Executive Summary

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EXECUTIVE SUMMARY

Purpose

On April 18, 2007, the Consent Decree negotiated between Sanitation District No. 1 (SD1), the U.S. Environmental Protection Agency, and the Kentucky Energy and Environment Cabinet became effective. The purpose of the Consent Decree was to establish a structure for developing and implementing plans to address SD1's combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs). Such overflows can degrade the quality of streams and rivers and are regulated through the federal Clean Water Act. SD1's Consent Decree is unique because it incorporates a watershed-based approach in the planning process that allows for the consideration of pollution sources beyond sewer overflows.

As required in the Consent Decree, SD1 has prepared Watershed Plans describing projects for addressing overflows and other water quality issues to be implemented over the next five years as well as an Integrated Plan for 2025. The Integrated Plan is conceptual in nature and will be used to guide the future five-year updates of the Watershed Plans. The deadline for full implementation of these Plans is December 31, 2025. Through this decree, SD1 will be managing the largest program of water quality improvement in Northern Kentucky's history.

Background

Like many urban regions of the United States, the wastewater collection system of Northern Kentucky is comprised of both combined sewers and separate sanitary sewers. Combined sewers carry sewage and storm water runoff and are typically found in the older areas of cities such as Covington, Newport, and Bellevue. During dry weather conditions, flow in SD1's combined sewer system is mostly comprised of sewage from homes and businesses and is conveyed to the Dry Creek Wastewater Treatment Plant. At the plant, wastewater is treated to remove pollutants before being discharged to the Ohio River. During wet weather conditions, the capacity of the combined sewer system can be exceeded due to storm water runoff. As a result, excess flow is discharged from the system at CSO outfalls. The SD1 combined sewer system has 97 of these outfalls, the majority of which are located along the Ohio River and Licking River.

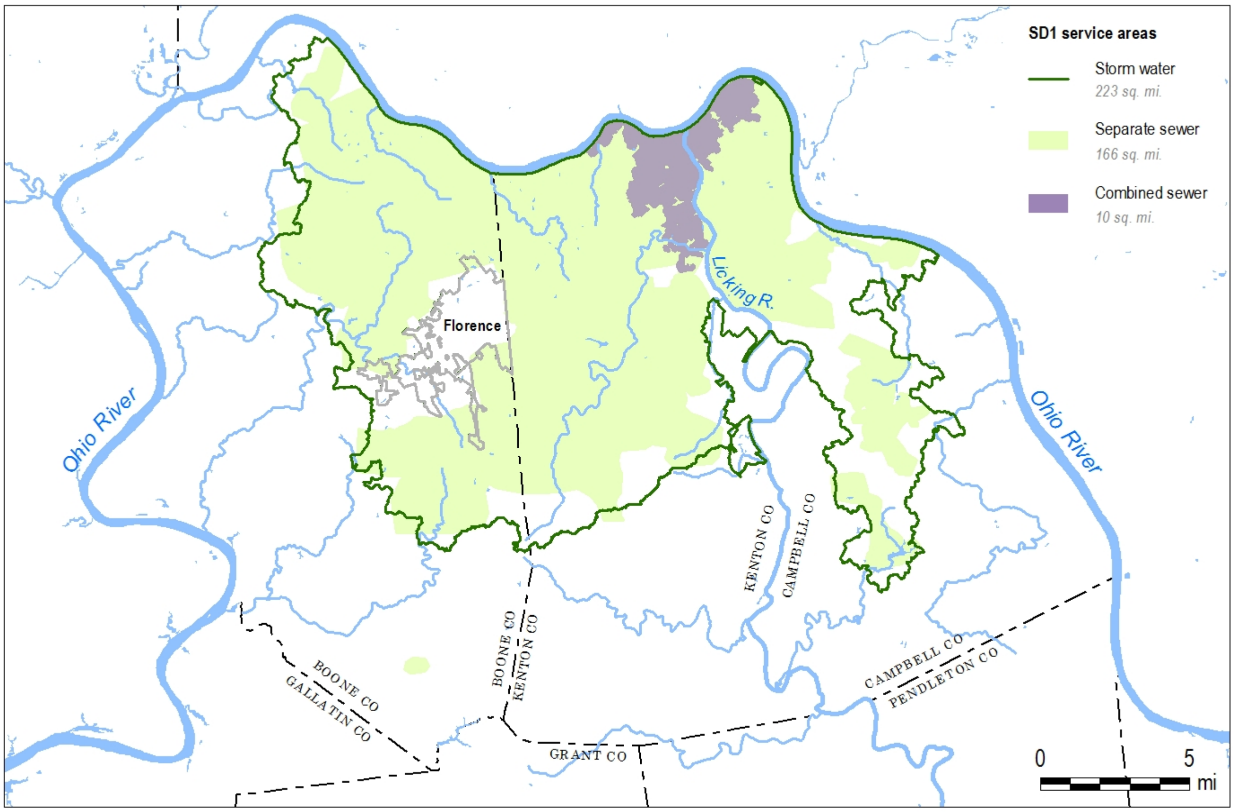
In more recently developed areas, a separate sanitary sewer system has been constructed to carry sanitary sewage and a separate storm sewer network has been constructed to carry storm water runoff. In properly functioning sanitary sewers, there is sufficient flow capacity in the system to convey all sewage to a treatment facility. In practice, separate sanitary sewers can be subject to additional flow during wet weather conditions. Increased wet weather flow in sanitary sewers can be caused by:

- Rain water inflow to the system from improper connections such as roof downspouts, driveway drains, etc.; and
- Rain water and ground water infiltration into aging manholes, pipes, and private laterals.

This increased wet weather flow has the potential to create SSOs. SSOs may also result from the loss of flow capacity in the system (pipe blockages or collapse) or malfunctions at pump stations. There are 126[1] confirmed recurring SSO points in the SD1 sanitary sewer system.

SD1's sanitary sewer service area encompasses 176 square miles of Campbell, Kenton and Boone Counties. The majority of this area is served by separate sanitary sewers as shown on Figure ES.1.

Figure ES.1 SD1 Service Area Overview (2009)



In addition to CSOs and SSOs, there are other pollution sources that can impact the quality of Northern Kentucky's waterways. These sources include polluted runoff (urban and agricultural land use), failing septic systems, and industrial point sources. The overall health of a waterway can also be affected by factors such as increased flows and erosion from the conversion of natural conditions to developed uses, the loss of riparian buffers along stream corridors, and the loss of wetlands.

[1] The number of confirmed SSO points is subject to change based on ongoing field investigations and hydraulic modeling of the collection system. The number quoted above was current as of the writing of the original Watershed Plans submitted June 30, 2009. This number is updated annually in the April Quarterly Report to the Kentucky Division of Water and the U.S. Environmental Protection Agency.

History of SD1

SD1 was established in 1946 by the Division of Sanitary Engineering of the Kentucky Department of Health pursuant to an amendment of Chapter 220 of the Kentucky Revised Statutes. This amendment gave SD1 the authority for the management, collection, transmission and treatment of wastewater. In 1954, SD1 completed the construction of Northern Kentucky's first wastewater treatment plant in the City of Bromley. In 1979, SD1 completed the construction of new interceptor sewers, associated pump stations, and the Dry Creek Wastewater Treatment Plant. To meet the needs of an expanding population, SD1 completed a major expansion of the Dry Creek plant in 1993.

Until 1995, a vast majority of the wastewater collection system of the Northern Kentucky region was owned, operated, and maintained by the different political jurisdictions of the region. In 1995, SD1 assumed ownership of this infrastructure for 28 municipalities and portions of three counties. By 1999, two more cities, Independence and Alexandria, had transferred their sewer system ownership and maintenance to SD1. At present, the Cities of Florence and Walton are the only jurisdictions in the region to retain ownership of their sewer systems. This consolidation process significantly increased the amount of infrastructure owned and maintained by SD1, as shown in Table ES.1.

Table ES.1 SD1 Infrastructure Inventory

	Before 1995	As of June 2009
Miles of sewer lines	128	1,600
Sanitary Pump Stations	16	129[1]
Catch Basins in Combined Sewer Area	0	3,302
Flood Pump Stations	0	15

Note:
[1] An additional thirteen (13) sanitary pump stations are operated by SD1 under contract.

At the time of this consolidation, it was recognized that there were a significant number of sewer overflows and other problems in the system. For example, the area served by the City of Alexandria's sewer system had been placed under a building moratorium in 1996 because of overflows at the Alexandria Wastewater Treatment Plant. The consolidation of the system represented an opportunity to address long-standing problems and improve sanitary sewer service for Northern Kentucky. Because the system is a complex network of pipes, pump stations, and treatment facilities, the previous structure of local control often hindered attempts to address sewer overflows. For example, excessive wet weather inflow into the sanitary sewer system of one jurisdiction could often lead to overflows in a downstream community.

As a regional utility, SD1 was able to direct resources to areas with the most pressing needs. For example, the Eastern Regional Water Reclamation Facility was constructed under SD1 management and replaced the failing Alexandria Wastewater Treatment Plant in 2007. The benefits of this project were the elimination of approximately eight million gallons of sewer overflow volume in a typical year and a lifting of the building moratorium. SD1's long-range planning abilities have also helped to anticipate and respond to ongoing development in Northern Kentucky. This was particularly important in high-growth areas such as Boone County, which doubled in population between 1990 (57,589 people) and 2008 (115,231 people).

In 2003, SD1 became the regional authority, as a co-permittee with local jurisdictions, for the Phase II storm water regulations promulgated by the U.S. Environmental Protection Agency. This was another step forward in improved water quality management for the region; consolidation provided many of the same benefits as the sanitary sewer consolidation, since streams and rivers typically flow across jurisdictional boundaries, and polluted runoff originating in one city may impact downstream areas. Over the past few years, SD1 has taken over ownership and responsibility from the local cities for much of Northern Kentucky's public storm sewer infrastructure. Currently, SD1 is responsible for approximately 400 miles of storm sewers and associated structures.

Watershed-based Approach

SD1's Consent Decree is the country's first enforcement action that allows a community to use the watershed management approach to more efficiently and cost-effectively meet federal Clean Water Act requirements for addressing CSOs and SSOs. This approach is based on the fact that sewer overflows are not the sole source of impairment for Northern Kentucky's streams and rivers. Traditionally, most Consent Decrees focus solely on CSOs and SSOs, with an emphasis on gray infrastructure solutions. SD1's watershed approach identifies the characteristics of individual watersheds and considers CSOs and SSOs along with other sources impacting the waterways (such as runoff and dry weather sources). Additionally, the iterative structure allows time to investigate new technologies and update the Integrated Plan for 2025 using information gained from the implementation of projects during each five-year cycle. In addition to providing the backbone for the Integrated Plan, SD1's watershed approach:

- Characterizes water quality impacts, sources and sensitive areas;
- Prioritizes overflows based on public health and sensitive areas;
- Recognizes other pollutant sources and their relative impacts and puts CSOs and SSOs into context with those sources;
- Provides a process to address and control highest regional priorities first to offset controls on CSOs, with a focus on implementation of green infrastructure;
- Uses an integrated approach of controls that will address both wet and dry weather sources of pollution, eliminate SSOs, comply with the CSO Control Policy and lead to a greater improvement in water quality and public health;
- Provides additional benefits to the community such as air quality, wildlife habitat, urban beautification, and economic development; and
- Directs funds to projects that provide the greatest benefits.

SD1 has studied what other utilities across the country have implemented and spent to comply with their CSO and SSO Consent Decrees, which have often not achieved significant improvements in the attainment of water quality standards. These utilities have, at times, been forced to continue to spend money beyond a cost-effective level of control that did not result in additional water quality improvement because the other sources of pollution were left unaddressed. This type of silo approach to water quality improvement is neither efficient nor cost-effective, particularly in today's challenging economic climate.

Many sewer overflow programs have been developed that relied exclusively on gray infrastructure such as storage tanks, conveyance pipes, and high-rate treatment facilities. While gray infrastructure has its place in any sewer improvement program, there are situations where alternative strategies are the more cost-effective and beneficial solution. SD1 believes that the best approach is to implement an integrated watershed-based approach in a way that conforms with the CSO Control Policy and the Consent Decree mandate to eliminate SSOs, but is more cost-effective and more effective in reducing pollutant levels (and runoff) than traditional approaches.

The watershed-based approach in SD1's Consent Decree allows for the consideration of alternative control strategies such as green infrastructure and watershed controls. These techniques, as described below, can be used to offset or delay traditional overflow controls:

- **Green infrastructure** are systems and practices that mimic the natural process to infiltrate, evapotranspirate, or reuse storm water. When trees and vegetation are replaced with impervious surfaces, natural processes are impacted by: 1) a reduction in infiltration and evapotranspiration; and 2) an increase in runoff. Examples of traditional green infrastructure include green roofs, rain gardens, vegetated swales, tree boxes, permeable pavements, rain water harvesting systems and other measures to prevent runoff from entering the sewer system.
- **Watershed controls** are systems and practices that can reduce pollution from sources other than sewer overflows, such as runoff (point and non-point sources) before it is discharged to the local waterways. The emphasis on pollutant reduction differentiates these controls from green infrastructure, which is primarily focused on mitigating hydrologic impacts. Examples of watershed controls include wetlands and retention/detention basins enhanced with bioretention or biofiltration systems. These controls could be either large regional facilities or smaller decentralized storm water catchment controls.

Watershed and green controls also provide additional community benefits, such as improved air quality, wildlife habitat, urban beautification, and economic development. The inclusion of these benefits into a comprehensive, capital-intensive, water quality improvement program represents a new approach for public utilities and regulators. There is a growing expectation among the public that these techniques for water quality management should be included in the planning process.

SD1 is responsible for managing most of the capital funding to be used towards water quality improvements in Northern Kentucky. Past experience has shown that wastewater and storm water systems can be managed more efficiently when a single organization has the ability to consider the overall system. A watershed-based approach is a logical extension of the sanitary and storm sewer system consolidation. While SD1 does not have authority to regulate all pollutant sources in Northern Kentucky, the role as a regional utility does provide the best opportunity for the development of plans that will focus resources towards the most critical areas of need, including helping to identify new policies and regulations, as well as partnerships that can be created for implementation of green infrastructure and watershed controls. Through the development of the Watershed Plans, SD1 will seek mechanisms to implement controls that extend beyond current authorities.

Characterization

To support the Watershed Plans and conform to the CSO Control Policy, it was necessary for SD1 to accurately characterize the combined and sanitary sewer systems, the watersheds and waterways of Northern Kentucky, and opportunities for alternative controls.

Sewer Systems

The sewer system characterization involved a combination of system mapping, rainfall monitoring, water quality sampling of CSO, SSO, and storm water outfalls, and hydraulic modeling of the combined and sanitary sewer systems. The hydraulic modeling task involved the development of a detailed computer model of the sewer systems. This model was used to calculate overflow characteristics (volume, duration, and activation frequency) and provide input to the water quality models. The hydraulic model was calibrated and validated using a combination of historical data and 12 months of data collected from approximately 250 flow monitors and 45 rain gauges in 2007 and 2008. The results were further validated by comparing model calculated overflow points to field investigations. The result was a state of the art hydraulic model that provides the best available representation of how SD1's sewer system operates during dry and wet weather conditions. This tool allows SD1 to have confidence in the calculated overflow volumes from the sewer system.

In accordance with standard guidelines, the hydraulic model was used to simulate "typical year" conditions. The rainfall record from 1970 was selected as the most representative of typical rainfall conditions for Northern Kentucky based on review of 50 years of rainfall data from the Cincinnati-Northern Kentucky International Airport. In the process of evaluating potential gray infrastructure projects, other rainfall conditions such as the one-year and five-year design storms and other extended typical periods of rainfall were also used in certain analyses. The calculated overflow volumes for current conditions using the typical year rainfall record are shown in Table ES.2.

Table ES.2 CSOs and SSOs for Current Conditions by Basin for a Typical Year (1970)

Basin	Number of CSOs	Total CSO Volume (Million Gallons) [1]	Number of Confirmed SSOs	Total SSO Volume (Million Gallons) [1 2]
North	26	796.2	45	7.5
Central	39	790.2	51	158.6
East	32	286.4	21	73.4
West	0	0	9	2.6
Total	97	1,872.8	126[3]	242.1

Note:
[1] Model calculations are current as of June 2009.

[2] Includes the model-calculated volume from model-predicted overflow locations, as well as the volume prior to the Eastern Regional sewer system improvements.

3 The number of confirmed SSO points is subject to change based on ongoing field investigations and hydraulic modeling of the collection system. The number quoted above was current as of the writing of the original Watershed Plans submitted June 30, 2009. This number is updated annually in the April Quarterly Report to Kentucky Division of Water and the U.S. Environmental Protection Agency.

Watersheds and Waterways

SD1's planning process involved a more thorough characterization of watersheds than is normally conducted in traditional sewer overflow control programs in order to identify opportunities for alternative controls beyond sewer overflow controls that could provide more public and water quality benefit for the dollar spent. This characterization involved both field data collection and water quality model development for Northern Kentucky's waterways to assess their current condition and response to overflows and other sources of pollution. Watershed characterization is particularly important in Northern Kentucky because of the wide variability in the size and characteristics of its watersheds. For example, the total watershed area of the Ohio River at its confluence with the Licking River is approximately 71,250 square miles, as compared to Taylor Creek which has a total watershed area of 4.2 square miles. Percent imperviousness ranges from three percent to 25 percent (2007 land cover) in the study area watersheds. These watersheds also contain exceptional waters and reference reach streams, an Outstanding State Resource Water, as well as numerous impaired waterways and threatened and endangered species.

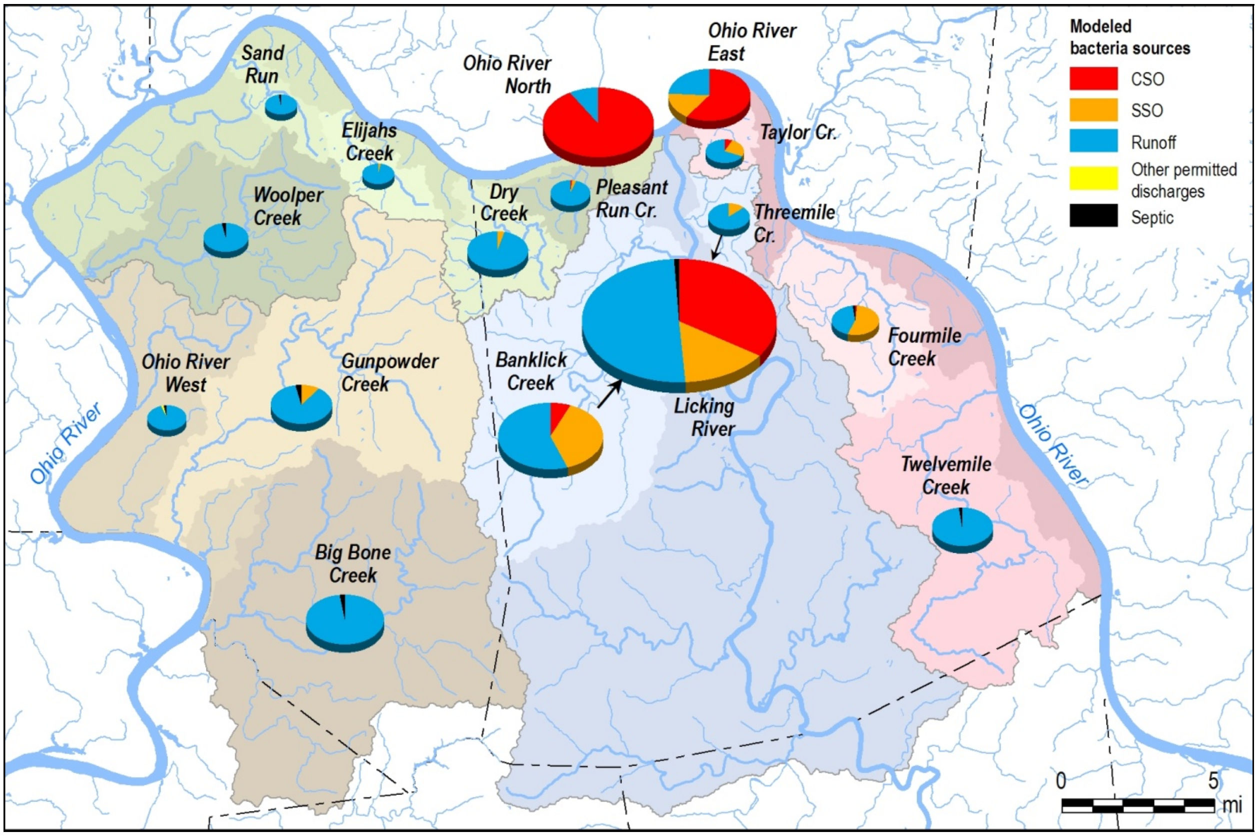
SD1's watershed characterization effort was based on a division of the entire three-county Northern Kentucky region into sixteen watersheds. SD1 compiled a variety of data from different sources, including current land use, zoning, and identified pollution sources other than sewer overflows. This effort was initiated in 2006 and SD1 continues to collect instream data from all sixteen watersheds, including water quality, flow, biologic and habitat data. While a variety of water quality data were collected, fecal coliform bacteria was the focus of the watershed characterization efforts. The selection of fecal coliform as the primary indicator of water quality in the Watershed

Plans is based on several factors. First, fecal coliform bacteria represent a public health risk because they are an indicator of pathogenic substances. Second, SSOs and CSOs are known sources of fecal coliform bacteria pollution to waterways. Third, earlier studies have also indicated elevated fecal coliform densities throughout Northern Kentucky watersheds. Most importantly, water quality standards for fecal coliform bacteria established by the Kentucky Division of Water and the Ohio River Valley Water Sanitation Commission were in place at the beginning of the watershed characterization work.

The most relevant fecal coliform water quality criteria with respect to the Watershed Plans are the 30-day maximum and the 30-day geometric mean, during the recreational season (May 1 to October 31). For the Ohio River, the 30-day maximum level is 400 colony forming units per 100 milliliters for 90 percent of the days within a 30-day period. The same level applies to all other waterways, but must be met for 80 percent of days. The 30-day geometric mean for all waterways is 200 colony forming units per 100 milliliters. In general, the 30-day maximum criterion is more stringent than the geometric mean for Northern Kentucky waterways.

SD1 developed a Watershed Assessment Tool to compile the results of the watershed and sewer characterization work. The Watershed Assessment Tool was developed for the entire three-county area and is used to calculate annual loads of fecal coliform, nitrogen, and phosphorus. The bacteria results were used to guide the development of detailed water quality models, evaluate watershed control opportunities, and provide a relative assessment of the effectiveness of different controls. Figure ES.2 provides a summary of the bacteria load results from the Watershed Assessment Tool for each of the sixteen modeled watersheds; the size of each pie chart in the figure is relative to the total bacteria load from its corresponding watershed (i.e., the Licking River watershed has a greater total load than Taylor Creek).

Figure ES.2 Watershed Assessment Tool Results for Current Conditions: Fecal Coliform Loading (June 2009)



More detailed water quality models were developed for the Banklick Creek, Taylor Creek, Licking River, and a combined section of the Ohio River / lower Licking River / lower Banklick Creek system. Two models were also developed for the watersheds in the three-county area that drain directly to the Ohio River. The models were developed using the instream water quality data (dry and wet weather conditions), sewer system hydraulic modeling results, storm water outfall sampling data, and other data. The detailed models calculate instream, hourly bacteria densities along the length of the modeled stream. These results were used to estimate the impact of different pollution sources, forecast the effect of different land development and pollutant control scenarios, and identify data gaps.

Opportunities for Alternative Controls

The characterization of alternative control opportunities (green infrastructure, watershed controls, and policies/regulations and partnership opportunities) covered a majority of the SD1 service area, with a particular emphasis in the combined sewer system. The focus on the combined sewer system was due to the potential benefits of green infrastructure in reducing CSO volumes, prior to the sizing and selection of gray infrastructure.

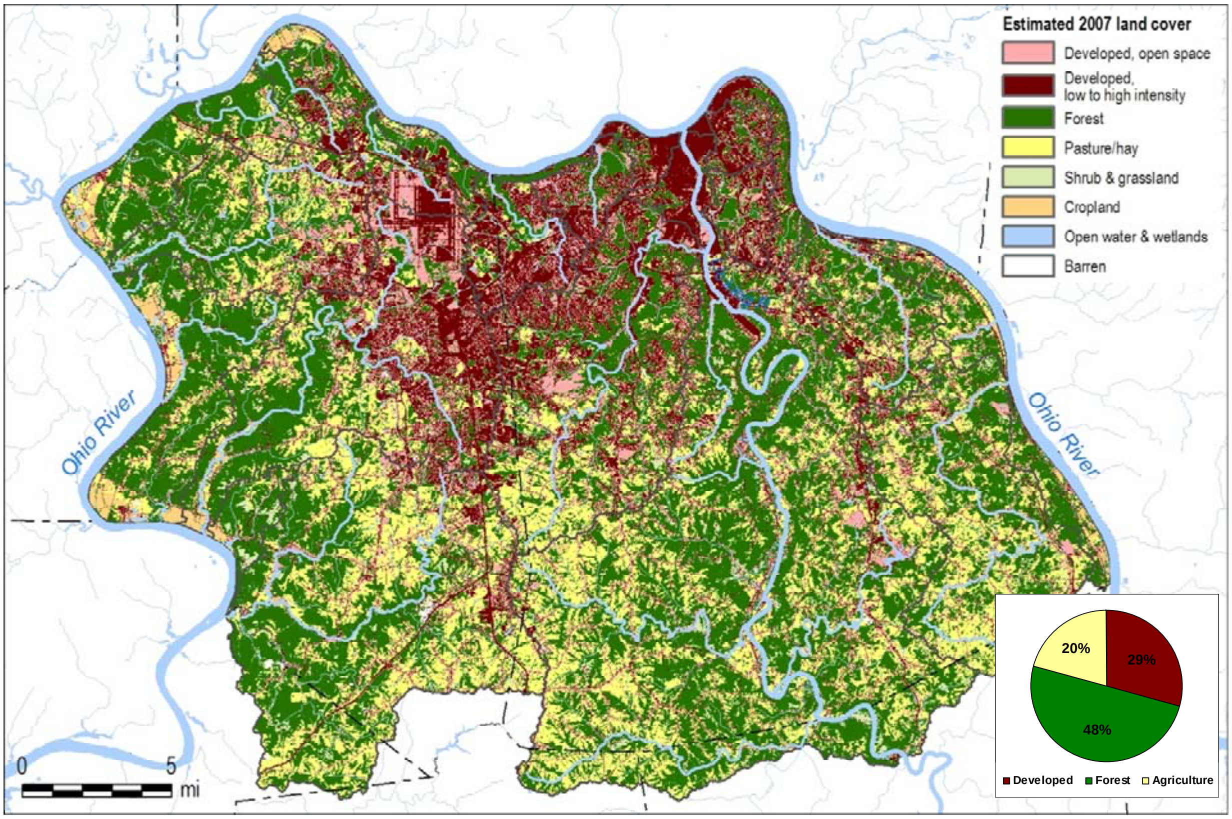
The green opportunities analysis included an inventory of natural features (including stream mapping, geology, soils, and tree canopy) and built systems (including impervious surface mapping, transportation corridors, sewer system mapping, and current/projected land use). As shown in Table ES.3, the characterization of the combined sewer area indicated that approximately 38 percent of the total combined sewer service area (ten square miles) is covered with impervious surface. This type of characterization is useful because storm water runoff volume is closely linked to the amount of impervious surface. The detailed analysis of green infrastructure opportunities in the combined sewer area focused on reducing this imperviousness or capturing and treating runoff to reduce combined sewer overflow volume.

Table ES.3 Impervious Surface in Combined Sewer System (2007)

Surface Type	Amount of Impervious Area (square feet)	Percentage of Total Impervious Area
Rooftops	44,000,000	46%
Roadways	33,000,000	36%
Parking, driveways and sidewalks	17,000,000	18%
Total	94,000,000	38%

The watershed control opportunities analysis utilized current (2007) land cover data (Figure ES.3), because there is often a correlation between land use and the selection of an appropriate watershed control (i.e., stream corridors in agricultural areas may be good candidates for the restoration of riparian buffers). This analysis focused on the watersheds with combined or sanitary sewer systems, and initially assessed the bacteria reduction benefits resulting from regional projects such as regional retention basins, constructed wetlands, and riparian buffers. Subsequent assessments included a more detailed assessment of potential benefits from decentralized controls, such as storm water wetlands and retention/detention basins enhanced with bioretention or biofiltration systems.

Figure ES.3 Estimated 2007 Land Cover



Integrated Plan for 2025

SD1's June 2009 Watershed Plans included an analysis of a suite of full system gray and/or integrated solution concepts that addressed all sewer overflows, as required under the Consent Decree. This 'bounding' analysis identified several types of solution 'concepts' and considered combinations of gray, green and watershed controls at varying levels of control. Overall, the bounding analysis showed that the various solution concepts exceeded U.S Environmental Protection Agency's affordability standards and fell short of fully achieving water quality standards due to the presence of pollution sources (some unknown) other than CSOs and SSOs.

Based on the conclusions of the bounding analysis, SD1 developed a detailed Five-year Improvement Program, but did not recommend a preferred Integrated Plan for 2025. The U.S. Environmental Protection Agency's feedback on the June 2009 document indicated a need for SD1 to identify a preferred system-wide solution set to address all overflows, regardless of affordability or effectiveness in achieving water quality standards.

SD1 conducted further analysis and identified a preferred Integrated Plan for 2025. The Integrated Plan includes the results of more detailed analyses of potential gray infrastructure, green infrastructure, and watershed controls. The analysis also compared the Integrated Plan with a Traditional Plan[1] using a suite of metrics to assess project benefits (both water quality and other associated benefits). The Integrated Plan for 2025:

- Provides a plan that eliminates SSOs (defined using a two-year level of service which is a calculated SSO discharge that occurs, on average, only once every two years);
- Provides a CSO level of control that meets the Presumption Approach under the CSO Policy (greater than 85 percent capture). Water quality modeling shows that if all other sources were controlled, this level of control would also meet water quality-based requirements for fecal coliform bacteria;
- Results in greater water quality benefit than a traditional plan (as measured by bacteria levels, days of water quality attainment, stream miles improved, and other additional benefits); and
- Prevents additional degradation of waterways in the future by requiring pollutant control with policies and regulations.

The Integrated Plan for 2025 does not, however, meet the U.S. Environmental Protection Agency's standards for affordability. SD1 has determined that the Plan is unaffordable and relief from the December 31, 2025 Consent Decree deadline (and/or other performance criteria) is therefore necessary through a material modification of the Consent Decree. Relief from the December 31, 2025 deadline (and/or other performance criteria) could be afforded through a number of mechanisms recognized by the CSO Control Policy and KRS 224.16-040, including extensions of deadlines, affordability reviews in conjunction with five-year Watershed Plan updates, Use Attainability Analyses, or combinations thereof. Consistent with the parties' agreement[2], the form and extent of the relief is not being addressed in this Integrated Plan. Rather, the purpose of the Integrated Plan for 2025 is to determine the most cost-effective approach to eliminate SSOs and address CSOs by December 31, 2025 consistent with the Consent Decree.

The following two sub-sections describe the bounding analysis and the analyses conducted to select the Integrated Plan for 2025. Both analyses used a 2025 future conditions baseline (no controls), as a standard reference point for comparison of potential 2025 solutions and their associated water quality improvements. When compared to current conditions, this future scenario indicated significant deterioration of water quality in Northern Kentucky's watersheds.

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[1] The Traditional Plan is a reference point for comparison with the Integrated Plan. SD1 defined the traditional plan as a gray-only solution concept that would result, on average, a calculated SSO discharge only once every two years and a CSO discharge only four times a year.

[2] The parties' agreement regarding resubmittal of the Watershed Plan to include an integrated approach to achieve the goals of the Consent Decree by December 31, 2025 was set out in a letter dated August 23, 2010. This letter recognized that the Integrated Plan for 2025, including any watershed controls proposed to offset CSO or delay SSO control, would be conceptual in nature.

Bounding Analysis

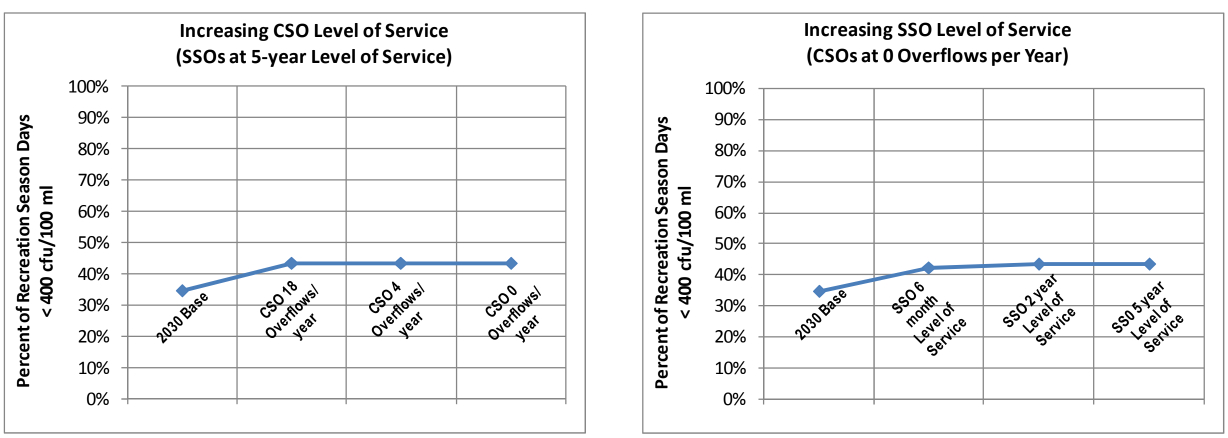
The bounding analysis presented in the June 2009 Watershed Plans compared a gray-only solution concept, at varying levels of control to various integrated solution concepts. The gray-only solution concept included the following technologies:

- Primary and secondary treatment expansion,
- High-rate treatment,
- Deep tunnel for storage and/or conveyance,
- Storage tanks, and
- Conveyance improvements (pump stations and piping).

This set of controls was then evaluated at a level of service for SSOs ranging from six months to five years and a level of control for CSOs ranging from 18 to zero overflows per typical year. The cost of the gray-only solution concept varied from $1.9 Billion to $3.2 Billion in 2009 dollars, depending on the level of overflow reduction.

Despite this massive investment in gray infrastructure and the corresponding reductions in overflow volume, SD1's water quality models often indicated minimal improvements in water quality standards compliance. For Banklick Creek, the elimination of all CSO volume increases compliance with the bacteria water quality standard by only seven percent (from 35 percent with no overflow control to 42 percent with the elimination of CSOs) (Figure ES.4). The elimination of SSOs (five-year level of service) on Banklick Creek similarly increases compliance by just six percent (from 35 percent with no control to 41 percent with elimination of SSOs). The Taylor Creek model also indicated minimal improvement in water quality standards compliance at similar levels of CSO and SSO control.

Figure ES.4 Water Quality Benefits of Increasing the Level of CSO and SSO Control in Banklick Creek



Note: cfu/100 ml stands for colony forming units per 100 milliliters.

For Banklick and Taylor Creeks, the limited value of sewer overflow control can be attributed to: (1) the overflow volume entering these streams is relatively small compared to other sources of pollution, and (2) the stream monitoring and models indicate that the water quality of both streams is severely impacted by dry weather and non-overflow wet weather sources of bacteria pollution.

The calculated water quality improvements in the Ohio River resulting from the control of SD1 overflows were also marginal, but for different reasons. While a majority of the total SD1 overflow volume flows directly into the Ohio River, SD1 overflows comprise only approximately six percent of the total annual bacteria load to the 13-mile reach of the river adjacent to Northern Kentucky. The Ohio River is subject to significant wet weather input of bacteria from sources other than SD1 overflows. These sources include CSOs and SSOs from other urban sewer utilities, as well as urban and agricultural runoff, both locally and upstream. While loads from SD1 overflows can result in elevated bacteria levels in the river, the duration of these levels is short enough that water quality standards are still met more than 90 percent of the time along the Kentucky shore, if other sources are controlled. These results show that controlling SD1 overflow sources that discharge to the Ohio River would result in little increase in compliance with water quality standards.

SD1's analysis indicates that the Licking River is affected by both SD1 overflows and other upstream sources, depending on the stretch of river examined. This highlights the need for a watershed-based approach that addresses the multiple sources of pollution contributing to the water quality impairment of this river.

The final assessment in the bounding analysis was a preliminary evaluation of integrated solution concepts consisting of a combination of gray infrastructure, green infrastructure, and watershed controls. The purpose of this evaluation was to determine whether a more cost-effective solution with increased improvement to water quality could be achieved using an integrated approach as compared to sewer overflow control only. This was a particularly important question to address given the extremely high-cost of a traditional gray-only solution and its limited benefits in water quality improvement.

The watershed and green controls used in this analysis represented assumptions regarding the implementation of controls for new development, the retrofit of runoff controls into existing development, the protection and re-establishment of riparian buffers where feasible, and control of dry weather-related bacteria sources. The analysis of the integrated solution concepts provided encouraging results - that a program based on lower levels of gray CSO and SSO controls with a moderate implementation of green and watershed controls yields greater water quality improvement than higher levels of overflow control utilizing gray-only solutions. The value of this assessment is its prediction that green and watershed controls can provide substantial improvements in water quality relative to their cost.

The most important conclusions resulting from the bounding analysis were as follows:

- A traditional gray-only program to eliminate SSOs and reduce CSOs varied from \$1.9 to \$3.2 Billion (2009 dollars). The economic analysis, conducted in June 2009, indicated that SD1 ratepayers do not have the ability to support this expensive of a program within the timing of the Consent Decree. For a \$3.2

Billion full program expenditure[3], the residential indicator was calculated to be 3.6 percent of median household income, which is well above the U.S. Environmental Protection Agency's threshold of two percent.

- Increasing levels of sewer overflow control provide diminishing returns in water quality and public health improvement. Even at high levels of overflow control, improvements in water quality from a traditional gray-only solution concept were limited.
- The impact of overflow control was not consistent across all watersheds, depending on watershed characteristics and the other sources of pollution. High levels of overflow control, however, provide diminishing instream water quality standards compliance returns in all watersheds.
- Decisions on overflow control should first target protection of human health, rather than compliance with water quality standards.
- Targeting dry weather and runoff sources can provide cost-effective improvements for complying with water quality standards.
- Green and watershed controls can be a more cost-effective approach for improving water quality and public health than gray-only controls.

The results of this work provided critical input into shaping the Integrated Plan for 2025, the updated economic analysis, and the selection of projects for the Five-year Improvement Program.

Additional Analyses to Develop the Integrated Plan

In reviewing the June 2009 Watershed Plans, the U.S. Environmental Protection Agency indicated that it generally supported SD1's Five-year Improvement Program, which was based on the findings from the bounding analysis. The agency requested, however, that SD1 conduct additional analyses of gray and integrated solutions to identify a single preferred solution set for 2025. This section summarizes those additional analyses, which are described in detail in Section 3.

SSO Elimination Evaluation

For the SSO elimination analysis, SD1 first prioritized the SSOs based on an evaluation of a series of factors, including annual activation frequency, public health risk, Consent Decree Appendix D listed overflows, and proximity to integrated solutions or early action projects. SD1 then used the hydraulic model to identify areas in the separate sewer system where more than two percent of annual rainfall was estimated to result in inflow and infiltration to the sanitary sewer system. Portions of the separate sewer service area were identified for Sanitary Sewer Evaluation Surveys, which will be used to develop projects to remove inflow and infiltration, construct storm water controls, and implement green infrastructure. Prioritization of these survey activities was based on SSO volume, public health impact, and coordination with other local projects.

SD1 then incorporated assumptions about the collective effectiveness of the inflow and infiltration removal projects into the hydraulic model. The model was run with the two-

[3] The $3.2 Billion Full Program Cost of the Traditional Plan includes Committed Projects for Asset Management; Initial Watershed Projects; traditional, gray-only controls for CSOs and SSOs (four CSO events per year and a two-year level of service for SSOs); and anticipated future effluent limits projects.

year, six-hour design storm under saturated antecedent conditions to simulate post-inflow and infiltration removal conditions and post Five-year Improvement Program using the 2030 future build-out condition. The model results were then used to size and cost the gray infrastructure improvements needed to achieve a two-year level of service for the remaining SSOs.

SD1 intends to continue the overall strategy for eliminating the remaining SSOs identified in the Five-year Improvement Program by first maximizing public and private inflow and infiltration reduction to reduce and, in some areas, eliminate overflows, renew crumbling infrastructure, and reduce public health risk. This approach is fundamental to SD1's asset management approach to renewing both the sanitary and storm sewer infrastructure on a neighborhood-by-neighborhood level. By also addressing the storm water runoff, SD1 will reduce storm water runoff peak flows and improve runoff quality through the implementation of green infrastructure.

CSO Long-term Control Plan Evaluation

This section summarizes the process SD1 used to develop the CSO long-term control plan. SD1 first conducted a detailed analysis of green infrastructure opportunities, both within the combined sewer system and SD1's entire service area. SD1 then used a "knee-of-the-curve" analysis to determine target levels of control for CSOs that would remain after full implementation of the green infrastructure programs. These targets were then used to evaluate costs and effectiveness of different gray infrastructure solutions for each CSO sub-basin. At the same time, SD1 evaluated the potential for watershed controls, such as storm water controls associated with inflow and infiltration projects (described above), regional watershed control measures[4] (retention basins, constructed wetlands), decentralized watershed controls (smaller-scale storm water wetlands, bioretention / bioinfiltration basins, enhanced retention basins), and stream restoration (in-channel practices, riparian buffer restoration, and livestock exclusion).

Green Infrastructure Opportunities Assessment

Subsequent to the June 2009 Watershed Plans, SD1 conducted a more detailed investigation of opportunities to reduce overflows through the use of green infrastructure, after accounting for the benefit of the Five-year Improvement Program. This analysis showed that green infrastructure projects can remove and treat storm water from approximately one-third of the combined sewer system area (2,349 of the 6,931 acres), reducing annual CSO volume by a total of 506 million gallons. Green infrastructure can also treat 562 million gallons per year of storm water within the remaining combined sewer system area.

SD1 also conducted an analysis of system-wide green infrastructure opportunities to identify high level, long term strategies to help improve the water quality in Northern Kentucky. These strategies did not result in specific projects, but will be used to guide project selection in future plans and identify potential demonstration projects during the five-year planning periods. This evaluation also resulted in the identification of system-

[4] Two major forms of regional watershed controls were considered: instream and side-stream. Instream regional controls were temporarily suspended as an option following feedback from the Agencies on the June 2009 Watershed Plans.

wide green programs that are part of the Integrated Plan. These programs include the Disconnection – Redirection – Infiltration Program (DRIP), the Green Infrastructure Project Partnership Program (GrIPP), and technical support for urban reforestation and riparian buffers. Through these programs, SD1 intends to demonstrate a cost-effective and sustainable approach to storm water management while working to reduce overflow volume and improve water quality, as well as to provide additional benefits to the communities.

In addition to these programs, SD1 recognizes the value of community partnerships for the success of implementing green infrastructure. To begin forming these partnerships, SD1 met with many communities and other stakeholders in Northern Kentucky to discuss potential opportunities for partnering on green infrastructure projects. Since implementation rates of these programs and partnerships depend on local priorities and are difficult to forecast, SD1 will monitor, evaluate and update the green infrastructure projects and programs every five years.

Gray Infrastructure Opportunities Assessment for Remaining CSOs

SD1 used the water quality models to evaluate whether increasing levels of CSO control would continue to provide additional water quality benefit after implementation of the Five-year Improvement Program and the Green Infrastructure Programs. This analysis, called the “knee-of-the-curve” in the CSO Control Policy, determines the point where the water quality benefit from additional levels of control diminishes compared to the increase in costs. SD1 used the “knee” to help develop a targeted level of CSO control to guide analysis of additional gray infrastructure opportunities. This analysis revealed that, with implementation of the Five-year Improvement Program and the Green Infrastructure Program, discharges from 20 CSOs could be eliminated and that many of the remaining CSOs would already meet or exceed the targeted level of control.

SD1 then built upon the Bounding Analysis (described previously) by evaluating various control strategies including regional storage (equalization), regional high-rate treatment, deep tunnel storage, and combinations of these technologies (as described in Section 3). Initial sizing was based on meeting the targeted levels of control identified from the knee-of-the-curve analysis. The analysis showed that the deep tunnel solution (selected as the Traditional Plan under the Bounding Analysis) was the most expensive. A combination of regional storage and high-rate treatment was determined to be the most cost-effective and was selected as the preferred conceptual solution. This option reduced untreated overflows by another 726 million gallons in a typical rainfall year (1970).

This preferred conceptual solution also is calculated to achieve a minimum of 85 percent and up to 94 percent system-wide capture[5] which meets the Presumption Approach in the CSO Control Policy. A further analysis was conducted with the water quality models to assure the plan would reasonably be expected to not cause or contribute to a water quality (in terms of bacteria) violation. That modeling analysis

[5] As stated in the CSO Control Policy in Section II.C.4.a.ii, percent capture is the “elimination or the capture for treatment … by volume of the combined sewage collected in the CSS during precipitation events on a system-wide annual basis.”

shows that, assuming other non-CSO sources are controlled within the implementation period, remaining CSOs would not cause or contribute to a water quality violation.

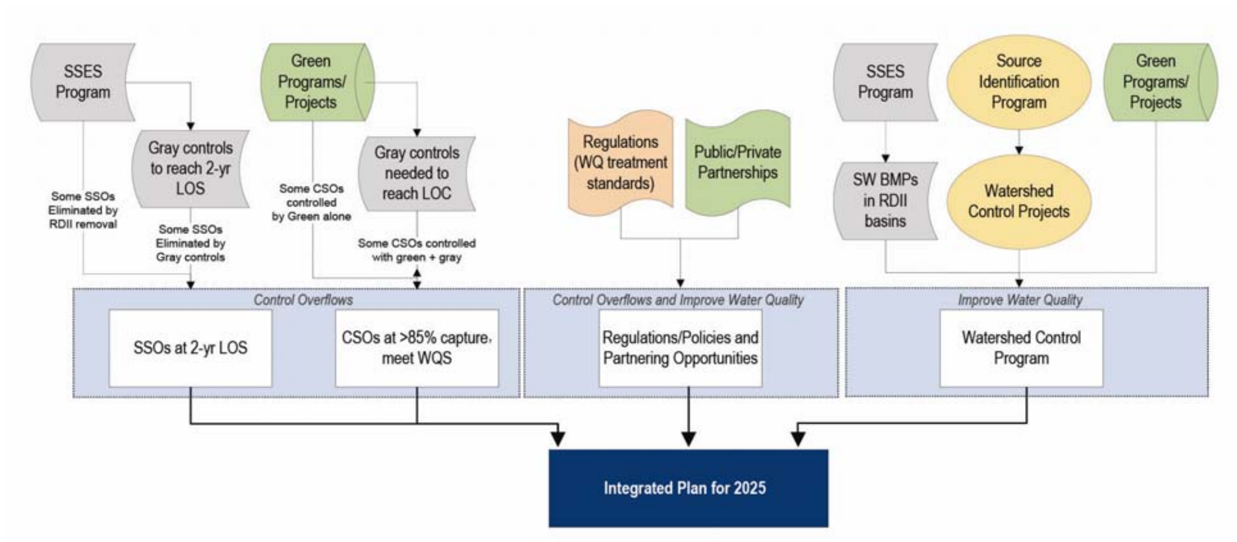
Other Opportunities Assessment

SD1 also expanded the 2009 watershed control analysis to determine if watershed controls could be used to cost-effectively enhance the level of CSO control and achieve greater water quality benefit. The analysis looked at controls such as storm water policies and regulations, a Source Identification Program, and storm water control measures that could be used to treat the storm water in areas associated with inflow and infiltration reduction projects.

Costs and Benefits of the Integrated Plan

The Integrated Plan for 2025 (Figure ES.5) incorporates these additional analyses. It has four components: SSO Elimination Program, CSO Long-term Control Plan, Watershed Control Program, and Policy/Regulations and Partnership Opportunities, as described above and in detail in Section 3. The Plan (beyond the Five-year Improvement Program), however, remains conceptual. This is because there is still significant uncertainty in the control design and modeling assumptions for the 2025 planning horizon. Consequently, the Plan will be refined and updated (in each five-year planning cycle) as more information and data become available.

Figure ES.5 Schematic of SD1's Integrated Plan for 2025.



Note: SSES = Sanitary Sewer Evaluation Survey; SSO = sanitary sewer overflow; RDII = rainfall derived inflow and infiltration; LOS = level of service; LOC = level of control; WQS = water quality standards; SW BMPs = storm water best management practices.

Table ES.4 summarizes the categories of projects and costs of the Integrated Plan for 2025. The cost of the Integrated Plan is $1.26 Billion in 2009 dollars and includes $103 Million for the System-wide and Basin Projects included in the Five-year Improvement Program; $463 Million in SSO control; $489 Million in CSO control; and $201 Million in watershed controls (including the storm water controls associated with SSO control). The $489 Million in CSO control includes an estimated $145 Million of SD1 funding for green infrastructure projects and green programs in the combined area; it is estimated that this will leverage an additional $13 Million investment in green infrastructure from the Kentucky Transportation Cabinet.

Table ES.4 Cost of Integrated Plan for 2025

Categories of Projects	Capital Cost (Current 2009 $ M)
System-wide and Basin Projects in Five-year Improvement Program (including River Water Intrusion)	$103
SSO Control – Source Reduction Projects	$248
SSO Control – Gray SSO Projects to meet 2-year level of service	$215
SUBTOTAL – SSO Control	$463
CSO Control – Green Tier 1 Projects in Combined Sewer System Area	$136
CSO Control – Green Programs in Combined Sewer System Area	$9.2
CSO Control – Gray CSO Projects to meet targeted Level of Control	$344
SUBTOTAL – CSO Control	$489
Watershed – Source Identification Program Decentralized Projects	$12
Watershed – Stormwater Best Management Practices in RDII Basins	$187
Watershed – Green Programs outside Combined Sewer System	$1.8
SUBTOTAL – Watershed and Programmatic Projects	$201
TOTAL Consent Decree Costs	*$1,260*
Committed Projects for Asset Management	$252
Public Structural Rehabilitation	$197
Facility Planning Projects	$254
Initial Watershed Projects	$241
Anticipated Future Effluent Limits Projects	$229
TOTAL Full Program Costs	*$2,430*

Table ES.5 presents the model-calculated CSO and SSO volumes for the current conditions (based on 2007 land use) and future conditions (using 2030 land use). Current conditions include the baseline condition (pre-implementation of the Watershed Plans) and full implementation of the Five-year Improvement Program. Future conditions include full implementation of the Five-year Improvement and Green Infrastructure Programs, and full implementation of both programs with additional regional storage and high rate treatment for the remaining CSOs. Results are shown for the typical rainfall year (1970) and the typical water quality evaluation period (1992 to 1996). This shows that substantial reductions in CSO (26 to 31 percent) and SSO (45 to 43 percent) volume could be achieved with the Five-year Improvement Program over existing conditions. Full implementation of the green infrastructure is estimated to provide an additional 23 to 24 percent of CSO reduction (over existing conditions). Full implementation of the Integrated Plan for 2025 is estimated to provide an 88 to 91 percent reduction in CSO volumes and eliminate SSOs.

Table ES.5 CSO and SSO Modeled Volumes

Scenario	Typical Year (1970)		Five-Year Period for Water Quality Evaluation (Annual Average of 1992-1996)	
	CSO Volume (Million Gallons)	SSO Volume (Million Gallons)[1]	CSO Volume (Million Gallons)	SSO Volume (Million Gallons)[1]
Existing Conditions (2007 land use)				
Current Conditions	1,873	242	2,073	247
After Five-Year Improvement Program	1,376	134	1,422	140
Future Conditions (2025, using 2030 land use)				
With Green Infrastructure Added	952	134	945	140
Integrated Plan for 2025 (With Additional Gray Infrastructure Added)	226	0	178	0

Notes:

Two planning horizons are provided, the 1970 "typical year" period and the five-year typical period (1992-1996) used for the water quality evaluations. The 1970 period, while typical from a rainfall perspective, had unusually low flow conditions in Banklick Creek and the Licking River, making it unsuitable for evaluating the water quality impacts of CSOs. The five-year period was typical from a combination of rainfall and instream flow conditions.

Model calculations are current as of February 2011.

[1] Includes the model-calculated volume from model-predicted overflow locations, as well as the volume prior to the Eastern Regional sewer system improvements.

An added benefit of SD1's Watershed Plans is that pollutant loads (other than bacteria) can be considered in selection of controls. Table ES.6 compares the estimated percent reduction in bacteria, nitrogen, and phosphorus loads from all sources in the Northern Kentucky watersheds from current conditions under the Traditional Plan and the Integrated Plan for 2025. The Integrated Plan provides significantly greater percent reduction than the Traditional Plan for many of the watersheds.

Table ES.6 Percent Reduction from Current Condition in Bacteria, Nitrogen, and Phosphorus Loads for the Traditional and Integrated Plans

	Bacteria Loads		**Total Nitrogen Loads**		**Total Phosphorus Loads**	
Watershed	Traditional Plan	Integrated Plan	Traditional Plan	Integrated Plan	Traditional Plan	Integrated Plan
Banklick Creek	40%	53%	1%	20%	1%	19%
Licking River	53%	53%	3%	6%	3%	6%
Taylor Creek	32%	46%	3%	25%	3%	24%
Fourmile Creek	56%	60%	1%	10%	1%	10%
Pleasant Run	6%	38%	0%	31%	0%	31%
Ohio River	75%	73%	4%	5%	3%	5%
Twelvemile Creek	0%	2%	0%	2%	0%	2%
Threemile Creek	16%	36%	0%	21%	1%	18%
Dry Creek	42%	52%	2%	18%	3%	19%
Elijahs Creek	0%	13%	1%	10%	0%	8%
Sand Run	0%	8%	0%	8%	0%	9%
Woolper Creek	59%	62%	0%	11%	1%	11%
Gunpowder Creek	1%	9%	0%	9%	0%	9%
Big Bone Creek	4%	9%	0%	8%	0%	8%
Total	**47%**	**51%**	**2%**	**9%**	**1%**	**8%**

SD1's Integrated Plan for 2025, as currently envisioned, achieves the following as compared to the future baseline and traditional plans:

- Elimination of SSOs at a two-year level of service;
- Elimination of 20 CSOs;
- Treatment of 562 million gallons per year of storm water through green infrastructure and reduction in storm water runoff quantity;
- Elimination of 1,287 million gallons per year of CSO volume from the completion of the Five-year Improvement Program and additional green infrastructure projects identified in the Integrated Plan for 2025;
- Treatment of 767 million gallons per year of CSO volume through high-rate treatment; and
- Minimum of 85 up to 94 percent capture and treatment of the volume of CSO.

The Traditional Plan that was evaluated under the Bounding Analysis used a level of control for CSOs at four overflows per year. SD1's analysis showed that, although the traditional plan results in less annual average volume of CSO over the five-year typical period (124 million gallons per year) versus the Integrated Plan for 2025 (178 million gallons per year as shown in Table ES.5), the water quality and other benefits of the

Traditional Plan are far less. Table ES.7 provides a comparison of some of the benefits under the traditional plan and the Integrated Plan for 2025 conditions.

As discussed in Section 3, the benefits of the Integrated Plan as compared to the traditional plan include:

- A greater reduction in bacteria levels (during both dry and wet weather conditions) and total bacteria loads from the watersheds.
- More water quality benefit using number of days where fecal coliform bacteria levels are less than 400 colony forming units during the recreation season (a common benchmark for safe recreating conditions). For example, the Traditional Plan results in 18 additional days of recreation in Banklick Creek (as compared to the baseline condition) whereas the Integrated Plan results in an additional 42 days of recreation.
- More water quality benefit using the average (geometric mean) of bacteria levels across the recreation season.
- Improved water quality in 148 miles of streams. These streams will also benefit from water quantity improvements from the integrated controls (gray, green, watershed, and policy/regulation).
- Greater reductions in total nitrogen and phosphorus loads from the three-county area.

Table ES.7 Additional Benefits of a Traditional Plan and the Integrated Plan (2025 Baseline)

Watershed	Additional Days of attainment (< 400 colony forming units per 100 milliliters)		Recreation Season geometric mean concentration (colony forming units per 100 milliliters)			Stream length with improved water quality (Miles)	
	Traditional Plan	Integrated Plan	Base-line	Traditional Plan	Integrated Plan	Traditional Plan	Integrated Plan
Banklick	+17	+41	1,080	586	310	1	19.1
Licking	+10	+11	136	105	96	4.8	9.2
Taylor	0	+1	2,628	2,572	2,204	0.2	2.5
Fourmile	+7	+8	446	323	305	2.1	9.5
Pleasant Run	0	+2	387	385	364	0.7	3.4
Ohio River	+7	+6	14	6	7	55.4	73.0
Twelvemile	0	+1	329	329	315	0	10.4
Threemile	+2	+4	517	492	464	0	4.3
Dry	+5	+7	514	426	402	0	7
Elijahs	0	+1	250	250	245	0	4
Sand	0	+1	488	484	467	0	5.8
Total	+63	+96				64.2	148.2

Notes:
Gunpowder, Big Bone, and Woolper were not assessed because the models have not been calibrated.
For modeling water quality benefit, the Pleasant Run Creek and Fourmile Creek CSOs were input directly to the Ohio River because of their proximity to the mouths of their respective creeks.
Ohio River model water quality results are presented at River Mile 471.32, just downstream of the Willow Run CSO. The reported numbers of stream miles improved for the Ohio River were calculated as the streamwise distance between the downstream extent of the study area (river mile 516.6 at the Boone County line) and the upstream most control for each scenario.

As compared to a traditional (gray-only) plan, the Integrated Plan, through its focus on multiple pollutant sources, is also anticipated to provide additional qualitative benefits for ecological and human health. Additional benefits include reduced public health risk, reduced flooding, improved aquatic habitat and biology, streambank stabilization and reduced erosion, preservation of green space and provision of opportunities to connect public lands and greenways, and support for community involvement and partnering.

Economic Analysis

Financing a long-term, capital intensive program without placing an unreasonable burden on ratepayers is one of SD1's biggest challenges. The timing of the Watershed Plans submission is unique, in that it is occurring in the midst of the most severe national economic crisis in generations. As a result, the financial affordability precedents from other utilities' sewer overflow control programs established in consent decree negotiations over the past ten years may no longer be valid.

SD1 is funded through a combination of sanitary and storm water utility rates and fees; no income is available from property taxes, sales taxes, or other taxes. Sanitary sewer rates currently represent more than 70 percent of this revenue stream. The current economic situation has the potential to significantly impact SD1's financial position. For example, the recession will clearly affect the ability of some ratepayers to pay increased sewer rates. As unemployment increases, credit markets tighten and foreclosures increase, some ratepayers will ultimately not be able to afford their sewer bills.

Further, recent legislation has limited SD1's Board of Directors ability to approve rate increases. On March 17, 2011, House Bill 26 was signed into law (effective June 8, 2011). This new law will require SD1 to submit all proposed rate increases of greater than five percent to the three county fiscal courts. On March 22, 2011, SD1's Board of Directors approved 15 percent rate increases for fiscal years 2012 and 2013. For fiscal year 2014 and thereafter, SD1 will have to submit any increase greater than five percent to the fiscal courts and unless at least two of the three fiscal courts approve the rate increase, the increase cannot occur.

This situation may directly impact the ability of SD1 to maintain adequate revenue, meet its bond coverage requirements, and keep a high credit rating. SD1 is required to maintain fiscally conservative accounting by the Board of Directors. The recent history of sanitary sewer rate adjustments (average annual increases over 14 percent for the last ten years) have supported a bond rating of AA or better. The minimum debt service coverage required by SD1's bond indenture is 125 percent; however, the Board of Directors has set a goal of 150 percent. With the current and projected impact of the economic crisis, there will be more pressure and scrutiny for future rate adjustments.

In addition to funding projects associated with the Consent Decree, SD1 has an obligation to operate and maintain current assets. These "Committed Projects" are asset management costs that are not discretionary, as they reflect the cost of doing business for a sewer and storm water utility. This would include projects to fix failing pipes, prevent loss of service and building backups, and minimize wet weather overflows.

Funding scenarios and affordability implications were developed for two time frames, the full Consent Decree implementation period ending in 2025 and the watershed planning cycle for the next five years.

Integrated Plan for 2025

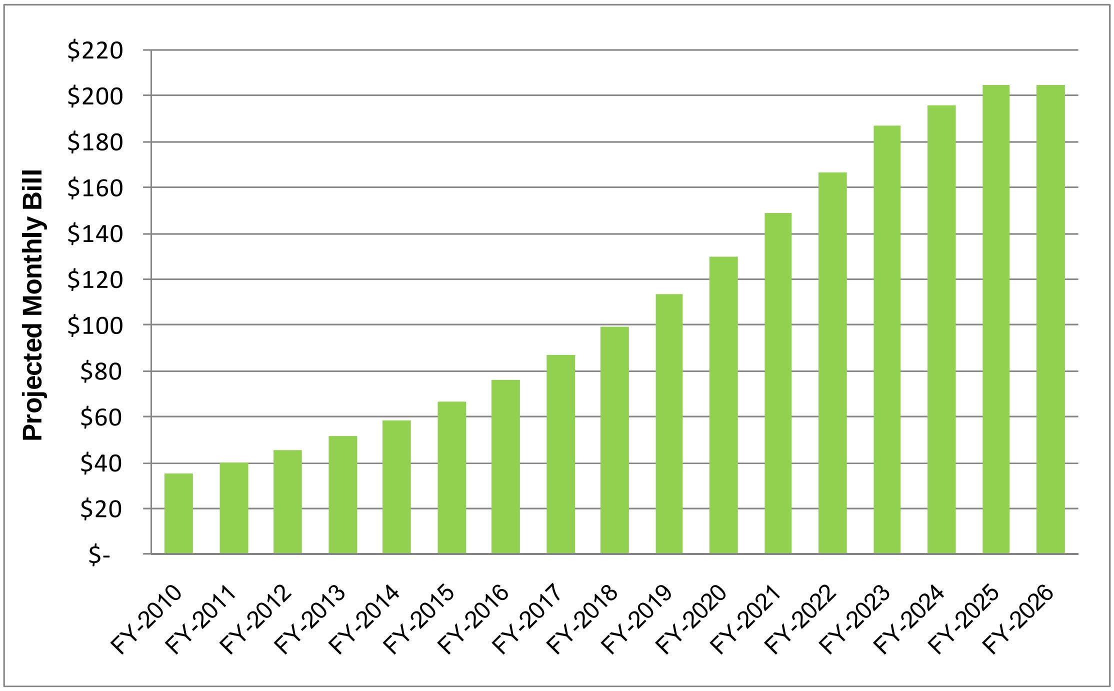
In accordance with the Consent Decree, SD1 used the Financial Capability Assessment approach that is typically included in long-term control plans for CSO control to assess the Integrated Plan for 2025 (Section 3). This Plan achieves a high level of SSO control (two-year level of service) and meets the Presumption Approach (e.g., minimum of 85 percent capture and treatment of wet weather flow) in the CSO Control Policy. The Full Program Costs for the Integrated Plan for 2025 (Table ES-4 above) were the basis for the formal U.S. Environmental Protection Agency's financial capability assessment analysis.

The Full Program Costs consist of the projected costs of the Integrated Plan for 2025 as well as the costs for the committed obligations of asset management for infrastructure and Initial Watershed Projects, and the obligations of anticipated future effluent limits for nutrients (i.e., nitrogen and phosphorus) at the treatment plants. The cost for SD1 to implement this full program is $2.4 Billion, in 2009 dollars (See Table ES.4).

Per the Financial Capability Assessment, this program equates to an annual cost per household of $1,680. The corresponding Residential Indicator is 3.0 percent, based on a median household income of $55,840 (overall SD1 service area). This analysis indicates that SD1's program is clearly in the "High Financial Impact" category. When assessed in terms of Northern Kentucky's lower-income communities, the financial impact is even greater. The seven lowest income communities (representing approximately 40 percent of the households in SD1's service area) have a median household income of $38,000. For these households, the Residential Indicator is 4.4 percent.

In addition to the Residential Indicator analysis, SD1 estimated the future rate increases that would be needed to support the Full Program Cost of the Integrated Plan for 2025. To assess the year-by-year impacts of the program, a conceptual schedule was developed to represent a construction sequence with final completion by 2025. This capital spending schedule was then incorporated into SD1's financial tools to estimate future rate requirements, as shown in Figure ES.6.

Figure ES.6 Residential Sewer Rates for the Full System Solution Concept – Future Projections (Future Dollars)



An average residential monthly sewer bill over $200 in 2025 represents an increase of 500 percent over 2010 rates ($35 per month). Even when allowing for future income growth, which is particularly difficult to predict in today's economic climate, these rate projections represent staggering increases that are unaffordable for SD1's ratepayers. The need for developing a watershed-based program that is cost effective, maximizes improvements to water quality and public health, and is supported by the public is clear.

Five-year Watershed Plan Horizon

The five-year cycle of the Watershed Plans also requires its own economic analysis. Because this analysis is not based on the full duration of the Consent Decree, the traditional affordability metrics such as the Residential Indicator are not directly applicable. Rather, SD1 used the estimated rate increase scenarios as the controlling indicator for determining an affordable five-year program.

As noted previously, SD1 has obligations both to the Committed Projects (asset management efforts) as well as the completion of the Initial Watershed Projects. These combined programs represent approximately $396 Million in capital spending over the five-year period of fiscal years 2010 to 2014. It should be noted that the two approved 15 percent rate increases in 2010 and 2011 were approved at the beginning of Northern Kentucky feeling the full brunt of the national economic crisis. This positioned SD1 with the funding to at least initiate significant improvements over the first five-year implementation cycle. Further, the two additional 15 percent rate increases for 2012 and 2013 were approved by the Board of Directors and Judges Executive in March 2011, immediately prior to this 2011 submittal. These increases for fiscal years 2010, 2011, 2012, and 2013 demonstrate the commitment by SD1, in particular its Board of Directors and Judges Executive, to fund SD1 initiatives upon demonstration of return on investment in terms of protecting public health and improving water quality. Future increases, however, will inevitably be linked to regional economic conditions in Northern Kentucky and restricted by affordability limitations and House Bill 26.

SD1's objective for the next five years is to complete the Initial Watershed Projects, continue working on the Committed Projects, and implement the System-wide and Basin Projects that have been identified through the watershed planning process. All of these projects will provide significant improvements in CSO reduction, SSO elimination, public health, and result in water quality benefits for Northern Kentucky's waterways. The Five-year Improvement Program requires an additional rate increase in fiscal year 2014, beyond the currently-approved increases (through fiscal year 2013 inclusive). In order to configure the Five-year Improvement Program, SD1 has assumed an additional 15 percent rate increase in fiscal year 2014. Under this scenario, the average residential customer using seven hundred cubic feet per month would be paying $35 per month in fiscal year 2010 and projected payment of $59 per month in fiscal year 2014.

Five-Year Improvement Program

Improvements to be made over the next five years include the completion of the Initial Watershed Projects, continued work on asset management in order to renew existing assets and reduce inflow and infiltration, and the implementation of System-wide and Basin Projects that have been identified through the watershed planning process. In addition, SD1 will evaluate, pursue, and seek commitments to ensure the successful implementation of green infrastructure in the Integrated Plan for 2025. These commitments will be included in updates to the five-year Watershed Plans and will serve as a model for future green infrastructure projects and programs.

Initial Watershed Projects

A total of 52 different Initial Watershed Projects are listed in Exhibit D of the Consent Decree. These projects can be broadly categorized into three groups, as shown in Table ES.8. The benefits associated with these projects include SSO elimination, CSO elimination, overflow volume reduction, increased treatment capacity, and increased conveyance capacity.

Table ES.8 Five-year Improvement Program: Initial Watershed Projects

Project Name	Benefit	Spending through 2009 ($ Millions)	Fiscal Year 2010-2014 Budget ($ Millions)
Western Regional (11 projects)	New water reclamation facility, conveyance improvements, SSO elimination	$46	$258
Eastern Regional (10 projects)	New water reclamation facility, conveyance improvements, SSO elimination	$75	$3
Pump Station and Sewer Improvements, Sewer Separation, and Overflow Studies (31 projects)	SSO elimination, CSO elimination, overflow volume reduction, increased conveyance capacity	$37	$0 (all projects completed)
Total		$158	$261

The Eastern Regional and Western Regional project groups represent the largest portion of the Initial Watershed Project set. The Eastern Regional projects were needed to eliminate the sewer overflows and resolve the 1996 sanction that led to a building moratorium in the Alexandria area; those projects are complete at this time. The Western Regional projects include the construction of the new Western Regional Water Reclamation Facility and significant sewer construction throughout the area tributary to that facility. The largest of these sewer projects is the $141 Million conveyance tunnel project. The Western Regional projects will serve as a cornerstone in the ultimate solution to SD1's sewer overflow problems. These projects allow for the diversion of wastewater flow away from stressed areas of the SD1 system such as the Dry Creek Wastewater Treatment Plant and Lakeview Pump Station, thereby eliminating sewer overflows and providing additional capacity to accommodate future growth.

Committed Projects

In addition to funding projects associated with the first Watershed Plans, SD1 has an obligation to operate and maintain current assets and to meet other obligations. These Committed Projects represent a total of approximately $144 Million in spending over the period of fiscal year 2010 through 2014. As shown in Table ES.9, these projects include high priority sewer repairs and replacements, a number of Consent Decree required programs, sewer asset renewal and inflow and infiltration reduction, improvements at pump stations and treatment facilities, and capital purchases.

Table ES.9 Five-year Improvement Program: Committed Projects

Project Name	Benefit	Fiscal Year 2010-2014 Budget ($ Million)
High-priority Sewer Projects	Critical sewer rehabilitation / replacement; Projects include Van Deren, Highland Pike, Wayman's Branch	$10.1
Nine Minimum Control Program	Element of Nine Minimum Controls Program, Consent Decree requirement	$2.1
River's Edge Inline Storage and Solids & Floatables Project	CSO volume reduction, Solids and Floatables Controls at 2 CSO outfalls	$5.2
Capacity, Management, Operations, and Maintenance Program	Consent Decree requirement; Projects include Pump Station Back-up Power, South Park Industrial Pump Station Overflow Elimination	$11.0
Consent Decree Planning, Implementation, Management	Necessary to ensure effective implementation of overall Consent Decree program	$12.2
Improvements at Dry Creek Wastewater Treatment Plant	System maintenance, increased treatment capacity	$28.8
Pump Station Projects	Pump station asset management and elimination	$14.9
Ongoing Sewer Rehabilitation / Repair Projects	Rehabilitation / replacement based on Continuous Sewer Assessment Program and Cities' opportunities; SSO elimination	$42.0
Storm Sewer Rehabilitation / Repair Projects	Storm water asset management	$11.0
Capital Purchases (vehicles, construction equipment, etc.)	Equipment	$6.6
	Total	$143.8

System-wide Projects and Basin-Specific Projects

As required in the Consent Decree, SD1 has developed a Five-year Improvement Program describing improvement projects to be implemented over the next five years. Information that was needed for the development of this program included the results of the system characterization, the bounding analysis, and the economic analysis. In addition, public participation was a critical component in the watershed planning process.

SD1 solicited public input through a variety of channels. Those included a widely-publicized and well-attended Watershed Summit meeting in 2007, the formation of a 53-member Watershed Community Council that met regularly over an 18-month period, and the development and distribution of a survey to assess the community's support of the Consent Decree program. Through that process, a set of criteria were established that guided the selection of projects for the Watershed Plans. Those criteria included:

- Reduction of sanitary sewage entering waterways,
- Reduction of polluted runoff,
- Public health benefits,
- Maintenance of critical, aging infrastructure, and
- Cost.

The selected projects for the Five-year Improvement Program includes both System-wide and Basin Projects. As shown in Table ES.10, these projects also include a combination of gray infrastructure, green infrastructure, and watershed control approaches.

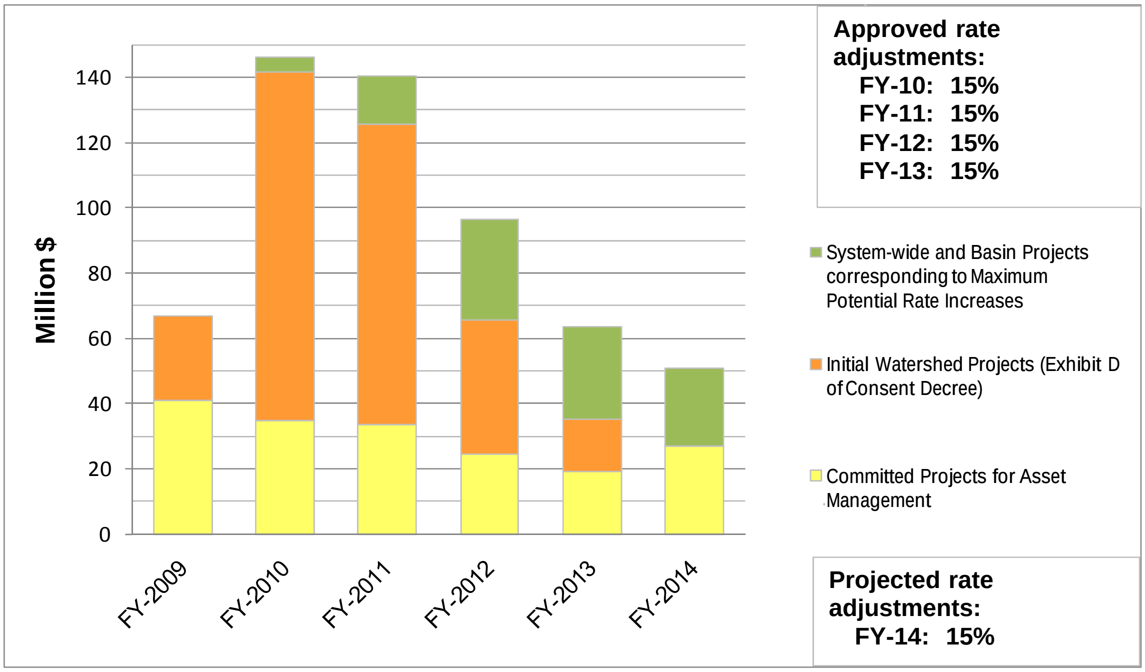
Table ES.10 Five-year Improvement Program: System-wide and Basin Projects

Project Name	Benefit	Fiscal Year 2010-2014 Budget ($ Millions)[1]
	System-wide	
River Water Intrusion Mitigation	CSO reduction	$5.0
Priority Inflow and Infiltration Source Identification and Removal	SSO reduction/elimination	$6.0
Green Programs (DRIP, GrIPP)	Source runoff control, CSO reduction, and pollutant load reduction from both CSO control and runoff	$2.0
Demonstration Projects (pilot projects, innovative technology testing)	Source runoff control, CSO reduction, and pollutant load reduction from both CSO control and runoff. Performance data to inform future Watershed Plans	$4.6
Dry Creek WTP Headworks Project	Increases the primary and disinfection capacity to 93 million gallons per day	$19.1
	System-wide Project Total	$36.7
	Central Basin	
Lakeview Pump Station Pumps Replacement	Increase pump station capacity and reliability	$5.4
Church Street (Gray, Green, and Watershed controls)	CSO reduction, storm water runoff, green space	$3.8
Vernon Lane –Public & Private Source Inflow and Infiltration Removal	SSO elimination	$3.8
Watershed Controls Pilot Projects - Regional and decentralized controls	Improve dry and wet weather water quality and stream conditions; Reduce public health risk; Pilot projects that will provide performance data to inform future plans	$3.6
Ripple Creek Pump Station Removal	SSO elimination	$0.9
	Central Basin Project Total	$17.5
	East Basin	
Ash Street Pump Station and Forcemain	CSO elimination (Sensitive area); SSO reduction	$19.7
	East Basin Project Total	$19.7
	North Basin	
Allen Fork Pump Station Overflow Elimination	SSO elimination	$8.3
Lakeside Park – Public Sewer Rehabilitation and Private Source Removal	SSO elimination	$5.8
Willow Run Dynamic Control	CSO reduction	$1.3
Willow Run Direct Entry Point Bar Racks	Reduce debris entry and reduce blockages	$0.06
Kentucky Transportation Cabinet Basin – Green Infrastructure Retrofit	CSO reduction, inform future green infrastructure	$1.5
	North Basin Project Total	$17.0
	West Basin	
Highland Acres Pump Station Removal	SSO elimination	$1.65
Kentucky Aire Pump Station Removal	SSO elimination	$4.0
	West Basin Project Total	$5.7
	System-wide and Basin Projects Total	$96.5

Note: [1]The System-wide and Basin Projects budget total from Table ES.4 Components and Cost of the Integrated Plan for 2025 of $103 Million differs from the budget total in Table ES.10 of $96.5 Million. The $103 Million includes the full river water intrusion (RWI) costs outside the five-year window, and is based on the current costs to date (fiscal year 2010 audited actual and fiscal years 2011 to 2014 budget with a 3% deflation rate to 2009 dollars) used in the Financial Capacity Assessment.

The total capital spending associated with all project work over the next five years is approximately $497 Million. The distribution of spending over that period is weighted towards Initial Watershed Projects in the first few years with a transition to the System-wide and Basin Projects towards the end, as shown in Figure ES.7.

Figure ES.7 Capital Spending and Rate Adjustment Schedule



Overflow Reduction Benefits

The overflow reduction benefit resulting from the projects described in the Five-year Improvement Program is substantial, with an overall 28 percent reduction in typical year sewer overflow volume. Based on hydraulic model results, the CSO volume for a typical year will be reduced by 493 million gallons, representing a 26 percent decrease from current conditions. The annual SSO volume, calculated for both confirmed and model-predicted overflow locations, for a typical year is reduced by 108 million gallons, representing a 44 percent decrease. The overflow reduction is associated with the projects presented in Table ES.11.

Table ES.11 Five-year Program: Overflow Reduction for Selected Projects

Project	Overflow Reduction in the Typical Year (millions of gallons)	
	CSO	SSO
Western Regional	-	59.7
Eastern Regional	-	8.0
River Water Intrusion Mitigation	281	7.5
Church Street	35	-
Ash Street Pump Station	2.4	21.6
Vernon Lane Infiltration/Inflow Reduction	-	3.8
Ripple Creek Pump Station Removal	-	0.3
Lakeside Park Improvements o Van Deren Sanitary Sewer Improvements o Avon Drive Sanitary Sewer Improvements o Public Sewer Rehabilitation and Private Source Removal	-	0.4
Additional System Improvements o Static Inline Storage o Bromley Wet Well Modifications o Willow Run Dynamic Control o Kentucky Transportation Cabinet Basin Retrofits o Taylor Creek Improvements	166.8	6.5
Disconnection – Redirection – Infiltration Program (DRIP) Green Infrastructure Project Partnership Program (GrIPP)	1	
Green Demonstration Projects o Kentucky Transportation Cabinet Bioretention Facility o Terraced Reforestation o St. Elizabeth's Rain Garden o 12th Street Rain Garden	11.2	
Selected Project Totals	497.4	107.8

Lakeview Pump Station- Example of Benefits of the Watershed Approach

The Lakeview Pump Station, located on Banklick Creek, was once SD1's largest SSO. Since SD1 entered into the Consent Decree, significant improvements have been completed at the Lakeview Pump Station and additional improvements will be completed within the next five years. As a result of those projects, the annual overflow volume from the Lakeview bypass will be reduced by more than 90 percent in a typical year. Water quality sampling shows that this reduction in overflow results in approximately ten additional days of achievement of instream water quality standards, annually. As SD1 evaluated control alternatives for the remaining overflow at the bypass, it was estimated that higher levels of control to eliminate the one million gallons of remaining annual overflow volume will produce no additional days of achievement of instream water quality standards for Banklick Creek.

The cost to construct a storage tank or install interim high rate treatment that would eliminate or treat the remaining overflow volume ranged between $15 Million to $27 Million. In addition, this investment would only address the overflow at the pump station and would do nothing to improve the condition of the water quality in the upper two-thirds of the watershed. Model results have shown that far greater water quality, community, and public health benefits can be achieved by directing resources toward the reduction of dry weather sources to Banklick Creek. Further, SD1's characterization efforts revealed that there were CSOs and SSOs contributing more than 38 million gallons of overflow volume in the Silver Grove area that were of greater public health risk than the remaining discharge from the Lakeview Pump Station. Because of these higher public health risk overflows, SD1 committed to addressing these problems in the Five-year Improvement Program.

SD1 is therefore proposing that the solution to address the remaining discharge at Lakeview be focused on the overall water quality issues within the Banklick Creek watershed, and that SD1 be allowed to delay eliminating this SSO. The proposed solution includes five components:

- Replace existing pumps at the Lakeview Pump Station to maximize and provide reliable peak pumping capacity;
- Redirect a portion of the Lakeview tributary area to the new Western Regional Water Reclamation Facility and reduce the annual calculated overflow from 10.6 to one million gallons (under construction);
- Conduct investigations and target cost-effective inflow and infiltration removal in the area remaining tributary to Lakeview to reduce wet weather flows and target upstream SSOs at locations with a higher risk for public exposure;
- Implement a Source Identification Program to detect sources of pollution (dry and wet weather-related) determined to exist through monitoring and modeling efforts; and
- Construct a wetland system along Banklick Creek to reduce dry weather bacteria levels and improve overall water quality in the downstream system.

This combination of controls represents a cost-effective solution that provides greater water quality, public health, and community benefits than a more costly investment to contain or treat the remaining one million gallons of overflow from the Lakeview Pump Station. In addition, by delaying action at Lakeview with respect to the remaining overflow volume, SD1 will be able to reallocate $20 Million over the next five years to the Ash Street Pump Station project in Silver Grove, which will provide approximately 38 million gallons of annual overflow reduction in a part of the system where the overflow has greater potential for public health impacts.

SD1 strongly believes that elimination of the remaining one million gallons of overflow for the typical year at the Lakeview Pump Station will be achieved through aggressive inflow and infiltration removal which will take some time to implement. Additional improvements needed to eliminate all remaining overflows in the Lakeview Pump Station service area will be implemented in subsequent Watershed Plan implementation phases.

This approach represents a change from the language of Exhibit E in the Consent Decree which specifies a completion date of December 31, 2013 for the construction of remedial measures at the Lakeview Pump Station to eliminate the bypass. However, the proposed solution described above supports the position that this modified approach will provide substantially greater improvements to water quality and public health. Therefore, the Watershed Plan provides for a delay in the December 31, 2013 Consent Decree deadline to eliminate the bypass at the Lakeview Pump Station.

Implementation Plan

SD1 has developed an implementation plan for the Five-year Improvement Program and the Integrated Plan for 2025, as described in Section 8. SD1 has budgeted for a substantial commitment in system-wide and basin projects in the first five years, as discussed above. These projects were selected based on criteria important to both SD1 and local stakeholders:

- Reduction of sanitary sewage entering waterways,
- Public health benefit,
- Reduction of storm water runoff pollutants,
- Cost effectiveness,
- Eco-friendliness, and
- Criticality of aging infrastructure.

Reduction of sanitary sewage entering waterways and public health benefit led SD1 to target SSOs that discharge in areas with a high potential for public contact; while many of these are small volume overflows, their public health risk made them a priority. Reduction in storm water runoff pollutants, cost effectiveness, and eco-friendliness led SD1 to include a range of green and watershed controls. These innovative techniques have the potential to provide cost-effective control of many different source types. Finally, criticality of aging infrastructure supported inclusion of system-wide controls such as infiltration and inflow source detection; these programs are directly aligned with SD1's institutional goal of maintaining existing infrastructure assets. These guiding principles were also used to establish priorities for selection and implementation of controls for the Integrated Plan for 2025.

Several of the five-year projects will be used to evaluate the benefit of integrated green, gray, and watershed solutions that are necessary components of the Integrated Plan for 2025. Many of these projects will include a performance monitoring program to allow SD1 to determine general effectiveness of different approaches and technologies, and to inform the prioritization of projects for subsequent Watershed Plans.

The Five-year Improvement Program projects and their timing for completion are ultimately linked to SD1's ability to obtain rate increases. The implementation schedule for the Five-year Program (presented in Section 8) balances the following key factors:

- **Financial Capability and Cash Flow:** Sequencing of work to fit within SD1's affordable capital budget;
- **Consent Decree Deadlines:** Impacts the timing of several Pump Station Overflow Elimination projects. Several stations with 2010 and 2013 deadlines

needed to be started earlier in the schedule so the overflows associated with those pump stations will be eliminated by their scheduled deadline;

- **Demonstration Projects:** Design and construct green and watershed demonstration projects or integrated control projects so that sufficient time was left to collect meaningful post-construction monitoring data to inform and support future plans; and,
- **Public Health Priorities:** Attempt to prioritize projects that will have the greatest public health benefits.

Through the characterization and planning work, SD1 identified three Initial Watershed Projects or Pump Station Overflow Elimination Projects that will not meet the dates stipulated in the appendices of the Consent Decree, or the subsequent approved Pump Station Overflow Elimination Plan. These projects are the Lakeview Pump Station, the Richwood Pump Station, and the Sunset Pump Station (details are provided in Section 8.3). Justification for the modifications is as follows:

- **Lakeview Pump Station:** SD1 is proposing to replace existing pumps at the Lakeview Pump Station to maximize and provide reliable peak pumping capacity; redirect a portion of the Lakeview tributary area to the new Western Regional Water Reclamation Facility and reduce the annual calculated overflow from 10.6 to one million gallons (under construction); conduct Sanitary Sewer Evaluation Studies to remove public and private inflow and infiltration; conduct a Source Identification Program in the Banklick Creek watershed; construct an innovative wetland system and other decentralized watershed controls; and spend $20 Million over the next five years to construct the Ash Street Pump Station project in Silver Grove. The Ash Street project will provide approximately 38 million gallons of annual overflow reduction in a part of the system where the overflow has greater potential for public health impacts.

- **Richwood Pump Station:** The upgrade of Richwood Pump Station and the construction of a new forcemain to redirect flows to the Western Regional System were originally included in the Initial Watershed Projects due to the pump station's potential lack of dry and wet weather capacity and its perceived reduction in overflow volume in the Lakeview system. Based on flow monitoring conducted in 2007 and 2008 as part of the hydraulic model calibration and validation and subsequent hydraulic modeling, SD1 has found that the Richwood Pump Station does not bypass during wet weather and has sufficient capacity to convey all dry and wet weather flows. In addition, redirecting the flows from the Richwood Pump Station to the Western Regional system did not significantly reduce overflows downstream in the Lakeview system. The potential future need to construct this project will be based on monitoring the existing upstream and downstream sewer system after the Western Regional Water Reclamation Facility is in operation. The timing of the upgrade and redirection of the Richwood Pump Station to the Western Regional System will be evaluated based on monitoring the available capacity of the pump station and the downstream Lakeview sewer system. Richwood Pump Station will receive a backup power solution as well to eliminate any overflows due to power outages.

- **Sunset Pump Station:** The original plan in the Pump Station Overflow Elimination Plan was for a private developer to partner with SD1 to construct a new pump station farther north to serve a new development as well as the existing Sunset Pump Station area. This new pump station (Arcadia Pump Station) would have eliminated the Sunset Pump Station and overflow and would have a firm capacity of 1.3 million gallons per day to provide capacity to convey peak dry and wet weather flows for current and future conditions. The original schedule provided in the Pump Station Overflow Elimination Plan stated construction would be complete by spring of 2009. Due to the significant economic downturn and the slow-down in the housing and lending markets, SD1's partnership with the developer to construct the new pump station was delayed. At this point in time, it is optimistic that SD1's partnership will be restored at some point in the future in order to complete the new pump station construction. SD1 has implemented an interim solution that provided the required capacity in the near term to eliminate the overflow. The solution constructed a new eight-inch force main and installed new discharge piping in the existing pump station to allow the existing pumps to provide the necessary capacity in order to eliminate overflows. A new back-up diesel-driven pump was also provided to be used during power outages. This project was completed ahead of the Consent Decree deadline of December 31, 2010.

As part of the implementation plan, SD1 has developed a post-construction monitoring plan in accordance with the U.S. Environmental Protection Agency's guidance and information needed to support continued implementation of the Watershed Plans. The post-construction monitoring plan includes monitoring programs specific to project performance monitoring (with an emphasis on green infrastructure projects), the sanitary sewer collection system and watershed monitoring.

Performance monitoring plans will be included in the detailed design for projects in the Five-year Improvement Program, as appropriate, and will continue through the full implementation of the Watershed Plans. Performance monitoring is necessary to evaluate specific watershed, green and integrated infrastructure control projects, test the effectiveness of phased controls (and aid in decisions about additional levels of control), and inform decisions about cost-effective projects in future control planning cycles. Because site-specific and cost data on these controls are needed for Northern Kentucky, performance monitoring may also be necessary to test the effectiveness of green infrastructure or watershed controls before decisions are made about implementation at other sites, or to inform the overall potential of these controls to improve water quality.

The green infrastructure performance monitoring will be a critical element in the early stages of SD1's overflow control strategy, and will ultimately shape the level and extent of specific strategies, as well as the overall role that green infrastructure will play in achieving SD1's water quality improvement goals for Northern Kentucky. The primary objectives of this monitoring are to measure and document specific project and/or storm water control measures performance and to compare this data to modeled projections. These data may also prove useful in identifying the key design parameters that impact overall performance which will then allow for better and more cost-effective designs moving forward.

The sanitary sewer collection system monitoring will provide information to continue to characterize the collection system and update the collection system models as projects are completed, generate quarterly and annual reporting of wet weather CSO and SSO activations, and monitor performance of constructed controls. As part of this ongoing characterization effort, SD1 will periodically update the model with new information from field inspections and, when necessary, verify that the model is still calibrated for its intended use.

Because SD1 is pursuing an Integrated Plan that includes green infrastructure and watershed controls in addition to traditional gray infrastructure controls, monitoring is needed throughout the 16 watersheds to measure the success of the Watershed Plans. The Watershed Monitoring Program consists of three phases that include collecting data to initially characterize the waterways, capture changes in the waterway conditions, and post-construction monitoring to assess improvements in overall water quality, biology and habitat after the Watershed Plans are implemented. The phases of the Watershed Monitoring Program are:

- Baseline Monitoring Characterization and Model Development (2006-2011),
- Baseline Trend Monitoring (2012-2026), and
- Post-Construction Monitoring (2026-2028).

These phases reflect the expected timing of activities needed to implement the Watershed Plans, to inform the five-year planning cycles of the Consent Decree, and to conform to the post-construction monitoring requirements of the CSO Control Policy. The Program includes monitoring to be conducted by SD1, continued cost-share funding for monitoring conducted by the United States Geological Survey, and collaboration with other parties that are conducting monitoring in Northern Kentucky, such as the Kentucky Division of Water, local universities, and non-governmental organizations.

Conclusion

SD1's Consent Decree is unique in that it incorporates a watershed-based approach that allows SD1 to put CSO and SSO controls into context with other sources of pollution, reflecting watershed-specific characteristics. This approach provides an alternative to traditional regulatory practices which target specific sources through individual pollution control programs. By taking a watershed-based approach, SD1 will make use of a wider variety of data to assess the relative impact of different pollutant sources on the receiving waterways.

This approach also prevents the pitfall of directing funds towards increasingly higher levels of CSO and SSO control when those improvements do not provide corresponding improvements in water quality. Traditionally, most consent decrees focus solely on CSOs and SSOs, with an emphasis on gray infrastructure solutions. SD1's watershed approach identifies the characteristics of individual watersheds and considers CSOs and SSOs along with other pollution sources impacting the waterways (such as runoff and dry weather sources). The iterative structure of SD1's Watershed Plans allows time to investigate new technologies and adjust the approach so that solutions for updated Plans will be developed using information gained from the implementation of projects during the first five years. This includes the pursuit of green infrastructure approaches that are more cost effective than traditional gray infrastructure, including mechanisms to ensure the implementation of such controls.

The U.S. Environmental Protection Agency acknowledges that “[for] some receiving water reaches within a watershed, CSOs could well be less significant contributors to nonattainment than storm water or upstream sources. In such cases, a large expenditure on CSO control could result in negligible improvement in water quality” (EPA, 1995b). Much of the work performed by SD1 thus far supports this statement. The proposed Integrated Plan for 2025, with gray and green infrastructure along with watershed controls is shown to be more cost effective at meeting the long-term goals of the Consent Decree. However, the Integrated Plan with a completion date of December 21, 2025, has also been shown to be unaffordable and, as stated previously, relief from the deadline (and/or other performance criteria) is therefore required.

The SD1 Consent Decree, developed in partnership with state and federal regulatory agencies, represents a paradigm shift in wet weather control programs. The watershed approach is one of the U.S. Environmental Protection Agency’s “Four Pillars” for sustaining water infrastructure (EPA, 2006). Under the watershed approach, priorities and solutions that provide the largest overall environmental impact are developed based on current information considering watershed-based, cost-effective alternatives as well as traditional gray-only infrastructure solutions. This process recognizes the need to consider environmental progress, make wise use of public resources, and direct funds towards the most significant problems first.

SD1’s Watershed Plans are focused on prioritizing those projects that maximize the return on investment, protect public health, and improve water quality. This approach also allows SD1 to compare gray-only controls against integrated sets of gray, green, and watershed solutions and calculate the estimated cost savings and greater net environmental benefit of the integrated solutions. The watershed approach provides SD1 with the opportunity to learn from experience and allows the information gained on project effectiveness to be factored into the next round of decision-making and project selection. The overall effectiveness of this new approach will require additional work for post-construction monitoring and results confirmation, which is why the Consent Decree requires the development and submittal of updated Watershed Plans every five years. This iterative cycle provides all stakeholders with an opportunity to review performance and benefits and make appropriate adjustments to program goals moving forward. The 28 percent reduction in overflow volume associated with this first Watershed Plan is indicative of the fact that substantial progress is being made towards the ultimate goals of the Consent Decree.

As a pioneer in this approach, SD1 will need to work closely with the regulatory agencies and local stakeholders to coordinate and maintain considerable flexibility throughout the duration of the Consent Decree. For example, this could mean that, in certain situations, it is sensible to accept a lower level of overflow control than traditional programs, in exchange for greater improvement in water quality through investments in a combination of controls that address other dry weather and wet weather-related sources. Likewise, directing resources toward other sources of pollution may provide a more substantial improvement in water quality. The planning of such projects will require assurances by SD1 that they can be implemented as well as the willingness of regulators to accept offsets or delays in typical overflow controls.

Given the adaptive nature of this approach and the conceptual nature of the Integrated Plan for 2025, the total cost of the SD1 program and a comprehensive schedule, with which controls are implemented over the full duration of the Consent Decree, cannot be precisely defined at this time. However, through these five-year cycles, SD1 will measure progress and ensure that funds are directed into control programs that meet regulatory mandates, maximize improvements in water quality and public health, and meet the expectations of the public.