, MODERATE SLOPE, TYPE C SOIL	4.3	LAWN, MODERATE SLOPE, TYPE C SOIL	2.18
ROOF, FLAT SLOPE	1.08	ROOF, FLAT SLOPE	.19
PAVED, FLAT SLOPE	1.32	PAVED, FLAT SLOPE	1.14
TOTAL	6.7	TOTAL	3.51



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LYDIG

Mount Vernon Schools

Project Title
MADISON ELEMENTARY SCHOOL
907 EAST FIR STREET
MOUNT VERNON, WA 98273

Project Numbers

MASTER PLANNING
NOT FOR CONSTRUCTION

Revision & Issue Dates
FEBRUARY 7, 2018 MASTER PLANNING

SCALE IN FEET
50 0 50 100

Sheet Title
EXISTING SITE DRAINAGE BASINS

Drawn By Checked By

Sheet Number
FIG A-1

Sheet Number Of

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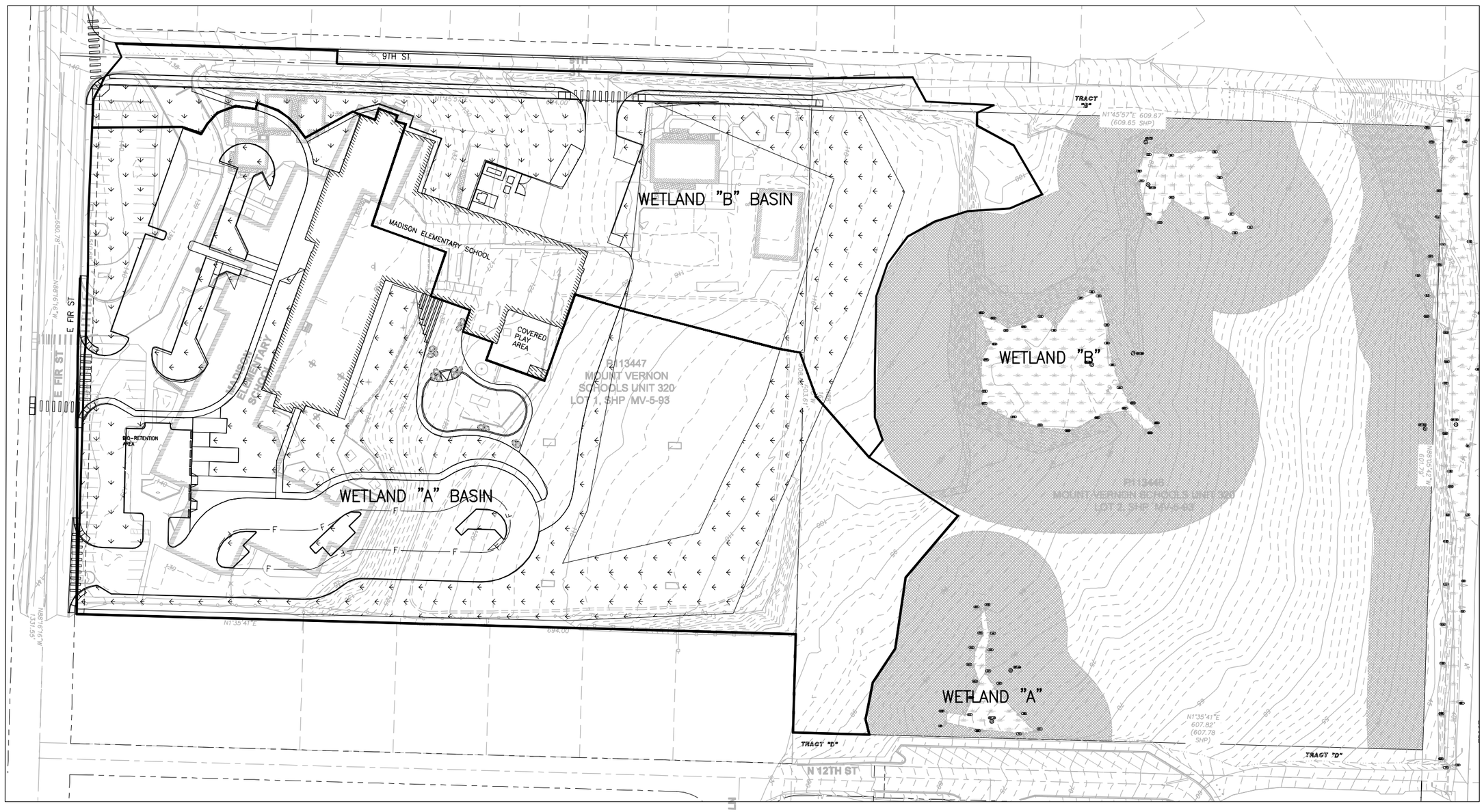
PROPOSED DRAINAGE BASINS			
WETLAND A		WETLAND B	
LAND COVER	AREA (ACRES)	LAND COVER	AREA (ACRES)
TO BIO-RETENTION			
BIO-RETENTION FACILITY	0.03		
ENHANCED SOILS, FLAT SLOPE, TYPE C	0.11		
PAVED, FLAT SLOPE	0.08		
DIRECT DISCHARGE TO WETLAND		DIRECT DISCHARGE TO WETLAND	
ENHANCED SOILS, STEEP SLOPE, TYPE C	0.83	ENHANCED SOILS, STEEP SLOPE, TYPE C	0.65
ENHANCED SOILS, FLAT SLOPE, TYPE C	2.05	ENHANCED SOILS, FLAT SLOPE, TYPE C	0.33
LAWN, FLAT SLOPE, TYPE C	0.83	LAWN, FLAT SLOPE, TYPE C	0.96
ROOF, FLAT SLOPE	0.50	ROOF, FLAT SLOPE	0.46
PAVED, FLAT SLOPE	2.19	PAVED, FLAT SLOPE	0.67
TOTAL	6.62	TOTAL	3.55



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FEBRUARY 7, 2018 MASTER PLANNING

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Sheet Title
PROPOSED SITE DRAINAGE BASINS

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Sheet Number
FIG A-2

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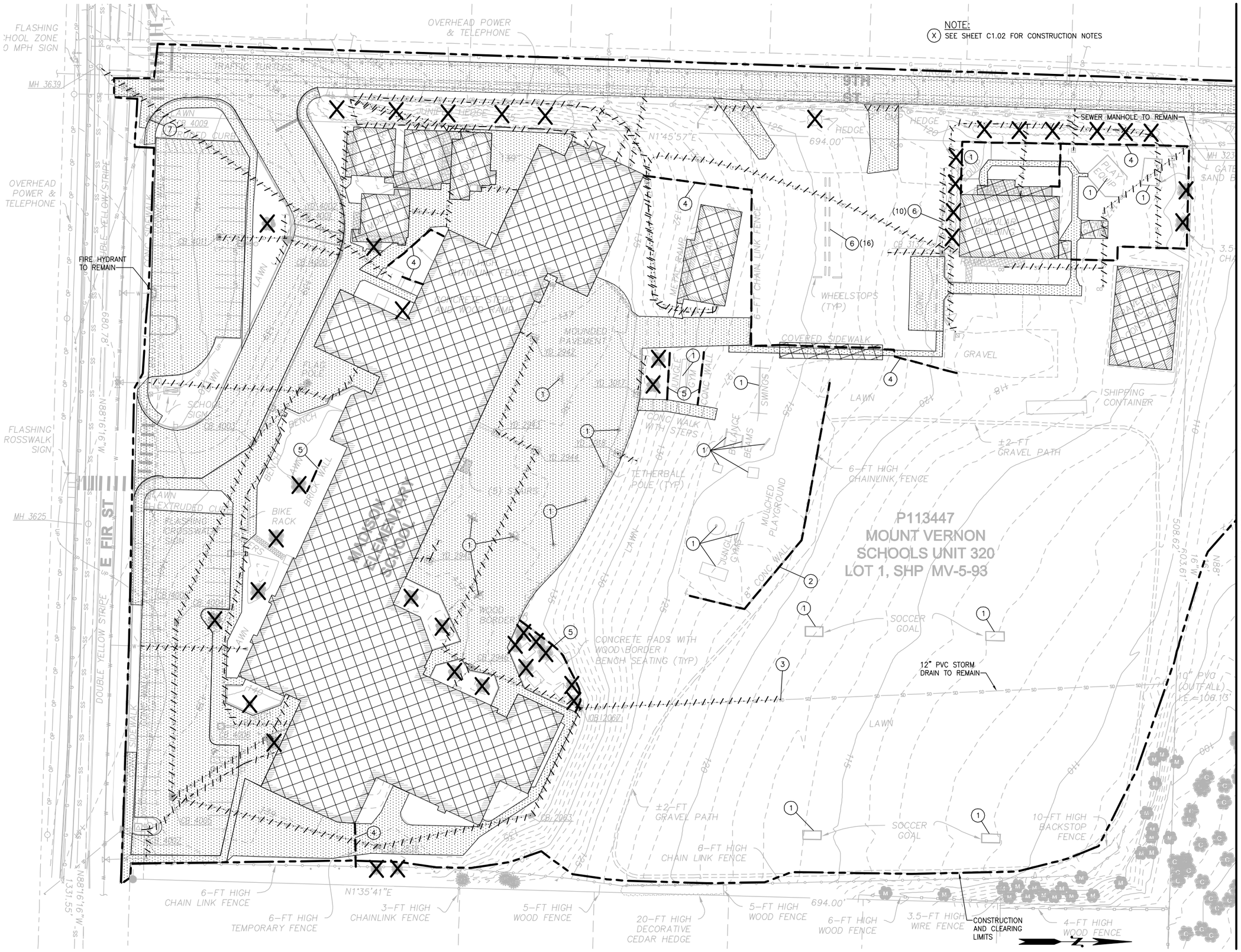

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DESIGN DEVELOPMENT
NOT FOR CONSTRUCTION

Revision & Issue Dates

JULY 28, 2017 — SCHEMATIC DESIGN

SCALE IN FEET
30 0 30 60

Sheet Title
CLEARING AND DEMOLITION PLAN

Drawn By — Checked By

Sheet Number
C 1.01

Sheet Number — Of

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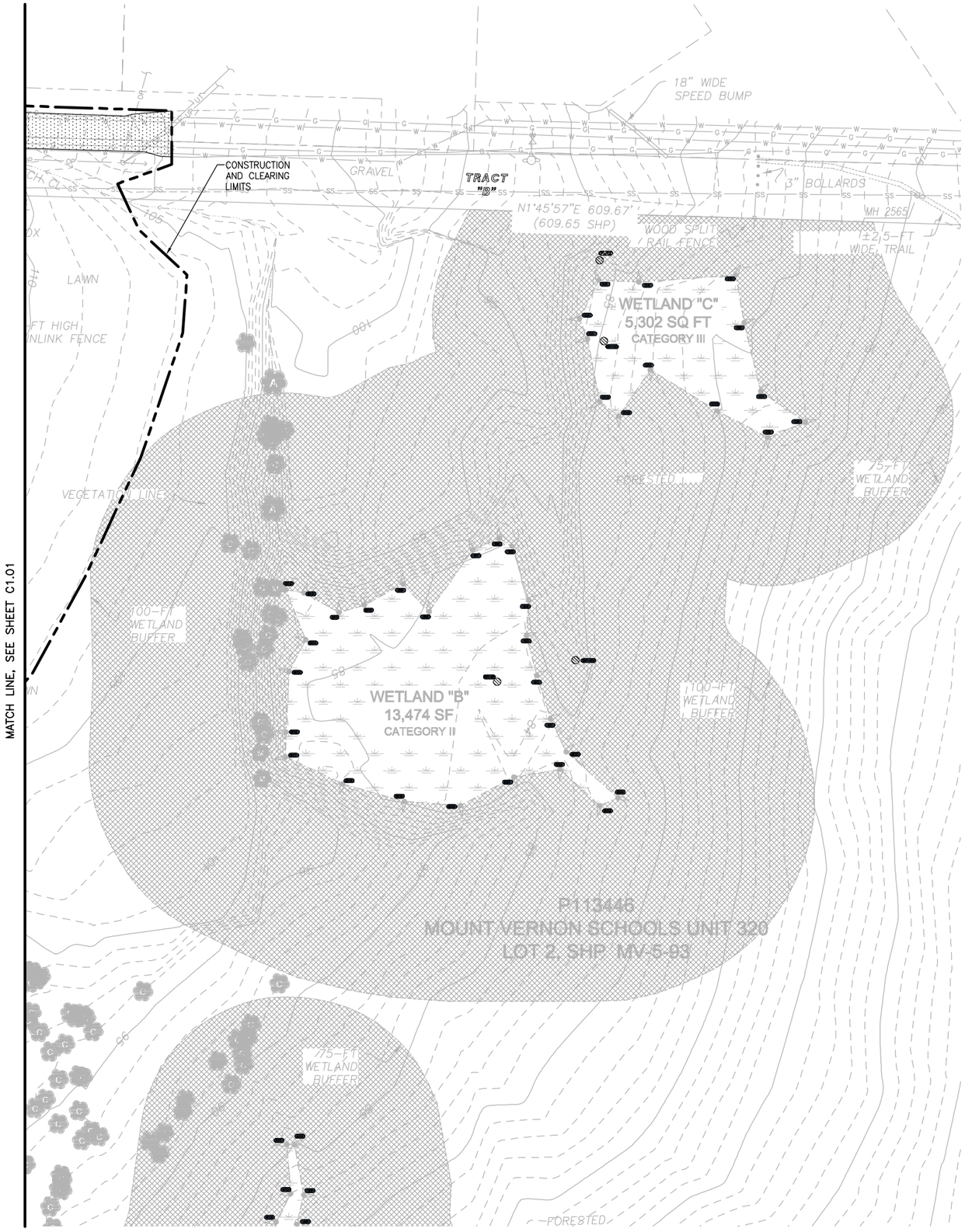

DEMOLITION LEGEND

- DEMOLISH OR ABANDON UTILITY LINE
- DEMOLISH BUILDING
- DEMOLISH PAVEMENT AND CURBS
- DEMOLISH TREE, BUSH OR HEDGE
- CLEARING/DEMOLITION LIMITS
- DEMOLISH SURFACE FEATURE SEE DEMOLITION CONSTRUCTION NOTES

DEMOLITION CONSTRUCTION NOTES:

1. DEMOLISH PLAYGROUND EQUIPMENT
2. DEMOLISH 8" CONCRETE WALL AND CHAIN LINK FENCE, APPROXIMATELY 205 LF
3. ABANDON 12" PVC STORM DRAIN SOUTH OF NEW CB #5. SEE SHEET C4.01.
4. DEMOLISH CHAIN LINK FENCE AND GATES
5. DEMOLISH WALL
6. DEMOLISH WHEEL STOPS
7. DEMOLISH TYPE 1 CATCH BASIN. PROTECT PIPES TO REMAIN. SEE SHEET C4.01.

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NOT FOR CONSTRUCTION

Revision & Issue Dates
JULY 28, 2017 SCHEMATIC DESIGN

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30 0 30 60

Sheet Title
CLEARING AND DEMOLITION PLAN

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Sheet Number
C 1.02

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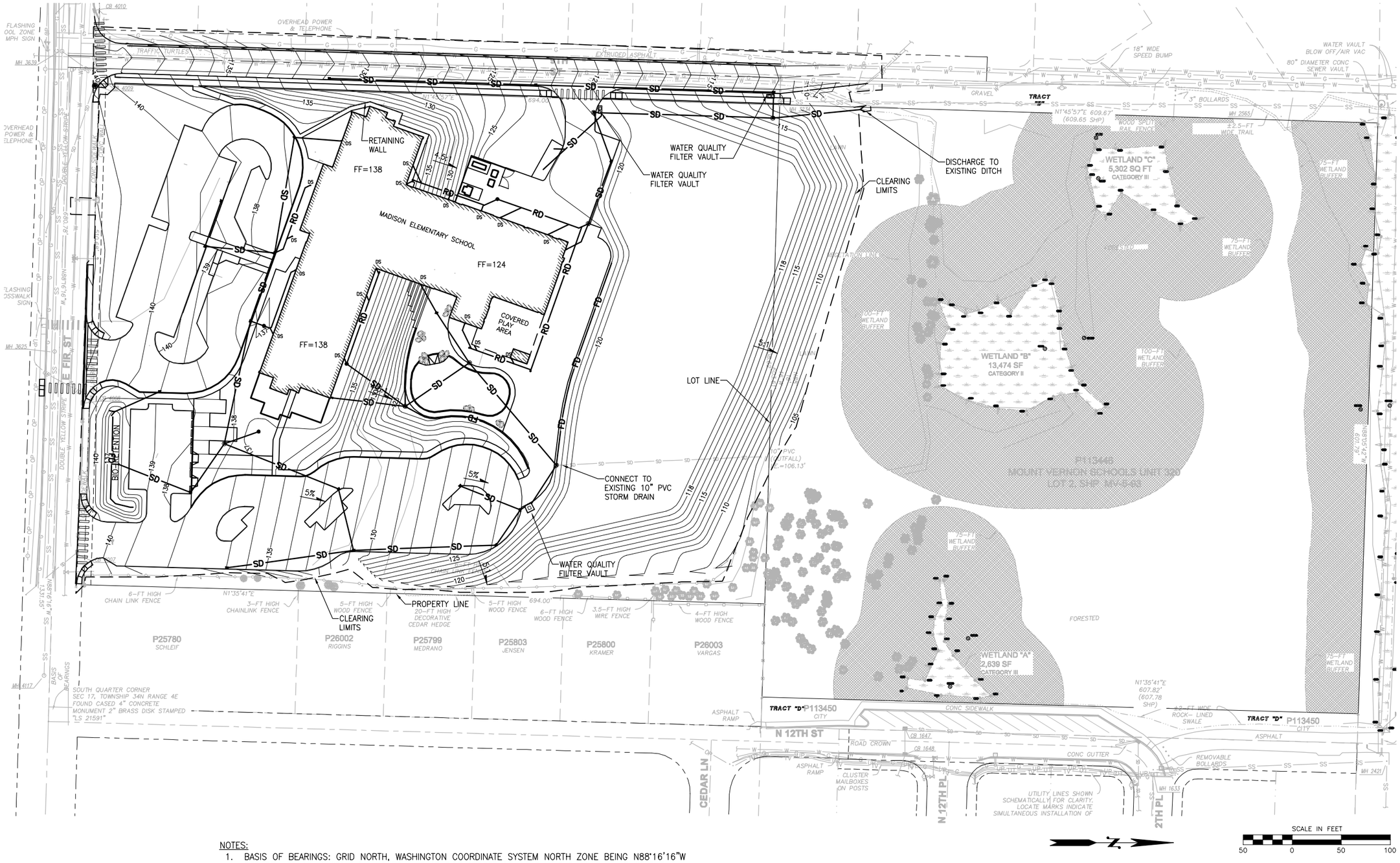

NOTES:

1. BASIS OF BEARINGS: GRID NORTH, WASHINGTON COORDINATE SYSTEM NORTH ZONE BEING N88°16'16"W BETWEEN FOUND CASED MONUMENTS IN EAST FIRE STREET DELINEATING THE SOUTH LINE OF THE SOUTHEAST QUARTER OF THE SOUTHWEST QUARTER OF SECTION 17, T 34 NORTH, RANGE 4 EAST, W.M.
2. VERTICAL DATUM IS NAVD 88 BASED ON GPS OBSERVATIONS.

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Project Numbers

MASTER PLANNING
NOT FOR CONSTRUCTION

Revision & Issue Dates
FEBRUARY 7, 2018 MASTER PLANNING

Sheet Title
MASTER PLAN GRADING & DRAINAGE PLAN

Drawn By Checked By

Sheet Number
C 2.00

Sheet Number Of

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Appendix B
Calculations

WASHINGTON STATE DEPARTMENT OF ECOLOGY

July 2017

GENERAL USE LEVEL DESIGNATION FOR BASIC, ENHANCED, AND PHOSPHORUS TREATMENT

For the

MWS-Linear Modular Wetland

Ecology's Decision:

Based on Modular Wetland Systems, Inc. application submissions, including the Technical Evaluation Report, dated April 1, 2014, Ecology hereby issues the following use level designation:

1. General use level designation (GULD) for the MWS-Linear Modular Wetland Stormwater Treatment System for Basic treatment
   - Sized at a hydraulic loading rate of 1 gallon per minute (gpm) per square foot (sq ft) of wetland cell surface area. For moderate pollutant loading rates (low to medium density residential basins), size the Prefilters at 3.0 gpm/sq ft of cartridge surface area. For high loading rates (commercial and industrial basins), size the Prefilters at 2.1 gpm/sq ft of cartridge surface area.
2. General use level designation (GULD) for the MWS-Linear Modular Wetland Stormwater Treatment System for Phosphorus treatment
   - Sized at a hydraulic loading rate of 1 gallon per minute (gpm) per square foot (sq ft) of wetland cell surface area. For moderate pollutant loading rates (low to medium density residential basins), size the Prefilters at 3.0 gpm/sq ft of cartridge surface area. For high loading rates (commercial and industrial basins), size the Prefilters at 2.1 gpm/sq ft of cartridge surface area.
3. General use level designation (GULD) for the MWS-Linear Modular Wetland Stormwater Treatment System for Enhanced treatment
   - Sized at a hydraulic loading rate of 1 gallon per minute (gpm) per square foot (sq ft) of wetland cell surface area. For moderate pollutant loading rates (low to medium density residential basins), size the Prefilters at 3.0 gpm/sq ft of cartridge surface area. For high loading rates (commercial and industrial basins), size the Prefilters at 2.1 gpm/sq ft of cartridge surface area.

4. Ecology approves the MWS - Linear Modular Wetland Stormwater Treatment System units for Basic, Phosphorus, and Enhanced treatment at the hydraulic loading rate listed above. Designers shall calculate the water quality design flow rates using the following procedures:

   - Western Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using the latest version of the Western Washington Hydrology Model or other Ecology-approved continuous runoff model.
   - Eastern Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using one of the three methods described in Chapter 2.2.5 of the Stormwater Management Manual for Eastern Washington (SWMMEW) or local manual.
   - Entire State: For treatment installed downstream of detention, the water quality design flow rate is the full 2-year release rate of the detention facility.

5. These use level designations have no expiration date but may be revoked or amended by Ecology, and are subject to the conditions specified below.

Ecology's Conditions of Use:

Applicants shall comply with the following conditions:

1. Design, assemble, install, operate, and maintain the MWS – Linear Modular Wetland Stormwater Treatment System units, in accordance with Modular Wetland Systems, Inc. applicable manuals and documents and the Ecology Decision.
2. Each site plan must undergo Modular Wetland Systems, Inc. review and approval before site installation. This ensures that site grading and slope are appropriate for use of a MWS – Linear Modular Wetland Stormwater Treatment System unit.
3. MWS – Linear Modular Wetland Stormwater Treatment System media shall conform to the specifications submitted to, and approved by, Ecology.
4. The applicant tested the MWS – Linear Modular Wetland Stormwater Treatment System with an external bypass weir. This weir limited the depth of water flowing through the media, and therefore the active treatment area, to below the root zone of the plants. This GULD applies to MWS – Linear Modular Wetland Stormwater Treatment Systems whether plants are included in the final product or not.
5. Maintenance: The required maintenance interval for stormwater treatment devices is often dependent upon the degree of pollutant loading from a particular drainage basin. Therefore, Ecology does not endorse or recommend a "one size fits all" maintenance cycle for a particular model/size of manufactured filter treatment device.

   - Typically, Modular Wetland Systems, Inc. designs MWS - Linear Modular Wetland systems for a target prefilter media life of 6 to 12 months.
   - Indications of the need for maintenance include effluent flow decreasing to below the design flow rate or decrease in treatment below required levels.
   - Owners/operators must inspect MWS - Linear Modular Wetland systems for a minimum of twelve months from the start of post-construction operation to determine site-specific

maintenance schedules and requirements. You must conduct inspections monthly during the wet season, and every other month during the dry season. (According to the SWMMWW, the wet season in western Washington is October 1 to April 30. According to SWMMEW, the wet season in eastern Washington is October 1 to June 30). After the first year of operation, owners/operators must conduct inspections based on the findings during the first year of inspections.

- Conduct inspections by qualified personnel, follow manufacturer's guidelines, and use methods capable of determining either a decrease in treated effluent flowrate and/or a decrease in pollutant removal ability.
- When inspections are performed, the following findings typically serve as maintenance triggers:
  - Standing water remains in the vault between rain events, or
  - Bypass occurs during storms smaller than the design storm.
  - If excessive floatables (trash and debris) are present (but no standing water or excessive sedimentation), perform a minor maintenance consisting of gross solids removal, not prefilter media replacement.
  - Additional data collection will be used to create a correlation between pretreatment chamber sediment depth and pre-filter clogging (see *Issues to be Addressed by the Company* section below)

6. Discharges from the MWS - Linear Modular Wetland Stormwater Treatment System units shall not cause or contribute to water quality standards violations in receiving waters.

Applicant:	Modular Wetland Systems, Inc.
Applicant's Address:	*PO. Box 869* *Oceanside, CA 92054*

Application Documents:

- *Original Application for Conditional Use Level Designation*, Modular Wetland System, Linear Stormwater Filtration System Modular Wetland Systems, Inc., January 2011
- *Quality Assurance Project Plan*: Modular Wetland system – Linear Treatment System performance Monitoring Project, draft, January 2011.
- *Revised Application for Conditional Use Level Designation*, Modular Wetland System, Linear Stormwater Filtration System Modular Wetland Systems, Inc., May 2011
- *Memorandum: Modular Wetland System-Linear GULD Application Supplementary Data, April 2014*
- *Technical Evaluation Report: Modular Wetland System Stormwater Treatment System Performance Monitoring, April 2014.*

Applicant's Use Level Request:

General use level designation as a Basic, Enhanced, and Phosphorus treatment device in accordance with Ecology's Guidance for Evaluating Emerging Stormwater Treatment Technologies Technology Assessment Protocol – Ecology (TAPE) January 2011 Revision.

Applicant's Performance Claims:

- The MWS – Linear Modular wetland is capable of removing a minimum of 80-percent of TSS from stormwater with influent concentrations between 100 and 200 mg/l.
- The MWS – Linear Modular wetland is capable of removing a minimum of 50-percent of Total Phosphorus from stormwater with influent concentrations between 0.1 and 0.5 mg/l.
- The MWS – Linear Modular wetland is capable of removing a minimum of 30-percent of dissolved Copper from stormwater with influent concentrations between 0.005 and 0.020 mg/l.
- The MWS – Linear Modular wetland is capable of removing a minimum of 60-percent of dissolved Zinc from stormwater with influent concentrations between 0.02 and 0.30 mg/l.

Ecology Recommendations:

- Modular Wetland Systems, Inc. has shown Ecology, through laboratory and field-testing, that the MWS - Linear Modular Wetland Stormwater Treatment System filter system is capable of attaining Ecology's Basic, Total phosphorus, and Enhanced treatment goals.

Findings of Fact:

<u>Laboratory Testing</u>

The MWS-Linear Modular wetland has the:

- Capability to remove 99 percent of total suspended solids (using Sil-Co-Sil 106) in a quarter-scale model with influent concentrations of 270 mg/L.
- Capability to remove 91 percent of total suspended solids (using Sil-Co-Sil 106) in laboratory conditions with influent concentrations of 84.6 mg/L at a flow rate of 3.0 gpm per square foot of media.
- Capability to remove 93 percent of dissolved Copper in a quarter-scale model with influent concentrations of 0.757 mg/L.
- Capability to remove 79 percent of dissolved Copper in laboratory conditions with influent concentrations of 0.567 mg/L at a flow rate of 3.0 gpm per square foot of media.
- Capability to remove 80.5-percent of dissolved Zinc in a quarter-scale model with influent concentrations of 0.95 mg/L at a flow rate of 3.0 gpm per square foot of media.
- Capability to remove 78-percent of dissolved Zinc in laboratory conditions with influent concentrations of 0.75 mg/L at a flow rate of 3.0 gpm per square foot of media.

Field Testing

- Modular Wetland Systems, Inc. conducted monitoring of an MWS-Linear (Model # MWS-L-4-13) from April 2012 through May 2013, at a transportation maintenance facility in Portland, Oregon. The manufacturer collected flow-weighted composite samples of the system's influent and effluent during 28 separate storm events. The system treated approximately 75 percent of the runoff from 53.5 inches of rainfall during the monitoring period. The applicant sized the system at 1 gpm/sq ft. (wetland media) and 3gpm/sq ft. (prefilter).
- Influent TSS concentrations for qualifying sampled storm events ranged from 20 to 339 mg/L. Average TSS removal for influent concentrations greater than 100 mg/L (n=7) averaged 85 percent. For influent concentrations in the range of 20-100 mg/L (n=18), the upper 95 percent confidence interval about the mean effluent concentration was 12.8 mg/L.
- Total phosphorus removal for 17 events with influent TP concentrations in the range of 0.1 to 0.5 mg/L averaged 65 percent. A bootstrap estimate of the lower 95 percent confidence limit (LCL95) of the mean total phosphorus reduction was 58 percent.
- The lower 95 percent confidence limit of the mean percent removal was 60.5 percent for dissolved zinc for influent concentrations in the range of 0.02 to 0.3 mg/L (n=11). The lower 95 percent confidence limit of the mean percent removal was 32.5 percent for dissolved copper for influent concentrations in the range of 0.005 to 0.02 mg/L (n=14) at flow rates up to 28 gpm (design flow rate 41 gpm). Laboratory test data augmented the data set, showing dissolved copper removal at the design flow rate of 41 gpm (93 percent reduction in influent dissolved copper of 0.757 mg/L).

Issues to be addressed by the Company:

1. Modular Wetland Systems, Inc. should collect maintenance and inspection data for the first year on all installations in the Northwest in order to assess standard maintenance requirements for various land uses in the region. Modular Wetland Systems, Inc. should use these data to establish required maintenance cycles.
2. Modular Wetland Systems, Inc. should collect pre-treatment chamber sediment depth data for the first year of operation for all installations in the Northwest. Modular Wetland Systems, Inc. will use these data to create a correlation between sediment depth and pre-filter clogging.

Technology Description:
Download at http://www.modularwetlands.com/

Contact Information:

Applicant: Zach Kent
BioClean A Forterra Company.
398 Vi9a El Centro
Oceanside, CA 92058
zach.kent@forterrabp.com

Applicant website: http://www.modularwetlands.com/

Ecology web link: http://www.ecy.wa.gov/programs/wg/stormwater/newtech/index.html

Ecology: Douglas C. Howie, P.E.
Department of Ecology
Water Quality Program
(360) 407-6444
douglas.howie@ecy.wa.gov

Revision History

Date	**Revision**
June 2011	Original use-level-designation document
September 2012	Revised dates for TER and expiration
January 2013	Modified Design Storm Description, added Revision Table, added maintenance discussion, modified format in accordance with Ecology standard
December 2013	Updated name of Applicant
April 2014	Approved GULD designation for Basic, Phosphorus, and Enhanced treatment
December 2015	Updated GULD to document the acceptance of MWS-Linear Modular Wetland installations with or without the inclusion of plants
July 2017	Revised Manufacturer Contact Information (name, address, and email)

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	Basin A Wetland
Site Name:	
Site Address:	
City:	
Report Date:	2/3/2018
Gage:	Burlington
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	1.00
Version Date:	2016/02/25
Version:	4.2.12

POC Thresholds

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Mod	4.3
Pervious Total	4.3
Impervious Land Use	acre
ROOF TOPS FLAT	1.08
DRIVEWAYS FLAT	1.32
Impervious Total	2.4
Basin Total	6.7

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

To Bioretention

Bypass:	Yes
GroundWater:	No
Pervious Land Use	acre
C, Pasture, Flat	0.11
Pervious Total	0.11
Impervious Land Use	acre
DRIVEWAYS FLAT	0.11
Impervious Total	0.11
Basin Total	0.22

Element Flows To:

Surface	Interflow	Groundwater
Surface retention 1	Surface retention 1	

Directly out

Bypass:	Yes
GroundWater:	No
Pervious Land Use	acre
C, Pasture, Flat	2.05
C, Pasture, Steep	0.83
C, Lawn, Flat	0.83
Pervious Total	3.71
Impervious Land Use	acre
ROOF TOPS FLAT	0.5
DRIVEWAYS FLAT	2.19
Impervious Total	2.69
Basin Total	6.4

Element Flows To:

Surface	Interflow	Groundwater

Routing Elements
Predeveloped Routing

Mitigated Routing

Bioretention 1

Bottom Length:	100.00 ft.
Bottom Width:	10.00 ft.
Material thickness of first layer:	1.5
Material type for first layer:	SMMWW 12 in/hr
Material thickness of second layer:	1.5
Material type for second layer:	Sand
Material thickness of third layer:	0
Material type for third layer:	GRAVEL
Underdrain used	
Underdrain Diameter (feet):	0.5
Orifice Diameter (in.):	0.5
Offset (in.):	0
Flow Through Underdrain (ac-ft.):	19.388
Total Outflow (ac-ft.):	19.388
Percent Through Underdrain:	100
Discharge Structure	
Riser Height:	0.5 ft.
Riser Diameter:	8 in.
Element Flows To:	
Outlet 1	Outlet 2

Bioretention Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.0758	0.0000	0.0000	0.0000
0.0440	0.0756	0.0005	0.0000	0.0000
0.0879	0.0747	0.0009	0.0001	0.0000
0.1319	0.0739	0.0014	0.0001	0.0000
0.1758	0.0730	0.0020	0.0002	0.0000
0.2198	0.0721	0.0025	0.0003	0.0000
0.2637	0.0713	0.0030	0.0006	0.0000
0.3077	0.0704	0.0036	0.0007	0.0000
0.3516	0.0695	0.0041	0.0011	0.0000
0.3956	0.0687	0.0047	0.0014	0.0000
0.4396	0.0678	0.0053	0.0019	0.0000
0.4835	0.0670	0.0059	0.0024	0.0000
0.5275	0.0661	0.0065	0.0029	0.0000
0.5714	0.0653	0.0072	0.0037	0.0000
0.6154	0.0644	0.0078	0.0040	0.0000
0.6593	0.0636	0.0085	0.0041	0.0000
0.7033	0.0627	0.0091	0.0042	0.0000
0.7473	0.0619	0.0098	0.0043	0.0000
0.7912	0.0611	0.0105	0.0045	0.0000
0.8352	0.0602	0.0113	0.0046	0.0000
0.8791	0.0594	0.0120	0.0047	0.0000
0.9231	0.0586	0.0127	0.0048	0.0000
0.9670	0.0578	0.0135	0.0049	0.0000
1.0110	0.0570	0.0143	0.0050	0.0000
1.0549	0.0562	0.0151	0.0051	0.0000
1.0989	0.0554	0.0159	0.0052	0.0000
1.1429	0.0545	0.0167	0.0053	0.0000
1.1868	0.0537	0.0175	0.0054	0.0000
1.2308	0.0529	0.0184	0.0055	0.0000

1.2747	0.0522	0.0193	0.0057	0.0000
1.3187	0.0514	0.0202	0.0058	0.0000
1.3626	0.0506	0.0211	0.0058	0.0000
1.4066	0.0498	0.0220	0.0059	0.0000
1.4505	0.0490	0.0229	0.0060	0.0000
1.4945	0.0482	0.0238	0.0061	0.0000
1.5385	0.0474	0.0247	0.0062	0.0000
1.5824	0.0467	0.0255	0.0063	0.0000
1.6264	0.0459	0.0264	0.0063	0.0000
1.6703	0.0451	0.0273	0.0064	0.0000
1.7143	0.0444	0.0282	0.0065	0.0000
1.7582	0.0436	0.0291	0.0066	0.0000
1.8022	0.0429	0.0300	0.0067	0.0000
1.8462	0.0421	0.0310	0.0067	0.0000
1.8901	0.0414	0.0319	0.0068	0.0000
1.9341	0.0406	0.0329	0.0069	0.0000
1.9780	0.0399	0.0339	0.0070	0.0000
2.0220	0.0391	0.0349	0.0070	0.0000
2.0659	0.0384	0.0359	0.0071	0.0000
2.1099	0.0376	0.0369	0.0072	0.0000
2.1538	0.0369	0.0379	0.0073	0.0000
2.1978	0.0362	0.0390	0.0074	0.0000
2.2418	0.0355	0.0400	0.0074	0.0000
2.2857	0.0347	0.0411	0.0075	0.0000
2.3297	0.0340	0.0422	0.0076	0.0000
2.3736	0.0333	0.0433	0.0076	0.0000
2.4176	0.0326	0.0445	0.0077	0.0000
2.4615	0.0319	0.0456	0.0078	0.0000
2.5055	0.0312	0.0468	0.0078	0.0000
2.5495	0.0305	0.0479	0.0079	0.0000
2.5934	0.0298	0.0491	0.0080	0.0000
2.6374	0.0291	0.0503	0.0080	0.0000
2.6813	0.0284	0.0515	0.0081	0.0000
2.7253	0.0277	0.0528	0.0082	0.0000
2.7692	0.0270	0.0540	0.0082	0.0000
2.8132	0.0263	0.0553	0.0083	0.0000
2.8571	0.0256	0.0565	0.0084	0.0000
2.9011	0.0250	0.0578	0.0084	0.0000
2.9451	0.0243	0.0591	0.0085	0.0000
2.9890	0.0236	0.0605	0.0117	0.0000
3.0000	0.0230	0.0608	0.0118	0.0000

Bioretention Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	To Amended(cfs)	Infilt(cfs)
3.0000	0.0758	0.0608	0.0000	0.2179	0.0000
3.0440	0.0767	0.0641	0.0000	0.2179	0.0000
3.0879	0.0776	0.0675	0.0000	0.2210	0.0000
3.1319	0.0785	0.0710	0.0000	0.2242	0.0000
3.1758	0.0794	0.0744	0.0000	0.2273	0.0000
3.2198	0.0803	0.0779	0.0000	0.2304	0.0000
3.2637	0.0812	0.0815	0.0000	0.2336	0.0000
3.3077	0.0821	0.0851	0.0000	0.2367	0.0000
3.3516	0.0830	0.0887	0.0000	0.2399	0.0000
3.3956	0.0839	0.0924	0.0000	0.2430	0.0000
3.4396	0.0848	0.0961	0.0000	0.2462	0.0000
3.4835	0.0858	0.0998	0.0000	0.2493	0.0000
3.5275	0.0867	0.1036	0.0322	0.2525	0.0000
3.5714	0.0876	0.1075	0.1341	0.2556	0.0000

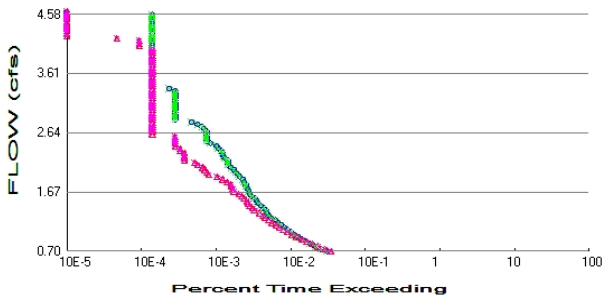
3.6154	0.0885	0.1113	0.2693	0.2588	0.0000
3.6593	0.0895	0.1152	0.4174	0.2619	0.0000
3.7033	0.0904	0.1192	0.5577	0.2650	0.0000
3.7473	0.0913	0.1232	0.6720	0.2682	0.0000
3.7912	0.0923	0.1272	0.7509	0.2713	0.0000
3.8352	0.0932	0.1313	0.8104	0.2745	0.0000
3.8791	0.0942	0.1354	0.8619	0.2776	0.0000
3.9231	0.0951	0.1396	0.9105	0.2808	0.0000
3.9670	0.0961	0.1438	0.9566	0.2839	0.0000
4.0000	0.0968	0.1470	1.0007	0.2863	0.0000

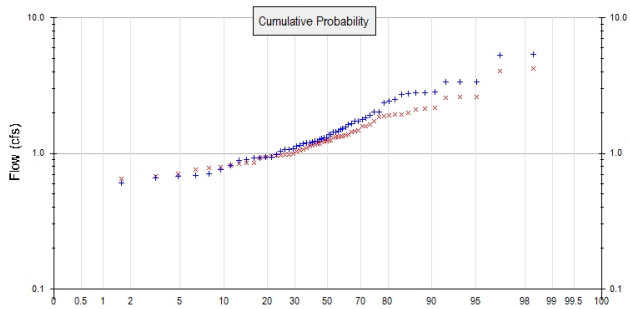
Surface retention 1

Element Flows To:

Outlet 1	Outlet 2
	Bioretention 1

Analysis Results
POC 1





\+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 4.3
Total Impervious Area: 2.4

Mitigated Landuse Totals for POC #1
Total Pervious Area: 3.82
Total Impervious Area: 2.8

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	1.390784
5 year	2.184813
10 year	2.822111
25 year	3.765379
50 year	4.57555
100 year	5.484107

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	1.247481
5 year	1.808428
10 year	2.241019
25 year	2.862045
50 year	3.381908
100 year	3.953575

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	2.786	2.107
1950	0.932	0.933
1951	2.487	1.937
1952	2.425	1.850
1953	2.756	2.153
1954	1.303	0.983
1955	0.882	0.839
1956	0.606	0.647
1957	2.788	1.982
1958	1.086	0.928

1959	1.191	1.001
1960	1.664	1.337
1961	0.981	0.854
1962	1.374	1.342
1963	1.125	0.947
1964	0.941	0.979
1965	3.360	2.604
1966	1.194	1.072
1967	1.733	1.880
1968	2.028	1.586
1969	1.185	0.971
1970	2.713	1.923
1971	1.626	1.357
1972	0.762	0.754
1973	1.522	1.319
1974	1.271	1.098
1975	3.355	2.586
1976	3.385	2.608
1977	1.070	1.039
1978	1.717	1.722
1979	1.235	1.146
1980	1.790	1.449
1981	1.071	1.180
1982	1.291	1.208
1983	1.301	1.124
1984	1.566	1.254
1985	1.237	1.385
1986	0.899	0.850
1987	0.816	0.819
1988	2.846	2.176
1989	1.150	1.178
1990	1.502	1.233
1991	2.026	1.623
1992	1.213	1.293
1993	0.657	0.679
1994	0.709	0.793
1995	0.675	0.711
1996	2.365	1.911
1997	5.287	4.218
1998	1.044	1.159
1999	0.576	0.609
2000	1.430	1.587
2001	0.942	1.046
2002	0.691	0.775
2003	0.921	0.971
2004	5.355	4.059
2005	1.434	1.312
2006	1.908	1.475
2007	1.466	1.253
2008	1.374	1.232
2009	1.832	1.439

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	5.3549	4.2184
2	5.2875	4.0589
3	3.3849	2.6080

4	3.3605	2.6045
5	3.3547	2.5862
6	2.8456	2.1758
7	2.7879	2.1526
8	2.7856	2.1071
9	2.7557	1.9817
10	2.7126	1.9375
11	2.4873	1.9233
12	2.4246	1.9108
13	2.3654	1.8804
14	2.0275	1.8501
15	2.0261	1.7217
16	1.9081	1.6227
17	1.8321	1.5871
18	1.7901	1.5863
19	1.7331	1.4750
20	1.7174	1.4489
21	1.6640	1.4393
22	1.6260	1.3854
23	1.5663	1.3566
24	1.5225	1.3424
25	1.5022	1.3370
26	1.4660	1.3188
27	1.4345	1.3121
28	1.4304	1.2926
29	1.3743	1.2541
30	1.3738	1.2526
31	1.3034	1.2330
32	1.3011	1.2323
33	1.2907	1.2079
34	1.2715	1.1802
35	1.2372	1.1778
36	1.2355	1.1586
37	1.2128	1.1460
38	1.1938	1.1241
39	1.1910	1.0982
40	1.1846	1.0721
41	1.1495	1.0461
42	1.1250	1.0386
43	1.0862	1.0009
44	1.0708	0.9830
45	1.0703	0.9791
46	1.0444	0.9712
47	0.9811	0.9708
48	0.9420	0.9472
49	0.9414	0.9329
50	0.9322	0.9278
51	0.9207	0.8535
52	0.8990	0.8500
53	0.8815	0.8387
54	0.8156	0.8194
55	0.7615	0.7928
56	0.7088	0.7750
57	0.6909	0.7535
58	0.6752	0.7112
59	0.6568	0.6785
60	0.6062	0.6473
61	0.5763	0.6087

Duration Flows

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.6954	654	745	113	Fail
0.7346	539	608	112	Fail
0.7738	455	497	109	Fail
0.8130	389	414	106	Fail
0.8522	345	346	100	Pass
0.8914	306	300	98	Pass
0.9306	265	253	95	Pass
0.9697	235	220	93	Pass
1.0089	212	190	89	Pass
1.0481	191	169	88	Pass
1.0873	176	150	85	Pass
1.1265	158	136	86	Pass
1.1657	145	119	82	Pass
1.2049	133	109	81	Pass
1.2441	116	95	81	Pass
1.2833	109	90	82	Pass
1.3225	103	82	79	Pass
1.3617	99	69	69	Pass
1.4009	92	65	70	Pass
1.4401	85	60	70	Pass
1.4793	79	58	73	Pass
1.5185	75	55	73	Pass
1.5576	70	50	71	Pass
1.5968	64	47	73	Pass
1.6360	60	43	71	Pass
1.6752	58	37	63	Pass
1.7144	57	36	63	Pass
1.7536	54	34	62	Pass
1.7928	53	34	64	Pass
1.8320	51	30	58	Pass
1.8712	49	26	53	Pass
1.9104	44	22	50	Pass
1.9496	42	17	40	Pass
1.9888	39	16	41	Pass
2.0280	37	15	40	Pass
2.0672	34	14	41	Pass
2.1064	31	12	38	Pass
2.1456	31	11	35	Pass
2.1847	31	8	25	Pass
2.2239	28	8	28	Pass
2.2631	27	8	29	Pass
2.3023	26	8	30	Pass
2.3415	25	7	28	Pass
2.3807	23	7	30	Pass
2.4199	22	6	27	Pass
2.4591	18	6	33	Pass
2.4983	16	6	37	Pass
2.5375	16	6	37	Pass
2.5767	16	6	37	Pass
2.6159	16	3	18	Pass
2.6551	16	3	18	Pass
2.6943	15	3	20	Pass
2.7335	14	3	21	Pass
2.7726	12	3	25	Pass

2.8118	10	3	30	Pass
2.8510	6	3	50	Pass
2.8902	6	3	50	Pass
2.9294	6	3	50	Pass
2.9686	6	3	50	Pass
3.0078	6	3	50	Pass
3.0470	6	3	50	Pass
3.0862	6	3	50	Pass
3.1254	6	3	50	Pass
3.1646	6	3	50	Pass
3.2038	6	3	50	Pass
3.2430	6	3	50	Pass
3.2822	6	3	50	Pass
3.3214	6	3	50	Pass
3.3606	5	3	60	Pass
3.3997	3	3	100	Pass
3.4389	3	3	100	Pass
3.4781	3	3	100	Pass
3.5173	3	3	100	Pass
3.5565	3	3	100	Pass
3.5957	3	3	100	Pass
3.6349	3	3	100	Pass
3.6741	3	3	100	Pass
3.7133	3	3	100	Pass
3.7525	3	3	100	Pass
3.7917	3	3	100	Pass
3.8309	3	3	100	Pass
3.8701	3	3	100	Pass
3.9093	3	3	100	Pass
3.9485	3	3	100	Pass
3.9876	3	3	100	Pass
4.0268	3	3	100	Pass
4.0660	3	2	66	Pass
4.1052	3	2	66	Pass
4.1444	3	2	66	Pass
4.1836	3	1	33	Pass
4.2228	3	0	0	Pass
4.2620	3	0	0	Pass
4.3012	3	0	0	Pass
4.3404	3	0	0	Pass
4.3796	3	0	0	Pass
4.4188	3	0	0	Pass
4.4580	3	0	0	Pass
4.4972	3	0	0	Pass
4.5364	3	0	0	Pass
4.5756	3	0	0	Pass

The development has an increase in flow durations from 1/2 Predeveloped 2 year flow to the 2 year flow or more than a 10% increase from the 2 year to the 50 year flow.

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
retention 1 POC	☑	17.64	19.39	0.00	☐	0.00	19.39	100.00	Treat. Credit
Total Volume Infiltrated		17.64	19.39	0.00		0.00	19.39	19 / 19 = 100%	Treat. Credit = 100%
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Failed

Model Default Modifications

Total of 0 changes have been made.

PERLND Changes

No PERLND changes have been made.

IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic

Mitigated Schematic

Predeveloped UCI File

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                    UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                               ***
WDM        26   Basin A Wetland.wdm
MESSU      25   MitBasin A Wetland.MES
           27   MitBasin A Wetland.L61
           28   MitBasin A Wetland.L62
           30   POCBasin A Wetland1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      13
      IMPLND       5
      PERLND      15
      PERLND      16
      IMPLND       4
      GENER        2
      RCHRES       1
      RCHRES       2
      COPY         1
      COPY       501
      COPY       601
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Surface retention  1        MAX                    1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  601         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
    2        24
  END OPCODE
  PARM
    #    #         K ***
    2             0.
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                           in  out           ***
   13     C, Pasture, Flat        1    1    1    1   27    0
   15     C, Pasture, Steep       1    1    1    1   27    0
   16     C, Lawn, Flat           1    1    1    1   27    0
  END GEN-INFO
```

```
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections ****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   13         0    0    1    0    0    0    0    0    0    0    0    0
   15         0    0    1    0    0    0    0    0    0    0    0    0
   16         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags **************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
   13         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   15         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   16         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   13         0    0    0    0    0    0    0    0    0    0    0
   15         0    0    0    0    0    0    0    0    0    0    0
   16         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   13              0       4.5      0.06       400      0.05       0.5     0.996
   15              0       4.5      0.06       400      0.15       0.5     0.996
   16              0       4.5      0.03       400      0.05       0.5     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   13              0         0         2         2         0         0         0
   15              0         0         2         2         0         0         0
   16              0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                                ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   13           0.15       0.4       0.3         6       0.5       0.4
   15           0.15      0.25       0.3         6       0.3       0.4
   16            0.1      0.25      0.25         6       0.5      0.25
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
               ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   13              0         0         0         0       2.5         1         0
   15              0         0         0         0       2.5         1         0
   16              0         0         0         0       2.5         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                       in  out           ***
    5      DRIVEWAYS/FLAT         1    1    1   27    0
    4      ROOF TOPS/FLAT         1    1    1   27    0
  END GEN-INFO
  *** Section IWATER***
```

```
  ACTIVITY
    <PLS > ************* Active Sections ****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    5         0    0    1    0    0    0
    4         0    0    1    0    0    0
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
    5         0    0    4    0    0    0    1    9
    4         0    0    4    0    0    0    1    9
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
    5         0    0    0    0    0
    4         0    0    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    5            400      0.01       0.1       0.1
    4            400      0.01       0.1       0.1
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    5              0         0
    4              0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    5              0         0
    4              0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
To Bioretention***
PERLND  13                       0.11     RCHRES   1      2
PERLND  13                       0.11     RCHRES   1      3
IMPLND   5                       0.11     RCHRES   1      5
To Bioretention***
PERLND  13                       0.11     COPY   501     14
PERLND  13                       0.11     COPY   601     14
Directly out***
PERLND  13                       2.05     COPY   501     12
PERLND  13                       2.05     COPY   601     12
PERLND  13                       2.05     COPY   501     13
PERLND  13                       2.05     COPY   601     13
PERLND  13                       2.05     COPY   501     14
PERLND  13                       2.05     COPY   601     14
PERLND  15                       0.83     COPY   501     12
PERLND  15                       0.83     COPY   601     12
PERLND  15                       0.83     COPY   501     13
PERLND  15                       0.83     COPY   601     13
PERLND  15                       0.83     COPY   501     14
PERLND  15                       0.83     COPY   601     14
PERLND  16                       0.83     COPY   501     12
PERLND  16                       0.83     COPY   601     12
PERLND  16                       0.83     COPY   501     13
```

```
PERLND  16                        0.83     COPY   601     13
PERLND  16                        0.83     COPY   501     14
PERLND  16                        0.83     COPY   601     14
IMPLND   4                         0.5     COPY   501     15
IMPLND   4                         0.5     COPY   601     15
IMPLND   5                        2.19     COPY   501     15
IMPLND   5                        2.19     COPY   601     15

******Routing******
PERLND  13                        0.11     COPY     1     12
IMPLND   5                        0.11     COPY     1     15
PERLND  13                        0.11     COPY     1     13
RCHRES   1                           1     RCHRES   2      8
RCHRES   2                           1     COPY   501     16
RCHRES   1                           1     COPY   501     17
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1
GENER    2 OUTPUT TIMSER      .0011111     RCHRES   1     EXTNL  OUTDGT 1



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                          in  out                             ***
    1     Surface retentio-008    3    1    1    1   28    0    1
    2     Bioretention  1         1    1    1    1   28    0    1
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections ****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
    1         1    0    0    0    0    0    0    0    0    0
    2         1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
    1         4    0    0    0    0    0    0    0    0    0    1    9
    2         4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                       ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
    1        0  1  0  0    4  5  6  0  0       0  1  0  0  0       2  1  2  2  2
    2        0  1  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
    1              1      0.01       0.0       0.0       0.5       0.0
    2              2      0.02       0.0       0.0       0.5       0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                          ***
```

```
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit        for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1            0         4.0  5.0  6.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
    2            0         4.0  0.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
*** User-Defined Variable Quantity Lines
***                          addr
***                        <------>
*** kwd  varnam optyp  opn  vari  s1 s2 s3 tp multiply  lc ls ac as agfn ***
  <****> <----> <----> <-> <----><-><-><-><-><--------> <><-> <><-> <--> ***
  UVQUAN vol2   RCHRES   2 VOL              4
  UVQUAN v2m2   GLOBAL     WORKSP  1        3
  UVQUAN vpo2   GLOBAL     WORKSP  2        3
  UVQUAN v2d2   GENER    2 K       1        3
*** User-Defined Target Variable Names
***                  addr or                       addr or
***                <------>                      <------>
*** kwd   varnam ct  vari  s1 s2 s3  frac oper     vari  s1 s2 s3  frac oper
  <****>  <----><-> <----><-><-><-> <---> <-->    <----><-><-><-> <---> <-->
  UVNAME  v2m2    1 WORKSP  1         1.0 QUAN
  UVNAME  vpo2    1 WORKSP  2         1.0 QUAN
  UVNAME  v2d2    1 K       1         1.0 QUAN
*** opt foplop dcdts  yr mo dy hr mn d t   vnam  s1 s2 s3 ac quantity  tc  ts rp
  <****><-><--><><-><--> <> <> <> <><><>  <----><-><-><-><-><--------> <> <-><->
  GENER   2                               v2m2            =  2501.
*** Compute remaining available pore space
  GENER   2                               vpo2            =  v2m2
  GENER   2                               vpo2           -=  vol2
*** Check to see if VPORA goes negative; if so set VPORA = 0.0
IF (vpo2 < 0.0) THEN
  GENER   2                               vpo2            =  0.0
END IF
*** Infiltration volume
  GENER   2                               v2d2            =  vpo2
END SPEC-ACTIONS
FTABLES
  FTABLE      2
   70    4
     Depth      Area    Volume  Outflow1 Velocity  Travel Time***
      (ft)   (acres) (acre-ft)   (cfs)   (ft/sec)    (Minutes)***
  0.000000  0.075849  0.000000  0.000000
  0.043956  0.075629  0.000468  0.000000
  0.087912  0.074747  0.000950  0.000054
  0.131868  0.073869  0.001445  0.000077
  0.175824  0.072993  0.001954  0.000222
  0.219780  0.072121  0.002476  0.000299
  0.263736  0.071253  0.003012  0.000557
  0.307692  0.070387  0.003562  0.000736
  0.351648  0.069525  0.004126  0.001097
  0.395604  0.068665  0.004703  0.001436
  0.439560  0.067809  0.005295  0.001872
  0.483516  0.066957  0.005900  0.002441
  0.527473  0.066107  0.006520  0.002912
  0.571429  0.065260  0.007154  0.003694
  0.615385  0.064417  0.007802  0.003961
  0.659341  0.063577  0.008464  0.004091
  0.703297  0.062740  0.009141  0.004214
  0.747253  0.061907  0.009832  0.004334
  0.791209  0.061076  0.010537  0.004451
  0.835165  0.060249  0.011258  0.004564
  0.879121  0.059425  0.011992  0.004675
  0.923077  0.058604  0.012742  0.004783
  0.967033  0.057786  0.013506  0.004889
  1.010989  0.056972  0.014285  0.004992
  1.054945  0.056160  0.015079  0.005093
  1.098901  0.055352  0.015887  0.005193
```

```
  1.142857  0.054547  0.016711  0.005290
  1.186813  0.053746  0.017550  0.005385
  1.230769  0.052947  0.018404  0.005479
  1.274725  0.052152  0.019273  0.005662
  1.318681  0.051360  0.020157  0.005751
  1.362637  0.050571  0.021057  0.005839
  1.406593  0.049785  0.021972  0.005926
  1.450549  0.049002  0.022902  0.006011
  1.494505  0.048223  0.023848  0.006095
  1.538462  0.047447  0.024689  0.006178
  1.582418  0.046674  0.025544  0.006260
  1.626374  0.045904  0.026412  0.006341
  1.670330  0.045137  0.027295  0.006420
  1.714286  0.044374  0.028191  0.006499
  1.758242  0.043614  0.029101  0.006577
  1.802198  0.042857  0.030025  0.006654
  1.846154  0.042103  0.030963  0.006730
  1.890110  0.041352  0.031915  0.006805
  1.934066  0.040605  0.032881  0.006879
  1.978022  0.039861  0.033861  0.006953
  2.021978  0.039120  0.034856  0.007025
  2.065934  0.038382  0.035865  0.007097
  2.109890  0.037647  0.036888  0.007239
  2.153846  0.036916  0.037925  0.007309
  2.197802  0.036187  0.038977  0.007379
  2.241758  0.035462  0.040044  0.007447
  2.285714  0.034740  0.041125  0.007515
  2.329670  0.034022  0.042221  0.007583
  2.373626  0.033306  0.043332  0.007649
  2.417582  0.032594  0.044457  0.007716
  2.461538  0.031885  0.045597  0.007781
  2.505495  0.031179  0.046752  0.007846
  2.549451  0.030476  0.047921  0.007911
  2.593407  0.029777  0.049106  0.007975
  2.637363  0.029080  0.050306  0.008039
  2.681319  0.028387  0.051521  0.008102
  2.725275  0.027697  0.052751  0.008165
  2.769231  0.027010  0.053996  0.008228
  2.813187  0.026327  0.055256  0.008291
  2.857143  0.025646  0.056532  0.008354
  2.901099  0.024969  0.057823  0.008415
  2.945055  0.024295  0.059130  0.008475
  2.989011  0.023624  0.060452  0.011725
  3.000000  0.022957  0.127648  0.011751
  END FTABLE  2
  FTABLE      1
   24    6
     Depth      Area    Volume  Outflow1  Outflow2  outflow 3 Velocity  Travel
Time***
      (ft)   (acres) (acre-ft)   (cfs)      (cfs)     (cfs)   (ft/sec)
(Minutes)***
  0.000000  0.022957  0.000000  0.000000  0.000000  0.000000
  0.043956  0.076735  0.003354  0.000000  0.217859  0.000000
  0.087912  0.077624  0.006746  0.000000  0.221005  0.000000
  0.131868  0.078516  0.010178  0.000000  0.224151  0.000000
  0.175824  0.079411  0.013649  0.000000  0.227297  0.000000
  0.219780  0.080309  0.017159  0.000000  0.230443  0.000000
  0.263736  0.081211  0.020709  0.000000  0.233589  0.000000
  0.307692  0.082115  0.024298  0.000000  0.236735  0.000000
  0.351648  0.083023  0.027928  0.000000  0.239881  0.000000
  0.395604  0.083934  0.031597  0.000000  0.243027  0.000000
  0.439560  0.084849  0.035307  0.000000  0.246173  0.000000
  0.483516  0.085766  0.039056  0.000000  0.249319  0.000000
  0.527473  0.086687  0.042847  0.032183  0.252465  0.000000
  0.571429  0.087611  0.046677  0.134060  0.255611  0.000000
  0.615385  0.088538  0.050549  0.269306  0.258757  0.000000
  0.659341  0.089468  0.054461  0.417367  0.261903  0.000000
  0.703297  0.090402  0.058414  0.557655  0.265049  0.000000
  0.747253  0.091338  0.062408  0.672007  0.268195  0.000000
  0.791209  0.092278  0.066444  0.750858  0.271340  0.000000
```

```
  0.835165  0.093221  0.070521  0.810413  0.274486  0.000000
  0.879121  0.094167  0.074639  0.861918  0.277632  0.000000
  0.923077  0.095117  0.078799  0.910514  0.280778  0.000000
  0.967033  0.096069  0.083001  0.956645  0.283924  0.000000
  1.000000  0.096786  0.086180  1.000651  0.286284  0.000000
  END FTABLE  1
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1              PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1              IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP
WDM      2 PREC     ENGL    1              RCHRES   1     EXTNL  PREC
WDM      1 EVAP     ENGL    0.5            RCHRES   1     EXTNL  POTEV
WDM      1 EVAP     ENGL    0.76           RCHRES   2     EXTNL  POTEV

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY     1 OUTPUT MEAN   1 1     48.4      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    801 FLOW     ENGL      REPL
COPY   601 OUTPUT MEAN   1 1     48.4      WDM    901 FLOW     ENGL      REPL
RCHRES   2 HYDR   RO     1 1        1      WDM   1000 FLOW     ENGL      REPL
RCHRES   2 HYDR   STAGE  1 1        1      WDM   1001 STAG     ENGL      REPL
RCHRES   1 HYDR   STAGE  1 1        1      WDM   1002 STAG     ENGL      REPL
RCHRES   1 HYDR   O      1 1        1      WDM   1003 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK        2
PERLND     PWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    2

  MASS-LINK        3
PERLND     PWATER IFWO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    3

  MASS-LINK        5
IMPLND     IWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    5

  MASS-LINK        8
RCHRES     OFLOW  OVOL   2                 RCHRES         INFLOW IVOL
  END MASS-LINK    8

  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

  MASS-LINK       13
PERLND     PWATER IFWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   13

  MASS-LINK       14
PERLND     PWATER AGWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   14

  MASS-LINK       15
IMPLND     IWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   15

  MASS-LINK       16
RCHRES     ROFLOW                          COPY           INPUT  MEAN
```

```
  END MASS-LINK   16

  MASS-LINK       17
RCHRES     OFLOW  OVOL   1                 COPY           INPUT  MEAN
  END MASS-LINK   17


END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

Mitigated HSPF Message File

Disclaimer

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WWHM2012

PROJECT REPORT

General Model Information

Project Name:	Basin B Wetland
Site Name:	
Site Address:	
City:	
Report Date:	2/3/2018
Gage:	Burlington
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	1.00
Version Date:	2016/02/25
Version:	4.2.12

POC Thresholds

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year

Landuse Basin Data
Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Mod	2.18
Pervious Total	2.18
Impervious Land Use	acre
ROOF TOPS FLAT	0.19
DRIVEWAYS FLAT	1.14
Impervious Total	1.33
Basin Total	3.51

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Direct

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Pasture, Steep	0.65
C, Lawn, Flat	0.96
C, Pasture, Flat	0.33
C, Lawn, Steep	0.48
Pervious Total	2.42
Impervious Land Use	acre
ROADS FLAT	0.61
ROOF TOPS FLAT	0.46
Impervious Total	1.07
Basin Total	3.49

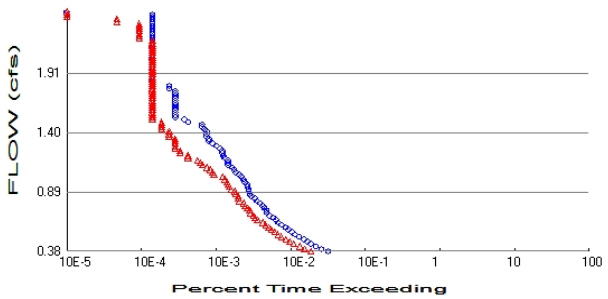
Element Flows To:

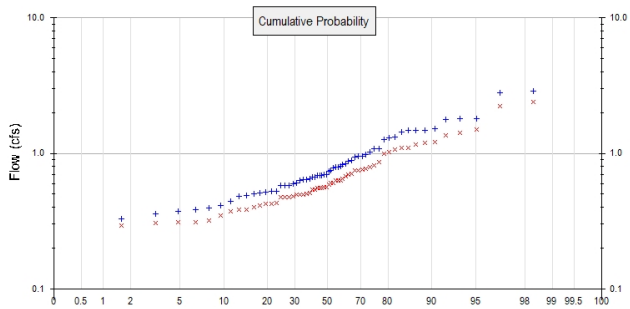
Surface	Interflow	Groundwater

Routing Elements
Predeveloped Routing

Mitigated Routing

Analysis Results
POC 1





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 2.18
Total Impervious Area: 1.33

Mitigated Landuse Totals for POC #1
Total Pervious Area: 2.42
Total Impervious Area: 1.07

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.752183
5 year	1.172391
10 year	1.507657
25 year	2.001534
50 year	2.423976
100 year	2.896178

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.604469
5 year	0.930102
10 year	1.187384
25 year	1.56344
50 year	1.882928
100 year	2.238144

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	1.477	1.203
1950	0.508	0.423
1951	1.322	1.072
1952	1.296	0.989
1953	1.472	1.154
1954	0.691	0.557
1955	0.480	0.382
1956	0.331	0.292
1957	1.487	1.103
1958	0.583	0.475

1959	0.642	0.498
1960	0.892	0.695
1961	0.528	0.427
1962	0.752	0.590
1963	0.605	0.476
1964	0.517	0.414
1965	1.806	1.350
1966	0.647	0.511
1967	0.957	0.772
1968	1.089	0.810
1969	0.636	0.499
1970	1.443	1.104
1971	0.870	0.705
1972	0.414	0.346
1973	0.823	0.633
1974	0.683	0.554
1975	1.772	1.502
1976	1.803	1.425
1977	0.581	0.481
1978	0.942	0.750
1979	0.669	0.541
1980	0.957	0.761
1981	0.592	0.495
1982	0.701	0.564
1983	0.699	0.566
1984	0.834	0.681
1985	0.685	0.554
1986	0.486	0.385
1987	0.440	0.374
1988	1.513	1.209
1989	0.631	0.502
1990	0.805	0.628
1991	1.080	0.858
1992	0.669	0.543
1993	0.356	0.310
1994	0.393	0.319
1995	0.371	0.304
1996	1.261	1.030
1997	2.798	2.389
1998	0.578	0.474
1999	0.315	0.267
2000	0.792	0.651
2001	0.521	0.426
2002	0.383	0.310
2003	0.503	0.398
2004	2.872	2.216
2005	0.780	0.607
2006	1.018	0.790
2007	0.788	0.627
2008	0.740	0.604
2009	0.981	0.753

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	2.8716	2.3886
2	2.7983	2.2157
3	1.8055	1.5020

4	1.8035	1.4246
5	1.7720	1.3501
6	1.5131	1.2085
7	1.4871	1.2032
8	1.4769	1.1543
9	1.4722	1.1036
10	1.4428	1.1029
11	1.3220	1.0722
12	1.2959	1.0297
13	1.2606	0.9892
14	1.0895	0.8579
15	1.0804	0.8098
16	1.0177	0.7905
17	0.9812	0.7722
18	0.9571	0.7613
19	0.9568	0.7529
20	0.9416	0.7499
21	0.8918	0.7045
22	0.8698	0.6949
23	0.8342	0.6809
24	0.8234	0.6512
25	0.8054	0.6334
26	0.7917	0.6284
27	0.7878	0.6268
28	0.7797	0.6066
29	0.7516	0.6039
30	0.7403	0.5899
31	0.7009	0.5661
32	0.6985	0.5640
33	0.6909	0.5569
34	0.6854	0.5540
35	0.6827	0.5539
36	0.6690	0.5427
37	0.6688	0.5408
38	0.6470	0.5115
39	0.6422	0.5022
40	0.6355	0.4988
41	0.6312	0.4981
42	0.6051	0.4951
43	0.5923	0.4810
44	0.5826	0.4759
45	0.5810	0.4747
46	0.5780	0.4743
47	0.5276	0.4271
48	0.5213	0.4259
49	0.5174	0.4227
50	0.5079	0.4142
51	0.5031	0.3985
52	0.4860	0.3850
53	0.4800	0.3823
54	0.4403	0.3738
55	0.4139	0.3456
56	0.3926	0.3187
57	0.3827	0.3105
58	0.3707	0.3102
59	0.3556	0.3045
60	0.3307	0.2919
61	0.3150	0.2673

Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.3761	673	400	59	Pass
0.3968	551	327	59	Pass
0.4175	465	284	61	Pass
0.4381	400	234	58	Pass
0.4588	353	207	58	Pass
0.4795	322	184	57	Pass
0.5002	277	160	57	Pass
0.5209	246	144	58	Pass
0.5416	220	130	59	Pass
0.5623	199	117	58	Pass
0.5829	182	109	59	Pass
0.6036	163	99	60	Pass
0.6243	147	91	61	Pass
0.6450	136	77	56	Pass
0.6657	125	71	56	Pass
0.6864	110	68	61	Pass
0.7071	104	62	59	Pass
0.7277	101	60	59	Pass
0.7484	94	56	59	Pass
0.7691	89	52	58	Pass
0.7898	83	50	60	Pass
0.8105	76	44	57	Pass
0.8312	71	42	59	Pass
0.8519	64	42	65	Pass
0.8725	60	39	65	Pass
0.8932	58	38	65	Pass
0.9139	58	34	58	Pass
0.9346	56	32	57	Pass
0.9553	55	31	56	Pass
0.9760	52	30	57	Pass
0.9967	50	28	56	Pass
1.0173	47	26	55	Pass
1.0380	43	20	46	Pass
1.0587	39	19	48	Pass
1.0794	37	18	48	Pass
1.1001	35	16	45	Pass
1.1208	31	14	45	Pass
1.1415	31	13	41	Pass
1.1621	31	12	38	Pass
1.1828	28	9	32	Pass
1.2035	27	9	33	Pass
1.2242	26	7	26	Pass
1.2449	26	7	26	Pass
1.2656	24	6	25	Pass
1.2863	22	6	27	Pass
1.3069	19	6	31	Pass
1.3276	17	6	35	Pass
1.3483	17	6	35	Pass
1.3690	16	5	31	Pass
1.3897	16	5	31	Pass
1.4104	16	5	31	Pass
1.4311	15	4	26	Pass
1.4517	14	4	28	Pass

1.4724	14	4	28	Pass
1.4931	9	4	44	Pass
1.5138	8	3	37	Pass
1.5345	6	3	50	Pass
1.5552	6	3	50	Pass
1.5759	6	3	50	Pass
1.5965	6	3	50	Pass
1.6172	6	3	50	Pass
1.6379	6	3	50	Pass
1.6586	6	3	50	Pass
1.6793	6	3	50	Pass
1.7000	6	3	50	Pass
1.7207	6	3	50	Pass
1.7413	6	3	50	Pass
1.7620	6	3	50	Pass
1.7827	5	3	60	Pass
1.8034	5	3	60	Pass
1.8241	3	3	100	Pass
1.8448	3	3	100	Pass
1.8655	3	3	100	Pass
1.8861	3	3	100	Pass
1.9068	3	3	100	Pass
1.9275	3	3	100	Pass
1.9482	3	3	100	Pass
1.9689	3	3	100	Pass
1.9896	3	3	100	Pass
2.0103	3	3	100	Pass
2.0309	3	3	100	Pass
2.0516	3	3	100	Pass
2.0723	3	3	100	Pass
2.0930	3	3	100	Pass
2.1137	3	3	100	Pass
2.1344	3	3	100	Pass
2.1551	3	3	100	Pass
2.1757	3	3	100	Pass
2.1964	3	3	100	Pass
2.2171	3	2	66	Pass
2.2378	3	2	66	Pass
2.2585	3	2	66	Pass
2.2792	3	2	66	Pass
2.2999	3	2	66	Pass
2.3205	3	2	66	Pass
2.3412	3	2	66	Pass
2.3619	3	1	33	Pass
2.3826	3	1	33	Pass
2.4033	3	0	0	Pass
2.4240	3	0	0	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
retention 1 POC	☑	17.64	19.39	0.00	☐	0.00	19.39	100.00	Treat. Credit
Total Volume Infiltrated		17.64	19.39	0.00		0.00	19.39	19 / 19 = 100%	Treat. Credit = 100%
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Failed

Model Default Modifications

Total of 0 changes have been made.

PERLND Changes

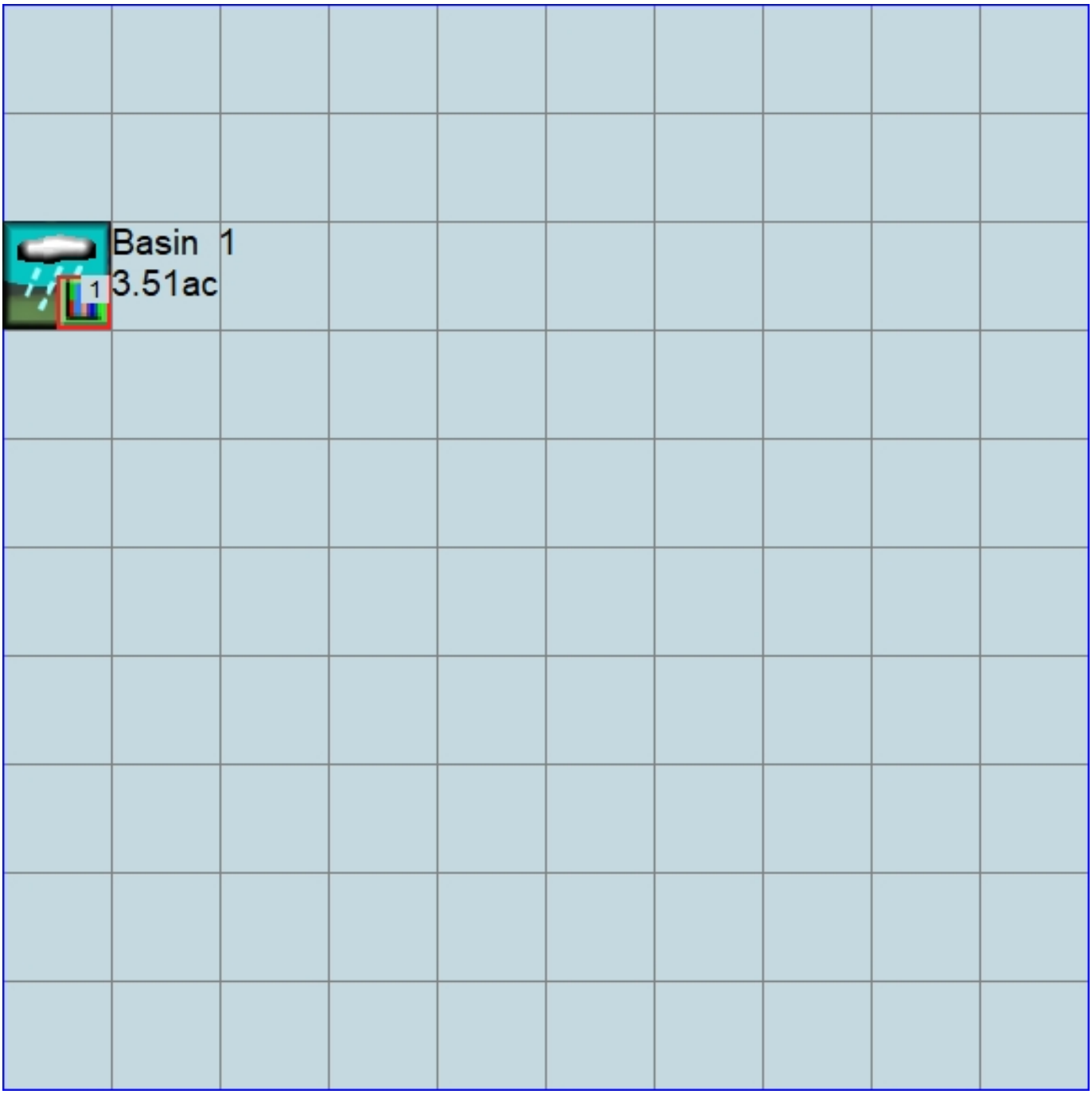
No PERLND changes have been made.

IMPLND Changes

No IMPLND changes have been made.

Appendix

Predeveloped Schematic



Mitigated Schematic

Predeveloped UCI File

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                    UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                               ***
WDM        26   Basin B Wetland.wdm
MESSU      25   MitBasin B Wetland.MES
           27   MitBasin B Wetland.L61
           28   MitBasin B Wetland.L62
           30   POCBasin B Wetland1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      15
      PERLND      16
      PERLND      13
      PERLND      18
      IMPLND       1
      IMPLND       4
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Direct                     MAX                     1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                           User  t-series Engl Metr ***
                                             in  out           ***
   15     C, Pasture, Steep       1    1    1    1   27    0
   16     C, Lawn, Flat           1    1    1    1   27    0
   13     C, Pasture, Flat        1    1    1    1   27    0
   18     C, Lawn, Steep          1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections ****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   15         0    0    1    0    0    0    0    0    0    0    0    0
```

```
  16         0    0    1    0    0    0    0    0    0    0    0    0
  13         0    0    1    0    0    0    0    0    0    0    0    0
  18         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags **************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
  15         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  16         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  13         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  18         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
  15         0    0    0    0    0    0    0    0    0    0    0
  16         0    0    0    0    0    0    0    0    0    0    0
  13         0    0    0    0    0    0    0    0    0    0    0
  18         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
  15             0       4.5      0.06       400      0.15       0.5     0.996
  16             0       4.5      0.03       400      0.05       0.5     0.996
  13             0       4.5      0.06       400      0.05       0.5     0.996
  18             0       4.5      0.03       400      0.15       0.5     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
  15             0         0         2         2         0         0         0
  16             0         0         2         2         0         0         0
  13             0         0         2         2         0         0         0
  18             0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                                ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
  15          0.15      0.25       0.3         6       0.3       0.4
  16           0.1      0.25      0.25         6       0.5      0.25
  13          0.15       0.4       0.3         6       0.5       0.4
  18           0.1      0.15      0.25         6       0.3      0.25
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
               ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
  15             0         0         0         0       2.5         1         0
  16             0         0         0         0       2.5         1         0
  13             0         0         0         0       2.5         1         0
  18             0         0         0         0       2.5         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                       in  out           ***
    1      ROADS/FLAT             1    1    1   27    0
    4      ROOF TOPS/FLAT         1    1    1   27    0
  END GEN-INFO
  *** Section IWATER***
```

```
  ACTIVITY
    <PLS > ************* Active Sections ****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    1         0    0    1    0    0    0
    4         0    0    1    0    0    0
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
    1         0    0    4    0    0    0    1    9
    4         0    0    4    0    0    0    1    9
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
    1         0    0    0    0    0
    4         0    0    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    1            400      0.01       0.1       0.1
    4            400      0.01       0.1       0.1
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    1              0         0
    4              0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    1              0         0
    4              0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Direct***
PERLND  15                        0.65     COPY   501     12
PERLND  15                        0.65     COPY   501     13
PERLND  15                        0.65     COPY   501     14
PERLND  16                        0.96     COPY   501     12
PERLND  16                        0.96     COPY   501     13
PERLND  16                        0.96     COPY   501     14
PERLND  13                        0.33     COPY   501     12
PERLND  13                        0.33     COPY   501     13
PERLND  13                        0.33     COPY   501     14
PERLND  18                        0.48     COPY   501     12
PERLND  18                        0.48     COPY   501     13
PERLND  18                        0.48     COPY   501     14
IMPLND   1                        0.61     COPY   501     15
IMPLND   4                        0.46     COPY   501     15

******Routing******
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
```

```
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1


<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                        in  out                               ***
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections ****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                   ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><-------><-------><-------><-------><-------><------->             ***
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                      ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit        for each possible exit
  <------><------->     <---><---><---><---><---> *** <---><---><---><---><--->
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1              PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1              IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY     1 OUTPUT MEAN   1 1     48.4      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    801 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
```

```
  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

  MASS-LINK       13
PERLND     PWATER IFWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   13

  MASS-LINK       14
PERLND     PWATER AGWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   14

  MASS-LINK       15
IMPLND     IWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   15


END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

Mitigated HSPF Message File

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Appendix C
Communication

Jeff Jenks

From: Lowell, Rebecca <rebeccab@mountvernonwa.gov>
Sent: Thursday, July 27, 2017 10:10 AM
To: Jeff Jenks; Chesterfield, Ana; Brian Ho
Cc: Julian Dodge; Wendell Johnson; Gerry Pless; Phillips, Chris
Subject: RE: MES - Master Plan questions

Hello All:

I asked the City's consultant Biologist, Dr. Lyndon Lee, to read through and respond to the issue outlined below as it relates to the City's Critical Areas Ordinance codified within Mount Vernon Municipal Code (MVMC) Chapter 15.40.

When there are potential critical area impacts from site development the City's stormwater regulations in MVMC 13.33 are supplemented and supported by our CAO (MVMC 15.40). As such, please see Dr. Lee's response to this particular issue and keep in mind that a critical area permit will likely be required for this development. I mention this because it would behoove the applicant to fully address this issue now instead of waiting and creating a potential delay in the processing of their permits.

> *Reading this, I would characterize the issue as a flaw in the WWHM model and a temporary loss of perspective regarding the overall intent of storm water protections and how to use the WWHM to achieve good design.*
>
> *Getting to the intent of the model and ordinances, the target is to ensure that with development, the existing wetland receives the quality and quantity of water in timing that mimics extant conditions or which improves the situation for the wetland. As long as this design achieves that standard, then the design team should write to that and justify their decisions.*

Thank you,

Rebecca Bradley-Lowell
Senior Planner
City of Mount Vernon
Development Services Department
910 Cleveland Ave / P.O. Box 809
Mount Vernon, WA 98273
360.336.6214

From: Jeff Jenks [mailto:jjenks@reidmiddleton.com]
Sent: Thursday, July 27, 2017 6:49 AM
To: Chesterfield, Ana <anac@mountvernonwa.gov>; Brian Ho <BrianH@tcfarchitecture.com>
Cc: Julian Dodge <jdodge@reidmiddleton.com>; Wendell Johnson <wjohnson@reidmiddleton.com>; Gerry Pless <Gerry@tcfarchitecture.com>; Lowell, Rebecca <rebeccab@mountvernonwa.gov>; Phillips, Chris <cphillips@mountvernonwa.gov>
Subject: RE: MES - Master Plan questions

Ana,

Our question relates to the interaction between Minimum Requirements #5 (LID), #6(Flow Control) and #8 (Wetland Protection) in the revised 2012 DOE manual, and the modelling methodology in MR#8/Appendix 1-D.
The flow control guidelines requires the existing conditions of the site be modelled as forested.
The Wetlands Protection guidelines (MR#8/Appendix 1-D) target maintaining existing volumes flowing to the wetland for a particular precipitation event (within a certain percentage). For the guideline in Appendix 1-D, this is modelled on a monthly and daily basis. Since this site is a developed site the existing conditions for Wetlands Protection is the current site conditions (a mix of hard surface and lawn).
The problem stems from attempting to model the Wetland Protection requirement with the flow control (detention system) applied when the two standards have different target existing conditions. When applying LID and flow control design to the site to mimic the forested condition, the act of the detention system controlling flow rates and durations effectively "moves" runoff volume reaching the wetland between days. While the runoff volume released from the detention system still reaches the wetland, it will not be modelled as reaching it on the same "daily" timetable as the existing condition. We have been able to successfully model the proposed site to meet the monthly wetland protection standard but cannot model it to meet the daily fluctuation standard when applying flow control with dissimilar existing conditions.

I believe this issue is simply a limitation of the WWHM model when dealing with wetlands fed by an already developed site and redeveloping that site to apply flow control. It seems like if the monthly wetlands protection volumes are being met in this case then the standard is being met.
Has the City encountered this situation before and do you have guidance or a standard on how to approach this case?

I hope my question is clear, if not please give me a call and we can discuss it.
Thanks for your help.

Jeff Jenks, PE
Project Engineer

Reid Middleton
Engineers | Planners | Surveyors

728 134th Street SW | Suite 200 | Everett, WA 98204
Office: 425-741-3800 | Fax: 425-741-3900

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From: Chesterfield, Ana [mailto:anac@mountvernonwa.gov]
Sent: Wednesday, July 26, 2017 4:17 PM
To: Brian Ho <BrianH@tcfarchitecture.com>
Cc: Julian Dodge <jdodge@reidmiddleton.com>; Jeff Jenks <jjenks@reidmiddleton.com>; Wendell Johnson <wjohnson@reidmiddleton.com>; Gerry Pless <Gerry@tcfarchitecture.com>; Lowell, Rebecca <rebeccab@mountvernonwa.gov>; Phillips, Chris <cphillips@mountvernonwa.gov>
Subject: RE: MES - Master Plan questions

Hello Brian,

Email is best. If they could put their questions in writing and email those that would be helpful. Please remember the project will be under the 2012 DOE manual revised December 2014.

The Department of Ecology revised (MR#8/see Appendix 1-D) how discharge into wetlands is handled. See attachment.

I am also attaching the City of Mount Vernon Ord. which adopted the 2012 DOE manual for your use and revised 13.33 Stormwater code and 15.40 Critical Areas code. Some of their questions might extend into the critical areas/planning realm so I have cc Rebecca as well.

Thanks, Ana

Ana Chesterfield
Development Services Engineering Manager
City of Mount Vernon
Development Services Department
Phone: (360)336-6214
For Inspections Call (360)336-6243
Web Site: http://www.mountvernonwa.gov

From: Brian Ho [mailto:BrianH@tcfarchitecture.com]
Sent: Wednesday, July 26, 2017 10:26 AM
To: Chesterfield, Ana <anac@mountvernonwa.gov>
Cc: Julian Dodge (jdodge@reidmiddleton.com) <jdodge@reidmiddleton.com>; Jeff Jenks (jjenks@reidmiddleton.com) <jjenks@reidmiddleton.com>; Wendell Johnson (wjohnson@reidmiddleton.com) <wjohnson@reidmiddleton.com>; Gerry Pless <Gerry@tcfarchitecture.com>
Subject: MES - Master Plan questions

Hi Ana,

We are working through early design and Master Plan preparation for the Madison replacement. Reid Middleton is our civil engineer on that project and they have been working closely with Reid Shockey to put documents together. They have some questions regarding the discharge into the wetlands on that site. Is it ok to have them contact you directly to get your input on how to interpret the requirements?

Thanks,

BRIAN HO | AIA, LEED® AP BD+C
MANAGING PRINCIPAL

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Appendix D
Maintenance Schedule & Agreement
(TO BE PROVIDED WITH BUILDING PERMIT APPLICATION)