each node was generally limited to up to two surface flow directions. This moves and retains the surface water fairly accurately until it can enter the system.

B.3.5 WEIRS AND STORAGE OVERFLOWS

Throughout the model, weirs are used to allow storage areas to spill into adjacent nodes or storage areas. The distance between these areas can sometimes be very long (> 300 feet) and the use of trapezoidal channels in these situations often introduces large continuity instabilities in XP-SWMM. Additionally, the true shape of the conveyance channel varies greatly over these long distances, so developing natural channels would require a large stationing and surveying effort. For these reasons, weirs were used to transfer water between these areas. Storage overflow weirs were added by determining the overflow elevation and receiving node for each of the storage areas and adding a weir link. Weirs in the model are generally oversized (broad-crested with a length of approximately 100 feet) to allow instantaneous transfer of water from one storage node to another.

Lastly, in XP-SWMM model development, it is important to minimize the double counting of storage for any surface water. In cases where storage node volume overlaps surface channels, double counting of storage was eliminated by modifying the surface channel within the volume footprint. Anywhere in which a surface channel overlapped with the 100-year, 24-hour flood volume footprint, the surface channel was turned off in the model and a weir was added in its place. One iteration of flood mapping was used to perform this modification. Weir crests were set to the upstream node surface elevation, assuring that any surcharged water is diverted directly to the storage node

Like other links, when a weir shares the same alignment as an existing feature, the Link ID number is retained. However, given that weirs are not actually multi-links within XP-SWMM, the prefix was changed to "WR" for the Link ID and "W" for the conduit ID. Any comments or assumptions about the weirs used in the model are available as attributed in the model weir GIS shapefile.

Figure 1 displays the locations of the aforementioned model elements and catchment delineations.

B.4 MODEL REASONABILITY

A good hydrologic and hydraulic model will simulate stormwater behavior and be a reliable tool for guiding management decisions and future development. With the availability of reliable monitoring data, a model can be calibrated to ensure that it provides results like those observed. The process of calibration includes evaluating the behavior of the model and adjusting input parameters to reduce the error between simulated and observed data, typically from one storm event. Calibration data may take the form of measured discharge (flow), high water marks (flood), or historical accounts (observations). The process also includes verification, which tests the parameter selection through modeling a different storm event and comparing the results to observed data.

In July 2011, a 4.7" rain event occurred in Glenwood over a 31-hour period. The rain event caused a highwater elevation of approximately 1142.89 feet and overtopping of TH28 between 4th Street NW and 5th Street NW. This rain event was modeled within the XP-SWMM to verify the accuracy of the model. The results of the model show a highwater elevation for that area to be 1142.24 feet, 0.65-feet below the observed highwater elevation. A complicating factor at this flooding location is the presence of sediment along with other debris in the culvert crossing of Perkins creek across TH 28. Based on the comparison of the model output to the observed highwater mark, the model is suitable for its intended purpose of identifying flood prone areas. Future uses of the model should consider the suitability on a case by case basis. The model would benefit from additional calibration should more observed flooding data become available.

B.5 BOUNDARY CONDITIONS

B.5.1 LAKE LEVEL

Flow conveyed through the model eventually outlets at various locations. These points are known as outfalls. Often these outfalls apply constraints to the model, also known as boundary conditions, which affect the modeling results. These boundary conditions can be static or time varying. The primary boundary condition in the study area is the Lake Minnewaska water level. The DNR identifies the Ordinary High Water Elevation (OHW) of Lake Minnewaska as 1138.76 feet (NAVD 88). Utilizing the OHW for boundary conditions is a reasonable assumption because there is a likelihood of Lake Minnewaska experiencing an OHW elevation during a rain event.

B.5.2 DIRECT DRAINAGE

The study area includes approximately 54.5 acres of land that drains directly to Lake Minnewaska along approximately 2.2 miles of shoreline. Because these areas do no contribute to the stormwater infrastructure system, the runoff from these areas will not affect infrastructure capacity or flooding. These areas were combined into one catchment.

B.6 RAINFALL EVENTS

Multiple rainfall events were used in the modeling process. The study area model is designed to hold the 500-year, 24-hour Atlas 14 storm event, and results are processed and reported for the 2-, 10-, and 100-year, 24-hour Atlas 14 storm events. The NRCS Type II-unit rainfall hyetographs were utilized in the model. The depths of the various events are given in **Table 4**. Depths are based on the areal average of the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 projections for the study area (NOAA, 2015). Each of the storms were entered into the study area model as MSE3 unit rainfall hyetographs and run with a multiplier corresponding to the total depth.

Table 4: Rainfall events used in modeling the study area

Event Name	Rainfall Type	Total Depth (in)	Duration (hrs)
2-year	NRCS Type II	2.61	24
10-year	NRCS Type II	3.79	24
100-year	NRCS Type II	6.17	24
500-year	NRCS Type II	8.24	24

B.7 JOB CONTROL

Job control settings determine how the model simulations are run and how the model engines carry out the calculations. This section describes what job control settings are used in the study area model runs.

The hydraulics job control primarily drives the time control. For storm events run in the study area model, a generic start date was used (1/1/2014). The events were run over a time period required to fully drain the model (four days). The final model runs were performed at a time step determined to provide model hydraulic continuity and resolution, and reduce continuity error to an acceptable percentage (generally ±2%). The time step for the study area model is 60 seconds. The hydrology and hydraulics engines were run simultaneously. The XP-SWMM default settings were used for all other hydraulic job control settings. Runoff job control settings were set to the XP-SWMM recommended default time control settings (dry time step of 86,400 seconds, transition time step of 60 seconds, and wet time step of 60 seconds). The hydraulic simulation start time was used for the runoff simulation as well. The XP-SWMM default settings were used for all other runoff job control settings.

Several configuration parameters were entered into the study area model settings. These parameters, their values, and their description are given in **Table 5**. The MINLEN parameter of 30 feet was used because it is the recommended default by XP. Performing hydraulic calculations at lengths less than 30 feet can introduce instabilities and continuity errors at various time steps. The MIN_TS parameter of 0.10 seconds and SPATIAL parameter of 0.55 were used based on a recommendation from XP to reduce model continuity errors. The former allows the model to iterate down to a smaller time step to improve continuity at problem links, while the latter modifies the spatial conduit weighting between the upstream and downstream ends of the pipe during hydraulic calculations (0.55 upstream and 0.45 downstream).

Table 5: Configuration parameters used in the study area model

Parameter Name	Value	Description
MINLEN	30	This parameter is used to alter the minimum length of conduits within the Analysis Engine
MIN_TS	0.10	This is the smallest time step used by the simulation
SPATIAL	0.55	This changes the spatial conduit weighting between the upstream and downstream ends

APPENDIX C – WATER QUALITY MODELING METHODS

C.1 MODEL DEVELOPMENT

The water quality model for the study area was developed using the Program for Predicting Polluting Particle Passage thru Pits, Puddles, & Ponds (P8) Urban Catchment Model, version 3.5. The model was selected based on its wide use throughout Minnesota and its simplicity in modeling urban watersheds.

P8 simulates rainfall, pollutant loading, and runoff from the watershed and subsequently routes the runoff through water quality treatment devices that simulate pollutant particle settling, decay, and filtration/infiltration.

C.1.1 HYDROLOGIC INPUTS

Hydrologic analysis determines the amount of excess precipitation (i.e., runoff) and the rate of that excess runoff. This analysis relies on several inputs known as hydrologic parameters.

P8 uses hourly precipitation records to generate runoff volumes and also requires daily temperature data. Historic precipitation and temperature data were obtained from the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center website for the Glenwood Municipal Airport station. When periods of record from that station were unavailable, records were supplimented with the Alexandria Municipal Airport station.

Often water quality models simulate multi-year periods to determine annual average loading values as shorter simulation periods may be impacted by abnormally dry or wet years. Periods of 30 years or longer are generally used for long-term simulations to compute annual average values. For this study, data was readily available from 1971-2013 and the model was run for a 40-year period, beginning September 1st 1973, after a 2-year warmup period.

Runoff from pervious areas and indirectly-connected impervious areas wass modeled in P8 using the SCS Curve Number (CN) methodology (USDA, 1964) developed for the Generalized Watershed Loading Functions (GWLF) model (Haith et al., 1992). Runoff from impervious areas starts after the cumulative storm rainfall exceeds the specified depression storage, and thereafter the runoff rate equals the rainfall intensity.

These methods require the calculation of watershed area, pervious CN, directly and indirectly connected impervious fractions, and depression storage. Unique hydrologic parameters were extracted from special GIS data over the 221 total P8 subwatersheds in the study area P8 model. P8 subwatersheds match the catchments used in the XP-SWMM study area model. Data inputs used in GIS to extract the hydrologic parameters included NRCS SURRGO soil data, National Land Cover Database (NLCD) land use, Pope County parcel data, and City of Minneapolis model guidance (Minneapolis, 2005). The city was subdivided into consolidated land use categories matching the Minneapolis model guidance and the subwatersheds were sampled with the area weighted average of the Minneapolis model guidance parameters outlined in **Table 1**.

Table 1: Met Council/City of Minneapolis model guidance land use hydrologic parameters used in P8 model

City of Minneapolis model guidance Consolidated Land Use Categories	% Impervious	DCIA Multiplier	Impervious Depression Storage (in)
Commercial/ Industrial	95	1	0.094
Mixed Urban	85	0.9	0.02
Multi-Family Residential	70	0.6	0.02
Recreational	5	0	0.02
Single Family Residential	50	0.6	0.02
Transportation Related	95	1	0.094

C.1.2 POLLUTANT LOADING

Precipitation events generate sediment and associated pollutant loadings from pervious and impervious surfaces throughout the watershed. The rate at which sediment particles accumulate throughout the watershed, as well the ability of particles to be removed by water quality BMPs via filtration and settling, is defined by particle characteristic assumptions and assumptions related to street sweeping operations. The pollutant load associated with particles is defined by water quality component assumptions applied in P8.

Sediment characteristics (such as settling velocity, filtration efficiency, mass accumulation rate, etc.) can vary greatly based on the size of individual sediment particles. For this reason, P8 allows for up to five typical particle sizes (referred to as particle fractions) to be modeled. The P8 default particle file, NURP50, has been applied to the study area model to define particle characteristics of five particle fractions.

The only modification made to the default NURP50 particle file was that filtration efficiencies applied to each particle class were adjusted to allow for the simulation of biofiltration. To reflect the removal that would be expected through infiltration, the P8 default efficiency is 90% for P0 and 100% for particle fractions P10 through P80. However, in order to simulate pollutant removal via filtration (pollutants not removed being conveyed downstream), the removal efficiencies were adjusted to reflect the typical phosphorus filtration efficiency of biofiltration systems reported in the Minnesota Pollution Control Agency's (MPCA) Minimal Impact Design Standards (MIDS) calculator. For the dissolved phosphorus fraction (particle fraction P0), the filtration efficiency was set to 20%. For the particulate fraction (particle fractions P10 through P80), the filtration efficiency was set to 80%.

The concentration of water quality pollutants (such as TP, lead, total Kjeldahl nitrogen (TKN), etc.) associated with each particle fraction is defined by water quality component assumptions applied in P8. For example, if the particle composition of TP associated with a particle class is 5,000 mg/kg, then the model assumes that 5,000 mg of TP is transported for every kilogram of that particle class transported. Because the pollutant particle composition associated with sediment can vary greatly depending on sediment size, P8 allows a unique pollutant particle composition (mg/kg) to be applied to each particle class. For the P8 model of this study area, the default water quality component parameters from the NURP50 particle file were assumed.

Street sweeping practices can reduce the buildup of sediment on street surfaces between precipitation events. For this reason, P8 defines impervious areas as either "swept" (road surfaces which are swept) or "unswept" (roads and other impervious surfaces which are not swept). The buildup of sediment on "swept" surfaces is reduced based on the sweeping schedule assigned (number of sweeping operation per week) and the sweeper efficiency applied to each sediment particle class. Sweeping was assumed to occur twice a year for the P8 model of this study area. The default value of 1 was used for the P8 'Sweeping Efficiency Scale Factor".

C.1.3 TREATMENT DEVICE INPUTS

The P8 model simulates pollutant removal at features that provide water quality treatment. These features are referred to as devices in P8. Treatment devices can be detention ponds, infiltration basins, swales, or a user-defined general device. Non-treatment devices with hydraulic residence time inputs are pipes, flow splitters, or aquifers. Required pond inputs include the bottom surface area, permanent pool area and depth, flood pool area and volume, infiltration rates, and the outlet type and size. Infiltration basins model the storage pool area and volume and infiltration rate. Swales use length, slope, bottom width, berm side slope, overflow elevation, Manning's 'n,' and an infiltration rate. A general device is versatile in modeling with an area and discharge vs. elevation table, and outflow by infiltration, normal, or overflow discharge rates. These inputs in all of the devices are used to model treatment of TP and TSS based on retention (i.e., hydraulic residence) time, subsequent settling and decay of particles, and through infiltration.

P8 currently allows for a maximum of 75 devices at which loadings and removals are calculated. 66 devices were used in the existing conditions model to preserve devices that may be added in future developments. This limits the spacial resolution available to analize the water quality of the runoff (as there are 238 catchments in the existing XP-SWMM model). The catchments from the XP-SWMM model had to be used as P8 subwatersheds, excluding 17 that did not contribute in a 500-year event. The P8 subwatersheds were then strategically merged (i.e., routed to a common device in P8) to create the selected P8 device drainage areas. The size and location of P8 device drainage areas was influenced by the anticipated location of future potential BMPs, locations of known flooding, and the need for spatial resolution and routing in model results. Additional effort was put into preserving the spatial resolution of the model to capture potentially higher loading from certain P8 subwatersheds.

The existing P8 model calculates pollutant removals for 34 devices modeled as 26 ponds and eight infiltration basins. Seven of these devices are existing BMPs. There are additional devices that do not provide treatment modeled as 32 pipes for network routing. Geometery for all treatment devices was obtained from the LiDAR DEM, as-built plans. Dead storage geometery was cacluated from an assumed depth of two feet for wetlands and four feet for ponds.

A general review of the soils in the watershed indicate generally high infiltrating soils. Soil Survey Geographic database (SSURGO) data shows predominantly A and B Hydrologic Soil Groups in the watershed. Infiltration was included for existing BMPs or for treatment devices at a location with no evidence of prolonged wetting in aerial photography. Infitration rates were assigned according to the Design Infiltration Rates table from the Minnesota Stormwater Manual website (MPCA, 2016) and the Hydrologic Soil Group (HSG) from SSURGO at that device location.

C.1.4 P8 MODEL PARAMETERS

The P8 model requires a variety of input parameters in addition to watershed, pollutant loading, and device data. The time steps per hour parameter defines the number of calculations performed per model hour. 15 time steps per hour (or a calculation every four minutes) was required to eliminate mass balance errors greater than 2%. P8 parameters not discussed in this section were left at the default settings as defined in P8 version 3.5.

Snowfall, the generation of snowpack, and snowmelt are modeled processes in P8. Depending on daily average air temperature, precipitation events in P8 are modeled as either rainfall or snowfall. Over winter and spring months, snowfall accumulates across the watershed as snowpack. As daily average air temperature begins to rise in the spring, accumulated snowpack is converted into snowmelt (i.e., runoff). All model parameters related to snowfall, snowpack, and snowmelt were left at default values.

The amount of runoff generated by a precipitation event is impacted by the antecedent moisture content (AMC) of the soil. P8 assumes either AMC2 (typical runoff potential) or AMC3 (highest runoff potential) depending on factors such as how much precipitation has been applied to the watershed over the last five days and whether the soil is frozen. Because AMC2 is the typical soil condition assumed by P8, pervious curve numbers applied throughout the watershed reflect AMC2 soil conditions. Default values were assumed for all parameters related to AMC calculation in P8.

C.2 MODEL RESULTS

Table 2: Existing deviceshed annual average generated load summary

Deviceshed	Area (acres)	TSS Watershed Load (lbs/yr)	TSS Delivered Load (lbs/yr)	TP Watershed Load (lbs/yr)	TP Delivered Load (lbs/yr)
HEI80255	22.1	4727	4727	15.2	15.2
HEI80505	23.4	2045	2045	6.6	6.6
HEI80533	2.7	457	151	1.5	1.0
SEH2050	9.8	1137	658	3.7	3.0
SA999002	21.8	4471	3	14.5	0.1
SEH1185	5.0	231	9	0.8	0.2
SA999005	6.3	33	15	0.1	0.1
SA999013	1.7	93	5	0.3	0.0
SA999017	26.6	746	189	2.6	1.6
SA999025	46.1	1867	61	6.1	1.6
SA999026	2.1	171	171	0.6	0.6

Deviceshed	Area (acres)	TSS Watershed Load (lbs/yr)	TSS Delivered Load (lbs/yr)	TP Watershed Load (lbs/yr)	TP Delivered Load (lbs/yr)
SA999027	168.6	2995	728	10.3	6.2
SA999034	8.6	228	26	0.8	0.3
SA999035	2.9	107	7	0.4	0.1
SEH2041	13.2	2007	461	6.5	3.7
SEH2034	2.3	27	8	0.1	0.1
SEH1159	43.4	7668	512	24.7	7.9
SEH1025	7.8	1800	1800	5.8	5.8
UK990120	12.1	1924	1924	6.2	6.2
SEH1037	15.9	5040	5040	16.1	16.1
SEH1099	69.5	7988	6041	25.8	24.8
SEH1136	0.2	35	35	0.1	0.1
SEH2031	85.8	4200	1311	13.7	8.7
SEH1081	31.1	4318	4318	13.9	13.9
UK990015	11.8	1943	1943	6.2	6.2
SEH1343	1.7	432	16	1.4	0.1
SEH2003	25.3	2495	192	8.0	3.1
SEH2005	56.5	2774	1058	9.1	7.3
SEH2032	28.8	4047	482	13.0	6.4
SEH2019	296.3	4324	3581	15.0	14.5
SEH2029	25.3	707	407	2.4	2.0
SEH2038	4.7	61	19	0.2	0.1
SEH2052	123.3	1235	387	4.4	3.1
SEH2055	1.8	79	31	0.3	0.2
SEH2065	3.9	143	98	0.5	0.4
SEH2073	82.5	3002	1339	10.0	7.8
SEH2079	65.4	2545	341	8.4	4.2
SEH2083	1.2	238	238	0.8	0.8
SEH2085	5.9	1033	1033	3.3	3.3
SEH971	34.2	1497	541	5.0	3.8
UK990005	55.9	1128	613	3.8	3.3
UK990006	0.5	18	8	0.1	0.0
UK990007	27.1	1822	278	5.9	2.7
UK990038	15.5	3741	3741	12.0	12.0
UK990083	6.6	1515	1515	4.9	4.9
UK990065	15.0	812	326	2.7	2.1
UK990066	6.4	721	597	2.3	2.3
UK990084	16.7	1586	1586	5.2	5.2
UK990085	0.6	70	70	0.2	0.2
UK990076	60.0	2568	97	8.5	1.7
SEH1049	2.9	125	125	0.4	0.4
UK990125	1.0	115	115	0.4	0.4
SEH1034	0.2	21	21	0.1	0.1

Deviceshed	Area (acres)	TSS Watershed Load (lbs/yr)	TSS Delivered Load (lbs/yr)	TP Watershed Load (lbs/yr)	TP Delivered Load (lbs/yr)
UK990109	54.7	1669	669	5.8	4.5
UK990141	5.2	1354	1354	4.3	4.3
UK990144	2.4	286	286	0.9	0.9
UK990132	12.7	1619	1619	5.3	5.3
UK990156	54.5	6228	6228	20.2	20.2
SEH5000	6.7	54	6	0.2	0.1
HEI80015	35.4	5540	2510	17.9	14.2
UK990030	65.7	8574	6483	27.6	26.5
HEI80517	26.4	3386	3386	10.9	10.9
SEH1084	23.1	546	546	1.9	1.9
SEH1133	45.0	4385	1759	14.2	11.2
UK990074	44.9	625	473	2.2	2.1
HEI80513	58.0	4417	4417	14.4	14.4
HEI80512	88.0	1191	590	4.2	3.2
TOTALS:	**2128.7**	**134,986**	**81,369**	**441**	**342**

Table 3: Existing devices annual average loading and removals

P8 name	Drainage Area (ac)	Annual TSS % Removal	Annual TSS Removal (lbs)	Annual TP % Removal	Annual TP Removal (lbs)
HEI80533	2.7	67%	307	34%	0.5
SEH2050	134.9	42%	765	20%	1.5
SA999002	21.8	99%	4424	99%	14.3
SEH1185	65.0	72%	2012	60%	5.5
SA999005	13.0	41%	19	22%	0.1
SA999013	1.7	91%	121	89%	0.4
SA999017	26.6	69%	518	36%	0.9
SA999025	46.1	87%	1616	56%	3.5
SA999027	345.2	76%	3434	40%	8.4
SA999034	8.6	89%	203	57%	0.4
SA999035	2.9	84%	89	51%	0.2
SEH2041	107.2	26%	1673	9%	2.9
SEH1159	65.2	71%	5473	44%	11.1
SEH2031	200.0	62%	5583	34%	14.5
SEH1343	1.7	96%	416	91%	1.3
SEH2003	25.3	50%	1240	16%	1.3
SEH2005	56.5	50%	1375	16%	1.5
SEH2032	28.8	48%	1951	15%	2.0
SEH2029	25.3	42%	300	16%	0.4
SEH2052	123.3	20%	252	3%	0.1
SEH2055	125.1	32%	321	12%	0.5
SEH2065	86.4	32%	663	15%	1.4
SEH2073	82.5	35%	1046	8%	0.8
SEH2079	130.4	45%	1494	16%	1.9
SEH971	34.2	52%	782	20%	1.0

P8 name	Drainage Area (ac)	Annual TSS % Removal	Annual TSS Removal (lbs)	Annual TP % Removal	Annual TP Removal (lbs)
UK990005	110.5	28%	568	8%	0.8
UK990006	52.9	21%	231	13%	1.0
UK990007	52.4	65%	1986	41%	5.1
UK990065	117.6	52%	3549	19%	4.3
UK990066	647.0	17%	1675	3%	1.6
SEH5000	6.7	74%	40	39%	0.1
HEI80015	35.4	55%	3031	21%	3.7
UK990030	394.1	24%	5057	4%	3.1
HEI80512	88.0	50%	601	23%	0.9
Totals:			**52,814**		**97.0**

APPENDIX D – REFERENCES

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APPENDIX E – CONCEPTUAL BMP DESIGN SHEETS

BMP 1 – Typical Bioretention with Curb Cut

Watershed: SEH1099

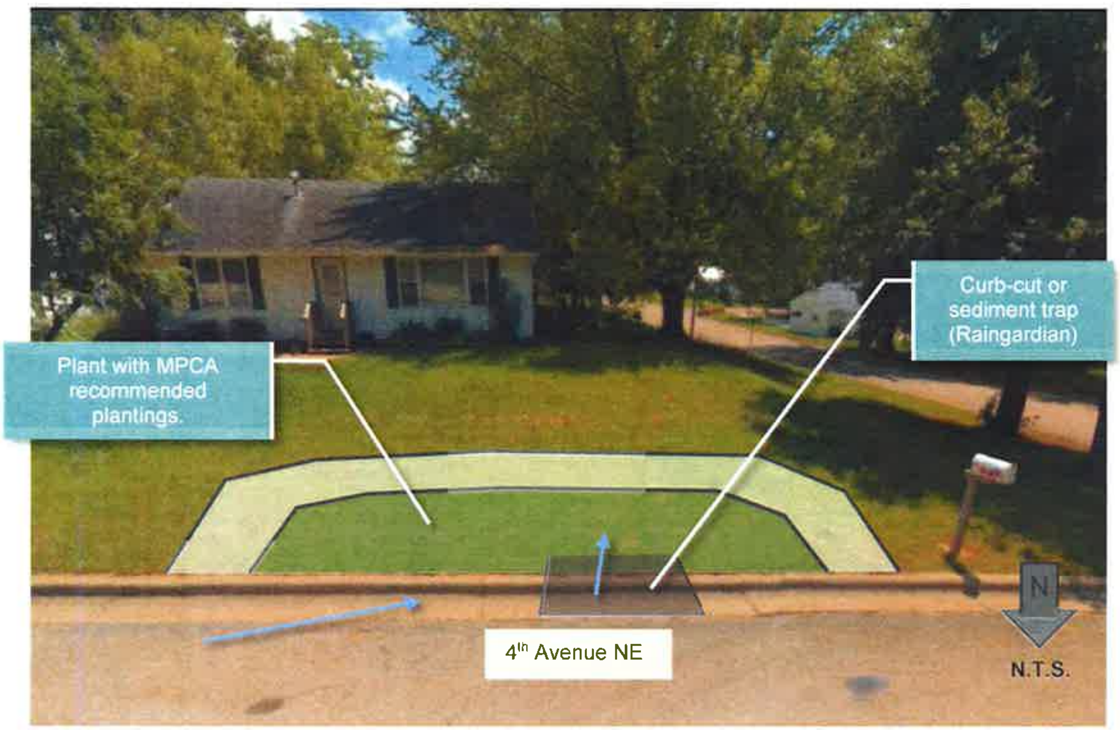
Location: Example: 4th Ave NE and 5th St NE;
See map for other potential locations

BMP Type: Bioretention (raingarden)

0.34 acres — Catchment Area

1,360 cu-ft — 1.1 inch Treatment Volume

0.5 lbs — Annual TP Removal

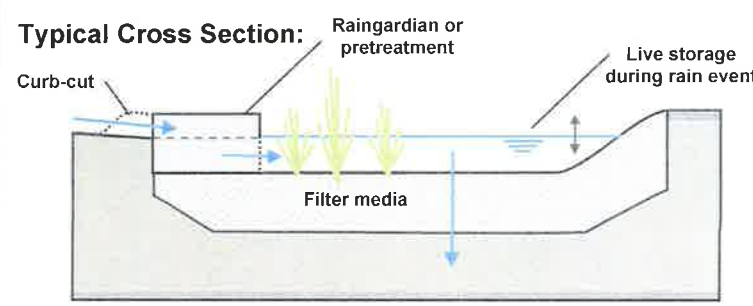


BMP Alternatives:	Est. Construction Cost:
• Infiltration Basin (grass bottom) • Filtration (using underdrain for areas restricting infiltration)	$14,000 (each) 3,900 $/lb TP **Ease of Maintenance:** Medium

Notes: BMP1 benefits include community involvement, education, homeowner aesthetics, and reduction of TSS and TP through biofiltration and infiltration. Community involvement in projects can help with installation or even funding.

Limitations/Cautions: Homeowner buy-in is essential to the project. Maintenance and upkeep is required for proper function, which poses difficulties to enforce or document. To make an impact in reduction of pollutants to Lake Minnewaska many raingardens must be implemented.

Typical Cross Section:



CONCEPTUAL BMP DESIGN

BMP 2 – HWY 55 POND NEAR CLYDE

Watershed: SEH2005

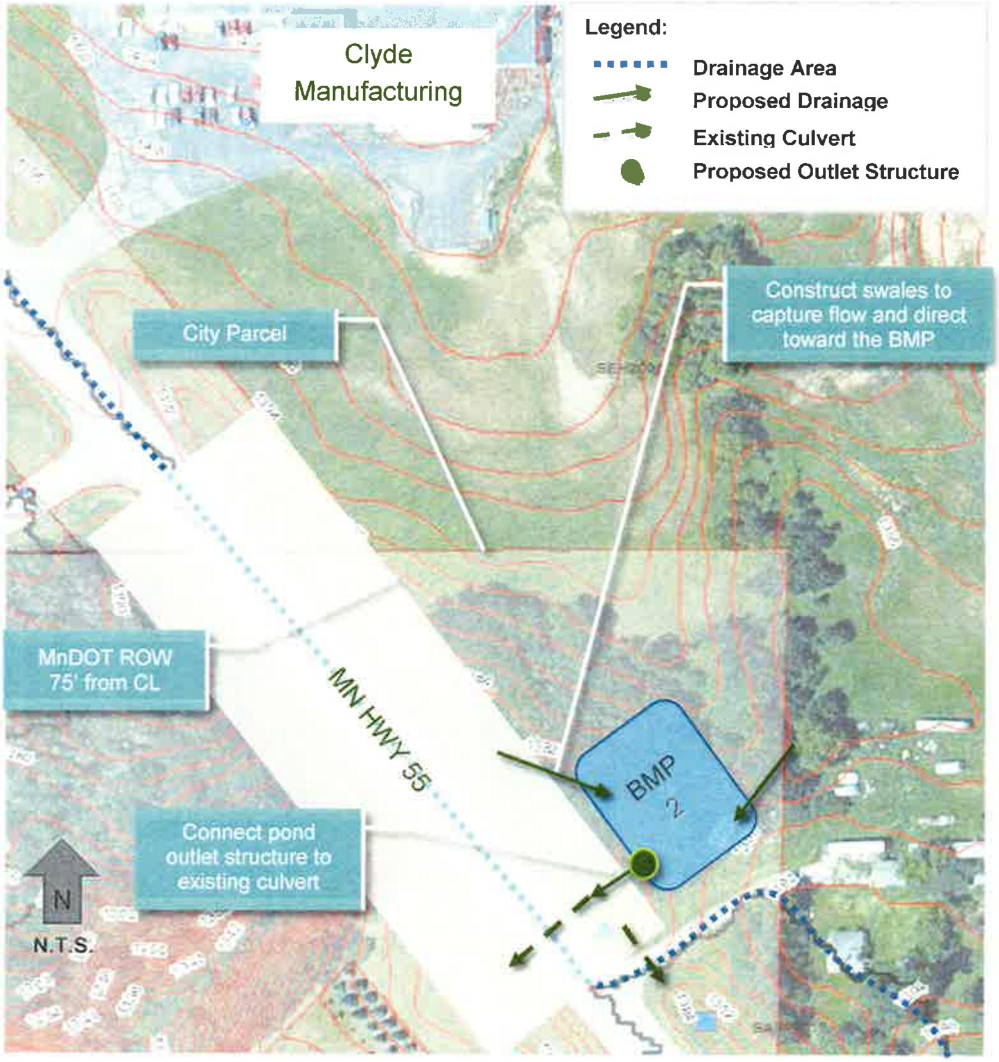
Location: Hwy 55, south of Clyde Machines property

BMP Type: Stormwater Pond

56 acres Catchment Area (17% Imperv.)

1.72 ac-ft Dead Storage

3.2 lbs Annual TP Removal



BMP Alternatives:

- Infiltration basin
- Infiltrating ditch checks along the swale

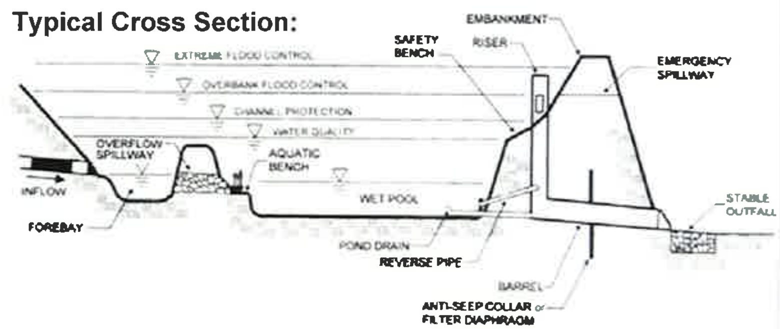
Est. Construction Cost:
$87,000
1,700 $/lb TP

Ease of Maintenance:
Easy to Medium

Notes: BMP 2 provides treatment and peak discharge reduction of runoff from part of Hwy 55 and two commercial developments; and it could treat future developments. This pond could be efficiently sized with a water quality model (such as P8) in or order to account for high-infiltrating soils, and eliminate oversizing the pond. Due to the soil type, the pond my infiltrate in which case the pond would act as an infiltration basin.

Limitations/Cautions: To capture runoff from the swale, grading the pond in could require an 8-10 foot cut of existing ground. Construction would be considerably easier if built within MnDOT ROW.

Typical Cross Section:



PRELIMINARY

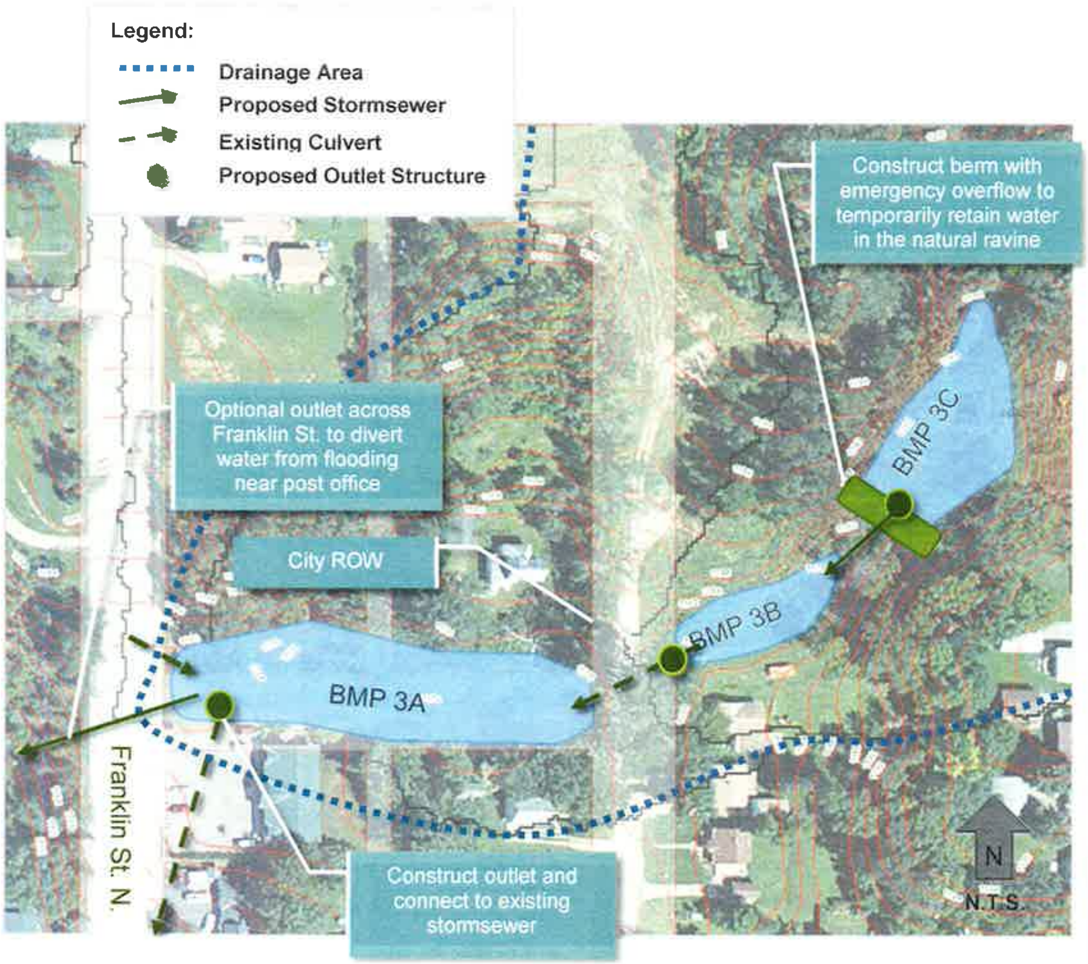
CONCEPTUAL BMP DESIGN

BMP 3 – FRANKLIN ST. N. RAVINE

Watershed: SEH2065 & SEH2073

Location: North of 6th Ave. NE between Franklin St. N. & 2nd St. NE

BMP Type: 3-Stage Dry Retention Basin (temporary storage)



86 acres — Catchment Area

3.1 ac-ft — Flood Storage

1.4 lb — Annual TP Removal

BMP Alternatives:

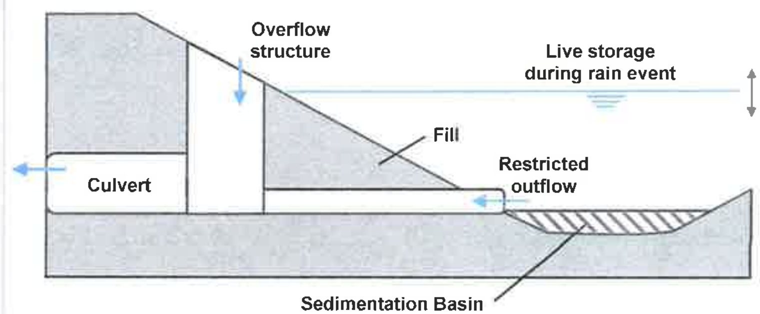
- Pond (add dead storage)
- Excavate larger storage

Est. Construction Cost:
$97,000
3,700 $/lb TP

Ease of Maintenance:
Easy

Notes: BMP 3 consists of three temporary storage basins in series to reduce discharge downstream. The basin 3A is shown with significant excavation to maximize storage. Basins 3B and 3C require minimal excavation, as storage is provided by the natural ravine geometry. A water quality component could be added to this BMP by including a pond or sedimentation basin in the basins. Also, designing staged outlets would provide retention for a wider range of rain events. **Limitations/Cautions:** Land acquisition or easements will be required for all basins. 2-foot freeboard over flood elevation to existing structures is recommended. Depending on the elevation of the buildings, this could reduce the amount of storage available.

Typical Cross Section:



PRELIMINARY

Conceptual BMP Design

BMP 4 – A&W Bioretention

Watershed: SEH2031

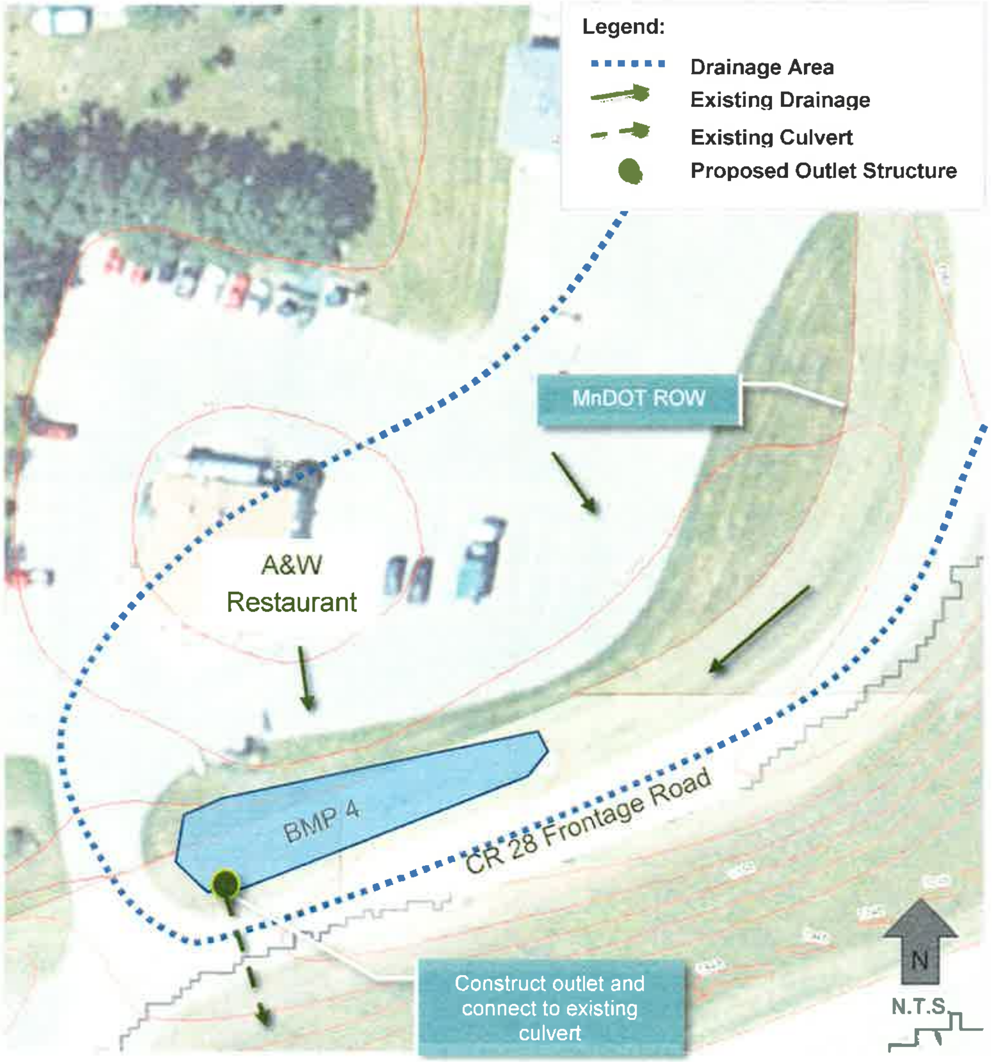
Location: A&W Restaurant near Hwy 55 and CR 28 Intersection

BMP Type: Bioretention Basin

1.6 acres — Catchment Area

4,500 cu-ft — 1.1 inch Treatment Volume

1.4 lb — Annual TP Removal



BMP Alternatives:

- Infiltration Basin
- Filtration (using an underdrain)
- Infiltrating ditch checks along the swale

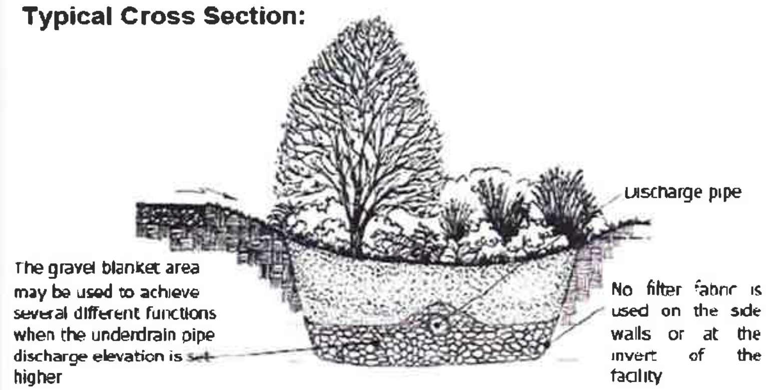
Est. Construction Cost:
$36,000
3,800 $/lb TP

Ease of Maintenance:
Medium

Notes: BMP 4 provides treatment of runoff from part of CR 28 Frontage Road and two commercial developments. Plantings in bioretention basins make them an aesthetically pleasing option and help with buy-in from land owners. Ditch checks along the swale may be a viable, inexpensive option.

Limitations/Cautions: Permission will be required to construct BMP 4 in MnDOT ROW along the CR 21 Frontage Road, as well as on the A&W Restaurant property.

Typical Cross Section:

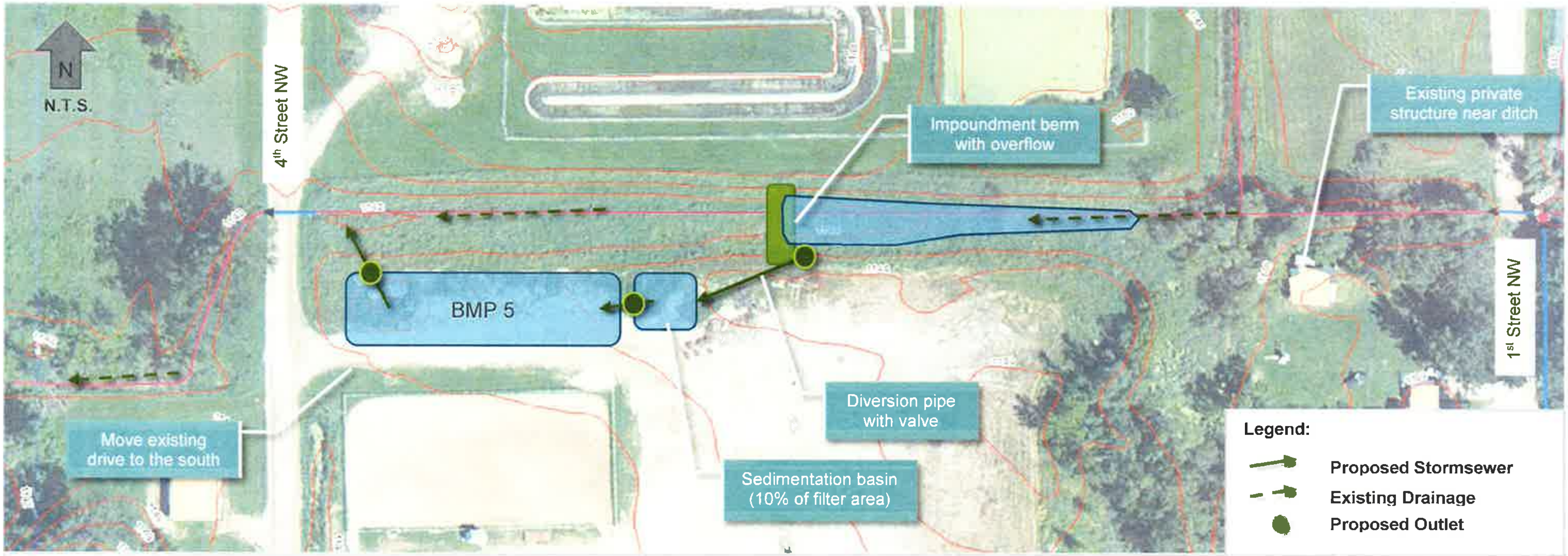


HoustonEngineering Inc

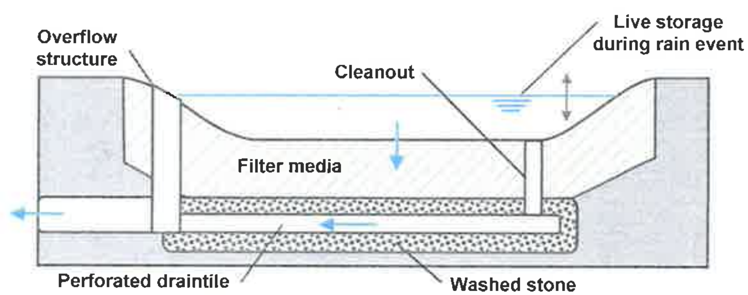
BMP 5 – FAIRGROUNDS FILTER

Location: North side of Pope County Fairgrounds
BMP Type: Low Flow Iron Enhanced Sand Filtration

214 acres — Catchment Area
0.4 ac-ft — Filter Storage
21 lbs — Annual TP Removal



Typical Cross Section:



Notes: BMP 5 will impound water in the existing ditch in order to divert low flows at a designed discharge to the iron enhanced sand filter. A valve will be installed for maintenance of the filter.

Limitations/Cautions: DNR permissions must be obtained for the BMP and impoundment. The impoundment will increase the chance of inundation of an upstream private structure. Shallow groundwater will likely require lining of the filter. Regular maintenance is a must to ensure proper functioning of the filter.

BMP Alternatives:
- Off-line filtration swale parallel to ditch
- Stormwater Pond

Est. Construction Cost:
$239,000 or 1,900 $/lb TP

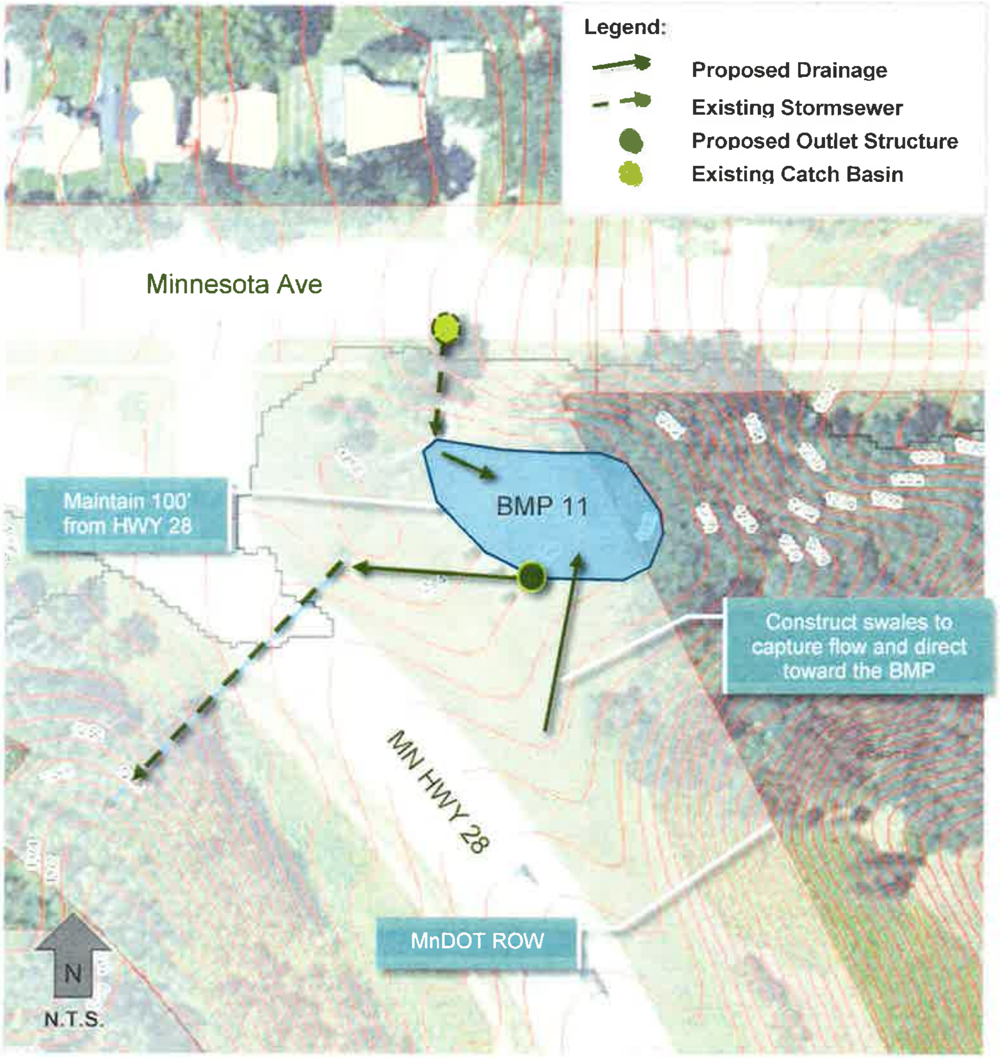
Ease of Maintenance:
Difficult

BMP 11B – HWY 28 & MINNESOTA AVE DEPRESSION

Watershed: SEH971

Location: East of Highway 28 and Minnesota Ave. Intersection

BMP Type: Biofiltration



BMP Alternatives:

- Infiltration depending on soil borings and groundwater
- *Pond (BMP11a)*

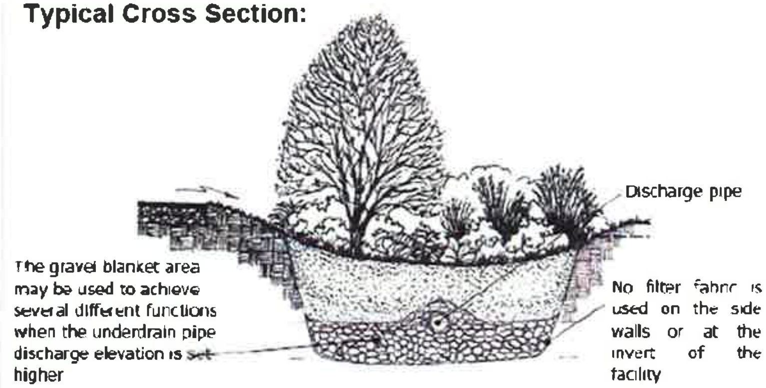
Est. Construction Cost:
$92,000
7,700 $/lb TP

Ease of Maintenance:
Difficult

Notes: Surface runoff will be collected through an existing catch basin on Minnesota Ave. with existing stormsewer discharging into the BMP. Additional runoff will be captured via a swale from the northeast ditch of Highway 28. Significant excavation will be required for the location shown, however, the location may vary depending on MnDOT offset requirements. If a smaller offset is acceptable, excavation could be reduced by locating the BMP further west.

Limitations/Cautions: Most of the BMP will be located within MnDOT ROW and permissions must be obtained. Furth modeling may require BMP upsizing due to the large pervious contributing area. This could be avoided by excluding capturing runoff from Hwy 28.

Typical Cross Section:



BMP 14 – 2ND AVE SW PARKING LOT TREE TRENCH

Watershed: UK990015

Location: Northwest corner of 2nd Ave. SW and Franklin St S

BMP Type: Tree Trench with Infiltration

0.6 acres — Catchment Area

2,400 cu-ft — 1.1 inch Treatment Volume

0.8 lbs — Estimate Annual TP Removal

BMP Alternatives:

- Infiltration Trench
- Permeable Pavement

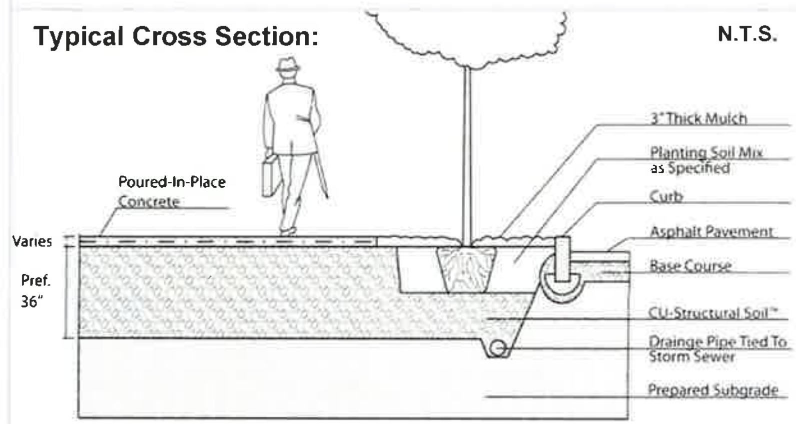
Est. Construction Cost:
$148,000
10,600 $/lb TP

Ease of Maintenance:
Difficult

Notes: A tree trench retrofit will provide treatment of the private parking lot via underground storage at potentially multiple locations along the perimeter of the lot. Design details of a tree trench system are essential and it is recommended to utilize guidance from the MN Stormwater Manual.

Limitations/Cautions: Infiltration will depend on soil borings and groundwater conditions. Further, there is no adjacent storm sewer to tie in a drainage pipe so filtration is likely impracticable.

Typical Cross Section: N.T.S.



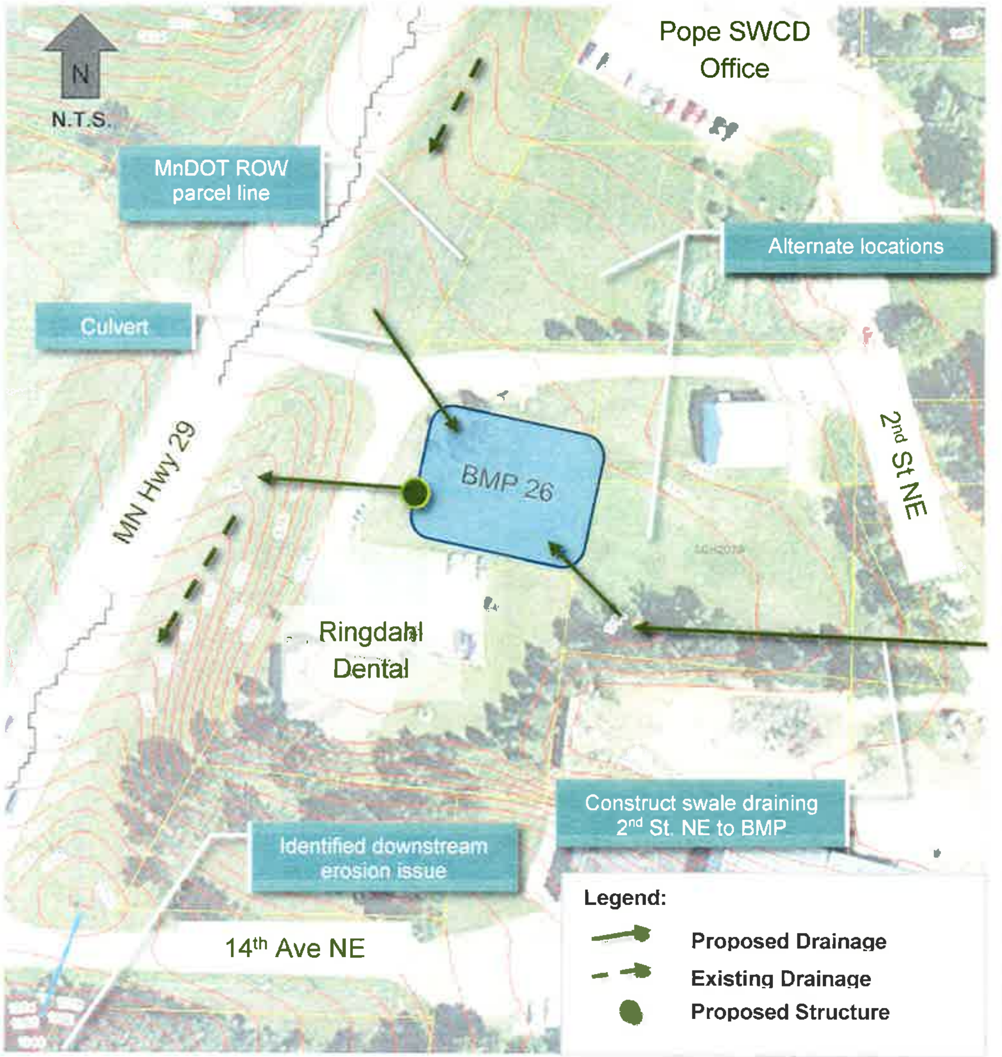
BMP 26 – Hwy 29 & 2nd St NE Detention Pond

Watershed: SEH2079

Location: East of Highway 29 near 2nd St NE

BMP Type: Stormwater Detention Pond

17 acres	Catchment Area
0.73 ac-ft	Flood Storage
1.4 lb	Annual TP Removal



BMP Alternatives:

- Infiltration - but erosion issue
- Filtration with liner
- Pond with liner (for aesthetics)

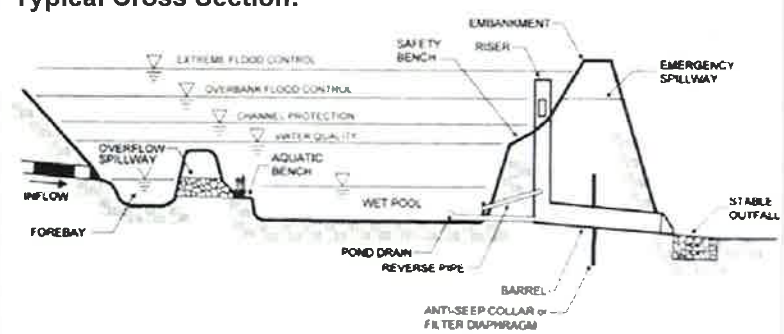
Est. Construction Cost:
$70,000
3,100 $/lb TP

Ease of Maintenance:
Medium

Notes: BMP will be designed to provide a water quality benefit and peak flow reduction to mitigate a downstream erosion issue. There are alternate locations available depending on landowner interests. It is recommended to improve 2nd St NE with curb and gutter to eliminate the road from washing out, and to better collect drainage to the BMP.

Limitations/Cautions: Infiltration is not recommended without subsurface flow studies due to concerns of exacerbating the downstream erosion issue. Therefore, the pond should be lined to prevent seepage.

Typical Cross Section:



APPENDIX F – BMP OPERATION & MAINTENANCE CHECKLISTS

Bioretention - operation and maintenance checklist		
Project:		
Location:		
Site Status:		
Date:		
Time:		
Inspector:		
Maintenance Item	**Satisfactory / Unsatisfactory**	**Comments**
1. Debris Cleanout (Monthly)		
Contributing areas clean of litter and vegetative debris		
No dumping of yard wastes into practice		
Bioretention area clean of litter and vegetative debris		
2. Vegetation (Monthly)		
Plant height taller than design water depth		
Fertilized per O&M plan		
Plant composition according to O&M plan		
Undesirable vegetation removed		
Grass height less than 6 inches		
No evidence of erosion		
3. Check Dams/Energy Dissipators/Sumps (Annual, After Major Storms)		
No evidence of sediment buildup		
Sumps should not be		
No evidence of erosion at downstream toe of drop structure		
4. Dewatering (Monthly)		
Dewaters between storms within 48 hours		
No evidence of standing water		
5. Sediment Deposition (Annual)		
Pretreatment areas clean of sediments		

Contributing drainage area stabilized and clear of erosion		
Winter sand deposition evacuated every spring		
6. Outlet/Overflow Spillway (Annual, After Major Storms)		
Good condition, no need for repair		
No evidence of erosion		
No evidence of any blockages		
7. Integrity of Filter Bed (Annual)		
Filter bed has not been blocked or filled inappropriately		
Comments:		
Actions to be taken:		

Infiltration trench-basin - operation and maintenance checklist		
Project:		
Location:		
Site Status:		
Date:		
Time:		
Inspector:		
Maintenance Item	**Satisfactory / Unsatisfactory**	**Comments**
1. Debris Cleanout (Monthly)		
Contributing areas clean of litter and vegetative debris		
Trench surface clean		
Inflow pipes clear		
Overflow spillway clear		
Inlet area cleanr		
2. Sediment Traps or Forebays (Annual)		
Obviously trapping		
Greater than 50% of		
3. Dewatering (Monthly)		
4. Vegetation (Monthly)		
Mowing done per O&M plan		
Minimum mowing depth		
Undesirable vegetation		
No evidence of erosion		
Fertilized per O&M plan		
5. Sediment Cleanout of Trench (Annual)		
No evidence of		
Sediment accumulation		
6. Sediment deposition of Basin (Annual)		
Clean of sediment		
Winter accumulation of sand removed each spring		
Contributing drainage area		
7. Inlets (Annual)		
Good condition		
No evidence of erosion		
8. Outlet/Overflow Spillway (Annual)		
Good condition, no need		
No evidence of erosion		
9. Aggregate Repairs (Annual)		
Surface of aggregate clean		
Top layer of stone does		
Trench does not need		

Comments:

Actions to be taken:

Media filter system - operation and maintenance checklist		
Project:		
Location:		
Site Status:		
Date:		
Time:		
Inspector:		
Maintenance Item	**Satisfactory / Unsatisfactory**	**Comments**
1. Debris Cleanout (Monthly)		
Contributing areas clean of litter and vegetative debris		
Filtration facility clean		
Inlet and outlets clear		
2. Oil and Grease (Monthly)		
No evidence of filter surface clogging		
Activities in drainage area minimize oil and grease entry		
3. Vegetation (Monthly)		
Contributing drainage area		
Undesirable vegetation removed		
No evidence of erosion		
Area mowed and clipping removed		
4. Sediment Traps and Forebays (Monthly)		
Water holding chambers		
No evidence of leakage		
Obviously trapping		
Greater than 50% storage		
5. Sediment Deposition (Annual)		
Filter chamber free of		
Contributing drainage area		
6. Structural Components (Annual)		
No evidence of structural deterioration		
Any grates are in good		
No evidence of spalling or		
7. Outlet/Overflow Spillway (Annual)		
Good condition, no need		
No evidence of erosion (if		
No evidence of blockages		
8. Overall Function of Facility (Annual)		

Evidence of flow		
No noticeable odors		
Comments:		
Actions to be taken:		

Project:		
Location:		
Site Status:		
Date:		
Time:		
Inspector:		
Maintenance Item	**Satisfactory / Unsatisfactory**	**Comments**
1. Embankment and emergency spillway (Annual, After Major Storms)		
1. Vegetation and ground cover adequate		
2. Embankment erosion		
3. Animal burrows		
4. Unauthorized plantingn		
5. Cracking, bulging, or sliding of embankment		
a. Upstream face		
b. Downstream face		
c. At or beyond toe		
downstream		
upstream		
d. Emergency spillway		
6. Pond, toe & chimney drains clear and functioning		
7. Seeps/leaks on downstream face		
8. Slope protection or riprap failure		
9. Vertical/horizontal alignment of top of dam "As-Built"		
10. Emergency spillway clear of obstructions and debris		
11. Other (specify)		
2. Riser and principal spillway (Annual)		
Type: Reinforced concrete ______ Corrugated pipe ______ Masonry ______		
1. Low flow orifice obstructed		
N2. Low flow trash rack. a. Debris removal necessary		
b. Corrosion control		
3. Weir trash rack maintenance a. Debris removal necessary		
4. Excessive sediment accumulation insider riser		
5. Concrete/masonry condition riser and barrels a. cracks or displacement		
No evidence of erosion at downstream toe		
b. Minor spalling (<1")		
c. Major spalling (rebars exposed)		
d. Joint failures		
No evidence of erosion at downstream toe		
No evidence of erosion at downstream toe		
e. Water tightness		
6. Metal pipe condition		
7. Control valve a. Operational/exercised		
No evidence of erosion at downstream toe		
b. Chained and locked		
8. Pond drain valve a. Operational/exercised		
b. Chained and locked		
9. Outfall channels functioning		
10. Other (specify)		
3. Permanent Pool (Wet Ponds) (Monthly)		
1. Undesirable vegetative growth		

2. Floating or floatable debris removal required		
3. Visible pollution		
4. Shoreline problem		
5. Other (specify)		
4. Sediment Forebays		
1.Sedimentation noted		
2. Sediment cleanout when depth < 50% design depth		
5. Dry Pond Areas		
1. Vegetation adequate		
2. Undesirable vegetative growth		
3. Undesirable woody vegetation		
3. Undesirable woody vegetation		
4. Low flow channels clear of obstructions		
5. Standing water or wet spots		
6. Sediment and / or trash accumulation		
7. Other (specify)		
6. Condition of Outfalls (Annual , After Major Storms)		
1. Riprap failures		
2. Slope erosion		
3. Storm drain pipes		
4.Endwalls / Headwalls		
5. Other (specify)		
7. Other (specify)		
7. Other (Monthly)		
1. Encroachment on pond, wetland or easement area		
2. Complaints from residents		
3.Aesthetics a. Grass growing required		
b. Graffiti removal neededs		
c. Other (specify)		
4. Conditions of maintenance access routes.		
5. Signs of hydrocarbon build-up		
6. Any public hazards (specify)		
8. Wetland Vegetation (Annual))		
1. Vegetation healthy and growing		
Wetland maintaining 50% surface area coverage of wetland plants after the second growing season.		
(If unsatisfactory, reinforcement plantings needed)		
2. Dominant wetland plants:		
Survival of desired wetland plant species		
Distribution according to landscaping plan?		
3. Evidence of invasive species		
4. Maintenance of adequate water depths for desired wetland plant species		
5. Harvesting of emergent plantings needed		
6. Have sediment accumulations reduced pool volume significantly or are plants "choked" with sediment		
7. Eutrophication level of the wetland.		
8. Other (specify)		
Comments:		
Actions to be taken:		

MAINTENANCE INSPECTION CHECKLIST FOR TREES FOR STORMWATER

Notes:

*Inspect tree minimum once a month and after every major storm during first year after planting.

*Unless otherwise notes in "minimum inspection frequency column", inspect items below minimum spring, fall, and after major storms; adjust frequency as needed based on project conditions.

See Minnesota Stormwater Manual for more information on inspection items listed below.

Project Name	Inspector Name
Project Address	Inspector Phone #
Owner Name	Weather Date of Inspection
Owner Phone #	Date of last rainfall prior to inspection
Date of Inspection	

Inspection Item	**Minimum Inspection Frequency***	**Date Last Inspected**	**Need to Inspect During Current Inspection**	**Describe Signs of Problems (if none, write "none")**	**Action Needed and Deadline**	**Date Completed**
Tree						
Tree health	Every Spring and Fall					
Tree safety	*					
Symptoms of under or overwatering	*					
Tree in need of pruning	Yearly					
Does trunk protection need to be replaced or removed?	Yearly until removed					
Do stakes need to be removed or stakes ties need to be replaced	First year only					
Does tree need to be straightened?	First year only					
Are there girdling roots?	Every 4-5 years					
Does soil or mulch need to be removed from root collar?	Yearly					
Soil test needed?	As needed if trees indicate possible soil problems					

Inspection Item	Inspection Frequency	Date Last Inspected	Need to Inspect During Current Inspection	Describe Signs of Problems (if none, write "none")	Action Needed and Deadline	Date Completed
Tree Opening						
Mulch layer less than 3" deep: needs additional mulch	Yearly					
Erosion	*					
Evidence of clogging	*					
Evidence of Standing Water	*					
Weeds present	As needed					
Accumulation of sediment, debris, or trash	*					
Does drawdown time meet project requirements?	*					
Inlet (Curb Cut at Tree Opening, Curb Cut at Catch Basin, Porous Pavement, Trench Drain, or Other)						
Accumulation of sediment, debris, or trash	*					
Erosion	*					
Pretreatment (Curb Cut at Tree Opening, Catch Basin, Porous Pavement, or Other)						
Accumulation of sediment, debris, or trash	*					
Erosion	*					
Evidence of Standing Water	*					
Evidence of Clogging	*					
Distribution and Drainage Pipes, Cleanouts						
Accumulation of sediment, debris, or trash	*					
Overflow/Outlet Structure						
Accumulation of sediment, debris, or trash	*					

Inspection Item	Inspection Frequency	Date Last Inspected	Need to Inspect During Current Inspection (Y/N)	Describe Signs of Problems (if none, write "none")	Action Needed and Deadline	Date Completed
Other						