technical memo

Project Name |	Marketplace District Reuse Feasibility Study	**Date** |	Apr. 05, 2023
To / Contact info |	BCWD Board of Managers		
Cc / Contact info |	Karen Kill, District Administrator		
From / Contact info |	Brett H. Emmons, PE, Camilla Cornell, PE, Ryan Fleming, PE, Kerri Robinson, Bill Yu		
Regarding |	District Stormwater Harvesting/Reuse Options at Marketplace Area (**DRAFT**)		

Background

In 2018 the BCWD identified a number of challenging issues and opportunities in the Highway 36 Corridor of BCWD, and within that corridor, the highly urbanized Marketplace Area. The need for regional treatment in order to provide runoff reduction and water quality treatment in the Long Lake drainage area was identified. These factors included:

1. BCWD rule revisions and impacts related to the MS4 permit requirement that limits the ability to use stormwater infiltration in Drinking Water Supply Management Areas (DWSMA's), which cover a substantial portion of the Long Lake Drainage Area, with a net result of more impacts at Long Lake.
2. BCWD discovered that there are expected additional flood risk-related issues on Long Lake, as well as locally in the road network, revealed with recent model simulations of design storm events using the more up-to-date NOAA Atlas 14 guidance.
3. Redevelopment and infill development activity that may lend itself to a streamlined process using regional treatment, if the BCWD could provide a regional solution and work with the developers at the early stages of the planning process, simplifying approvals and reducing redevelopment conflicts.
4. Reviewing the successful precedence of a regional stormwater reuse in the metropolitan community of Waconia that simplified stormwater approvals and created a win-win situation for the city and developers.

In response to these issues and opportunities, EOR made a presentation to the Board of Managers at the October 2018 Board Meeting to share ideas for regional treatment options on parcels that may redevelop and others that have yet to be developed. Four quadrants/sectors were identified for potential implementation of treatment and volume control options (Figure 1). These regional treatment ideas included exploring opportunities for stormwater reuse on a regional stormwater management (SWM) system. One example of that arose organically as part of the new interchange project. Initial regional ideas included the parcel on the northeast corner of Hwy 36 and Manning Avenue and future site of a medical campus and the future Hy-Vee site in the southeast corner of the same intersection, and opportunities to increase storage and treatment in the ravine south of Hwy 36 that drains to Long Lake. The new interchange is utilizing reuse to meet it stormwater treatment requirements, and due to the regional approach, space available in the ROW, and need for fill to build up bridge approaches, it is actually far exceeding the minimal standard and benefiting Long Lake. The Regional or District opportunities are not being implemented at this time, but may still exist in the future.

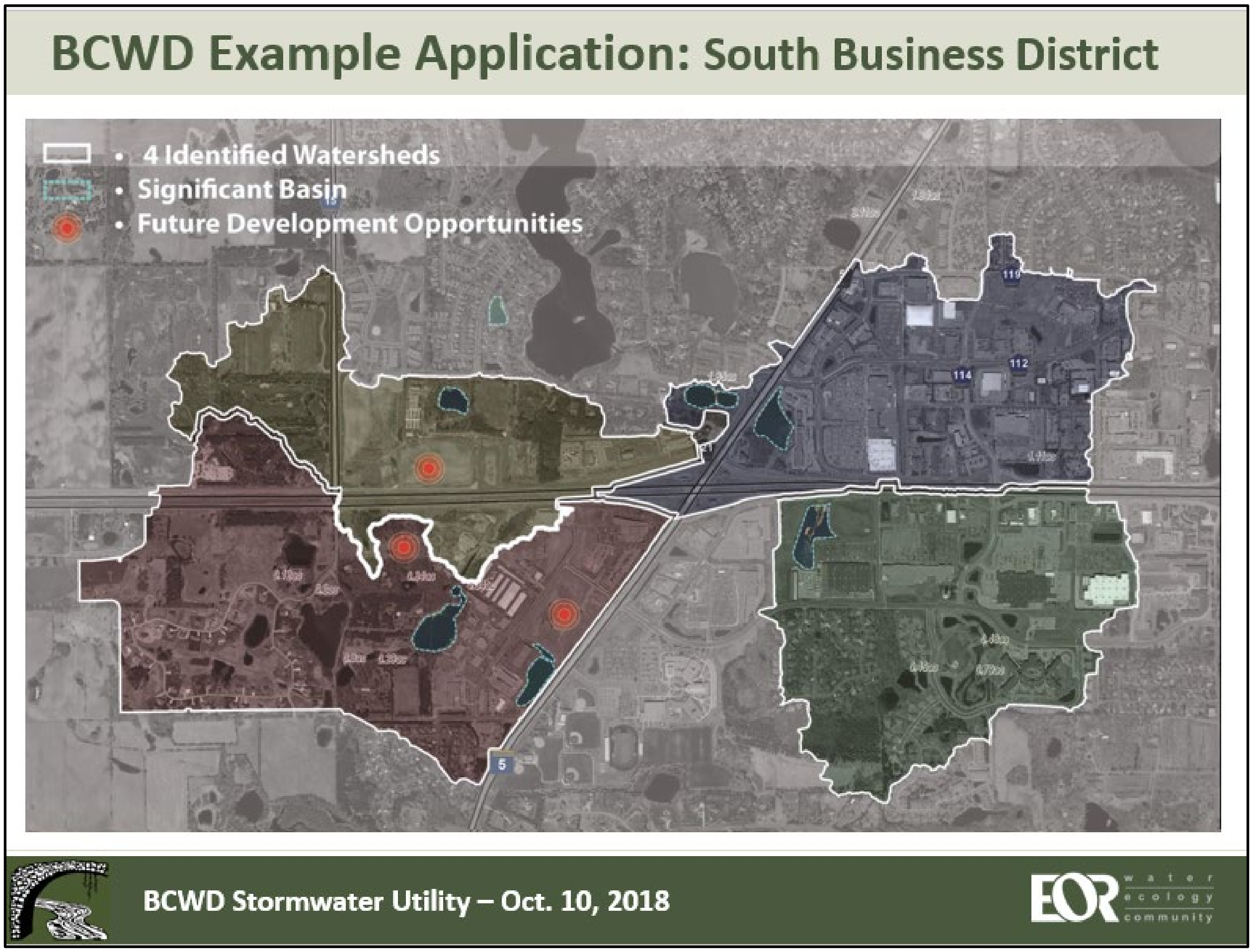

Figure 1: Areas of interest for stormwater treatment and control options

In addition, EOR has identified potential stormwater reuse retrofit opportunities on both sides of Highway 36 including the Marketplace drainage area (in the City of Stillwater) and the drainage area to Menard's Pond (in Oak Park Heights). The 2022 budget recommendation from District staff included a feasibility study to explore the viability of stormwater reuse in the Marketplace drainage area as a starting point and to test the approach in a challenging, highly developed setting. The description in the 2022 budget recommendations is as follows:

In an effort to reduce stormwater volumes and provide dissolved phosphorus treatment for Long Lake, it is proposed that the BCWD investigate the feasibility of stormwater reuse opportunities in the greater Marketplace Area of Stillwater. The study will look at opportunities to capture and re-use stormwater within the Marketplace development as well as the large pond along Stillwater Boulevard and Brewers Pond. Example opportunities include Lift Bridge Brewing, Abrahmson's, Rick's Automotive, Bethany Evangelical Convent, St. Croix Sensory, Arrow Building Center, several banks, and the townhomes near Brewer's Pond. The study will focus on areas where water is currently ponded and where there are local needs for irrigation.

According to the tasks identified in the scope of services, this feasibility study has estimated, through a high-level assessment, how much runoff reduction and water quality treatment would be provided by implementing reuse in this developed portion (Figure 2) of the watershed.

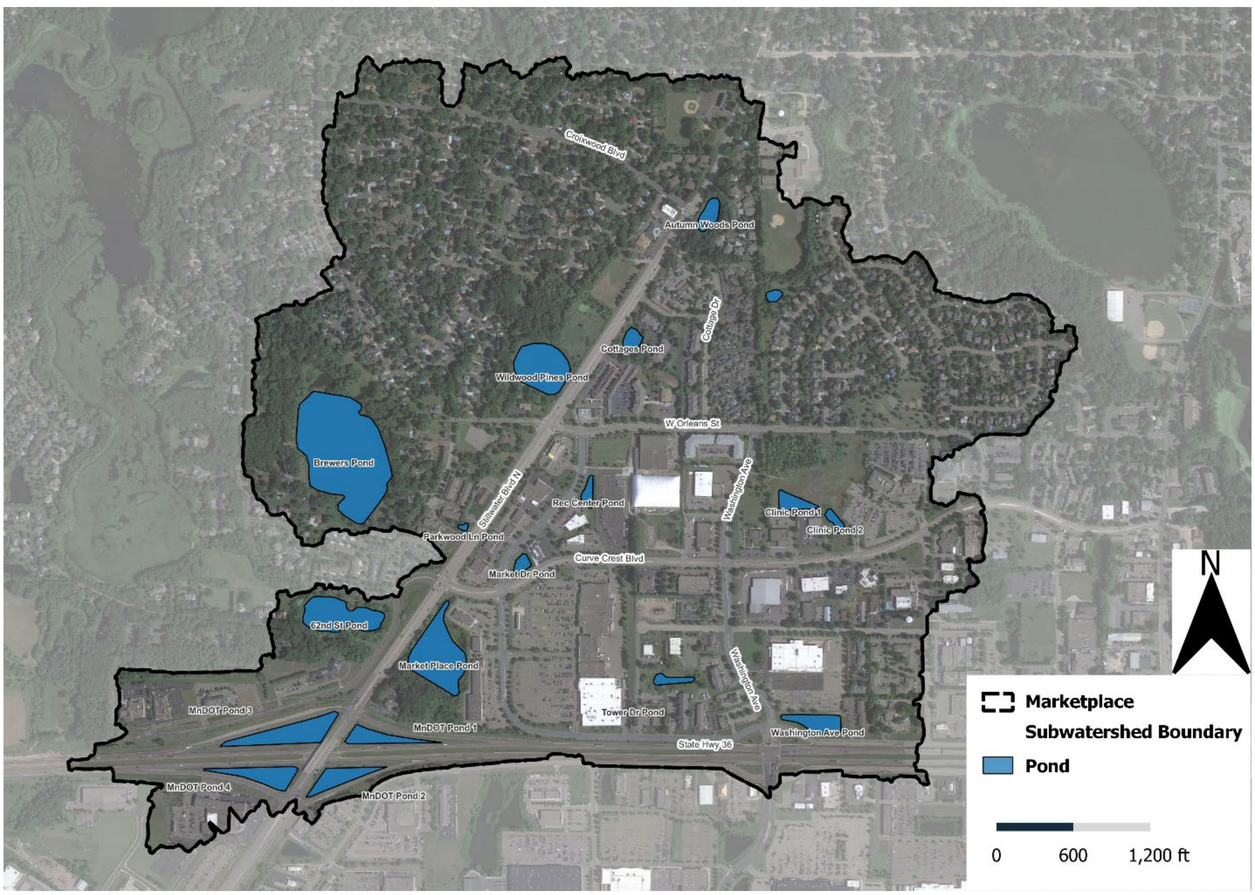

Figure 2. Subwatershed Boundary of Greater Marketplace Area, Stillwater

DRAFT

The focus of this feasibility study is to begin with one of the four areas, the Marketplace sector north of Hwy 36 and east of Hwy 5. All of these improvements across the four sectors have the potential to significantly improve the flooding and water quality situation on Long Lake, and downstream.

Marketplace Area Overview

The Marketplace Area, along with the drainage area of Brewers Pond and four interchange ponds, covers a total area of 648 acres and contains a mix of commercial and residential areas, allowing for numerous reuse opportunities (e.g., irrigation, car wash, hotel laundry, etc.). Meanwhile, a 1000-foot additional zone outside the Marketplace Area drainage boundary, which covers an additional 436 acres, is being considered for additional potential water reuse opportunities if end uses such as irrigation make sense and the water sources have matching capacity. Several locations within the area tend to flood frequently during rain events, as is illustrated in a few examples through model outputs (Figure 3 and Figure 4) and corroborated by anecdotes. It is of interest to examine whether more capacity can be found within the storm sewer network through the beneficial reuse of stormwater potentially resulting in a decrease in extent or duration of these nuisance flooding events. There are also flooding issues around 62nd St. pond that this project could also help.

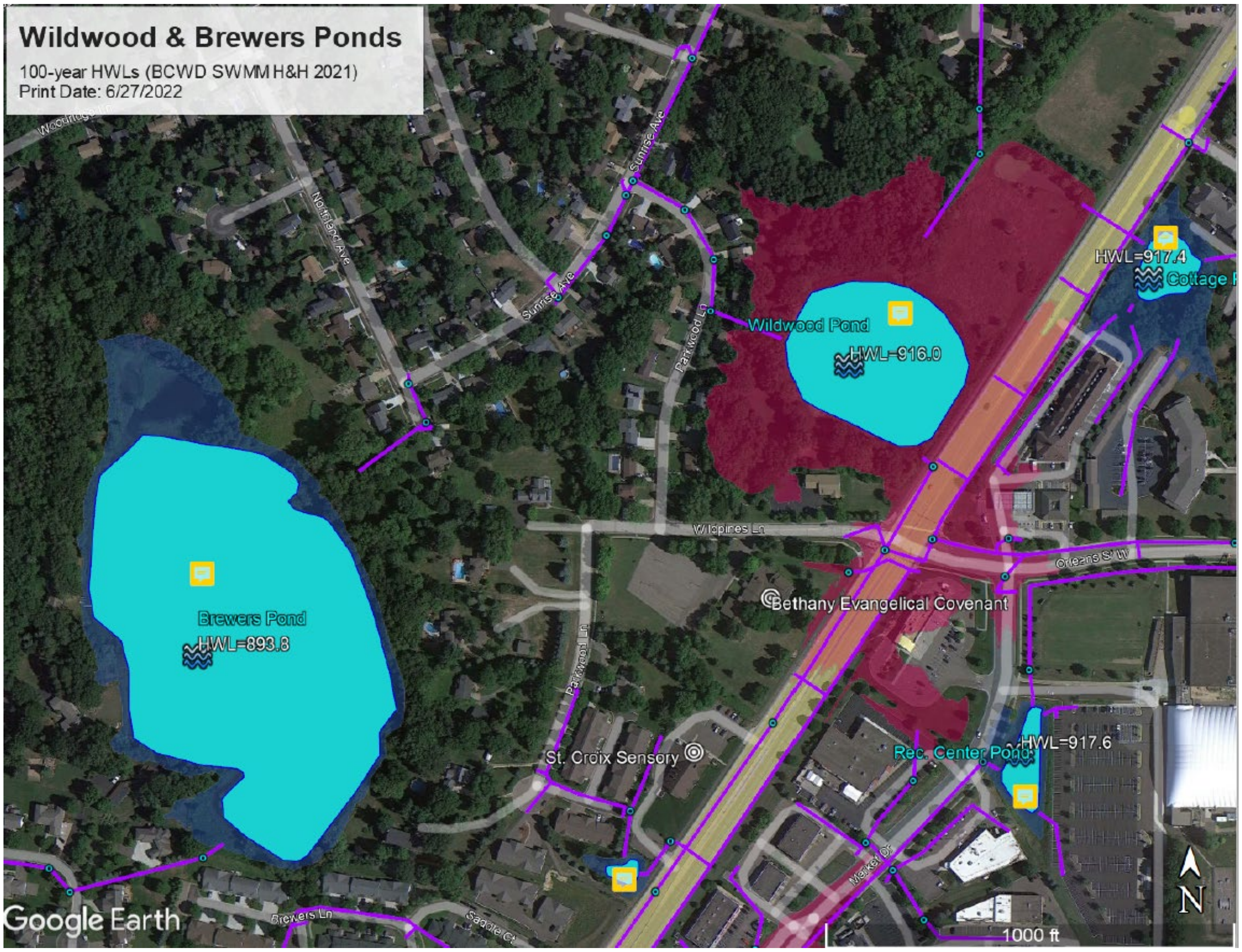

Figure 3: Locations of surface ponding around Wildwood and Brewers Ponds (100-year return period event)

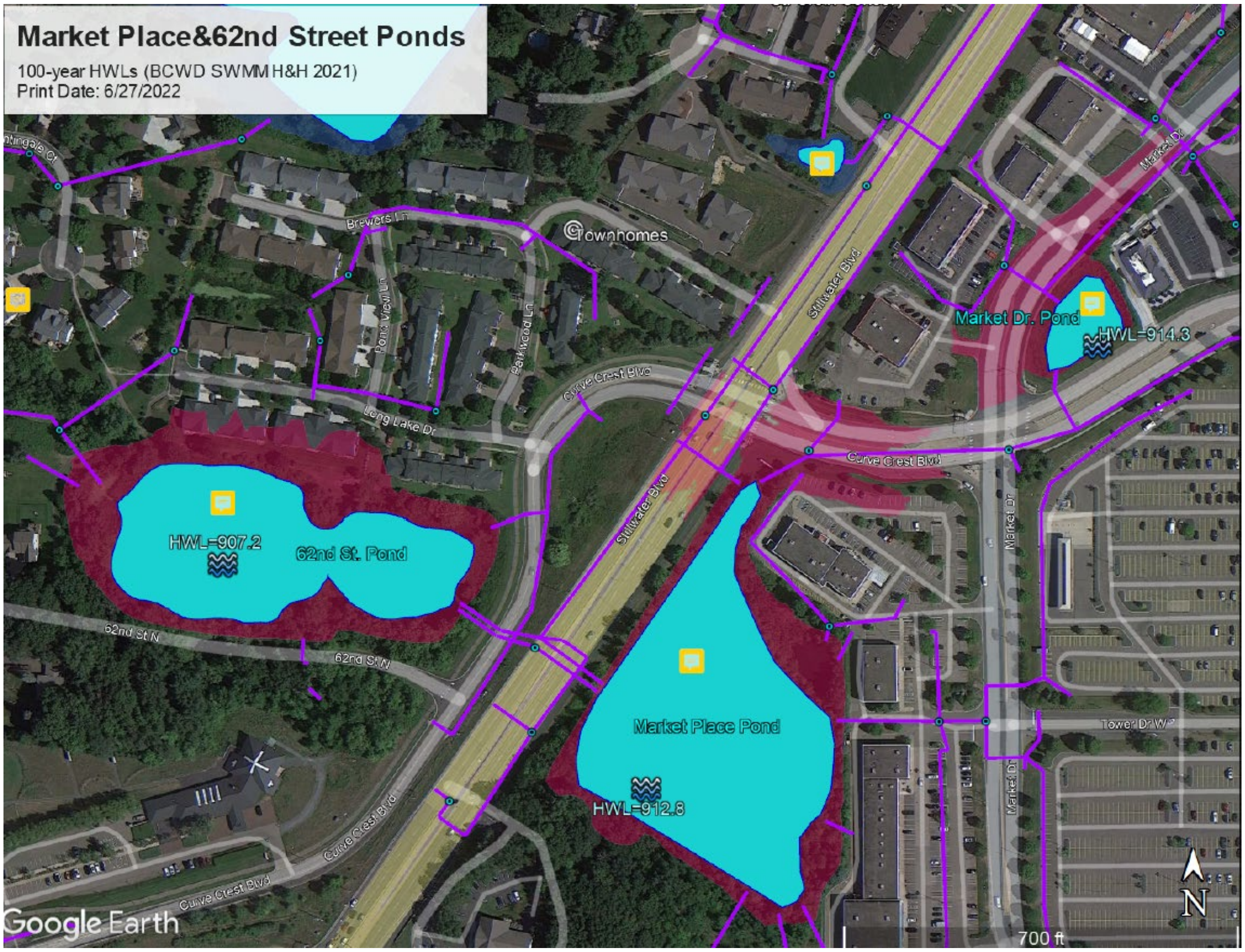

Figure 4: Locations of surface ponding around Marketplace and 62 Street Ponds (100-year return period event)

As shown in Figure 5, property ownership is distinguished as private and public by using parcel information from the City of Stillwater to better assemble the water reuse opportunities and quantity.

DRAFT

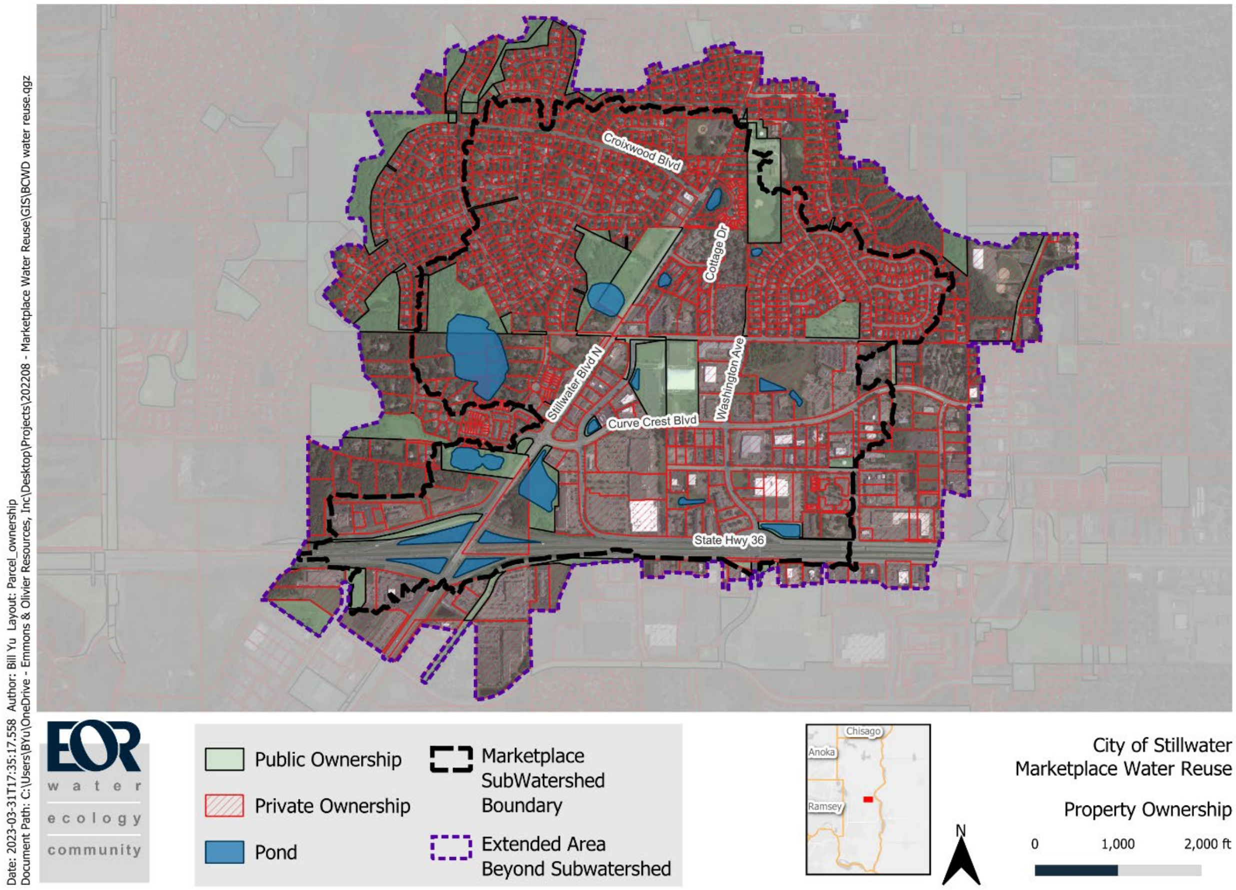

Figure 5. Marketplace Property Ownership

In 2015, a high-resolution (1-Meter) Land Cover Classification raster dataset was completed by University of Minnesota for the seven-county Twin Cities Metropolitan area, which we used in this project to estimate green space for irrigation in the Marketplace Area. A brief field investigation was conducted to review the accuracy of the open space layout depicted in the land cover raster and to investigate the irrigation opportunities for green space in the Marketplace area. Figure 6 shows the green space layout with various types of vegetation coverage (Grass/Shrub, Deciduous Tree Canopy, Coniferous Tree Canopy).

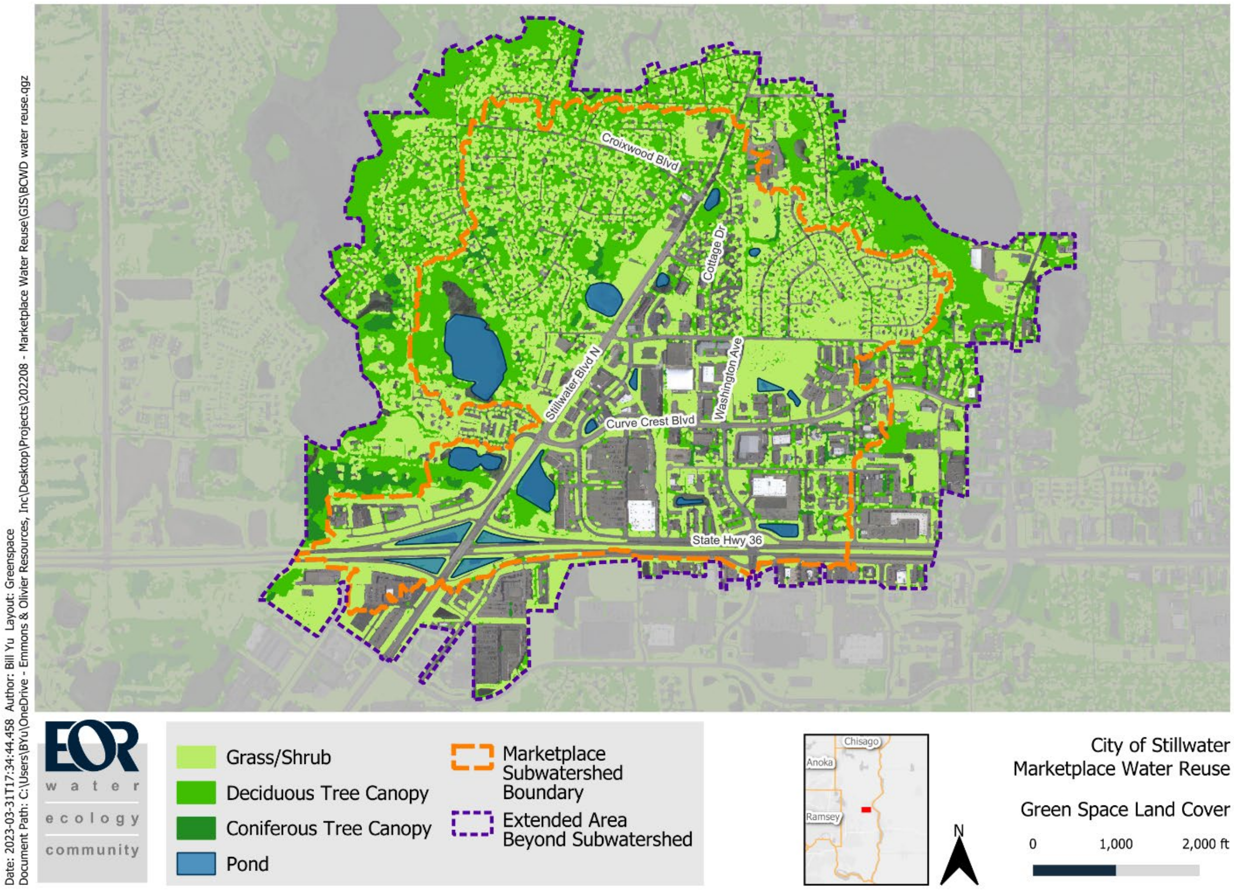

Figure 6. Green Space Land Cover in Marketplace Area

Runoff from the defined Marketplace Area in this study flows into the regional stormwater ponds and eventually goes into Long Lake to the west of the Marketplace area, as shown in Figure 7. According to EOR's recent flood risk assessment for Long Lake, the surrounding homes are at high risk of flooding due to increased precipitation intensity and frequency expected with climate change. The flow into Long Lake would be reduced and the flood damage would be mitigated by reducing runoff water volume from the upstream ponds.

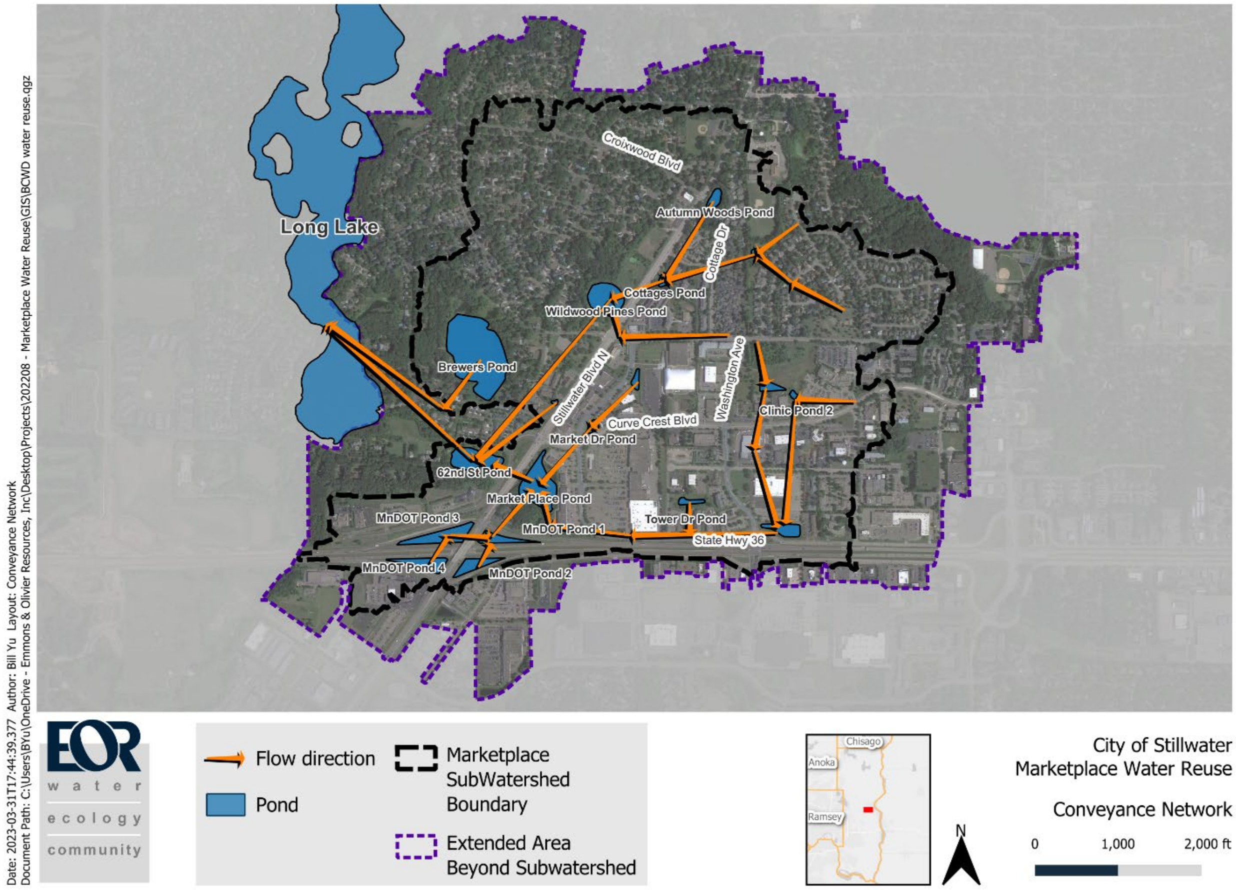

Figure 7. Pond and Pipe System Conveyance Network

Re-usable Water Resource

In 2020, EOR updated the BCWD's Hydrologic and Hydraulic (H&H) model, including catchment updates based on NOAA's Atlas 14 and updated LiDAR data released in 2014. As shown in Figure 2 a total of 18 ponding areas (including Brewers Pond) are considered as potential sources of water storage and reuse at this early stage, initial assessment. Each pond's available storage volume is assumed to be the volume between the normal water level and a maximum drawdown of 3 feet. The ponds' as-built drawings were reviewed to estimate the available storage volume, and DEM data was used to calculate the storage volume when no as-built drawings were available. When there is no information available for the pond and the DEM does not capture the topography below the normal water level, the side slope is assumed to be 3:1 with overall depth sufficient to allow a 3 foot drawdown to estimate the storage volume.

For purposes of reuse modeling, model configuration, and getting an overall understanding of the parameters and water balance, this analysis and reuse modeling uses aggregated storage and not individual basins. This provides an initial assessment of how the various reuse elements are balanced in the Marketplace sector: the water sources (runoff from development), the water storage (focusing on existing ponds, initially), and water end uses (green spaces for irrigation), It is beyond the scope of this initial assessment to optimize the layout, using certain districts and zones for irrigation. After this preliminary feasibility of determining if reuse can make a sizeable impact in the water budget of this urbanized sector, a next phase would include the task of looking at the details of how that could be happen, including logistical and cost issues to optimize the system.

Storage information is summarized in Table 1.

Table 1. Pond Available Storage Volume information

Pond	Storage (ft^3)	Portion of Total Storage Volume (%)	Estimation Source	Storage Option
Brewers	1,605,050	47.9%	LiDAR	1, 2
62nd St	389,710	11.6%	LiDAR	1, 2, 3
Market Place	372,740	11.1%	3:1 Side Slope Assumed	1, 2, 3
Wildwood Pines	369,000	11.0%	LiDAR	1, 2, 3
MnDOT 3	102,630	3.1%	As-Built Drawing	2
Clinic #2	89,180	2.7%	LiDAR	2
Washington Ave	84,130	2.5%	As-Built Drawing	2
Autumn Woods	75,110	2.2%	LiDAR	2
Clinic #1	56,160	1.7%	LiDAR	2
Tower Dr	52,630	1.6%	As-Built Drawing	
Rec Center	46,820	1.4%	LiDAR	
MnDOT 2	35,730	1.1%	As-Built Drawing	
Cottages	29,450	0.9%	3:1 Side Slope Assumed	
Benson or Highlands	22,560	0.7%	As-Built Drawing	
Parkwood In	9,980	0.3%	As-Built Drawing	
Market Dr	7,320	0.2%	3:1 Side Slope Assumed	

Given the costs of installing a pump station to lift water from a stormwater pond for reuse, using water from a pond with a large storage volume provides more cost-effective reuse opportunities.

Brewers Pond, 62^{nd} St Pond, Market Place Pond, and Wildwood Pines Pond can each provide more than 10% of the total storage volume, for a total storage volume of 2,736,500 ft^3 (81.7% of the total pond storage volume) These four ponds were considered as Storage Option 1. Four larger-sized pump stations will be required in this case.

MnDOT3 Pond, Clinic #1 Pond, Clinic #2 Pond, Washington Ave Pond, and Autumn Woods Pond all have 1.7% to 3.1% of the storage volume available in each pond, bringing the total storage volume of 3,143,700 ft^3 (93.3% of total pond storage volume). These five ponds were added to the ponds in Storage Option 1 to create Storage Option 2. Clinic #1 Pond and Clinic #2 Pond could share a single pump station due to their close spatial proximity. As a result, four additional medium-sized pump stations will be required.

Brewer's Pond is a peaceful and picturesque nature feature in the heart of Stillwater, which is a popular spot for fishing, walking and hiking, wildlife viewing, boating and padding, and picnicking. The water levels in the Brewer's Pond could affect the recreational activities provided for the residents who live nearby. Therefore, in the third storage option, Brewer's Pond is removed resulting in a reduced total storage volume of 1,538,700 ft^3 (46% of the total pond storage volume).

Stormwater Reuse Model and Irrigation Demand

EOR used a stormwater reuse model (Emmons & Olivier Resources Inc. 2013. Stormwater Harvesting: Accounting of Benefits and Feasibility. MWMO Watershed Bulletin 2013 - 3. 78 pp.) to assess the feasibility of stormwater capture and reuse for irrigation at the Marketplace Area. A harvest and reuse system analysis is based on a water balance, comparing the harvested water supply (surface runoff), the storage (ponding), along with the demand (irrigation) through time in order to determine how much stormwater volume can be diverted prior to ending up in Long Lake. The model used also accounts for rainfall timing such that irrigation is not applied directly after a rain on saturated soils. These three factors, water supply, water demand and storage, as they fluctuate through time based on actual rain records, are the key aspects determining the performance and effectiveness of any harvesting and reuse system. EOR collected data from multiple sources including the BCWD, City of Stillwater and State resources to characterize the three factors within the Stormwater Reuse Model.

- Water Supply/Source (Runoff)
    - Size of contributing watershed
    - Soils mapping and geotechnical investigation
    - Land use characteristics of watersheds

    - Existing storm sewer infrastructure locations
    - Precipitation records
- Water Demand
    - Existing public/private open space irrigation
    - Potential green streets locations
    - Irrigation depth estimate
    - Precipitation records (constraining when irrigation is applied)
    - Potential commercial/industrial non-potable use
- Storage Options
    - Topography
    - Existing stormwater ponds – nearby and on-site

In this feasibility study, several scenarios are modelled. The water demand is the primary factor determining the feasibility in each scenario and is characterized in Table 2, below. Each scenario is detailed in the following sections, with maps and graphics to illustrate the potential irrigation areas, and containing summary tables of the key parameters and system performance.

Table 2. Summary of Water Reuse Model Scenario - End Uses of Water

Scenario	Criteria
1	Existing and Potential (Green Street) Public Green Space Irrigation
2	Public, Green Street, and Prioritized Private Green Space Irrigation
3	Public and All Private Green Space & Green Street Irrigation
4	All Public and Private Green Space within the Extended Area & Green Street Irrigation
5	Scenario 3 Irrigation + Commercial Water Use
6	Prioritized Public and Private Green Space, Green Street Irrigation + Commercial Water Use

Scenario 1

In Scenario 1, irrigation of green space in public areas and within the road rights-of-way is assumed since these areas comprise the largest amount (75%) of green space the city owns and manages. As shown in Figure 8, the public parcels have 49 acres of green space and the roadside areas have 42 acres of irrigable green space.

In order to support a greener and more sustainable city, EOR proposes enhancing the green space within the right-of-way (ROW) to enable the areas to intercept more runoff and accept irrigation into features such as street trees, permeable pavements, rain gardens (bioretention), and swales. Incorporation of these types of features into the ROW is termed "Green streets" and provides a variety of benefits in terms of water management, economic, environmental, and social perspectives. Green streets protect water quality by filtering and treating runoff before it reaches surface water resources, reduce peak stormwater flows and reduce the total stormwater volume by retaining additional water in soils and through vegetation uptake and evapotranspiration. Other benefits include replenishing groundwater supplies, absorbing carbon, improving air quality, reducing urban heat island effects, improving neighborhood aesthetics, and connecting parks and open space to the built environment. Figure 9 shows a minor arterial green street, recently designed by EOR, with built in storage within roadside tree trenches for irrigation after storm events. Figure 10 shows a typical green street design layout for commercial streets from the EPA's Green Street Conceptual Design Guide.

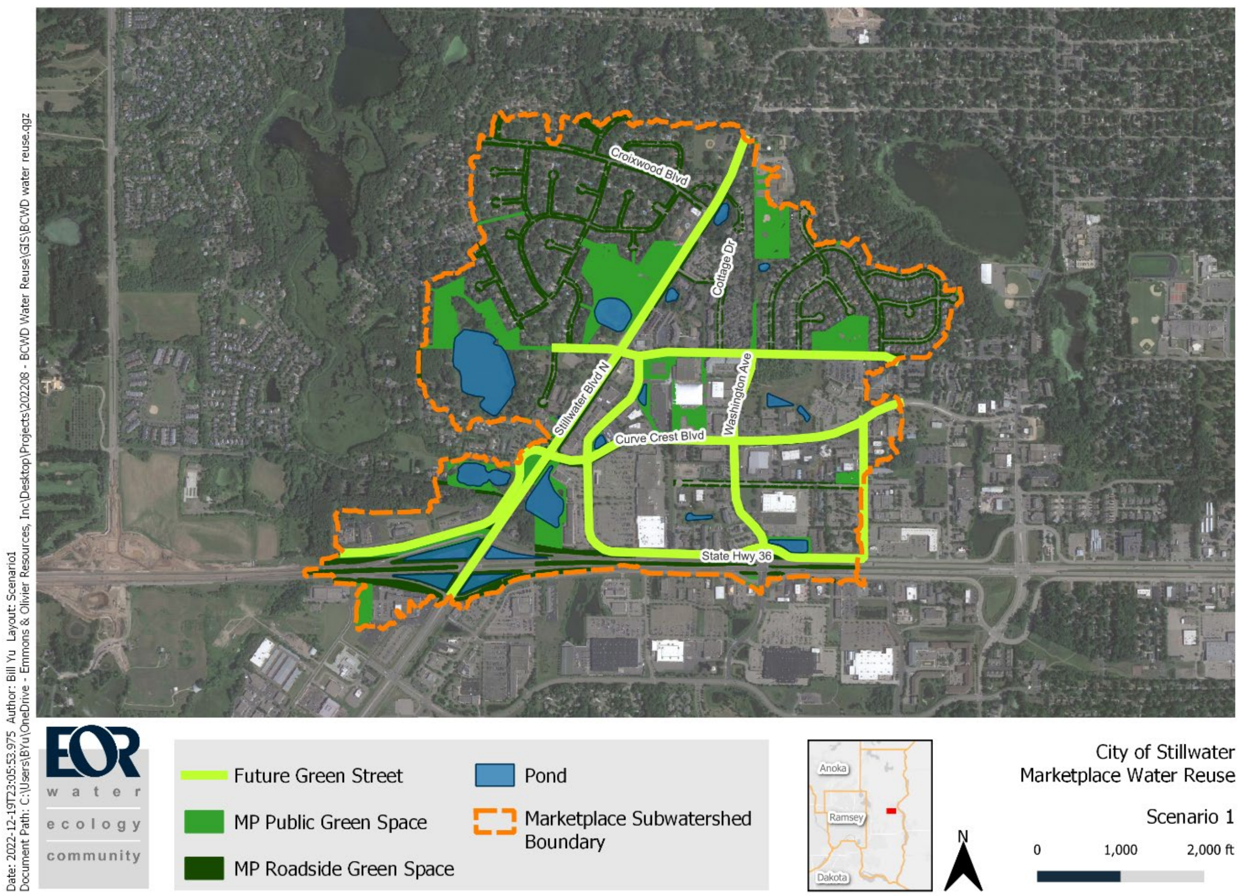

Figure 8. Green Space Cover for Irrigation – Scenario 1

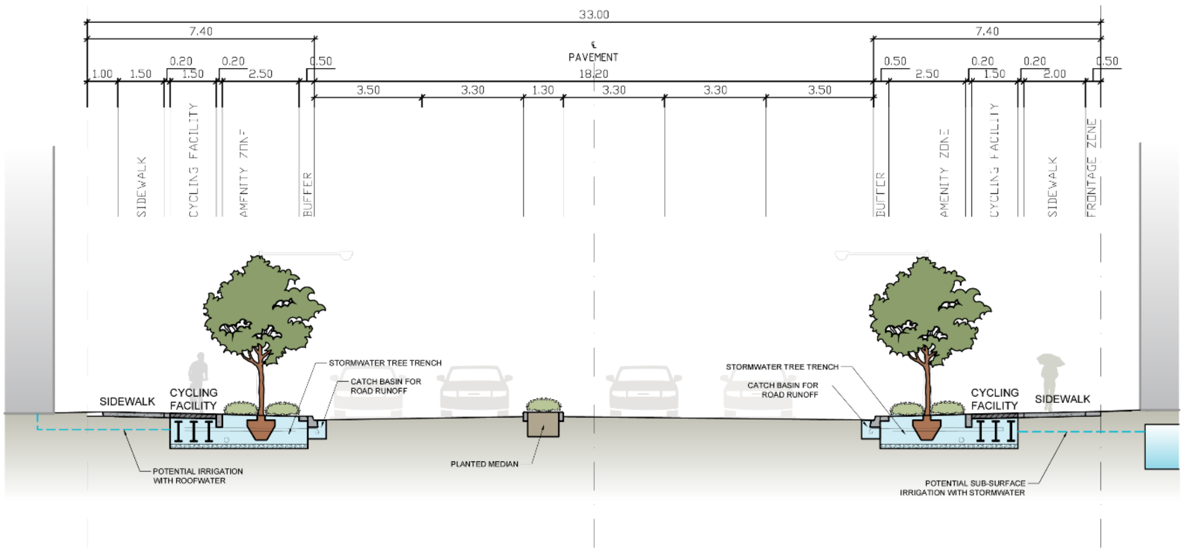

Figure 9. Minor Arterial Green Street Design with Tree Trenches

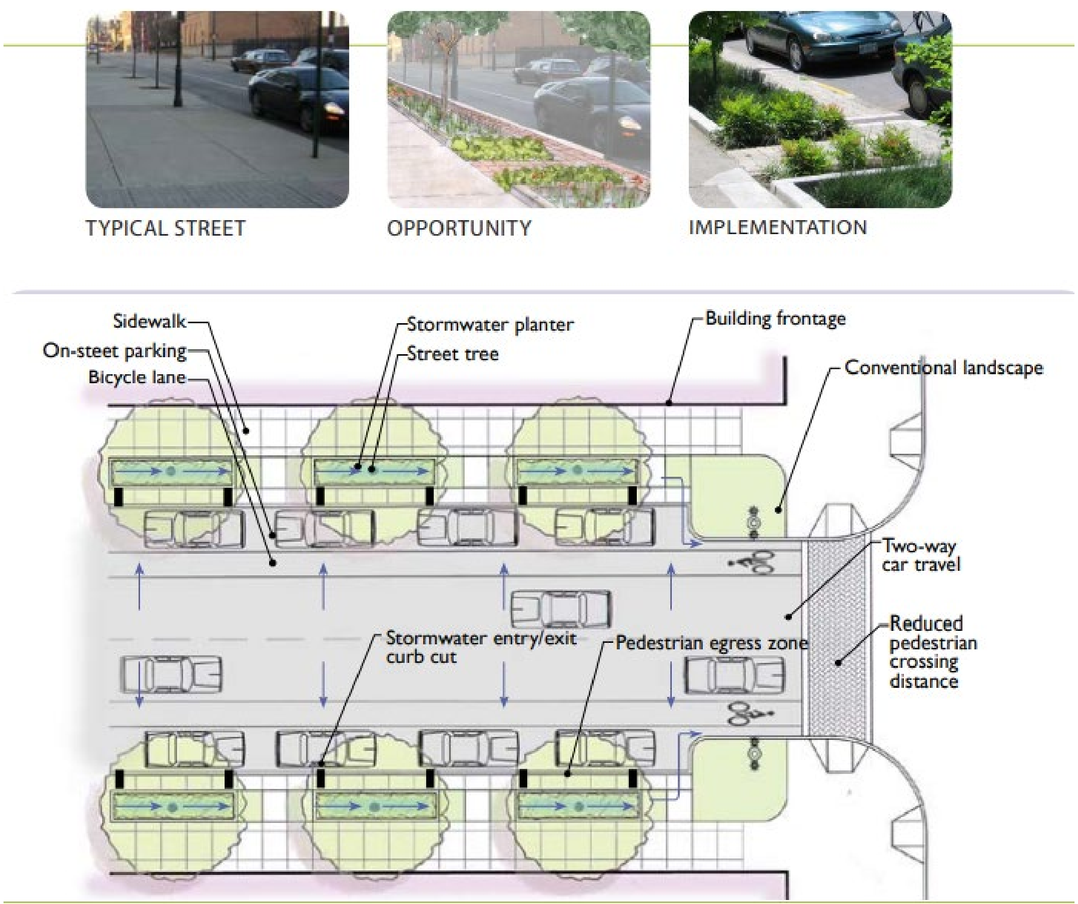

Figure 10. Green Street Conceptual Design for Commercial Streets (EPA, 2009)

DRAFT

Typically green streets and tree trenches are only treating the immediate drainage area that flows to it passively. This reuse application of green streets is going a step further to ensure the capacity of the system is maximized with the ability to bring in additional water stored from the last runoff event and use it up. The total length of proposed green street inside the Marketplace Area is 5.3 miles (27,900 ft), as illustrated in Figure 8If tree trenches are proposed on both sides of the green street at 50-foot intervals, approximately 1000 trees will be planted within the green street redevelopment. According to Comprehensive Environmental Inc.'s Tree Canopy Stormwater Implementation & Outreach Program (2017), one medium size (12") tree intercepts 1,432 gallons of water per year, which is equivalent to irrigating 70 ft^2 green space at a rate of 0.8 inch per week. The water interception by 1000 trees is equivalent to irrigating 1.6 acres of green space. In this scenario, tree trenches have the potential to provide approximately 125,000 ft^3 of underground storage volume assuming width and depth of 4 ft and 3.5 ft, respectively. This additional storage capacity in tree trenches was included in the storage of the scenarios including green streets to account for the additional capacity in a reuse configuration.

The Irrigation rate of turf was compared to common values used by irrigation contractors in the upper Midwest area. A local example of this is the Stillwater Country Club, where they use well water to irrigate about 75 acres of turf from May to October at a reported water conservation irrigation rate of 0.5 inches per week. To support a stormwater volume reduction objective rather than a source water conservation objective, the irrigation rate used commonly in the irrigation industry of 1.5 inches per week was used. In a stormwater volume reduction objective situation, occasional periods without water available for irrigation should not be seen as negative since the ability to irrigate is opportunistic rather than required. If needed, other sources of irrigation water, such as city water supply normally used, can be included as a backup or supplement..

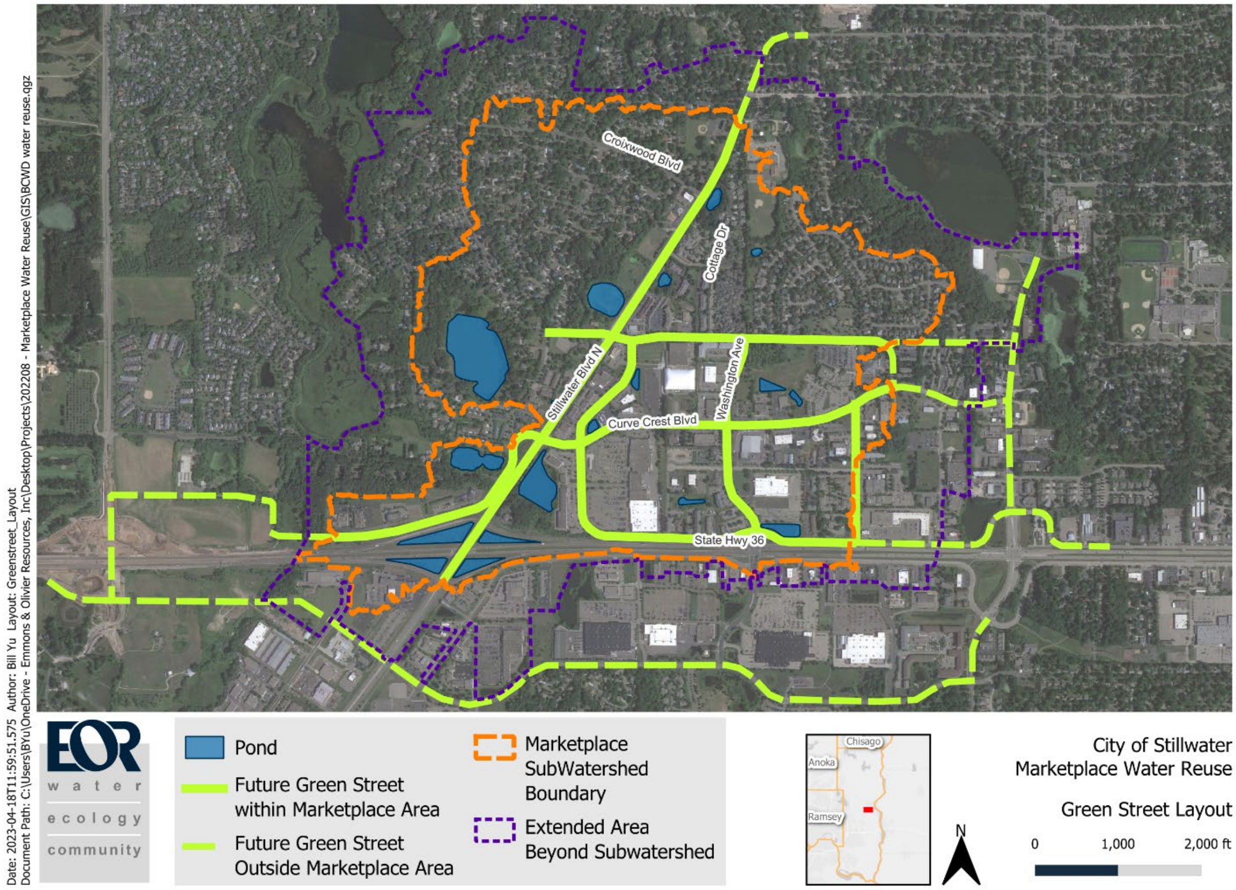

Figure 11. Future Green Street Development Conceptual Layout Plan

DRAFT

Scenario 2

According to information provided by the City, some private business owners in the marketplace area are currently using the public water supply for irrigation on their property. In Scenario 2, these commercial parcels are considered as prioritized private parcels, and their green space area is added to the irrigable area already assumed in Scenario 1. We assume that 75% of the prioritized green space will be irrigated with reuse water because these business owners are already using water supply for irrigation and will likely be willing to use reuse water as a substitute to save money without installing a new irrigation system. The assumption of 75% is intended to provide a net balance as some areas that currently irrigate may not be included in the data provided while some that are marked as irrigating may not irrigate their entire vegetated area. As shown in Figure 12, the prioritized green space has a total area of 48 acres.

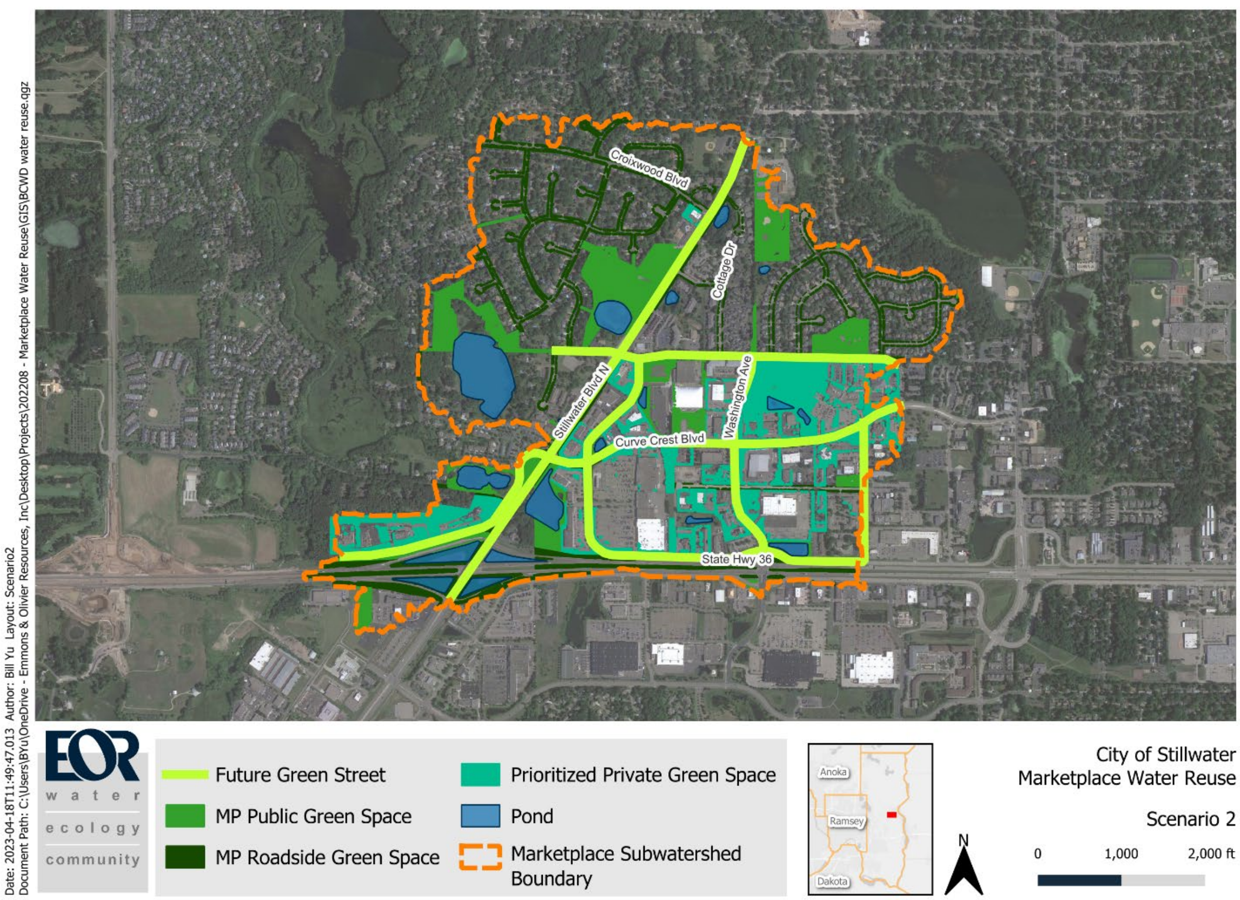

Figure 12. Green Space Cover for Irrigation – Scenario 2

Scenario 3

Scenario 3 assumes that 20% of all the remaining green space in the private parcels (except the prioritized private business included in Scenario 2 with 75% irrigated area) will be irrigated using reuse water. This approach would be realized if a public entity provided irrigation in lower density residential areas, which is not common (except Hugo, MN), but is possible. A low adoption rate of 20% is used because the majority of the additional parcels are single family residential parcels owned by many different people, who may not all have existing irrigation systems, and many others who do irrigate but may not want to switch sources. If a residential program were successful, this assumption may be overly conservative, and performance could be higher. Figure 13 shows the additional green space and yard, however in the model calculations only 20% of the green space in the remaining private land is assumed to use this irrigation source. This results in adding an additional 37 acres of irrigation area to the area assumed in Scenario 2.

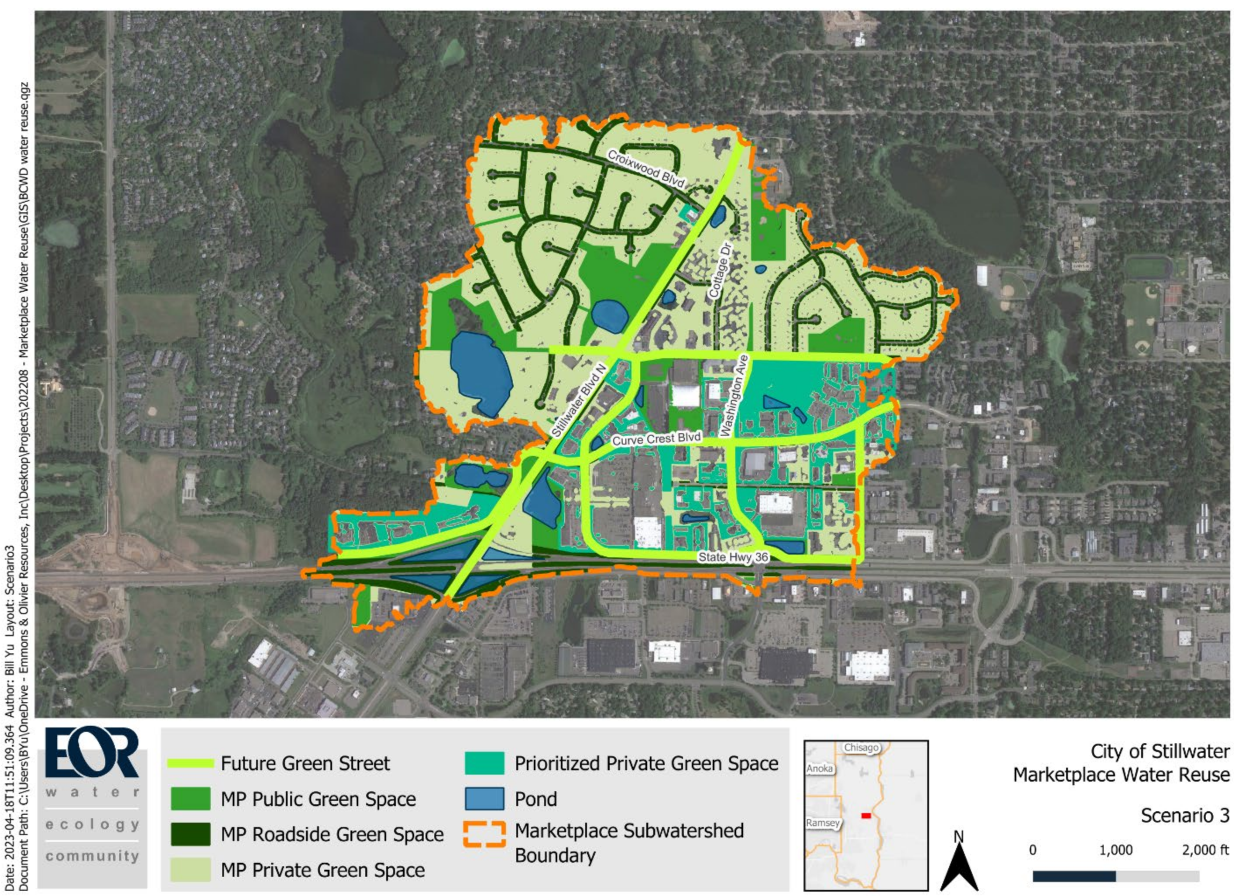

Figure 13. Green Space Cover for Irrigation – Scenario 3

DRAFT

Scenario 4

Scenario 4 adds some irrigation opportunities for the green space outside the Marketplace area to the irrigable area in Scenario 3. These other, extended areas are included in recognition that for pumped irrigation water, the subwatershed boundary is fairly arbitrary, and water could be delivered to appropriate adjacent green spaces. In this case, only 20% of the public and roadside green space and 10% of the private green space in the surrounding area are assumed to irrigate using reuse water as a conservative assumption. The green space (public, roadside, and private) in buffer area adds additional 31 acres of irrigation area, as shown in Figure 14. The irrigable areas from Scenario 3 remain the same, and this extended area is added to the total irrigable area.

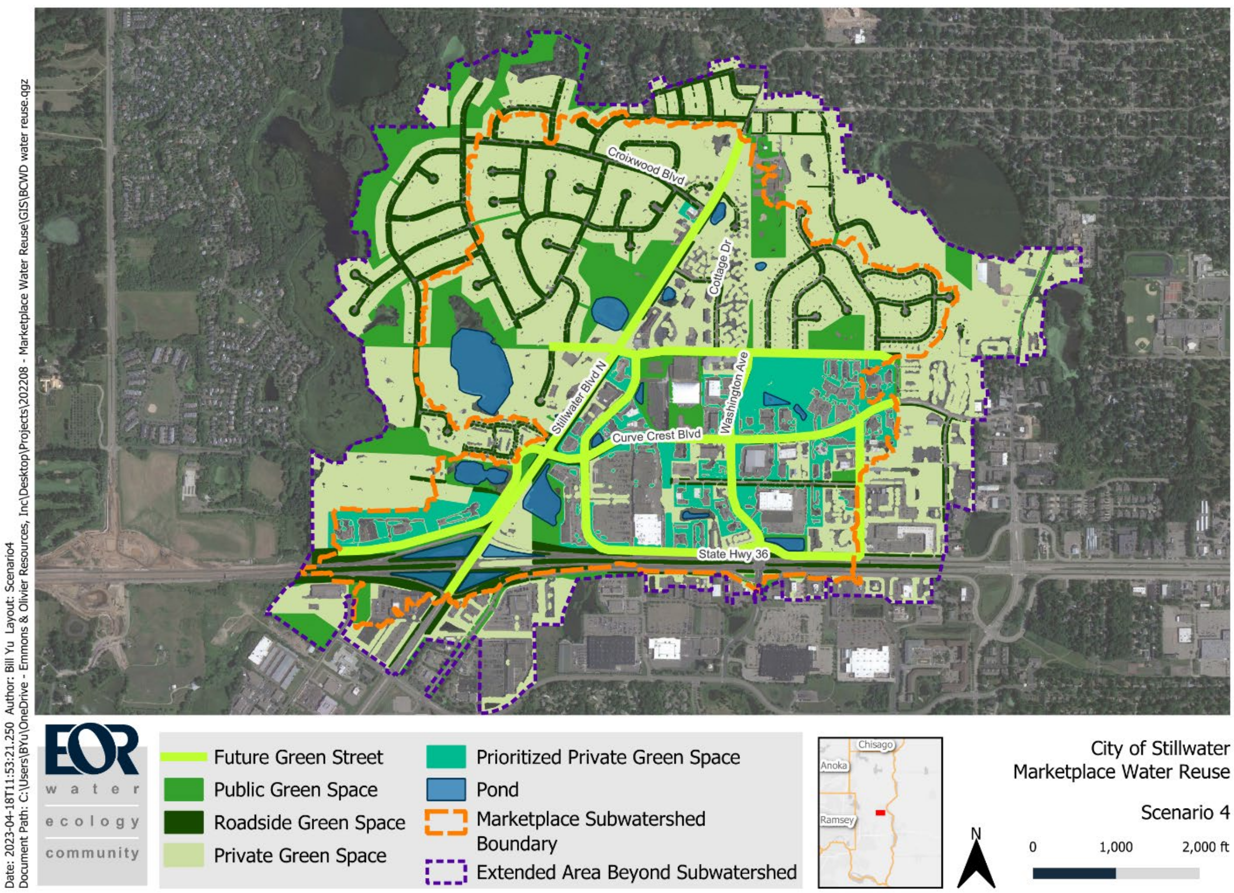

Figure 14. Green Space Cover for Irrigation – Scenario 4

DRAFT

Scenario 5

In this scenario, continuous commercial water use is considered on top of the Scenario 3 demands. One advantage of this is being able to use water even in the season changing "shoulder months" when irrigation demand may be less. An evaluation of the commercial businesses operating in the Marketplace Area identified the following list of non-potable water demands with high potential opportunities for water reuse:

- Car wash
- Nursery with potted plants
- Hotels – laundry
- Fitness center – laundry, facility cleaning
- Brewery – processing/wash water

Two car washes are located in the area, the Holiday Station Stores Car Wash, which has one tunnel; and the Marketplace Car Wash, which has four tunnels. Assuming each tunnel serves 50 cars per day and each car wash uses 120 gallons of water, for a total daily water consumption of 30,000 gallons for the car wash business (Carl Black Chevrolet Buick GMC Orlando, 2020).

A 3,000 ft^2 greenhouse with 2,400 ft^2 of plants requires a peak use rate of 720 to 960 gallons per day, according to a Greenhouse Water System study conducted by John W. Bartok in 2009. Abrahamson Nurseries has a 4,000 ft^2 greenhouse with approximately 3,000 ft^2 of plants, requiring an average of 1,000 gallons of water per day.

Four hotels are in the Marketplace area, Country Inn & Suites By Radisson, Coratel Inn & Suites By Jasper, GranStay Hotel & Suites Stillwater, and Americas Best Value Inn Stillwater. According to Colorado Waterwise's Water Savings Analysis for St. Regis Resort, an average hotel uses 100 gallons per day/room. Because we are unable to count the number of rooms in these hotels, we conservatively assume that each hotel has 20 rooms based on the footprint area, which estimates 8,000 gallons of water usage per day for on-site laundry at the hotels.

According to a case study for the Longfellow Clubs, a Boston group of seven sports facilities, the Marketplace area has eight fitness centers that require 5,000 gallons of water per day for cleaning and laundry (CleanLink, 2014).

There is one brewing company in the Marketplace area, which is the Lift Bridge Brewing Company. In 2018, a news article written by Kavita Kumar indicated that the Lift Bridge Brewing Company is expected to produce 27,000 barrels in that year and more in the future. In this case, we assume the

Lift Bridge Brewing Company can produce 30,000 barrels on average now, which is 1,274 gallons of beer per day. According to the article "Water Usage in Breweries" in Brewer World, one liter of beer requires 2.1 liter of process water, 1 liter of general-purpose water, and 0.2 liters of service water. In this case, the Lift Bridge Brewing Company could use 4,200 gallons of reuse water per day for the brewer processing. The total daily demand from these commercial sources is 48,200 gallons.

Scenario 6

Commercial areas have a higher demand for water for continuous use and irrigation. With an existing irrigation system in the commercial area, the resistance to implementing a new irrigation system or retrofitting the current irrigation system's connection to the new irrigation system is considered lower for commercial landowners than for residential landowners. Commercial area and public area are more centralized in the downstream area, which is closer to the ponds that provide the supply for water reuse. The commercial and public areas are more centralized in the downstream area, which is closer to the ponds that supply water for reuse. Meanwhile, the residential area is located upstream of the Marketplace subwatershed, which has a higher cost of delivering reuse water as well as a significant barrier and uncertainty regarding residential landowners' willingness to install an irrigation system. The uncertainty is more of an issue for single family neighborhoods than for multi-family housing, which has common ownership & and maintenance of green spaces and past successful applications of reuse.

In this scenario, water reuse and irrigation are prioritized to the central commercial area in order to achieve higher water reuse efficiency, as shown in Figure 15. By not including the multi-family housing in the estimates, it is a conservative analysis. More capacity may be gained if these multi-family residential areas were added.

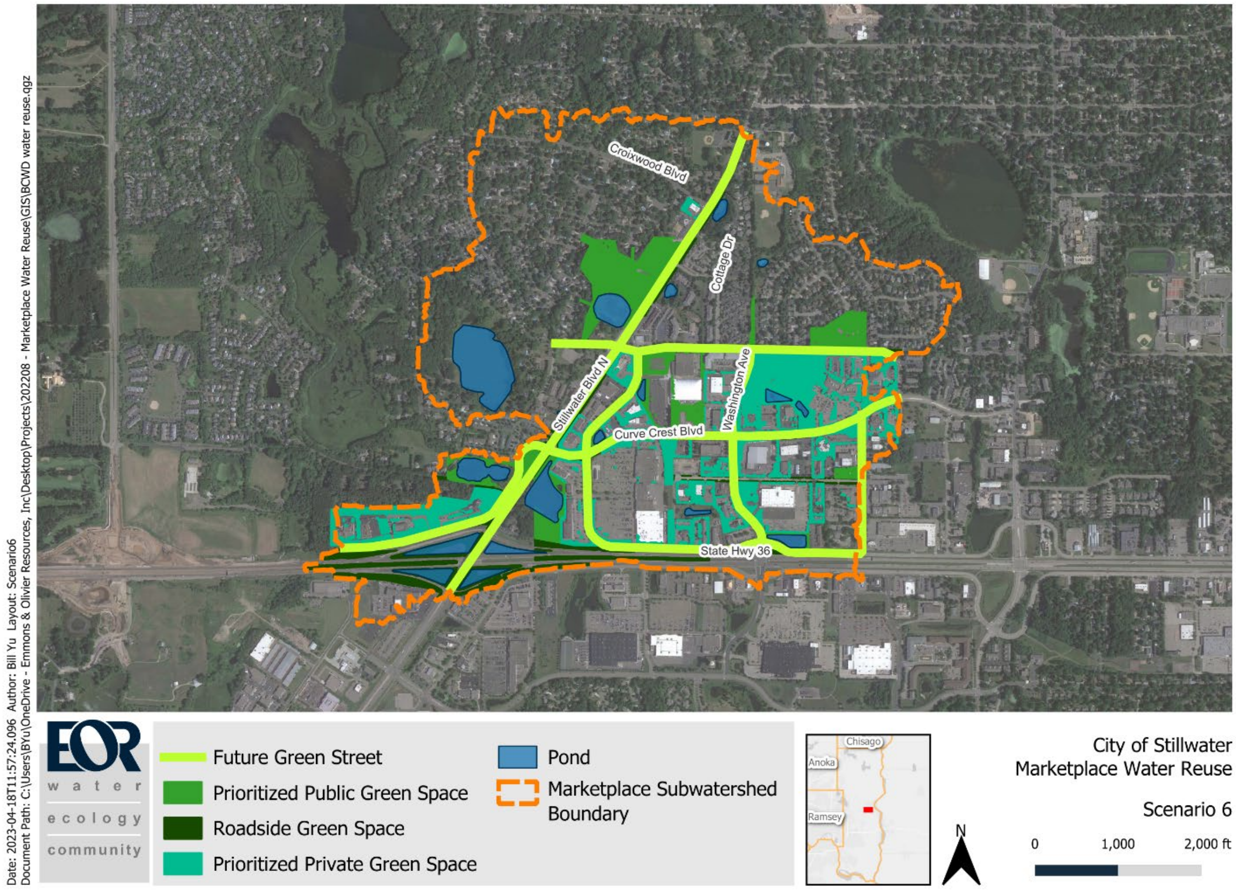

Figure 15. Green Space Cover for Irrigation – Scenario 6

Results

Table 3 summarizes the reuse model results for all scenarios and storage options, and Figure 16 - Figure 21 illustrate the annual dynamics of the combined pond storage volumes. When compared to Storage Option 1, the additional storage provided by the 5 ponds in Storage Option 2 slightly increases the flow reduction to Long Lake by between 1%-5% in all scenarios. If larger storage areas such as Brewer's Pond are available, then the benefits of additional storage volume provided by these 5 ponds is not significant. There is also the logistics of managing the outflow from additional ponds, either with additional 4 pumps stations or valves. If larger storage areas like Brewer's Pond are not feasible, then these storage areas may become more important.

As the irrigation area increases from 70 acres in Scenario 1 to 174 acres in Scenario 4, the annual flow to Long Lake is reduced by 32.5% in Storage Option 1 to 50.9% in Scenario 4, showing that adding end uses/irrigation area is effective at increasing volume reductions. Scenario 5 adds continuous commercial water reuse to the irrigation use in Scenario 3, resulting in an additional 11%

reduction in flow to Long Lake. In Scenario 6, reducing the irrigation area from 143 acres to the prioritized 79 acres increases flows to Long Lake over Scenario 5, reducing infrastructure, while still providing approximately a 45% annual flow reduction. Meanwhile, because irrigation is only focused on the prioritized area, the cost and difficulty of installing new irrigation is significantly reduced. In Scenarios 5 and 6, Storage Option 1 reduces annual flow to Long Lake by approximately 58% (10.7 million ft^3) and 47% (8.7 million ft^3) respectively, compared to current average annual flows.

Storage Option 3 excludes Brewer's Pond, which is the largest in size and potentially has the most storage volume. Scenarios 1-4 still result in a considerable 33% to 46% annual flow reduction. The drainage area contributing to Brewer's Pond (53 ac) was removed from the estimation of annual runoff volume. The annual flow reduction with commercial water reuse, as estimated in Scenarios 5 and 6 is 52% and 45%, respectively.

Irrigation Scenario	Storage Option	Summary	Drainage Area (acres)	Irrigation Area (acres)	From the Watershed (ft^3/year)	To Overflow	To Irrigation	To Evaporation	To Continuous Use		Total Reuse
Existing	1	Existing Condition	648	0	18,550,204	77%	0%	17%	0%		0%
	2		648		18,550,204	75%	0%	17%	0%		0%
	3		595		17,027,225	86%	0%	10%	0%		0%
1	1	Green Street + Marketplace Public Green Space	648	70	18,550,204	44%	36%	17%	0%		36%
	2		648		18,550,204	42%	37%	17%	0%		37%
	3		595		17,027,225	55%	33%	10%	0%		33%
2	1	Green Street + Marketplace Public and Prioritized Private Green Space	648	106	18,550,204	36%	44%	17%	0%		44%
	2		648		18,550,204	33%	47%	17%	0%		47
	3		595		17,027,225	48%	40%	10%	0%		40%
3	1	Green Street + Marketplace Public and All Private Green Space	648	143	18,550,204	29%	51%	17%	0%		51%
	2		648		18,550,204	26%	54%	17%	0%		54%
	3		595		17,027,225	44%	44%	10%	0%		44%
4	1	Green Street + Public and Private Green Space Within Buffer Boundary	648	174	18,550,204	26%	55%	17%	0%		55%
	2		648		18,550,204	21%	59%	17%	0%		59%
	3		595		17,027,225	42%	46%	10%	0%		46%
5	1	Scenario 3 + Commercial Water Usage	648	143	18,550,204	24%	47%	17%	11%		58%
	2		648		18,550,204	21%	50%	17%	11%		61%
	3		595		17,027,225	38%	41%	10%	11%		52%
6	1	Prioritized Public and Private Green Space + Commercial Water Usage	648	79	18,550,204	36%	35%	17%	12%		47%
	2		648		18,550,204	33%	37%	17%	12%		49%
	3		595		17,027,225	45%	33%	10%	13%		45%

Table 3. Summarized Reuse Model Results for all scenarios and storage options

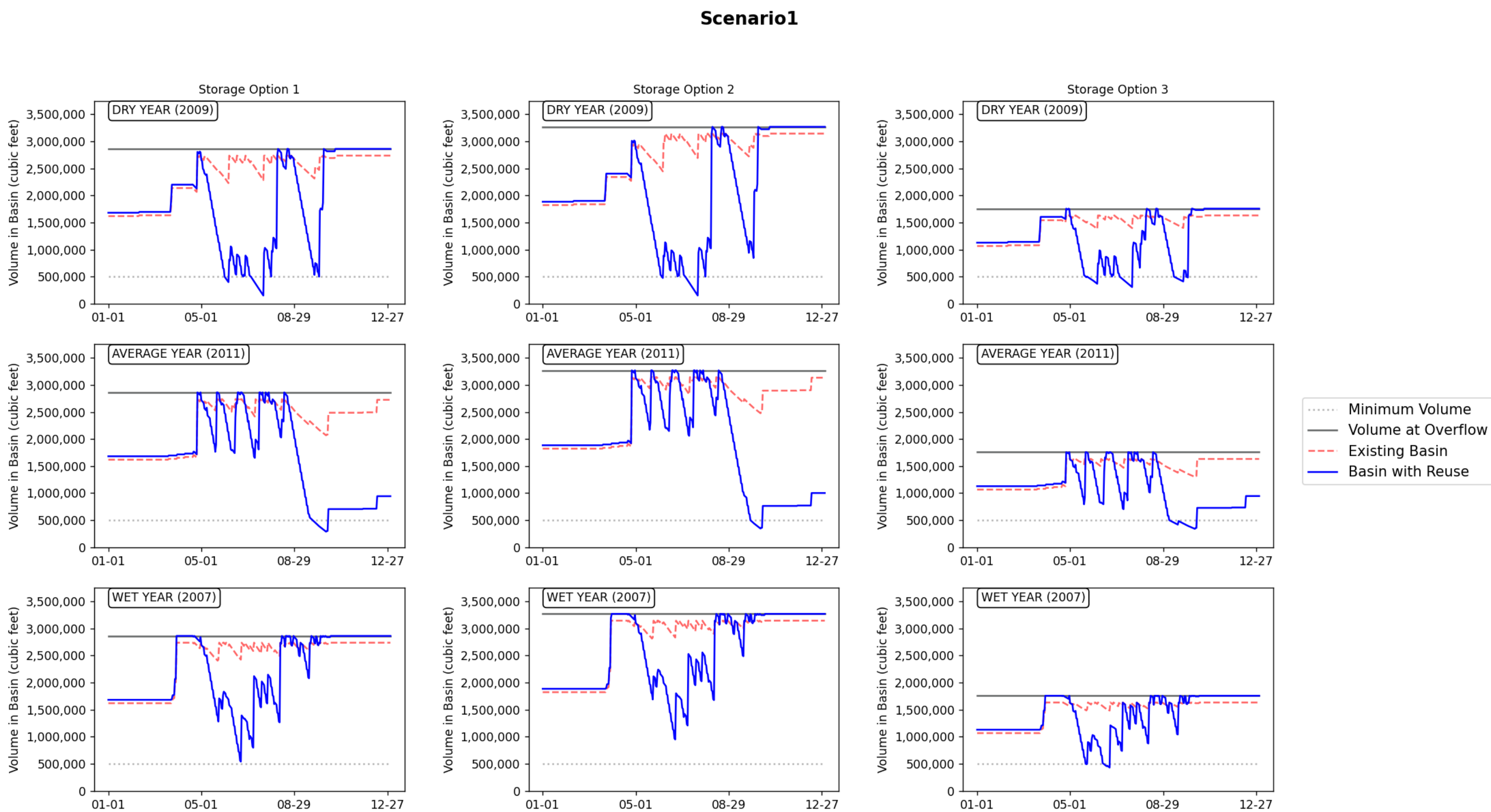

Figure 16. Annual Basin Dynamics – Scenario 1

DRAFT

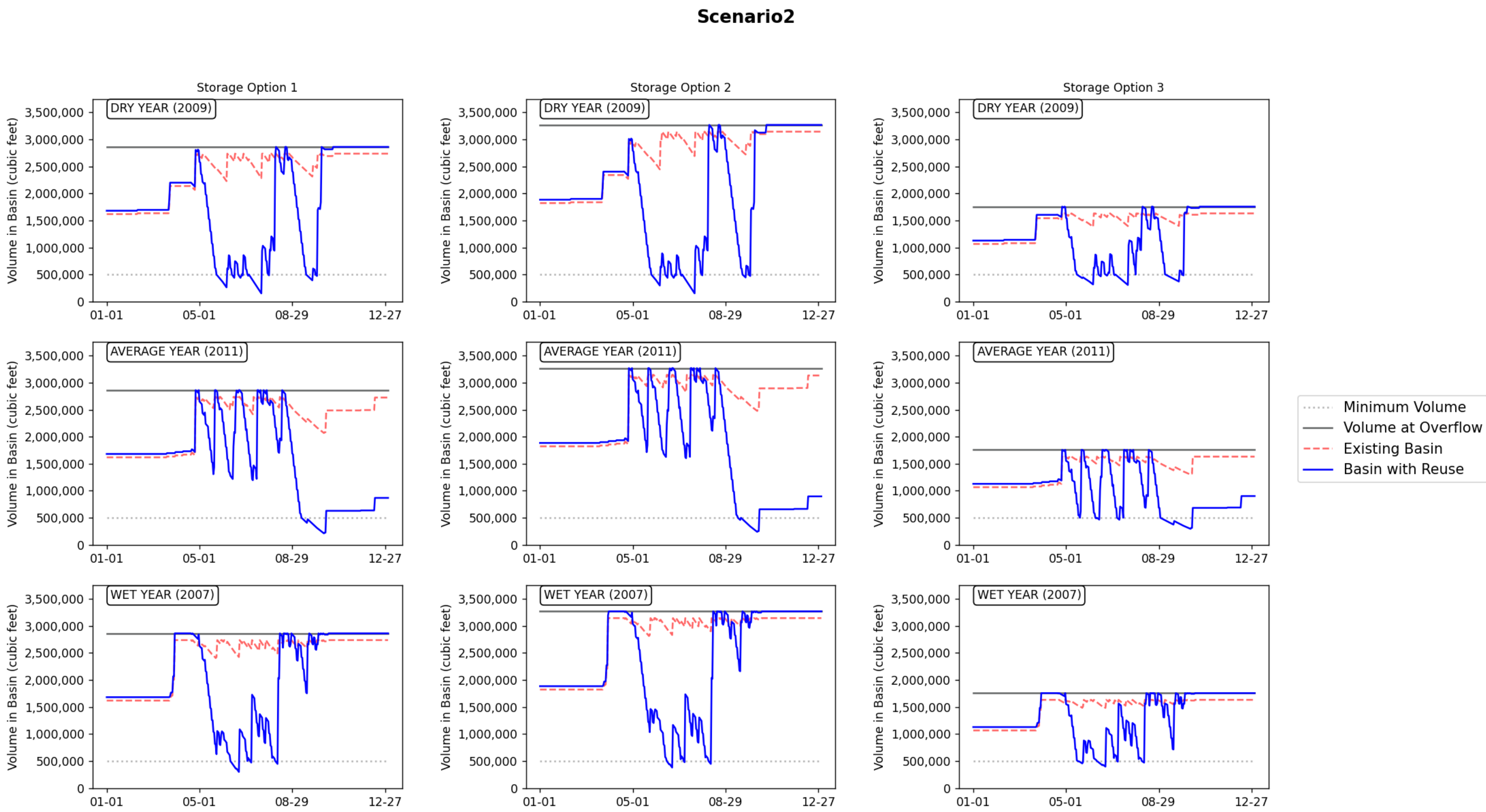

Figure 17. Annual Basin Dynamics – Scenario 2

DRAFT

Scenario3

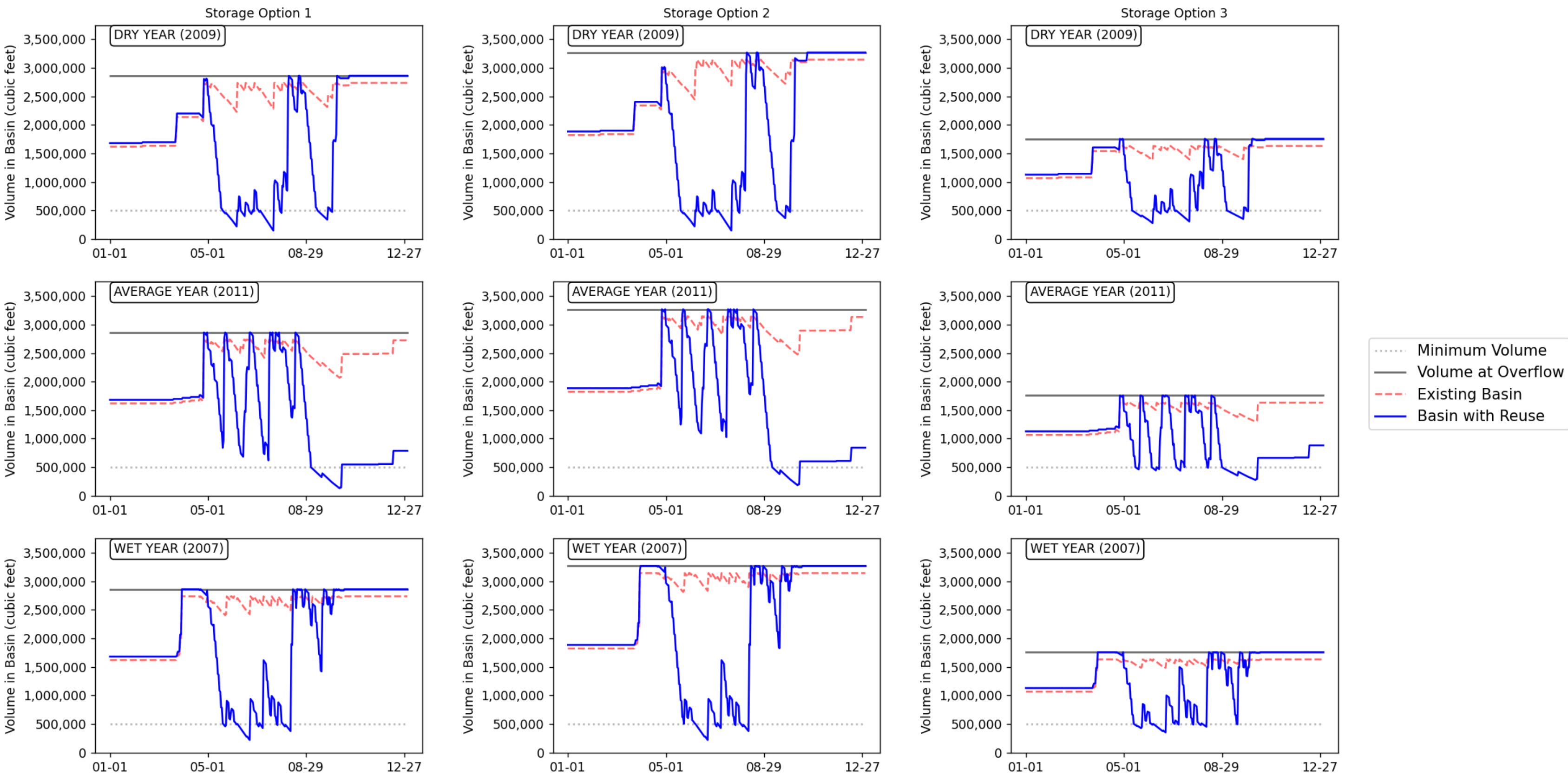

Figure 18. Annual Basin Dynamics – Scenario 3

DRAFT

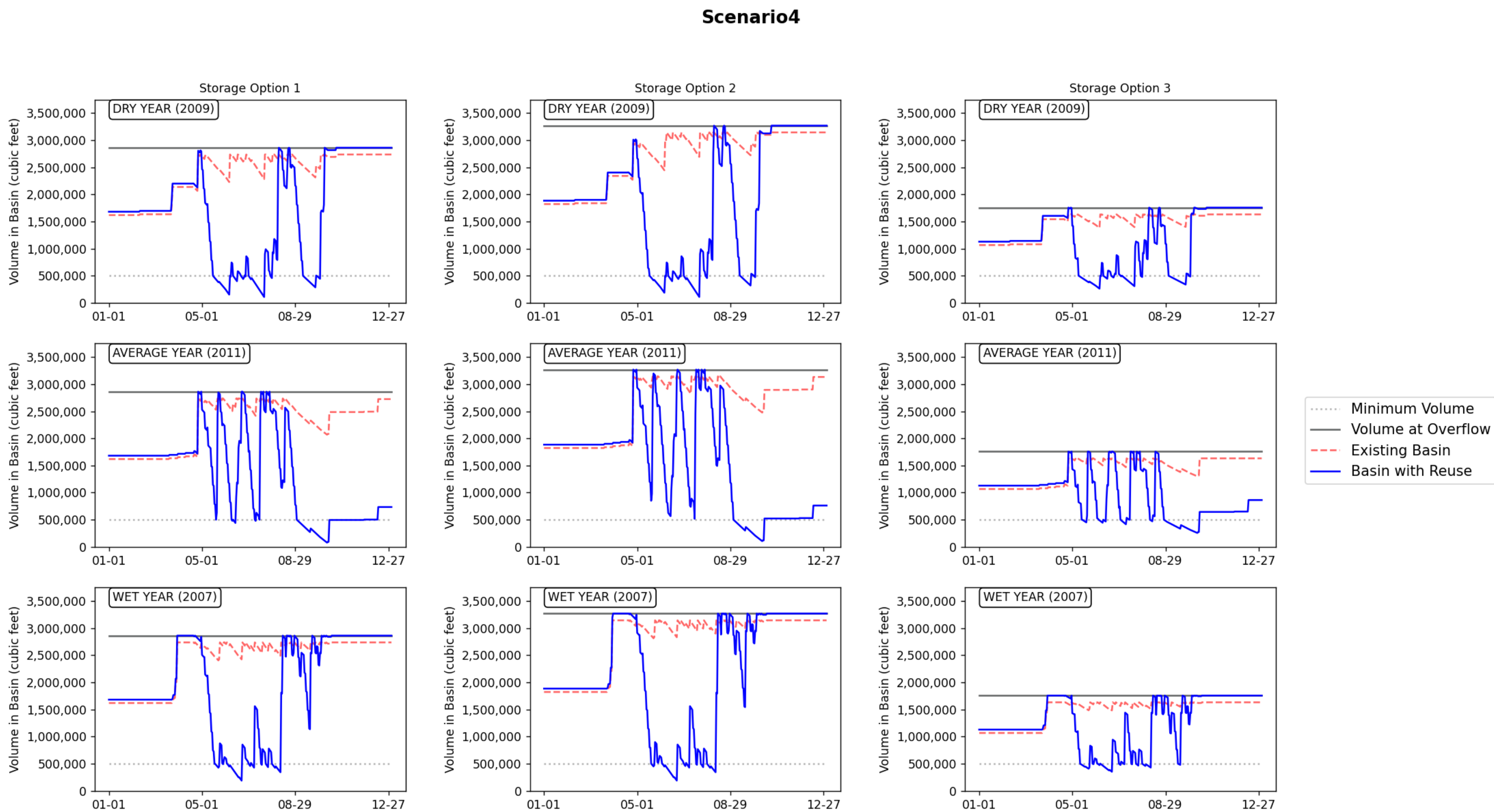

Figure 19. Annual Basin Dynamics – Scenario 4

DRAFT

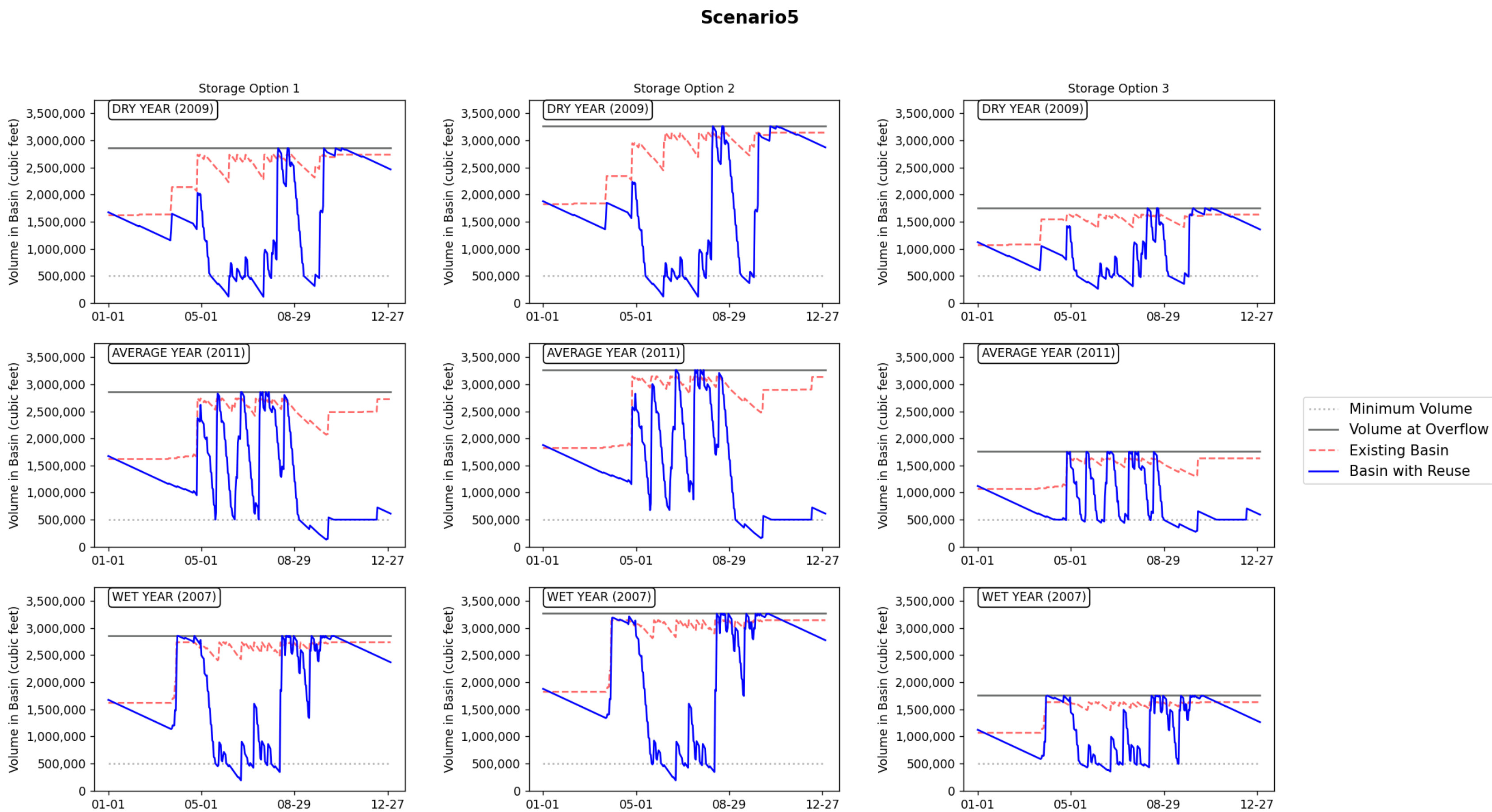

Figure 20. Annual Basin Dynamics – Scenario 5

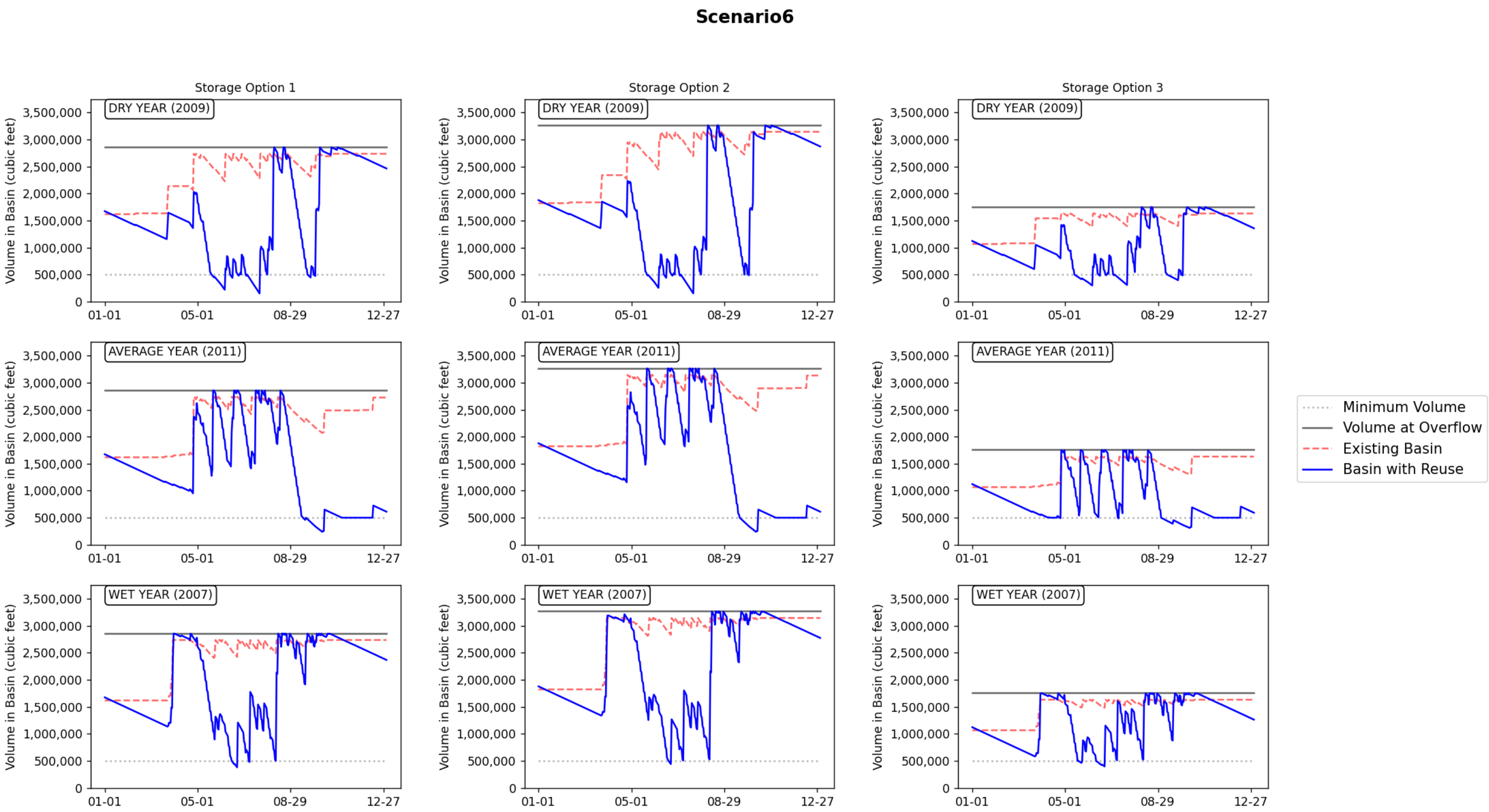

Figure 21. Annual Basin Dynamics – Scenario 6

DRAFT

Irrigation System Layout

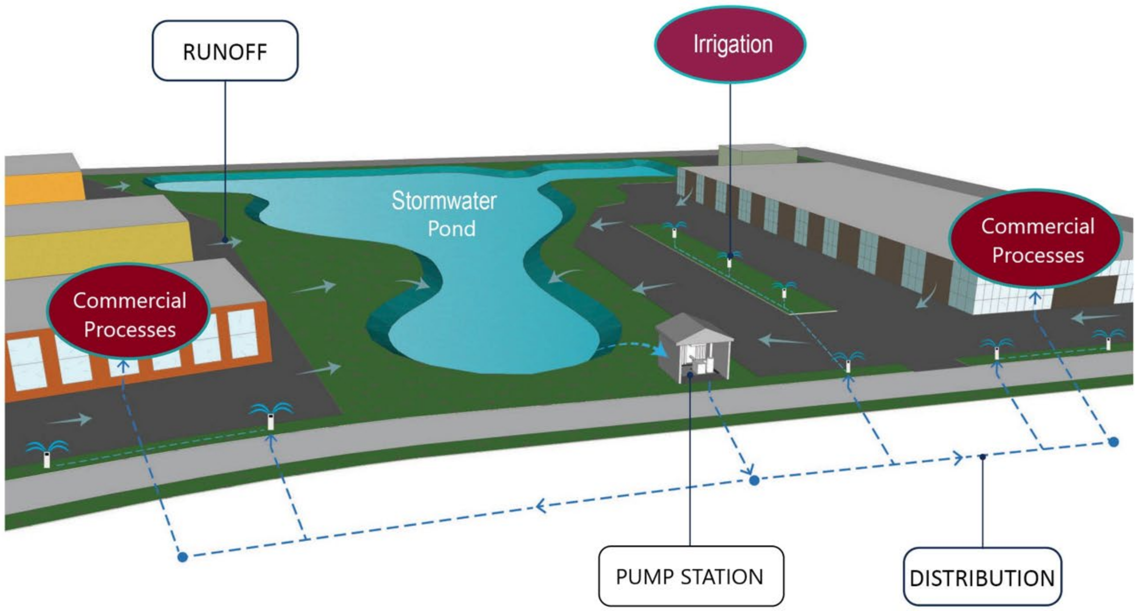

Figure 22. Stormwater Pond Water Reuse Concept Diagram

As shown in Figure 22, the pump station lifts water from the stormwater pond and transports it through the distribution line to the commercial process or irrigation. To manage the reuse water flow, each pump station has its own zone and distribution line system, as well as shut-off valves and a controller. Common non-potable water uses in commercial processes may require minimal treatment to reach usable water quality.For situation that require treatment, it will likely involve filtering and UV lamps to prevent biofouling and kill pathogens. UV treatment systems for large commercial-scale sites cost between $140,000 and $230,000 (Rainfresh Commercial 2021).

Cost Estimate

Based on the information provided, it appears that Storage Option 1 and Storage Option 3 are the most cost-effective options for the source of water reuse depending on whether storage water in Brewer's Pond is restricted for water reuse, and a conceptual plan has been developed to convey reuse water to irrigate the green space throughout the Marketplace Area. This plan includes pump station locations and a distribution line system layout, but details such as pump sizes and service areas have not been determined. Conceptually the entire district could be centralized with final distribution from the larger storage area and supplied throughout the area, but likewise, it may be more feasible and practical to set up some districts either for phasing purposes and/or piping infrastructure efficiencies. The districtwide vs. sub area system layout should be examined further in future phases.

It is important to note that while Storage Option 2 may provide additional water supply and reduce flow volume to Long Lake, the cost of building at least 4 more pump stations are likely to outweigh these benefits. To realize the added volume of Storage Option 2 in a more cost-effective way, there may be opportunities to reduce the number of pump stations by modifying the outlet elevation of the upstream ponds and adding a smart valve to control the release of water to downstream ponds. By lowering the outlet elevation and controlling the water release, the need for some of the pump stations may be eliminated, resulting in potential cost savings. It is important to recognize that implementing these control modifications would require more detailed design and construction, which would incur additional costs. Therefore, the feasibility and cost-effectiveness of these control option modifications would need to be carefully evaluated.

Overall, the conceptual plan for Storage Option 3 is presented in Figure 23, which provides a starting point for conveying reuse water to irrigate green spaces in the Marketplace Area. Further planning and design will be necessary to determine specific details such as pump sizes and service areas.

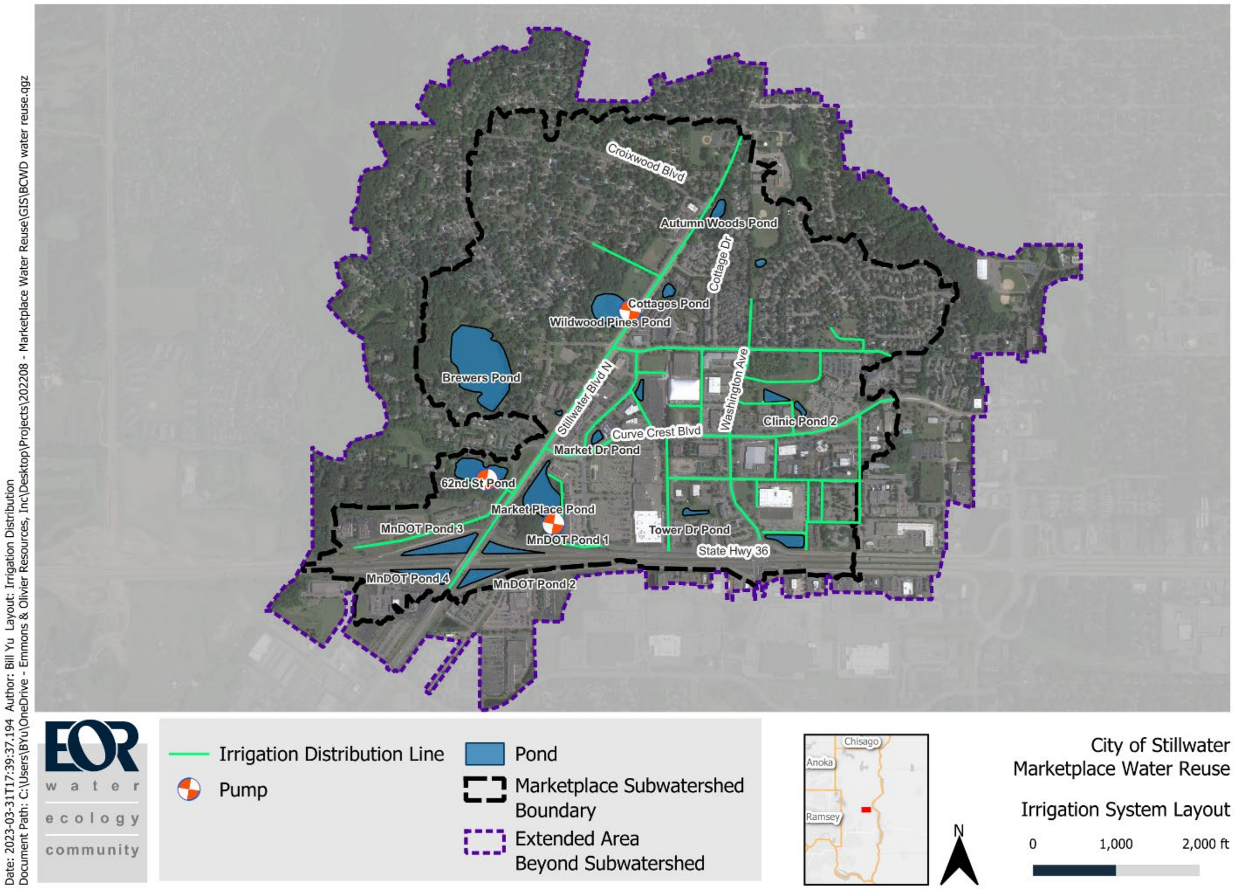

Figure 23. Marketplace Irrigation Distribution System Conceptual Layout Plan, Storage Option 3

As illustrated in Figure 23, the irrigation system distribution piping is proposed to cover the public space, and commercial/industrial users. Ideally, the City will be able to generate buy-in from the majority of property owners in a specific neighborhood or on a specific route or street and bring the treated stormwater to areas with demand while saving costs by not servicing areas with less support or commitment to tie into it. Broad distribution of treated stormwater throughout residential neighborhoods with an assumed uptake of 20% seems reasonable, but also presents challenges. The irrigation would need to be strategic, since putting piping in all residential neighborhoods for only a 20% hookup would appear cost prohibitive. For this reason, extension into the residential areas is not included. One priority to examine in the future would be to connect to multi-family properties, since these have one/common ownership, shared open space maintenance, and often have existing irrigation present. The estimated cost for the irrigation system within the Marketplace commercial area (Scenario 6) is $5,376,000 (Storage Option 1) and the cost reduces to $4,776,000 (Storage Option 3) when Brewer’s Pond is removed from the evaluation (see Table 4). The cost estimate is based on the average manufacturers' bidding price from previous water reuse projects EOR designed in the City of Stillwater and does not include minor items (e.g. valves, irrigation heads, etc.). The other projects used for source cost data included irrigation and pumps for large water users with high delivery demands, namely golf courses. The pump requirements for smaller scale, residential settings may not require the same delivery capacities, and thus may be less expensive systems than assumed here.

Table 4. Cost Estimate of Irrigation System for Scenario 6

Item	Quantity		Unit Price	Sum	
	Storage Option 1 with Brewer's Pond	Storage Option 3 w/o Brewer's Pond		Storage Option 1 with Brewer's Pond	Storage Option 3 w/o Brewer's Pond
Pump Station Package	4 EA	3 EA	$400,000	$1,600,000	$1,200,000
Distribution Line	40,000 ft	38,000 ft	$70	$2,800,000	$2,660,000
Irrigation Pipe	79 acres	79 acres	$4,000	$316,000	$316,000
UV treatment	4 EA	3 EA	$200,000	$800,000	$600,000
Total:				$5,516,000	$4,776,000

DRAFT

Conclusion

The six scenarios for stormwater capture and reuse detailed in this memo were developed first with the highest potential water reuse opportunities and new use opportunities were added in each subsequent scenario. Further analysis of the available storage and confirmed end uses, such as using the District detailed H&H model, would be needed to quantify the benefits, but the relatively large size of the reduction, often exceeding 50% volume reductions, warrants further investigation into what benefits downstream could be realized.

Annual Runoff Volume **Reductions** to Long Lake Range from 33% - 69%:

- Smallest Scale = **33%**
  - Scenario 1, Storage Option 3
  - Irrigation of only Public (Parks and Rd ROW) - 70 Ac.
  - Lessor Storage (3 Storm Ponds, w/out Brewer's Pond)
- Moderate Scale = **51%**
  - Scenario 3, Storage Option 1
  - Irrigation of Some Public (Parks and Rd ROW) and Private – 143 Ac.
  - Larger Storage (9 Storm Ponds, including Brewer's Pond)
- Larger Scale = **69%**
  - Scenarios 4 + Commercial Water Use (Scenarios 5 & 6), Storage Option 1
  - Irrigation of Public and Private Open Spaces in Extended Area – 174 Ac.
  - Commercial Water Use
  - Larger Storage (9 Storm Ponds, including Brewer's Pond)
- Optimized & Scaled Scenario = **45%**
  - Scenario 6, Storage Option 3
  - Irrigation of Prioritized Public and Private – 79 Ac.
  - Lessor Storage (3 Storm Ponds, w/out Brewer's Pond)

It is worth noting that these scenarios were developed using existing storage ponds as currently configured in the study area. If new storage were created, either through new development/redevelopment of ponds and tanks, modifying the existing pond outlets to optimize storage, or district/city-led project(s) to create storage, the performance could be improved and the added reductions from using challenging, larger basins like Brewer's Pond would be unnecessary.

One main driver and tangible consideration for the reconfigured Market Place district stormwater system and utilization of this new stormwater reuse approach, are the existing risks of flooding on Long Lake. No detailed analysis or H&H analysis of how reuse could benefit flooding on Long Lake was performed in this preliminary analysis. Using past models of the area, based on order of magnitude volumes involved, it does appear promising that reuse could provide some benefit by reducing the Long Lake flooding and is worth examining further to better quantify.

- Long Lk flood reductions from earlier modelling – Simplified reduction estimates:
  - 100-year water level rise on Long Lake = 5.1 feet
  - Market Place HWL depth contribution (all runoff removed) = 24% (1.2 feet)
  - If reuse provides 50% volume reduction = ~ 0.6 feet
  - Reduced volumes could lead to less frequent and shorter duration flooding
- Local flooding of streets and private lots could also benefit

If this approach were to be extended to the other three areas or quadrants along the Hwy 36 corridor (see Fig. 1), as has been discussed at previous Board meetings, the benefits could be significant.

Flooding concerns that could be mitigated through reuse not only occur regionally on Long Lake, but also locally. The updated BCWD SWMM H&H model in 2021 reveals that the roads and parking lots near Washington Ave. Pond, Wildwood pond, 62nd St. Pond, Market Place Pond, and Market Dr. Pond will experience overland flooding based on 100-year HWL footprint. However, implementing water reuse opportunities has the potential to reduce the HWLs. A reduction in HWLs is possible since the ponds are planned to be drawn down by 3 feet for reuse, freeing up storage for runoff during storm events and mitigating the anticipated overland flooding in these areas.

There are a host of co-benefits to a reuse approach that should also be considered. The substantial water quality benefits realized through projects that use stormwater for irrigation are achieved by reducing the amount of stormwater runoff that flows out of a watershed, and keeping all the nutrients, solid and dissolved, that cause lake algae blooms out of the lake. The water can be captured and distributed over a vegetated surface through irrigation. This reclaimed water evaporates during irrigation, evapotranspirates through plants, or percolates through the soil where it has the potential to replenish local groundwater supplies (WERF, 2001).

Reductions of total phosphorus are a priority in the management of Long Lake, and ultimately Brown's Creek and the St. Croix River, as well as critical to meeting regulatory TMDL targets. By reusing stormwater runoff in the local stormwater ponds for irrigation (or other reuse), nearly all of the phosphorus contained in the stormwater is also captured. In Scenario 6, approximately 55% of phosphorus is estimated to remain in the pond sediment and the other 45% is treated and applied to the Marketplace green space through irrigation and commercial water usage. From the reuse model and its simple water quality analysis, it is estimated that a maximum of 150 lbs/yr of phosphorus could be removed if Scenario 6 were implemented with Storage Option 3. Phosphorus reductions would be less, though roughly proportional, for scenarios that reuse less captured runoff.

It is important to realize that a significant benefit to lake and stream water quality is in removing dissolved, bio-available phosphorus. Traditional ponds are very poor at removing dissolved, bio-available phosphorus and studies have recently indicated that bio-available phosphorus has a disproportionately large impact on lakes. The dissolved fraction of phosphorus is the hardest to remove and control, however reuse is ideally suited to preventing its discharge into receiving waters making reuse very valuable for water quality improvement.

Since a key component in stormwater reuse is the ability to capture and store runoff for later use, there are other management scenarios worth exploring in the future. Further quantification of benefits and planning would be required to determine the feasibility and cost-effectiveness of these potential solutions:

- Excavate existing ponds to restore water volume and increase available storage, since this is something that is needed to maintain urban ponds regardless.
- Raise the normal water level above the outlet elevation temporarily using a smart control system while using storm prediction services to release water at the appropriate time before large events. Use of smart control system would require careful analysis and design to ensure the efficient and effective use of the storage capacity, but these technologies are already in use in other jurisdictions and types of infrastructure (e.g. water distribution, wastewater systems, traffic control, etc).

In summary, the effectiveness of District Reuse would range based on the storage volume available (existing basins, future storage) and end use of stored water (irrigation, businesses). Implementing water reuse opportunities can effectively reduce the flow volume to Long Lake and reduce flooding, both within Long Lake and other previously identified street/lot flooding.

Next Steps

The next steps necessary to move this concept forward will require **discussions and collaboration between City of Stillwater, BCWD, Washington County, and MNDOT. Local landowners and business owners are also stakeholders that will need to be part of the conversation.** EOR can provide additional context and support with technical input on the various combination of variables and outcomes, as requested. Potential next steps and actions include:

1. Storage - Determine the maximum reasonable drawdown and actual storage volume in each pond that is being considered as a source of reuse water.
   - Is it feasible to use storage water from Brewer's Pond? Is drawdown of another amount such as 6 inches, one (1) foot, or two (2) feet reasonable?
   - What is the lowest water level that practically works for each pond?
   - Obtain detailed information for the ponds for parameters that were assumed in this assessment, including side slopes, depths and outlet controls, to improve the estimation of pond storage volumes.
   - Can ponds be physically altered to improve their storage availability, such as dredging out sediments in the ponds (good maintenance practice regardless) to hold more water?
   - Can pond outlet structures be modified to hold more water?
   - Would smart controls, that are tied into weather predictions, provide more optimized storage for greater storage and better results?
2. End Use - Determine the feasibility of irrigation opportunities and commercial water use opportunities.
   - Is 75% of public green space irrigated by reuse water achievable?
   - Is it feasible to use stormwater to irrigate 75% of prioritized private green spaces that currently irrigate (mostly commercial land use)? Is the private owner willing to switch to reused water?
   - Identify multi-family residential sites that could be connected to the reuse irrigation.
   - Develop preliminary designs of green street, layout and design components (permeable paver, tree trench, curb extension, etc.) to facilitate straight-forward implementation when city reconstruction is needed or redevelopment triggers a change.
   - In consultation with the City, evaluate the cost-benefit effectiveness and practicality of the reuse scenarios and storage options.
3. Landowner Interest & Outreach – Contacting private landowners to expand water end uses.

- What is the process of reaching landowners and who should lead the outreach process?
- What supporting and outreach materials would be most effective and needed to improve reception by landowners?
- What are the legal aspects of supplying stormwater for irrigation and how can those be managed?

4. Irrigation Zones - Integration of the stormwater sources into the Marketplace irrigation system.
   - Are smaller zones from single ponds or large distribution areas from collector ponds preferred, or a combination depending on each site and surrounding development? What criteria will be used to optimize distribution zones?
   - How does the system need to be designed so that the pump stations and valves are able to convey the water from a downstream pond to upstream irrigation areas?
5. Modeling and Quantify Benefits – Utilize information collected above to test the system performance and HWL reductions using the District's SWMM model.
   - Analyze flood benefits, integrating the annual water budget form of reuse modeling and event-based form of flood evaluation. Methods could include continuous simulation of past "flood events" on Long Lake (or local streets), or it could look at the amount of time the reuse ponds will provide benefits (periods where they are drawing down).
   - Note that the flood risks currently exist, so any decrease in frequency or probability of flooding provides benefit, particularly in comparison to designing a new system and utilizing "conservative" worst-case assumptions of stormwater ponds that are full.
6. Preliminary Design – Develop the design of selected reuse scenario and storage options in coordination with the City and Watershed District.
   - Conduct detailed water reuse analysis for <u>each pond</u> considering the benefits of combining volumes from multiple ponds, potential demands of proximal development or redevelopment and irrigation opportunities.
   - Review phasing issues and scenarios to determine if and when sub-areas should be implemented.
7. Costs - Detailed cost estimate for each irrigation sub-district, or districtwide, depending on the preferred approach.
8. Funding - Discuss cost-sharing options with partners, recuperating capital costs with permit in lieu of fees, irrigation water supply user fees to support operations and maintenance

(Waconia example), and other funding sources (e.g., grants) to pursue the Marketplace Area reuse project.

9. Regional Compliance Approach – Develop a framework and potential policy language to determine when and how development impacts can be offset by District/Sub-District Reuse to meet some stormwater permit requirements.
   - Weigh the benefits (👍) and limitations (👎) of District Reuse to meet some BCWD requirements

     👍 Less design time and time spent on questions for applicant

     👍 More certainty in the permitting process for applicant and District from a streamlined process

     👍 Significantly greater performance/outcomes for volume control and water quality than site-based BMPs (MIDS, DWSMA restrictions on infiltration) translating directly into improved protection of Long Lake

     👍/👎 Payment into regional system fund eases complexity of up-front payments, but results in less transparency on how fees are set and what they are used for

     👎Development may occur ahead of facilities coming on-line resulting in significant capital outlay with potentially unknown payback period

     👎 Uncertainty about which agency/department is responsible for O&M (BCWD, City, Contracted, other)

     👎 Uncertainty about adoption rates and requirements/demands for end uses (irrigation, industrial/commercial users)