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Flood Grouting for Infiltration Reduction on Private Side Sewers

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Flood Grouting for Infiltration Reduction on Private Side Sewers

by:

Martha Burke
Seattle Public Utilities

M. Steven Merrill
Robert W. Jacobsen
H. Justin Twenter
Brown and Caldwell

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For more information, contact:
Water Environment Research Foundation
635 Slaters Lane, Suite G-110
Alexandria, VA 22314-1177
Tel: (571) 384-2100
Fax: (703) 299-0742
www.werf.org
werf@werf.org

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Research Team

Principal Investigators:
Martha Burke, M.P.A.
Seattle Public Utilities

M. Steven Merrill, Ph.D., P.E.
Brown and Caldwell

Project Team:
Robert W. Jacobsen, M.S., P.E.
Brent Robinson, M.S., E.I.T.
H. Justin Twenter, M.S., P.E.
Brown and Caldwell

WERF Project Subcommittee

Innovative Infrastructure Research Committee Members

Kendall M. Jacob, P.E.
Cobb County

Jeff Leighton
City of Portland Water Bureau

Daniel Murray
U.S. Environmental Protection Agency

Michael Royer
U.S. Environmental Protection Agency

Steve Whipp
United Utilities North West

Walter L. Graf, Jr.
Water Environment Research Foundation

Daniel M. Woltering, Ph.D.
Water Environment Research Foundation – IIRC Chair

Water Environment Research Foundation Staff

Director of Research: Daniel M. Woltering, Ph.D.
Program Director/Manager: Walter L. Graf, Jr.

ABSTRACT AND BENEFITS

Abstract:

The sewers in Seattle's Broadview neighborhood, built in the 1950s, experience significant inflow and infiltration. Intense wet weather events have resulted in sewer overflows into private residences and the environment and previous work indicates that the majority of this excess flow comes from infiltration. As a result, an infiltration reduction project was investigated to reduce overflows. To reduce that infiltration and achieve maximum success, all components of the sewer system – mainlines, maintenance holes, and private side sewers – have to be addressed. Seattle Public Utilities determined through a business case that to reduce infiltration, flood grouting was the most cost-effective, least-disruptive methodology.

Flood grouting involves applying two chemicals in separate steps to treat an entire section of the sewer system between two maintenance holes, including the side sewers. The segment is filled completely to the maintenance hole rim and utilizes hydrostatic pressure by the chemical fluid to apply the grout to the system.

To determine the success of the project, flow meters were installed in the system to document before and after conditions for modeling analysis. The effectiveness of this approach at reducing infiltration compared to the cost, the challenges associated with working on private property, and lessons learned are documented in this report.

Benefits:

- Demonstrates in detail how to conduct a flood grouting project.
- Presents actual lessons learned from completing a flood grouting project.
- Includes how to calculate the effectiveness of the project.
- Shares Seattle Public Utilities business case methodology for approving projects.
- Describes the public outreach campaign used to gain public acceptance.

Keywords: Flood grouting, infiltration, Sanipor, trenchless rehabilitation, sanitary sewers, flow monitoring, modeling.

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LIST OF ABBREVIATIONS

AwwaRF	American Water Works Association Research Foundation
Bravo	Bravo Environmental NW Inc.
CCTV	closed-circuit television
cfm	cubic feet per minute
CIP	capital improvement program
CIPP	cast-in-place pipe
CMOM	Capacity, Management, Operations, and Maintenance
CSO	combined sewer overflow
GIS	geographic information system
gpd	gallon(s) per day
GVW	gross vehicle weight
HDPE	high-density polyethylene
I/I	infiltration and inflow
lf	linear foot/feet
LP3	Log Pearson Type III
mgd	million gallons per day
MH	maintenance hole (manhole)
NPDES	National Pollutant Discharge Elimination System
NPV	net present value
O&M	operation and maintenance
PMP	Project Management Plan
PV	present value
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
SG	specific gravity
SPU	Seattle Public Utilities
SSO	sanitary sewer overflow
SWMM	Storm Water Management Model
U.S. EPA	United States Environmental Protection Agency
vf	vertical foot
WBS	Work Breakdown Structure
WERF	Water Environment Research Foundation
WRF	Water Research Foundation

EXECUTIVE SUMMARY

ES.1 Introduction

The Broadview neighborhood in the northwest corner of the city of Seattle, Washington, has experienced frequent wet weather sanitary sewer backups into private property and sanitary sewer overflows (SSOs) into the public rights-of-way. Seattle Public Utilities (SPU) initiated several sewer studies to determine the source of the wet weather flow and to identify solutions to mitigate sewer surcharges leading to overflows. These studies indicated that infiltration into the sanitary sewer system is the leading source of wet weather flows. Extensive flow monitoring and hydraulic modeling has attributed almost 80% of the peak flow during large storm events to infiltration.

Many engineering studies have determined that for an infiltration reduction project to have optimal success, rehabilitation must address all sewer infrastructure components: the maintenance holes (MHs), mainlines, and side sewers up to the building connection. In Seattle, the property owners own the entire length of the side sewer, from the building to the connection point with the mainline and SPU historically has never conducted work on private property. However, to achieve the goal of reducing sanitary sewer backups, the privately owned side sewers needed to be included in a rehabilitation effort. SPU decided to conduct a pilot project to learn about new and innovative infiltration reduction methods, validate its business case evaluation process, and assess the viability of working on private property. SPU selected flood grouting as the method of rehabilitating the system. Flood grouting is the process of internally flooding an entire segment of sewer (MH to MH) and the side sewers all at once with a two-part chemical process that leaches out to the surrounding soil through pipe defects to seal the pipe from infiltration.

A smaller sewershed basin within the Broadview neighborhood was selected as the location in which to conduct the pilot project. This basin drained to one of the areas that had experienced the highest number of backup claims. The 30-acre pilot area consisted of 88 parcels and 27 MH-to-MH sections with 28 MHs ranging from 4-17’ deep. There are 5,880’ of 6”- and 8”-diameter concrete mainline pipes and roughly 9,725’ of 4”-, 6”-, and 8”-diameter side sewers, mainly consisting of concrete pipe with some polyvinyl chloride (PVC) pipe.

ES.2 Business Case

SPU requires that large projects greater than $1 million in project value go through a business case evaluation process to identify a preferred alternative and to validate the need for the project. A selection process identified four leading alternatives for the infiltration reduction project: flood grouting, joint grouting, pipe bursting, and cast-in-place pipe (CIPP) lining. The much higher cost and disruptive nature of open cut pipe replacement eliminated it from more detailed analysis. Cost estimates for each of the methods were developed and these costs were then compared to the benefits of completing the project. Some of the benefits include reduced claims, reduced storage costs at a regional wet weather treatment facility, reduced conveyance and treatment costs, and installing cleanouts on side sewers and inspecting privately held sewer assets. The business case process identified flood grouting as having the greatest benefit cost ratio of all the options and it was therefore selected as the preferred alternative for the infiltration reduction project.

ES.3 Community Engagement

For the pilot project to maximize infiltration reduction, it was important to include the maximum length of side sewers possible. To achieve that objective, SPU had to get permission to enter private property and to work on the privately owned side sewers. SPU conducted an extensive education campaign. This included holding several community meetings, mailing informational flyers, developing a website, and following up with telephone calls, and an onsite meeting with the contractor to show the expected equipment to be used during the construction process. This work resulted in a 95% signup rate from the affected residents. The remaining 5% of the houses had a cleanout installed on the side sewers within SPU's right-of-way and the portion of the sewer within the right-of-way was rehabilitated.

ES.4 Project Results

The flood grouting took place in late summer/early fall 2011. All of the MHs and mainlines were sealed; however, only 30% of the total side sewer length could be accessed for sealing due to several reasons, including multiple side sewer branches on each house, landscaping, elevation differences, and homeowner approval of the cleanout location. Approximately 56% of the entire sewer basin was sealed. Based on measured exfiltration rates of the flood grouting chemicals, the sections that were sealed had a 99% improvement in their exfiltration rates. The average total construction cost per foot of sewer sealed was $77 for this pilot project.

SPU maintains a network of flow meters and rain gauges in the Broadview area that was augmented with additional flow meters to capture before and after information. The recorded depth, velocity, and flow rate was used to calibrate two sewer models, one for before the project and one for after the project. Long-term simulations that were conducted reveal that the project reduced the peak hour flow rate coming out of the pilot basin by 41% and reduced the storm event volumes by 66%[1].

The business case benefits were recomputed following completion of the project. The total project costs came in 16% higher than estimated ($1,478,000 versus $1,275,000). Because the side sewers were not sealed to the extent as originally anticipated, the reduction of peak flows were not as high as expected although the total volume reduced exceeded estimates. The total value of the benefits was concluded to be $1,595,000 versus the estimated $1,842,000. Despite this, the benefits still exceeded costs by a ratio of 1.08. The actual construction cost was $1,033,400, resulting in a construction benefit cost ratio of 1.54. SPU intends to continue the use of this technology in select locations where sewer infiltration has been determined to contribute significantly to wet weather flow issues.

[1] Based on a 10-year recurrence interval storm.

CHAPTER 1.0

INTRODUCTION

Existing sewage systems are prone to increasing amounts of infiltration due to aging and deteriorating pipes. This can cause flows to increase tenfold or more during periods of rain, when the antecedent groundwater conditions are high, increasing treatment costs and reducing pipe capacity, possibly leading to surcharging and backups.

Optimizing system capacity by reducing infiltration and/or inflow is one of the standards that the U.S. Environmental Protection Agency (U.S. EPA) has required of wastewater utilities in Consent Orders and Capacity, Management, Operations, and Maintenance (CMOM) guidelines. Significant research has been done on techniques for reducing infiltration, including Water Environment Research Foundation (WERF)'s reports on *Methods for Cost-Effective Rehabilitation of Private Lateral Sewers* (Sterling et al., 2006), and *Reducing Peak Rainfall-Derived Infiltration/Inflow Rates – Case Studies and Protocol* (Merrill et al., 2003). These studies indicate that in order to achieve significant reduction in infiltration, private side sewers as well as mainlines must be addressed – introducing additional complexities in terms of legal issues as well as public acceptance for any proposed project.

Cost-effectiveness is another important consideration. The following questions need to be answered: Does the benefit justify the cost including any associated risk of the project? How does infiltration reduction compare to other options to optimize capacity such as inflow reduction, enhanced maintenance, or upsizing pipe?

Seattle Public Utilities (SPU) recently completed a pilot project to reduce infiltration in a separated sewer system using a process called flood grouting. This process simultaneously seals large portions of a system, including maintenance holes (MHs), sewer mains, and side sewers to reduce infiltration into sanitary sewers. There were three main objectives for the pilot:

1. Evaluate cost-effective infiltration reduction
2. Assess the scalability of using a flood grouting approach for infiltration control
3. Evaluate the need for and concerns related to private property sewer rehabilitation

The majority of the homes and sanitary sewers in the Broadview neighborhood, located in northwest Seattle, were built in the early 1950s. Over time the concrete pipes and MHs have deteriorated and the joints have separated, allowing excessive amounts of infiltration into the sewer system. The neighborhood has a history of basement backups during wet weather events, especially along 12th Avenue NW.

Previous engineering studies (Herrera, 2009 and 2010) conducted in this area determined that a significant quantity of infiltration enters the sanitary sewer system during wet weather events. Infiltration and inflow (I/I) added to base flows exceeds the capacity of the system, causing the wastewater to back up and overflow into basements or overtop MHs. Through hydraulic modeling, it has been determined that if infiltration is broadly reduced throughout 12th Avenue NW, backups due to wet weather can be reduced if not totally eliminated.

To address infiltration, SPU evaluated several technologies and proposed doing a pilot project for 12th Avenue NW. Prior to obtaining approval to proceed with this pilot project, SPU required that a "business case" be prepared to compare the total life-cycle cost of the proposed option to other alternatives, which included joint grouting, pipe bursting, cast-in-place pipe (CIPP) lining, and replacement with new upsized pipe. Of the alternatives evaluated, flood grouting (Sanipor) was shown to have the highest net present value (NPV). Flood grouting is the process of internally flooding an entire segment of sewer (MH to MH) and the side sewers all at once with a two-part chemical process that leaches out to the surrounding soil through pipe defects to seal the pipe from infiltration. At the time of this project, this technology had been used in Europe fairly extensively, but has had only limited use in the United States.

This report summarizes the results of application of the flood grouting technology using monitoring done prior to, during, and after completion of the application. It measures the amount of flow reduction and compares that to the total project costs as tracked through SPU's cost accounting system. In addition, the potential is assessed for the use of this technology to reduce the risk for future backups in the Broadview neighborhood as well as its applicability in other locations.

CHAPTER 2.0

PROJECT DESIGN

This chapter describes the design of the flood grouting pilot project, including the location, technology used, flow and rainfall monitoring, model design, and the Quality Assurance Project Plan (QAPP).

2.1 Location of the Project

The flood grouting pilot project was conducted in a residential area consisting of single-family homes in the Broadview neighborhood in the northwest part of the city of Seattle, Washington, shown in Figure 2-1.

2.1.1 Description of Project Area

The majority of homes and infrastructure in this area were constructed in the early 1950s, when the area was part of the Greenwood Sanitation District. In 1954, the area was incorporated into the city of Seattle. The sewer system was constructed mainly with concrete pipe and concrete block MHs. Surface water drainage infrastructure was constructed with a ditch-and-culvert system. Over time, the concrete sewers and MHs have degraded (cracks, open joints, and mortar loss), allowing an excessive amount of infiltration to enter the sewer system. In addition, as the area has developed over the last 60 years the amount of impervious area has increased. This increase has surpassed the capacity of the ditch and culvert drainage system, causing localized standing water and flooding issues during large rain events.

2.1.2 Background: Why This Location Was Chosen

The Broadview neighborhood has experienced multiple flooding events and sewer backups over the years resulting from wet weather events. Localized pipe replacement projects have relieved localized surcharging at hydraulic restrictions but have not addressed larger conveyance limitations within the pipe network. Flow monitoring data and hydraulic modeling indicated that the system is very sensitive to the added wet weather I/I that results from large storm events. Storm-related infiltration is extremely variable and significantly increases the peak rate of flow beyond the capacity of the downstream conveyance system. This results in surcharging of customer connections to the sanitary sewer mainline. This is especially true of the mainline serving the lower 12th Avenue NW basin, as shown in Figure 2-2. The pilot area was chosen because it is within an area that showed signs of high infiltration, is a discrete area where the whole system could be rehabilitated, is large enough to accurately measure flows, and has a good location for flow metering.

Figure 2-1. Project Location Map.

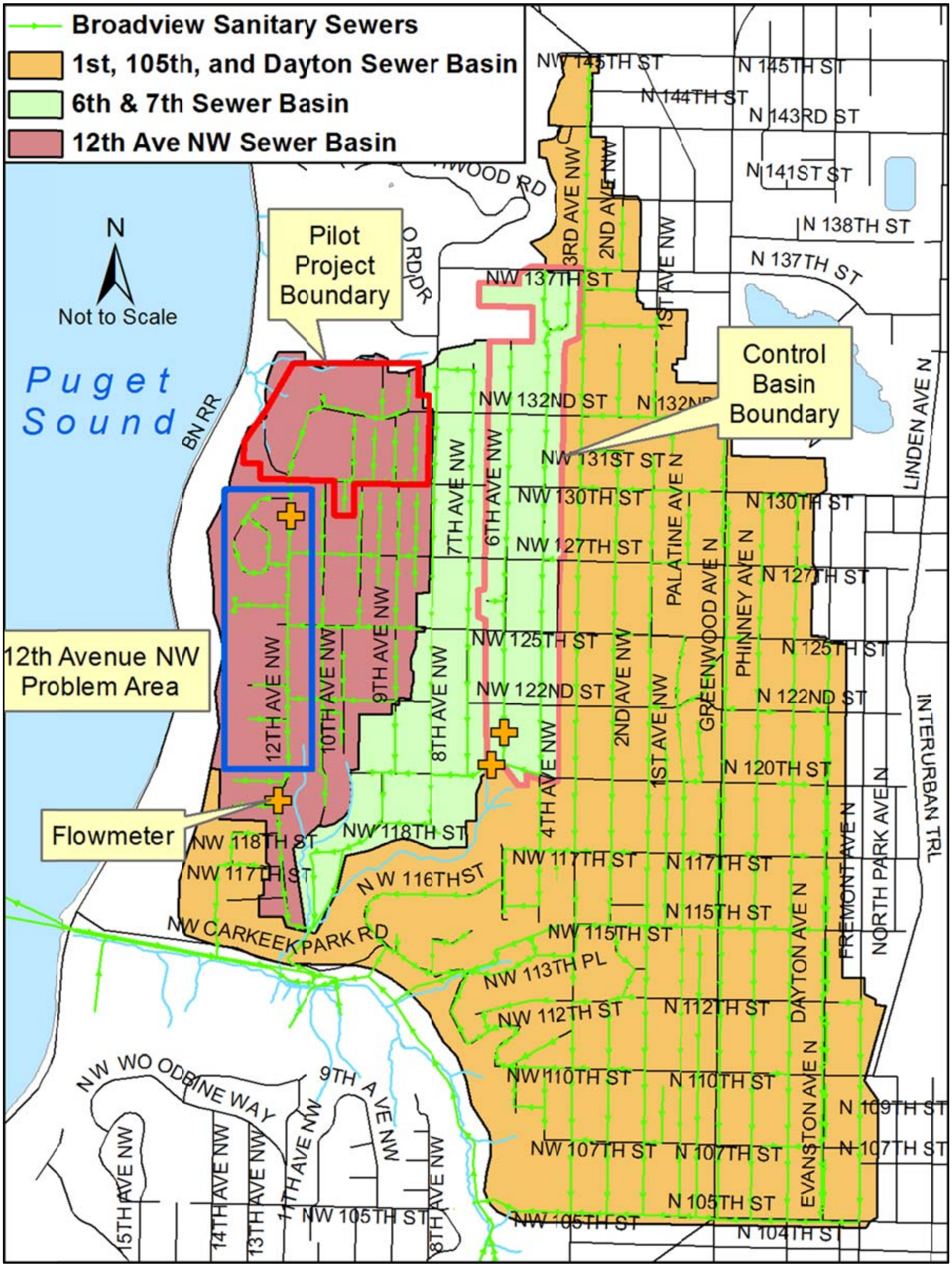


Figure 2-2. Map of Broadview Sewer Basins.

The 30-acre pilot area as shown in Figure 2-3 consisted of 88 parcels and 27 MH-to-MH sections with 28 MHs ranging from 4-17' deep. There are 5,880' of 6"- and 8"-diameter concrete mainline pipes and roughly 9,725' of 4"-, 6"-, and 8"-diameter side sewers, mainly consisting of concrete pipe with some newer polyvinyl chloride (PVC) pipe.

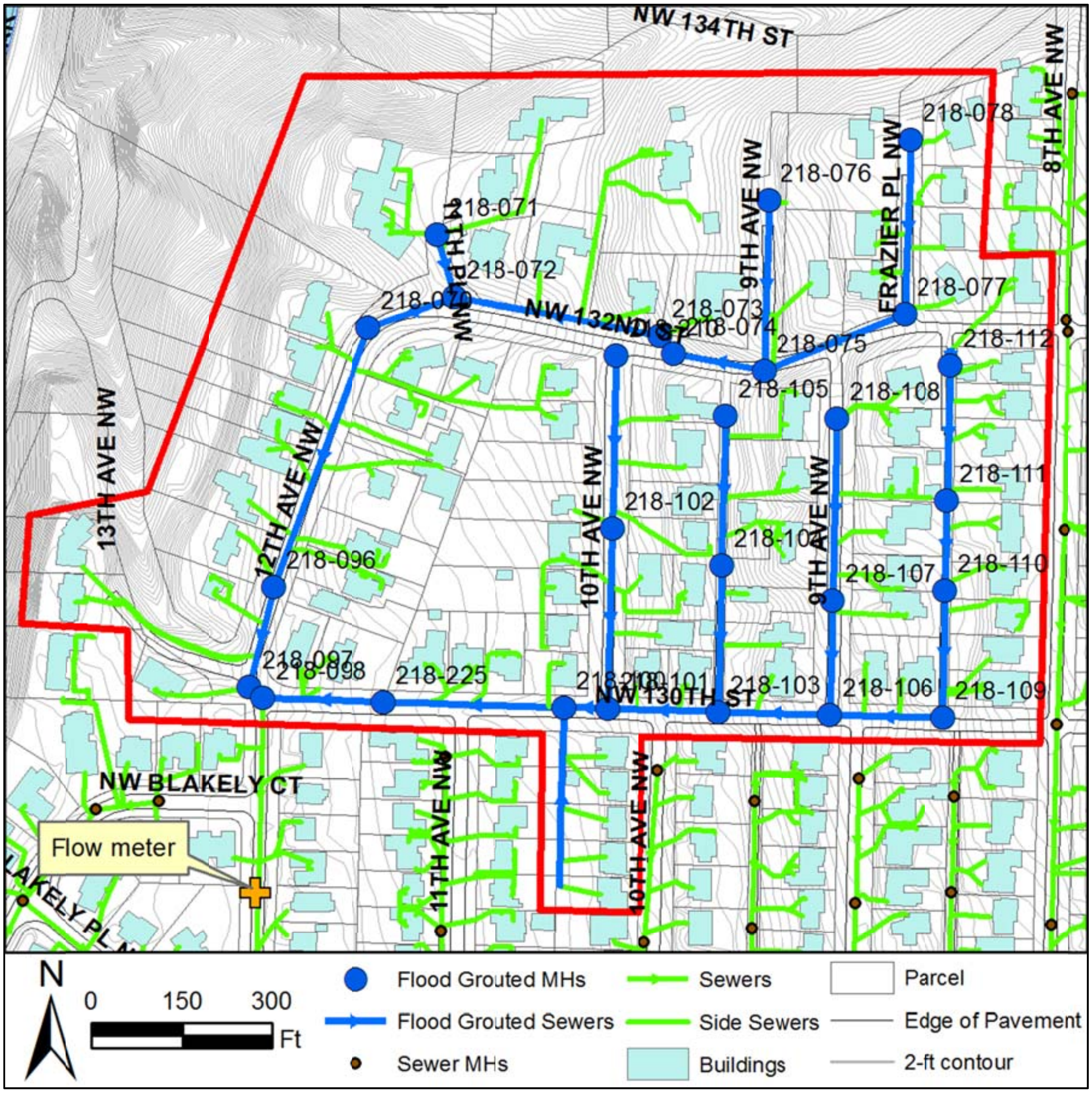


Figure 2-3. Pilot Basin.

Hydraulic modeling (calibrated at a downstream flow meter prior to installation of the upper basin pilot project flow meter) was used to determine the three components of wet weather flow: base dry weather flow, inflow, and infiltration. As shown in Figure 2-4, peak wet weather infiltration was determined to be almost 80% of the total peak flow after inflow ceases.

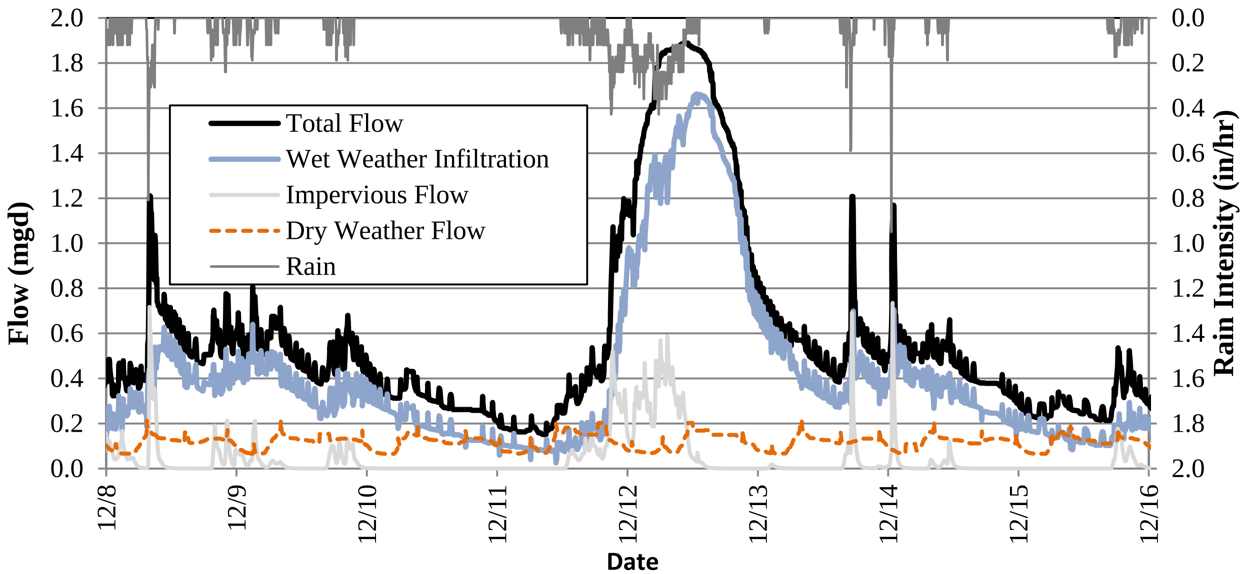


Figure 2-4. Inflow versus Infiltration Along 12th Avenue NW.

In addition to infiltration being the largest contributor of flows during large storms in this basin, this area has an overwhelmed storm drainage system during large storm events. Inflow sources could not easily be disconnected and relocated without causing or exacerbating surface water flooding. Modeling also showed that removing inflow sources alone would not significantly reduce the hydraulic grade line to reduce the occurrences of basement backups and sanitary sewer overflows (SSOs).

2.2 Technology Used

The technology selected to reduce infiltration in the pilot basin is a method called flood grouting.

2.2.1 Description of Flood Grouting

Flood grouting is the process of internally flooding an entire sewer segment (MH to MH) and the side sewers all at once with a two-part liquid grout process that leaches out to the surrounding soil through pipe defects to seal the pipe from infiltration. The two components react with each other to form a gel and bind the surrounding soil to create a watertight seal. The gel completes its chemical reaction and hardens over a period of two to three days, but is watertight almost immediately. As can be seen in Figure 2-5, the chemicals leach out 6-12" from the pipe, where the chemicals interact with the surrounding soil resulting in a sandstone-like matrix. The grouting materials and technical expertise for this project were provided by Sanipor, headquartered in Vienna, Austria. The chemicals used in the system are silicate-based and are non-toxic to the surrounding soil and groundwater, as has been confirmed by several German and other European authorities and institutions (WRc certificate PT/325/0811).

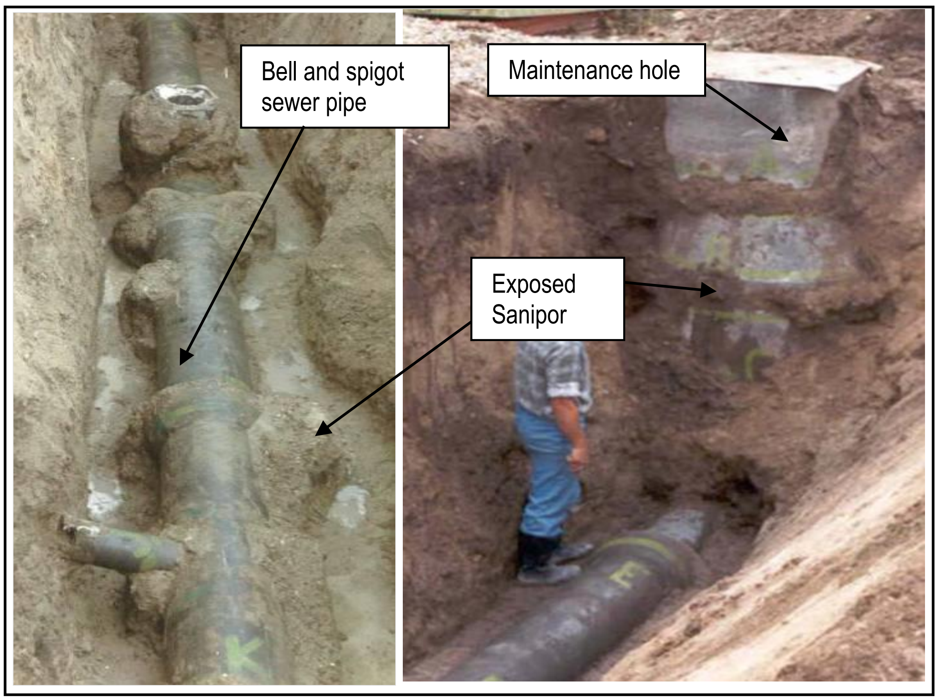


Figure 2-5. Sanipor Demonstration: Sandstone-like Matrix Where Sanipor Has Interacted with Surrounding Soil.

Following flushing of the segment and installation of the plugs in all side sewers and MHs, the sewer segment is filled to the top of the upstream MH with the first of the two grouting liquids, called S1 by Sanipor, a sodium silicate liquid, with a viscous, syrup-like consistency. The liquid level is monitored from the upstream MH rim every five minutes to document the exfiltration rate. Should the liquid level drop more than 12-18", additional liquid is added to bring the elevation back to the rim surface. This is done to provide and maintain the greatest head on the system to provide the maximum exfiltration potential of the liquid into the surrounding soil. S1 is allowed sufficient time, ranging from 30-45 minutes, to exfiltrate into the surrounding soil and is then immediately pumped out of the sewer system back into a tanker truck for reuse in the next pipe segment. The entire segment is then jetted to remove any S1 chemical from the interiors of the pipes and MHs. The process is repeated with the second grouting liquid, called S2 by Sanipor, a silicic acid solution, with a non-viscous, watery consistency. Because S2 behaves similarly to water, the rate at which it exfiltrates the system can be used as an "after" exfiltration rate to document the immediate effectiveness of the grouting process. Depending on leakage rates, the S1/S2 process can be repeated several times on each segment to ensure that the system is properly treated. A typical MH-to-MH reach, including all connected side sewers, can be completed in about 8-10 hours. Figure 2-6 depicts the steps of the flood grouting process.

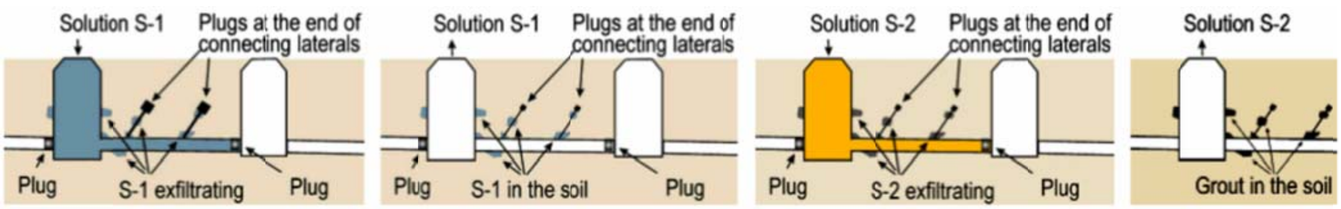


Figure 2-6. Flood Grouting Process. (Sterling, 2006)

The significant advantage of flood grouting is that it simultaneously treats all three components of the sewer system (MHs, mainlines, and side sewers). It seals all potential leaks in the system from infiltration, including those that are not visible during inspections.

For additional information on flood grouting (Sanipor), see:

- WERF report: Methods for Cost-Effective Rehabilitation of Private Lateral Sewers, 02-CTS-5, 2006
- EPA report: State of Technology for Rehabilitation of Wastewater Collection Systems, EPA/600/R-10/078, 2010
- Material Safety Data Sheets in Appendix A

2.2.2 Other Technologies Considered

Prior to selecting flood grouting as the method to reduce infiltration in the pilot project basin additional technologies were considered. These included:

- Open-trench replacement
- CIPP
- Pipe bursting
- Joint grouting

A business case was completed to narrow the above alternatives down to the one with the greatest benefit/cost ratio. Chapter 3.0 discusses the implementation of the business case.

2.3 Flow and Rainfall Monitoring

This section describes flow and rainfall monitoring, including location and installation of flow meters and rain gauges.

2.3.1 Location and Installation of Flow Meters

Flow meters were installed throughout the Broadview sewer basin to assist in building a calibrated hydraulic model. Additional flow meters were added to this network to assist in developing a more focused model for the pilot project area. The flow meters recorded observations of depth and velocity in the sewer pipes every five minutes. An independent flow metering company was responsible for the operation of the flow meters and data processing. A typical flow meter installation is shown in Figures 2-7 and 2-8.

Figure 2-7. Flow Meter Data Logger.

Figure 2-8. Flow Meter Sensing Instruments.

As shown in Figure 2-9, the flow meters were installed at the outlet of the pilot project basin and further downstream at the outlet of the 12th Avenue NW basin. There were also meters installed at the outlet, and further downstream, of the control basin (described in Section 2.4.2).

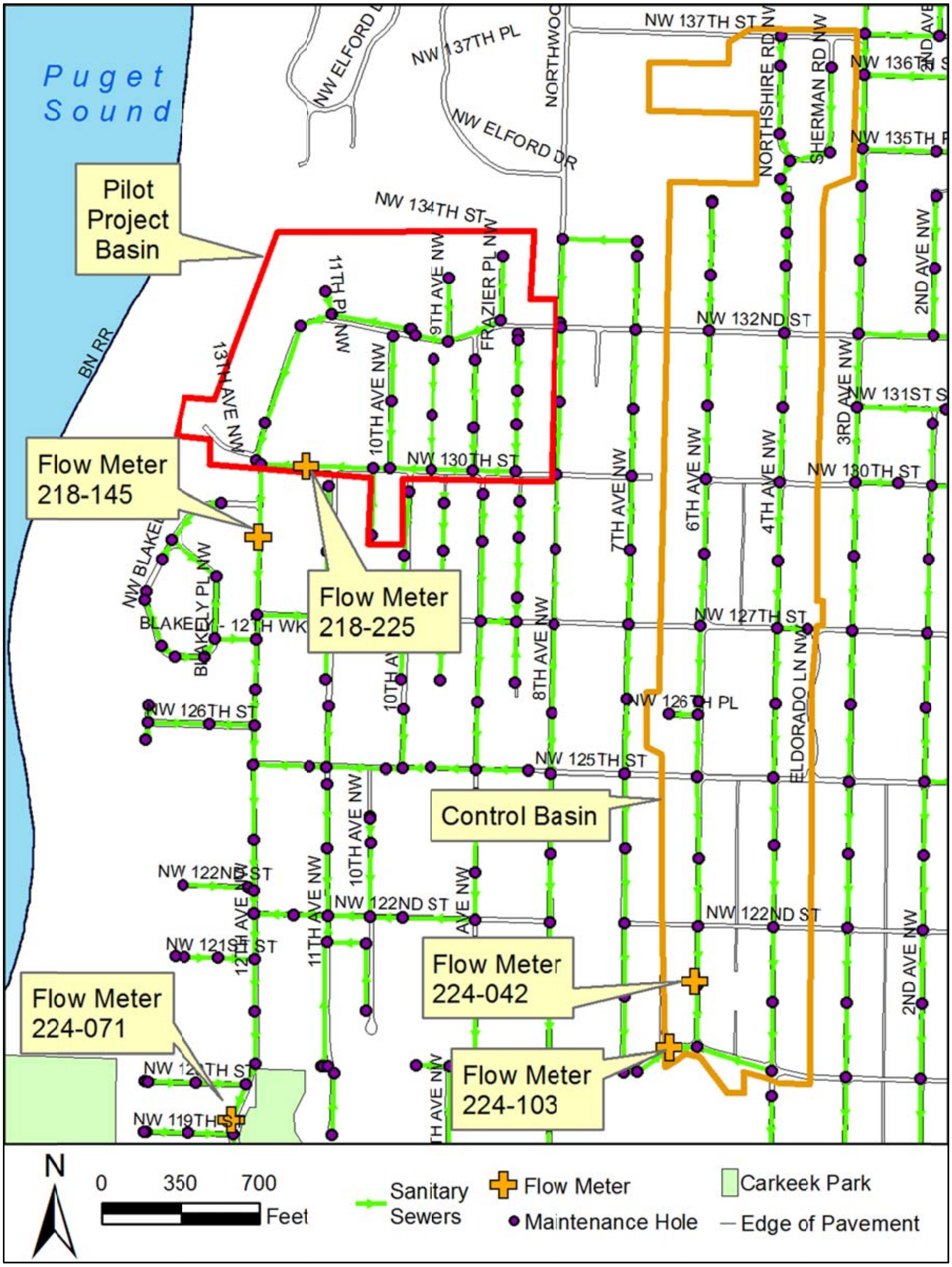


Figure 2-9. Map of Flow Meter Locations.

Flow monitoring occurred before and after the flood grouting pilot project. The installation dates of the flow meters are shown in Table 2-1.

Table 2-1. Flow Meter Locations.

Flow Meter ID	Cross Streets	Installation Date
218-145	12th Ave NW & NW Blakely Ct	2/24/2011
224-103	6th Ave NW & NW 122th St	2/24/2011
218-225	11th Ave NW & NW 130th St	6/2/2011
224-042	6th Ave NW & NW 122th St	12/3/2010
224-071	12th Ave NW & NW 119th St	2/1/2010

2.3.2 Location and Installation of Rain Gauges

SPU currently maintains a network of rain gauges throughout the city. Rain gauges 01 and 07 were used for this project. The locations of the rain gauges are shown in Figure 2-10. Rain gauges are tipping bucket-style. The rainfall information used for this project was at logged at one-minute intervals. Typical installations of the rain gauges are shown in Figures 2-11 and 2-12.

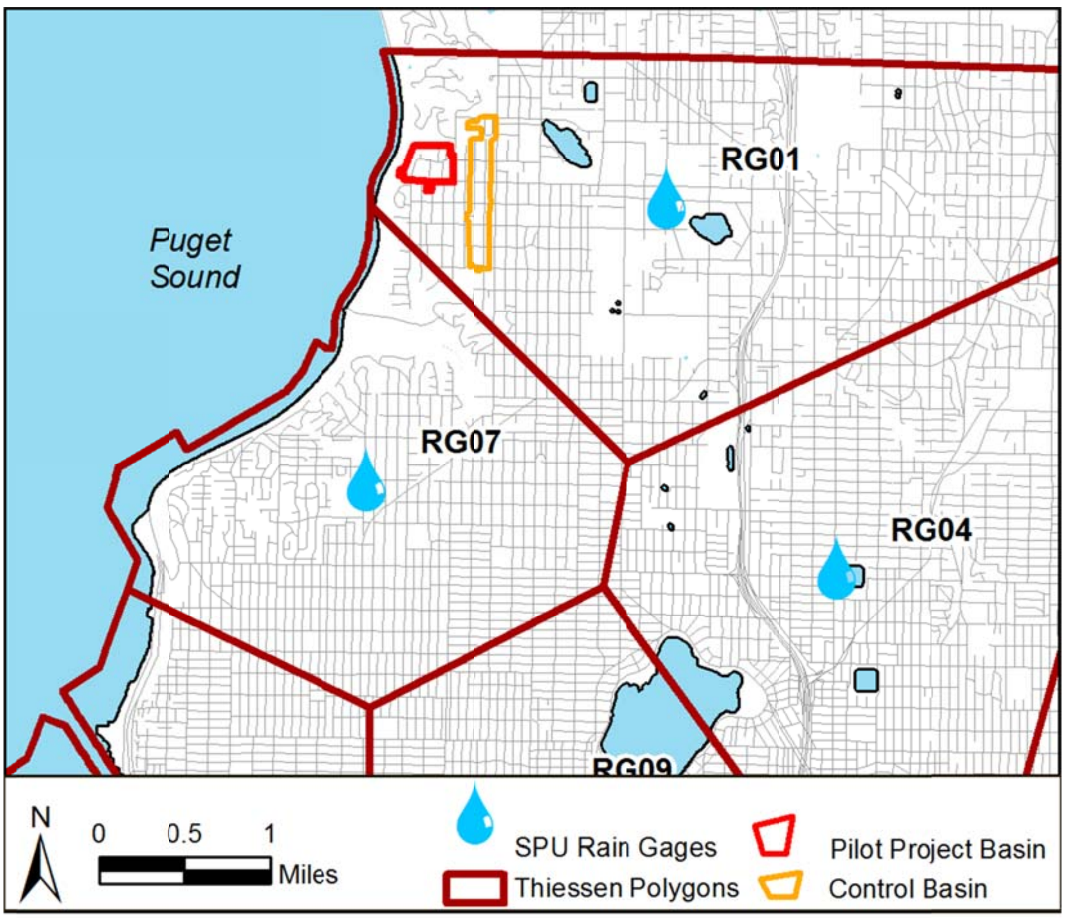


Figure 2-10. Rain Gauge Location Map.

Figure 2-11. Rain Gauge 07 Tipping Bucket.

Figure 2-12. Rain Gauge 07 Data Logger.

2.4. Model Design

The two methods that were employed to assess effectiveness of I/I reduction are described below.

2.4.1 Continuous Simulation

The WERF project report *Reducing Peak Rainfall-Derived Infiltration/Inflow Rates: Case Studies and Protocol* (Merrill et al., 2003) presents several methods for developing predictive equations to describe I/I (e.g., hydrologic modeling). Of those methods presented in the report, Method 5, statistical comparison of continuous simulation models, was implemented for this analysis. This method was considered the most suitable for determining I/I flow removal success because it provides the best representation of I/I for a variety of flow and rainfall.

The method utilizes long-term (continuous) simulations of two models – one calibrated to before and one calibrated to after rehabilitation conditions – to develop I/I flow occurrence (Log Pearson Type III [LP3]) frequency distributions. Comparison of the frequency distributions, for specific return intervals, is used to measure I/I removal effectiveness. More details regarding this analysis method are found in the WERF report (Merrill et al., 2003).

SPU provided a hydrologic and hydraulic model, developed by others, for use in this project. The model was developed using the EPA Storm Water Management Model (SWMM5) platform and had been calibrated using available flow monitoring data (from 2010-2012).

The model employs three types of subcatchments for simulation of hydrology: pervious, disconnected impervious, and connected impervious. Connected impervious is routed directly to the sanitary sewer representing direct inflow to the system. The simulated runoff from the disconnected impervious subcatchment is routed to the pervious subcatchment. Simulated surface runoff from the pervious subcatchment is routed to the storm system while subsurface flow is routed to a SWMM aquifer, which simulates infiltration to the sewer system using the SWMM groundwater model. A second aquifer was added during model calibration to better simulate extended-duration recessions after storm events and long-term groundwater baseflow infiltration, which was difficult to represent with one aquifer alone.

The application of the method for determining I/I flow removal consisted of first calibrating the model to pre-rehabilitation flow monitoring data. Then the pre-rehabilitation model was simulated for the post-rehabilitation time period to see if there was a measurable change, which there was in this case. Therefore, a new model was developed for the post-rehabilitation time period and calibrated to the flow monitoring data. Both calibrated models were simulated for the 34 years of available rainfall, the results (both peak flow and volume) were fit to LP3 distributions, and comparison of I/I peaks and volumes was completed to assess effectiveness of the rehabilitation. This process is shown in Figure 2-13.

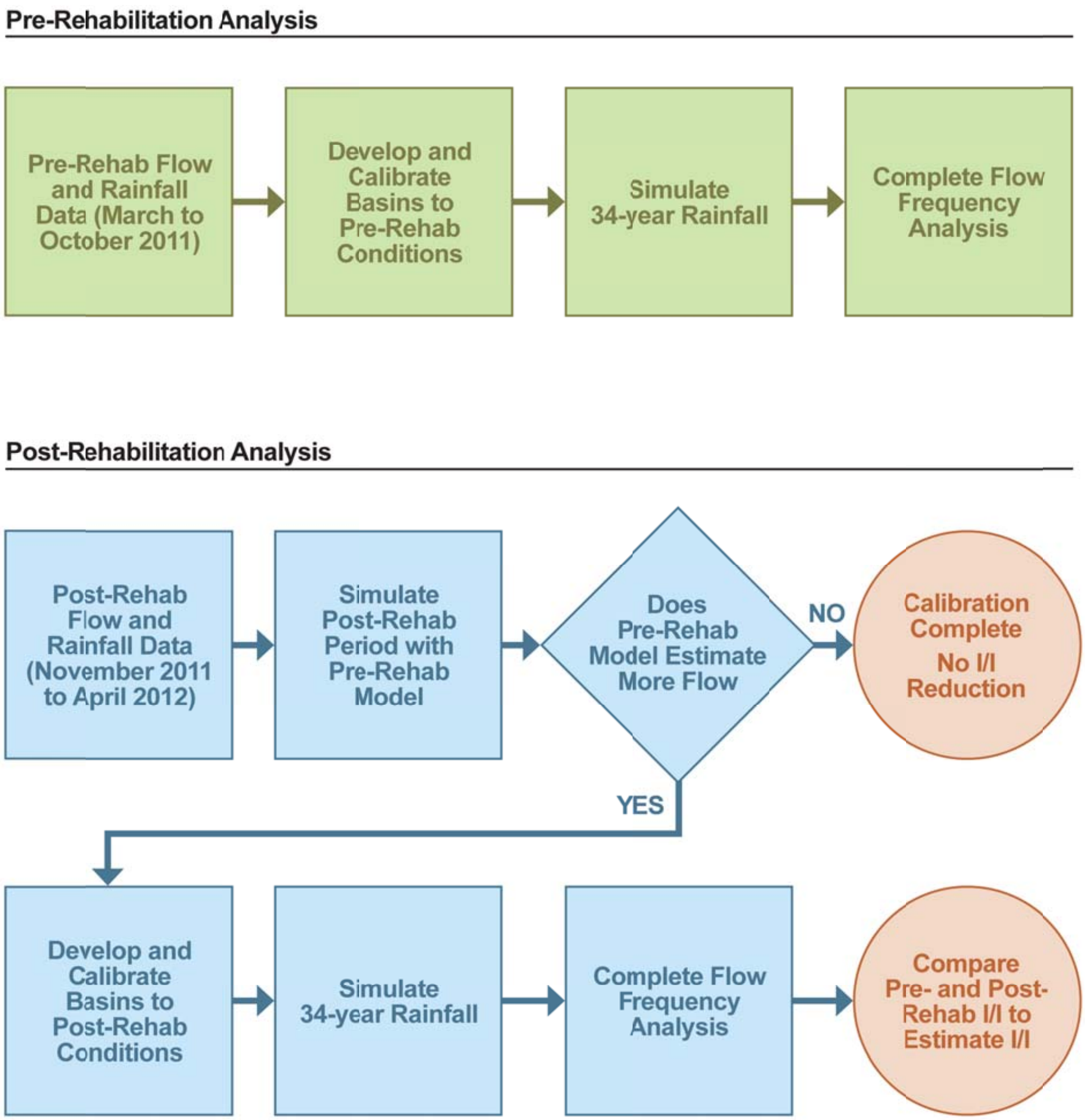


Figure 2-13. Modeling Approach for Estimating I/I Reduction.

2.4.2 Control Basin

In addition to the continuous simulation approach described above, the flow data collected before and after the rehabilitation (at 218-145) were compared to flow data in similar periods at the nearby flow meter (218-103) as a control basin. In this comparison, peak flows occurring in response to rainfall are identified in the record at both meters and the estimated dry weather flow is subtracted from the measured peak flows. The resulting estimate of peak I/I flow in the rehabilitated basin is plotted against the estimated I/I in the control basin. Any difference in the slope of a regression line drawn through the before and after rehabilitation plots is an indication of a change in the I/I rate in the basin. The same analysis is conducted for I/I volumes in each identified event. The steps in this control basin analysis are as follows:

1. Collect flow and rainfall data from rehabilitated and control basins.
2. Estimate the dry weather flow hydrograph at each meter during both the pre- and post-rehabilitation monitoring periods.
3. Subtract the estimated dry weather flow hydrograph from the measured flows during rain events.
4. Compute the peak I/I (maximum difference of measured flow and dry weather hydrograph) for each event.
5. Compute the volume of I/I during each rain event (accumulated difference of measured flow and dry weather hydrograph). Rain events are assumed to end when a 24-hour period without rain has occurred.
6. Plot the peak I/I rates from the rehabilitated basin against the values from the control basin for each of the pre- and post-rehabilitation periods. Develop lines of best fit to these sets of data. The reduction in peak I/I is then indicated by the difference in the slopes of the best-fit lines. The same procedure is used to estimate reduction in I/I volume using the estimated volume data from each period. Ordinarily, the intercept of the best-fit lines should be set to zero.

2.5 Quality Assurance Project Plan

A QAPP was developed for this project. The QAPP outlines the procedures used for determining infiltration reduction, selecting flow metering locations, and validating the data recorded from the flow meters.

Flow meter 218-225, as shown in Figure 2-9, was added later in the project to assist in dividing up the flows from the two mainlines that combine and flow to flow meter 218-145 from NW 130th Street and NW 132nd Street. After the meter was installed, the initial data were quality assurance/quality control (QA/QC)-reviewed per the developed QAPP for this project. The data were deemed to be insufficient because flow in the pipe was too low to accurately measure. This flow meter was removed and the data were not used for analysis of this project.

Flow meter 224-042 was the intended control basin. The flow meter data were found to be unreliable when reviewing the quality of the data prior to utilization per the QAPP. The data quality at flow meter 224-103 was found to be of higher quality. Therefore, this flow meter was utilized as the control basin flow meter.

CHAPTER 3.0

BUSINESS CASE DEVELOPMENT

This chapter explains the development of the business case used to evaluate the flood grouting pilot project.

3.1 How SPU Develops and Applies Business Cases

All major capital projects at SPU, including the flood grouting pilot, go through an assessment process at several stages in their development. This process, which was formalized in 2011, is termed the “Stage Gate Process.” The process starts with a problem assessment, including an early analysis of available options to address the problem. This is “Stage Gate 1.” The costs and benefits of the most viable options are compared in a quantitative economic analysis and if the net benefits are positive, taking into account the “triple bottom line,” the project is presented to SPU senior management to get approval for funding to proceed to design for the “preferred option.” This is “Stage Gate 2.” Triple bottom line takes into account environmental and social aspects of a project in conjunction with the actual fiscal costs. These first two stage gates, which form the investigation and analysis work, are done in one branch of SPU. As the project moves to design, a more detailed Project Management Plan (PMP) is developed under a different branch responsible for design and construction. The PMP includes a detailed schedule and a detailed cost estimate, including a register of risks associated with the project with a cost contingency. The final product of this “Stage Gate 3” is the completed design and bid package ready for advertisement. Additional stage gates follow the project through to commissioning.

3.2 Quantification of Benefits and Costs for Flood Grouting

Prior to approval of the pilot, the proposal was assessed in a business case that compared the cost and benefits of alternatives in order to maximize the net benefit not only to the utility (SPU), but to the community at large. Many different construction methods can be used to reduce infiltration in sanitary sewer pipes. Each method has its own advantages and disadvantages that have to be carefully evaluated in relation to the project site to determine the most appropriate construction method. For the Broadview project, viable alternatives include flood grouting, joint grouting, pipe bursting, and CIPP lining. Open-trench replacement of private side sewers was eliminated from consideration in the Broadview neighborhood due to the cost and the disruptive nature of the construction method. A more detailed description of other potential infiltration control methods is presented below.

3.2.1 Description of Alternative Methods

This section describes the flood grouting, joint grouting, pipe bursting, and CIPP lining methods of pipe rehabilitation.

3.2.1.1 Flood Grouting (Sanipor)

Flood grouting is the process of internally flooding an entire reach of sewer (MH to MH) and the side sewers all at once with a two-part chemical process that leaches out to the surrounding soil through pipe defects to seal the pipe from infiltration. The two chemicals react with each other to form a gel and bind the surrounding soil to create a watertight seal. The significant advantage of flood grouting is that it simultaneously treats all three components of the sewer system (MHs, mainlines, and side sewers). It seals all possible leaks in the system from infiltration, including those that are not visible during inspections. Once the chemicals react with each other, they also provide a root inhibitor to assist in keeping roots out of the sewers (Sterling, 2010). The longevity of the seal on flood grouted sewers is not well understood at this time. One of the earliest applications of Sanipor in the U.S. was in Florida in the early 1990s. The sewer was re-inspected 10 years later. The previously identified leaks that were sealed were not leaking in the new inspection. However, new leaks had developed in the system. In theory, the inorganic soil/grout matrix formed from flood grouting has an indefinite service life.

A disadvantage of flood grouting is that it does not provide full structural rehabilitation. The product helps to stabilize the pipe, but it does not renew the service life of the assets like some of the other alternatives do.

3.2.1.2 Joint Grouting (Test and Seal)

Joint grouting (Figure 3-1) is the process of injecting grout into each joint in the mainline and side sewers. The process involves moving a packing machine to a joint and inflating a bladder on both sides of the joint to seal off the joint. The sealed area is then tested with air pressure to determine if the joint leaks or not. If the joint fails the test, then grout is injected into the joint to seal it from potential infiltration.

The main advantage of joint grouting is that this method has a minimal disturbance to the neighborhood and bypassing is not required. Aside from cleanout installations, if required, no excavations are required. Lateral connections have been tested and sealed as far as 30’ from the mainline pipe with no cleanout or aboveground access required. Typically, the work being performed across the United States has an effective sealing distance varying from 8” up to 7’ up in the lateral. Pressure grouting distances that are longer than 7’ into the lateral from the mainline normally require pre-cleaning and inspection, which adds to the job costs (Anctil, 2012).

A disadvantage is that, like flood grouting, joint grouting is not a structural repair method. The product helps stabilize the pipe and surrounding soil, but it does not renew the service life of the assets. As shown in Figure 3-1, the longer the packing tube is, the more difficult the installation becomes; the grout (gel) may set too quickly and may not effectively seal the joint (Sterling, 2006). Recent advances along with knowledgeable applicators can modify set times to minimize this. Also, joint grouting mainly seals open joints; it is not effective for long lateral cracks along the pipe, nor can the same equipment be used to seal MHs at the same time.

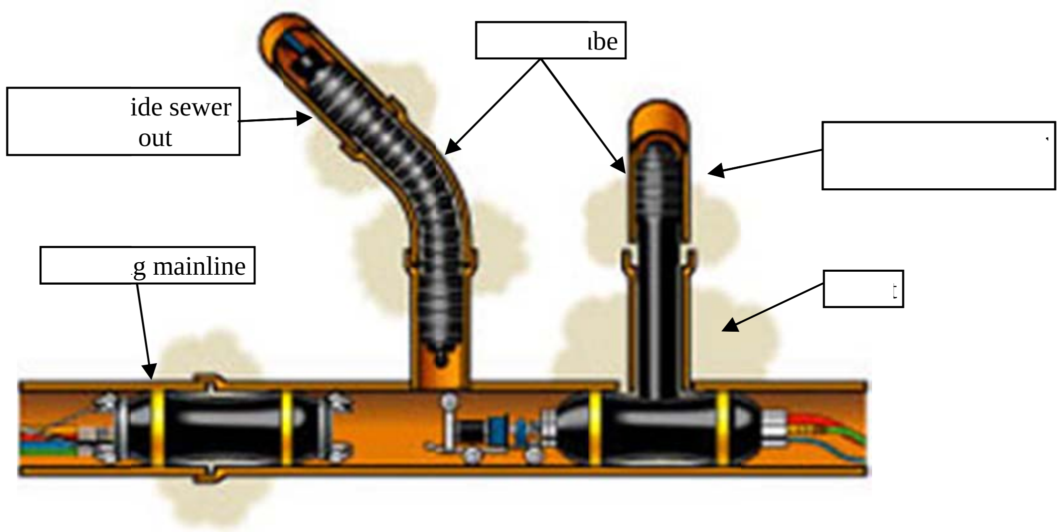


Figure 3-1. Joint Grouting.
(Logiball, 2012)

3.2.1.3 Pipe Bursting

Pipe bursting (Figure 3-2) is the process of pulling a new pipe into the existing host pipe. To complete the installation process two access pits have to be dug: one on the receiving end and one on the insertion end. A pulling system located at the receiving (pulling) pit pulls the new pipe, usually high-density polyethylene (HDPE) pipe, through the host pipe, breaking it apart and pushing it out to the surrounding soil. Pipe bursting is not done to reduce I/I in MHs so another technology then has to be chosen to correct leaking MHs.

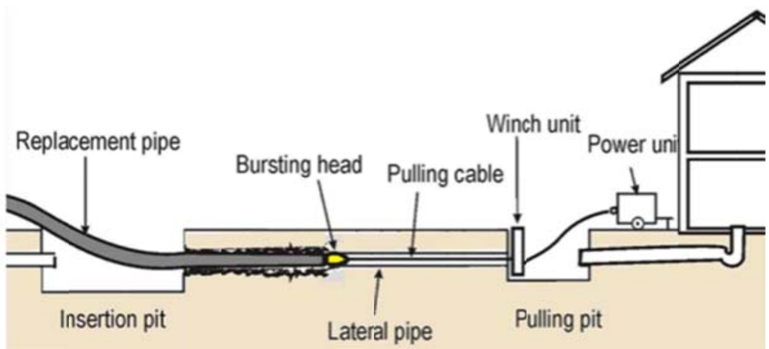


Figure 3-2. Pipe Bursting.
(Sterling, 2006)

The main advantage to pipe bursting is that it completely replaces the sewer pipes with a new jointless pipe. The pipe that is being replaced does not require cleaning or de-rooting prior to rehabilitation like both grouting methods and CIPP lining require. The process does not require any chemicals that need to be stored, mixed, and handled. Lastly, the diameter of the side sewers can be upsized one pipe diameter; e.g., a 4” diameter side sewer can be replaced with a 6” diameter side sewer to increase its hydraulic capacity if needed.

The main disadvantage to pipe bursting is that two access pits (typically 4’ by 4’) have to be excavated for side sewer rehabilitation. Usually one pit is dug on private property adjacent to the building and a second pit is located in the roadway adjacent to the mainline pipe for side sewer replacement. Consequently, access to private property can be an issue. When the new pipe is pulled into the existing pipe, some soil displacement may occur, putting nearby utilities and paved surfaces at risk of being damaged.

3.2.1.4 Cured-In-Place Pipe

CIPP lining a pipe (Figure 3-3) is the process of inserting a resin-impregnated felt lining tube into the host pipe, expanding the liner, and curing the resin to cast a new pipe within the existing pipe. Several different resins and tube materials are available on the market, but the same general methodology applies to all products.

A typical MH-to-MH reach can be CIPP-lined in one working day. In a large project like the Broadview pilot project, two or three side sewers can be lined in a typical working day. CIPP lining does not seal MHs from infiltration. Another method must be used to seal MHs.

An advantage of CIPP lining is that it provides a structurally sound, jointless asset. Even though the liners take up volume in the host pipe, the smoother walls generally maintain the hydraulic capacity of the pipes. Because the only excavation needed is a cleanout, deep pipes can be rehabilitated more easily than with other techniques that require excavations.

A disadvantage of lining pipes is that the liner follows the alignment of the host pipe, meaning that a sag in the host pipe will remain in the lined pipe. If there are severe offset joints or many fittings, lining cannot be completed. It is possible for roots to grow into the annular space between the liner and the host pipe that could damage the liner. If hydrophilic end seals are not used, groundwater can migrate along the annular space and re-enter the sewer system.

Figure 3-3. CIPP Lining.
(Perma-Liner, 2012)

3.2.1.5 Alternatives Summary

Table 3-1 summarizes the positive and negative attributes of each of the four viable rehabilitation methods for infiltration reduction in the Broadview area.

Table 3-1. Positive and Negative Attributes of Alternatives.

Item	Flood Grouting	Joint Grouting	Pipe Bursting	CIPP Lining
Construction time for an average Broadview MH-to-MH reach*	8 hours	3 days^	4 days+	3 days^
Seals side sewers	Yes	Yes	Yes	Yes
Seals mainlines	Yes	Yes	Yes	Yes
Seals MHs	Yes	No	No	No
Seals cracks and pipe wall porosity	Yes	No	Yes	Yes
Requires excavation beyond cleanouts	No	No	Yes	No
Restores structurally integrity	No	No	Yes	Yes

** Eight side sewers and 300 feet mainline pipe.*

^ Additional time required for MH rehabilitation.

+ Additional time required for mainline and MH rehabilitation

Green: Positive attribute.
Red: Negative attribute.

3.2.1.6 Relative Effectiveness

Some alternatives are more effective at reducing infiltration. Because of its limitations in addressing pipe cracks and pipe wall porosity, joint grouting will be less effective in reducing infiltration in Broadview. A review of SPU sewers constructed in the same time frame as the side sewers indicated pipe cracking and porous surfaces; therefore, the effectiveness of joint grouting compared to the other alternatives will be less.

3.2.2 Benefits

There are both indirect non-monetary benefits and direct monetary benefits from completing this infiltration reduction project. These benefits are summarized below.

3.2.2.1 Direct Monetized Benefits

The direct monetary benefits include reduced flooding and backup costs, avoided or reduced cost of improvements within the Carkeek Park combined sewer overflow (CSO) contributory area, reduced daily conveyance and treatment costs as described below, and installation of cleanouts and inspection of the private side sewers.

Backup Avoidance As stated earlier, 20 documented backups have been associated with the infiltration along 12th Avenue NW in Broadview from 1996 to 2010. Distributing the flow from the bottom of 12th Avenue NW throughout its basin on a per foot basis, the NW 130th and 132nd Street basins can be assumed to be responsible for 4.5 of those backups. An earlier business case calculated the cost of a backup to average $40,000. However, more recent analysis has shown much higher costs ranging up to $100,000. This increase reflects changing property values as well as legal costs. Taking those higher costs into account, assuming that future backups continue to occur at the rate of past backups, a design life of 20 years, and a discount rate of 3%, the present value (PV) of anticipated backup avoidance is $490,000.

King County CSO Mitigation 12th Avenue NW flows to the Carkeek Park CSO treatment facility. This CSO facility must meet the overflow control requirements of King County's National Pollutant Discharge Elimination System (NPDES) permit. King County has noted that water quality standards may not be achievable at increased flows with the current treatment technology in place at Carkeek, and that the plant runs at its operating limits with the current wet weather flows[2]. Any flow that is reduced from 12th Avenue NW is flow that does not have to be handled by the CSO facility. A volume reduction of about 200,000 gallons is expected following an infiltration reduction program on NW 130th/132nd Streets, based on preliminary modeling results for a storm event that may cause overflow issues. Assuming a cost of $6/gallon stored (based on costs developed for SPU's Long-Term Control Plan Alternatives Evaluation Report), there is a benefit of $1.2 million in avoided storage construction costs.

Reduced Treatment Costs The average daily flow rate from NW 130th/132nd Streets is expected to be reduced by 10,000 gallons per day (gpd) based on the preliminary modeling. Assuming an average conveyance and treatment cost of $1.50/1,000 gallons (based on typical industry-wide treatment costs) the 20-year PV of avoided conveyance and treatment costs is about $42,000 at a 3% discount rate. It was assumed this benefit would be realized immediately.

Cleanouts None of the homes within the project area had outside cleanouts. Installing a cleanout to the homes provides a valuable resource to the homeowner to aid in future inspections and possible further rehabilitation methods. The value of inspection of the homeowners' side sewer also has a value. The estimated price for installation of the cleanout was $1,000 a piece and the estimate for the inspection was $250 per side sewer. This results in a total benefit for the 88 homeowners of $110,000. It was assumed this benefit would be realized immediately.

3.2.2.2 Non-Monetized Benefits

Non-monetized benefits include increasing the service life of the sewer assets, technology transfer, and building agency relationships.

Increased Service Life Infiltration and operation and maintenance (O&M) activities such as cleaning can stress a conveyance system and reduce service life. Infiltration can sluice the surrounding soil into the pipe, undermining the support the soil provides. This can lead to sags and severely offset joints. High-pressure jetting to clean the accumulated sediments in pipes can exacerbate the sluicing action and can remove deteriorated sections of pipe. Reducing infiltration, and thus maintenance, can increase the service life of a conveyance system.

Technology Transfer SPU realizes costs associated with analyzing, adopting, and implementing a new technology. Costs associated with analyzing and adopting a new technology are generally onetime costs. If SPU adopts flood grouting through a pilot study, a portion of the costs associated with analyzing and adopting the technology would be borne by the pilot study.

Agency Relationships Other agencies such as the EPA and King County will recognize SPU's efforts to reduce infiltration. Reducing infiltration will contribute to a reduction in CSO events, which can create an environment of collaboration and improve agency relationships and interactions.

[2] King County Puget Sound Beaches CSO Control Projects: North Beach Basin Presentation to Broadview Sewer Task Force, July 29, 2010, Meeting Summary.

3.2.3 Costs

The cost estimates for infiltration rehabilitation on NW 130th/132nd Streets for the various rehabilitation techniques are presented below. Flood grouting is the only rehabilitation method that rehabilitates MHs along with pipe. Therefore, a separate cost item is included for the other three evaluated methods to complete an epoxy coating in all of the MHs (cost is per vertical foot [vf] of MH). Defects located on side sewers will not have to be corrected prior to pipe bursting, so it is anticipated that fewer repairs will be needed for a pipe bursting job. Costs for joint grouting, CIPP lining, and pipe bursting were developed from the WERF report titled *Methods for Cost-Effective Rehabilitation of Private Lateral Sewers,* 02-CTS-5, 2006.

Flood Grouting The cost estimate to complete a flood grouting project is presented in Table 3-2.

Table 3-2. Sanipor Cost Estimate.

Item	Quantity	Unit	Unit Cost	Total Cost
Grouting chemicals (S1 and S2)	1	each	$240,000	$240,000
Sanipor representatives	25	days	$2,300	$57,500
Pre-inspection CCTV	5,900' of mainline and 10,600' of side sewer	lf	$3.00	$49,581
Cleanout installation	88	each	$1,000	$88,000
Defect repair	Estimated 8 spot repairs	each	$8,100	$64,800
Cleaning mainline and side sewer	5,900' of mainline and 10,600' of side sewer	lf	$1.50	$24,791
Flood grouting process*	25	days	$2,925	$75,000
Post CCTV	5,900' of mainline and 10,600' of side sewer	lf	$1.50	$24,791
			Construction subtotal	$624,462
			Tax (9.80%)	$61,197
			Construction total	$685,659
			PM, design engineering, admin	$377,113
			Project subtotal	$1,062,772
			Project contingent (20%)	$212,554
			Total estimated project costs	$1,275,000

** Includes plugging, exfiltration tests, bypass pumping, pumping in and out S1, flushing system, pumping in and out S2, flushing system, repeat if necessary.*

Joint Grouting The cost estimate to complete a joint grouting project is presented in Table 3-3.

Table 3-3. Joint Grouting Cost Estimate.

Item	Quantity	Unit	Unit Cost	Total Cost
Pre-inspection CCTV	5,900' of mainline and 10,600' of side sewer	lf	$3.00	$49,581
Cleanout installation	88	each	$1,000	$88,000
Defect repair	Estimated 8 spot repairs	each	$8,100	$64,800
Cleaning mainline and side sewer	5,900' of mainline and 10,600' of side sewer	lf	$1.50	$24,791
Joint grouting mainlines	5,900	lf	$20.00	$118,000
Joint grouting side sewers	7,920	lf	$25.00	$198,000
MH rehabilitation	260	vf	$300.00	$78,000
Post CCTV	5,900' of mainline and 10,600' of side sewer	lf	$1.50	$24,791
			Construction subtotal	$645,962
			Tax (9.80%)	$63,304
			Construction total	$709,266
			PM, design engineering, admin	$390,096
			Project subtotal	$1,099,363
			Project contingent (20%)	$219,873
			Total estimated project costs	$1,320,000

Pipe Bursting The cost estimate to complete a pipe bursting project is presented in Table 3-4.

Table 3-4. Pipe Bursting Cost Estimate

Item	Quantity	Unit	Unit Cost	Total Cost
Pre-inspection CCTV	5,900' of mainline and 10,600' of side sewer	lf	$3.00	$49,581
Cleanout installation	88	each	$500	$44,000
Defect Repair	Estimated 4 spot repairs	each	$15,000	$60,000
Side sewer pipe bursting	10,600	lf	$100	$1,060,000
Mainline pipe bursting	5,900	lf	$80.00	$472,000
MH rehabilitation	260	vf	$300.00	$78,000
Post CCTV	5,900' of mainline and 10,600' of side sewer	lf	$1.50	$24,791
			Construction subtotal	$1,788,372
			Tax (9.80%)	$175,260
			Construction total	$1,963,632
			PM, design engineering, admin	$1,079,998
			Project subtotal	$3,043,629
			Project contingent (20%)	$608,726
			Total estimated project costs	$3,650,000

CIPP Lining The cost estimate to complete a CIPP lining project is presented in Table 3-5.

Table 3-5. CIPP Lining Cost Estimate.

Item	Quantity	Unit	Unit Cost	Total Cost
Pre-inspection CCTV	5,900' of mainline and 10,600' of side sewer	lf	$3.00	$49,581
Cleanout installation	88	each	$1,000	$88,000
Defect repair	Estimated 8 spot repairs	each	$8,100	$64,800
Side sewer CIPP	10,600	lf	$100	$1,060,000
Mainline CIPP	5,900	lf	$80.00	$472,000
MH rehabilitation	260	vf	$300.00	$78,000
Post CCTV	5,900' of mainline and 10,600' of side sewer	lf	$1.50	$24,791
			Construction subtotal	$1,837,172
			Tax (9.80%)	$180,043
			Construction total	$2,017,214
			PM, design engineering, admin	$1,109,468
			Project subtotal	$3,126,682
			Project contingent (20%)	$625,336
			Total estimated project costs	$3,750,000

3.2.3.1 Cost Comparison

The total project capital costs of the four rehabilitation alternatives are presented below.

- Flood grouting (Sanipor): $1,275,000
- Joint grouting: $1,320,000
- Pipe bursting: $3,650,000
- CIPP lining: $3,750,000

3.2.3.2 Salvage Value

Pipe bursting and CIPP lining essentially replace the pipes and renew the service life of the pipes, expected to be 100 years. Both types of grouting are expected to have a service life of at least 20 years. Assuming a linear depreciation rate, pipes renewed by bursting and lining will still have 80% of their value left when the pipes would have to be replaced if they were grouted. To account for the remaining service life by bursting or lining, the “salvage value” (present value at 3% discount rate of the remaining useful life of the asset) is subtracted from the costs of the rehabilitation methods

3.2.3.3 Net Present Value

Table 3-6 shows the net present value of the options.

Table 3-6. Net Present Value.

Method	Reduced Backups	CSO Storage Reduction	Avoided Treatment	Cleanouts and Inspection	Total Benefit	Initial Cost	Salvage Value	Net Present Value
Flood grouting	$490,000	$1,200,000	$42,000	$110,000	$1,842,000	$1,275,000	$0	$567,000
Joint grouting	$490,000	$1,200,000	$42,000	$110,000	$1,842,000	$1,320,000	$0	$522,000
Pipe bursting	$490,000	$1,200,000	$42,000	$110,000	$1,842,000	$3,650,000	$1,617,000	-$191,000
CIPP lining	$490,000	$1,200,000	$42,000	$110,000	$1,842,000	$3,750,000	$1,661,000	-$247,000

Table 3-6 shows that flood grouting has the highest NPV of the options. It was recommended to implement the I/I reduction program using $1.1 million of capital improvement program (CIP) funding in the spending plan for 2011. Additional money was budgeted for 2012 to cover monitoring and the final report on the process. Flood grouting was utilized to determine its viability for future SPU infiltration reduction programs.

3.3 How SPU Develops and Tracks a Project Management Plan

Once the business case has been approved, the project moves to Stage Gate 3 through the development of the **Project Management Plan**. Elements from the business case are further refined through an **Initial Scope Statement** that provides an overview of the project, how it came about, and why it is necessary. The Scope section of the Initial Scope Statement helps define the project boundaries, and what will have to happen for it to be successful and accepted by the customer. It describes the work that will occur as part of the project and the deliverables that will be produced. These deliverables include a risk registry, cost plan, 30% design, and an O&M manual. A high-level diagram of the project organizational structure is included showing roles and lines of internal communication as well as who is involved in the governance. A milestone table with the key milestones for the project and the expected completion dates based on the known information is also included.

The Initial Scope Statement is further refined and detailed as a **Work Breakdown Structure** (WBS). The WBS, developed with the project team, groups project elements to organize and define the total scope of the project. It lists all the phases and work packages required to undertake the project with an expected duration, cost, and resource requirement. These are linked to the appropriate accounting codes to enable the project manager to track both budget and actuals.

One component of the WBS is the **Risk Plan**. The objective of project risk management is to decrease the probability and impact of risk events to a project's scope, schedule, cost, and quality. Creating a Risk Plan includes four main activities: risk identification, analysis, assigning a risk manager, and developing a response strategy. The first step in creating a Risk Plan is to identify and document all the potential risk events. The risk identification process is conducted with at least the project manager and key subject matter experts from the project team.

The two primary components of risk analysis are the impact to the project, measured relative to scope, schedule, cost, and quality; and probability of the risk. The impact is rated from very low to very high (>20% increase to cost, project quality is such as to be unusable). Similarly the probability of the event occurring is ranked from very low to very high (>75% chance of occurring). The risk priority is based on the product of the Impact and Probability ratings. This product is called the risk score. For high-priority risks a response strategy is developed by the project team to reduce or account for that risk and over the project life those risks are tracked and eliminated if the risk is resolved or removed. Standard risk strategies include accept, mitigate, avoid, transfer, and/or provide a contingency reserve.

Once the scope is fully developed, the **Project Schedule** is created in Microsoft Project. The Phases and Work Packages are placed into the correct sequence; durations are estimated and important Milestones are added. Some work packages may need to be broken down into smaller activities.

Similarly, a **Cost Plan** documents the financial resources required during each phase of the project and the expected rate of spending. The cost of labor, other resources, consultant contracts, construction contracts, and reserves are estimated to the level of detail appropriate for the project phase. The primary deliverable is the **Cost Plan Spreadsheet**, which is used to develop, monitor, and control the plan. A Cost Plan includes the following components:

- **Base Cost:** The sum of life-to-date actual, plus current projection of anticipated project costs in today's dollars, not including reserves.
- **Reserves:** The combination of contingency reserve and management reserve.
- **Total Cost:** Base Cost plus Reserves, in today's dollars.
- **Total Cost Projection:** The project team's best estimate of what the project will cost. This is the amount that is approved by management and becomes the Governance Approved Amount. This figure is equal to the Total Cost adjusted to take into account anticipated inflation.

All of these components – the scope, the work breakdown, the risks, schedule, and cost estimates – together comprise the PMP. This more detailed document with any revised budget estimate is approved by a management team before the project goes into final design. It is tracked in the Enterprise Project Management System, which provides everyone with an up-to-date status of the project including key milestones, risks, schedule, and expenditures.

A diagram of some of the major components of SPU's PMP is shown in Figure 3-4.

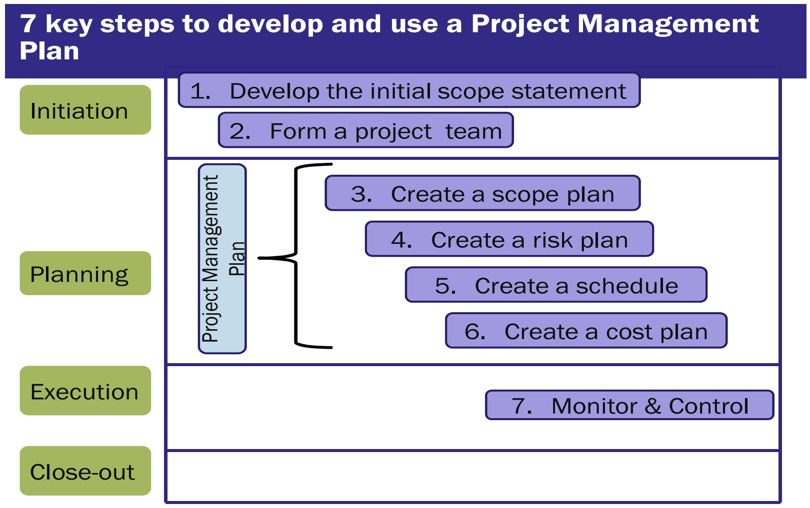


Figure 3-4. Seven Steps for a Project Management Plan with SPU.

3.4 The Project Management Plan for the Flood Grouting Pilot Project

A PMP was developed for the flood grouting pilot, basically following the process described above. Given the nature of the project, some of the steps were simplified. For example, the work was done using a service contract rather than going through a public works bid process. This method was chosen because there were not multiple providers of flood grouting materials. Therefore, the work could not be publicly bid. Most of the work was done by a contractor, and the project manager also served as the onsite construction manager. This approach helped to make the project execution more efficient, saving time and money. But at the start, management viewed this new approach as a potential risk to include in the Risk Register. If it was determined that the project was required to bid the work as a public works project, that would add delay and cost, making it difficult to complete the work in one season, due to the increased effort of producing a public works project per SPU standards and methods.

Another significant risk was the inclusion of side sewers in the pilot. In Seattle, the property owner is responsible for the side sewer, up to the connection to the mainline. SPU has not traditionally done work on private side sewers. There was the question of whether public funds could be expended on what would essentially result in an improvement to private property. There was also the issue of obtaining the acceptance and approval of the homeowners affected by the pilot project.

The issue of use of public funds was addressed through an opinion issued by the Washington Attorney General's office that stated that sewer districts have statutory authority to use public funds to repair or replace side sewers located on private property if doing so will increase sewer capacity by reducing I/I (McKenna, 2009). This opinion has been the basis for funding I/I projects that include side sewers for several municipalities in Washington State.

Finally, an additional risk was related to the lack of experience with the flood grouting technology in the Northwest. Flood grouting has been used a number of times in Europe, especially in Germany, and has gone through a rigorous licensing process, but its application to sewers was limited to some smaller applications in Florida and the Midwest. In fact, this pilot was the largest application of Sanipor to date in the United States.

Each of these risks, as well as others, were ranked and a contingency was included in the PMP. The budget for the project was refined and increased, including contingencies to account for the perceived risks. The detailed budget and schedule formed the PMP for the project. Copies of the Scope Statement, Schedule, and Risk Register documents are included in Appendix B.

CHAPTER 4.0

COMMUNITY ENGAGEMENT

As previously noted, one of the perceived risks was public acceptance of the project. In order to seal side sewers, cleanouts had to be installed on each side sewer, close to each house, which required a signed right-of-entry from the homeowner. Seattle had not previously done projects that addressed privately owned side sewers. In reviewing projects that require voluntary participation to be successful, both within Seattle and elsewhere, it was apparent that the participants may have to feel that the benefits outweigh any risks before they agree. Success of a project may often depend on both addressing community concerns and effectively implementing a variety of outreach strategies. Methods to achieve these goals are described below.

4.1 Addressing Community Concerns

Public acceptance of a project like the flood grouting pilot project may depend on how well the utility addresses residents' concerns, including both making the benefits clear and assuaging any fears.

How Does This Project Benefit Me? It is generally understood that people work to maximize the personal value of their decisions. Although people may participate in a program because "it is the right thing to do," or because of community benefits, more people might sign on if it benefits them personally. SPU conducted some focus groups that clearly demonstrated this perspective. Utilities can provide these benefits to individuals because it saves the system money. In the case of the flood grouting pilot, homeowners had the benefit of having their side sewer inspected, cleaned, and if necessary, repaired at no cost to them. More and more homeowners are becoming aware of the potential personal cost for this service, and many municipalities are beginning to require this to be done before a home is sold.

What Is the Risk to Me? Customers may weigh the risk of the project before they agree to participate. This considers both the risk of the project itself, as well as the level of trust they have in the agency sponsoring the project. It is easier to destroy trust than to build it, a dynamic known as the "trust asymmetry principle." As an example, SPU is conducting another pilot project that will pay for the installation of a backflow preventer for houses that have experienced backups in the past and are at risk for future backups. A number of customers were reluctant to agree to the installation both because they fear that the devices may fail, and because they do not trust SPU. This lack of trust was based on feeling that they were not treated fairly in the past or because they do not trust government in general. SPU attempted to address such fears through information and some of the techniques described in Section 4.2. While the customer may have legitimate fears, these need to be taken into account and estimated participation rates adjusted accordingly.

4.2 Strategies to Building Community Acceptance and Participation

Numerous approaches can be applied to reach out to a community and build support for a project like the flood grouting pilot project. Some of these approaches are described below.

The Neighborhood Approach It is possible that the best spokesman for the project is a neighbor of the customer or homeowner being asked to participate. Neighborhood activists, the community council, or the neighborhood blog can be very effective allies in getting others to also sign on. Following many years of repeated sewer issues in the Broadview neighborhood, community members banded together to form the Broadview Task Force. The goal of the task force is to work directly with SPU to solve the sewage and drainage issues in Broadview. Early on in the conceptual phase of this pilot project, SPU presented the flood grouting option to the task force with the goal of gauging its interest and to hear what the Task Force thought the community at large might think of this type of project. The task force was very interested in the project and urged SPU to proceed. It became an advocate for SPU in the community to help obtain the required public acceptance and move the project forward. In addition, SPU had the support of some of the early adopters on one block of the pilot area, who then talked to their neighbors to encourage them to sign up too.

Success Breeds Success When people can see that a project has worked elsewhere, especially close by, they may be more willing to sign up in the future. King County conducted a pilot project in 2003 and 2004 in which it replaced side sewers using pipe bursting. When the County later conducted a similar project in neighboring Skyway, the County had a participation rate of over 90%. However, the opposite can also occur, where one negative example can adversely affect other projects.

Social Norming Although people may want to see a personal tangible benefit to participation, they may also want to be seen publically as doing something good. One SPU program, the RainWise Program, has appealed to this tendency by providing signs that participants can place in their yards showing that they have an SPU rain garden.

Tell Them, and Tell Them Again It can take time for acceptance of a new program to sink in. Communication specialists say people need to be exposed to information up to five times before they consciously hear it and are receptive to it (Graham, 2000). This communication can take many forms. SPU conducted three public meetings prior to initiating construction activities and one following construction. The first public meeting was a comprehensive Broadview neighborhood meeting, where SPU provided updates on all of its recent accomplishments in the neighborhood and its future plans, including this pilot project. The next public meeting was held specifically for the residents within the pilot project boundary. SPU went in detail through the project outlining what was going to happen – the initial closed-circuit television (CCTV) inspection, cleanout installation, the actual grouting process, and then project cleanup. The third public meeting was held at the project site. The contractor brought CCTV trucks, vactor trucks, and the actual workers who would be working in the area. This allowed the residents to see up-close who would be doing work in their neighborhood and the size of the required construction equipment (Figure 4-1). The last public meeting, held following completion of the project, was presented to the entire Broadview neighborhood. These first two and last meetings were held in large meeting spaces (church and community center) in the Broadview neighborhood.

Figure 4-1. Onsite Community Meeting.

Access Agreements To complete work on private property, SPU was required to obtain access agreements with each property owner in the pilot basin. The access agreement allowed SPU to enter private property, inspect the side sewer, install cleanouts, and repair the side sewer if required. This legal document, provided in Appendix C, was developed by SPU in assistance with its legal department. Prior to initiating any type of field work in the pilot basin, SPU waited until it received over 75% of the access agreements. For this project to be a success SPU needed the support of the community and it needed to maximize the sealing potential of the project by sealing the greatest possible length of private side sewer. The public meetings were followed by a letter sent to the homeowners in the pilot area requesting their participation in the project by signing the right-of-entry agreement. A follow-up phone call was made to those who did not respond, then a door hanger, and finally a registered letter. This combination of outreach techniques garnered a participation rate of 95%. For properties that would not provide an access agreement, the internal inspections were limited to the portion of the side sewer within SPU's right-of-way and the cleanouts were installed at the property line. It was determined that a 75% signup was a break-even point for obtaining the desired infiltration reduction. Once SPU received the desired level of participation, field work commenced in conjunction with additional work to obtain additional access agreements.

Using Social Media Per the Experian Marketing Services 2011 report *The 2011 Social Media Consumer Trend and Benchmark Report*, over 91% of the online population now use social media such as Facebook and Twitter. The use of social media in government outreach efforts has grown rapidly over the last three years, and public utilities are also turning to social media. New mobile app programs such as YourGOV help public utilities officials more efficiently communicate with the public on a range of issues. It *can* be a cheaper form of communication, and a way to reach more people at a time. However, no social media was used for this pilot project.

Evaluate Your Audience Part of the answer to the above question depends on who you are trying to reach. In the Broadview area, for example, the neighborhood population tends to be older, long-term residents. Some neighborhood activists do not even use e-mail, much less social media. An American Water Works Association Research Foundation[3] (AwwaRF) study (Mobley et al., 2005) found that households with seniors were more likely to read information that was mailed to them along with their water bill. On the other hand, many rely on these media, as well as neighborhood blogs.

E-mailing and LISTSERVs E-government enables public officials to communicate with citizens without the logistical complications and delays associated with community meetings and normal mail services. The public can benefit from online interactive features that facilitate communication between citizens and their government. LISTSERVs are relatively easy to establish and allow agencies to quickly distribute information to a large audience. Recent articles note that the trend over the last 10 years is that of decreasing phone calls to utilities in favor of e-mails. The Public Works Director of Golden, Colorado, recently observed that over the last five years phone calls to his department had declined by roughly 80%, coinciding with an "exponential increase" in e-mails (McLaughlin, 2011). For Broadview, SPU established a LISTSERV as a means of getting information out about the various projects in the area in a timely fashion.

Websites Website updates provide an efficient way to convey information to a large number of people. However, as with e-mailings and LISTSERVs, website updates require an Internet connection and technological savvy. Website updates, in addition to Twitter feeds and other Internet-based outreach methods, are increasingly part of the Open Government and Web 2.0 movements. SPU recently established a website for the Broadview projects. In addition, a neighborhood blog, broadviewseattle.org, posted information and updates about SPU's program in the community.

When Voluntary Participation Does Not Work SPU has been very reluctant to require participation in programs even when it has the legal authority to do so, preferring to encourage voluntary participation whenever possible. For example, under the Seattle Municipal Code Section 21.16.180, SPU can require property owners to repair their side sewer if it is causing damage to the City's infrastructure or endangering the public health, but this authority is applied sparingly. However, for the flood grouting pilot, for those few properties whose owners did not agree to participate, the cleanouts were placed in the right-of-way to seal off those side sewers prior to applying the grout.

As reduction in I/I becomes a federal and state requirement, it is likely that participation by the public will move from voluntary to mandatory. That has already happened in many other municipalities such as Hartford, Connecticut (Pendleton and Griffiths, 2012). Nevertheless, good, successful communication with the public will continue to be essential for such programs to work.

[3] Currently called Water Research Foundation.

CHAPTER 5.0

DESCRIPTION OF THE CONSTRUCTION PROCESS

This chapter describes the construction phase of the flood grouting pilot project.

5.1 Contracting and the Use of Sanipor

The work for this pilot project was done through a service contract and did not require a public works bid process. SPU was able to directly utilize a contractor from an approved list of contractors to complete the flood grouting project. The approved list was queried to narrow the list down to contractors that had the required equipment, size, and expertise to be able to successfully complete the project. Bravo Environmental NW Inc. (Bravo) was selected as the preferred contractor. It had the most appropriate experience and the required equipment. Bravo also had existing CCTV inspection and sewer cleaning contracts with SPU that were augmented to include these required services for the flood grouting work.

Sanipor requires a license agreement to be able to use its product. SPU and Brown and Caldwell introduced Bravo and Sanipor to each other for the two parties to negotiate and develop a temporary project-specific license agreement. The cost for this license was passed on to SPU. Sanipor ordered the chemicals from EKA Chemicals, Inc. The S1 (manufactured in Moses Lake, Washington, Spokane, Washington, and Portland, Oregon) came in large tanker trucks (Figure 5-1) and the S2 (manufactured in Green Bay, Wisconsin) came in 270-gallon tote bins (Figure 5-2).

Figure 5-1. S1 Tanker Delivery.

Figure 5-2. S2 Tote Bins.

5.2 Construction: Pre-Flood Grouting Activities

The implementation phase of the project began in July 2011 with the initial cleaning and CCTV inspection of the mainlines. The mainline sewers were generally found to be in fair shape. No large collapses, root balls, or other significant defects were located. Significant signs of infiltration (staining, encrustation, and drippers) were identified. The CCTV inspection found three pipes that transitioned mid-reach from 6-8” in diameter with the smaller-diameter pipe inserted into the larger-diameter pipe. On those same lines, the upstream MH was actually a lamp hole (cleanout on the mainline). The lamp holes did not provide the access needed for the inspection, cleaning, or grouting and the transitions prevented cameras from reaching the ends of the lines. SPU installed pre-cast MHs at these locations to bring them up to standards under its O&M budget and the associated costs are not included in this project.

Once SPU received a significant number of right-of-entry forms from homeowners, inspection and installation of the cleanouts began. Most of the homes were inspected using side-launch cameras from the main sewer line. The inspection not only determined the condition of the lines, but also was used to assist in locating potential cleanout installations. A sonde was attached to the camera head to identify the location and depth of the camera head on the surface. The majority of the houses had multiple side sewers branching off to various locations of the house. The cleanout was positioned downstream a few feet from the most downstream branch. This also included side sewers that served multiple houses. This scenario is shown in Figure 5-3.

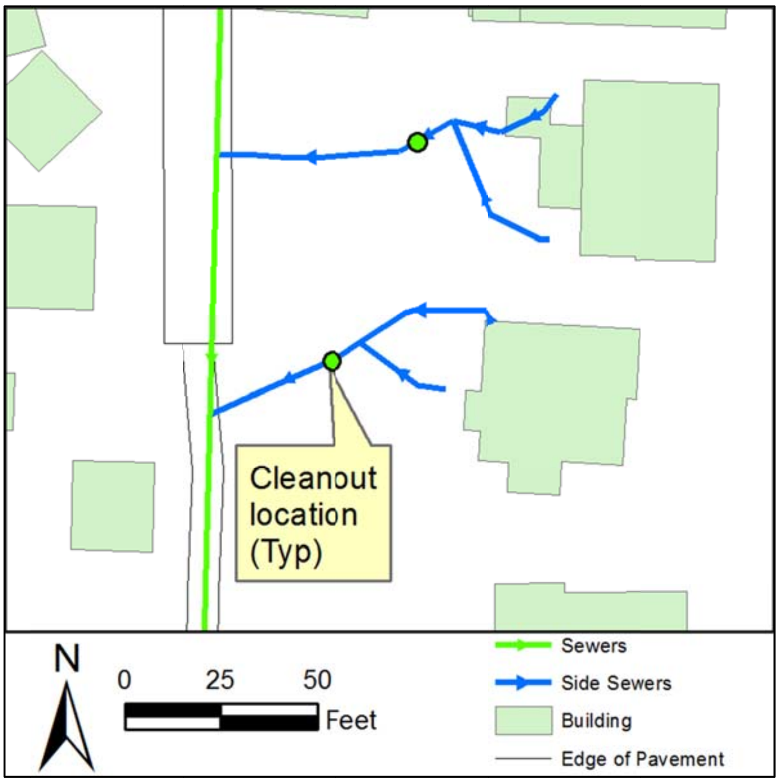


Figure 5-3. Depiction of Multiple Side Sewer Branches.

Several of the houses could not be inspected from the mainline for several reasons. At these houses, push cameras (Figure 5-4) were used through existing inside cleanouts or by removing toilets and inserting the camera through that opening. The inspection of the side sewers revealed that the geographic information system (GIS) mapping of the side sewers in this area was incorrect at several locations. Project-specific mapping was updated to reflect the correct location of the side sewers and all cleanouts were surveyed to record their location. The side sewers were found to be in a similar condition as the mainlines.

Figure 5-4. Side Sewer Inspection Camera.

Following inspection, the cleanouts were installed at the locations identified by the internal inspection. In some instances, landscaping and homeowner approval modified the previously identified locations. Due to the multiple branches (as shown in Figure 5-3), landscaping, elevation differences, and homeowner approvals, approximately only 30% (about 3,000') of the total side sewer length could be sealed. The cleanouts were installed by the Vac-A-Tee method, as shown in Figures 5-5 and 5-6. This minimally invasive process utilizes vacuum excavation to expose the side sewer to determine where a new riser pipe can be attached.

Figure 5-5. Excavating for Vac-A-Tee.

Figure 5-6. Attaching the Vac-A-Tee.

Generally this operation went smoothly, except in a few places where the locations from the internal inspection were off by a few feet. In these circumstances the excavated hole ended up being larger than it otherwise would have been.

5.3 Construction: Flood Grouting

The flood grouting operations began on August 10, 2011, and were completed on October 5, 2011. Grouting operations were done under the onsite guidance and direction of Sanipor representatives. Prior to any sewer shutdowns, residents received notice four days and again one day before the operation that they could not use water during the grouting process, generally from 9 a.m. to 6 p.m. Copies of the advanced shutdown notices are included in Appendix D. The flood grouting process began with a pre-cleaning of the MHs, mainlines, and side sewers. Next, plugs were installed in upstream and downstream MHs in the mainline pipe and side sewers through the newly installed cleanouts. Logiball Push-Type plugs, Type A, were used to plug the side sewers through the cleanouts. The plugs were inserted on the house side of the cleanout, leaving the cleanout unobstructed to allow air to escape while the system is flooded. Figures 5-7 through 5-10 depict the process of plugging the side sewers.

Figure 5-7. Side Sewer Plugs.

Figure 5-8. Deflated Plug Prior to Insertion.

Figure 5-9. Folding Plug in Half.

Figure 5-10. Inserting Plug into Side Sewer.

Once all the plugs were installed, S1 was discharged into the upstream MH and allowed to fill the entire system until the liquid level reached the upstream MH rim. The liquid level was measured every five minutes to monitor its exfiltration rate. If the liquid dropped excessively, the level was topped off to maintain the maximum possible hydrostatic pressure on the system. After a period of 30-45 minutes, S1 was extracted out of the MH back into the vactor truck. The system was then rinsed to remove as much S1 from the inside of the pipes as possible to keep S1 and S2 from reacting inside the pipe, potentially causing a blockage. All of the plugs were reinserted and the process was repeated with S2. During the grouting process a contractor constantly monitors the pressures of the plugs to immediately identify any issues should they arise. The filling and measuring process of the two chemicals are shown in Figures 5-11 and 5-12.

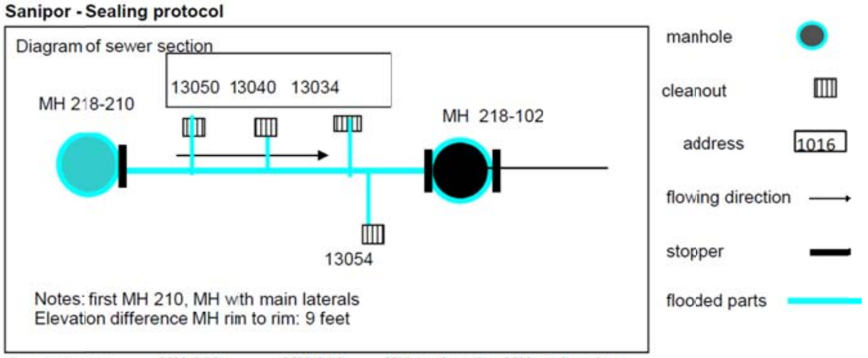
Figure 5-11. Filling and Measuring S1.

Figure 5-12. Filling with S2.

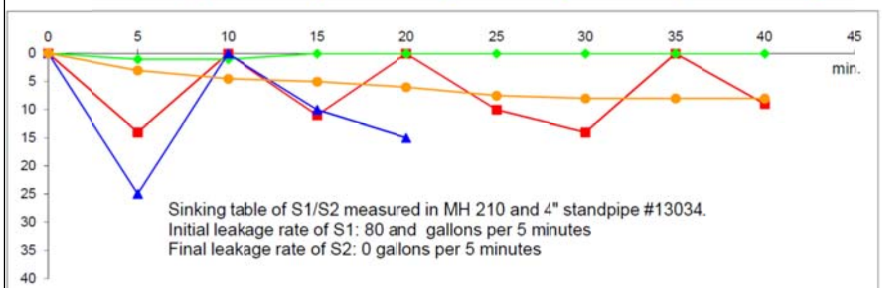
In several instances, the first application of S2 did not achieve the desired exfiltration rate. In these cases the whole process was repeated until the segment achieved the desired sealing goals. The sealing goal, provided by Sanipor based on European acceptance of new concrete pipelines, was set at an allowed exfiltration rate of 0.74 gallons per 100 square feet of wet inner surface in 30 minutes. The exfiltration depths were recorded and are stored in graphs as shown in Figure 5-14 and Appendix E. A typical setup is shown in Figure 5-14, where the upstream MH was treated separately from the mainline to minimize chemical loss and to assist in achieving the greatest sealing potential. The majority of the MHs were made from concrete blocks and were very leaky, as shown in Figure 5-13.

Figure 5-13. Leaky Concrete Block Maintenance Hole.

Sanipor - Sealing protocol



Flooded parts:	MH 210	MH 210	MH and main	MH and mains		
Time	11:50	12:50	8:23	9:20		
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) 2. cycle S1	sinking (inch) 2. cycle S2	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0	0	0		
5	14	1	25	3		
10	0	1	0	4.5		
15	11	0	10	5		
20	0	0	15	6		
25	10	0		7.5		
30	14	0		8		
35	0	0		8		
40	9	0		8		
45						



main pipe and Ø inch	laterals length(feet)	volume gallons
8	287	750
6	56	82

manholes: Ø inch	218-210 to 218-102 dept (feet)	volume gallons
48	9.1	855
48	10.9	1,024

Location: *Seattle, 10 th Ave NW*
Date: *23. 8. and 13.09.2011*
Supervisor: *Ferenc Pall*
Contractor: *Bravo Envrionmental Inc.*

Figure 5-14. Flood Grouting Sealing Results.

Only four to five segments required actual bypass pumping during the grouting operations. Typically the upstream pipe could store any received flows or a flow-through plug could be used to transport sewage through an MH without contaminating the grout. When bypass pumping was required, a small trash pump was used to pump accumulated sewage via a 3”-diameter discharge hose running along the street to the next downstream MH (Figure 5-15).

Figure 5-15. Bypass Pumping Setup.

At the end of the flood grouting work, a significant amount of the flood grouting chemical was left over. Of the 18,000 gallons of S1 ordered 9,600 gallons remained, and of the 9,000 gallons of S2 ordered 5,200 gallons remained. There were primarily three reasons for this. The volume ordered was estimated on sealing the full length of the side sewers, but only 30% of the side sewer length was sealed. Second, the infrastructure sealed using less chemical than anticipated. Lastly, Sanipor included a safety factor in its order because the chemicals have an 8-10 week lead time to be shipped from the manufacturer, EKA Chemicals, Inc. Sanipor did not want to shut the project down for that time period should the chemicals be used up prior to completion. SPU utilized the remaining chemicals by sealing just MHs in other sections of the Broadview sewer basin. Sealing MHs is a simpler process than when the mainlines and side sewers are included. No public notification or bypass pumping is required and it can be completed in all weather conditions.

5.4 Construction Equipment

The large-scale and special equipment required for the flood grouting process is shown in Table 5-1.

Table 5-1. Special Equipment List.

Equipment	Details
S1 truck (Figure 5-16)	2008 Vactor 2115 centrifugal compressor combination sewer cleaner (fan unit) 15-cubic-yard debris barrel 2,500 gallons of liquid storage (S1) 5-axle 68,500-pound gross vehicle weight (GVW) 0 to 8,000 cubic feet per minute (cfm): operating range 2,500 to 4,500 cfm
S2 truck (Figure 5-17)	2007 Volvo VHD swap loader 4,200-gallon Predator vacuum body (roll off) 550 cfm Fruitland rotary vane vacuum pump 7-axle 78,500-pound GVW (single), 105,500-pound GVW (tandem)
Sewer plugs	Ten 4" Logiball pneumatic side sewer plugs Ten 6" Logiball pneumatic side sewer plugs Four 6" to 12" pneumatic blocking plugs Four 6" to 12" pneumatic flow-through (3") plugs Four 8" to 12" pneumatic flow-through (4") plugs

Figure 5-16. S1 Truck.

Figure 5-17. S2 Truck.

5.5 Use of Remaining Grouting Liquids

The remaining grouting liquids were used to seal 52 additional MHs elsewhere in the Broadview sewershed. Because the chemicals had been used previously and contaminated with water and sewage, the shelf life became limited compared to virgin material. To determine if sealing just the MHs does lead to infiltration reduction, the majority of the MHs along a branch of sewer draining to flow meter 224-103 was sealed, as shown in Figure 5-18. At the time of the MH sealing, this area was not intended to be part of the control basin. Of the 22 MHs, 18 MHS were sealed. The MHs that were not sealed were either not located or located in an easement where the trucks could not access. The modeling results determining infiltration reduction are discussed in Section 6.2.

Figure 5-18. Maintenance Hole Sealing Locations.

CHAPTER 6.0

PROJECT RESULTS

This chapter describes the results of the flood grouting pilot project.

6.1 Construction Results

One of the benefits of flood grouting is that it provides immediate results on the post-exfiltration rate of the system. The exfiltration rate of the S2 chemical, which has a non-viscous, water-like consistency, can be used to determine the immediate post-flood grouting leakage rate. The leakage rates are determined by measuring the drawdown of the liquid from a reference point (usually MH rim) in five-minute intervals and estimating the volume from the MH diameter. The post-exfiltration rate percent improvement for each of the 27 sewer segments ranged from 93-100% improvements, with an average improvement of 99%. Table 6-1, Flood Grouting Sealing Rates, is compiled from the information provided in Appendix E.

Table 6-1. Flood Grouting Sealing Rates.

Upstream MH	Downstream MH	Before Rate*	After Rate*	Reduction
218-108	218-107	1.5	0.1	93%
218-104	218-103	5	0	100%
218-103	218-101	5	0	100%
218-078	218-077	10	0	100%
218-112	218-111	15	0	100%
218-105	218-104	15	0	100%
218-097	218-098	60	0	100%
218-100	218-225	95	0	100%
218-111	218-110	170	0	100%
218-070	218-096	40	2	95%
218-109	218-106	50	1	98%
218-220	218-100	100	2	98%
218-075	218-074	25	0	100%
218-102	218-101	30	0	100%
218-101	218-100	15	1	93%
218-106	218-103	15	1	93%
218-110	218-109	180	0	100%
218-107	218-106	160	0.3	100%
218-073	218-072	5	0	100%
218-071	218-072	2	0	100%
218-210	218-102	80	0	100%
218-077	218-075	5	0	100%
218-096	218-097	20	0	100%
218-225	218-098	10	0	100%
218-072	218-070	20	0	100%
218-076	218-075	5	0	100%
218-074	218-073	2	0	100%
Total		1,141	7.4	99%

** Gallons per 5 minutes calculated by Sanipor.*

6.2 Monitoring/Modeling Results

Results from flow monitoring, hydrologic modeling, and the flood grouting effectiveness assessment are discussed below.

6.2.1 Flow Monitoring

The project flow monitoring period includes two rainfall events with 12- and 24-hour total depths ranked in the highest 25 for the RG 07 rainfall record from January 1978 to March 2012. These events occurred in early March and late November 2011. These two events occurred before and after the flood grouting was completed, respectively. Prior to the beginning of the project, a 12-hour, 50-year storm occurred in December 2010.

Comparison of the flow meter data from the two monitoring locations (218-145 and 224-071) for the two rainfall events described above provides visual evidence of the flood grouting effect. Specifically, as shown in Figure 6-1, review of the pre-project meter data shows agreement between the pilot project location (218-145) and downstream, including areas where flood grouting did not occur, at the outlet of the 12th Avenue NW basin (224-071). The extended recession after peak flows at both locations indicates the presence of considerable infiltration in the system with a similar response to rainfall in both the upstream and downstream sections of the system.

The November 2011 rainfall event, which occurred after flood grouting, produces visually different meter data signatures at the two monitoring locations. In particular, the 12th Avenue NW basin outlet location (224-071) has an extended recession after the peak flow (similar to the pre-project data) as shown in Figure 6-2. However, the pilot project location (218-145) data shows a sharp recession after the peak flow. This reduced recession for the pilot project meter during post-project monitoring is evidence of flood grouting effectiveness in reducing infiltration.

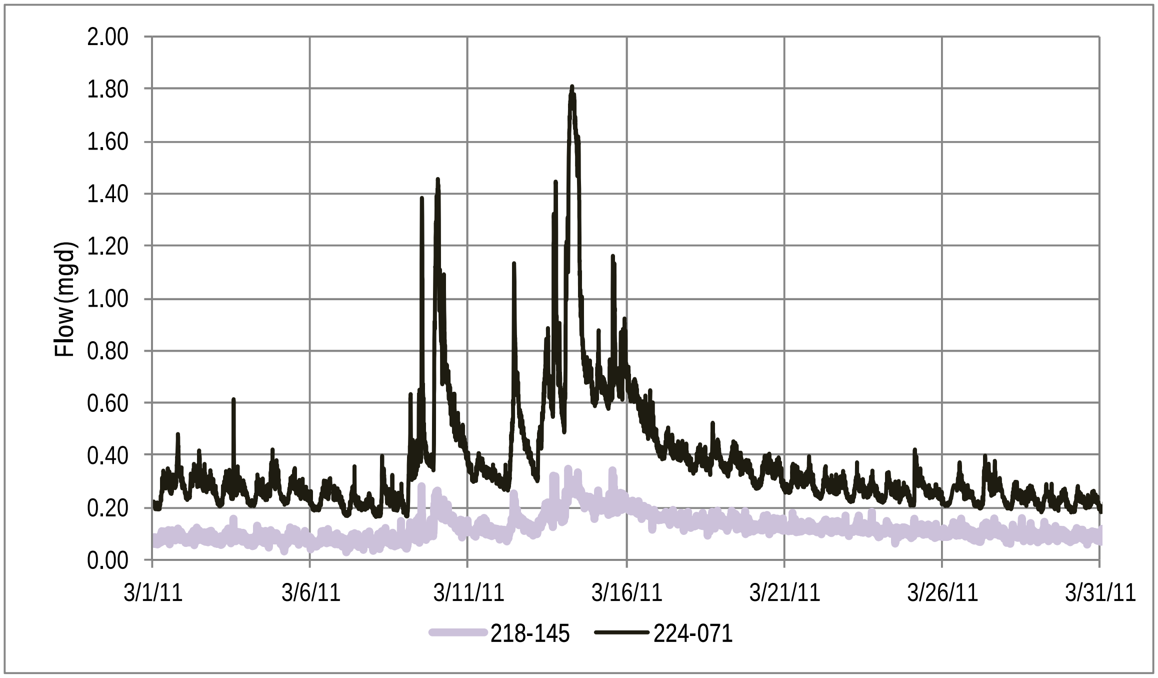


Figure 6-1. Flow Monitoring Data Before Flood Grouting (Pre-Project) at Two Locations.

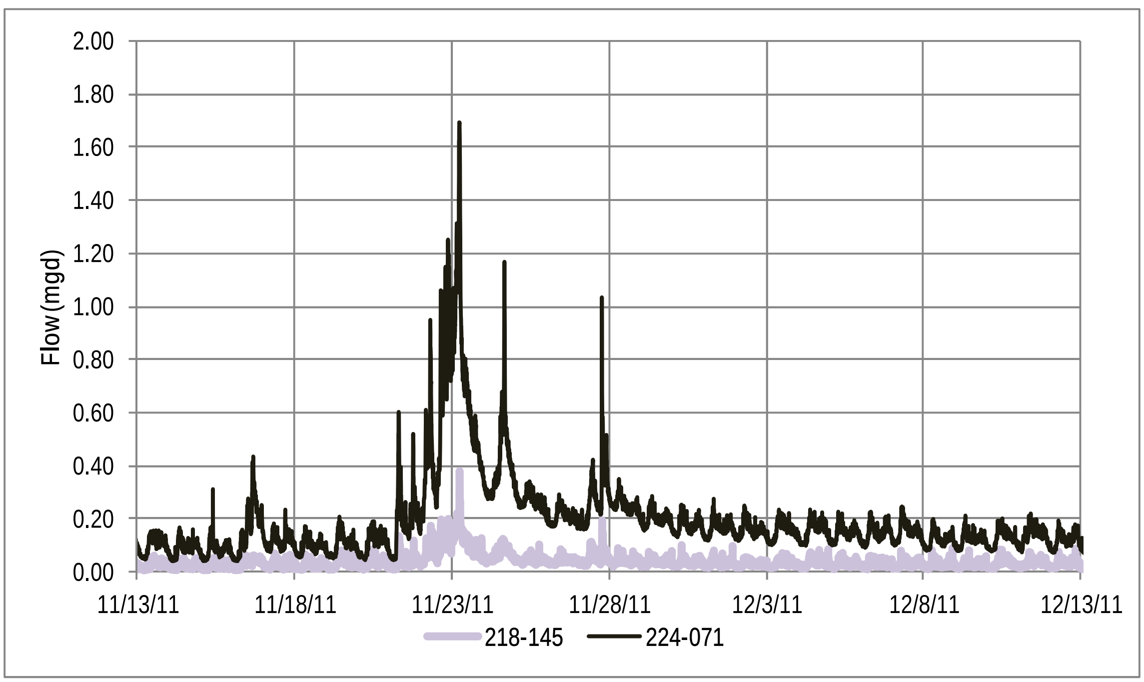


Figure 6-2. Flow Monitoring Data After Flood Grouting (Post-Project) at Two Locations.

Figure 6-3 presents a scatter plot of flow at the project meter site (218-145) against the downstream meter (224-071) for the recessions in the two events discussed above. A dramatic difference is evident, further documenting a change in I/I after the project.

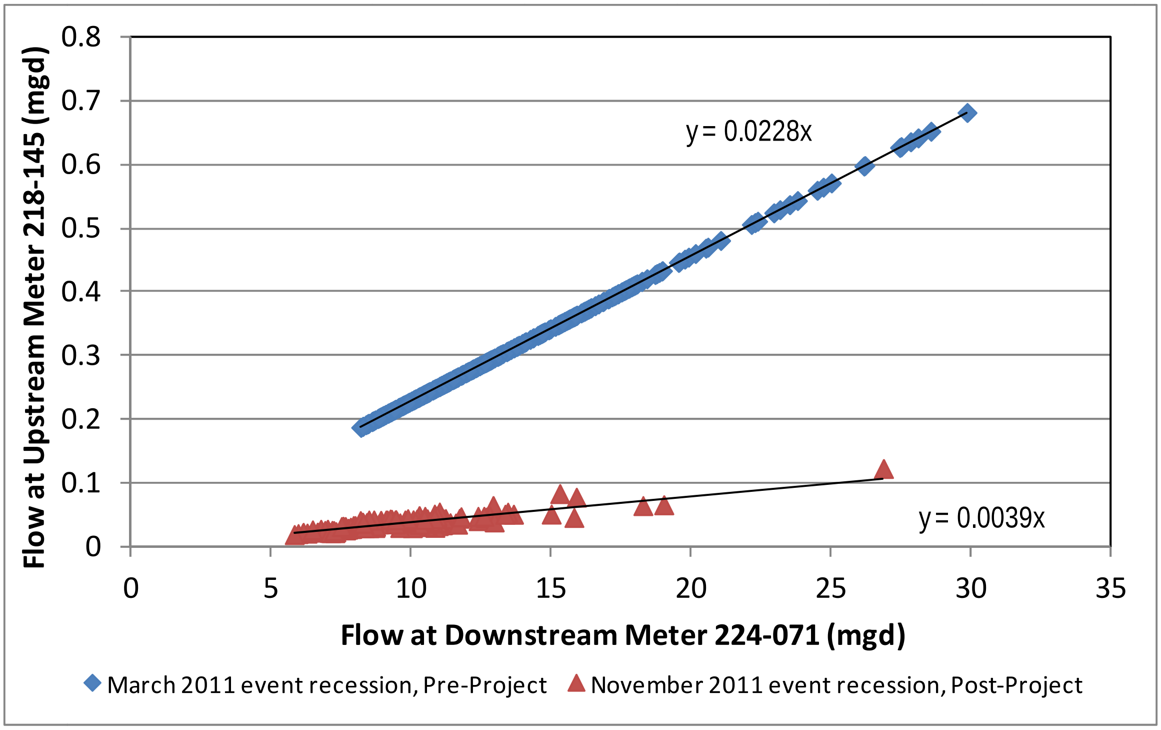


Figure 6-3. Scatter Plots of Flow at Meter 218-145 Against 224-071 Flow for Recessions of March 2011 and November 2011 Events. The Relationship is Obviously Changed.

6.2.2 Hydrologic Modeling

The two methods employed to assess effectiveness of I/I reduction are described in detail in Section 2.4. The results from each method are presented below.

6.2.2.1 Comparison of Continuous Simulation Model Results

The two continuous hydrologic and hydraulic models developed to predict I/I before and after rehabilitation were calibrated to the flow monitoring data at 218-145 and 224-071, as described in Section 2.4.1. A satisfactory fit between observed and simulated flows was achieved for both monitoring periods, as shown in Figures 6-4, 6-5, and 6-6. The flow volume goodness-of-fit for the pre-project (March 2011 through September 2011) and post-project (October 2011 through April 2012) models was 1.16 and 1.12, respectively.

The model simulates flow higher than observed during the recession of the November 2011 (after rehabilitation) event (Figure 6-6). The model was calibrated to simulate groundwater necessary to match the long recessions after storm events typical in the mid to late wet season. However, when the model matched these events, the early wet season events (similar to November 2011) had additional I/I simulated in the recession. This may result in a lower estimate of I/I reduction when comparing pre- and post-rehabilitation models because the model simulates more infiltration than is observed for the pre-rehabilitation condition.

The calibrated I/I models differ principally in the value of the long-term response to rainfall, suggesting the reduction occurred mostly for the long-term infiltration sources rather than the faster-responding sources. This is consistent with the fact that much of the faster-acting upper side sewers (which are the portion of the side sewer located closest to the house) could not be addressed and inflow sources were not removed. The long-term reduction of infiltration was represented in the model by lowering the coefficient (A1) controlling groundwater contributing to the sanitary pipes. This does not reduce the volume of groundwater simulated by the model, but it reduces the amount of groundwater entering the pipes, which is consistent with the rehabilitation employed.

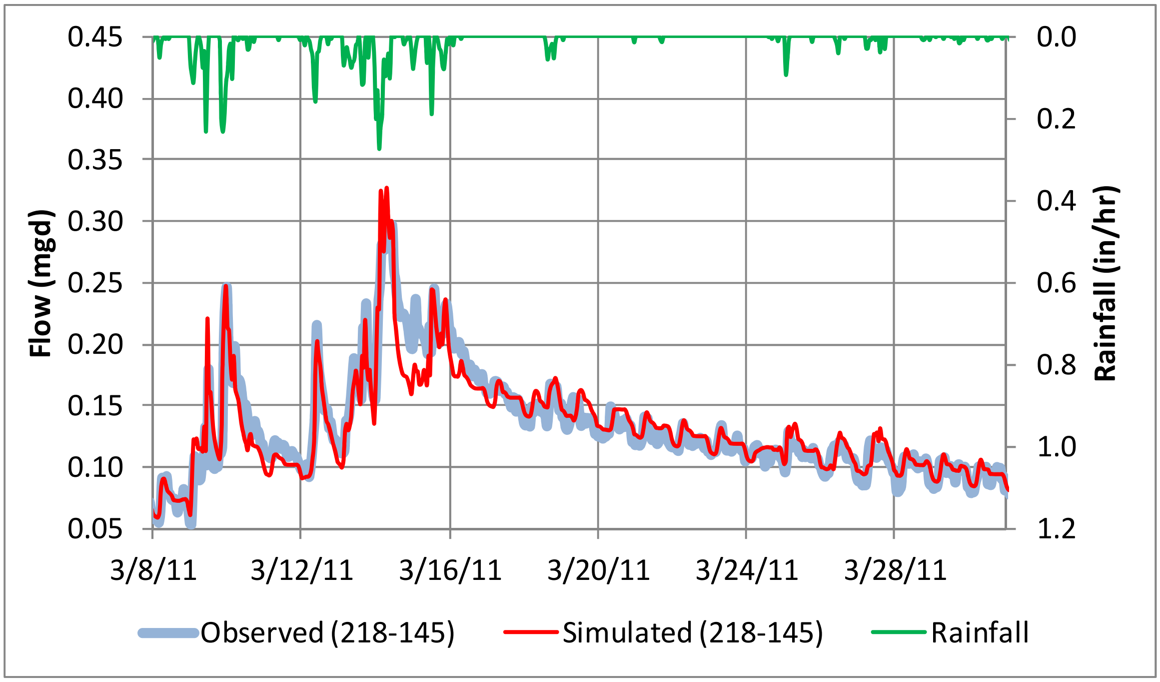


Figure 6-4. Pre-Project Model Calibration for March 2011 Rainfall Event.

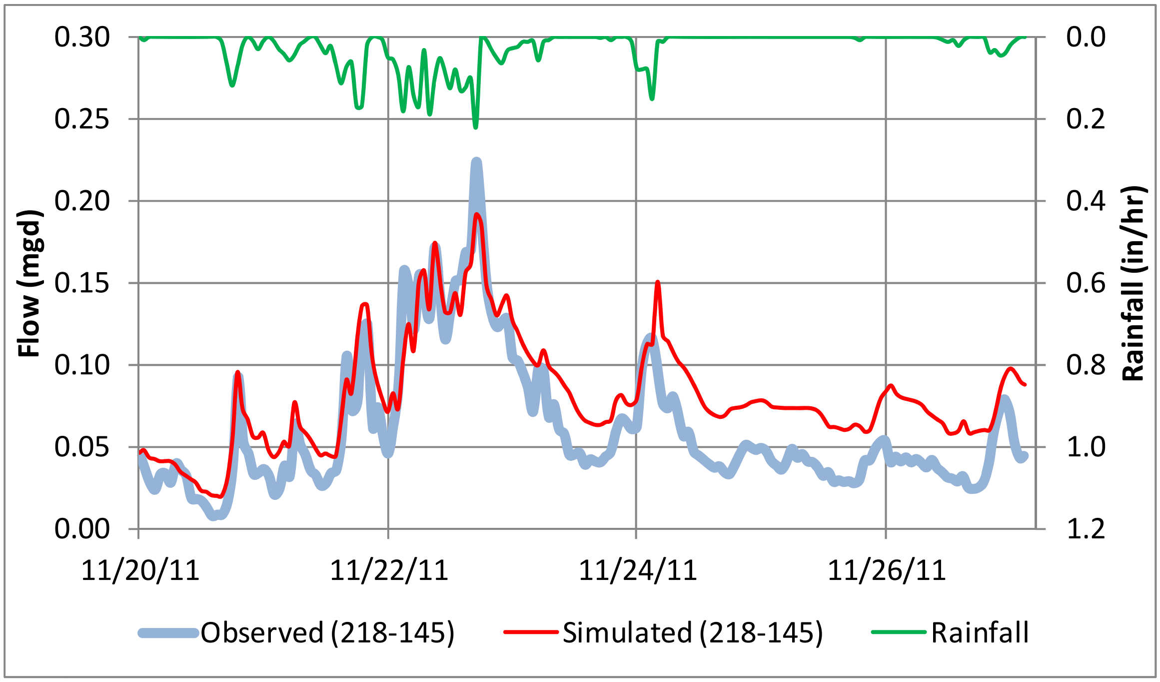


Figure 6-5. Post-Project Model Calibration for November 2011 Rainfall Event.

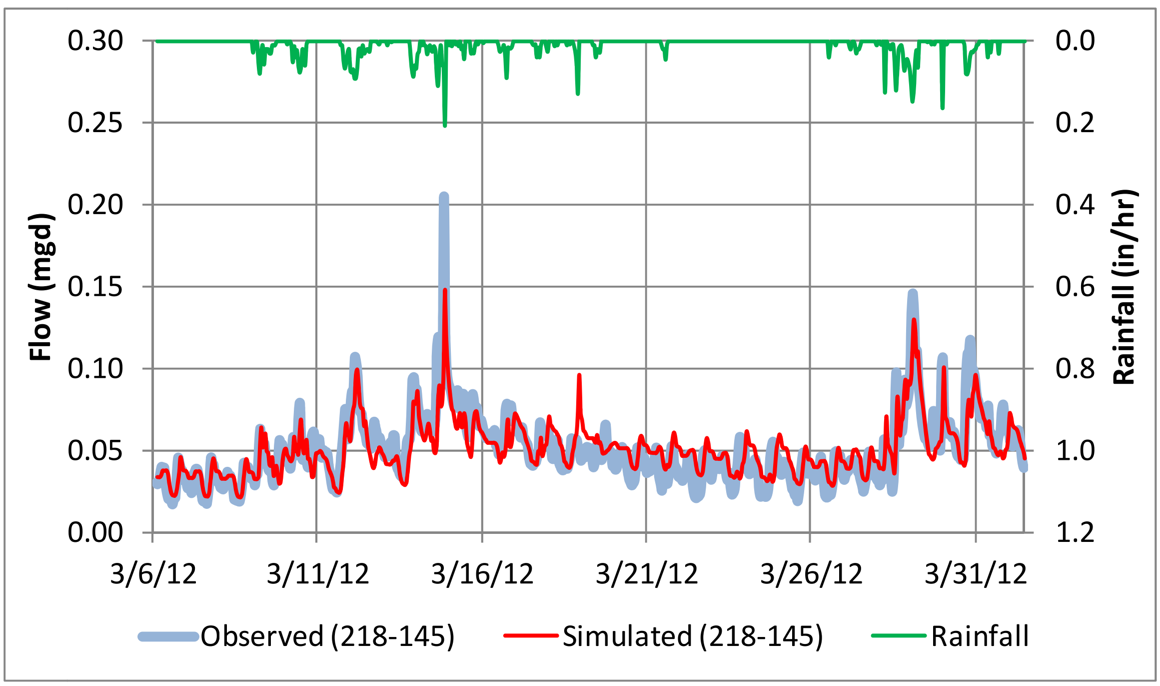


Figure 6-6. Post-Project Model Calibration for March 2012 Rainfall Events.

To compare the pre- and post-rehabilitation condition flows statistically, both models were used to simulate long-term flow conditions with the full SPU rain gauge record. First, the simulated annual peak hourly I/I were fit to an LP3 distribution and pre- and post-project values for similar recurrence intervals were compared. The results of this are shown in Figure 6-7. This comparison indicates a reduction of peak hourly flow I/I of approximately 41% for recurrence intervals of 10 years and greater. This relatively low reduction again reflects the fact that the project did not address directly connected runoff from impervious sources like rooftops and sump pumps, nor was it able to seal the fast-acting upper side sewers.

Figure 6-8 shows the recurrence interval statistics for the peak annual 24-hour I/I flow. A reduction by the project of about 32% is indicated for the 10-year recurrence interval.

A similar analysis and comparison was completed for simulated total I/I event volume. An event was defined by periods where I/I flow was greater than 0.13 million gallons per day (mgd) and separated by a minimum period of 6 hours. An "event," so defined, can last from one to many days. The annual maximum event I/I volume frequency comparison is shown in Figure 6-9.

As is evident visually, the reduction in event I/I volume for a given recurrence interval is greater than the reduction in peak flow. Specifically, for recurrence intervals of 10 years and greater, the reduction in maximum annual event I/I volume from pre-project to post-project has an average of approximately 66%. While less important for conveyance analysis, the event volume reduction is important to assess the impact of the project on downstream wastewater treatment costs. Table 6-2 summarizes the above and other statistics.

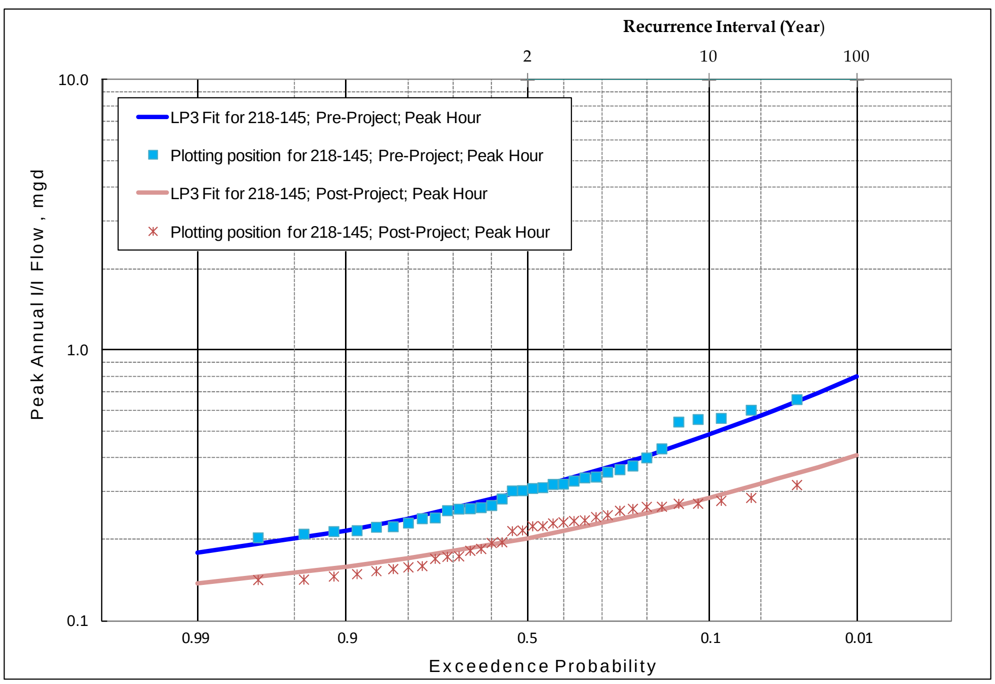


Figure 6-7. Peak Hour I/I Flow Frequency for Pre- and Post-Project Simulation Results (1978-2012).

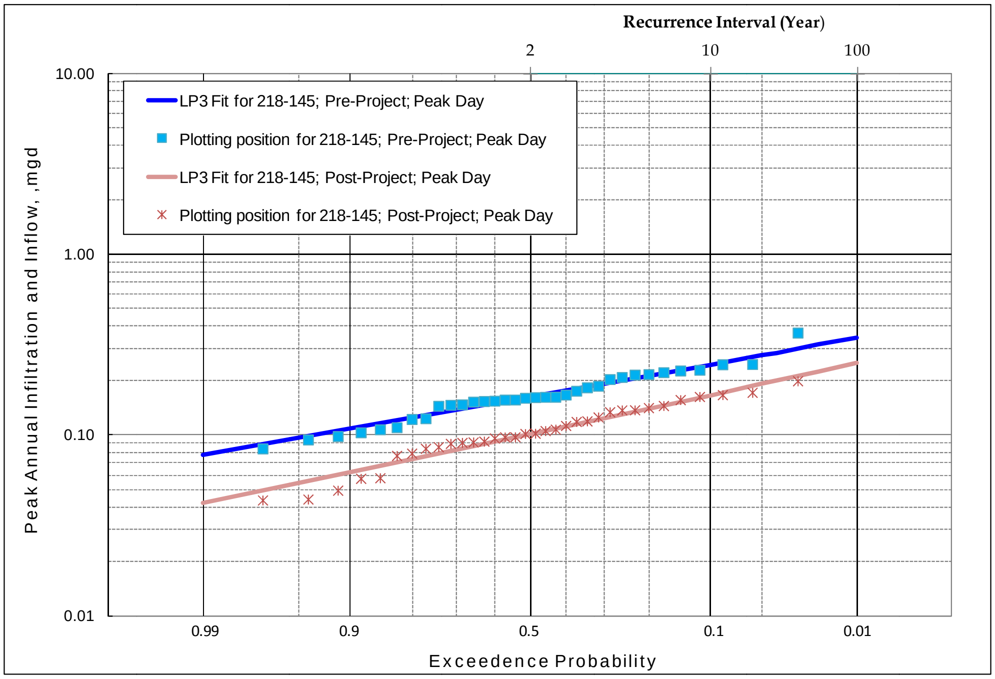


Figure 6-8. Peak Day I/I Flow Frequency for Pre- and Post-Project Simulation Results (1978-2012).

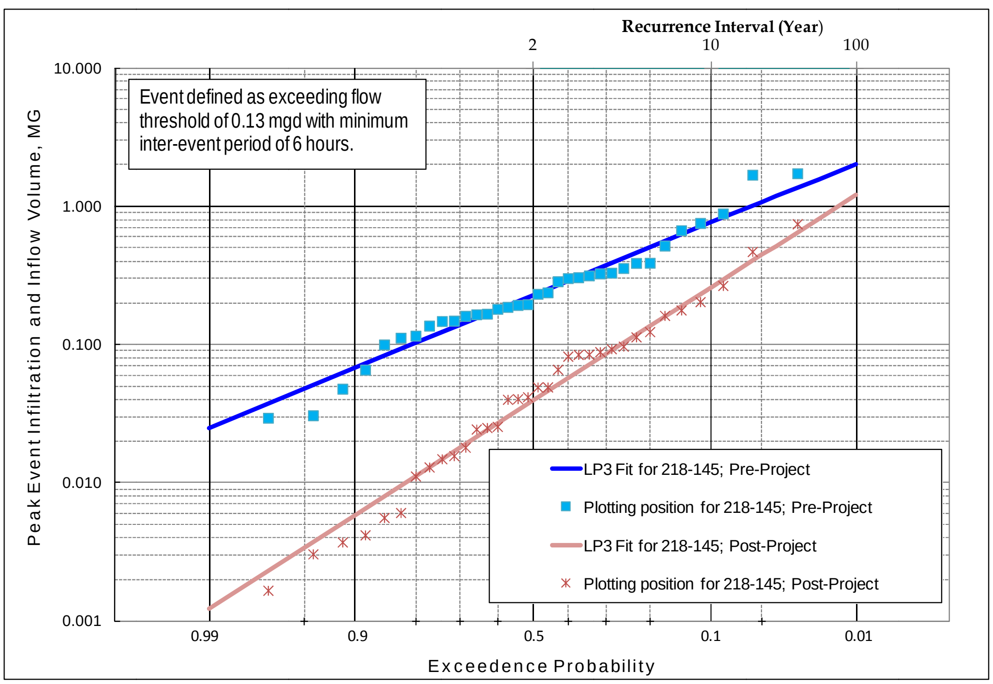


Figure 6-9. Event I/I Volume Frequency for Pre- and Post-Project Simulation Results (1978-2012).

Table 6-2. Summary of I/I Reduction.

Statistic [a]	Before Project	After Project	Percent Reduction
Peak hour I/I (mgd)	0.49	0.28	41%
Peak 24-hr I/I (mgd)	0.25	0.17	32%
Maximum event vol. (mg)	0.76	0.25	66%
Annual average I/I (mgd)	0.03	0.01	68%
Dry weather flow (mgd)	0.03	0.025	15%

[a] *Values for once-in-10-year recurrence except for annual and dry weather flow.*

6.2.2.2 Control Basin

The results of comparing peak flows at meter 218-145 with those at 224-103 for the monitoring period are shown in Figure 6-10. The comparison indicates the flood grouting achieved removal of peak I/I flow. More specifically, the lower slope of the best fit line for post-project data (compared to the pre-project best fit line) signifies a lower I/I peak flow rate. Therefore, the control basin analysis supports the continuous simulation model finding.

Figure 6-10 does not include the pre-rehabilitation flow for the March 13, 2011, event because the 224-103 meter had several missing data points during this event. This was the largest peak flow value for the 218-145 meter.

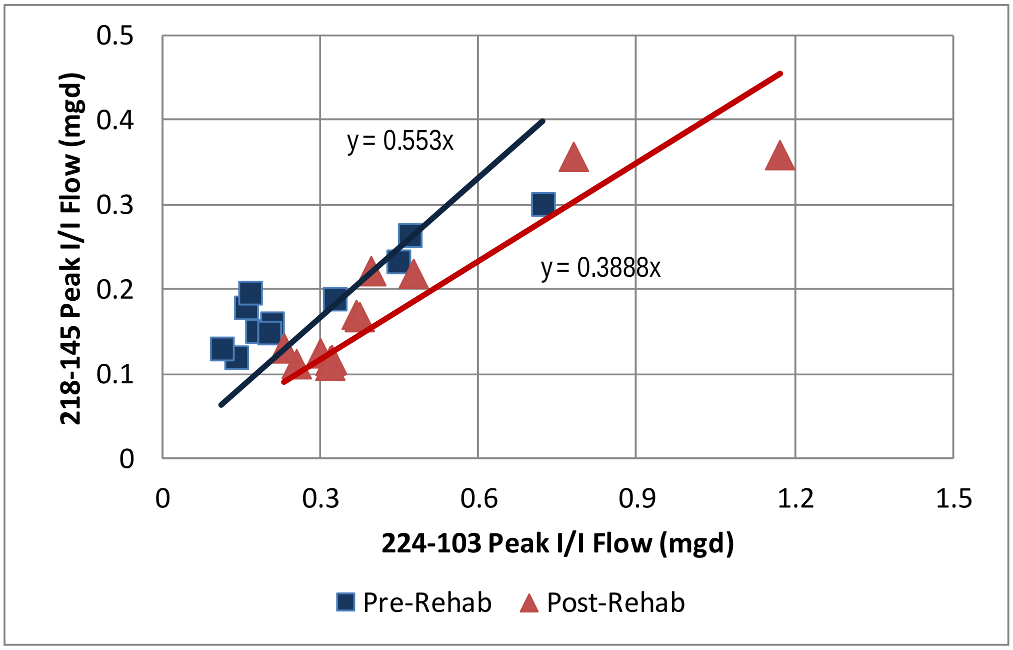


Figure 6-10. Scatter Plots of Peak I/I Flow Measured at Meter 224-103 Compared to Peak I/I Flow Measured at Meter 218-145 for Pre- and Post-Rehabilitation Periods (March 2011 to April 2012).

The event volumes at each meter were also compared for the monitoring period, as shown in Figure 6-11. Similar to the peak flow comparison above, the different slopes of the pre- and post-project best fit lines indicate the flood grouting achieved a significant removal of I/I volume. This conclusion supports the long-term, continuous simulation results.

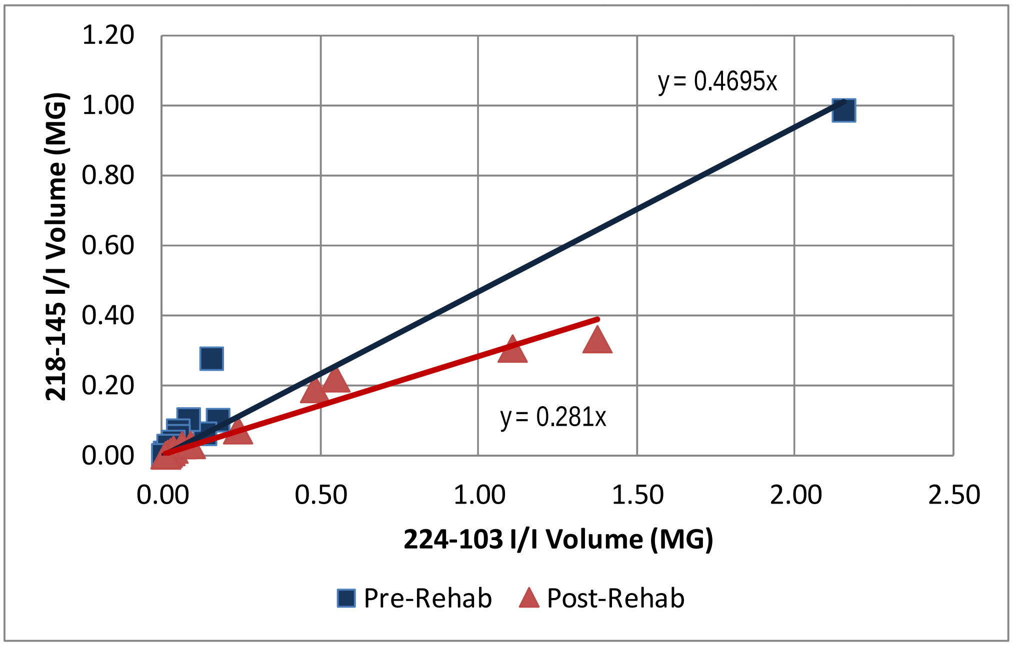


Figure 6-11. Scatter Plots of Event I/I Volume Measured at Meter 224-103 Compared to Event I/I Volume Measured at Meter 218-145 for Pre- and Post-Rehabilitation Periods (March 2011 to April 2012).

As discussed in Section 6.2.3, the MH sealing along half of the contributory area to flow meter 224-103 did not change the flow patterns at flow meter 224-103.

6.2.3 Maintenance Hole Sealing

The City used remaining chemical at the conclusion of the flood grouting project to seal only MHs in the control basin along 4th Avenue NW. The effect, if any, of reducing I/I as a result of the MH grouting was of interest. The flow monitoring data at the meter downstream of the sealing, 224-103, was used for comparing the pre-rehabilitation (before January 2012) and post-rehabilitation I/I.

The peak flow monitoring data were compared to antecedent rainfall (12 hours) for select events, which resulted in identification of a relationship between I/I and antecedent rainfall for both pre- and post-rehabilitation monitoring periods. The relationship, measured by the slope of the best fit line for the data for pre- and post-rehabilitation, did not differ significantly. This similarity suggests that the MH-only rehabilitation did not have a significant effect on I/I reduction. The comparison is shown in Figure 6-12.

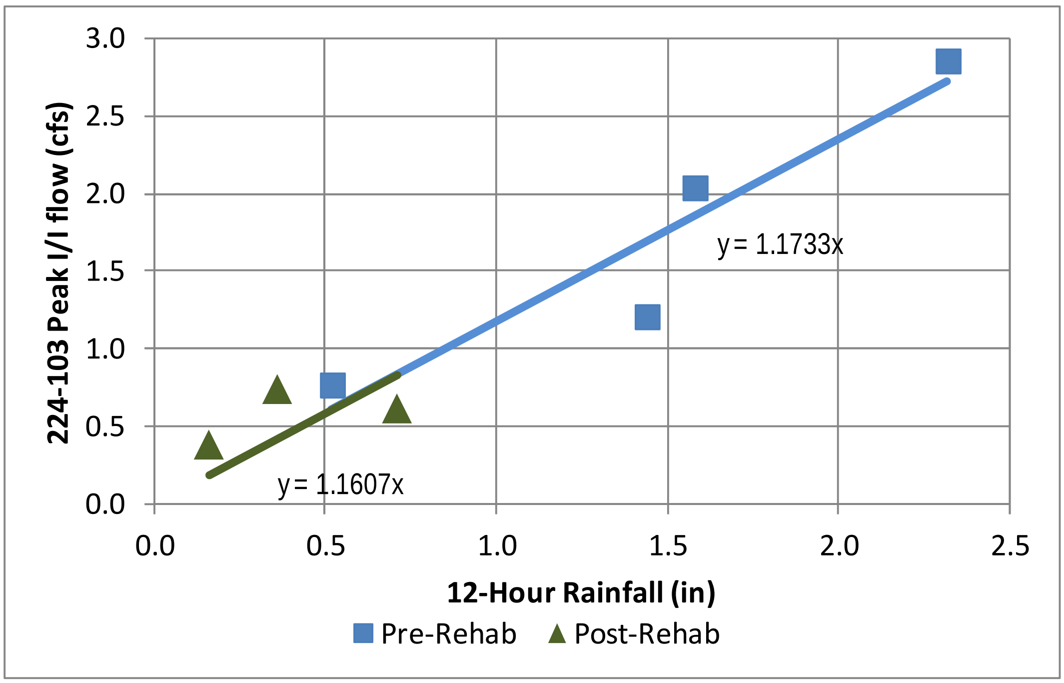


Figure 6-12. Scatter Plot of Event I/I Peak Flow Measured at Meter 224-103 Compared to Rainfall 12 Hours Preceding Event Measured at SPU RG 07 for Pre- and Post-Maintenance Hole Only Rehabilitation (December 2010 to March 2012).

In addition to the comparison above, observed baseflow was compared for the pre- and post-rehabilitation periods. Flood grouting the MHs, if effective in reducing I/I, would reduce the base, long-term infiltration observed as baseflow in the monitoring data. However, comparison of baseflow for August 2011 (pre-rehabilitation) and August 2012 (post-rehabilitation) show no significant difference in baseflow. This supports the conclusion, along with the previous analysis, that there is no significant reduction of I/I as a result of flood grouting MHs.

6.3 Costs

SPU was very conscientious about tracking all associated costs with this project. This included preparation of the business case, flow monitoring, public relations, and preliminary engineering. The money spent prior to construction was about $110,000. In addition to the contractor's construction cost (Table 6-3), SPU spent an additional $210,000 on construction support, flow monitoring, and consultants. An additional $125,000 was spent between SPU and outside consultants on project closeout and evaluation. Therefore, the total estimated money spent on this project from initiation through evaluation and closeout is as follows:

- Preliminary selection and engineering.............$110,000
- Construction...$1,243,000
- Project closeout and evaluation $125,000
- Total...$1,478,000

The original project cost estimate for this pilot project was $1,275,000. The actual costs ended up $203,000 (16%) over the original estimate. The higher cost was principally due to higher chemical costs than anticipated, the project construction work taking nine days longer to complete than anticipated, and conducting 3D mapping of the installed cleanouts and MHs not included in the original estimate.

Table 6-3. Total Contractor Construction Costs.

Item	Total Cost
Pre-inspection/cleaning	$47,950
C/O installation	$109,536
Flood grouting work by contractor	$210,564
Post-work cleanup and CCTV	$24,650
Equipment, bypass pumping, mobilization, etc.	$38,500
Sanipor chemicals	$335,029
Sanipor labor and mobilization	$101,410
Subtotal	$867,639
PM, overhead, contingency	$76,116
Total	$943,755
Washington state sales tax (9.5%)	$89,657
Total construction cost	$1,033,412

6.3.1 Comparative Costs

One of the challenges of developing a unit cost of flood grouting is that it is applied to all of the sewer system components at once. Traditionally, side sewers, mainlines, and MHs all have separate unit costs for rehabilitation, because different methods are applied to each. Although such a cost split among sewer system components is not possible, several options are available for doing so. These options include allocation by treated system cost value, linear distance of system component, internal surface area of system component, and potentially others.

For this comparison, this flood grouting project will be assessed on a linear distance basis. The unit price from this project will be the sum of the side sewers (2,900 linear feet [lf]), mainlines (5,880 lf), and the vertical footage of the MHs (260 lf) that was actually sealed divided by the construction costs. The total length of the sewer assets sealed was 9,040 lf. This resulted in a total project cost of $164/lf and a construction unit cost of $114/lf.

A significant volume of chemical was left over after the completion of the grouting. This remaining volume had a value of about $224,000. If the leftover chemical value is subtracted from the construction cost, the construction cost is reduced to $810,000, resulting in a unit construction cost of $90/lf.

Because this was the first time that the contractor has worked with flood grouting chemicals, additional resources were allocated for having Sanipor officials to be present to supervise, train, and conduct the grouting. This was an additional $111,000 after taxes. The contractor is now versed in the flood grouting process, and would no longer need this additional cost for future projects. Reducing the chemical used cost of $810,000 by $111,000 equals $699,000, which reduces the construction unit cost to $77/lf.

The business case developed cost estimates for the alternative infiltration control technologies of joint grouting, CIPP lining, and pipe bursting. The estimated construction unit cost estimates and the actual flood grouting unit cost are as follows:

- Joint grouting: $50/lf
- Flood grouting: $77/lf
- CIPP lining: $120/lf
- Pipe bursting: $120/lf

The sewers within the project area have a fair number of cracks and other defects that would not have been sealed by joint grouting. While joint grouting is less expensive then flood grouting, it is believed that this method would not have sealed the sewers as well as flood grouting, due to the limitations described earlier.

There are several alternative ways to develop unit costs for flood grouting. In addition to a length of pipe sealed, one can use surface area of the assets treated, the cubic volume of the assets treated, or the number of houses within the project boundary. The other unit costs are listed in Table 6-4.

Table 6-4. Unit Construction Costs.

Measurement	Units	Cost	Unit Cost
Length (ft)	9,040	$699,000	$77
Inner surface area (ft^2)	20,570	$699,000	$34
Volume (ft^3)	13,755	$699,000	$51
No. of houses	88	$699,000	$7,943

6.3.1.1 Cost of Installing the Cleanouts

The contractor charged $1,300 to install each cleanout via LMK's Vac-A-Tee method. Cleanouts could have been installed less expensively using excavation methods, but such methods result in greater disruption to landscaping. Because of SPU's commitment to cause as little disturbance to the community as possible, the extra cost for this less intrusive method was accepted. If a community already has outside cleanouts installed and in good condition, this considerable cost would not be necessary, further increasing the cost-effectiveness of flood grouting.

6.4 Updates to Business Case Inputs

The business case used to validate the financial efficacy of this project was very dependent upon both the cost and the benefit inputs. The benefits and costs inputs were reevaluated after construction costs were known, and the updated business case is discussed below.

Monetary amounts were given to three benefits from completing this project: reduced claims, offset CSO storage volume, and reduced daily conveyance and treatment costs. The average daily infiltration was shown to be reduced significantly more than anticipated. The original estimate was that the daily infiltration would be reduced by about 10,000 gpd; however, the actual reduction is 27,400 gpd. The NPV of this amount (3%, 20 years) is $113,000 versus $42,000 as originally estimated.

The reduced peak flow from a large storm event that may have to be managed at King County's CSO facility was determined to be 150,000 gallons versus the estimated 200,000 gallons. This results in a lower benefit of $900,000 versus the estimated $1.2 million.

The before and after modeled hydraulic grade lines were compared to each other and to surveyed basement elevations of nearby houses. It was determined that over a long-term simulation of 34 years' worth of rainfall data, there may have been 10 fewer basement backups (claims) following completion of this pilot project. The NPV of this amount (3%, 20 years, $100,000/claim) is $450,000 versus the estimated $490,000.

The cost for each cleanout ended up being $1,304 versus the estimated $1,000 for each installation. The inspection cost of $250 per each side sewer remained the same. Because some side sewers were shared, only 85 cleanout and inspections had to take place. The updated benefit for the homeowners of this work is $132,000. Table 6-5 shows the updated NPV of the pilot project.

Table 6-5. Updated Net Present Value: Flood Grouting.

	Reduced Backups	CSO Storage Reduction	Avoided Treatment	Cleanouts and Inspection	Total Benefit	Initial Cost	Salvage Value	Net Present Value
Original	$490,000	$1,200,000	$42,000	$110,000	$1,842,000	$1,275,000	$0	$567,000
Updated	$450,000	$900,000	$113,000	$132,000	$1,595,000	$1,478,000	$0	$117,000

The monetized benefits from completing this pilot project are higher than the cost of completing the project. While the benefits are not as high as originally estimated, this project is thought to be a success. If the project was completed now, knowing what the project team now knows, the costs would be about $300,000 less, moving the NPV even higher. Some of the improved cost efficiencies include having a better understanding of the volume of chemicals to order and the knowledge of how to conduct the actual grouting paid for as part of the pilot.

Additional non-monetized benefits have also been realized. Where the flood grouting was completed, the soils have been solidified, stabilizing the pipe, and reducing the susceptibility to sluice in soils, causing sags and breaks in the pipe. SPU has learned valuable lessons on dealing with private property and how to move forward with future work on private property. The project team now has firsthand experience with flood grouting. The information and know-how gained from this project can be utilized on future projects. In addition, the situation with being able to capture only a smaller percentage of the side sewers can be used to properly estimate the outcome from completing a future project. Further, in areas of extremely complex side sewers and hilly areas, knowing the limitations of flood grouting may sway the team to use another rehabilitation method in such circumstances.

Updated NPVs for the alternative rehabilitation methods cannot be calculated because it is not known what removal rates those methods would have accomplished and their costs could have been significantly different than estimated.

6.5 Challenges and Lessons Learned

The following section describes lessons learned from the flood grouting pilot project, including construction challenges and side sewer lessons learned.

6.5.1 Construction Challenges

As with any new technology, challenges and unanticipated conditions were encountered. First and foremost was the topography of the project site. The hilly site has considerable elevation differences between upstream and downstream MHs and the high and low sides of the street. The worst-case MH-to-MH reach had a 30-foot difference in rim elevations, and that occurred over a horizontal distance of 250'. To maximize the application of the grout, riser pipes were installed on low-side cleanouts to help manipulate the hydraulic grade, as shown in Figure 6-13.

Figure 6-13. Riser Pipes.

Since the completion of the pilot project, an alternative method used to plug the side sewers during the grouting has been identified. This method is believed to provide additional protection to the houses, provide an early warning method to alert contractors in the event of grout bypassing the plugs, and make it easier to manipulate the hydraulic grade line. Previously, one inflatable plug was inserted in the house side of the side sewer from the cleanout. There was no way to detect if grout was leaking past the plug and flooding a house. A side sewer flow-through inflatable plug with a flexible hose to the surface can be used on the sewer side of the cleanout (a vent is required to relieve air pressure as the system is filled with grout). As backup to this in case of flow-through plug failure, the traditional inflatable plug can be used on the house side of the cleanout. In addition to two plugs, the invert of the cleanout is left open for visual verification of any leaks from the primary flow-through plug.

Another challenge was that at three locations the chemicals leaked out from cracks in the pavement on the downhill side of pipe segments (Figures 6-14 and 6-15). In these instances, the chemical elevation was immediately brought down and the application continued in lifts (repeating the sealing process, increasing the elevation of the liquid in the MH in 2-3-foot increments) to slowly seal the higher pipes. When S1 is allowed to dry on the surface, it solidifies with a glass-like consistency. Immediate and thorough spill response is a necessity. Bravo had a street sweeper on site that was used to clean up S1 that migrated its way to the surface.

Figure 6-14. S1 Leaking Through Pavement.

Figure 6-15. S1 Projecting Through Pavement.

Chemical S1 has a specific gravity (SG) of 1.4. Because of this, the contractor had to be very careful about how much chemical it could put in the tanker trucks before exceeding weight limits (the trucks would be overweight before the tanks were full). In addition to the loading concerns, the contractor had to send the truck used for S1 to the shop for repairs on the brake system twice during construction due to the heavy loads and parking on the steep streets (Schumacher, 2011). Also because of S1's weight and viscosity, a very powerful pump is needed to be able to quickly pump out the liquid from the sewer system. The grouting application needs a very quick transfer from S1 to S2 to properly seal the system and avoid having the S1 either leach back into the pipes or migrate too far away in the soil before it can react with the S2. The contractor had to switch trucks that originally contained each chemical because the pump on the original S1 truck was not powerful enough to pump the heavy liquid. No such issues affect working with the S2 product.

6.5.2 Side Sewer Issues

One of the known and accepted risks of this project was the potential to flood a basement with either clean water during a clean water test or with one of the two chemicals. Unfortunately, this did occur on this project. Each instance was unique and the cause and a solution were identified for each case.

The lessons learned from this include making sure that the side sewer plug is properly inserted into the side sewer. When the side sewer is deep (greater than 7'), it is challenging to visually confirm from the surface that the plug is properly inserted and inflated, and that nothing is interfering with the plug. On these deep side sewers it is beneficial to insert an inspection camera down the cleanout to see the plug and verify that it is properly placed.

A second lesson learned is that in locations where hydrostatic pressures will be elevated, greater than 20’, using a second side sewer plug may be required. This is especially true where the side sewer is made of concrete pipe and has exposed aggregate. The exposed aggregate may prevent the plug from properly sealing and allow some chemical or water past. The second plug provides redundancy to help mitigate this possibility. It may be necessary to install a second cleanout to place the second plug.

A third lesson is that both internal mapping and surface mapping must be verified and corroborated. The two sources of information need to be overlaid onto each other and all connections must be accounted for and distances matched to each other so that a side sewer connection is not missed.

A final construction lesson learned on this project is that backflow preventers may not properly work during grouting operations. The first chemical used (S1) has an SG of 1.4. Normally closed rubber flappers used on some backflow preventers have an SG ranging from 1.33 to 1.36 (RectorSeal, 2012). Because the flappers are lighter than S1, the flapper floats and does not prevent the fluid from passing the backflow valve.

6.6 Further Considerations

The following section describes some further considerations related to working on private side sewers, groundwater, and contracting.

6.6.1 Dealing with Side Sewers

As previously mentioned, the property owners own and maintain the side sewers from the house to the sewer main connection. It had been SPU’s policy not to touch the private side sewers or do any work on private property. A growing body of industry literature supports the position that for an infiltration reduction project to achieve maximum potential reduction, side sewers have to be included in the rehabilitation effort (Merrill et al., 2003). With the goal of reducing wet weather backups in the Broadview neighborhood, SPU decided that it is willing to undertake work on private property. In consultation with its lawyer, SPU developed access agreements to allow access to the private property and to work on the privately held assets (see Appendix C).

From Section 6.1, it has been shown that where the sewer system was rehabilitated, on average, 99% of the infiltration sources have been eliminated. However, as shown in the modeling results, there still is an appreciable volume of infiltration of the system. The only portion of the system that was not treated was the upper private side sewers. Within the completed pilot project basin 1,750’ (18% of the total length) of side sewers lie within the right-of-way and an additional 1,150’ (12% of the total length) was sealed beyond the right-of-way. This left 6,825’ (70% of the total length) untreated. The researchers believe that this shows how important it is to deal with the side sewers. To achieve the maximum peak flow reduction, the shallower, upper side sewers close to houses need to be addressed in conjunction with the rest of the system. The time and money spent on public outreach is necessary to accomplish this.

6.6.2 Groundwater Issues

When conducting an infiltration reduction project, changes to the groundwater after the sewer system is sealed must be evaluated. Some outcomes from sealing the sewers may be increased "wet basements," increased wet areas or standing water, seeps (groundwater coming out onto the surface) occurring where they have not before, or increased flow in existing seeps. It is challenging, time-consuming, and costly to attempt to model the groundwater changes and predict what may happen and where.

A change in the groundwater elevation was accounted for in this project's Risk Register as potentially occurring. Predicting where the changes would occur and their magnitude was not attempted. It was decided that changes to how the groundwater expressed itself that warranted correction would be addressed as they occurred. In some projects the risks may be too great for this approach. In these instances groundwater control may be required, or a solution other than infiltration reduction is required to provide sewer capacity.

6.6.3 Contracting

The project team is currently aware of only two providers of the flood grouting chemicals and know-how in the United States. Neither of these two companies install their product and they have to team with or provide their product to a sewer service construction company. The limited source of providers can cause challenges when trying to competitively bid a flood grouting project. For flood grouting to become more cost effective and widespread, a strong local presence of the chemical providers needs to develop in the United States. In addition, more construction companies are needed that have the equipment, experience, and know-how to successfully implement a flood grouting project to increase competition and increase the ability to competitively bid a flood grouting project.

6.7 Conclusions

This project was successful from several perspectives:

- ♦ The technology is successful in reducing infiltration with relatively little disruption to the community and at a potentially lower cost than other technologies.
- ♦ Working on private side sewers is both necessary to attain maximum infiltration reduction and is achievable with effective public outreach.
- ♦ Use of flexible contracting options such as use of a service contract can improve project efficiency by reducing "soft costs".

At the same time it is important to keep in mind some of the challenges to implementing flood grouting:

- ♦ At this time there are limited options of vendors supplying the technology in the United States.
- ♦ It is important to use an experienced contractor who has all the needed equipment including appropriate plugs, CCTV cameras, and pumps with sufficient power.
- ♦ As much of the side sewer length as possible needs to be sealed to maximize infiltration reduction.
- ♦ The potential impact of controlling infiltration on groundwater migration needs to be considered. Certain soil types or topography such as steep slope areas may not be good candidates for infiltration control.

APPENDIX A

MATERIAL SAFETY DATA SHEETS

MATERIAL SAFETY DATA SHEET

http://www.ekamsds.com

1. Chemical Product and Company Identification

Eka Chemicals Inc.
1775 West Oak Commons Court
Marietta, GA 30062
USA

24 Hour Emergency Number
US CHEMTREC 1-800-424-9300
CANADA CANUTEC 1-613-966-6666

Product Name
SANIPOR® S1

CAS #

Chemical Type
Aqueous solution.

Intended Use
To repair leaking sewers and laterals

2 Hazards Identification

Emergency Overview	A viscous colorless to yellowish odorless liquid.
Routes of Exposure	The most likely exposure routes are by skin and eye contact.
Potential Health Effects	
Ingestion	May irritate the mouth, throat, esophagus, and stomach
Skin	May irritate.
Eyes	Moderately irritating
Inhalation	Inhalation of mist can cause respiratory irritation.
Target organs	No Information
Chronic Effects	None known
Medical Conditions Aggravated by Exposure	None known
Potential Environmental Effects	Due to high pH, release into surface water may be harmful to aquatic life

3. Composition / Information on Ingredients

Component	*CAS #*	*% Wt/Wt*
Sodium silicate	1344-09-8	> 1 %

Ingredient Information Not applicable

4. First Aid Measures

First Aid

Ingestion	Immediately rinse mouth with water. Keep at rest and obtain medical attention.DO NOT INDUCE VOMITING.
Skin	Immediately wash with plenty of soap and water. Remove all contaminated clothing which should be laundered before reuse.
Eyes	Immediately wash eye with water for at least 15 minutes.
Inhalation	Remove patient to fresh air and seek medical attention if breathing becomes difficult.
Notes to Physician	No Information

5. Fire Fighting Measures

Flammable Properties	None known
Extinguishing Media	
Suitable Extinguishing Media	Not applicable
Unsuitable Extinguishing Media	Not applicable
Protection of Fire Fighters	
Protective Equipment for Fire Fighters	Toxic fumes evolved on combustion,self-contained breathing apparatus must be worn.
Specific Hazards Arising From the Chemical	The product is not flammable but it may sustain combustion.

6. Accidental Release Measures

Personal Precautions	Goggles, rubber/PVC gloves. Full working clothes recommended.
Environmental Precautions	In accordance with local, state, provincial, and federal regulations. Spills should be contained, solidified and placed in a suitable container for disposal in a properly permitted chemical disposal facility. Do not discharge into waterways or sewerage systems.
Methods for Containment	Stop source of leak if possible. Dike the spilled material, where this is possible. Contain spill using noncombustible material such as vermiculite, sand or earth. Block any potential routes to water systems.
Methods for Clean-up	Sweep up or gather material and place in appropriate container for disposal. Wash spill area thoroughly. Wear appropriate protective equipment during cleanup.

7. Handling and Storage

Handling Procedures	Avoid contact with skin and eyes. Handle in a well-ventilated place. Avoid spillage on floor as the product is slippery. Normal handling precautions applicable to industrial chemicals. May react with ammonia salts resulting in ammonia gas
Storage Procedures	Keep containers closed. Store in clean steel or plastic containers. Separate from acids, reactive metals, and ammonium salts. Storage temperature 0-95C. Loading temperature 45-95C. Do not store in aluminum, fiberglass, copper, brass, zinc, or galvanized containers.

8. Exposure Controls / Personal Protection

Exposure Guidelines	Amorphous silica: OSHA exposure limit: 5 mg/m3 Si02 respirable dust or mist, 10 mg/m3 total. 8 hour time weighted average.
Engineering Controls	Use local exhaust if misting occurs. Natural ventilation is adequate in absence of mists.
Personal Protective Equipment	
Eyes/Face	Goggles or face shield. An eyewash station should be made available.
Skin	Use rubber/PVC gloves. Full working clothes recommended.
Respiratory	Use NIOSH/MSHA approved respirator for dusty or misty conditions.

9. Physical & Chemical Properties

Apperance	
Form	Liquid
Color	Clear - light yellow
Odor	Faint
Odour Threshold	Not Available.
Physical State	liquid

pH	11.3 pH
Melting Point	26.6 °F (-3 °C)
Freezing Point	Not Available.
Boiling Point	217.4 °F (103 °C)
Flash Point	Not Applicable
Evaporation Rate	Not Available.
Flammability	Not Flammable
Upper/Lower Flammability	Not Available.
Vapor Pressure	Comparable with Water
Vapor Density	Not Available.
Specific Gravity	1.39 g/l g/cm3 (20oC), 41o Be, 11.62 lbs/gal
Solubility (H2O)	Miscible
Coefficient of Water/Oil Distribution	Not Available.
Octanol/H2O Coeff	Not Available.
Auto Ignition Temperature	Not Applicable
Decomposition Temperature	Not Available.
Viscosity	50 - 100 mPa.s

10. Chemical Stability & Reactivity Information

Chemical Stability	Stable under normal conditions.
Incompatible Materials	Incompatible with acids.
Hazardous Decomposition Products	None reasonably foreseeable.
Possibility of Hazardous Reactions	Product is stable, no hazardous polymerization will occur.

11. Toxicological Information

Component Analysis - LD50	This product has not been tested for toxicology. A component of this product, sodium silicate, when tested at 100% had an acute oral LD50 in rats of >1500mg/kg
Inhalation Effects	Mist or aerosols may cause slight irritation.
Irritation to skin	Moderately irritating.
Irritation to eyes	Moderately irritating.
Sensitization Data	Not expected to be a sensitizer.
Carcinogenicity/mutagenicity & long term effects	Main component not listed by IARC, NTP, or OSHA as carcinogen.
Neurotoxicity	None available.
Reproductive toxicity/teratogenicity	No test information.
Epidemiology	Not applicable

12. Ecological Information

Ecotoxicity

Aquatic toxicity	No test information available.

Ecological Information	Sodium silicate is moderately toxic to aquatic life.
Environmental Effects	High pH of product may be harmful to aquatic life.
Persistance/Degradability	Not applicable since product is an inorganic compound
Bioaccumulation/Accumulation	No test data. However it is not expected.
Mobility in Environmental Media	No data available.

13. Disposal Considerations

Disposal Instructions	Clean up and dispose of waste in accordance with all federal, state, and local environmental regulations. Recycling of containers may be permitted, provided the container is "empty", as described in 40 CFR 261.7(b)(1)", when the container is used within the United States. When the container is used within Canada, the following regulations apply: "A container that has been completely emptied using common practices, and that contains less than 2.5 cm of residue, is typically considered to be an "empty container" and not subject to regulation as a hazardous material or hazardous waste" (see also Ontario - O. Reg. 347, Quebec - O.C. 1091-2004, B.C. - B.C. Reg. 63/88, Alberta - Reg. 192/96, and/or Saskatchewan - E.10.2, Reg. 3, as appropriate).
Waste Codes	Not applicable.

14. Transport information

Goods Description	Not applicable
General	Not regulated as dangerous goods.
Transport Summary	Not classified as dangerous for transport.

15. Regulatory Information

US Federal Regulations	Components of this product have been checked against the non-confidential TSCA inventory by CAS Registry Number. Components not identified on this non-confidential inventory are exempt from listing (i.e. as polymers) or are listed on the confidential inventory as declared by the supplier.
OSHA Regulated	Eye/skin irritant as defined in 29 CFR 1910.1200.
SARA 302	Not subject to SARA Section 302
SARA 311/312	Not subject to SARA Section 311/312.
SARA 313	Not subject to SARA Section 313.
Canada DSL	In compliance.
WHMIS Classification	Controlled. D2B. Poisonous and infectious material : other toxic effects. Eye/skin irritant
General	Not applicable.

16. Other Information

HMIS RATINGS		***NFPA RATINGS***	
Health	2	*Health*	2
Flammability Classification	0	*Flammability Classification*	0
Reactivity	0	*Reactivity*	0
Pers. Prot		*Special Hazards*	

This MSDS is not intended for use outside of North America

Other Information SANIPOR® is a registered trademark of Sanipor Ltd. in the United States and several other countries.

Disclaimer The product is intended for sale only to industrial users. The information in this MSDS is intended to assist these users in determining the suitability of this product for their business applications. Users must inspect and test the product before use to satisfy themselves as to the contents and suitability. Eka Chemicals specifically disclaims all warranties express or implied; specifically, ALL WARRANTIES AS TO SUITABILITY, FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY OF THIS PRODUCT. The exclusive remedy for all proven claims is replacement of our product. In no event shall Eka Chemicals be liable for any special, incidental, or consequential damages. The information in this MSDS should be provided by the buyer, transporter or other handlers of this product to all who will use, handle, store, transport or otherwise potentially be exposed to this product. The MSDS has been prepared for the guidance of such persons and Eka Chemicals believes this information to be reliable and up-to-date as to the date of publication, but makes no warranty that it is. If the revision date of this MSDS is more than three years old then contact Eka Chemicals for an updated version.

Issue Date: *21-May-2008*

MSDS Sections Updated

Accidental Release Measures: Containment Procedures
Accidental Release Measures: Evacuation Procedures
Accidental Release Measures: Spill Or Leak Procedure
Ecological Information: Aquatic toxicity
Ecological Information: Biodegradability
Ecological Information: Ecological Information
Ecological Information: Environmental Effects
Handling and Storage: Handling Procedures
Handling and Storage: Storage Procedures
Hazards Identification: Emergency Overview
Other Information: Disclaimer
Other Information: Other Information
Physical & Chemical Properties: Physical & Chemical Properties
Toxicological Information: Acute Toxicity
Toxicological Information: Carcinogenicity/mutagenicity & long term effects
Toxicological Information: Component Analysis - LD50
Toxicological Information: Irritation to skin
Toxicological Information: Reproductive toxicity/teratogenicity
Toxicological Information: Sensitization data

MATERIAL SAFETY DATA SHEET

http://www.ekamsds.com

1. Chemical Product and Company Identification

Eka Chemicals Inc.
1775 West Oak Commons Court
Marietta, GA 30062
USA

24 Hour Emergency Number
US CHEMTREC 1-800-424-9300
CANADA CANUTEC 1-613-966-6666

Product Name
SANIPOR® S2

CAS #

Chemical Type
Aqueous solution.

Intended Use
Sewer repair

2 Hazards Identification

Emergency Overview	A colorless odorless clear liquid which is a mild skin and eye irritant.
Routes of Exposure	The most likely exposure routes are by skin and eye contact.
Potential Health Effects	
Ingestion	No Information
Skin	May irritate.
Eyes	May cause irritation and redness.
Inhalation	Irritation possible, especially from heated material Vapours may irritate the respiratory tract.
Target organs	Eyes, skin and respiratory tract
Chronic Effects	No Information
Medical Conditions Aggravated by Exposure	No Information

3. Composition / Information on Ingredients

Component	*CAS #*	*% Wt/Wt*
None		

Ingredient Information Silicic acid dispersion in water

4. First Aid Measures

First Aid

Ingestion	Consult a physician. Do not induce vomiting or give anything by mouth to an unconscious person.
Skin	Immediately flush contaminated skin with water. If the chemicals penetrate clothing, immediately remove the clothing and flush the skin with water. Immediately take off all contaminated clothing.
Eyes	Flush immediately with water for at least 15 minutes. Do not rub eyes. Get medical attention or advice.
Inhalation	Remove patient to fresh air and seek medical attention if breathing becomes difficult.
Notes to Physician	Not available

5. Fire Fighting Measures

Flammable Properties	Not available
Extinguishing Media	
Suitable Extinguishing Media	Carbon dioxide, dry foam, powder
Unsuitable Extinguishing Media	Do not use water
Protection of Fire Fighters	
Protective Equipment for Fire Fighters	Wear self contained breathing apparatus for fire fighting if necessary.
Specific Hazards Arising From the Chemical	Toxic gasses such as carbon monoxide may be released during fire. Carbon monoxide and carbon dioxide.

6. Accidental Release Measures

Personal Precautions	Goggles, PVC/PE gloves and full working clothes recommended.
Environmental Precautions	Contain and absorb with sand or earth. Transfer to a suitable container for disposal. Water may be used to complete the cleaning process.
Methods for Containment	Contain the discharged material.
Methods for Clean-up	Thoroughly wash the area with water after a spill or leak clean-up.

7. Handling and Storage

Handling Procedures	Handle in well-ventilated area. Avoid breathing vapors and mists. Avoid direct or prolonged contact with skin or eyes.
Storage Procedures	Protect from freezing and elevated temperatures. Storage temperature preferred between 10C and 30C

8. Exposure Controls / Personal Protection

Exposure Guidelines	Not available
Engineering Controls	Ensure adequate ventilation, especially in confined areas.
Personal Protective Equipment	
Eyes/Face	Safety glasses with side-shields. Do not wear contact lenses. Eye wash fountain and emergency showers are recommended. Avoid contact with the skin and the eyes.
Skin	Full working clothes recommended. Contaminated clothing should be laundered before re-use. Use impervious clothing to avoid skin contact. Eye wash fountain and emergency showers are recommended. Avoid contact with the skin and the eyes.
Respiratory	Not applicable under normal conditions. Avoid prolonged exposure.
Hand	Use impervious clothing to avoid skin contact.

9. Physical & Chemical Properties

Apperance	
Form	Liquid
Color	Colourless,opalescent
Odor	Faint
Odour Threshold	Not Available.
Physical State	liquid
pH	4.5 - 5.5

Melting Point	Not Available.
Freezing Point	32 °F (0 °C)
Boiling Point	212 °F (100 °C)
Flash Point	230 °F (110 °C)
Evaporation Rate	Not Available.
Flammability	Not Available
Upper/Lower Flammability	Not Available.
Vapor Pressure	2.2 kPa (20C) Comparable with water
Vapor Density	Not Available.
Specific Gravity	Not Available.
Solubility (H2O)	Miscible in water
Coefficient of Water/Oil Distribution	Not Available.
Octanol/H2O Coeff	Not Available.
Auto Ignition Temperature	Not Available.
Decomposition Temperature	Not Available.
Viscosity	5 - 15 mPa.s
Density	1100 - 1200 kg/m³

10. Chemical Stability & Reactivity Information

Chemical Stability	Stable under normal conditions.
Conditions to Avoid	High heat and open flames
Incompatible Materials	Incompatible with strong oxidizing agents.
Hazardous Decomposition Products	Oxides of carbon.
Possibility of Hazardous Reactions	No Information

11. Toxicological Information

Acute Effects	LD50 (oral,rat) > 2000 mg/kg.
Inhalation Effects	Not an aniticipated route of exposure under normal conditions of use. No known effects.
Irritation to skin	Prolonged contact may cause irritation.
Irritation to eyes	May cause eye irritation.

12. Ecological Information

Ecotoxicity

Aquatic toxicity	Fish: LC50 (96hr) > 100 mg/l
Ecological Information	48h EC 50 (Daphnia) > 100 mg/l; 96h EC50 (algae) > 100 mg/l; EC50 (bacteria) > 100 mg/l.
Persistance/Degradability	Readily biodegradable
Bioaccumulation/Accumulation	Does not bioaccumulate.
Mobility in Environmental Media	Readily absorbed into soil.

13. Disposal Considerations

Disposal Instructions	In accordance with municipal, provincial, state and federal regulations. Recycling of containers may be permitted, provided the container is “empty”, as described in 40 CFR 261.7(b)(1)”, when the container is used within the United States. When the container is used within Canada, the following regulations apply: “A container that has been completely emptied using common practices, and that contains less than 2.5 cm of residue, is typically considered to be an "empty container" and not subject to regulation as a hazardous material or hazardous waste” (see also Ontario - O. Reg. 347, Quebec - O.C. 1091-2004, B.C. - B.C. Reg. 63/88, Alberta - Reg. 192/96, and/or Saskatchewan - E.10.2, Reg. 3, as appropriate).

14. Transport information

Goods Description	Not applicable
General	Not regulated as dangerous goods.
Transport Summary	Not classified as dangerous for transport.

15. Regulatory Information

US Federal Regulations	Components of this product have been checked against the non-confidential TSCA inventory by CAS Registry Number. Components not identified on this non-confidential inventory are either exempt from listing (i.e. polymers, hydrates) or are listed on the confidential inventory as declared by the supplier.
OSHA Regulated	Not regulated by OSHA.
SARA 302	Not subject to SARA Section 302.
SARA 311/312	Not subject to SARA Section 311/312
SARA 313	Not subject to SARA Section 313.
Canada DSL	In compliance.
WHMIS Classification	Not controlled

16. Other Information

HMIS RATINGS		***NFPA RATINGS***	
Health	1	*Health*	1
Flammability Classification	0	*Flammability Classification*	0
Reactivity	0	*Reactivity*	0
Pers. Prot		*Special Hazards*	

Other Information	SANIPOR® is a registered trademark of Sanipor Ltd. in the United States and several other countries.

Disclaimer

The product is intended for sale only to industrial users. The information in this MSDS is intended to assist these users in determining the suitability of this product for their business applications. Users must inspect and test the product before use to satisfy themselves as to the contents and suitability. Eka Chemicals specifically disclaims all warranties express or implied; specifically, ALL WARRANTIES AS TO SUITABILITY, FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY OF THIS PRODUCT. The exclusive remedy for all proven claims is replacement of our product. In no event shall Eka Chemicals be liable for any special, incidental, or consequential damages. The information in this MSDS should be provided by the buyer, transporter or other handlers of this product to all who will use, handle, store, transport or otherwise potentially be exposed to this product. The MSDS has been prepared for the guidance of such persons and Eka Chemicals believes this information to be reliable and up-to-date as to the date of publication, but makes no warranty that it is. If the revision date of this MSDS is more than three years old then contact Eka Chemicals for an updated version.

Issue Date: *21-May-2008*

MSDS Sections Updated

Handling and Storage: Storage Procedures

Other Information: Other Information

Physical & Chemical Properties: Physical & Chemical Properties

APPENDIX B

PROJECT MANAGEMENT PLAN MATERIALS

Scope Statement
C310011 – Broadview Infiltration Reduction Pilot

Purpose

The Scope Statement helps clearly communicate the scope to the reader of this document. Elements from the Business Case are further refined in this document. Although the Specifier is the primary author of the initial document the expectation is the Project Manager will be amajor contributor to the content. This document is revised during the PMP development from input received from members of the team.

Project Information

Project Name	Broadview Infiltration Reduction Pilot
Activity Number	C310011 (E309003 for some related O&M activities)
Executive Sponsor	Trish Rhay
Fund & Business Area	Gary Schimek
Specifier	Martha Burke
Project Manager	Jim Johnson

1.1. Project History

The 12th Ave NW sewer basin (a dedicated sanitary sewer system) has been determined to suffer from capacity limitations based on field observations, flow monitoring data, and computer modeling. There have been numerous studies over the years with the earliest dated 1979. There have been unregulated discharges and sewer backups documented in December 1996, December 2007 and yet again in December 2010. AMC approved Business Case on 3/2/11 for $1,275,000 to proceed with this the pilot project.

1.2. Problem or Opportunity Statement

The entire 12th Ave NW sewer basin has been determined to suffer from capacity limitations during extreme wet weather events. Recent additional modeling performed subsequent to the 12/12/10 storm indicates groundwater infiltration as a significant portion of the volume in the pipe during these events.

Water Environment Research Foundation (WERF) has offered a $112,000 grant to SPU to pilot a innovative technology that seals the entire sewer system, including maintenance holes, mainline and side sewers to reduce groundwater infiltration. The technology is proprietary, Sanipor™, and is technically referred to as chemical grouting or flood grouting.

The technology is not fully tested in the United States, this pilot would be the largest treatment area to date in North America. However in limited cases where it has been utilized in the U.S. it has been shown to be very effective, and the technology is more widely used in Europe, where it was developed.

This pilot project will allow SPU to evaluate the practicality of the technology, its costs, public acceptance and effectiveness as a tool in reducing groundwater infiltration in sanitary and combined sewer systems where wet weather groundwater infiltration taxes system capacity and creates problems such as overflows (CSO or

SSO), unregulated discharges (such as at maintenance holes) or sewer back-ups into structures.

The success of the project in increasing capacity by reducing flows in this particular area will hinge largely on the relative amount of groundwater infiltration in the pipe, as compared to the actual sanitary sewer flows and stormwater inflow through connections to the sanitary sewer of such things as downspout connections, yard drains, and perhaps even stormwater infrastructure. As noted above, recent modeling has indicated that groundwater infiltration appears to be a significant portion of the wet weather flow.

1.3. External Influences

There is an expectation from the community that SPU will be addressing capacity problems in this sewer basin in the near future. This project has been contemplated for some time, however the implementation schedule is now of higher concern as a result of the December 12, 2010 storm event. During that event, the system was in a surcharged condition, and resulted in upland discharges from maintenance holes, as well as backups into select homes where the structure's lower elevation connections were below the hydraulic grade line of the surcharged sewer system.

2. Project Vision

2.1. Project Goals

Demonstrate that the Sanipor™ technology of sealing the sewer system from groundwater infiltration provides a measurable reduction in wet-weather flows.

2.2. Project Objectives

Validate the technique, contracting method for implementation, public acceptance/participation and the cost-effectiveness of the technology at reducing groundwater infiltration into the sanitary sewer system where the technology is implemented.

3. Scope

3.1. Product Scope

The product scope includes:

- Tv inspections of up to 16,000-ft of sewer lines
- Installation of up to 88 sidesewer cleanouts
- Spot repairs (for planning purposes, we've assumed 10 spot repairs)
- Flood grout of up to 11,000 ft of side sewers (approximately 88 side sewers)
- Flood grout of 5000-ft of mainline sewers

The project is located in the Broadview basin between NW 130th St and NW 132nd St, and between 8th and 12th Avenues NW.

3.1.1. Out-of-Scope Items, Product

- Sewer "sealing" technologies other than Sanipor™
- Sewer repairs too large for crews or JOC, if major repairs are required, the project team will amend the PMP through a Change Management process.

3.2. Project Scope

Deliverable	Deliverable Description
Monitoring	Install and maintain monitors in order to analyze before/after condition to evaluate effectiveness (monitors are already in place). Evaluate data.
Public outreach program	Obtain support of Broadview community and more directly the affected homeowners.
Permission to Enter	Signed rights-of-entry from 60 – 88 home owners to allow TV inspections, sewer clean out installation and flood grouting of private sidesewers.
Permits	SEPA exemption, SDOT permits (over the counter permits for side sewer work and staging)
Quality Assurance Project Plan (QAPP) Development and Pre and Post –project modeling	WORK done by Brown & Caldwell
Design	60% and 90% design for any spot repairs done by JOC and or Crews
Construction oversight	CMD will oversee work done by JOC contractor and spot check work done by crews (JIM?). Project Manager and Specifier will oversee flood grouting
Service contracts	Approved service contracts for: -tv inspection of private sidesewers - installation of sewer cleanouts (per D. Stubblefield) - flood grouting
Open Cut repairs	Spot repairs (done by crews or under Job Order Contracting - JOC)
In-house construction by crews	In-house work includes: -tv mainlines - spot repairs
Water Environmental Research Foundation (WERF) grant	Contract signed by both SPU and WERF.
QAPP	Approved both internally (SPU) & externally (WERF)
Economic analysis	Economic analysis will be performed on project costs at project completion to determine the economics of this technology vs other more "traditional" technologies such as joint grouting, pipe relining, pipe bursting, or open cut replacement.
Interim Report	Status report at the end of 2011
Final Report	Report to WERF on project results 2012
Internal assessment of pilot	Internal determination by the project team on whether the pilot is worth repeating.

3.2.1. Out-of-Scope Items, Project

- Standard Public Works (PW) contracting method for implementation

- Other technologies for implementation, such as traditional grouting, pipe relining, pipe bursting or open trench replacement* of mains/laterals

* with certain exceptions where spot repairs are indicated by video inspections

3.3. Project Assumptions

- Groundwater infiltration is a major contributor to wet-weather flows in the sewer lines.
- Over 75% of homeowners provide rights of entry. (If not, SPU will install the sewer cleanouts at the edge of the right-of-way, and only a portion of the sidesewer will be grouted.)
- Sanipor is a technology that can be successfully implemented in the City by regional contractors.
- Flood grouting will result in a measurable decrease in wet-weather flows.
- Community will accept and participate in the project at a meaningful level, where success can be measured.

3.4. Relationship to Other Projects

If this pilot project is successful, this approach may be used on other sewer back up areas in Seattle.

3.5. External Dependencies

The project is not dependent on any external projects.

3.6. Project Success Criteria

A comparison of flow monitoring data before and after the pilot will be used to assess the success of the project. The data will be compared to determine the percent removal of groundwater infiltration. This methodology has been used by others for the same purpose. The flow monitoring will be implemented by USM. Flow monitors are presently installed for monitoring of the baseline condition.

The flood grouting is expected to reduce flows in the sanitary sewer. The project team does not expect that this effort alone will solve downstream sewer back ups.

4. Implementation Plan Summary

4.1. Contracting and Consulting Approach

This project has a non-standard contracting approach due to the pilot nature and work on private property. The project will use consultants, internal design staff, in-house crews, various service vendors and probably the Job Order Contractor (JOC). Details are shown in section 3.2.

The flood grouting is considered “service work” and will be done via a blanket vendor contract. SPU will work with FAS to select a contractor to conduct this service.

The sewer clean out installation is also considered “service work” if it is done without the use excavators. FAS is currently accepting bids for a new plumbing contract that is broad enough to include this work.

Sanipor representatives, WERF experts, and King County staff will be brought in to advise during the design and construction phases to insure a high quality implementation of the process.

4.2. Deviations from Standards

This is not a traditional design-bid-build project. It will be implemented with a combination of in-house work, vendor and JOC support.

This is a pilot project to try a new technique, so it there are no existing standards for flood grouting.

The Project Manager will be responsible for all communications between the vendor, the JOC contractor and the crews. An estimated 5 -10 spot repairs will be managed by Jeff Williams and Young Kim as part of the Sewer Spot repair program.
SPU will pre-purchase the flood grouting chemicals because the purchase has a long-lead time. SPU will sole source this purchase from Sanipor.

5. Communication Summary

5.1. Community and Political Influences

In the Broadview community, the project team will work with the Broadview Sewer Task Force.

The project requires considerable outreach to approximately 85 homeowners. The outreach will support rights-of-entry, inform residents of construction schedule and impacts. The flood grouting will take place over several weeks in 26 or so installations. During that process, individual homes will be “off the sewer” for an estimated 8 hours.

This project also requires successful communication with private property owners to obtain rights-of-entry and no sewer backups (which would be caused from homeowners flushing during the 8-hour grout process).

5.2. Project Organization

Martha Burke, Specifier
Jim Johnson, Project Manager
Gary Schimek, Budget Area Manager
Trish Rhay, Director of Drainage and Wastewater
Wan-Yee Kuo, Senior Engineer
Jeff Williams, Pipes Asset Manager

5.3. Project Governance

AMC on 3/2/2011 for BC #2, approved.

PDOC approval of PMP pending completion.

It is unclear how this project will complete Stagegates 3 -5 for the grouting, given its use of service contracts (rather than public works contracts) and combination of contracting methods.

6. Budget and Schedule Summary

6.1. Schedule Estimate

See attached detailed schedule.
The project team anticipates that all construction will be completed in 2011, with monitoring and reporting activities in 2012. Flood grouting is best done in dry weather, and there is a risk that delays could push the flood grouting into 2012.

6.2. Cost Estimate

The project work is currently billed to E309003. In the near future, costs related to work in this PMP will be billed to C310011. The life to date costs ($95,000) will remain in E309009 (JIM or will they be transferred)

For details see attachments

6.3. Approved Budget

Current Approved Budget	1,100,000 (in 2011 Spending Plan)
Approved By:	AMC
Date Approved:	3/2/11

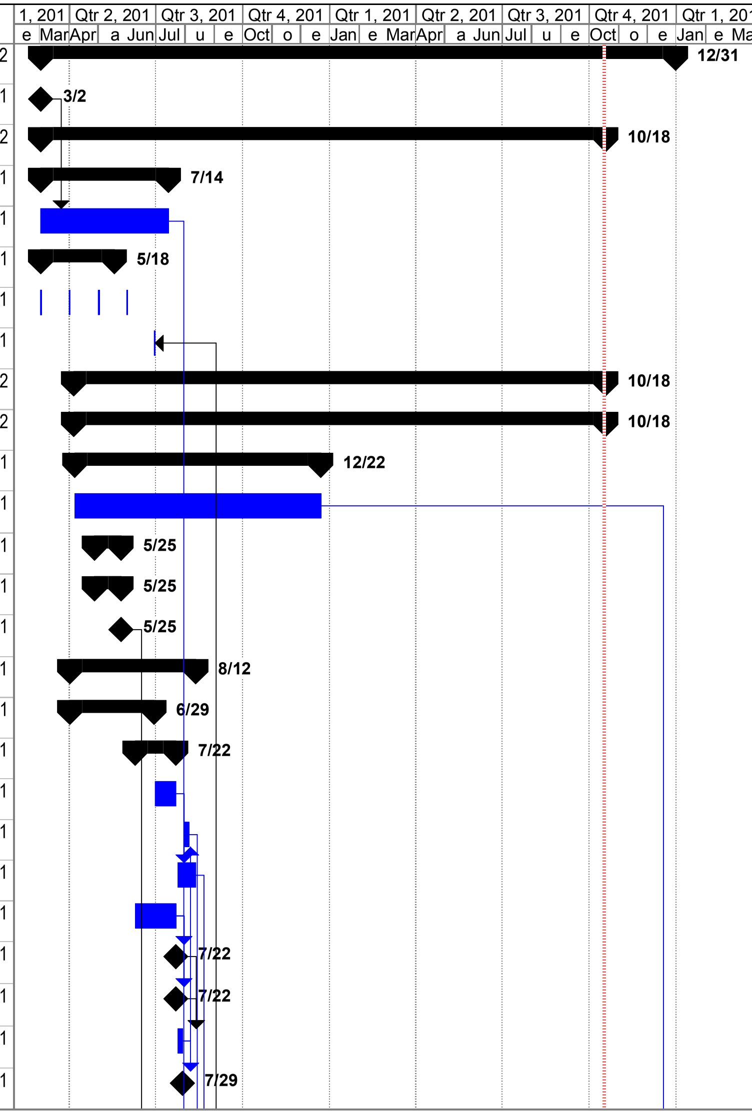
Appendix A. Revision History

Revision Date	Version	Summary of Changes	Prepared By
3/16/11	First draft		Jim Johnson
3/29/11	Review comments		Martha Burke
5/10/11	Review comments	Final scope statement prep	Lori Taylor
5/12/11	Draft Final	Accept comments thru 5/11	Jim Johnson
5/18/11	Review Final	Submitted to PDOC	Jim Johnson
5/19/11	Review Final	Comments from C. Woelfel	Jim Johnson

Broadview Infiltration Reduction Pilot - Job Order PW Contract

PDOC Review

ID	Task Name	Duration	Start	Finish
1	Broadview Infiltration Reduction Pilot	462 days	Wed 3/2/11	Mon 12/31/12
2	Project Start	0 days	Wed 3/2/11	Wed 3/2/11
3	Design	414 days	Wed 3/2/11	Thu 10/18/12
4	Project Management	95 days	Wed 3/2/11	Thu 7/14/11
5	General Proj. Mgmt.-D Phase	95 days	Wed 3/2/11	Thu 7/14/11
6	Develop PMP - D, C, Close Out Ph	56 days	Wed 3/2/11	Wed 5/18/11
16	Proj. Mgmt. Team Mtgs	65 days	Wed 3/2/11	Wed 6/1/11
23	Lessons Learned: Design Phase	1 day	Thu 6/30/11	Thu 6/30/11
24	Communications Support	389 days	Wed 4/6/11	Thu 10/18/12
25	Community Meetings	389 days	Wed 4/6/11	Thu 10/18/12
31	Informational Mailings	180 days	Thu 4/7/11	Thu 12/22/11
35	Develop & Monitoring of Website, PAN	180 days	Thu 4/7/11	Thu 12/22/11
36	Real Property Services	20 days	Thu 4/28/11	Wed 5/25/11
37	Right of Entry Forms	20 days	Thu 4/28/11	Wed 5/25/11
43	Decision Point: Resident Participation Level	0 days	Wed 5/25/11	Wed 5/25/11
44	Identify Existing Conditions	93 days	Fri 4/1/11	Fri 8/12/11
45	Prepare & Complete QAPP for Monitoring	62 days	Fri 4/1/11	Wed 6/29/11
52	CCTV Field Investigation	30 days	Thu 6/9/11	Fri 7/22/11
55	Survey & Mapping of Existing Conditions	15 days	Fri 7/1/11	Fri 7/22/11
56	PERC-Prelim. Engr Resource Composite	5 days	Mon 8/1/11	Fri 8/5/11
57	Develop Project Site Base Map (or side sewer card)	15 days	Mon 7/25/11	Fri 8/12/11
58	Asset QA/QC by Crews (review tapes during Videoing)	30 days	Fri 6/10/11	Fri 7/22/11
59	Decision Point: Condition Assess_Phys. Spot Repairs	0 days	Fri 7/22/11	Fri 7/22/11
60	Decision Point: Full Line Repairs vs. Flood Grouting (Sags)	0 days	Fri 7/22/11	Fri 7/22/11
61	Asset QA/QC by SPU Crews or contr. (spot sewer work)	5 days	Mon 7/25/11	Fri 7/29/11
62	Decision Point: Vendor vs. JOC vs PW Contract	0 days	Fri 7/29/11	Fri 7/29/11



Author:
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6/27/2011
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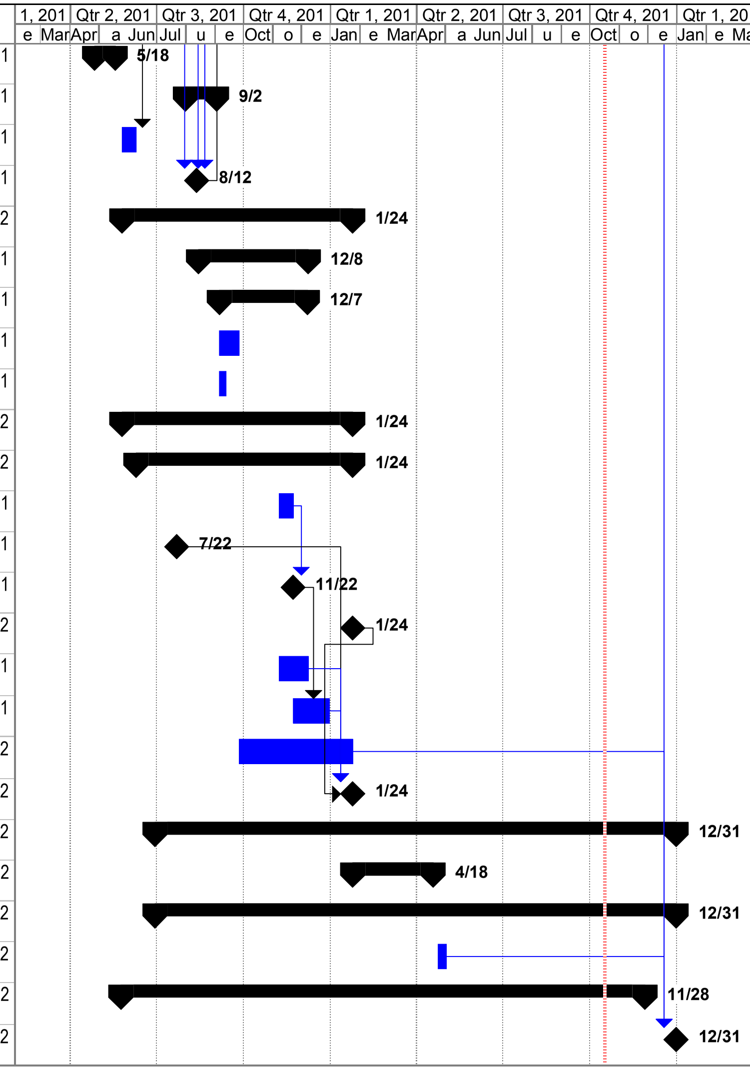
WERF

Broadview Infiltration Reduction Pilot - Job Order PW Contract

PDOC Review

ID	Task Name	Duration	Start	Finish
63	SEPA Review	16 days	Wed 4/27/11	Wed 5/18/11
67	90% Design	25 days	Mon 8/1/11	Fri 9/2/11
74	Contractor Selection Process (Plumb Svc Contractor)	10 days	Thu 5/26/11	Thu 6/9/11
75	Design Compl_Contract Award-Milestone	0 days	Fri 8/12/11	Fri 8/12/11
76	Construction	165 days	Wed 5/25/11	Tue 1/24/12
77	Project Management	80 days	Mon 8/15/11	Thu 12/8/11
87	Communications Support	64 days	Tue 9/6/11	Wed 12/7/11
91	Prep for Constr. Precon Mtg with JOC Contractor	15 days	Tue 9/6/11	Mon 9/26/11
92	SDOT St Use Permit (obtain by JOC & Crew)	5 days	Tue 9/6/11	Mon 9/12/11
93	Contractors (No Labor)	165 days	Wed 5/25/11	Tue 1/24/12
103	Original Contract Labor (CMD Inspection)	155 days	Fri 6/10/11	Tue 1/24/12
107	Change Order Labor (JOC Contract)	10 days	Tue 11/8/11	Tue 11/22/11
108	Substantial Completion Cleanout-Milestone	0 days	Fri 7/22/11	Fri 7/22/11
109	Substantial Completion JOC Contract-Milestone	0 days	Tue 11/22/11	Tue 11/22/11
110	Substantial Completion Grouting-Milestone	0 days	Tue 1/24/12	Tue 1/24/12
111	Testing & Commissioning	20 days	Tue 11/8/11	Thu 12/8/11
112	Develop & Resolve Punch List (JOC Contract)	25 days	Wed 11/23/11	Fri 12/30/11
113	Public Works Allocation	80 days	Tue 9/27/11	Tue 1/24/12
114	Physical Compl. (all work)-Milestone	0 days	Tue 1/24/12	Tue 1/24/12
115	Close Out	377 days	Thu 6/30/11	Mon 12/31/12
116	Project Management	60 days	Wed 1/25/12	Wed 4/18/12
123	Close Out Activities	377 days	Thu 6/30/11	Mon 12/31/12
133	SG #5: Approval to Close Project	7 days	Tue 4/24/12	Wed 5/2/12
134	Reserves	380 days	Wed 5/25/11	Wed 11/28/12
137	Project_Close Out Complete-Milestone	0 days	Mon 12/31/12	Mon 12/31/12



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Risk Register: Broadview Infiltration Pilot

#	Risk Identification	Risk Analysis				Risk Response		Contingent Response (if applicable)			Monitor & Control	
	Decription	Impact Rating	Probability Rating	Score	Priority	Response Strategy	Response Plan	Response Plan Cost	Probability of Risk Occurrence	Contingency Reserve	Assigned to	Status
1	Describe the risk	1 - Very Low	1 - Very Low	1	Low		What are you going to do about it?	$50,000	10%	$ 5,000.00	Insert Name	Open
2		1 - Very Low	5 - Very High	5	Medium					$ -		
3		2 - Low	5 - Very High	10	High					$ -		
4		4 - High	4 - High	16	Critical					$ -		
1	Contract between City's contractor and Sanipor results in schedule delay (ie: unable to negotiate terms btwn supplier and prime)	5 - Very High	5 - Very High	25	Critical	Mitigate	Martha to chat with Sanipor to determine the criticality			$ -	Martha	open
3	The SaniPor process is not completed before the 2011 wet season	5 - Very High	4 - High	20	Critical	Contingent Response	Prep work this year, with grouting next year. Addtl costs are for delay costs only, no inflation of work task costs	$12,000	50%	$ 6,000.00	Martha	open
4	New purchasing services contract (ie: cleanout installation contractor) or not having a decision in a timely manner, resulting in contracting mechanism delaying 2011 construction	5 - Very High	4 - High	20	Critical	Mitigate	Engage SPU Management to apply pressure on FAS contracting.			$ -	Jim	open
5	New purchasing services contract (ie: CCTV from Private Property) or not having a decision in a timely manner, resulting in contracting mechanism delaying 2011 construction	5 - Very High	4 - High	20	Critical	Mitigate	Engage SPU Management to apply pressure on FAS contracting.				Jim	open
6	Problems with existing purchasing services contract (ie: Sewer Services) resulting in unclear decisions, not having a decision in a timely manner, contracting mechanism delays 2011 construction schedule	5 - Very High	4 - High	20	Critical	Mitigate	Engage SPU Management to apply pressure on FAS contracting.			$ -	Jim	open
7	The project must go through the Public Works process rather than a JOC contract (open cut sewer repairs). Includes development of project manual & PERC plan, etc.	5 - Very High	3 - Moderate	15	Critical	Contingent Response	Add decision point to Schedule. Set aside money and develop the steps/plan on how to respond. Grouting delayed till 2012	$273,835	25%	$ 68,458.75	Jim	open
8	Poor Clarity in existing purchasing svcs contract (ie: Sewer Services) for Sanipor resulting in unclear decisions, not having a decision in a timely manner, contracting mechanism delays 2011 construction schedule	5 - Very High	3 - Moderate	15	Critical	Mitigate	SPU Management applies pressure on FAS contracting. Create decision tree on who decides contracting strategy			$ -	Jim	open
9	If the spot repairs on mainline are done by FOM crews, FOM is not able to provide crews within the requested timeframe. (FOM has only 1.5 rehab crews)	4 - High	3 - Moderate	12	High	Mitigate	Get right of way forms back ASAP. Schedule CCTV ASAP to develop problem list to give flexibility to schedule FOM crews. Solicit SPU management support that this is a priority project. Plan B: delegate other priorities to Jeff's contract options			$ -	Jeff	open
10	Speed of decision by FAS on purchasing services eligibility delays the project	4 - High	3 - Moderate	12	High	Mitigate	SPU Management applies pressure on FAS contracting. Create decision tree on who decides contracting strategy			$ -	Martha	open
11	Lack of lead time for notifications to community (meetings, traffic Impacts, shut off of utilities, etc.) resulting in community dissatisfaction and schedule delay	4 - High	3 - Moderate	12	High	Mitigate	Create communication plan and schedule. Clarify in house communication approval process and expedite where possible.			$ -	Mike	open
12	CCTV/community participation cannot access a minimum of at least 75% of the necessary areas (resulting in cancellation of the project)	5 - Very High	2 - Low	10	High	Accept	See response for risk # 30			$ -	Martha	open
13	CCTV identifies more defects then flood grouting would address and would result in flood grouting not being an appropriate rehab method (FOM crews not an option). Resulting in project being cancelled.	5 - Very High	2 - Low	10	High	Accept	Include decision point into schedule			$ -	Martha	open
2	the project can go through Vendor (B Contract/Purchase Order with SPU Crews) process rather than a JOC contract (side sewer contractor). POSITIVE RISK/DEDUCT.	5 - Very High	2 - Low	10	High	Contingent Response	Develop steps/plan on how to respond	-$41,735	25%	$ (10,433.75)	Jim	open
14	a MH-MH reach takes longer than the expected 8 hours to complete & results in schedule delay	3 - Moderate	3 - Moderate	9	Medium	Accept	If a second or 3rd application can not be completed within an 8 hour workday, resched that section for another day and come back.			$ -	Dennis	open
15	There is a delay in obtaining the required noise variance permits	3 - Moderate	3 - Moderate	9	Medium	Accept	Figure out early to see if night or weekend work is required, work with community to see if they are OK with it, then engage DPD.			$ -	Jim	open
16	Some side sewers must be CCTV'd from private property looking downstream resulting in schedule and cost increases	2 - Low	4 - High	8	Medium	Mitigate	Engage main sewer TV contractor services early, to identify these, work with prop owners to get right of entry signed			$ -	Jeff	open
17	Some homeowner(s) will not sign (by the end of May) the Right of Entry form for a MH-MH reach	2 - Low	4 - High	8	Medium	Mitigate	Low so long as the extensive community outreach to ensure maximal participation level limits the numbers of non participating props. There will be some who choose not to participate, they get cleanout at right-of-way			$ -	Jim	open
18	a MH-MH reach takes longer than the expected 8 hours to complete & results in customers without access to their facilities	4 - High	2 - Low	8	Medium	Accept	If a second or 3rd application can not be completed within an 8 hour workday, resched that section for another day and come back.				Dennis	open
19	SDOT does not respond promptly for street use/utility permits	4 - High	2 - Low	8	Medium	Mitigate	engage SDOT early in the process				Jim	open
20	During construction, the City approved vendor is not able to successfully do the SaniPor process	4 - High	2 - Low	8	Medium	Accept	ensure the contractor selected from the Sewer Svc Vendor list has proper equipment and staff, engage Sanipor Tech Rep in assisting the contractor in preparation for job			$ -	Dennis	open
21	Early onset of wet season prohibits grouting in 2011	4 - High	2 - Low	8	Medium	Accept	Add decision point to schedule. Grout in 2012. Communicate with community on variables.				Martha	open
22	Some cleanouts are difficult to install (difficult access for heavy equipment resulting in hand digging)	2 - Low	3 - Moderate	6	Medium	Accept	if location proves too expensive, move C.O. to ROW to avoid costs, time implications of difficult site			$ -	Jim	open

WERF

Risk Register: Broadview Infiltration Pilot

#	Risk Identification	Risk Analysis				Risk Response		Contingent Response (if applicable)			Monitor & Control	
#	Decription	Impact Rating	Probability Rating	Score	Priority	Response Strategy	Response Plan	Response Plan Cost	Probability of Risk Occurrence	Contingency Reserve	Assigned to	Status
23	Create damage to the system (ie: mainline, private property, etc.)	2 - Low	3 - Moderate	6	Medium	Accept	Review tv tapes carefully and meet with B&C if in doubt. Thought to apply mostly to sags.			$ -	Jim	open
24	a MH-MH reach takes longer than the expected 8 hours to complete & results in cost increase for contractor (depending on bid item structure)	2 - Low	3 - Moderate	6	Medium	Accept	Risk of our contracting method with Sewer Svc Purch Service Contract, they are paid T&M, Sanipor Tech Rep will insure proper process, but still some risk.				Dennis	open
25	The clean water test results in flooding on private property on 1-2 houses.	3 - Moderate	2 - Low	6	Medium	Mitigate	Insure plugs are all in.			$ -	Dennis	open
26	The sewers are so leaky that it requires mulitiple applications of SaniPor resulting in increasing the volume of chemicals used and duration to apply. Increased costs	3 - Moderate	2 - Low	6	Medium	Accept	Sanipor to have Tech Rep on site, to measure falling head of surcharged system to determine when leakage rates are acceptable, may require extra application and may have to come back to affected segment			$ -	Dennis	open
27	Data gathered during preliminary investigation does not accurately depict the pipe network (ie: unanticipated side sewer)	3 - Moderate	2 - Low	6	Medium	Mitigate	Review and x-check tapes against GIS and maximo records to be sure all side sewers id'd			$ -	Jeff	open
28	CCTV does not provide the necessary information resulting in the flooding of a house	4 - High	1 - Very Low	4	Low	Mitigate	Review and x-check tapes against GIS and maximo records to be sure all side sewers id'd			$ -	Jeff	open
29	USM pipe Asset Mgmt must schedule resources to complete CCTV inspection condition assessment (emergency elsewhere)	2 - Low	2 - Low	4	Low	Accept	Pay for overtime review if necessary			$ -	Jeff	open
30	Community objects to project and delays the project	2 - Low	2 - Low	4	Low	Mitigate	engage community early and often with info				Martha	open
31	The community objects to the parking reductions during construction	2 - Low	2 - Low	4	Low	Accept	Work with community to ID their concerns about construction activity			$ -	Jim	open
32	The groundwater records assessment indicates that the SaniPor process will adversely increase groundwater conditions	2 - Low	2 - Low	4	Low	Accept	Review existing records			$ -	Martha	closed
33	It is determined there must be a SEPA	4 - High	1 - Very Low	4	Low	Accept	engage EMS early enough to allow time to complete without delaying project			$ -	Jim	open
34	The City approved vendor is not able to successfully install some clean outs (ie: installed in city right of way on their side sewer and affects the effectiveness of the project)	2 - Low	2 - Low	4	Low	Accept	Extensive community outreach to ensure maximal participation level, there will be some who choose not to participate, they get cleanout at right-of-way			$ -	Jim	open
35	Clarity in existing purchasing services contract (Ie: CCTV) resulting in unclear decisions, not having a decision in a timely manner, contracting mechanism delays 2011 construction schedule	2 - Low	2 - Low	4	Low	Accept	work with FAS now on new Sewer Svc contract (existg expires 7/31)			$ -	Jeff	open
36	The quality of the Flow monitor data is poor (QAPP) results show that the pilot technology was not successful					Accept	Won't know till end of project.			$ -	Martha	open
										$ 64,025.00		

APPENDIX C

COMMUNITY ENGAGEMENT INFORMATION

FREQUENTLY ASKED QUESTIONS

1. What is this project and why is SPU proposing it?

Seattle Public Utilities (SPU) has initiated a capital program to improve the sewer and associated drainage system in the Broadview neighborhood. As part of that program, SPU is planning a pilot project to evaluate a method to reduce the amount of groundwater leaking into the sewer system. This leakage is called infiltration and comes from gaps or cracks in the main sewer pipes and side sewer pipes from peoples' homes. The technology will use two non-toxic chemicals to seal the joints (where there may be gaps) and cracks in the sanitary sewer mainline and side (private lateral) sewer lines where water may enter the system when the ground is saturated.

2. How will this project affect me, my property and my side sewer?

Before the grouting is done, all the sewers in the project area, including side sewers, must be inspected by a special camera that travels through the sewers. This determines areas in both the mainline system and side sewers that require cleaning, root removal, or structural damage repair. These problems will be repaired first. Then, section by section, the system will be treated with the chemical grout.

a. Am I in the pilot project area?

The pilot is planned for the area between NW 130th and NW 132nd Street, and 8th and 12th Ave NW. The accompanying map shows the location and the parcels included in the pilot.

b. Will it benefit my property?

Repairs of side sewers can be expensive if left until they cease to function. The first step is installation of a cleanout (or access point) outside of the house if one doesn't currently exist. As part of this pilot, participating homeowners will have their side sewer inspected, cleaned and repaired as needed.

c. Will it cost me anything?

Because this project will enhance the condition and functioning of the City's sewer infrastructure, and improve service, reducing the possibility of backups occurring, this service is provided at **no cost** to the homeowner.

3. Are there any risks from participating in the project?

This is a pilot project as this technology has not been applied in the northwest, although it has been used elsewhere in the country. With this pilot, SPU is evaluating whether this technology significantly reduces infiltration and the costs as compared to other technologies. The risk of problems occurring during this pilot project is low, since it is a relatively non invasive procedure. SPU will correct any problems created as a direct result of the grouting process.

4. Will I be able to use my plumbing while it is going on?

Your access to plumbing fixtures (sinks, shower or baths, toilets and laundry facilities), will be restricted for short periods of time while any repairs are performed on your side sewer, or when a cleanout is installed. During the grouting process itself, you may be restricted for a period of up to eight hours. You will receive timely notification of any necessary restrictions.

5. **What is a cleanout? Will installation damage my garden/lawn? Will SPU restore it?**
   A cleanout is an access point to the side sewer (sometimes also called a service lateral) much like a manhole in the street. For homes of the average Broadview vintage, these are frequently located in the basement, crawl space or garage floor. These are all areas that are less convenient and in some cases can create unsanitary conditions during sewer servicing. If there is no outside cleanout, SPU will install one. In most cases only a small hole will be needed for the installation. The cleanout must be located on the side sewer (service lateral) line, but SPU can coordinate the cleanout location with you. SPU will restore the property as close as possible to its previous condition after installation. SPU will use the cleanout to inspect, and service your side sewer and to perform the chemical grouting.

6. **Why do I need to sign a Permission-to-Enter (right of entry) form? What if I choose not to participate?**
   For the City to enter your private property to conduct the work, a right of entry is required. If you do not wish to participate, a cleanout will be installed in the right-of-way (ROW) to prevent the grouting from extending beyond the ROW. However, you will still not be able to use your home's plumbing while the grouting is being done for the main line in front of your house.

7. **If you are inspecting and cleaning my side sewer, will I get a report on the results?**
   Yes, we will provide you a report of the TV inspection if you wish.

8. **How will this project impact the Broadview community?**

   a. **Will it solve the problems we have with sewers in Broadview?**
      The purpose of this pilot project is to evaluate whether this grouting technology might be used in other parts of Broadview or elsewhere throughout the City. If it works in reducing infiltration and the costs are comparable with other technologies, it will be applied in more areas to help reduce the excess flows in the sewer lines, and reduce the chance of backups. However the pilot project is not expected to have a significant impact on the existing problem of wet weather sewer capacity in Broadview.

   b. **Will it solve the drainage problems we have in Broadview?**
      No, this project is not designed to improve surface drainage.

9. **Will the seal created by this pilot keep out roots?**
   Yes, it should. The reacted grout mildly increases the local PH to a point that roots do not like, plus the grout blocks the roots' source of water – the sewers.

10. **How long will the seal last?**
    This was done in salty seawater conditions in Sarasota, Florida, and 20 years later the pipes are still in excellent condition.

11. **What if my side sewer line is higher in the ground than the main sewer line?**

The highest the process will go is the highest point of the main line connecting to your side sewer. A temporary extension might be attached during this process to try to raise the elevation, however there may be circumstances where we might not be able to reach the entire side sewer pipe due to excessive elevation differences.

12. **Are the chemicals toxic? What is the name of the chemicals?**
    No, the chemicals are proprietary, so the names of them are not available. However, according to the MSDS the chemicals are silica (a naturally occurring substance) based. They are inert once the reaction is complete. However during handling of the raw unreacted, concentrated chemicals, safety procedures must be followed as the chemicals if ingested, splashed into the eyes or onto the skin can cause irritation. The contractor will follow all recommended handling procedures and take steps to insure that the public does not come into contact with the chemicals (one of the reasons your side sewer will be plugged during the grouting process)

13. **Can this work in any type of soil?**
    Yes, it works in virtually any soil and is especially suited to our granular type soils.

14. **What if there are a lot of repairs that take a long time to fix?**
    At present in the absence of actual inspection of the lines, we have estimated the number based on those found in a similar project in nearby Shoreline. If there is a lot of damage however, the physical repair work will take longer; this could delay the grouting process.

15. **How many trucks will be in the neighborhood during the project?**
    Listed in likely order of process:
    i. For CTTV, one large box van
    ii. For cleanout installation, one vactor truck and a support vehicle or two
    iii. For cleaning, one large vactor truck
    iv. For sewer repairs, a tracked excavator or a rubber-tired tractor backhoe loader, dump trucks, and a support vehicle or two
    v. For the grouting, 2 large vactor trucks and 1 jetting truck, and some smaller support vehicles, vans or pickups

16. **How much will property be disturbed?**
    The disturbance will be minor but it will depend on whether a cleanout or repair if needed. Property will be restored to its pre-project state.

17. **Will flooding be exacerbated by this project, due to more groundwater not entering sewer pipes?**
    Because of the limited area for the pilot project, SPU does not believe the pilot will raise the groundwater table. The larger capital project will focus on additional issues not addressed in this pilot. For the larger project, we are presently evaluating groundwater information that we already have, to identify gaps where more information is needed. We may install some monitoring wells in some locations to gather more information and to confirm whether or not larger scale projects (infiltration reduction to sewer main lines) or infiltration of stormwater (natural drainage systems) will negatively influence groundwater levels.

18. **Will you have to do more than one application of the chemicals in some cases?**
The contractor will evaluate the leakage rate after the application of the chemicals. If the leakage rate is too high, another application may be necessary. In those cases, the lines would take longer.

19. **How much will this pilot project cost?**
We estimate $1.4 million.

20. **On how many parcels further down 12th would you need to replicate this pilot project, if the pilot is successful?**
All of the sewers and side sewers further down 12th could be flood grouted. However, we likely won't have to do this. Once we know the infiltration removal rate, we will be able to re-model the system to determine the additional length of pipe we will have to rehabilitate to protect the area from wet weather overflows. We would likely only seal sufficient properties in order to reduce/eliminate backups, which is not to say that we would eliminate *all* infiltration to the system.

21. **How will you determine if the pilot project is successful?**
Two-pronged: 1) measure the degree that infiltration was reduced, 2) assess the cost/benefit of this technology compared to other technologies in similar pilots

22. **Why not get a bigger bang for your buck and do the worst area?**
To truly test the technology, we need an area free of flow through from other areas. In addition, we do not know where the "worst" area is infiltration-wise. We know where sewers backup, but that does not mean the infiltration there is causing the excessive flows; it could come from far away.

City of Seattle
Michael McGinn, Mayor
Seattle Public Utilities
Ray Hoffman, Director

Project Notice

BROADVIEW SEWER INFILTRATION REDUCTION PILOT PROJECT

What the Project Is

Seattle Public Utilities (SPU) has initiated a capital program to improve the sewer and drainage system in the Broadview neighborhood. As part of that program, SPU is planning a pilot project to evaluate a method to reduce the amount of groundwater leaking into the sewer system. This leakage is called infiltration and comes both from gaps or cracks in the main sewer and in the side sewers from peoples' homes. The pilot is planned for the area between NW 130th and NW 132nd Street, and 8th and 12th Ave NW.

How It Works

The project will use two non-toxic chemicals to seal the joints (where there may be gaps) and cracks in the sanitary sewer mainline and side (private lateral) sewer lines where water may be entering the system when the ground is saturated.

Before the grouting is done, all the sewers within the project area, including side sewers, must first be inspected by a special camera that travels through the sewer. SPU will use this camera to determine areas in both the mainline system and side sewers that require cleaning, root removal, or structural damage repair. These problems will be repaired first. Then, section by section, the system will be treated with the chemical grout.

What This Means for Homeowners

As part of this pilot, participating homeowners will have their side sewer inspected, cleaned, and if needed repaired. A cleanout will be installed if one doesn't currently exist. Because this project will enhance the condition and functioning of the City's sewer infrastructure, and improve service, reducing the possibility of backups occurring, this service is provided at **no cost** to the homeowner.

After this preliminary work, the grout is applied on a section by section basis. A section is generally from one maintenance hole to the next, including all side sewers from homes or structures connected to that section. During the application process the homeowner will not be able to utilize their sewers. A plug will be installed at each home's sewer connection to prevent the anything from entering the home or entering the pipe system. Residents will not be able to do laundry, flush toilets, or bathe during that time, generally no more than 8 hours. When the sealing is complete, the remainder of the grout is pumped out, the plugs are removed and the system is placed back into operation.

Your participation is key!
SPU will soon be sending out a Permission To Enter Private Property form (PTEPP). This form gives the City your permission to use the sewer camera to inspect your side sewer lateral service and document its condition.

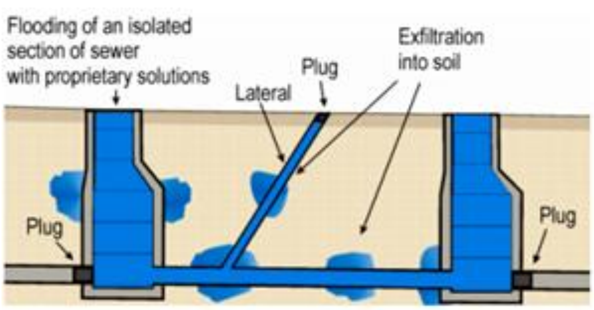
If there are defects found during inspection the PTEPP also give SPU permission to correct these defects. If you do not have an exterior cleanout or inspection point outside of your home, SPU will install one. This exterior inspection point will be where the plug is installed in order to complete the grouting process. If further work is needed after the inspection, that work (defect repair, cleanout installation and the grouting itself) will be coordinated with you in advance.

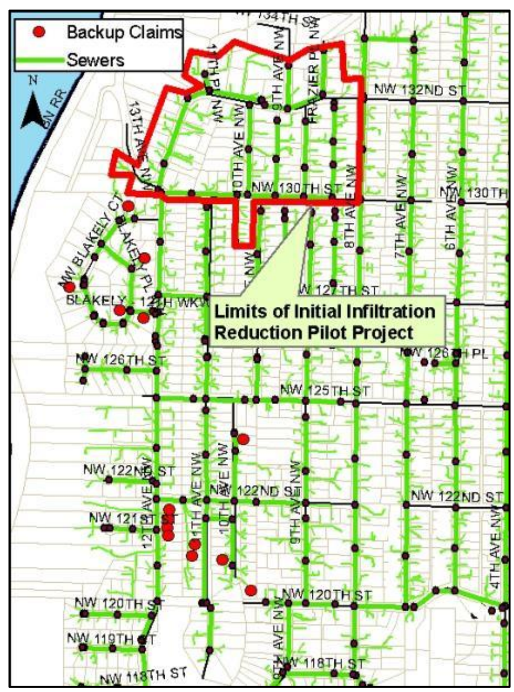
The PTEPP form requires that the City restore your property to an equal condition that existed before the work was performed. This process will improve your lateral service connection function and service life and will help SPU evaluate whether or not this technology will be a useful tool to solving the flooding and sewer backups in Broadview.

How much will it cost / how is it funded?
The budget to complete this project is $1.4 million and is funded through drainage and sewer rates, as well as through a federal grant.

Construction schedule / what's next?
SPU would like to begin TV inspection in June, develop a list of physical work needed for construction in late summer, followed by the grouting process. SPU would like to complete the project before the next storm season.

For further information: Jim Johnson, at (206) 684-5829 or jim.johnson@seattle.gov or Martha Burke, at (206) 684-7686 or martha.burke@seattle.gov .





Seattle Municipal Tower, 700 5th Avenue, Suite 4500, PO Box 34018, Seattle, WA 98124-4018
Tel: (206) 684-5950, TTY/TDD: (206) 233-7241, Fax: (206) 233-1532, Internet Address: http//www.seattle.gov/.util/

City of Seattle
Seattle Public Utilities

May 6, 2011

Dear Resident or Property Owner:

Seattle Public Utilities (SPU) is initiating a pilot project in Broadview to evaluate a technique for reducing sewer backups that can occur in the area during wet weather. We believe we can do this by sealing leaks and cracks that contribute substantially to "infiltration," the leaking of groundwater, into the sewer system.

On April 27th, we held a meeting for the residents of the project area to explain the project in detail. If you attended, thank you. If we have already received your Permission to Enter form, a really big thank you! This letter provides more information to those unable to attend and includes materials to answer some of the questions that might arise and a permission form for your participation.

The project area is the upper portion of the 12th Avenue Northwest sewer line and we want to complete the pilot project this year. It will begin with inspecting the sewers in the area, using a camera that travels through the sewers. This video inspection includes the main sewer line as well as the side sewers leading from your house.

Our inspection first will identify areas requiring cleaning and repair. Because the project involves both the main line and side sewers, it may be necessary to install a cleanout for the side sewer near your house, if one does not already exist, and to do any required repairs or cleaning. Once this is done, a technique called "flood grouting" will be used to seal the pipes throughout the sewer lines.

Any work on the side sewers associated with this pilot project will be done at no cost to the resident. However, to do this, SPU needs to have access to your property to inspect the side sewer, install the cleanouts and make the necessary repairs. For this reason, homeowners need to sign an agreement allowing that access.

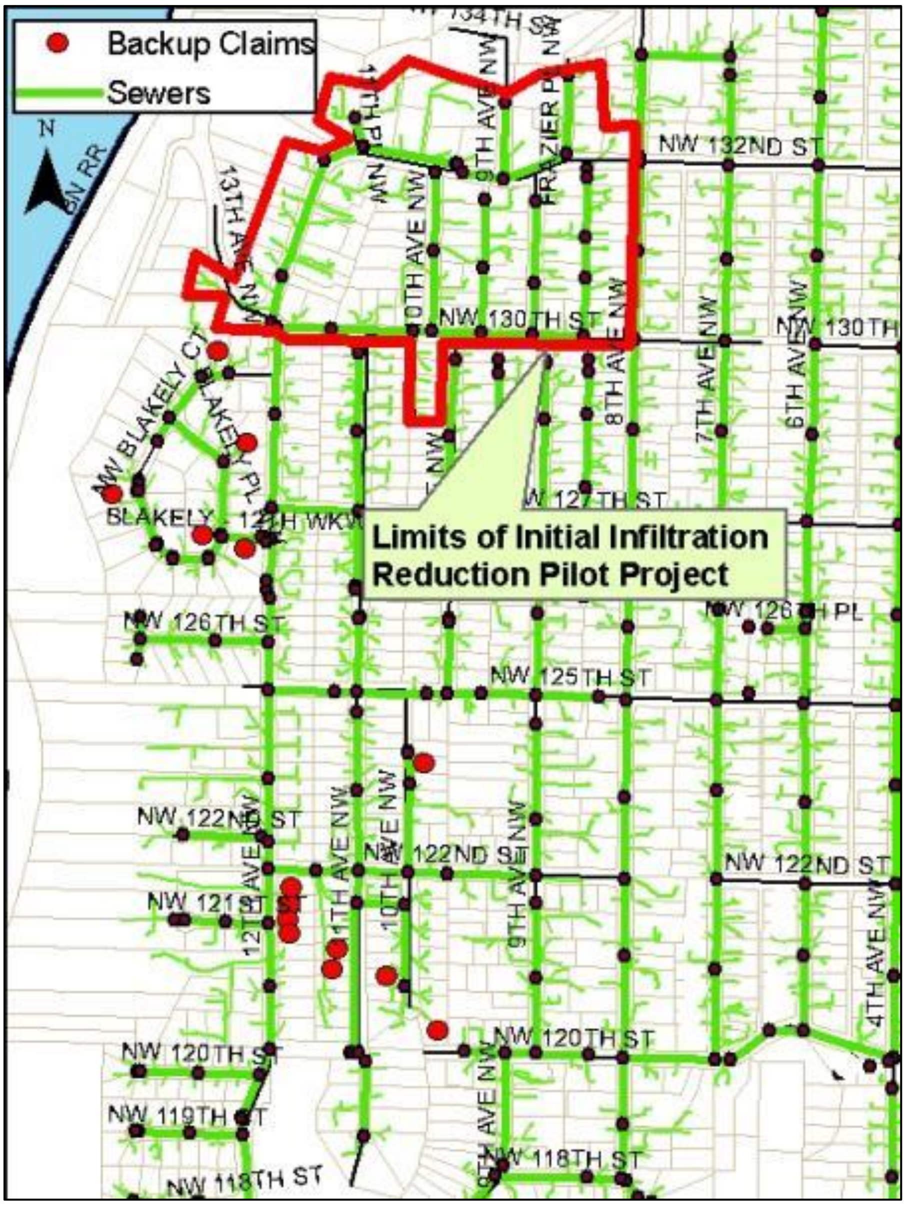
Attached is a detailed map of the project area plus answers to questions you might have about the project. We have also included the **Permission Form** that we need you to sign to participate in the project.

Please feel free to contact me at 206-684-5829 or jim.johnson@seattle.gov or Martha Burke at 206-684-7686 or martha.burke@seattle.gov for more information.

The success of this pilot depends on the participation of you and your neighbors in the community. Please sign the access permission form and return it in the enclosed return envelope no later than May 20th.

Thank you!

Jim Johnson
Project Manager
Seattle Public Utilities



PERMISSION TO ENTER PRIVATE PROPERTY

PROJECT: Broadview Sewer Infiltration Reduction Pilot Project

RECITALS

A. Seattle Public Utilities (SPU) is performing a pilot project that will evaluate the effectiveness of sealing sewer mains and private side sewers to reduce infiltration in a limited area of study in the Broadview neighborhood.
B. As part of this study, SPU will grout sewer main lines and side sewers within the area of study to seal them from infiltration. In order for this study to be successfully evaluated, private side sewers being grouted must be in a state of decent repair, and new cleanouts may need to be installed on the side sewer.
C. By signing this Permission to Enter Agreement, the Owner of the property requests that SPU and/or a contractor working on SPU's behalf perform the following work on the owners property:
    a. Camera inspection of the property side sewer
    b. Side sewer cleaning, as necessary
    c. Side sewer root cutting, as necessary
    d. Installation of a new clean out on the existing side sewer at a location on the homeowner's property as necessary
    e. Side sewer repairs as necessary
D. The individual completing this form ("Owner") is willing to have the above work done in accordance with the terms and conditions of this agreement.
E. The Owner owns a residence ("Property") in Seattle, King County, WA, described as follows

STREET ADDRESS: ____

(House No.) *(Street)*

______ ____

(City) *(State)* *(Zip)*

Parcel No: ___________________________

Is the house occupied by tenants or someone other than the Owner? YES or NO (Please circle one)

TERMS AND CONDITIONS

1. **Ownership of Property:** The Owner warrants that he/she is the lawful owner of the Property and has good right and authority to authorize entry onto the property for the performance of the work described above.
2. **No Guarantee Of Work:** The Owner's signature on this Permission to Enter Private Property form is not a guarantee that the work described herein will be completed. Whether the work shall actually be performed is within the discretion of the City.
3. **Conditions of Work:** SPU or its designee shall perform the work described in this form without seeking financial contribution from the Owner. The type, method of work, and location of any cleanout shall be determined by the City. The City will attempt to consult with the property owner regarding the location of the cleanout before installation. The work will be performed in a workmanlike manner in accordance with applicable City code.

PERMISSION TO ENTER PRIVATE PROPERTY

4. **Notice of Work:** SPU or its designee will notify the property owner of the work to be performed at least 4 days in advance of each phase of work by leaving written notice at the front door of the residence.
5. **Consent to work:** The Owner authorizes and grants a license to SPU and its agents to enter upon the property from 7:00 A.M. to 7 P.M. (Pacific Standard Time) to perform the above described work.
6. **Temporary interruption to service**: SPU and/or its agents will be required to temporarily disable the property's side sewer for a limited periods during the work. The Owner will be notified of this interruption at least 12 hours in advance by written notice. The Owner agrees not to run water or flush toilets in the house during the designated period. The Owner further agrees to be responsible for any damage caused by the Owner's operation of plumbing equipment during the interruption to service period. *The Owner is responsible for ensuring compliance with these interruption-to-service requirements, including compliance by tenants.*
7. **Work does not affect Real Property Rights**: SPU and its agents' work does not diminish or increase property rights for the Owner. After completion of the work, Owner will continue to be responsible for the maintenance and repair of the side sewer between the sewered building on the property and the sewer main.
8. **Restoration and Operation**: Upon completion of the work described above, to the extent it is undertaken, SPU or its agents shall use reasonable efforts to restore the property as near as possible to its condition prior to the work.
9. **Term of Agreement**: This agreement shall remain in full force commencing on the date of signature herein until completion of work described herein or, at the latest, September 1, 2012.

Owner(s)________________________________ ________________________

(Owner Signature) *(Owner Printed Name)*

____ ________________________

(Joint Owner Signature) *(Joint Owner Printed Name)*

Date____________________________________

Home Phone______________________________

Work Phone______________________________

APPENDIX D

ADVANCED NOTICE FLYERS

City of Seattle
Seattle Public Utilities

Advance Notice of Utility Service Interruption

ATTENTION: Sewer Service Interruption expected on ______________________, 2011.

Dear Property Owner or Resident:

Recently you received communications in the mail detailing the Sewer Infiltration Reduction Pilot Project. This project is intended to improve the performance of the sewer system in your neighborhood.

SPU understands that any interruption of your sewer service can be very inconvenient, and we are committed to giving you as much advanced notice as possible. SPU and our contractor, Bravo, appreciate your understanding and cooperation.

This letter serves as your legal notice that a sewer service interruption to your property is imminent, in not less than 4 days from now.

The estimated day of the interruption is noted above under the heading "ATTENTION:"

This is the expected day that the chemical process is applied to the mainline sewer system in your vicinity. This work will be conducted on a weekday during business hours as outlined below:

- SPU has installed a cleanout on your side sewer (service lateral).
- On the day of chemical treatment, a plug will be installed at the cleanout to prevent sewage from your property from entering and contaminating the process and to prevent the chemicals from entering your property or home.
- **Use of plumbing fixtures (tubs, sinks, toilets, showers, laundry facilities, etc.) is not possible during this time period.**
- **Use of plumbing fixtures during this time may result in flooding and damage to your house and property.** SPU assumes no liability for damages due to your failure to comply with the service interruption.
- The service interruption will be approximately 8 hours.
- SPU will provide additional notice to you the night before the service interruption by a door hanger notice, and again by knocking on your door on the day of the service interruption. Orange stickers will be provided with the morning of notice for you to place on your plumbing fixtures and water using appliances to remind you.

Ray Hoffman, Director
Seattle Public Utilities
700 5th Avenue, Suite 4900
PO Box 34018
Seattle, WA 98124-4018

Tel (206) 684-5851
Fax (206) 684-4631
TDD (206) 233-7241
ray.hoffman@seattle.gov

- **This process is weather dependent**. If significant rain is forecast after this notice or occurs on the day of grouting, we may delay, by one day, so watch for subsequent notices.
- You will be notified in the afternoon when sewer service is restored, **but in no case will this be later than 6 p.m.**
- If your service is interrupted for the treatment and unexpectedly it was not successful, we will need to come back to treat again. If this happens we will again give you not less than 4 days notice. We will not return the very next day.
- Bravo will be providing a portable SaniCan facility that will be on the street section that is being grouted for your use.

If you have questions or need more information, please call 684-5829 or jim.johnson@seattle.gov or Martha Burke at 684-7686 or martha.burke@seattle.gov .

Sincerely,

Jim Johnson
Project Manager

City of Seattle
Seattle Public Utilities

Notice of Utility Service Interruption

ATTENTION: Sewer Service Interruption expected TOMORROW _______________, 2011

Dear Property Owner or Resident:

Recently you received an "Advanced Notice of Utility Service Interruption" for the Sewer Infiltration Reduction Pilot Project in your neighborhood.

SPU understands that any interruption of your sewer service can be very inconvenient, and we are committed to give you as much advanced notice as possible. SPU and our contractor, Bravo, appreciate your understanding and cooperation.

This letter serves as your <u>legal notice</u> that a sewer service interruption to your property is imminent, in <u>not less than 12 hours from now</u>.

The <u>estimated day</u> of the interruption is noted above under the heading "ATTENTION:"

This is the expected day that the chemical process is applied to the mainline sewer system in your vicinity. This work will be conducted tomorrow during business hours as outlined below:

- SPU has installed a cleanout on your side sewer (service lateral).
- Tomorrow morning, a plug will be installed at the cleanout to prevent sewage from your property from entering and contaminating the process and to prevent the chemicals from entering your property or home.
- **Use of plumbing fixtures (tubs, sinks, toilets, showers, laundry facilities, etc.) is <u>not possible</u> tomorrow.**
- The service interruption will be approximately 8 hours.
- **Use of plumbing fixtures <u>may result in flooding and damage</u> to your house and property.** SPU assumes no liability for damages due to your failure to comply with the service interruption.
- SPU will provide additional notice to you tomorrow morning by knocking on your door. Orange stickers will be provided to you to place on your plumbing fixtures and water-using appliances to remind you.
- **This process is weather dependent.** If significant rain occurs tomorrow we may delay, by one day, so watch for further notices.
- You will be notified in the afternoon when sewer service is restored, **but in no case will this be later than 6 p.m.**

Ray Hoffman, Director
Seattle Public Utilities
700 5th Avenue, Suite 4900
PO Box 34018
Seattle, WA 98124-4018

Tel (206) 684-5851
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ray.hoffman@seattle.gov

- If your service is interrupted for the treatment and unexpectedly it was not successful, we will need to come back to treat again. If this happens we will again give you not less than 4 days notice. We will not return the very next day.
- Bravo will be providing a portable SaniCan facility that will be on the street section that is being grouted for your use.

If you have questions or need more information, please call 684-5829 or jim.johnson@seattle.gov or Martha Burke at 684-7686 or martha.burke@seattle.gov .

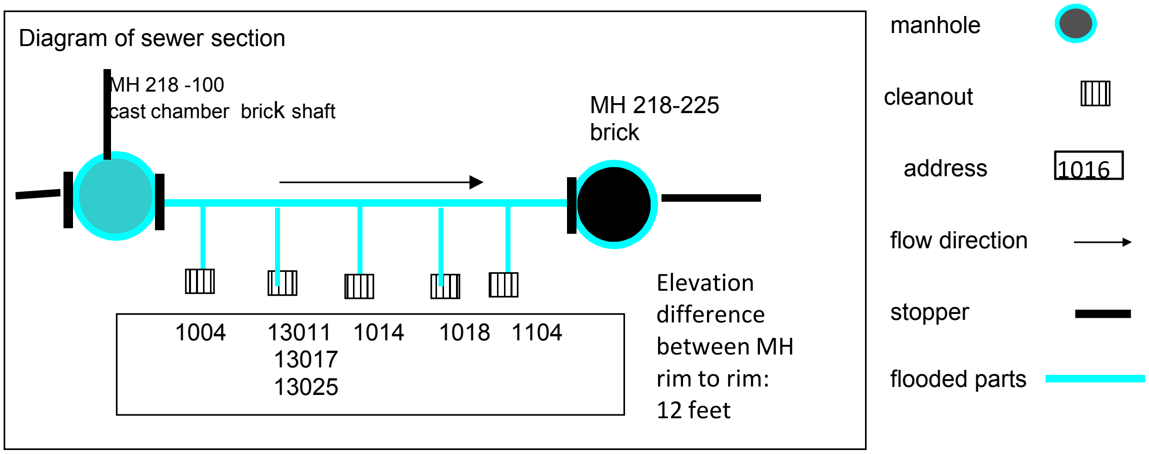
Sincerely,

Jim Johnson
Project Manager

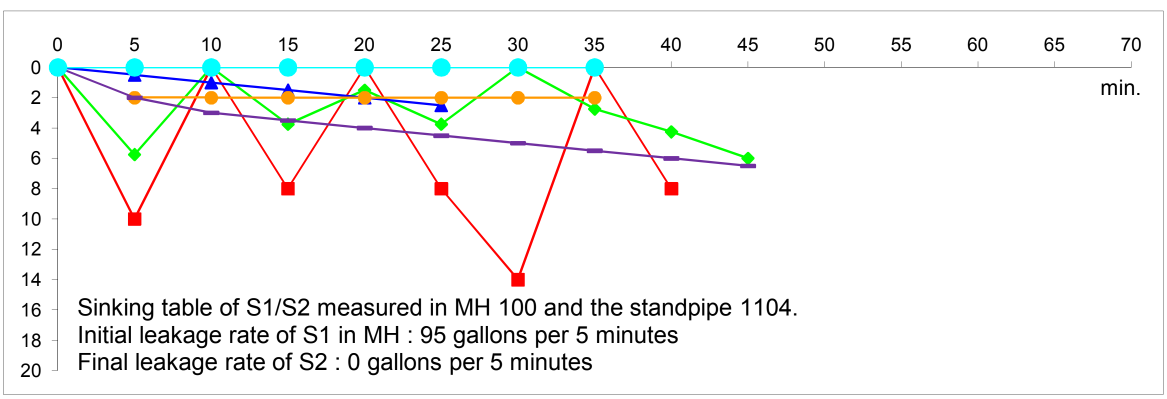
APPENDIX E

SEALING PROTOCOLS

Sanipor - Sealing protocol



Flooded parts:	MH 100	MH 100	MH 100	MH 100	MH+main+lat	MH, lat.+main
Time	10:52	11:40	13:00	13:45	10:00	12:15
minutes	sinking (inch) **1. cycle S1**	sinking (inch) **1. cycle S2**	sinking (inch) **2. cycle S1**	sinking (inch) **2. cycle S2**	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2
0	0	0	0		0	0
5	10	5.75	0.5	2	2	0
10	0	0	1	2	3	0
15	8	3.75	1.5	2	3.5	0
20	0	1.5	2	2	4	0
25	8	3.75	2.5	2	4.5	0
30	14	0		2	5	0
35	0	2.75		2	5.5	0
40	8	4.25			6	
45		6			6.5	
50						
55						
60						
65						
70						



main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*301*	*786*
6	*300*	*441*

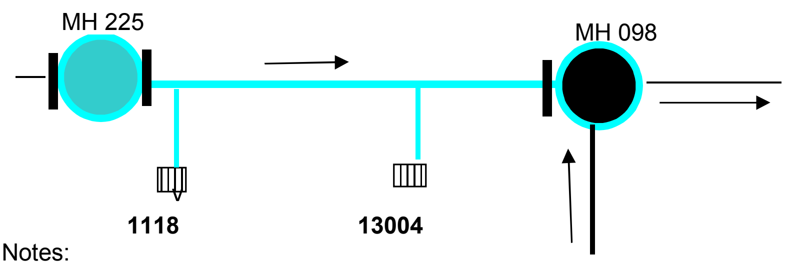
manholes:	*218-100 to 218-225*	
Ø inch	dept (feet)	volume gallons
48	*13*	*1,222*
48	*9.3*	*874*

Location: *Seattle, NW 130 th St.*
Date: *1 and 6 September 2011*

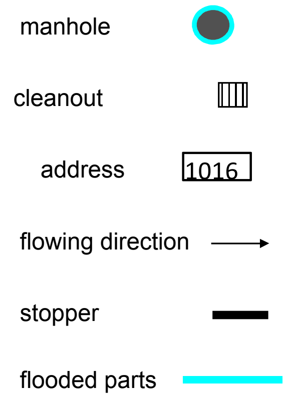
Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol

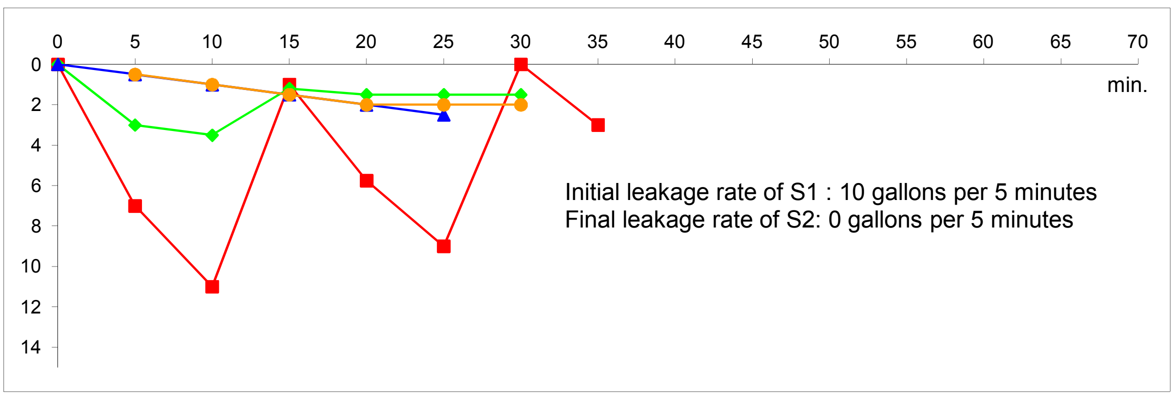
Diagram of sewer section



Notes:
Drop of S1/S2 was measured in MH 98 (20") and standpipe # 13004 (4")
Elevation difference between MH rim to rim: 15 ft



Flooded parts.	MH 98	MH 98	MH+Main+lat	MH+Main+lat		
Time	9:54	10:50	12:23	13:35		
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking 2. cycle S1	sinking 2. cycle S2	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0	0			
5	7	3	0.5	0.5		
10	11	3.5	1	1		
15	1	1.2	1.5	1.5		
20	5.75	1.5	2	2		
25	9	1.5	2.5	2		
30	0	1.5		2		
35	3					
40						
45						
50						
55						
60						
65						
70						



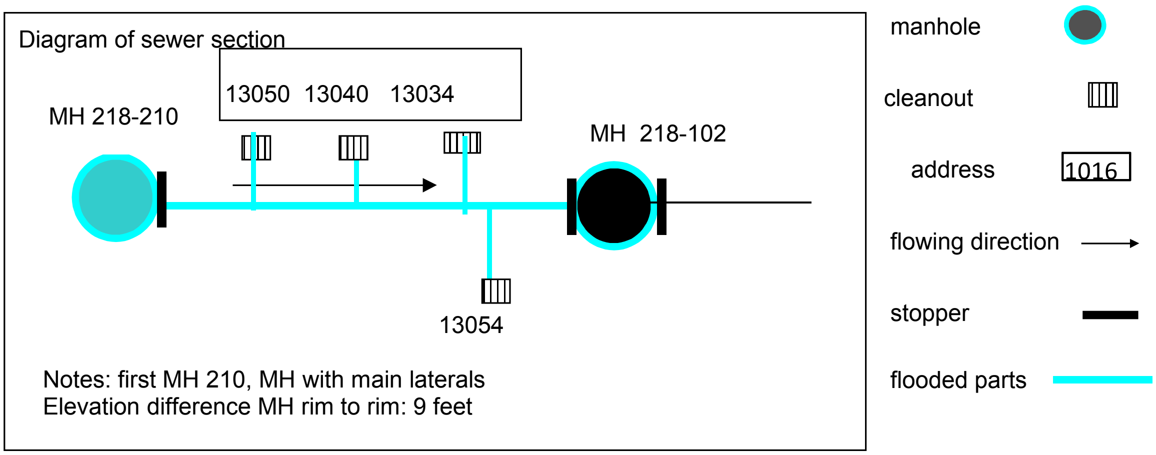
main pipe and laterals Ø inch	limited length(feet)	volume gallons
8	*200*	*522*
6	*45*	*66*

manholes: Ø inch	*218-225 to 218-098* dept (feet)	volume gallons
48	*9.3*	*874*
48	*8.1*	*761*

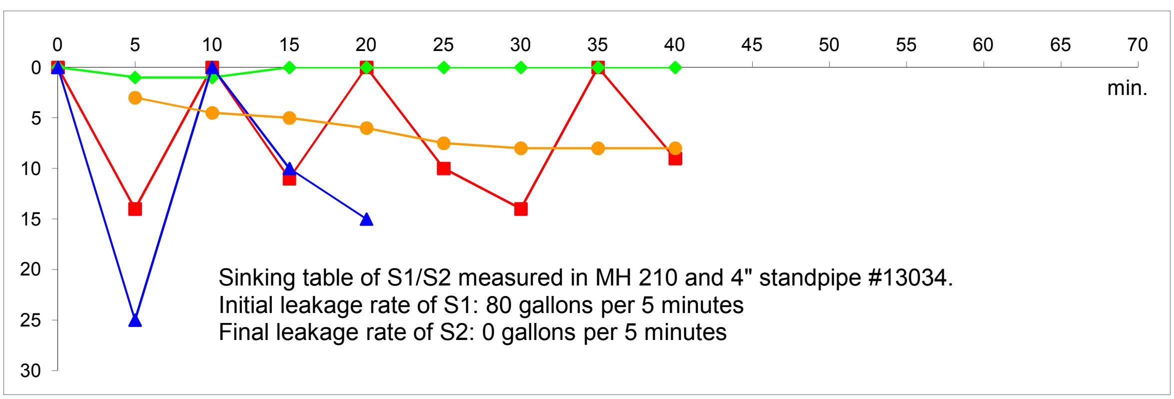
Location: *Seattle, 130 th St NW*
Date: *12 September 2011*

Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Environmental Inc.*

Sanipor - Sealing protocol



Flooded parts:	MH 210	MH 210	MH and main	MH and mains		
Time	11:50	12:50	8:23	9:20		
minutes	sinking (inch) **1. cycle S1**	sinking (inch) **1. cycle S2**	sinking (inch) **2. cycle S1**	sinking (inch) **2. cycle S2**	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0	0			
5	14	1	25	3		
10	0	1	0	4.5		
15	11	0	10	5		
20	0	0	15	6		
25	10	0		7.5		
30	14	0		8		
35	0	0		8		
40	9	0		8		
45						
50						
55						
60						
65						
70						



main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*287*	*749*
6	*56*	*82*

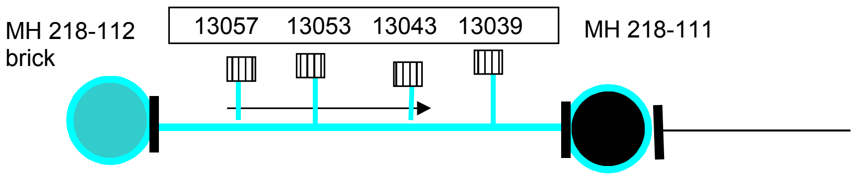
manholes:	*218-210 to 218-102*	
Ø inch	dept (feet)	volume gallons
48	*9.1*	*855*
48	*10.9*	*1,025*

Location: *Seattle, 10 th Ave NW*
Date: *23 August and 13 September 2011*

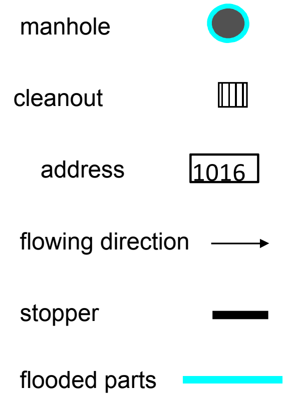
Supervisor: *Ferenc Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol

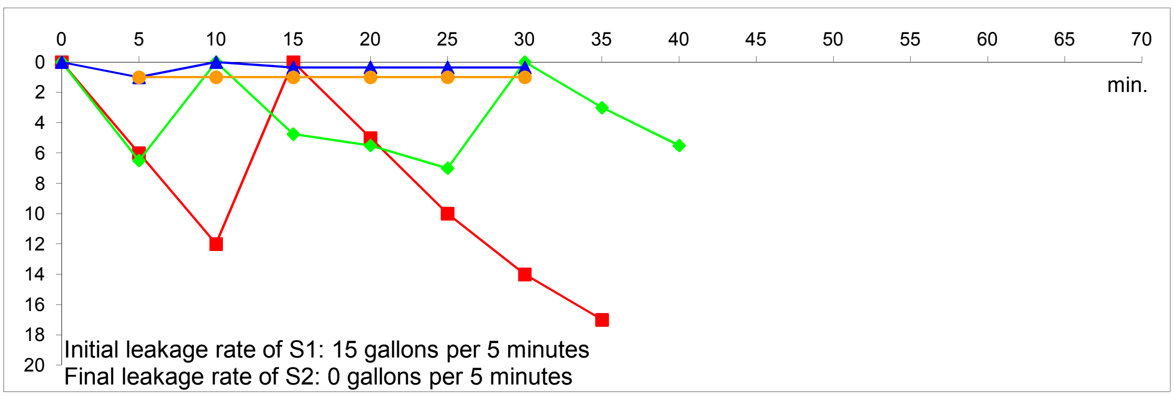
Diagram of sewer section



Notes: MH 112 , MH with main and laterals
Drop measured in 24" MH shaft #112
Elevation difference MH rim to rim: 4 feet.



Flooded Parts	MH	MH	MH +main+lat	MH +main+lat		
Time	10:16	12:18	13:45	14:45		
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) 2. cycle S1	sinking (inch) 2. cycle S2	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0	0			
5	6	6.5	1	1		
10	12	0	0	1		
15	0	4.75	0.35	1		
20	5	5.5	0.35	1		
25	10	7	0.35	1		
30	14	0	0.35	1		
35	17	3				
40		5.5				
45						
50						
55						
60						
65						
70						



main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*253*	*661*
6	*198*	*291*

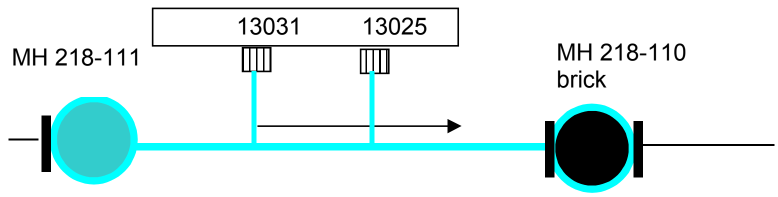
manholes:	*218-112 to 218-111*	
Ø inch	dept (feet)	volume gallons
48	*5.5*	*517*
48	*5.1*	*479*

Location: *Seattle, Lane between 8th and 9th Ave NW*
Date: *17 August 2011*

Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol

Diagram of sewer section



Notes: MH 111 , then MH and mainline + laterals together
Elevation difference between MH rim to rim: 10 feet

manhole

cleanout

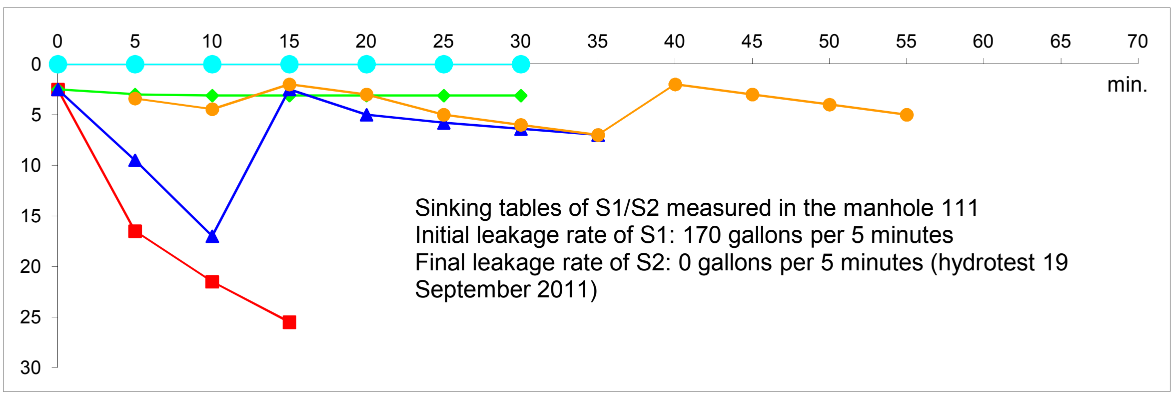
address 1016

flow direction

stopper

flooded parts

Flooded parts:	MH 111	MH 111	MH+main+lat	MH+main+lat	MH111	MH+main+lat
Time	11:00	11:29	13:40	15:08	Hydrotest 19th September	
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) 2. cycle S1	sinking (inch) 2. cycle S2	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	2.5	2.5	2.5		0	0
5	16.5	3	9.5	3.4	0	0
10	21.5	3.1	17	4.45	0	0
15	25.5	3.1	2.5	2	0	0
20		3.1	5	3	0	0
25		3.1	5.8	5	0	0
30		3.1	6.4	6	0	0
35			7	7		
40				2		
45				3		
50				4		
55				5		
60						
65						
70						



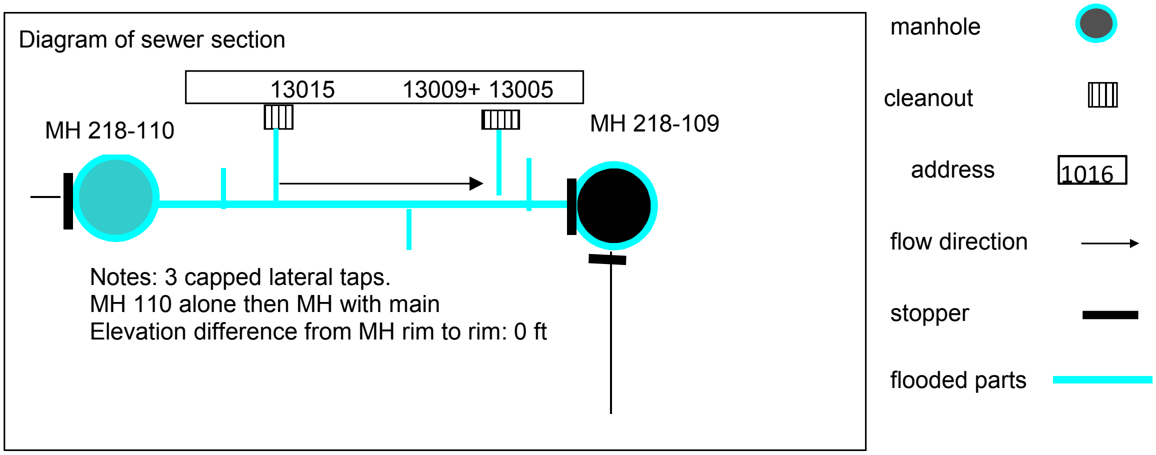
main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*150*	*392*
6	*37*	*54*

manholes:	*218-111 (to 218-110)*	
Ø inch	dept (feet)	volume gallons
48	*7.2*	*677*
48	*6.9*	*649*

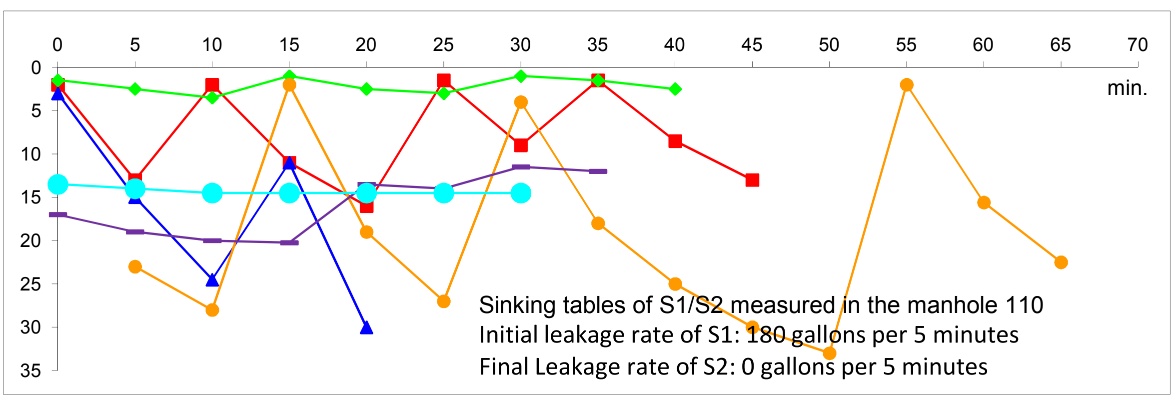
Location: *Seattle, Lane between 8th and 9th Ave NW*
Date: *12 August 2011*

Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Environmental*

Sanipor - Sealing protocol



Flooded parts:	MH110	MH 110	MH+main+lat	MH+main+lat	MH+main+lat	MH+main+lat
Time	10:05	11:00	13:50	15:06	12:43	13:47
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) 2. cycle S1	sinking (inch) 2. cycle S2	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	2	1.5	3		17	13.5
5	13	2.5	15	23	19	14
10	2	3.5	24.5	28	20	14.5
15	11	1	11	2	20.25	14.5
20	16	2.5	30	19	13.5	14.5
25	1.5	3		27	14	14.5
30	9	1		4	11.5	14.5
35	1.5	1.5		18	12	
40	8.5	2.5		25		
45	13			30		
50				33		
55				2		
60				15.6		
65				22.5		
70						



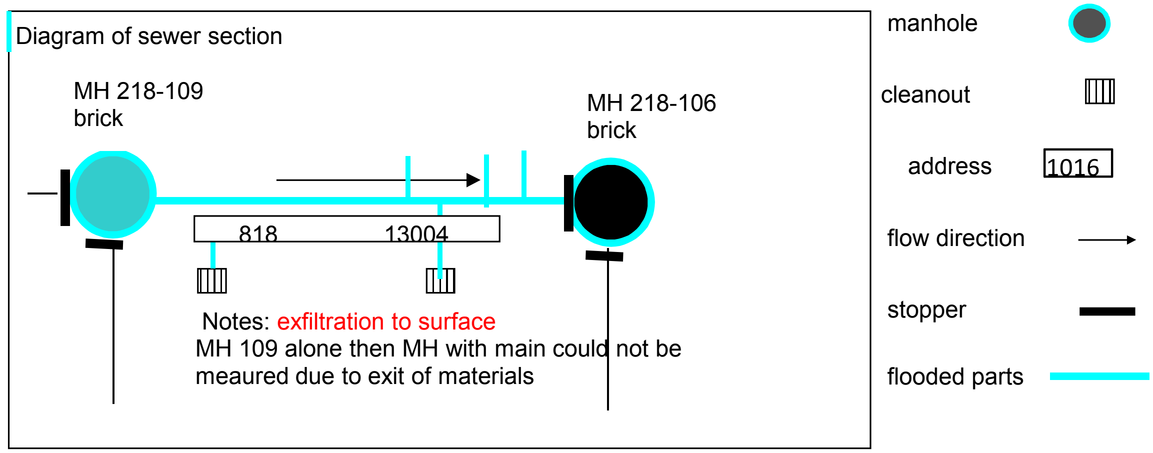
main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*222*	*580*
6	*30*	*44*

manholes:	*218-110 to 218-109*	
Ø inch	dept (feet)	volume gallons
48	*7.3*	*686*
48	*15.6*	*1,466*

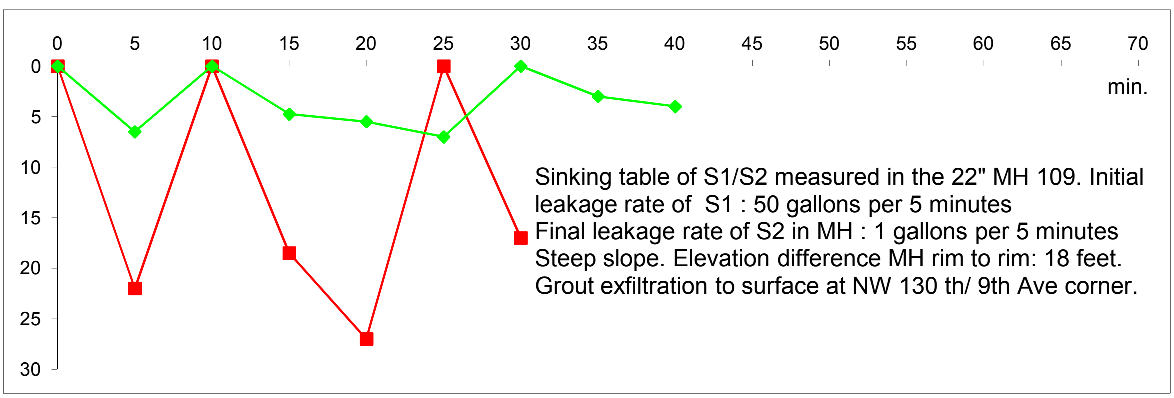
Location: *Seattle, Lane between 8th and 9th Ave NW*
Date: *15 August and 3 October 2011*

Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol



flooded parts:	**MH109**	**MH 109**	MH and main	MH and main	**no measure possible.**	
Time	**9:00**	**9:50**	11:32	12:40		
minutes	sinking (inch) **1. cycle S1**	sinking (inch) **1. cycle S2**	sinking (inch) **2. cycle S1**	sinking (inch) **2. cycle S2**	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0				
5	22	6.5				
10	0	0				
15	18.5	4.75				
20	27	5.5				
25	0	7				
30	17	0				
35		3				
40		4				
45						
50						
55						
60						
65						
70						



main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*188*	*491*
6	*60*	*88*

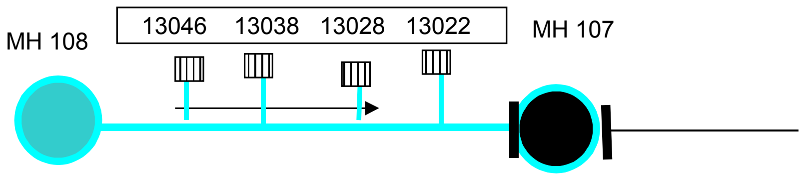
manholes:	*218-109 to 218-106*	
Ø inch	dept (feet)	volume gallons
48	*15.6*	*1,466*
48	*10.3*	*968*

Location: *Seattle, NW 130th St.*
Date: *19 August 2011*

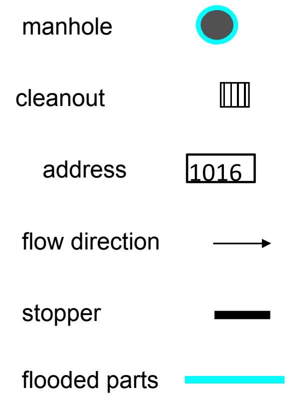
Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol

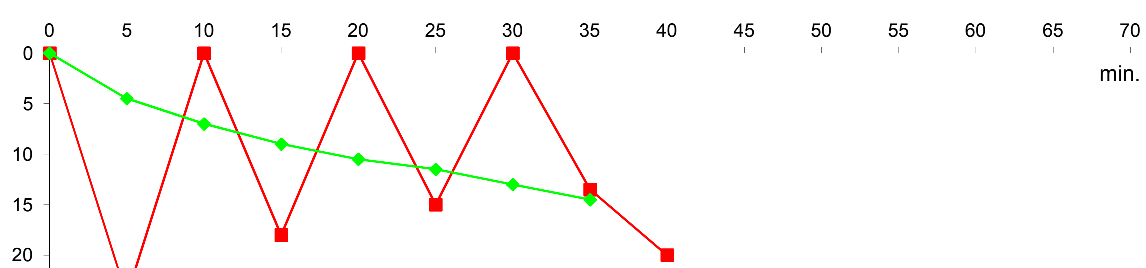
Diagram of sewer section



Notes: MH 107 new cast with main and laterals
Drop measured in standpipe # 13022 (4")
Elevation difference MH rim to rim: 14 feet.



Flooded Parts	**MH +main+lat**	**MH +main+lat**				
Time	**12:08**	**13:22**				
minutes	sinking (inch) **1. cycle S1**	sinking (inch) **1. cycle S2**	sinking (inch) **2. cycle S1**	sinking (inch) **2. cycle S2**	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0				
5	24	4.5				
10	0	7				
15	18	9				
20	0	10.5				
25	15	11.5				
30	0	13				
35	13.5	14.5				
40	20					
45						
50						
55						
60						
65						
70						



Sinking table of S1/S2 measured in the 4" standpipe.
Initial leakage rate of S1: 1.5 gallons per 5 minutes
Final leakage rate of S2: 0.1 gallons per 5 minues

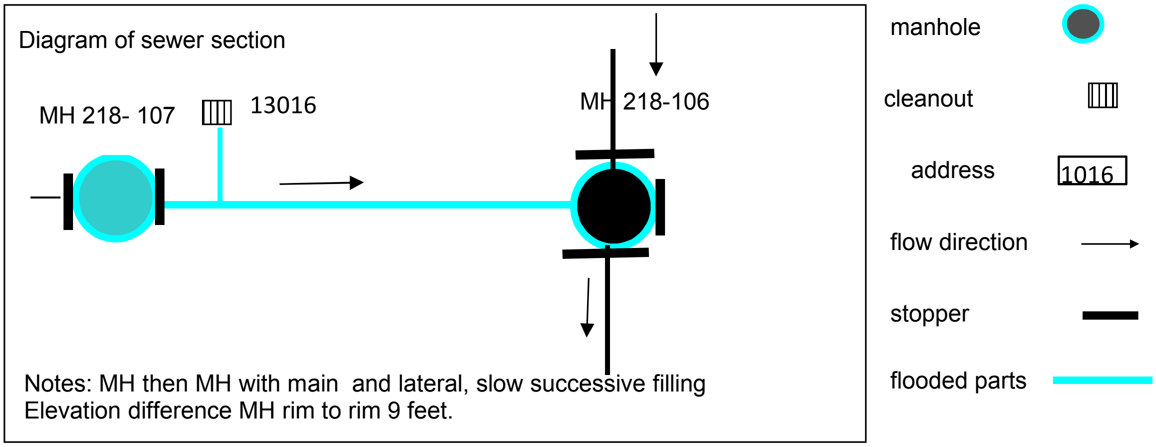
main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*302*	*789*
6	*87*	*128*

manholes:	*218-108 to 218-107*	
Ø inch	dept (feet)	volume gallons
48	*7.1*	*667*
48	*5.8*	*545*

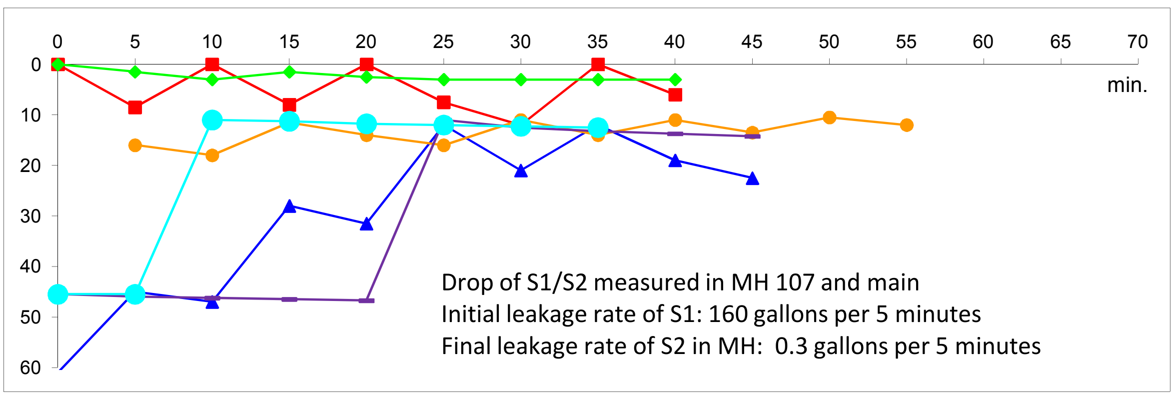
Location: *Seattle, 9th Ave NW*
Date: *15 September 2011*

Supervisor: *Csilla Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol



Flooded parts:	MH 107	MH 107	MH+Main + lat	MH+Main+lat	MH+Main + lat	MH+Main+lat
Time	11:45	12:25	8:29	9:50	11:30	1:30
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking 2. cycle S1	sinking 2. cycle S2	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0	61		45.5	45.5
5	8.5	1.5	45	16	46	45.5
10	0	3	47	18	46.25	11
15	8	1.5	28	11.5	46.5	11.25
20	0	2.5	31.5	14	46.75	11.75
25	7.5	3	12	16	11	12
30	12	3	21	11	12.5	12.25
35	0	3	12	14	13.25	12.5
40	6	3	19	11	13.75	
45			22.5	13.5	14.25	
50				10.5		
55				12		
60						
65						
70						



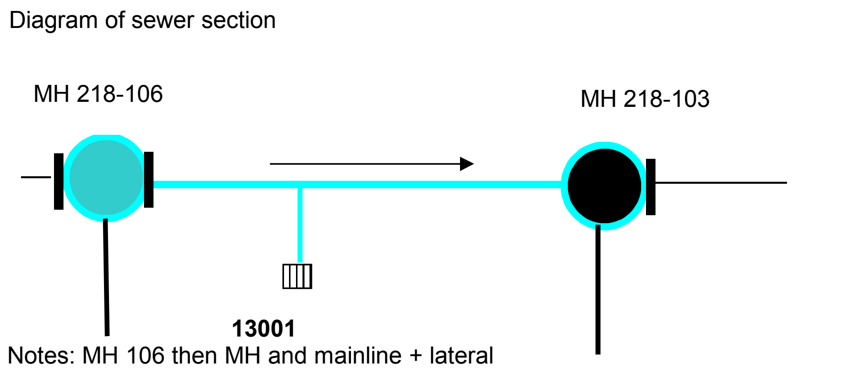
main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*91*	*238*
6	*28*	*41*

manholes:	*218-107 to 218-106*	
Ø inch	dept (feet)	volume gallons
48	*5.8*	*545*
48	*10.3*	*968*

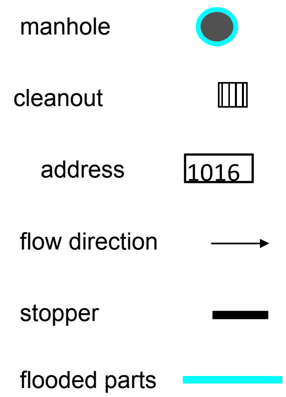
Location: *Seattle, 9th Ave. NW*
Date: *13 and 15 September and 3 October 2011*

Supervisor: *Ferenc Pall, Csilla Pall*
Contractor: *Bravo Environmental Inc.*

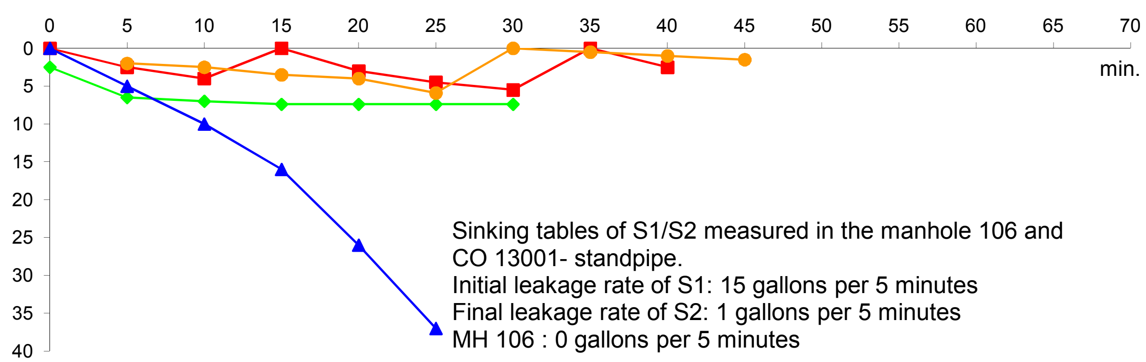
Sanipor - Sealing protocol



Notes: MH 106 then MH and mainline + lateral
Elevation difference MH rim to rim: 24 feet



Flooded parts:	MH 106	MH 106	MH+main+lat	MH+main+lat		
Time	11:13	12:05	13:22	14:35		
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking **cm** 2. cycle S1	sinking **cm** 2. cycle S2	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	2.5	0			
5	2.5	6.5	5	2		
10	4	7	10	2.5		
15	0	7.4	16	3.5		
20	3	7.4	26	4		
25	4.5	7.4	37	5.9		
30	5.5	7.4		0		
35	0			0.5		
40	2.5			1		
45				1.5		
50						
55						
60						
65						
70						



Sinking tables of S1/S2 measured in the manhole 106 and CO 13001- standpipe.
Initial leakage rate of S1: 15 gallons per 5 minutes
Final leakage rate of S2: 1 gallons per 5 minutes
MH 106 : 0 gallons per 5 minutes

main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*187*	*488*
6	*5*	*7*

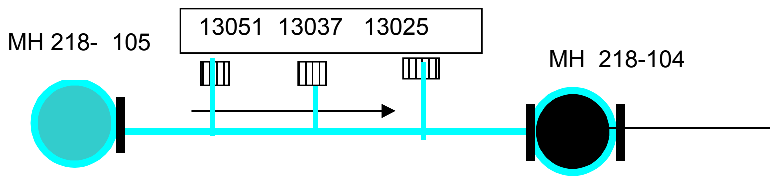
manholes:	*218-106 (to 103)*	
Ø inch	dept (feet)	volume gallons
48	*10.3*	*968*
48	*8.3*	*780*

Location: *Seattle, NW 130 th St.*
Date: *29 August 2011*

Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Environmental Inc.*

Sanipor - Sealing protocol

Diagram of sewer section



Notes: New precast MH 105, MH with main laterals
Elevation difference MH rim to rim: 5 feet

manhole

cleanout

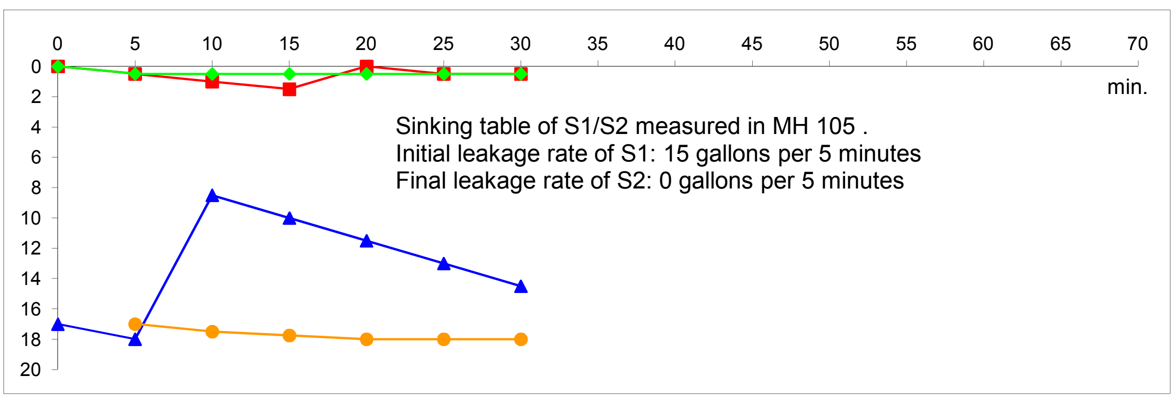
address 1016

flow direction

stopper

flooded parts

Flooded parts:	MH 150	MH 105	MH and main	MH and mains		
Time	8:40	9:28	12:10	13:45		
minutes	sinking (inch) **1. cycle S1**	sinking (inch) **1. cycle S2**	sinking (inch) **2. cycle S1**	sinking (inch) **2. cycle S2**	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0	17			
5	0.5	0.5	18	17		
10	1	0.5	8.5	17.5		
15	1.5	0.5	10	17.75		
20	0	0.5	11.5	18		
25	0.5	0.5	13	18		
30	0.5	0.5	14.5	18		
35						
40						
45						
50						
55						
60						
65						
70						

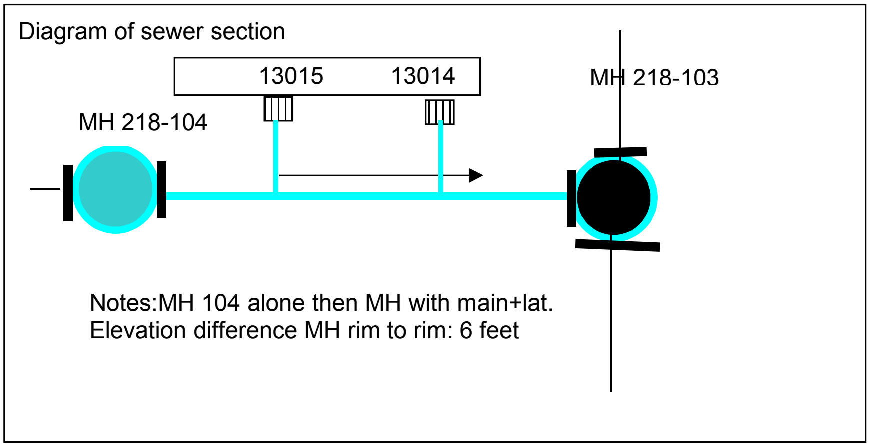


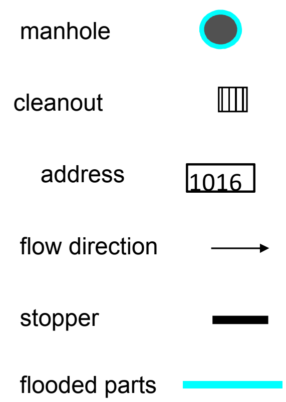
main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*49*	*128*
6	*75*	*110*

manholes:	*218-150 to 218-104*	
Ø inch	dept (feet)	volume gallons
48	*9.1*	*855*
48	*10.9*	*1,025*

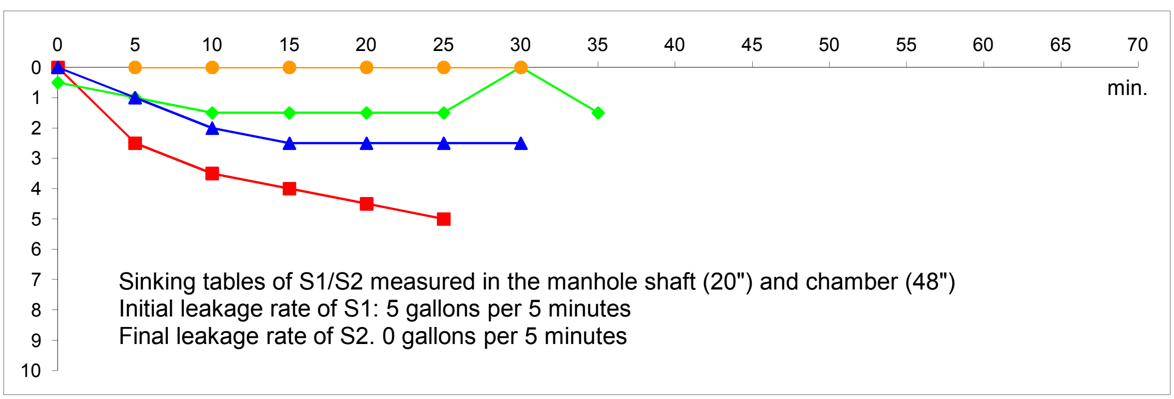
Location: *Seattle, Lane between 9th and 10 th Ave NW*
Date: *21 September 2011*
Supervisor: *Csilla Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol





Flooded parts:	MH 104	MH 104	MH and main	MH and main		
Time	8:20	9:07	10:25	11:40		
minutes	sinking (inch) **1. cycle S1**	sinking (inch) **1. cycle S2**	sinking (inch) **2. cycle S1**	sinking (inch) **2. cycle S2**	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0.5	0			
5	2.5	1	1	0		
10	3.5	1.5	2	0		
15	4	1.5	2.5	0		
20	4.5	1.5	2.5	0		
25	5	1.5	2.5	0		
30		1,5,	2.5	0		
35		1.5				
40						
45						
50						
55						
60						
65						
70						



main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*244*	*637*
6	*60*	*88*

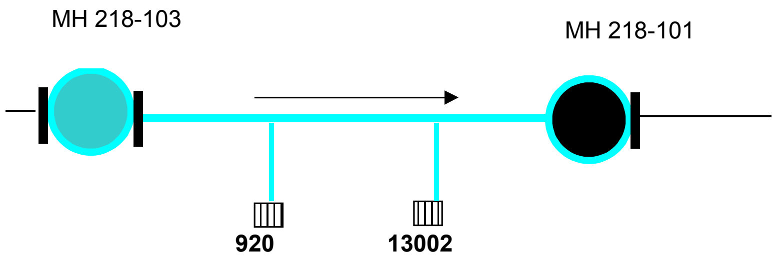
manholes:	*218-104 to 218-103*	
Ø inch	dept (feet)	volume gallons
48	*8.8*	*827*
48	*9.3*	*874*

Location: *Seattle,Lane between 9 and 10 th Ave NW*
Date: *16 September 2011*

Supervisor: *Csilla Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol

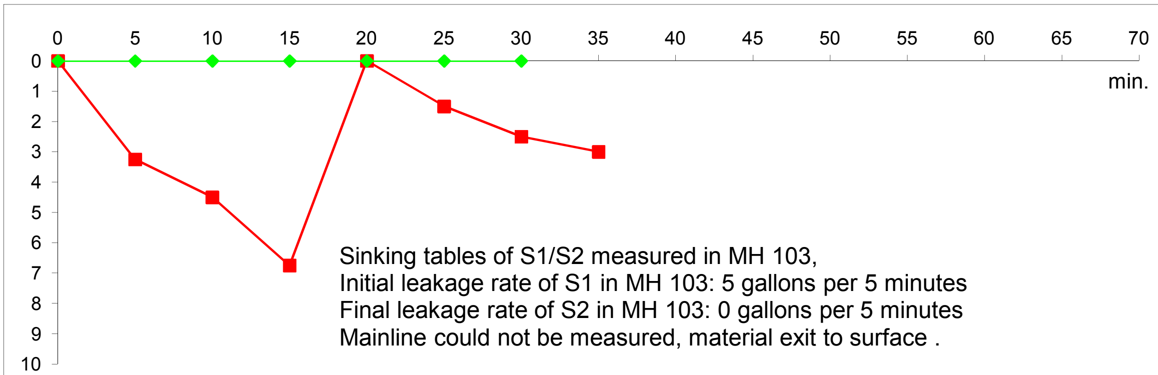
Diagram of sewer section



MH 103 (brick) and additionally main +2 laterals flooded in 2 cycles, no correct measurement possible, due to exfiltration on street surface
Elevation difference MH rim to rim: 24 feet

manhole
cleanout
address 1016
flow direction
flowing direction
stopper
flooded parts

Flooded Parts:	**MH 103**	**MH 103**	Main + laterals	Main + laterals	Main + laterals	Main + laterals
Time	**9:35**	**10:27**	11:30	12:35	14:10	15:10
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) **2. cycle S1**	sinking (inch) **2. cycle S2**
0	0	0				
5	3.25	0				
10	4.5	0				
15	6.75	0				
20	0	0				
25	1.5	0				
30	2.5	0				
35	3					
40						
45						
50						
55						
60						
65						
70						



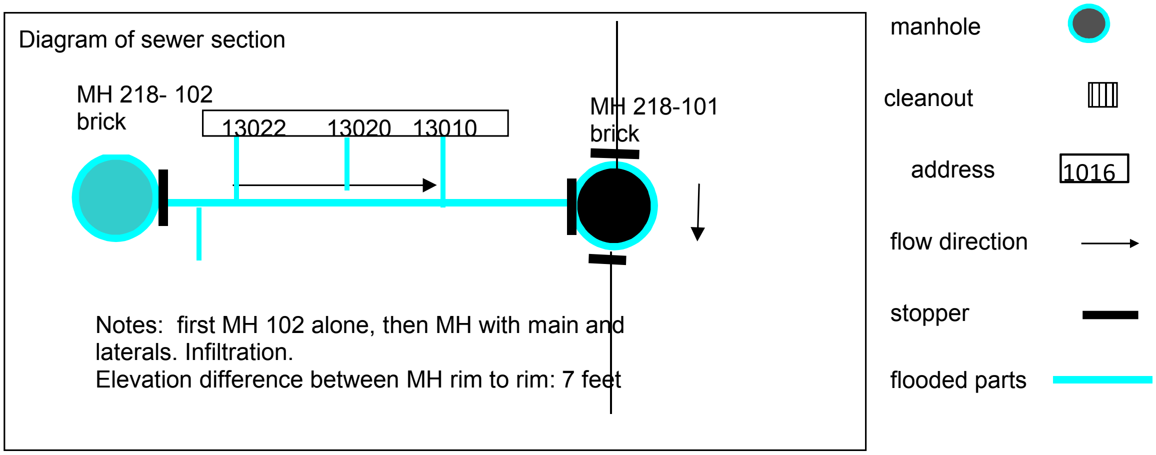
main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*185*	*483*
6	*33*	*48*

manholes:	*218-103 (to 101)*	
Ø inch	dept (feet)	volume gallons
48	*9.3*	*874*
48	*15.8*	*1,485*

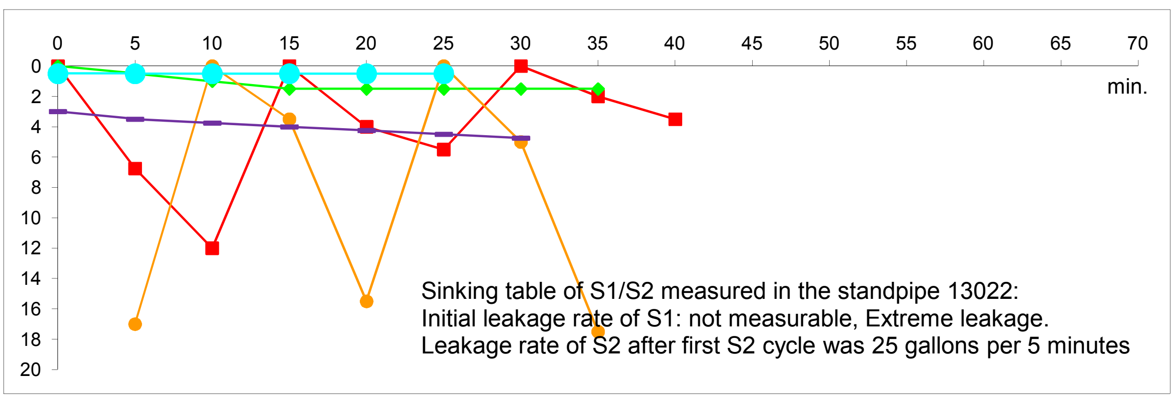
Location: *Seattle, NW 130 th St Ave.*
Date: *31 August 2011*

Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Environmental Inc.*

Sanipor - Sealing protocol **First cycles**



Date:	MH 102	MH 102	MH+main+lat	MH+main+lat	MH 101	MH 102
Time	8:23	9:20	11:20	13:00	Hydrotest 19 th September	
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) 2. cycle S1	sinking (inch) 2. cycle S2	sinking (inch) water	sinking (inch) water
0	0	0			3	0.5
5	6.75	0.5		17	3.5	0.5
10	12	1		0	3.75	0.5
15	0	1.5		3.5	4	0.5
20	4	1.5		15.5	4.25	0.5
25	5.5	1.5		0	4.5	0.5
30	0	1.5		5	4.75	
35	2	1.5		17.5		
40	3.5					
45						
50						
55						
60						
65						
70						



Sinking table of S1/S2 measured in the standpipe 13022:
Initial leakage rate of S1: not measurable, Extreme leakage.
Leakage rate of S2 after first S2 cycle was 25 gallons per 5 minutes

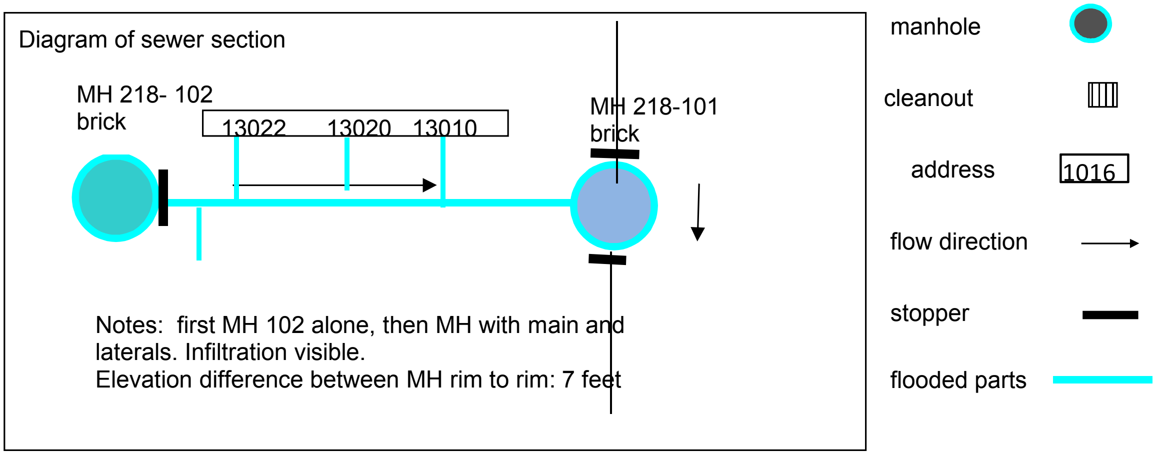
main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*300*	*783*
6	*70*	*103*

manholes:	*218-102 to 218-101*	
Ø inch	dept (feet)	volume gallons
48	*10.9*	*1,025*
48	*15.8*	*1,485*

Location: *Seattle, 10 th Ave NW*
Date: *7 September 2011*

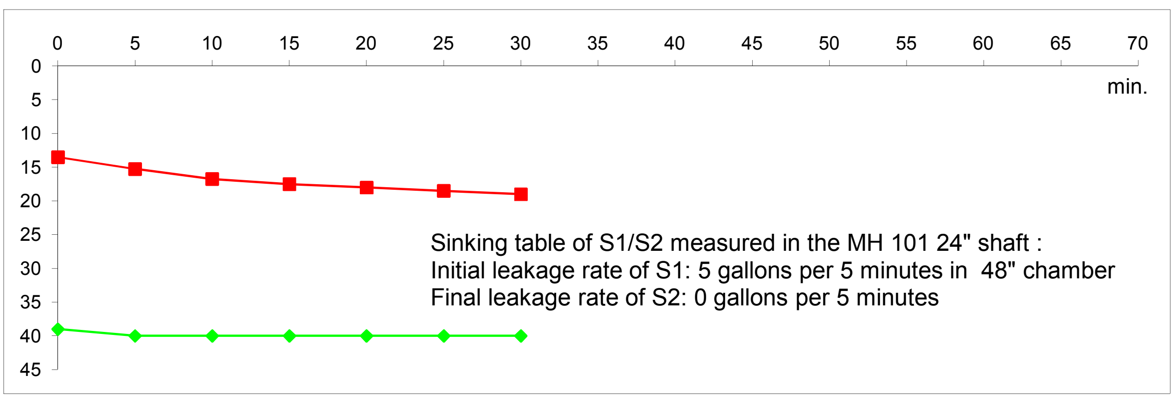
Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol resealing



Date: **MH 101 +main MH 101 +main**
Time **13:15 9:20**

minutes	sinking (inch) **1. cycle S1**	sinking (inch) **1. cycle S2**	sinking (inch) **2. cycle S1**	sinking (inch) **2. cycle S2**	sinking (inch) **water**	sinking (inch) **water**
0	13.5	39				
5	15.25	40				
10	16.75	40				
15	17.5	40				
20	18	40				
25	18.5	40				
30	19	40				
35						
40						
45						
50						
55						
60						
65						
70						



main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*300*	*783*
6	*70*	*103*

manholes:	*218-102 to 218-101*	
Ø inch	dept (feet)	volume gallons
48	*10.9*	*1,025*
48	*15.8*	*1,485*

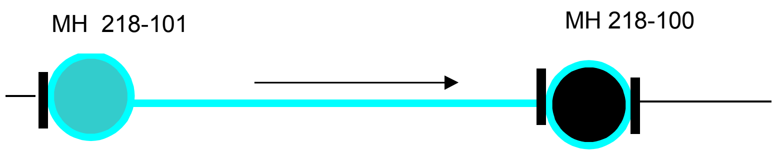
Location: *Seattle, 10 th Ave NW*
Date: *6 October 2011*

Supervisor: *Csilla Pall*
Contractor: *Bravo Envrionmental Inc.*

WERF

Sanipor - Sealing protocol

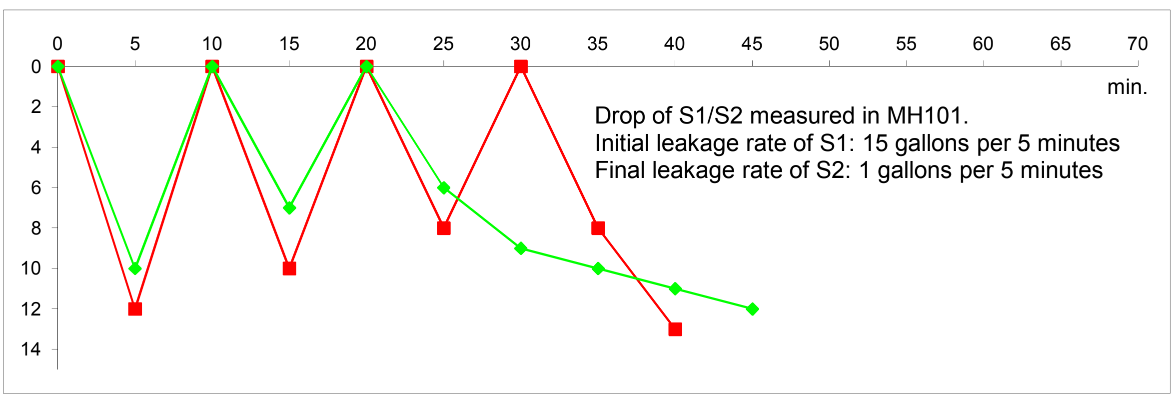
Diagram of sewer section



Notes: MH 101 (brick shaft and pre-cast chamber) with main.
Plug in DS MH was untight.
Elevation difference MH rim to rim: 7 feet

manhole
cleanout
address 1016
flow direction
stopper
flooded parts

Flooded parts:	**MH +main**	**MH+main**				
Time	**8:00**	**9:35**				
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) 2. cycle S1	sinking (inch) 2. cycle S2	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0				
5	12	10				
10	0	0				
15	10	7				
20	0	0				
25	8	6				
30	0	9				
35	8	10				
40	13	11				
45		12				
50						
55						
60						
65						
70						



main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*72*	*188*

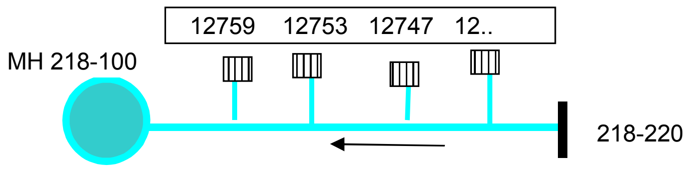
manholes:	*218-101 (to 100)*	
Ø inch	dept (feet)	volume gallons
48	*15.8*	*1,485*
48	*13*	*1,222*

Location: *Seattle, NW 130th .St.*
Date: *26 August 2011*

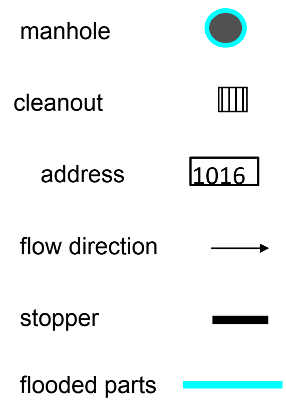
Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Environmental Inc.*

Sanipor - Sealing protocol

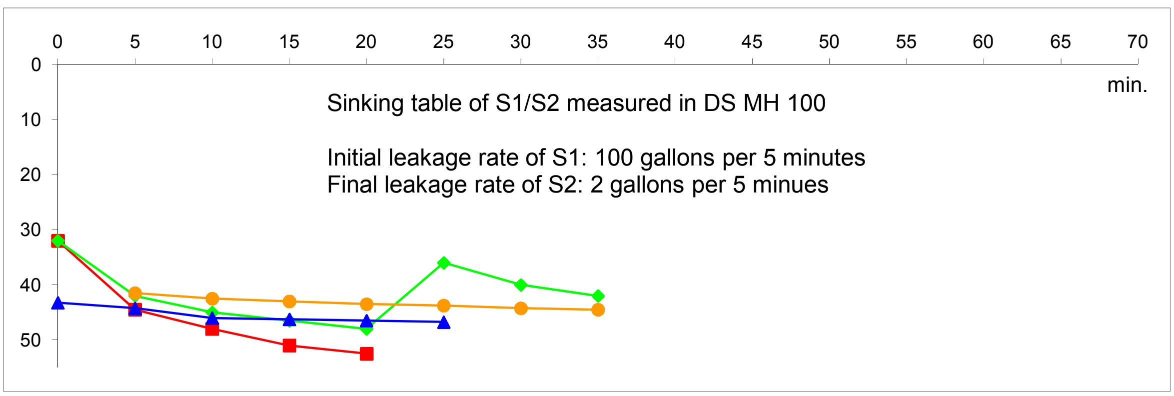
Diagram of sewer section



Notes: MH 100 with main and laterals
Drop measured in MH 100, no US MH # 220 exists.
Elevation difference MH rim to ground level: 12 feet.



Flooded Parts	**MH +main+lat**	**MH +main+lat**	**MH +main+lat**	**MH +main+lat**		
Time	**11:08**	**13:12**	**9:45**	**11:10**		
minutes	sinking (inch) **1. cycle S1**	sinking (inch) **1. cycle S2**	sinking (inch) **2. cycle S1**	sinking (inch) **2. cycle S2**	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	32	32	43.25			
5	44.5	42	44.25	41.5		
10	48	45	46	42.5		
15	51	46.5	46.25	43		
20	52.5	48	46.5	43.5		
25		36	46.75	43.75		
30		40		44.25		
35		42		44.5		
40						
45						
50						
55						
60						
65						
70						



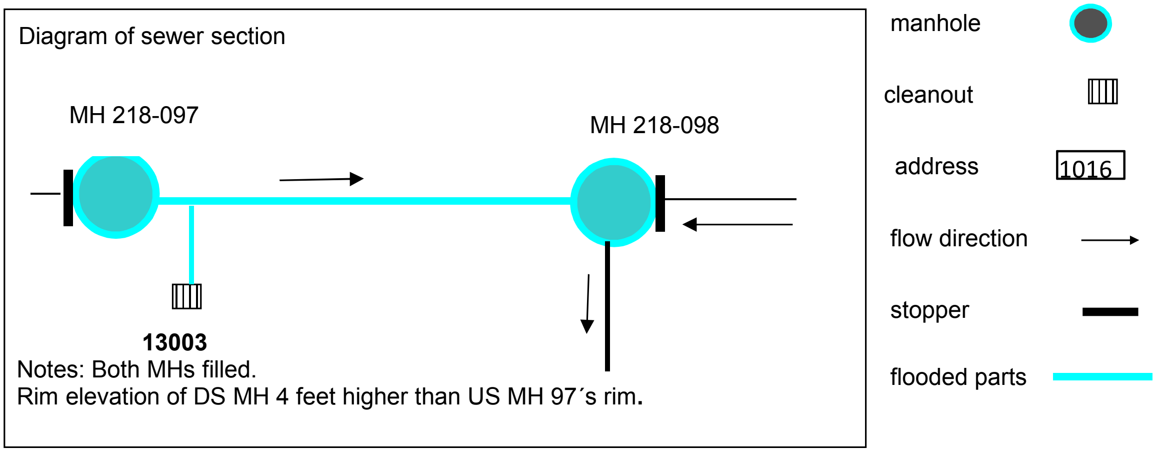
main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*300*	*783*
6	*60*	*88*

manholes:	*218-100 to 218-220*	
Ø inch	dept (feet)	volume gallons
0	*0*	*0*
48	*13*	*1,222*

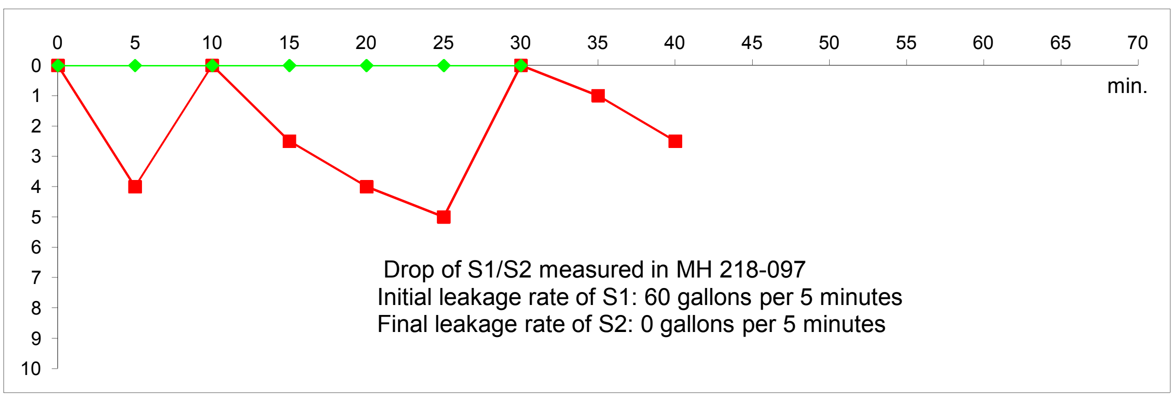
Location: *Seattle, Lane between 10 and 11th Ave NW*
Date: *22 September and 6 October 2011*

Supervisor: *Tim Lagunas, Csilla Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol



Flooded parts	MHs main,lat	MHs main,lat				
Time	14:45	15:50				
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking 2. cycle S1	sinking 2. cycle S2	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0				
5	4	0				
10	0	0				
15	2.5	0				
20	4	0				
25	5	0				
30	0	0				
35	1					
40	2.5					
45						
50						
55						
60						
65						
70						



main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	29	76
6	30	44

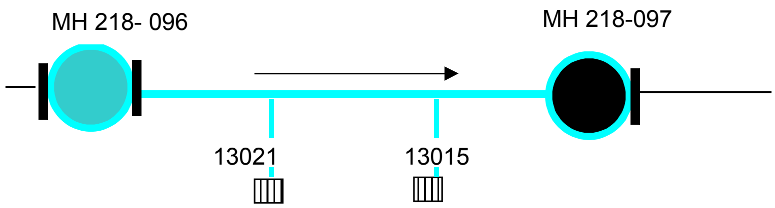
manholes:	*218-097 to 218-098*	
Ø inch	dept (feet)	volume gallons
48	4.9	461
48	8.1	761

Location: *Seattle, 12 th Ave.NW*
Date: *6 September 2011*

Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Environmental Inc.*

Sanipor - Sealing protocol

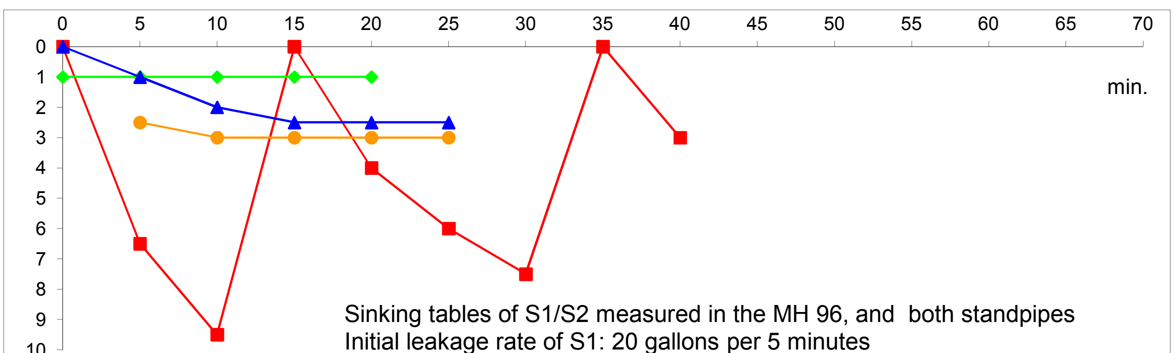
Diagram of sewer section



Notes: MH 218- 096 (brick) alone and with 2 laterals
Elevation difference MH rim to rim: 7 feet

manhole
cleanout
address 1016
flow direction
stopper
flooded parts

Flooded parts:	MH 96	MH96	main +laterals	main+laterals		
Time	9:35	10:37	11:40	12:45		
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) 1. cycle S1	sinking (inch) 3. cycle S2
0	0	1	0			
5	6.5	1	1	2.5		
10	9.5	1	2	3		
15	0	1	2.5	3		
20	4	1	2.5	3		
25	6		2.5	3		
30	7.5					
35	0					
40	3					
45						
50						
55						
60						
65						
70						



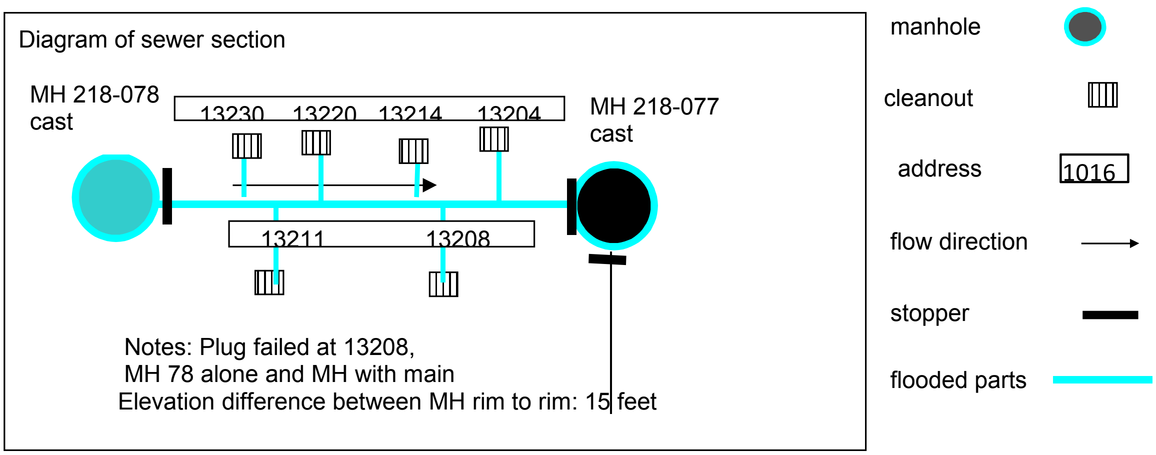
main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*171*	*447*
6	*44*	*65*

manholes:	*218-072 (to 070)*	
Ø inch	dept (feet)	volume gallons
48	*11.2*	*1,053*
48	*4.9*	*461*

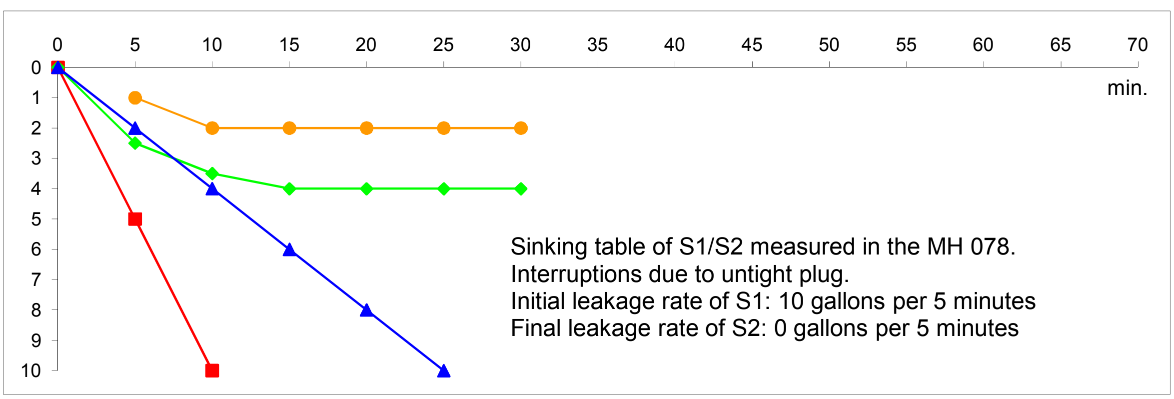
Location: *Seattle, 12th Ave NW .*
Date: *2 September 2011*

Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Environmental Inc.*

Sanipor - Sealing protocol



Flooded parts:	**MH 78**	**MH78**	**MH 78+main**	**MH 78+main**		
Time	**9:43**	**11:04**	**12:50**	**13:40**		
minutes	sinking (inch) **1. cycle S1**	sinking (inch) **1. cycle S2**	sinking (inch) **2. cycle S1**	sinking (inch) **2. cycle S2**	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0	0			
5	5	2.5	2	1		
10	10	3.5	4	2		
15		4	6	2		
20		4	8	2		
25		4	10	2		
30		4		2		
35						
40						
45						
50						
55						
60						
65						
70						



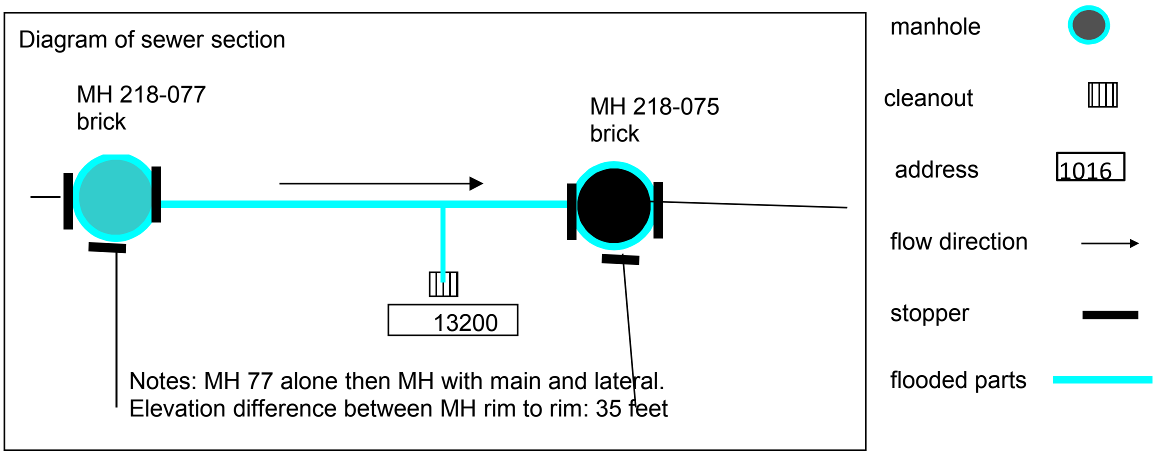
main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*290*	*757*
6	*100*	*147*

manholes:	*218-078 to 218-077*	
Ø inch	dept (feet)	volume gallons
48	*7.2*	*677*
48	*12*	*1,128*

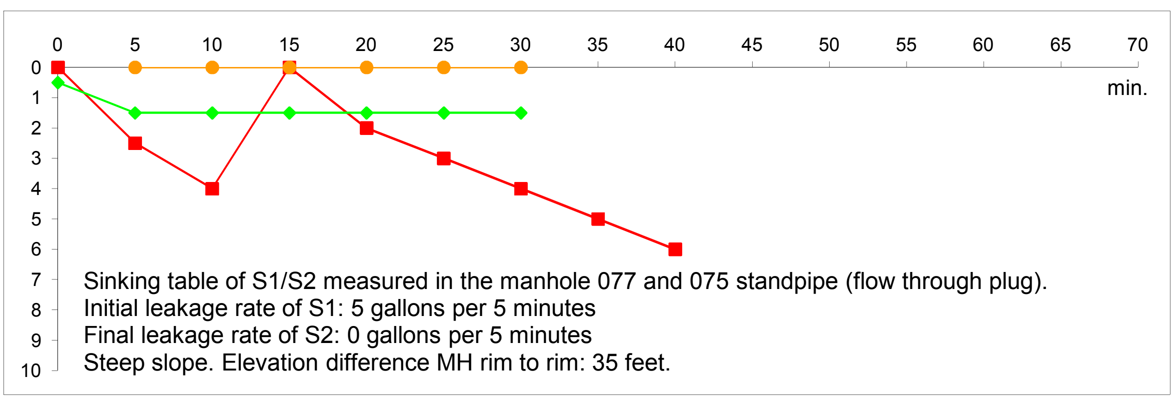
Location: *Seattle, Frazier Pl, NW*
Date: *16 and 25 August 2011*

Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol



Flooded parts:	MH 77	MH 77	MH +main+lat	MH +main+lat		
Time	8:25	9:26	10:43	12:10		
minutes	sinking (inch) **1. cycle S1**	sinking (inch) **1. cycle S2**	sinking (inch) **2. cycle S1**	sinking (inch) **2. cycle S2**	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0.5				
5	2.5	1.5		0		
10	4	1.5		0		
15	0	1.5		0		
20	2	1.5		0		
25	3	1.5		0		
30	4	1.5		0		
35	5					
40	6					
45						
50						
55						
60						
65						
70						



main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*252*	*658*
6	*50*	*73*

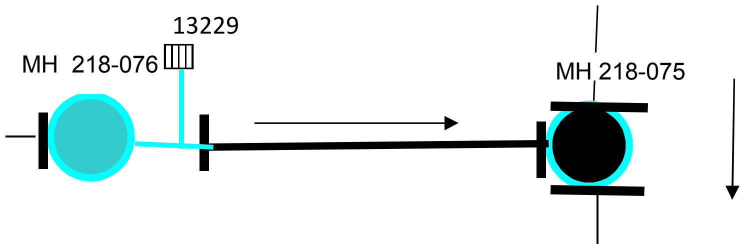
manholes:	*218-077 to 218-075*	
Ø inch	dept (feet)	volume gallons
48	*12.3*	*1,156*
48	*8.3*	*780*

Location: *Seattle, NW 132nd ST*
Date: *18 August 2011*

Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol

Diagram of sewer section



Notes: MH 76 (pre-cast) and one lateral sealed in 2 cycles
Elevation difference between MH rim to rim: 17 feet
Exfiltration of materials to surface, measurement not possible in lower

manhole

cleanout

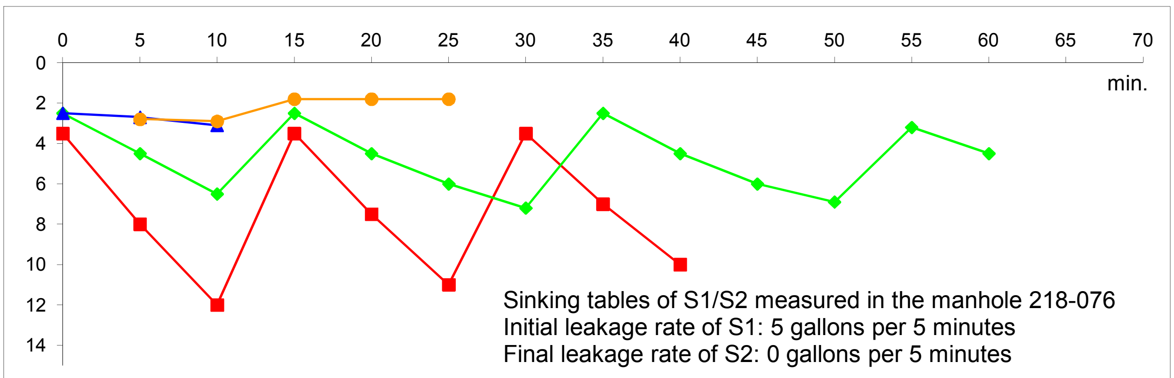
address 1016

flow direction

stopper

flooded parts

Flooded parts	**MH 076 + lat**	**MH 076 + lat**	**MH 076 + lat**	**MH 076 + lat**		
Time	**12:00**	**13:36**	**15:00**	**15:55**		
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) 2. cycle S1	sinking (inch) 2. cycle S2	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	3.5	2.5	2.5			
5	8	4.5	2.7	2.8		
10	12	6.5	3.1	2.9		
15	3.5	2.5		1.8		
20	7.5	4.5		1.8		
25	11	6		1.8		
30	3.5	7.2				
35	7	2.5				
40	10	4.5				
45		6				
50		6.9				
55		3.2				
60		4.5				
65						
70						



main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*8*	*21*
6	*10*	*15*

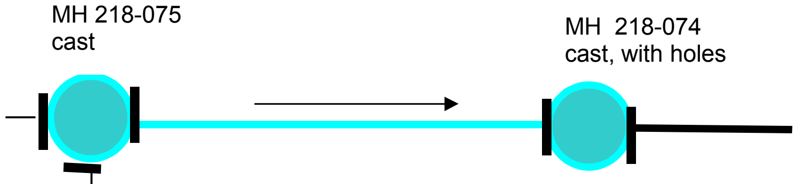
manholes:	*218-076 (to 075)*	
Ø inch	dept (feet)	volume gallons
48	*6.9*	*649*
48	*8.3*	*780*

Location: *Seattle, 9th Ave. NW*
Date: *10 August 2011*

Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Environmental Inc.*

Sanipor - Sealing protocol

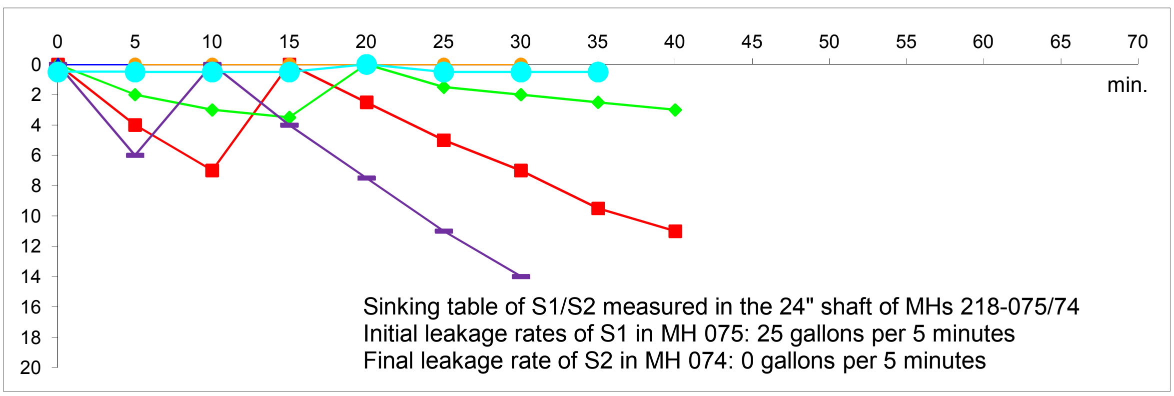
Diagram of sewer section



Notes: MH 75 , Main then MH 74 were flooded separately.
Mainline was watertight. No drop visible/measurable.
Steep slope. Elevation difference MH rim to rim 24 feet.

- manhole
- cleanout
- address 1016
- flow direction
- stopper
- flooded parts

Flooded Parts:	MH 75	MH 75	Main pipe	Main pipe	MH 74	MH 74
Time	9:10	10:02	11:22	12:06	13:13	13:47
minutes	sinking (inch) **1. cycle S1**	sinking (inch) **1. cycle S2**	sinking (inch) **2. cycle S1**	sinking (inch) **2. cycle S2**	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0	0		0	0.5
5	4	2	0	0	6	0.5
10	7	3	0	0	0	0.5
15	0	3.5	0	0	4	0.5
20	2.5	0	0	0	7.5	0.5
25	5	1.5	0	0	11	0.5
30	7	2	0	0	14	0.5
35	9.5	2.5				0.5
40	11	3				
45						
50						
55						
60						
65						
70						



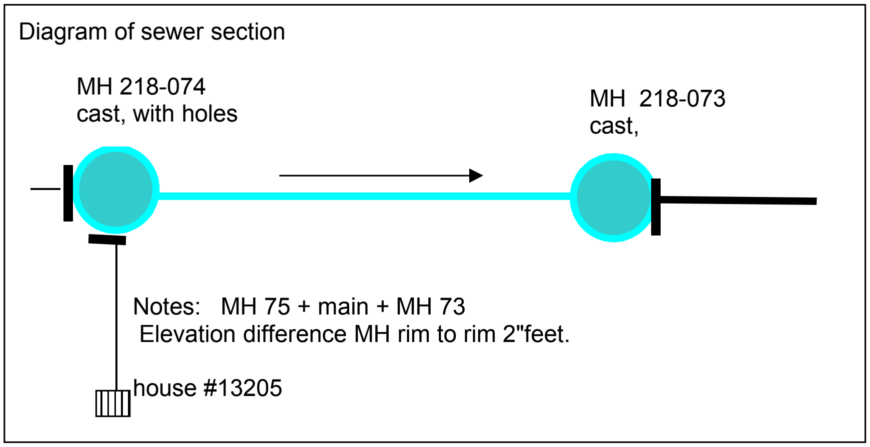
main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*153*	*400*

manholes:	*218-075 to 218-074*	
Ø inch	dept (feet)	volume gallons
48	*8.3*	*780*
48	*8.1*	*761*

Location: *Seattle, NW 132 nd St.*
Date: *22 August 2011*

Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol



manhole

cleanout

address 1016

flow direction

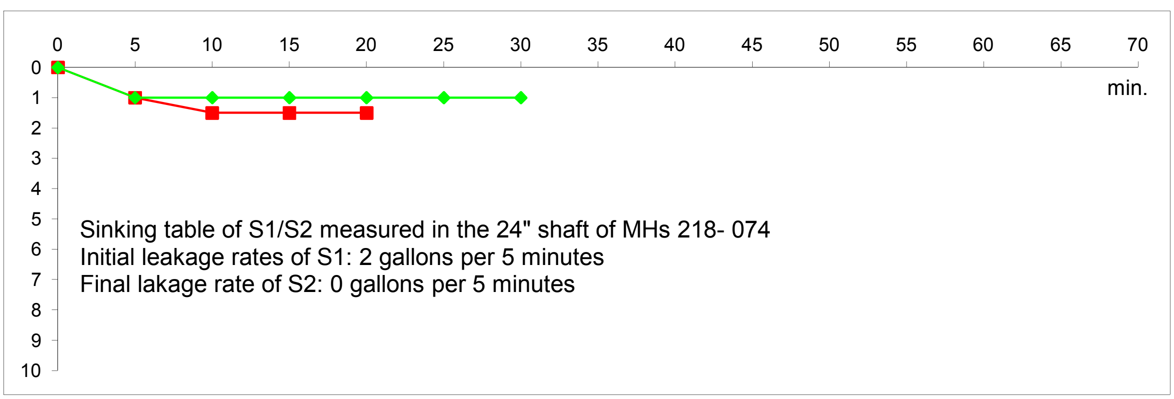
stopper

flooded parts

Flooded Parts: **MH +main+MH** **MH +main+MH**

Time **9:30** **10:02**

minutes	sinking (inch) **1. cycle S1**	sinking (inch) **1. cycle S2**	sinking (inch) **2. cycle S1**	sinking (inch) **2. cycle S2**	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0				
5	1	1				
10	1.5	1				
15	1.5	1				
20	1.5	1				
25		1				
30		1				
35						
40						
45						
50						
55						
60						
65						
70						



main pipe and laterals		
Ø inch	length(feet)	volume gallons
8	*38*	*99*

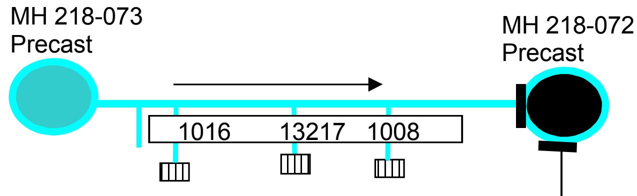
manholes:	*218-075 to 218-074*	
Ø inch	dept (feet)	volume gallons
48	*8.3*	*780*
48	*11.5*	*1,081*

Location: *Seattle, NW 132 nd St.*
Date: *23 August 2011*

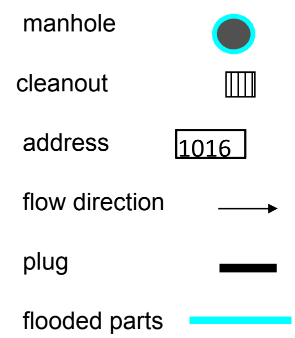
Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol

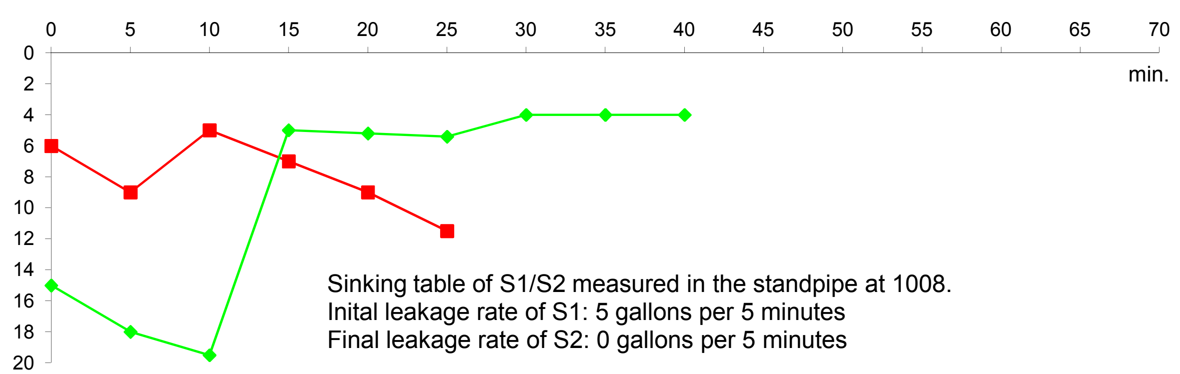
Diagram of sewer section



Notes: MH holes in the bottom, infiltration
MH 73 alone ( ) , MH with main
Steep slope. Elevation difference MH rim to rim: 35 feet



Flooded Part:	MH & Main	MH & Main				
Time	9:43	11:04				
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) 2. cycle S1	sinking (inch) 2. cycle S2	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	6	15				
5	9	18				
10	5	19.5				
15	7	5				
20	9	5.2				
25	11.5	5.4				
30		4				
35		4				
40		4				
45						
50						
55						
60						
65						
70						



Sinking table of S1/S2 measured in the standpipe at 1008.
Inital leakage rate of S1: 5 gallons per 5 minutes
Final leakage rate of S2: 0 gallons per 5 minutes

main pipe and laterals

Ø inch	length(feet)	volume (gal)
8	*350*	*914*
6	*135*	*198*

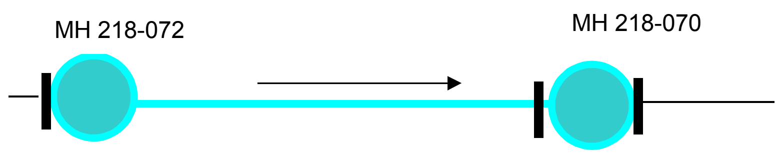
manholes: *218-073 to 218-072*

Ø inch	dept (feet)	volume (gal)
48	*11.5*	*1,081*
48	*11.3*	*1,062*
Total Flooded Volume		2,193

Location: *Seattle, NW 132 nd St.*
Date: *24 August 2011*
Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol

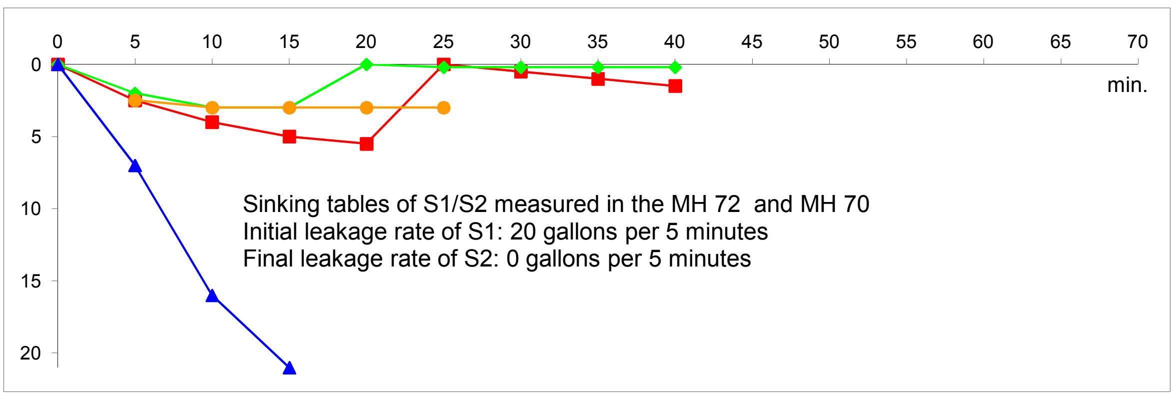
Diagram of sewer section



Notes: MH 218- 072 (cast) with mainline, MH(brick) - 070
Elevation difference from MH rim to rim : 2 feet

manhole	
cleanout	
address	1016
flow direction	
stopper	
flooded parts	

Flooded Part:	MH72 +main+lat	MH72 +main+lat	MH70	MH 70		
Time	9:15	11:07	13:25	14:00		
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) 1. cycle S1	sinking (inch) 3. cycle S2
0	0	0	0			
5	2.5	2	7	2.5		
10	4	3	16	3		
15	5	3	21	3		
20	5.5	0		3		
25	0	0.2		3		
30	0.5	0.2				
35	1	0.2				
40	1.5	0.2				
45						
50						
55						
60						
65						
70						



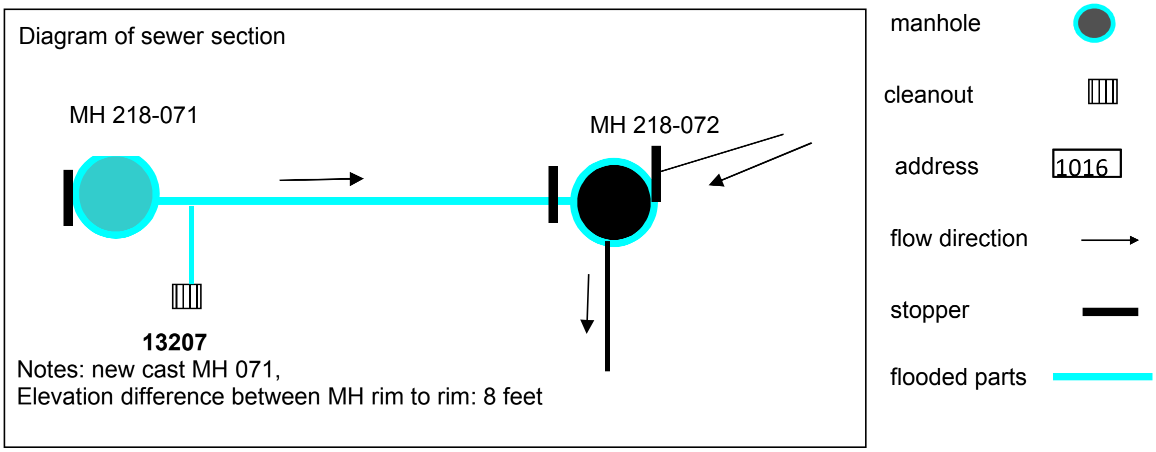
main pipe and laterals		
Ø inch	length(feet)	volume/gallon
8	*151*	*394*

manholes:	*218-072 to 218-070*	
Ø inch	dept (feet)	volume gallons
48	*11.3*	*1,062*
48	*15*	*1,410*

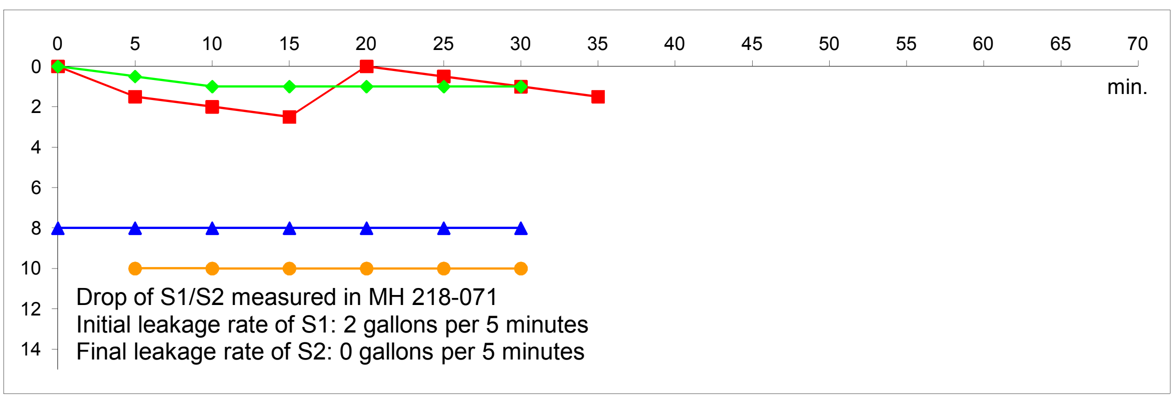
Location: *Seattle, NW 132 ND .*
Date: *30 August 2011*

Supervisor: *Csilla Pall, Ferenc Pall*
Contractor: *Bravo Environmental Inc.*

Sanipor - Sealing protocol



Flooded parts	MH 071	MH 071	MH+Main+lat	MH+Main+lat		
Time	8:30	9:27	11:15	12:10		
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking 2. cycle S1	sinking 2. cycle S2	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	0	0	8			
5	1.5	0.5	8	10		
10	2	1	8	10		
15	2.5	1	8	10		
20	0	1	8	10		
25	0.5	1	8	10		
30	1	1	8	10		
35	1.5					
40						
45						
50						
55						
60						
65						
70						



main pipe and laterals Ø inch	limited length(feet)	volume gallons
8	*108*	*282*
6	*24*	*35*

manholes: *218-071 to 218-072* Ø inch	dept (feet)	volume gallons
48	*9.3*	*874*
48	*11.3*	*1,062*

Location: *Seattle, 11th PL NW*
Date: *20 September 2011*

Supervisor: *Csilla Pall*
Contractor: *Bravo Environmental Inc.*

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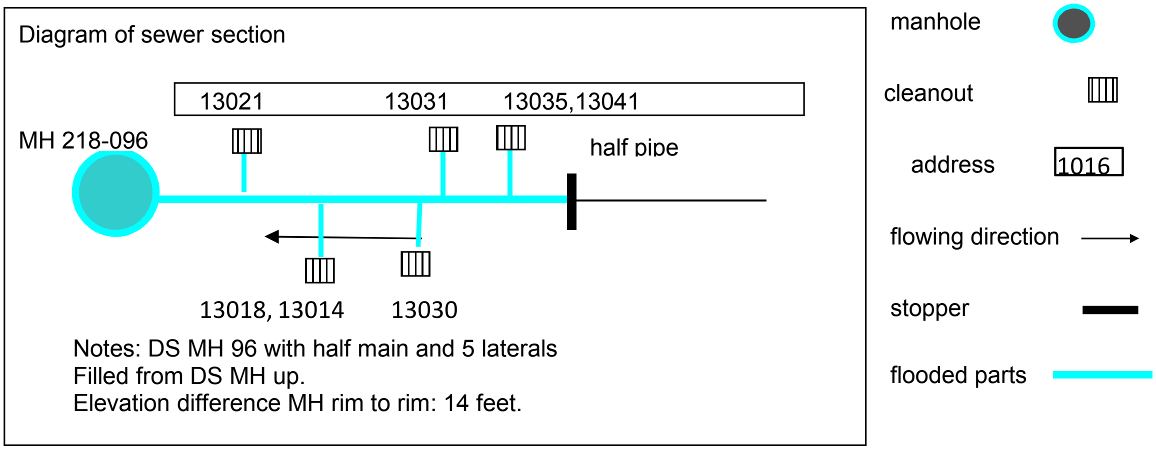
Sanipor - Sealing protocol



Flooded Parts	MH +main+lat	MH +main+lat				
Time	11:25	13:35				
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) 2. cycle S1	sinking (inch) 2. cycle S2	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	13	13				
5	15.5	13.25				
10	18	13.5				
15	20	13.75				
20	21	14				
25	22.5	14.25				
30	23	14.25				
35	24	14.25				
40						
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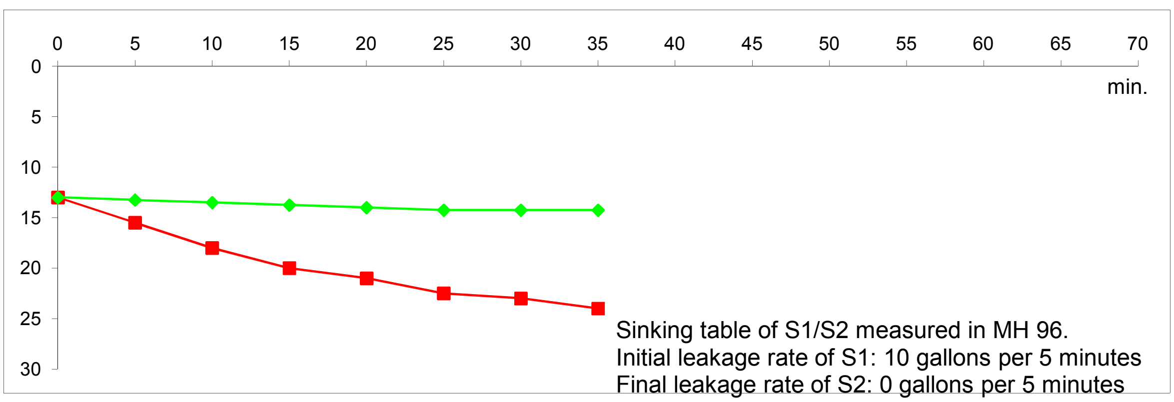
50						
55						
60						
65						
70						



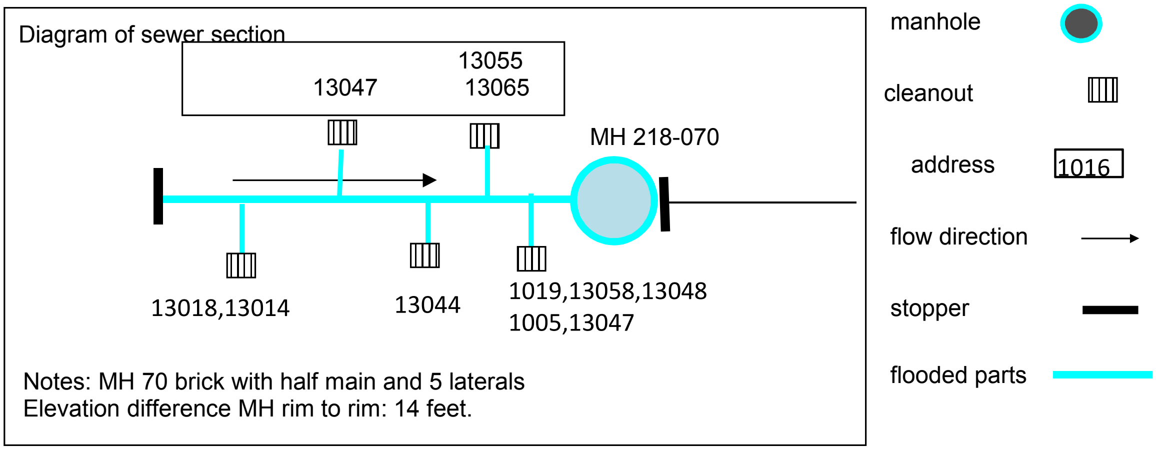
main pipe and laterals Ø inch	total length(feet)	volume gallons
8	*460*	*1,201*
6	*200*	*294*

manholes: *218-1-070 to 218-096* Ø inch	dept (feet)	volume gallons
48	*11.2*	*1,053*
48	*15*	*1,410*

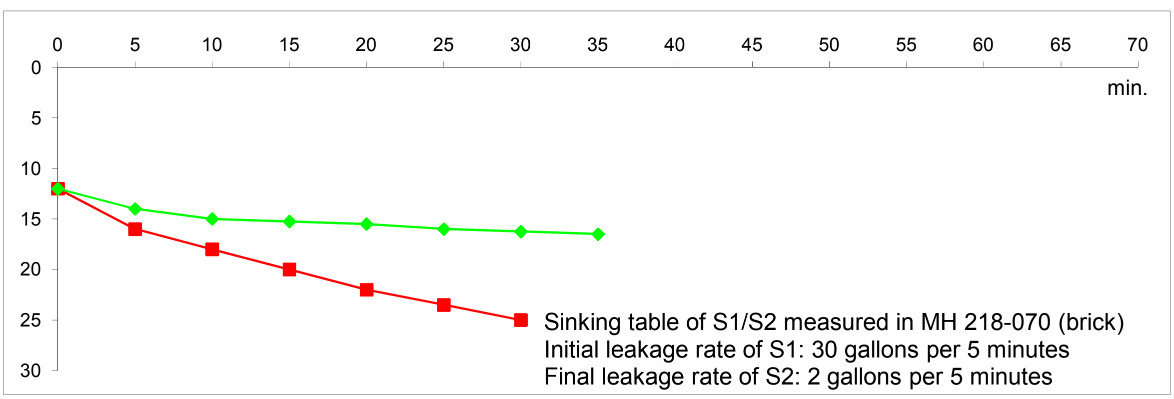
Location: *Seattle, 12 th Ave NW*
Date: *28 September 2011*

Supervisor: *Csilla Pall*
Contractor: *Bravo Envrionmental Inc.*

Sanipor - Sealing protocol



Flooded Parts	MH +main+lat	MH +main+lat				
Time	11:45	13:35				
minutes	sinking (inch) 1. cycle S1	sinking (inch) 1. cycle S2	sinking (inch) 2. cycle S1	sinking (inch) 2. cycle S2	sinking (inch) 3. cycle S1	sinking (inch) 3. cycle S2
0	12	12				
5	16	14				
10	18	15				
15	20	15.25				
20	22	15.5				
25	23.5	16				
30	25	16.25				
35		16.5				
40						
45						
50						
55						
60						
65						
70						



main pipe and laterals Ø inch	*total* length(feet)	volume gallons
8	*460*	*1,201*
6	*200*	*294*

manholes: *218-070 to 218-096* Ø inch	dept (feet)	volume gallons
48	*15*	*1,410*
48	*11.2*	*1,053*

Location: *Seattle, 12th Ave NW*
Date: *29 September 2011*

Supervisor: *Csilla Pall*
Contractor: *Bravo Envrionmental Inc.*

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