

# **PILOT PROJECT REPORT**

## **EXECUTIVE SUMMARY**

### **Regional Infiltration and Inflow Control Program King County, Washington**

October 2004



**King County**

Department of  
Natural Resources and Parks

**Wastewater Treatment Division**



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Pilot Project Report—Executive Summary

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# Executive Summary

In December 1999, the King County Council approved the development of a Regional Infiltration and Inflow (I/I) Control Program as part of the Regional Wastewater Services Plan (RWSP). The purposes of the program are to reduce the risk of sanitary sewer overflows and the cost of adding capacity to facilities that convey wastewater to County treatment plants.

In 2000, the County’s Wastewater Treatment Division, in cooperation with the local component agencies that it serves, launched an ambitious six-year \$41-million I/I control study. The study includes efforts to identify sources of I/I, test the effectiveness of various I/I control technologies, examine the benefits and costs of I/I control, and prepare a regional plan for reducing I/I in local agency collection systems.

Completion of ten I/I control pilot projects in January 2004 marks a major milestone in the study. The following text provides background on the I/I control program and summarizes the experiences gained from the pilot projects.

## What Is Infiltration and Inflow (I/I)?

King County provides wastewater services to 34 local agencies (cities and sewer districts) in its wastewater service area. These agencies own, operate, and maintain pipelines that are tributary to the King County conveyance system. Pipelines in the County system carry the flow from local areas to two major regional wastewater treatment plants—the West Point plant in Seattle and the South plant in Renton.

Most of the conveyance system, except in some areas of the City of Seattle, consists of “separated” sewers intended to collect wastewater from homes and businesses for treatment. In a separated system, a different set of pipes collects stormwater. However, during periods of rain, “clean” stormwater runoff and groundwater may enter the separated sewers.

This clean water, referred to as infiltration and inflow, is expressed in terms of the volume of clean water originating from the total land area being served, or gallons per acre per day (gpad). Recent flow modeling efforts indicate that about 95 percent of I/I in the County’s separated sewers originates in local systems, primarily in side sewers on private property and in other sources in these systems.

### A few useful definitions...

**Infiltration.** Groundwater that seeps into sewers through holes, breaks, joint failures, defective connections, and other openings.

**Inflow.** Stormwater that rapidly flows into sewers via roof and foundation drains, catch basins, downspouts, manhole covers, and other sources.

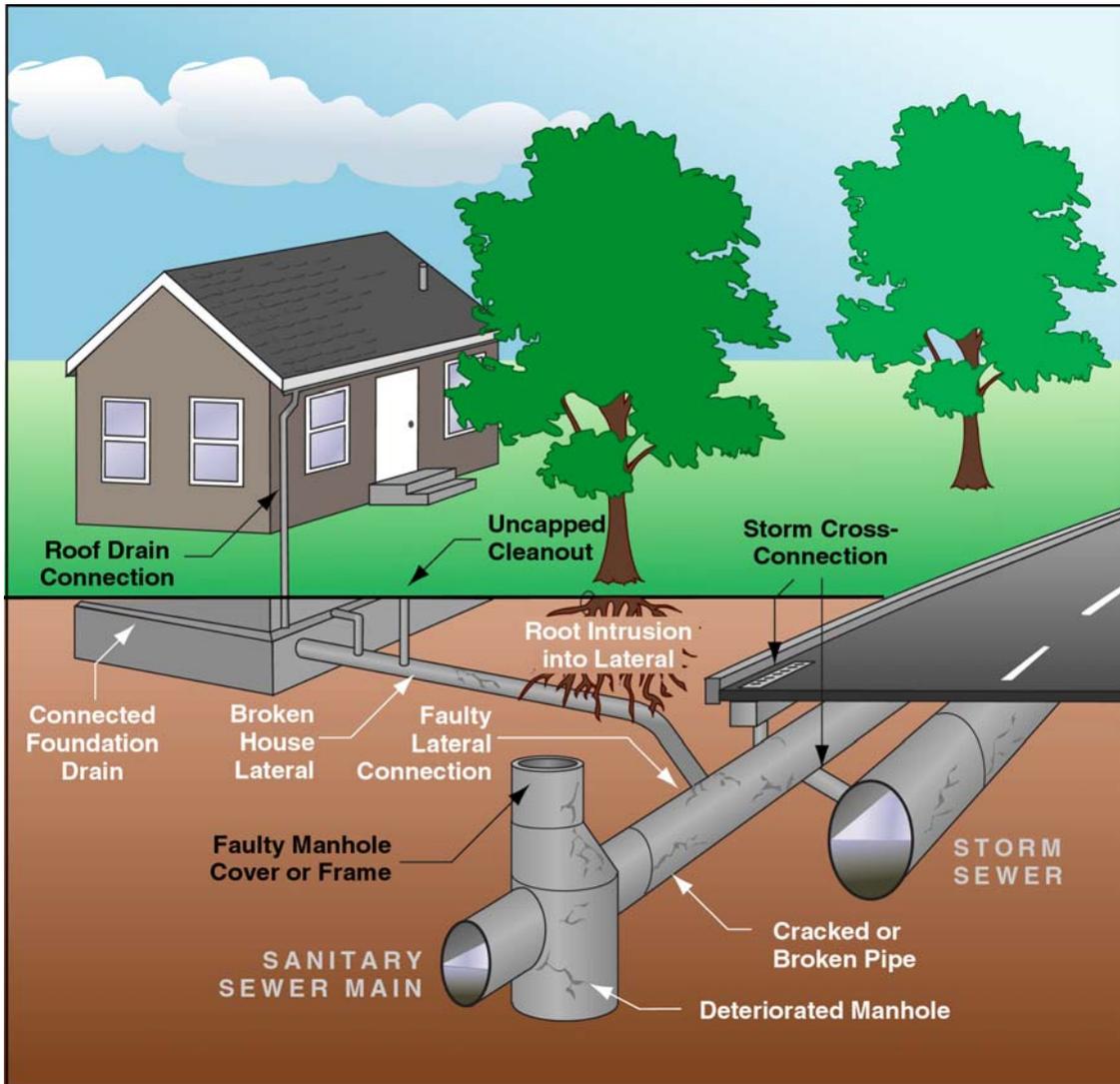
**Lateral sewer.** The portion of the individual house sewer pipe that is in the public right-of-way.

**Separated sewer.** A pipe designed to accept and transport household, industrial, and commercial wastewater and to exclude stormwater sources.

**Side sewer.** The portion of the individual house sewer pipe that extends from the house to the public right-of-way.

**Infiltration** is subsurface flow, or groundwater, that seeps into sewers through holes, breaks, joint failures, defective connections, and other openings. Infiltration can happen throughout the year, but the volumes are usually greater after large storms or prolonged wet periods.

**Inflow** is stormwater that rapidly flows into sewers via roof and foundation drains, catch basins, downspouts, manhole covers, and other sources.



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**Key:**

- ← Inflow Source
- ← Infiltration Source

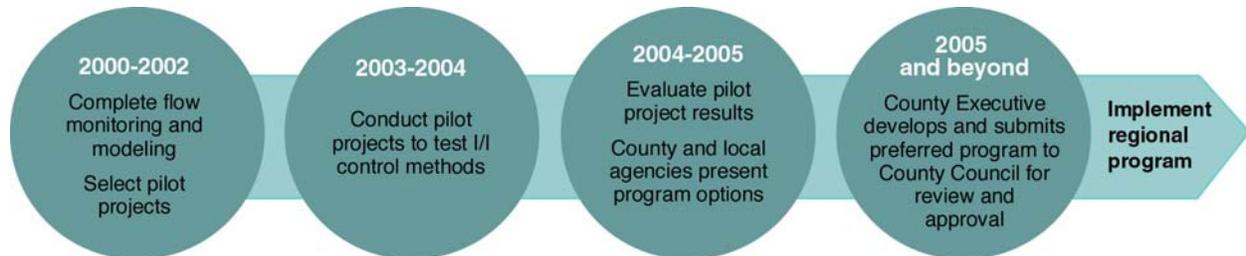
## Why Do We Want to Control I/I?

The King County Wastewater Treatment Division’s (WTD) mandate is to protect public health and the environment. It meets this mandate by ensuring that there is enough capacity in the conveyance system to manage peak flow and to prevent sewage overflows from occurring in the system. The County defines peak flow as the combination of wastewater expected to be generated at any given time and the I/I predicted to be in the system as the result of a storm or series of storms that, on average, occur only once in 20 years.

Results of recent flow modeling indicate that about 75 percent of the peak flow to the South plant, which serves only separated sewers, comes from I/I. Excess I/I can drive the need for enlarging and replacing conveyance facilities (pipes and pump stations) with facilities large enough to convey these additional flows. If cost-effective methods for I/I control can be identified and implemented, capital costs for conveyance improvements could be reduced by eliminating, delaying, or phasing conveyance projects.

## What Is the I/I Control Program?

The RWSP directs King County to develop a Regional Infiltration and Inflow Control Program that will rehabilitate conveyance facilities to control I/I when (1) the cost of rehabilitation is less than the cost of conveying and treating the I/I flow or (2) when rehabilitation would provide significant environmental benefits.



The first phase of the program is a comprehensive six-year study that began in 2000 and consists of five steps:

- Define current levels of I/I for each local agency tributary to the regional system.
- Select and construct pilot projects to demonstrate the cost-effectiveness of collection system rehabilitation projects.
- Develop model standards, procedures, and policies for use by local agencies to reduce I/I in their systems.
- Identify cost-effective options to remove up to 30 percent of I/I expected to occur in local agency systems during a 20-year peak flow condition.
- Develop a long-term regional I/I control plan for review and approval by the County Council.

## What Have We Done So Far?

To define current levels of I/I for each local agency, about 800 flow meters were installed in drainage basins throughout the separated sewer system to identify sources and volumes of I/I during the winter season. Originally, only one year of monitoring was planned. Another year was added because the first year of monitoring occurred during the region's driest winter in more than 40 years (between November 1, 2000, and January 15, 2001). The second season of monitoring, conducted between November 1, 2001, and January 15, 2002, measured record-setting rains and produced excellent results.

To demonstrate the cost-effectiveness of collection system rehabilitation projects and to gain a better understanding of the issues associated with implementing such projects, ten demonstration I/I pilot projects were constructed in local agency systems. Model standards, procedures, and policies were drafted and then applied to the pilot projects to test how well the standards, procedures, and policies would work to guide future I/I control projects in local systems. Construction of the pilot projects started mid 2003. Construction on the last pilot project was completed in January 2004. Post-pilot-project flow monitoring was completed during winter 2003–2004; results were modeled to determine the effectiveness of the projects in reducing I/I.

## What Are the Next Steps?

Now that the pilot projects are completed and their results are documented, the County will use the flow information collected during the I/I study to conduct a Regional Needs Assessment of its conveyance system that will project when conveyance facilities will exceed the 20-year peak flow capacity standard. An analysis of flow monitoring data for the pilot projects and cost comparisons with traditional methods for providing capacity will be completed by the end of 2004. An Alternatives/Options report will then be prepared and submitted by March 1, 2005. The report will present a set of options for consideration in development of the long-range I/I control program.

As information becomes available on the cost-effectiveness of I/I control, the County will assess the benefits of I/I control measures versus identified conveyance improvements. If I/I measures are deemed more cost-effective in specific areas of the system, related conveyance projects may be delayed, reduced in scope, eliminated, or divided into phases. By December 31, 2005, the King County Executive will submit to the King County Council a plan for a long-term Regional Inflow and Infiltration Control Program. The plan will identify target I/I levels for local systems. It also will identify long-term I/I control measures to meet these targets and to serve as cost-effective alternatives to planned conveyance and treatment projects.

## What Makes the I/I Program Unique?

Several features distinguish King County's Regional Infiltration and Inflow Control Program from other I/I control programs in the country:

- The program is **voluntary**. Other I/I control programs were developed in response to

federal or state agency consent orders or other regulatory mandates. King County and local agencies initiated the program in an effort to increase system efficiencies and control wastewater treatment rates.

- The program involves **projects in local systems**. It is unusual for a regional wastewater agency to participate in sewer rehabilitation projects in local systems, including lateral and side sewer projects on private property served by these systems.
- The program tests **new assessment and rehabilitation technologies**. The technical report on the pilot projects contains valuable information that agencies can use as a resource for their I/I control.
- The program included a **comprehensive flow monitoring effort**. With over 800 flow meters installed the first year and 775 the second year, the two-year flow monitoring study enabled the County and local agencies to dramatically improve their understanding of the system.
- Most important, the program is being planned and implemented in **partnership with the local agencies that contribute wastewater to the King County system**. The County has conducted more than 50 meetings and workshops with local agencies since the study began.

Throughout the first phase of the program, King County has been working with the Metropolitan Water Pollution Abatement Advisory Committee (MWPAAC)—a committee composed of representatives from the local component agencies. MWPAAC has worked closely with the County and its consultant in identifying and selecting the pilot projects, developing draft standards, and, most recently, reviewing pilot project results and helping define a range of alternatives for long-term I/I control. Much of the consensus building and decision making has taken place in a series of workshops. These workshops facilitated discussion and generated valuable insights that have helped shape the development of the long-term I/I control plan.

A benefit of this collaboration has been a strengthening of relationships, a better understanding of local and County needs, and a solid foundation for future collaborative projects that could enhance resource management and reduce costs for each agency and its customers.

## How Were the Pilot Projects Selected?

The pilot project selection process showcases the high degree of collaboration that defines the I/I program. Local agencies developed ten criteria to be used to select the locations of the pilot projects and the types of technologies to be implemented in the projects. These criteria stressed the importance of selecting projects that would provide information for future regional I/I control program efforts. Projects were to represent a geographic balance throughout the region, serve as models for future projects, and provide environmental benefits for the region.

To aid the selection process, program staff presented information about candidate basins, including flow data, age of sewer system, and type of pipe. In April 2002, local agencies nominated and voted on basins. They selected nine basins to serve as distinct pilot projects and three basins to be combined into a single pilot project focused on manhole rehabilitation.

## Where Are the Pilot Projects—and What Was Done?

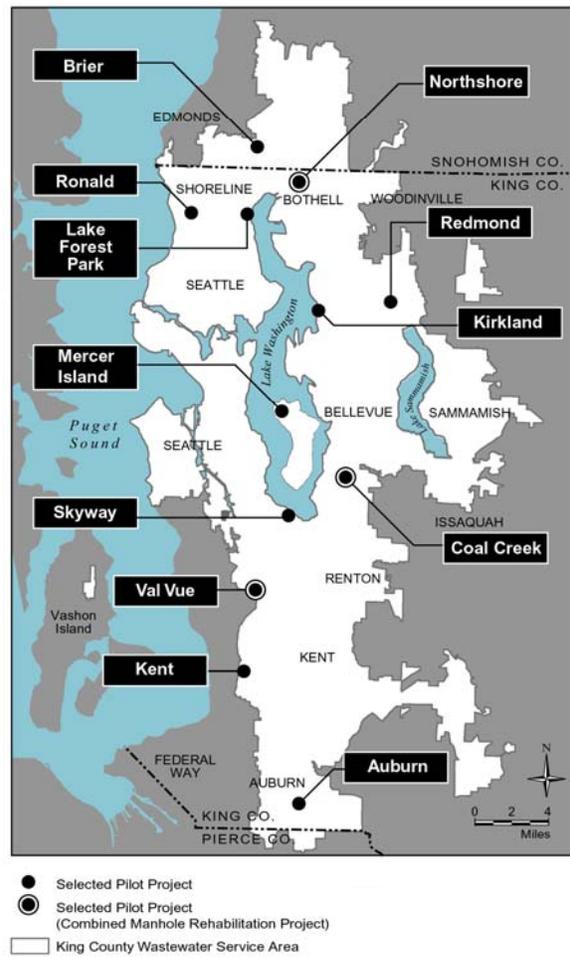
The selected pilot projects include a mix of projects on public and private property in twelve local agency jurisdictions: City of Auburn, City of Brier, Skyway Water and Sewer District (formerly known as Bryn Mawr), Coal Creek Utility District, City of Kent, City of Kirkland, City of Lake Forest Park, City of Mercer Island, Northshore Utility District, City of Redmond, Ronald Wastewater District (formerly known as Shoreline Wastewater Management), and Val Vue Sewer District. The combined Coal Creek, Northshore, and Val Vue projects make up the “Manhole Project.”

Work on each pilot project consisted of identifying I/I sources through field investigations, designing and constructing rehabilitation improvements, and monitoring post-construction flows to determine the effectiveness of the rehabilitation.

In the second half of 2002, the program’s consulting team performed a sewer system evaluation survey (SSES) to support selection and detailed design of I/I control measures. The survey involved cleaning mainlines and manholes, using closed-circuit TV (CCTV) to identify sources of infiltration, and using smoke testing to identify sources of inflow.

In addition to using the results of the SSES, King County and local agencies applied the pilot project selection criteria and the draft design standards, procedures, and policies—also developed collaboratively with local agencies—to select and design specific technologies to be tested in the pilot projects. Key objectives were to gain experience with a variety of sewer system repair technologies in manholes, mains, laterals, and side sewers and to stay within the County’s \$9 million construction budget.

The selected technologies included lining pipes using a cured-in-place material, replacing pipes by pipe bursting or open-cut methods, replacing manholes, rehabilitating manholes using chemical grouting or epoxy injection and adjusting frames and covers, and installing cleanouts.



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The County’s consultant designed nine of the ten pilot projects. The Ronald Wastewater District used its own consulting firm for design and construction management for the pilot project in its district. In the Ronald and Skyway pilot projects, the local agencies contributed additional funds above the \$900,000 for each project contributed by King County in order to expand the scope of work in their basins.

Results of post-rehabilitation flow monitoring, conducted in each of the pilot project basins during the winter of 2003-2004, were compared with results of pre-rehabilitation flow monitoring. Computer simulation models were developed and then calibrated to the pre- and post-measured flow responses to a continuous 60-year record of storms. The models helped to establish a common basis for determining I/I reduction effectiveness and to project the 20-year peak flow rates in each basin.

**Rehabilitation in Local Sewers**

	Mains	Manholes	Laterals	Side Sewers
Auburn	●	●	●	●
Brier	●	●		
Coal Creek		●		
Kent			●	●
Kirkland	●	●	●	
Lake Forest Park	●	●		
Mercer Island	●			
Northshore		●		
Redmond	●	●	●	
Ronald			●	●
Skyway	●	●	●	●
Val Vue		●		

## What Have We Learned From the Pilot Projects So Far?

The pilot projects provided valuable insights into implementation, costs, and effectiveness of I/I control projects. (See the table at the end of this summary.) The most important lesson learned so far is that monitoring and rehabilitation of sewer collection systems can successfully identify, target, and reduce I/I—in large part because of strong collaboration at every step of the process.

The study illustrated that areas with I/I can be identified through comprehensive wet-weather flow monitoring. The project team also learned how to improve monitoring and surveying techniques for future efforts. They learned, for example, that identifying system defects through the SSES would be more effective if the surveys were completed during the wet season. Several sources of infiltration that eluded detection through the SSES—which was completed during the dry season—were subsequently identified during pilot project construction and post-rehabilitation inspection work, both completed during the wet season.

Rehabilitation technologies reduced I/I in eight of the ten pilot projects. The highest reduction (87 percent) occurred in Skyway, where the entire system was rehabilitated. Reductions in Kent (76 percent) and Ronald (74 percent) were also high. All three projects included rehabilitation of laterals and side sewers on private property. This result corroborates the assumption that a high percentage of I/I originates on private property. A 37 percent reduction on Mercer Island, which

included only sewer main rehabilitation, further corroborates that a high percentage of I/I originates in laterals and side sewers.

No measurable reduction of I/I from pilot projects in Auburn and Kirkland is likely because only a small percentage of each basin was rehabilitated and the impact of the work on the overall I/I rate was small. The Manhole Project resulted in no measurable reduction (Coal Creek and Val Vue) or only 23 percent reduction (Northshore). These results suggest that very little I/I reduction can result from manhole rehabilitation alone.

Another important lesson learned is that I/I control would not have been possible without the support of the local agencies and private property owners. Owners were engaged before, during, and after the projects through advance public information and education, property owner incentives, and active local agency participation. Property owners helped to locate cleanouts and refrained from using the sewers while construction was in progress.

Two contractors were responsible for seven of the ten pilot projects. The experiences with all the contractors were very good. Because of the limited number of contractors, these experiences and the successful bid costs may not be representative of future rehabilitation construction contracts.

The final construction cost for the ten pilot projects is \$7.8 million. Local agencies contributed \$0.67 million; King County contributed the remaining \$7.13 million. In addition to construction costs, total pilot project costs shown in the summary table include costs for SSES, design, pre- and post-rehabilitation flow monitoring, construction management, and modeling and analysis. Even though the greatest reductions may occur from rehabilitating side sewers and laterals, experience with the Skyway project and with expanded bids for the Kent and other projects indicates that rehabilitating sewer mains at the same time as side sewers and laterals are rehabilitated can be done for a relatively small increase in cost.

**A few lessons learned...**

Sources and volumes of I/I can be identified through comprehensive wet-weather flow monitoring.

Sewer system evaluation surveys are most effective when done in the wet-weather season.

I/I can be reduced through sewer rehabilitation.

A high percentage of I/I tends to originate in side sewers and laterals.

Very little I/I reduction will likely result from manhole rehabilitation alone.

Success of I/I control projects depends on a high level of cooperation with local agencies and private property owners.

Rehabilitating sewer mains at the same time that side sewers and laterals are rehabilitated may be done for a relatively small increase in cost.

## How to Learn More About the Pilot Projects

The *Pilot Project Report, Regional Infiltration and Inflow Control Program, King County, Washington* provides detailed information on the selection, design, construction, costs, and results of the pilot projects. The information in the report is technical. Its purpose is not only to record what was done but also to serve as the basis for additional studies on the costs and benefits of I/I control measures and as a resource for other agencies in the country in their efforts to control I/I.

Copies of the *Pilot Project Report* may be obtained by contacting Mark Buscher at (206) 684-1242 or mark.buscher@metrokc.gov. The full report also is available at <http://dnr.metrokc.gov/wtd/i-i/>.

Summary of I/I Pilot Project Results

	Mains Manholes (MH) Laterals (L) Side Sewers (SS)	% of Basin Improved <sup>a</sup>	20 Year Peak I/I <sup>b</sup>			Construction Cost	Total Cost
			Pre-Rehab (gpad)	Post- Rehab (gpad)	Reduction %		
Auburn	● ● ● ●	11% of mains	8,900	8,900	NMR	\$384,700	\$749,400
Brier	● ●	23% of mains	10,100	5,000	50%	\$372,700	\$820,400
Kent	● ●	100% of L and SS	12,700	3,100	76%	\$1,080,700	\$1,446,900
Kirkland	● ● ●	25% of mains	11,000	7,900	28%	\$838,200	\$1,190,400
Lake Forest Park	● ●	35% of mains	22,500	7,100	69%	\$790,400	\$1,228,900
Manhole Project	●		17,800	16,300	23% <sup>c</sup>	\$200,800	\$660,200
Mercer Island	●	70% of mains	8,200	5,200	37%	\$815,800	\$1,218,600
Redmond	● ● ●	36% of mains	1,000	1,000	NMR	\$840,100	\$1,273,400
Ronald	● ●	72% of L and SS	18,200	4,800	74%	\$1,077,300	\$1,531,400
Skyway	● ● ● ●	100% of mains	63,200	8,400	87%	\$1,395,200	\$1,883,900

NMR = no measurable reduction.

<sup>a</sup> “% Improved” refers to the percentage of the identified elements of the sewer system that were rehabilitated during the pilot project.

<sup>b</sup> The 20-year peak pre-rehabilitation I/I rate is a model-predicted rate; the I/I rates used to select the pilot projects were the measured I/I rates for the maximum storm observed during the flow monitoring period.

<sup>c</sup> The pre- and post-rehabilitation flows shown for the Manhole Project are the combined flows for all three basins in the project. The 23 percent reduction occurred in the Northshore basin; there was no measurable reduction in the Coal Creek and Val Vue basins.

