November 3, 2010

Ms. Kathleen Pritchard
Village President
Village of Whitefish Bay
25300 N. Marlborough Drive
Whitefish Bay, WI 53217-5399

Dear Ms. Pritchard,

We are extremely grateful for the chance to create an analysis and make a recommendation about the storm water flooding that has been plaguing the village. After much thought and deliberation we have decided that the most worthy option the village should follow to reduce the amount of storm water flow into sanitary sewage lines is to invest in installing sump pumps in area homes.

Our group, although united in this recommendation, realizes that this is not the only answer that tries to reduce the amount of inflow and infiltration of storm water. Yet in making our analysis, the four of us made it a priority to find a solution that would make sure that the village would be able to follow guidelines decided by the MMSD in which the local communities must show that they are reducing excessive flows from their sanitary sewers as soon as possible. Out of all the options we considered, installing sump pumps will most drastically reduce the amount of storm water leaking into the sanitary system at the best cost, within a quick time-span.

With this in mind, we have come up with this solution knowing that it will lend itself to meeting regulations while affording the village the opportunity to work on other solutions that will lower the amount of inflow and infiltration and the amount of flooded basement. We believe that the village cares about the present and future health of its residents, water quality, and environment as much as anyone else could, and will take a necessary policy course towards the betterment of all involved.

Sincerely,

Heath Anderson, Craig Huebner, Mitch Ptacek, Jeffrey Worthen

Executive Summary:

Problem Statement:
The recent increased prevalence and severity of flooding and sewage backups in Whitefish Bay has fueled public outcry for new solutions. The sewage backups endanger public health, cost thousands of dollars to citizens, and threaten home values. The inundation of rain water into the sanitary sewer system is the major cause of basement sewage backups.

Process:
The five alternatives listed below each take a different approach with the goal of reducing stormwater into sanitary sewer lines. All the alternatives address different aspects of MMSD's sec. 3.202 to reduce peak hourly flow rate.

Alternative Overview:
1) *No Action:* Although this may be an economical solution, it will not solve any short or long time goals of reducing the amount of stormwater entering the sanitary system.
2) *Green Infrastructure*. The village will install pervious pavement on key parking lanes. A second option that was identified was the installation of bioswales.
3) *Sump pump:* The village will pay to install sump pumps to reduce basement backups by syphoning both, clear water from the foundation drains in addition to any sewage back flow from the sanitary system.
4) *Education (Reducing Water Usage)*: This solution focuses on decreasing residents' use of water through pedagogic means by hiring a consultant through a multi-municipality partnership.
5) *Repair/Replace damaged private sanitary laterals*: Seventy percent of homes in Whitefish Bay are fifty years or older, assuming that the laterals are in need of repair or replacement. Repairing laterals will reduce I&I from sanitary sewers by ten percent.

Final Recommendation:
After compiling the data and measuring the alternatives against the criteria two alternatives asserted themselves as the dominate method of reducing basement backups: sump pumps and pervious pavers. However, the pervious pavers alternative was too risky because of the unknown direct impact of reducing clear water entering the sanitary system was too great to overlook.
With that said, the alternative that is being recommended is installing sump pumps in 710 households split equally over a 10 year period, by 2020, of the affected area. The implementation of this alternative would reduce the amount of clear water directly entering the sanitary system by 4,429,564 gallons per day. Additionally, this alternative allows Whitefish Bay to maintain the Board's budget goal of reducing the levy taxes from 3% to 0%. By this definition the cost of 710 sump pump instillation is $2,840,000 over 10 years (2020) is under the current 2.8% ($3,500,000) over ten years.

Problem:

The Village of Whitefish Bay has a history of six storm water flooding events since 1997, with the flooding events becoming more prevalent in recent years:

-June, 1997	5.9 inches rain in 2 days
-August, 1998	3.8 inches rain in 2 days
-2004	(reported event, do not have details)
-June, 2008	6.2 inches of rain in 2 days
-July 15, 2010	5.6 inches of rain in 12 hours
-July 22, 2010	7.5 inches of rain in 4 hours; over 9 inches of rain in 2 days

The July 22, 2010 storm alone flooded 710 basements, however 54 percent reported clear water flooding while 46 percent reported sewage backups.

Whitefish Bay's sewer system features separate storm and sanitary sewer lines along with 95 percent of the MMSD system. Constructed between 1910 and 1950 and containing 38.6 miles of village owned pipes, most of the system is designed for a 10 year storm event or a rainfall equal to 1.2 inches per hour or 3.88 inches per day. Additionally, MMSD limits the amount of water which the village can discharge to 21,000 gallons per acre.

The problem with the current system is its inability to prevent sewage backups into basements due to storm water infiltration. The two sources of potential infiltration are from municipal and private infrastructure. These sources include: leaking manholes, broken pipes, and catch basins to sanitary sewer, leaking laterals, downspout connections to sanitary sewer, private drains connected to sanitary sewer, and foundation drains connected to the sanitary sewer. Approximately 75 percent of homes within Whitefish Bay have foundation drains connected to the sanitary sewer system.

Over the past four years the village has spent $9 million on sanitary sewer and $3.5 million on storm sewer upgrades to improve the quality of the aging system. These upgrades have been conducted as continuous system maintenance rather than an overall flood reduction plan. Increases in large rain events and sewage backups have fueled public outcry for the Village of Whitefish Bay to exam and implement additional storm water management approaches.

Problem Statement:

The recent increased prevalence and severity of flooding and sewage backups in Whitefish Bay has fueled public outcry for new solutions. The sewage backups endanger public health, cost thousands of dollars to citizens, and threaten home values. The inundation of rain water into the sanitary sewer system is the major cause of basement sewage backups.

Criteria:

Effectiveness: The preferred alternative must reduce the amount of clear water in the sanitary system by at least 3,374,000 gallons per day during a 10 year storm event by the year 2020.

Rationale: By reducing the amount of clear water entering the sanitary system one is effectively reducing the number of basement backups. The calculation begins by obtaining the limit of gallons per day, authorized by MMSD based on historical figures, over the entire community. Multiply the area of Whitefish Bay (1536 acres) by the flow rate limit of 21,000 gal/acre/day resulting in 32,256,000 gallons per day. Then subtract the 32,256,000 from the maximum amount of rain fall during a 10-year rain event (35,630,000). The 10-year rain event used for this analysis was provided by MMSD and occurred on June 9, 2008. The calculation appears as follows:

1536 acres * 21,000 gal/acre/day = 32,256,000 gal/day
35,630,000 - 32,256,000 = 3,374,000 gal/day
(See Appendix A for detail)

Subtracting the two figures provides an amount of clear water that needs to be removed from the sanitary system to bring Whitefish Bay into compliance during a 10-year storm. 2020 was chosen as the year to complete the implementation of the preferred alternative because it corresponds with the 2020 facility plan.

Cost: The preferred alternative must not increase the city property tax rate by more than 2.8% annually for the next ten years (2010).

Rationale: By raising property taxes within the village within 3% is within the board's recommended ability. Allowing for other reasons for tax increase leaves about a one percent increase for storm water inflow and infiltration measures. There appears to be a consensus that most residents are willing to pay for prevention measures as long as flooding doesn't happen again. However, there is also a consensus that citizens don't want to pay any more in taxes. Raising taxes at a low level for ten years should be adequate enough to reduce flooding. The 2010 village budget was approximately $12.5 million. A 2.8% increase for the first year would be $350,000 devoted to storm water programs. Over the next ten years $350,000 will be added to each year to sum to $3,500,000

Environmental: The preferred alternative must provide additional environmental benefits

Rationale: Some alternatives may contribute little benefit to the environment or even cause negative environmental effects, while other alternatives can positively contribute to environmental sustainability. The preferred alternative will promote the latter.

Organizational support: The preferred alternative must be one which the Whitefish Bay Department of Public Works and Engineering has the necessary authority and resources to maintain and monitor.

Rationale: As one considers alternatives which may or may not be outside the typical work currently being done by the Village of Whitefish Bay we need to consider how the alternative will be maintained and monitored. Current budgetary concerns are more focused on the implementation of alternatives rather than the long term maintenance costs of those alternatives. Additionally, Whitefish Bay needs the authority to maintain and monitor the preferred alternative in order to ensure its long term viability.

Alternatives:

Alternative #1: No Action

The Village of Whitefish Bay could take no additional actions aside from monitoring the new MIS connection, located at Fairmount, to determine if the connected has alleviated basement backups. Additionally, continue with ongoing construction/reconstruction of piping.

Alternative #2: Green Infrastructure

One Alternative for reducing storm water infiltration into the Whitefish Bay sanitary sewer system is to implement non-pipe or green infrastructure solutions. These solutions aim to store, convey, and use rainwater in a way which mimics natural hydrology. The implementation of these solutions reduces the amount of water which enters the sewer systems by delaying it at the surface and then allowing the rainwater to percolate through the ground and recharge underground aquifers.

The two green infrastructure solutions we chose to include in this analysis were bio-swales and porous pavement. These where chosen due to their lower cost and higher effectiveness as compared to other solutions. These options were also selected due to their ability to be implemented within the current right of way, as private property infrastructure would be difficult to implement.

The medians and vegetated terrace strips along the street where originally designed to provide a buffer between pedestrians and cars, however they can be redesigned as bioswales. In addition to retaining rainwater and recharging aquifers, bioswales also increase evaporation helping to cool the area. Unlike compacted lawn turf which is surprisingly impervious to rainfall, bioswales can hold 5 gallons of water/cu. ft. at a cost of approximately $3 -$10 per cu. ft.

By using porous paving water is able to naturally filter into the soil rather than be diverted into the sewer system. Additionally, some porous paving, such as pervious concrete filters and traps many heavy metals and hydrocarbons while replenishing ground aquifers. There is essentially no distinction between driving and parking lanes in Whitefish Bay or most cities, however these lanes often do not need to meet the same engineering requirements of the driving lanes. The alternative proposes that street parking along major streets be replaced with porous asphalt or concrete, or permeable pavers. The advantage of using these materials on the parking lanes is that they will last longer and since the roads slope away from the center, they can capture runoff from the driving lanes. Porous pavement can reduce storm water runoff by 130,680 - 740,530 gallons/acre or 3 - 17 gallons/ sq. ft. at a cost of approximately $87,120 - $217,800 per acre.

The solutions would be implemented in the current public right of ways of major streets (as determined by traffic counts), this would be done to maximize the visibility of these solutions. Based on other land use studies it can be estimated that 25% of the land in Whitefish Bay is covered by streets and approximately .45% of the street area is the parking lanes. Additionally, we focused only on the major streets, which are approximately 10% of all the streets in Whitefish Bay. In calculating the land area to be used for bioswales, we estimated that 8% of the

village area was used by median and street terraces. Again we are proposing that the alternative only be applied to 10% of that area which is along major streets as defined by 2007 WI-DOT Traffic Counts.

Alternative#3: Sump Pump
Reducing the number of basement backups is to reduce the amount of clear water entering the sanitary system via downspouts and foundation drains is how the group defines this option. Based on a research and diagrams provided from MMSD, it is clear that a sump pump can alleviate the problem of clear water entering the sanitary system through the foundation drain and/or through the downspouts. According to the Whitefish Bay Village Engineer stated that 75% of the homes still had foundation drains connected to the sanitary system. Sump pumps can vary power and cost. The horsepower and vertical lift the pump dictates how many gallons per hour (GPH) the pump can handle. The GPH to vertical lift is an inverse relationship, as the lift increases the GPH decrease on a 1:1 ratio, respectively. For this study the GPH figure is calculated based on an average submerged sump of 15 feet from the surface and being able to pump an average of 2000 gallons an hour.
(See Appendix B for detail)

Alternative #4: Education (Reducing Water Usage)
By investing in strategies that educate and encourage community residents to reduce their initial consumption of water and in the instruction of water conveyance, the village will help lessen the severity of area flooding and the number of sewage backups. By not using water in the first place, that water will not enter the system to re-enter it during dire rain events.

With funds that have been pooled together, a storm water partnership with neighboring North Shore communities will allow Whitefish Bay the opportunity to have access to a storm water I&E (Information and Education) specialist. This expert will be on hand to give presentations, create displays and programs, attend fairs, give interviews to various media outlets, conduct BMP (Best Management Practices) tours of local homes and businesses, and write grant proposals for additional educational funding.

The I&E specialist will be in charge of innovative programs similar to the "40 Gallon Challenge," an incentive-based educational program pioneered in Georgia. In return for receiving a rain-barrel, 300 residents pledged to reduce their water use by 40 gallons a day. They did this by attending a class where they learned how to change their water use habits and by checking for leaky appliances and infrastructure. These water-saving techniques on the other side of the pipe and keeping that water out of circulation were retained and continued by residents after the program was done after its first year.

Alternative#5: Repair/Replace damaged private sanitary laterals
Laterals are pipes that run from the base of a house down towards the public sewer pipe that usually runs underneath the street. In Whitefish Bay (WFB), the average length of a private sanitary lateral is 40 feet. With approximately 5,457 households in the village, that accounts for over 41 miles of private laterals. With the average house in Whitefish Bay being 58 years old, there is a large chance that many of these pipes are damaged and allowing infiltration of ground water into the sanitary sewer. Infiltration can be caused by a variety of different reasons:

- Clay pipes deteriorating since installation
- Plant roots piercing pipes and causing cracks
- Shearing at the connection of the lateral to the sewer main or building plumbing

An implementation project performed in Mequon, WI to replace laterals conducted smoke tests at 2,000 homes (about half the city) and found that only 100 had poor lateral conditions. This is 5% of the total number of homes. Brown Deer performed a similar project and found that 60% of the first 128 homes they tested had lateral problems. Both Mequon and Brown Deer have a younger average house age compared to Whitefish Bay. Mequon's average age of a home is 24 years, Brown Deer is 34 years and Whitefish Bay is 58 years. With an increased home age comes a more aged lateral connection, resulting in more laterals that need to be replaced.

According to the 2000 U.S. census, 70% of homes in WFB were built prior to 1950. Assuming then that 70% of homes older than 50 years have lateral problems, Whitefish Bay will have 3,820 homes that require lateral repairs.

A study performed by Water Environment Research Foundation (WERF) based out of Alexandria, VA stated that 24% of total Inflow and Infiltration (I/I) comes from private laterals. If these laterals are repaired, they can yield savings of 5 - 30% during peak flows. Another study done in Mequon, WI stated that faulty laterals leak 500 gal/min into the system during heavy rain storms. This translates to a similar percentage as the WERF study. A recent report given by Yaggy Colby Associates to the village of Whitefish Bay stated that sanitary lateral repair contributes to a 10 - 20% decrease in I/I. If we take a conservative percentage on how effective replacement of laterals will be from these studies, assuming all damaged laterals are repaired/replaced in the village of Whitefish Bay, clearwater I/I can be reduced by 10%.

Evaluation:

Alternative One: No Action

Effectiveness - With no action the storm sewers will continue flow as they have been. A ten year rain event will still be able to match the maximum 35,630,000 gallons per day, inundating the storm sewer system into the sanitary sewers.

- *Fails this criterion*

Cost - From 2006 to 2010, over $9 million was spent on WFB sanitary sewer upgrades and $3.5 million on storm sewer upgrades. Cost will continue to follow this trend as the village pays for future planned upgrades.

- *Passes this criterion*

Environmental - Leaving the system as is with the planned gradual upgrades, leaves no additional benefits environmentally.

- *Fails this criterion*

Organizational Support - Since the village will not be taking any action in this alternative, no additional municipal maintenance will be provided.

- *Passes this criterion*

Alternative Two: Green Infrastructure

Effectiveness - If pervious paving is used it would capture 7,527,168 gallons of water and meet the effectiveness criterion. If bioswales are used they would capture 8,030,286 gallons of water, meeting the effectiveness criterion. (See Appendix C for detail)

- *Passes this criterion*

Cost - If pervious paving is used as the green infrastructure solution it would cost $2,634,508.80, and would therefore be within the cost criterion. If bioswales are used as the green infrastructure it would cost $10,439,371.80 and would not meet the cost criterion. (See Appendix C for detail)

- *Pervious paving passes this criterion, Bioswales fails this criterion*

Environmental - In addition to reducing storm water runoff, this alternative also provides water quality benefits by filtering out contaminants and heavy metals while recharging ground aquifers.

- *Passes this criterion*

Organizational Support - Both of the proposed "Green Infrastructure" solutions would fail to meet the organizational support criterion, as they would both require additional staff and equipment resources to maintain. The porous pavers could require some annual maintenance and vacuum sweeping. The new bioswales would require additional maintenance to care for the new plantings.

- *Fails this criterion*

Alternative Three: Sump Pump

Effectiveness - The cost of a sump pump is in direct correlation with the horsepower (hp) and gallon per hour (GPH) of the pump. For an average costing sump pump of about $230.00 the sump pump with pump approximately 2,000 GPH with a vertical lift of 15 feet. As the vertical lift varies, so does the ability to GPH. As stated before the relationship between vertical lift and GPH is an inverse one. According to the calculations the sump pump will remove 4,429,564 gallons daily during a 10 year storm from a foundation drain, and in therefore reducing/delaying the amount of clear water entering the sanitary system. This figure was calculated by taking the annual average sanitary flow MMSD receives from Whitefish Bay (652,000 gal.) and subtracting it from the total amount of flow in a 10 year storm that MMSD receives in 24 hours from Whitefish Bay (35,630,000 gal.). This gives a flow of 34,978,000 gallons in excess of an average day. According to the 1999 EarthTech Sanitary System Evaluation Survey (SSES), 73% of foundation drains are connected to sanitary sewer. This means that the estimated amount of water for a 10 year storm inflow from a foundation drain equals 25,533,940 gallons (73% x 34,978,000). Taking 25,533,940 gallons and dividing it by the number of homes with inflow from a foundation drain 4093 (5457 x 75%) results in a contribution of 6239 gallons per household into Metropolitan Interceptor Sewer (MIS). Multiplying 6239 gallons per household by the number of homes that reported flooding (710) results in a reduction of 4,429,564 gallons per day. Furthermore, implementing sumps at 710 residences doesn't have to occur in the first

year. Spread out, the city could implement sump pumps at 71 residences per year till 2020. (See Appendix D for detail)

- *Passes this criterion*

Cost - The cost of the sump pump will ultimately depend on the size corresponding with the gals of water pumped per hour and construction costs. The Milwaukee Journal Sentinel reported that "...estimated it would cost about $2,000 just to disconnect the drain and put in the sump pump" (JSOnline).According to the Whitefish Bay Village Engineer, the cost for a sump pump instillation ranges for $3,000-$5,000. Based on these figures it is logical to take the average, a sump pump instillation cost approximately $4,000 per homeowner and $2,840,000 by 2020 for the 710 residences affected. (See Works Cited)

- *Passes this criterion*

Environmental - Because of how the sump pump functions raw sewage may enter the storm water system. The sump pump pumps clear water from foundation drains and or raw sewage from the sanitary system up to the surface and discharges it across the lawn or other surface where it will proceed to enter the storm system via storm drains. Because of sewage entering the storm system the sump pump does not have additional benefits to the environment.

- *Fails this criterion*

Organizational support - This alternative passed the organization support criterion based on the fact that there is no additional charge to the municipality for maintenance. The only charge is for the capital cost after that the maintenance for items such as the sump pump will be left to the homeowner.

- *Passes this criterion*

Alternative Four: Education (Reducing Water Usage)

Effectiveness - Through precedence of the 40 Gallon Challenge in Georgia, residents were challenged to meet the obvious goal of saving 40 gallons a day. 300 households participated and theoretically saved a total of 12,000 gallons a day, which turns out to 4.4 million gallons a year. If each household in WFB were to practice close to 80 million gallons of water a year, or about 220,000 gallons a day, would be cut out circulation city-wide at the onset of the water circulation loop.

- *Fails this criterion*

Cost - The cost of a joint-community educational program would cost $50,000 a year to pay for the salary and benefits for the I&P specialist, as well as program costs, and there will be an annual 5% increase built in to keep in pace with inflation and salary raises. If divided evenly amongst the seven communities of North Shore (WFB, Shorewood, Fox Point, Bayside, Glendale, Brown Deer, and River Hills) the cost annually the first year for each would be $7150. A total ten year cost for WFB for this program totals at $90,000. Then there is an additional one time cost of $30,000 is to be spent on incentive rain-barrels for the 40 Gallon Challenge program (at an average of $100 a rain barrel for 300) to be implemented in after the specialist is hired. This is an investment of $120,000 over ten years.

- *Passes this criterion*

Environmental - This alternative addresses the preventative measure of avoiding infiltration and inflow by reducing the amount of water being used in the first place and by stressing best management practices. Less demand for this water means less water that needs to be captured and cleaned, and therefore less demand for power and electricity. Conservation of these resources occurs from people realizing that their actions make a difference.

- *Passes this criterion*

Organizational Support - Since this alternative is set up as an inter-community endeavor, it falls outside the direct realm of the village's public works and engineering department. The specialist works as consultant dividing time amongst the seven communities. There is no additional work to be maintained by the village.

- *Passes this criterion*

Alternative Five: Repair/Replace damaged private sanitary laterals

Effectiveness - If all laterals are either replaced or repaired, 4,722,030 gallons of flow will be reduced from MIS. This figure was calculated by taking the annual average sanitary flow MMSD receives from Whitefish Bay (652,000 gal.) and subtracting it from the total amount of flow in a 10 year storm that MMSD receives in 24 hours from Whitefish Bay (35,630,000 gal.). This gives a flow of 34,978,000 gallons in excess of an average day. According to the 1999 EarthTech Sanitary System Evaluation Survey (SSES), approximately 15% of inflow to MIS comes from sanitary lateral Inflow and Infiltration (I/I). This means that the estimated amount of water for a 10 year storm inflow from sanitary laterals equals 5,246,700 gallons (15% x 34,978,000). As described in the alternative description on the previous page (p.7) repairing all of the damaged laterals in the village will result in a 10% reduction in I/I into sanitary sewers. A 10% reduction from the 5,246,700 equals 4,722,030 gallons of clear water in the sanitary system during a 10 year storm.

- *Passes this criterion*

Cost - The cost to replace a damaged private sanitary lateral is approximately $3000. If 70% of Whitefish Bay homes are in need of lateral repair, the total cost to replace all 3,820 damaged laterals will be $11,460,000.

- *Fails this criterion*

Environmental - Although this alternative effectively reduces the amount of I/I into sanitary sewers, it does not have any additional environmental benefits to the community and natural life.

- *Fails this criterion*

Organizational Support - After the replacement of damaged laterals is complete, monitoring the success of implementation is difficult to examine for the village DPW and Engineering. It also requires a collaborative effort between private property owners and the village on how and when it is possible or required to test the quality of new laterals which proves to be difficult.

- *Fails this criterion*

Goeller Scorecard

Most preferred	Preferred	Least Preferred

		Effectiveness	Cost	Environmental	Organizational Support
1. No Action		N/A	$0.00	No additional benefits	No additional maintenance
2. Green Infrastructure	Bioswales	8,030,286	$10,439,731	Water quality improvement	Additional maintenance
	Pervious pavers	7,527,168 gal	$2,634,508		
3. Sump Pumps		4,429,564 gal/day reduced	$2,840,000	No additional benefits	No additional maintenance
4. Education		12,000 to 220,000 gal/day reduced	$120,000	Yes resource conservation	No additional maintenance
5. Lateral Work		4,722,030 gal/day reduced	$11,460,000	No additional benefits	*No additional maintenance

- *Due to complexity of accurately measuring the alternative post implementation it is difficult to gauge

Recommendation:

After compiling the data and measuring the alternatives against the criteria two alternatives asserted themselves as the dominate method of reducing basement backups: sump pumps and pervious pavers. However, the pervious pavers alternative was too risky because of the unknown direct impact of reducing clear water entering the sanitary system was too great to overlook. With that said, the alternative that is being recommended is installing sump pumps in 710 household split equally over a 10 year period, by 2020, of the affected area. Although the Education alternative met three of the "most preferred" criteria, effectiveness was weighed as the most important criterion. The implementation of the sump pump alternative would reduce the amount of clear water directly entering the sanitary system by 4,429,564 gallons per day. Additionally, this alternative allows Whitefish Bay to maintain the Board's budget goal of reducing the levy taxes from 3% to 0%. By this definition the cost of 710 sump pump instillation is $2,840,000 over 10 years (2020) is under the current 2.8% ($3,500,000) over ten years.

An additional opportunity that comes along with this alternative is the implementation of green infrastructure in private property as well as along public right of way. Our group would recommend the continued research of how the village can work with the community to encourage green infrastructure solutions that could team up with the sump pump solution.

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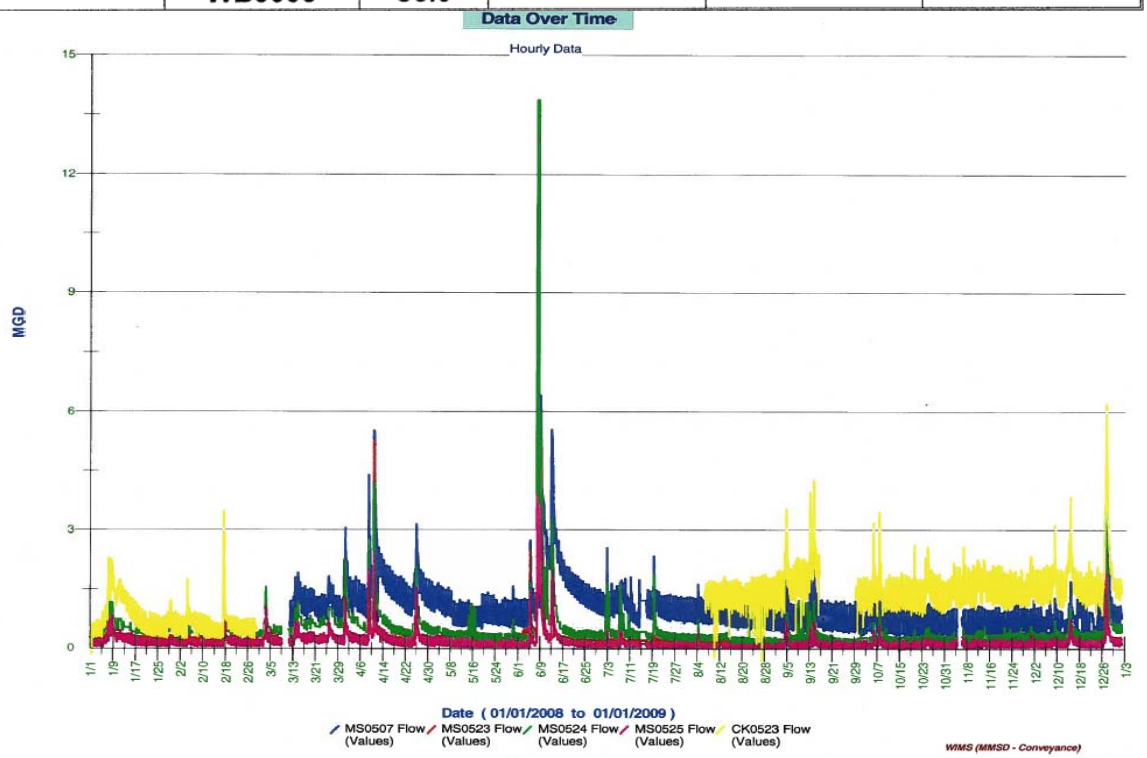
Appendix A

Compliance chart Whitefish Bay received from MMSD

Metershed	Sewersheds	Area (Acres)	Peak Hourly Flow Rate (gallons per acre per day)		
			Level-Only Data	Area-Velocity Data	Limit
MS0523	SH5006 **WB5003**	163.9 **86.6**	36,000	30,800	21,000



Statistical Data Report

Data Over Time
From 01/01/2008 to 01/01/2009

Statistic	MS0507 Flow	MS0523 Flow	MS0524 Flow	MS0525 Flow	CK0523 Flow
# Values	7059	8511	8701	8679	4670
Maximum	6.403011	5.280000	13.874500	3.869000	6.205000
Minimum	0.111107	0.000000	0.106980	0.005629	- 0.376000
Mean	1.055778	0.262772	0.472099	0.170298	1.302152
Variance	0.411536	0.147813	0.272896	0.053762	0.352527
Standard Dev.	0.641511	0.384464	0.522394	0.231866	0.593740
Mean + . . .	3s = 2.980311	3s = 1.416165	3s = 2.039282	3s = 0.865895	3s = 3.083372
Mean + . . .	2s = 2.338800	2s = 1.031701	2s = 1.516888	2s = 0.634030	2s = 2.489632
Mean - . . .	2s = - 0.227244	2s = - 0.506156	2s = - 0.572689	2s = - 0.293433	2s = 0.114671
Mean - . . .	3s = - 0.868755	3s = - 0.890620	3s = - 1.095084	3s = - 0.525299	3s = - 0.479069
UCL	None	None	None	None	None
UWL	None	None	None	None	None
QC Mean	None	None	None	None	None
LWL	None	None	None	None	None
LCL	None	None	None	None	None
Mean x . . .	3.27 = 3.4524	3.27 = 0.8593	3.27 = 1.5438	3.27 = 0.5569	3.27 = 4.2580
Mean x . . .	2.51 = 2.6500	2.51 = 0.6596	2.51 = 1.1850	2.51 = 0.4274	2.51 = 3.2684

Printed Tuesday, November 02, 2010

OPS SQL **MMSD - Conveyance**

Appendix B

Blain's Farm & Fleet

Make	Unit	Price	Blain #	Type	HP	Primary/ Secondary	GPH @ 0'	GPH @ 5'	GPH @ 10'	GPH @ 15'	GPH @ 20'
Wayne	"Simple Sump" Cast Iron	$400.00	612800	Submersible	1/2	Primary	4200	3900	3150	2100	N/A
						Secondary	3300	2800	2300	1500	N/A
Wayne	Submersible Cast Iron	$170.00	574469	Submersible	3/4	Primary	4300+	4300	3500	2550	1100
Water Ace	Cast Iron	$120.00	658362	Submersible	1/2	Primary	3520	3120	2400	1780	900
Averages		$230.00					3860	3773	3017	2143	1000

Appendix C

Alternative #2: Green Infrastructure and Technology

Calculations for the pervious paving solution:

Calculations of land area on which this solution will be implemented:

Whitefish Bay Land Area: 1,536 Acres

x .25 = Street Area: 384 Acres

x .10 = major Street Area: 38.4 Acres

x .45 = parking lanes: 17.28 Acres (752,716.8 sq. ft.)

Water Reduction Calculations:

130,680 - 740,520 gallons/acre or (3 - 17 gallons/sq. ft.)

Using the average of 435,600 gallons/acre

17.28 Acres * 435,600 gallons/acre = 7,527,168 gallons

Cost Calculations:

$87,120 - $217,800 per acre

Using the average of $152,460 per acre

17.28 Acres * $152,460 per acre = $2,634,508.80

Calculations for the bioswales solution will be:

Calculations of land area on which this solution will be implemented:

Whitefish Bay Land Area: 1,536 Acres

x .08 = Street Area: 122.88 Acres

x .10 = major Street Area: 12.29 Acres (535,352.4 sq. ft.)

Water Reduction Calculations:

5 gallons / cu. ft.

(based on a 3 feet deep bioswale)

1,606,057.2 cu. ft. * 5 gallons / cu. ft. = 8,030,286 gallons

Cost Calculations:

$3 - $10 per cu. ft.

Using the average of $6.50 per cu. ft.

1,606,057.2 cu. ft. * $6.50 cu. ft. = $10,439,371.80

CONSTRUCTION (CAPITAL) COST COMPARISON OF GREEN INFRASTRUCTURE MEASURES

No. of actions	GI Measure	Capital Cost per Unit of Measurement	Gallons per Unit of Measurement	Cost per Gallon	Action Classification	DEEP TUNNEL COST $2.42/GALLON
SINGLE	STORMWATER TREES	$250/each	169-449 gallons/year	$0.80	EVAPOTRANSPIRATION	
SINGLE	RAIN BARREL	$45-$190/each	40-80 gallons/barrel	$1.95 (MMSD Barrel = $0.81 /gallon)	STORAGE	
SINGLE	CISTERN	$500-$10,000/ each	Dependent on cistern size	$1.00 (based on 500 gallon cistern)	STORAGE	
DOUBLE	RAIN GARDENS	$3-$12/sq. ft.	1-3 gallons/sq. ft.	$3.75	STORAGE, EVAPOTRANSPIRATION	
DOUBLE	NATIVE LANDSCAPING	$3,400-$5,975/ acre	43,560-87,120 gallons/acre OR (1-2 gallons sq. ft.)	$0.07	STORAGE, EVAPOTRANSPIRATION	
DOUBLE	BIO-SWALE	$3-$10 cu. ft.	5 gal/cu. ft. (based on swale size of 10m long × 2m wide × 1m depth)	$1.30	STORAGE, EVAPOTRANSPIRATION	
DOUBLE	GREENWAYS (Walk/Bike Trail/ Riparian)	$200,000 - $500,000/mile	246,000 gallons/mile (based on 75 ft wide × 1 mile long trail)	$0.70	STORAGE, EVAPOTRANSPIRATION	
DOUBLE	GREEN ROOF	$8-$25/sq. ft	1.0-5.0 gallons/sq. ft.	$5.50	INFILTRATION, EVAPOTRANSPIRATION	
DOUBLE	POROUS PAVEMENT	$87,120-$217,800/acre	130,680-740,520 galllons/acre *OR* (3-17 gallons/sq. ft.)	$0.35	INFILTRATION, STORAGE	
TRIPLE	GREEN ALLEY/ STREET/ PARKING LOT	$260,000-$455,000/acre	130,680-740,520 gallons/acre *OR* (3-17 gallons/sq. ft.)	$0.82	INFILTRATION, STORAGE, EVAPOTRANSPIRATION	
TRIPLE	CONSTRUCTED WETLANDS	$39,000-$82,000/acre	360,000-1.5 million gallons/ acre *OR* (8.3-34 gallons/sq. ft.)	$0.06	INFILTRATION, STORAGE, EVAPOTRANSPIRATION	

KEY

ACTION SYMBOLS

- INFILTRATION
- STORAGE
- EVAPOTRANSPIRATION

- 50¢
- DEEP TUNNEL COST

These are approximate costs and holding capacities, since systems are specialized for their location and region. The price and holding capacity ranges vary based on specific designs.

Deep Tunnel cost is based on capital investment cost/holding capacity.

Cost/gallon is calculated by taking the capital cost only divided by the number of gallons per unit measurement. This is not a complete cost. For instance, land acquisition costs are not included. Therefore, additional investigation is recommended.

Note: if there is a price/capacity range, the average of each was taken and used for the calculation.

Appendix D

Table 1: Steps to calculate gallons of water removed by a sump pump

Steps					
	10 year storm gallons/day		average gallons/day		Gallons to be removed
1	35,630,000	-	652,000	=	34,978,000
			% of homes connected to sanitary		Gallons of homes connected to sanitary
2	34,978,000	*	.73	=	25,533,940
			# of home w/foundation connections and Inflow		gallons of clear water/household
3	25,533,940	/	4,093	=	6,238
			# of homes reported flooding		Gallons of Clearwater removed via sump pump
4	6,238	*	710	=	4,429,293