Chapter 3

Watershed Flow Regime Restoration Evaluation Process

BMP Evaluation Process

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CH2MHILL

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CHAPTER 3

BMP Evaluation Process

Introduction

This chapter is one of a series of related documents[1] developed under a study to address Great Lakes flow regime-based ecosystem improvement projects. These chapters are presented individually because different applications are anticipated depending upon end users' goals. Chapters may be useful to users individually or collectively[2].

This chapter outlines a process for evaluating BMP performance in meeting flow restoration goals. Case studies for five BMP applications and two watershed flow restoration scenarios are examined. The first two BMP case studies examine the performance of two detention-based BMPs: a retrofit of an existing pond, and a regional inline detention facility. The subsequent two BMP case studies examine the performance of two infiltration-based BMPs. The final BMP case study examines the performance of conservation planning sites. The two watershed flow restoration case studies examine BMP application throughout a watershed. BMP performance is measured by the facility's ability to meet the flow restoration target under given design storm conditions.

Individual BMP Analysis Case Studies

Stormwater BMPs for implementation of flow regime restoration require planning, design and real property legal protection. The BMPs not only need to be designed well, but also need to be maintained in order to continue to perform their intended function.

The case studies described below detail the engineering planning and design elements important to flow regime restoration and describe how having an easement around the BMP increases the confidence that the BMP will continue to perform as intended. A real property easement is a mechanism which guarantees the property will continue to be legally set aside for use as a BMP. In some instances, an easement may not be practical, such as in the case of BMPs on private residential property. However, where easements do not perpetuate that the land will be used for a BMP, the confidence decreases that the BMP will realize the intended benefits. Establishing a legal easement on the land around the BMP is one tool available to increase confidence that the BMP will remain in existence and continue to perform the intended flow regime improvement role.

Appendix 3A provides information on the use of easements and an example of a conservation easement applicable to stormwater BMPs.

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[1] Executive Summary, Chapter 1: Watershed Flow Regime Restoration Evaluation Process, Chapter 2: Developing Stormwater BMP Quality Gallon Metric, Chapter 3: BMP Evaluation Process, Chapter 4: Quality Gallon Accounting System Protocol, Chapter 5: Facilitating and Funding Stormwater Management for Ecosystem Improvement, Chapter 6: Ecosystem Improvement Transaction Example Contracts, Chapter 7: Study Evaluation, Chapter 8: Study Communication Summary

[2] The project team members (CH2M HILL in association with The Conservation Fund, Cook and Franke, Public Sector Consultants, and Stormtech) acknowledge the generous support from the Great Lakes Protection Fund as part of their Growing Water suite of research projects.

Case Study: Farmington Hills Detention Basin Retrofit

The flow restoration benefits of an existing stormwater detention facility in the headwaters of the Upper Rouge River were evaluated. The facility was originally designed with a more stringent release rate than necessary to meet regulatory requirements. This evaluation examined both the regulatory and as-built performance. Further analysis was performed to develop a retrofit solution to meet flow restoration goals.

Current Design

The facility is a wet detention basin located on a 23.4 acre commercial site in Farmington Hills, Michigan. An easement protects the area occupied by the BMP. The drainage area is 59 percent impervious. A 22-minute time of concentration was calculated for the site. The basin was designed to meet Farmington Hills' detention criteria, which requires stormwater storage for 2 inches of rainfall over the entire site. This yields 1,271,000 gallons (3.9 acre-feet) of storage with a release rate of less than 0.2 cubic feet per second (cfs) per acre of drainage area. The Oakland County Method was used to determine that a maximum orifice diameter of 8 inches was needed in the riser to achieve the required flow rate. The final pond design provides 1,306,000 gallons (4.0 acre-feet) of storage with 1 foot of freeboard (Minoru Yamasaki Associates 2001). A 6-inch-diameter orifice was installed during construction, providing a more conservative release rate than necessary to meet regulatory requirements.

Retrofit Criteria

Retrofit potential for flow restoration was assessed using a 24-hour design storm. Design precipitation depths are defined for each watershed in Chapter 1. For example purposes, the analysis assumes a design precipitation of 0.9 inches. Retrofit design should provide a balance between two criteria:

1. The 24-hour average flow release rate should approach the ecological flow target yield defined in Chapter 1. For the Rouge River, this yield is 0.9 cfs/square kilometer for the 5 percent exceedence level flow, equivalent to an average release rate of 0.09 cfs for the Farmington Hills drainage basin.
2. Pond drawdown time from peak storage should not exceed 72 hours. This criterion is based on the average rainfall inter-event period for the two watersheds; 2–3 days is an approximate interval between rainfall events.

BMP Performance

The Hydrologic Modeling System (HEC-HMS) model was used to evaluate the pond retrofit. The model was used to route stormwater flow from the development through the detention pond. All impervious area was assumed to be directly connected to the drainage system. A runoff curve number of 61, corresponding to B soils with pasture in good condition, was used for open spaces.

Three scenarios were modeled: the existing pond as characterized in the as-built plans (6-inch outflow pipe), the regulatory design (8-inch outflow pipe), and a retrofit condition that attempts to provide a release rate consistent with flow restoration goals. The modeled pond depths above the permanent pool for the simulation period are plotted in Figure 3-1.

The maximum 24-hour average outflow rate and maximum storage for each scenario are provided in Table 3-1.

An outlet equivalent to a 3-inch orifice was chosen for the retrofit design. The design allowed the pond to meet the 72-hour drawdown criteria, while reducing the 24-hour average flow to 0.16 cfs, which represents a 45 percent reduction from the County requirements. To completely match the target release rate, a drawdown time of 6 or more days would be required, which is usually unacceptable for detention pond designs.

The retrofit of the existing BMP provides 39,000 additional gallons (0.12 acre-feet) of storage beyond what is currently provided by the pond to meet the above stated design criteria. The additional storage volume is the *credit* that the retrofit receives towards meeting flow restoration goals.

FIGURE 3-1
Farmington Hills Pond Outflow Hydrograph for Flow Restoration Design Storm
Outlet diameter set as required to match regulatory requirements, as-built conditions, and proposed retrofit conditions.

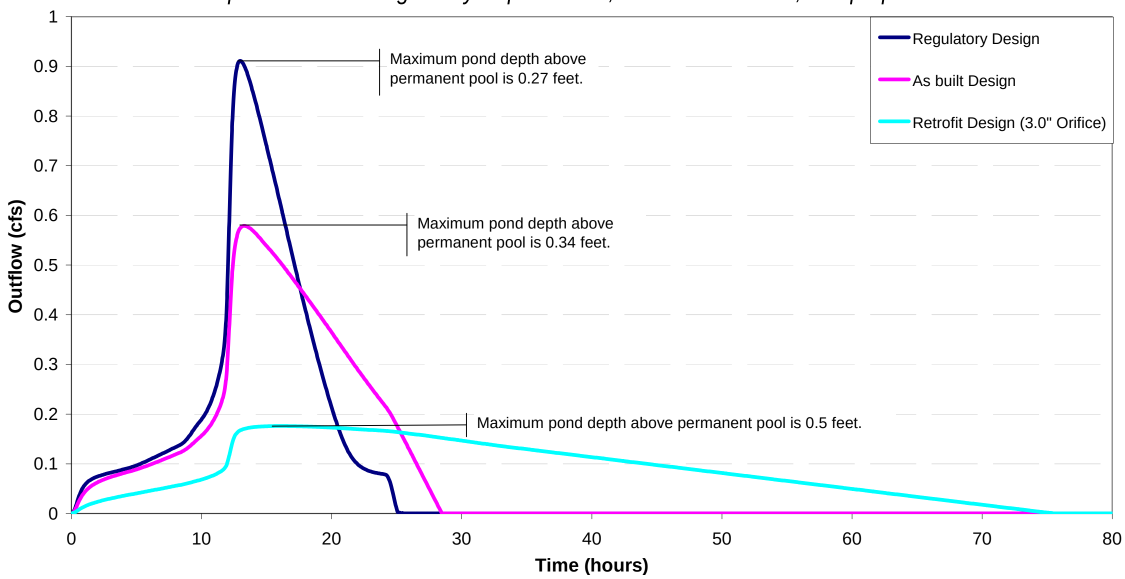


TABLE 3-1
Farmington Hills BMP Performance

Design	Maximum 24-Hour Average Outflow (cfs)	Drawdown (hours)	Storage (gallons)
Regulatory Design (8-inch outlet)	0.29	8.5	72,000
As-built Design (6-inch outlet)	0.28	14	88,000
Retrofit Design (3-inch outlet)	0.16	55	127,000
Additional Storage Provided by Retrofit			39,000

Quality Gallons Calculation

The number of Quality Gallons for an offline wet detention basin is related to the BMP Type, BMP Location, and BMP Priority. Chapter 2 documents the value of the Quality Gallon multiplier when a BMP is located in a headwater area, but the area is not a high priority for restoration (assumed in this example). The Quality Gallon multipliers are shown in Table 3-2.

TABLE 3-2
Quality Gallon Calculation—Farmington Hills Case Study

Multiplier	Value
BMP Type Multiplier (Offline Wet Detention Basin)	1.1
BMP Location Multiplier (Headwater)	1.6
BMP Priority Multiplier (Low Priority)	1.0
Quality Gallons (39,000 1.1 x 1.6 x 1.0)	**69,000**

The combined effect of all multipliers provides a Quality Gallon *credit* that is 1.8 times the incremental volume that is created by the BMP retrofit, or 69,000 Quality Gallons. The Quality Gallon *credit* will change with the BMP type, location, and priority. For example, if this BMP were located further downstream in a middle reach, the location multiplier would be reduced to 1.3 and the available *credit* would then be reduced to 56,000 Quality Gallons, a difference of nearly 20 percent. Multiplier values are established by the stakeholders and are specific to the priorities of each watershed. In a watershed where stakeholders placed a greater emphasis on temperature reduction, an offline wet detention basin would receive a lower score, decreasing the available *credit*, because the BMP can increase the water temperature from exposure to the sun.

Case Study: Idyl Wyld Regional Stormwater Detention Retrofit

A regional stormwater detention facility located on the Idyl Wyld Golf Course in Livonia, Michigan, was evaluated to determine how it would perform under the flow restoration design storm. This facility is located in a middle reach of the Upper Rouge River watershed and consists of both inline and offline storage.

Current Design

The facility includes an inline detention system that creates offline floodplain storage (in constructed ponds) along a tributary to the Upper Rouge River. A 7-foot-long weir was constructed at the downstream end of the project site that creates a backwater condition and fills the floodplain storage ponds (Hubbel, Roth, and Clark, Inc. 2004a). There is an easement restricting the use of the area occupied by the BMP, consequently it is likely that the BMP will be maintained indefinitely. A total of 2,632 acres drain to the facility. Soil types in this area are silt loams, sandy loams, and loamy sands. The watershed is 49 percent impervious.

Retrofit Criteria

Retrofit performance was assessed using a 24-hour flow restoration design storm. Design precipitation depths are defined for each watershed in Chapter 1. For example purposes, the analysis assumes a design precipitation of 0.9 inches. Retrofit design should provide a balance between two criteria:

1. The 24-hour average release rate should approach the flow restoration target yield defined in Chapter 1. For the Rouge River, this yield is 0.9 cfs/square kilometer for the 5 percent exceedence flow, equivalent to an average release rate of 10 cfs for the Idyl Wyld drainage basin.
2. Pond drawdown time from peak storage should not exceed 72 hours. The criteria is based on the average rainfall inter-event period for the watershed; 2–3 days is an approximate interval between rainfall events.

BMP Performance

An existing, unsteady-flow River Analysis System (HEC-RAS) model was used to evaluate the effectiveness of the structure for the flow restoration design storm (Hubbel, Roth, and Clark, Inc. 2004b). The BMP provided 3,718,000 gallons (11.4 acre-feet) of storage. The peak flow decreased from 224 cfs upstream of the BMP to 184 cfs at the outlet of the structure. However, the change in the 24-hour average flow was less significant, decreasing from 49 to 47 cfs.

To improve the 24-hour performance, the weir could be shortened to hold back more water, but that would result in a barrier to fish movement under some flow conditions. Because fisheries are an important component of flow regime restoration, fish passage restrictions were not allowed. As was seen in the Farmington Hills Pond retrofit example, a detention pond is not likely to achieve the target flow yield condition. Consequently, while the restoration does not fully achieve the flow regime restoration design standards, gallon credits are available in the amount of 3,718,000 gallons (497,024 cubic feet, 11.4 acre-feet).

Quality Gallons Calculation

The number of Quality Gallons for an inline wet detention basin is related to the BMP Type, BMP Location, and BMP Priority. Chapter 2 documents that when a BMP is located in a middle reach area that is a high priority for restoration (assumed in this example), the Quality Gallon multipliers are as shown in Table 3-3.

TABLE 3-3
Quality Gallon Calculation—Idyl Wyld Case Study

Multiplier	Value
BMP Type Multiplier (Inline Wet Detention Basin)	0.9
BMP Location Multiplier (Middle)	1.3
BMP Priority Multiplier (High Priority)	1.6
Quality Gallons (3,718,000 x 0.9 x 1.3 x 1.6)	**6,651,000**

In this example, an inline wet detention basin has a multiplier of 0.9. The combined effect of all multipliers provides a Quality Gallon *credit* which is 1.8 times the gallon *credit* assigned to the BMP, or 6,651,000 gallons. While the BMP Type multiplier in this example was lower than that assigned to an offline wet detention basin, the high priority of the project and its location in a middle reach yield a multiplier equal to that in the previous example.

Case Study: Miller Brewing Company Bioretention

The performance of an existing bioretention facility located in the lower Menomonee River, Wisconsin, was evaluated for its effectiveness in meeting flow restoration goals.

Current Design

The facility is a rain garden and bioretention swale owned and operated by Miller Brewing Company (Miller). It was developed as a demonstration project through a partnership between the Milwaukee Metropolitan Sewerage District (MMSD) and Miller. The site does not have an easement restricting the use of the area occupied by the BMP, but the partnership agreement required continued maintenance of the BMP by the landowner. Consequently, it is believed that the BMP will be maintained indefinitely. The facility is designed to capture, slow, and treat runoff from a 37,800-square-foot parking lot tributary to the bioretention swale. The BMP tributary area is outlined in Figure 3-2, an aerial photograph of the site prior to project implementation. The BMP location is indicated in green.

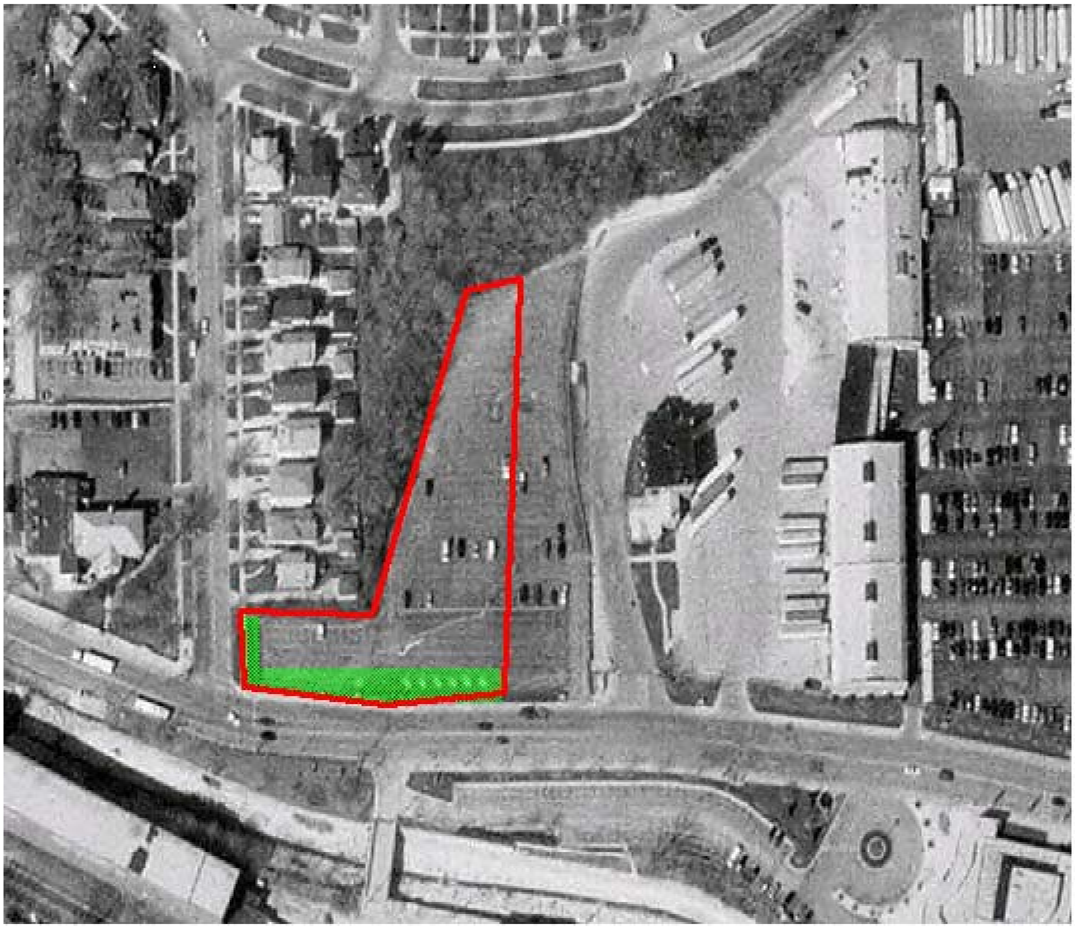
The facility is 375 feet long and 40 feet wide. The northern zone consists of a 20-feet-wide filter strip of mesic prairie native grasses and forbs with some trees that pre-treats runoff from the parking lot. The center zone, approximately 8 feet wide and flat, forms a dry mesic prairie planted on a 12-inch filter bed (sandy loam and leaf mulch) underlain by an 18-inch bed of clean stone. The filter bed consists of loamy sand and leaf mulch. The zone is drained through infiltration and a perforated underdrain located at the bottom of the stone layer. The south zone is approximately 11 feet wide and forms a buffer to the street. An 18-inch fiberglass check dam installed at the midpoint of the swale creates additional storage and forces water to infiltrate through the filter bed (TEI Corporation 2005).

Retrofit Criteria

Retrofit performance was assessed using a 24-hour flow-restoration design storm. Design precipitation depths are defined for each watershed in Chapter 1. For the Menomonee River, the depth is 1.1 inches.

The 24-hour average peak release rate should approach the flow restoration target yield defined in Chapter 1. For the Menomonee River, the yield is 1.6 cfs/square kilometer. Because of the small tributary area to the facility, this is equivalent to an average release rate of 0.006 cfs. Rain gardens and bioretention facilities meet the design release rate if they have the capacity to store the design storm without overflowing.

FIGURE 3-2
Aerial Photograph of the Miller Bioretention Site Prior to Project Implementation
Source: SEWRPC



BMP Performance

Monitoring was performed at the facility over a 6-month period. The flow rate was measured at a V-notch weir in the storm inlet into which the facility's underdrain discharges. Precipitation was measured using a rain gage installed at the east edge of the rain garden. During the monitoring period, 1-inch and 0.75-inch precipitation events occurred and resulted in no discharge from the facility. Discharge was measured only once following a 3.58-inch storm event. The measured runoff volume from the facility was equivalent to 40 percent of the total precipitation depth over the drainage area. The volume difference was attributed to infiltration and losses that occurred when water overtopped the structures used to divert water to the facility (TEI Corporation 2005). Therefore, this event could not be used to evaluate the facility's performance. Nevertheless, based on the results for the smaller storms, this BMP is capable of controlling runoff from the design storm. Assuming that initial abstractions will be negligible in the parking lot, this BMP provides 26,000 gallons (0.08 acre-feet) of storage for the design storm.

Because the site does not have an easement or permanent protection for the BMP, it is possible that the land for the BMP could be converted to some other use. Consequently, its value is not equal to a similar BMP that has such protection. For that reason, the BMP storage volume was reduced to 80 percent of the total volume, for a credit of 21,000 gallons (0.06 acre-feet). A discounted value of 80 percent was assumed using a net present value analysis and estimating that the land would continue to be used for a BMP for an average of 50 years. If applied to multiple BMP sites, the discounted value of 80 percent would correspond to some BMP parcels lasting longer than 50 years and others lasting for a shorter period. The discounted value could be higher if the land were used for a BMP over a longer period or lower for a shorter time.

Quality Gallons Calculation

The number of Quality Gallons for a rain garden is related to the BMP Type, BMP Location, and BMP Priority. Chapter 2 documents that when a BMP is located in a lower reach area that is a high priority for restoration (assumed in this example), the Quality Gallon multipliers are as shown in Table 3-4.

TABLE 3-4
Quality Gallon Calculation—Miller Case Study

Multiplier	Value
BMP Type Multiplier (Bioretention)	1.5
BMP Location Multiplier (Lower)	1.0
BMP Priority Multiplier (High Priority)	1.6
Quality Gallons (21,000 x 1.46 x 1.0 x 1.6)	**49,000**

In this example, bioretention has a multiplier of 1.5. The high priority of this BMP coupled with the high value placed on bioretention by watershed stakeholders provides a Quality Gallon *credit* which is 2.3 times the storage volume assigned to the BMP, or 49,000 Quality Gallons (0.15 acre-feet).

If this facility were located in the headwaters of the watershed, the multiplier would increase to 3.7 and the overall Quality Gallons would be 78,000 (0.24 acre-feet), an increase of 62 percent, a greater quality *credit* than was assigned to the offline wet detention basin case study despite the small size of the bioretention facility. The confidence in BMP benefits could also be increased by providing an easement around the BMP requiring the land be used for stormwater treatment purposes. In this example, the Quality Gallons could be increased by 20 percent by placing an easement around the BMP.

Case Study: Constructed Wetland Retrofit

The potential to implement flow restoration principles into a proposed floodplain improvement near State Street and Hwy 41 in Milwaukee, Wisconsin, was evaluated. The site drains to the Menomonee River.

Proposed Design

The proposed facility is a 3.5-acre constructed wetland located within the 4-acre proposed site outline shown in the aerial photograph in Figure 3-3. The facility would be designed to capture, slow, and treat runoff from the storm sewer system draining to the site before ultimately releasing it into the Menomonee River. The runoff currently receives no treatment. This system collects stormwater from a 51-acre area with a mix of commercial, residential, and woodland land uses. The hypothetical design assumes an overflow weir set at bank elevation with a sediment forebay to trap incoming sediment. It is also assumed that an easement restricting the use of the area occupied by the BMP would be developed. Consequently, the area should be maintained indefinitely. Figure 3-3 outlines the drainage area.

FIGURE 3-3
Aerial View of a Hypothetical State Street Constructed Wetland
(Source: SEWRPC) The drainage area is outlined in red. BMP implementation area is shaded green. Yellow denotes existing storm sewer.

Retrofit Criteria

Retrofit performance was assessed using a 24-hour flow restoration design storm. Design precipitation depths are defined for each watershed in Chapter 1. For the Menomonee River, the depth is 1.1 inches. Retrofit design should provide an optimum balance between two criteria:

1. The 24-hour average peak release rate should approach the flow restoration target yield defined in Chapter 1. For the Menomonee River, this yield is 1.6 cfs/square kilometer, equivalent to an average release rate of 0.3 cfs for the tributary drainage area.
2. Pond drawdown time from peak storage should not exceed 72 hours. This criterion is based on the average rainfall inter-event period for the watershed; 2–3 days is an approximate interval between rainfall events.

BMP Flow Restoration Performance

HEC-HMS was used to calculate runoff from the design storm over the tributary area and route it through the constructed wetland. The volume of storage necessary to control the storm was then used to assign flow restoration gallons to the BMP.

Releasing water at a rate of 0.3 cfs required a 120-hour drawdown time to completely drain the wetland. In practice, water depths would likely recede more quickly during the growing season due to evapotranspiration and infiltration. The maximum depth in the wetlands to meet the design criteria was 6.4 inches, which corresponds to a maximum storage of 1.9 acre-feet. The volume of flow restoration storage provided by this BMP is 619,000 gallons (1.9 acre-feet).

Quality Gallons Calculation

The number of Quality Gallons for a constructed wetland is related to the BMP Type, BMP Location, and BMP Priority. Chapter 2 documents that when a BMP is located in a lower reach area that is a high priority for restoration (assumed in this example), the Quality Gallon multipliers are as shown in Table 3-5.

TABLE 3-5
Quality Gallon Calculation—Constructed Wetland Retrofit Case Study

Multiplier	Value
BMP Type Multiplier (stormwater wetland)	1.8
BMP Location Multiplier (Lower)	1.0
BMP Priority Multiplier (High Priority)	1.6
Quality Gallons (619,000 x 1.77 x 1.0 x 1.6)	**1,753,000**

The Quality Gallon *credit* for this example is 2.8 times the storage volume assigned to the BMP or 1,753,000 Quality Gallons (5.4 acre-feet). Although the storage volume for this BMP is smaller than that associated with the conservation site described below, the high priority of the project and the high value assigned to stormwater wetlands by project stakeholders yields a higher Quality Gallons *credit*.

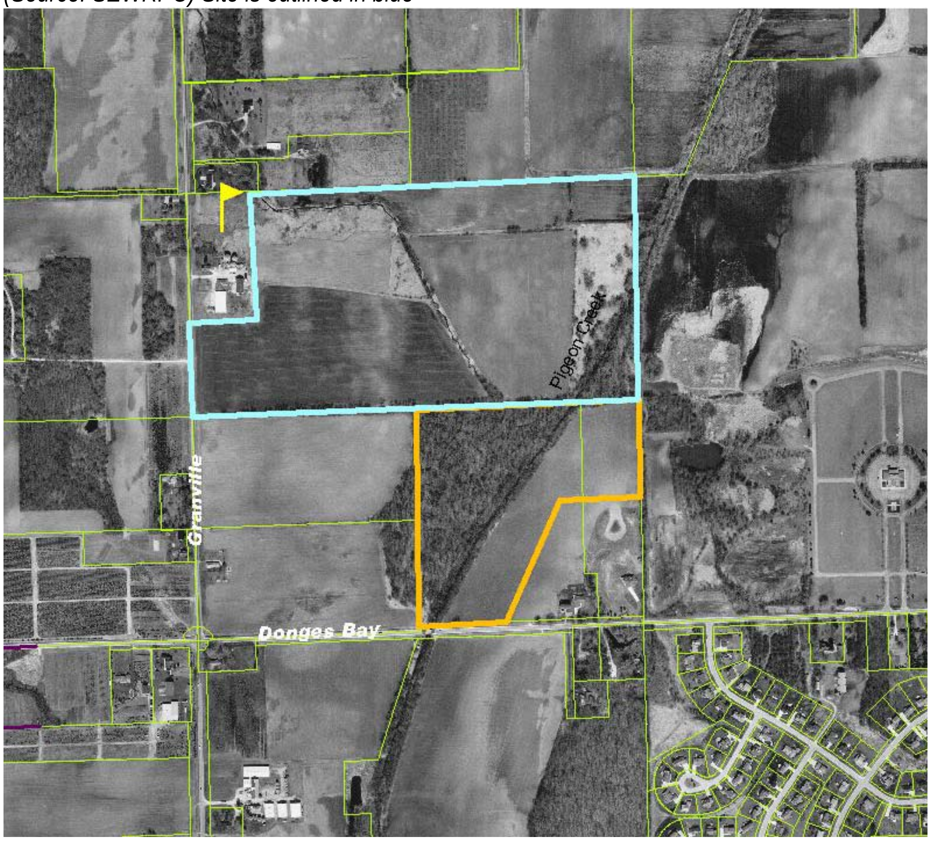
Case Study: Conservation Planning

The flow restoration benefits of a conservation site purchased in the headwaters of the Menomonee River watershed were explored in this case study.

Conservation Site Description

The Hoerig Property, located in the City of Mequon, was purchased as part of the MMSD Conservation Plan program in August 2005. An aerial photograph of the site is shown in Figure 3-4. Both Pigeon Creek and the Little Menomonee River flow though this 73.5-acre site, which contains approximately 80 percent hydric soils. The site provides a wide floodplain for both waterways (MMSD 2006). Portions of the Little Menomonee River have been channelized. The site does not receive significant runoff from tributary impervious area.

FIGURE 3-4
Aerial View of Hoerig Conservation Site
(Source: SEWRPC) Site is outlined in blue



BMP Flow Restoration Performance

MMSD purchased the Hoerig site to maintain its natural hydrology. Preserving the property also saves wildlife habitat and creates recreational opportunities for people living in the region. It is difficult to quantify the flow regime restoration benefit because it does not provide a direct physical change in the watershed; rather it protects the watershed from future impacts through preservation. To account for the important role that preservation plays in protecting future watershed hydrology, a partial credit system was developed for preservation sites like the Hoerig property.

Approximately 660 feet of Pigeon Creek and 2,000 feet of the Little Menomonee River flow across the Hoerig site. With some exceptions, Wisconsin law (NR 151) requires that a buffer greater than 50 feet be provided for properties adjacent to streams. With 100 feet of buffer across the stream corridor (50 feet on both sides of the river), at most 6.1 acres of the site are protected under current state law. The remaining 67.4 acres represent an area that would not otherwise be preserved and should consequently be available for a flow regime restoration credit associated with preservation. It is important to note that even though a narrow buffer strip along the stream is preserved under Wisconsin law, from a practical point of view, a land preservation program must purchase entire parcels and not pick and choose between developable and un-developable acreage within a parcel, especially when buffer requirement exceptions exist within the law.

Based on Chapter 1, the volume associated with preservation is equal to 50 percent of the design storm depth over the property. For the Hoerig site, this depth is 0.55 inches over the 67.4 acre area, resulting in a volume of 1,007,000 gallons (3.1 acre-feet). A value of 50 percent was used for conservation because no restoration occurs through conservation. A value of 100 percent would be similar to designing a BMP to retrofit an area that is entirely impervious. At the same time, preservation does have a beneficial effect because if the site were left to develop, even with the best stormwater management practices, there would still be changes to the flow regime. Consequently, a value of 50 percent was assumed. The assignment of the percent credit would be determined through a consensus-based process among stakeholders in the watershed.

Quality Gallons Calculation

The number of Quality Gallons for a conservation site is related to the BMP Type, BMP Location, and BMP Priority. Chapter 2 documents that when a BMP is located in a headwater area that is not a high priority for restoration (assumed in this example), the Quality Gallon multipliers are as shown in Table 3-6.

TABLE 3-6
Quality Gallon Calculation—Conservation Planning Case Study

Multiplier	Value
BMP Type Multiplier (Conservation Site)	1.0
BMP Location Multiplier (Headwater)	1.6
BMP Priority Multiplier (Not a priority)	1.0
Quality Gallons (1,007,000 x 1.0 x 1.6 x 1.0)	**1,611,000**

In this example, the conservation site is given a BMP type multiplier of 1.0. Although the site is not a priority location, its location in the headwaters gives it a location multiplier of 1.6, which increases the overall multiplier to 1.6 times the storage volume assigned to the BMP or 1,611,000 Quality Gallons (4.9 acre-feet).

Wetlands maintenance and restoration at these sites could further improve the flow regime and increase the Quality Gallons associated with the site. As development in the area increases, future flow restoration benefits could be obtained by directing runoff from impervious areas toward stormwater wetlands that could be constructed at the site.

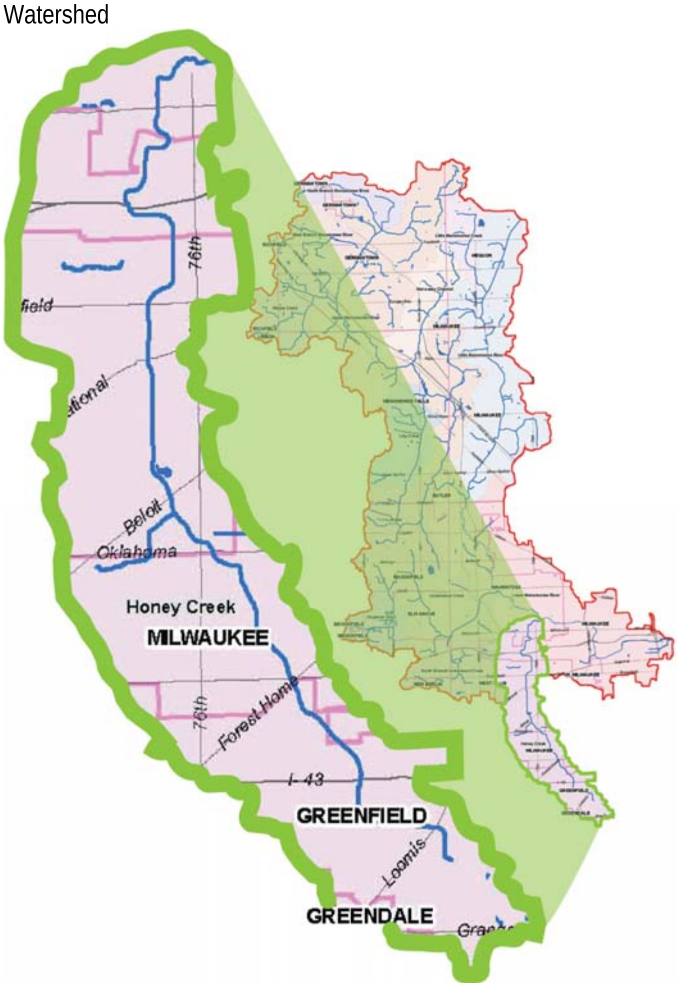
Watershed-Wide Analysis Case Studies

Besides analysis of individual BMPs, gallon estimates can be made for watershed-wide planning purposes based on planning analysis and watershed restoration goal setting. The watershed wide analysis illustrates the opportunity to package projects in different scales: small rain garden projects on individual residential lots to comprehensive neighborhood-wide or watershed-wide rain garden implementation efforts. In practice, BMP implementation for flow regime restoration would require multiple small projects. However, practically, many small projects would likely be lumped together to create larger projects. Using the latter approach, estimating the amount of flow regime restoration provided by various BMP implementation scenarios is discussed below.

Case Study: Honey Creek Subwatershed

HSPF modeling was used to quantify the effect of implementing rain gardens and permeable pavers to treat 50 percent of residential and 50 percent of commercial imperviousness on a subwatershed scale. The results of this analysis are discussed in Appendix 1B. This document provides a discussion of both the volume credit achieved and the cost associated with this effort for two representative subwatersheds: Honey Creek in the Menomonee River basin and tributary area 12 in the Upper Rouge River.

FIGURE 3-5
Honey Creek Subwatershed Location within the Menomonee River Watershed



Honey Creek is located in the southwestern corner of the Menomonee River watershed and terminates in the lower reaches of the Menomonee River as shown in Figure 3-5. The subwatershed tributary area is 10.8 square miles with 36 percent imperviousness. Table 3-7 provides a summary of land use in the basin.

Rain Garden Implementation

Rain gardens (bioretention BMPs) are applicable to approximately 68 percent of the subwatershed, or 4,705 acres of high- and low-density residential property. To treat 50 percent of the residential area, an estimated 161 acres of rain garden would need to be implemented. Assuming 6 inches of ponding depth, the rain gardens provide 26 million gallons towards flow regime restoration. Model results for this installation (Figure 3-6) show a drop in watershed yield for exceedance values below 15 percent, bringing the subwatershed closer to its ecological target flow.

A planning-level cost estimate for do-it-yourself installation materials is \$3–5 / square feet (ft^2), roughly \$29,000,000 for this implementation. Complete installation by a specialty contractor would increase the cost to $10–12/ft². Table 3-8 provides a summary of implementation cost and storage calculations.

FIGURE 3-6
HSPF Model Results for Honey Creek Subwatershed

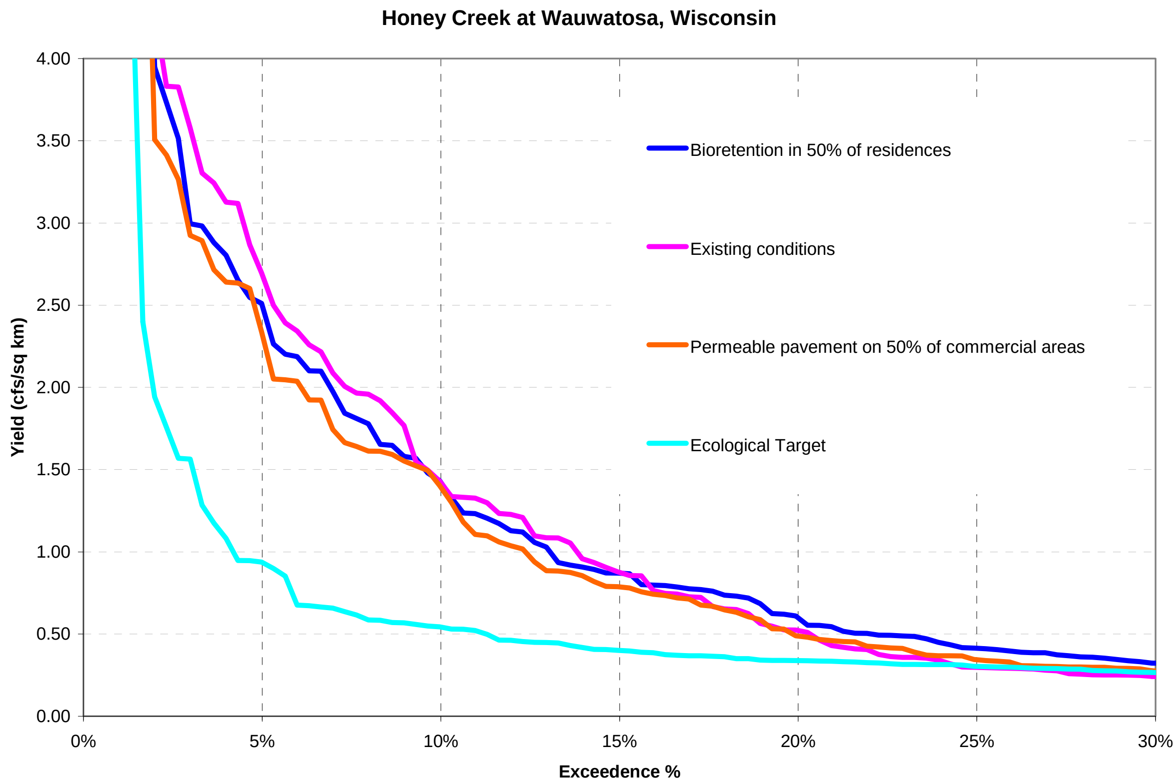


TABLE 3-7
Honey Creek Land Use

Land Use	Area (acre)	Total Land Use (%)	Imperviousness (%)
Forest/Open/Agriculture	723	10.40	0
Low Density Resident	3,839	55.2	17
High Density Resident	866	12.5	5
Commercial/Industrial	1,243	17.9	13
Transportation/Utility	278	4.0	2
Total	6,949	100.0	36

TABLE 3-8
Rain Garden Implementation

Parameter	Honey Creek	Tributary Area 12
Residential Area (acres)	4,705	2,143
Rain garden area available, 10% of residential pervious area (acres)	323	149
Rain garden area implemented, 50% of available (acres)	161	74
Rain garden area implemented 50% of available (sq. ft.)	7,034,000	3,241,000
Installation Cost ($4 /sq. ft., materials only)	$ 29,000,000	$ 13,000,000
Treated volume (gallons)	26,308,000	12,122,000

Permeable Pavement Implementation

Commercial areas account for about a third (13 percent of the 36 percent) of imperviousness in the subwatershed. Of the 870 commercial impervious acres, it is assumed that 50 percent are treated with permeable pavement installation in 25 percent of the impervious area. To treat 50 percent of the available area, 217 acres of permeable pavement would need to be installed. Assuming 6 inches of available storage depth, the permeable pavement areas create 35 million gallons towards flow regime restoration. Model results for this installation (Figure 3-6) demonstrate a drop in watershed yield similar to the rain garden implementation.

Using a planning-level cost estimate of $\$4/\text{ft}^2$ translates into roughly $38,000,000 for this implementation. Table 3-9 provides a summary of implementation cost and storage calculations.

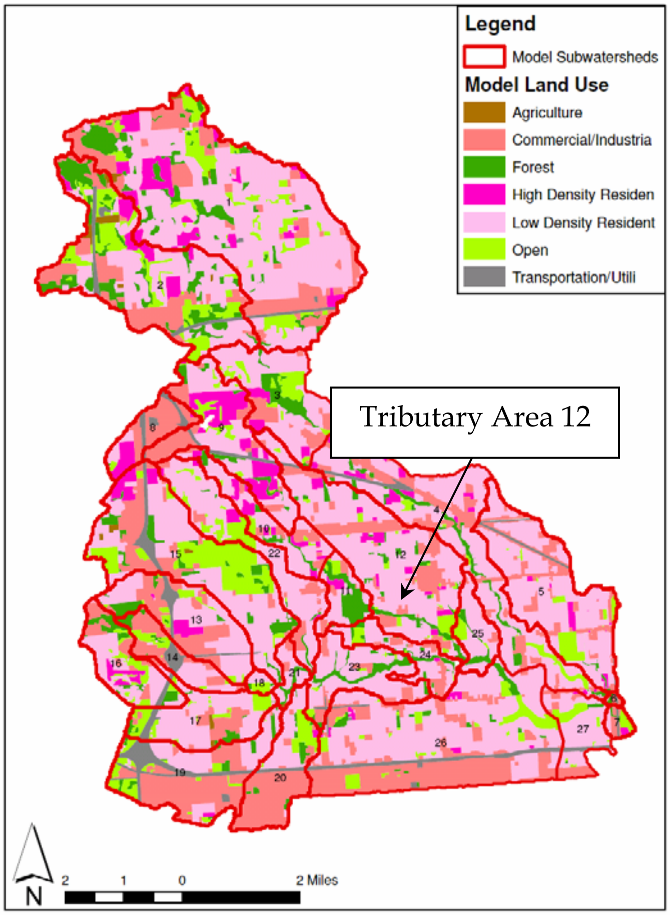
TABLE 3-9
Permeable Pavement Implementation

Parameter	Honey Creek	Tributary Area 12
Total commercial impervious area (acres)	869	417
Pavement area available, 25% of imperviousness (acres)	217	104
Commercial imperviousness treated, 50% of imperviousness (acres)	435	209
Pavement area implemented 50% of available (sq. ft.)	9,468,000	4,544,000
Installation cost ($4 / sq. ft.)	$ 38,000,000	$ 19,000,000
Treated volume (gallons)	35,410,000	16,995,000

Case Study: Upper Rouge Tributary Area 12

Tributary area 12 is located in the middle reaches of the Upper Rouge River as shown in Figure 3-7. The tributary area is 4.8 square miles with 35 percent imperviousness. Table 3-10 provides a summary of land use in the basin.

FIGURE 3-7
Tributary Area 12 Location within the Upper Rouge River Watershed



Rain Garden Implementation

Rain gardens (bioretention BMPs) are applicable to approximately 69 percent of the tributary area, or 2,143 acres of high- and low-density residential property. To treat 50 percent of the residential area, 74 acres of rain garden would need to be implemented. Assuming 6 inches of ponding depth, the rain gardens create 12 million gallons of flow restoration storage volume. Model results for the Rouge River subwatershed (Figure 3-8) indicate that a 50 percent rain garden implementation provides one third of the yield reduction needed to meet the ecological target for the subwatershed.

A planning-level cost estimate for do-it-yourself installation materials is \$3–5/ft^2, roughly \$13,000,000 for this implementation. Complete installation by a specialty contractor would increase the cost to \$10–12/ft^2. Table 3-8 provides a summary of implementation cost and storage calculations.

TABLE 3-10

Upper Rouge Tributary 12 Land Use

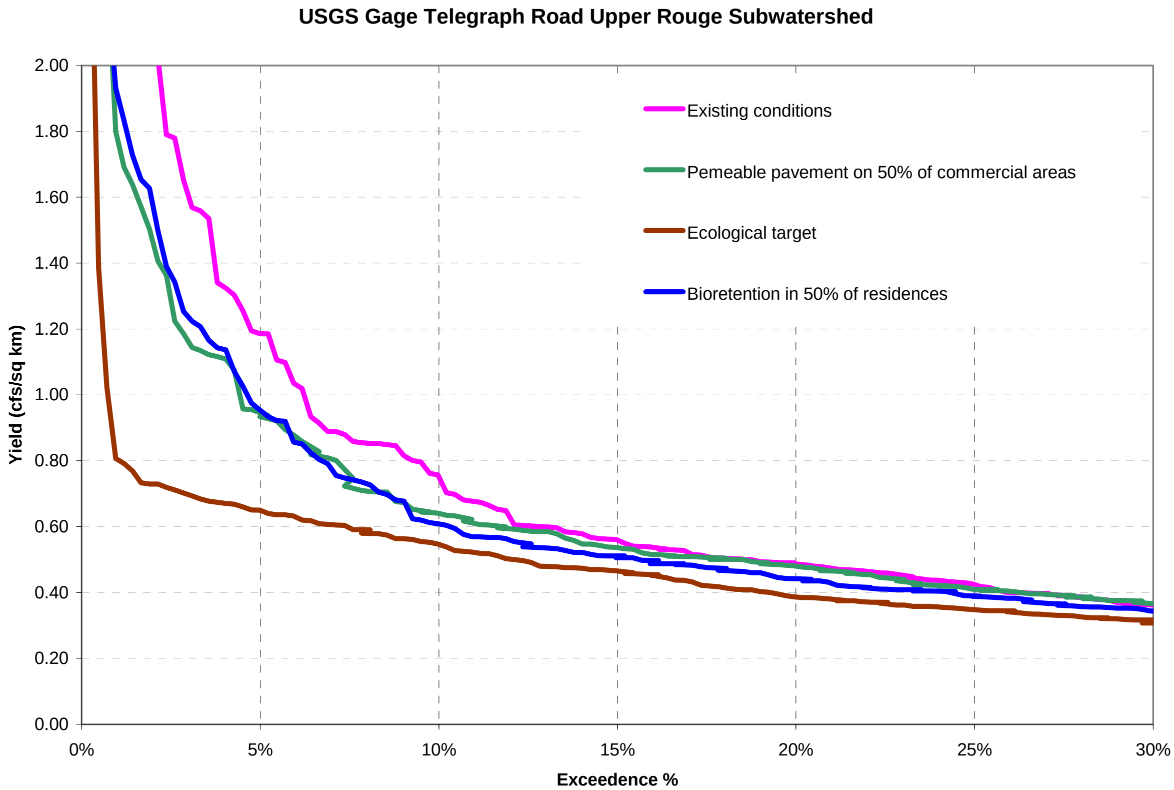
Land Use	Area (acre)	Total Land Use (%)	Impervious (%)
Forest/Open/Agriculture	336	10.9	0
Low Density Resident	2,013	65.1	20
High Density Resident	130	4.2	2
Commercial/Industrial	596	19.3	14
Transportation/Utility	15	0.5	0
Total	3,090	100.0	35

Permeable Pavement Implementation

Commercial imperviousness accounts for more than a third (14 percent of the 35 percent) of imperviousness in tributary area 12. Of these 417 impervious acres, it is assumed that 50 percent of the imperviousness can be treated using 25 percent of the imperviousness converted to pervious pavers. To treat 50 percent of the commercial impervious area, 104 acres of permeable pavement would need to be installed. Assuming 6 inches of available storage depth, this creates 17 million gallons of flow restoration storage volume. As with the rain garden implementation, a 50 percent permeable pavement installation in the Rouge River subwatershed provides approximately one third of the yield reduction needed to meet ecological targets (Figure 3-8).

A planning-level cost estimate is $4/ft^2$, roughly $19,000,000 for this implementation. Table 3-9 provides a summary of implementation cost and storage calculations.

FIGURE 3-8
HSPF Model Results for Upper Rouge River Subwatershed at Telegraph Road



Watershed Implmenetation Case Study Summary

Implementing rain gardens and permeable pavement in the Honey Creek subwatershed would provide nearly 62 million gallons towards flow regime restoration at a planning level cost of $ 67,000,000. A comparable implementation in tributary area 12 of the Upper Rouge River provides 29 million gallons towards flow regime restoration at a cost of $ 32,000,000. These values represent a major watershed wide implementation effort which would have water quality benefits in addition to flow regime restoration benefits. The implementation would include numerous small projects, but would likely be implemented on a neighborhood or watershed scale. For example, the number of rain gardens on individual residential lots would be on the order of 14,000 for the Honey Creek subwatershed and 6,000 for tributary area 12 and cost around $2,000 to $4,000 each. Implementation would occur more efficiently by packaging the construction into groups of projects.

Both Honey Creek and the Upper Rouge Tributary Area 12 are highly developed areas with a significant mix of residential and commercial properties that were built prior to stormwater detention requirements. There are opportunities to obtain significant flow regime restoration benefits using infiltration BMP retrofits. The cost to implement this strategy is significant and is proportional to the size and imperviousness of the watershed.

An estimate of the number of Quality Gallons provided for rain gardens or permeable pavement implementation would need to include information on BMP location and priority multipliers. On a sub-watershed scale, the location and priority multipliers could vary within the sub-watershed. Assuming the average BMP location is within a middle reach (multiplier 1.3) and the priority multiplier equals 1.0, the number of Quality Gallons produced would be 110 million in Honey Creek and 52 million in the sub-watershed of the Upper Rouge River.

References

Hubbel, Roth, and Clark, Inc. 2004a. *Idyl Wyld Retention Facility Construction Drawings*. Prepared for the City of Livonia, MI.

Hubbel, Roth, and Clark, Inc. 2004b. *Idyl Wyld Retention Facility HEC-RAS Model*. Prepared for the City of Livonia, MI.

Milwaukee Metropolitan Sewerage District (MMSD). 2006. *Greenseams*. http://www.mmsd.com/floodmanagement/greenseams.cfm.

SEWRPC. 2000. Southeastern Wisconsin Regional Planning Commission Aerial Photographs.

TEI Corporation. 2005. *Milwaukee Metropolitan Sewerage District Stormwater Best Management Practices Partnership Miller Brewing Rain Garden and Bioretention Swale Final Report*. Report to MMSD, Milwaukee, WI.

Minoru Yamasaki Associates. 2001. *Motorola Farmington Hills Corporate Campus I., As-built Construction Drawings*. Prepared for Farmington Hills Corporate Investors, LLC, Bloomfield Hills, MI.

Appendix 3A

Conservation Easement References and Example

APPENDIX 3A

Conservation Easement References and Example

The following websites and publications provide detailed information about conservation easements. An easement template is also provided. Examples of contracts for projects, including those involving easements are included in Chapter 6 - *Ecosystem Improvement Transaction Example Contracts*.

Easement Legislation

- Federal tax law permits conservation easements, specifically the Federal Internal Revenue Code Title 26 USC 170(h) qualified conservation contribution (http://www.charitablesystems.com/C/C2-a011.html)

Publications

- Barret, Thomas S. and Stefan Nagel. 1996. *Model Conservation Easement and Historic Preservation Easement.* Land Trust Alliance, Washington D.C.
- Land Trust Alliance. 1999. *Conservation Options A Landowners Guide.* Washington D.C.
- Lind, Brenda. *Working Forest Conservation Easements.* The Land Trust Alliance, Washington D.C.
- Gustanski, Julie Ann, H., Roderick H. Squires, and Jean Hocker, Eds. 2000. *Protecting the Land: Conservation Easements Past, Present and Future.* Island Press.

Web Sites

- California Forest Stewardship Program

  http://ceres.ca.gov/foreststeward/html/landowners.html#Anchor-Conservation-55669

  Provides information on private forest stewardship in California lands. The section titled Information for Landowners provides information on easements as well as other management topics.

- Land Trust Alliance

  http://www.lta.org/conserve/options.htm#easement

  Provides general information to landowners, as well as links to specific articles about conservation easements and publications created by the Land Trust Alliance for landowners.

- The Nature Conservancy

  http://nature.org/aboutus/howwework/conservationmethods/privatelands/conservationeasements/

  Provides several different pages about conservation easements including information on how they evolved, myths about them, and statistical facts in the United States, and example easements.

- The Pacific Forest Trust

  http://www.pacificforest.org/services/easements.html

  Provides general descriptions of conservation easements, as well as real life examples of forest property owners in California, Oregon, and Washington who have protected their lands through conservation easements.

- Private Landowner Network

  http://www.privatelandownernetwork.org/plnpro/wfce.asp

  Provides articles and information on working forest conservation easements, as well as other private land issues.

Elements of a Conservation Easement
(Not for Execution)

The outline below provides some sample elements of a conservation easement. The elements listed below do not represent an exclusive list. The purpose of this outline is informational only. This outline should not be used to execute an easement. Those wishing to execute an easement are advised to seek professional assistance.

When recorded Mail To:

____

DEED OF CONSERVATION EASEMENT

THIS GRANT DEED OF CONSERVATION EASEMENT is made this ____ day of ___________, 200__, by _______________________., having an address at _________________________("Grantor"), in favor of ____________, [a qualified entity], ("Grantee").

RECITALS

Recitals create the basis/support for the easement, reflect public conservation values of the property and purposes of the easement

Example Elements

A. [Affirmation that both Grantor and Grantee are able to grant easement and hold easements respectively]

B. [Specific conservation values of property: natural, percent imperviousness, ecological, cultural, educational, scenic, forested and open space, and public recreational values]
Note that these can be explained separately

C. [Conservation values officially recognized by the state and/or federal government].

D. [Intent of Grantor to protect values by limiting certain activities/land uses]

E. [Intent of Grantor to sell or donate easement in perpetuity]

AGREEMENT

[This section includes the enforceable terms of the easement]

Grantor and Grantee ("the parties") mutually agree as follows:

1. Grant of Easement [Language whereby Grantor conveys easement to Grantee]

2. Acceptance of Easement. [Language indicating Grantees acceptance and commitment to carry out easement duties in perpetuity]

3. Purpose. It is the purpose of this Easement to: [list purposes consistent with conservation values as recited above, for example enhance land's ability to moderate flows, protect habitat, etc.:]

4. Such purposes are consistent with and in accordance with the U.S. Internal Revenue Code, Section 170(h).

5. Rights of Grantee. [Language specifying certain rights granted to grantee in perpetuity to accomplish purpose of easement]

6. Prohibited or Restricted Uses. [Language may include general prohibition of uses that are inconsistent with easement purposes; Exhibit C can itemize specific prohibited uses]

7. Reserved Rights. [Language reserving certain use rights for Grantor, which may include recreation, among other things]

8. Mediation. [Language regarding how disputes between Grantor and Grantee may be resolved] *Note, other forms of dispute resolution, beside mediation, may be inserted.*

9. Grantee's Remedies. [Language regarding remedies that may be available to the Grantee in the event of an easement violation – for example injunctive relief, damages, emergency enforcement, scope of relief etc.]

10. Venue; Consent to Suit. [Language regarding choice of legal venue for addressing disputes]

11. Access. [Language may specify whether or not public access will be provided in the easement]

12. Costs, Legal Requirements and Liabilities. [Language regarding Grantor's responsibility to bear costs and liabilities associated with ownership of property. These responsibilities would include taxes and environmental matters, among other things].

13. Extinguishment. [Language regarding legal court process for extinguishing easement, in part or in whole, and costs associated with doing so]

14. Valuation. [Language regarding formula for determining market value of easement].

15. Condemnation. [Language regarding proportionate compensation to Grantor and Grantee in event of condemnation of easement property].

16. Amendment. [Language governing process and scope of any amendments to easement].

17. Assignment. [Language regarding ability to assign easement to another qualified entity].

18. Executory Limitation. [Language regarding back-up grantee in event Grantee ceases to exist].

19. Subsequent Transfers. [Language regarding Grantor's responsibility to incorporate terms of easement in subsequent transfers of interests in easement property].

20. General Provisions. [General language regarding interpretation of easement agreement, for example, controlling law, liberal construction, severability, access to counsel, joint obligation etc.]

TO HAVE AND TO HOLD unto the Grantee, its successors and assigns forever.

WITNESS the following signatures:

DATED: ________________ GRANTOR: ____
[Name]

DATED: _______________ GRANTEE: ____
[Name]

BY: ______________________________

A. Legal Description of Property

B. Index to the Baseline Report

[Specific language of property conditions and conservation values]

C. Restrictions

[This section may include specific use restrictions of the easement]