Appendix C

CSO Community Case Studies

Community Case Study

Atlanta, GA—Region 4

Number of CSO Outfalls

10 (originally)
7 (currently)

Combined Sewer Service Area

19 square miles

Sewer Service Area

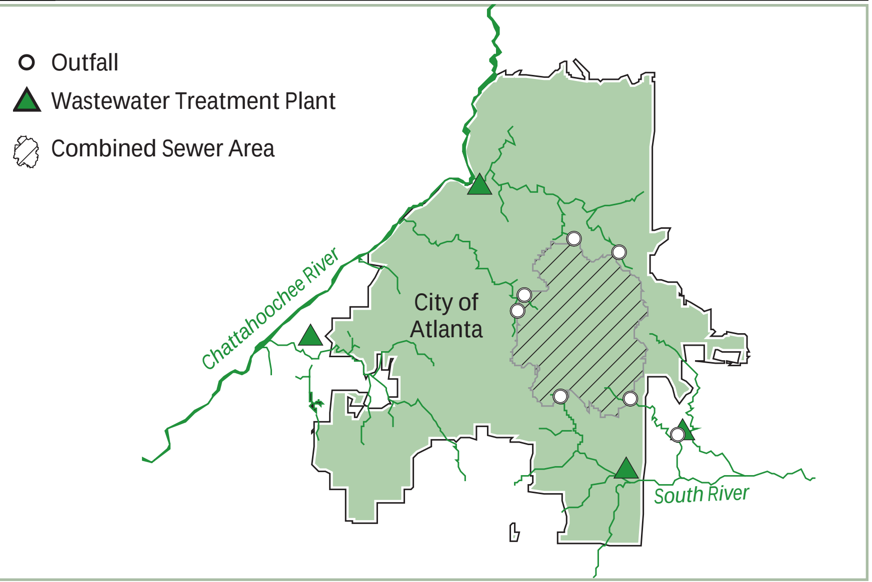
260 square miles

Wastewater Treatment Capacity

194 mgd (secondary)

Receiving Water(s)

South River, Chattahoochee River



Controls

- Atlanta constructed seven CSO control facilities, covered under six permits, which provide treatment to wet weather flows prior to discharge.
- The city separated approximately 15 percent of CSS area in the early 1990s.
- Additional proposed controls include two storage and treatment systems and localized sewer separation.

Photo: Trash screens at Atlanta's Intrenchment Creek CSO Center. *Courtesy of Atlanta Department of Public Works*

Program Highlights

- Settlement of a civil judicial enforcement action for violation of the Clean Water Act and Georgia Water Quality Control Act has required the city to develop and implement additional CSO controls.
- Controls implemented as of 2000 have reduced CSO volume by 60 percent and solids loading by 75 percent.
- The LTCP proposed by Atlanta in March 2001 will reduce overflow events from 60 to four per year per outfall.

Background on Atlanta CSOs

The CSS service area is centered in central downtown Atlanta. The city is situated on a ridge between the South River to the southeast and the Chattahoochee River to the northwest. Most of the city's CSOs are in the headward area of small watersheds that are tributary to these rivers. The CSO facilities are grouped according to the watershed in which they are located.

Atlanta's CSS covers approximately 19 square miles. It represents a small fraction of the city's sewer service area of 260 square miles, but it includes the most highly developed section in the Metro Atlanta region. This CSS area in the downtown business district serves approximately 103,000 residents and a daytime population of 202,000. Based upon a sewer system evaluation and survey of the East Side sewers, the city estimates that there are approximately 200 miles of combined sewers in the entire CSS.

Atlanta has four permitted POTWS: R.M. Clayton, Utoy Creek, Intrenchment Creek and South River. These facilities treated over 54 billion gallons of wastewater in 2000. There are also seven CSO treatment facilities covered under six permits.

A civil judicial enforcement action was taken jointly against Atlanta by the EPA, the Georgia Department of Natural Resources–Environmental Protection Division (GDNR-EPD), Upper Chattahoochee Riverkeeper Fund, Inc., the Chattahoochee Riverkeeper, Inc., and W. Robert Hancock, Jr. for violations of the CWA and Georgia Water Quality Control Act. Extensive CSO activity by the city during the last three years was undertaken in connection with the resulting CSO consent decree.

Status of Implementation

System Characterization

Atlanta constructed seven CSO control facilities in the mid-1980s and early 1990s to provide a level of CSO treatment that met state and federal regulations. The city also separated a 3.4-square-mile portion of the CSS area.

Three CSO treatment facilities, McDaniel, Custer, and Intrenchment Creek (the latter two covered under one permit), are located in east Atlanta. These facilities were constructed in the mid-1980s. Each one treats wet weather combined wastewater flows in a different manner.

- McDaniel CSO Facility – Low flows, up to 5.5 mgd, are captured and diverted to the South River wastewater treatment plant. In the event of higher flows, flow exceeds the interceptor sewer capacity and enters a 6 MG storage vault. While the vault is being filled, the stored storm water-sewage mixture is pumped to the sanitary sewer at a rate of 3 mgd. Any excess flow is coarse bar screened, disinfected, and routed over a weir into a tributary of the South River.
- Custer CSO Facility – Low flows are captured in a sanitary interceptor. When flows exceed 20 mgd, a gate closes the entrance to the interceptor sewer and all flow is routed over a weir through coarse bar screens into a concrete channel that leads to the Custer CSO Facility. High flows to the Custer CSO Facility are routed into a storage tunnel that connects to the Intrenchment Creek CSO Treatment Facility—or over the weir into Intrenchment Creek when the tunnel capacity is exceeded.
- Intrenchment Creek CSO Facility – The storage tunnel between the Custer outfalls and this facility is designed to capture and treat the first 30 to 34 MG of wet-weather flow to the tunnel. At the Intrenchment Creek CSO Treatment Facility, the captured flow is subjected to a physical and chemical treatment process and the effluent is then discharged into Intrenchment Creek. Treated effluent discharged from this facility contains lower concentrations of pollutants than discharges from the other East Area facilities, meeting the original 1985 reduction goal for biochemical oxygen demand and total suspended solids.

The four CSO facilities in the West Area of Atlanta are Greensferry, North Avenue, Tanyard Creek, and Clear Creek. These CSO facilities provide rotating fine screens and disinfection treatment.

An extensive system characterization and sampling program was conducted under a consent decree during 1999 and 2000 to characterize the CSS and discharges. EPA and GDNR-EPD approved the evaluation program on March 10, 1999 and approved the resulting evaluation report on September 21, 2000. To the best of the city's knowledge, this was the most extensive CSO characterization in the nation to date. In addition to the intensive system characterization, the city monitors overflows monthly as part of its permit conditions.

NMC

Creation of Maintenance, Operations, and Management Systems (MOMS) plans provided guidance to city personnel regarding the O&M requirements of each of the city's CSO facilities, as well as management strategies to control CSOs. The completed MOMS plans were submitted in December 1998 and were approved by EPA and GDNR-EPD in June 1999. The development of the MOMS plans addressed the NMC. There have been at least two dry weather overflows covered under the Consent Decree for which EPA and GDNR-EPD imposed a stipulated penalty. The overflows were due to non-sewer related problems (water line break and drinking water plant backwash).

The city has kept citizens informed of CSO developments with an informational website. Six Citizen Advisory Groups have been formed, and these groups have been given tours of CSO facilities and invited to attend public meetings to learn of developments in managing CSOs.

LTCP

The city submitted a proposed LTCP to EPA and GDNR-EPD in March 2001 under the requirements of the consent decree. The Administrative Order requires that EPA and GDNR-EPD authorize a plan, and that the city implement the plan by mid-2007, unless an alternative schedule is approved. It is the city's goal to complete the CSO consent decree agenda according to the schedule put forth in the Administrative Order.

The construction of two storage and treatment systems and the partial separation of additional areas are proposed in the LTCP. The storage and treatment systems will reduce the current number of overflows from approximately 60 or more per year to an average of four per year. CSO volume and pollution reduction at the outfalls will be at least 80 percent. Although there is already a significant improvement in the East Area with the storage units installed there, it will require three times more storage volume to reduce the number of events to only four per year. Reducing the number of discharges below the average of four per year increases the required storage (and cost) exponentially for only small improvements in pollutant reduction.

Costs and Financing

The city has invested about $244 million (1994 dollars) in the existing control facilities. This figure includes the total capital costs of planning, design, and construction of the CSO treatment facilities. The city has also spent $500 million for integrated wastewater treatment system improvement program and sewer system repair and relief projects, some of which provide additional treatment capacity in the sewer system. This figure does not include the capital cost of implementing the CSO consent decree activities to date, which were approximately $15 million. All of these capital activities were funded by bonds paid by the general funding available from the wastewater utility. The proposed LTCP is expected to require an additional capital cost of about $950 million (2001 dollars).

Financing for the preferred LTCP option is uncertain. While the city has good credit ratings and bonding capacity, the total funding needs may outpace the bonding capacity unless there are significant rate increases. The impact of the whole wastewater program, funded solely by monthly sewer bills, could be at least 2.6 times the current rate. This may constitute a high impact on households in Atlanta and could raise issues about the affordability of the program. The city is seeking assistance from EPA and GDNR-EPD to address this issue.

Water Quality Issues

CSO treatment is provided at each CSO outfall. The West Area CSO facilities have rotating fine screens and disinfection treatment. The East Area CSO facilities have storage and more advanced treatment. Even with these controls, the federal court ruled that Atlanta's CSOs were violating water quality standards. Because there is little opportunity for dilution at the outfall points, enforcement of water quality standards is at the end-of-pipe.

The CSO sampling results confirmed several characteristics widely known about storm water runoff and CSO. This evaluation also identified compliance issues for metals and toxicity, such as:

- Each sewershed needs individual consideration for developing representative concentrations.
- The hardness of both the CSO effluent and rainfall is relatively low, resulting in more stringent water quality criteria.
- The Intrenchment CSO Facility met the average and the maximum bacteria criteria. Fecal coliform levels from the Westside facilities still occasionally exceed the maximum criteria.
- Highly variable first flush effects were observed early in runoff events. The range of these effects was different from event-to-event and was not always present for every pollutant.
- Residual chlorine from the CSO treatment facility occasionally caused acute toxicity, based on whole effluent toxicity tests, whereas heavy metals did not cause toxicity. Dechlorinated effluent did not cause toxicity.
- The city collected supplemental storm water data using clean methods to better characterize metals and to determine contributions from parking lots and parks. Urban storm water discharges present challenges similar to CSO for complying with water quality standards. However, the majority of pollutants discharged from the CSO outfall were attributed to the deposition of sanitary sewage in the sewers during dry weather, rather than from storm water. The only storm water constituent that made a significant contribution was zinc.

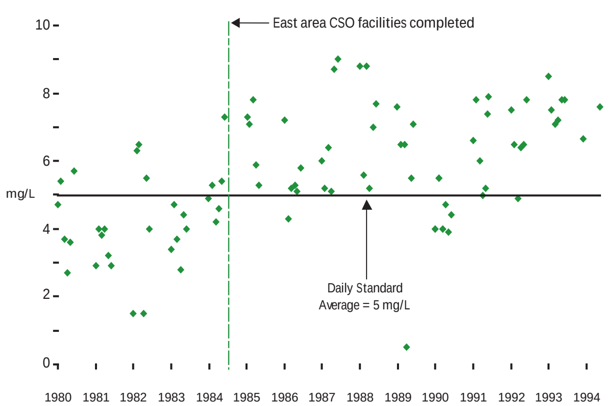
Enforcement Issues

The extensive CSO control activity during the last three years was undertaken in connection with the settlement of a civil judicial enforcement action taken jointly by the EPA, GDNR-EPD, Upper Chattahoochee Riverkeeper Fund, Inc., the Chattahoochee Riverkeeper, Inc., and W. Robert Hancock, Jr., for violations of the Federal Clean Water Act and Georgia Water Quality Control Act. The city is working diligently to meet all consent decree deadlines and will continue to implement its CSO and SSO programs under the settlement terms. The CSO consent decree calls for compliance by mid-2007, unless otherwise amended, and the SSO consent decree calls for compliance by 2014. In addition to the implementation of corrective CSO and SSO measures, the settlement requires Atlanta to create a greenway corridor and to clean up selected streams, as well as to pay a cash penalty of $3.2 million.

Results

The initial projects implemented in the mid-1980s in the East Area had the primary goal of reducing oxygen demanding substances in the South River. In addition to adding storage to the two CSO sewersheds, the South River and Intrenchment Creek wastewater treatment plant discharges were relocated to the Chattahoochee River. As shown in the figure at right, dissolved oxygen levels improved in the South River as a result, with reductions in CSO volume (60 percent), the number of CSO discharges (84 percent), and total CSO loadings (75 percent for total suspended solids).

Observed Summer Dissolved Oxygen Levels in the South River



Despite these improvements, the federal court still found that further improvements were necessary. The proposed LTCP calls for load reductions of approximately 85 percent.

Examples of Progress

Working closely with EPA, GDNR-EPD the Upper Chattahoochee Riverkeeper and other environmental organizations, the city has had no Discharge Monitoring Report violations at Atlanta's wastewater treatment facilities. However, the city has had dry weather overflows for which they have paid stipulated penalties.

The Atlanta Wastewater Systems Improvement Program accelerated ongoing sewer improvements, including a capacity certification program for new development and an intensive evaluation of sewer pipe conditions throughout the city. Many of the immediate sewer replacement and rehabilitation projects required under the terms of the SSO consent decree are projects that are included in the 1994 Bond Referendum approved by the voters (final bond issuance did not occur until 1999). Most of the major projects have been designed and some are under construction. Many moved forward as a result of the lawsuit and bills passed by the Georgia Legislature. A number of the projects originally included in the 1994 Bond Referendum have become outdated and must be redesigned.

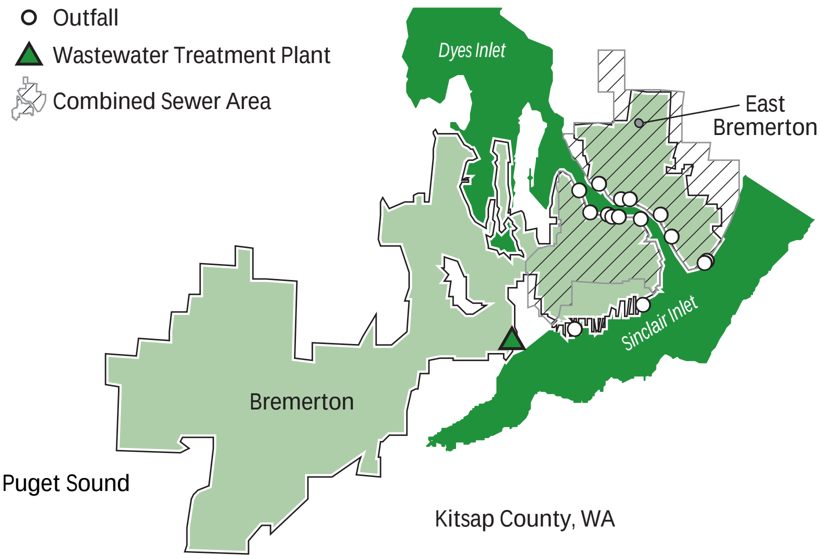
All consent decree construction completion deadlines associated with the LTCP have been met to date. Interim improvements required to protect public health were completed for the East Side CSO facilities.

The city completed an extensive and thorough assessment of the CSS system. They are working with a citizen advisory group, environmental organizations, EPA, and GDNR-EPD to evaluate an array of long-term solutions to Atlanta's CSO water quality problems.

References

Tyler Richards, City of Atlanta, Atlanta, GA. Personal communication with Limno-Tech, Inc. staff on details of the CSS overflow plan and program, summer 2001.

Community Case Study — Bremerton, WA—Region 10



Number of CSO Outfalls

19 (originally)
16 (currently)

Combined Sewer Service Area

5.2 square miles

Wastewater Treatment Capacity

32.5 mgd (primary)
7.6 mgd (secondary)

Receiving Water(s)

Port Washington Narrows, Dyes Inlet and Sinclair Inlet of Puget Sound

Controls

- Sewer separation projects were initiated in 1983.
- The city ordinance provides reimbursement for storm water separation projects on private property (e.g. disconnecting roof leaders from the combined sewer system).
- Bremerton has used off-line storage and increased conveyance capacity in the sewersheds where controls have been implemented. This approach is also planned for other sewersheds.

Photo: City of Bremerton and Bremerton Naval Shipyard.
Courtesy of US Navy

Program Highlights

- CSO outfalls have been reduced from 19 to 16.
- As of 2000, Bremerton achieved a 69 percent reduction in CSO volume and a 56% reduction in frequency of overflow events from baseline conditions.
- A consent order requires the city to limit CSOs to no more than one event per year at each outfall by December 2008.

Background on Bremerton CSOs

Bremerton's collection system serves 36,000 residents of the city and a small unincorporated portion of Kitsap County. The sewer system consists of 188 miles of gravity sewers, 33 pump stations, and 16 miles of force mains. The combined sewer service area comprises 5.2 square miles in ten sewersheds serving East Bremerton and West Bremerton. Inverted siphons carry sewage from East Bremerton under the Port Washington Narrows. All of the city's sewage is treated at the Charleston POTW, along with wastewater from the Puget Sound Naval Shipyard, other U.S. Navy facilities, and Kitsap County Sewer District No. 1. This plant has an average flow of 7.6 mgd and a maximum design flow of 32.5 mgd. It discharges into Sinclair Inlet, southwest of the City. Excess flows from the CSS are discharged from 16 outfalls located along the Port Washington Narrows and Sinclair Inlet of Puget Sound; 70 to 90 percent of this excess flow is estimated to be storm water or rain induced infiltration (RII).

Status of Implementation

The City of Bremerton began addressing CSOs in the late 1970s and separating its sewers in 1983. State legislation requires the city to limit CSOs to no more than one event at each outfall annually by 2011. The city agreed to meet a 2008 schedule specified in a federal consent decree resulting from a third party Clean Water Act lawsuit. Storm water discharge from new developments into the CSS is prohibited. The city must update its CSO reduction plan with each 5-year NPDES permit cycle, and submit a status report each May on implementation activities. The report provides details on the past year's frequency and volume for each CSO, and whether overflow at a site has increased over the baseline annual condition. Documentation of the previous year's CSO reduction accomplishments and planned projects for the next year are also included.

In 1992, the city completed its first CSO reduction plan in accordance with Washington State Department of Ecology (Ecology) guidelines (CH2M Hill, 1992). This plan included:

- Documentation of the CSO system and improvements.
- Computation of baseline annual frequency and volume of CSO discharges.
- Sampling and analysis of CSO discharges effluent and sediment at CSO structures and outfalls.
- Evaluation and selection of general control, reduction and treatment methods.
- Description (including costs) and evaluation of alternatives and recommendation of CSO reduction projects.
- Analysis of the effects of the proposed projects on the WWTP operation.
- Recommendations for future studies.
- Preparation of an implementation schedule and financing plan.

The 1992 CSO reduction plan proposed sewer separation as the primary means to reach the one event per year level in many of the city's sewersheds.

CSO volume and frequency data became available in 1994 when the CSO and rainfall monitoring system went on-line. Monitoring helped to identify sewersheds that receive direct storm water inflow and areas that had large amounts of RII. It was found that large amounts of roof and parking lot drainage from private properties goes directly into the CSS. A city ordinance provides funding authority for a program to assist private property owners with development and implementation of storm water separation projects by January 2002 and beyond, as funds are available. This program is called the Cooperative Approach to CSO Reduction.

Bremerton has published three educational brochures, hosted workshops, developed an internet website, and produced a how-to video that covers the CSO reduction program goals and requirements (Berthiaume, 2000). Private property owners willing to disconnect storm water inflow can obtain free technical assistance, site assessments and detailed planning from a city representative. The City Council approved a reimbursement schedule that pays the property owner based on the type of connection and the effort it will take to redirect the storm water to its yard, the street, or other conveyance. Separation work completed in the right-of-way is provided at no cost to the property owner. The city representative and property owner work together under this program to complete the site assessment. The method of separation is agreed to in a signed contract. When the separation work has been completed, the property owner calls for a post-separation inspection. If completed per the agreement, payment is made to the property owner and the property status is updated in the city's wastewater account data base. Bremerton established a fee schedule for private properties that have improperly connected storm water to the sanitary sewer system. If a private property has a storm water connection to the sanitary sewer system, the existing storm water fee, based on a per account or equivalent impervious surface unit, is increased 25 percent annually, beginning in 2002 to 100 percent of the fee by January 2005.

In 1999, Bremerton developed a hydrologic and hydraulic conveyance model to support facility planning. The city also carried out additional work including an inflow and infiltration study, installation of flow meters, and smoke and dye testing. The city initiated a source-tracing program to be implemented if contaminants in CSOs exceed marine chronic water quality criteria.

Bremerton updated its CSO Reduction Plan in 2000 (HDR, 2000). CSO reduction alternatives were evaluated based on an October 30, 1997 storm event. This storm has a one-year recurrence interval with a high intensity accumulation of rainfall at the end of the storm with two days of wet antecedent conditions. The storm produced a high flows well suited for developing improvements primarily associated with increasing conveyance capacity. Reduction options that were considered included sewer separation, removal of RII, increased conveyance capacity, storage, and treatment. Significant findings included:

- Separation should be continued, but only to provide a long-term benefit for collection and treatment of sanitary sewage. Separation will not reduce the overflows to one event per year since a major portion of the extraneous flow during major events is from RII.
- Removal of RII is feasible only when cost-effective and achievable within the schedule.
- Providing some storage offers valuable benefits, particularly when combined with onsite treatment or conveyance, but is not cost effective in all sewersheds because of site limitations and the volume of combined sewage.
- Increased conveyance capacity is needed to prevent overflows, but downstream impacts on the sewers and increased flow to the WWTP need to be considered.
- Treatment of CSOs at the old Manette WWTP site was the most cost effective method of reducing untreated overflows from East Bremerton.

Many of the controls were completed in 2000. Flow slipping (intentional blocking of storm water from entering the CSS at catch basins for the purpose of routing, or slipping it, elsewhere) and installation of new storm water sewer mains also contributed to reduced CSO discharges during 2000.

Nine Minimum Controls

Bremerton addresses all of the NMC in its annual reports. Monitoring of CSOs and receiving water bodies began in 1995, and there are no ongoing problems with dry weather overflows or floatables. The city has water conservation, rain barrels, recycling, and hazardous waste disposal programs in addition to the programs previously described. The city sweeps all major streets every six to ten weeks, and cleans each catch basin annually. The city also initiated planning in individual storm water basins. These efforts all reduce contaminants in CSOs. Upgrades to wastewater collection system controls and the installation of a Supervisory Control and Data Acquisition (SCADA) system have increased overall system reliability.

Costs and Financing

Bremerton completed CSO control projects in three sewersheds at a capital cost of approximately $17 million. It is estimated that an additional $27 million is needed to complete improvements for the seven remaining sewersheds. Annual operation and maintenance costs are currently $4.5 million and are expected to increase to $6.0 million by 2008. The city's wastewater utility has no bonding capacity until 2007. Therefore, outside financial resources are necessary to complete the program. Existing projects were funded through Interfund Loans, Public Works Trust Fund (PWTF) loans, Centennial Clean Water Funds (CCWF) loans/grants, State Revolving Funds (SRF) loans, and user fees. Future projects will be funded by these sources plus direct congressional grant appropriations ($3.48 million to date). Current debt service for funding CSO projects through these programs adds $1.1 million to the annual cost to the wastewater utility. Assuming $40 million for CSO programmatic capital loan requirements, it is anticipated that annual debt service will increase to $2.6 million in 2008 providing existing low interest loan terms.

Local match requirements are a significant issue for the city. EPA regulations preclude using SRF as matching funds for grants and PWTF also does not allow using grant funds as match. The current implementation schedule is dependent on several revenue assumptions, including continued annual consumer rate increases consistent with inflation, a minimum 1 percent system growth, third party recovery from ongoing litigation, and financing with loans or grants. Without the financing and sufficient match, the city will not be able to meet the implementation schedule. According to the 2000 Washington Water and Wastewater Rate Survey, Bremerton has some of the most expensive wastewater rates in the state (number 36 of 39 surveyed, ranked from lowest to highest) at $45.10 per month (Black and Veatch, 2000).

The Cooperative Approach to CSO Reduction program is supported by a grant from the CCWF and matching funds from Bremerton. Revenues from the grant will be expended by mid-2002 and the city plans to continue the program with O&M funds through 2005. Beginning in January 2002, revenues collected from the new storm water fee will be used to offset the cost of design, construction and the operation and maintenance of the new CSO reduction facilities that are needed to control and treat the extra water from the remaining improper connections.

Water Quality Issues

Water quality issues in Puget Sound include a ban on commercial harvesting of shellfish, threats to public health, and threats to endangered species. Sinclair and Dyes Inlets have documented water quality problems from a variety of sources, including failing septic systems, urban runoff, industrial and military sites, and CSOs. Efforts to address these sources of pollution have helped to improve, but have not solved, water quality problems in the area.

The Bremerton-Kitsap County Health District has issued a closure advisory for all species of shellfish, crab, bottom fish, and rockfish in Dyes Inlet, Port Washington Narrows, and Sinclair Inlet due to chemical or biological pollution. The closure to commercial harvesting of shellfish, due to point and nonpoint pollution, impacts the economy, reduces jobs, and causes the public to avoid the use of beaches. Additionally, the health district has issued an advisory for areas that periodically experience high levels of point and nonpoint pollution during heavy rains. This advisory includes Dyes Inlet, Port Washington Narrows, and Sinclair Inlet. Public use of Port Washington Narrows includes four major waterfront parks and more than seven other public access sites. Year-round recreational uses of these waters such as sport fishing, scuba diving, and swimming increase the potential risk to the general population.

The US Navy's ENVVEST program is developing a model that can be used by the Washington State Department of Health (DOH) to determine the transport and fate of fecal coliform if the city were to have an overflow event. This is a cooperative program among the Navy, EPA, Ecology and other organizations. Shellfish beds have been periodically monitored since they have been closed to harvest since 1969. Significant efforts have been made to reduce point and nonpoint pollution.

The Dyes Inlet currently meets water quality standards for shellfish. However, due to the existence of CSO structures and the potential for an overflow event, the DOH has not opened these shellfish beds for commercial harvesting. Discussion of re-certifying the shellfish beds in Dyes Inlet for restricted or limited harvesting is possible once DOH has a tool to calculate the fate and transport of fecal coliform due to a CSO.

There are 22 square miles of critical nearshore salmonid habitat that surround the CSO outfalls and range up to four miles downstream of the discharges. CSOs potentially affect the Chinook and Chum Salmon and Bull Trout, which are threatened under the

Endangered Species Act. Studies are underway to determine the actual extent of the threat and the effects of reducing pollutant sources.

Enforcement Issues

In 1993, Bremerton entered into a Consent Decree that further addressed its CSOs but did not include sewer moratoriums. Amendments to this decree were adopted in 1999 through mediation (Ballbach, 1999). The city agreed:

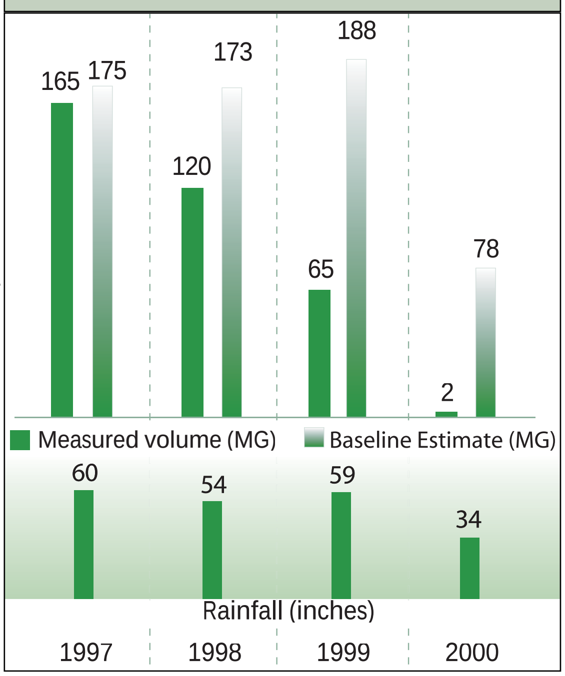
- To achieve a 95 percent reduction in CSO flows by 2003, subject to extraordinary events and extreme year anomalies.
- To accelerate the CSO reduction schedule to achieve the goal of one overflow per year or less at each outfall by December 2008.
- To pay for a Financial Feasibility Study if schedule modifications become necessary.

In November 2000, a second citizens group issued a notice of intent to file suit against the city for failure to meet the requirements of the Consent Decree.

Results

Bremerton has eliminated three CSO outfalls. As shown, the city's efforts have reduced CSO volume by 69 percent from baseline conditions (City of Bremerton, 1999). The city also reduced the annual number of overflow events by 56 percent. In 2000, the City achieved a 96 percent reduction in volume, and an 89 percent reduction in frequency of overflow events. Nine of 16 CSO outfalls overflowed only once or did not overflow at all in 2000 (Bertiaume, 2000). Some of the reduction can be attributed to the unusually low rainfall (20 inches less than normal). However, Bremerton believes it is on the way to achieving a goal of one overflow or less per outfall on an annual basis.

Annual CSO Volume and Rainfall



References

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Black and Veatch, 2000. *2000 Washington Water and Wastewater Rate Survey*. Seattle, WA.

CH2M Hill, 1992. *Combined Sewer Overflow Reduction Plan*. Prepared for the City of Bremerton, Washington. 1992.

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HDR, 2000. *Bremerton CSO Reduction Plan Update*. Prepared for the City of Bremerton, Washington. 2000.

Community Case Study — Burlington, IA—Region 7

Number of CSO Outfalls

20 (originally)
11 (currently)

Combined Sewer Service Area

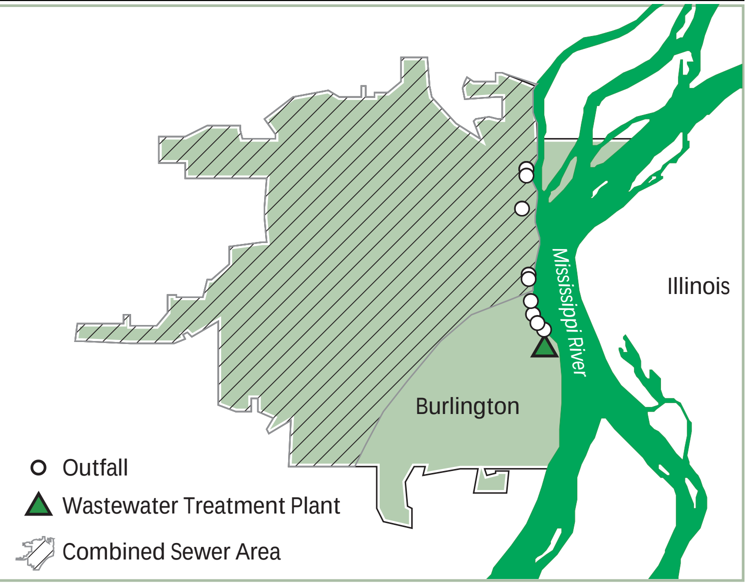
2.9 square miles

Wastewater Treatment Capacity

18 mgd

Receiving Water(s)

Mississippi River



Controls

- Burlington has been separating portions of its CSS since the 1970s through major street reconstruction projects.
- Work on eliminating individual CSOs started in 1982.
- As part of a 1996 CSO study, a number of CSO control alternatives were evaluated, but the city decided to continue to pursue sewer separation.

Photo: Great River Bridge over the Mississippi River in Burlington.
Courtesy of Hawkeye Magazine

Program Highlights

- CSO outfalls have been reduced from 20 to 11.
- Burlington developed a plan to eliminate CSO discharges with sewer separation that will be completed by 2017.
- Burlington has merged a wide array of television inspection and existing sewer system information in a common, detailed data base to facilitate inspection and reporting.

Background on Burlington CSOs

Burlington, Iowa is a hilly city located on the banks of the Mississippi River with a population of 27,500. The city's sewer system is a mix of sanitary, storm, and combined sewers. Combined sewers were commonly constructed until the 1960s and primarily serve the downtown area. Downtown Burlington is the largest retail center in Southeast Iowa containing more than 75 shops and restaurants.

The sewer system serves 5,250 acres through 135 miles of sewers, and has 10,451 customer connections. Six sewersheds and 1,870 acres (36 percent of the sewer system) are served by combined sewers. The Hawkeye basin comprises two thirds of the city's sewer system and 18.5 percent (664 acres) of the drainage area is combined. The South and Market Street sewersheds, the next largest in size (493 and 273 acres respectively), are 100 percent combined. The Cascade sewershed is the next largest at 318 acres, and 32 percent (102 acres) combined. The Angular and Locust sewersheds represent 273 and 65 acres of combined sewers, respectively. Four other minor sewersheds, the Silver, Gnahn, Osborn, and Harrison, serve a combined area of 91 acres.

Burlington operates an activated sludge wastewater treatment plant with an average design flow of 9.0 mgd and a peak flow capacity of 18.0 mgd. The city has worked on eliminating CSOs through separation and has reduced CSO outfalls from 20 to 11. The wastewater treatment plant and the remaining CSOs discharge to the Mississippi River. The Iowa Department of Natural Resources (DNR) has designated this stretch of the Mississippi for primary contact recreation (Class A) and as a significant resource warm water (Class B- WW) .

Status of Implementation

The DNR's "Special Conditions for CSOs" requires that the city: (1) determine the hydraulic capacity of the sewers between the CSO and the wastewater treatment plant; and (2) develop an operational plan for the combined system. Burlington has adopted a long-range goal of separating the combined sewer systems to comply with DNR and EPA requirements. The City has separated storm and sanitary sewers on major street reconstruction projects since the 1970s. Implementing the long-range goal will extend through 2017 because of the significant cost to completely separate the sewer system.

Burlington eliminated five CSOs through sewer separation projects between 1982 and 1993. In 1993, the City submitted the *Report of Combined Sewer Overflows: Part 1* to the DNR (City of Burlington, 1993). The City concluded that the capacity of the sewers was adequate for current average dry weather flows, except for the Hawkeye sewershed. Anticipated development in the Hawkeye sewershed, combined with significant inflow from Hawkeye Creek and an unnamed tributary, was predicted to exceed the capacity of that system, which was calculated to be 15.4 mgd. Burlington also identified dry weather overflows at three locations.

In 1995, the city submitted the *Report of Combined Sewer Overflows: Part 2* to the DNR (City of Burlington, 1995). This report addressed NMC activities that are described in the following summary. The city identified a number of repairs to the sewer system and CSO outfalls, located a number of dry weather overflows and CSOs for elimination, and found a previously unknown CSO at a lift station.

NMC	Activity
Proper O&M	Clean, inspect, monitor flows. Conduct regular inspections by wastewater treatment plant personnel after every rainfall event.
Maximize collection system storage	Raise dam heights. Disconnect all roof drains and smoke test entire collection system to locate unnecessary sources of inflow.
Review pretreatment requirements	Develop storm water management plans to control storm water from new development sites.
Maximize flow to POTW	Raise dam heights to increase flow.
Prohibit CSO during dry weather	Replace pipe at CSO 016. Separate 26 acres at Gnahn and Osborn.
Control solids and floatables	Study alternatives once data are available.
Pollution prevention	Institute a recycling program.
Public notification	Publish results of CSO monitoring in the newspaper.
Monitoring	Install monitoring at seven active CSOs to measure number of activations, quantity of water discharged, water quality, and notify wastewater treatment plant personnel.

Burlington prepared a 20-year CSO Control Plan in 1996. This plan outlines a 20-year capital improvement program, describes the condition of the sewers, provides flow monitoring information, and analyzes potential flow conditions during a standard storm (5-year, 1-hour event, 2 inches of rain). A number of CSO control alternatives were evaluated. Inlet control storage, in-line storage, off-line storage, deep tunnel storage, and swirl concentrators/disinfection were eliminated due to ineffectiveness or cost. The City elected to use separation as the primary means of CSO control, and established six phases to be implemented by 2017. The schedule and costs associated with each phase is summarized below.

Phases and Outfalls Addressed	Schedule	Cost
1. Modify CSO and sewers, separate combined areas, and conduct inspections and eliminate improper private connections (eliminate eight CSOs; modify five others).	1996	$ 1.5 million
2. Separate the Hawkeye sewershed (eliminate one CSO).	1998 to 2002	$13.3 million
3. Separate the Cascade CSS (eliminate two CSOs).	2003	$ 3.1 million
4. Separate the Locust, Harrison, and South sewersheds (eliminate one CSO).	2003 to 2007	$ 5.0 million
5. Separate the Angular sewershed (eliminate one CSO).	2008 to 2012	$ 4.9 million
6. Separate the Market sewershed (eliminate 012) (eliminate one CSO).	2013 to 2017	$ 7.3 million
Total Cost		**$35.1million**

Many of the Phase 1 controls were completed in 1996. Work on Phase 2, the Hawkeye Sewer Separation Project, began in early 1999. The Hawkeye Project has three parts and is expected to take five years to complete. Part 1 of the Hawkeye project includes studying the system (flow monitoring, manhole inspection, smoke testing, dyed water flooding, line cleaning and television inspection) to identify sewer capacities and proper sizing of sanitary trunk lines, and to identify sources of unknown inflow such as roof drain, back yard inlets, etc. Burlington used this opportunity to develop an innovative approach to sewer television inspection and reporting, where the information collected on the sewer system was delivered on digital video discs (DVD). A wide array of television inspection and existing information on the sewer system was merged into a common, detailed data base management system. This approach saved time in collecting, annotating, analyzing and reviewing information as well as providing permanent records with a design life of at least 100 years (Carhoff, 2000). These data are also being entered into a county-wide GIS that should be available in 2002.

Part 2 of the Hawkeye Project consists of separating storm water inlets. The city intends to implement a storm water management plan for each of the main trunks entering the Hawkeye sewer. Part 3 consists of installing sanitary trunk sewers into the Hawkeye trunk sewer to convey sanitary flow to the wastewater treatment plant. Storm water will be conveyed in the existing trunk sewer to local receiving waters.

After the Hawkeye Project is completed, the city will reevaluate the 20-year plan. Separation will continue to the maximum extent possible, and the city will consider using innovative end-of-pipe treatment technologies to address remaining overflows.

Costs, Financing and Results

Burlington used a mix of Community Development Block Grants, federal grants, and bonds to finance CSO control. Prior to the initiation of the Hawkeye project, the city spent more than $2.9 million to separate sewers within 464 acres of the service area and to eliminate five CSOs.

The Hawkeye Sewer Separation Project is a $13.3 million project, where 82 percent of the budget will fund sewer construction, 13 percent inspection and smoke testing, and the remaining 5 percent repairs to the trunk sewers. In 1998, the city was awarded a federal special infrastructure grant for $7 million. The city is providing the local cost-share through bond issuance and user fees. When complete, the Hawkeye Sewer Separation Project should eliminate 60 overflows per year and 1.5 mgd of CSO discharged to the Mississippi River.

The city is facing an additional $20.3 million cost to implement the remainder of the 20-year CSO Control Plan and is seeking a grant to support this completion. The 20-year implementation schedule and financing for the plan are both critical issues for Burlington. Many of the residents are on fixed incomes or earning low wages, and cannot afford increased sewer rates. Federal grant funding is therefore a key component of the city's LTCP.

References

Carhoff, Bob. 2000. "Computer Technology Improves Sewer TV Inspection and Reporting." *Public Works*, March, pp. 42-43.

City of Burlington, Iowa. 1993. *Report of Combined Sewer Overflows: Part 1*. City of Burlington, Burlington, IA.

City of Burlington, Iowa. 1995. *Report of Combined Sewer Overflows: Part 2*. City of Burlington, Burlington, IA.

Number of CSO Outfalls

408

Combined Sewer Service Area

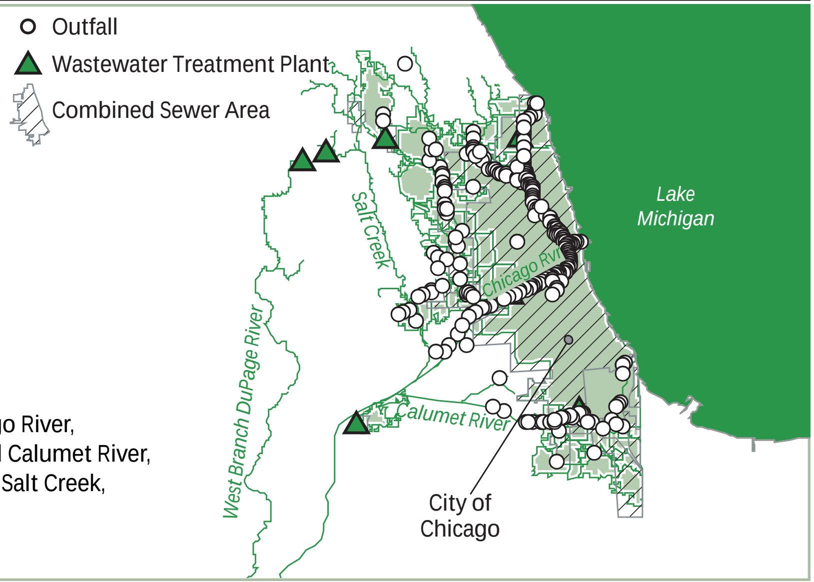
375 square miles

Wastewater Treatment Capacity

2,434 mgd (secondary)

Receiving Water(s)

Addison Creek, Calumet River, Calumet Sag Channel, Chicago River, Chicago Ship Channel, Des Plaines River, Flagg Creek, Grand Calumet River, Little Calumet River, North Shore Channel, Oak Lawn Creek, Salt Creek, San & Ship Canal, Weller's Creek



Controls

- Large diameter, deep rock tunnels are used to capture, convey, and store wet weather flows.
- Reservoirs are currently being constructed to provide flood control and additional CSO control benefits.

Photo: New deep rock tunnel, part of Chicago's extensive Tunnel and Reservoir Plan (TARP).
Courtesy of MWRDGC

Program Highlights

- Construction of CSO control projects began in 1975.
- As of 2000, 93% of all CSO outfalls have been intercepted by TARP.
- To date, TARP tunnels have captured and facilitated the treatment of more than 565 billion gallons of CSOs.

Background on Chicago CSOs

CSOs and CSO control are a complex regional issue in the greater Chicago metropolitan area where there are a total of 408 CSOs along 81 miles of waterways. The majority of the outfalls are regulated through NPDES permits issued to 52 municipal jurisdictions, including the City of Chicago. The Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) maintains regional treatment facilities and has responsibility for outfalls near the plants and along the interceptors. The MWRDGC combined sewer service area comprises 375 square miles and serves a population of over 3 million. It is estimated that there are over 5,000 miles of sewers within the combined sewer area. The rated treatment capacities of the seven MWRDGC water reclamation plants (WRPs) are:

WRP	Design Average Flow (mgd)	Design Maximum Flow (mgd)
Stickney	1,200	1,440
North Side	333	450
Calumet	354	430
Kirie	52	110
Egan	30	50
Hanover Park	12	22
Lemont	2	4
Total	**1,983**	**2,506**

Status of Implementation

MWRDGC is implementing a two-phased approach to address CSO and flood control known as the Tunnel and Reservoir Plan, or TARP. The construction of large diameter, deep rock tunnels for the storage of combined sewage is the centerpiece of TARP Phase I. The construction of reservoirs to primarily address flooding issues is the main component of TARP Phase II.

TARP Phase I is the MWRDGC's LTCP. TARP Phase I captures, conveys, and stores wet weather combined sewer flows in excess of interceptor capacity until they can be pumped out to existing WRPs for full advanced secondary treatment when plant capacity becomes available following storms. TARP Phase I consists of 109.4 miles of tunnels 9 to 33 feet in diameter, three tunnel dewatering pumping stations, over 250 drop shafts, and over 600 associated near-surface connecting and flow regulating structures. CSOs are intercepted at all outfalls. The system is designed to facilitate capture and treatment of the CSO first flush from all storms, and all of the CSO from the smaller, more frequent storms. This equates to a reduction of approximately 84 percent of the pollution load. Reservoirs being built under TARP Phase II are primarily intended for flood control and are not part of the LTCP, although they will provide additional CSO pollution control benefits.

TARP was developed through a joint effort of the State of Illinois, Cook County, the City of Chicago, and the MWRDGC. It represents a hybrid of the best eight of over 50 water management plans proposed and studied beginning in the mid-1960s. TARP has been designed to protect Lake Michigan and Chicago-area waterways from CSO pollution, and to significantly reduce local basement flooding. Officially adopted by the MWRDGC in 1972 with construction beginning in 1975, TARP was the first comprehensive Clean Water Act CSO control plan developed for a major metropolitan area.

The design for TARP is based on the presumption approach. The storage tunnels built under Phase I are designed to pick up all 408 CSOs within the service area, but were designed to work with the reservoir system, which is not yet complete. The result has been that when multiple storm events occur within a short period of time, the storage tunnels sometimes do not drain completely, producing short-term capacity reductions. Since the CSOs serve as CSS emergency relief points, TARP has cautioned all 52 member cities and villages not to disconnect their outfalls unless they feel confident their local sewer systems are adequate to handle wet weather flows without surcharging that may lead to street or basement flooding.

Approximately 75 TARP Phase I construction contracts have been completed, with only two remaining. As of September 2001, 93.4 miles of tunnel system were complete and in operation, 8.1 miles of tunnel were under construction, and 7.9 miles of tunnel were expected to be under construction by late 2001. Of the 2.3 billion gallons of CSO storage tunnel capacity, 2.1 billion gallons (92 percent) are online. Phase II, reservoir construction, is not as far advanced. A summary of TARP progress follows.

Tunnels and Related Facilities (Phase I)

System	Construction Costs	Miles Total	Miles Complete
Mainstream	$1,142	40.5	40.5
Calumet	$711	36.7	20.7
O'Hare	$64	6.6	6.6
Des Plaines	$469	25.6	25.6
Total	**$2,386**	**109.4**	**93.4**

Reservoirs (Phase II)

System	Construction Costs	Capacity Total (Billion Gallons)	Capacity Complete (Billion Gallons)
McCook	$521	10.5	0
Thornton	$105	4.8	0
O'Hare	$48	0.4	0.4
Total	**$674**	**15.7**	**0.4**

There are no dry weather overflows in the service area. The potential for dry weather flow is greatly reduced by a number of factors including:

- The inherent design of the sewer system.
- Infiltration and inflow (I/I) control programs implemented in separate sewer areas in local villages and cities upstream of the combined sewer area.
- MWRDGC 's sewer construction permit programs governing sewer connections tributary to its interceptors and treatment plants.
- MWRDGC's own O&M programs and sewer rehabilitation efforts on its 550-mile interceptor sewer system.

Costs and Financing

TARP Phase I construction progress has been continuous since beginning in 1975. Construction contracts totaling more than 2.2 billion dollars of the budgeted $2.4 billion have already been spent (91 percent). Annual O&M costs between1997 and 1999 averaged $8.1 million per year. The construction cost for the final TARP Phase I tunnel (the Little Calumet Leg Tunnel) is estimated to cost $160 million.

Early federal and state construction grants greatly reduced the MWRDGC's direct cost-share for the project. After cessation of the federal construction grants program, the MWRDGC committed itself to completing TARP exclusively utilizing its own funding resources. However, due to the large costs involved, funding availability has been the primary reason that construction has not progressed faster.

TARP's large scope, high implementation cost, and unique, untested nature has sparked hot debate and heavy news media coverage, including a segment on CBS' "60 Minutes". While evaluated as being the most cost-effective solution, TARP opponents offered alternatives they believed to be cheaper and as effective. Other solutions were proposed including smaller scale decentralized facilities, roof-top and street storage, park storage, sewer restrictions, relief sewers, downspout disconnection, and basement sewer backup prevention devices. All suggestions were evaluated, and it was found that none of the TARP alternatives would achieve the stated goals.

After $739 million in TARP construction contracts had been awarded (75 percent federally funded) in 1979, the United States General Accounting Office (GAO) issued a report, *Combined Sewer Flooding and Pollution—A National Problem: The Search for Solutions in Chicago* (GAO, 1979). This report analyzed TARP's cost versus it's objectives. A conclusion was in the form of a question: "Both phases of TARP and associated projects offer a promising solution to the (CSO) problem. But can the country afford it?" The GAO recommended ceasing further federal funding of TARP until a reassessment was made to see if less costly alternatives existed, and to consider adopting more flexible water quality goals for the waterways affected by CSOs. The MWRDGC and local political leadership vigorously objected to both recommendations and to GAO's estimate of TARP's cost, which was three to four times higher than the MWRDGC's estimated cost. More studies were conducted and TARP was reaffirmed as the most cost-effective alternative.

Water Quality Issues

MWRDGC conducts several water quality monitoring programs in the Chicago and Calumet waterway systems. Water quality samples are taken on a weekly basis for general chemistry and metals. In addition, dissolved oxygen monitoring is conducted on a continuous basis with in-place monitors. MWRDGC also conducts fish population surveys to track changes in the numbers of fish and fish species present in waterways. The results of these studies have documented dramatic improvement in water quality. MWRDGC believes that the completion of TARP Phase I (its LTCP) will result in compliance with the water quality standards.

By letter dated June 28, 1995, the State of Illinois Environmental Protection Agency concurred with the MWRDGC advising that "the Agency believes that the completion of TARP will be adequate to meet water quality standards and protect the designated used of the receiving waters pursuant to Section I.C of the CSO Control Policy.

Results

TARP tunnel fill levels and pumpout are measured to determine total CSO capture during storm events. Major portions of the TARP tunnel system were placed in operation beginning in the mid 1980s, with new segments coming on-line afterwards. To date, the 93.4 miles of completed TARP tunnels have captured and facilitated treatment of over 565 billion gallons of first and second flush combined sewage that would have otherwise spilled to local rivers and streams.

The frequency of CSO occurrences has decreased from nearly 100 times per year to less than 15 times per year.

Marked visible improvement in the condition of waterways has spurred recreational and other uses of the Chicago River including tourism and sightseeing, boating, canoeing, and fishing. Once perceived by many as a virtual open sewer, the river system has been cleaned up by TARP. This has brought about enhanced real estate values and booming riverside development, including hotels, office/apartment buildings, restaurants, riverwalks, marinas, and canoe/kayak launches. Fish, including various species of game fish, and other aquatic wildlife, have returned to the river system in dramatic numbers. The year 2000 Bassmaster Fishing Tournament was held in Chicago on its restored waterways.

TARP has received much recognition and numerous awards from government agencies and technical/professional organizations for its innovative and effective design and performance. The project has garnered favorable press from local media for its performance, and much local support from local villages and cities.

References

GAO, 1979. *Combined Sewer Flooding and Pollution—A National Problem: The Search for Solutions in Chicago,* CED 79-77. Washington, DC.

MWRDGC, 1998. *Report No. 98-23: Water Quality Improvements in the Chicago and Calumet Waterways Between 1975 and 1993 Associated with the Operation of Water Reclamation Plants, the Tunnel and Reservoir System, and Instream and Sidestream Aeration Stations*. Chicago, IL.

Community Case Study — Columbus, GA—Region 4

Number of CSO Outfalls

16

Combined Sewer Service Area

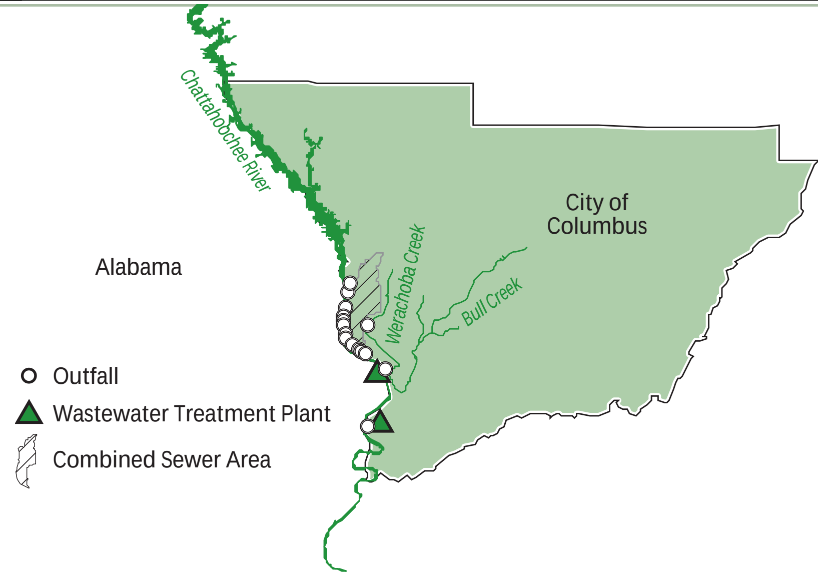
4.1 square miles

Wastewater Treatment Capacity

42 mgd (secondary)

Receiving Water(s)

Chattahoochee River



Controls

- Two water resources facilities (WRFs) provide direct treatment of CSOs. One WRF is a national demonstration facility used to evaluate alternative technologies to remove CSO contaminants and provide environmentally sensitive disinfection. Technologies evaluated include flow controls, screening, grit handling, vortex separation, compressed media filtration, UV disinfection, chlorination and dechlorination, and other disinfection methods. The other WRF provides CSO pumping, screening, vortex separation with chlorine disinfection, grit handling, and residuals disposal.

Vortex separation facility under construction.
Courtesy of Columbus Water Works.

- A strategically placed sanitary relief line is used to transport half of the sanitary sewage to the wastewater treatment plant, outside the bounds of the CSS.
- Remaining CSO discharges have been relocated downstream of public access areas.

Program Highlights

- Columbus' CSO program has been fully implemented. Compliance monitoring and performance testing continue.
- The Chattahoochee River now meets water quality standards for all criteria including bacteria.
- An extensive public education program involving numerous public hearings, news articles, water bill flyers, watershed workshops, and seminars was a key component of the development and implementation of the LTCP.

Background on Columbus, GA CSOs

The Columbus CSS extends over 2,600 acres of the old downtown area draining to the Chattahoochee River. Until controls were implemented, there were 5,200 acres of combined sewer with 16 CSO outfalls to the river. The average annual river flow is 6,500 cfs, with a flow of 3,500 cfs on average in summer and a regulated low flow of 1,160 cfs. Prior to CSO control, elevated levels of fecal coliform bacteria and visible sewage debris often plagued the Chattahoochee. Columbus began to implement CSO controls in 1995, including two water resources facilities (WRFs). One of the WRFs, in Uptown Park, also serves as a CSO technology testing facility.

Status of Implementation

The Columbus Water Works (CWW) has fully implemented an LTCP based on the demonstration approach of the CSO Control Policy. The LTCP was implemented by December 31, 1995, in compliance with Georgia State law. The Columbus program included characterization of the system and receiving water impacts, implementation of the NMC, pilot testing of alternative technologies, long-term planning, structural controls, and post-construction monitoring to demonstrate compliance with water quality standards.

Program development activities culminated in a $95 million capital program that included:

- Municipal treatment plant upgrades
- Sewer separation
- Diversion structure
- Collector and transport conduits
- Pumping stations
- Two CSO treatment facilities (WRFs)
- Associated river walk, trail and parks
- Five-year technology demonstration testing

The technology demonstration part of the program evaluated technologies for pollutant removal (including screening, vortex separation, filtration processes, flow controls) and several disinfection methods (including ultraviolet light, sodium hypochlorite, paracetic acid and chlorine dioxide). Sodium bisulfite dechlorination was also evaluated for dechlorination (Boner, 2001). Sewer separation was focused mainly in the upstream catchments where this type of solution made economic sense or had a high benefit-to-cost ratio. One strategically placed sanitary relief line eliminated half of the sanitary sewage that entered the CSS.

System Characterization

Columbus began its sampling program in 1990 and has continued the monitoring of area streams, rivers, and municipal infrastructure since then. From 1990 to 1993 the city conducted wet weather sampling of CSOs, streams, rivers and pilot facilities constructed to evaluate alternative CSO treatment technologies. CWW subsequently conducted two national demonstration programs to evaluate CSO controls. These programs included 38 monitoring stations on streams, river, and CSO control facilities including individual process components.

A wet weather monitoring program has been the focal point of Columbus' effort to understand wet weather pollution, its impact on the environment, and cost-effective means to control and reduce the problem. Watershed monitoring stations included flow measurement, automatic sampling and multi-parameter continuous-probe measurements. Analytical tests included *E. Coli* and fecal coliform bacteria, cryptosporidium and giardia, suspended solids and particle distribution, oxygen demands, nutrients and metals. Probe measurements included dissolved oxygen, turbidity, pH, temperature, and conductivity. Aquatic biology and habitat measurements in over 30 locations were monitored on a quarterly and/or biannual schedule to assess macroinvertebrates and fish populations over a two-year period. Monitoring was conducted to:

- Quantify CSO pollutant loadings
- Measure watershed health and impacts of wet weather pollution
- Determine performance of the various technologies tested

- Calibrate the EPA BASINS model
- Develop a framework for area TMDLs
- Show compliance with the CSO Control Policy for the controls implemented

Characterization findings show that all of these objectives were achieved, and that several protocols for monitoring and modeling have significant national benefit. The CWW monitoring, modeling and technology performance testing was peer reviewed by the Water Environment Research Foundation.

Nine Minimum Controls

In concert with the CSO Control Policy development, CWW evaluated the optimization of its system and organization together with its long-term planning to address NMC requirements. The NMC were identified for the Columbus system, implemented, and documented in a June 1995 report to the Georgia Department of Natural Resources - Environmental Protection Division, the NPDES permitting authority.

The system has been surveyed and hydraulically modeled, and there are no dry weather sewer overflows.

An extensive public education program involving public hearings, news articles, water bill flyers, watershed workshops, and university seminars has been conducted during the planning, implementation, and subsequent testing phases of the CWW CSO program. A continued program is being provided through CWW activities and support of organizations such as Leadership Columbus, the Oxbow Environmental Learning Center, Adopt-A-Stream, and River Kids.

Long Term Control Plan

Columbus developed its LTCP based on the demonstration approach of the CSO Control Policy. Demonstration requires that remaining CSOs after implementation of controls must not preclude the attainment of water quality standards or contribute to water quality impairment. In Columbus, this determination is made through a TMDL allocation process. Columbus was able to quantify pollutant contributions and link the source and the ability to attain water quality standards to water quality targets. This analysis led to a level of CSO control beyond which there is no "reasonable potential to cause or contribute to exceedances of water quality standards." The result was a post-construction Phase II CSO NPDES Permit that had no numeric limits other than "performance standards based on average design conditions and consistent with the facilities implemented and demonstrated." Columbus continues to monitor the receiving water and CSO effluent. The data are aggregated with the calibrated BASINS model output to demonstrate on a periodic basis (monthly if possible) that the source contributions and comparison with ambient monitoring data add to the database supporting the TMDL allocation process.

Costs and Financing

Funds for the initial assessment studies, design and early construction were obtained through revenue bonds. To obtain the necessary additional funds, the issue was taken to the public through a series of hearings, workshops and through other outreach vehicles. Incorporating the river walk and park amenities into the project played a key role in drawing public interest to the river and the need for water quality and human health protection. An environmental learning center supported by CWW was created through a partnership with the Columbus State University. The center has since become the focal point for community discussions on environmental resources and municipal infrastructure issues.

CWW furthered its public involvement by developing alternative financing methods including a special options sales tax (SPLOST), Ad Valorem tax, water and sewer rate increases, and a user fee approach. The SPLOST approach was put before public vote and won. The net result was that the facilities were paid in full shortly after the construction was completed. This reduced the potential water rate user costs by eliminating the long-term indebtedness and interest that normally accompanies municipal infrastructure projects.

Capital costs for the CSO program are delineated in the table below. The total capital expenditure of $95 million is based upon 1995 completed construction cost. Sewer separation costs amounted to $15,000 per acre. The municipal treatment cost component is not included in the $95 million CSO program because it serves other purposes in addition to CSO, but enables compliance with the NMC by maximizing flow to the wastewater treatment plant, or POTW.

CSO Program Element	1995 Construction Cost
Municipal Treatment	$8,500,000
Sewer Separation	$5,100,000
Transport Systems	$43,359,593
Uptown Park WRF	$22,711,160
South Commons WRF	$22,126,000
Technology Demonstrations	$1,736,000
Total	**$95,000,000**

The CWW has an annual CSO operating budget of $1 million which includes labor, power, chemicals, spare parts, materials and equipment replacement. Capital and operating costs by process for the Uptown Park WRF are shown in the tables below. The

CWW Annual Operations and Maintenance

CSO Control	O&M Cost	% of Total
Grit Handling	$104,880	48%
Dechlorination	$25,871	12%
Comp. Media Filtration	$21,400	10%
Chemical Disinfection	$19,174	9%
Vortex Separation	$16,320	7%
Trash Screening	$13,480	6%
UV Disinfection	$9,320	5%
Flow Controls	$8,400	3%
Total O&M	**$218,846**	

major capital costs are in the structural components. The dominant operating costs are associated with grit handling and removal.

CWW Capital Costs

CSO Control	Capital Cost	% of Total
Vortex Separation	$4.8 million	40%
Trash Screening	$2.4 million	20%
Comp. Media Filtration	$1.2 million	10%
UV Disinfection	$1.2 million	10%
Flow Controls	$1.2 million	10%
Grit Handling	$0.7 million	6%
Dechlorination	$0.2 million	2%
Chemical Disinfection	$0.2 million	2%
Total Capital Cost	**$12.0 million**	

Water Quality Issues

Water quality and beneficial use improvements have been the direct result of the CSO control program in Columbus. The Chattahoochee River now meets water quality standards for all criteria including bacteria. The river, especially in the downtown area and location of the CSOs, is aesthetically free of trash, oil and grease and other sewage debris. The old CSO outfalls are no longer visible.

Enforcement Issues

Georgia Law enacted in 1990, and amended in 1991, required five CSO cities in the state to eliminate or control their CSO problem to meet water quality standards by December 31, 1995. The CWW was placed under a CSO NPDES Permit, issued March 31, 1992, and accompanied by an Administrative Order requiring implementation of planning, design and construction of control facilities. The permit also required regular monitoring and reporting of discharges from the existing CSOs. CWW completed all requirements of this permit and Order ahead of schedule.

In 1997 and 1998, the NPDES permit renewal was negotiated with the benefit of having two years of operational and monitoring data of the CSOs, the river, and a start of a calibrated EPA BASINS model of the urban watershed. The negotiated CSO permit is considered a post-Phase II permit with regard to the CSO Control Policy. The permit requires that the facilities be operated in accordance with the demonstrated CSO program. The permit requires monitoring of the facility discharges and receiving water. The results are reported in a mass balance spreadsheet that allows the comparison of the accumulated source contributions and the downstream measurements.

Results

The Columbus CSO program is fully implemented. Compliance monitoring and performance testing continues. Columbus has plans to implement an integrated real-time monitoring network that will collect and manage the data for compliance reporting, measure watershed restoration progress, and provide early warning of watershed disturbances for drinking water protection. The monitoring network will include urban area creeks and river, CSOs and treatment plants. Watershed characterization data including near real-time displays will be available to the public via the internet.

Performance testing at the Uptown Park WRF has generated the data necessary to evaluate combinations of the technologies tested. The alternative evaluation process considered the annual distribution of rainfall and runoff events such that annual yields (quantity per acre per year) and the reduction in yield can be assessed versus the cost for the treatment scenario. The costs and benefits for different treatment levels provided by technologies demonstrated in Columbus were also evaluated. For example, the capital cost per pound of total suspended solids removal increased from $27 per pound at the 63 percent removal rate to $63 per pound at the 80 percent removal rate.

A new bromine-based chemical is being tested with potential for higher treatment rate capabilities with minimal residuals. This technology evaluation is being undertaken through a collaboration of the Georgia Institute of Technology, the chemical manufacturer, and CWW. It is anticipated that other partnerships will be generated to evaluate various CSO technologies at the Uptown Park WRF.

The primary goal of the Columbus CSO control program was to reduce fecal coliform bacteria to levels meeting water quality standards in the Chattahoochee River. Watershed measurements and a TMDL formulation were required to make this determination. Area watersheds were monitored over a three-year period and the BASINS model was calibrated from the measured data. The results of this evaluation show that the CSOs do not cause or contribute to water quality standards violations. As shown in the table at right, the fecal coliform removal rate was extremely successful, but other pollutants of concern were also significantly reduced.

Pollutant	Removal as % of Annual Load
BOD	55—61%
TSS	52—62%
Fecal coliform	95—99%
Copper	66—75%
Lead	62—83%
Zinc	62—82%

The 30-day geometric mean fecal coliform represents all contributing sources and is well within the summer and winter water quality criteria of 500 and 1,000 colonies per 100 ml. The maximum daily standard of 4,000 colonies per 100 ml was exceeded periodically (a few days within a two-year period), but was attributed to urban and suburban streams that discharge to the river. Remaining bacteria attributable to CSO after treatment is a small fraction of that contributed by the urban and rural watersheds.

The next challenge for the area is to implement management strategies that will focus on urban watershed protection including area drinking water supplies. In accomplishing these goals, policies and ordinances will be developed and watershed technologies will be demonstrated. Ultimately site-specific criteria defining water body use and protective measures will be developed. The regional and local partnerships and the environmental education network established by CWW will continue to be the focal point of these efforts.

Most of the future needs for Columbus will be associated with storm water controls. The costs of urban watershed management could be very large and demand a sound-science approach to test alternative technology. Columbus has initiated several projects to evaluate wet weather control strategies in which performance results will be applied on a broader basis to quantify costs and benefits of watershed restoration.

Citations

Boner, Mark. Wet Weather Engineering and Technology (WWETCO), Columbus, GA. Personal communication with Limno-Tech, Inc. staff on details of the combined sewer overflow plan and program. Summer 2001.

Community Case Study — Louisville, KY—Region 4

Number of CSO Outfalls

115

Combined Sewer Service Area

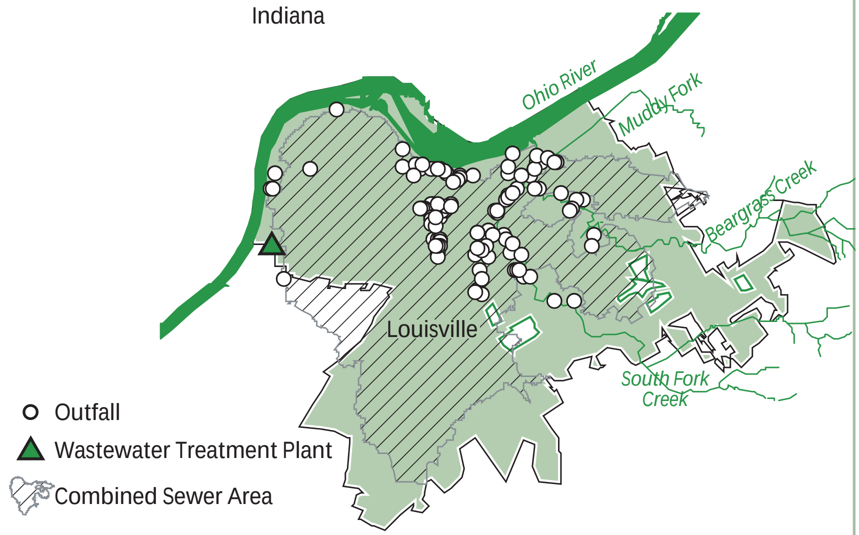
375 square miles

Wastewater Treatment Capacity

250 mgd (primary)
140 mgd (secondary)

Receiving Water(s)

Ohio River



Controls

- The Louisville and Jefferson County Metropolitan Sewer District (LJCMSD) has initiated in-line storage projects, separation projects, storage basin projects, and pilot CSO treatment projects.
- LJCMSD is currently working to expand wet weather capacity at its treatment plant by 40 percent, from 250 to 350 mgd.

Photo: Inflatable dam at the Sneads Branch CSO.
Courtesy of LJCMSD

Program Highlights

- Five CSO outfalls have been eliminated.
- CSO frequency has been reduced by 27 percent and CSO volume has been reduced by 13 percent. This keeps 681 million gallons per year of combined sewage out of local receiving waters.
- LJCMSD's program to install backflow prevention devices in homes to eliminate sewer backups has been used as a national model.

Background on Louisville CSOs

The Louisville and Jefferson County Metropolitan Sewer District (LJCMSD) provides sewer service as well as storm water utility management to the Louisville, Kentucky community. The sewer customer base is just over 198,000 and has grown at a rate of 12 percent over the past five years. Sewer service is provided by a combination of separate sanitary sewers and combined sewers. The total length of sewers within the service area is over 3,000 miles including 680 miles of combined sewers built before 1995. The combined sewer service area is heavily urbanized and covers approximately 24,000 acres. There are currently a total of 115 CSO outfalls within the CSS.

Wastewater flow is treated at the Morris Forman Wastewater Treatment Plant (MFWTP). MFWTP is capable of providing full secondary treatment for up to 140 mgd and primary treatment for an additional 110 mgd during wet weather periods. A project is currently underway which will increase the wet weather primary treatment capacity from 250 mgd to 350 mgd.

Status of Implementation

Nine Minimum Controls

All of the NMC have been implemented, and LJCMSD provided NMC documentation to the State of Kentucky. Many of the NMC activities were being implemented by LJCMSD before the CSO Control Policy was issued in 1994.

LJCMSD established a maintenance program in the 1980s to focus on inspection and maintenance of CSO outfalls. Each CSO outfall is inspected on a set schedule. The frequency of the inspection ranges from daily to monthly depending on the particular outfall size, history of the discharge, and past maintenance problems. Dry weather overflows have essentially been eliminated through regular maintenance activity.

Regularly scheduled cleaning of over 25,000 storm water catch basins in the CSS result in the removal of over 600 tons/year of street debris and litter. This program reduces pollutant discharge from CSOs and prevents plugging and dry weather blockages in the sewer system.

For notification of overflows, LJCMSD located signs at each CSO outfall to inform the public of the outfall and the reason for the outfall. The public is asked to call LJCMSD customer service if a dry weather overflow is occurring. During extreme wet weather events, LJCMSD purchases time on local radio stations to inform the public to stay out of the streams for safety reasons. LJCMSD's website (www.msdlouky.org) has additional information about CSOs and water quality.

Long Term Control Plan

LJCMSD developed a flow-monitoring program in 1991 to characterize the CSS. Flow monitors were installed at 50 locations throughout the CSS. This information was used to develop and calibrate a SWMM model to simulate the combined system. Long-term quality samplers are located at 12 overflow locations. Permanent real-time flow monitors are in place in three locations and additional locations are planned as part of real-time control projects.

LJCMSD has developed an LTCP as required by their NPDES permit and has been implementing the plan within five-year increments for which the LJCMSD Board can commit funding. The plan is dynamic. It will continue to evolve and improve based upon new data (water quality impacts, land uses), new technology, and emerging regulations. The LTCP has been submitted to the State of Kentucky. LJCMSD is working to implement the LTCP, although it has not yet been approved by the state.

The LTCP is based upon a mixture of the presumption and demonstration approaches described in the CSO Control Policy. The combined sewer area in Louisville is divided into three regions. CSO controls in Region 1 are based on the presumption approach, and CSO controls in Regions 2 and 3 are based on the demonstration approach. Region 1 discharges to streams, which in turn discharge to the Ohio River; Regions 2 and 3 discharge directly to the Ohio River.

LJCMSD has prioritized activities outlined in its LTCP so that controls for overflows impacting sensitive areas are implemented first. One key effort has been to address overflows in the most upstream areas of Region 1 that are located in a public park. The location of these outfalls increases the risk of the public coming in contact with CSO discharges and therefore the control of these CSOs has been given a high priority.

Costs

To date, LJCMSD has spent an estimated $25 million in implementing its LTCP. Full implementation will cost an estimated $210 million; this projection will be affected by the availability of funding for CSO control and the complexity of completing projects in fully urbanized areas.

LJCMSD is using its resources as efficiently as possible to implement the high priority control identified in its LTCP. The specific control measures outlined in the LTCP are continually reviewed in light of changing technology, improved understanding of the system, and the performance of controls that have been implemented. It should also be noted that LJCMSD has numerous programs that result in water quality improvements. LJCMSD attempts to allocate resources based on a combination of regulatory requirements, customer needs, and water quality benefits.

Water Quality Issues

Based on extensive and ongoing watershed monitoring, LJCMSD believes that, because of the impacts of heavy urbanization, meeting current water quality standards in many local CSO receiving waters will be difficult. In fact, LJCMSD believes that when the LTCP is fully implemented, water quality standards will not be attained. For example, fecal coliform standards will still be exceeded about 30% of the time. Meeting current water quality standards will require an integrated effort that addresses not only CSO discharges, but also other point and non-point discharges (including storm water and sanitary sewer overflows). To help prioritize and address the many programs, LJCMSD is initiating a "Water Quality Tool" computer program that will work to predict the benefits of various projects in specific watersheds and compare them. This "Tool" is being developed by merging the computer models HSPF and SWMM.

Enforcement Issues

LJCMSD has been aggressively addressing CSOs to improve water quality through O&M efforts as well as capital projects. Dry weather overflows have been virtually eliminated. Various capital projects to eliminate overflows have been completed along with two pilot projects to treat CSO discharges. The State of Kentucky has chosen, for now, to address CSO issues through the permitting program rather than through enforcement. Therefore, to date, no communities in Kentucky have been issued enforcement actions related to the development and implementation of CSO controls, as described in the CSO Control Policy.

Results

A range of projects have been successfully implemented to date. LJCMSD has initiated in-line storage projects, separation projects, storage basin projects, and pilot CSO treatment projects. These pilot treatment projects are being reviewed by both Water Environment Research Foundation and NSF International.

In an effort to address one of the key issues of CSOs – human contact - LJCMSD has been installing backflow prevention devices in the basements of homes to eliminate sewer backup from surcharged combined sewers. This program has become a national model with 5,100 homes protected to date.

LJCMSD has developed a county-wide geographic information system (GIS) to catalogue and track all aspects of the sewer system (i.e., pipe length, pipe type, etc). Upgrades will include condition ratings and other sewer operation and maintenance information. Work order tracking for operation and maintenance activities has recently been implemented. These attributes are recorded and attached to the infrastructure assets within the GIS.

Visual representation of reductions in average CSO volume and frequency for LJCMSD Regions 1, 2, and 3 and a system-wide description of pollutant load reductions are provided in the accompanying graphs. These numbers reflect the effect of the system improvements and form the basis for measuring the achieved reductions in overflow volumes and frequencies for each region and the CSS as a whole.

Based on system improvements implemented between July 1993 and July 1999:

- Five CSOs have been eliminated through various projects, including separation.
- Average annual CSO volume has been reduced from 5,153 million gallons per year to 4,472 million gallons per year, a reduction of 681 million gallons per year, or 13 percent.
- The frequency of CSO discharges was reduced from 5,361 overflows per year to 3,898, representing an overall reduction of 27 percent.
- CSO loads of biological oxygen demand were decreased from 3.2 million pounds to 2.9 million pounds per year, an overall decrease of eight percent.
- CSO loads of total suspended solids were decreased from 7.2 million pounds to 6.5 million pounds per year, an overall decrease of 10 percent.

LTCP storage projects now under construction will provide further reductions in CSO frequency, volume, and pollutant loading. Based on a system assessment, LJCMSD has also begun implementation of a real-time control project that will result in additional reductions in the next five years.

References

AMSA, 1994. *Approaches to Combined Sewer Overflow Program Development: A CSO Assessment Report*. AMSA, Washington D.C. November 1994.

Community Case Study — MWRA, Boston, MA—Region 1

Number of CSO Outfalls

84 (originally)
63 (currently)

Combined Sewer Service Area

14 square miles

Sewer Service Area

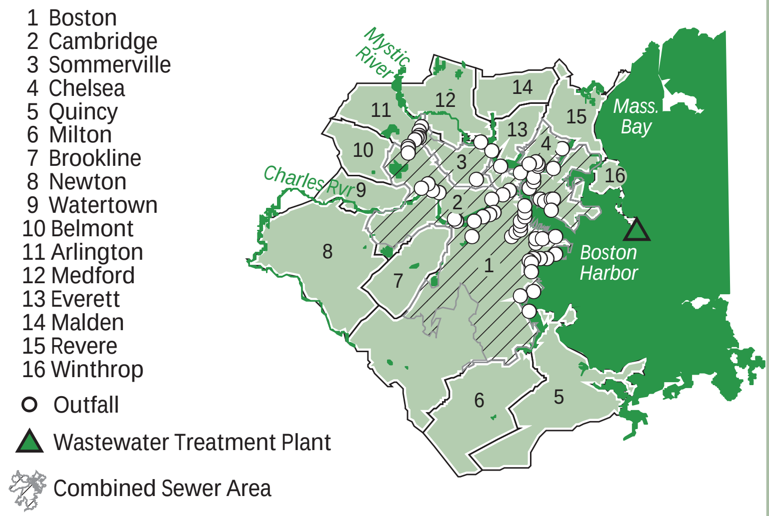
407 square miles

Wastewater Treatment Capacity

1,270 mgd (primary)
540 (secondary)

Receiving Water(s)

Charles River, Upper Mystic River, Alewife Brook



Controls

- The current expanded treatment plant capacity is 540 mgd of secondary treatment and 1,270 mgd of primary treatment.
- Five CSO treatment facilities provide screening, disinfection, and dechlorination for more than half of CSO discharges.
- A network of 70 temporary and 200 permanent flow meters was used to assess system function and develop a collection system model.

Photo: New dechlorination system at the Cottage Farm POTW.
Courtesy of MWRA.

Program Highlights

- 21of 84 CSO outfalls have been eliminated.
- 15 additional CSO outfalls will be eliminated when the CSO plan is fully implemented by 2008.
- It is estimated that CSO volume has been reduced from approximately 3,300 million gallons in 1988 to 850 million gallons in 2000.
- MWRA worked with the State of Massachusetts to collect data sufficient to support revision of water quality standards for segments of the Charles River and the Upper Mystic River and Alewife Brook.

Background on Boston CSOs

The Massachusetts Water Resource Authority (MWRA) provides wastewater services to 43 communities, including the City of Boston and the surrounding metropolitan area. It owns and maintains 228 miles of interceptor sewers that receive wastewater from 5,400 miles of municipal sewers at over 1,800 separate connections.

As a result of a civil judicial action initiated by EPA, MWRA was required to implement secondary treatment and CSO controls. MWRA's LTCP addresses 84 CSO outfalls permitted to MWRA or to the Boston Water and Sewer Commission, the City of Cambridge, the City of Chelsea or the City of Somerville (the "CSO communities"). Some of the outfalls have been closed through NMC and LTCP efforts completed to date. Flows at six of the outfalls presently receive screening, disinfection and dechlorination at five CSO treatment facilities owned and operated by MWRA. More than half of the CSO flow discharged to area waters passes through these five facilities.

MWRA's CSS area covers 14 square miles, with a service population of 550,000 people. The separate sewer service area is 393 square miles, with a service population of about two million people. All wastewater flow is conveyed to the new Deer Island Wastewater Treatment Plant, which was upgraded in 1999 to expand capacity and provide secondary treatment.

The Deer Island Wastewater Treatment Plant has an average dry weather design flow of 480 mgd. It currently treats an average dry day flow of 330 mgd and an average daily flow (dry and wet days) of 375 mgd. The plant has a primary treatment capacity of 1,270 mgd and a secondary treatment capacity of 540 mgd. Flows that exceed 540 mgd are bypassed around secondary treatment, blended with primary and secondary effluent, and discharged through MWRA's 9.5-mile ocean outfall.

Status of Implementation

In 1987, MWRA entered into a stipulation in the Federal Court Order in the Boston Harbor Case by which it assumed responsibility for development and implementation of an LTCP for its CSO outfalls, as well as outfalls owned and operated by its CSO communities. In December 1994, MWRA completed the Final CSO Conceptual Plan and System Master Plan (the "Conceptual Plan"), in which MWRA recommended short-term and long-term CSO control plans (MWRA, 1994). The LTCP was developed in the context of a system-wide master plan and in accordance with the new CSO Control Policy issued by EPA in April 1994. In addition to CSO control, the master planning process considered system improvement strategies that addressed transport capacity, treatment capacity, and infiltration/inflow removal.

The Conceptual Plan recommended more than 100 system optimization projects that could be implemented immediately at relatively low cost to maximize wet weather conveyance and in-system storage in the short-term. For the long-term, it recommended 28 wastewater system improvements covering a range of CSO control technologies that targeted site-specific CSO impacts and site-specific water quality goals.

In August 1997, MWRA completed the Final CSO Facilities Plan and Environmental Impact Report (the "Facilities Plan"), which carried the Conceptual Plan projects through facilities planning and state environmental review processes, resulting in some plan changes (MWRA, 1997). The Facilities Plan recommended 25 projects to control CSO discharges to 14 receiving water segments.

For each of the projects in the plan, design, and construction milestones have been incorporated into the Federal Court schedule. To date, seven of the 25 projects are complete, and an additional 11 projects are in construction. All projects are to be completed by November 2008.

System Characterization

The key performance measures used by MWRA in developing the plan and monitoring achievement of plan goals are frequency and volume of CSO "in a typical rainfall year". The typical rainfall year was developed by MWRA using 40 years of rainfall records and approved by EPA. MWRA conducted a metering and modeling program in 1992-1993 to support development of the LTCP. Meters were installed at more than 70 CSO outfall locations for a period of at least several months. MWRA also utilized data from more than 200 permanent flow meters it maintains throughout its collection system. MWRA conducts receiving water and sediment sampling to track water quality trends, including fecal coliform, enterococci, anthropogenic viruses and bacteriophage, chlorophyll, nutrients, DO, clarity, toxic contaminants and other parameters.

To meet long-term NPDES monitoring requirements, MWRA is evaluating hydraulic models and will select and build an appropriate model for future applications to assess system and facility optimization. When it becomes available, the new model will be used to estimate CSO discharges for NPDES reporting purposes and to assess system performance as MWRA continues to implement the LTCP. Along with this new hydraulic model, the MWRA will implement permanent meters located in the collection pipes and at each of the CSO facilities, headworks and pumping stations. Temporary meters will be installed at or just upstream of CSO outfalls. Installation and collection of data from temporary meters will be scheduled on a rotating subsystem basis, with preference given to those outfalls for which the information is most critical (e.g., where a CSO control project has been completed and performance verification is desired). At CSO treatment facilities, the NPDES permit requires sampling and monitoring activities, and MWRA performs additional sampling and monitoring for routine operational control purposes. MWRA's NPDES permit includes limits on bacteria, residual chlorine, toxicity and pH at CSO treatment facilities.

NMC

MWRA submitted its NMC compliance documentation on December 31, 1996. Dry weather overflows caused by capacity problems or other structural conditions were eliminated in the early 1990's through a series of fast-track CSO projects. Control of dry weather overflows is now managed through field operations efforts, including frequent system inspections and routine and as-needed maintenance, to remove obstructions.

Public notification is provided through the posting of signs at every CSO outfall, and through a flagging system at beaches and in other high-use recreational areas, such as the Charles River.

LTCP

MWRA's LTCP was developed using the demonstration approach. This included utilization of a watershed-based analysis to consider CSO and non-CSO sources and the potential for attainment of water quality standards in each of 14 receiving water segments in or as a tributary to Boston Harbor or Dorchester Bay. The contribution of CSO discharges to water quality degradation was evaluated in detail, and a baseline water quality assessment was performed in 1993-1994. The 1997 Facilities Plan became the primary source of information for a use attainability analysis (UAA) that was prepared by the Massachusetts Department of Environmental Protection (DEP) to support its approval of the CSO plan, including review and revision of water quality standards.

The CSO plan proposes elimination of CSO discharges to critical use areas (i.e. beaches and shellfish areas), significant reduction or treatment of discharges to less sensitive waters, and means to control floatable materials where CSO discharges will remain. All 25 projects in MWRA's LTCP were approved by EPA and DEP in 1997-1998, and are included in the Federal Court Order in the Boston Harbor Case, with detailed design and construction milestones. However, MWRA is reevaluating several projects, which may result in significant project changes that will have to be approved. In addition, the level of CSO control for the Charles River and for the Upper Mystic River/Alewife Brook is under review, pursuant to water quality standards variances issued by DEP. Final water quality standards determinations are expected to be made at the end of the variance periods (currently October 2001 and March 2002).

As of May 2001, CSO discharges have been eliminated at 21 of the 84 outfalls. An additional 15 outfalls are scheduled to be closed to CSO discharges by 2008, when the CSO plan is fully implemented.

Costs

The capital cost for design and construction to implement the LTCP is estimated to be $548 million (in 2001 dollars). Approximately $110 million has been spent. Annual O&M cost for the CSS is estimated to be $2 million per year.

Water Quality Issues

Implementation of the NMC has resulted in the elimination of dry weather overflows and a significant reduction in CSO discharges. The CSO reductions to date are primarily due to capital-intensive programs to increase conveyance capacity to the new Deer Island Treatment Plant, and to CSO system optimization plans that maximized in-system storage through weir raising and tide gate repair/replacement. Receiving water sampling programs show steady water quality improvement over the past decade.

Completion of MWRA's LTCP is intended to bring CSO discharges into compliance with water quality standards. Final decisions on what those standards should be for the Charles River, Alewife Brook and Upper Mystic River will not be made until additional water quality information is collected and evaluated by MWRA and the DEP, pursuant to conditions in the water quality standards variances. In all receiving water segments, water quality standards may at times continue to be violated due to non-CSO sources (e.g., storm water) following full implementation of CSO controls in the LTCP.

Enforcement Issues

Development and implementation of the LTCP are subject to detailed schedule milestones in the Federal Court Order in the Boston Harbor Case. MWRA's recently renewed NPDES permit (Phase I CSO) also requires implementation of the plan. Phase II CSO requirements are expected to be added to the permit soon, and will require CSO discharges to meet the Facilities Plan CSO activation frequency and volume predictions, as the CSO plan is implemented.

Results and Accomplishments

MWRA estimates that total annual volume of CSO discharge has been reduced from about 3.3 billion gallons in 1988 to about 850 million gallons today, primarily through improvements to its Deer Island Treatment Plant and transport system. Seven of the 25 CSO construction projects that make up the LTCP are complete, and 11 more are in construction. Full implementation of the LTCP is predicted to further reduce discharges to about 400 million gallons, with approximately 95% of the remaining CSO flows receiving screening, disinfection and dechlorination.

In addition to closing 21 of the 84 outfalls to date, MWRA has virtually eliminated residual chlorine in chlorinated effluent from its CSO treatment facilities, which process more than half of the approximately 850 million gallons of CSO presently discharged to metropolitan Boston waters in a typical year.

References

Kubiak, David, Massachusetts Water Resource Authority, Boston,MA. Personal communication with Limno-Tech, Inc. staff on details of the combined sewer overflow plan and program. Summer 2001.

MWRA, 1994. Final CSO Conceptual Plan and System Master Plan. Boston, MA.

MWRA, 1997. Final CSO Facilities Plan and Environmental Impact Report. Boston, MA.

Community Case Study

Muncie, IN—Region 5

Number of CSO Outfalls

30 (originally)
24 (currently)

Combined Sewer Service Area

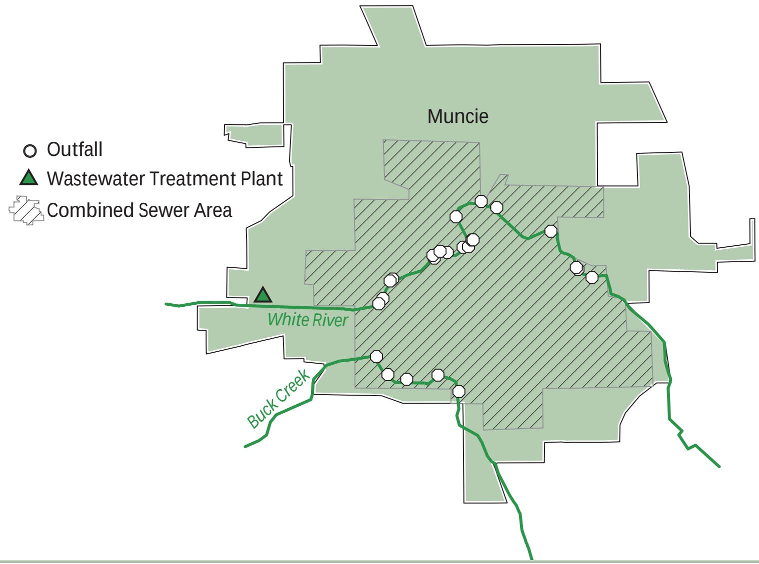
10.2 square miles

Wastewater Treatment Capacity

27 mgd (tertiary)

Receiving Water(s)

White River, Buck Creek



Controls

- Muncie's CSO abatement efforts have focused on sewer separation and treatment plant upgrades.
- Better O&M practices (e.g., sewer flushing and street sweeping) have improved system performance during wet weather.
- The presumption approach was used as the basis for development of the LTCP scheduled to be submitted to the state by November 2001.
- A SWMM model was used in system characterization and to evaluate the collection system/controls.

Photo: The White River, one of Muncie's two CSO receiving waters.
Courtesy of Nathan Bilger

Program Highlights

- CSO outfalls have been reduced from 30 to 24.
- Muncie has implemented the NMC.
- Muncie is working on a Use Attainability Analysis (UAA) to request a temporary suspension of designated uses during wet weather.
- Muncie recently completed a $5 million sewer separation projects in response to a 1985 enforcement action.

Background on Muncie CSOs

The Muncie Sanitary District (MSD) provides sewer service to the City of Muncie, Indiana and to a number of developments outside the city. The Muncie Water Pollution Control Facility (WPCF) has a capacity of 27 mgd (Huyck, 2001). It is anticipated that the MSD service area will continue to grow. Two newly developed sewer systems in surrounding areas are expected to eventually discharge to the WPCF.

Status of Implementation

MSD prepared a Stream Reach Characterization & Evaluation Report (SRCER) in 1999 to meet a requirement of its NPDES permit (Amlin, 1999). The SRCER details the impacts of CSOs on the White River. MSD used a SWMM model to facilitate SRCER development and to evaluate its combined sewer system. Total inflow to the collection system, average annual pollutant loadings, and average annual discharge loadings were calculated from the SWMM model simulations. The SRCER also includes proposed controls for CSO abatement. SRCER recommendations were considered in the development of Muncie's LTCP, described below.

Nine Minimum Controls

MSD has implemented the NMC as described in EPA's 1994 CSO Control Policy. A CSO Operational Plan, required by the state, serves as a reporting mechanism for eight of the nine minimum controls. MSD Operational Plan was approved March 24, 2001. The SRCER, also required by the state, fulfils the monitoring requirement of the ninth minimum control.

MSD has collected water quality and biotic data from affected areas of the White River through baseline studies for the past 26 years. Results of the baseline studies are presented in the SRCER. While the data show dramatic improvement in the water quality in the White River through Muncie, as measured by both chemical and biological indices, improvements are not only due to CSO abatement efforts. Improvements in water quality likely reflect the composite of pollution abatement programs, including CSO control efforts, sewer cleaning, street sweeping, and public education. Currently, MSD is enumerating *E. coli* populations, on a weekly basis, above and below the MSD CSO outfalls known to potentially affect the water quality of the West Fork of the White River.

MSD has not experienced dry weather overflows. As part of its maintenance program, MSD has recently purchased two new jet-vactor trucks and one new street sweeper. Two sweepers are used five days per week, weather permitting. The jet-vactor trucks clean sewers and manholes on a continuous basis, five days per week.

MSD public notification activities include public meetings and sign placement near the CSO outfalls. Recently, MSD and the Citizen's CSO Advisory Committee held two meetings regarding the LTCP. MSD has prepared warning signs to be placed at selected CSO outfalls to warn citizens about possible health hazards as a result of CSO discharges. The signs direct observers to call MSD if they witness dry weather overflows. Brochures describing the LTCP have been prepared, and MSD plans to distribute them when the LTCP has been finalized. In addition, MSD plans to use its web site to explain CSOs and intends to develop a video for public information and education.

To date, sewer separation and treatment plant upgrades have been important components of MSD's CSO abatement efforts. In addition, MSD has improved the operation of the existing combined system with more extensive O&M practices (e.g., street sweeping and sewer cleaning).

Long Term Control Plan

MSD is using the presumption approach in developing its LTCP. Under the terms and conditions of its NPDES permit, MSD must submit an LTCP by November 2001. As stated above, information obtained from SRCER and SWMM model is being used to develop the city's LTCP. MSD is currently in the process of selecting the CSO abatement alternatives for its LTCP.

Muncie's draft LTCP gives priority to eliminating discharges to sensitive areas. Public input is also an important component of the LTCP and is required by EPA and Indiana Department of Environmental Management (IDEM). A subcommittee of the Muncie Citizens CSO Advisory Committee has been established to determine those areas along the White River considered to be the most sensitive (e.g., parks, schools, and places of public use). CSOs that discharge to sensitive areas will be eliminated, relocated, or treated.

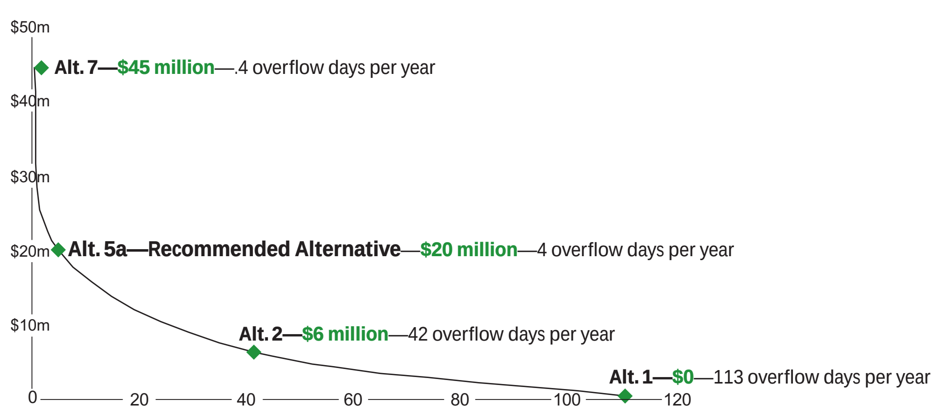
Costs and Financing

MSD has spent over $5 million on sewer separation over the past 10 years. Currently, MSD is spending $15.5 million for improvement and renovations to its WPCF to provide better treatment of sewage and combined sewage. Upon approval of the LTCP by IDEM, additional funds will be appropriated for improvements to the WPCF, the conveyance system, and storage facilities. MSD has spent in excess of $200,000 in engineering fees for SWMM modeling, and $550,000 has been spent for two new jet-vactor trucks and a new street sweeper. MSD spends approximately $340,000 per year to keep the jet-vactor trucks and street sweepers operating continuously five days per week.

MSD is currently in the process of selecting cost-effective CSO abatement alternatives for its LTCP. Eight CSO control alternatives under consideration are described in the table below. The impact of local sewage rate increases are considered by MSD when evaluating alternatives and implementation schedule. MSD is working on the financial capability assessment that is required by IDEM when scheduling CSO control projects. The State Revolving Loan program is an important funding source for CSO control projects.

Alternative (MG/year)	CSO Volume (lbs/year)	CBOD Load Days/Year	Overflow	Cost	Description of Alternative
1	434	78,328	113	$0	"No Action"
2	358	64,621	42	$6,755,000	In-system storage
3	188	56,571	42	$22,176,000	Partial sewer separation
4	286	52,524	113	$6,027,000	Increased pumping and WPCF primary treatment
5	41	6,315	42	$15,687,000	25 MG storage basin, increased pumping, WPCF treatment, and in-system storage
5a	27	5,173	4	$19,815,000	25 MG storage basin, increased pumping, in-system storage, and separation at CSO 28
6	40	3,743	29	$31,108,000	25 MG storage basin, increased pumping, WPCT treatment, in-system storage, and partial sewer separation
7	0	0	0.4	$45,410,400	Complete sewer separation

An evaluation of modeling results and monitoring data indicates that the presumptive criteria for the LTCP can be met through the implementation of Alternative 5a at a cost of $19.8 million (in 2000 dollars). Alternative 5a involves a combination of CSO controls including a 25 million gallon storage basin, increased pumping and WPCF treatment, in-system storage, and sewer separation. It is the most cost-effective solution for the MSD CSO control plan, as shown on the "knee-of-the-curve" graph below.



Affordability constraints make the elimination of all CSOs (e.g., Alternative 7) unfeasible. Elimination of all CSOs is estimated to cost $45-65 million. IDEM has not approved any of the CSO abatement alternatives considered by MSD for its LTCP, including Alternative 5a. MSD is scheduled to submit its LTCP in November 2001 for state review.

One of the greatest needs for MSD is the replacement of some of the sewer infrastructure. Many of the sewers are approaching 100 years in age and need to be replaced or restored. For example, the main interceptor from the downtown area to the WPCF is 100 years old. It needs to be completely lined and structurally repaired. The preliminary estimate for this repair work is approximately $2 million, and is included in the cost-effective alternative for CSO reduction.

Water Quality Issues

MSD believes that the implementation of the NMC has reduced the frequency and duration of overflows over the past several years, primarily through sewer cleaning activities. However, data is not available to document the reductions.

The MSD stream monitoring program has found that non-CSO sources of pollution greatly affect the White River. Consequently, MSD believes that compliance with existing water quality standards will not be achieved even if all CSOs are eliminated. MSD is working on an IDEM required Use Attainability Analysis (UAA) to support a request for a temporary suspension of designated uses during wet weather.

Enforcement Issues

In 1985, IDEM issued an Agreed Order to MSD as a result of a fish kill in the White River, attributed to pollutant levels from a "first flush" of the CSOs. The $5 million sewer separation project, mentioned above, was completed as a result of the Agreed Order. Since 1985, no fish kills attributable to MSD CSO discharges have occurred.

Results

MSD has spent $5 million on sewer separation projects. MSD has also improved O&M practices within the collection system (e.g., street sweeping five days per week). In addition, upgrades are being made to the WPCF to increase the treatment efficiency at the plant. MSD has eliminated six CSOs to date.

MSD applied a SWMM model to evaluate its collection system and to investigate impacts of its CSOs on the White River. A SRCER was produced to document model findings, describe monitoring efforts in the White River, and present recommendations for future CSO abatement efforts. MSD is currently in the process of developing its LTCP, and the SRCER has been instrumental in this process. The ultimate goals of the MSD LTCP are as follows:

- Capture "first flush" of the CSOs.
- Remove solids and floatables.
- Decrease bacterial levels.
- Reduce discharges to the minimum level affordable.
- Eliminate CSOs to sensitive areas.

References

Amlin, Eugene P.E., 1999. *Stream Reach and Characterization and Evaluation Report*. Muncie, IN.

Huyck, Richard, Director, Bureau of Water Quality, Muncie Sanitary District. Personal communication with Limno-Tech,Inc. staff on details of CSO system and CSO control planning in Muncie, and review of case study. Spring/Summer 2001.

Community Case Study North Bergen, NJ—Region 2

Number of CSO Outfalls

10

Combined Sewer Service Area

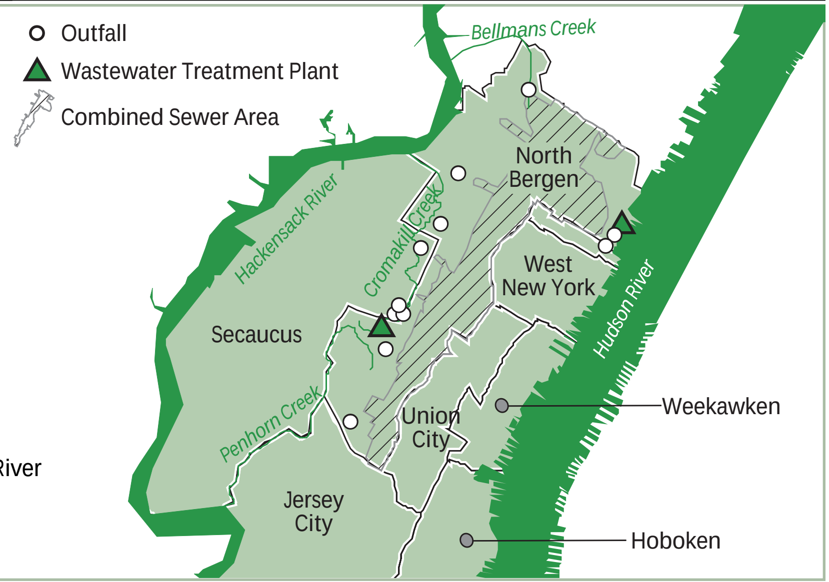
1.8 square miles

Wastewater Treatment Capacity

10 mgd

Receiving Water(s)

Bellmans Creek, Penhorn Creek, Cromakill Creek, Hudson River



Controls

- The minimum controls required by the New Jersey Department of Environmental Protection (NJDEP) permit have been implemented.
- Solids and floatables control has been installed at all CSO outfalls.
- Netting technology is used at most outfalls to control floatables. There are two end-of pipe chambers, three in-line chambers, two floating trash traps, and one manually-cleaned bar rack.

Photo: Solids and floatables controls, such as the nets pictured here, are installed at all North Bergen CSOs.
Courtesy of NJDEP

Program Highlights

- North Bergen has reduced the number of overflow points from 13 to 10.
- The solid and floatables control facilities have captured more than 68 tons of debris that would have been discharged to the Hudson River and various tributaries of the Hackensack River.
- Approximately 40 tons per year of solids are removed by in-line and end-of-pipe netting systems.

Background on North Bergen CSOs

The township of North Bergen, New Jersey has a population of approximately 48,000. North Bergen is served by a CSS that covers 1,130 acres. The North Bergen Municipal Utilities Authority (NBMUA) is responsible for all CSOs and control systems within the township. Two wastewater treatment plants service the township. The Central Treatment Plant services the West Side of North Bergen and lies within the Hackensack River drainage basin. The Woodcliff Treatment Plant services the East Side of North Bergen and lies within the Hudson River drainage basin.

There are currently 10 CSO outfalls in the North Bergen CSS that are regulated by 36 flow control chambers. Six of the flow control chambers have mechanical regulators which limit the flow to the interceptor by means of a sluice gate and a float mechanism. The other 30 chambers use static control devices such as weirs, baffles, or orifices to control flow to the interceptor and allow excess overflow to the CSO outfalls.

Status of Implementation

NBMUA's control plan has focused on solids and floatables control (Fischer, 2001). Solids and floatables controls have been installed at all CSO outfalls to capture half-inch in diameter and larger materials. Nine CSO outfall pipes have been retrofitted with netting technology, and one CSO outfall uses a stationary bar rack for floatables control. The start-up date for the entire CSO control system was December 17, 1999.

Other infrastructure improvements made by NBMUA as part of their efforts to control CSOs include installation of a new vortex valve regulator upstream of an existing pump station, and installation of a separate 48-inch combined sewer outfall pipe that eliminated the older systems which combined the plant outfall and the CSO.

System Characterization

NBMUA completed a *Combined Sewer Overflow Characterization Study* in 1997 (Killam, 1997). NBMUA plans to conduct additional flow and water quality monitoring as part of its CSO control plan. The monitoring information will be used to develop a SWMM/EXTRAN model of the CSS. The monitoring and modeling plan is currently under review by NJDEP.

Nine Minimum Controls

NBMUA has implemented the minimum controls required by their NPDES permit, including :

- Prohibition of dry weather overflows
- Solids and floatables control
- Development and implementation of proper operation and maintenance (O&M) programs
- Maximization of flow to the publicly owner treatment works (POTW)
- Public notification/reporting requirements

Long Term Control Plan

The control plan adopted by NBMUA focuses on the control of solids and floatables. Cost estimates have been computed for disinfection at outfalls that may be added at a future date. Full LTCP development is incorporated into the ongoing statewide watershed management and TMDL processes.

Costs and Financing

The $3.9 million solids and floatables project was funded through a low interest loan provided by the NJDEP and the New Jersey Environmental Infrastructure Trust (NJEIT). By using the NJDEP/NJEIT loan, the NBMUA saved the users of the system nearly $1.5 million compared to conventional financing. Cost estimates to add disinfection with ultraviolet lamps have been performed as part of the planning process. Disinfection at nine CSO outfalls is expected to cost approximately $24.2 million.

Budget tracking for CSO-related O&M has been set up, but sufficient data is not yet available to estimate annual O&M costs. O&M primarily consists of changing out the netting bags and disposing of the collected solids. Nets are changed out approximately once per month at each of the sites.

Enforcement Issues

In September 1993, NJDEP issued an Administrative Order citing NBMUA for failing to meet the CSO permit discharge requirements. In January 1996, NBMUA entered into an Administrative Consent Order to submit, among other things, an Interim/Final Solids and

Floatables Control Plan. The Interim/Final Solids and Floatables Control Plan was approved by NJDEP in July 1996 and involved reducing the number of CSO outlets from 13 to 10 and installing solids and floatables netting devices at each of the CSOs (EPA, 2001).

Results

Since installing the netting systems in 1999, the solid and floatables control facilities have captured more than 68 tons of debris that would have been deposited in the Hudson River and various tributaries of the Hackensack River. It is estimated that over 40 tons of solids will be removed per year through implementation of the Solids and Floatables Control Plan. The tracking of the debris captured is a measure that is well understood by the public.

Lack of historical operating information on the technology was a hurdle for this project. At the time of the planning study, netting technology in in-line chambers had not been installed or operated as a solid and floatable collection technique anywhere in the United States. NBMUA now has extensive experience operating solids and floatables control facilities and can provide other CSO communities with construction and operational information needed to make decisions utilizing netting technology for CSO solids and floatables control.

References

EPA, 2001. *Combined Sewer Overflows in Region 2: Audit Report of the Inspector General*. New York, NY.

Killam, 1977. *Combined Sewer Overflow Characterization Study*. Milburn, NJ.

Fischer, Robert, Executive Director, North Bergen Municipal Utilities Authority. Personal communication with Limno-Tech, Inc. staff on details of the combined sewer overflow plan and program. Summer 2001.

Community Case Study — Randolph, VT—Region 1

Number of CSO Outfalls

6 (originally)
3 (currently)

Combined Sewer Service Area

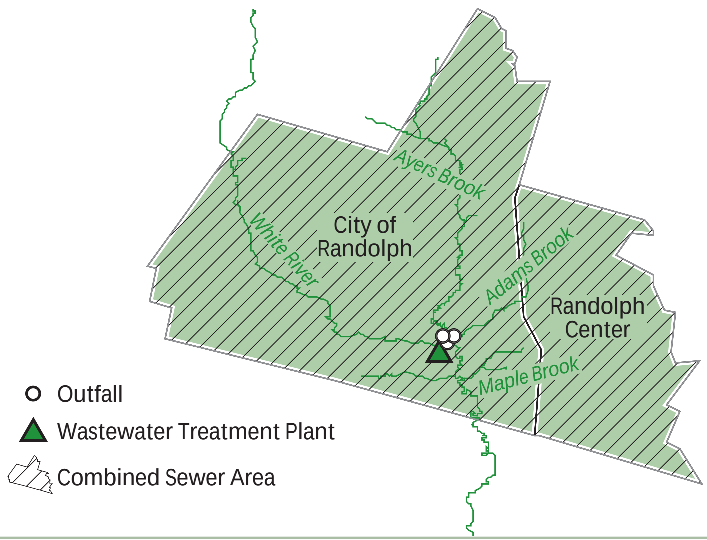
Undetermined

Wastewater Treatment Capacity

0.4 mgd (secondary)

Receiving Water(s)

White River



Controls

- Randolph has implemented the six minimum controls required in its NPDES permit.
- Sewer separation has been the principal CSO control implemented. Randolph has disconnected 44 of its 52 catch basins from the CSS.
- Randolph is planning to upgrade its wastewater treatment plant (WWTP) as part of the next phase of its CSO control efforts.

Photo: Three branches of the White River flow through Randolph. Gifford Bridge, shown, is located on the Second Branch.
Courtesy of Tom Hildreth

Program Highlights

- CSO outfalls have been reduced from six to three through sewer separation.
- Sewer separation has reduced the duration of overflows at the WWTP by 80 percent.
- The target date for completing implementation of CSO controls is 2006.
- A February 2001 Administrative Order requires Randolph to implement a sampling protocol and monitoring for its three remaining outfalls.

Background on Randolph CSOs

Randolph has a population of 2,270 and is located in the Green Mountains in central Vermont, approximately 27 miles from the state capital Montpelier. The exact size of the combined sewer system is small but undetermined, and centered in the older downtown area.

Status of Implementation

Randolph has completed sewer separation projects in three stages. The main CSO abatement project was completed in 1996, when 44 of 52 catch basins were separated from the collection system in the village area. New storm water collection systems were also constructed throughout much of downtown Randolph and adjacent residential areas at this time. More work was completed in 1997 and 1999 when an additional six catch basins were separated. At the present time, it is estimated that three catch basins remain connected to the sanitary system. No monitoring to assess the effectiveness of the work completed is available. At the direction of the State of Vermont, Randolph is undertaking an eight-month study to determine the effectiveness of CSO efforts implemented to date, and to determine if additional work may be required.

Nine Minimum Controls

The State of Vermont has not required CSO communities to implement all of the NMC as part of their NPDES permits. Nonetheless, on a community-specific basis, the state has required that systems employ a series of BMPs. As required by their permit Randolph has documented implementation of the following BMPs:

- Proper O&M programs for the sewer system and the CSOs
- Maximum use of the collection system for storage
- Maximization of flow to the POTW for treatment
- Prohibition of CSOs during dry weather
- Pollution prevention
- Monitoring

Long-Term Control Plan

The State of Vermont does not require CSO communities to submit formal documentation for its long-term CSO control plans. Instead, communities are required to submit engineering reports to outline their CSO abatement plan and funding needs. On February 3, 1993, Randolph submitted the final engineering report of the "Evaluation of Combined Sewer Overflows for Randolph" to the state. This report was approved on November 19, 1993. To date, sewer separation has been the principal focus of the town's abatement efforts to eliminate CSOs.

The State of Vermont uses a design storm approach to CSO elimination. In Vermont, communities that opted for sewer separation were required to be able to capture and provide full treatment for a minimum design flow generated by a 24-hour, 2.5 inch rainfall.

Randolph completed their initial control plan in November 1996. Upon further investigation, it was determined that the completed sewer separation projects were not fully successful in controlling CSOs. Bypasses still occurred at the WWTP during rain events. Further data was needed to evaluate the town's CSO abatement program, and to plan future abatement projects. The CSO control plan was reopened, and the target date for implementing the revised control plan is 2006.

Costs

Preliminary engineering and design work for Randolph's CSO abatement program took place between 1991 and 1994. This work was funded through a state planning advance program, and costs were approximately $0.25 million. As of 1997, approximately $2.66 million had been spent for Randolph's main CSO abatement program and development of its first LTCP. Funding was provided through state grants (25 percent), through state revolving loans (50 percent), and from Randolph (25 percent).

A capital plan has been proposed for the next stage of the CSO abatement program. Randolph requested wastewater revolving loan funds on August 8, 2000 to upgrade the WWTP and to address inflow and infiltration issues and other CSO control needs. The plan, which includes infrastructure repairs and sewer separation, spans six years (2001-2006), and has a projected cost of $1.12 million. Approximately $0.5 million is related to CSO control. The planned projects include sewer line replacement and upgrades, collapsed and failing manholes replacement and reconstruction, and continued sewer separation.

Enforcement Issues

Although Randolph has reduced CSOs events through sewer separation projects, overflows still occur. Randolph experienced 17 overflows at the WWTP in the year 2000. For this reason, the state issued an Administrative Order (1272 Order #3-1198) to Randolph, dated February 8, 2001. This Administrative Order requires Randolph to develop a CSO monitoring plan/sampling protocol for its three existing CSO outfalls (Kooiker, 2001).

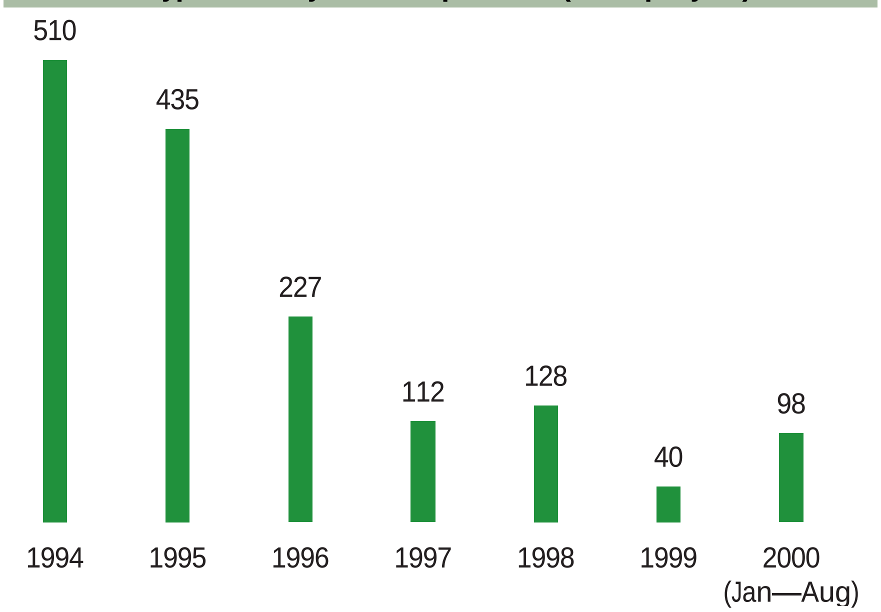
The Administrative Order requires Randolph to obtain composite samples of the combined discharge from the WWTP during eight CSO events between March 1 and September 30, 2001. The composite samples will be analyzed for biochemical oxygen demand, total suspended solids, and *E. coli.* to determine compliance with the permitted discharge effluent limits. The other two CSO outfalls are also being monitored for overflow events using "tattle-tale" blocks, or block testing. Blocks of wood will be placed inside the overflow or pump station lines. Movement of disappearance of a block following a precipitation event indicates that an overflow has occurred. A rain gage is being used to document the cumulative rainfall amount, rainfall intensity, and rainfall duration so that local precipitation events can be quantified and related to sewer system performance.

The data collected from implementation of this monitoring plan will provide guidance on remaining CSO control needs and help Randolph identify the best course of action for future CSO abatement efforts. A CSO abatement program effectiveness report will be submitted to the state (due September 30, 2001) to fulfill the requirements set forth in the Administrative Order.

Results

Three CSO outfalls have been eliminated since Randolph initiated its CSO abatement program. Only three known catch basins remain connected to the sanitary sewers as a result of Randolph's sewer separation efforts. An 80 percent reduction in the duration of CSOs has been observed at the WWTP. This reduction is based upon a comparison of data collected from a recent 20-month period (1/1999-8/2000) with data collected prior to the main CSO abatement project. Overflow (bypass) data at the Randolph WWTP are provided in the accompanying graph. (Note: 1999 was a very dry year and 2000 was a very wet year.)

Bypass History at Randolph WWTP (hours per year)



References

Town of Randolph, 1993. *Evaluation of Combined Sewer Overflows for the Town of Randolph*, submitted to the Vermont Agency of Natural Resources (ANR). Randolph, VT.

Kooiker, Brian, State of Vermont, Agency of Natural Resources, Department of Environmental Conservation, Wastewater Management Division. Personal communication. Spring/Summer 2001.

Community Case Study — Richmond, VA—Region 3

Number of CSO Outfalls

31, plus 1 diffuser port in the James River

Combined Sewer Service Area

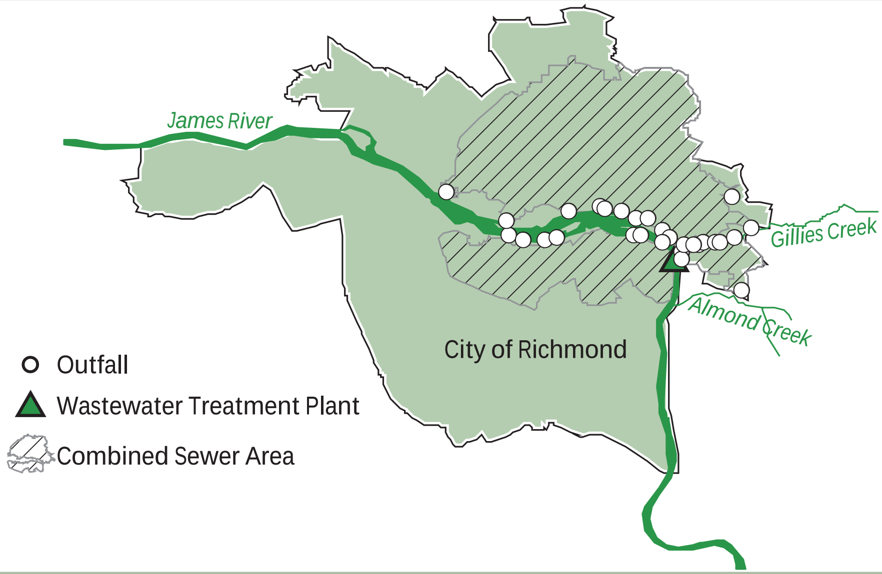
18.8 square miles

Wastewater Treatment Capacity

75 mgd (secondary)

Receiving Water(s)

James River, Gillies Creek



Controls

- Richmond has implemented the NMC and documents continued compliance in an annual report submitted to the Virginia Department of Environmental Quality (DEQ)
- Richmond utilizes a 50 million gallon retention facility to capture and store for later treatment wet weather flows from the city's largest drainage basin.
- Conveyance and retention facilities have been employed to relocate CSO discharges downstream of the Falls of the James, a well-known recreation area frequented by kayakers.

Photo: Construction of a 6.7 million gallon storage tunnel along the Falls of the James.
Courtesy of Richmond DPU

Background on Richmond CSOs

Richmond is the capital of Virginia and it is centrally located in the state. The population of Richmond is approximately 210,000, and the city spreads out over 38,000 acres. The CSS is owned and operated by the Department of Public Utilities (DPU), and it occupies 12,000 acres, or one-third of the city. The DPU also owns and operates a 75 mgd wastewater treatment plant (WWTP). The James River bisects the city and is the center of transportation and recreation activities. The Falls of the James area is an important recreational resource and a component of the Virginia scenic river system. It consists of sets of rapids and pools and adjacent parkland that provide substantial habitat and attract whitewater enthusiasts. There are 31 CSO outfalls within Richmond that discharge to the James River or local urban creeks. The Shockoe Creek CSO is the largest, with a drainage area of over 6,000 acres. It discharges to the tidal James River, just below the Falls of the James.

Richmond has been actively implementing CSO controls for over 20 years in a three-phase program. Phase I was completed in 1990 and Phase II will be completed in 2002.

Program Highlights

- Richmond submitted a Draft Long-Term CSO Control Plan Re-Evaluation in May 2001 to the DEQ.
- LTCP Phase I and II controls have reduced overflow volumes by 40 percent.
- LTCP Phase I and II controls provide an additional 131 days per year in which water quality in the James River meets water quality standards, beyond the "no CSO control" condition.
- Restoration of the city's historic canal system occurred as Phase II CSO interceptors were placed in an abandoned canal bed. Restoration of the canal was a centerpiece of a major downtown revitalization project.
- Sampling to support Phase III controls indicates that upstream bacteria loads will prevent attainment of water quality standards even if CSOs were completely eliminated.

The plan for Phase III was submitted to the Virginia DEQ as a Draft Long Term CSO Control Plan Re-Evaluation in May of 2001 (City of Richmond, 2001).

Status of Implementation

Richmond began addressing CSO problems back in the 1970s. Early studies including monitoring and modeling led to the Phase I program. Completed in 1990, the major components of Phase I were construction of the 50 million gallon Shockoe Retention Facility and expansion of WWTP capacity from 45 to 70 mgd.

Phase II controls were planned in the late 1980s and implemented in the 1990s. Phase II was focused on reducing CSO discharges to the Falls of the James. The major components of Phase II included expansion of conveyance facilities on the south side of the James River, expansion of conveyance facilities on the north side of the James River, and construction of a 6.7 million gallon storage tunnel on the north side (scheduled to commence operation in late 2001). Another aspect of Phase II was a requirement to re-evaluate the CSO control plan following implementation and develop a Phase III plan.

System Characterization

Richmond has engaged in characterization monitoring and modeling activities for nearly 20 years. Key activities include:

- Mapping the combined sewer are to characterize land use and surface features in each drainage area.
- Review of construction documents for collection system to determine sewer diameter, length, and slope.
- Implementation of collection system and receiving water monitoring programs.
- Development and application of collection system and receiving water models.

Nine Minimum Controls

Richmond has identified and implemented control measures under each of the NMC. Documentation was submitted to DEQ in December 1996 (City of Richmond, 1996) and has been followed by annual reports on continued compliance. Highlights of the NMC program include:

- Adjustment of CSO regulator controls to optimize storage in interceptor system.
- Formation of a 24-hour on-call team to respond to reported dry weather overflows.
- On-going public education programs, including offering advice on proper disposal of waste (e.g., household wastes, leaves, use of fertilizers).
- Continued use of BMPs to control pollutants from runoff.
- Installation of continuous flow monitors and wet weather overflow samplers at the Shockoe CSO to monitor frequency and volume, with annual reports provided to DEQ.

Long Term Control Plan

Richmond has been developing and refining its LTCP for over two decades. The continuing objective is to abate or eliminate the adverse impacts to the James River from CSOs through the use of innovative and low maintenance solutions.

Richmond developed a thorough characterization of its CSS through extensive inspections, monitoring and modeling. Monitoring programs have been implemented to quantify:

- Flow and pollutant concentrations at the Shockoe CSO outfall and other select outfalls within the CSS.
- Storage in the Shockoe Retention Facility.

- Water quality conditions in the James River above the CSO discharges, through the Falls of the James area, and along a 20-mile area below Richmond.

Richmond also developed computer models of the collection system and CSO-impacted waters for use in the analysis of CSS performance, receiving water impacts, and the evaluation of control alternatives. Monitoring data was used to calibrate and verify the models.

A full range of CSO control alternatives were evaluated as part of the LTCP development. This evaluation included:

- Sewer separation
- In-system storage
- Disinfection
- High-rate filtration
- Retention basins
- Swirl concentrators
- Sedimentation basins
- Screening
- Additional conveyance capacity
- BMPs and source control
- Expansion of the WWTP

The selection of a preferred plan for Phase III involved analysis of CSO volume and frequency, water quality, financial impacts, and public input. The preferred plan builds on projects completed under Phases I and II. The components of the plan for Phase III included:

- Expansion of the Shockoe Retention Facility
- Expansion of wet weather treatment capacity at the WWTP
- Disinfection at key outfalls
- Control of solids and floatables at remaining outfalls

Costs and Financing

Richmond has used a variety of funding sources including bonds, low-interest loans from the state, and federal grants to underwrite the cost of constructing, operating and maintaining CSO control facilities. To date, the city has spent nearly $221 million on capital improvements in the CSS and invests another $6.7 million annually on CSO-related operations and maintenance activities. The city estimates that implementation of the Phase III controls will cost an additional $242 million.

Water Quality Issues

The implementation of Phases I and II of the city's CSO control program have significantly improved aesthetics and water quality in the James River. Specifically, water quality modeling indicates that these controls provide an additional 131 days per year in which water quality in the James River meets water quality standards, beyond the no CSO control condition. Receiving water modeling results from the Phase III re-evaluation indicates that the upstream bacteria loads will prevent full attainment of the current water quality standards even if the city completely eliminates CSO discharges.

Enforcement Issues

Richmond signed a Special Order with the Virginia DEQ in 1985 that required the city to develop and implement a CSO control program. In 1992, the State Water Control Board issued a consent Special Order requiring implementation of additional controls identified in Phase II of the city's CSO program. Then, in 1996, the DEQ amended the Special Order to accelerate the north side CSO control projects. DEQ issued a consent Special Order to the City in 1999, which advanced the schedule for the re-evaluation of the CSO program in the context of EPA's CSO Control Policy. A draft plan describing the proposed Phase III controls was submitted to the state in May 2001. The city also submits annual detailed reports to the state to allow the state to monitor and verify compliance with the Order.

Results

Richmond has realized many benefits from its CSO control program. The city has reduced overflow volume to the James River by more than 40 percent, from 3 billion gallons per year to 1.8 billion gallons per year. Further, overflows to the sensitive park areas along the James River have been reduced to an average of one event per year. All of the overflows remaining in the park areas now receive local treatment to control solids and floatables prior to discharge to the river. In addition to storage, the Shockoe Retention Facility provides floatables control for more than two-thirds of all overflows.

Richmond's CSO projects have also provided tangential benefits including the restoration of the City's historic canal system as Phase II CSO interceptors were placed in the abandoned canal bed. The restored canal has become a focus for commercial and recreational activities.

Richmond's efforts to control CSOs were recognized in 1999 as the city received a National Combined Sewer Overflows Control Program Excellence Award from EPA. In addition, the Richmond CSO Control Program has received awards and recognition from local environmental and stakeholder groups and from users of the James River.

References

City of Richmond, Virginia. 1996. *Combined Sewer System Documentation Report on Nine Minimum Controls*. Submitted to Virginia Department of Environmental Quality, Richmond, VA.

City of Richmond, Virginia. 2001. *Draft Long-Term CSO Control Plan Re-evaluation*. Submitted to Virginia Department of Environmental Quality, Richmond, VA.

Number of CSO Outfalls

168

Combined Sewer Service Area

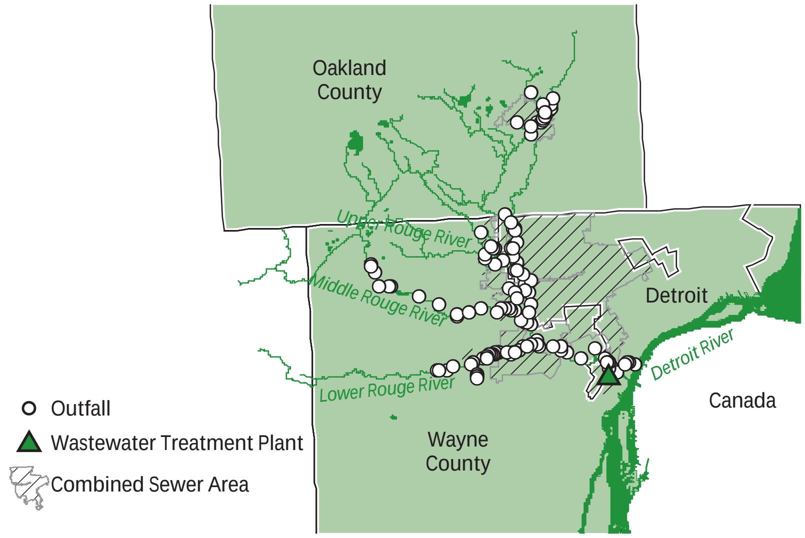
93 square miles

Wastewater Treatment Capacity

1,700 mgd (primary)
930 mgd (secondary)

Receiving Water(s)

Rouge River and tributaries



Controls

- CSO control activities in the Rouge River Watershed are focused on sewer separation and construction of local retention treatment basins.
- The NMC have been implemented for all uncontrolled CSOs for which the construction of permanent control facilities is not imminent.
- Under its NMC program the City of Detroit installed outfall control gates at seven CSOs to eliminate CSO discharges during small events.
- A total of 10 retention treatment basins and one tunnel represent the major new CSO facilities that are planned, under construction, or in operation.

Photo: Retention basin under construction in Dearborn, MI.
Courtesy of EPA

Background on Rouge River Watershed CSOs

The Rouge River Watershed occupies 438 square miles in southeastern Michigan. The south and east portions of the watershed are highly urbanized and include parts of Detroit and its suburbs. The Rouge River Watershed is home to approximately 1.5 million people spread across 48 communities and 3 counties. The Rouge River itself extends for more than 100 miles, with 50 miles flowing through accessible public parklands. The Rouge River discharges to the Detroit River and affects water quality conditions in that water body as well as Lake Erie. Congress appropriated money through EPA and Wayne County, Michigan in 1992 for the Rouge River National Wet Weather Demonstration Project (Rouge Project). The Rouge Project is a comprehensive program to manage wet weather pollution to restore the water quality of the Rouge River. This cooperative watershed management effort between federal, state and local agencies is supported by multi-year grants from the federal government with additional funding from local communities.

Program Highlights

- The Rouge River National Wet Weather Demonstration Project coordinates CSO implementation in 16 CSO communities in conjunction with other non-CSO restoration efforts on a watershed basis.
- About 30 miles of the Rouge River that were CSO-impacted in 1994 are now completely free of uncontrolled CSO discharges.
- The amount of combined sewage captured for treatment has increased due to construction of CSO retention treatment basins.
- Untreated overflows in excess of 50 times per year have been reduced to treated overflows occurring one to seven times per year where retention treatment basins have been implemented.
- Monitoring indicates improved dissolved oxygen conditions associated with the implementation of CSO controls in the Rouge River.

As of 1994, there were a total of 168 permitted CSOs discharging into the Rouge River and its tributaries. These outfalls, owned and operated by Wayne County, the City of Detroit, and 14 other CSO communities, are concentrated in the lower portions of the watershed. Several of the permitted outfalls are reported to be overflow structures which discharge to interceptors, which then discharge into the Rouge River or one of its tributaries. There are 40 CSO outfalls that discharge to the Detroit River that are not included in the Rouge River case study. The combined sewer area comprised 20 percent of the watershed in 1994, or 60,000 acres. All dry weather flows and some wet weather flows from these CSSs are delivered to the Detroit POTW along with other flows from outside the watershed. The Detroit POTW has a primary treatment capacity of 1,700 mgd and a secondary treatment capacity of 930 mgd.

Status of Implementation

Michigan's equivalent to the NMC has been implemented for all uncontrolled CSOs for which the construction of permanent control facilities is not imminent. The most significant NMC capital expenditure was the construction of outfall control gates at seven combined sewer outfalls in the Rouge River watershed owned by the City of Detroit. During wet weather events, these gates have eliminated CSO discharges during small rain events by maximizing the use of in-system storage. Other measures have not required significant capital expenditures.

Each CSO community with uncontrolled CSOs has taken measures to prevent the occurrence of dry weather overflows. Each CSO community reports CSO discharges to the Michigan Department of Environmental Quality (MDEQ), which provides public notification by posting the reported information on a website. State law also requires CSO permittees to self-report to downstream communities and one major local newspaper.

LTCPs are implemented in three phases as established through NPDES permits:

- Phase I— elimination of raw sewage and the protection of public health for approximately 40 percent of the combined sewer area.
- Phase II— elimination of raw sewage and the protection of public health for the remaining combined sewer area.
- Phase III— meet water quality standards in the Rouge River.

Under Phase I, six communities separated their sewers and nine communities constructed a total of 10 retention treatment basins. Each of these retention treatment basins is sized for different design storms, and several employ innovative technologies. These facilities also incorporate a variety of additional features or variations in compartment sizing and sequencing in order to improve their effectiveness. The retention treatment basins capture most wet weather flows for later conveyance to the Detroit POTW for treatment. Flows from very large wet weather events that are not captured by the retention treatment basins receive screening, skimming, settling, and disinfection prior to discharge. These projects have effectively eliminated or controlled the discharge of untreated sewage from approximately half of the watershed's CSOs.

Working with the CSO communities, MDEQ established rigorous "Criteria for Success in CSO Treatment" to evaluate whether the CSO basins met the Phase I goals of elimination of raw sewage discharges and protection of public health. MDEQ established a work group that included state personnel, CSO permittees and consultants to assess the evaluation process.

A detailed evaluation study of the CSO retention treatment basins constructed thus far is underway to examine the performance of the facilities and the water quality impacts of their discharges. Basin influent and effluent flow and water quality are monitored for at least two years at each facility. In addition, river monitoring is performed to identify benefits associated with CSO control. The results of the evaluation study, coupled with efforts to control storm water and other pollution sources in the watershed, will provide the basis for the Phase II and Phase III CSO control program to address the remaining water quality issues. The information gained from the evaluation of design storms and control technologies will also be useful nationwide in determining cost effective CSO controls to meet water quality standards.

It is important to note that MDEQ has concluded that all six of the CSO treatment facilities that have completed data collection are currently meeting the Phase I criteria of the elimination of raw sewage and the protection of public health. In addition, the first three CSO basins evaluated are achieving the Phase III goal of meeting water quality standards at times of discharge, except for meeting the yet-to-be-evaluated total residual chlorine standard.

Costs and Financing

CSO-related capital expenditures are funded by a combination of federal and local funding sources, with some communities using state revolving loan funds. Local funding is being generated by sewer rate increases, or issuance of general obligation bonds that are repaid through property taxes. Capital expenditures for Phase I CSO projects in the watershed total about $350 million, with another $5 million spent annually on CSO-related O&M. Another $1.3 billion of capital expenditure is needed to complete implementation of LTCP facilities in the watershed, along with $15 million annually for additional CSO-related O&M.

Water Quality Issues

Before implementation of CSO controls began in 1994, excursions of the water quality standards for dissolved oxygen and bacteria occurred frequently in CSO-impacted reaches of the Rouge River and its tributaries. Evidence of raw sewage was visible in the river during wet weather events, and visible on river bank vegetation and woody debris after events. Implementation of the NMC, the Phase I CSO control projects, and other watershed management measures has resulted in significant improvement in river conditions. In river reaches now free of uncontrolled CSOs, exceedances of the dissolved oxygen standard have been almost eliminated, the amount of bacteria in the river during wet weather events has been greatly reduced, and visible evidence of raw sewage has been eliminated. However, completion of the LTCP will not result in complete compliance with water quality standards due to other pollution sources within the watershed.

Enforcement Issues

Several enforcement actions have been taken by MDEQ relative to the Phase I CSO control projects:

- One project was aborted due to construction problems, and MDEQ issued an administrative consent order requiring the community to complete a revised CSO control project. This project is currently under design.
- One project is not yet complete due to construction delays and an enforcement action was initiated to ensure its timely completion.
- An amended federal consent judgment was issued in part for the failure to complete three projects on schedule. These projects are now complete and operational.

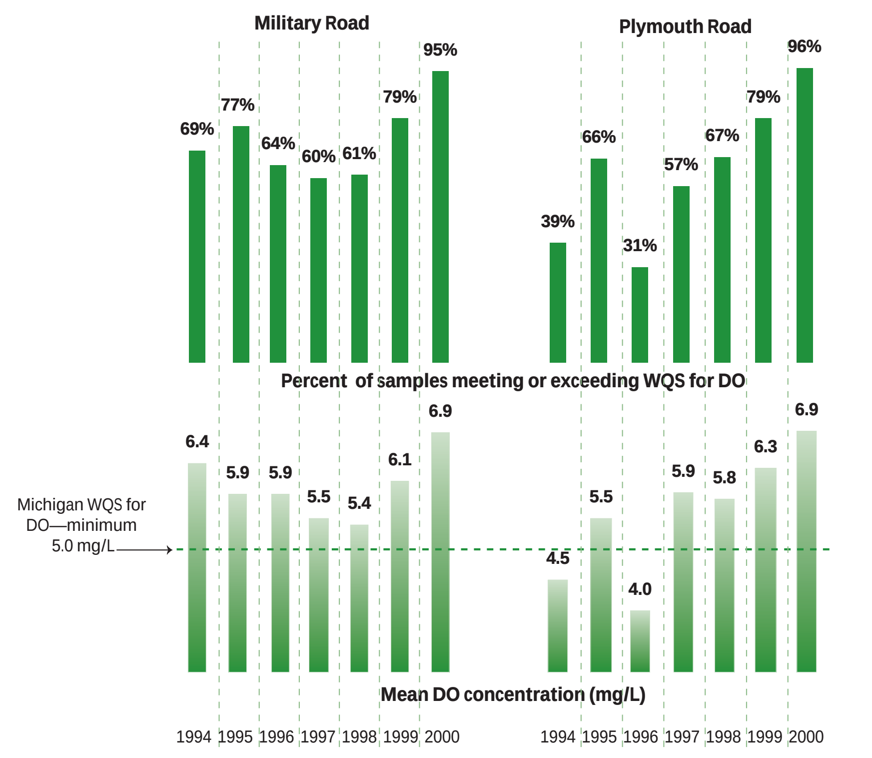
Results

Some of the key results and accomplishments of the Rouge Project are as follows:

- About 30 miles of the Rouge River that were CSO-impacted in 1994 are now completely free of uncontrolled CSO discharges.
- Two years of performance monitoring data for the first six CSO basins shows the following:
  - About 72 percent (933 million gallons) of the combined sewage that previously went to the river was captured and treated at the Detroit POTW.
  - Untreated overflows in excess of 50 times per year have been reduced to treated overflows occurring one to seven times per year.
  - Even in areas with remaining uncontrolled CSOs upstream, continuous dissolved oxygen data are showing dramatic improvements in river conditions due to upstream CSO control projects and other watershed management measures/changes.

As shown in the figure below, on the Main Rouge River (Military Road monitoring station) the percent of continuous dissolved oxygen levels meeting or exceeding water

Dissolved Oxygen Increases at Main and Lower Rouge Monitoring Stations



quality standards increased from less than 60 percent in 1998 to 95 percent in 2000. On the Lower Rouge River (Plymouth Road monitoring station) the percent of continuous dissolved oxygen levels at or above water quality standards increased from less than 30 percent in 1994 to 96 percent in 2000 (see figure, below).

Work groups have reached consensus with MDEQ that the first six CSO retention treatment basins evaluated are meeting MDEQ-defined criteria for protecting public health and eliminating raw sewage. Additionally, work groups have reached consensus with MDEQ that the first three CSO basins evaluated are achieving MDEQ-defined criteria for achieving water quality standards at times of discharge, except for meeting the yet-to-be-evaluated total residual chlorine standard.

In addition to the above, the aesthetics of the Rouge River and its tributaries are greatly improved, and there is evidence of aquatic habitat improvement. Recreational use of the Rouge River is increasing.

References

Ed Kluitenberg, Applied Science, Inc. Personal communication with Limno-Tech, Inc. staff on details of the combined sewer overflow plan and program. Summer 2001.

Rouge River Project Web Site (http://www.wcdoe.org/rougeriver/).

Community Case Study Saginaw, MI—Region 5

Number of CSO Outfalls

16

Combined Sewer Service Area

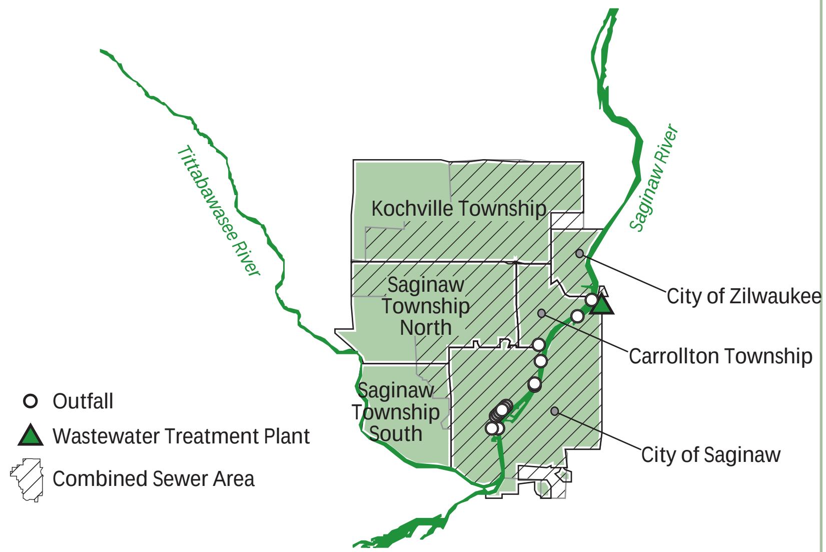
16.1 square miles

Wastewater Treatment Capacity

32 mgd (secondary)

Receiving Water(s)

Saginaw River



Controls

- Retention treatment basins with disinfection facilities have been the focus of Saginaw's CSO control efforts.
- Construction of relief sewers was initiated to provide capacity to bring wet weather flows to the retention facilities.
- Saginaw also considered sewer separation but found the costs to be prohibitive.

The Saginaw River has undergone significant cleanup and restoration in recent years.
Photo: EPA

Program Highlights

- 20 of 36 CSO outfalls have been eliminated as part of Saginaw's CSO Control Program.
- Seven of the remaining CSO outfalls have facilities that provide primary treatment and disinfection.
- Saginaw continues to monitor upstream and downstream bacteria levels during CSO discharge events and report the results to both the state and local county health departments.

Background on Saginaw CSOs

The City of Saginaw is located in the east central portion of Michigan's lower peninsula. The city lies within the Saginaw River Watershed, and the river runs through the city for approximately five miles. The Saginaw River flows 15 miles northward from the City of Saginaw into Saginaw Bay, in the southeastern section of Lake Huron. Saginaw Bay is widely used for fishing, boating and recreation. Both the Saginaw River and Saginaw Bay have been defined as two of 42 "areas of concern" by the International Joint Commission on the Great Lakes.

Saginaw owns and operates a wastewater treatment plant (WWTP) and collection system that serve Saginaw as well as the neighboring communities of Zilwaukee, Carrolton Township, Kochville Township, and portions of Saginaw Township. Much of the collection system is combined with CSO outfalls that discharge during wet weather into the Saginaw River. Saginaw's WWTP began as a primary treatment facility in 1952. Secondary treatment facilities and phosphorus removal equipment were added to the plant in 1975. The WWTP began treating wastewater of the neighboring communities in 1991. (Vasold, 2001).

System Characterization

The combined sewer service area covers approximately 10,325 acres. Only a small portion of Saginaw (200 acres) is served by separate sewers. There were 36 permitted CSO outfalls in Saginaw in 1990, consisting of 31 sewage regulator chambers and five storm water and combined sewer pumping station relief points. The number of permitted CSO outfalls was reduced to 16 by 2000, and includes seven CSO outfalls where primary treatment and disinfection are provided.

The Saginaw WWTP has a 32 mgd capacity during dry weather and 70 mgd during wet weather. Seven CSO retention treatment basins (RTBs) have been constructed to provide primary treatment and disinfection, as shown below.

Facility	Capacity (mgd)	Treatment Methods	Discharge Volume (mgd)	Year In Service	Cost (Millions)
Hancock	3.5	Primary sed, skimming, disinfection	51.3	1977	$6.6
Weiss	9.5	Swirl conc, disinfection	248.0	1993	$16.9
Webber	3.6	Primary sed, skimming, disinfection	34.8	1994	$6.6
Emerson	5.0	Primary sed, skimming, disinfection	33.4	1994	$15.9
Salt/Fraser	2.8	Primary sed, skimming, disinfection	2.0	1995	$22.9
Fitzhugh	1.2	Primary sed, skimming, disinfection	2.8	1994	$4.8
14th Street	6.8	Skimming, settling, vortex sep, disinfection	36.6	1992	$8.5

The pollutant removal effectiveness varied among the RTBs, as shown below.

Facility Name	Volume	BOD	TSS	Phosphorus	Ammonia
Hancock	22%	50%	51%	40%	39%
Weiss	29%	54%	77%	55%	68%
Webber	38%	52%	61%	33%	62%
Emerson	36%	57%	39%	38%	67%
Salt/Fraser	48%	60%	68%	53%	73%
Fitzhugh	42%	57%	84%	56%	85%
14th Street	59%	83%	79%	76%	80%

Status of Implementation

Saginaw considered two alternatives for control of its CSOs: sewer separation and storage and treatment. A cost comparison of the two alternatives was conducted in 1990, and the results are as follows:

Alternative (Millions)	Construction Cost (Millions)	Present Worth (Millions)	Annual Equivalent Cost
Sewer Separation	$309.8	$285.1	$31.0
Storage and Treatment	$170.8	$78.1	$18.0

The storage and treatment alternative was selected because of the cost advantage. This alternative was then divided into Phases A, B and C. Phases A and B have been completed, resulting in the elimination of all untreated CSOs.

Phase	CSO Control(s)
A	Storage for the two-inch, one-hour storm event Two-thirds of storage volume will be provided for settling, skimming, and disinfection
B	Additional collector sewers and retention basin capacity, in order to eliminate all untreated combined sewer overflows
C*	Additional retention basin capacity to meet the MDEQ definition of adequate treatment (total retention of the one-year, one-hour rainfall event and one-half hour detention of the ten-year, one-hour event.)

*Note: Whether or not Phase C will be required will be determined by the MDEQ after review of a facilities evaluation report. The determination will be based on whether additional controls are necessary to comply with water quality standards.

Nine Minimum Controls

Saginaw has implemented the NMC. There are no dry weather overflows in Saginaw's system, except in emergency situations. When CSO discharges occur, state and county officials, as well as local media are contacted as part of the city's notification procedure. Within 24 hours, volume estimates are furnished, and a written report is supplied within five days of the conclusion of the overflow event. Upstream and downstream *E. Coli* levels are monitored during CSO discharge events, and reported to the state and to the Bay and Saginaw County Health Departments.

Long Term Control Plan

Saginaw has adopted a modified version of the presumption approach in its LTCP. Phase C of the CSO Control Plan is to construct additional capacity in the retention and treatment basins to meet Michigan's presumption approach. Twenty of 36 CSO outfalls have been eliminated.

Capital costs for Phase A were approximately $80.7 million. Capital costs for Phase B were approximately $24.5 million. The primary funding mechanism employed by Saginaw to cover the costs of CSO control was the Michigan Clean Water State Revolving Fund. The average household user cost in Saginaw is currently approximately $243 per year (debt service, operation, maintenance, and replacement). Phase B projects are anticipated to increase costs by approximately $32 per year. Estimated costs for Phase C projects are $65.6 million.

Results and Accomplishments

It was estimated in 1990 that nearly three billion gallons per year of untreated CSO was discharged by the City of Saginaw. Implementation of Phase A and Phase B CSO controls are estimated to have reduced the volume of overflow to 760 million gallons per year, a 74 percent reduction. Direct discharge of untreated combined sewage has been eliminated under virtually all circumstances with the completion of Phase B CSO controls.

The City of Saginaw received a first place award in EPA's National CSO Control Program Excellence Awards in 1998 for progress made in implementing its CSO Control Program.

References

John Vasold, Saginaw Wastewater Treatment Division, Saginaw, MI. Personal communication with Limno-Tech, Inc. staff on details of the combined sewer overflow plan and program. Summer 2001.

Community Case Study — San Francisco, CA—Region 9

Number of CSO Outfalls

43 (originally)
36 (currently)

Combined Sewer Service Area

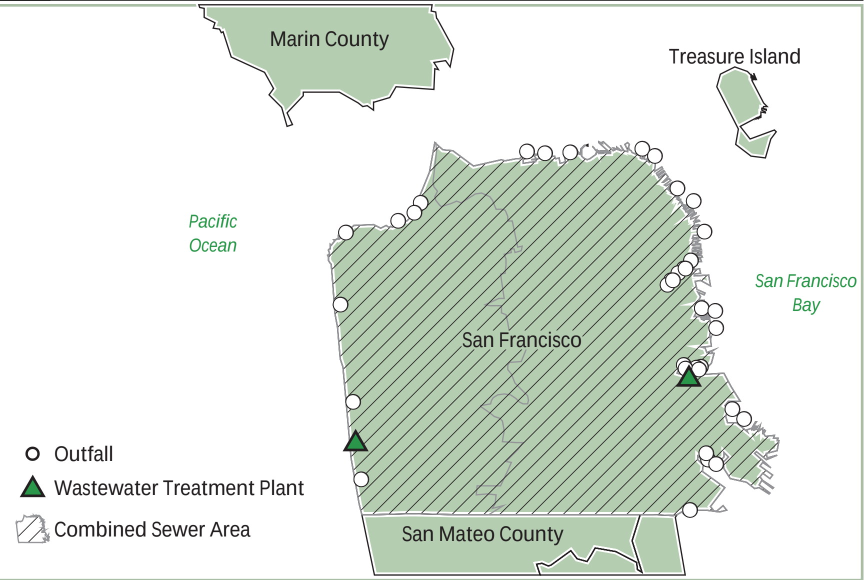
49 square miles

Wastewater Treatment Capacity

272 mgd (primary)
194 mgd (secondary)

Receiving Water(s)

Islais Creek, San Francisco Bay, Pacific Ocean



Controls

- San Francisco completed implementation of its LTCP in 1997; initial CSO control began in the early 1970s.
- Wet weather treatment facilities provide 272 mgd of primary treatment and disinfection for wet weather flows.
- Storage and transport structures hold flow until treatment plant capacity becomes available.

Photo: Islais Creek CSO Wet Weather Treatment and Storage Facility
Courtesy San Francisco PUC

Program Highlights

- CSO outfalls have been reduced from 43 to 36.
- CSO events have been reduced by over 75 percent, and CSO volume by 81 percent.
- An estimated 94 percent reduction in beach postings has occurred since implementation of CSO controls.
- CSO control has improved City assets and enhanced water quality of nearshore areas of the Bay and Ocean.

Background on San Francisco CSOs

The combined sewer service area of the City and County of San Francisco is approximately 31,360 acres and serves an estimated population of 800,000. There are no significant separated sewer service areas within the city. There are six main drainage basins within the service area and approximately 898 miles of combined sewer.

Prior to the implementation of CSO controls, an average of 7.5 billion gallons of CSO discharged during the wet weather season (October to April) each year. The overflow frequency was approximately 58 times per year, and there were 43 CSO outfalls. All of the CSOs discharged into marine waters.

The city and County of San Francisco own and operate three wastewater treatment plants in addition to the storage/transport facilities constructed for CSO control. The Southeast Water Pollution Control Plant (WPCP) is the city's largest wastewater treatment plant and has a peak secondary treatment capacity of 150 mgd. The plant discharges through an outfall to San Francisco Bay. The outfall has a capacity of 100 mgd, and flows in excess of 100 mgd are discharged to Islais Creek, a saltwater embayment. The Southeast WPCP was expanded in 1982 to provide a wet weather capacity of 250 mgd for peak wet weather flows. This was achieved using the 150 mgd of available secondary treatment capacity and 100 mgd of primary treatment capacity.

The North Point Wet Weather Facilities serves an area of approximately 6,500 acres in the northeastern part of the city. The facilities provide primary treatment (i.e., screening and settling), disinfection, and dechlorination of combined wet weather flows up to 150 mgd.

The Oceanside WPCP has a peak secondary treatment capacity of 43 mgd and a wet weather treatment capacity of 65 mgd. The capacities of the treatment facilities used by San Francisco to treat dry weather and wet weather flows are summarized in the table below.

Treatment Plant	Secondary Capacity (mgd)	Primary Capacity (mgd)	Peak Flow Capacity (mgd)
Southeast WPCP	150	100	250
North Point Wet Weather Facilities	None	150	150
Oceanside WPCP	43	22	65
Total	**193**	**272**	**465**

Status of Implementation

CSO Planning History

Planning for CSO control began in the early-1970s. The city Department of Public Works assessed various measures to upgrade treatment and control CSOs between 1970 and 1974. The Wastewater Master Plan was approved in concept by the San Francisco Board of Supervisors in January 1975. Based upon this planning effort, the San Francisco Regional Water Quality Control Board issued the city its first NPDES permit for the CSO structures. This permit was issued in the mid-1970s and set monitoring requirements and tentative control levels at some of the structures, as well as requiring additional studies of CSO control measures. In late 1978 and 1979, the permits were revised and the required CSO control levels were established based upon cost-benefit analyses.

System Characterization

The revised permits allowed a long-term average of 10 overflows per year where the shoreline usage is predominantly industrial and maritime, between eight and four overflows per year in areas where water contact recreation occurs, and only one overflow per year in an area where there are shellfish beds. The permits also require that:

- Wet weather treatment facilities are at maximum capacity before CSOs are allowed.
- Industrial source control and BMPs to control nonpoint source pollution must be implemented.
- Floatables are contained in the storage/transport structures.
- Treatment plant effluent, CSOs, and receiving waters are monitored for pollutants.
- Beaches are posted following CSO events.

To intercept the flows, a series of large underground storage and transport structures (referred to as storage/transport boxes) were constructed along San Francisco's shoreline. Gravity and pumping are used to transport the stored wet weather flows to the treatment plants as treatment plant capacity becomes available. In addition to these storage/transport boxes, the treatment plants were upgraded to expand the secondary and wet weather treatment capacities.

The system is designed and operated so that all dry weather flows are kept in the sewer system and routed to either the Southeast WPCP or the Oceanside WPCP for treatment. In wet weather the storage/transport boxes allow primary sedimentation to occur and are designed to remove floatables and reduce suspended solids concentration by approximately 30 percent. The capacities of these structures are summarized in the accompanying table. After a rain event, the settled solids are conveyed to the wastewater treatment plants. Therefore, all overflows from the storage/transport boxes receive some treatment prior to discharge through the outfalls.

WPCP System	Storage/Transport Structure	Capacity (mgd)
Westside Core System	Westside	50.0
	Richmond	10.0
	Lake Merced	10.0
Bayside Core System	Northshore	17.5
	Mariposa	0.7
	Islais Creek	37.0
	Yosemite/Fitch	11.5
	Sunnydale	5.7
	Channel	28.0
Total		**170.4**

The Bayside Core System consists of seven miles of underground storage/transport boxes. These boxes drain to major pump stations where all dry weather flows are pumped to the Southeast WPCP for treatment before being discharged into San Francisco Bay. During wet weather, the North Point Wet Weather Facilities are brought online. Flows in the boxes exceeding the combined wet weather capacity of the Southeast WPCP and the North Point Wet Weather Facilities receive partial treatment in the boxes before discharge.

The Westside Core System consists of a 2.5 mile long storage/transport box, the Oceanside WPCP, and the Southwest Ocean Outfall. The city has also constructed consolidation conduits, tunnels, and new pump stations to intercept overflows and divert them to the storage/transport boxes.

In addition to the massive capital improvements, the city embarked on a program of toxics source control and pollution prevention. The Water Pollution Prevention Program was developed in response to several state and federal permits, orders, and waste minimization strategies. It consists of best management practices targeting educational and technical outreach, increased inspection and sampling of non-traditional pollutant sources, mandated waste minimization, and storm water pollution prevention plans.

Nine Minimum Controls

San Francisco has implemented the NMC. Wet weather-related monitoring activities include characterization of CSO discharges for various chemical constituents. Following a CSO event beaches are posted as not meeting state recreational water contact standards. Local surf shops and swim clubs are contacted and a toll free recreational water quality hotline is available to the public. The city is also in the process of developing access to EPA's BEACH Watch website.

Long Term Control Plan

San Francisco completed implementation of its LTCP in 1997 and the planned capital improvements for controlling CSOs to the allowed number of annual overflows. The city's LTCP gave priority to eliminating discharges to sensitive areas; a CSO outfall at Baker

Beach in the Golden Gate National Recreational Area has been eliminated given the sensitivity of the habitat and potential human exposure.

Costs and Financing

The total capital costs associated with completing the LTCP were approximately $1.45 billion. The annual CSO-related O&M costs are approximately $20 million. Nearly $700 million in federal and state grants were received by San Francisco to assist in the planning, design, and construction of the CSO control system. The remaining $750 million, raised by revenue bonds and to be repaid by sewer rater, were city funds.

The North Point Wet Weather Facilities, which are more than 50 years old, are in need of improvement. Certain equipment is obsolete and some spare parts are no longer available on the market. Pollutant removal is less than optimal and in some instances discharges approach current effluent limits. With the consideration of future expansion, an upgrade is being planned for the facilities. The project involves: 1) upgrading primary sedimentation tanks and equipment with high rate clarification units, 2) replacing chlorine-based disinfection system with a more environmentally-friendly, medium pressure, ultraviolet radiation disinfection system capable of achieving current NPDES fecal coliform standard, and 3) upgrading ancillary equipment (pre-treatment, pumps, piping, electrical/instrumentation) to meet needs of treatment processes. The upgrade is projected to cost $38 million.

There are also plans to increase the capacity of the outfalls in conjunction with the North Point upgrades described above. The outfalls were constructed in the 1950's and the diffusers were added in the 1970's. Both are necessary to meet the discharge permit requirements of a minimum 10:1 dilution. Since the North Point Facilities are used for wet weather treatment only, and are not always in operation, barnacles and crustaceans inhabit the outfall system and have created blockages, thereby reducing its capacity and efficiency. The projected cost for increasing the capacity of the outfalls from 150 mgd to 300 mgd is $22 million.

Depending on the outcome of current negotiations between the city and the Navy, the city may be responsible for system upgrades and expansion at Hunters Point and Treasure Island. San Francisco's remaining needs also depend on potential changes to water quality standards previously discussed.

Water Quality Issues

Since 1972 the city has conducted ongoing sampling to evaluate the impacts of CSO discharges and to assess the environmental improvements gained from CSO control. On the Westside, where prior to the program as much as 83% of the storm flows were discharged untreated at the Pacific Ocean shoreline, only 13% of the storm flows are discharged at the shoreline and all of this overflow receives partial treatment.

Although San Francisco's LTCP has been completely implemented there are unresolved issues regarding water quality standards compliance. The state anticipates that it will be reviewing the appropriateness of the water quality standards in the near future. The city may have to implement additional programs depending on the outcome of that review.

Results

CSO volume and frequency have been reduced greatly since CSO controls have been implemented. Citywide pollutant reductions resulting from the city's LTCP are summarized as follows:

Item	Before Control	After Control	% Reduction
Number of CSO events	58 - 80	1-10	98-75
Annual CSO Volume (MG)	7,500	1,350	81
Suspended Solids Discharge (tons/yr)	3,550	450	87
BOD_5 Discharge (tons/year)	2,700	300	89
Beach Postings (days/year)	200	12	94

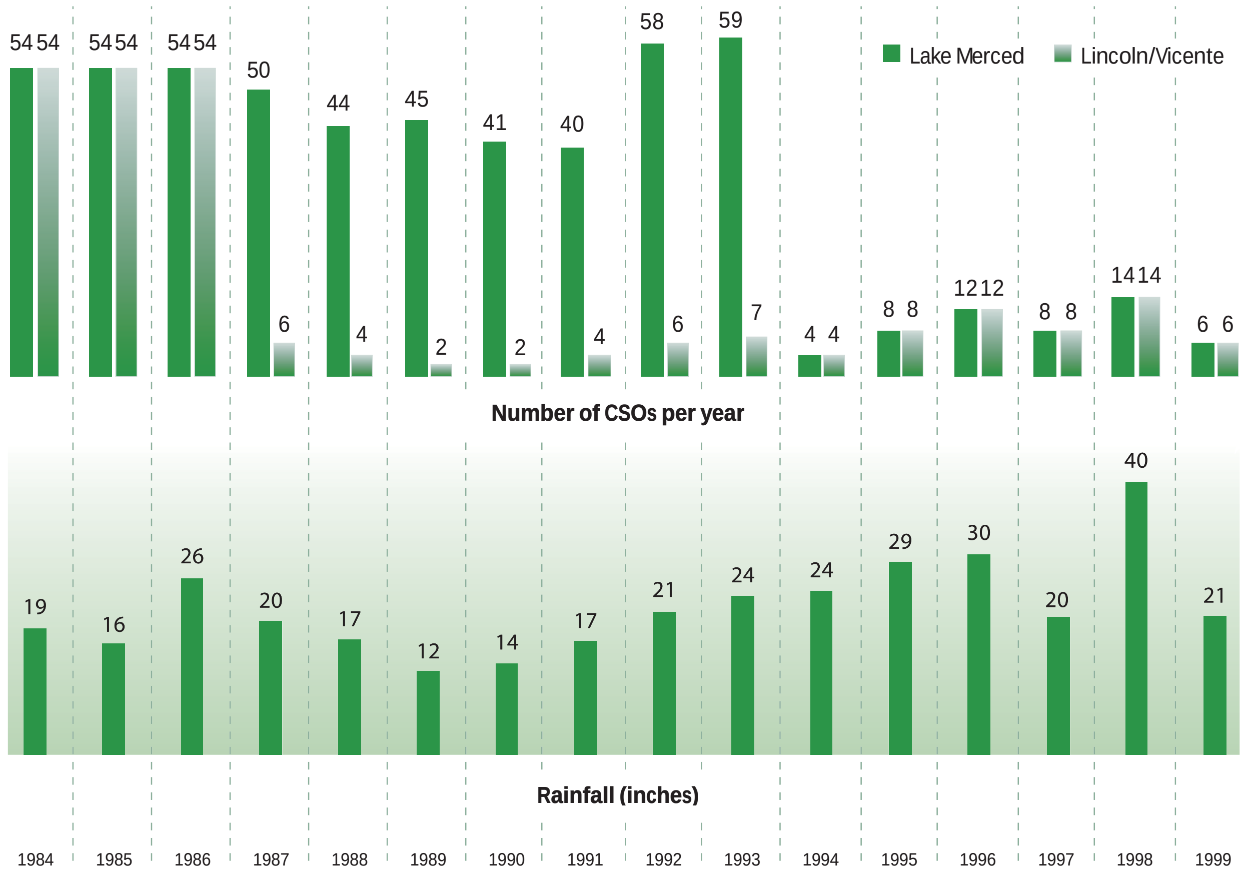
San Francisco developed its LTCP in conjunction with the regulatory agencies and started to implement the plan in 1974. Within 20 years the following systems were complete: (1) the Westside system, which reduced overflows to eight times per year into the Pacific Ocean along the central portion of Ocean Beach; (2) the Northshore system, which reduced overflows to four times per year along the northshore of the city the Golden Gate and Bay Bridges; (3) the Channel system, which reduced overflows to 10 times per year from the Bay Bridge to Mission Creek; and (4) the Sunnydale/Yosemite system, which reduced overflows to one time per year south of Islais Creek to the southern city boundary.

In 1994, the Lake Merced Transport system was tied to the Westside system, which further reduced overflows to the Pacific Ocean from the southwestern section of San Francisco. Shortly thereafter the Islais Creek system was completed, which reduced overflows to 10 times per year from Mission Creek to Islais Creek along the eastern boundary of the city. In 1997, the Richmond Transport connected flow from the northwestern edge of the city to the Westside system, diverting flow that previously spilled onto Baker and China Beaches.

Prior to CSO control implementation, San Francisco beaches were routinely posted from October to April during the wet weather season for not complying with state recreational water contact standards. Rainfall in excess of 0.02 inches per hour resulted in CSOs around the entire city. As CSO control structures were put in service, the number of CSOs to San Francisco shoreline areas have been reduced as described above. The number of CSOs that occur is dependent upon the amount of annual rainfall and the duration and intensity of each rainfall event.

From 1994 through 1996, a significant portion of control structures were in place and the number of days the beaches were posted ranged from 196 to 217, while rainfall ranged from 23.7 to 26.3 inches. In 1997, the first partial year of complete CSO control implementation, the number of days beaches were posted dropped to 54, but rainfall was only 19.1 inches. In 1998, the first complete year of full implementation, the number of days beaches were posted dropped to 48 and rainfall was significantly higher, measuring 33.5 inches. Since 1998, annual rainfall in San Francisco has ranged from 22 to 27 inches and the days that beaches were posted decreased to between eight and 15 days. In recent years, beaches remain posted only while sampling indicates that bacteria concentrations are above state bacteria standards. This is typically only a period of one to three days. An estimated 94% reduction in beach postings has occurred due to implementation of CSO controls. As shown in the following figure, these reductions have been achieved during both wet and dry years.

CSO Frequency and Rainfall at Lincoln/Vicente and Lake Merced Overflow Structures



This reduction in the numbers and volume of CSO events during the past 25 years has facilitated the transition of San Francisco's coastline from industrial uses to tourist, recreational, and residential uses by improving and enhancing the water quality of nearshore areas of the bay and ocean. The continuing economic development of the Fisherman's Wharf area south to Pac Bell Park and the water contact recreation enjoyed at Crissy Field, Fort Point, Baker, and Ocean Beaches (all within the Golden Gate National Recreational Area) have been supported in part by the control and treatment of combined sewer overflows (Lavelle, 2001).

San Francisco Bay has been listed for several pollutants under CWA Section 303(d). The listing has resulted in a need for developing TMDLs for certain pollutants, such as copper and nickel. The outcome of TMDLs may require further control measures for CSOs. These control measures have not been determined at this time.

References

Jane Lavelle, San Francisco Planning Bureau, Public Utilities Commission, San Francisco, CA. Personal communication with Limno-Tech, Inc. staff on details of the combined sewer overflow plan and program. Summer 2001.

Community Case Study South Portland, ME—Region 1

Number of CSO Outfalls

35 (originally)

25 (currently)

Combined Sewer Service Area

12 square miles

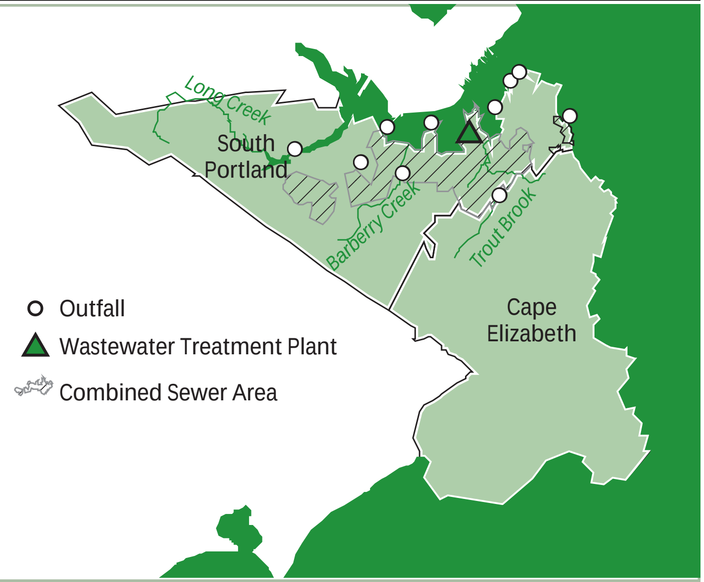
Wastewater Treatment Capacity

56 mgd (primary)

22.9 mgd (secondary)

Receiving Water(s)

Fore River, Casco Bay



Controls

- South Portland's program has relied on sewer separation, removing private inflow sources (roof leaders and sump pumps), expansion of wet weather treatment capacity, and upgrading sewer lines.
- Technical advice and financial incentives have been used to encourage inflow control.
- Wet weather wastewater treatment plant capacity was expanded from 12 mgd to 56 mgd.

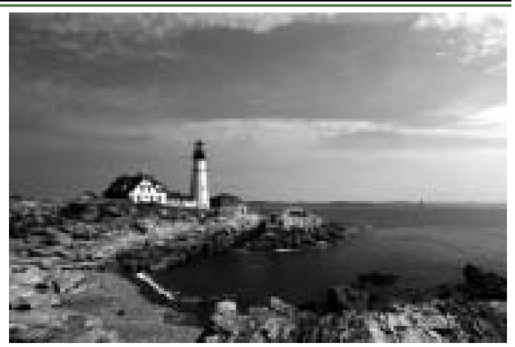


Photo: Lighthouse at Portland Head on Casco Bay. *Photodisc*

Program Highlights

- 25 of 35 CSO outfalls have been eliminated.
- 80 percent reduction in CSO volume was achieved between 1988 and 1993.
- Real time flow monitoring is used to quantify flows. All CSO outfalls are continually monitored.
- The Friends of Casco Bay have recognized South Portland for the positive impact of its CSO control program on the Bay.

Background on South Portland CSOs

South Portland has a population of 22,300 and is located in southern coastal Maine. South Portland is served by a CSS which is comprised of 16.6 miles of combined sewer pipes that cover an area of 7,680 acres. CSOs in the system discharge directly (or indirectly via ponds, creeks, and brooks) to the Fore River and Casco Bay. Both of these water bodies are classified by the Maine Department of Environmental Protection (DEP) for swimming, fishing, and shellfish harvesting. Casco Bay was also designated by EPA as an Estuary of National Significance in 1987. It is an important economic resource for Maine, supporting commercial fishing, tourism, shipping, manufacturing, and service businesses.

Status of Implementation

Characterization

South Portland initiated their CSO Control program in 1988. City staff inventoried, numbered and mapped all of the sewer pipes, catch basins, and manholes. Thirty-five CSO outfalls were identified. Inflow and infiltration was high in the city's aging sewer system. The average age of the system was approximately 50 years, and the oldest sewer pipes date to the 1880s (City of South Portland 1992 and 1993).

South Portland installed an extensive system of real-time flow monitoring equipment to characterize their CSS and existing CSOs. All CSO outfalls in the system are continuously monitored, and the duration, overflow rate, total volume, and time of day of each CSO is recorded. South Portland also maintains rain gauges to be able to correlate overflow and precipitation events. Flow monitoring has provided many benefits for South Portland's CSO control program. The real-time flow data: (1) provide basic information for the city to understand CSS performance, (2) enable the progress of the CSO control program to be tracked, (3) produce information for comparison of CSO control alternatives, and (4) serve as an important component of compliance monitoring. South Portland has maintained rainfall records and flow records from the CSO outfalls and pump stations since 1992. Other monitoring efforts related to the CSO program include collection of bacteria data (enterococci) at swimming beaches. These efforts have enabled South Portland to collect site-specific data on existing CSOs, and to calculate pollutant loadings and receiving water impacts. This comprehensive monitoring program has also aided the development of South Portland's LTCP.

Nine Minimum Controls

The NMC were required for South Portland as part of the DEP CSO Discharge License, and an enforcement action (consent agreement with EPA Region 1, dated January 28, 1992). South Portland has been recognized by the DEP for its implementation and documentation of the NMC, considered to be one of the best of 44 Maine CSO communities (City of South Portland, 1997).

Proper O&M was recognized to be an important component of CSO control. The city's sewer maintenance division is responsible for cleaning and inspection of the collection system. In addition, they maintain an emergency on-call system to quickly identify, eliminate, or mitigate any problems that might arise. No dry weather overflows occurred in 1999. In the previous three years, dry weather overflows occurred due to power or equipment failures that have since been corrected with backup power arrangements. Because South Portland continuously monitors flows at all CSO outfalls, dry weather overflows are quickly discovered and eliminated.

Signs are placed at all CSO locations to inform the public of possible wet-weather hazards. The signs are regularly checked and replaced if damaged or missing. The Willard Beach outfall is recognized as a sensitive area for CSO activity because it is a public swimming area. Bacteria testing has been performed at the outfall twice weekly during the summer since 1991. While beach closings have occurred, none corresponded directly with CSO discharges.

South Portland has implemented an aggressive program to reduce inflow to the CSS. Homes and commercial establishments with roof leaders and basement sump pumps directly connected to the CSS were identified. South Portland provided technical and financial support to owners to have roof leaders and sump pumps redirected from the CSS. A summary of CSO source control measures implemented by South Portland follows.

Source Control Activity and Progress as of 1999	Purpose
Roof Leader Disconnection—257 homes	Stormwater Inflow Reduction
Sump Pump Removal—213 removed	Stormwater Inflow Reduction
Catch Basin Cleaning—460 tons debris annually	Pollution Prevention
Street Sweeping—2,000 cy debris removed annually	Pollution Prevention
Annual community hazardous waste collection	Pollution Prevention

Long Term Control Plan

South Portland has been implementing CSO controls since 1988. The LTCP is based upon the demonstration approach. Priority has been given to eliminating the CSO discharges near the bathing beach, a sensitive area. Sewer separation, adjustment of weir heights, upgrading of pumps stations, upgrading of POTW capacity, and many other in-system controls have contributed to substantial reductions in the number of CSO outfalls and the volume of CSO discharge. The types of in-system control measures implemented since 1988 by South Portland are listed below.

System Controls Implemented as of 1999	Type
Infiltration/inflow control	Collection System Optimization and Control
Real-time flow control (50% overflow decrease realized by adjusting weirs)	Collection System Optimization and Control
Sewer cleaning	Collection System Optimization and Control
Manhole/pump station maintenance	Collection System Optimization and Control
Sewer rehabilitation	Collection System Optimization and Control
Sewer separation (680 acres separated between 1986-1998)	Collection System Optimization and Control
Outfall elimination	Collection System Optimization and Control
In-line netting	Floatables Control
Baffles (installed at 11 locations in CSS)	Floatables Control
Screening improvements at discharge point	Floatables Control
In-line storage (weirs adjusted to maximize in-line storage)	Storage (In-Line and Off-Line)
Upgraded pump stations (6 pump stations upgraded)	Storage (In-Line and Off-Line)
Upgraded POTW capacity (with additional wet weather primaries)	Storage (In-Line and Off-Line)

Costs and Financing

South Portland has spent over $9 million to control CSOs. Most of this has been financed through voter-approved bonding. Costs for sewer separation of 680 acres of the combined system were approximately $6 million and the separation projects scheduled over 10 years. Capital costs for the POTW upgrade were $9.2 million, but only a small portion of this is associated with CSO control. The cost to upgrade six pump stations was $1.3 million. Capital costs for planned LTCP controls are $13.8 million, including $5 million for partial sewer separation (to be complete by December 2005). Annual O&M costs are approximately $350,000 per year.

Enforcement Issues

South Portland was the first non-National Municipal Policy referral in EPA Region 1 in which the EPA sought relief for wet weather discharges only. As part of the consent agreement (entered into court on April 16, 1992), South Portland paid $30,000 in penalties for violations of the CWA and its Maine CSO Discharge License. The consent agreement required, among other things, that yearly CSO progress reports be submitted to the DEP.

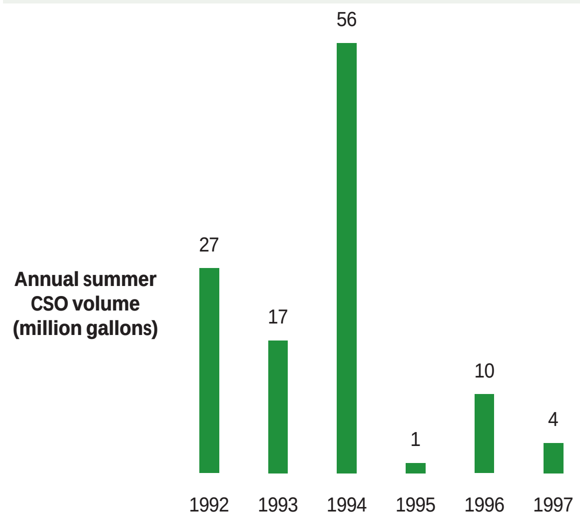
Results

South Portland initiated its CSO control program in 1988. The city's initial CSO master plan focused on maximizing flow to the POTW. This involved increasing pump station capacity, maximizing flow (conveyance capacity) to the treatment plant, and upgrading treatment and storage capacity at the plant. The current CSO control program primarily relies upon separating and upgrading (replacing) sewers and removing private inflow sources through roof leader and sump pump redirection. The removal of inflow and infiltration sources has eliminated approximately 700 million gallons per year from entering the CSS. Overall, South Portland had achieved an 80 percent reduction in total CSO volumes in an average rainfall year by 1993. In addition, 25 of 35 CSO outfalls have been eliminated through sewer separation and other system improvements.

Prior to the POTW upgrade, 60 percent of the total CSO volume was discharged at the plant. Secondary treatment capacity at the POTW was upgraded from 12 to 22.9 mgd. Wet weather flows in excess of the upgraded secondary treatment capacity are diverted to empty storage/treatment tanks for primary treatment. CSO bypass of secondary treatment is permitted under peak flow conditions. In total, maximum treatment capacity was expanded to approximately 56 mgd (22.9 mgd secondary, plus 33 mgd of primary treatment). The wet weather treatment capacity has not been exceeded since the upgrade.

South Portland has also observed a reduction in summer CSOs. Monitored volumes for summer CSOs from 1992 through 1997 are shown in the figure at right. South Portland has been recognized by the Friends of Casco Bay for its positive impact on the Bay.

Summer CSO Volume Reductions, 1992—1997



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Pineo, David, Engineering Department, City of South Portland, ME. Personal communication with Limno-Tech, Inc. staff on details of the combined sewer overflow plan and program. Summer 2001.

Community Case Study — Washington, D.C.—Region 3

Number of CSO Outfalls

60

Combined Sewer Service Area

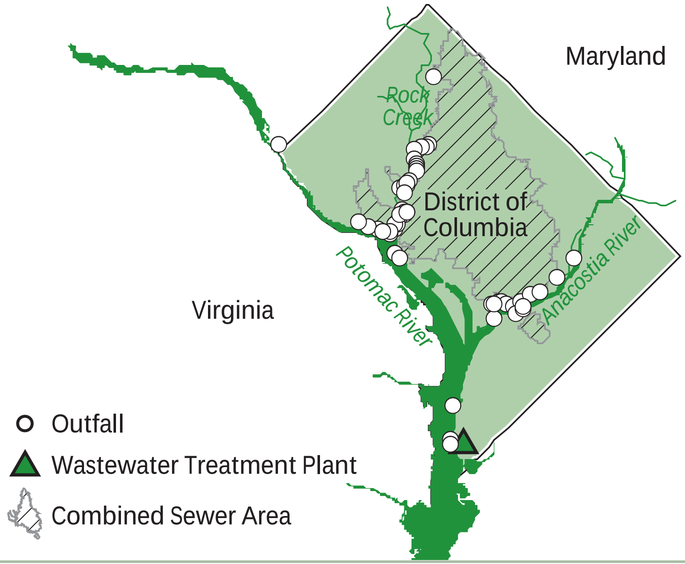
20.2 square miles

Wastewater Treatment Capacity

1,076 (primary)
740 mgd (secondary)
370 mgd (advanced)

Receiving Water(s)

Rock Creek, Anacostia River, Potomac River



Controls

- Phase I CSO Controls were completed in 1991 and featured the Northeast Boundary Swirl Facility, inflatable dams for in-system storage, expanded pumping capacity, and expanded wet weather capacity at the Advanced Wastewater Treatment Plant at Blue Plains.
- NMC measures include regular inspections of critical facilities such as outfalls, regulators, pump stations and tide gates; maximizing storage in the collection system through use of inflatable dams; and pretreatment of industrial flows.

Photo: Potomac River in Georgetown, Washington, D.C.
Courtesy of Greeley & Hansen Engineers, Inc.

Background on Washington, D.C. CSOs

The District of Columbia Water and Sewer Authority (WASA) operates a wastewater collection system consisting of separate and combined sewers. Approximately one-third of the District, or 12,955 acres, is served by a CSS. The remaining two-thirds is served by separate sanitary sewers and a separate storm water system (SSWS). The combined sewer service area is located primarily in the older central part of the District, and it was primarily constructed by the federal government.

Wastewater from the District and surrounding suburban areas is treated at WASA's Advanced Wastewater Treatment Plant at Blue Plains, a 370 mgd regional facility. Most of the flow that is conveyed to Blue Plains from suburban jurisdictions passes through the CSS. During wet weather events, the combined sewer portion of the system produces

Program Highlights

- NMCs were implemented and documented in 1996 with updates in 1999 and 2000.
- The draft LTCP was submitted in June 2001 to EPA Region 3 and the DC Department of Health, and is based upon the demonstration approach.
- The recommended CSO control program includes three storage tunnels, pump station rehabilitation, regulator improvements, and low impact development retrofits.
- The estimated cost to implement the recommended CSO controls is approximately $1 billion.
- Compliance with the requirements of the CWA will not be accomplished unless other sources are controlled in conjunction with CSO control.
- Incorporation of wet weather provisions in water quality standards has been requested.

CSOs that discharge into receiving waters. There are a total of 60 CSO outfalls listed in WASA's NPDES permit that discharge to Rock Creek, the Anacostia River, the Potomac River and tributary waters. The WASA NPDES permit is administered by EPA Region 3.

Status of Implementation

WASA and its predecessor organizations have been addressing CSO issues for several decades and have spent over $35 million for CSO abatement. Phase I CSO controls were completed in 1991 and featured: the Northeast Boundary Swirl Facility, inflatable dams for in-system storage, expanded pumping capacity, and expanded wet weather treatment capacity at Blue Plains.

Nine Minimum Controls

WASA has an NMC program in place to address CSOs. WASA first provided documentation on its NMC program in December 1996 (DHA, 1996). In July 1999 WASA prepared a report which updated the earlier NMC documentation (EPMC III, 1999). The summary report provided an update on various activities undertaken by WASA as part of the NMC program and included recommendations for enhancement of several activities associated with this program. An NMC Action Plan prepared in February 2000 details a schedule for implementing recommended enhancements. Examples of measures that have been implemented include:

- Regular inspections of critical facilities such as outfalls, regulators, pump stations and tide gates.
- Maximization of storage in the collection system through the use of inflatable dams.
- Inspections and maintenance of regulators and outfalls to prevent and correct dry weather overflows.
- Operation of the Northeast Boundary Swirl Facility to control CSOs and floatables.
- Operation of skimmer boats on the Anacostia and screens at certain pump stations to control floatables.
- Installation and demonstration evaluation of an end-of-pipe netting system for floatables control at CSO outfall 018.
- Placement of signs at outfalls for public notification.
- Development of a CSO web page on the WASA website.
- Major maintenance projects such as the cleaning of the Eastside Interceptor and the sonar inspection of the Anacostia siphons.

Long Term Control Plan

WASA initiated development of an LTCP in 1998. Extensive monitoring and modeling was undertaken to characterize the system during LTCP development. Flow and water quality monitoring in both the CSS and SSWS were employed to determine the hydraulic response of the system to rainfall. Receiving water monitoring was used to assess in-stream conditions, impacts, and upstream sources. The evaluation of CSO control alternatives involved development and application of CSS and SSWS models and receiving water models for Rock Creek, the Anacostia River and the Potomac River.

WASA submitted a draft LTCP to EPA Region 3 and the District of Columbia Department of Health in June 2001 (EPMC III, 2001). The recommended CSO control program is based upon the demonstration approach. The major elements of the draft LTCP and associated costs are summarized by receiving water in the following table. It is anticipated that WASA's final recommended LTCP will be submitted to the regulatory agencies for approval at the end of 2001.

Recommended LTCP Component	Capital Cost (in millions)	Annual O&M Cost (in millions)
System-wide low-impact development retrofit	$3	$0.2
Anacostia River System Improvements—pump station rehabilitation, additional tunnel storage, and new interceptor	$816	$9.1
Rock Creek System Improvements—partial separation, additional tunnel storage, and monitoring	$39	$0.5
Potomac River System Improvements—additional tunnel storage, pump station rehabilitation and dewatering	$170	$2.7
Blue Plains WWTP excess flow treatment improvements	$22	$0.4
Total	**$1,050**	**$12.9**

As shown below, the recommended LTCP is expected to reduce the volume and frequency of CSOs.

LTCP Alternative	Anacostia River	Potomac River	Rock Creek	System Total
CSO Overflow Volume (MG/year)				
No Controls	2,142	1,063	49	3,254
Phase I Controls (1991)	1,485	953	52	2,490
Recommended LTCP	96	157	11	264
Number of Overflows Per Year				
No Controls	75	74	30	—
With Phase 1 Controls (1991)	75	74	30	—
Recommended LTCP	4	12	4	—

Cost and Financing

Implementation of the recommended CSO control program is estimated to cost more than $1 billion (2001 dollars). WASA conducted a financial capability assessment and affordability analysis to evaluate the impact of the recommended program on ratepayers. The analysis considered existing rates, the rate increase associated with WASA's current non-CSO capital improvements, and the rate increase associated with the addition of the recommended CSO control program.

Using EPA guidance, wastewater treatment costs, including the recommended CSO control program, are projected to impose a medium burden based on median household income. For lower income households, current wastewater treatment costs are projected to impose a medium burden without any additional CSO controls. Addition of the recommended CSO control program greatly increases the burden level. At this time, WASA cannot predict whether financial assistance in the form of grants or other mechanisms will be available. Without such assistance, the cost of implementing CSO controls will place a major burden on rate payers, particularly those least able to afford it.

A 20-year implementation schedule for the recommended control plan was developed based on the financial capability assessment and practical aspects associated with long linear construction operations. WASA identified several early action items where implementation can proceed without waiting for approval of the complete LTCP. Early action items include low impact development retrofits, rehabilitation and improvements at pumping stations, completion of sewer separation in Luzon Valley, and monitoring and regulator improvements along Rock Creek.

Water Quality Issues

Water quality assessment concentrated on bacteria and dissolved oxygen. The CSO control program is expected to significantly reduce bacteria concentrations in all receiving waters, and improve dissolved oxygen levels in the Anacostia River. However, current water quality standards will not be attained in Rock Creek and in the Anacostia River unless upstream point and nonpoint sources are controlled in conjunction with CSO control. The draft LTCP includes a suggestion to revise provisions in the current District of Columbia water quality standards to reflect the wet weather nature of CSOs. The LTCP meets the allocation requirements of the Anacostia TMDL for biochemical oxygen demand as published by the DC Department of Health (DC Department of Health, 2001).

References

DC Department of Health, 2001. *Biochemical Oxygen Demand Total Maximum Daily Load for the Anacostia River*. Washington, DC.

Delon Hampton and Associates (DHA), 1996. *CSO Abatement Program: Nine Minimum Control Compliance Report*. Prepared for WASA. Washington, DC.

Engineering Program Management Consultant (EPMC) III, 1999. *Combined Sewer System Nine Minimum Controls Summary Report - Draft*. Prepared for WASA. Washington,. DC.

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Community Case Study — Wheeling, WV—Region 3

Number of CSO Outfalls

259 (originally)
211 (currently permitted)
168 (reported by City)

Combined Sewer Service Area

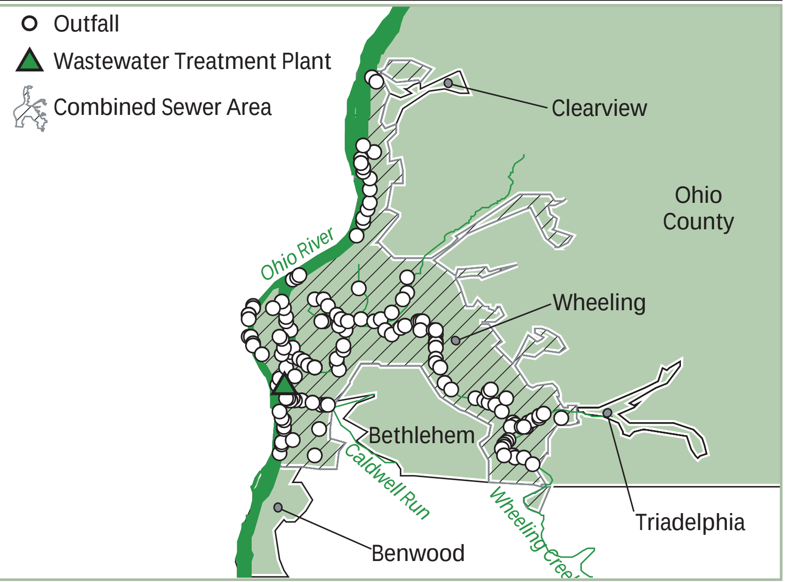
11 square miles

Wastewater Treatment Capacity

25 mgd (primary)
10 mgd (secondary)

Receiving Water(s)

Ohio River, Wheeling Creek, and Caldwell Run



Controls

- Proposed CSO control efforts focus largely on sewer separation projects at critical locations.
- The City of Wheeling has installed wire mesh traps to capture solid and floatable debris at key CSO outfalls.

Photo: Suspension bridge over Ohio River.
Courtesy of James Janos

Program Highlights

- 91 of 259 outfalls have been eliminated.
- The estimated capture of wet weather flows for treatment has increased from 25 percent to 40 percent.
- A declining population and a declining industrial and residential revenue base has led to reduced revenue for operation of sewer and wastewater facilities.
- Financial limitations of the city restrict expenditures to $1 million per year for sewer separation, but nearly $30 million is needed for priority CSO control projects.

Background on Wheeling CSOs

The City of Wheeling is located in the northern panhandle of West Virginia. The Wheeling Water Pollution Control Division (WPCD) operates a CSS that covers 7,040 acres, and a POTW with a secondary treatment capacity of 10 mgd. There are 168 CSOs in Wheeling.

The WPCD has made progress in implementing CSO controls in the face of several challenges. One challenge is steep topography. The City is surrounded to the north, east, and south by steep terrain, and it is bounded to the west by the Ohio River. The steep terrain on three sides results in rapid runoff to the CSS. As little as 0.1 inches of rain will cause flows received at the POTW to increase by three to four times their average daily flow, and CSOs begin to occur. Another challenge is that various components of the city's CSS date back to the mid-1800s, leading to substantial inflow and infiltration. Wheeling is also facing a declining population and a depressed financial condition. Ultimate compliance with water quality standards may be nearly impossible for the community unless the full benefit of the flexibility provided in the CSO Control Policy is utilized.

Status of Implementation

The WPCD has completed several CSO discharge characterization studies, has implemented the NMC, and has submitted an LTCP to the West Virginia Department of Environmental Protection (DEP) for approval.

System Characterization

Wheeling developed a *Conceptual Plan for the Analysis and Minimization of Combined Sewer Overflow Discharges* in1993. The plan outlined CSS deficiencies and prioritized subsequent CSO control activities. The plan was based on collection system analysis using SWMM and STORM models. At the time of this report, the annual percent capture of total flow entering the CSS was estimated to be 25 percent, with virtually 100 percent capture during dry weather flow conditions. In addition to the conceptual plan, Wheeling has also completed several studies in effort to characterize its CSO discharges, including:

- Analysis of water quality upstream and downstream of CSO discharges.
- Monitoring of rates and durations of representative discharges during rainfall conditions.
- Analysis of the quality of representative discharges.

Nine Minimum Controls

Wheeling developed its implementation plan for NMC in August 1996 (Smith Environmental Technologies Corporation, 1996). This plan was approved by the DEP and the Ohio River Valley Water Sanitation Commission (ORSANCO) in December 1996. The City has successfully demonstrated implementation of each of the NMC. Examples of activities conducted to fulfill the NMC requirements include:

- Daily inspection and maintenance of the collection system.
- Modification of CSO structures and sewer cleaning to maximize in-system storage.
- Installation of wire mesh traps for solids and floatables control.
- Maximization of flow to the WWTP (assisted by use of a CSO-related bypass).
- Flow monitoring and sampling.
- Development and distribution of educational and public notice materials.

Dry weather overflows continue to occur. These overflows are attributed to temporary blockages in the collection system, and to occasional surface water tie-ins that drain into overflow pipes. During dry weather conditions, the drainage from these tie-ins does not contact sanitary sewage flowing in the collection system. All observed dry weather overflows are immediately inspected when identified or reported, and blockages are removed.

Long-Term Control Plan

Wheeling submitted its LTCP on April 28, 2000 in accordance with their compliance schedule. The LTCP is under review by the DEP.

The proposed LTCP follows the demonstration approach. This is considered the necessary approach since the City cannot meet the 85 percent capture requirement of the presumption approach. Wheeling's draft March 2001 permit requires that, at a minimum, the LTCP must consist of continued maintenance and implementation of the NMC, provided there are no adverse water quality impacts. As part of its LTCP, Wheeling commits to the continued maintenance and implementation of the NMC.

The city submitted data (collected as part of the NMC requirements) to demonstrate no adverse impacts to receiving water quality due to CSO discharges. This data is presented in the 1998 report entitled *Evaluation of Small System CSO Discharges on Water Quality* (City of Wheeling WPCD and BCM Engineers, 1998). It includes more than four years of quarterly monitoring data collected during wet and dry weather periods at several points along the Ohio River and its tributaries, including locations upstream and downstream of CSO outfalls. Parameters sampled include: pH, hardness, ammonia nitrogen, total suspended solids, five-day biochemical oxygen demand, dissolved oxygen, oil and grease, fecal coliform, total coliform, lead, zinc, cadmium, and copper.

The city is also undertaking small sewer separation projects at critical locations, outside the scope of the proposed LTCP.

Costs and Financing

An April 2001 CSO Needs Survey for the City of Wheeling identified the most immediate capital needs for the Wheeling wastewater collection and treatment systems (GGJ Consulting Engineers, Inc., 2001). It was estimated that $29.5 million was needed to complete priority projects directly related to CSO control, including sewer separation projects at critical locations. An earlier 1989 engineering study estimated that complete CSO control could cost up to $350 million (in 1989 dollars).

Wheeling lacks the funds necessary to complete priority projects. The WPCD's annual budget of approximately $4 million is expended on existing O&M expenses and debt service. The WPCD and the City of Wheeling Economic and Community Development Department jointly expend approximately $1 million per year on priority sewer separation projects within the City. These separation projects have been on-going for more than 10 years.

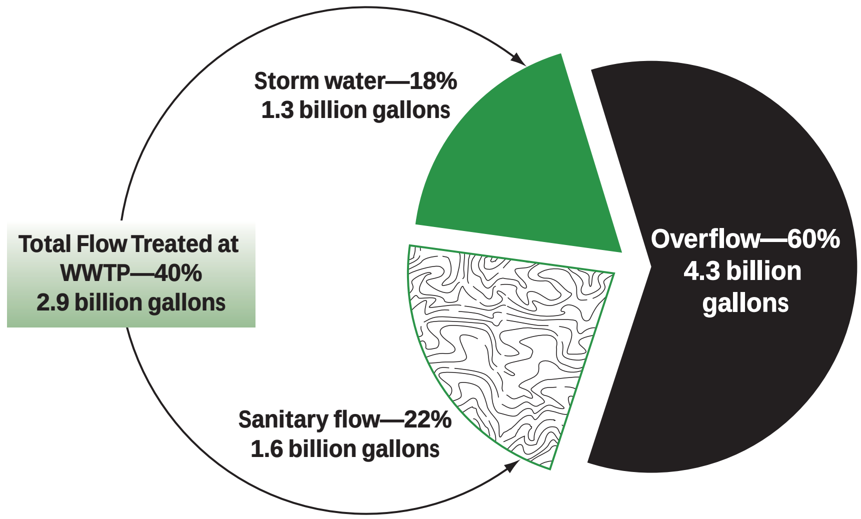
The industrial and residential revenue base is decreasing. The city's population declined by 70 between 1930 and1990. Between fiscal years 1999-2000 and 2000-2001, WPCD revenues decreased by more than five percent. The remaining population has limited resources to compensate for the losses. Approximately 17 percent of the city's population lives below the poverty line, and more than 25 percent are on a low or fixed income. Sewer rate increases have been pursued by the WPCD, but no increases have been enacted since 1995. Wheeling has made several requests for state and federal grant monies in recent years for their priority projects, but no grants have been provided to date. Additional revenue bonds and SRF loans are being considered to assist in raising funds.

Enforcement Issues

High river levels occur in the Ohio River during the winter and spring, due to runoff and operation of locks and dams by the Army Corps of Engineers. Backflow preventors on approximately 80 CSO outfalls along the Ohio River are not designed for high flow conditions. Consequently, a substantial amount of river water enters the CSS through approximately 80 CSO outfalls and is conveyed to the WWTP for treatment. This inflow of river water disrupts system operations related to biological processes. The result is WWTP permit effluent violations for biochemical oxygen demand, total suspended solids, and mass limits, even at lower flows. Plant operators do what is possible with treatment chemicals and system adjustments, but they are unable to fully address the problem. It will cost the City approximately $1 million for improvements to prevent the river inflow.

Results

Implementation of the NMC, sewer separation in priority areas, and other controls have increased the flow captured for treatment from 25 percent to 40 percent of the 7.2 billion gallons entering the CSS annually, as shown in the figure below.



The City has reduced the number of CSO outfalls from 259 to 168. This reduction includes 64 CSO outfalls that have been structurally modified to become inactive (i.e., plugged), and 27 CSO outfalls that have been eliminated through localized sewer separation.

References

City of Wheeling WPCD and BCM Engineers, 1998. *Water Pollution Control Division Evaluation of Small System CSO Discharges on Water Quality*. Report prepared for submittal to the West Virginia DEP. Wheeling, WV.

GGJ Consulting Engineers, Inc., 2001. *Capital Needs Improvement Project Review*. Report prepared for the City of Wheeling. Wheeling, WV.

King Campbell, Superintendent, City of Wheeling Water Pollution Control Division. Personal communication with Limno-Tech, Inc. staff on details of the combined sewer overflow plan and program. Summer 2001.