4.0 Alternatives Evaluation

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4.1 Introduction

This section describes specific CSO control alternatives the City of Indianapolis considered in developing its CSO long-term control plan (LTCP). Section 3 discussed the city's evaluation of available control technologies that act to reduce or mitigate CSO discharges. This section discusses how the city combined the most viable CSO technologies into systemwide plan alternatives and how those alternatives were compared and evaluated against each other to identify a preferred plan. Indianapolis will implement a number of CSO control technologies tailored specifically for its advanced wastewater treatment (AWT) plants, sewer system, and waterways. Alternatives selected will be prioritized and phased in over time, as described in Section 7. The performance and cost estimates provided in this section are based on standard engineering practices. As improvements are brought online, the city will evaluate their effectiveness and reassess and modify subsequent phases of the program as needed. The city may determine that one technology performs better than expected, thus reducing the need for storage volume or additional treatment technologies in a later phase of the program.

4.2 Evaluation Factors

During evaluation of LTCP alternatives, the City of Indianapolis considered the following factors:

- Cost-effectiveness,
- CSO control goals,
- Regulatory compliance, and
- Community input.

4.2.1 Cost-Effectiveness

CSO controls represent the city's largest public works investment ever, and will place a significant financial burden on Indianapolis residents. As with any city project, the CSO program must be designed to achieve the greatest benefits with the lowest reasonable cost. Therefore, reasonable and realistic cost estimates for CSO projects were evaluated against each project's ability to meet city goals, regulatory requirements and citizen concerns. Using standard cost-performance analyses, the city evaluated the cost-effectiveness of CSO control alternatives to identify the optimum control alternative for improving water quality, protecting public health, and meeting regulatory requirements. The city also conducted a financial capability analysis (based upon U.S. EPA guidance and local and state-based measures of fiscal stress) in order to determine the financial impact of CSO controls on ratepayers. This analysis is presented in Section 6.

4.2.2 CSO Control Goals

The city's goals for addressing combined sewer overflows in the long-term control plan include controlling solids and floatables caused by combined sewer overflows; capturing "first flush" discharges; and meeting state and federal requirements for dissolved oxygen (DO) and bacteria. The selected CSO control program will control solids and floatables, capture the first flush, and meet DO requirements. However, the city's modeling and analysis has shown that even if all CSOs were immediately eliminated, waterways still would not meet the state's current water quality standards for bacteria at all times. While CSOs are the most significant source of bacteria in Indianapolis streams, bacteria exceedances are also caused by many other factors, such as failed septic systems, upstream pollution, urban stormwater runoff, and sewer infrastructure problems such as breaks and backups that must be repaired. Cost-effectiveness was a major factor in evaluating the bacteria benefits of CSO control alternatives, as described below.

4.2.3 Regulatory Compliance

The city evaluated CSO controls for their ability to meet both water quality-based and technology-based requirements under the Clean Water Act. In order to identify the optimum CSO control program, the city considered Indianapolis's unique conditions, and evaluated the effectiveness of various control alternatives and strategies, as required by state and federal law.

CSO controls must be designed to comply with discharge requirements in the city's National Pollutant Discharge Elimination System (NPDES) permits and with water quality standards and regulations developed under the Clean Water Act. These requirements include in-stream water quality

standards for dissolved oxygen, *E. coli* bacteria and other pollutants that might be related to CSO discharges. NPDES permit limits will have a significant impact on the cost of the city's CSO control program. Later in Section 4, there is discussion on the need for an NPDES permit modification to accommodate planned improvements to wet-weather treatment at the Belmont AWT plant. Improvements to the Belmont and Southport wastewater treatment facilities are an integral part of the city's long-term control plan.

4.2.4 Community Input

In addition to meeting state and federal regulatory requirements, the long-term control plan must be designed to be responsive to community input. Indianapolis has conducted an extensive process to gather citizen ideas and opinions on CSO controls. A Raw Sewage Overflow Advisory Committee appointed by Mayor Bart Peterson issued a number of recommendations in 2000 after reviewing public input. Details about the city's public outreach programs, the Raw Sewage Overflow Advisory Committee and Wet Weather Technical Advisory Committee are documented in Section 5.

The city considered comments received via letter, the Web site, and during numerous public meetings, meetings with the Wet Weather Technical Advisory Committee, and other organizations in Indianapolis. In 2004 the city conducted a series of public meetings and discussions with stakeholders on sewage overflow control options. Issues of importance to the community have been factored into the control plan and schedule in Section 7.

4.3 Source Control Measures

The city evaluated a number of structural and non-structural source control measures to determine their ability to help reduce the water quality impacts of CSOs and other non-point sources of pollution in Marion County. These source control measures include:

- Industrial pretreatment program
- Stream bank restoration
- Sewer service for unsewered areas
- Stormwater control and management
- Infiltration/inflow abatement
- Pollution prevention
- Sewer separation
- In-line storage
- Watershed coordinator / riverkeeper

4.3.1 Industrial Pretreatment Program

One of the Nine Minimum Controls required of CSO communities is a review and possible modification of industrial pretreatment requirements. According to U.S. EPA's May 1995 Guidance for Nine Minimum Controls:

> "The objective of this control is to minimize the impacts of discharges into [combined sewer systems] from nondomestic sources (i. e., industrial and commercial sources, such as restaurants and gas stations) during wet weather events, and to minimize CSO occurrences by modifying inspection, reporting, and oversight procedures within the approved pretreatment program."

While approximately 45 percent of significant industrial users (SIU) in Indianapolis are physically located outside the CSO area, the wastewater discharged from most SIUs eventually passes through the combined sewer system. Therefore, the city's pretreatment requirements can impact the pollution entering streams from CSOs.

Since Indianapolis began its pretreatment program in 1985, it has recorded substantial improvement in the quality of industrial wastewater discharged to the Indianapolis municipal sewer system. The discharge of some heavy metals has been reduced by as much as 90 percent from 1988 levels. Industries have made significant improvements in implementing strategies to reduce loadings from their facilities.

The city's long-term control plan will significantly reduce the frequency of overflows and, therefore, any industrial impacts on the streams. During LTCP implementation, the city will work to minimize SIU impacts through the policy described in Section 4.3.1.2. Following full implementation of the LTCP, SIU impacts are expected to be insignificant in relation to the types of storm events causing overflows.

4.3.1.1 Potential Industrial Pretreatment Program Improvements

Indianapolis evaluated a number of alternatives for mitigating the effect of CSO discharges containing industrial wastewater. Each alternative was evaluated for its feasibility, benefits, and the potential burden on industrial users. The alternatives considered by the city are described briefly below:

Decrease Flow: During impending or actual wet-weather events, industrial users would be notified to limit the amount of wastewater discharged to the sewer system. This alternative requires specific knowledge of the CSO structures affected, their location within the sewer system, the industries contributing to that sewer segment, prompt notification to the affected industrial users, and re-notification to allow normal operations to resume. Impacts to be considered:

- Not feasible for all industries to shut down or modify production or manufacturing activities to limit flows.
- May be applicable to some batch-type processes or groundwater remediation wells.
- Industry reaction time will vary.
- Length of the flow limitation period may be limited due to flow or space availability.
- Potential adverse impacts on the base load to the AWT plants could upset the biological treatment systems.
- Additional costs to industry for shutdown, startup or modification of production processes. Impact on economic development due to flow limitation requirements during wet weather.

Hold All Flows: During storm events or known CSO activity, industries would be required to terminate all processes generating wastewater to the sewer or to hold and store wastewater during the CSO event. This alternative would require shutdown of industrial activity or construction of a holding basin, pond or tank. The same notification procedures would be necessary as described in the "decrease flow" alternative. Impacts to be considered:

- Not feasible for all industries to shut down or modify production or manufacturing activities to limit flows.
- May be applicable to some batch-type processes or groundwater remediation wells.
- Releasing held flows could cause higher peak loads to the AWT plants, potentially upsetting the treatment process.
- Would require structured release from industries to reduce peak load following a storm event.
- Increased cost to industries to construct holding facilities

Divert Strong Flows: Industries would be required to hold and store only those flows that could have an impact on the quality of water discharged during a CSO event. A comprehensive evaluation by the city of all separable flows at each industry would be necessary to identify those waste streams to be held during wet weather. Notification procedures would be required. Impacts to be considered:

- Similar impacts to "Hold All Flows" alternative.
- Would require segregating, quantifying and designating flow streams to isolate "high strength" waste streams.
- Significant cost to city and industry.
- Potential severe impact on base load at AWT plants, possibly upsetting the biological treatment systems.

Eliminate Clear Water Flows: Determine the presence of any clear water or uncontaminated waste streams being discharged to the sewer and require their elimination from the system. These waste streams would consist mainly of non-contact cooling water, foundation sumps, and other collected clear water. However, this alternative could increase concentrations of some pollutants and make it difficult to meet NPDES permit limits at the wastewater treatment plants. Impacts to be considered:

- Ability to meet NPDES permit limits.
- Increased cost to industry to implement.
- Availability of alternative discharge locations (storm sewers or drainage ways).
- Potential for negative water quality impacts on streams.

Flow Reduction/Zero Discharge: Industries would be encouraged to investigate measures for flow reduction or zero discharge. Because these alternatives tend to be costly, some type of incentive program would be necessary. Impacts to be considered:

- Loss of significant baseflow and load to AWT plants.
- Increased cost may force industry to look at other options (such as relocation outside of Marion County).

Upgrade Pretreatment: Industries could be required to install and/or upgrade pretreatment equipment to further improve the quality of discharge to the sewer. This could be particularly useful for any target pollutants identified as a water quality concern during CSO events. Impacts to be considered:

- Removal of AWT plant base load.
- Increased cost to industry.
- May require incentives to implement.
- Would likely impact industries disproportionately depending on pollutant types and concentrations in their discharges.

Revise Pretreatment Limits: For targeted pollutants, effluent limitations promulgated in Chapter 671 of the Indianapolis regulations could be revised to reflect the reduction necessary to protect the water quality of the CSO receiving stream. This could include not only toxins, but also oxygen-demanding pollutants, floatables, and solids. Impacts to be considered:

- Removal of AWT plant base load.
- Increased cost to industry.
- May require incentives to implement.
- Could likely impact industries disproportionately depending on pollutant types and concentrations in their discharges.

Reroute Industrial Discharges: In some cases, industrial discharges might be rerouted to a separate sewer system or possibly a new CSO relief interceptor. Routing industrial flows to a CSO relief interceptor would eliminate industrial contributions to wet-weather overflows by directing flows to the city's proposed deep tunnel. However, the interceptor would need to be designed with a downstream diversion structure that would send dry-weather flows to the treatment plants instead of the tunnel. A separate sewer for industrial flows could also be constructed to eliminate industrial impacts on overflows. Impacts to be considered:

- Need to configure CSO relief interceptors to send industrial flows to treatment plant during dry weather.
- Increased cost to reroute plant flows and/or construct connector sewers.

Increase Sewer Rates/Fees: Although not a solution per se, an increase in sewer discharge fees would generate additional revenue to fund the cost of CSO improvements, but also may create an incentive for users to reduce discharge volume. Since a major portion of sewer revenues are collected from industrial users, Indianapolis must be cautious about rate increases that might cause industries to either move production out of Indianapolis or install their own treatment systems. Either sceanario would reduce industrial revenues needed to pay for system improvements. Impacts to be considered:

- Increased cost to industry.
- Impact on economic development.
- Large increases could cause industries to relocate to another community, thus placing a greater burden on residential ratepayers.

4.3.1.2 Pretreatment Permitting Policy

In January 2005, the city issued the *Office of Environmental Services Industrial Pretreatment Permitting Policy and Process*. The document describes how the city made decisions during LTCP development on new or increased discharges by the industrialized community in the CSO area. It was developed in consultation with the city's Industrial Dischargers Advisory Committee (IDAC). This process, which was necessary for clarification during LTCP development, will be revised and re-evaluated as CSO controls reduce or eliminate industrial impacts. The city's decision-making process includes reviewing several factors, such as:

- The number of CSOs between the discharger and the treatment plant
- The frequency of discharges from affected CSOs
- The magnitude of discharges from downstream CSOs (overflow volume/year)
- The potential magnitude of pollutant load from CSOs
- Stream reach characteristics (recreational use and low flow levels)
- Conventional pollutant parameters found in the affected CSOs (BOD, TSS and other)

If a permit application raises major concerns across multiple factors, modifications to reduce CSO impacts may be required. This will include a review of potential solutions with the discharger, including:

- What is physically possible to reduce impacts on CSOs (holding, diverting, treating, or redirecting flows)
- Economic feasibility of various options to the discharger, city or others
- Whether the discharge can be piped or redirected around the CSOs
- Treatability at the city's advanced wastewater treatment plants, including capacity, economic feasibility and physical feasibility

The city evaluates these factors on a case-by-case basis, looking for opportunities to minimize potential wet-weather impacts from industrial dischargers, where feasible. Examples of recent city decisions include:

Indianapolis International Airport: The airport's pretreatment permit allows the discharge of de-icing pond fluids into the city's sewer. The permit requires in-sewer monitors to measure the level of flow in the receiving interceptor. At

80 percent of a pre-determined capacity, the airport is required to cut off flows to the system. At 70 percent, the airport can again discharge into the system.

Indianapolis Water: The city agreed to allow the former Indianapolis Water Company to discharge its alum sludge into the sewer system, but required them to build 10 days of holding tank capacity at the Fall Creek and White River plants. Both the Fall Creek and White River discharges by the Water Company are no longer permitted.

Central Library: The Indianapolis-Marion County Public Library wanted to discharge 5-11 mgd of groundwater into the combined sewer system during construction at its Central Library downtown. To reduce combined sewer impacts, the library was asked to construct a 16-inch force main that took the discharge to a storm sewer near Interstate 65.

Rolls Royce: The company asked to discharge 30,000 gallons per day from remediation lagoons into the sewer system. The city asked Rolls Royce to have capacity to hold flows during wet weather and the company agreed. Rolls Royce receives notifications of CSO overflows and is required to hold flows during those times.

Table 4-1
Prioritized Significant Industrial Users by Discharge Volume

Significant Industrial Users	Discharge Volume (gallons/day)
National Starch	2,799,000
Eli Lilly - LTC	1,581,800
Quaker Oats	617,000
Covanta Indianapolis	518,250
Indianapolis International Airport	500,000
U.S. Filter Corp.	429000
Hebrew National Kosher Foods	340,000
Reilly Industries - Remediation	325,000
Reilly Industries, Inc.	290,000
Ecological Systems, Inc.	255,000
Citizens Thermal Energy	241,000
Crossroads Dairy	207,000
Citizens Gas & Coke	206,000
Quemetco, Inc.	201,800
Pepsi Americas	192,110
Cintas Corp.	180,000
Industrial Anodizing Co., Inc.	171,200
Metalworking Lubricants Co.	161,400
HH Sumco, Inc.	154,500
Visteon Corp.	151,000
Sensient Technologies, Inc.	138,000
Colors, Inc.	128,810
ConAgra	128,600
Alsco, Inc.	124,500

The city's long-term plans seek to provide sufficient capacity in the sewer system and treatment plants to accommodate industrial, commercial and residential growth. Where possible, industries are encouraged to consult with the city in advance when major increases in flow or load are anticipated, so the city can incorporate these plans into its capital improvement program budget and schedule, if necessary. In some cases, industry may be asked to provide capital funds to build projects necessary to address industry's needs and the needs of affected streams.

4.3.1.3 Priority Industries

The Indianapolis Pretreatment Program regulates the discharges from approximately 200 industries. Among the regulated users, there are several specific facilities and/or types of industries that could have a significant impact on the volume and characteristics of flow through a CSO structure. **Table 4-1** shows the 24 significant industrial users with daily discharge flows greater than 100,000 gallons per day (gpd). Values are based upon daily averages from 2003 self-reported industry flow monitoring. **Table 4-2** prioritizes some of these industries based on four specific pollutants

Table 4-2
Prioritized Significant Industrial Users Based on Pollutant Parameters

Ammonia
Eli Lilly and Company
Reilly Industries
Citizens Gas and Coke Utility
Heritage Environmental Services
Micronutrients, Inc.

Biochemical Oxygen Demand
National Starch and Chemical
Eli Lilly and Company-LTC
Reilly Industries
Indianapolis International Airport
Quaker Oats Company

Total Suspended Solids
National Starch and Chemical
Citizens Gas and Coke Utility
Crossroad Farms
Heritage Environmental Services
Pepsi Americas

Metals
Metalworking Lubricants Co.
Precision Metal Cleaning
Heritage Environmental Services
Diversified Systems, Inc.
South Side Landfill, Inc.

of concern. Approximately 10 facilities discharge the majority of the industrial contribution for biological oxygen demand (BOD), total suspended solids (TSS), and ammonia.

Most facilities discharging heavy metals to the city sewer system are required to meet stringent federal standards. Section 2.9 discusses the methodology the city used to characterize significant industrial discharges with toxins identified in their waste stream. This EPA-approved analysis is limited due to its theoretical nature, but was useful for `prioritizing stream segments for CSO control.

The city will continue to address toxic pollutants at the source or in the planning of CSO projects. The city also will continue to work with IDAC and individual industries on any modifications to its pretreatment program.

4.3.2 Stream Bank Restoration

Water quality throughout the nation has improved following implementation of the Clean Water Act; however, in recent years, researchers have noticed that overall water quality in the nation's streams, lakes and rivers appears to have reached a plateau. Researchers have targeted non-point source pollution as the cause of this plateau, and linked the primary sources either directly or indirectly to human activity. To continue improvement in water quality, the U.S. EPA Office of Water has recommended ecological restoration (U.S. EPA, 1996). The goal of restoration is to protect remaining natural features, reclaim culturally disturbed areas to more of a natural state, and improve stream quality through stakeholder volunteer activities and cooperation. Such restoration techniques reduce non-point source pollution, improve overall stream quality, and can be implemented concurrent to the hard structure approaches that target point-source discharge reduction.

By restoring stream banks and habitats, the city can reduce non-point source pollution. While restoration techniques cannot fully preclude installation of hard structure CSO controls, they may reduce the number and/or size of the hard structures and can enhance the quality of a stream once CSOs have been reduced. The ability of a landscape to perform and sustain natural functions such as conditioning the air and water is heavily dependent upon the ecological health of a region (Patchett and Wilhelm, 1997). By 1876, 60 percent of the land in Marion County had been cleared of its original forests and by 1999, less than two percent of land area contained natural forest structure and species composition (Brothers, 1994), (Mertz and Miller, 1999).

As Marion County was deforested, runoff increased, since the extensive forest no longer intercepted rainfall. As runoff increased, groundwater infiltration decreased, reducing base flow to the streams. As early as 1897, Ryland Brown was writing that the residents of Marion County had never seen streams flood to the levels that they were reaching at the time, nor did anyone remember stream flow being so low during the summer months. Brown wrote that it was believed that the changes in stream flow were in response to the clearing of all the trees. Following the initial clear cutting of Marion County's forests, hydrologic modification continued with extensive drainage improvements, including many miles of field tile to increase the amount of tillable land. This change further increased runoff and decreased infiltration by eliminating depressional storage, or surface ponding, in many areas.

Hydrology of Marion County streams also is affected as the urbanized, developed portion of the city continues to expand, with a resultant increase in the percentage of impervious cover in the county. Impervious cover can be broadly defined as the sum of roads, parking lots, sidewalks, rooftops, and other impermeable surfaces of urban environments (Center for Watershed Protection, 2000). The hydrologic response to increased urbanization is the same as seen for the initial deforestation and agricultural drainage: increased runoff and decreased groundwater infiltration. The impact on urban streams can be seen in both the deepening and widening of the stream channel to adjust to the increased peak flows, and in the decline in water quality that can be attributed to urban stormwater. These impacts were described earlier in Section 2.

The impact of urban stormwater on Indianapolis' streams is apparent in that CSO controls by themselves would not achieve any additional days of compliance with the *E. coli* daily maximum bacteria standard, as described later in Section 4.6. Dry weather and stormwater sources would still cause exceedances of water quality standards approximately 157 days per year in the White River with CSO controls (ICST, 2004). Therefore, watershed improvements, riparian habitat restoration and stream bank restoration programs are important to enhancing the water quality in Indianapolis' streams.

The forested corridors along the headwaters may have the greatest impact on downstream water quality. In most watersheds, the first- through third-order streams constitute over 90 percent of the lineal stream length (Alliance for the Chesapeake Bay, 1998). A natural riparian forest structure removes nutrients and sediments, and lowers water temperatures before the stream reaches a main third-order

channel (USFS, 2000). Some of the core functions of the riparian forest are as follows:

Sediment Control: "The roots of trees hold together the soil to resist the erosive force of water. This keeps sediments and nutrients bound to it, out of the stream." (Alliance for the Chesapeake Bay, 1998)

Habitat Biodiversity: "Roots and fallen logs slow stream flow and create pools that form unique microenvironments. Pools support species of macro-invertebrates different from those in riffles only a few feet away. Fallen debris also traps leaves, twigs, fruit seeds and other material in the stream, allowing it to decay and be used by stream-dwelling organisms." (Alliance for the Chesapeake Bay, 1998)

Food: "The two primary sources of food energy input to streams are litter-fall (leaves, twigs, fruit seeds, and other organic debris) from streamside vegetation and algae production. Recent studies have shown that in a healthy stream, leaf litter is trapped and consumed in a relatively small area, rarely moving more than 100 yards; therefore, an upstream forest provides little food to a non-forested area downstream." (Alliance for the Chesapeake Bay, 1998)

Temperature Control: "The leaf canopy of trees provides shade that helps to control water temperatures. Maximum summer temperatures in a deforested stream may be 10-20 degrees warmer than in a forested stream. Temperature changes of only 4-10 degrees usually alter the life history characteristics of macro-invertebrates that form an important part of the food web." (Alliance for the Chesapeake Bay, 1998)

"In addition, shaded streams support algal communities dominated by diatoms — a type of algae favored by many species — throughout the year while areas getting more sunlight are dominated by filamentous algae. While crayfish and a few insects will consume filamentous algae, most macro-invertebrate species cannot because they have evolved as specialists for scraping diatoms from the bottom. Where the tree canopy completely covers the water surface, this area will have the greatest impact on improving habitat along the stream, providing maximum control over light and temperature extremes. The dissolved oxygen rates go up in shaded areas of the stream. In addition, in shaded areas the algae concentrations from abnormally high nutrient levels do not bloom as much, hence nighttime dissolved oxygen rates drop less dramatically." (Alliance for the Chesapeake Bay, 1998)

Restoration activities conducted by the city have been ongoing since 1995 and have included wetland rehabilitation, reforestation, prairie establishment, native plant landscaping and management of high quality natural areas. **Figure 4-1** shows restoration projects that were occurring in 2004 along a number of Marion County streams. Such restoration activities are beneficial not only in terms of aesthetics, but can serve as a basis for creating an effective and sustainable watershed protection program for the region. In order to develop such a program, it is important to consider not only the environmental factors but the economic and cultural impacts of various plans as well.

Stream bank restoration could occur in city-owned parks and greenways, or along private land through long-term or perpetual easements developed in partnership with landowners. Research shows that restoration along smaller headwater streams and drainage corridors yields the most benefit in improved water quality, followed by mid-size streams. The key to successful restoration is prevention. It is much easier to protect and manage an existing streamside forest buffer than to attempt to reforest a streamside lawn. The city is developing a watershed-based strategy for restoring stream banks and protecting natural areas that contribute to better water quality.

Restoration sites could be selected based on the following criteria:

1) Sites that have existing high quality natural areas,
2) Sites that would best accomplish clean water initiatives and/or habitat restoration,
3) Sites that meet public needs for wildlife observation and other passive recreational uses,
4) Areas where restoration is most likely to be successful, and
5) Areas where restoration could be conducted as part of an existing capital improvement program.

Restoration projects should be designed to require little maintenance as they mature. Projects also could enlist the help of volunteers, including students, conservation groups, religious organizations, scouting groups, business/corporate groups, and others.

4.3.3 Sewer Service for Unsewered Areas

Indianapolis has the second-highest concentration (10.3 percent) of homes served by septic systems among U.S. cities (Indianapolis Star, 1996). Jacksonville, Florida, another unified city-county government, was first with 24.1 percent

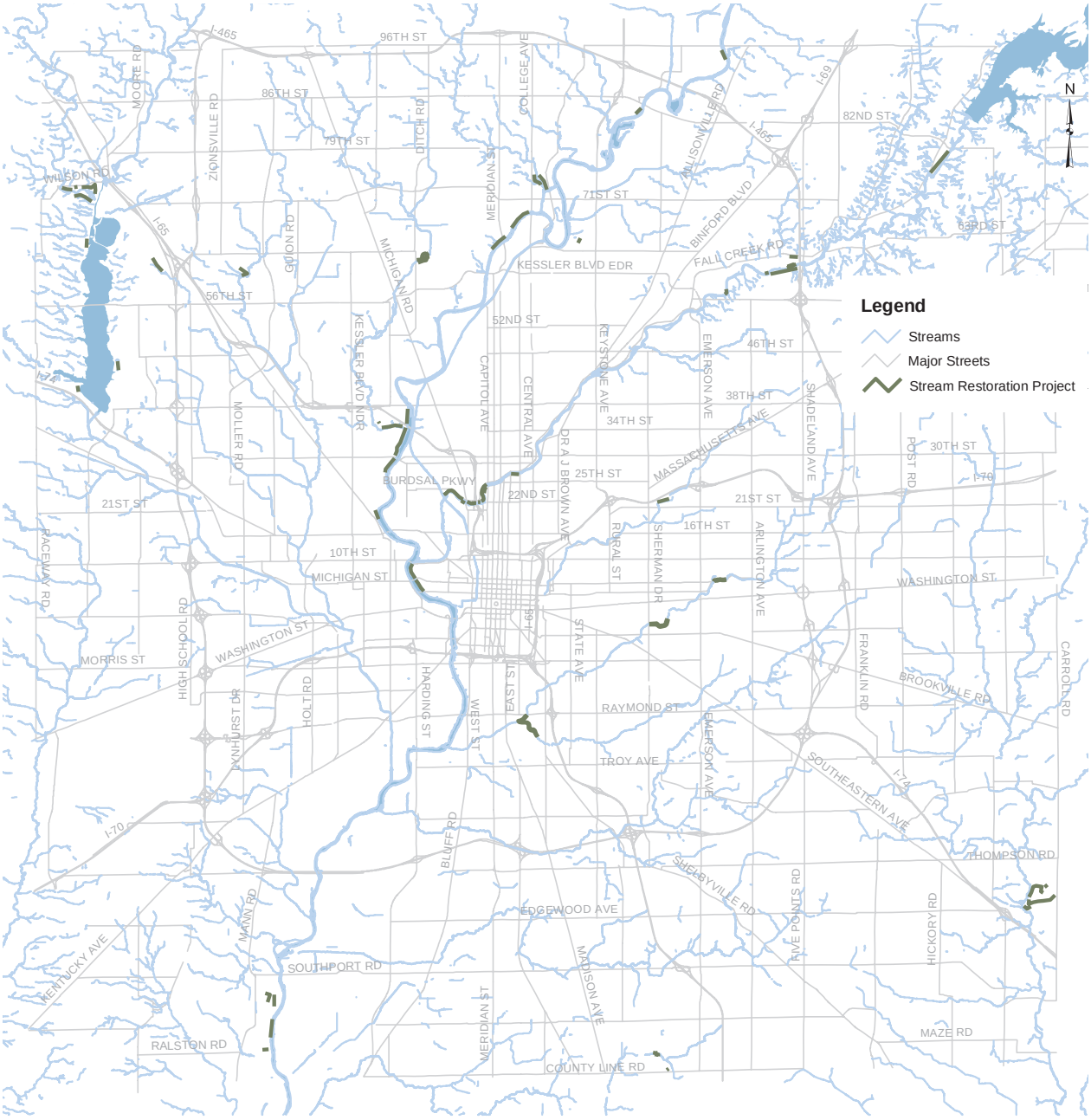


Figure 4-1
Stream Restoration Projects from 1994 through 2004

of homes served by septic systems (Indianapolis Star, 1996). Of the 320,000 homes in Marion County, approximately 18,000 are served by septic systems that were targeted for replacement in the 1998 Barrett Law Master Plan. Since the implementation of the Barrett Law Master Plan, another 12,000 properties served by septic systems have been identified that cannot be readily addressed by consolidated sewer service projects. Failed systems leach bacteria into local ditches and streams and could contaminate groundwater wells used for drinking water. In the early 1980s Purdue ran the RWASTE program on all of the soil profiles found in Indiana. According to the site selection criteria in the ISDH rule at the time, 80 percent of the land area in Indiana was unsuitable for conventional septic systems (Purdue, 2000). More recent work by Bill Hosteter of the Natural Resource Conservation Service suggests that approximately 93 percent of the soils in Marion County would have severe limitations for septic systems (Purdue, 2000).

In 1996, a Department of Public Works study (Ambient Bacteriological Study of the White River and its Tributaries) noted that most tributaries in Marion County exceed the *E. coli* standard during dry weather 20 to 40 percent of the time, or more. Pogues Run, Bean Creek, Crooked Creek, and State Ditch exceed the standard more than 60 percent of the time, the study said. Because these exceedances often occur during dry weather, combined sewer overflows could not be the cause. One factor in these exceedances is likely to be failing septic systems.

Historically, Indianapolis has used the 1905 Indiana Barrett Law to fund sanitary sewer extensions into unsewered areas. Under Barrett Law, local governments charge or assess impacted property owners the costs associated with these construction projects. Construction costs include the installation of the main trunk line to the neighborhood, a lateral stub-out to each property line, mobilization and demobilization of equipment, maintenance of traffic and restoration.

Since 2000, the city has worked to make the Barrett Law process less burdensome for homeowners by allowing monthly instead of yearly payments and allowing property owners to finance the project over 10-, 20- or 30-year periods. However, the expense of paying for the Barrett Law assessments are burdensome for many property owners, especially the elderly and those with fixed or low incomes.

For these reasons, the city has decided to change its policy and begin paying the costs of public sewer construction in neighborhoods on septic systems. Under the Septic Tank Elimination Program, property owners still will be responsible for costs of construction on private property, including the cost of connecting their home or business to the new sewer and shutting down the septic system. Property owners who still owe assessments under the old Barrett Law system will stop making payments. The city will primarily finance existing and future projects through its sanitary sewer revenues. An affordable loan program is being created to help qualified homeowners finance private property costs associated with septic conversion projects.

The city has prioritized 161 unsewered areas for conversion to sewers. The master plan ranks each area based on the following criteria: septic failure rate, stream bacteriological impairment, wellfield protection, presence of residential wells, proximity to greenways, petitions from residents or Marion County Health & Hospital Corp., number of residents in favor of the project, cost, downstream capacity, correlation to drainage projects, and areas tributary to combined sewer overflows. The project priority matrix is included in **Appendix C**. The project priority list is periodically reviewed and projects are re-prioritized based on changes in conditions or the need to coordinate the installation of a new sewer system in a neighborhood with other street or utility work that occurs.

The additional dry-weather flow generated from the 18,000 homes in the master plan is projected to be approximately 4.9 mgd. The two AWT plants, as currently designed, have sufficient dry-weather capacity to treat this projected additional flow, as discussed later in this section.

The conversion of septic tanks to sanitary sewers will allow for noticeable water quality improvements, particularly during dry weather. As the city evaluated CSO controls, it also prepared cost-benefit analyses comparing the bacteriological, human health, and receiving stream costs and benefits of sewering unsewered areas in designated priority areas. Elimination of these septic systems in the county would reduce both the bacteria levels and duration of contamination to the streams. The city estimates that sewering these priority areas would reduce exceedances of the *E. coli* bacteria daily maximum standard of 235 cfu/100 mL in the White River from 178 days per year to 172 days per year. For Pleasant Run the improvement is greater, reducing the days of exceedance from 215 days per year to 126 days per year. The improvements in the other tributaries would be similar to Pleasant Run. The ability to meet the *E. coli* standard is limited by the impact of stormwater on the streams. However, failing septic systems are a significant dry-weather source of *E. coli* bacteria to Marion County streams. Sewering these areas also will reduce harmful pathogens and bacterial contamination in yards, neighborhood ditches and streams, where people — and especially children — are more likely to come in contact with contaminated water.

4.3.4 Stormwater Control and Management

Stormwater makes up the greatest volume of CSO discharges, making the retention of stormwater a critical component of CSO controls (Metcalf and Eddy, 1991). Poor stormwater control in portions of the county can contribute to CSO discharges in the central portion of the city. In areas with poor stormwater control, standing water may increase inflow and infiltration (I/I) of clear water into sanitary sewers, thereby making the sanitary system the de facto drainage system. A number of sanitary sewers feed into the combined sewer network. I/I may contribute to sewer service problems including manhole surcharging, basement backups, decreased downstream interceptor conveyance capacity, increased CSO occurrences and increased cost of wastewater treatment.

Poor stormwater control can also impact unsewered areas, since standing water over septic fields can prevent drainage fields from working properly. Pollutant discharge from these septic systems can lead to bacterial impairment of streams or ground water. This can also increase the cost of treating surface water and ground water used as a source of drinking water.

In 1998, the city commissioned a Stormwater Master Plan that identified and prioritized stormwater project needs in Marion County, ranging from maintenance activities to capital improvement projects. On February 1, 1998, the Indiana Department of Environmental Management (IDEM) issued NPDES Stormwater Discharge Permit Number INS000001 to the City of Indianapolis. This permit was revised and renewed on October 1, 2004.

To implement the Stormwater Master Plan, improve stormwater runoff quality, and comply with the terms of the NPDES stormwater permit, the city has developed a Stormwater Management Program. The Stormwater Management Program focuses on the correlation between drainage, stormwater quality, and other wet-weather programs to demonstrate how proactive and coordinated stormwater management might facilitate regulatory compliance and reduce costs.

4.3.4.1 Stormwater Control Requirements

In 2002, the city revised its Stormwater Design & Construction Specifications Manual and stormwater ordinance to help address stormwater quality issues. The revised ordinance and technical manual require the use of best management practices (BMPs) to preserve natural filtration and pollutant removal in city landscapes. These practices include stormwater detention ponds, constructed wetlands, buffer strips, and other stormwater detention and filtration technologies. These practices help reduce pollutants in stormwater, manage and control runoff entering the city's combined sewer system, and improve the quality of the runoff into area streams.

In Indianapolis, control of stormwater runoff quality is based on a target removal of 80 percent of total suspended solids. The requirements apply to all developments that disturb areas greater than 0.49 acres in Marion County, except the cities of Beech Grove, Lawrence, Southport and Speedway. By requiring BMPs within the combined sewer area, the city has exceeded NPDES stormwater permit requirements and demonstrated its resolve to better control stormwater runoff in order to mitigate combined sewer overflows.

In addition to TSS removal, developers also must design BMPs to treat the first flush of runoff. Based on estimates in relevant literature, including Watershed Protection Techniques and the final report of the Nationwide Urban Runoff Program, BMPs designed to treat the first flush runoff in the Indianapolis area would treat the runoff of any storm of less than 1 inch. In a typical year, approximately 94 percent of rainfall events generate less than 1 inch of rainfall depth. In theory, therefore, an integrated network of BMPs in place throughout the city could control runoff of up to 94 percent of storms annually.

4.3.4.2 Stormwater Master Plan

Figure 4-2 illustrates the widespread nature of drainage and stormwater problems throughout Marion County. The map illustrates complaints compiled from the Mayor's Action Center, the Soil and Water Conservation District, elected officials, mail, phone, neighborhood meetings, and the Internet. The complaints identify problems and issues related to water quality, poor drainage, flooding, stream protection, and other environmental impacts. Under the Stormwater Master Plan, the city has used its database of more than 12,000 stormwater and drainage complaints to identify approximately 350 areas with stormwater concerns.

The city's stormwater program investigates all registered complaints using a systematic approach in order to treat each project equally and fairly. Assigned priorities then determine which complaints are incorporated into the city's capital improvement program. In 2004, the capital program included approximately 145 stormwater projects scheduled to be completed from 2004 through 2007.

4.3.4.3 Stormwater Utility

In 2001, the City-County Council created the Marion County Stormwater Utility under Ordinance No. 43-2001. This ordinance became effective on June 6, 2001. Assessments for a stormwater utility fee created by this ordinance began on September 6, 2001, to help fund the utility and needed stormwater capital projects.

Stormwater utility fee credits provide a financial incentive to owners of developed commercial and industrial properties to control and treat stormwater runoff. The credits are available to customers who (1) discharge a portion of their stormwater directly into major waterways without sending it through the public drainage system, or (2) who have facilities or controls in place to temporarily store or treat stormwater runoff, thereby reducing the impact on the drainage system. Property owners can receive credits on their stormwater utility bills of 5 to 100 percent, depending on the type of stormwater controls they have in place. The city's Stormwater Credit Manual details the policies and procedures applicable to the stormwater user fee credit program and is available online at http://www.indygov.org/stormwater.

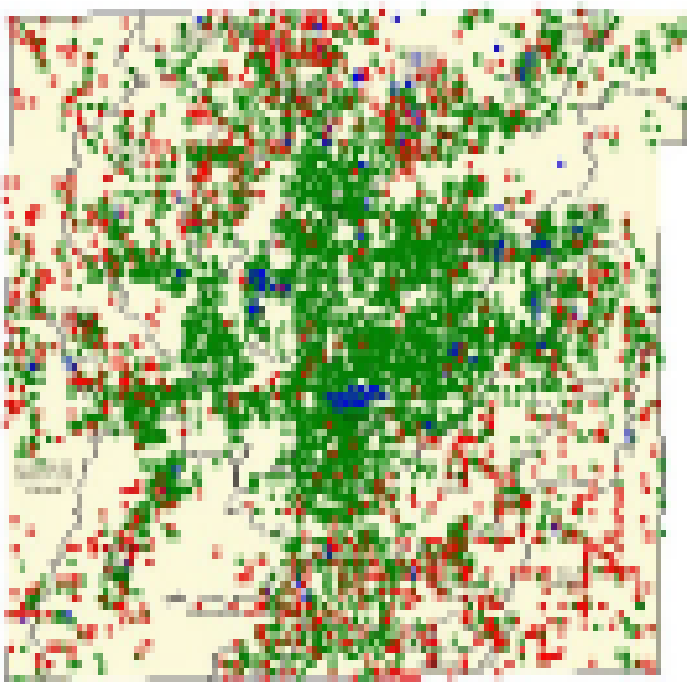


Figure 4-2
Marion County Drainage Complaints

4.3.5 Infiltration/Inflow Abatement

Infiltration and inflow is clear water other than wastewater that enters a sewer system. Infiltration is water entering a sewer system through defective pipes, pipe joints, connections, or manholes. Inflow is water entering a sewer system from sources such as roof drains, foundation drains, yard drains, area drains, manhole covers, or cross connections between storm sewers and sanitary sewers. In the City of Indianapolis, recent studies suggest that more than 50 percent of dry-weather flow in the sanitary sewer system is I/I, and that percentage increases dramatically during wet weather (HNTB, 2004).

For most of the sewers in Marion County the measured wet-weather peak I/I is three to five times the dry-weather average daily flow carried by the sewers. The problem is most serious in the South Fall Creek Interceptor, where the wet-weather peak I/I has been measured at eight times that of dry-weather average daily flow. The large increase in I/I from dry weather to wet weather suggests that many I/I sources exist in the combined and separate sewers contributing to this combined interceptor. By reducing excessive infiltration and inflow in these tributary sewers, the city could reduce flows coming into the combined sewer system. This would make more capacity available in the downstream interceptors and AWT plants to convey and treat combined sewage.

The city is addressing the infiltration and inflow problem in several ways:

Studies: In 1998, Indianapolis completed a *Basin Master Plan* that prioritized sanitary sewer basins requiring possible sewer investigation, rehabilitation, and additional capacity. The highest priority areas generally were located along the city's oldest separate sanitary sewers. These sewers are located in more fully developed areas, and include the most clear-water sources. Excessive stormwater inflow and groundwater infiltration were common, particularly in areas with poor stormwater control.

In 2004, the *Marion County Sanitary Sewer Master Plan* was completed. This document further evaluated the long-term sanitary interceptor sewer needs for Marion County and provided data on the measured flows, including I/I, in the city's interceptors.

Sanitary Sewer Rehab: Based on the above two systemwide studies and a series of basin studies conducted in the past 15 years, the city has evaluated structural and hydraulic conditions in nine of its largest sewer basins.

Four of the nine basins have already undergone repairs (Nora, Castleton, Fall Creek, and Belmont North). Four of the remaining basins (Bridgeport Interceptor, East Marion County Regional Interceptor, Lick Creek 51, and Lick Creek 53) still have rehabilitation projects pending. Additional analysis is being completed on the ninth (South Marion County Regional Interceptor).

Both the Indianapolis Department of Public Works (DPW) Engineering and United Water conduct sanitary sewer rehabilitation activities in both the sanitary and combined sewer areas. DPW Engineering is generally responsible for large diameter rehabilitation projects. United Water corrective activities include minor and major maintenance activities and minor capital improvement targets for structural rehab; sanitary, combined and storm mainline rehab; manhole adjustments; and stormwater ditching.

Leak Busters/Grease Busters: The city reinstituted this committee in 2004 to address I/I and grease blockage conditions that can lead to sanitary sewer overflows (SSOs). Participants include staff from DPW Engineering, Operations and Customer Service; Marion County Health Department, the Department of Metropolitan Development; and United Water. Goals include addressing I/I mitigation and enforcement, SSO response and reporting, grease blockages, and illegal connections. Through Leak Busters/Grease Busters the city hopes to reduce:

- Sewer backups into residential, commercial, and industrial establishments
- SSOs from the sewer collection system
- Financial risks associated with overflows and primary effluent overflows at the AWT plants
- Costs for capital improvement projects associated with the sanitary sewer collection system and AWT plants
- AWT plant processing costs

Manhole Inspections: Through the Leak Busters program, the city is expanding its manhole inspection and assessment initiatives. DPW and United Water are developing protocols and training additional staff members to perform manhole inspections, conduct assessments, and take corrective action. The goal is to reduce inflow and infiltration at manholes.

Smoke and Dye Testing: Historically, the city's smoke and dye testing program kept two engineering consultant firms under contract to assist in investigations of neighborhoods experiencing I/I problems. The Leak Busters program will add training for DPW Operations staff in smoke and dye testing techniques. The city's goal is to train two or three Leak Buster crews to investigate I/I problems as necessary. An annual plan will coordinate additional efforts between DPW Engineering, Operations and United Water.

Private I/I Removal Project: Private sources of inflow and infiltration have been identified as major problems in a number of cities. Indianapolis initiated a study in 1998 (Private Inflow and Infiltration Pilot Project) to evaluate the significance of this issue. Finding and fixing sewer defects on private property has been found beneficial in other communities, including Fort Wayne and Louisville.

The primary goals of the pilot project were to find and fix sewer defects to sanitary sewers on private property and to quantify the amount of clear water removed from the system. The secondary goal was to develop a mechanism to partner with homeowners to fix the defects with public funds. A pilot study in one neighborhood (Windsong at Geist Sewer Evaluation) was established to determine the causes of overflows at lift stations as well as sewer backups into homes. Many sump pump connections were identified; 16 percent of the 200 homes inspected had defects.

Correct Connect: The Correct Connect program was developed in 2004 to educate residents about the problems caused by illegal connections and teach them how to become compliant with existing ordinances. Through the program, residents and partner organizations will learn the benefits of disconnecting their illegal connections and be given the tools and/or resources needed to redesign their existing connections. The program will provide several ways for the public to get involved, including self-correction, disconnection assistance, volunteer opportunities and neighborhood disconnection events. An educational video, brochures and partnerships with local businesses are part of this campaign.

Inflow and infiltration into the sanitary system is also believed to be contributing to overflows at the city's three constructed SSO locations (105,113, and 124). The city is working to identify clear water sources (I/I) and capacity limitations that are contributing to sanitary sewer overflows at these locations. Projects are in planning or design to eliminate these constructed SSOs.

Infiltration and inflow abatement through additional sewer rehabilitation and a private inflow disconnection program would result in reduced amounts of clear water entering the city's sewer system. Lower I/I occurrences would reduce combined sewer flow and ultimately reduce CSO discharges. Careful consideration must be given to coordinating and

prioritizing these projects in conjunction with the city's CSO long-term control plan.

Fats, Oils and Grease (FOG) Program: Chapter 671 of the Indianapolis-Marion County Municipal Code requires restaurants, bars and other food service establishments to install a grease interceptor (commonly known as grease traps) in the waste line leading from plumbing fixtures or equipment where grease may be introduced to the sewer system. {Sec. 671-4(g)} City code also prohibits the discharge to any city sewer of any solid or viscous substances that may cause obstruction to sewer flow, such as grease.

Grease interceptors must be properly sized, installed and maintained. In reality, city inspections have found that many are not maintained on a regular basis. DPW's Office of Environmental Services (OES), the Department of Metropolitan Development and the Marion County Health Department have entered into a memorandum of understanding that gives health department inspectors the authority to inspect grease interceptors in food establishments. Routine inspections are performed every three to 12 months, depending on the complexity of food preparation at each establishment. Violations of city code are referred to OES for followup under a four-step progressive enforcement procedure. The procedure begins with education and is followed by increasing penalties for repeat violations within a 12-month period.

In addition, the city's FOG program includes the development of educational materials for owners, kitchen managers and staff in food establishments. These are being developed in partnership with groups representing restaurant and tavern owners and other food preparation facilities. Material will be included in the associations' training materials for food safety certification. The program's goal is to reduce grease-caused sewer blockages and eliminate the need for targeted cleaning of city sewers to prevent grease blockage problems.

4.3.6 Pollution Prevention Programs

Pollution prevention programs help reduce the amount of contaminants and floatables that enter the combined sewer system and the receiving waters via CSOs. Indianapolis has implemented a number of pollution prevention programs that address these concerns. This section briefly describes the following pollution prevention methods employed in Indianapolis, and potential benefits:

- Street cleaning
- Solid waste collection and recycling
- Product use restrictions
- Control of illegal dumping
- Bulk refuse disposal
- Hazardous waste collection
- Water conservation
- Sediment removal
- Large diameter sewer cleaning

Street Cleaning: Street cleaning practices remove a considerable solids load from the watershed surface, preventing this load from entering receiving streams. Within the "mile square" downtown (the area bordered by East, West, North, and South streets), the city cleans the streets five nights per week (comprising 76.1 curb miles weekly). Most of the areas swept on a daily or weekly basis are within the combined sewer service area. In 2003, the city cleaned more than 37,600 lane miles of streets. This number represents the total lane miles swept and not the total roadway miles. As an example, in the downtown CSO area sweeping both lanes of the same 10 roadway miles weekly will result in 2 lane miles/mile of roadway x 10 road miles x 52 weeks = 1,040 lane miles swept, or approximately 520 road miles annually.

The number of lane miles swept in the CSO area varies slightly from year to year. However, based on 1999 statistics, approximately 84 percent of the total lane miles swept are located in the CSO area and about 16 percent of the total lane miles swept are in the separate sewer area. Since the total pollutant load removed from all streets is approximately 8 million pounds, the city estimates it removes approximately 6.7 million pounds of debris from streets inside the CSO area annually. Outside the CSO area, the city complies with street cleaning requirements in its NPDES stormwater permit.

Street pollutants accumulate at varying rates, depending upon local land use patterns, road surface characteristics, and local weather patterns. Studies have shown that there are certain times when street cleaning is very effective in improving water quality. In areas with defined wet and dry seasons, cleaning prior to the wet season is likely to be beneficial. Street cleaning also has proven effective following snowmelt and heavy leaf fall. However, Nationwide Urban Runoff Program studies show that street cleaning produces no significant reduction in nitrogen or phosphorus concentrations. Other studies performed in California demonstrated that up to 50 percent of the total solids and heavy metals could be removed from urban runoff if the streets are cleaned once or twice a day. When the cleaning activities occur once or twice a month, the removal rate drops to less than 5 percent.

Table 4-3 presents the potential sources of pollution that accumulate on urban streets and the type of pollutants that result from those sources.

While street cleaning has been widely practiced for litter and dust control, its implementation as a stormwater pollution control practice is a fairly recent development. For street cleaning to have a beneficial effect on water quality in urban areas, a schedule of frequent cleaning must be established. The physical removal of particulates and attached fine pollutant particles from the street surface may lessen the pollutant load transferred to receiving waters. The water quality in the receiving streams will be improved due to the lower total solids and heavy metal loads. Aquatic life and other water uses may benefit from the lower turbidity and toxic effects.

Street cleaning is likely to be beneficial in high-density urban areas subject to high levels of traffic, but it may not be applicable in areas where parking cannot be banned periodically. Further, street cleaning may not be beneficial on paved surfaces that are in poor condition or do not have curbs. Implementation of a cost-effective street cleaning program requires careful consideration of both cleaning equipment and cleaning schedule. Street cleaning techniques are typically inefficient in picking up fine solids (less than 43 microns). These fine solids make up only 5.9 percent of the total solids, but account for approximately 25 percent of the oxygen demand and 50 percent of the algal nutrient source in stormwater. Downstream water quality can be greatly improved by using street cleaners to reduce the amount of particulate pollutants in conjunction with BMPs, effective in trapping the fine solids not removed by the street cleaners.

Most of the city's sweeping contractors use vacuum sweepers. Estimates of the efficiency of street cleaners in removing total dust and dirt on paved surfaces are 90 percent for vacuum devices, assuming a smoothly paved surface and no interference from parked vehicles.

Mechanical street cleaners use rotating brooms and water spray to control dust, moving the dirt into a storage hopper on a moving conveyor. Vacuum-assisted mechanical street cleaners utilize vacuum systems to transport dirt from rotating brooms to the hopper, where the transported dirt is saturated with water. This system has been used in Europe for many years but has seen limited use in the United States.

Solid Waste Collection and Recycling: Indianapolis has a number of solid waste collection and recycling programs that support pollution prevention as a CSO control. Litter in the downtown portion of the CSO area is controlled by the widespread use of trash receptacles, which are emptied daily. In particularly high traffic/high profile areas, receptacles are emptied twice per day.

In addition, the city conducts a recycling program for used motor oil by arrangement with several automotive service businesses. Residents can recycle used motor oil by dropping it off at any of 40 locations throughout the county. Additional details about this program can be found in the following subsection on hazardous waste collection.

Table 4-3
Street-Related Sources of Pollution

Source	Pollutant
Local Soil Erosion	Particulates (inert)
Local Plants and Soils (transported by wind and traffic)	Nitrogen and Phosphorus
Wear of Asphalt Street Surface	Phenoic Compounds
Spills and Leaks from Vehicles	Grease, Petroleum, N-arraffin, and Lead
Spills from Vehicles (oil additives)	Phosphorus and Zinc
Combustion of Leaded Fuels	Lead
Tire Wear	Lead, Zinc, and Asbestos
Wear of Clutch and Brake Linings	Asbestos, Lead Chromium, Copper, and Nickel
Deicing Compounds (traffic dependent); Possible Roadway Abrasion and Local Soils	Chlorides, complex cyanide
Wear of Vehicle and Metal Parts	Copper, Nickel and Chromium

Product Use Restrictions: By placing restrictions on the use of certain products, the city can potentially prevent pollution from CSOs. For example, in April 1994 the city changed its use of herbicides on city-owned property to protect surface water bodies from toxic pollutants. The city has identified eight specific herbicides by product name that city employees may not use near surface waters, and has identified two specific herbicide products that have been determined safe for use near surface waters.

Control of Illegal Dumping: Tires, construction debris and other heavy trash items are sometimes dumped on vacant lots, riverbanks and other uninhabited areas. The city vigorously enforces illegal dumping restrictions. In 2003, the city partnered with the Indianapolis Police Department to support the hiring of two officers dedicated to the pursuit of illegal dumping activities. This has increased efforts to curb illegal dumping in the city and prosecute individuals responsible for such illegal activities. In addition, the city has incorporated the collection of roadside trash into its roadside and median mowing contract. In 2003, this program collected approximately 1,300 cubic yards of trash.

Heavy Trash Disposal: The city offers several mechanisms for residents to easily dispose of heavy trash. On a monthly basis, residents can place bulk items for curbside pickup. In addition, the city provides special weekly disposal of heavy trash items at its transfer station for a nominal charge of $2/car and $5/truck.

Hazardous Waste Collection: DPW's Office of Environmental Services (OES) administers the ToxDrop program, which has been incorporated into the city's NPDES Stormwater Permit. The ToxDrop program allows the public and conditionally exempt small quantity generators to properly dispose of used automotive fluids, such as antifreeze and motor oil, as well as household chemicals, solvents, batteries, and paint. Small businesses that generate less than 200 pounds or less than 300 gallons of hazardous waste annually also can use this service with prior approval of the program's administrator.

The ToxDrop program has helped reduce the illegal dumping of hazardous materials and oils on vacant properties and in streams, and illegal dumping into the sanitary sewer system, where it could cause an upset of the wastewater treatment plant. Since its inception eight years ago, the program has expanded from a twice-per-year event to three permanent sites. Currently, Indianapolis residents may drop off household hazardous waste by appointment Tuesday through Thursday between the hours of 10 a.m. and 2 p.m., or without an appointment on most Saturdays. The ToxDrop facilities are located at Trader's Point collection site (7400 N. Lafayette Road), the Perry Township Government Center (4925 Shelby Street), and at the Indianapolis Police Department Training Academy (9044 E. 10th Street). In 2004, the city also sponsored two special ToxDrop collection events for used electronic equipment. Information on ToxDrop hours and locations is available to residents by telephone, e-mail, or at the city's Internet site. The city spends approximately $450,000 annually on the program.

In 2004, the ToxDrop program collected 623,000 pounds of materials. The amount of waste collected at the ToxDrop sites has increased each year, as the program has expanded and publicized its services (**Figure 4-3**).

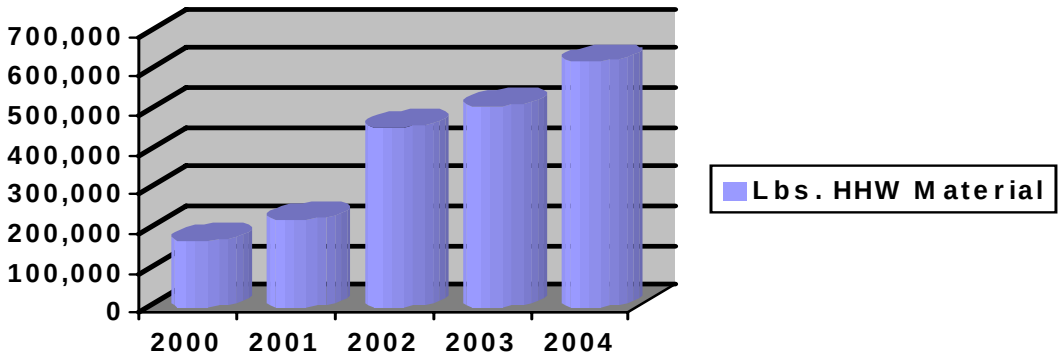


Figure 4-3
Annual Pounds of Hazardous Waste Collected by ToxDrop

ToxDrop also provides a mobile collection service that sets up at various locations around the county on an irregular basis to collect household hazardous waste. This program includes an annual Toxaway Day in conjunction with Earth Day Indiana's annual spring celebration.

In addition, the city has established approximately 40 conveniently located commercial vendors that accept used motor oil from the general public in the county. From May 2003 to May 2004, OES collection centers collected 117 barrels, or approximately 6,435 gallons, of waste oil. OES has purchased a storage tank and pumping equipment that will allow further expansion of this program.

The city also administers the greater-Indianapolis regional mercury awareness program for the State of Indiana. This program serves the eight counties immediately adjacent to Marion County and is designed to educate citizens on the environmental and health-related dangers associated with mercury and to encourage the proper disposal of mercury-containing items. In 2003 this program collected 2,300 pounds of mercury and mercury containing devices, and 2,100 lineal feet of florescent light bulbs. In addition to this program, OES also collected 42,000 pounds of computer equipment and cell phones. Electronics, especially those containing cathode ray tubes, are complex products that contain a range of metals, such as lead, cadmium and mercury, which can be harmful to the environment if they are improperly disposed of and the metals are allowed to leach into soil and water.

Water Conservation: Indianapolis Water maintains an aggressive program of leak detection and correction in its water distribution system. This program corrects leakage of clean water from water lines, which can infiltrate the sewer system. This program supports the CSO program objectives to minimize clean water entry into the sewer system while potentially minimizing the withdrawal of water from the streams for domestic use. The city's 2002 acquisition of Indianapolis Water will enable improved partnerships to promote water conservation and seek new technologies and methods for reducing unnecessary water usage.

Sediment Removal: While sediments are naturally occurring substances on a streambed generated by soil erosion, sludge is found in sediments when sewage solids settle on the bottom of a stream. The city has initiated a program to locate, identify, and quantify the sludge and sediment deposits in the White River and its tributaries. The city plans to sample and analyze the deposits prior to removal. If it is determined that removal of the deposits from the receiving streams will not cause other significant environmental problems, the city will then remove selected deposits. In addition, the city will continue to require developers to include erosion control plans in stormwater permits for new development projects, and the city code enforcement staff will review construction activities in the field to ensure compliance with the city ordinances and reduce the sediment loads to streams.

Large Diameter Sewer Cleaning: The velocity of sewage flow in large diameter combined sewers is very low during dry weather, thereby resulting in large deposits of solids in the combined system. Large storm events flush the deposits out of the combined sewer and cause large surges of solids at the city's treatment facilities and, during overflow events, into the streams. A program of regular cleaning can reduce the wet-weather first-flush surges of solids into the streams and the solids processing system at the Belmont plant.

4.3.7 Sewer Separation

4.3.7 Sewer Separation

Separating a combined sewer should improve water quality by reducing or eliminating sanitary discharges. However, sewer separation would allow more untreated urban stormwater to flow into city streams. While the increase may at times be offset by the decreased pollution from combined sewer overflows, urban stormwater does carry many pollutants. Without stormwater mitigation, increased loads of heavy metals, sediments, and nutrients may run off into local waterways. A study performed in North Dorchester Bay, Massachusetts, indicated that sewer separation potentially removed only 45 percent of overall fecal coliform, due to increased contributions from non-point sources of bacteria (U.S. EPA 1999). During the development of the District of Columbia Water and Sewer Authority's CSO Long Term Control Plan, model-predicted biological oxygen demand reduction for complete sewer separation in the Anacostia River basin only equated to a 9 percent decrease from the existing system (DC 2002).

Separating part or all of the combined system into distinct storm and sanitary sewer systems would entail the construction of at least one new sewer system and potential rehabilitation of the reused sewer system, thereby providing a tighter system with a renewed service life. Separating the sewers also provides an opportunity for incidental infrastructure work (road paving and the repair or replacement of miscellaneous utilities, such as water and cable lines) that could be conducted more cost-effectively if it were to coincide with sewer separation.

Complete sewer separation throughout the combined sewer area would, however, be costly and extremely disruptive to the daily commerce and activities in a city of Indianapolis' size, requiring construction under most streets in the central city. The problem is most significant in the downtown area. 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 (such as road repairs); land uses and costs; and the construction method used. Project construction occurring in industrial areas where hazardous materials or wastes may be present will likely increase the project cost.

The actual costs for sewer separation projects are highly variable and must reflect actual site conditions. To estimate costs, the city compiled data from its Septic Tank Elimination Program, where the city brings sanitary sewers into neighborhoods served by septic systems, and from several construction cost opinions for sewer separation projects throughout the county. The data indicates that an estimate of $75,000 per acre (in rural areas) to $100,000 per acre (in urban areas) would be a reasonable assumption to use when estimating sewer separation project costs in Indianapolis.

Few U.S. cities of Indianapolis' size are located on waterways as small as the White River. Thus, stormwater, like combined sewer overflows, in Marion County may have a disproportionate impact on the White River and its tributaries, when compared to similar cities on larger bodies of water. Wide-scale mitigation of stormwater impacts prior to discharge to the streams would be extremely difficult in most of the combined sewer area where there is little vacant land for mitigation measures. Although complete sewer separation was one of the options considered during the LTCP alternatives analysis, the city has determined that large-scale sewer separation is not the most cost-effective or environmentally beneficial solution for controlling CSOs and reducing bacteria in Marion County streams. This is demonstrated in greater detail in Section 4.6.

4.3.7.1 Localized Sewer Separation

Although large-scale sewer separation is not cost-effective, localized sewer separation may be a feasible and cost effective technology for areas with isolated CSOs, areas that are already partially separated, or areas that are undergoing redevelopment.

During development of the city's early action projects to reduce CSOs, localized sewer separation projects were identified in a number of areas. Separation projects are already in planning or underway for the following outfalls:

CSOs 217 and 218: This project will eliminate isolated overflow points in Mars Hill and other neighborhoods along State Ditch.

CSO 235: This project will eliminate the only outfall affecting Lick Creek on the city's Southside.

CSO 275: This project will eliminate an overflow point on lower White River through localized sewer separation and upgrades at the AWT plants.

CSO 103: This project will eliminate overflows affecting Fall Creek through sewer separation and rehabilitation in neighborhoods near 39th Street and Sherman Drive.

CSO 017: This project will eliminate an outfall at the upstream end of Bean Creek, which flows into Garfield Park.

CSO 046: This project will eliminate an outfall to White River in the Municipal Gardens area.

The city will further evaluate each CSO project, project area during facilities planning to determine if additional localized sewer separation could be achieved and is the most cost-effective solution within the project boundaries consistent with the criteria described below. In addition, the city will evaluate the feasibility of localized sewer separation as an incidental infrastructure improvement when reviewing sewer connection permit applications for redevelopment in the combined sewer area using the criteria described below.

4.3.7.2 Criteria for Sewer Separation

The city reviews the feasibility of sewer separation for each redevelopment in the combined sewer area on a case-by-case basis. In some cases, the city may require lift station agreements or place other operation and maintenance requirements on the developer. If the developer has access to a storm sewer network, they must have a separate storm sewer. If there is no direct discharge point for stormwater on the property, the city will review the economics and construction issues associated with connecting to nearby access points.

The city considers the following factors when determining whether sewer separation is appropriate for redevelopment in the combined sewer area:

- Capacity of affected sewers
- Projected flow being added to sewer (average and peak)
- Sewer improvement projects planned and how they will affect capacity
- Sewer separation's impacts on water quality
- Feasibility or ease of separation, including economics and location
- Availability of a practical or feasible direct discharge point for stormwater
- Requirements for best management practices and holding times that might mitigate impacts on the combined sewers

The city is reviewing and updating its sanitary sewer design and construction standards, including factors for determining whether sewer separation is appropriate for redevelopment in the combined sewer area. During discussions with stakeholders, DPW has agreed that the following factors should be incorporated into the revised standards:

- Capacity in receiving sewer to accept stormwater flow, and planned capital improvement projects identified within the city's CSO long-term control plan or other plans
- Impacts on water quality
- Feasibility of separation, including the costs to treat, construct, and manage the sewer system as a separated, or combined, system
- Other appropriate factors

4.3.8 Watershed Coordinator/Riverkeeper

As the City of Indianapolis continues to implement its long-term control plan, it could establish a riverkeeper for the streams in Marion County. This position, which is similar to a watershed coordinator, would be responsible for integrating the city's many stream-related programs and would provide a visible symbol of the city's commitment to improving water quality.

Decisions about water resources are complicated by the number of municipal, state, and federal agencies that are involved in the decision-making process and the wide variety of interest groups that want to participate. The public may be left with the perception that no one "speaks" for the river. Establishing a riverkeeper to help facilitate and coordinate the activities of the involved parties could help improve communication.

Riverkeepers have been established for a number of U.S. waterways, including the Catawba, Chattahoochee, Kansas, Willamette and Wabash rivers. Most often, riverkeepers are based with nonprofit, non-governmental organizations. The specific duties of a riverkeeper vary. In some parts of the country, the riverkeeper's primary duty is to monitor water quality and water use. In other areas, the riverkeeper's primary role is as a lobbyist and advocate for the stream. Common to all riverkeepers is the role of maintaining a visible presence on the streams.

4.4 Collection System Controls

Maximizing storage in the collection system is one of U.S EPA's recommended nine minimum controls for combined sewer systems. The city has documented its initial efforts to maximize collection system storage in its CSO Operational Plan (ICST, May 2003). These efforts included adjusting regulator weir heights and improving collection system inspection and maintenance activities. During development of the long-term control plan, the city evaluated more complex sewer system modifications such as in-line storage. In-system storage options can reduce capital costs of CSO control by utilizing underused capacity in the existing sewer system. Such systems must be designed carefully to prevent potential complications such as sewer backups, increased solids deposition, and accelerated sewer deterioration.

4.4.1 In-Line Storage Alternatives

Figure 4-4 illustrates assumptions made in evaluating the in-system storage capacity of the city's combined sewer system. This figure shows that in-system storage will extend only to a location upstream (called the storage limit) where the water elevation in the combined sewer trunk or branches equals the elevation of the outfall pipe or regulator downstream. If an attempt is made to store wastewater above this storage limit, surcharging of manholes and sewage backups into basements may occur.

The areas of the city's combined sewer system best suited for in-system storage are the large, flat combined sewer trunks associated with the larger CSO outfalls. Therefore, when analyzing the available in-system storage volumes, the city gave greater attention to those outfalls with pipe diameters greater than or equal to 84 inches. The city also estimated the in-system storage volume of other diameter ranges greater than or equal to 36 inches, arriving at an estimated 26 million gallons (MG) of total in-system storage in combined sewer trunks greater than 36 inches. **Table 4-4** shows the five CSO outfall diameter ranges studied for this investigation.

Though it is technically possible to store 26 million gallons of wastewater within the city's combined sewer system, further analysis showed it might not be economically feasible or beneficial to do so. The in-system storage estimate reflects potential storage from 85 CSO outfalls greater than 36 inches in diameter. **Figure 4-5** shows the locations of these outfalls along with their associated tributary areas. Of the 85 outfalls, 75 percent (64 outfalls) are between 36 and 72 inches in diameter.

The CSO outfalls between 36 inches and 72 inches in diameter contribute only 28 percent (7 million gallons) of the estimated 26 MG in-system storage volume. The other 19 million gallons can be found in the 21 CSO outfalls with pipe diameters greater than or equal to 72 inches. **Figure 4-6** demonstrates how available in-system storage volume

per outfall increases with increasing CSO outfall diameter and depicts the total in-system storage volume and total number of outfalls associated with each diameter range.

Figure 4-6 also illustrates that the smaller diameter CSO outfalls are greater in total number but produce minimal in-system storage potential. This suggests that retrofitting all outfalls with overflow control structures may not be economical or cost-effective. In addition, each control structure installed adds to the overall risk of mechanical failure, which may result in basement backups.

As noted in Section 3, either mechanical gates or inflatable dams may be used for in-system storage of sewage in a pipe or sewer trunk. As part of its alternatives evaluation, the city evaluated the costs and benefits of both technologies. In addition, the city has installed an innovative in-sewer pinch valve technology to manage and direct flows between interceptors. The city's evaluation of each technology alternative is described below.

4.4.1.1 Mechanical Sluice Gate Control System

A typical mechanical sluice gate system is shown in **Figure 4-7**. As the figure demonstrates, there are two sluice gates required for in-system storage and flow control. The regulator gate, which is normally in the open position, is activated automatically in response to signals from a water depth monitor in the interceptor. When the interceptor is full, the regulator gate will close and regulate the flow entering the interceptor as additional capacity becomes available.

The outfall gate, which is normally closed, is activated automatically in response to three different monitors: a river

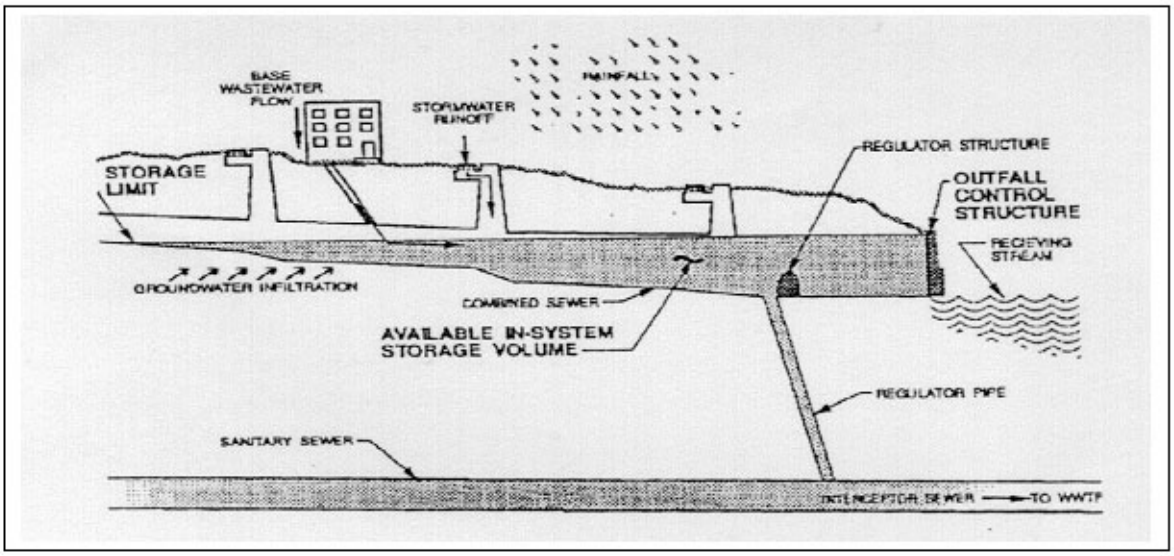


Figure 4-4
Available In-System Storage Volume

Table 4-4
Available Storage Capacity Within Selected CSO Outfall Diameter Ranges

Outfall Diameter Range (in.)	No. of Outfalls	Average Length (ft.)	Average Drainage Area (acre)	Average Storage Volume (MG)	Total Length (ft.)	Total Drainage Area (acre)	Total Storage Volume (MG)
36 - < 48	28	1,573	76	0.075	44,044	2,128	2.10
48 - < 60	25	1,799	220	0.112	44,975	5,500	2.80
60 - < 72	11	3,181	200	0.217	34,991	2,200	2.39
72 - < 84	9	4,285	316	0.463	38,565	2,844	4.17
> 84	12	4,585	951	1.222	55,020	11,412	14.66
Total	85				217,595	24,084	26.12

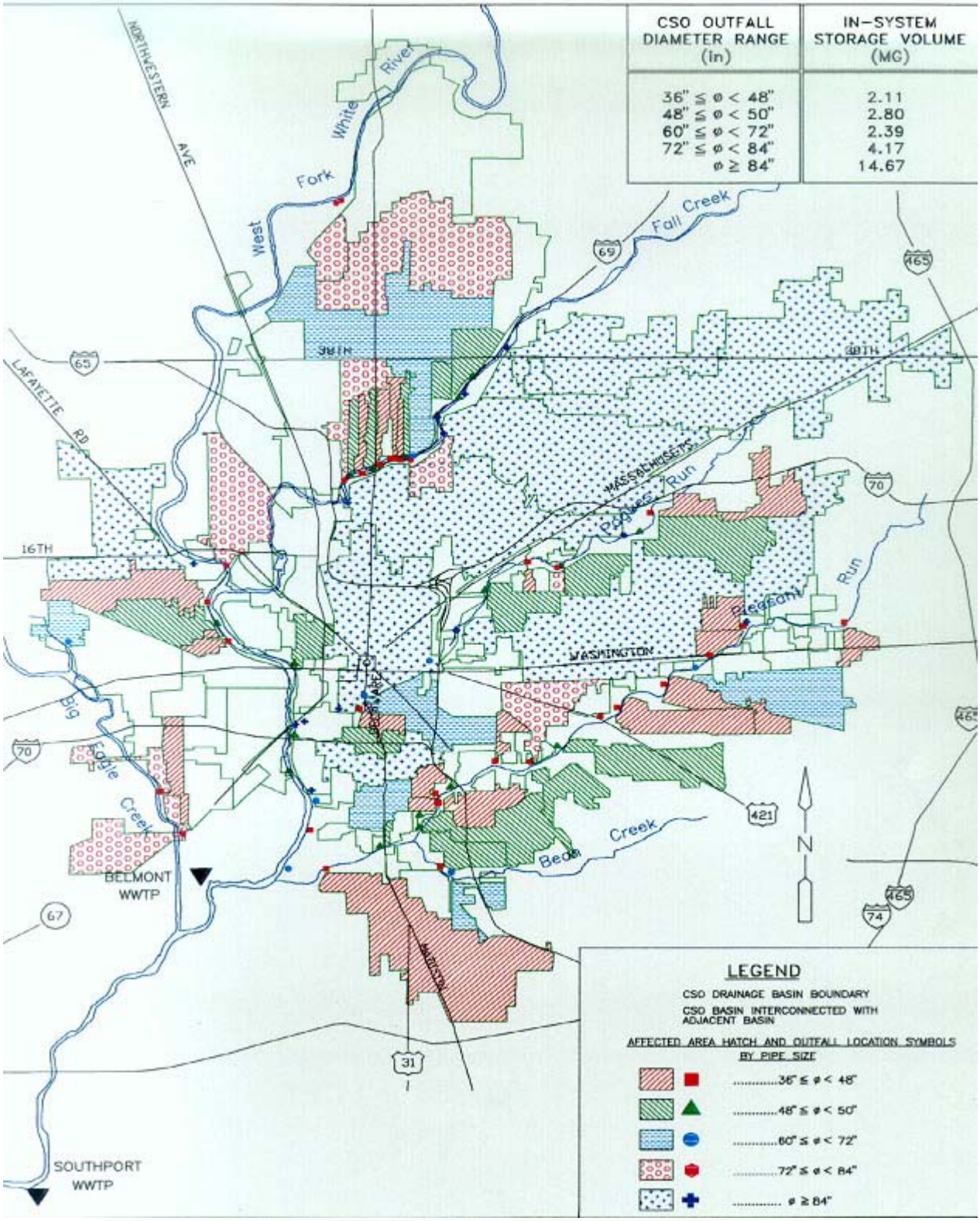


Figure 4-5
CSO Outfall and Tributary Area Location Map for In-System Storage

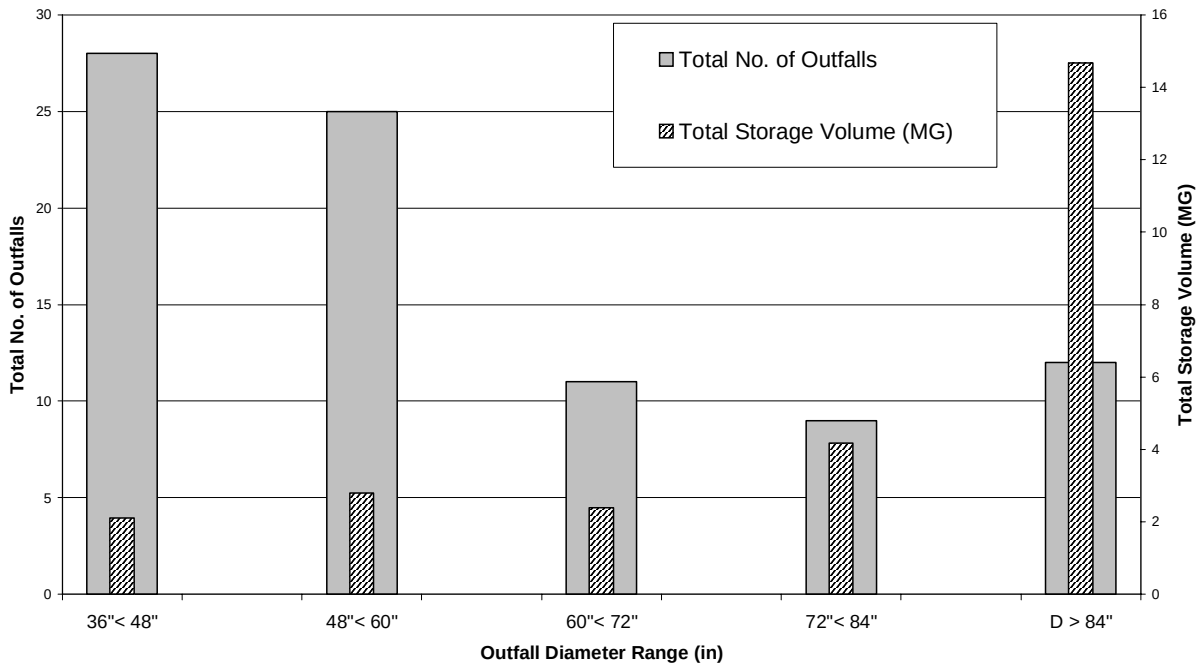


Figure 4-6
In-System Storage Analysis

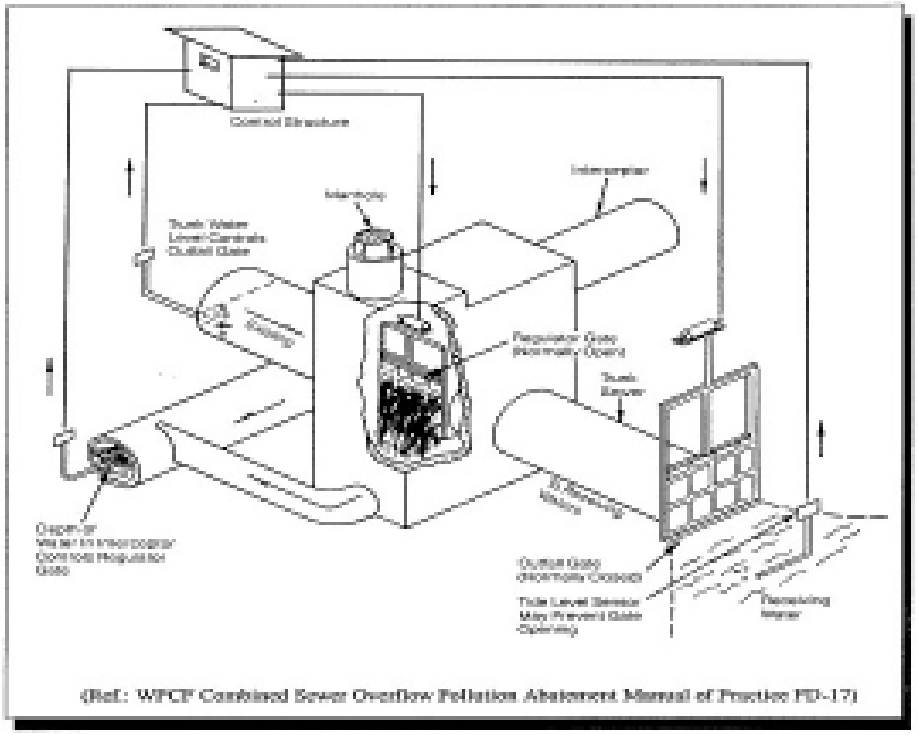


Figure 4-7
Mechanical Sluice Gates

level sensor in the receiving stream, level sensor in the receiving stream, a water depth monitor in the combined sewer trunk, and an extensive rain gauge network that monitors incoming storms. The tide level sensor is used to prevent the outfall gate from opening during high water conditions and creating backwater effects from the receiving stream. The other two monitors are used to prevent upstream basement or street flooding by opening the outfall gate when either the depth in the combined sewer trunk or potential rainfall threatens the storage limit.

Although the sluice gate system is operated automatically, it must be equipped with a manual override in case of equipment failure. Also, since this system's function is critical during wet weather, a backup power source is needed to provide power in case of electrical failure.

There are many advantages in using a mechanical sluice gate system to provide for in-system storage or diversion structures. The City of Indianapolis has CSO outfalls that vary in shape (circular, semicircular, rectangular, and various combinations of these) and size (36 inches to 156 inches). A sluice gate system will work regardless of the outfall's shape and size. In particular, special design accommodations can be made for CSO outfalls greater than or equal to 120 inches, with a maximum size of 192 inches.

Sluice gates can also completely seal off large outfalls that may be too large for an inflatable dam. The regulator gate is very beneficial in this type of system because it can help manage flows to the downstream AWT plant. In addition, the sluice gates have a normal life span of 30 to 50 years but require continued maintenance, including periodic cleaning and lubrication of the stem and hoisting mechanisms. Finally, sluice gates are designed to withstand high water conditions of rising receiving streams.

However, sluice gate systems are complex and have posed significant problems in some communities. Because they are not fail-safe, there is potential for causing basement backup problems. The sluice gate system's electrical and mechanical components require a certain level of maintenance. Maintenance can involve repairs to the actuator, purging or cleaning of the level sensors, and removing debris from the gates and gate openings. Debris also can become trapped underneath the gate and prevent it from closing fully. Auxiliary power sources may be required to open the gates in the event of a power failure.

The city installed a mechanical sluice gate in CSO outfall 058 in 1997 as part of a pilot project to evaluate both mechanical gates and inflatable dams.

4.4.1.2 Inflatable Dams

Inflatable dams are rubberized fabric devices that can be inflated during smaller wet-weather events to hold wastewater within the sewer system and prevent combined sewage from entering the receiving streams. **Figure 4-8** shows a schematic of an inflatable dam in the outfall pipe of a combined sewer.

These dams, which are normally in a semi-inflated position, can be designed to activate automatically from a master control center in response to upstream water levels or surface rainfall data. If monitors indicate that the in-system storage volume may exceed the storage limit, then the dam structure is automatically deflated, and an overflow will occur. In the event of an exhaust valve malfunction or other system breakdown, the dam contains a safety valve that would deflate the dam and prevent backups into basements and streets.

The air supply to inflate the dam, which is either produced by a compressor or supplied from a storage tank, is located on-site in an equipment vault. This on-site equipment vault also contains a manual control to deflate the dam in case of equipment failure.

The city installed an inflatable dam in CSO outfall 053 in 1997 as part of its pilot study of in-system storage technologies. Since 2002, the city has installed additional inflatable dams along Fall Creek, Pleasant Run and Pogues Run, including some dams equipped with real-time control capabilities. The city's experience with inflatable dams has demonstrated their viability for in-system control in the Indianapolis collection system.

Since the dams are generally made from a heavy fabric or rubber, they do not require a substantial amount of in-pipe maintenance; however, some maintenance is required for the instrumentation inside the equipment vault. Also, these dams must include pressure relief valves, mechanical deflation controls, and backup manual deflation valves to ensure that basement or street flooding do not occur during a power failure. Finally, installation of the dams does not require major reconstruction of the existing system, therefore limiting the amount of time and manpower needed and making them cost-effective.

Although the fabric and rubber material used in these structures is durable, sharp objects can penetrate them. In addition, since inflatable dams are installed directly inside the combined sewer outfall pipe, they must be able to accommodate the various pipe shapes in the city's

system. Currently an inflatable dam cannot accommodate two pipe shapes: rectangular pipe outfalls with a rise greater than the span and semicircular pipe outfalls that are not rounded at the base.

Another limitation with inflatable dams is that they have a maximum design height of approximately 144 inches, and a minimum design height of approximately 48 inches. If inflatable dams are to be used in combined sewer outfall pipes smaller than 48 inches in diameter, they must be prefabricated in a sleeve and inserted into the existing pipe. They cannot be installed in the field because there would not be enough head clearance for crew members to work. Finally, if high water conditions are a major concern, inflatable dams require special design of the anchoring system to withstand backwater from the receiving stream.

Table 4-5 and **Figure 4-9** compare the costs of mechanical sluice gates relative to inflatable dams in various diameter sewers. These costs constitute budgetary estimates and are based upon manufacturers' equipment prices and other related construction costs. In addition, the budgetary construction unit costs were compared to the Indianapolis Clean Stream Team's (ICST) experience in implementing these types of controls in various cities in the Midwest. Although the overall unit costs do not take into consideration site-specific design requirements, they still offer enough information to evaluate the feasibility of in-system storage. As can be seen from the table and graph, sluice gates are often the most cost-effective technology for smaller diameter pipes, while inflatable dams are usually most cost-effective for the larger diameter pipes.

However, the selection of these controls is generally site-specific and cost is not usually the controlling factor.

4.4.1.3 Pinch Valves

In addition to the use of inflatable dams and sluice gates, the City of Indianapolis won an award in 2004 from the American Public Works Association for the innovative use of pinch valves in large diameter sewers to assist in the diversion of combined sewer flows from one wastewater treatment plant to another.

In a pair of innovative projects, the city accomplished the following achievements:

- First-time installation of large diameter (72") pinch valves in a sewer system
- First-time installation of sluice gates to modulate up-stream water levels by controlling inflation pressure in a pinch valve, instead of operating as completely closed or completely open

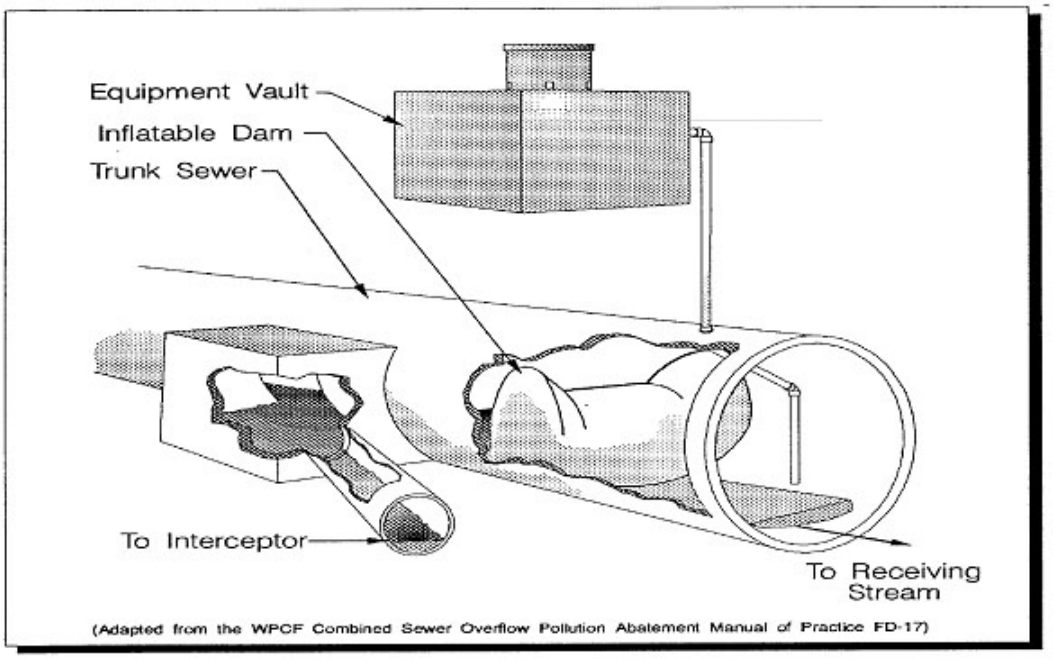


Figure 4-8
Typical Inflatable Dam

Table 4-5
Comparisons of Budgetary Costs for In-System Storage Devices

			Sluice Gates		Inflatable Dams	
Outfall Diameter	Number of Outfalls	Potential In-Line Storage (MG)	Estimated Cost per Gal. of Storage	Mechanical Sluice Gate Cost per Unit	Estimated Cost per Gal. of Storage	Inflatable Dam Cost per Unit
36"≤D< 48"	28	2.11	$ 4.07	$ 268,728	$ 7.71	$ 580,886
48"≤D< 60"	25	2.8	$ 3.18	$ 356,404	$ 5.49	$ 614,439
60"≤D< 72"	11	2.39	$ 2.26	$ 490,411	$ 3.15	$ 685,215
72"≤D< 84"	9	4.17	$ 1.26	$ 584,502	$ 1.88	$ 870,280
D ≥ 84"	12	14.67	$ 0.96	$ 1,169,004	$ 0.95	$ 1,156,529

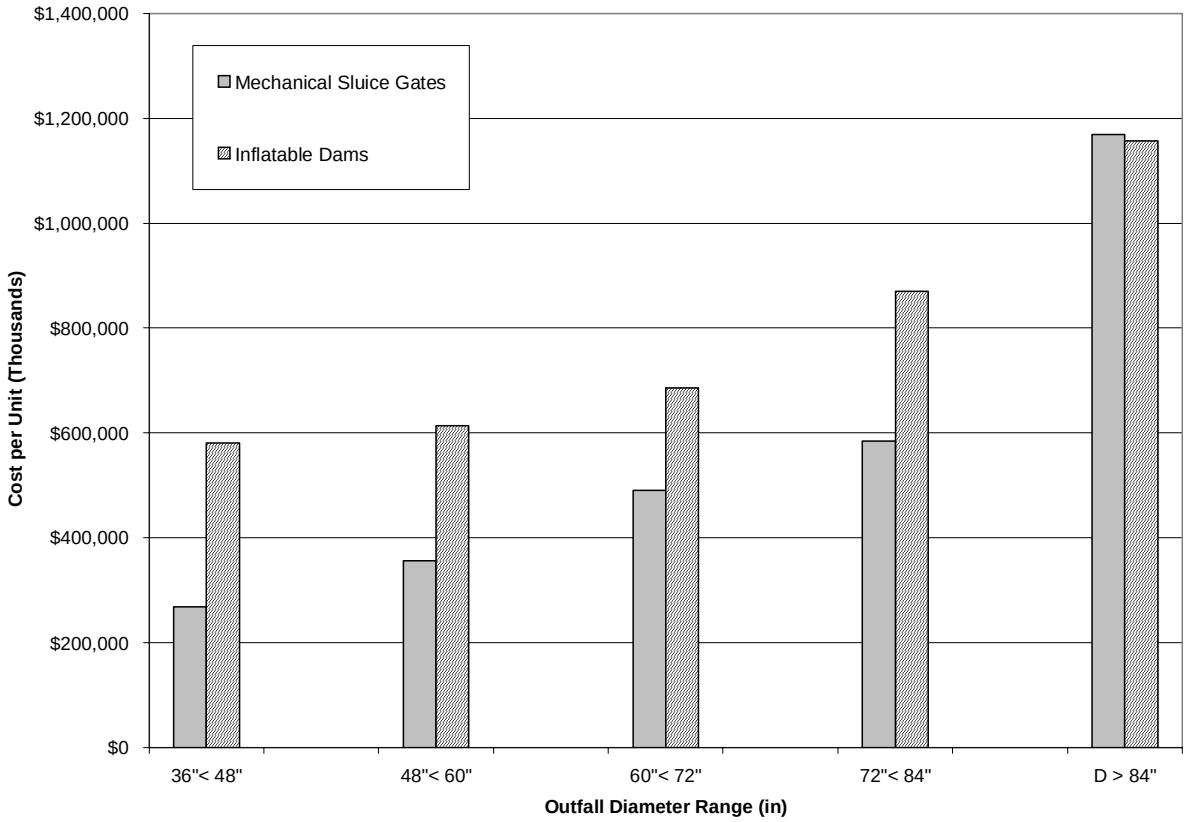


Figure 4-9
Cost Comparison Analysis - In-System Storage Devices

- Retrofit of valves into existing sewers with no large, expensive valve chambers and no loss of conveyance capacity
- Minimum bypass pumping needed during valve installation

The diversion of flow into an under-utilized interceptor is a key component in improving the efficiency of the system. Several locations within the city's sewer system provide interconnections between interceptors. The city found that if flow were restricted in one interceptor it could be diverted into an interconnecting interceptor with available capacity and sent to a treatment plant with available capacity.

The pinch valve concept was developed as the city evaluated the possibility of diverting flow within two interceptors adjacent to White River. These sites, at 10th Street and McCarty Street, showed great promise but needed to meet two strict criteria to move forward: existing interceptors had to remain in service during construction and the valves could not reduce flow area.

The first in-system control alternative the city examined was an inflatable dam, a proven technology for large diameter installations. To meet the requirement of no loss of flow area, the use of an inflatable dam would have required removing a section of existing 72" interceptor and replacing it with an oversized 84" pipe. When construction would be complete, the clamping plates and concrete fillet would have reduced the flow area of the 84" pipe to that of a 72" pipe. The construction of the inflatable dam also would have required a significant amount of bypass pumping during construction and installation. The construction elements of this option led the city to look for an easier, more cost-effective alternative.

The alternative the city investigated and eventually selected was a 72-inch pinch valve (see **Figure 4-10**) manufactured by Red Valve. The city selected this alternative for two reasons:

1. The pinch valve vault and control structures could be built around the existing live interceptor.

2. When the valve was delivered onsite, the contractor could cut a section of the existing interceptor away, and slip the valve in place. This resulted in approximately 12 hours of bypass pumping during valve installation. These installations took place during evening hours and did not impact the local customers in any significant manner.

Figure 4-10
72-Inch Pinch Valve

The use of this technology is innovative for several reasons. This is a new use for pinch valve technology. Pinch valves had never been used before to control flow within interceptors.

Pinch valve technology allows the city to regulate the amount of flow diverted. Instead of technologies that divert all or no flow, the city modulates the pinch valve to send some of the diverted flow to an interceptor not using its full capacity. Excess wastewater is allowed through the other interceptor by modulating the inflation pressure of the pinch valve. Operating in this manner, the city makes fullest use of the capacity of the existing interceptor system.

Pinch valves also are cost-effective solutions, requiring less labor, less de-watering, less equipment and materials, and easier construction methods. The city has estimated pinch valves could save $150,000 to $300,000 per installation when compared to inflatable dams.

4.4.2 Real-Time Control

Mechanical gates, inflatable dams or pinch valves may be employed as part of a highly automated real-time control (RTC) system. RTC is a sophisticated in-line storage method that uses sewer depth and rainfall monitors to control the amount of wastewater being stored, transported, and directed throughout the sewer system. This highly automated system can increase efficiency and holding capacity within the existing sewer system by creating real-time response to rain as it falls over the city. Dams, valves or gates allow sewage to flow from one interceptor into another intercep-

tor during intense rainfall and runoff, and can hold flow back when rain subsides and capacity is needed in another part of the city.

RTC monitors require a power source and telecommunication lines to communicate with a central computer system. The computer system processes the monitoring data every few seconds or minutes, using data to make control decisions at the CSO, such as whether to open or shut the sluice gates or valves, or inflate or deflate the dams.

These instantaneous decisions cannot always rely upon depth data alone but must also incorporate rainfall data. Releasing in-system storage volumes by opening a sluice gate, operating a pinch valve or deflating a dam is not instantaneous. Therefore, incorporating rainfall data into the decision process is necessary to give the system enough time to react to an approaching storm that has intensities or durations that will breach the storage limit, thus preparing the in-system storage release process before basement or surface flooding occurs. Rain gauges must be spaced to accurately monitor the average thunderstorm size of four to five miles. A real-time control system of this type maximizes the full storage capability of the collection system while avoiding upstream basement flooding and spills to the environment, thereby minimizing public health concerns and CSO impacts on the receiving water.

The benefits of RTC in sewer systems are not limited to CSO volume reduction. RTC may play an important role in the following aspects of maintenance/operations:

- Responding to emergency situations and conditions during either wet- or dry-weather periods, including power loss, infrastructure damage, or equipment failure
- Isolating parts of the system for maintenance or construction
- Reducing energy consumption
- Maintaining flow regime and (sewage) velocities that will prevent/reduce sediment deposition
- Reducing equipment wear

RTC facilities also can reduce the potential for either basement or surface flooding. Since rain does not fall evenly over the CSO watershed, flows into the combined sewer system vary from place to place. RTC uses the fill/decant cycles of the entire system to improve storage capacity. By making better use of the existing capacity, the city can reduce spending on new storage facilities.

Additionally, by controlling the flow within the system, peak rainfalls are better managed, allowing more flows to be treated at the AWT plants. RTC also can be used to provide control of existing lift stations and future off-line storage structures, creating a systemwide control system that can optimize the city's capacity to predict and control sewage overflows.

RTC also can balance the hydraulic load in the collection system, reduce backup flows, provide dynamic and stepped storage, manage specific flow constraints, and provide fast dewatering of in-line and off-line storage facilities.

However, while RTC does potentially increase storage at a relatively low cost, the risk of flooding basements with raw sewage increases as additional RTC devices are installed in the collection system and as storage is attempted in smaller sewers. While RTC reduces capital costs of CSO controls, operation and maintenance costs can be more expensive over the long term. Furthermore, proper operation and maintenance of an RTC system is critical to protecting citizens from basement flooding. Also, flooded buildings pose a significantly higher likelihood of unintentional human contact and resulting health effects than combined sewer overflows into the streams.

4.4.3 SCADA System

To achieve maximum effectiveness, the RTC system must be linked with a communication network. The city recently completed a study for a Supervisory Control and Data Acquisition (SCADA) system. *Final Report (Draft) SCADA System Development Project, April 2004,* was prepared by Donohue & Associates. This report recommends that the city construct a SCADA system that uses a wireless broadband communication system incorporating the countywide microwave structure of the Metropolitan Emergency Communications Agency (MECA). While the term SCADA is used to describe a variety of control system configurations, the most applicable definition for Indianapolis describes a monitoring and control system spread over a wide geographical area, where autonomous control units located at remote sites are networked to a central facility using land lines or communication links. A SCADA system consists of three primary elements: remote site equipment, a communication network, and control facility.

SCADA systems collect information from numerous remote sites on either a real-time or periodic basis so that system managers can be aware of system status, identify current operating needs, manage equipment maintenance, and take action to minimize or avert operational upsets. Effective use of SCADA will optimize the use of a wastewater conveyance system while saving operation and maintenance costs.

The proposed SCADA system is intended to provide the capabilities and performance necessary for it to become the cornerstone management tool for the city's wastewater collection system. This system will replace the city's existing wastewater conveyance alarm system. The proposed SCADA system will provide for monitoring and control of wastewater sites located throughout the Marion County area. The city currently owns a large number of wastewater sites that either control wastewater flow or provide information important in managing that flow. Implementation of the CSO long-term control plan will add a significant number of new facilities. The recommended SCADA system has the capacity to address anticipated needs for a 10-year planning period. Initially, approximately 250 existing sites would be added to the SCADA system. An additional 400 sites could be incorporated in the future as they are constructed.

The SCADA system would be constructed in multiple phases. The first phase would include installation of system hardware and software, improvements of MECA facilities, addition of broadband radio connection, and equipment enhancements and data collection from selected remote sites. Additional phases of construction would include configuration of software for additional sites, addition of point-to-point broadband radio connections and equipment enhancements and data collection from the remaining remote sites. The completed RTC structures would be included in the initial SCADA development plan. Additional RTC facilities could be added to SCADA as they are constructed.

4.4.4 Summary

Collection system controls and in-system storage are a viable approach for reducing the volumes of CSOs discharging to receiving streams. To determine the potential effectiveness of this technique, the city screened all its CSO outfalls greater than 36 inches. From this screening, the team found that in-system storage could be achieved cost-effectively by retrofitting outfalls greater than 72 inches with in-system storage devices, such as mechanical sluice gates, pinch valves or inflatable dams.

The City of Indianapolis is aggressively moving forward to achieve an early level of CSO control through in-line storage projects. Following pilot testing in the late 1990s, the city completed several inflatable dam installations in 2001-02 in various watersheds to increase system storage and reduce CSO impacts. The city is also designing and constructing a number of additional in-line storage projects. In addition to these projects, the use of systemwide RTC and several other in-line storage controls are being evaluated. These projects are an integral part of the city's recommended plan for long-term CSO control and are further described in Section 7.

The cost of in-system storage can be considerably less than the marginal cost of adding additional storage to any new storage facilities that may be constructed. Preliminary analysis indicates that under virtually any long-term planning scenario, these devices should prove to be cost-effective. However, real-time control facilities must be carefully designed, operated and maintained to minimize risks of basement backups or flooding. Implementation of a regional, independent, automatic, reactive control RTC strategy, in combination with a SCADA system, is expected to provide the city with the capabilities and performance necessary for managing its wastewater collection system, maximizing in-system storage capacity, and reducing potential risks.

4.5 Evaluation of CSO Control Plan Components

CSO control planning in Indianapolis has been an iterative process, in which lessons learned from the analysis of one system component have led to refinements in the analysis and assumptions used for another system component. The analysis of CSO control alternatives has involved extensive analysis of the following five major system components:

- Deep Tunnel Storage and Conveyance
- Combined Sewer Collection System & Watershed Improvements
- Belmont AWT Plant Improvements
- Southport AWT Plant Improvements
- Interplant Connection

Each of these five components must be planned and designed to be compatible with the conveyance and treatment needs and/or capacities of the other four components. The analysis must include combined sewer flows being captured in the tributaries and in White River for conveyance to and

treatment at the Belmont and Southport AWT plants. The city sought to address the following questions in developing its systemwide CSO control plan: How much additional flow will be captured in the collection system? How will it be stored and conveyed to the treatment facilities? What level of treatment will wet-weather flows receive? How will flows between the two treatment facilities be managed?

Figure 4-11 represents the basic components of the existing Indianapolis wastewater collection and treatment facilities: the two AWT plants, their respective service areas, and the interplant diversion that enables part of the wastewater from the Belmont service area to be treated at the Southport plant. The dashed arrows in this figure represent the overflows that occur during wet weather from (1) CSO outfalls throughout the combined sewer areas in the Belmont service area, (2) CSOs at the headworks of the two AWT plants, and (3) primary effluent bypasses at the two AWT plants.

The challenges posed for the AWT plants by wet-weather surges and captured CSO flow resulting from CSO control measures led the city to develop the *Interplant Connection Facilities Plan* (ICST, 2004). This plan investigated approaches to convey all or part of the systemwide captured combined sewage to the Southport facility for treatment. The facility planning effort also developed and evaluated various concepts for expanding the Southport facility to provide effective treatment of the captured combined sewage. Expansion alternatives for the Belmont facility were evaluated previously during preparation of the 2001 long-term control plan and subsequent pilot studies at the facility.

Figure 4-12 illustrates the general framework of the CSO LTCP used in the *Interplant Connection Facility Plan*. At the heart of this plan is a deep tunnel for capturing CSOs and a new interplant connection for conveying the captured flow to the Southport plant. The design criteria for the interplant connection and new wet-weather treatment facilities is dependant upon the size and dewatering flow pattern from the deep tunnel, which in turn is dependant upon the extent to which CSO discharges are captured after various improvements are made to the collection system.

This section summarizes the city's iterative analysis of the five system components, focusing on their inter-relationships and their ability to satisfy regulatory requirements and address citizen concerns. Section 4.6 describes the systemwide CSO control alternatives that resulted from this iterative analysis, and also compares their costs and benefits.

As described in Section 3, the city's technology screening and evaluation demonstrated that increased storage and conveyance to upgraded and expanded AWT plants is the most cost-effective technology for CSO control in Indianapolis. The technology evaluation also concluded that a remote treatment facility at the downstream end of the Fall Creek and Pogues Run watersheds, in conjunction with increased storage, warranted further evaluation. Each of these concepts, along with sewer separation, was carried into the alternatives evaluation described below.

4.5.1 Deep Tunnel Storage and Conveyance

Given the complexity of the overall sewage collection and treatment system, the city used several computer models to simulate the performance of several important building blocks:

1) A 5-year NetSTORM model was used to simulate how the LTCP components for capturing CSOs would have performed had they been in operation from 1996 through 2000.
2) A newly developed deep tunnel model was used to provide preliminary analyses of the various tunnel dewatering rates and volumes for various scenarios. The input flow data to the tunnel model came from the captured CSO output flow data generated by the 5-year NetSTORM model.
3) The integrated tunnel model was used to (1) evaluate the feasibility of a new aboveground equalization basin near CSO 117 (known as EQ Basin 117) and (2) assess the workability of splitting the captured CSO flows between the two AWT plants.
4) Updated versions of the Belmont and Southport "treatment rate vs. storage volume" models were used to examine how additional flow from captured CSO flows and future growth within the service areas would affect headworks pumping capacities, on-site storage volumes and treatment rates needed to achieve specific wet-weather overflow frequencies at the AWT plants.
5) The detailed Stormwater Management Model (SWMM) was used to more fully explore the interplant connection planning objectives. SWMM was also used for continuous simulation of a "representative year" of precipitation data.

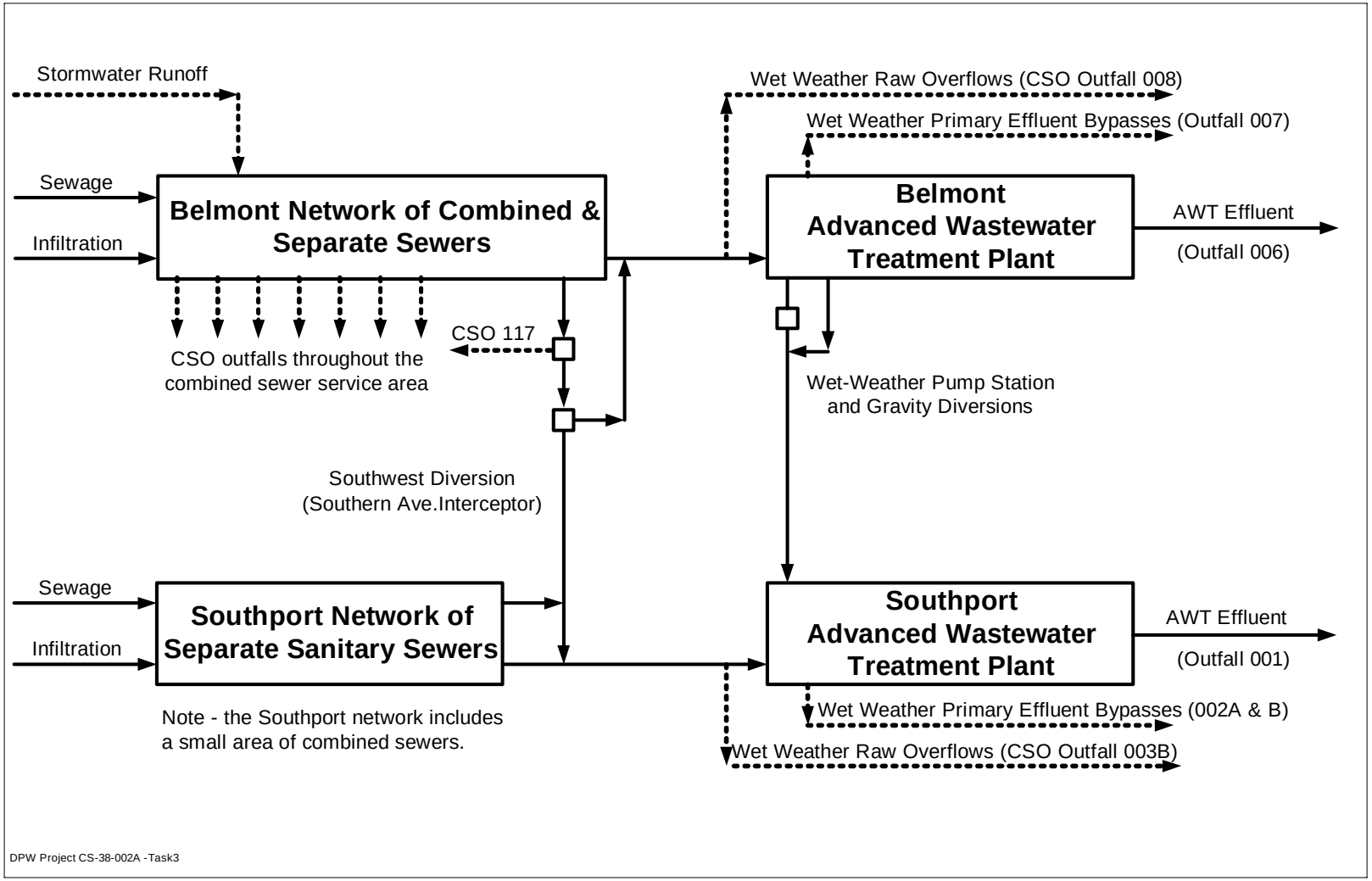
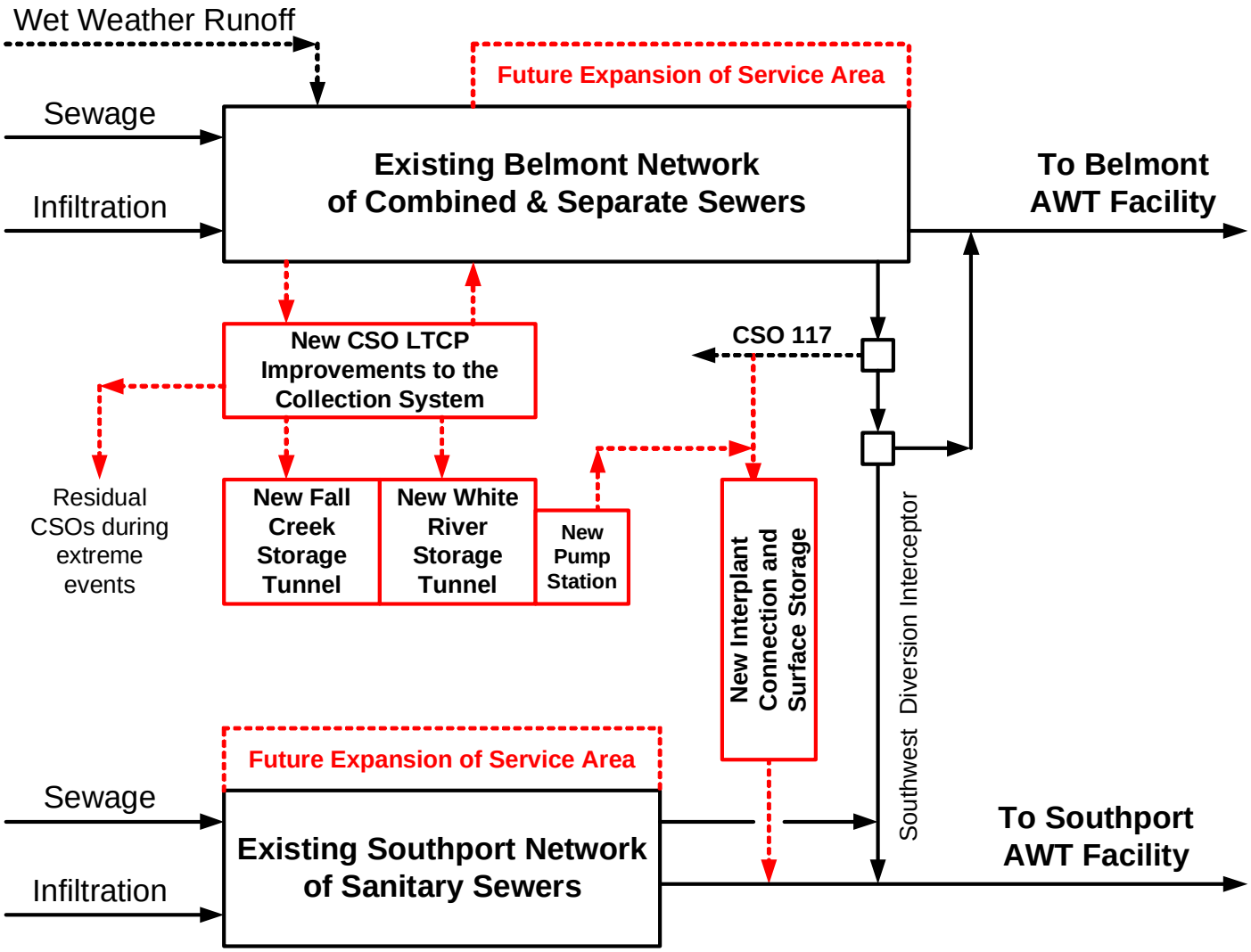


Figure 4-11
Indianapolis Wastewater Collection and Treatment Facilities



Note - The Southport network includes a small area of combined sewers.

Figure 4-12
Schematic of CSO Long Term Control Plan Variant

Additional information on development and calibration of the SWMM and NetSTORM models can be found in the *Indianapolis CSO LTCP Hydraulic and Water Quality Modeling Development Report* (Department of Public Works - Indianapolis Clean Stream Team (DPW-ICST), 2004).

To determine the flow capacity the interplant connection would need to accommodate the captured CSO flows pumped out of the deep tunnel, the city used captured CSO flowrates from the 5-year NetSTORM simulations as input to the integrated tunnel model. This provided the basis for an analysis of tunnel volume and dewatering rates. For a given set of input flow data, the tunnel model computed the annual average number of overflows that would occur for any combination of tunnel volume and dewatering rate assumed. For a given tunnel-dewatering rate, the tunnel volume was adjusted to obtain overflow event frequencies of 1, 4, 6, 8, 12 and 16 per year.

During the analysis, the city evaluated whether part of the captured CSO flows should be sent to the Belmont plant or whether it should all be sent to the Southport plant. The analysis evaluated, via computer simulations, what would have happened had the tunnel and flow-splitting provisions been in place during the 5-year period from 1996 through 2000.

The results also showed that attempting to split the tunnel flow between the Belmont and Southport AWT plants would be limited, because an expanded Belmont plant would have limited reserve capacity to treat captured CSO flows from the tunnel. Also, provisions for splitting part of the flow to the Belmont facility would not reduce the cost of improvements needed for CSO treatment at the Southport plant. This is because the full 150 mgd rate of tunnel dewatering would frequently be imposed on the Southport facility regardless of efforts to split part of the CSO load to the Belmont plant. Based on this analysis, the city's recommendation is to route the full amount of captured CSO flow to the Southport facility.

Based on an analysis of wet-weather flow data and simulation results for the period 1996-2000, the captured CSO flows from the collection system would approximately double the total wet-weather flow to the treatment plants. The existing Belmont plant currently manages almost all the wet-weather flow. Accordingly, a plan for sending all of the captured CSO flows to the Southport plant would result in the Belmont and Southport facilities each receiving about half of the wet-weather flow to the combined sewer system.

In order to determine the flow capacity needed to accommodate the captured CSO flows pumped out of the deep tunnel, an analysis of tunnel volume and dewatering rates was performed during the *Interplant Connection Facilities Plan*. In this analysis, captured CSO flowrates from alternative NetSTORM simulations were used as input to a tunnel simulation model. The results provided the following insights regarding tunnel volume requirements:

- The tunnel volume needed to achieve relatively low overflow frequencies is significantly reduced as the tunnel dewatering rate is increased.
- The tunnel volume requirement is very sensitive to the level of CSO overflow control. For example, the results suggested that the tunnel volume needed for a control level of one event per year would be nearly twice that needed for a control level of four events per year.
- As the tunnel dewatering rate is increased, a point of diminishing returns is reached where associated reductions of required tunnel volume become small. The knee of the curve for four events per year indicated that benefits decrease when dewatering rates climb higher than 150 mgd. The knee of the curve for eight events per year indicated there would be no benefit for a dewatering flow rate higher than about 75 mgd.

The results for tunnel volume and dewatering rate were not particularly sensitive to whether the CSO from structure 117 was diverted to the tunnel or to the interplant connection sewer. The results also indicated there would be no benefit for the tunnel dewatering rate to be higher than 150 mgd, even for tunnel sizes projected to control overflow frequencies down to one event per year. Thus, the city concluded that the maximum capacity for the interplant connection line would be 150 mgd if it were to accept only the dewatering flow from the tunnel.

4.5.2 Combined Sewer Collection System & Watershed Improvements

Utilizing the interplant facility planning analysis of tunnel volume and dewatering rates, the city proceeded with a more detailed evaluation of CSO controls within the collection system. Within the collection system, the city evaluated a variety of technologies and combinations of technologies

for CSO control and abatement. As noted in Section 3 (CSO Abatement Technologies), the technology analysis yielded the following general conclusions:

- Storage/conveyance technologies ranked highest at all levels of control due to reliability, water quality improvements and cost-effectiveness.
- Remote treatment technologies scored poorly due to operating and technical issues, but may be viable combined with a tunnel on Fall Creek or storage on Pogues Run. Remote treatment also carries heightened operational and security concerns.
- Hybrid technologies (storage then treatment) can score well on cost-effectiveness but never scored as well as storage/conveyance by itself.
- Sewer separation scored poorly on financial issues but has merits on smaller, remote watersheds.

Technologies that passed the initial screening described in Section 3 were developed into watershed alternatives during the development of systemwide plans. Three systemwide plans for the collection system were developed:

- CSO Control Plan 1: Storage and conveyance to central treatment facilities in all watersheds
- CSO Control Plan 2: Storage with remote treatment in the Fall Creek and Pogues Run watersheds and storage/conveyance to central treatment facilities in other watersheds
- CSO Control Plan 3: Sewer separation in all watersheds

A physical description of the structural alternatives evaluated for each watershed is provided below in sections 4.5.2.1 through 4.5.2.8. Information on project costs and water quality impacts of the alternatives is provided in Section 4.6, Evaluation of Systemwide CSO Control Alternatives.

Early Action Projects: The city has identified a number of early action projects to reduce combined sewer overflows and improve stream water quality prior to finalizing its CSO long-term control plan. U.S. EPA and IDEM have concurred with the city's decision to move these projects forward and to include these projects in the LTCP. Early action projects include in-line storage, off-line storage, sewer separation, and CSO-related AWT plant improvements. Active projects are in various stages of development, including planning, design or construction. All parties have recognized that these projects should be advanced because of their benefit to the environment, added capacities created, and resolution of localized problems. These projects provide a foundation for the overall plan and demonstrate the city's commitment to moving forward to improve water quality within local waterways. A detailed listing and breakdown of these projects is included in Section 7. The costs and benefits of all CSO control plans described below and in Section 4.6 include these early action projects.

4.5.2.1 Fall Creek

In the Fall Creek watershed, a deep storage tunnel ranked high in the watershed technology screening described in Section 3, as did a relief interceptor. Fall Creek is located approximately four miles from the Belmont AWT plant. The Fall Creek watershed also experiences high peak flowrates. Therefore, the pipe diameter that would be required for a relief interceptor would be close in size to that required for a storage tunnel. Since CSOs in upper Fall Creek contribute a significant amount of combined sewer overflows (roughly 40 percent of the total systemwide), large upstream conveyance pipes would be required. A storage tunnel would provide greater flexibility in developing solutions for the downstream system. For these reasons, a deep storage tunnel was selected for the Fall Creek watershed. The technology evaluation also concluded that a remote treatment facility at the end of the tunnel in the watershed warranted further evaluation.

Two plans were considered in the Fall Creek watershed.

Plan 1: A deep tunnel would be constructed along Fall Creek to store captured CSO flows. The tunnel would begin near 34th Street and Sutherland Avenue and would generally run parallel to Fall Creek in a southwesterly direction, ending near 10th Street and Stadium Drive, where it would connect to the central tunnel.

As shown in **Figure 4-13**, the tunnel size would range from 20 feet in diameter for 90 percent system capture (to store 40 million gallons) to 39 feet in equivalent constructable diameter[1] for 99 percent system capture (to store 162 million gallons). The tunnel length would be approximately 18,600 feet (3.5 miles).

[1]Equivalent diameter refers to the tunnel or pipe diameter with the same surface area as the constructable box structure.

Plan 2: A separate deep tunnel would be constructed along Fall Creek to store captured CSO flows (**Figure 4-14**). The tunnel would begin near 34th Street and Sutherland Avenue and end near 10th Street and Stadium Drive, essentially at the same alignment as Plan 1. However, instead of connecting to the central tunnel, a pump station would be constructed at the southern terminus to dewater the tunnel and convey the stored flow to the city's sewer collection system and a remote treatment facility. The treatment facility, located near the confluence of Fall Creek and White River, would include mechanical screens, pumping facilities, enhanced high rate clarification (EHRC) and ultraviolet (UV) disinfection. The treated effluent would be discharged into the White River. The facility would be sized to dewater the tunnel within two days.

The estimated tunnel diameter and storage volume for Plan 2 would match Plan 1, described above. The Plan 2 tunnel length would be approximately 18,800 feet (3.6 miles). The remote treatment facility peak flow capacity would range from 20 mgd for 90 percent system capture to 81 mgd for 99 percent system capture.

Collection sewers would be required under both Plan 1 and Plan 2 to capture and convey CSO flows from upstream outfalls into the deep tunnel. Two collection sewers were sized in the Fall Creek watershed: one to collect captured CSO flows from CSOs 216, 135, 141 and 066 located upstream of the tunnel's northern terminus, and a second to collect captured CSO flows from CSOs 050 and 050A near Watkins Park. Additional collection sewers would be required to group CSOs along the deep tunnel to reduce the number of tunnel shafts. For Plan 2 only, a collection sewer was also sized to collect captured CSO flows from CSOs 043 and 044 within the White River watershed, as shown in **Figure 4-14**.

4.5.2.2 Pogues Run

In the Pogues Run watershed, the city's completed and ongoing projects, outfall-specific solutions, and localized capturing and redirection of CSOs will control the majority of overflows. During early phases of the city's CSO control program, Indianapolis took an aggressive approach toward addressing urban flooding, stormwater quality, and CSO impacts along Pogues Run. Several projects along Pogues Run are already constructed and operational. Another project will convert one of two existing underground conduits into a combined sewage conveyance/storage facility. The technology evaluation also concluded that a remote treatment facility at the end of the watershed in conjunction with a storage tunnel warranted further evaluation.

Two plans were evaluated for Pogues Run.

Plan 1: One of the two barrels of the existing underground Pogues Run box culvert would be converted to store/convey captured CSO flows from various outfalls along lower Pogues Run to a central tunnel (**Figure 4-15**). The existing barrel has adequate hydraulic capacity to carry CSO flows to the central tunnel for system capture levels of 90, 93, and 95 percent. For capture levels of 97 and 99 percent, a collection sewer would be constructed to capture and convey CSO flows along lower Pogues Run, as shown on Figure **4-15**. This interceptor would begin at the upstream end of the Pogues Run box culvert, near New York Street and Dorman Street. The interceptor would run parallel to Pogues Run in a southwesterly direction and would end at Ray Street and White River to convey CSO flows into the central tunnel. The interceptor would range from 72 inches in diameter for 97 percent system capture (to convey 50 mgd) to 192 inches in equivalent pipe diameter for 99 percent system capture (to convey 400 mgd), as shown on **Figure 4-15**. The interceptor length would be approximately 14,700 feet (2.8 miles).

Figure 4-15 also shows additional CSO control facilities within the Pogues Run watershed. An off-line storage facility would be constructed in or near Spades Park for outfalls located in upper Pogues Run. The facility would range in size from 4.0 to 9.5 MG, depending on the level of control selected. Solids and floatables would be removed through a screening system. A collection interceptor would be constructed to convey captured CSO flow to the storage/treatment facility from CSOs 102, 101, 100, 099, 098, 097, 096, 095, and 036. The interceptor maximum size would range from 60 inches in diameter for 90 percent system capture to 168 inches in equivalent pipe diameter for 99 percent system capture, as shown on **Figure 4-15**. The interceptor length would be approximately 9,000 feet (1.7 miles). If capture levels of 97 or 99 percent are required, the city will evaluate during facility planning whether to extend the collection interceptor described above for lower Pogues Run in order to reduce the storage basin size required in Spades Park. The captured CSO flows would be stored in a subsurface storage facility and pumped back into the existing interceptor at the end of a storm event.

CSO Facility	System Capture 90%		93%		95%		97%		99%	
Deep Tunnel (Volume/Diameter)	40 MG	20'	62 MG	24'	76 MG	27'	110 MG	32'	162 MG	39'

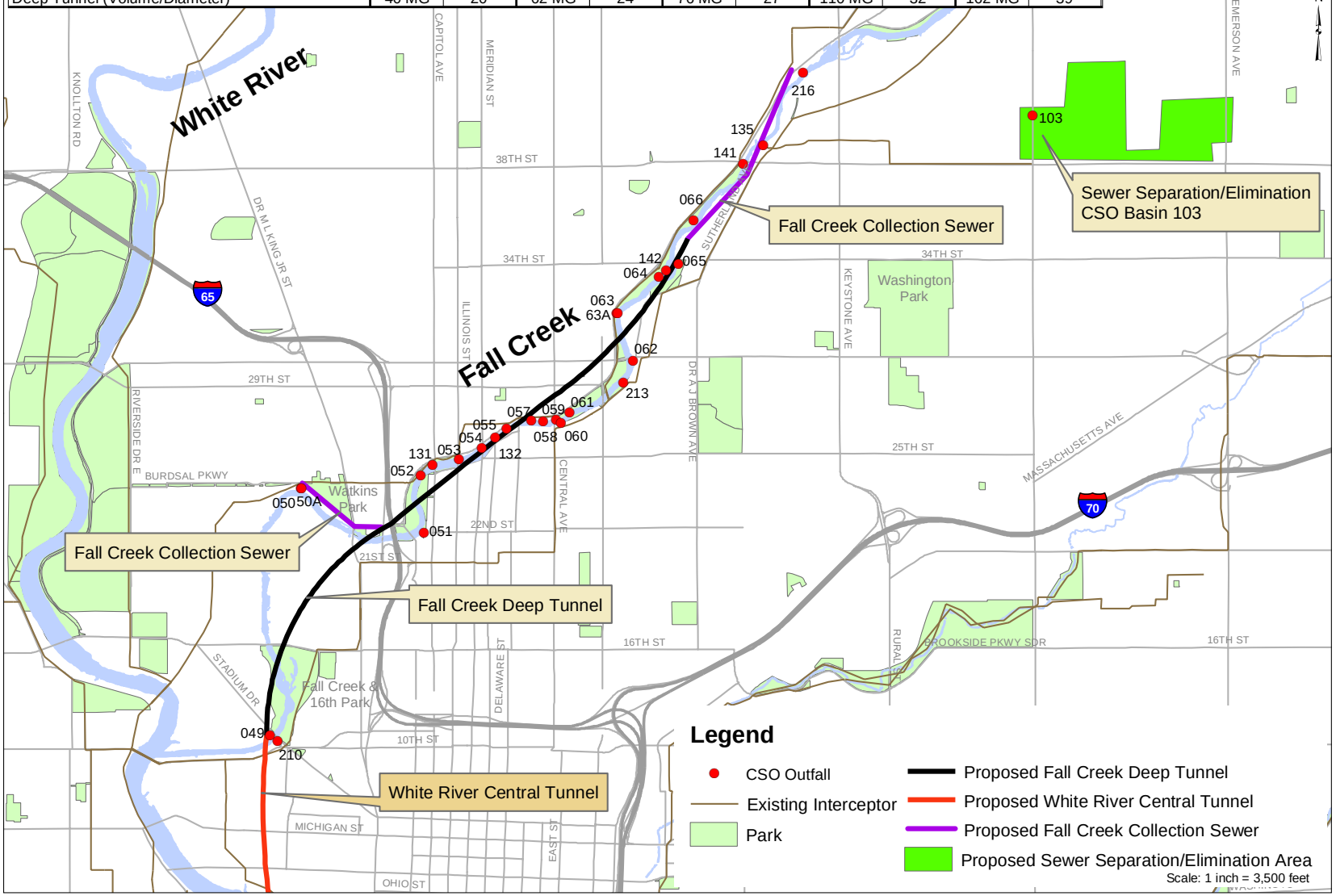


Figure 4-13
Fall Creek Plan 1

CSO Facility	System Capture 90%		93%		95%		97%		99%	
Deep Tunnel (Volume/Diameter)	40 MG	20'	62 MG	24'	76 MG	27'	110 MG	32'	162 MG	39'
Deep Pumping & Remote Treatment Facilities	20 mgd		31 mgd		38 mgd		55 mgd		81 mgd	

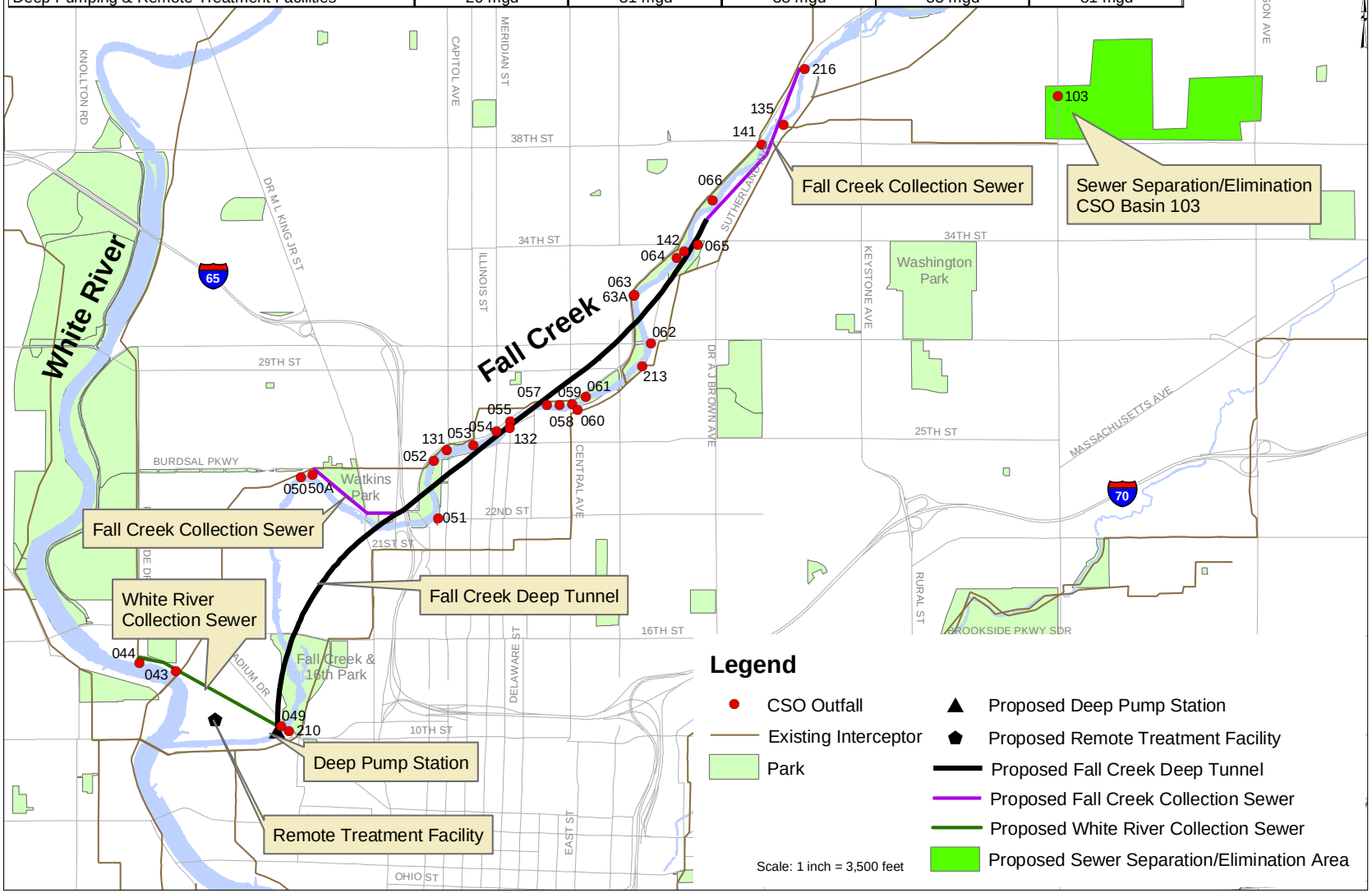


Figure 4-14
Fall Creek Plan 2

CSO Facility	System Capture 90%		93%		95%		97%		99%	
Upper Pogues Run Collection Interceptor (Flow/Diameter) Reach 1	0 mgd	N/A	2 mgd	12"	14 mgd	30"	40 mgd	48"	100 mgd	72"
Upper Pogues Run Collection Interceptor (Flow/Diameter) Reach 2	50 mgd	60"	102 mgd	72"	139 mgd	96"	250 mgd	120"	500 mgd	168"
Spades Park Storage/Treatment Facility (Volume)	4 MG		7.5 MG		9.5 MG		14.5 MG		26 MG	
Lower Pogues Run Collection Interceptor (Flow/Diameter)	125 mgd	N/A	300 mgd	N/A	500 mgd	N/A	800 mgd	72"	1400 mgd	192"

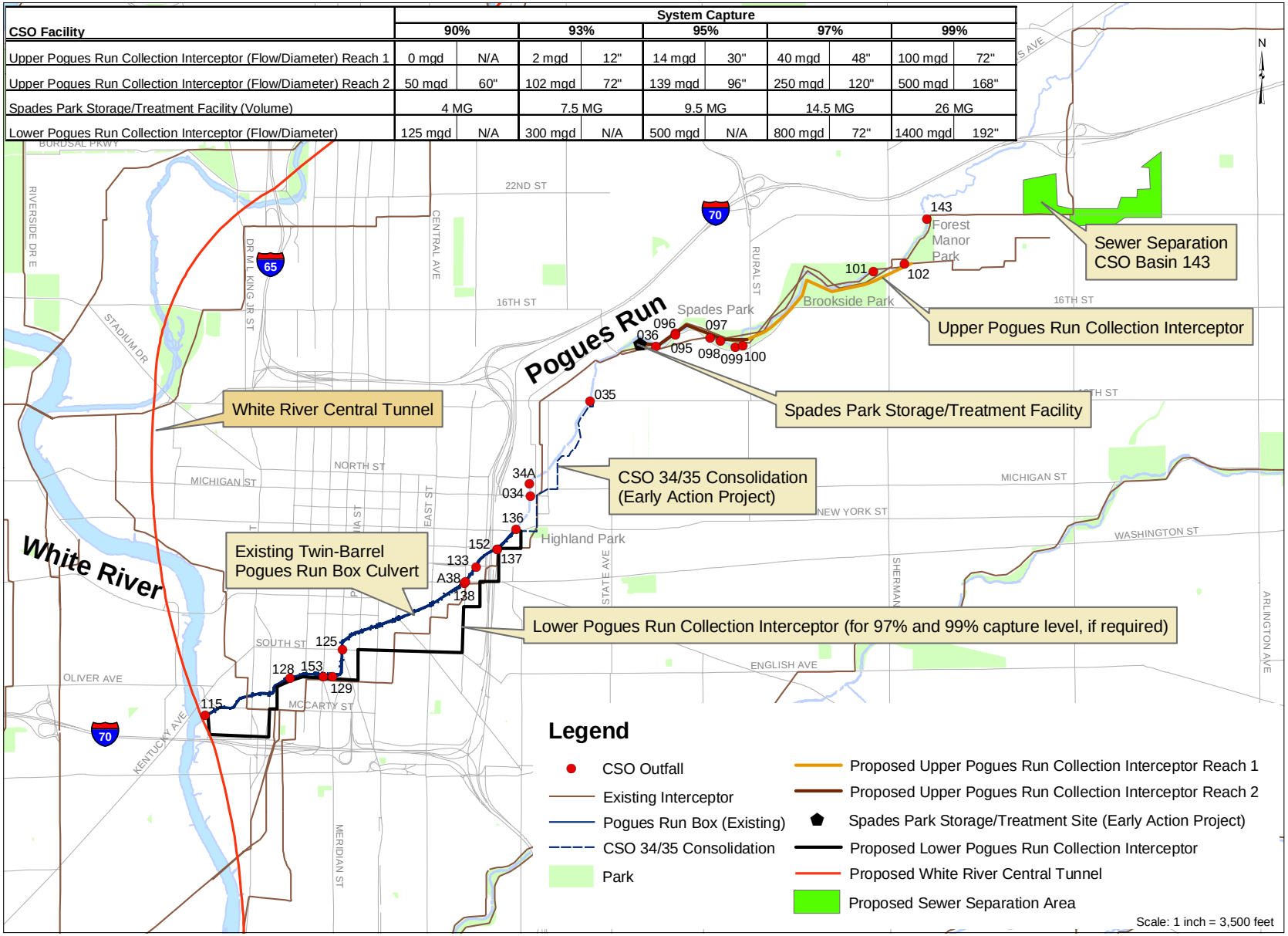


Figure 4-15
Pogues Run Plan 1

Sewer separation would be implemented within the combined sewer area tributary to CSO 143, thus eliminating this remote CSO upstream of Forest Manor Park.

Plan 2: A deep tunnel would be constructed along Pogues Run to store captured CSO flows (**Figure 4-16**). The tunnel would begin at the upstream end of the existing Pogues Run box culvert, near New York Street and Dorman Street. The tunnel would then run parallel to the Pogues Run box culvert in a southwesterly direction, ending near Ray Street and the White River. A pump station would be constructed at this terminus point to dewater the tunnel and convey the stored flow to a remote treatment facility. This facility would be located near the confluence of Pogues Run and White River. The remote treatment facility would include mechanical screens, pumping facilities, EHRC, and UV disinfection. The treated effluent would be discharged into the White River. The facility would be sized to dewater the tunnel within two days.

Collection sewers would be required to capture and convey CSO flows into the deep tunnel. The tunnel size would range from 20 feet in diameter for 90 percent system capture (to store 20 million gallons) to 40 feet in equivalent constructable diameter for 99 percent system capture (to store 100 million gallons). The tunnel length would be approximately 10,900 feet (2.1 miles). The remote treatment facility peak flow capacity would range from 10 mgd for 90 percent system capture to 50 mgd for 99 percent system capture.

One of the two barrels of the existing underground Pogues Run box culvert would be utilized to store captured CSO flows from outfalls along lower White River. Initial studies indicate that the barrel has approximately 10 million gallons of storage volume available. The remaining CSO volume would be rerouted to the deep tunnel described above.

As with Plan 1, Plan 2 would include additional CSO control improvements in the Pogues Run watershed, including a Spades Park satellite storage/treatment facility and a collection interceptor to convey flows to the Spades Park facility. As shown in **Figure 4-16**, interceptor alignment, diameter, and length would match those in Plan 1. Sewer separation would be implemented to eliminate CSO 143 upstream of Forest Manor Park.

4.5.2.3 Pleasant Run/Bean Creek

In the Pleasant Run watershed, a relief interceptor ranked high in the watershed technology screening described in Section 3, as did a deep storage tunnel. Because Pleasant Run is located near the proposed central tunnel and AWT plants, storage in the central tunnel becomes more favorable than storage along Pleasant Run. Additionally, roughly half of the overflows on Pleasant Run occur at the downstream end of the watershed near the central tunnel. For these reasons, a relief interceptor was selected to convey flows from Pleasant Run to the central tunnel.

Under both Plan 1 and Plan 2, a collection interceptor would be constructed to capture and convey CSO flows from various outfalls along Pleasant Run (**Figure 4-17**). This interceptor would begin at the upstream end of Pleasant Run, within the Pleasant Run Golf Course. The interceptor would then run parallel to Pleasant Run in a southwesterly direction and would connect with the central tunnel at Bluff Road and Southern Avenue. The interceptor maximum size would range from 72 inches in diameter for 90 percent system capture (to convey 105 mgd) to 216 inches in equivalent pipe diameter for 99 percent system capture (to convey 920 mgd), as shown on **Figure 4-17**. The interceptor length would be approximately 42,600 feet (8.1 miles). A collection interceptor would also be required to capture CSO flows from outfalls along Bean Creek and convey them to the proposed Pleasant Run interceptor. In addition, sewer separation would be implemented within the combined sewer area tributary to CSO 017, eliminating this remote CSO on Bean Creek. The city is also considering installation of a separate smaller diameter interceptor, parallel to the new relief interceptor, to serve Citizens Gas and other industries along the interceptor corridor. However, this interceptor has not been included in the LTCP cost estimates for Pleasant Run.

4.5.2.4 Eagle Creek

The Eagle Creek watershed has only five CSOs, which are fairly distant from each other. Thus, consolidating the CSOs for off-line storage or remote treatment is not cost-effective. For these reasons, a collection interceptor was selected for the Eagle Creek watershed.

Under both Plan 1 and Plan 2, a collection interceptor would be constructed, beginning at Eagle Creek and Vermont Street (**Figure 4-18**). The interceptor would run generally parallel to Eagle Creek in a southeasterly direction and would end at the Belmont AWT plant headworks facility. Approximately half of the diverted flow would be conveyed to the Belmont AWT plant via the Eagle Creek collection interceptor, and the remainder would be conveyed to the Southport AWT plant via the existing West Marion County interceptor. The interceptor size would range from 48 inches in diameter for 90 percent system capture (to convey 45 mgd) to 108 inches in diameter for 99 percent system capture (to convey 220 mgd), as shown on **Figure 4-18**. The interceptor length would be approximately 24,900 feet (4.7 miles).

CSO Facility	System Capture 90%		93%		95%		97%		99%	
Upper Pogues Run Collection Interceptor (Flow/Diameter) Reach 1	0 mgd	N/A	2 mgd	12"	14 mgd	30"	40 mgd	48"	100 mgd	72"
Upper Pogues Run Collection Interceptor (Flow/Diameter) Reach 2	50 mgd	60"	102 mgd	72"	139 mgd	96"	250 mgd	120"	500 mgd	168"
Spades Park Storage/Treatment Facility (Volume)	4 MG		7.5 MG		9.5 MG		14.5 MG		26 MG	
Lower Pogues Run Deep Tunnel (Volume/Diameter)	20 MG	18'	33 MG	23'	43 MG	26'	66 MG	33'	100 MG	40'
Deep Pumping & Remote Treatment Facilities	10 mgd		17 mgd		22 mgd		33 mgd		50 mgd	

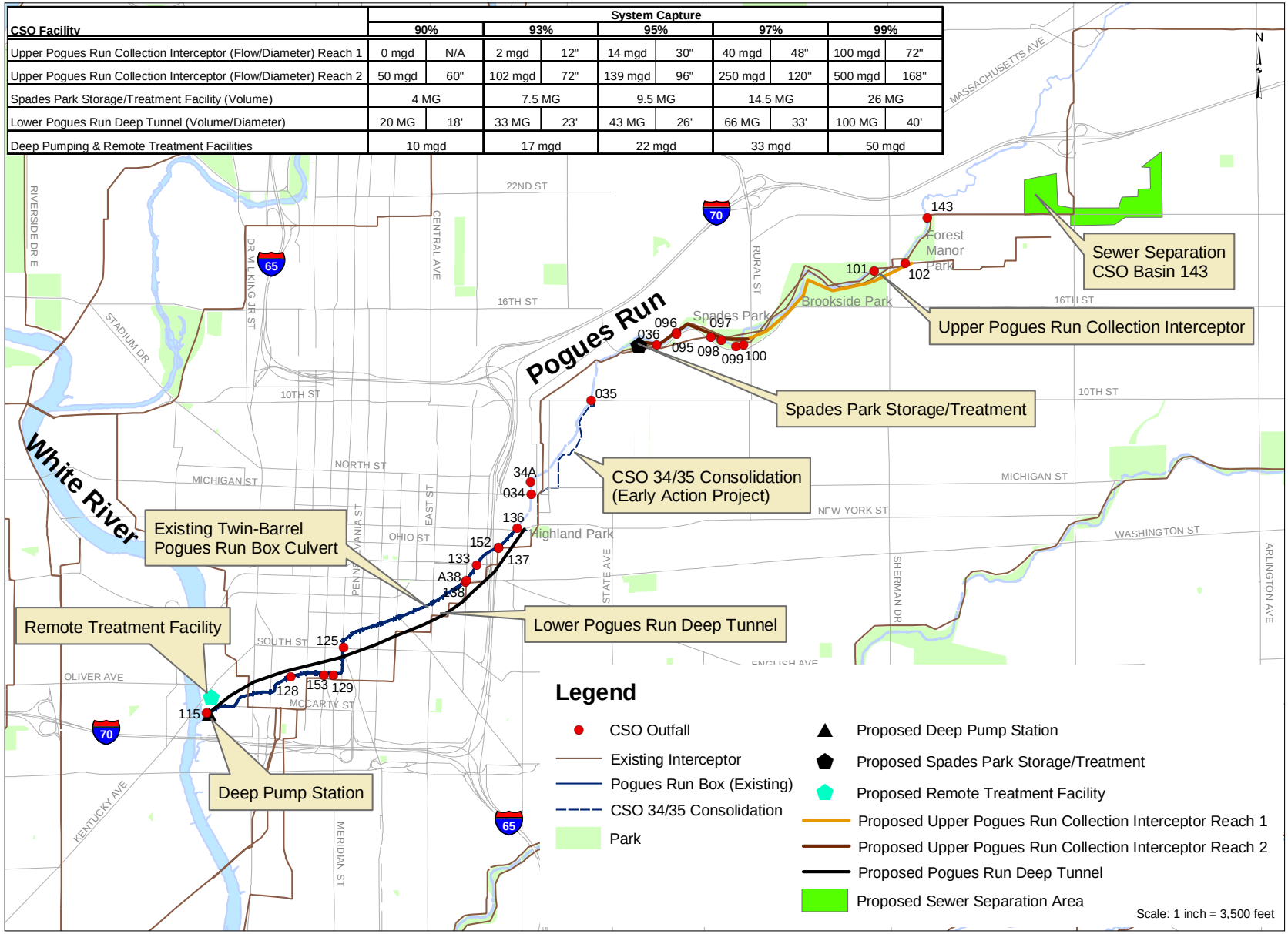


Figure 4-16
Pogues Run Plan 2

CSO Facility	System Capture 90%		93%		95%		97%		99%	
Pleasant Run Collection Interceptor (Flow/Diameter) Reach 1	35 mgd	42"	90 mgd	72"	120 mgd	84"	189 mgd	102"	331 mgd	132"
Pleasant Run Collection Interceptor (Flow/Diameter) Reach 2	60 mgd	60"	185 mgd	96"	260 mgd	120"	385 mgd	144"	736 mgd	192"
Bean Creek Collection Interceptor (Flow/Diameter)	3 mgd	15"	10 mgd	24"	15 mgd	30"	25 mgd	42"	55 mgd	60"
Pleasant Run Collection Interceptor (Flow/Diameter) Reach 3	105 mgd	72"	260 mgd	120"	355 mgd	132"	500 mgd	168"	919 mgd	216"

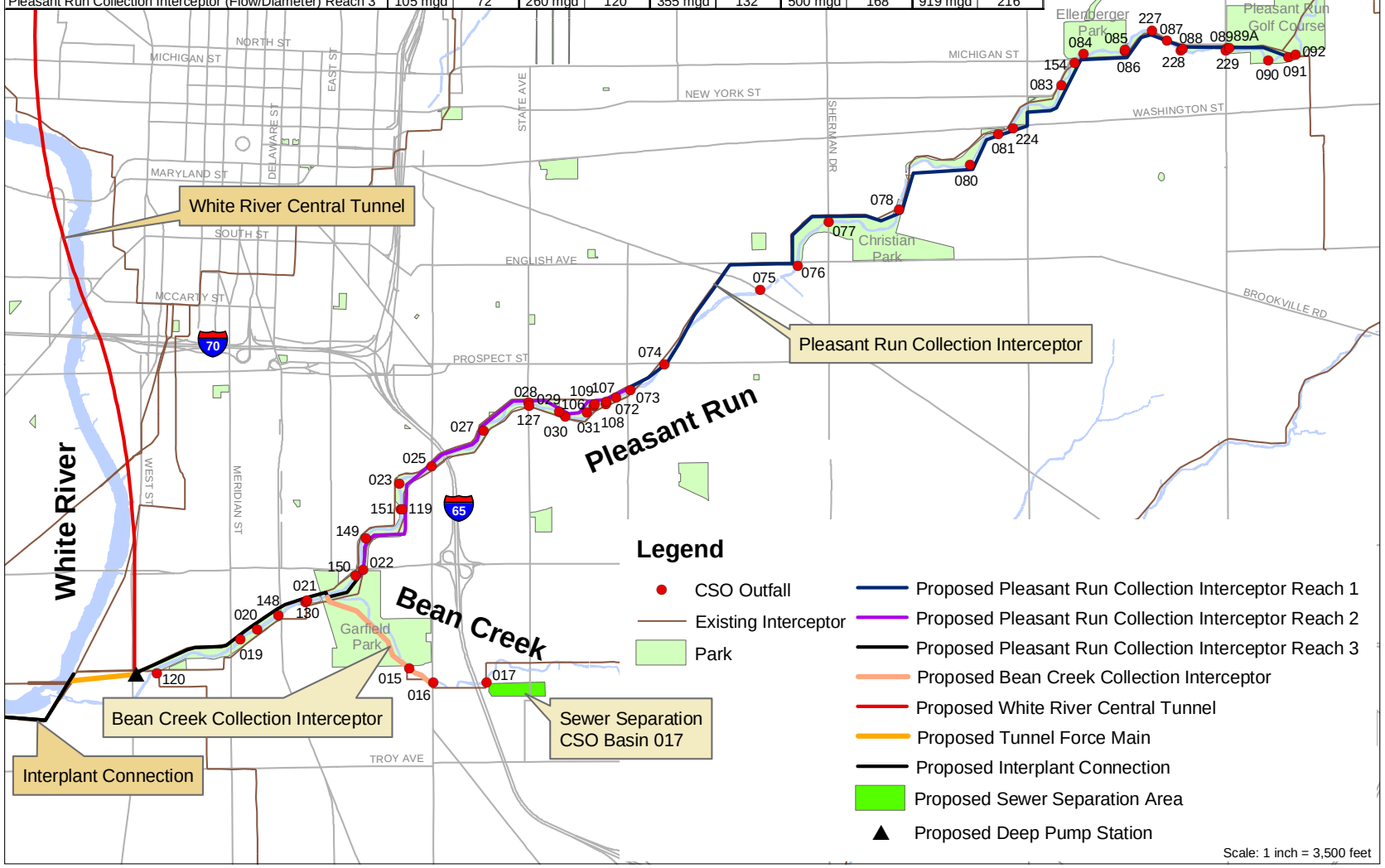


Figure 4-17
Pleasant Run Plan 1 and 2

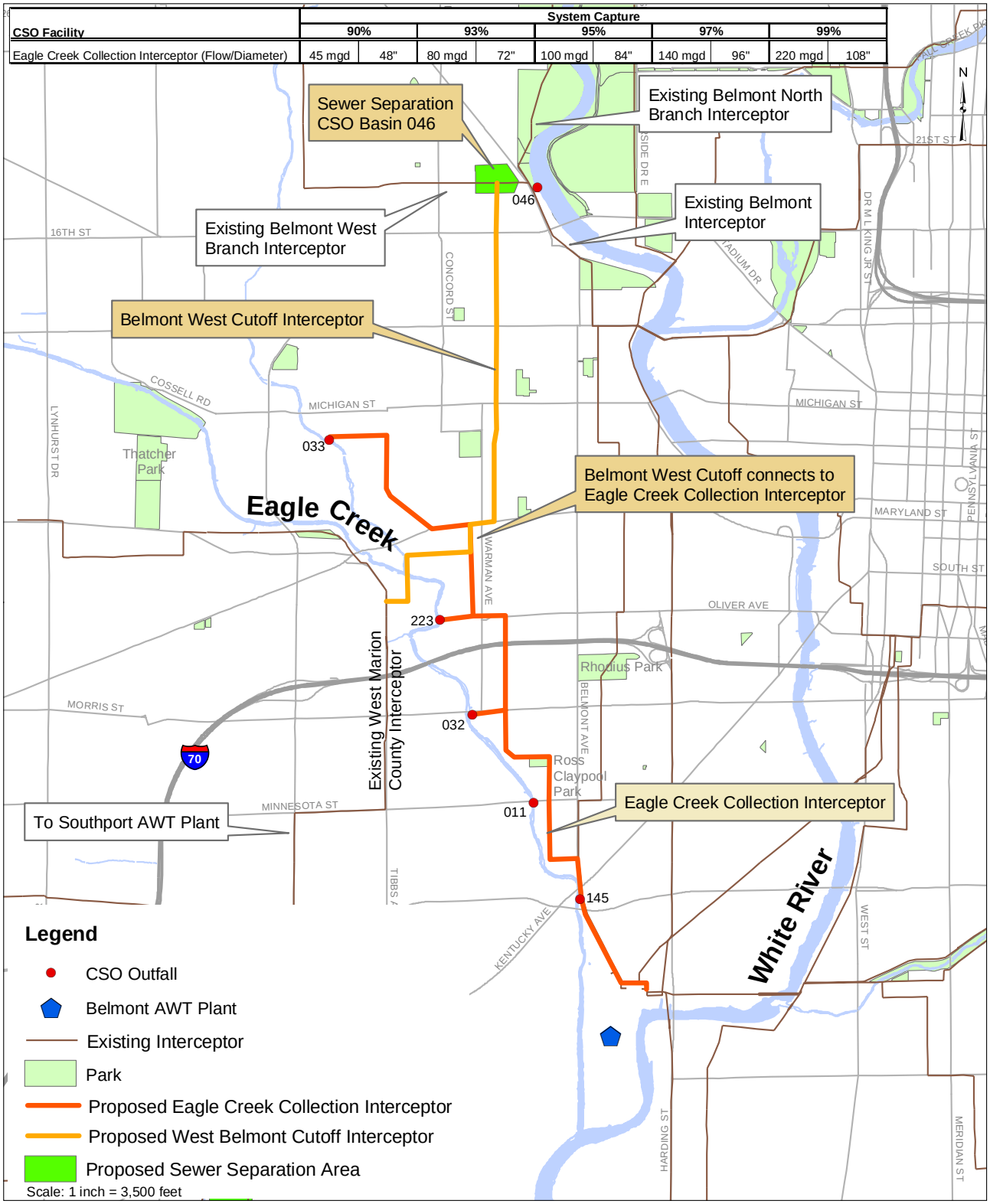


Figure 4-18
Eagle Creek Plan 1 and 2

The interceptor is planned in conjunction with the Belmont West cutoff interceptor to divert flow from the Belmont North and Belmont West interceptors to the Southport AWT plant.

4.5.2.5 White River

In the White River watershed, the city's ongoing projects will store and treat CSOs located in upper White River and will eliminate CSO 275 by sewer separation in lower White River. The White River runs through the center of Indianapolis' system. For this reason, a central tunnel was selected for the White River watershed to store and convey captured CSO flows from the tributaries and from captured White River CSOs to upgraded and expanded AWT plants.

Two plans were evaluated for White River.

Plan 1: The central tunnel for White River would begin near 10th Street and Stadium Drive, at the terminus of the deep storage tunnel for the Fall Creek watershed (**Figures 4-19 and 20**). The tunnel would run parallel to White River in a southerly direction and would end at Bluff Road and Southern Avenue, near the Southwest Diversion Structure. A pump station would be constructed near this structure to dewater the tunnel and convey the stored flow into the interplant connection for ultimate treatment at the Southport AWT plant. The tunnel size would range from 14 feet in diameter for 90 percent system capture (to store 20.5 million gallons) to 55 feet in equivalent constructable diameter for 99 percent system capture (to store 342 million gallons), as shown on **Figure 4-19**. The tunnel length would be approximately 19,300 feet (3.7 miles).

Two collection sewers would be required in the White River watershed to collect CSOs remotely located from the central tunnel: one to collect captured CSO flows from CSOs 043 and 044 and a second to collect captured CSO flows from CSOs 045, 042, 041, 147 and 040 (**Figure 4-20**). Additional collection sewers may be required to group CSOs along the central tunnel to reduce the number of tunnel drop shafts. At higher capture rates (97 and 99 percent), headworks overflows from CSO 008 also would need to be conveyed to the central tunnel.

In addition, sewer separation is planned to eliminate CSO 046. A satellite storage/treatment facility would also be constructed for CSO 205 at the Riviera Club facility along upper White River.

Plan 2: A separate deep central tunnel would be constructed along White River (**Figures 4-21 and 22**). The tunnel would begin at Ray Street and White River, south of the confluence of Pogues Run and White River. The tunnel would generally parallel White River in a southerly direction and would end at Bluff Road and Southern Avenue, near the Southwest Diversion Structure. As with Plan 1, a pump station would dewater the tunnel and convey flows to the interplant connection. The tunnel size would range from 14 feet in diameter for 90 percent system capture (to store 8 million gallons) to 58 feet in equivalent constructable diameter for 99 percent system capture (to store 182 million gallons). The tunnel length would be approximately 9,200 feet (1.7 miles).

Two collection sewers would be required to collect CSOs located away from the central tunnel: one to collect captured CSO flows from CSOs 037, 038 and 039 and a second to collect captured CSO flows from CSOs 045, 042, 041, 147 and 040 (**Figures 4-21 and 22**). Additional collection sewers may be required to group CSOs along central tunnel to reduce the number of tunnel drop shafts. At higher capture rates (97 and 99 percent), headworks overflows from CSO 008 also would need to be conveyed to the central tunnel.

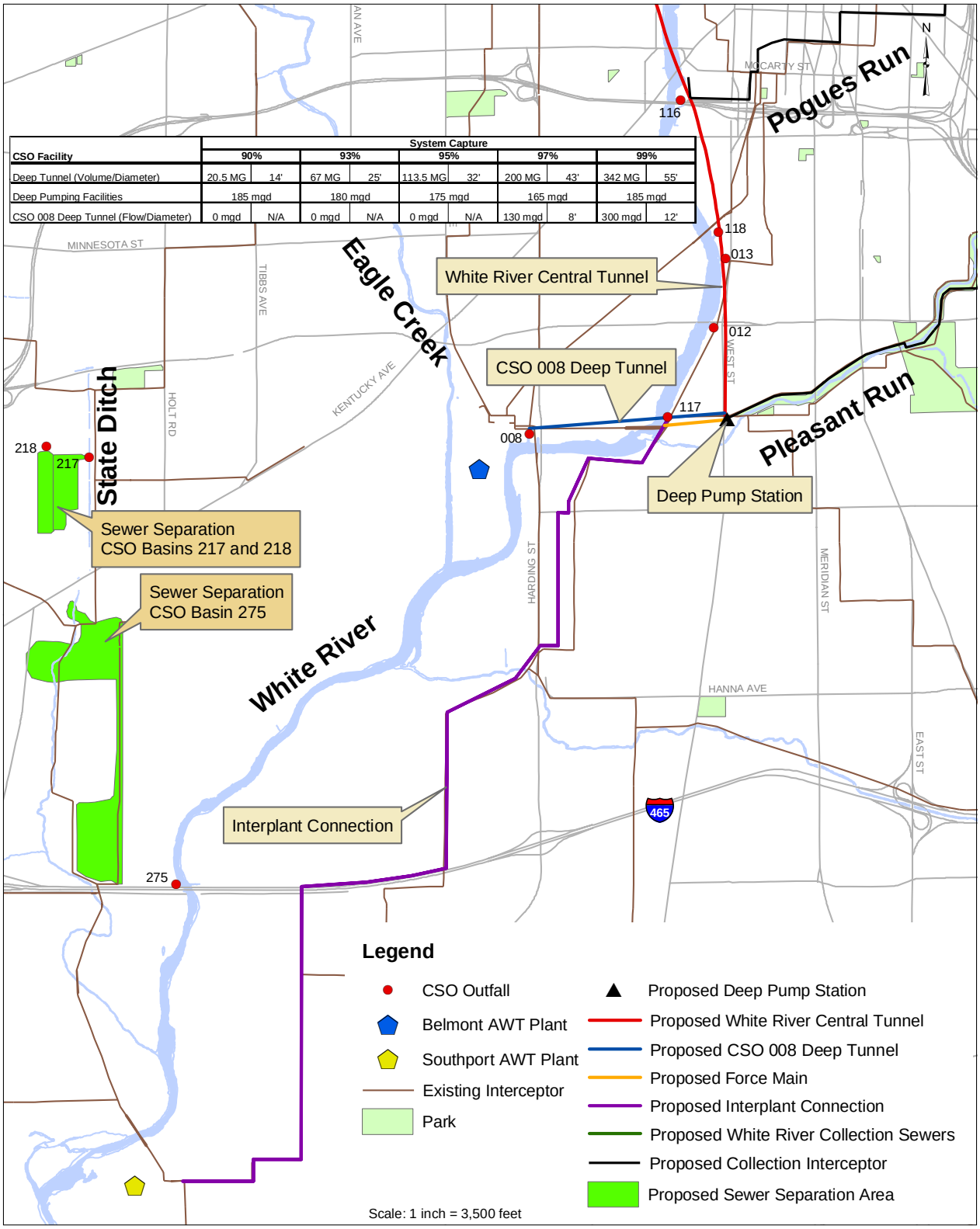
As with Plan 1, sewer separation for CSO 046 and satellite storage/treatment for CSO 205 would also be included in Plan 2 for White River.

4.5.2.6 State Ditch/Lick Creek

Sewer separation is being employed in State Ditch and Lick Creek as part of the city's early action projects to eliminate CSOs 217, 218 and 235 in these watersheds.

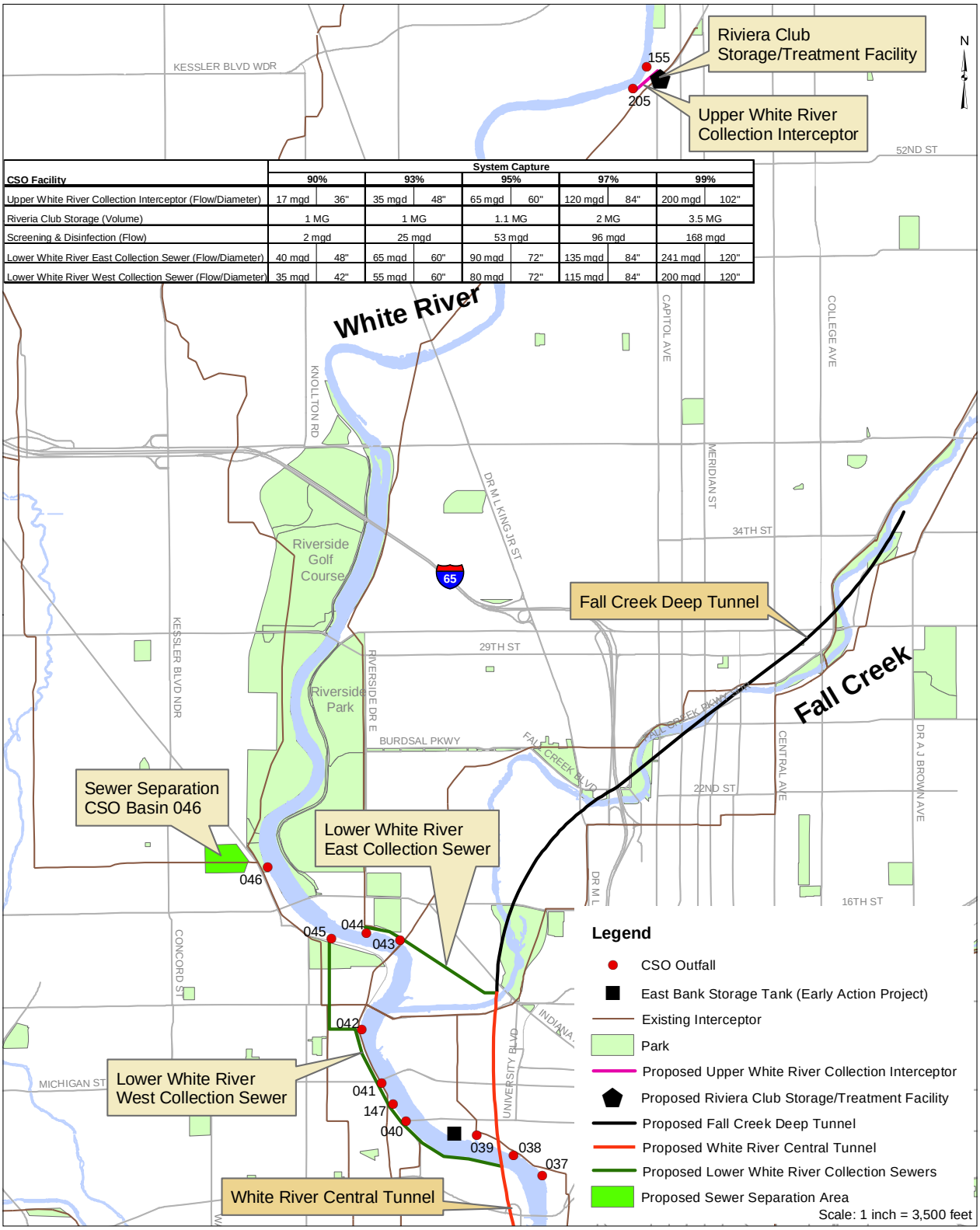
4.5.2.7 Complete Sewer Separation

As noted earlier, CSO Control Plan 3 includes separation of existing combined sewers in all watersheds to eliminate combined sewer overflows (**Figure 4-23**). Existing combined sewers would be converted to either a separate sanitary sewer or a separate storm sewer. The selection would be based on many factors, including the size of the combined sewer, its connection to the interceptor, number of lateral connections and other factors. In some instances, the existing combined sewer may need total replacement. A new sewer system (sanitary or storm) would be constructed. Sanitary flows would be conveyed to the AWT plants and would receive advanced treatment. This plan does not include expansion of the AWT plants; however, it is likely that the plants would continue to receive higher flows during wet-weather periods due to infiltration into the sanitary system. Further analysis may be required to determine whether secondary capacity would need to be expanded to match primary capacity and eliminate the PE Bypass. The stormwater flows would be conveyed to stormwater best management practices, such as ponds and sand filters, prior to ultimate discharge into streams.



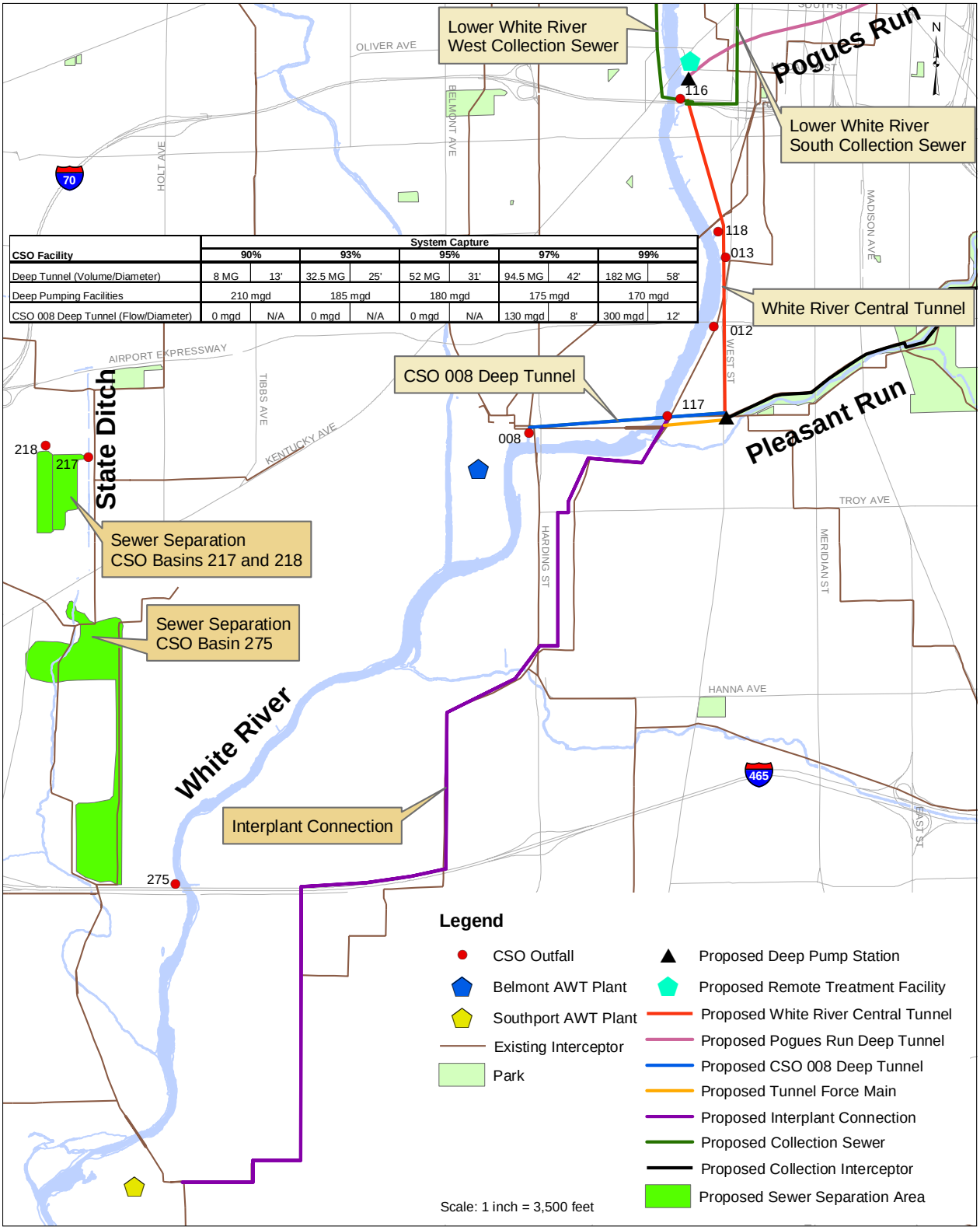
CSO Facility	System Capture									
	90%		93%		95%		97%		99%	
Deep Tunnel (Volume/Diameter)	20.5 MG	14'	67 MG	25'	113.5 MG	32'	200 MG	43'	342 MG	55'
Deep Pumping Facilities	185 mgd		180 mgd		175 mgd		165 mgd		185 mgd	
CSO 008 Deep Tunnel (Flow/Diameter)	0 mgd	N/A	0 mgd	N/A	0 mgd	N/A	130 mgd	8'	300 mgd	12'

Figure 4-19
White River Plan 1
(Map 1 of 2)



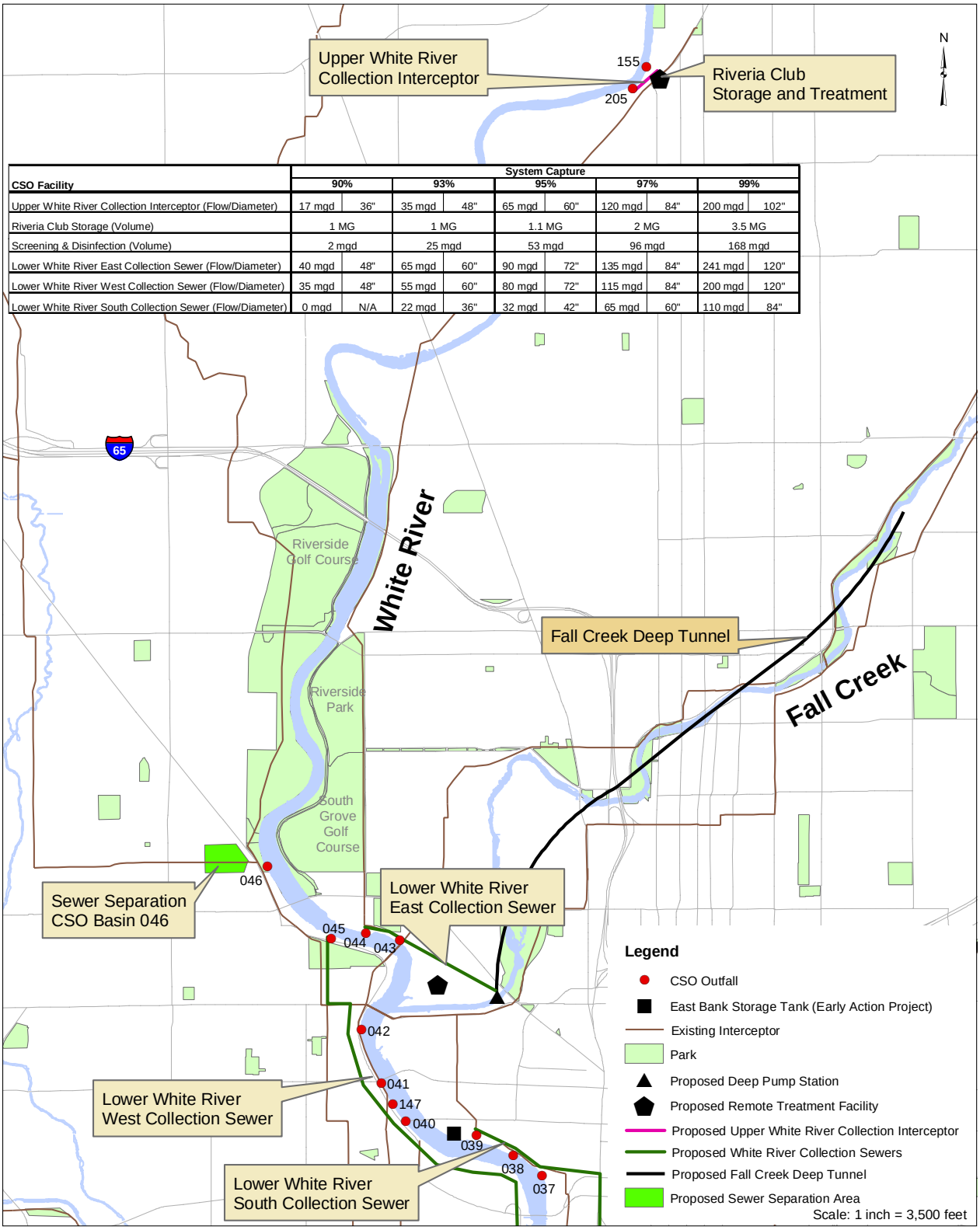
CSO Facility	System Capture									
	90%		93%		95%		97%		99%	
Upper White River Collection Interceptor (Flow/Diameter)	17 mgd	36"	35 mgd	48"	65 mgd	60"	120 mgd	84"	200 mgd	102"
Riveria Club Storage (Volume)	1 MG		1 MG		1.1 MG		2 MG		3.5 MG	
Screening & Disinfection (Flow)	2 mgd		25 mgd		53 mgd		96 mgd		168 mgd	
Lower White River East Collection Sewer (Flow/Diameter)	40 mgd	48"	65 mgd	60"	90 mgd	72"	135 mgd	84"	241 mgd	120"
Lower White River West Collection Sewer (Flow/Diameter)	35 mgd	42"	55 mgd	60"	80 mgd	72"	115 mgd	84"	200 mgd	120"

Figure 4-20
White River Plan 1
(Map 2 of 2)



CSO Facility	System Capture									
	90%		93%		95%		97%		99%	
Deep Tunnel (Volume/Diameter)	8 MG	13'	32.5 MG	25'	52 MG	31'	94.5 MG	42'	182 MG	58'
Deep Pumping Facilities	210 mgd		185 mgd		180 mgd		175 mgd		170 mgd	
CSO 008 Deep Tunnel (Flow/Diameter)	0 mgd	N/A	0 mgd	N/A	0 mgd	N/A	130 mgd	8'	300 mgd	12'

Figure 4-21
White River Plan 2
(Map 1 of 2)



CSO Facility	System Capture 90%		93%		95%		97%		99%	
Upper White River Collection Interceptor (Flow/Diameter)	17 mgd	36"	35 mgd	48"	65 mgd	60"	120 mgd	84"	200 mgd	102"
Riveria Club Storage (Volume)	1 MG		1 MG		1.1 MG		2 MG		3.5 MG	
Screening & Disinfection (Volume)	2 mgd		25 mgd		53 mgd		96 mgd		168 mgd	
Lower White River East Collection Sewer (Flow/Diameter)	40 mgd	48"	65 mgd	60"	90 mgd	72"	135 mgd	84"	241 mgd	120"
Lower White River West Collection Sewer (Flow/Diameter)	35 mgd	48"	55 mgd	60"	80 mgd	72"	115 mgd	84"	200 mgd	120"
Lower White River South Collection Sewer (Flow/Diameter)	0 mgd	N/A	22 mgd	36"	32 mgd	42"	65 mgd	60"	110 mgd	84"

Figure 4-22
White River Plan 2
(Map 2 of 2)

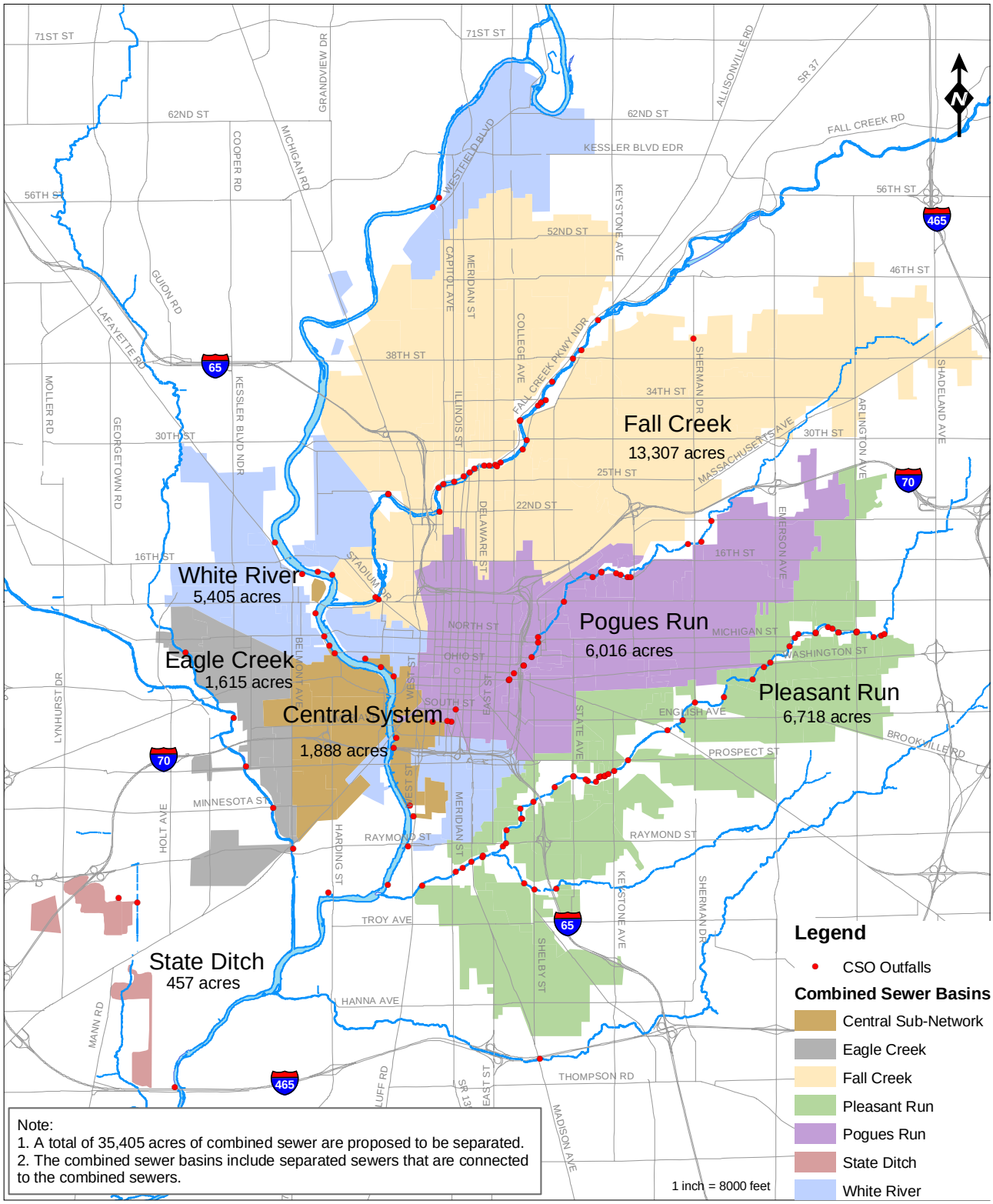


Figure 4-23
Total Sewer Separation Plan 3

4.5.2.8 Additional Watershed Improvement Projects

The city is committed to improving the quality of the streams and rivers that originate or flow through Marion County. As described earlier in Section 2, other pollution sources originating within Marion County also have a significant impact on the water quality of CSO receiving streams. Upstream sources also contribute to poor stream quality. For these reasons, the city evaluated other control alternatives that might enhance or supplement the benefits of structural CSO controls. These additional controls included measures to eliminate failing septic systems, install stormwater controls, remove illicit connections, restore streambanks, and remove polluted sediments. The city's evaluation of these controls was described earlier in Sections 4.3.2 through 4.3.6.

The city also evaluated flow augmentation alternatives to improve dry-weather *E. coli* compliance and dam modifications/aeration to ensure dissolved oxygen compliance. **Figure 4-24** shows the projected location of needed facilities while **Table 4-6** presents a list and projected cost of these projects. Some options for flow augmentation and dissolved oxygen enhancement are listed below.

4.5.2.8.1 Dry-Weather *E. coli* Compliance

Flow Augmentation in Fall Creek, Pogues Run, Pleasant Run, and Eagle Creek. The relationship between urbanization and stream base flow is poorly understood (CWP, 2002). The combination of high peak flows associated with storm runoff and very low flow conditions at other times tends to describe the hydrology of many urban streams. Current theory suggests that by the time low baseflow conditions are observed in an urban stream, the local water table has fallen and alternate methods for restoring baseflow to the stream must be considered. In Indianapolis, low flow conditions in Fall Creek, Pogues Run, Pleasant Run, and Eagle Creek during dry weather in late summer and fall appear to correlate with excessive *E. coli* bacteria concentrations in the streams. This suggests that these streams do not have adequate baseflow to absorb the ambient pollutant load and that flow augmentation should be considered to improve dry-weather bacteria compliance. A number of methods have been studied for baseflow augmentation. Some methods being considered include:

Effluent Reuse: This would involve pumping highly treated effluent into each stream by constructing an effluent force main from the Belmont AWT plant. One possible alignment for the proposed Belmont effluent force main would parallel White River north to its confluence with Pleasant Run, then follow Pleasant Run northeast to Rural Street, then north along the Rural Street/Keystone Avenue corridor to Fall Creek. This alignment would provide the opportunity to supplement the flows in both Pleasant Run and Pogues Run. A separate Belmont effluent force main would be constructed to augment flow in Eagle Creek. During low-flow periods, these effluent force mains could improve dry-weather *E. coli* bacteria compliance by delivering 2.5 mgd of Belmont effluent into Fall Creek, 0.5 to 2 mgd in Pogues Run, 0.1 mgd in Pleasant Run, and 2.25 mgd in Eagle Creek. This effluent could be re-aerated via a cascade aerator as it discharges into each stream, or possibly discharged into a constructed wetland.

The quality of the Belmont effluent would need to be further evaluated prior to considering its reuse for flow augmentation in the low-flow tributary streams. Specifically, concentrations of dissolved solids (mainly from sodium, sulfates, calcium and chlorides), nitrogen, phosphorus and BOD would be evaluated to determine their impacts on the tributaries and to assess the feasibility of effluent reuse to augment tributary stream flows.

Groundwater Wells: Another method being considered would establish deep groundwater wells in the headwaters of each stream sized to provide the required flow.

Headwater Basins: The Pleasant Run and Pogues Run watersheds have a potential for preserving and naturalizing the forested headwaters of both streams. If the upstream catchments of these streams were expanded and the runoff was routed into constructed wetlands, flow could be moderated and baseflow increased. The city has had success with this type of project by constructing two linked basins mid-stream on Pogues Run to moderate stormwater flows. During the 2003 Labor Day storms, these basins prevented downstream flooding and slowly released flow into the Pogues Run channel as the storm passed. Headwater basins work in a similar fashion, but are designed to hold stormwater and rainfall further upstream. The slow percolation of the water through the constructed wetland cleans the water and increases the baseflow into the stream by slowing runoff into the main channel.

Water Releases: The downstream flow of Eagle Creek and Fall Creek are determined by discharges from dams at Eagle Creek and Geist reservoirs and water withdrawals by Indianapolis Water (Fall Creek) and the Town of Speedway (Eagle Creek). The ${}_7Q_{10}$ flow for Fall Creek above the Keystone Dam is 24 mgd, while Indianapolis Water withdraws up to 30 mgd at the Keystone Dam for the Indianapolis public water supply. During low flow periods, as little as .08 mgd falls over the dam. Water quality modeling suggests that the

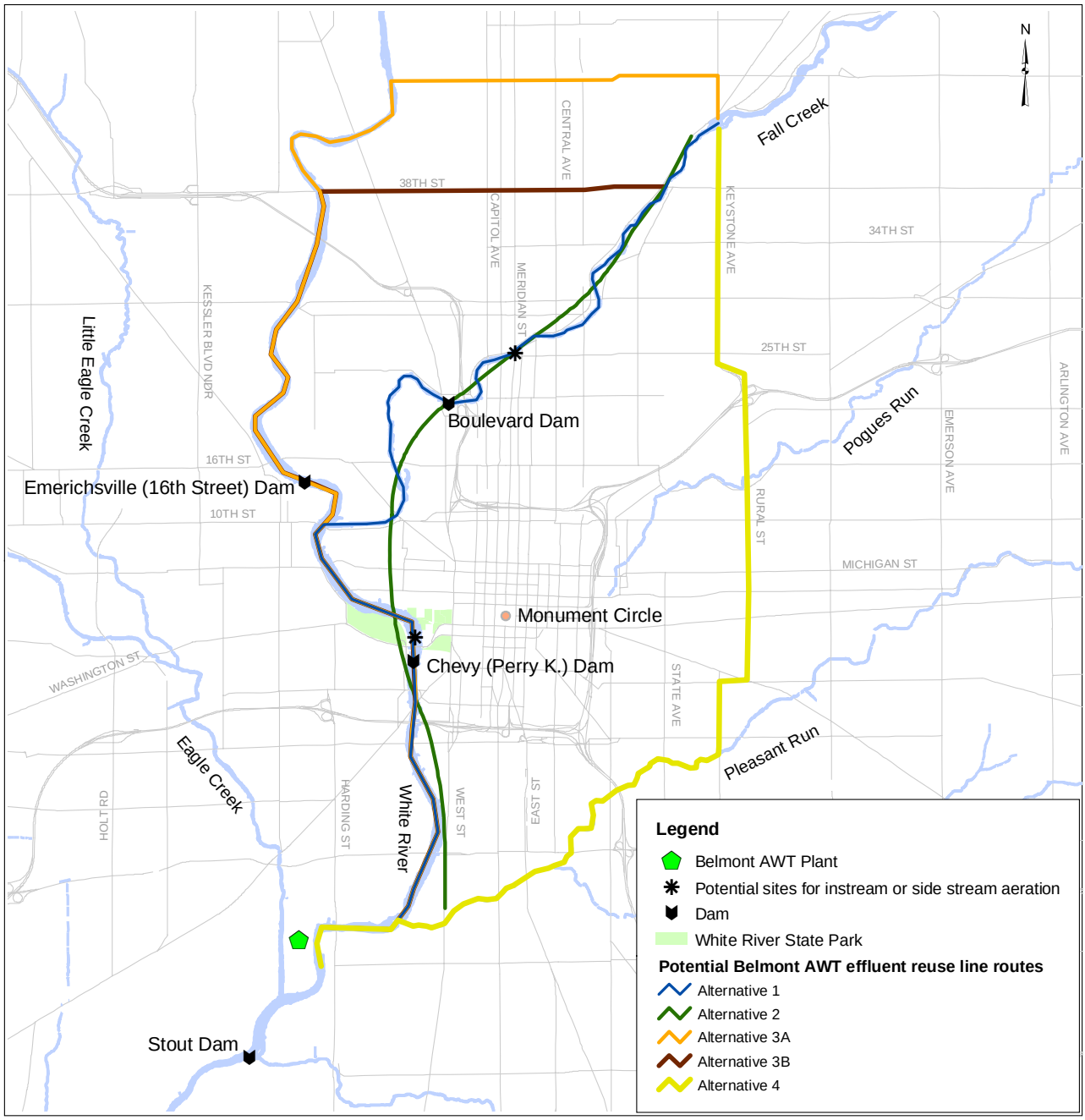


Figure 4-24
Watershed Improvement Projects

Table 4-6
Watershed Improvement Cost Estimate

City Project #	Project Description	Watershed	Project Cost
TBD	Accelerated Septic Tank Elimination Project	All	$32,400,000
TBD	Stormwater Capital Improvement Plan	All	TBD
TBD	Streambank Restoration and Sediment Removal	All	$4,000,000
TBD	Illicit Connection Removal	All	TBD
TBD	Flow Augmentation in Tributaries	All	$20,795,500
CS-18-027	Fall Creek Temporary Aeration and White River Temporary Aeration	Fall Creek / White River	$373,000
CS-18-028	Removal of Boulevard Dam	Fall Creek	$750,000
CS-24-025	White River Permanent Aeration	White River	$3,000,000
CS-38-001	Stout Dam Modification	White River	$2,000,000
		Total Cost	$63,400,000

addition of 2.5 mgd would be adequate to improve *E. coli* compliance at the Keystone Dam. Either an increase in flow from the reservoir or a reduction in the removal of water at the Keystone Dam could provide the needed additional flow. Water releases from Eagle Creek Reservoir are currently tied to flow conditions in White River and the public water supply requirements of the Town of Speedway. Flow over the dam is adjusted to maintain a minimum downstream flow at the USGS gauge of 2.5 mgd. The Town of Speedway withdraws approximately 2.5 mgd from Eagle Creek above the Indianapolis CSO area to supply its public water utility. Studies suggest that an additional 2.25 mgd is needed in the CSO area to improve *E. coli* compliance during dry weather in Eagle Creek. Some combination of increased flow from the reservoir or reduced withdrawals could provide the needed flow.

Fall Creek Wastewater Treatment Plant: Another option considered in 2000-01 was a water reclamation facility located in upper Fall Creek. This facility became less attractive when analysis showed that upgrades at the central AWT plants could provide the added treatment required for the conveyed and captured CSO flows at less cost and with fewer operational concerns.

As the city moves into the design phase with LTCP projects, these flow augmentation options will be considered in the context of the complete design and coupled with other watershed improvements to improve the overall water quality and aesthetics of the streams. For cost-estimating purposes, the city has assumed flow augmentation would be accomplished through an effluent reuse force main at a cost of $21 million.

4.5.2.8.2 Dissolved Oxygen Enhancement

Dam Modifications in Fall Creek. In order to improve dissolved oxygen compliance, the city evaluated the possibility of dam removal on Fall Creek. The Indianapolis Power & Light/City of Indianapolis Dam at Boulevard Place (Boulevard Dam) has no known current use. Elimination of this dam would help to moderate the dissolved oxygen problems observed in Fall Creek upstream of Boulevard Dam. Elimination or modification of the Boulevard Dam would be subject to approval and coordination with the dam's owner and regulatory authorities.

Dam Modifications in White River. The city also has recorded dissolved oxygen sags upstream of both the Chevy and Stout dams along the White River during wet-weather events. The city has evaluated possible modifications to those dams to improve dissolved oxygen levels. Modifications could include upgrading the Chevy Dam and making alterations to an underwater structure along the Stout Dam that diverts flow into the Indianapolis Power & Light intake area during low flows. Any modifications would have to be coordinated closely with the dam owners and regulatory authorities.

Aeration in Fall Creek. In order to increase the dissolved oxygen levels in Fall Creek and White River, the city also evaluated side stream aeration and in-stream fountains. Although the 2000-2002 weekly and monthly sampling presented in Figure 2-41 show Fall Creek upstream of the Boulevard Dam in compliance with the dissolved oxygen standard of 4.0 mg/L, studies have shown that the dissolved oxygen levels in this location are often critically low. The

city has evaluated an in-stream fountain west of the Meridian Street Bridge on Fall Creek. This evaluation concluded that an in-stream fountain would increase the dissolved oxygen levels prior to full implementation of CSO controls while beautifying the area.

Aeration in White River. After an overflow occurs during wet weather, the dissolved oxygen content of the White River can fall significantly. In order to help relieve this condition, permanent and temporary aeration stations could be installed. These are both aesthetically pleasing and beneficial to the river during low dissolved oxygen conditions. The temporary aeration facility could consist of a truck- or trailer-mounted pump with a float-mounted spray head and suction device. This unit could be used to provide portable, temporary aeration in areas where low dissolved oxygen conditions typically occur during low flow periods. The pump/aeration spray and suction unit could be pushed or floated into the stream. The pump would draw water from the river and aerate it by spraying it into the air. A side stream aeration facility or in-stream fountain located in White River above the Chevy Dam also would help increase the dissolved oxygen levels in the river. This project would enhance the overall stream quality while providing an aesthetically pleasing feature along the White River State Park. Similar projects in other cities have proven to be very successful in increasing dissolved oxygen concentrations.

4.5.3 Belmont AWT Plant Improvements

Collection system controls and deep tunnels constructed under Plan 1 or Plan 2 will convey CSO flows to the city's existing wastewater treatment facilities. Improvements to both facilities will be required, as described below for the Belmont AWT plant and subsection 4.5.4, discussing needed Southport AWT plant improvements.

4.5.3.1 Overview

The Belmont AWT plant has a design average flow capacity of 120 mgd with a peak hourly flow capacity of 270 mgd through primary treatment, but only 150 mgd of peak hourly flow capacity for secondary and advanced treatment (two-stage biological nitrification, filtration and effluent disinfection). The Belmont AWT plant serves the combined sewer system and thus experiences substantial surges of flow during wet weather. Wet-weather flowrates that exceed the headworks pumping capacity overflow as combined sewage from CSO Outfall 008. Wet-weather flowrates that exceed secondary treatment capacities are discharged through the primary effluent Bypass at Outfall 007. Collectively, the annual wet-weather volume of combined sewage and primary effluent discharged from the Belmont AWT plant accounts for nearly half of the total CSO impact on Marion County streams. The PE Bypass is the single largest source of BOD imposed on White River during wet weather. Accordingly, the objectives for wet-weather improvements to the Belmont plant are to:

1) eliminate the non-emergency need for a primary effluent bypass, and
2) reduce the headworks combined sewer overflows.

Initial concepts for the two strategies were described in the 2001 CSO Long Term Control Plan and Water Quality Improvement Report. The city has updated, reviewed and discussed the report with both IDEM and U.S. EPA Region V. As a result of the IDEM/EPA review, the city has modified its analysis of the wet-weather treatment alternatives, as described below.

Alternatives for achieving these two objectives were developed and compared in an engineering analysis completed in 2001 (WREP, 2001).[2] The assessment considered the tradeoffs between adding wet-weather storage basins and increasing the rate of treatment. Additional analysis was completed in 2002 and 2004. For additional information, see the following reports:

- *System Analysis of CSO Long Term Control Plan Improvements* (CDM, 2002).
- *The Interplant Connection Facility Plan* (ICST, 2004).
- *Bio-roughing System Clarification and High Rate Clarification Pilot Studies* (Shrewsberry, 2004).

The recommended concepts for expanded and upgraded wet-weather treatment processes at the Belmont plant would maintain the existing design average capacity at 120 mgd, but expand the peak hourly capacity through conventional secondary treatment to 300 mgd. A flow schematic of the key components is shown in **Figure 4-25** and the general layout is illustrated in **Figure 4-26**.

Additional wet-weather pumping capacity would be provided at the headworks to reduce wet-weather overflows to Outfall 008. This would most likely be accomplished by retrofitting the original headworks pump station that was abandoned when the current headworks was constructed. Wet-

[2]White River Environmental Partnership (WREP), "Wet Weather Primary Effluent Bypass Elimination Technical Memoranda 1-4," prepared by D. Hackworth and R. Roper for Indianapolis DPW, March 2001. This document was included in Appendix A of the 2001 LTCP.

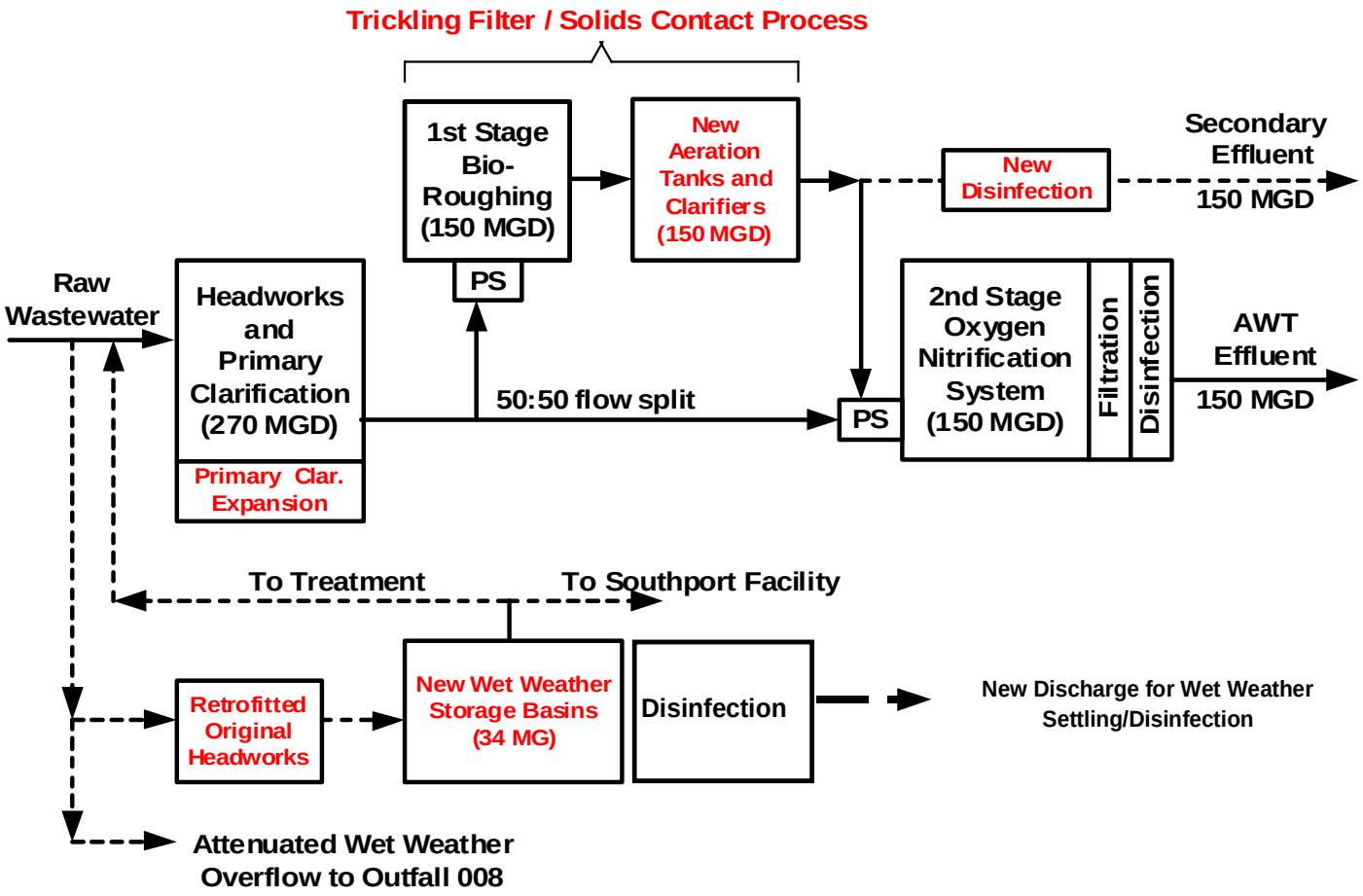


Figure 4-25
Wet-weather Treatment Improvements Recommended for the Belmont AWT Plant

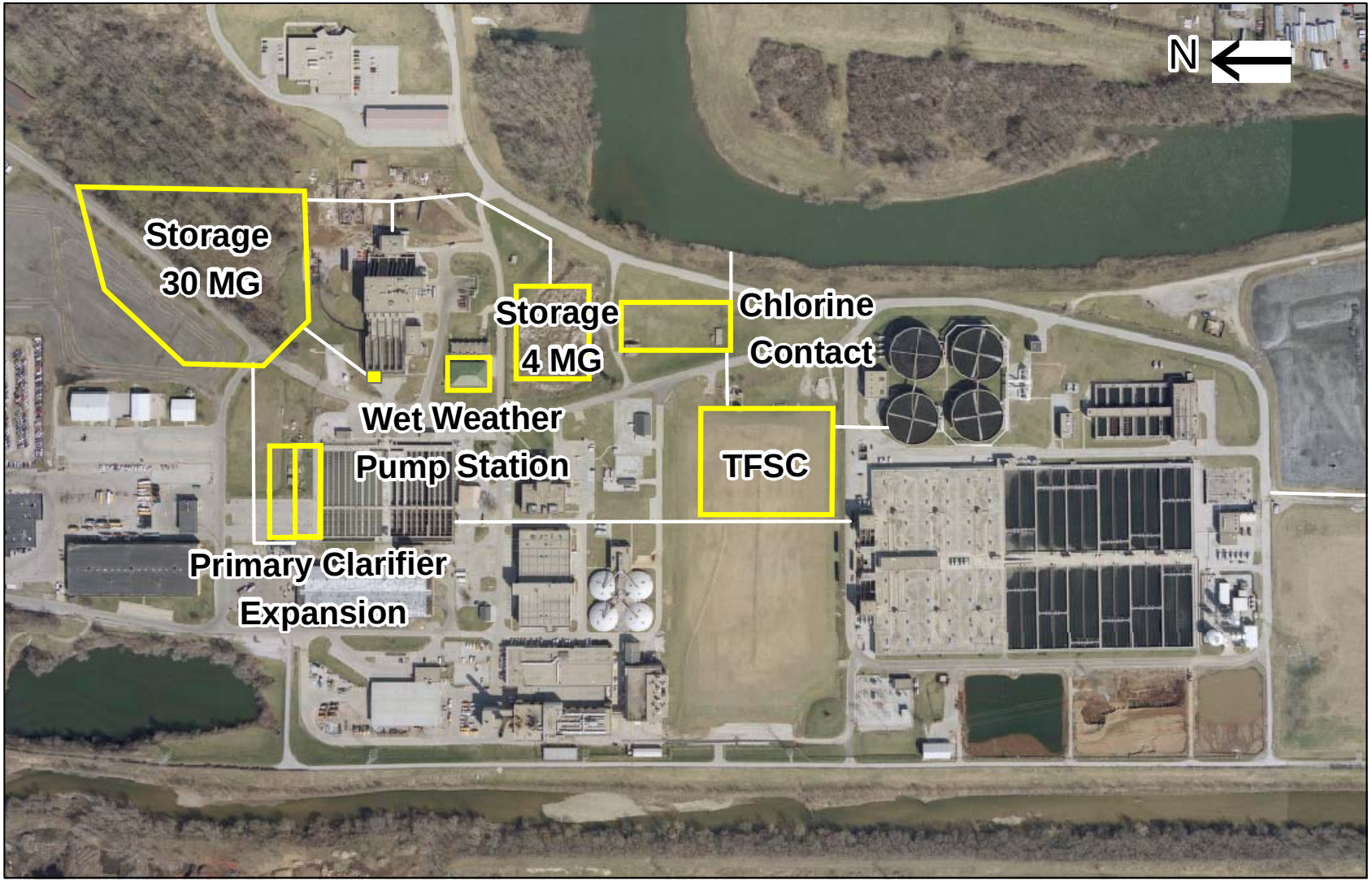


Figure 4-26
General Layout of Belmont AWT Plant Wet-weather Treatment Improvements

weather storage basins, constructed as early action projects, will serve to reduce PE bypasses during the interim period needed for upgrading the first-stage bio-roughing process to secondary treatment. The storage basins will ultimately be used to collect captured CSO flow from the expanded headworks pumping facility for bleed-back to the expanded treatment system and/or transfer to the Southport plant. Collectively, these improvements are expected to eliminate PE bypasses and reduce headworks overflow events. Additional headworks pumping capacity and some form of high rate chemical treatment (such as a 150 mgd EHRC process or screening/disinfection) may be needed if more stringent levels of CSO control are required. For cost-estimating purposes in the LTCP, a 150 mgd EHRC facility has been presumed along with associated chemical sludge storage and processing equipment.

4.5.3.2 PE Bypass

The city's analysis showed that doubling the wet-weather rate of treatment to eliminate the non-emergency need for PE bypasses would also optimize the volume of on-site storage needed to reduce the headworks overflows. The degree of treatment needed for the primary effluent bypasses was evaluated under four different categories of treatment: primary treatment (the base case), advanced primary treatment (removal of suspended solids only), conventional biological treatment (removal of suspended solids and soluble BOD), and advanced biological treatment (removal of suspended solids, soluble BOD and ammonia-nitrogen). The city performed a desktop analysis based on actual plant flowrates and concentrations from 1996-2000 to enable comparison of the four likely effluent qualities. Analysis of the blended effluent quality from the existing and supplemental treatment processes indicated the need for some form of biological treatment for effective removal of soluble BOD during wet weather, but that ammonia removal was not necessary.

The study also identified that the least-cost method for achieving conventional secondary treatment of the PE Bypass would be to upgrade the existing 150-mgd first-stage trickling filter bio-roughing process. During dry-weather flow conditions, the upgraded first stage would continue to operate in series (in line) with the existing second stage oxygen activated sludge nitrification process. During wet weather, however, the two stages would be progressively uncoupled when the instantaneous flowrates reach and exceed the 150 mgd capacity of the individual stages. At the extreme condition, the two stages of biological treatment would be uncoupled completely for operation in parallel (side by side). The existing second stage would provide 150 mgd of advanced biological treatment and the upgraded first stage would provide 150 mgd of conventional secondary treatment. Recommended improvements to the existing first-stage bioroughing process included the addition of intermediate clarifiers for effective removal of suspended solids. The PE Bypass outfall (007) will remain in place for plant emergencies.

A more rigorous assessment of the tradeoffs between on-site storage volume and rate of treatment was summarized in the report *"System Analysis of CSO Long Term Control Plan Improvements"* (CDM, 2002). The analysis examined a variety of systemwide scenarios based on the 2001 LTCP. Each scenario was evaluated in terms of its effect on storage volumes and treatment rates needed at the Belmont and Southport facilities. The results provided updated estimates needed to support the preliminary design of the wet-weather storage basins and related early action improvements at both facilities. The results also demonstrated that provisions of the 2001 LTCP would impose too much captured CSO flows on the Belmont plant and that there was available treatment capacity at the Southport AWT plant. This reinforced the long-standing concept that a new interplant connection sewer was needed to convey captured CSO flows to the Southport plant. It also led to the conclusion that the Southport facility would need to play a larger role in the CSO long-term control plan than had been envisioned in 2001.

4.5.3.2.1 Wet-weather Storage Basins

Construction of wet-weather holding basins began in January 2004. The basins include a 4 MG basin south of plant headworks, a 30 MG basin north of plant headworks, and an expansion of the primary clarifiers to provide the firm capacity needed to accommodate peak flowrates of 300 mgd. Initially, the 4 MG and 30 MG basins will be used to capture about half of the annual average PE Bypass events. Following construction of additional biological treatment capacity to eliminate the PE bypasses, the basins would be available to store combined sewer overflows from CSO 008 that exceed Belmont's nominal 300 mgd capacity, or possibly be utilized as flow-through basins for clarification of wet-weather flows.

4.5.3.2.2 Bio-roughing Process Upgrade

The city conducted extensive pilot testing at the Belmont AWT plant in 2003 to evaluate several chemical clarification methods for removing suspended solids from the effluent of the existing trickling filter bio-roughing system (BRS). The goal of the bio-roughing solids clarification concept was to provide the equivalent of secondary biological treat-

ment of wet-weather primary effluent bypasses using the existing bio-roughing system for soluble BOD removal and new clarification equipment for suspended solids removal.

The results from the pilot program showed that chemically assisted clarification technologies such as ACTIFLO and DensaDeg were able to consistently achieve effluent TSS concentrations below 45 mg/L when applied to the trickling filter bio-roughing effluent. However, chemical requirements and associated sludge generation rates were relatively severe for this particular application. Conventional clarification of the BRS effluent without some form of chemical or biological coagulation of the suspended solids was shown to be unreliable.

BOD_5 removal estimates based on piloted TSS removals suggested that traditional monthly secondary standards for BOD_5 (i.e., 30 mg/L monthly average limits) could not reliably be achieved by chemically assisted clarification methods. This is because chemically assisted clarification has essentially no effect on reducing the relatively high Belmont soluble BOD concentration. Therefore, the city concluded that the wet-weather treatment process at the Belmont plant must be more aggressive in terms of removing soluble BOD_5.

Accordingly, the city is proposing a trickling filter/solids contact (TF/SC) process, in which new solids clarifiers following the bio-roughing towers would be supplemented with biological contact and reaeration tanks. In other words, the existing bio-roughing process would be upgraded to a TF/SC process, a well-established and highly economical secondary treatment method. The city is proposing the TF/SC process at the Belmont AWT plant for the following reasons:

- The TF/SC process is an effective secondary biological treatment process that will help eliminate uncertainty associated with the variability in soluble BOD_5 loads.
- The TF/SC process has a demonstrated track record (with approximately 100 secondary plants in operation in North America).
- The TF/SC process can be used during dry weather to reduce the organic load imposed on the oxygen nitrification system (ONS), thereby providing expanded dry-weather as well as wet-weather organic load capacity.
- Technical assessments of full-scale TF/SC facilities by wastewater treatment professionals have concluded that clarifier sizing can be reduced compared to that suggested by Ten States Standards.
- The TF/SC process might provide an effective backup for secondary treatment, should the ONS need to be taken off-line.
- The solids generation rates from the TF/SC process are substantially less than that from advanced primary treatment processes that require high chemical doses.

The design criteria for the TF/SC upgrade would be based on state-of-the-art technical assessments such as that recently reported by Parker and others (2001).[3] Collectively, the improvements would enable up to 300 mgd of effective secondary biological treatment at the Belmont facility during wet weather, thereby doubling the current 150 mgd peak hourly capacity.

The CSO LTCP includes treatment of the PE Bypass as a high priority project. The PE Bypass is the single largest discharge point for BOD_5 and TSS imposed on the White River. As shown in **Table 4-7**, the PE Bypass contributes a pollutant load to White River during 50 to 60 rain events per year that is nearly equal to the final effluent outfall (Outfall 006) during the course of the entire year. Treatment of wet-weather flows through a TF/SC process will improve receiving water quality by preventing the discharge of nearly 2.3 million pounds of pollutants (BOD and suspended solids) per year into the river.

4.5.3.2.3 Wet-weather Flow Disinfection

The effluent from the TF/SC process would be disinfected during wet-weather discharges by chlorination/dechlorination. Existing abandoned chlorine contact tanks (having a capacity of approximately 120 mgd) will be uncovered, possibly rehabilitated and expanded to 150 mgd by raising the wall height. The condition of the concrete chlorine contact tanks is unknown at this time. Hydraulically, it is better to route the clarified flows to the east through these chlorine contact tanks for discharge to the White River via the original Belmont outfall.

The city has budgeted for physical recombination and has applied for $17.5 million in State Revolving Fund funding to cover total project costs. Discharging disinfected effluent through the original Belmont outfall is preferred by the city based on hydraulics and costs. For long-term control planning, rehabilitating and expanding the existing chlorine contact tanks to 150 mgd and discharging disinfected effluent through the original Belmont outfall will be used as an early action project (or baseline condition).

It is important to note that the existing PE Bypass structure at Outfall 007 would not be eliminated due to IDEM's re-

[3]Parker, D.S. and others, "Review of Two Decades of Experience with TF/SC Process," Journal of Environmental Engineering, p. 380-387, May 2001.

Table 4-7
Primary Effluent Bypass BOD and TSS Loads
Trickling Filter / Solids Contact Process - Belmont AWT Plant

Belmont Outfall	Flow MG/Yr	BOD (lbs/Year)		TSS (lbs/Year)	
		Existing	Future w/ TF/SC	Existing	Future w/ TF/SC
PE Bypass (Outfall 007)	1,190	1,174,000	0	1,429,000	0
New Wet Weather Outfall 005	637	N/A	133,000	N/A	159,000
AWT Effluent (Outfall 006)	35,040	1,286,000	N/A	1,724,000	N/A

TF/SC - Trickling Filter/Solids Contact

Average Belmont AWT Effluent BOD for 1997-2004	4.4	mg/L
Average Belmont AWT Effluent TSS for 1997-2004	5.9	mg/L
Secondary Limits - TF/SC - cBOD5 - monthly average	25	mg/L
Secondary Limits - TF/SC - TSS - monthly average	30	mg/L

Notes:
1. TF/SC - Trickling Filter / Solids Contact secondary treatment process.
2. The Belmont AWT effluent for the period 1997 - 2004 averaged 96.0 mgd, 4.4 mg/L BOD, and 5.9 mg/L TSS.
3. Outfall 007 (PE Bypass) existing volume and loads are based on 1997-2004 averages from 50-60 rain events per year.
4. The estimates of TF/SC discharges to new Outfall 005 were based on an annual average flow of 637 MG and CBOD and TSS concentrations of 25 mg/L and 30 mg/L, respectively. The flow reduction was projected from the use of new wet weather storage basins.
5. The 637 MG estimate of annual average secondary effluent flow to new Outfall 005 does not take into account additional volumes

quirement to retain it as an emergency plant bypass and possible future use consistent with 40 CFR 122.41 (m).

4.5.3.2.4 NPDES Permit Modification Request

On July 30, 2004, the city submitted a written request for an NPDES permit modification for the Belmont AWT plant that will include upgraded wet-weather treatment facilities and a new wet-weather outfall. The request comes after detailed study by the city to determine the improvements needed to provide increased hydraulic and biological treatment capacity at the Belmont AWT plant to further reduce the effects of wet-weather discharges on the White River.

The analysis presented in Appendix A of the 2001 LTCP assessed the level of treatment necessary to meet water quality standards during CSO events. It concluded that the appropriate degree of treatment falls somewhere between advanced primary treatment and full secondary treatment. Moreover, the assessment concluded that nitrification of wet-weather flows that exceed the existing AWT plant nitrification capacity would not be necessary due to the dilute influent ammonia concentrations observed during these events. The city has requested that the NPDES permit for the Belmont AWT plant be modified to authorize discharge of secondary effluent from a new Outfall 005 during wet weather. The authorization to discharge would be related to precipitation events or snowmelts that cause hydraulic loading beyond the current 150 mgd capacity of the ONS portion of the AWT facility. IDEM, through a recent draft permit, has approved in concept a request for secondary treatment limits based on the treatment limits shown in **Table 4-8** for outfall 005 and internal outfall 105. As of late August 2005, this permit had not yet been released for public comment.

4.5.3.3 Reduction of Headworks Overflows

In order to reduce headworks overflows at the Belmont AWT plant, the city will construct a new screening facility and rehabilitate the original Belmont headworks to serve as a 150- to 300-mgd wet-weather pump station. The aggregate headworks pumping capacity would thus be increased to 450 to 600 mgd. This project would require reopening or replacing the original Belmont sewers that were abandoned and plugged when the new headworks was constructed in the late 1980s. The flows would be pumped via new raw sewage pumps in the original Belmont pump station that is currently abandoned.

Current planning estimates indicated the Belmont headworks would need to be expanded by 160 mgd to achieve an average of 12 headworks overflows per year, 250 mgd for 6 headworks overflows per year, and 300 mgd for 4, 2, and 0.5 headworks overflows per year. Captured flow would be pumped to the 30 MG and 4 MG wet-weather storage basins for bleedback into the expanded treatment system. The design for the 30 MG holding basin includes provisions for dewatering the basin to the Southport plant. The treatment-versus-storage modeling results presented in the interplant connection report suggested that average headworks overflow frequencies could be reduced to 4 to 6 per year, provided that none of the captured flow from the deep tunnel is imposed on the Belmont plant.

To reduce headworks overflow frequencies to an average of 2 and 0.5 untreated overflows per year, an additional 150 mgd treatment train would likely be needed such as EHRC, chlorination/dechlorination, and effluent reaeration. The EHRC units would treat excess flows from the basins that could not be bled back into the treatment system or sent to the Southport facility.

Because this process would be operated intermittently, it would need to be preceded by the 30 MG flow equalization basin to enable smooth startup. Utilization of such a process treatment train would likely be very limited (only a few times per year). Moreover, considering that overflow from the wet-weather storage basins would probably be well clarified, the application of EHRC would likely provide somewhat redundant treatment. Application of EHRC has thus lost favor as a key component of the LTCP for the Belmont facility. A more plausible backup option would be to pump excess volume to an entry shaft of the deep tunnel. However, that would make the tunnel storage volume requirement larger and more costly.

Additional options are being considered for further reducing Belmont wet-weather overflows to Outfall 008. These include (1) utilizing the Southwest Diversion and Interplant Connection to convey flows to the Southport plant, (2) reversing flow in the siphon located between Outfall 008 and the Southwest Diversion Structure, and (3) constructing a new sewer from Outfall 008 to the interplant connection.

For long-term control planning, pumping captured flow to the 30 MG and 4 MG wet-weather storage basins was considered the baseline level of improvements needed to achieve annual average headworks overflow frequencies of 4 to 6 per year. Alternatives to further reduce the frequency of untreated CSO overflows include allowing the wet-weather storage basins to clarify and overflow to additional disinfection facilities during extreme events, adding EHRC and disinfection for extreme events, or transfer to the tunnel during extreme events. These high control alternatives were further evaluated through NetSTORM modeling to develop facility costs for LTCP purposes. Ultimately, this evaluation will be refined through SWMM modeling during facility planning.

4.5.3.4 Provisions for Future Capacity

To account for projected future growth, the city evaluated growth projections for Marion County during preparation of the *Interplant Connection Facility Plan* (ICST, 2004). Recent sanitary sewer master planning reports and histori-

Table 4-8
Requested Limits for Internal Outfall 105

	Monthly Avg.	Weekly Avg.	Daily Minimum	Daily Maximum
$CBOD_5$ (mg/L)	25	40	--	--
TSS, (mg/L)	30	45	--	--
pH, SU	--	--	6.0	9.0

Requested Limits for Wet Weather Outfall 005

	Monthly Avg.	Weekly Avg.	Daily Minimum	Daily Maximum
$CBOD_5$ (mg/L)	Report	Report	--	--
TSS, (mg/L)	Report	Report	--	--
pH, SU	--	--	6.0	9.0
E. coli (colonies/100 mL)	125	--	--	235
Total Res. Chlorine (mg/L)	0.01	--	--	0.02

cal data were analyzed to estimate how dry-weather system flowrates might increase in the future. This enabled the analysis of wet-weather treatment improvements needed at the Belmont and Southport facilities to account for future increases in dry-weather flow from the service areas.

The master planning reports predicted "ultimate" build-out conditions. The city concluded that these estimates of future flow increases most likely overstate what will actually happen over the next 20 years, because the areas studied are unlikely to all develop at the same time. Nevertheless, the estimates showed that flow increases in the Southport service area are likely to be larger than those in the Belmont service area, and that the flow increase could be substantial.

The historical method employed in the *Interplant Connection Facility Plan* (ICST, 2004) analyzed the rate over time system flowrates have increased at the Belmont and Southport facilities. The starting point for this analysis was 1967, the first full year of secondary treatment operations at the Southport plant. The data for "treated flow" for the early years of operation were obtained from the annual reports of operation on file at the Belmont facility; and data for more recent years were developed from the effluent flow data from monthly operating reports. Care was taken in this analysis to ensure that the data did not erroneously include in-plant recycle flows or double count flow diverted from Belmont to Southport. The results, in **Figure 4-27**, show that flowrates at the Belmont plant have not changed significantly over the past 36 years. All of the increase in flow has occurred at the Southport plant alone. This observation is not surprising because the original intent of the Southport plant was to relieve the Belmont plant from excess flows.

The city created a linear regression analysis of the annual flow data to develop a more realistic projection of future system flowrates. **Figure 4-28** shows the results. The line of "best fit" is from the linear regression equation shown in the insert. The strong influence of weather conditions on groundwater infiltration rates is largely responsible for much of the remaining variability. Nevertheless, the regression analysis showed a relatively steady increase in flow equivalent to about 13.5 mgd per decade. For the current system flowrate of about 182 mgd (for year 2002 using the regression equation), the regression analysis suggested that by year 2023, the system annual average flowrate could increase to about 211 mgd, a flow increase of about 29 MGD over the next 20 years. Although the future is uncertain, the project team allocated 10 mgd of growth to the Belmont plant and 20 mgd to the Southport plant for facilities planning purposes.

The Southport plant is projected to receive an annual average of 25 mgd of additional flow over the next 20 years, 5 mgd of which was assumed to come from the Belmont service area and 20 mgd from the Southport service area. The annual average flow of 25 mgd was translated to a peak hourly flowrate of 50 mgd using a peaking factor of 2.0. The city believes this allocation for peak hourly flow from future growth in the service area to be conservative in relation to the peaking factors apparently employed for the design of the current facilities.

In accordance with these projections, the design flow criteria for the upgraded and expanded Southport plant includes a provision for treatment of up to 25 mgd continuously diverted away from the headworks of the Belmont plant. This is, in part, to ensure that the Belmont plant has ample hydraulic capacity for accommodating future growth within the service area. It is also to ensure the biological wet-weather treatment process planned for the Southport plant has enough flow to enable it to be viable during dry-weather periods.

4.5.3.5 Sludge Management

Sludge processing equipment for the two AWT plants are consolidated at the Belmont plant. The current operations include sludge thickening, dewatering and incineration. Considering that the concentration of suspended solids in the "first flush" of captured CSO flows is generally very high, the additional solids load imposed on the sludge processing facilities may be substantial, especially considering the short time period during which they are generated. Also, provisions to transfer and process the biosolids that accumulate in deep tunnel storage must be addressed.

Although a comprehensive facility plan for managing the increased solids generation has not yet been completed, provisions will need to include the following: (1) removing the Southport primary sludge load from Belmont primary clarifiers and processing the solids by some other method; (2) processing the additional biosolids that will be generated from the Belmont and Southport wet-weather treatment processes; (3) processing the additional primary solids and grit generated from treatment of captured CSO flows from the Belmont headworks; and (4) processing the additional primary solids generated from treatment of captured CSO flows at Southport from the deep tunnel. Current plans call for dewatering the storage tunnel to Southport for treatment, but directing the final tunnel flows with the heaviest concentration of solids to Belmont to achieve higher efficiency in solids transport and treatment. Space has been reserved at the Belmont site for needed sludge processing improvements.

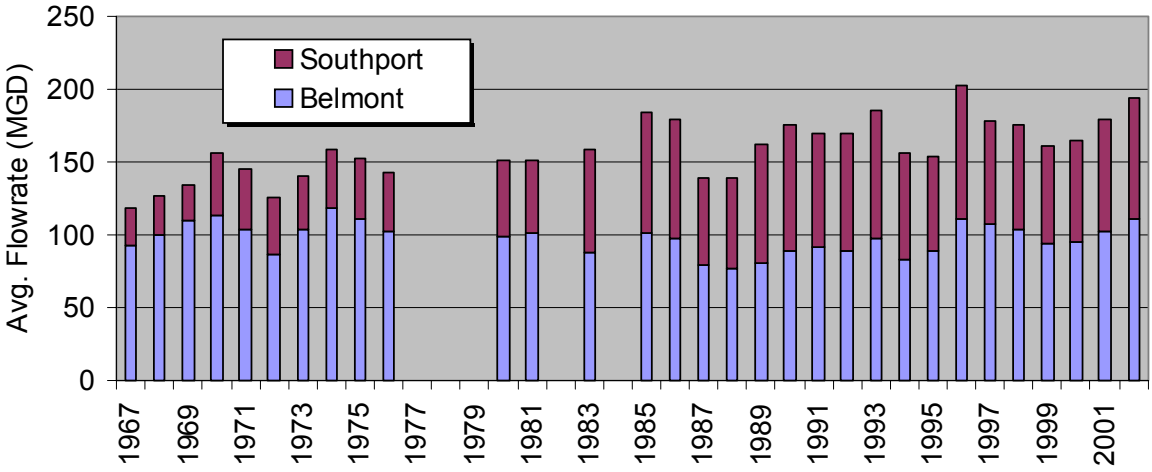


Figure 4-27
Annual Average System Flowrates

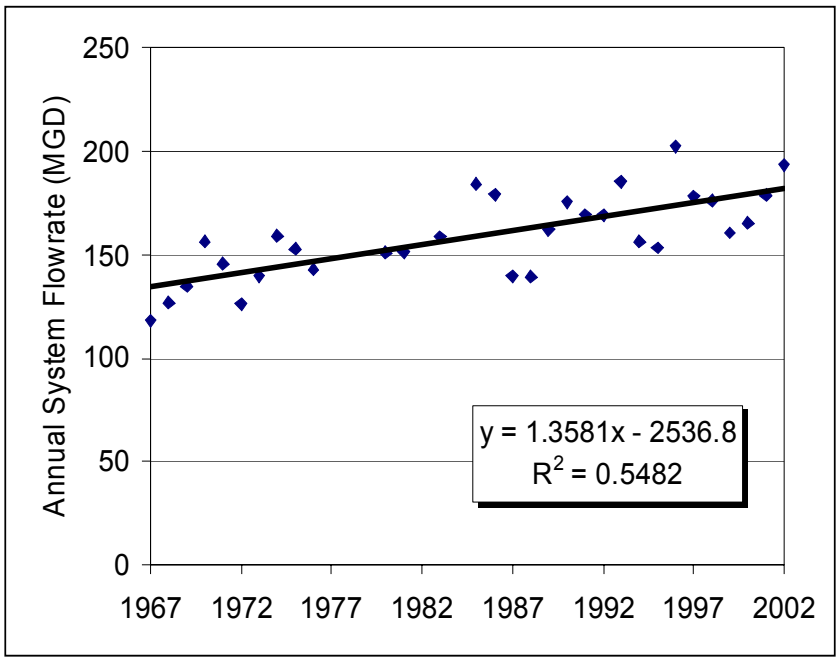


Figure 4-28
Regression Analysis of System Annual Flowrates

4.5.3.6 Summary of Recommended Belmont AWT Plant Improvements

The list of Belmont plant improvements needed for eliminating the wet-weather primary effluent bypasses and reducing headworks overflows is as follows:

- New 30 MG and 4 MG wet-weather storage basins for flow equalization
- New equalization basin outfall pipe to wet-weather disinfection facility
- Two new primary clarifiers to supplement the existing clarifiers
- New aeration tanks and intermediate clarifiers to upgrade the existing trickling filter bio-roughing process to a 150 mgd TF/SC secondary treatment process
- Rehabilitation and expansion of an existing abandoned chlorine contact tank to provide 150 mgd disinfection capacity for the TF/SC effluent
- Retrofitting the original Belmont plant outfall for discharge of the disinfected TF/SC effluent during wet weather
- Rehabilitation and expansion of original, abandoned Belmont headworks facility for a peak wet-weather capacity of 150-300 mgd with new screening and aerated grit removal
- Reopening and replacement of original, abandoned Belmont sewers
- New sewer from Outfall 008 for flow diversion
- New sludge handling facilities
- New process/yard piping

The project (capital) cost for improvements to the Belmont AWT plant described in this section is $172 million, as shown in **Table 4-9**. This recommended approach is subject to more detailed design analysis and value engineering.

4.5.4 Southport AWT Plant Improvements

4.5.4.1 Overview

Although flows directed to the Southport AWT plant are primarily from separate sanitary sewers, some combined sewage flows to Southport from the Belmont service area and the Southport combined sewer service area. The existing Southwest Diversion interceptor allows flexibility in balancing the normal dry-weather flows between the two plants. It also helps to ensure that the aggregate capacity of the two plants is maximized during wet weather before CSOs occur in the collection system and at the plants. In addition, the city continues to pump sewage from the Belmont headworks to the Tibbs interceptor via updated facilities. This results in about a third of the Southport plant dry-weather flow originating from the combined sewer service area.

During the development of the *Interplant Connection Facilities Plan*, it became clear that the Southport plant would need to play an even greater role in relieving the Belmont plant from the burden of treating CSO flows. Assuming the plant would be required to help achieve a low frequency of wet-weather overflow events, the facilities plan indicated that the Belmont plant, even with upgraded and expanded treatment facilities, would not be capable of accommodating much of the captured CSO flow. The facility plan also indicated that, unless methods such as sewer separation or satellite CSO treatment are remarkably successful, the Southport plant could ultimately be called upon to provide treatment of captured CSO flow at rates equivalent to the current peak capacity of the plant (150 mgd).

Table 4-9
Belmont AWT Plant Cost Estimate[1]

Description	Capital Cost
New Headworks Facility with Screens	$ 38,700,000
New Grit Facility w/ Flow Split	$ 8,900,000
New Intermediate Clarifiers	$ 49,400,000
New Return Sludge Pumping	$ 14,400,000
Effluent Disinfection - Chlorination/Dechlorination	$ 13,000,000
Solids Contact/Reaeration[1]	$ 7,100,000
Belmont Anaerobic Digester Facility (BE-78-001)	$ 29,200,000
Yard Piping and Valves	$ 11,300,000
TOTAL CAPITAL COST	$ 172,100,000

1 - based on costs developed for the BRSC Design Criteria Report

The *Interplant Connection Facilities Plan* presented a detailed evaluation of wet-weather treatment alternatives at the Southport plant to accommodate the additional wet-weather loads, which potentially could include the entire volume of CSO captured with the new LTCP facilities. Accordingly, the analysis focused on alternative strategies for processing the captured CSO flows from the deep tunnel along with provisions for dealing with current wet-weather flow surges and for future growth in the service area.

The analysis began with a screening of alternatives for splitting captured CSO flow between the two plants. This analysis concluded that all captured CSO flow should be conveyed to the Southport plant for the following reasons:

- Wet-weather flow capacity would seldom be available at the Belmont plant for sharing the load
- Options available for treating additional wet-weather flow at Belmont would be limited
- Treatment and permitting requirements at a third location, such as along Fall Creek, would be challenging
- The Southport plant offers many possibilities, including space for consolidated treatment of captured CSO flows

The city, therefore, developed and evaluated alternatives that would enable the Southport plant to treat current wet-weather flow surges, future captured CSO flows, and additional dry-weather flow from future growth within the service area.

4.5.4.2 Existing Facilities

As a starting point, the city conducted a process analysis of the existing Southport AWT facilities. The analysis included a review of plant flowrates, raw sewage pollutant loadings, and performance analyses of the various treatment processes that comprise the plant. The activities for performing this analysis included the following:

- Assembly of a 7.5-year daily database of treatment process operating data
- Field trips to inspect the Southport and Belmont plants
- Literature review of plant design records, operating manuals and annual reports
- Meetings and discussions with the plant operators
- Process performance analyses

The Southport AWT plant has a design average flow capacity of 125 mgd and a design peak flow capacity of 150 mgd. The plant may ultimately be called upon to treat captured CSO flows at rates equivalent to its current peak capacity. The city therefore considered strategies for essentially doubling the rate at which the Southport facility can effectively treat wastewater.

The city first conducted a process analysis that yielded the following insights:

- The process flow sheet for the Southport AWT plant is complex. Future improvements to the facility should strive to simplify the process flow sheet.
- Wet-weather overflows and/or bypasses occur at the Southport plant about eight times per year, although these will be significantly reduced by the addition of the new 75 mgd headworks pump station and 25 MG wet-weather flow storage basin.
- The minimum dry-weather sanitary flow to the Southport facility is about 50 mgd, and the peak infiltration rate in interceptors to the Southport plant appears to be about 45 mgd. Thus at times, infiltration can nearly double the dry-weather flow to the Southport plant.
- During wet-weather flow conditions, the peak daily effluent flowrates reach the 150 mgd design capacity for the overall facility. In addition, the facility design average flowrate of 125 mgd is reached or exceeded several times per year, undoubtedly from maximized treatment of wet-weather flows when groundwater infiltration is high.
- Raw sewage loads for BOD, TSS and ammonia-N are generally within the original design criteria of the facility. However, high TSS loads are imposed on the Southport plant when the Belmont gravity diversion line is used; and extremely high soluble BOD loads are imposed by deicer wastes from the Indianapolis airport.
- Although the primary clarifiers seem to function reasonably well, they are nearly 40 years old, are too shallow to meet current design standards, and have no reserve capacity to treat flowrates in excess of 150 mgd.
- The bio-roughing towers appear to be functioning properly and within the acceptable hydraulic and organic loads.
- ONS could recoup about 10 mgd of allocated flow capacity if the tertiary filtration backwash and other in-plant return streams were dealt with in some other fashion. Methods to consider include a dedicated flow equalization tank and/or treatment in the air nitrification system (ANS).
- The ANS has an aggregate aeration tank volume about 25 percent larger than that for oxygenation nitrification system (ONS): 20.2 MG versus 16.2 MG. However, the

ANS clarifiers are only about 28 percent the size of the ONS clarifiers and are very shallow, thereby limiting the effective capacity of the ANS.

- The BOD and TSS loads imposed on the ONS sometimes exceed the design criteria. Fortunately, the ONS design criteria were conservative so that performance to date has been reliable.

4.5.4.3 CSO Treatment Alternatives

The following four concepts were developed to expand the Southport plant to a peak capacity of 375 mgd, achieving an additional 225 mgd of treatment:

Concept 1: Retrofit the ANS to provide 75 mgd of biological treatment and construct a 150 mgd physical-chemical process to treat the captured CSO flows.

Concept 2: Retrofit the ANS to provide 150 mgd of biological treatment and construct a 75 mgd expansion of the oxygen nitrification process.

Concept 3: Retrofit the ANS to provide 225 mgd of biological treatment.

Concept 4: Retrofit the ANS to provide 150 mgd of biological treatment (including half of the 150 mgd of captured CSO flows) and construct a 75 mgd physical-chemical process to treat the more dilute half of the captured CSO flows.

Each concept would effectively remove suspended solids and associated particulate BOD. However, Concept 1 would provide no removal of soluble BOD or ammonia-N; Concept 2 would remove both soluble BOD and ammonia-N; and Concept 3 would remove soluble BOD but not ammonia. Concept 4 would remove soluble BOD and ammonia for the first 150 mgd of captured CSO flow but not for the remaining 75 mgd.

Table 4-10 shows the general ranking of the four concepts based on the comparisons of major treatment plant attributes. The ranking consisted of comparing the concepts of effluent quality, operation and maintenance issues, expandability, future regulations, and cost. In this ranking system, "1" is the highest rating; the concept with the lowest aggregate score is the preferred concept. As can be seen, Concept 4 was at or near the top for all criteria considered. For a description of the ranking system, see Section 9.8 of the *Interplant Connection Facilities Plan*.

4.5.4.4 Summary of Recommended Southport AWT Plant Improvements

Based upon the screening analysis described above, the city selected Concept 4 as the basis for expanding the Southport AWT plant in accordance with the CSO LTCP.

The city recommends that the Southport facility be expanded to enable a peak hourly flowrate of 425 mgd through conventional primary treatment and, after flow equalization, a peak treatment capacity of 375 mgd through the rest of the facility. The 375 mgd peak capacity represents a 225 mgd increase over the current peak capacity of 150 mgd. Of the 375 mgd total, 300 mgd would receive biological treatment and the remaining 75 mgd, if needed, would be treated by some form of advanced primary treatment such as enhanced

Table 4-10
Ranking Analysis of Alternative Concepts

	Concept 1	Concept 2	Concept 3	Concept 4
Effluent quality	3	1	3	2
Ease of operation	2	3	4	1
Sludge processing	2	3	4	1
Compatibility	1	1	2	1
In-plant recycle streams	1	1	1	1
Energy	2	4	3	1
Expandability	2	1	3	2
Adaptability to future	3	1	2	1
Capital cost	2	3	1	2
Score (low score is best)	**18**	**18**	**23**	**12**

high rate clarification. The need for the 75 mgd advanced primary treatment process is contingent on a more rigorous analysis of the maximum dewatering rate needed for the deep tunnel. However, recent results from modeling studies predict that the 75 mgd process would only be needed for dealing with especially large events that occur only about once every two years, on average.

The recommended plan for expanding the Southport facility is as follows and as shown in **Figure 4-29** (process flow sheet) and **Figure 4-30** (general layout of expanded facilities):

Construction of all new headworks, including screening and aerated grit removal.

This recommendation is based on the nearly three-fold increase in capacity and the importance of a blended raw wastewater for downstream process reliability. If needed and affordable, the portion of the captured CSO flows that is treated by advanced primary treatment would be segregated from the mainstream to ensure effluent soluble BOD remains low.

Supplement the existing primary clarifiers with new primary clarifiers.

These improvements would be conservatively designed to treat a peak hourly flow of 275 mgd and an average flow of 125 mgd. This sizing allows for one of the existing cluster of ANS primary clarifiers to be occasionally out of service for maintenance. The existing primary clarifiers would generally be on line all the time at a relatively low flow in readiness for treating wet-weather surges up to 150 mgd. Including 75 mgd of primary treatment recommended for the EHRC process, the overall primary treatment capacity with all units in operation would be 500 mgd. Subject to further planning, a portion of this capacity could be set up for 75 mgd of advanced primary treatment so as to avoid the complexity that would otherwise result from a stand-alone EHRC facility.

Retrofit the existing 30 mgd ammonia nitrification system to provide 150 mgd of aggressive biological treatment during peak wet-weather flow periods, including efficient nitrification at flows up to about 120 mgd.

The existing aeration tanks would be fitted with new fine bubble air diffusers and the aeration blowers would be replaced or supplemented as needed. The existing ANS final clarifiers would be replaced with larger circular or rectangular units having a peak capacity of 150 MG. The surface area requirement is 125,000 square feet.

Leave the existing oxygen nitrification system intact, but revise the rated capacity upward to 100 mgd average (compared to 95 mgd average) and 150 mgd peak (compared to 125 mgd).

The basis of the improved rating would be demonstrated performance, upgraded primary clarification to reduce the solids loading, recognized design criteria, and elimination of flows imposed on the ONS from filter backwashing.

The planned 75 mgd wet-weather pump station and 25 MG wet-weather holding basins for flow equalization would reduce by 50 mgd the peak hourly flow through the headworks, preliminary treatment and primary treatment. The peak flowrates imposed on downstream biological facilities would thus be 300 mgd. These projects are part of the city's early action projects already underway.

Collectively, the improvements to ANS and ONS would enable up to 300 mgd of effective biological treatment at the Southport plant, thereby doubling the current 150 mgd capacity. The flow sheet would be simplified, and the system would enable flow surges from over half of the captured CSO events to be absorbed in the mainstream plant without special provisions for starting up additional process equipment.

The design average flow capacity for biological nitrification would increase to 150 mgd, even though the design requirement would be only 125 mgd average. Thus there would be a built-in safety factor of 25 mgd for future growth in addition to the 25 mgd allocated over the next 20 years.

The recommended plan for biological treatment would satisfy all but 75 mgd of the 375 mgd peak treatment rate. As noted earlier, the remainder, if needed, would be treated via advanced primary treatment. One concept for accomplishing this is illustrated in **Figures 4-29** and **4-30**. For that option, a 75 mgd EHRC process would be used to treat the most dilute part of captured CSO flows in excess of the 75 mgd treated biologically. Because this process would be operated intermittently, it would need to be preceded by a 15 MG holding basin to enable smooth startup. The basin would also need to be fitted with preliminary treatment equipment such as swirl concentrators to remove grit, heavy solids and floatables. Installation of a 75 mgd primary settling basin within or adjacent to the holding basin would also be needed.

The final sizing of the EHRC process depends on the needed tunnel volume and the captured CSO dewatering rate. If this rate were 75 mgd rather than 150 mgd, then the EHRC process would not be needed.

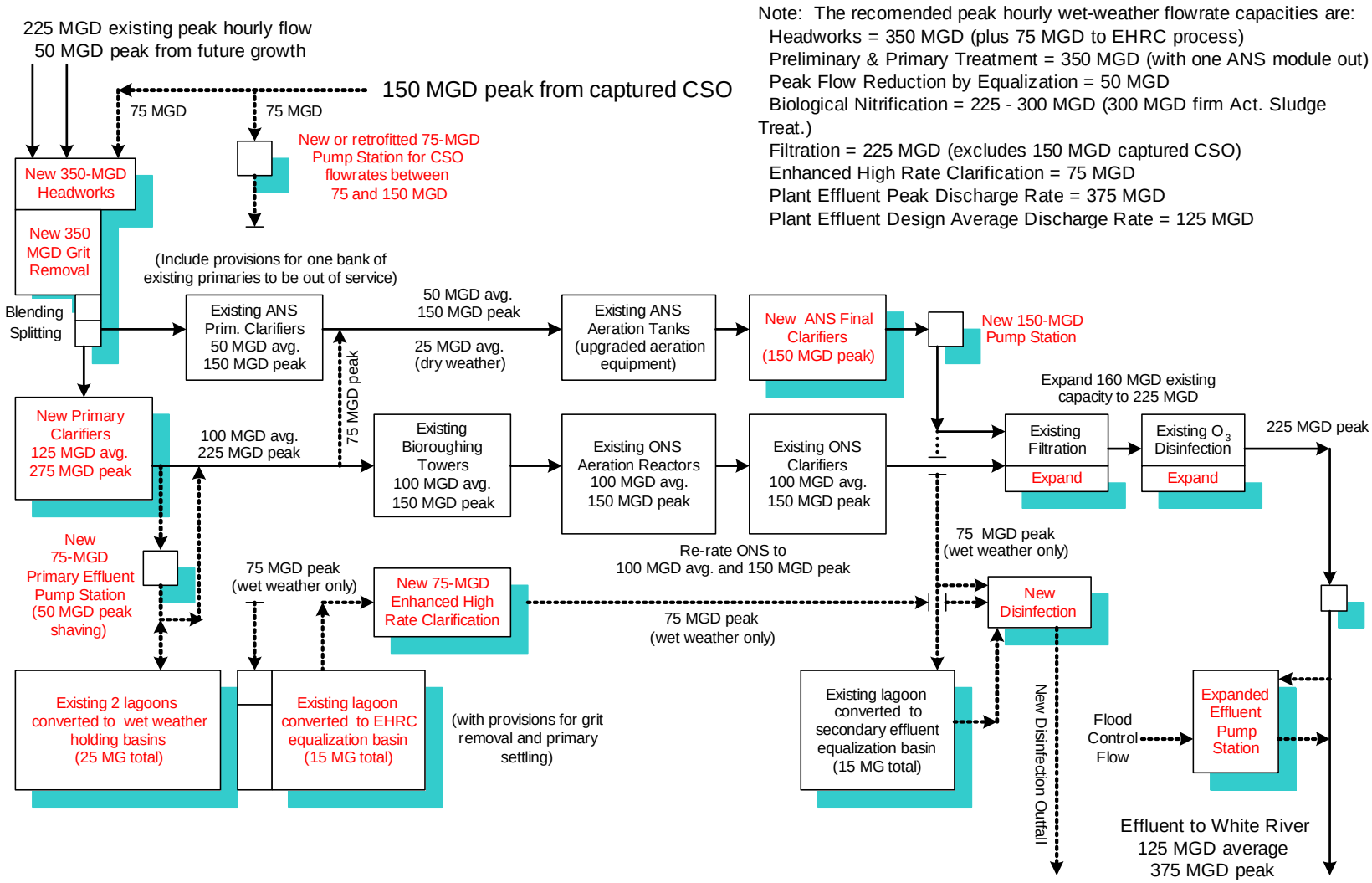


Figure 4-29
Southport Facility Process Flow Sheet

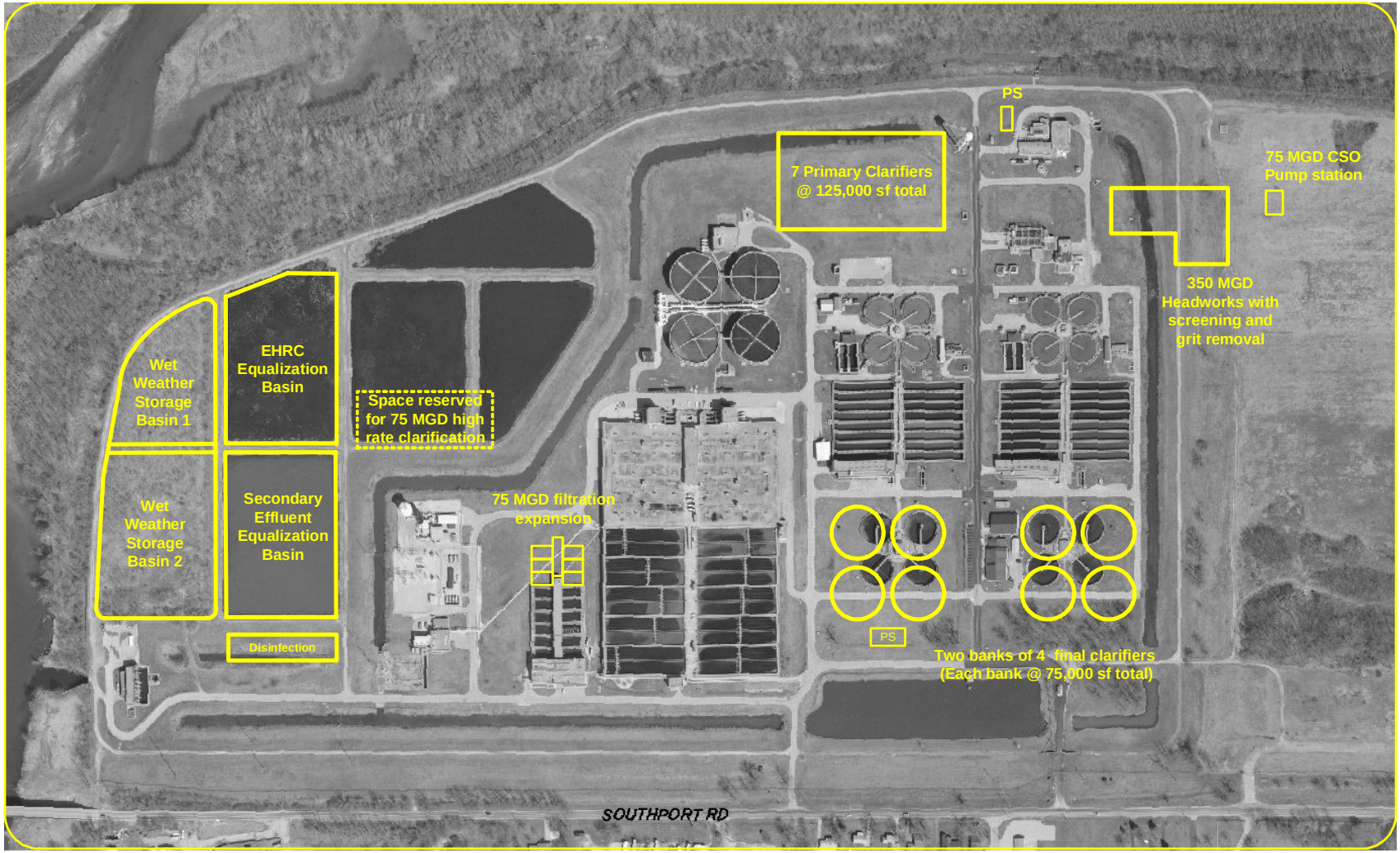


Figure 4-30
Southport Facility Expansion and CSO Treatment

The project (capital) cost for improvements to the Southport facility described in this section is $249 million, as shown in **Table 4-11**. This recommended concept is subject to more detailed process analysis, cost comparisons and value engineering.

4.5.5 Interplant Connection

4.5.5.1 Interplant Connection Alternatives

Five alternative concepts for the interplant connection were developed and evaluated in the *Interplant Connection Facility Plan.* The five concepts are illustrated in **Figure 4-31**.

Concept 1: Captured overflow from CSO 117 would be pumped to Equalization (EQ) Basin 117. The captured CSO flows from EQ Basin 117 and from the new Fall Creek–White River tunnel would be conveyed to the Southport plant via the new interplant connection sewer. This was the preliminary concept for the interplant connection.

Concept 2: Captured CSO flows from Structure 117 would be sent to the deep tunnel. EQ Basin 117 would be relatively large (60 MG) and would receive the dewatering flow from the deep tunnel.

Concept 3: Captured CSO flows from Structure 117 would be sent directly to the interplant connection, which would flow to a 275 mgd pumping station at Southport.

Concept 4: Captured CSO flows from Structure 117 would be routed directly to the tunnel. Two versions of Concept 4 were considered that differed only in the size of the interplant connection sewer. Concept 4a assumed a 108-inch-diameter interceptor, while Concept 4b assumed a 144-inch-diameter interceptor with a substantially larger conveyance capacity. This would enable reserve capacity in the event the need later arises to send more wet-weather flow to the Southport plant in addition to the 150 mgd of captured CSO flows from the tunnel. The tradeoff between Concept 4a and 4b is that Concept 4a is the lowest cost but does not allow for additional capacity. Concept 4b is most costly but has the flexibility of excess capacity.

Concept 5: The Fall Creek-White River deep tunnel would be extended all the way to the Southport plant in place of constructing a conventional gravity sewer (Southport Extension Tunnel). This concept was developed based on the range of tunnel volumes resulting from the deep tunnel model. A single new pump station (150 mgd) would be located at the Southport plant to dewater the deep tunnel and convey the captured CSO flows to expanded Southport treatment operations.

Table 4-11
Southport AWT Plant Cost Estimate[1]

Description	Capital Cost
Raw Wastewater (Captured CSO) Pump Station for EHRC (75-MGD firm capacity)	13,100,000
New 350-MGD Headworks Facility w/ Screening	45,400,000
New 350-MGD Grit Removal Facility with Blending and Flow Split	13,700,000
New 125-MGD/275-MGD Primary Clarifiers (125,000 sf)	51,900,000
New 15-MG EHRC Basin w/ grit removal and primary settling	6,700,000
New 75-MGD EHRC Facility	22,100,000
New ANS Aeration Equipment	8,000,000
New ANS Return Activated Sludge (RAS) Pumping	5,900,000
New ANS Final Clarifiers (8 units each @ 155' diameter)	54,800,000
New Effluent Pump Station on ANS (150-MGD firm capacity)	6,000,000
New 15 MG – Sec. Effluent Equalization Basin w/Aerators	5,600,000
Add Supplemental Disinfection Process (chlorination /dechlorination)	7,300,000
Yard Piping and Valves	9,000,000
TOTAL CAPITAL COST	249,400,000

[1] - Based on costs developed for the Interplant Connection Facilities Plan

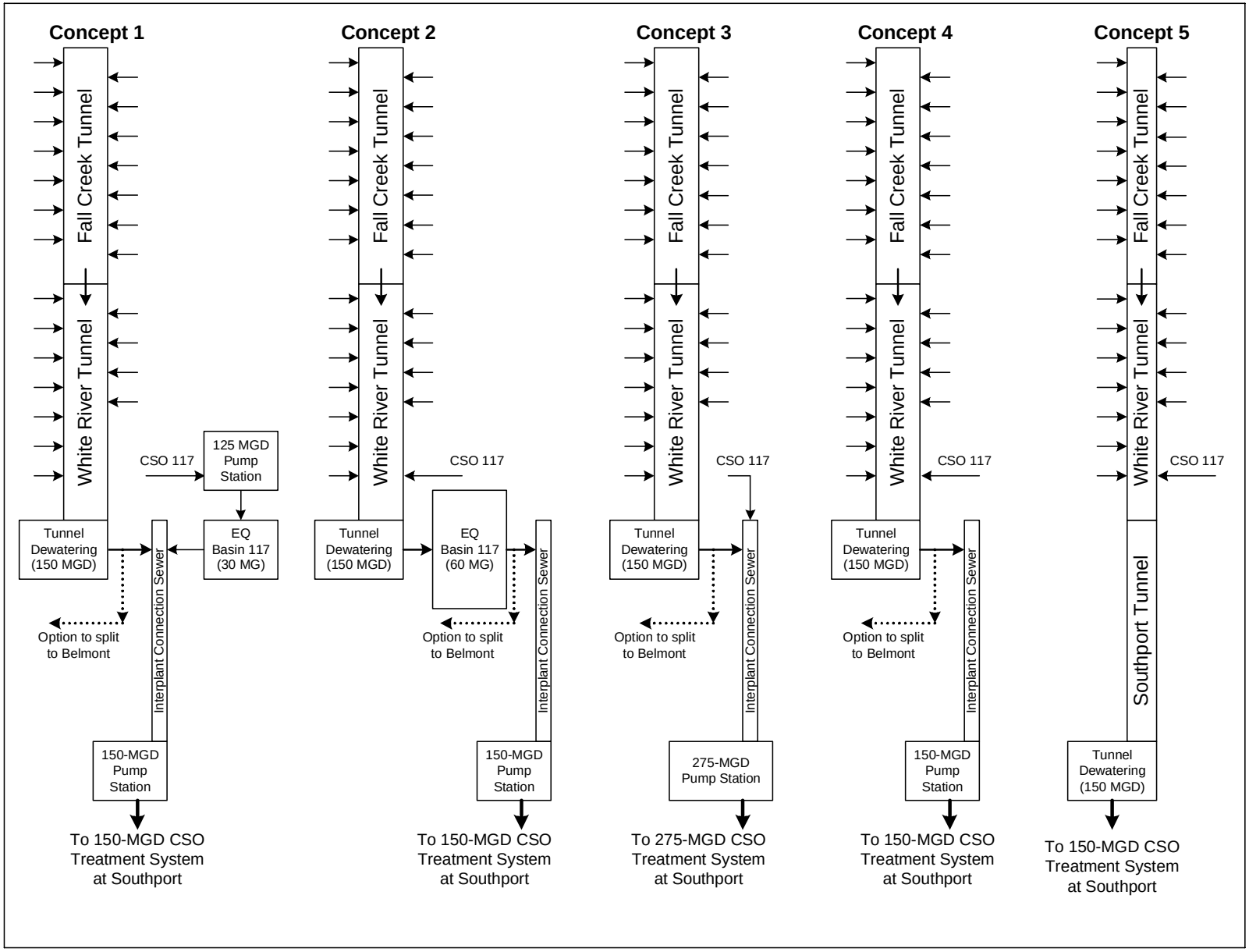


Figure 4-31
Alternative Concepts for the Interplant Connection

As shown in **Figure 4-31**, Concepts 1 through 4 included provisions for splitting captured CSO flows between the Belmont and Southport AWT plants.

For all five concepts, the city reviewed physical characteristics of the land where the interplant connection sewer would be constructed, including topography, geology, hydrology, flood hazard areas, land use, and groundwater. A schematic plan and profile for an initial route was prepared and then evaluated for technical, economical, environmental and constructability factors. Because several conflicts arose, the city selected for detailed study a revised alignment along the selected route from the Interstate 465 north right of way to the Southport AWT facility. **Figure 4-32** shows the revised route alignment.

The assumed routing of the tunnel system in the *Interplant Connection Facility Plan* follows Fall Creek and the White River. The tunnel is about 10 miles long from its start at 42nd Street and Fall Creek to CSO 117. Extending the tunnel to the Southport plant for Concept 5 would increase its length by another 5.6 miles (Southport Extension Tunnel). The tunnel diameters examined varied from 16 feet to 31 feet. Depths varied from 120 feet to 200 feet.

4.5.5.2 Facility Sizes and Capacities

Year 2002 flow data for monitored CSO outfalls were reviewed to gain a better understanding of the importance of CSO 117 relative to other CSO outfalls. The field monitoring data showed that the annual overflow volume from CSO 117, though significant, is not especially large compared to several of the other CSO outfalls. Nevertheless, if the overflow from CSO 117 was captured and bled back to the collection system, a large equalization basin (30 MG to 60 MG) and a large pumping station (125 mgd capacity) would be needed. On the basis of the computer modeling results, the city assumed the peak instantaneous overflow rate from CSO 117 to be 125 mgd.

The needed capacity for the interplant connection depends on whether it would be used for capturing CSO 117 alone, for conveying the tunnel dewatering flow alone, or for conveying both CSO 117 and the tunnel dewatering flow. As previously stated, the maximum dewatering rate for the tunnel likely would not exceed 150 mgd, and CSO 117 peak overflow rates likely would not exceed 125 mgd. Thus, if the interplant connection were used for conveying the tunnel dewatering flow alone, the peak capacity needed would be 150 mgd. A peak capacity of about 275 mgd would be needed if the interconnection were sized to convey both CSO 117 overflows and the tunnel dewatering, as in Concept 3.

A drawback to sizing the interplant connection for the combined flowrate is that it would nearly double the required capacity of the CSO treatment facility. Moreover, there would be little reason for segregating CSO 117 from the deep tunnel because, as was shown by results from the tunnel model, it has very little influence on the required tunnel volume and dewatering rate.

Concept 5 involved extending the tunnel to the Southport plant rather than building a conventional interplant connection sewer (Southport Extension Tunnel). The reasoning was that for a particular tunnel volume requirement, the incremental cost increase to build a longer tunnel of smaller diameter to the Southport facility might be offset by the savings from the avoided construction of the interplant connection sewer and a redundant pumping station. Because the tunnel volume is not yet known, the analysis considered a broad range of tunnel volumes to allow assessment of tradeoffs between terminating the tunnel near CSO 117 versus terminating it at the Southport plant.

4.5.5.3 Cost Comparisons of Alternatives

Cost estimates were developed using procedures intended to provide sufficient level of detail to support facility planning-level comparisons of alternative project approaches.

Estimates of probable capital and operating costs were developed for Concepts 1 through 5. To provide a common basis of comparison, the costs included the overall tunnel, rather than just the extension from CSO 117 to the Southport AWT plant. The cost estimates were developed over a range of tunnel volumes to see if future decisions regarding the tunnel volume requirements would affect which concept was preferred for the interplant connection. **Figure 4-33** shows the results from the capital cost comparisons.

4.5.5.4 Conclusions

The following conclusions were drawn from the cost comparative analyses:

Concept 1 was screened out due to overall cost and complexity. A complex system of pumping and equalization would be required to simply capture CSO 117. In addition, tunnel volume would not be significantly reduced.

Concept 2 was also screened out due to overall cost and complexity. The capital cost for a 60 mgd EQ Basin 117 would provide limited benefits because the basin would have limited effect on reducing either the capacity of the CSO treatment system or the tunnel volume.

Figure 4-32
Proposed Routing of the Interplant Connection

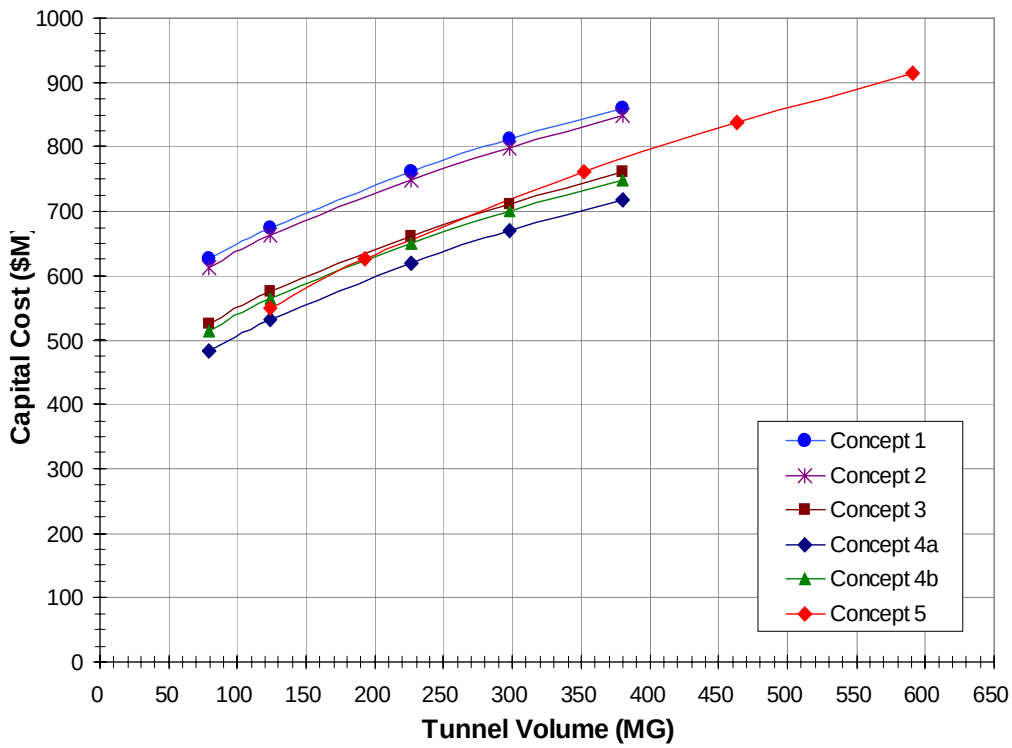
Concept 3 was screened out because it would require a sewer capacity of 275 mgd compared to only 150 mgd for Concept 4b. More importantly, it would require a 275 mgd CSO treatment system rather than a 150 mgd CSO treatment system.

Concepts 4a and 4b both met the project criteria and were among the least expensive options. **Figure 4-34** suggests that Concept 4a is the least cost alternative; however, it does not provide expansion capacity above the proposed tunnel-dewatering rate.

Concept 5 was screened out because (1) uncertainty as to whether existing underground stone quarries between the Belmont and Southport AWT plants would physically block the likely routing; (2) long delays in implementing the interplant connection because it would be tied in with the rest of the deep tunnel project; (3) limited operational flexibility; and (4) relatively little likelihood that the concept would cost less than the conventional methods of Concepts 4a and 4b.

The project criteria were satisfied by both Concept 4a and 4b, with 4a having the lower cost. However, considering the resulting benefit of reserve capacity, the city determined that Concept 4b would be moved forward into design. If no major construction issues develop during the detailed design phase related to the increased diameter, construction of 4b would be recommended.

In summary, the recommended concept for the interplant connection consists of a 144-inch-diameter interceptor that would originate near CSO 117 (east of the Belmont plant on the east side of White River). It would terminate near the headworks of the Southport plant. The interceptor would have a capacity of approximately 345 mgd and a length of approximately 33,000 feet (**Figure 4-32**). Additional capacity was added to the 150 mgd needed in the screening analysis in order provide reserve storage/conveyance capacity and to send additional flow to the Southport plant, if necessary. Initially the interceptor would store and convey CSO captured from Structure 117. After the deep tunnel system is constructed, the new interceptor would convey CSO captured in the tunnel. The project (capital) cost for the interplant connection is estimated to be $140 million.



Note: The capital cost is comprised of the components for each concept as shown in Figure 4-31, which includes the deep tunnel, pumping facilities, and interplant connection.

Figure 4-33
Capital Cost Comparison of Interplant Connection Concepts

4.6 Evaluation of Systemwide CSO Control Alternatives

Based upon its analysis of the five system components described above, the city developed 11 systemwide long-term control plan options and conducted an evaluation of each option's costs and benefits. The options fell into three overall plan concepts:

CSO Control Plan 1: Storage/conveyance in all watersheds and AWT plant improvements

CSO Control Plan 2: Remote treatment/storage in Fall Creek and Pogues Run watersheds and storage/conveyance in other watersheds with AWT plant improvements

CSO Control Plan 3: Sewer separation in all watersheds

4.6.1 Systemwide Plan Descriptions

4.6.1.1 CSO Control Plan 1

This plan would employ storage/conveyance in all watersheds combined with AWT plant improvements. Controls were evaluated at five levels of control: 90, 93, 95, 97 and 99 percent capture. Percent capture is a U.S. EPA measure of the annual wet-weather sewage flow that is captured and treated before discharge. For example, "90 percent capture" means that the alternative will capture 90 percent of the total volume of flow collected in the combined sewer system during precipitation events on a system-wide, annual average basis (not 90 percent of the volume currently being discharged). These levels of control correspond to annual average overflow frequencies of 12, 6, 4, 2 and 0.5 (one overflow every two years), respectively. The collection system alternatives correspond to the Plan 1 options described earlier in Section 4.5.2 and illustrated in **Figure 4-34**.

Plan 1 includes collection of outfalls on a regional basis using deep tunnels and conveyance facilities. It also includes near-surface collection conduits and satellite near-surface storage/treatment facilities for remotely located outfalls. The deep tunnels would serve primarily as storage facilities and the stored flows would be pumped out to the AWT facilities at the end of a storm event. The AWT facilities would be expanded and upgraded to provide treatment of wet-weather flows.

The key features of Plan 1 are:

- A central tunnel system from along Fall Creek and White River, with a pumping facility located near Southwest Diversion Structure.
- Collection interceptor conduits for remote outfalls along Fall Creek and White River to covey wet-weather flows into central tunnel system.
- Satellite storage/disinfection facilities for remotely located outfalls along upper White River and upper Pogues Run.
- Collection interceptor conduits along Pogues Run and Pleasant Run (and Bean Creek) to convey wet-weather flows into central tunnel system.
- A collection interceptor conduit along Eagle Creek to convey wet-weather flows to Belmont AWT plant.
- The interplant connection interceptor conduit from the Southwest Diversion Structure to the Southport AWT plant to convey pumped out stored flows from tunnel, following a rain event.
- Belmont AWT plant improvements.
- Southport AWT plant improvements.
- Local sewer separation projects to eliminate isolated overflows on State Ditch, Lick Creek and the upstream ends of Fall Creek, Pogues Run and Bean Creek.

Watershed improvements and early action projects are described below in Sections 4.6.1.4 and 4.6.1.5.

4.6.1.2 CSO Control Plan 2

This plan would employ storage with remote treatment in Fall Creek and Pogues Run watersheds and storage/conveyance to expanded AWT facilities in the remaining major watersheds, evaluated at five levels of control: 90, 93, 95, 97 and 99 percent capture. The levels of control correspond to annual average overflow frequencies of 12, 6, 4, 2 and 0.5, respectively. The collection system alternatives correspond to the Plan 2 options described earlier in Section 4.5.2 and illustrated in **Figure 4-35**.

Plan 2 includes collection of outfalls on a regional basis using deep tunnels and treatment facilities. It also includes near-surface collection conduits and satellite near-surface storage/treatment facilities for remotely located outfalls. The deep tunnels would serve primarily as storage facilities and the stored flows would be pumped out to the remote treatment facilities or to the AWT plants at the end of a storm event. The AWT plants would be expanded and upgraded to provide treatment of wet-weather flows.

The key features of Plan 2 are:

- A separate tunnel system, pumping facility and remote treatment facility for Fall Creek and Pogues Run watersheds.

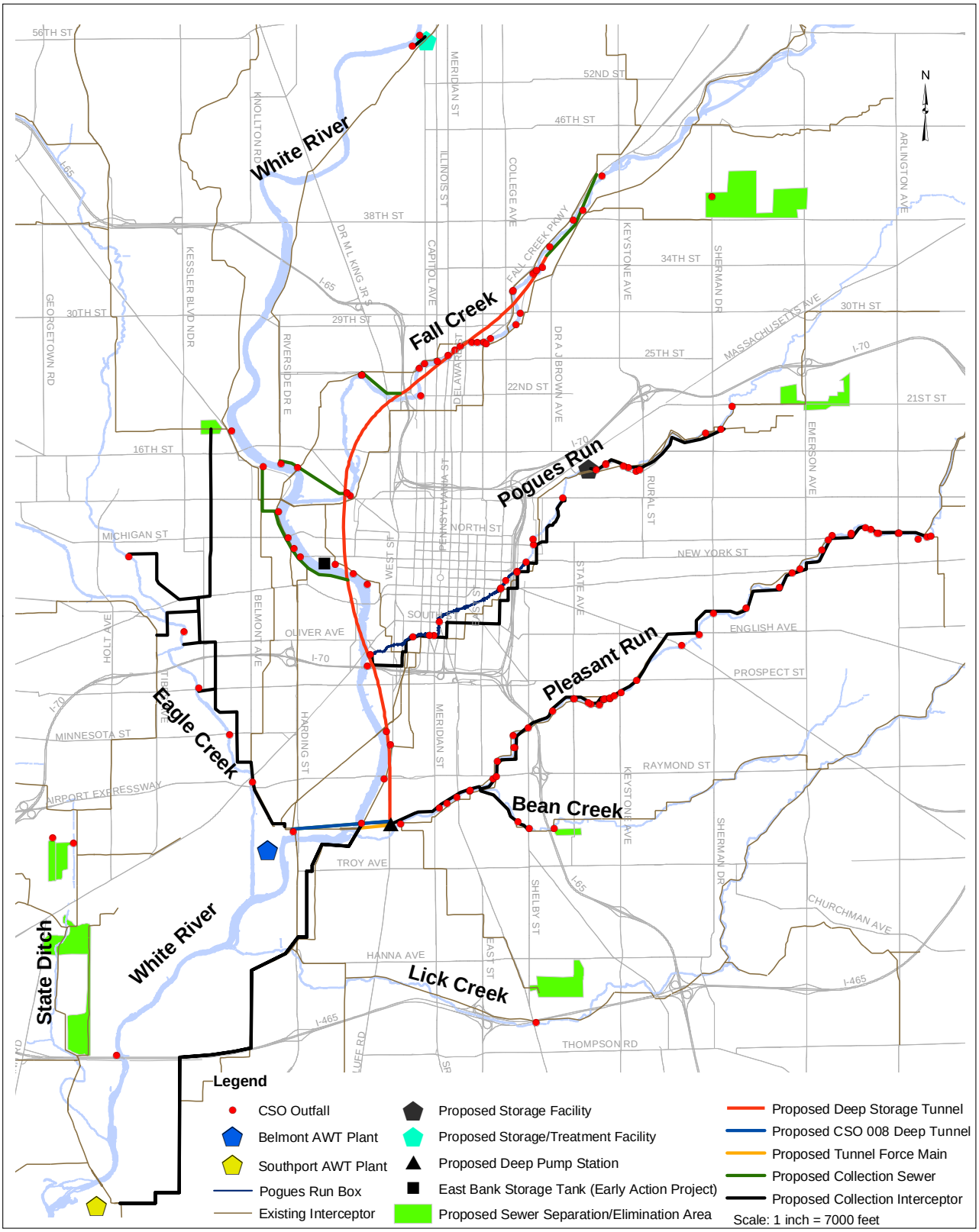


Figure 4-34
CSO Control Plan 1

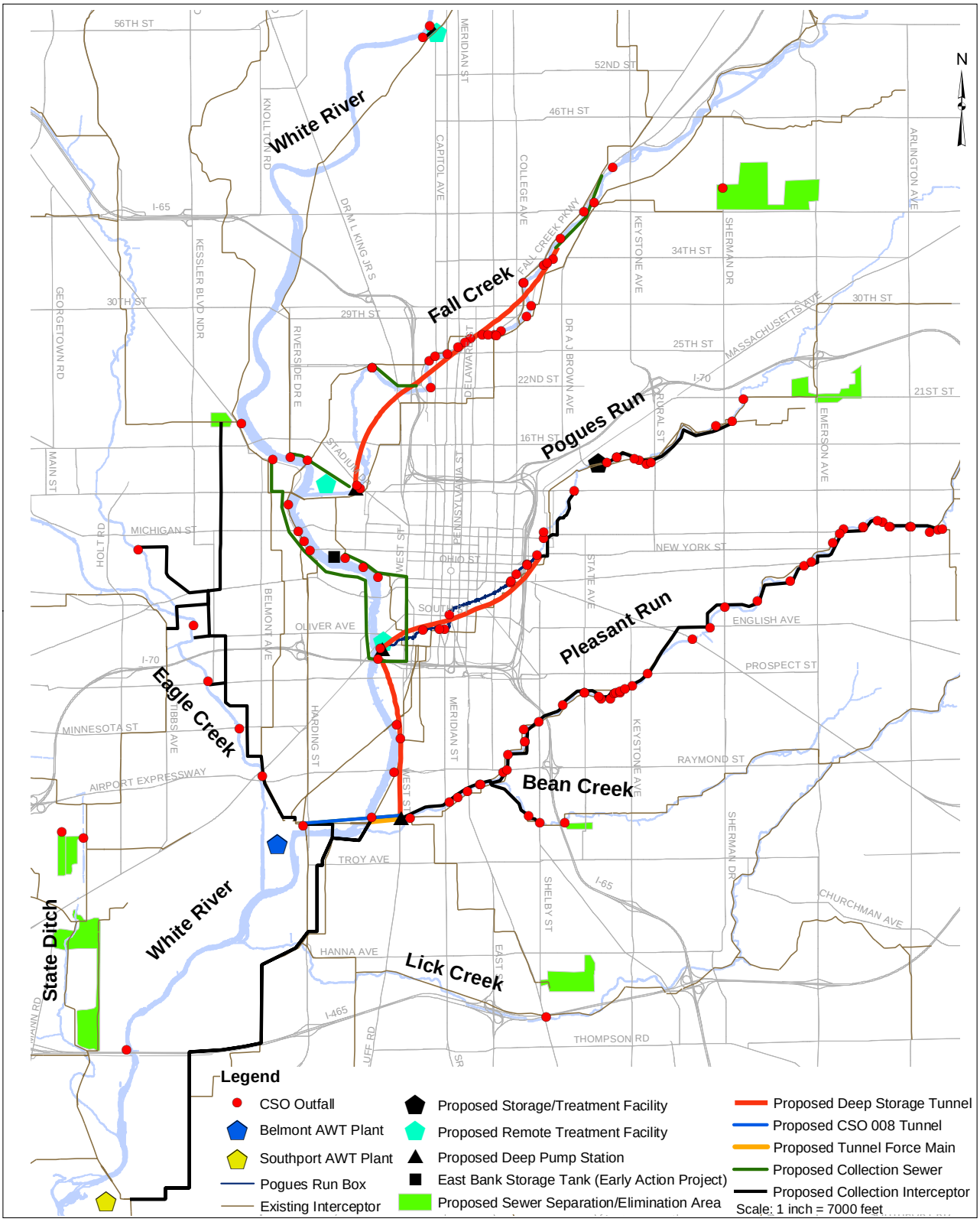


Figure 4-35
CSO Control Plan 2

- A separate tunnel system for White River watershed with a pumping facility near Southwest Diversion Structure.
- Collection interceptor conduits for remote outfalls along Fall Creek, Pogues Run and White River to covey wet-weather flows into each tributary tunnel system.
- Satellite storage/treatment facilities for remotely located outfalls along upper White River and upper Pogues Run.
- Collection interceptor conduits along Pleasant Run (and Bean Creek) to convey wet-weather flows into White River tunnel system.
- A collection interceptor conduit along Eagle Creek to convey wet-weather flows to Belmont AWT plant.
- The interplant connection interceptor conduit from the Southwest Diversion Structure to the Southport AWT plant to convey pumped out stored flows from tunnel, following a rain event.
- Belmont AWT plant improvements.
- Southport AWT plant improvements.
- Local sewer separation projects to eliminate isolated overflows on State Ditch, Lick Creek and the upstream ends of Fall Creek, Pogues Run and Bean Creek.
- Watershed improvements and early action projects described below in Sections 4.6.1.4 and 4.6.1.5.

4.6.1.3 CSO Control Plan 3

CSO Control Plan 3 includes separation of existing combined sewers in all watersheds to eliminate combined sewer overflows (shown previously in **Figure 4-23**). The existing AWT plants would be hydraulically adequate to provide treatment of sanitary flows including predicted future flows and would not be upgraded and expanded. The interplant connection also would not be required.

For Plan 3, the existing combined sewers would be converted to either a separate sanitary sewer or a separate storm sewer. The selection would be based on many factors, including the size of the combined sewer, its connection to the interceptor, number of lateral connections and other factors. In some instances, the existing combined sewer may need total replacement. A new sewer system (sanitary or storm) would be constructed. Sanitary flows would be conveyed to the AWT plants and would receive advanced treatment. This plan does not include expansion of the AWT plants; however, it is likely that the plants would continue to receive additional flows during wet-weather periods due to infiltration into the sanitary system. The stormwater flows would be conveyed to stormwater best management practices, such as ponds and sand filters, prior to ultimate discharge into streams.

The key features of Plan 3 are:

- Total sewer separation in all watersheds, including Fall Creek, Pogues Run, Pleasant Run, Eagle Creek, State Ditch and White River.
- The stormwater flows would be conveyed to stormwater best management practices, such as ponds and sand filters, prior to ultimate discharge into streams.
- The interplant connection project would not be constructed.
- The Belmont and Southport AWT plants would not be expanded.
- Watershed improvements described below in Section 4.6.1.5.

The 11 systemwide control plan options (five options for Plan 1, five for Plan 2 and one for Plan 3) are summarized and compared to current capture and overflow conditions in **Table 4-12**.

4.6.1.4 Early Action Projects

The city's analysis of Plan 1 and Plan 2 incorporated the costs of early action projects, including:

- Major combined sewer improvement and rehabilitation projects from 1995 to 2002
- In-system storage projects at CSO 080, 084, 118, 053, 058, 101, 063, 063A and 065
- Re-routing of CSO 205 to Lift Station 507
- Modifications to Lift Station 507 to eliminate CSO 156
- Elimination of CSOs 103, 217, 218, 275 and 235
- West Belmont cut-off sewer project
- East Bank storage tank to mitigate overflows at CSO 039
- Consolidation sewer at CSOs 034/035 and conversion of half of Pogues Run conduit to CSO storage tunnel
- Vortex separator pilot project at CSO 045
- Real-time control projects
- Interceptor capacity improvement projects
- Pogues Run and Lake Sullivan wetlands
- Flow equalization basins, Belmont facility storage basin, raw sewage pumping, and other Belmont and Southport AWT plant improvements

Where applicable and quantifiable, the benefits of these projects were incorporated into the NetSTORM model to produce projected water quality benefits for the systemwide CSO control plans.

4.6.1.5 Watershed Improvements

The city's analysis of the systemwide CSO control plans also incorporated the costs and benefits of additional non-CSO improvements to further enhance water quality and stream aesthetics. As noted earlier in Section 4.5.2.8, these improvements would address non-CSO sources of pollution in the watersheds or maximize the benefits of the city's selected CSO control plan. These improvements include:

- Building sewers for neighborhoods now served by septic systems
- Implementing projects to reduce flooding and improve stormwater drainage
- Restoring streambanks and removing polluted sediments from streams
- Disconnecting downspouts, sump pumps and other illicit connections that take up sewer capacity
- Adding flow to tributaries to improve stream appearance and wildlife habitat *(Plans 1 and 2 only)*
- Improving oxygen levels in streams by adding aeration on Fall Creek and White River, removing Boulevard Dam on Fall Creek and modifying Stout Dam on White River *(Plans 1 and 2 only)*

Even though these measures are not a required component of the LTCP and will be implemented at the city's discretion, the water quality modeling performed to evaluate the effectiveness of the systemwide CSO control plans assumes the completion of these projects to improve water quality.

4.6.2 Estimated Costs

Once the components of the systemwide plans were developed, the city developed a methodology to size and cost the CSO control facilities and to determine their associated water quality benefit.

The first step involved modifying the city's existing NetSTORM collection system hydraulic model to reflect recently completed CSO control projects and future flows. These modifications included adding details from the projects completed, ongoing and future confirmed system upgrades, and future flow projections within the city's sewer network. This modified model provided the foundation on which the systemwide plans were developed.

The future flow projections were drawn from the *Interplant Connection Facilities Plan* (ICST, 2004), which projected flow increases of 10 mgd for the Belmont AWT plant service area and 20 mgd for the Southport AWT plant service area over a 20-year planning period. These flow increases

Table 4-12
Summary of Systemwide CSO Control Plan Options

	Percent Capture	Days of Untreated Overflows per Year
Current Conditions	63%	60
Plan 1: Storage and Conveyance Facilities	90%	12
	93%	6
	95%	4
	97%	2
	99%	0.5
Plan 2: Storage and Conveyance with Remote Treatment	90%	12
	94%	6
	95%	4
	98%	2
	99%	0.5
Plan 3: Total Sewer Separation	100%	0

were allocated to individual interceptors by calculating ratios from the ultimate build-out average dry-weather flow projections presented in the draft *Marion County Sanitary Sewer Master Plan* (HNTB, 2004).

The second step involved performing hydraulic modeling of the systemwide plans. Hydraulic analysis was conducted based on a 50-year rainfall series using the NetSTORM model. The model produced flowrates and volumes used to size the CSO control facilities for both Plan 1 and Plan 2.

Key CSO control facilities were identified for Plan 1 and Plan 2 and preliminarily sited. Once preliminary sites were selected and hydraulic modeling results were available, CSO control facilities were sized accordingly. Planning costs for CSO control facilities were then estimated using the city's *Cost Estimating Procedures for CSO Control Alternatives Evaluation* (ICST, 2004), which is based on U.S. EPA references, where available, adjusted to local conditions. The local conditions are estimated as contingencies including site adjustment factors, land, engineering, administration and inspection, and unknown factors. The present worth costs are given in March 2004 dollars and based on a 20-year period.

Plan 1: The estimated capital and present worth costs for CSO Control Plan 1 at different capture levels are summarized in **Table 4-13** and illustrated in **Figure 4-36**, showing a breakdown in cost for the five major system components. Note that tunnel and collection system costs are the most sensitive to increases in the overall level of control. A detailed cost estimate for each capture level analyzed is included in **Appendix C**. The project (capital) cost for Plan 1 ranges from $1.315 billion for 90 percent system capture to $2.961 billion for 99 percent system capture. The present worth cost ranges from $1.444 billion for 90 percent system capture to $3.027 billion for 99 percent system capture. These costs include $63.4 million for watershed improvement projects described in Section 4.5.2.8.

Plan 2: The estimated capital and present worth costs for CSO Control Plan 2, at different capture levels, are summarized in **Table 4-14** and illustrated in **Figure 4-37**, showing a breakdown in cost for the five major system components. As with Plan 1, tunnel and collection system costs are the most sensitive to increases in the overall level of control. A detailed cost estimate for each capture level analyzed is included in **Appendix C**. The project (capital) cost for Plan 2 ranges from $1.394 billion for 90 percent system capture to $2.901 billion for 99 percent system capture. The present worth cost ranges from $1.545 billion for 90 percent system capture to $3.032 billion for 99 percent system capture. At all levels of control, Plan 2 is a more expensive option than Plan 1.

Plan 3: The estimated capital and present worth costs for CSO Control Plan 3 are summarized in **Table 4-15**. The planning level costing was performed using the total combined sewer service area acreage for individual watersheds. A detailed cost estimate is included in **Appendix C**. The project (capital) cost for Plan 3 is estimated to be $6.025 billion. The present worth cost is $6.201 billion, the most expensive CSO control option evaluated.

4.6.3 Water Quality Impacts

In-stream water quality modeling was performed to demonstrate results attained by the city's current system and to evaluate the projected benefits of various systemwide CSO control measures. In conjunction with full structural controls, the city evaluated watershed improvements that enhance or supplement the benefits of CSO controls and help improve water quality. In particular, this evaluation focused on reductions in *E. coli* bacteria and dissolved oxygen impacts described in Section 2 (Existing Conditions).

The following subsections summarize the predicted environmental benefits of the CSO control alternatives, with and without watershed improvements. Where the text, tables and graphs refer to the "existing" sewer system, this is defined as the city's sewer system prior to 2002, when a number of early action projects were initiated.

4.6.3.1 CSO Volume Reduction

Table 4-16 summarizes the percent capture, annual average overflow frequencies, overflow volume removed, and residual overflows discharged into the receiving streams for the proposed Plan 1 CSO control facilities. Results are shown by watershed. The White River values represent the sum of all the tributary values *plus* the direct discharges to White River itself. The first row (watershed percent capture) indicates the percent captured by the pre-2002 (existing) system and proposed CSO control facilities. The second row (CSO volume removed) indicates the average annual CSO volume removed by the proposed CSO control facilities. The third row (CSO volume discharged) indicates the average annual CSO volume discharged to the stream with the proposed CSO control facilities in place. For Plan 1, estimated annual volume discharged to the stream is reduced to 1,542 million gallons at 90 percent system capture and 140 million gallons at 99 percent system capture, compared

Table 4-13
CSO Control Plan 1 Cost Estimate

Description	Cost ($M) System Capture				
	90%	93%	95%	97%	99%
Tributaries					
Fall Creek	158	179	197	227	441
Pogues Run	77	100	113	154	264
Pleasant Run	50	99	130	189	282
Eagle Creek	18	24	32	60	75
Tributaries Capital Cost Subtotal	303	401	472	630	1063
White River and Central System					
Upper White River	10	19	29	46	70
Lower White River & Central System	234	287	321	650	1014
White River and Central System Capital Cost Subtotal	245	306	350	696	1083
AWT System					
Interplant Connection	140	140	140	140	140
Belmont AWT	154	165	172	172	172
Southport AWT	221	221	221	221	249
AWT System Capital Cost Subtotal	514	525	533	533	562
Early Action Plans Capital Cost Subtotal	189	189	189	189	189
Watershed Improvements Capital Cost Subtotal	63	63	63	63	63
TOTAL CAPITAL COST	**1315**	**1484**	**1607**	**2111**	**2961**
Present Worth Operation and Maintenance Cost	110	119	126	145	188
Present Worth Replacement Cost	93	97	100	104	115
Present Worth Salvage Value	-75	-89	-99	-152	-236
TOTAL PRESENT WORTH COST	**1444**	**1612**	**1734**	**2208**	**3027**

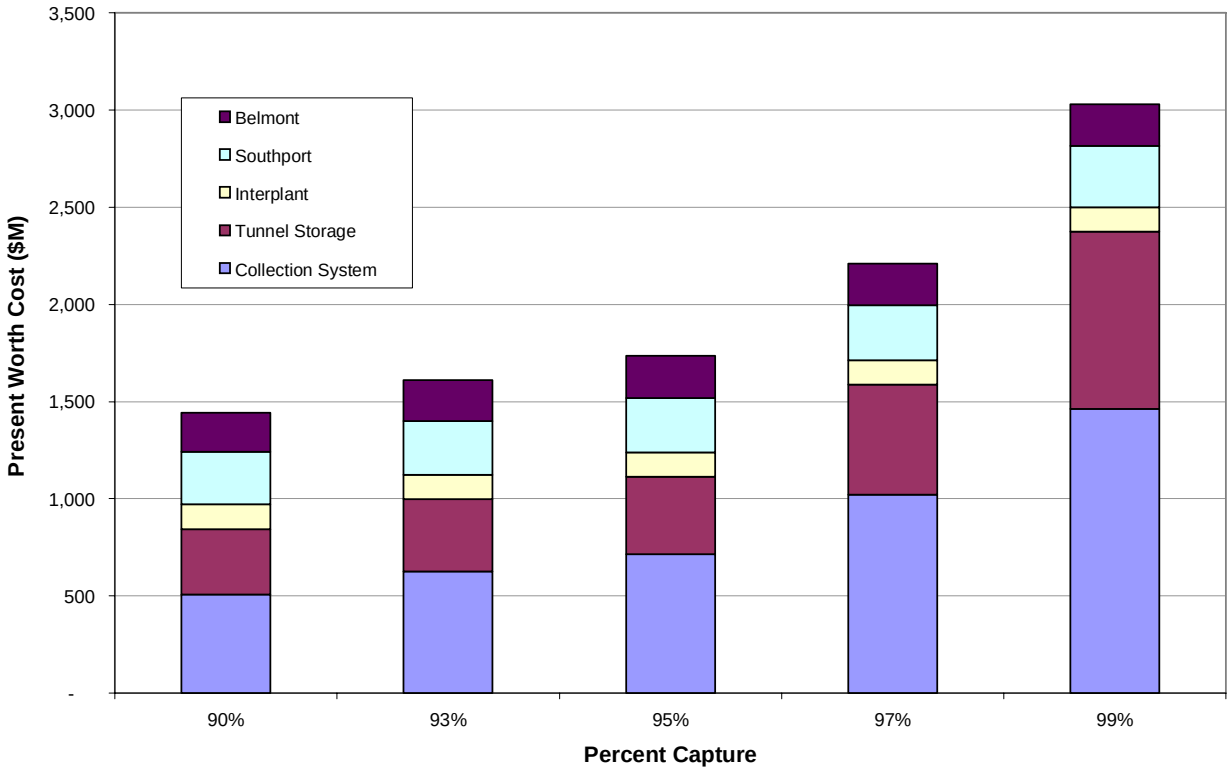


Figure 4-36
CSO Control Plan 1 Cost Estimate by Percent Capture

Table 4-14
CSO Control Plan 2 Cost Estimate

Description	Cost ($M) System Capture				
	90%	94%	95%	98%	99%
Tributaries					
Fall Creek	191.9	225.7	253.3	302.3	547.4
Pogues Run	173.1	217.8	245.5	308	496.1
Pleasant Run	50.1	98.9	130.2	189.1	282.2
Eagle Creek	17.7	23.5	31.8	60.4	75.4
Tributaries Capital Cost Subtotal	432.8	565.9	660.8	859.8	1,401.00
White River and Central System					
Upper White River	10.3	18.6	28.6	46.3	69.7
Lower White River & Central System	183.3	205.9	221.6	388	645.2
White River and Central System Capital Cost Subtotal	193.6	224.5	250.2	434.3	714.9
AWT System					
Interplant Connection	140	140	140	140	140
Belmont AWT	153.7	164.7	172.1	172.1	172.1
Southport AWT	220.6	220.6	220.6	220.6	220.6
AWT System Capital Cost Subtotal	514.3	525.3	532.7	532.7	532.7
Early Action Plans Capital Cost Subtotal	189.3	189.3	189.3	189.3	189.3
Watershed Improvements Capital Cost Subtotal	63.3	63.3	63.3	63.3	63.3
TOTAL CAPITAL COST	**1,393.4**	**1,568.3**	**1,696.4**	**2,079.4**	**2,901.2**
Present Worth Operation and Maintenance Cost	130	140.1	149.5	172.2	221.2
Present Worth Replacement Cost	100.4	106.5	111.4	119.7	130.1
Present Worth Salvage Value	-77.6	-91.2	-100.9	-136.1	-219.1
TOTAL PRESENT WORTH COST	**1,545.4**	**1,722.6**	**1,855.2**	**2,234.2**	**3,032.3**

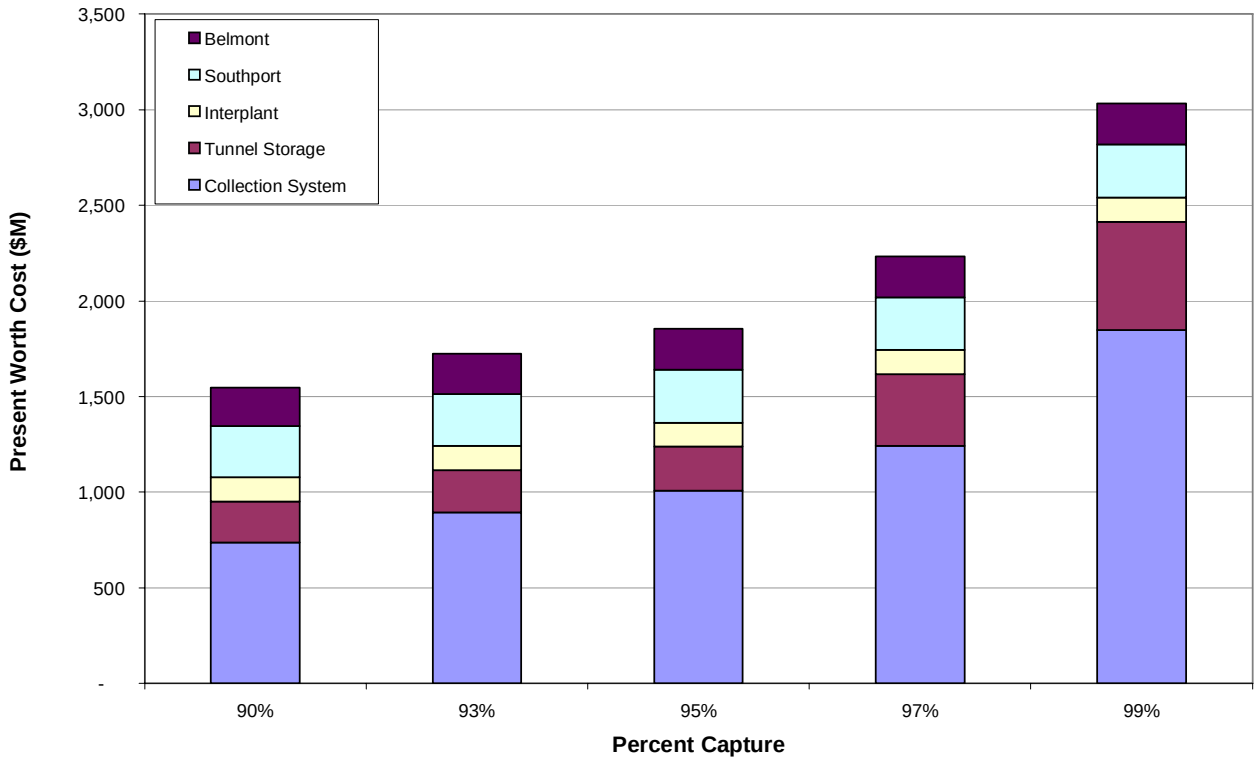


Figure 4-37
CSO Control Plan 2 Cost Estimate by Percent Capture

Table 4-15
CSO Control Plan 3 Cost Estimate

Description	CSO Area (acres)	Cost ($M)
Tributaries		
Fall Creek	13,307	2,305.00
Pogues Run	6,016	1,042.10
Pleasant Run	6,718	1,076.60
Eagle Creek	1,615	258.8
State Ditch	457	79.3
Tributaries Acreage and Capital Cost Subtotal	28,113	4,761.80
White River		
Central Sub-Network	1,888	327.1
White River	5,405	936.3
White River Acreage and Capital Cost Subtotal	7,293	1,263.40
AWT System		
Interplant Connection	-	0
Belmont AWT	-	0
Southport AWT	-	0
AWT System Capital Cost Subtotal		0
Early Action Plans Capital Cost Subtotal	-	0
Watershed Improvements Capital Cost Subtotal	-	0
TOTAL ACREAGE AND CAPITAL COST	**35,406**	**6,025.20**
Present Worth Operation and Maintenance Cost	-	175.5
Present Worth Replacement Cost	-	0
Present Worth Salvage Value	-	-1,154.10
TOTAL ACREAGE AND PRESENT WORTH COST	**35,406**	**5,046.60**

to the pre-2002 system discharge of 7.866 billion gallons (including the primary effluent bypass at the AWT plants). **Table 4-17** summarizes the same information for the Plan 2 CSO control facilities. For Plan 2, estimated annual volume discharged to the stream is reduced to 1,514 million gallons at 90 percent system capture and 135 million gallons at 99 percent system capture.

Figure 4-38 graphically illustrates this same information. The first group of bars (Pre-2002) shows annual overflow volume produced by the city's pre-2002 sewer system. The PE bypass volume is represented by a solid gray bar and the collection system volume by a thatched gray bar. The next five groups compare the estimated collection system overflow volumes for the five control level alternatives (90-99 percent capture). Under all five levels of control, the PE Bypass overflow volume would be eliminated. Under Plan 3, all sewers would be separated, eliminating the discharge of combined sewage into receiving streams. By capturing the first flush and reducing the frequency of overflows, all alternatives would significantly reduce or eliminate odors, floating sewage, and trash in neighborhood streams.

4.6.3.2 BOD Residual Loads

Figure 4-39 illustrates the residual BOD loads to the White River and tributaries in recent years and how various levels of additional CSO control would reduce residuals even further. Similar to **Figure 4-38**, the first group of bars (pre-2002) shows annual BOD load based on the city's pre-2002 sewer system. The next five groups show the estimated performance for the five control alternatives. As shown in the graph, Plan 1 performs better than Plan 2 at all levels of control in reducing BOD loads, due to higher levels of treatment at the AWT facilities. For Plan 1, estimated residual BOD loads range from 1,190,000 pounds at 90 percent capture to 370,000 pounds at 99 percent capture. For Plan 2, estimated residual BOD loads range from 1,560,000 pounds at 90 percent capture to 920,000 pounds at 99 percent capture. Plan 3 (sewer separation) would result in residual BOD loads of 510,000 pounds/year. Although sanitary sewage would receive AWT-level treatment under Plan 3, stormwater would continue to carry significant BOD loads to the waterways.

Table 4-16
Estimated CSO Volume Reductions for Plan 1

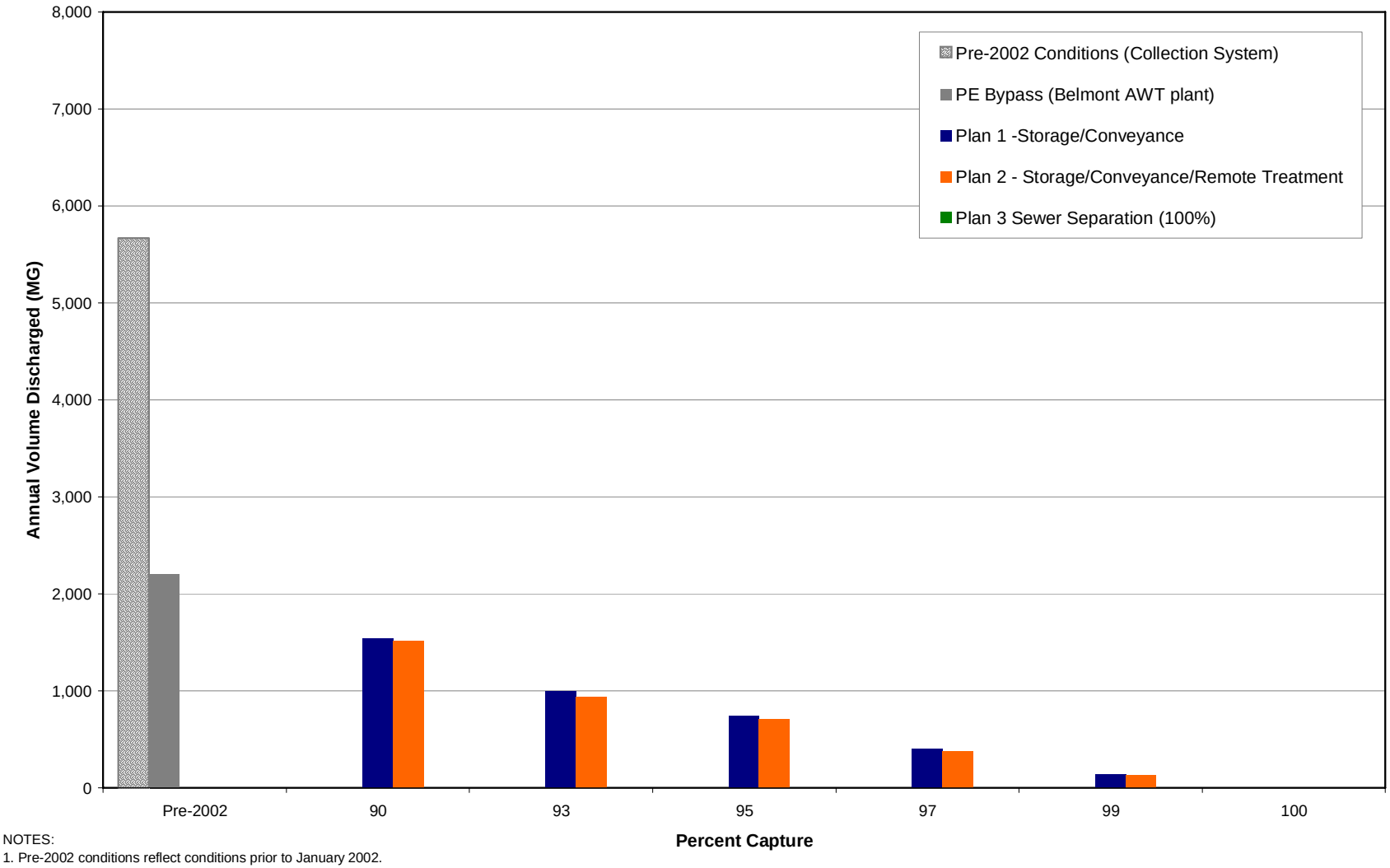
Watershed	Systemwide Percent Capture				
	90%	93%	95%	97%	99%
Fall Creek					
Watershed Percent Capture of CSO Volume	88%	93%	95%	97%	99%
Average Annual CSO Volume Removed (MG)	1,170	1,369	1,449	1,559	1,628
Average Annual Residual CSO Volume Discharged (MG)	498	299	219	110	40
Average Annual Untreated Overflow Events	12	6	4	2	0.5
Pogues Run					
Watershed Percent Capture of CSO Volume	89%	94%	96%	98%	99%
Average Annual CSO Volume Removed (MG)	759	911	977	1,035	1,082
Average Annual Residual CSO Volume Discharged (MG)	341	189	124	66	19
Average Annual Untreated Overflow Events	12	6	4	2	0.5
Pleasant Run					
Watershed Percent Capture of CSO Volume	94%	97%	98%	99%	99.6%
Average Annual CSO Volume Removed (MG)	207	281	304	326	351
Average Annual Residual CSO Volume Discharged (MG)	155	81	57	36	10
Average Annual Untreated Overflow Events	12	6	4	2	0.5
Eagle Creek					
Watershed Percent Capture of CSO Volume	92%	96%	97%	98%	99%
Average Annual CSO Volume Removed (MG)	31	48	53	58	63
Average Annual Residual CSO Volume Discharged (MG)	35	18	13	8	3
Average Annual Untreated Overflow Events	12	6	4	2	0.5
White River[1]					
Watershed Percent Capture of CSO Volume	90%	93%	95%	97%	99%
Average Annual CSO Volume Removed (MG)	4125	4664	4924	5256	5526
Average Annual Residual CSO Volume Discharged (MG)	1542	1002	742	410	140
Average Annual Untreated Overflow Events	12	6	4	2	0.5

[1] White River data includes totals for entire CSO system.

Table 4-17
Estimated CSO Volume Reductions for Plan 2

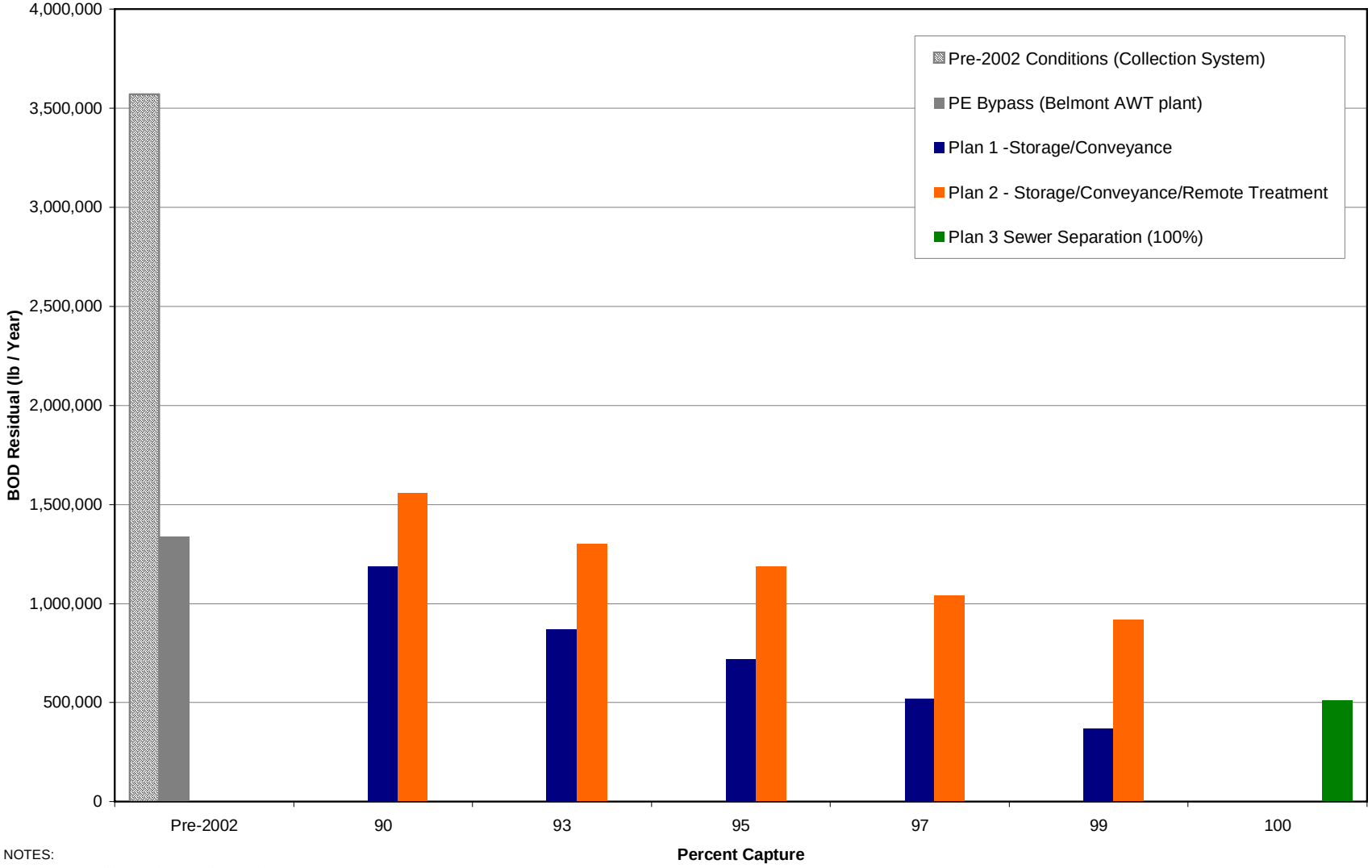
Watershed	Systemwide Percent Capture				
	90%	94%	95%	98%	99%
Fall Creek					
Watershed Percent Capture of CSO Volume	88%	93%	95%	97%	99%
Average Annual CSO Volume Removed (MG)	1,170	1,369	1,449	1,559	1,628
Average Annual Residual CSO Volume Discharged (MG)	498	299	219	110	40
Average Annual Untreated Overflow Events	12	6	4	2	0.5
Pogues Run					
Watershed Percent Capture of CSO Volume	87%	92%	94%	97%	99%
Average Annual CSO Volume Removed (MG)	687	852	924	1,016	1,072
Average Annual Residual CSO Volume Discharged (MG)	414	248	176	85	29
Average Annual Untreated Overflow Events	12	6	4	2	0.5
Pleasant Run					
Watershed Percent Capture of CSO Volume	94%	97%	98%	99%	100%
Average Annual CSO Volume Removed (MG)	207	281	304	326	351
Average Annual Residual CSO Volume Discharged (MG)	155	81	57	36	10
Average Annual Untreated Overflow Events	12	6	4	2	0.5
Eagle Creek					
Watershed Percent Capture of CSO Volume	92%	96%	97%	98%	99%
Average Annual CSO Volume Removed (MG)	31	48	53	58	63
Average Annual Residual CSO Volume Discharged (MG)	35	18	13	8	3
Average Annual Untreated Overflow Events	12	6	4	2	0.5
White River					
Watershed Percent Capture of CSO Volume	90%	94%	95%	98%	99%
Average Annual CSO Volume Removed (MG)	4152	4729	4958	5293	5531
Average Annual Residual CSO Volume Discharged (MG)	1514	937	708	373	135
Average Annual Untreated Overflow Events	12	6	4	2	0.5

[1] White River data includes totals for entire CSO system.



NOTES:
1. Pre-2002 conditions reflect conditions prior to January 2002.
2. The actual percent capture at 93% and 97% for Plan 1 is 93.4% and 97.3% and for Plan 2 is 93.8% and 97.5% respectively. For comparison purposes, these were rounded to the same whole number.

Figure 4-38
Annual Volume Discharge by Percent Capture



NOTES:
1. Pre-2002 conditions reflect conditions prior to January 2002.
2. The actual percent capture at 93% and 97% for Plan 1 is 93.4% and 97.3% and for Plan 2 is 93.8% and 97.5% respectively. For comparison purposes, these were rounded to the same whole number.

Figure 4-39
Annual BOD Reduction by Percent Capture

4.6.3.3 Dissolved Oxygen Impacts

As described in Section 2 (Existing Conditions), the dissolved oxygen levels in White River and Fall Creek can fall to critically low levels during summer storm events that occur during low flow periods, most notably immediately upstream of existing dams. Combined with dam removal or instream aeration, CSO controls resulting in at least 90 percent system capture would achieve dissolved oxygen standards on White River and Fall Creek. Alternatively, DO standards could be met on both streams under 93 percent system capture, if combined with dam removal on Fall Creek and dam modification on White River.

Based upon water quality modeling results, all alternatives evaluated would eliminate dissolved oxygen violations in White River and Fall Creek when both CSO controls and watershed improvements (dam removal/modification and aeration) are employed. Therefore, all alternatives are expected to prevent CSO-related fish kills and reduce stress on fish and other aquatic wildlife related to suppressed dissolved oxygen levels, especially if the watershed improvements are implemented. The city plans to remove Boulevard Dam in Fall Creek, modify Chevy and Stout dams in White River, and provide aeration within White River and Fall Creek to ensure attainment of the dissolved oxygen standard.

4.6.3.4 *E. coli* Bacteria Impacts

The state's geometric mean standard for *E. coli* bacteria is 125 cfu per 100 mL. Based upon 2000-2002 sampling data, White River's geometric mean value currently exceeds 460 cfu/100 mL. Modeling predicts that CSO controls will improve the geometric mean value in the White River and its tributaries, but the standard will not be achieved. With the addition of watershed improvements, the geometric mean can be further reduced, although not enough to achieve the standard in all watersheds except the Pogues Run watershed. **Table 4-18** summarizes the existing geometric mean for each stream and how the alternatives would improve this value, both with and without watershed improvements. **Figure 4-40** displays the White River results graphically, showing all three plan options and each level of control evaluated. For Plan 1 and Plan 2, the estimated *E. coli* geometric mean ranges from 234 cfu per 100 mL at 90 percent system capture to 203 cfu per 100 mL at 99 percent system capture. When watershed improvements are employed, the mean is expected to fall to 190 cfu per 100 mL at 90 percent system capture and 164 cfu per 100 mL at 99 percent system capture. Sewer separation with watershed improvements is expected to achieve a geometric mean of 168 cfu per 100 mL.

Indiana's single sample maximum standard for *E. coli* bacteria is 235 cfu per 100 mL to protect full-body recreational uses. The city's analysis revealed that CSO controls alone would slightly improve the number of days that the White River and its tributaries would meet the single sample standard. However, current background and non-point sources prevent the streams from achieving these standards at all times, even if all CSOs were eliminated. **Table 4-19** summarizes the estimated number of days each CSO-impacted stream would exceed the single sample standard, including a comparison of existing (pre-2002) conditions with varying levels of CSO control. **Figure 4-41** graphically shows how each of the CSO control alternatives could affect bacteria exceedances in the White River. The data represents the number of days each year that bacteria levels are predicted to exceed the 235 cfu/100 mL standard when factoring all current sources of bacteria, including CSOs, upstream sources, and stormwater runoff. Under Plan 1 and Plan 2, CSO controls alone would reduce from 178 to 157 the number of days per year that White River would exceed the standard. The addition of watershed improvements would further reduce the days of exceedance to 135 days per year, on average. Sewer separation, in comparison, would reduce the days of exceedances to 137 per year.

Under all alternatives, *E. coli* bacteria concentrations in White River and its tributaries are expected to decrease during wet weather. To demonstrate this reduction, U.S. EPA suggested including targets of 2,000, 5,000, and 10,000 cfu per 100 mL as additional evaluation tools to measure reductions in peak *E. coli* levels in the streams. The city's analysis demonstrates that CSO controls would significantly reduce the number of days that instream *E. coli* levels exceed these higher targets. **Table 4-20** summarizes the estimated number of days *E. coli* levels would exceed 2,000 cfu/100 mL in CSO-impacted streams. Plan 1 and Plan 2 show similar results, reducing the number of days White River exceeds 2,000 cfu/100 mL from the current 69 per year to 16-4 days, depending on the level of control and whether other improvements are made to reduce bacteria sources in the watershed. The performance at the 95 percent capture level *with* watershed improvements is equivalent to the 97 percent capture level *without* watershed improvements – both achieving seven days that exceed 2,000 cfu/100 mL in White River. Similarly, the 93 percent capture *with* watershed improvements is expected to provide benefits equal to 95 percent *without* watershed improvements – both achieving nine days that exceed 2,000 cfu/100 mL in White River. Total sewer separation, including watershed improvements and BMPs for bacteria reduction, is predicted to achieve seven days that exceed 2,000 cfu/100 mL in White River.

Table 4-18
Estimated *E. coli* Bacteria Impacts (Geometric Mean in cfu/100mL)

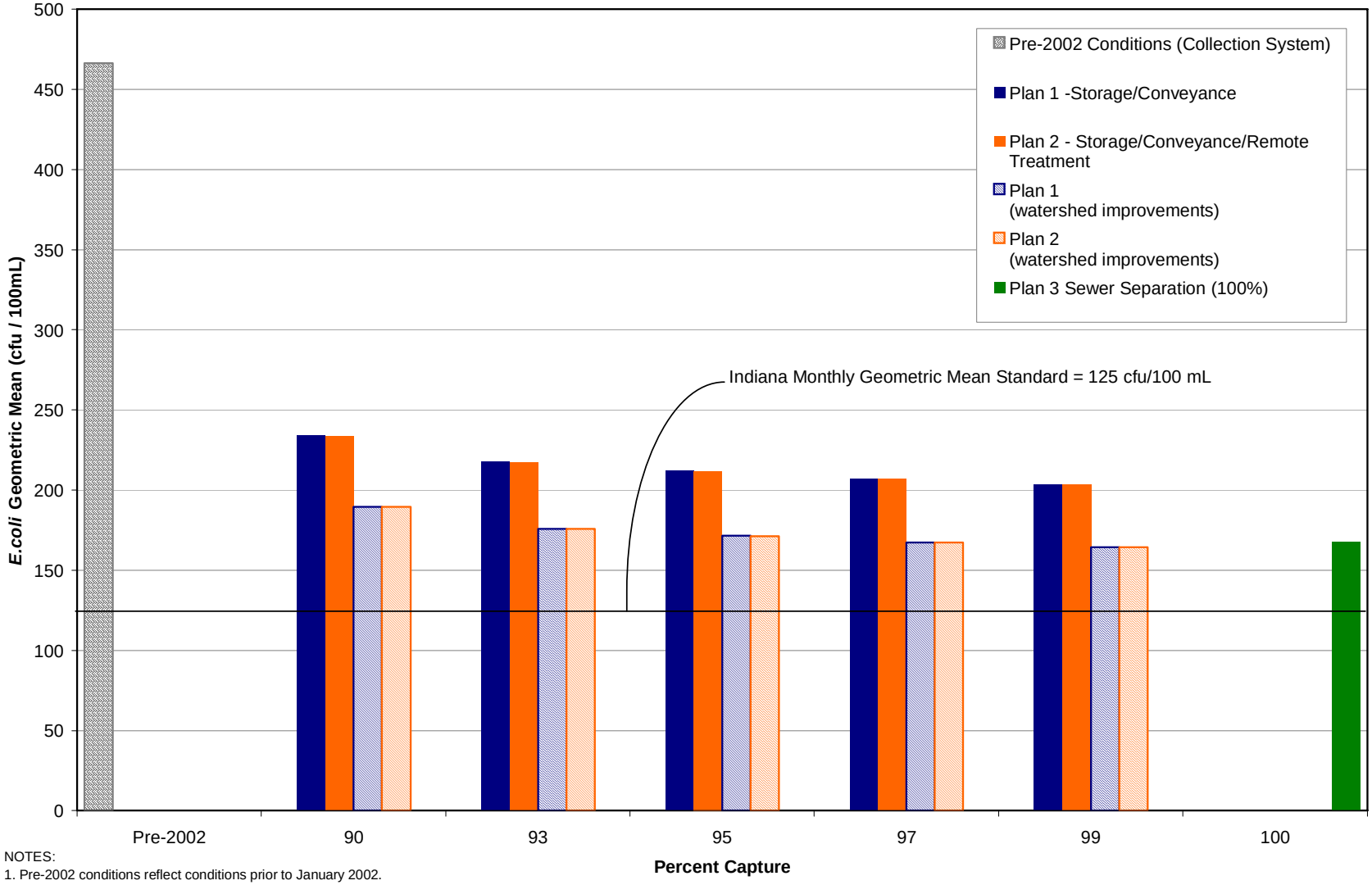
Watershed	Systemwide Percent Capture[1]						
	Existing	90%	93%	95%	97%	99%	100%
Fall Creek							
Without Watershed Improvements	361	228	211	206	201	198	210
With Watershed Improvements	361	168	156	152	148	146	157
Pogues Run							
Without Watershed Improvements	606	213	193	186	180	175	356
With Watershed Improvements	606	109	99	95	92	90	230
Pleasant Run							
Without Watershed Improvements	495	357	329	320	312	306	305
With Watershed Improvements	495	149	137	133	130	127	127
Eagle Creek							
Without Watershed Improvements	285	262	256	253	250	249	253
With Watershed Improvements	285	196	189	187	185	183	187
White River							
Without Watershed Improvements	466	234	218	212	207	203	207
With Watershed Improvements	466	190	176	172	167	164	168

Notes:
1. The actual percent capture at 93% and 97% for Plan 1 is 93.4% and 97.3% and for Plan 2 is 93.8% and 97.5%, respectively. For comparison purposes, these were rounded to the same whole number. Plan 3, Total Sewer Separation, is 100% capture.
2. Indiana's monthly geometric mean standard is 125 cfu/100 mL.

Table 4-19
Estimated *E. coli* Bacteria Impacts (Days over 235 cfu/100 mL)

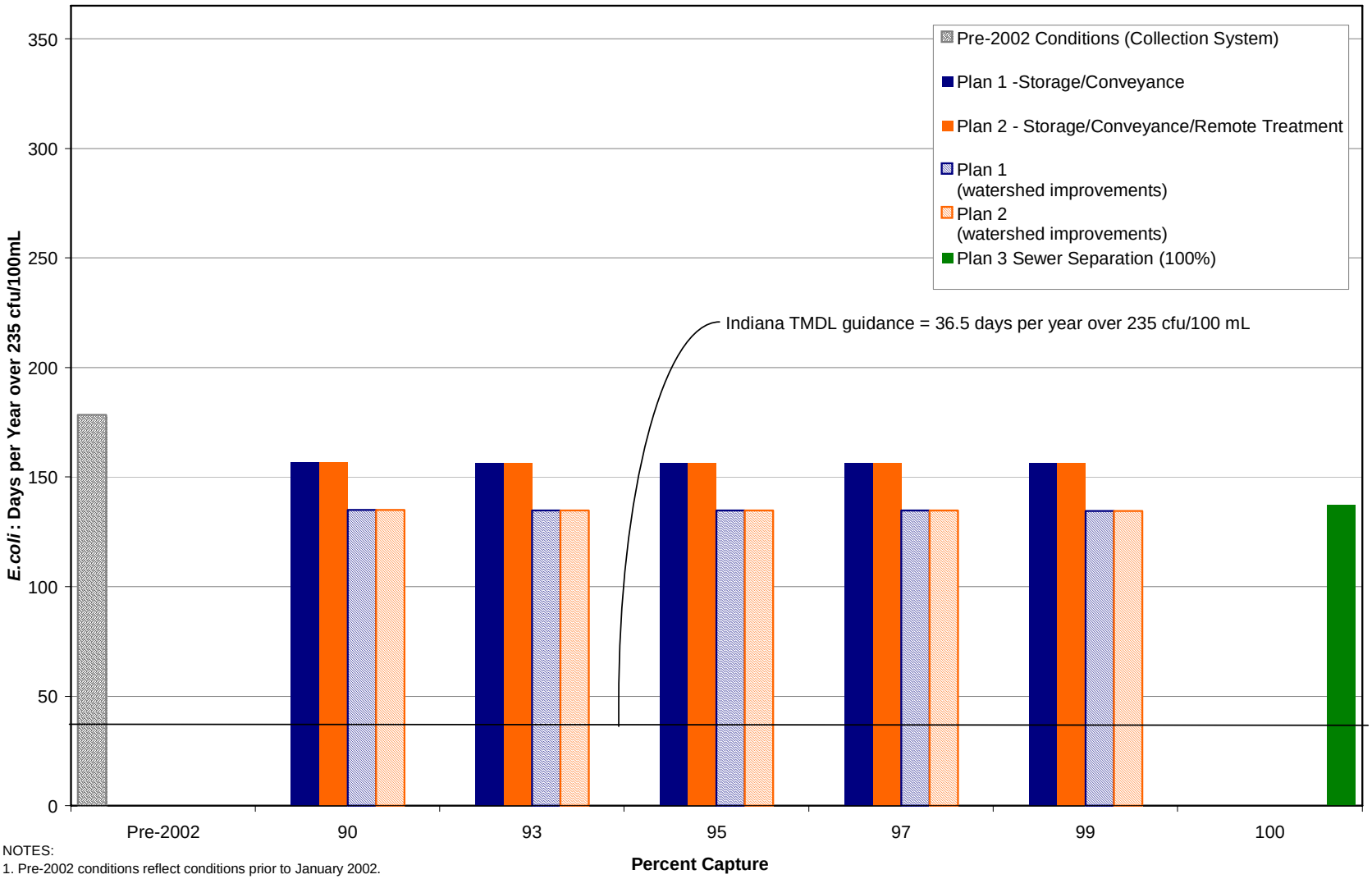
Watershed	Systemwide Percent Capture[1]						
	Existing	90%	93%	95%	97%	99%	100%
Fall Creek							
Without Watershed Improvements	188	170	170	170	170	170	178
With Watershed Improvements	188	134	134	134	134	134	142
Pogues Run							
Without Watershed Improvements	177	156	155	155	155	154	231
With Watershed Improvements	177	60	59	59	59	58	170
Pleasant Run							
Without Watershed Improvements	215	214	214	214	214	214	214
With Watershed Improvements	215	100	100	100	100	100	100
Eagle Creek							
Without Watershed Improvements	200	198	197	197	197	197	199
With Watershed Improvements	200	146	145	145	145	145	147
White River							
Without Watershed Improvements	178	157	157	157	157	156	157
With Watershed Improvements	178	135	135	135	135	134	137

Notes:
1. The actual percent capture at 93% and 97% for Plan 1 is 93.4% and 97.3% and for Plan 2 is 93.8% and 97.5%, respectively. For comparison purposes, these were rounded to the same whole number. Plan 3, Total Sewer Separation, is 100% capture.
2. Indiana's TMDL criteria equals no more than 36.5 days per year over 235cfu/100mL.



NOTES:
1. Pre-2002 conditions reflect conditions prior to January 2002.
2. The actual percent capture at 93% and 97% for Plan 1 is 93.4% and 97.3% and for Plan 2 is 93.8% and 97.5% respectively. For comparison purposes, these were rounded to the same whole number.

Figure 4-40
White River Watershed Plan Options and Level of Control Evaluated: Percent Capture and *E. coli* Levels



NOTES:
1. Pre-2002 conditions reflect conditions prior to January 2002.
2. The actual percent capture at 93% and 97% for Plan 1 is 93.4% and 97.3% and for Plan 2 is 93.8% and 97.5% respectively. For comparison purposes, these were rounded to the same whole number.

Figure 4-41
White River Watershed Plan Options and Level of Control Evaluated:
***E. coli* Bacteria Exceedances**

The city's modeling of higher peak values of 5,000 and 10,000 cfu revealed that CSO controls would result in one day exceeding the 5,000 and 10,000 cfu values for each day of overflow. For example, the 95 percent capture alternative would achieve an annual average of four overflows per year and four days exceeding 5,000 and 10,000 cfu/100 mL on White River.

The city's analysis demonstrates that a combination of control measures would be required to improve water quality and provide greater protection of public health along Indianapolis waterways. These measures would include additional storage (both within the existing combined sewer system and in new structures), additional conveyance, additional treatment capacity at the city's AWT plants, and watershed improvements. However, because the city cannot achieve the *E. coli* single sample maximum at all times, it will pursue a Use Attainability Analysis (UAA) and seek state approval of a wet-weather use subcategory for those storm events that will exceed the capacity of CSO control facilities. For more information on the UAA, see Section 9.

4.6.4 Other Evaluation Factors

4.6.4.1 Cost-Effectiveness

CSO controls represent a significant public works investment that will place a financial burden on Indianapolis residents. The CSO control program must be designed to achieve significant and tangible benefits with affordable costs. To analyze these costs and benefits, the city developed a variety of cost-benefit curves.

Cost-benefit curves are used to compare similar alternatives over a range of design conditions or capture levels. Typically, these comparisons indicate that for lower levels of control, small increments of increased cost would result in large increments of improved performance. For high levels of control, large increments of increased cost typically re-

Table 4-20
Estimated *E. coli* Bacteria Impacts (Days over 2000 cfu/100 mL)

Watershed	Systemwide Percent Capture[1]						
	Existing	90%	93%	95%	97%	99%	100%
Fall Creek							
Without Watershed Improvements	63	12	7	5	3	2	0
With Watershed Improvements	63	12	6	4	2	1	0
Pogues Run							
Without Watershed Improvements	77	13	7	5	4	2	5
With Watershed Improvements	77	12	6	4	2	1	0
Pleasant Run							
Without Watershed Improvements	50	21	17	15	14	13	5
With Watershed Improvements	50	12	6	4	2	1	0
Eagle Creek							
Without Watershed Improvements	35	25	22	21	20	19	21
With Watershed Improvements	35	16	11	10	8	7	10
White River							
Without Watershed Improvements	69	16	11	9	7	7	9
With Watershed Improvements	69	14	9	7	5	4	7

Notes:
1. Estimated bacteria impacts for Plan 1 and Plan 2 were identical for at all levels of control. The actual percent capture at 93% and 97% for Plan 1 is 93.4% and 97.3% and for Plan 2 is 93.8% and 97.5%, respectively. For comparison purposes, these were rounded to the same whole number. Plan 3, Total Sewer Separation, is 100% capture.
2. Indiana's TMDL criteria equals no more than 36.5 days per year over 235cfu/100mL.

sult in increasingly smaller increments of improved performance. The optimal point, or "knee-of-the-curve," is a point where the incremental change in the cost of the control alternatives per change in performance of the control alternative changes most rapidly, indicating that the slope of the curve is changing from shallow to steep or vice versa.

Present worth costs for each alternative are presented in **Figure 4-42** against CSO percent capture level. Costs are presented for CSO controls alone and in conjunction with additional watershed improvements. The least cost alternative is CSO Control Plan 1 (storage and conveyance) at 90 percent capture while CSO Control Plan 3 (sewer separation) is the highest cost. Across the different CSO control levels, CSO Control Plan 1 is always the lowest cost alternative. Plan 3 is extremely expensive at more than $6 billion. For CSO Control Plan 1 and CSO Control Plan 2, the city has determined that the systemwide knee-of-the-curve is at 95 percent capture, with the knee of the curve for Fall Creek at 97 percent capture.

Figure 4-43 shows another cost-benefit curve based on the expected reduction in days exceeding the *E. coli* bacteria standard of 235 cfu per 100 mL. Days of exceedance are presented for CSO controls alone and controls in conjunction with additional watershed improvements. As described earlier, under current conditions, Indianapolis would not meet in-stream water quality standards for bacteria during wet weather even with elimination of all CSOs. Increasing the system percent capture level from 90 to 99 percent only achieves one additional day of compliance with the standard. The figure illustrates that greater water quality benefits can be achieved through a combined program of controlling CSOs and implementing other projects to address additional bacteria sources in the watersheds.

A similar illustration is included in **Figure 4-44**, where days over 10,000 cfu per 100 mL are presented. The figure illustrates the rapidly increasing incremental costs associated with achieving fewer days beyond 95 percent capture. For example, in order to improve performance from four days per year to one every two years, the city would have to spend an additional $1.297 billion. When evaluating cost and bacteria performance, the city has determined that the systemwide knee of the curve is at 95 percent capture, with the knee of the curve for Fall Creek at 97 percent capture.

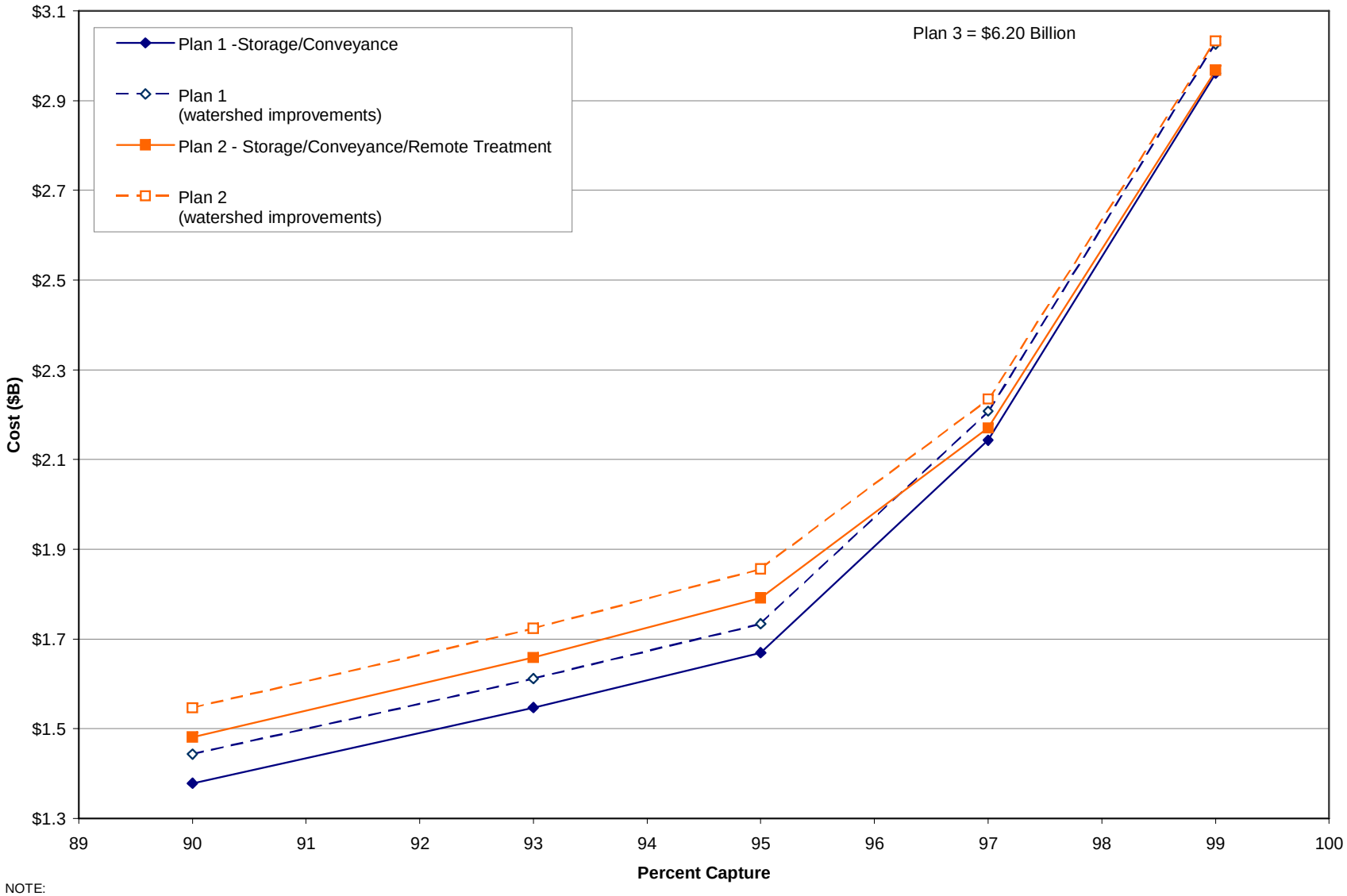
In line with the watershed technology screening, the city also evaluated the following cost-benefit curves: cost per gallon of CSO captured, cost per pound of BOD removed, and cost per unit of *E. coli* bacteria removed per year. The results are presented in **Figure 4-45**, **Figure 4-46**, and **Figure 4-47**, respectively. For Plan 1 and Plan 2, the city has determined that the systemwide knee of the curve is at 95 percent capture, with the knee of the curve for Fall Creek at 97 percent capture.

4.6.4.2 Higher CSO Control in Tributaries

Some members of the city's advisory committees have advocated placing a higher priority on controlling CSOs in the tributaries because they are neighborhood streams where they presume that people, especially children, are more likely to come into contact with the water. Ultimately, water quality conditions in the White River would be improved both by controlling CSOs along the tributaries and by controlling CSOs that directly discharge to the White River.

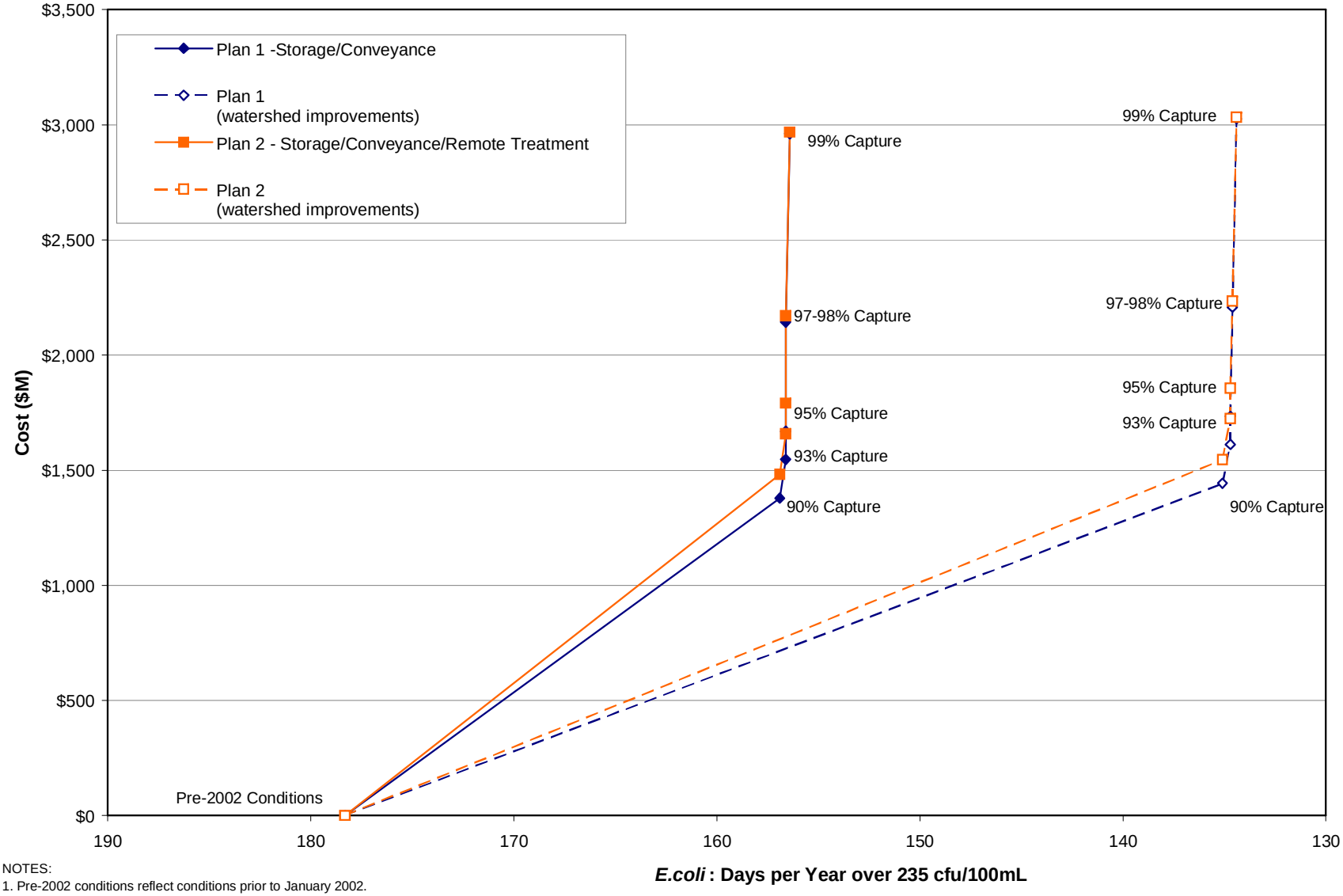
For this reason, the city considered alternatives that would achieve a higher percent capture on the tributaries and a lower corresponding percent capture in the White River. For example, one alternative might include 95 percent capture within the tributaries (roughly 4 untreated overflows per year) and 93 percent capture in the White River (roughly 6 overflows). To accommodate this, the project team was able to determine costs for such plans without performing additional modeling or detailed cost estimating by interpolating from the costs developed for the established systemwide plans.

U.S. EPA and IDEM specifically requested cost estimates for 93 percent system capture in White River and 95, 97, and 99 percent system capture in the tributaries for CSO Control Plan 1. They were also interested in the cost for 93 percent system capture in White River and 99 percent capture on the tributaries for CSO Control Plan 2. The present worth costs for the mixed plans requested by the U.S. EPA and IDEM are included in **Figure 4-48**. The resulting cost falls between the 93 and 95 percent capture levels; in all cases, the costs fall closer to the higher capture level cost. For example, the cost for 93 percent capture in White River and 99 percent capture on the tributaries for Plan 1 falls closer to the cost to provide 99 percent capture systemwide. Therefore, lowering controls on White River was not determined to be a method to significantly reduce program costs, or to transfer CSO control investments to the tributaries in order to gain greater protection in the smaller streams. Providing lesser protection on White River also would lessen protection of downstream users, raise environmental equity concerns and lessen protection for increasing recreational use within Marion County.



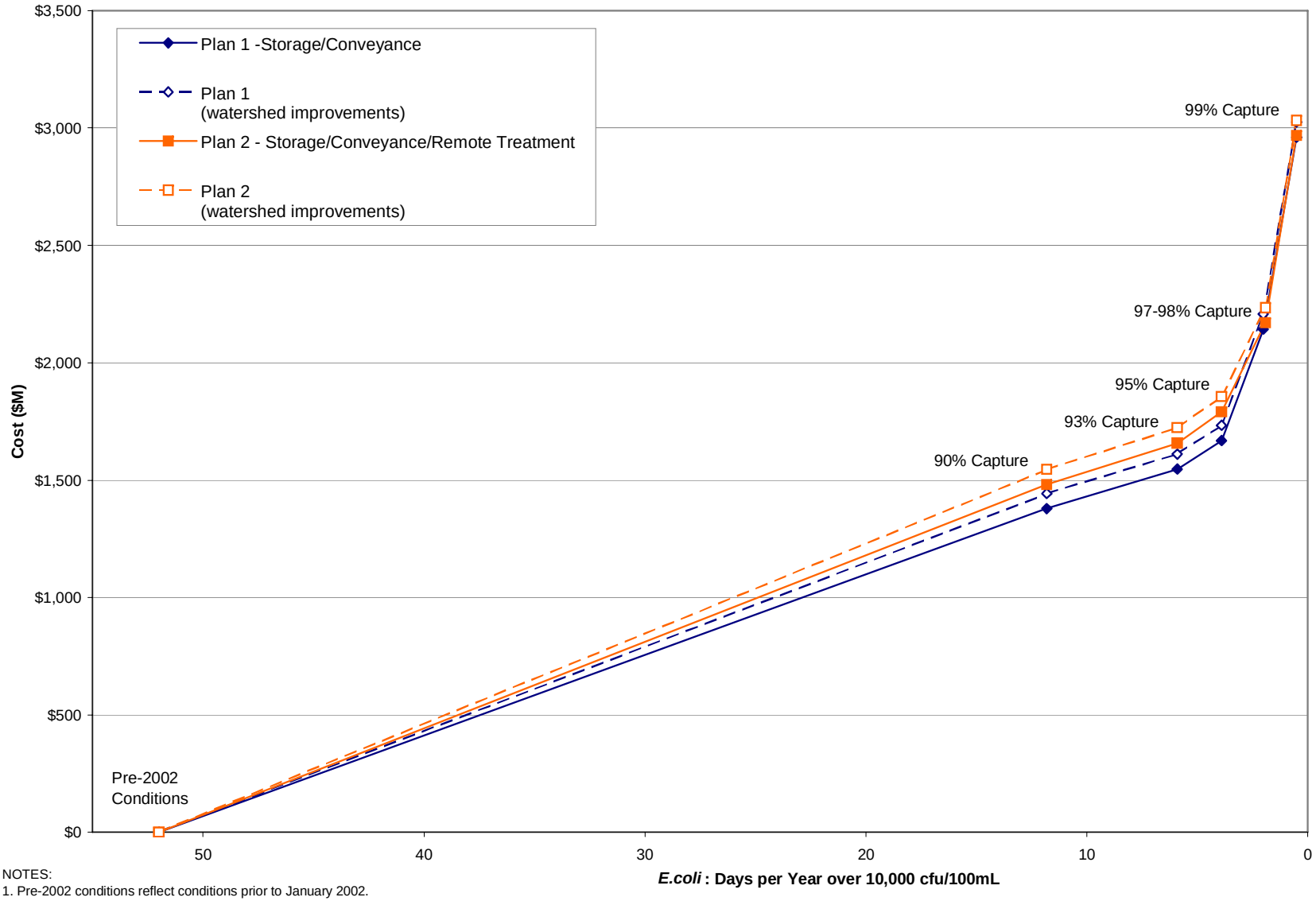
NOTE:
1. The actual percent capture at 93% and 97% for Plan 1 is 93.4% and 97.3% and for Plan 2 is 93.8% and 97.5% respectively. For comparison purposes, these were rounded to the same whole number.

Figure 4-42
Present Worth Costs for Each Alternative by Percent Capture



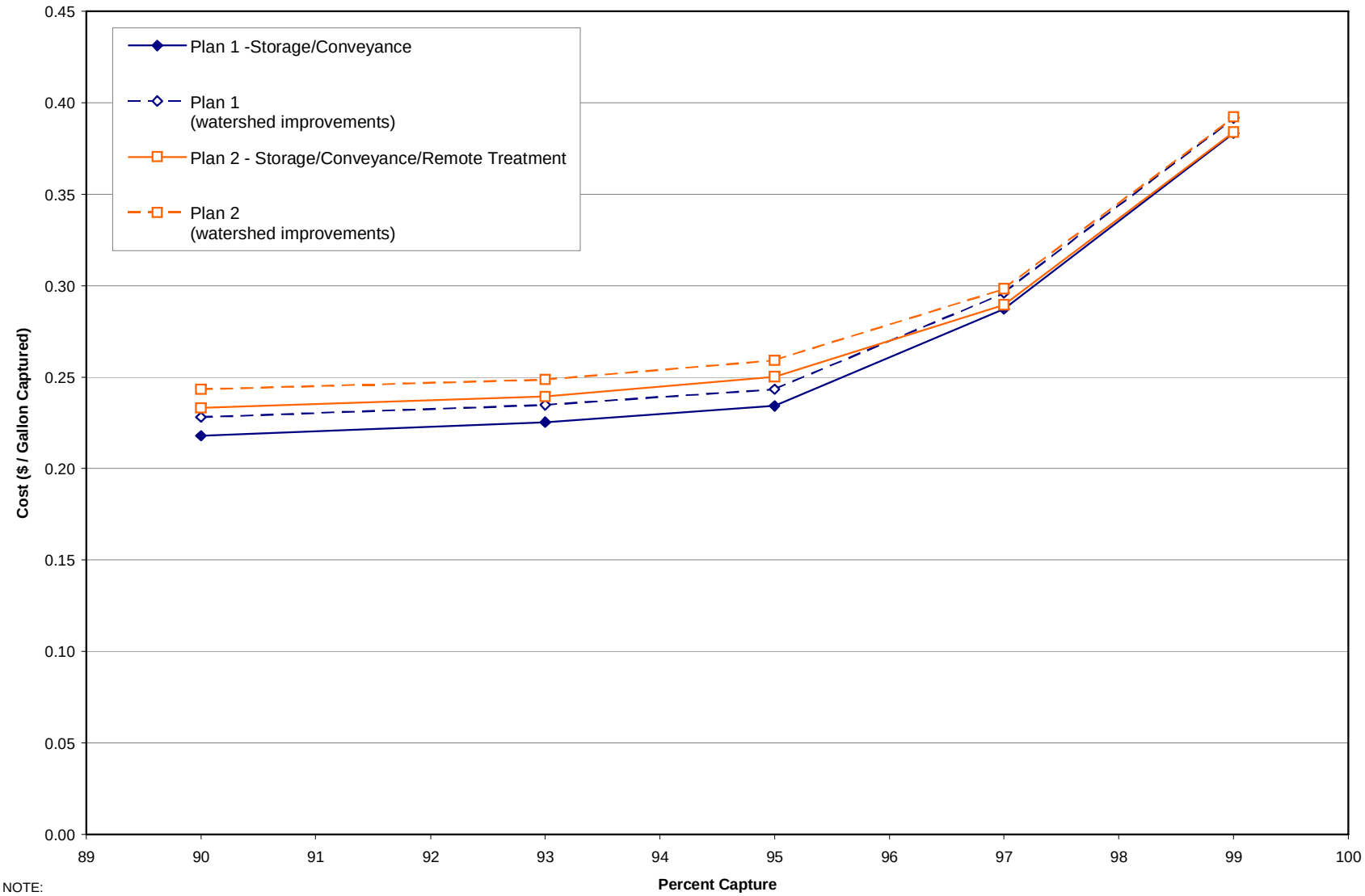
NOTES:
1. Pre-2002 conditions reflect conditions prior to January 2002.
2. The actual percent capture at 93% and 97% for Plan 1 is 93.4% and 97.3% and for Plan 2 is 93.8% and 97.5% respectively. For comparison purposes, these were rounded to the same whole number.

Figure 4-43
Present Worth Costs for Each Alternative by *E. coli* Days per Year Over 235 cfu/ 100mL



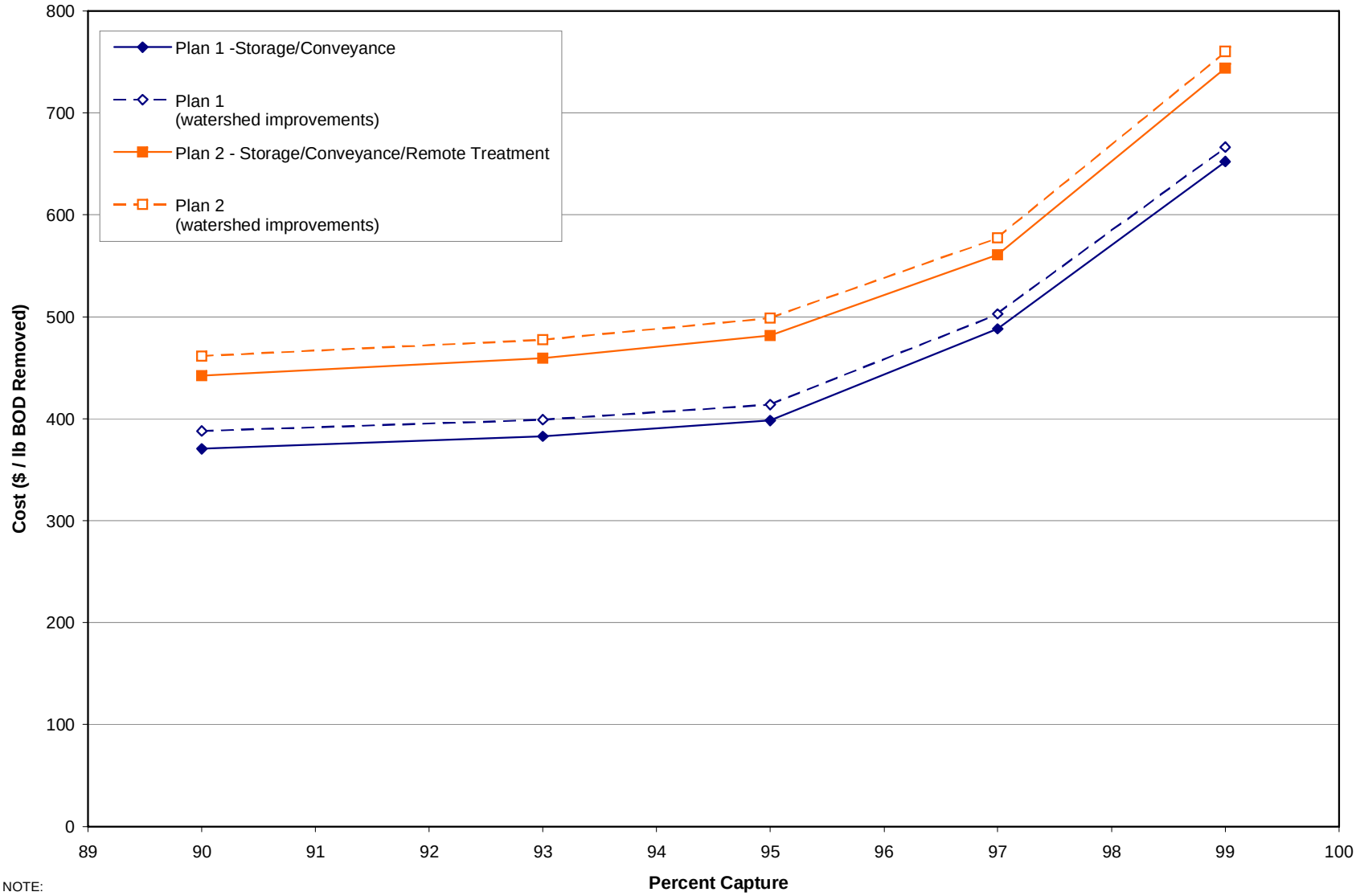
NOTES:
1. Pre-2002 conditions reflect conditions prior to January 2002.
2. The actual percent capture at 93% and 97% for Plan 1 is 93.4% and 97.3% and for Plan 2 is 93.8% and 97.5% respectively. For comparison purposes, these were rounded to the same whole number.

Figure 4-44
Present Worth Costs for Each Alternative by *E. coli* Days per Year Over 10,000 cfu/100mL



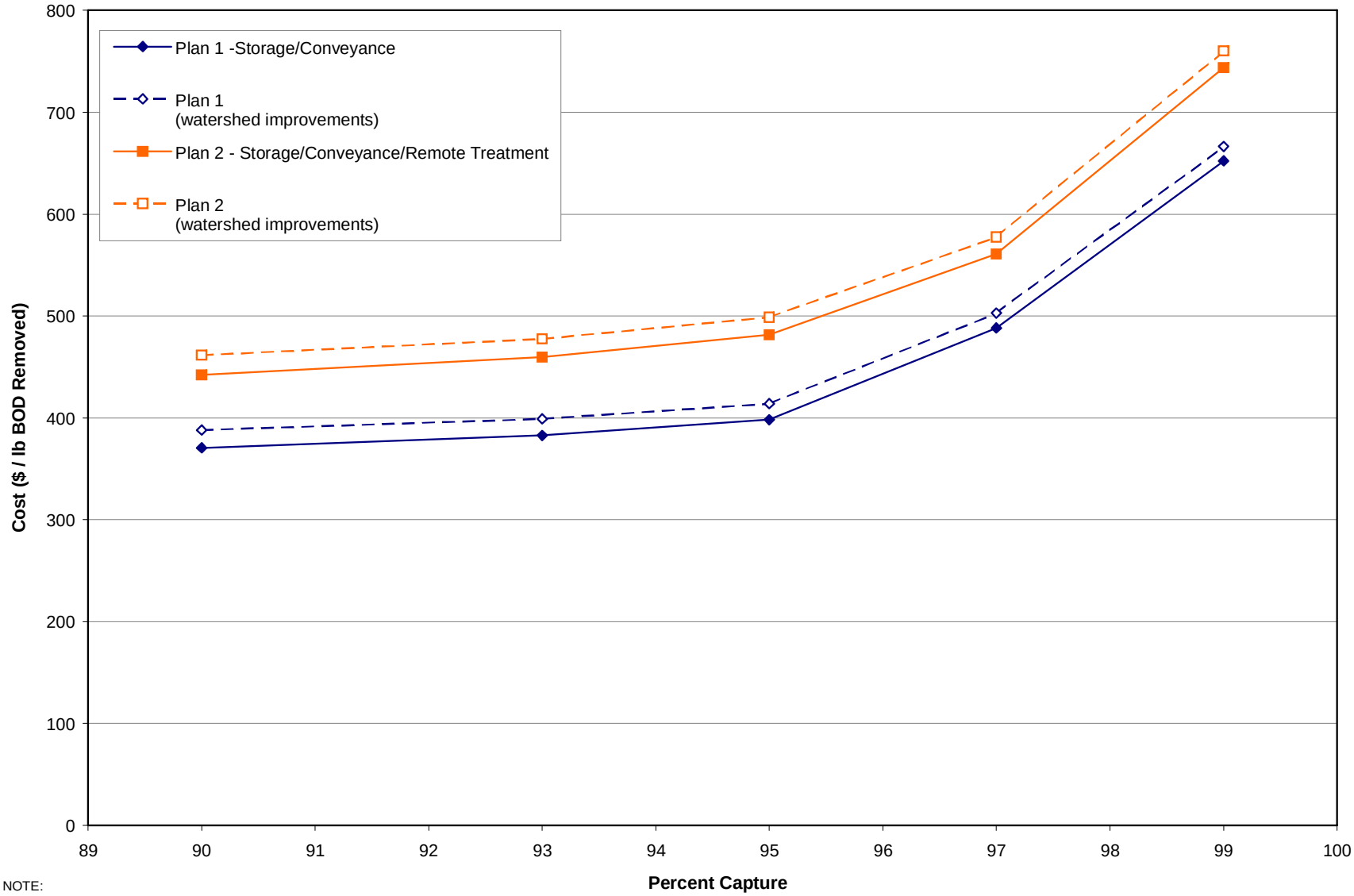
NOTE:
1. The actual percent capture at 93% and 97% for Plan 1 is 93.4% and 97.3% and for Plan 2 is 93.8% and 97.5% respectively. For comparison purposes, these were rounded to the same whole number.

Figure 4-45
Present Worth Costs ($ / Gal. Captured) for Each Alternative by Percent Capture



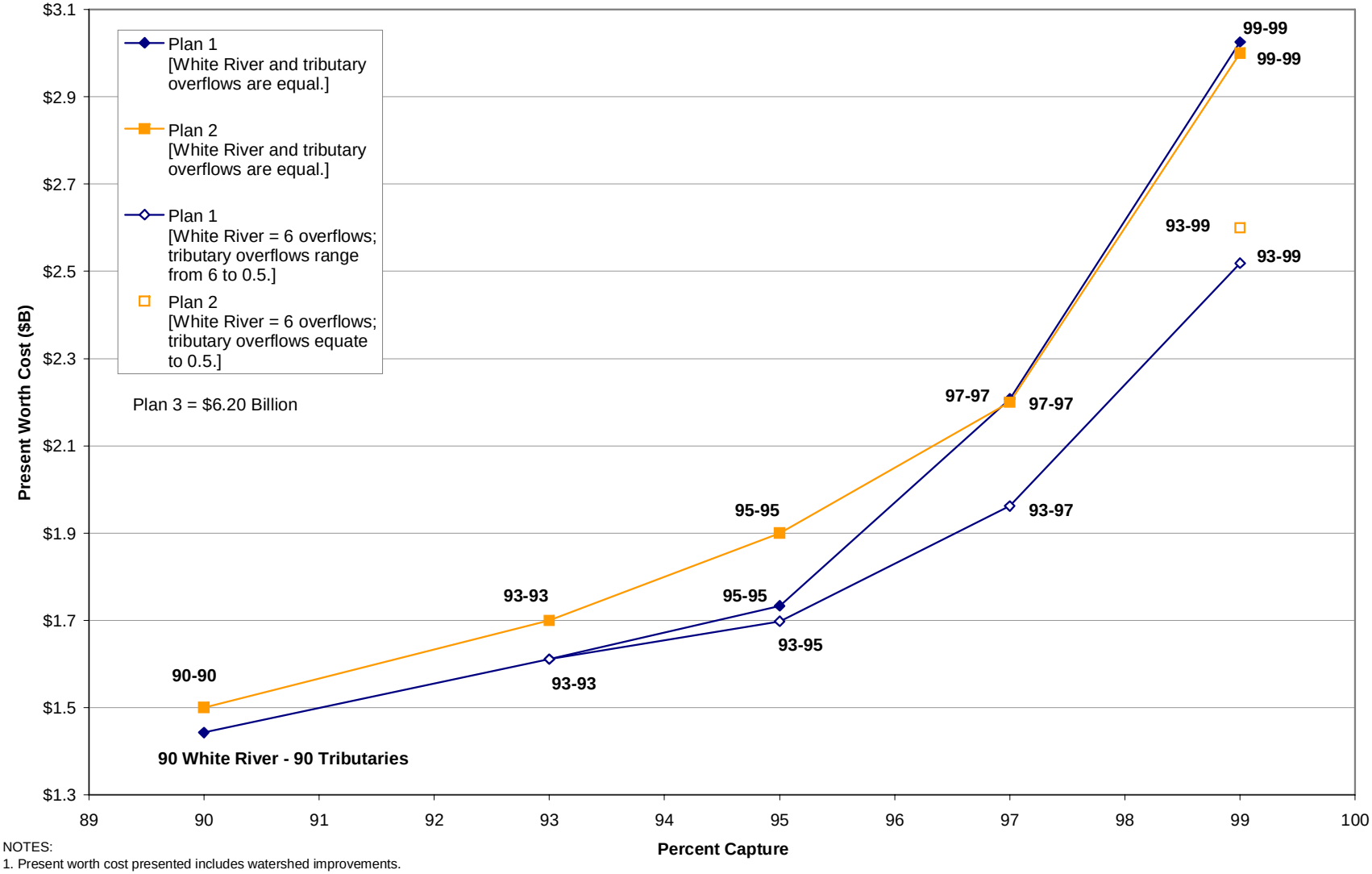
NOTE:
1. The actual percent capture at 93% and 97% for Plan 1 is 93.4% and 97.3% and for Plan 2 is 93.8% and 97.5% respectively. For comparison purposes, these were rounded to the same whole number.

Figure 4-46
Present Worth Costs ($ / lb BOD Removed) for Each Alternative by Percent Capture



NOTE:
1. The actual percent capture at 93% and 97% for Plan 1 is 93.4% and 97.3% and for Plan 2 is 93.8% and 97.5% respectively. For comparison purposes, these were rounded to the same whole number.

Figure 4-47
Present Worth Costs ($M / unit *E. coli* Bacteria Removed) for Each Alternative by Percent Capture



NOTES:
1. Present worth cost presented includes watershed improvements.
2. Plan 2 cost for 6 overflows on White River and 0.5 overflows on tributaries shown only as requested by EPA at April 26, 2004 meeting.
3. The actual percent capture at 93% and 97% for Plan 1 is 93.4% and 97.3% and for Plan 2 is 93.8% and 97.5% respectively. For comparison purposes, these were rounded to the same whole number.

Figure 4-48
Present Worth Costs for Mixed Plans by Percent Capture

4.6.4.3 Neighborhood Issues

The systemwide CSO control alternatives evaluation included community input regarding neighborhood issues. Those neighborhood issues included the following:

Siting Concerns: How close are facilities to homes, parks, schools, roads, and so on? How difficult would it be to site this alternative at projected locations? What effect would this alternative have on the existing area?

Safety and Security: Are there public safety issues associated with the proposed alternative, such as use of chemicals for treatment, creation of habitat for vector/nuisance populations (such as mosquitoes and flies)? Are there security issues, such as a potential for vandalism, terrorism, sabotage, and so on?

Disruption to Neighborhood (Construction): Disruption may include physical disturbance, rerouting, temporary blocking of facilities, and so on. How much disruption will be caused to the use of streets, sidewalks, parks, and yards during construction? How long will the disruption last?

Aesthetics: How will the alternative have a visual impact on the existing landscape? Can the alternative be seen from a home or public gathering place, such as a park? Can the design of any new facilities consider/incorporate surrounding architecture, landscaping, neighborhood themes, and so on? How will environmental justice concerns be addressed?

Noise: How much and when will noise occur during construction? How much noise will be present in the long-term from operating procedures such as pumps, blowers, etc.?

Odor: Are odors expected to be reduced in surrounding areas during long-term operation? Are odors in the area going to be increased during long-term operation?

Truck Traffic (Operation): How frequently will trucks travel through a neighborhood for regular operation and maintenance activities?

Advisory committee members and city staff evaluated the criteria through a pair-wise comparison to develop weighting factors for each individual criterion. The summed criteria weighting factors were converted to a percent. Results of the criteria weighting are presented in **Table 4-21**. Safety and security received the highest weight while neighborhood disruption and truck traffic ranked lowest.

Table 4-21
Neighborhood Issues Criterion Ranking

	Neighborhood Issues									
Criteria	Siting Concerns	Safety and Security	Neighborhood Disruption (Construction)	Aesthetics	Noise	Odor	Truck Traffic (Operation)	Sum	Criteria Weight	Rank
Siting Concerns		1	3	2	1	1	3	11	13.1%	4
Safety and Security	3		3	3	1	1	3	14	16.7%	3
Neighborhood Disruption (Construction)	1	1		1	1	1	2	7	8.3%	7
Aesthetics	2	1	3		1	1	2	10	11.9%	5
Noise	3	3	3	3		2	3	17	20.2%	1
Odor	3	3	3	3	2		3	17	20.2%	1
Truck Traffic (Operation)	1	1	2	2	1	1		8	9.5%	6
							TOTAL	84	100%	

Key:
1 = lower than
2 = same as
3 = higher than

Once the weights were established, the systemwide CSO control alternatives were evaluated for each individual criterion. The alternatives were evaluated without regard to different levels of CSO control. For example, when considering siting concerns, committee members and city staff determined that CSO Control Plan 3 (sewer separation) ranked highest when compared to CSO Control Plan 1 (storage and conveyance) and CSO Control Plan 2 (storage, conveyance, and remote treatment). Results of this ranking are presented in **Table 4-22**.

Through this weighting and ranking, committee members and city staff determined that CSO Control Plan 1 (storage and conveyance) received the highest overall ranking based upon neighborhood issues. In comparison, the remote treatment facilities in CSO Control Plan 2 create concerns over siting, noise, odor, truck traffic during operation and aesthetics. Sewer separation raised concerns over neighborhood disruption, and to some extent siting, aesthetics and truck traffic.

4.6.4.4 Seasonality of Overflows

Advisory committee members also asked the city to analyze when predicted overflows are likely to occur. For example, are most overflows likely to occur in the winter months when people are not likely to be exposed, or in the summer months? The city used hydraulic model runs to estimate how the sewer system would perform throughout the year if CSO control facilities were built, based on varying levels of capture. The analysis is based upon 54 years of rainfall data.

The results of this analysis are summarized in **Table 4-23**. The chart shows that under pre-2002 conditions, the system overflows 60 times per year, on average. This value ranges from a low of 45 overflows/year to a high of 79 overflows/year, depending on wet weather events. During the recreational season of April 1 through October 31, overflows occur 37 times/year, on average. This value ranges from a low of 24 overflows/year to a high of 50/year during the recreational season.

Values are also shown in the table to predict how the system would respond to storms at 93 percent, 95 percent or 97 percent capture. At 93 percent capture, facilities are expected to overflow an estimated six times per year, but would range from a low of one event to 12 events per year during the 54-year period that was studied. At 95 percent, the annual average is four events per year, but the range is from zero events to 10, depending on weather conditions each year. At 97 percent, the annual average is two, but the annual range is from zero to six. Because larger storm events tend to occur in the summer months, approximately 70-75 percent of the annual average overflows would occur during the recreational season, as the city's analysis showed.

The city also developed graphs showing estimated overflow events distributed by month. An "overflow event" is defined as a storm or precipitation event that causes one or more untreated overflows from from the combined sewer system. Overflows may occur from more than one outfall pipe and into more than one stream in a single "overflow event." The graphs demonstrate how the system would perform each month, based upon the 1950-2003 rainfall record in Indianapolis. **Figures 4-49** through **4-51** compare current conditions to a specific level of control: 93, 95 or 97 percent capture.

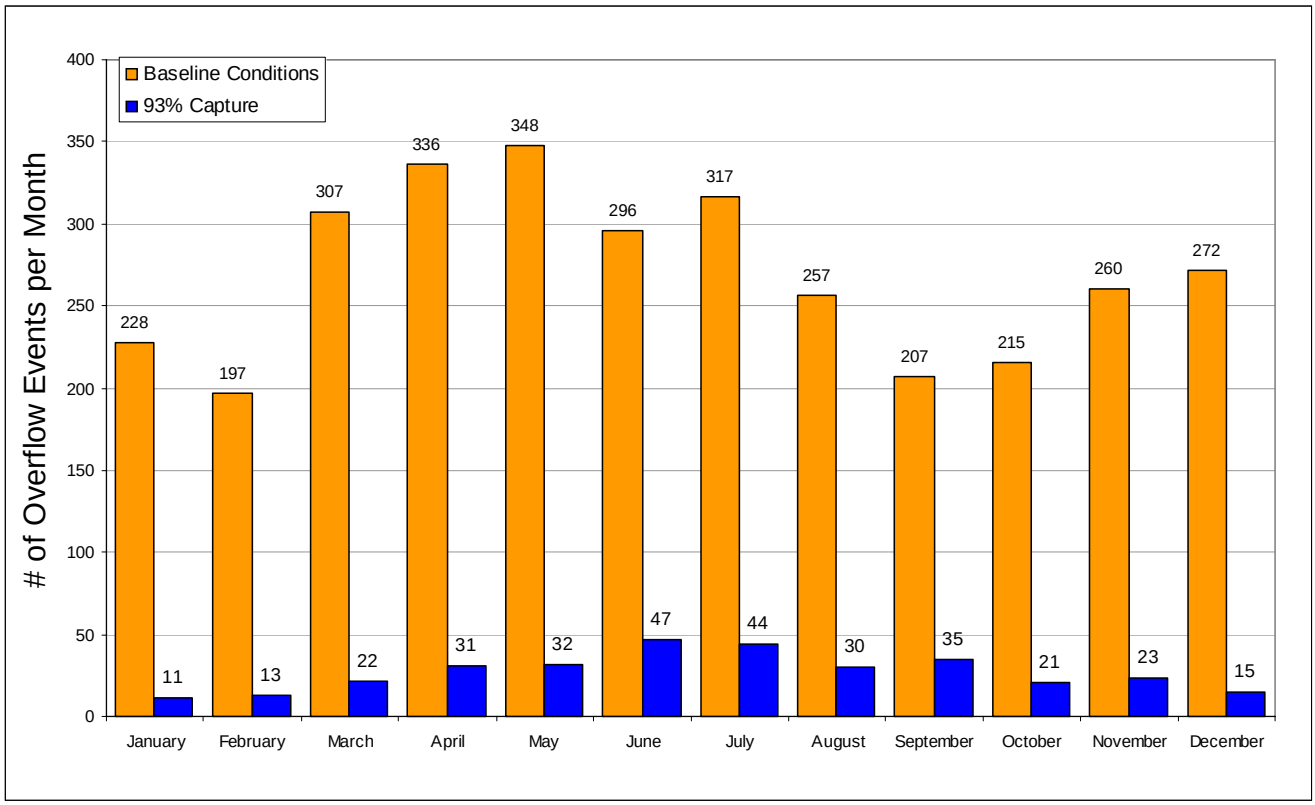
At 93 percent capture, an estimated 324 overflow events would occur over the 54-year time period, with the greatest number of events occurring in the April-September timeframe. The distribution of events changes from the current conditions because larger storms tend to occur in summer months. Similarly, at 95 percent and 97 percent capture the number of events in each month falls. However, the winter months are the biggest beneficiaries of going from 95 to 97 percent capture.

Table 4-22
Neighborhood Issues Plan Ranking

Criteria Weight		Criteria Description	Rank Plan 1	Rank Plan 2	Rank Plan 3
13.1%		**Siting Concerns**	1	2	2
-	1	How close are facilities to homes, parks, schools, roads, etc.?	1	3	1
-	2	How difficult would it be to site this alternative at projected locations?	1	2	3
-	3	What effect would this alternative have on the existing area?	1	2	3
Score Subtotal			3	7	7
16.7%		**Safety and Security**	1	3	1
-	1	Are there public safety issues associated with the proposed alternative, such as use of chemicals for treatment, creation of habitat for vector/nuisance populations (i.e. mosquitoes and flies)?	1	3	1
-	2	Are there security issues, such as potential for vandalism, terrorism, sabotage, etc.?	1	3	1
Score Subtotal			2	6	2
8.3%		**Neighborhood Disruption (Construction)**	1	2	3
-	1	How much disruption will be caused to the use of streets, sidewalks, parks, yards, etc., during construction?	1	1	3
-	2	How long will the disruption last?	1	2	3
Score Subtotal			2	3	6
11.9%		**Aesthetics**	1	3	2
-	1	How will the alternative have a visual impact on the existing landscape?	1	3	3
-	2	Can the alternative be seen from a home or public gathering place, such as a park?	2	3	1
-	3	Can the design of any new facilities consider/incorporate surrounding architecture, landscaping, neighborhood themes, etc.?	1	3	1
-	4	How will environmental justice concerns be addressed?	1	3	1
Score Subtotal			5	12	6
20.2%		**Noise**	1	3	1
-	1	How much and when will noise occur during construction?			
-	2	How much noise will be present in the long-term from operating procedures such as pumps, blowers, etc.?	2	3	2
Score Subtotal			2	3	2
20.2%		**Odor**	2	3	1
-	1	Are odors expected to be reduced in surrounding areas during long-term operation?			
-	2	Are odors in the area going to be increased during long-term operation?	2	3	1
Score Subtotal			2	3	1
9.5%		**Truck Traffic (Operation)**	1	3	2
-	1	How frequently will trucks travel through a neighborhood for regular operation and maintenance activities?	1	3	2
Score Subtotal			1	3	2
Total Score			1.2	2.8	1.5
RANK			1	3	2

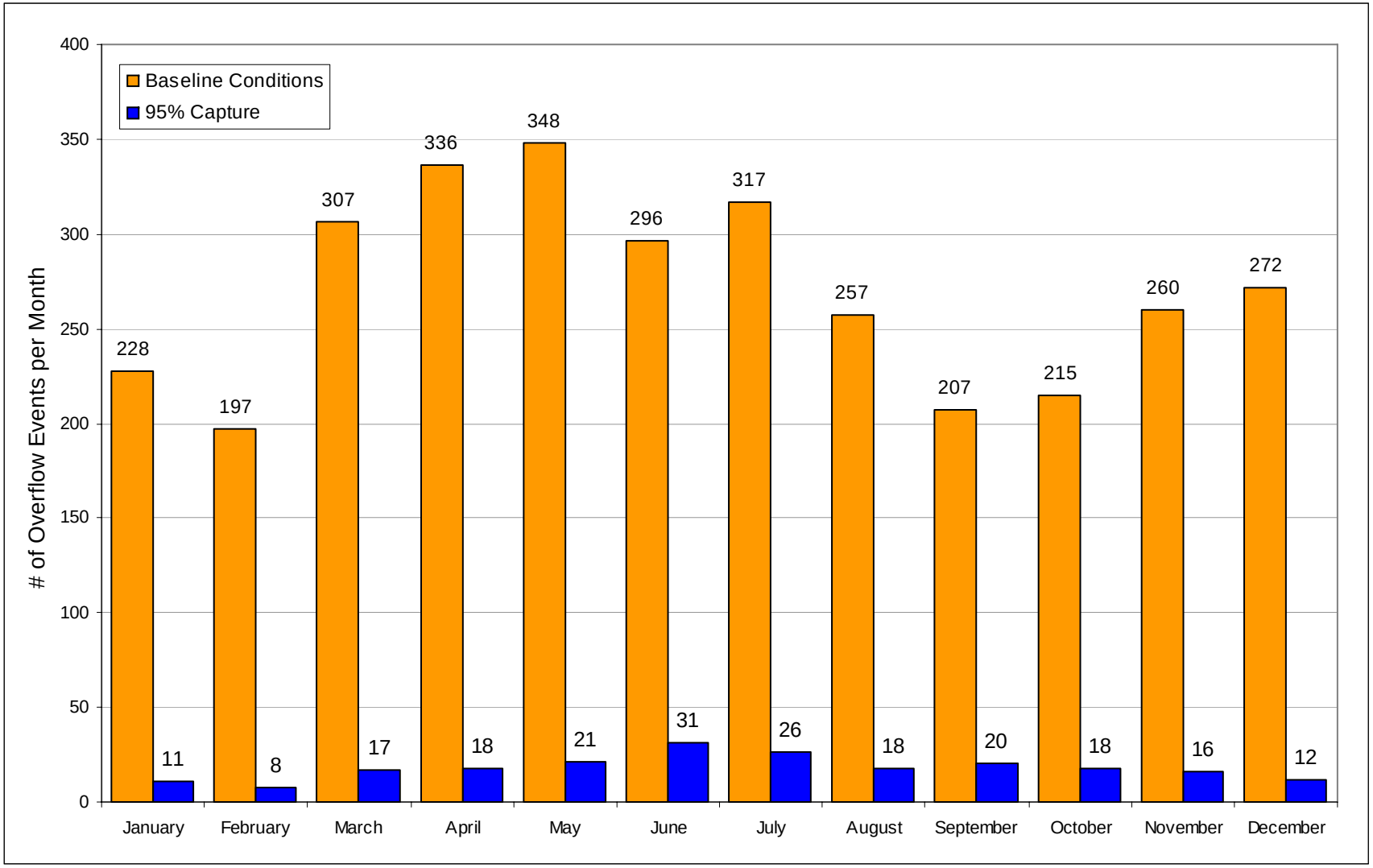
Table 4-23
Distribution of Modeled Overflow Events: Annual vs. Recreational Season

Percent Capture	Avg. No. of Overflow Events/Year	Annual Overflow Events: (Range)	Avg. No. OF Events During Rec. Season/Year	Rec. Season Overflow Events: (Range)
63% (Baseline)	60	45-79	37	24-50
93%	6	1-12	4.4	0-10
95%	4	0-10	2.8	0-6
97%	2	0-6	1.5	0-5



Source: 1950-2003 NetSTORM simulation. Baseline conditions and systemwide Plan 1, 93% capture level of control.
Note: (1) For baseline conditions, there are 3,240 events presented over 54 years of record for an annual average frequency of 60 events per year.
(2) For the 93% capture level of control, there are 324 events presented over 54 years of record.
(3) It is estimated that at least one CSO outfall structure would discharge for the plotted number of events each month.

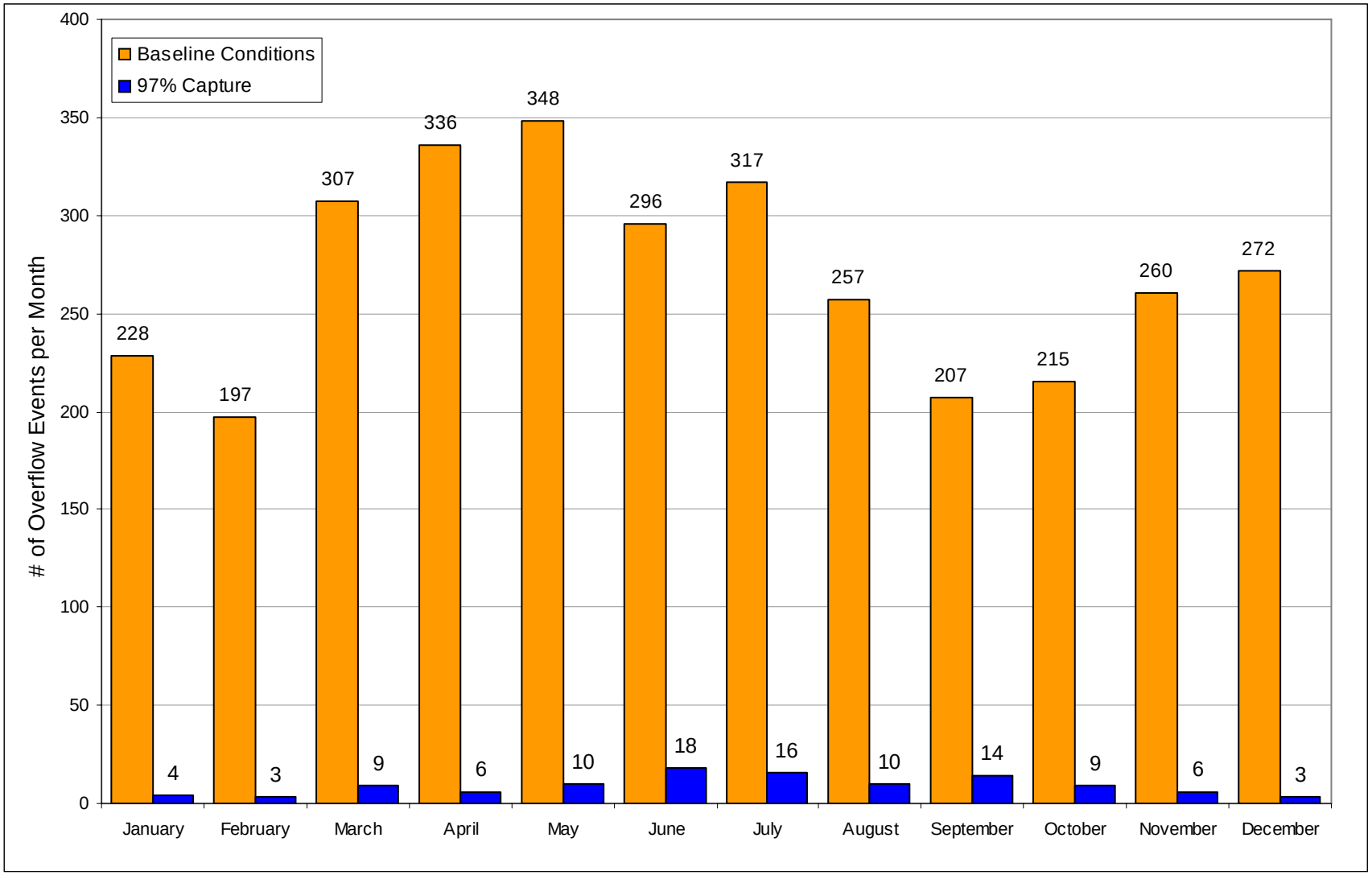
Figure 4-49
Current Conditions Compared to 93% Capture Level of Control



Source: 1950-2003 NetSTORM simulation. Baseline conditions and systemwide Plan 1, 95% capture level of control.

Note: (1) For baseline conditions, there are 3,240 events presented over 54 years of record for an annual average frequency of 60 events per year.
(2) For the 95% capture level of control, there are 216 events presented over 54 years of record.
(3) It is estimated that at least one CSO outfall structure would discharge for the plotted number of events each month.

Figure 4-50
Current Conditions Compared to 95% Capture Level of Control



Source: 1950-2003 NetSTORM simulation. Baseline conditions and systemwide Plan 1, 97% capture level of control.

Note: (1) For baseline conditions, there are 3,240 events presented over 54 years of record for an annual average frequency of 60 events per year.
(2) For the 97% capture level of control, there are 108 events presented over 54 years of record.
(3) It is estimated that at least one CSO outfall structure would discharge for the plotted number of events each month.

Figure 4-51
Current Conditions Compared to 97% Capture Level of Control

4.7 Summary

In summary, the long-term control planning process has been iterative and ultimately resulted in five overall components:

- Constructing a deep tunnel to capture CSO flows from the White River and its tributaries.
- Making site-specific improvements to the collection system within the individual watersheds, to eliminate, consolidate or direct CSO flows to the deep tunnel.
- Improvements at the Belmont AWT plant to eliminate primary effluent bypasses and reduce headworks overflows.
- Unlocking capacity at the Southport AWT plant to treat captured CSO flows from the central tunnel.
- Constructing an interplant connection between the Belmont and Southport AWT plants with its main purpose to convey captured CSO flows from the deep tunnel to the Southport AWT plant.

These components were developed into three systemwide plan concepts:

CSO Control Plan 1: Storage/conveyance in all watersheds and AWT plant improvements, evaluated for five levels of control: 90, 93, 95, 97 and 99 percent capture.

CSO Control Plan 2: Remote treatment/storage in Fall Creek and Pogues Run watersheds and storage/conveyance in other watersheds, with AWT plant improvements, evaluated under five levels of control: 90, 93, 95, 97 and 99 percent capture.

CSO Control Plan 3: Sewer separation in all watersheds.

The city's analysis of the costs, water quality impacts and other evaluation factors yielded the following general conclusions:

- Plan 1 is the lowest-cost alternative among the three plan concepts evaluated. Plan 3 is the most expensive. Plan 1 ranks first relative to neighborhood issues identified by city staff and citizen advisory committees.
- At each level of control evaluated, Plan 1 and Plan 2 achieve similar results for CSO volume reduction, dissolved oxygen impacts, and *E. coli* bacteria impacts. Plan 1 performs better than Plan 2 at BOD reduction, due to the higher level of treatment provided at the city's AWT plants.
- Plan 3 (sewer separation) is the only option that would eliminate CSO overflows; however, its $6.2 billion cost would need to be evaluated against the city's financial capability. Sewer separation also raises concerns regarding disruption to the community and increased loads of untreated stormwater to the streams.
- No CSO control alternative would achieve the state's recreational water quality standards for *E. coli* bacteria at all times. However, CSO controls will reduce the number of days that *E. coli* values exceed higher targets of 2,000, 5,000 or 10,000 cfu/100 mL.
- Other pollutant sources within and outside Marion County also have a significant impact on the water quality of CSO receiving streams. For these reasons, the city evaluated other control alternatives that might enhance or supplement the benefits of structural CSO controls. These additional controls include measures to eliminate failing septic systems, install stormwater controls, remove illicit connections, restore streambanks, remove polluted sediments, increase flow and improve dissolved oxygen levels in the streams.
- Because the city cannot achieve the *E. coli* single sample maximum at all times, it will prepare a Use Attainability Analysis (UAA) and seek state approval of a wet-weather use subcategory for those storm events that will exceed the capacity of CSO control facilities.
- The city has determined that cost-benefit analyses based on units of *E. coli* removed, pounds of BOD removed and CSO gallons captured place the systemwide knee of the curve at 95 percent capture, with the knee of the curve for Fall Creek at 97 percent capture.
- The city also evaluated the potential costs and benefits of achieving higher levels of control in the tributaries vs. White River and analyzed the seasonal and monthly distribution of predicted overflow events under varying levels of control.

The results of this analysis were presented to Marion County residents during a public outreach process in October 2004, as described in Section 5. The costs also were used in developing the city's financial capability analysis, as described in Section 6. Both public input and financial capability were used to help select the recommended plan described in Section 7.