November 3, 2010
Kathleen Pritchard
Village Board President
5300 N. Marlborough Drive
Whitefish Bay, WI 53217-5399

November 3, 2010

Dear Kathleen Pritchard,

Thank you for the opportunity to provide a recommendation to the Village of Whitefish Bay's Village Board. Residents are understandably angered that heavy rains on July 15th and 22nd of this year produced sanitary and clear water back-ups in private basements. In addition, inflow and infiltration produced street flooding. The problem is severe and requires immediate attention by the Village Board and must incorporate input from a variety of professional sources.

We evaluated possible alternatives based on effectiveness to handle clear water, the cost efficiency per gallon of storm water managed, the overall cost of the alternative, and prioritizing the homes affected in the July rain events. We feel these are the most important criteria because the basement backup flooding must be reduced

Our first alternative focuses on taking legal action to require the disconnection of foundation drains from private laterals in conjunction with repairing any broken laterals. Our second alternative involves upgrading the entire sewer system so that it is able to handle a larger capacity of storm flow. Our third alternative is a natural drainage system utilizing public funds. Our final alternative is to take no action and allow incremental capital improvements to continue repairing broken storm sewer infrastructure.

Our recommendation follows to implement the first alternative: take legal action to require the disconnection of foundation drains from private laterals. Our logic is that these connections over burden the sanitary system with water collected during storm events. This is an out-dated method of a sanitary system in a private residence. This cannot handle the combination of heavy storm events and compact residential structure. Our recommendation follows how to implement this strategy which is in-line with legal code.

Thank you for taking the time to read our recommendation.

Sincerely,

Nicholas Jaeckle, Jorian Giorno, Jen Hagenow, and Rachana Kothari

Executive Summary

The following report provides an analysis and recommendations of alternatives for the Village of Whitefish Bay to address and correct the problems of basement sanitary backups and flooding.

The flooding of basements in the Village of Whitefish Bay in recent years by both storm water and sanitary sewerage has created major health, safety, and welfare issues. Citizens of the community pay relatively high taxes and expect to receive a correspondingly high level of services. Either directly or indirectly experiencing the trauma connected with flooding of basements has resulted in the citizens of Whitefish Bay uniting under the common theme that the flooding must be stopped. What is more the Village has already begun a lengthy and costly sewer upgrade project touted as the solution to rectify an outdated system and past flooding.

A huge contributor to basement backups is the amount of water entering the sanitary sewer which should be directed into storm sewers. Contributing to this are a variety of public and private sources as well as inappropriate storm water management design. Each of these components was thoughtfully assessed during the creation of this plan.

After researching a wide range of possible alternatives, we selected the following: Legally require the disconnection of foundation drains and the televising and repair of private laterals, upgrade the system, implement natural drainage solutions, and no action (maintaining the current course of action). These alternatives were chosen due to the ease with which they could be evaluated in comparison to one another and more importantly as practical solutions for solving the current problem in the Village.

The proposed alternatives were evaluated based on 4 measurable criteria: an efficiency component suggesting the best solution should cost no more than $1 per gallon of storm water managed, an effectiveness criteria determining that 50% of the additional amount from a 100 year storm should be managed by the alternative, An equity component intended to prioritize the 994 homes which experienced flooding in July 2010, and a cost criterion delineating no more than $3 million (the current allocation annually from the Capital Improvement Budget) should be spent each year for the next 10 years.

In concluding our analysis we recognized the best alternative according to the selected criteria was to legally require foundation drain disconnections and private lateral repairs to significantly reduce the amount of clear water entering the storm water system from private sources. The preferred alternative allows the best outcome for the Village of Whitefish Bay as a comprehensive unit. Over a 10 year time frame modest improvements can be made annually to private sources of storm water entering sanitary sewers. While the cost burden may appear great the health and welfare of Whitefish Bay are most strongly protected by addressing the major problem of storm water overwhelming the sanitary sewer.

Problem Statement

In July, 2010, two torrential rain storms resulted in severe flooding in the Village of Whitefish

Bay. On July 15th, the Village was hit with 5.6 inches of rain in 12 hours and on July 22nd, 7.5 inches in 4 hours. Both events caused varying levels of basement drain back-ups of clear water and sewage and severe street flooding. The Village collected almost 200 reports of private residence flooding from the July 15th storm, and over 800 from the July 22nd storm, almost half of which included sewer backups. The damages from these events are estimated to be more than $37 million (as reported by the Milwaukee Journal Sentinel). Many residents are frustrated by what they see as a lack of response at the government level.

The events intensified discussion about the adequacy of the current storm water system to handle heavy storms which surpass the sewer's peak-flow capacity. The Village of Whitefish Bay's storm water system was constructed to accommodate rains from a ten-year storm, defined as 1.2 inches of rainfall in one hour, or 3.88 inches of rainfall in one day. The chances of a 10-year flood occurring once in any given year is 10%, or in 10 years, about 65%. However, the incidence of extreme storms is increasing. Prior to the two major events this year, heavy rains resulting in flooding were reported in June 1997 (4.7 inches in 6 hours), August 1998 (2.9 inches in 16 hours), July 1999 (4.3 inches 4 hours) and June, 2008 (8.7 inches in 24 hours). The current system is unable to manage additional water produced during these extreme weather events.

The Village of Whitefish Bay sewer system is designed to carry waste from private properties to the district system for treatment which either then conveys it directly to treatment facilities or stores it temporarily until capacity is available to treat it. Surface water (clear water) is sent directly to local waterways. In extreme conditions, the sanitary system experiences surcharges and water contaminated with sewage flows into local waterways and may backup into streets. The result is extreme flooding, contamination of resulting in severe flooding.

Inflow and infiltration into the sanitary system at private residences is a major source of stress on the sewer system. Based on the 1981 MMSD Private Property Infiltration/Inflow Pilot Project, of the 4,500 homes in Whitefish Bay, over 75% (3,500) have foundation drains connected to the sanitary sewer laterals. Foundation drains are said to contribute a significant amount of inflow to sanitary sewers. Likewise, an illegally connected sump pump can contribute up to 7,000 gallons of water to the sanitary system per day. Other sources of known infiltration come from downspouts, and cracked pipes. Many residences are unaware of the extent to which their illegal connections overburden the sewer system and may be reluctant to fix the illegal connections, due to the cost they would incur. The Village does not have a strategy for addressing this issue at this time.

The frequency and severity of major storm events has caused severe flooding in Whitefish Bay. While the Village has already put $12.5 million within the last four years to repair and rehabilitate 24% of the aging public sewer system, many residents are frustrated by what they see as a lack of response to flooding events by the government. Similarly, the amount of money that the government has put into system improvements is significant, and the government fears backlash from residents should more taxpayer money go into fixing the problem, especially since only a portion of the community suffered flooding at personal residences from recent storms. Also, while it is clear that rehabilitating the public system decreases the incidence of flooding in the Village, inflow and infiltration on private property is also a known and remediable cause of

flooding. The Village needs to act fast to reassure residents that they are addressing the problem, but a long-term and sustainable solution is also necessary.

Criteria

In order for the Village to properly assess proposed solutions to the flooding problems, measurable criteria have been established to align any solution with the Village's and its residents' best interests. These criteria will ensure that multiple aspects of the problems are adequately addressed

Effectiveness: The preferred alternative must be able to manage 50% of the additional amount of clear water in a 100 year storm by January 1st, 2017.
Rationale: A one hundred year storm (a recurrence interval of 1%) will generate 5.88 inches of water in a 24 hour period. The equivalent measure of 5.88 inches in a 24 hour period in gallons of storm water is 214,592,718.564 gallons over the 2.1 square miles Whitefish Bay encompasses1. The current system is designed for a 10 year storm event (10% recurrence interval) which is the industry standard for storm water management/conveyance. A 10 year storm will yield a rainfall of 3.62 inches or 132,113,204.286 gallons of water in a 24 hour period. That means any new storm water management system needs to account for an additional 82,479,514.278 gallons of storm water to have the capacity to withstand a 100 year rainfall event. The preferred alternative must be able to handle 50% of this additional amount within a time frame of 6 years beginning from 2011.

Efficiency: The preferred alternative must spend no more than $1 of public and private funds per gallon of storm water managed through changes, upgrades and/or retrofits of the storm water management system.
Rationale- This solution should be achieved at the lowest dollar amount per gallon of storm water managed to provide residents and taxpayers with the best possible outcome. If the Village spends more than $1 per gallon, then there is the chance it will cost more to manage the storm water than the value of the benefits provided to the community.

Equity: The preferred alternative must prioritize the 994 properties that have reported the backups and flooding this year.
Rationale: A number of residents who have suffered flooding this year, especially sanitary backups, believe that the Village has an obligation to prevent the flooding. Historic evidence based on flood recurrence at these residences suggests that they may be more susceptible to flooding, due to poor drainage, high groundwater, aging infrastructure, or other reasons as yet unidentified and unsolved. Prioritizing homes that have experienced the majority of flooding and flood damage (over $10 million) will assuage residents' frustrations and mitigate the risk of future flooding.

Cost: The preferred alternative must not require the Village to spend more than $3 million per year over the next 10 years on sanitary and storm sewer improvements from 2011-2021.
Rationale: The Village's projects should coincide with MMSD's 10 year time frame. The village projects spending $3 million next year on water improvements totaling $30 million over

the next 10 years. Additional funding for separate projects of $3 million from MMSD over the next 10 years would be needed out of the $150 Million for sewer improvements in the region. From 2006-2010 the Village spent $12.5 million on sanitary and storm sewer improvements.

Alternatives

Alternative #1- Legally require the disconnection of foundation drains and the televising and repair of private laterals

The Village of Whitefish Bay still allows the majority of foundation drains to remain connected to private sewer laterals through a grandfather clause. Upon the sale of the homes with grandfathered plumbing certain updates must be made. One update is to disconnect the foundation drain from the lateral and thus from the sanitary sewer. However, it is estimated that despite this change in the code over 50 years ago over 70% of the foundation drains in the Village still remain connected to the sanitary system. It is also estimated that Inflow and Infiltration of clear water into the sanitary sewers accounts for between 60-80% of volume during peak storm water flow. Legally requiring disconnections and private lateral repairs can remove large quantities of clear water from the sanitary system as seen in the case of the Village of Fox Point.#

In lieu of the past decade's storm events the Village must mandate the removal of all foundation drain connections from the sanitary sewer and the repair of defective private laterals. The Village has a legal obligation under section 13.57, Storm Water Management, of the Village plumbing code to protect the health and welfare of citizens. To avoid crippling economic hardship for home owners a generous time frame for compliance is necessary. The objective is to end devastating sanitary sewer backups not to punish residents with outdated and ineffective systems.

An accommodating time frame of no less than 10 years should be established to begin lateral repairs and foundation drain disconnections. Undertaking a project of this magnitude will allow significant economies of scale and cost sharing options. It is estimated that on average it costs about $6000 to replace a leaking lateral. To disconnect a foundation drain and replace with a sum-pump the estimated cost is between $2,000 and $3,000. As the Village moves in a planned and purposeful manner, residents can either begin repairing and disconnecting immediately after assessment to take advantage of the benefits of cost sharing and economies of scale or wait to make repairs at any point before the deadline.

Alternative#2: Upgrading the system

Under this alternative, Whitefish Bay could replace their aging sewer system and upgrade it through design to handle future extreme weather events. The current system of the village is designed according to the industry standard for storm water management to handle a 10-year storm event and is defined as 1.2 inches of rainfall in one hour or 3.62 inches of rainfall in one day can withstand about 132,113,204.286 gallons. A ten-year storm has a 10% chance of occurring in a given year. Both July storms exceeded the hourly and daily ten-year storm amounts resulting in about 214,592,718.564 gallons in 2.14 square mile area. The frequency of intense rains has increased over the past two decades and we can expect storms exceeding the

design limits of the sewer system over the coming years. Thus, increasing the capacity of the current system to handle the flow of discharges it should be designed for a 100-year storm event. A 100-year storm event has a 1% recurrence interval and is defined as 5.88 inches of rainfall in one day or 6.14 inches in two days and can withstand additional 82,479,514.278 gallons (difference).

The other components of the current systems which needed to be addressed are the opposite flow of storm sewer from sanitary sewer and outdated catch basin design. With the up gradation of the system, locations with these problems should be identified and designed using engineering modeling to estimate proper elevations and basin designs. The up gradation is accompanied by retrofitting streets and even though the village comprises reasonably flat topography, low points and high points can be designed to delay the water discharges during peak flows or extreme weather conditions. The engineering modeling and designing of a robust system requires time frame of about a year and sufficient funds should be allocated for it.

The flooding events from past two decades have caused millions of dollars in damage for village and its residents, even though the village is continuously spending millions of dollars annually for infrastructure improvements from several years. It would be better if the village uses its money in upgrading the system to efficiently handle extreme weather events and not to abuse them with an outdated and inefficient system. The cost of upgrading the system is estimated to be greater than about $1 billion resulting in $ 100 million annually through 10 years. The process requires phasing to upgrade the village's 2.1 square miles of land area properly and thus a strategic plan should be carry out in order to do so. The new up graded system will be inter-generationally equitable as it will serve future generations too.

Alternative #3: Natural Drainage Solutions

Natural drainage systems (NDS) are an innovative alternative to traditional storm water management systems. The primary goal of NDS is to reduce the volume and rate of storm water runoff. NDSs limit the negative impacts of intense storms by redesigning middle and high density areas to include natural areas that absorb and slow storm water, infiltrate and remediate pollutants, and reduce impervious surfaces through the use of porous pavement and other related materials. The absorption of excess storm water into the water table helps hydrate dry areas in the summer months, reducing the need for outdoor water use (the largest residential water use).[1] An added benefit is that living infrastructure, unlike grey infrastructure, increases in functional value over time.

The use of NDS has advanced from small pilot projects to large-scale City and resident supported storm water management solutions. For this study, we analyzed comparable projects in Seattle, WA, that focused on drainage goals of conveyance, flood control and minimizing the flow of storm water off-site through street retro-fitting and the creation of bioretention swales. As in Whitefish Bay, street available in the right of way was limited, but constructing 14' roadways with 2' flattened curbs on either side allows space for two fire trucks to pass one another, and pedestrian access. Initial capital costs were $1083.33 per lineal foot, but once installed, NDSs didn't deteriorate like traditional street infrastructure and underground pipes. Heavy plantings on either side of the street (in an average case, 100 trees and 1100 shrubs in a

six square block area) created natural support and reinforcement of the grey infrastructure.

Our alternative considers a pilot project in the area bordered by E. Courtland Pl. to the south, N. Idlewild Ave. to the west, E. Hampton Rd. to the north, and N. Marlborough Dr. to the east. The pilot project area covers about .0475 square miles (30.4 square acres/ 1,324,224 square feet) and is located in the area with the highest concentration of flood reporting for the July storms. From conception to completion of construction, a project of this size and nature will take about 47 months. (one year for preliminary engineering, 14 months for design, and 21 months for construction). Although exact results will likely differ, for this study we derived figures for this alternative from pilot and established projects in Seattle, WA and information provided by MMSD.

Alternative #4: No Action

The No Action alternative stipulates that the village should maintain its status quo and carry out the assigned projects with their allocated budget from annual capital improvements program generally. With the recent flooding event this year, causing physical, financial and emotional damage to the village and its residents, there is a need and thrust to address the problem of inflow and infiltration that has exacerbated the peak flow capacities resulting in failure of system during heavy rains. Currently, the village is looking for alternative solutions to address this multifaceted problem and is in planning stage. They have allocated funds from their annual CIP budget to address this problem. Additionally, private sources like MMSD have announced to contribute about $150 million through 10 years to address this issue in its 411 square miles district. It has been estimated that from $150 million, the village will get about $6million (estimated using ratios from prior distribution of funds by MMSD). With all the funds in place and moral burden, there is a thrust to take action. Maintaining status quo is slowing the process to take action and is increasing anger among village residents and affecting their health, safety, morale and welfare.

Alternative Evaluation

Alternative 1: Legally require the disconnection of foundation drains and the televising and repair of private laterals

Effectiveness I:

The City of Wauwatosa study recently found that during the peak flow of the July 22nd storm a foundation drain in the City delivered around 50 gallons per minute to the sanitary system. 20% of this amount is a credible estimate of the total inflow of clear water into the sanitary system during a 100 year storm event. By taking 20% or 10 gallons a minute and calculating the impact it would have in a 24 hour period from the 3150 homes in Whitefish Bay that still have foundation connections, it is revealed that up to 45.4 million gallons of water potentially enter the sanitary system through this source alone. Making only 315 or 10% of these disconnections would remove 453,600 gallons of water from the sanitary system during a storm event where 24 hour rain totals are only 20% of the peak flow of the July 22nd storm.

Efficiency:

Reducing the inflow of 45.4 million gallons of clear water via foundation drain disconnections of the remaining 70% would cost the Village $.21 per gallon of storm water. Similarly, reducing the amount of water infiltrating through private laterals by 20 million gallons would cost $1.08 per gallon. This combination yields a dollar per gallon figure of $.47.

Equity:

The 10 year time frame and legal requirement that all houses must make repairs and disconnections provides a strong degree of horizontal equity. It does not however provide the vertical equity that this criterion would suggest should be distinguished between the 994 flooded homes and the other home which received no flooding. Indirectly, the greater the number of homes making repairs and disconnections the less likely the 994 previously flooded homes will be to experience flooding.

Cost:

It is estimated that 80% of the laterals in Wauwatosa, a suburb with similarly aged infrastructure, are leaking significantly. In Whitefish Bay there are still about 70% of the foundation drains still connected to the sanitary sewer. If 75% of homes need both that is $25.31 million. If only 5% of homes need lateral repairs the total is $1.35 million. The total cost would be $26.7 million to make these repairs. The Village of Whitefish Bay has spent about $3 million per year on sewer improvements over the past 4 years. Over the suggested 10 year time frame this would require total spending of $2.67 million annually.

Alternative 2: Upgrading the system

Effectiveness:

This alternative will meet the effectiveness criterion as with the up-gradation of the system for a 100-year storm event the infiltration issue will be addressed and rectified. Moreover, with the increased capacity of the system to handle 132,113,204.286 gallons (of current system) to 214,592,718.564 gallons will provide an additional margin of 82,479,514.278 gallons. It does not directly address the issue of getting clear water from private residences to sanitary system but with an additional margin it can handle issues like this.

Efficiency:

This alternative will not likely to meet this criterion as installation of new system is a long term solution and costs more than 1 billion dollars. Thus, even though considering the annual capital budget of village, this alternative will be estimated to spend more than $1 to manage per gallon of storm water.

Equity:

The upgrade of the system is a long term solution and requires strategic planning and management. Phasing of the projects could be done to target areas of greatest need. Thus, the allocated funding should be consumed in addressing that in first phase. Thus, this alternative will certainly meet this criterion.

Cost:

The 2.1 square miles of Village consists of about 208,000 total lineal feet and the average cost of replacing of aged sewer line using traditional dig and replace method averages about $60 per foot or $6000 per 100 sewer foot pipe.[1] That provides us with an estimated cost of about 12.5 million dollars for just replacing the pipes. If the cost of pipes and

[1] http://www.costhelper.com/cost/home-garden/sewer-line.html

weight is added to construction[2], total estimated cost exceeds and results in over 1 billion dollars. This estimate does not include cost of development of engineering model and other related costs. If this estimated cost is distributed over 10 years it will lead to about 100 million dollars annually and with the annual capital budget of 3 million dollars annually allocated by the village this alternative will not meet this criterion.

Alternative 3: Natural Drainage Solutions

Effectiveness:

Studies from pilot areas in the West show NDS can prevent as much as 99 percent of the wet season runoff from flowing directly into waterways from outflows or non-point sources. However, extreme storms unique to this area, such as those in July, and differences in soil type indicate we should derive numbers from MMSD and local projects to calculate this criterion. Instead, by calculating the success of instruments used in NDS, we arrive at a location-appropriate figure. Assuming we have 66,211 square feet to convert (5% of the 1,324,224 square foot project area) and use half for swales that absorb 144.4 gallons per square foot, we conserve 4,780,434 gallons/year. Another 25% can be used for rain gardens, which absorb 83 gallons per square foot and save 1,373,816 per year. Finally, conversion to pervious pavement and encouraging other aeration and absorption, such as tree planting, can reduce run-off by 160 gallons per square foot (a total of 2,648,440). The total amount of water saved from the system is 8,802,690 gallons.[3]

Efficiency:

The total pro is estimated to cost $325,000 and absorb 8,802,690 gallons of water per year, which averages to $2.71 per gallon.

The preferred alternative must spend no more than $1 of public and private funds per gallon of storm water managed through changes, upgrades and/or retrofits of the storm water management system.

Equity:

The NDS will incorporate or border 151 of the 994 reported basement flooding and backup properties, or about 15% of the total.

Cost:

NDS solution requires no expenditure on sanitary and storm sewer improvements. However, at $1083.33 per lineal foot, the total project cost for NDS is estimated to be 325,000.

Alternative 4: No Action

Effectiveness:

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2 http://books.google.com/books?id=6cgJAAAAIAAJ&pg=PA229&lpg=PA229&dq=calculating+cost+of+laying+new+sewerage+pipe&source=bl&ots=A0tbbQGWPt&sig=Mz0HnAxqQpC_sLto-CmpO2JlTXo&hl=en&ei=AyjQTNaQBsfhnQfNu4GOBg&sa=X&oi=book_result&ct=result&resnum=1&ved=0CBkQ6AEwAA#v=onepage&q&f=false

http://www.cnt.org/natural-resources/demonstration-projects/st-margaret-mary-church-case-study

With the no action alternative, there is no guarantee that the current system will be able to manage 50% of the additional 82,479,514.278 gallons of water within a time frame of 6 years. Therefore this alternative does not seem to meet this criterion.

Efficiency:

This alternative will not likely to meet this criterion as even with the funds in place for village there is no guarantee that the villages action to upgrade and/or retrofits the storm water management will reduce the amount of flow in an economic way.

Equity:

This alternative will likely to meet the criterion. By providing any solution to these areas first with unit as block will certainly affect the performance of the entire system.

Cost:

By maintain status quo the village of Whitefish Bay will most likely to spend about $30 million from their annual CIP budget during a time period of 10 years i.e. $3 million annually. Additional funds from MMSD will be used strategically to address specific problem. It seems that this alternative most certainly will meet this criterion.

Recommendation

Legally require the disconnection of foundation drains and the televising and repair of private laterals

Implement the first alternative: take legal action to require the disconnection of foundation drains from private laterals. Our logic is that these connections over burden the sanitary system with water collected during storm events. This is an out-dated method of a sanitary system in a private residence. This cannot handle the combination of heavy storm events and compact residential structure. Our recommendation follows how to implement this strategy which is in-line with legal code.

Goeller
Scorecard

Alternative	Criteria			
	Effectiveness	Efficiency	Cost	Equity
1. Legally require the disconnection of foundation drains and the televising and repair of private laterals	45,400,000 gal	$.47/gal	$2,670,000	addresses horizontal equity; depending on implementation may also address vertical equity
2. Upgrading the system	Can withstand additional 50% of clear water	> than $ 1 to handle per gallon of water	> than $1 billion	With phasing prioritization is feasible
4.Natural Drainage System	8,802,690 gal*	$2.71/gal	$325,000	151
4. No Action	No guarantee of managing additional 50% clear water entering into system	Uncertain	$ 3 million/ year through 10 years	Prioritization with block unit is feasible
Target	41,250,000 gallons	$1/gallon	3,000,000/year	prioritize 994 flooded

most preferred	
preferred	
least preferred	

Appendix

Chances of Being Flooded		
Period of Time	10-year Flood	25-year Flood
1 year	10%	4%
10 years	65%	34%
20 years	88%	56%
30 years	96%	71%
50 years	99%	87%

Source: www.whitefishbaynow.com

Heavy Rains Resulting in Flooding		
Date	Inches	Timeframe
6/21/1997	4.7	6 hours
8/6/1998	2.9	16 hours
7/21/1999	4.3	4 hours
6/7/2008	8.7	24 hours
7/14/2010	3.6	9 hours
7/22/2010	8.5	8 hours

Source: www.whitefishbaynow.com

Alternative 1: Calculations

1. Alternative 1: Village of Fox Point ordinance document
http://www.vil.fox-point.wi.us/vertical/Sites/%7B83EA0406-DD07-4114-A4A0-57078ECDDD72%7D/uploads/%7BB17B848C-9784-4B22-97D0-395D0DC53413%7D.PDF

Effectiveness 1:
2. The village can target 10% of the homes in WFB each year for 10 years to accomplish the goal. If 70% of homes need foundation drain disconnections. That is 3150 homes or 315 homes per year.

Effectiveness 2:
3. The village can target 10% of the homes in WFB each year for 10 years to accomplish the goal.
If 80% of homes need lateral repairs/replacements. That is 3600 homes or 360 homes per year.

Efficiency:
4. $9.45 million for foundation drain and sum-pump in 70% of homes
$21.6 million total for lateral repairs in 80% of homes

Cost:
5. 75% of homes need both- $7500*3375= $25.31 million
5% need only lateral repairs- $6000*225= $1.35million
Total cost= $26.66 million
Total annual cost for 10 years= $2.67million/year

Alternative 3: References

Calcualtion for WFB NDS Pilot Area	
.25 miles * .19 miles = .0475 miles = 30.4 acres	

SEA Program Comparisons:
http://www.greeninfrastructurewiki.com/page/Seattle+SEA+(Street+Edge+Alternative)+Streets

Local NDS -- Chicago Figures: http://www.cnt.org/natural-resources/demonstration-projects/st-margaret-mary-church-case-study