Chapter 5

Pilot Project Design

This chapter describes the pilot project design process, including objectives, definition of basin types, and steps followed. The selection process for system components to be rehabilitated is discussed, as well as the selection process for rehabilitation technologies and products. Public and agency involvement and environmental issues are also described.

> **Note:** The pilot project basin and rehabilitation maps (Figures 5-2 through 5-25) are located at the end of the chapter (section 5.6).

5.1 Design Objectives

The aim of the pilot project design effort was to develop designs that satisfied the following objectives:

- Repair defects in the collection system to reduce I/I
- Repair defects in selected collection system components – including manholes, mains, laterals, and/or side sewers
- Develop rehabilitation improvements which fit within the construction budget
- Use a variety of proven and mostly trenchless rehabilitation techniques to gain experience with different methods and costs of sewer system repair

The Sewer System Evaluation Survey (SSES) results and information obtained about the collection system, basin characteristics, and mini-basin surface features were used in the design effort.

5.2 Pilot and Control Basins

5.2.1 Pilot Basins

During the selection process, project locations were identified on a broad scale, encompassing entire mini-basins. However, it was anticipated that rehabilitation of the entire sewer system in a mini-basin was infeasible due to budget constraints. Therefore, it was assumed that a sub-basin would be delineated within the mini-basin, and that the actual rehabilitation work would be performed within this sub-basin. The sub-basin where the rehabilitation work took place was defined as the “pilot basin”. The pilot basin could encompass either part of or all the mini-basin (see Table 5-1). Figure 5-1 shows the locations of the pilot projects.

Table 5-1. Area Encompassed by Pilot Basin

Pilot Basin Area	Pilot Project
Same as mini-basin	Lake Forest Park, Ronald, Manhole Project (Coal Creek, Northshore, and Val Vue)
Smaller than mini-basin	Auburn, Brier, Kent, Kirkland, Mercer Island, Redmond, Skyway

The decision to delineate a pilot basin within a mini-basin was made during late summer 2002 during the early phases of design. It was acknowledged that one consequence of delineating pilot basins early on in the design process was the necessity of speculating about trends in the defects that had been observed. At the time, a limited amount of the SSES work had been completed. The schedule for delineating pilot basins was driven by the following flow monitoring concerns:

- The need to conduct pre-rehabilitation flow monitoring on the pilot basin if it was smaller than the mini-basin. The proposed pre-rehabilitation flow-monitoring period was November 1, 2002 to January 15, 2003. If the pilot basin was the same as the mini-basin, the flow data from the flow monitoring seasons for 2000/2001 and 2001/2002 were sufficient to characterize the pre-rehabilitation flows.
- The need to conduct field evaluations of the outlet manholes prior to flow monitoring. The suitability of each manhole as a flow monitoring point needed to be evaluated. If the manhole was unsuitable because of poor flow monitoring conditions such as high velocities or susceptible to debris accumulation, the pilot basin needed to be adjusted and other manholes evaluated. This manhole investigation needed to be completed 1 to 2 months in advance of the flow monitoring.

During the design phase for the Auburn and Redmond pilot projects, rehabilitation work was added within the mini-basin, but outside the delineated pilot basin. This effectively created a second pilot basin within the overall mini-basin for these two pilot project areas. King County determined that the mini-basin flow meter could be used to evaluate the reduction effectiveness in the Auburn and Redmond pilot basins. Second pilot basins are identified as Pilot Basin B in Table 5-2 and in Figure 5-2 and Figure 5-11. (Figures 5-2 through 5-25 are located at the end of the chapter.)

To quantify flows for the Kent pilot project, it was necessary to install two flow meters due to the tributary patterns. Flows from Basins A and B were combined for analysis purposes. Figure 5-4 shows the Kent pilot basins.

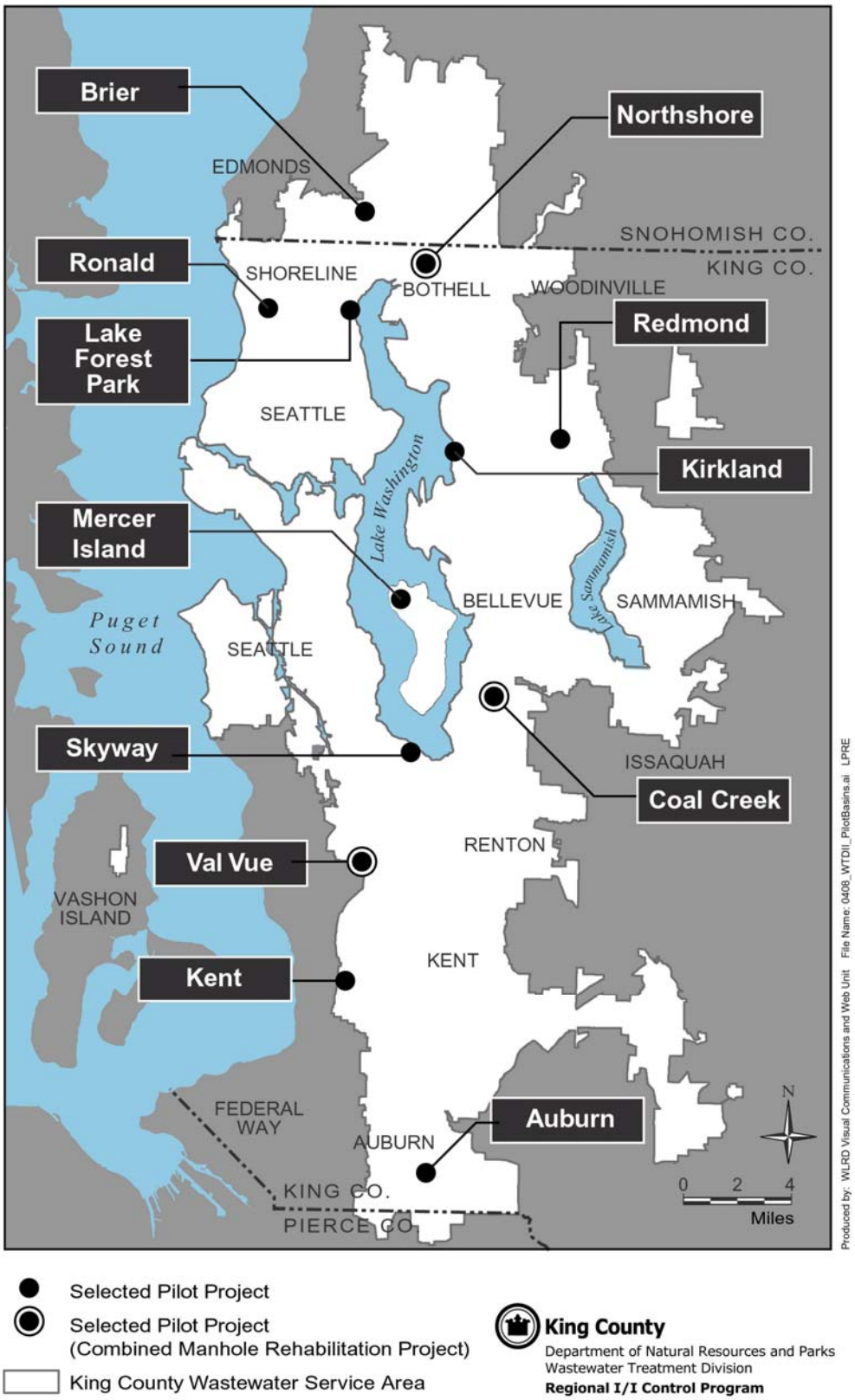

Figure 5-1 Selected Pilot Project Location Map

5.2.2 Control Basins

One of the pilot project objectives was to document I/I reduction resulting from rehabilitation of a sewer system. In order to do so and to obtain comparison data at the same time, it was desirable to simultaneously monitor "control basins" in the vicinity of the pilot basins.

The criteria for establishing a control basin included:

- Basin size similarity to the pilot basin so that the measured flows from each are comparable
- Sewer system similarity to the pilot basin in regard to construction and age
- A flow response to rainfall similar to that of the pilot basin (if the information was available)

With regard to the last criterion, no flow data existed to compare with the pilot basin unless an entire mini-basin was proposed as a control basin. In that case, data could be obtained under the assumption that the mini-basin flow data was representative of the entire basin. The pre- and post-rehabilitation flow monitoring of the pilot and control basins is discussed further in Chapter 8.

Given that the entire mini-basin served as the pilot basin for the Manhole Project (Coal Creek, Northshore, and Val Vue), Lake Forest Park, and Ronald, control basins were selected from other mini-basins in the vicinity of the pilot project. No pre-rehabilitation flow monitoring was conducted in these basins during the winter of 2002-2003 because the flow data from the flow monitoring seasons for 2000/2001 and 2001/2002 were sufficient to characterize the pre-rehabilitation flows. The mini-basin meter numbers used for the control basins were Lake Forest Park--RON039, Coal Creek--CCR009, Northshore--BOT012, Val Vue--VAL017, and Ronald--RON045.

5.2.3 Mini-Basin, Pilot, and Control Basin Size and Features

Figure 5-2 through Figure 5-13 shows the final pilot and control basin boundaries for each of the pilot projects. Table 5-2 shows the acreage and linear feet of sewer main for the pilot basins, control basins, and mini-basins.

The flow meter names as shown in the figures were assigned at the beginning of the 2002-2003 flow monitoring season, and in some cases do not correspond directly with the name of the basin monitored because of the pilot and control basin configuration or subsequent changes in the design. For example, in Figure 5-2, the flow meter measuring flows from Pilot Basin B was named "Auburn Control". The inconsistency is the result of the lower half of the basin being changed from a control basin to a Pilot Basin B, as discussed in the next section. The "Auburn Control" meter was also installed in the same manhole that was used in previous flow monitoring seasons to measure flows from the entire mini-basin. In Brier, Kirkland, Lake Forest Park, Ronald, and the Manhole Projects, the pilot basin meters were installed for the 2002-2003 flow-monitoring season in the same manhole that was used in the previous flow monitoring seasons to measure flows from the entire mini-basin.

Table 5-2. Pilot Basin, Control Basin, and Mini-Basin Size

Pilot Project Name	Figure No.	Mini-Basin Meter No.	Acres				Linear Feet of Main			
			Total Mini-Basin	Pilot A	Pilot B	Control	Total Mini-Basin	Pilot A	Pilot B	Control
Auburn	Figure 5-2	ABN002	470	292	178	(1)	30,768	18,893	11,876	(1)
Brier	Figure 5-3	BRR004	223	97	--	126	28,583	12,970	--	15,609
Kent	Figure 5-4	KNT014	156	20	21	30	24,649	3,276	3,324	4,855
Kirkland	Figure 5-5	KRK011	162	112	--	50	23,075	16,406	--	6,669
Lake Forest Park	Figure 5-6	RON041	145	145	--	218 (2)	25,873	25,873	--	34,289 (2)
Manhole Coal Creek	Figure 5-7	CCR002	165	165	--	97 (2)	27,550	27,550	--	15,214 (2)
Manhole Northshore	Figure 5-8	NUD038	365	365	--	158 (2)	40,318	40,318	--	17,038 (2)
Manhole Val Vue	Figure 5-9	VAL019	87	87	--	220 (2)	15,250	15,245	--	28,442 (2)
Mercer Island	Figure 5-10	MRC012	140	31	75	34	29,057	22,462	--	6,595
Redmond	Figure 5-11	RDM009	182	73	52	57	35,548	14,900	8,243	12,405
Ronald	Figure 5-12	RON002	95	95	--	104 (2)	13,097	13,097	--	18,624 (2)
Skyway	Figure 5-13	BLS002	156	47	--	38	33,674	10,038	--	8,791

(1) Pilot Basin B in Auburn was also the control basin for the beginning of the 2003-2004 post-rehabilitation flow-monitoring period.
(2) These control basins were separate from the mini-basin selected as the pilot project (See Table 5-1).

5.2.3.1 Pilot Basins with Boundaries Smaller Than the Mini-Basin

For each of the following pilot projects the pilot basin was reduced from the original mini-basin selected for the pilot project. The following sections describe the issues considered in defining the actual pilot basin.

Auburn

The City of Auburn suspected that capacity-related problems were present at approximately the midpoint in the mini-basin. In addition, analysis of the hydraulic sewer conveyance system in the lower half of the mini-basin determined that system capacity was less than the measured peak flows, suggesting error in the flow data. Based on these two issues, a pilot basin was delineated to include the upper half of the Auburn mini-basin just upstream of the point of suspected capacity problems. This area is shown in
Figure 5-2 as Pilot Basin A.

The SSES investigations identified very few defects in the sewer mains and manholes. Several of the laterals and side sewers in the pilot basin were inspected and very few defects were identified. However, defects were identified in the private sewers of the Auburn Adventist Academy (see Figure 5-14). As a result, the rehabilitation effort focused on this private sewer system.

The lower half of the Auburn mini-basin was originally proposed as the control basin; however, subsequent field investigations established that several manholes in the lower portion of the basin were subject to surface inundation. Thus, it was decided that work would also be conducted in the lower portion of the basin primarily for targeting inflow. This area, which became a second pilot basin, is labeled as Pilot Basin B in Figure 5-2.

Brier

In the Brier mini-basin, the SSES showed defects in the sewer mains, manholes, and service connections. The defects were distributed throughout the mini-basin, but were slightly more prevalent in the southern half. Some of the sewer mains were replaced in 1982 with polyvinyl chloride (PVC) pipe. Thus, the pilot project focused on repair of defects in: (a) portions of the system that were not replaced in 1982, and (b) portions of the 1982 system that had failed connections. The southern half of the mini-basin was selected as the Brier pilot basin because of the slightly higher number of defects found in that area. The control basin became the northern half of the mini-basin. The pilot and control basins are illustrated in Figure 5-3.

Kent

In the Kent mini-basin, the SSES investigations identified few defects in the sewer mains, manholes, or service connections. It was concluded that the source of I/I was likely in the side sewers. The northwest portion of the mini-basin, upstream of the city's Linda Heights Pump

Station, was chosen as the pilot basin. This area was selected as the pilot basin for two reasons. First, the City of Kent staff stated that there had been more side sewer problems (such as backups) in this area than in the rest of the mini-basin, and second, the size of this area allowed for all side sewers and laterals to be rehabilitated within the project budget.

Due to the sewer main configuration in the northwest portion of the mini-basin, two flow meters were necessary to quantify flows from this area. There were, in effect, two separate pilot basins adjacent to each other, and the flow monitoring results could be added. These pilot basins are labeled Pilot Basin A and Pilot Basin B, as shown in Figure 5-4.

The control basin was chosen because of its close proximity to the pilot basin and its similarity in acreage and land use. The control basin is shown in Figure 5-4.

Kirkland

In the Kirkland mini-basin, initial SSES results generally revealed defects in sewer mains, manholes, laterals, side sewers, and in several direct inflow sources. It was also known that the sewer main was recently replaced along Lake Washington Boulevard Northeast. Therefore, it was decided that I/I improvements would be performed on side street portions of the collection system located east of Lake Washington Boulevard Northeast.

It was determined that splitting the mini-basin in half would provide two comparable basins due to the similarity in topography and land use density in the narrow north-to-south mini-basin. Either basin could have been selected as the pilot basin; each was roughly the appropriate size for the available construction funds. Pipe condition was about the same in both basins. However, the City of Kirkland had experienced many more maintenance problems with the sewer mains in the northern half of the mini-basin. Thus, the northern half was selected as the pilot basin, as shown in Figure 5-5. The southern half of the mini-basin was selected as the control basin.

Mercer Island

In the Mercer Island mini-basin, significant defects were found by the SSES within the sewer mains and service connections. It was anticipated that the pilot project would focus on rehabilitation of sewer mains and service connections only. The anticipated rehabilitation method was cured-in-place pipe. Based on initial cost estimates for lining sewer mains, a pilot basin was selected in the northern portion of the mini-basin. This pilot basin could be readily monitored, and its selection would allow all sewer mains and service connections within the pilot basin to be rehabilitated within the project budget. A control basin of similar size was selected adjacent to the pilot basin.

As design progressed, it became apparent that by limiting rehabilitation to the sewer main and service connections, the cost would be significantly less than originally anticipated. Therefore, an additional area to be rehabilitated was added in the southern portion of the mini-basin, becoming, in effect, a second pilot basin. The additional area did not include any part of the control basin.

As shown in Figure 5-10, the pilot basin in the northern portion of the mini-basin is labeled Pilot Basin A and the southern portion is labeled Pilot Basin B. The figure also shows the control basin.

Redmond

Within the Redmond mini-basin, the SSES identified defects in all portions of the collection system. However, the hydrograph for the Redmond mini-basin showed that almost all the I/I was slow response, suggesting base infiltration. Well head records showed that the groundwater level within the Redmond mini-basin was approximately at the invert of sewer mains at the low end of the basin during the summer, and was approximately 8 feet higher during the winter. Thus, it was anticipated that repair of sewer mains, service connections, and laterals could be performed anywhere in the mini-basin.

After some initial work, it was discovered that the sewer main at the low end of the system was on a busy arterial, under a railroad bridge, and next to the Sammamish River, which would have complicated rehabilitation construction. Due to these difficulties, it was thought that more I/I defects could be rehabilitated within the project budget in other portions of the mini-basin. Thus, the western portion of the system was left out of the pilot basin.

Two approximately equal areas located in the northeast and southeast portions of the mini-basin were selected as the pilot and control basins. After selecting comparable areas that could be flow monitored, the northeast portion of the mini-basin was designated as the pilot basin and the southeast portion as the control basin. The condition of sewer mains, service connections, and laterals was comparable in both areas. However, a very active commercial area and two principal arterials were located in the southeast area. This would have dictated that work be accomplished at night within a short time frame. The northeast portion had some commercial and multi-family dwellings, thereby requiring some night work, but also had lower-traffic-volume local streets on which to work.

Subsequent to selection of the pilot and control basins, cost estimates were revised. It was determined that some additional work could be performed. The additional work was conducted in the western half of the mini-basin, which, in effect, became a second pilot basin. As shown in Figure 5-11, the northeast portion of the mini-basin is designated Pilot Basin A, the west portion as Pilot Basin B, and the southeast portion served as the control basin.

Skyway

Engineering work related to I/I rehabilitation had been previously completed in the Skyway mini-basin. There was an existing project within the mini-basin that had been bid twice by the local agency. A contract was not awarded due to the fact that bid prices were higher than the project budget. This existing project, located within the southwest portion of the mini-basin, included complete plans and specifications. A review of SSES data confirmed that defects were significant within the area of this project. Defects were noted within the sewer mains, manholes, service connections, laterals, and side sewers. It was decided that for the Skyway pilot project, a

full system rehabilitation would be performed. The project area defined for the previous project became the selected pilot basin, thereby allowing use of the existing plans as a base.

An area adjacent to the pilot basin and of similar size was added as the control basin. The pilot basin, mini-basin, and control basin are shown in Figure 5-14.

5.3 Design Process

King County completed the design of all pilot projects with the exception of the Ronald project. The Ronald Wastewater District managed the design and construction of its own pilot project. Information about the design of the Ronald project was provided to the County. It was considered in the selection of rehabilitation technologies and processes along with the other projects.

The design process for the nine County-designed pilot projects was largely conducted as a collaborative effort. A design team was assembled consisting of five designers and two team managers, a lead designer was assigned to each pilot project, and frequent meetings were held to share information among team members. The design team followed the process outlined below.

- Identify types of I/I based on hydrographs
- Evaluate SSES work and identify defects
- Define a variety of system components to be rehabilitated
- Select rehabilitation technologies to be used
- Select which techniques and/or products would be used on each pilot project
- Develop construction drawings and specifications
- Develop engineer's estimate of cost

Each of these steps is described in further detail below.

5.3.1 Hydrographs and I/I Flow Rates

Hydrographs and I/I flow rates were used during design in several ways:

- The hydrograph flow response suggested which system components contributed to I/I. This allowed SSES efforts to be focused and allowed designers to look more closely at SSES results in various areas of the system.
- Flow response related to rainfall and flow rate information supported design decisions for all portions of the system when SSES information was incomplete.
- Flow rate information allowed designers to judge whether the defects identified in the SSES were significant enough to cause the I/I rate shown, or, whether additional defects existed but were not detected by the SSES.

A copy of the mini-basin hydrographs for the 2001-2002 flow-monitoring season is included in Appendix A along with nomination forms for pilot project candidates.

Table 5-3 summarizes the type of flow responses in each of the mini-basins selected for pilot projects, the I/I flow rate, and the suspected system components which contributed to I/I based on the hydrograph flow response for each mini-basin. Suspected sources were further defined through SSES investigations and designers' knowledge of the collection system.

Table 5-3. Pilot Project Flow Responses, I/I Flow Rates, and Suspected System Components

Pilot Project	Hydrograph Flow Response	I/I Flow Rate (gpad)[1]	Suspected Sources of I/I			
			Manhole	Sewer Main	Lateral and Side Sewer	Inflow
Auburn	Fast response and rapid infiltration	10,030	●	●	●	●
Brier	Rapid infiltration	6,338	●	●	●	
Kent	Fast response and rapid infiltration	7,709	●	●	●	●
Kirkland	Fast response and rapid infiltration	7,289	●	●	●	●
Lake Forest Park	Fast response and rapid infiltration	7,962	●	●	●	●
Manhole Coal Creek	Rapid infiltration	4,202	●	●	●	
Manhole Northshore	Fast response and rapid infiltration	6,025	●	●	●	●
Manhole Val Vue	Fast response	4,307	●		●	●
Mercer Island	Fast response and rapid infiltration	13,719	●	●	●	●
Redmond	Slow infiltration	5,250	●	●		
Ronald	Fast response and rapid infiltration	11,279	●	●	●	●
Skyway	Fast response and rapid infiltration	27,167	●	●	●	●

[1]gallons per acre per day

5.3.2 Identification of Defects Using SSES Data

The largest single factor used when selecting proposed improvements was the SSES data on the type and location of defects. A detailed discussion of the SSES is included in Chapter 3 and in the separate SSES reports prepared for each pilot project.

Manhole and mainline closed circuit television (CCTV) inspections were performed on almost all portions of the system for each pilot project. An exception was the Manhole Project, where only manhole inspections were performed. Smoke testing and lateral CCTV were performed on portions of the system in some pilot projects. Side sewer CCTV was performed less frequently.

While the SSES used a coding system for quantifying defects, pilot project designers used both the coded data and the direct data. The SSES was approximately 70-percent complete when the pilot project design effort began. Designers immediately reviewed the CCTV tapes and other various reports (manhole, smoke test). In order to meet the pilot project schedule, design progressed and major design decisions were finalized as the last SSES data was delivered and reviewed.

Table 5-4 summarizes defects found by pilot project designer review of the raw SSES data. A qualitative description of the severity of defects is provided for each of the system components. This includes:

- Major – defects were found in a significant percentage (greater than 40 percent) of the system components
- Minor – defects were found in a minor percentage (10 to 40 percent) of the system components
- None – essentially no defects (less than 10 percent) were found in the system components
- Unknown – the SSES was not conducted in the system component

A quantitative description was provided for the inflow sources based primarily on smoke testing. In general, very few direct inflow sources were identified through smoke testing. The pilot project basin descriptions for inflow include:

- Few – a small number (generally 20 or less) of inflow sources were found in the basin
- None – essentially no inflow sources were found

The review of the SSES data by the pilot project designers focused on potential sources of I/I, whereas the SSES reports primarily emphasized structural defects. Therefore, there are some inconsistencies between conclusions of the two reviews.

Table 5-4. I/I Defect Locations Based Upon SSES

Pilot Project	Sewer Main	Manhole	Lateral	Side Sewer	Service Connection	Inflow
Auburn[1]	Minor	Minor	Minor	Minor	Minor	Few
Brier	Minor	Minor	Unknown	Unknown	Minor	None
Kent	Minor	Minor	None	Unknown	None	Few
Kirkland	Major	Minor	Minor	Minor	Major	Few
Lake Forest Park	Minor	Minor	Unknown	Unknown	Minor	Few
Manhole Coal Creek	Unknown	Major	Unknown	Unknown	Unknown	Few
Manhole Northshore	Unknown	Major	Unknown	Unknown	Unknown	Few
Manhole Val Vue	Unknown	Minor	Unknown	Unknown	Unknown	None
Mercer Island	Major	None	Unknown	Unknown	Major	Few
Redmond	Minor	Minor	Minor	Unknown	Minor	None
Ronald	None	None	Minor	Major	Minor	Few
Skyway	Major	Major	Major	Major	Major	Few

[1] Defects in the manholes, sewer mains, lateral, and side sewers were identified primarily in the private sewers of the Auburn Adventist Academy. Sewers in the remainder of the basin were generally in very good condition.

5.3.3 Selection of System Components to be Rehabilitated

The next phase of the design met one of the original design objectives; that is, to select a variety of system components to be rehabilitated by the pilot projects. It was desirable to compare removal effectiveness based solely on rehabilitation of specific system components. Designers proposed the system components on which each pilot project would focus. Their proposal was based on suspected defect locations as shown by the hydrographs (Table 5-3) and on locations of known defects as identified by the SSES (Table 5-4).

When SSES data did not clearly identify I/I sources in the system, designers used other information to try to determine the most likely source of I/I. Other information came from the local agencies on existing pipe materials and on any other specific collection system details they knew about. Side sewer cards were obtained from the local agencies to identify the age and type of construction.

Designers met to collaboratively select the variety of system components and combinations of system components to be rehabilitated in the pilot projects. Where needed, projects were adjusted to ensure that the overall variety and combinations were present. It is important to note that not all defects were proposed for rehabilitation on each pilot project. Two examples of this

are the Kirkland and Mercer Island pilot projects. Both of these projects identified inflow sources; however, neither project included inflow removal because other system components were selected as the project's primary focus. Table 5-5 shows the sewer system components selected for rehabilitation in each pilot project.

Table 5-5. Sewer System Components to be Rehabilitated

Pilot Project	Sewer Main	Manhole	Lateral	Side Sewer
Auburn Pilot A	●	●	●	●
Auburn Pilot B		●		
Brier	●	●		
Kent			●	●
Kirkland	●	●	●	
Lake Forest Park	●	●		
Manhole - Coal Creek		●		
Manhole - Northshore		●		
Manhole- Val Vue		●		
Mercer Island Pilot A	●			
Mercer Island Pilot B	●			
Redmond Pilot A	●	●	●	
Redmond Pilot B	●	●	●	
Ronald				●
Skyway	●	●	●	●

Figure 5-14 through Figure 5-25 show the location and amount of system component rehabilitation included in the design of each pilot project.

In Auburn, few defects were identified in the public sewer system, and very little work was done in Auburn Pilot A. Auburn Pilot B was chosen as the one pilot basin that would primarily target inflow. This decision came late in the design process when field investigations established that several manholes in this basin were subject to surface water inundation. Minor defects were found in other system components in Auburn Pilot Basin A, but did not appear to account for all of the I/I in the mini-basin. Given that Auburn Pilot Basin B was monitored separately from Pilot Basin A, it was advantageous to target inflow in Pilot Basin B.

Kent was ultimately chosen as the one pilot project to exclusively target laterals and side sewers. The SSES showed only a few defects in the sewer mains and manholes of the pilot basin. About 20 percent of the laterals in the basin were inspected and no defects were found. Designers suspected that there were defects in the side sewers because of the lack of defects in the other system components that were inspected.

One design objective was to repair defects in selected system components. Given that information was unavailable about which side sewers had defects, the decision was made to rehabilitate all laterals and side sewers within the pilot basin where rights-of-entry could be obtained. Rights-of-entry were granted for approximately 95 percent of the parcels within the pilot basin. In this way, Kent became the pilot project that tested the removal effectiveness of rehabilitating all laterals and side sewers within a pilot basin.

Kirkland was originally selected as a pilot basin where side sewers would be included as part of the rehabilitation. However, during design it was discovered that many side sewer alignments were not well known. The pilot basin was located on a hillside where side sewers historically connected to mains on the adjacent lower street, even when they had to cross another lot. While this process changed over time, side sewer cards from adjacent lots often conflicted with each other. The SSES was also inconclusive in determining alignment of many side sewers. It would have been very difficult to develop a construction contract that could identify where the contractor would work as well as provide accurate linear footage estimates for side sewer construction. Thus, Kirkland became the pilot project where sewer mains, manholes, and laterals would be rehabilitated, given that all these components showed defects.

The Lake Forest Park pilot basin had defects that were scattered throughout the mini-basin. Instead of focusing on rehabilitation of all system components within a smaller pilot basin, it was decided that work would be done throughout the mini-basin where defects were found. With this approach, contractor costs could increase due to additional setups; however, there was potential for greater removal effectiveness over a larger area for the total amount of work performed.

For the Mercer Island pilot basin, the work involved only sewer mains and service connections. There were a few inflow sources found by positive smoke tests. Given the age of the system, there may also have been lateral and side sewer defects. Designers chose to focus solely on sewer mains and service connections in this pilot basin, thereby testing removal effectiveness based on just those system components within the public domain.

The Skyway pilot basin had major defects in many system components. It was therefore selected as the pilot basin where a full system replacement would be performed. Within the entire pilot basin, all portions of the collection system were replaced from the house to the lateral connection at the sewer main.

5.3.4 Selection of Rehabilitation Technologies and Techniques

Typical technologies for replacing a sewer main are pipe bursting and cured-in-place pipe. These technologies include many variations in method (called techniques in this report) and individual products.

Designers began with a list of rehabilitation technologies (see Chapter 4), then refined the list based on the following selection criteria:

- Proven process for use in sewer system rehabilitation
- Process well suited to defects and location of selected components
- Regionally available, experienced contractors
- Accepted by the local agency

Not all of the technologies and techniques listed in Chapter 4 could be used; there were only 12 pilot basins in which to try certain processes.

There were also technologies and techniques that did not meet one or more of the selection criteria. This should not negatively reflect on the technologies or techniques that were not chosen, as these may be ideally suited for use in some other situation.

5.3.4.1 Selection of Rehabilitation Technologies

Technologies selected for sewer main rehabilitation included:

- Pipe bursting
- Cured-in-place pipe (CIPP)
- Service connection rehabilitation liners
- Joint grouting
- Dig and replace

Technologies selected for manhole rehabilitation included:

- Replacement with new manholes
- Interior coating
- Fiberglass lining
- Chemical grouting
- Spot repairs/pipe penetrations
- Mechanical chimney barriers

- Frame and cover repairs
- Manhole pans

Technologies selected for lateral and/or side sewer rehabilitation included:

- Service connection and lateral liners (SCLLs)
- CIPP
- Pipe bursting
- Dig and replace

5.3.4.2 Selection of Rehabilitation Techniques and/or Products

To begin the selection process for rehabilitation techniques and products, designers identified the technology that they judged the best fit for the targeted components of their pilot project. Designers then met to collaborate and to ensure that sufficient variety and combinations were represented in the pilot project program.

Some of the technologies selected fell into major categories, such as CIPP. Variation was achieved within this category by specifying a particular product, resin, or fabric for some of the pilot projects and on others by letting the market dictate which of these techniques or products would be selected. In this way, information was obtained on processes that offered benefits other than lowest cost, and on processes that are typically chosen based solely on market factors. Other techniques, such as manhole pans, were less complex and were simply specified on several pilot projects.

Table 5-6 shows the rehabilitation techniques and products selected for each pilot project.

Table 5-6. Selected Rehabilitation Techniques and Products

Pilot Project	Selected Rehabilitation Techniques and Products
Auburn	Pipe burst 2,163 linear feet (lf) main Pipe burst or dig and replace 13 laterals and 19 side sewers Replace 13 manholes Install manhole pans in 9 manholes
Brier	Line 2,938 lf of main with polyester or vinylester resin, contractor's choice of fabric, inverted CIPP Seal service connection with lateral connection liner[1] Chemical grout 51 manholes or install Poly-Triplex® fiberglass liner[1] (install manhole pans in 8 manholes)
Kent[2]	Line 139 laterals and 172 side sewers with T-Liner®[1] or CIPP

Pilot Project	Selected Rehabilitation Techniques and Products
Kirkland	Pipe burst 4,157 lf of main Dig and replace or pipe burst 74 laterals Replace 18 manholes
Lake Forest Park	Line 8,973 lf of main with epoxy resin, contractor's choice of fabric, inverted CIPP Seal service connection with contractor's choice of liner Install interior cementitious coating or interior grouting in 47 manholes
Manhole Coal Creek[3]	Chemical grout 51 manholes Install interior chimney coating in 15 manholes Replace a paving ring in 1 manhole Install a manhole pan in 1 manhole Install a frame raised to grade in 1 manhole
Manhole Northshore[3]	Chemical grout 76 manholes Install interior chimney boot in 27 manholes Install interior chimney coating in 13 manholes Install raised frames in 7 manholes
Manhole Val Vue[3]	Install cementitious liner in 5 manholes Chemical grout 24 manholes Install interior chimney coating in 5 manholes Install raised frames in 2 manholes
Mercer Island	Install CIPP in 15,635 lf of main with contractor's choice of resin, fabric, insertion method, and design for fully deteriorated pipe Seal service connection with contractor's choice of liner
Redmond	Line 6,057 lf of main with MultiLiner®[1] (polyester or vinylester resin, fiberglass fabric, pulled-in, CIPP) Pipe burst 265 lf of main Seal service connections with TOP HAT™[1] Install T-Liner®[1] in 17 laterals Chemical grout 32 manholes
Ronald	Pipe burst 64 laterals and 209 side sewers
Skyway	Pipe burst or dig and replace 9,524 lf of main and 163 laterals and side sewers Replace 36 manholes

[1]Sole source product
[2]During the design process, Kent was selected as the lateral and side sewer project to use CIPP for rehabilitating the sewer main
[3]The Manhole Project was originally bid to also include interior epoxy, polyurethane, and cementitious coatings. These products were removed from the contract and the project was re-bid. See Chapter 6 for further explanation.

5.3.4.3 Sole Source Products

During design of the pilot projects, several specific products were identified as potentially beneficial for sanitary sewer rehabilitation. In order to try a full range of products for the pilot projects, it was necessary to specify some of these as sole source products to ensure that the proper data was received for evaluation of these technologies. Where sole source products were chosen, one or more of the following criteria were present:

- The product had been used in previous sewer collection system rehabilitation projects; it was not considered experimental, and bid prices could be verified against previous cost information.
- The product was known to offer a technology with the potential to be useful and cost effective in a large number of installations.
- Two or more regional contractors who install similar products, such as CIPP, were expected to bid on the project. The sole source specification required that a specific method be used such as MultiLiner®.
- The product restored sewer collection systems in locations or with methods of installation specifically matching the types of problems found on the various pilot projects.

For each pilot project where a specific product or several products were identified (sole source), there was another pilot project where rehabilitation of the same collection system component with a similar technique was limited only by a performance specification.

Where sole source products were used on County-administered projects, a waiver from its Standard Procurement Procedures was obtained from the County Contracts Division. Sole source products specified in the various pilot project contract documents are shown in Table 5-7.

Table 5-7. Sole Source Products

Pilot Project	Product	Manufacturer	Collection System Component
Brier	Lateral Connection Liner Poly-Triplex® PTLS-4400	Nu Flow Technologies Poly-Triplex® Technologies	Lateral Liner Manhole Liner
Kent	T-Liner®	LMK Enterprises	Lateral Liner
Redmond	MultiLiner® TOP HAT™ T-Liner®	Pacific Multilining Inc. Cosmic Sondermaschinenbau LMK Enterprises	Sewer Main Liner Service Connection Liner Lateral Liner

5.3.5 Contract Specification Development

For 9 of the 10 pilot projects, the design team prepared the technical specifications. Contract specifications followed the Construction Specifications Institute (CSI) format. The design team used the King County standard specification sections as a starting point, modifying some for the work to be performed.

The Ronald Wastewater District used specifications developed by its own design consultant. As managers of their own construction programs, both Ronald and Skyway produced bidding documents and defined the general conditions for the contracts in their areas. For the remaining eight projects, King County administered contracts produced by County Procurement and Contracts Services using the general conditions and bidding documents.

5.3.5.1 Standards and Testing

Standards

In 2002, the Metropolitan Water Pollution Abatement Advisory Committee (MWPAAC) worked with the County and its consulting team to develop draft standards, procedures, and guidelines for I/I control in the region. The design team used these draft standards and procedures during design of the pilot projects. As a result of the lessons learned, these standards and procedures will undergo some changes when the Committee and design team begin to evaluate them in 2004. The draft I/I standards include guidelines on planning, design, construction, testing, inspection, and warranties for both public and private facilities.

For technical specifications, the County standard specifications provided a starting point. Designers also used other standards, including: (a) standard specifications from other I/I projects within the United States, (b) manufacturers' standards, (c) accepted regional standards such as the *Standard Specifications for Public Works Construction*, known as the Green Book, and (d) the Washington State Department of Ecology's *Criteria for Sewage Works Design*, 1998, known as the Orange Book. When standards conflicted, the designers used professional judgment to prepare a set of specifications that would meet the objectives of the pilot projects and I/I program.

Portions of the technical specifications also came from designers' experience. Technical sections involving several of the specialized rehabilitation technologies were sent to the manufacturers for review and comment. Designers then evaluated their comments and incorporated selected changes.

For reference standards, designers generally used American Society of Testing and Materials (ASTM) standards, and in some instances, used the American Association of State Highway Transportation Officials (AASHTO) standards.

For quality control, several sections were sent to an independent engineer for review. The sections then went through an internal quality control and quality assurance review by the design team. Finally, sections went through a County quality control and quality assurance review before being approved for advertisement.

Testing

Testing requirements were specified for the pilot projects to see how readily some tests could be used and to maintain inspection control over quality of the product and/or installation. When testing requirements were applied, there was always a reference standard.

5.3.5.2 Contractor Qualification

Contractor qualification sections were added to the technical sections for each of the rehabilitation technologies. Because most of the technologies are relatively new, appropriate qualifications were essential to ensure qualified installation of each process. It was important that the contractors awarded the construction contracts have suitable experience and personnel to perform the work.

Qualification requirements are discussed further in Chapter 6.

5.3.5.3 Warranties

Because most of the rehabilitation technologies are relatively new, contracts required warranties of 18 months to 5 years for most products. A requirement was added for some warranties that both the contractor and the manufacturer (or assembler) equally warrant the products. The typical 1-year warranty was required on all other products and workmanship.

5.3.6 Contract Drawing Development

For all pilot projects except Ronald, design team members prepared contract drawings. For the eight County-administered projects, King County standard title block and drafting conventions were used. When detailed information was required for a particular system component, schedules were used to summarize information. Bold numbering or letters referenced a schedule or construction note on the drawing and typically indicated proposed rehabilitation measures. In this way, the proposed rehabilitation measures were the most dominant feature on the drawings, but did not obscure existing utility information underneath.

An existing set of base drawings from a previous bid was used as a starting point for the Skyway pilot project. These base drawings were modified to update existing utility information, existing features, proposed rehabilitation measures, and to update the title block. For the Ronald project, the Ronald Wastewater District hired its own consultant to develop contract drawings.

All drawings were drafted in AutoCAD® and scaled to be 22 inches by 34 inches full size, which allowed for true scale half-size drawings on 11-inch by 17-inch paper.

For quality control, all drawings went through an internal quality control and quality assurance review by the design team. Finally, sections went through a County quality control and quality assurance review before approval for advertisement.

5.3.6.1 Aerial Photos

Most of the pilot projects included aerial photos in the design drawings. In some cases, the local agency provided aerial photos, and for others, flights were contracted to obtain the photos. New aerial photos were ordered when existing aerial photos were more than a few years old or were taken at an elevation too high to show surface features. New photo instructions were specific about the need to produce 20-scale drawings, which was the scale used for design.

On the Skyway project, aerial photos were supplemented with a visual ground survey to identify significant features that were not clear in aerial photos. These features were then noted on the plans.

One detriment of using aerial photos was that they did not copy well on a copy machine. This was not a problem with bid sets, because all plans were printed from the computer files. However, this was a problem for working documents made from copies of the bid sets. Another difficulty was that the darkness of the photo obscured other features on the plans. Designers solved this problem by using a white line for surface features.

Some of the aerial photos were used in AutoCAD® with the Land Development Desktop module and MrSID® program, which helped project drafters by decreasing file size and re-generation time. Some files were used as Joint Photographic Experts Group (JPG) files in AutoCAD®. While cumbersome, there were no other difficulties with this method.

5.3.6.2 Base Mapping

Base mapping used on the plans was either provided by the local agencies or came from the County Geographic Information System (GIS). This mapping typically included property lines, some existing utilities, existing curb line, and parcel numbers. In addition, the design team obtained maps from utility companies likely to have facilities in the area, particularly for those pilot projects with proposed excavation work.

Parcel numbers were changed to addresses and buildings were labeled in some of the pilot projects.

The accuracy of property line and utility information on the base mapping was not field verified. To deal with this issue, a note was added to drawings stating that the contractor was to verify such information. Most work was done in residential areas where common utilities such as overhead power poles and water meters allowed for approximate property line location determinations. When cleanouts were placed adjacent to the right-of-way, it was noted on the plans that the Project Representative for the County would determine where cleanouts would be

placed. When in doubt, the Project Representative could adjust the cleanout location slightly to the right-of-way side of the property line.

Boundary surveys were not performed on any of the pilot projects. Control surveys were performed to provide a basis of control for the aerial photos.

5.3.7 Engineer's Estimate of Cost

Upon completion of the plans and specifications, the design engineers estimated construction costs. Contingency and sales tax were added to arrive at the total construction cost.

The estimates were based on pricing provided by contractors, suppliers, and on each designer's knowledge of the conditions and type of construction activities. The estimated County cost, including contingency and sales tax, was $7,600,000 for all pilot projects. The County budget for construction of the pilot projects was $9,000,000. Thus, the estimated cost was less than the budget at the end of design. Designers kept cost in mind and attempted to provide an overall rehabilitation for each pilot project.

In addition to the costs described above, additional amounts of work and additional funding by two local agencies for work in their jurisdictions was estimated at $1,118,000, and was included in the original design.

Detailed bid tabulations, including the engineer's estimates, are provided in Appendix C. All construction costs were based upon labor rates that conformed with the Washington State Prevailing Wage Rates for Public Works Contracts.

5.3.8 Pilot Project Design Objectives Met

The four objectives of the pilot project design effort were met (refer to Table 5-8). Data were collected on I/I removal and the various rehabilitation technologies, techniques, and products.

Table 5-8. Summary of Pilot Project Design Objectives Met

Objective	Result
Repair defects in the collection system to reduce I/I.	Repair of defects was largely accomplished by targeting the collection system components where the most substantial defects were found or suspected. While it was not the intention to repair all defects within each pilot basin, the final design targeted many of the major defects shown in Table 5-3 and Table 5-4.
Repair defects in selected collection system components, including manholes, mains, laterals, and/or side sewers.	Repair of defects in selected system components was accomplished, as shown in Table 5-5. A good mix of system component types and combinations of components was represented.
Develop rehabilitation improvements within the construction budget	Development of rehabilitation improvements within the overall construction budget was accomplished. The engineer's estimated cost of construction without tax is included in Chapter 6. Adding in tax and subtracting the amount that two agencies contributed resulted in a County cost of approximately $7,600,000 for all pilot projects. The County budget for construction of the pilot projects was $9,000,000.
Use a variety of proven and mostly trenchless rehabilitation techniques to gain experience with different methods and costs of sewer system repair.	The use of a variety of proven and mostly trenchless rehabilitation techniques was accomplished. As shown in Table 5-6, each pilot project offered a different technology or type of system component, product component, or level of contractor choice. This resulted in utilization of the largest possible number of techniques, given the limited number of pilot projects.

5.4 Public and Agency Involvement

5.4.1 Public Involvement

Public involvement responsibilities were coordinated between King County and each of the local agencies. King County offered support and performed some of the tasks as requested by the agencies. Some public involvement responsibilities were delegated to the contractor (as required by the project documents).

Public involvement varied for each project depending on the nature of the work, agency preferences, and whether the work was to take place on private property or within the public right-of-way. One or several public meetings were held in Kent, Kirkland, Redmond, Ronald, and Skyway. County and local agency staff obtained right-of-entry forms for Auburn, Brier, Kent, Kirkland, Lake Forest Park, the Manhole Project, Ronald, and Skyway. Work occurred on

private property in Auburn, Brier, Kent, Lake Forest Park, the Manhole Project, Ronald, and Skyway.

Some of the informational items used to convey the message to the public were:

- Public information mailer
  - Meeting announcement
  - Contact neighborhood groups
- Public meeting
  - Computer presentation and graphics
  - Mailer
  - Door hanger
  - Web site
- Right-of-entry request (form to be signed by property owner)
  - Right-of-entry form for investigation and rehabilitation
  - Door-to-door and mailer
  - Project information sheet
- Program Web site with information on pilot projects
- King County and local agency staff available to answer questions
- Project signs describing program

5.4.2 Agency Involvement

The I/I Control Program pilot projects were a cooperative effort between King County and the agencies. This cooperation continued from selection and design through construction.

On each pilot project, design engineers talked to and/or met with the agencies during early stages of the design to confirm basic design direction. Two formal review meetings were scheduled at roughly the 60- and 90-percent completion milestones during design. Agencies were given copies of the plans at these milestones and asked to review and comment on the plans, specifications, and cost estimates.

Agencies provided their standard details and sewer standards prior to the start of the design effort. These standards were followed as closely as possible, while still conforming to the Draft Regional I/I Control Standards and Procedures. Agencies also provided much of the required information for the design including aerial photos, base mapping, utility maps, system information, etc.

At the policy level, MWPAAC members received design progress updates during their monthly meetings.

5.5 Environmental Review and Permitting

5.5.1 Environmental Review

King County staff conducted environmental reviews on all 10 pilot projects. Information used for these reviews included:

- Design team memoranda documenting the basin description, SSES results, proposed rehabilitation measures and quantities, estimated excavation quantities, and required permits
- Environmental technical memoranda documenting research results for hazardous materials, wetland/wildlife, landslide/erosion, and groundwater systems
- Additional information from the I/I Web site and I/I project team, as requested

Through the environmental review, the County determined that the Manhole Project was categorically exempt under Section 197-11-800 of the State Environmental Policy Act (SEPA). Two separate checklists were prepared for the Skyway and Ronald projects, and both were issued a Determination of Non-Significance (DNS). King County was the lead agency for these environmental reviews. No comments were received on either DNS.

For the other seven pilot projects, the County issued a combined review/SEPA checklist/DNS. No comments were received on the DNS.

5.5.2 Permitting

Additional state, county, or agency permits were required for most of the pilot projects. These were either: (a) obtained by the County and included in the bid sets, or (b) the contractor was required to obtain the permit. Following is a list of permit types required on some or all of the pilot projects and the agency responsible for issuing the permit:

- Industrial Waste Discharge Authorization for Trench Dewatering, King County
- Dewatering Discharge Permit, local agency
- Right-of-Way or Street Use Permit, local agency
- Shoreline Permit, local agency
- Side Sewer Permit, local agency
- Clearing and Grading Permit, King County
- Trail Use Permit, King County
- Asbestos Removal Permit, Puget Sound Clean Air Agency and Washington Department of Labor and Industry
- Hydrant Use Permit, local agency