United States Environmental Protection Agency | Office of Water Washington, D.C. | EPA 832-F-99-041 September 1999

Combined Sewer Overflow Management Fact Sheet
Sewer Separation

DESCRIPTION

Sewer systems that convey both sanitary sewage and storm water through a single pipe are referred to as combined sewer systems (CSSs). In dry weather and during light to moderate rainfall, the CSS is able to convey all flows to the wastewater treatment facility. During periods of heavy rainfall, however, the capacity of the CSS may be exceeded, often causing untreated combined sewage and storm water to back up into basements and to overflow from manholes onto surface streets. Traditionally, CSS outfalls were designed to discharge directly into receiving waters during combined sewer overflows (CSOs). This was done to prevent the excessive combined flows from directly impacting public health via basement and street flooding.

In addition to flooding problems, CSOs can cause problems in receiving water bodies. CSOs can contain untreated domestic, industrial, and commercial wastes, as well as storm water runoff. Contaminants contributed by these sources include potentially high concentrations of suspended solids, biochemical oxygen demand (BOD), oils and grease, toxics, nutrients, floatables, pathogenic microorganisms, and other pollutants. CSO pollution has caused many receiving waters to exceed water quality standards, resulting in threats to public health, aquatic species, or aquatic habitat. CSO pollutants have impaired receiving water body uses and have contributed to restrictions on shellfish harvesting, occasional fish kills, and numerous beach closures. Potential odors and solids deposits in the receiving water body can also compromise aesthetics and limit recreational uses of the water body.

Many communities have studied and evaluated CSO control strategies that would effectively reduce, if not necessarily eliminate, CSOs and their associated health and ecological risks. One of the strategies often considered is sewer separation.

Sewer separation is the practice of separating the combined, single pipe system into separate sewers for sanitary and storm water flows. In a separate system, storm water is conveyed to a storm water outfall for discharge directly into the receiving water. Based on a comprehensive review of a community's sewer system, separating part or all of its combined systems into distinct storm and sanitary sewer systems may be feasible. Communities that elect for partial separation typically use other CSO controls in the areas that are not separated.

APPLICABILITY

Sewer separation can be considered wherever there is a CSS. However, an evaluation of the most appropriate CSO control should be performed prior to selecting sewer separation or any other measure. Sewer separation has often been the appropriate technology in areas where one or more of the following conditions exist:

- Most sewers are already separated;
- Siting constraints and costs prohibit the use of other structural measures;
- The uses and the assimilative capacities of receiving waters prohibit the use of other CSO controls;

- Other CSO strategies are not publicly acceptable;
- Additional infrastructure improvements, such as road repaving, are also required;
- The combined system is undersized;
- Elimination of CSOs is desired; and/or
- Other CSO measures are not able to achieve the community's goals.

Sewer separation has been used effectively in many communities. Most of the approximately 1,000 communities that are served by CSSs are located in the Northeast and the Great Lakes region. Complete or partial separation of CSSs has occurred in many of these areas, as well as in several locations in the West. Cities that have completely or partially separated CSSs include: Minneapolis, St. Paul, and South St. Paul, MN; the metro Detroit, MI, area; the metro Boston, MA, area; Salem and Portland, OR; the metro Seattle, WA, area; Lynchburg, VA; Bangor, ME; Hartford and Norwich, CT; and Remington, IN. Columbus, OH, has recently elected to separate its CSS as well.

One of the largest sewer separation projects occurred in Minneapolis, St. Paul, and South St. Paul, MN. The project involved pipe separation in more than 21,000 acres of drainage area. By December 1996, 189 miles of storm sewers and 11.9 miles of sanitary sewers had been installed. This program was needed to reduce the number of overflows that were estimated to occur an average of once every three days (*American City and County*, 1996). Overflows have been significantly reduced by this separation project.

ADVANTAGES AND DISADVANTAGES

Positive impacts resulting from sewer separation include: reduction or elimination of basement and street flooding; reduction or elimination of sanitary discharges to receiving waters; decreased impacts to aquatic species and habitat; decreased contact risk with pathogens and bacteria from domestic sewage in the receiving water; and relief from CSO regulations. In addition, incidental infrastructure work (e.g., road repaving and the repair or replacement of miscellaneous utilities, such as water and cable lines) could be conducted more cost effectively if it were to coincide with sewer separation. For example, as a result of the CSO program in the City of St. Paul, MN, streets were paved and handicap ramps were added to sidewalks, gas and water mains were installed, gas services were renewed or replaced, lead water service connections were replaced, and street lights were installed.

Separating CSSs may contribute to improvements to water quality due to the reduction or elimination of sanitary discharges to receiving water bodies. However, the increased storm water discharges resulting from sewer separation could decrease the positive impacts of the separation unless storm water discharges are mitigated. Without mitigation, increased loads of storm water pollutants, including heavy metals, sediments, and nutrients, may run off into local water bodies. For example, in Atlanta, GA, sewer separation was predicted to increase pollution to local creeks (AMSA, 1994) as polluted storm water previously reaching the treatment plants now is discharged directly into receiving waters. However, in many cases, separating sewers reduces pollution to receiving waters, as described above for St. Paul, MN. A second example of successfully reducing pollution to receiving water bodies has occurred in Juneau, AK. It has been reported that in Juneau, where there is in excess of 70 inches of precipitation a year, the storm water concentrations conveyed through the recently separated storm water sewers are rather dilute. This has also been attributed to large quantities of clean groundwater that infiltrate into the storm sewer, relatively clean activities within the watershed, and several non-point source pollution control programs within the City (City of Juneau, 1997). Existing and future storm water impacts to the receiving water body should be evaluated prior to implementing sewer separation.

Negative impacts associated with sewer separation include extensive construction and construction related impacts (e.g., noise, dust, erosion), disruption to residents and businesses, possible disruptions in sewer service, and the need for storm water controls or best management practices.

In addition, complete separation of sanitary and storm water flows can be hard to accomplish whether the combined sewer is converted to a storm sewer or to a sanitary sewer. Complete separation of a CSS would involve disconnection of all storm water drainage structures, sump pumps, and roof and footer drains. Disconnection of footer drains is often not cost effective. Some communities have offered financial incentives to homeowners and businesses for voluntarily disconnecting some of these storm water sources from sanitary sewers. Many communities have also passed ordinances requiring the disconnection. Despite these provisions, there is still potential for some storm water flows to remain connected to sanitary sewers. Likewise, complete disconnection of sanitary flows from a converted storm water sewer may be difficult to accomplish, but is usually more successful than eliminating all storm flow connections from connected sanitary sewers.

KEY PROGRAM COMPONENTS

Decisions for a CSO control strategy should be made on a site-by-site basis utilizing drainage area data, receiving water use and water quality data, and sewer system data. Sewer system information can be obtained from review of sewer plans, television inspection, and flooding records. Communities may consider performing house to house inventories of house connections to the combined system (i.e., sanitary and roof drains). This was successfully done in parts of the metropolitan Boston area. Modeling and Geographical Information Systems (GIS) may be useful data analysis and prediction tools.

Using these data, communities should determine what CSO controls, or combination of controls, will meet performance goals established by the community. Other factors, such as cost effectiveness, natural and urban topography and soil types, siting constraints, location of current and future utilities, land use and cover, existing sewer capacity, layout, and condition, pump and treatment plant capacities, and requirement for other infrastructure work in the same area, should be considered before finalizing project plans. For example, sewer separation was selected in Minneapolis, South St. Paul, and St. Paul, MN, due to local needs for eliminating sewage backups into basements, reducing street flooding, and reconstructing aging portions of the sewer system (MWCC, 1984).

Sewer separation can be accomplished through installing new storm or sanitary sewers to be used in conjunction with the existing sewer. Economics, capacity, condition, and layout of the combined sewer are the typical factors used in deciding the existing line's post-separation use.

An advantage of converting the combined sewer to a sanitary sewer (referred to as a converted sanitary sewer in this document) is that all sanitary flows are already connected to the converted sanitary sewer. Using the existing combined sewer as the sanitary sewer and installing a new storm sewer would likely require that any overflow weirs, gates, or other regulating devices remaining in the converted sanitary system be bulkheaded or otherwise disabled to eliminate the potential for sewage to overflow. In addition, storm water drainage structures, sump pumps, and roof drains must be disconnected from the converted sanitary system and connected to the new storm water sewer. This will provide more capacity in the converted sanitary sewer and will reduce the possibility of overflows. Building footer drains, however, are often left connected to the existing combined system and do consume some of the converted sanitary sewer capacity. Rehabilitation or relining of the converted sanitary system, storage tanks, and/or equalization basins may be required if infiltration is a significant problem due to cracks or inadequate construction materials (e.g., brick sewers). In some cases, such as in Juneau, AK, the existing combined sewer may be in such poor condition that new sanitary sewers, as well as new storm sewers, are constructed.

There are some circumstances that may make the conversion of the combined sewer to a storm sewer (referred to as a converted storm sewer in this document) more appropriate. For instance, combined sewers that have a large diameter and have little slope (less than 3 percent) would not have the flushing velocity required of a sanitary sewer. In cases such as this, the existing CSS may be more appropriately converted to a storm sewer, provided that the sewer has sufficient capacity for safe conveyance of the local design storm. A smaller sewer should be appropriately designed, sized, and constructed to convey the sanitary flows. Storm, roof, and footer drains, as well as catchbasins could remain connected to the converted storm sewer. Sanitary connections, however, would need to be disconnected and conveyed to the new sanitary line. Any remaining sanitary lines connected to the converted storm sewer will cause direct discharges of sanitary flows to the receiving water body. Post-separation sampling and monitoring of the converted storm sewer is typically required to confirm that all sanitary flows have been removed from the converted storm sewer and redirected into the sanitary sewer. Conversion of the combined sewer to a storm sewer would also require that the interceptor connection at the regulating device (e.g., weir or gate) be plugged, and may potentially require modifications to prevent water from stagnating upstream of the regulator.

Consideration should be given to coordinating sewer separation with improvements to other utilities, as this enhances the cost-effectiveness of both/all projects and minimizes disruption to the public.

IMPLEMENTATION

Sewer separation reduces and often eliminates untreated sanitary discharges from discharging into receiving water bodies, and therefore positively impacts receiving water quality. Sewer separation, however, greatly increases untreated storm water discharges to the receiving water body. In a CSS, at least some of the storm water flows are treated at the treatment plant. The performance achieved with sewer separation will vary depending on the existing storm water pollutant loading and the existing sanitary pollutant loading. For example, a study performed for North Dorchester Bay, MA, estimated that the overall fecal coliform removal potentially achieved by sewer separation was only 45 percent (Metcalf & Eddy, 1994). This was attributed to the increase in storm water discharges to the receiving water body, and the corresponding increase in non-point runoff pollutants.

Actual fecal coliform removal rates have been determined for several sites where sewer separation has been implemented. Water quality monitoring data collected in St. Paul and Minneapolis from 1976 to 1996 indicated a fecal coliform concentration reduction of 70 percent. One of the four sites where data was collected reduced fecal coliform concentrations from an average of 500 organisms per 100 mL to 150 organisms per 100 mL. At another site, fecal coliforms were reduced from 489 organisms per 100 mL to 143 organisms per 100 mL (Richman, 1996). This reduction has been attributed to sewer separation and to the reduction in the number of overflows occurring every year.

Sewer separation may also result in other related improvements to water quality. In stretches of the Mississippi, water quality improvements attributed to sewer separation projects have resulted in the return of the pollution-sensitive Hexagenia mayfly after a 30 year absence; the return of Bald Eagles to the area; and the recovery of fish populations and diversity from 3 species to over 25 species (Cities of Minneapolis, et. al., 1996).

Monitoring the performance of CSO control strategies at the Rouge River Demonstration Program has been underway since the summer of 1997. Part of the monitoring program will identify the effectiveness of sewer separation in terms of improvements to water quality. Instream monitoring is also occurring in Portland, OR. The supplemental data will add to the performance data collected in Minnesota (70 percent fecal coliform reduction) and estimated for Massachusetts (45 percent fecal coliform reduction).

OPERATIONS AND MAINTENANCE

The Operations and Maintenance (O&M requirements of separated sewers are generally the same as those of other sewer systems. Maintenance must be conducted on pump stations (including routinely cleaning wet wells, testing for adequate pumping capacity, and exercising pumps and stand-by generators), sewer lines, and catchbasins and grit chambers. Catchbasins and grit chambers located in the sanitary or storm sewer system will require routine cleaning to prevent accumulation of sediment. Jet spray cleaning, pumping, and vacuuming are common methods for cleaning catchbasins and grit chambers.

In addition, all sewer lines, and in particular sewers that were previously combined, need to be monitored to verify hydraulic capacity and to identify infiltration and inflow. Basement or street flooding is a likely indication of hydraulic capacity or gradient problems in the sewer and may require major repairs. Excessive infiltration into a converted sanitary sewer may require rehabilitation of the sewer system. Methods for assessing the condition of the sewers include modeling, smoke testing, and television inspection. Monitoring will identify cracked and collapsed sewers that will need to be repaired. In addition, monitoring can identify the location and cause of sewer blockages. To prevent blockages, lodged debris, sediment, and grit must be removed on a regular basis.

Post-separation monitoring and sampling may be required to ensure that no sanitary flows are still connected to the storm sewer and being directly discharged to the receiving water body. Alternatively, simple dye studies can be employed to verify separation.

COSTS

Separation costs vary considerably due to the location and layout of existing sewers; the location of other utilities that will have to be avoided during construction; other infrastructure work that may be required; land uses and costs; and the construction method used (e.g., open cut verses microtunneling). Communities that have other infrastructure requirements (such as road repairs) in addition to sewer separation may find that upgrading the facilities simultaneously can result in a much lower cost relative to upgrading them independently. Construction occurring in existing right-of-ways would probably not require land acquisition, and thus would not add to the project cost. Project costs could increase depending on the land use. For example, project construction occurring in an industrial area that contained hazardous materials or wastes would likely increase the project cost. Methods of construction, such as the need to tunnel or bore versus open cutting, can also add to the cost. Project costs could also increase if sanitary equalization basins are required as part of the separation project or if storm water best management practices are required to control the increased storm water discharges to the receiving water body.

Actual construction costs are available from the St. Paul sewer separation project. For that project, sewer separation costs ranged from $8,350/acre to$40,060/acre, with an average cost of $15,400/acre (all costs are in 1984 dollars). Estimates from the City of Portland and Detroit are $18,000/acre and $67,800/acre, respectively.

The Rouge River project has also generated good cost data for sewer separation. Costs were approximately $377,000 for separating approximately 600 meters of pipe on a small residential street (CSO Area 42, Windsor Avenue), which included costs for removing existing pavement, laying a new sewer line, and re-paving and re-sodding. A second project (CSO Area uing cost $1.3 million to separate approximately 2,600 meters of pipe. All costs are presented in 1995 dollars.

The cost of operation and maintenance (O&M) of the separated sewer system is difficult to predict. Factors contributing to the O&M costs include the age and the condition of the previously combined sewer, the length and diameter of the sewers, the frequency and the amount of sand and grit removed, and the size of drainage areas.

Sewer separation can reduce treatment and O&M costs at the receiving treatment plant by potentially eliminating storm water flows to the plant. Energy costs for transporting flows to the treatment plant could also be reduced due to the reduced flow volume.

REFERENCES

1. *American City and County*, 1996. "CSO Control Revitalizes Stretch of the Mississippi," pp. 31-32.

2. Association of Metropolitan Sewerage Agencies (AMSA), 1994. *Approaches to Combined Sewer Overflow Program Development*. Washington, D.C.

3. City and Borough of Juneau, Alaska, 1997. Personal Communication with Ernie Mueller with the City and Borough of Juneau, Public Works.

4. Metcalf & Eddy, 1994. *Final CSO Conceptual Plan and System Master Plan: Part II CSO Strategies*. Prepared for the Massachusetts Water Resources Authority. Wakefield, MA.

5. Metropolitan Waste Control Commission (MWCC), 1984. *MWCC Metro 201 Facilities Plan*. St. Paul, MN.

6. Cities of Minneapolis, Saint Paul, South St. Paul, and Metropolitan Council Environmental Services, 1996. *Separating Combined Sewers to Improve and Protect Mississippi River Water Quality: A Ten-Year Commitment. Annual Progress Report to the Public - Year Ten*. Minneapolis, St. Paul, South St. Paul, MN.

7. City of Portland, Oregon, 1997. Personal communication with Lester Lee, City of Portland.

8. Richman, M., 1996. "Sewer Separation Lowers Fecal Coliform Levels in the Mississippi River". Water Environment & Technology, Vol. 8, No. 11, pp 20-22.

9. Wade-Trim, 1997. Personal communication with Laura Crane, Wade-Trim.

ADDITIONAL INFORMATION

City of Columbus, Ohio
Laurie Mehl
Public Utilities, Division of Sewerage and Drainage
910 Dublin Road, Room 32
Columbus, OH 43215

Borough and City of Juneau, Alaska
Ernie Mueller
Department of Public Works
5433 Shaune Dr.
Juneau, AK 99801

Michigan City, Indiana, Sanitary District
Tim Haus
532 Franklin Street
Michigan City, IN 46361

City of New Haven, Connecticut
Raymond Smedberg
Water Pollution Control Authority
345 East Shore Parkway
New Haven, CT 06510

City of Portland, Oregon
Lester Lee
City of Portland Bureau of Environmental Services
1211 Southwest 5th Avenue, Suite 800
Portland, OR 97204

Rouge River Demonstration Project
Vyto Kaunelis
Wayne County Department of Environment
415 Clifford Street, 7th Floor
Detroit, MI 48226

City of Saco, Maine
Larry Nadeau
Department of Public Works
300 Main Street
Saco, ME 04072

City of St. Paul, Minnesota
Mike Kassan
Sewer Utility, Department of Public Works
1000 City Hall Annex
St. Paul, MN 55102

The mention of trade names or commercial products does not constitute endorsement or recommendation for the use by the U.S. Environmental Protection Agency.

For more information contact:

Municipal Technology Branch
U.S. EPA
Mail Code 4204
401 M St., S.W.

OWM MTB
Excellence in compliance through optimal technical solutions
MUNICIPAL TECHNOLOGY BRANCH