

Section 2

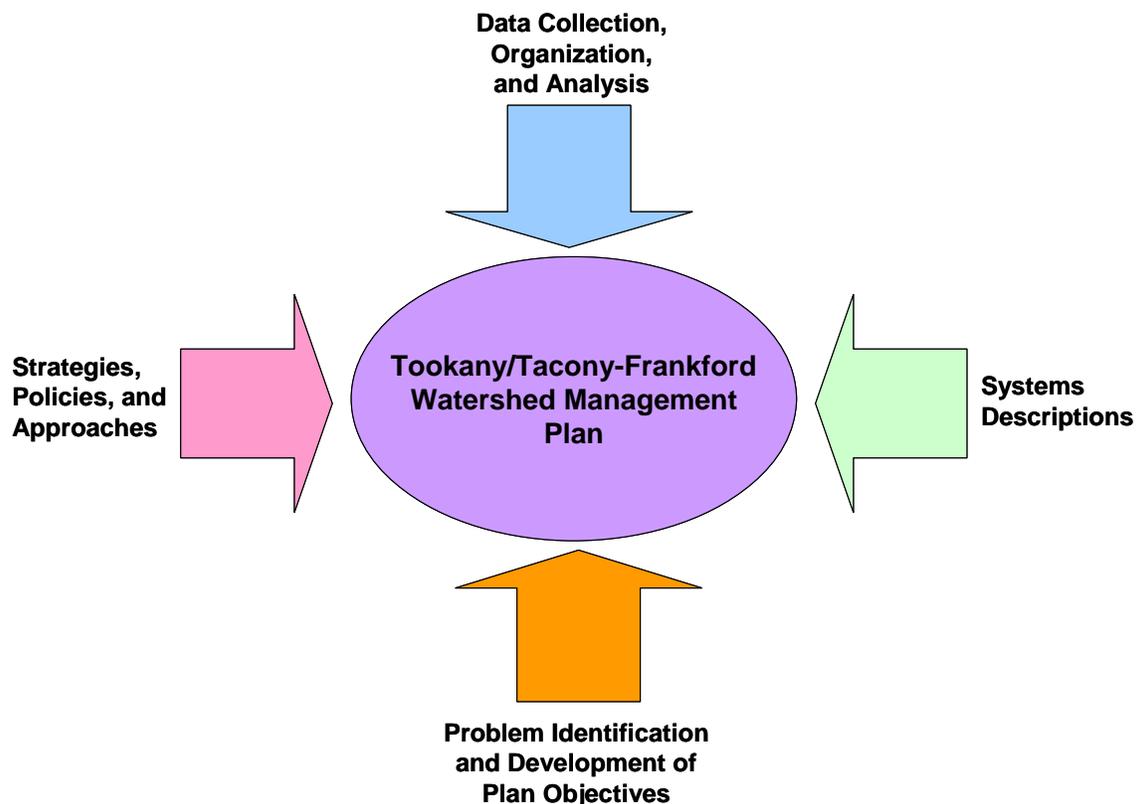
Integrated Watershed Management for the Tookany/Tacony-Frankford Watershed

This section describes the watershed planning approach behind the TTFIWMP. It outlines the types of existing and new data that were assembled and analyzed, as well as the process for modeling stormwater flow under various scenarios. Several key concepts of the TTFIWMP are introduced: the overall goals and objectives (detailed in Section 3), the 21 watershed “indicators” (Section 4); and the screening of numerous methods, or “management options,” for meeting the goals (Section 7). In addition, this section introduces the approach of setting multiple strategies – Targets A, B, and C – for promoting successful implementation of the TTFIWMP.

The watershed planning approach that serves as the framework for the Tookany/Tacony-Frankford Integrated Watershed Management Plan (TTFIWMP) contains many of the activities included in Philadelphia’s CSO Long Term Control Plan and coordinates each of the five regulatory programs discussed in Section 1.4.

2.1 General Planning Approach

The general approach followed for the TTFIWMP has four major elements, as illustrated below, each with multiple tasks specific to the planning efforts within the TTF Watershed.



Data Collection, Organization, and Analysis

The initial step in the planning process is the collection and organization of existing data on surface water hydrology and quality, wastewater collection and treatment, combined sewer overflows, stormwater control, land use, stream habitat and biological conditions, and historic and cultural resources. In addition, existing rules, regulations, and guidelines pertaining to watershed management at federal, state, basin commission, county, and municipal levels also are examined for coherence and completeness in facilitating the achievement of watershed planning goals.

Data are collected by many agencies and organizations in various forms, ranging from reports to databases and Geographic Information System (GIS) files. Field data collection efforts were undertaken prior to the study, and expanded once data gaps were identified.

Systems Description

The planning approach for an urban stream must focus on the relationship between the natural watershed systems (both groundwater and surface water) and the constructed systems related to land use that influence the hydrologic cycle, such as water supply, wastewater collection and treatment, and stormwater collection. A critical step in the planning process is to examine this relationship in all its complexity and to explore the adequacy of the existing regulatory structure at the federal, state, county, and municipal level to properly manage these natural and built systems. In urban watersheds, the natural systems are, by definition, influenced by the altered environment, and existing conditions reflect these influences. It is not, however, always obvious which constructed systems are having the most influence, and what that influence is. Analyzing and understanding the water resources and water supply/wastewater/stormwater facilities and their interrelationship provides a sound basis for subsequent planning, leading to the development of a realistic set of planning objectives.

Problem Identification and Development of Plan Objectives

Existing problems and issues of water quality, stream habitat, and streamflow related to the urbanization of the watershed can be identified through analyses of:

- Prior studies and assessments;
- Existing data;
- New field data;
- Stakeholder input.

Problems and issues identified through data analysis must be compared with problems and issues brought forward by stakeholders. An initial list of problems and issues then are transformed into a preliminary set of goals and objectives. These goals and objectives may reveal data gaps and may require additional data collection and analysis. Ultimately, with stakeholder collaboration, a final list of goals and objectives is established that truly reflects the conditions of the watershed. These goals and objectives are prioritized by the stakeholders based on the results of the data analysis.

The priority of objectives becomes the basis for developing a recommended alternative. Potential constraints on implementation require that the objectives be broken down into phased targets, in which an alternative is developed to meet interim objectives. In this way, the effectiveness of implementation can be monitored, and targets adjusted, as more is learned about the watershed, its physical characteristics, and evolving water quality regulations.

Strategies, Policies, and Approaches

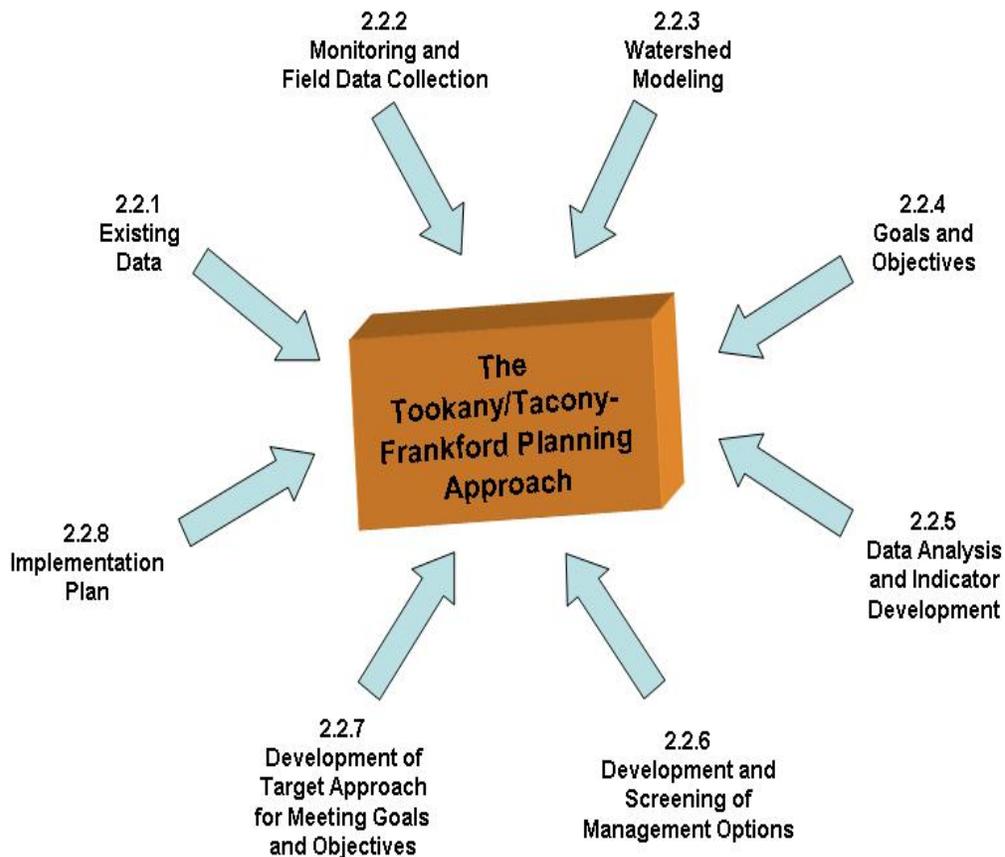
Once end targets and interim targets are established, with a clear list of associated planning objectives based on sound scientific analysis and consensus among stakeholders, a recommended alternative can be developed to meet the agreed upon targets and objectives. This alternative combines selected options from among the many suggested municipal actions, recommendations on water supply and wastewater collection system improvements, potential measures to protect water quality from point sources, best management practices for stormwater control, measures to control sanitary and combined sewer overflows, changes to land use and zoning, stream channel and streambank restoration measures, etc.

Section 8 of this plan provides Implementation Guidelines on how best to combine the many options in a coherent fashion within the context of the watershed-wide management objectives. The plan is designed to provide an implementation process and guidelines to achieve the stated objectives over a specified period of time.

2.2 The Tookany/Tacony-Frankford Planning Approach

As mentioned above, the approach and specific tasks for the TTFIWMP are intended to meet the criteria of the five major regulatory programs discussed in Section 1.4.

In order to establish environmental goals and identify the indicators that measure progress toward these goals, the Tookany/Tacony-Frankford planning strategy utilizes the “plan-do-check-review” methodology often called the “adaptive management approach.” To satisfy the five elements included in this procedure, the Tookany/Tacony-Frankford planning process moved from data collection and analysis to plan development in an organized manner, with constant interaction with the established stakeholder groups. The primary data collection, analysis, and technical planning activities of the TTFIWMP are outlined below, and the stakeholder process is discussed in Section 3.



2.2.1 Existing Data

PWD assembled relevant existing data and information collected in the past by other agencies and by prior studies. Several types of geographic and physical data were collected.

Geographic and Demographic Data

The base map for the project study area was prepared from U.S. Census Bureau's TIGER (Topologically Integrated Geographic Encoding and Referencing) database. These files contain local and state political boundaries, rivers and waterways, roads and railroads, and census block and block group boundaries for demographic analysis.

Meteorological Data

In addition to U.S. Census data, meteorological data was gathered to analyze streamflow responses to seasonal changes, climate variation, and storms, and to model stormwater flows. Long-term rainfall data was obtained from the National Oceanic and Atmospheric Administration's rainfall gauge at the Philadelphia International Airport. This gauge has over 100 years of hourly precipitation data, from 1902 through the present. In addition to this long-term rainfall gauge, the PWD CSO Program has over 10 years of 15-minute rainfall data from 24 rain gauges. Ten of these gauges are in the vicinity of the TTF Watershed. The available rainfall data for each gauge is summarized in Table 2.1, and Figure 2.1 shows their locations (next page). Data from each gauge was analyzed for accuracy and completeness and then subjected to statistical analyses to check for changes in the gauge location or physical layout, as well as to explore correlations among gauges to identify potential over- or under-catch trends.

Rain Gauge Data: PWD maintains a database of 15-minute accumulated precipitation depths collected from its county-wide 24 tipping bucket rain gauge network for the period 1990 to the present. The uncorrected, 2.5-minute accumulated, 0.01 inch tip count, rain gauge data is subjected to preliminary quality assurance and quality control procedures. Identification and flagging of bad or missing data is performed for each rainfall event on a monthly basis by visual inspection comparing 15-minute accumulated measurements at nearby gauges and looking for patterns of obvious gauge failures, including plugged gauges and erratic tipping. Next, a bias adjustment procedure is performed to normalize systematic rain gauge biases across the network. Finally, all data flagged as bad or missing is filled with data from up to five nearby gauges using inverse-distance-squared weighting. A continuous rainfall record at each gauge location is thereby produced for use in continuous hydrologic model simulations.

Radar Rainfall Data: Gauge calibrated radar rainfall estimates have been obtained from Vieux and Associates for seven wet weather events sampled during 2003. The spatial resolution of this data is approximately 1km x 1km grid covering the extended watershed area. The 15-minute accumulated rainfall depths are derived from the National Weather Service's Mount Holly, NJ, level 2 radar reflectivity data that has been calibrated to PWD's rain gauge data using mean field bias adjustment. Mean field bias adjustment preserves the average rainfall depth measured at the rain gauges along with the spatial distribution represented by the radar reflectivity data.

Representative Wet Weather Year: A representative year of rainfall data was constructed to more easily evaluate the effectiveness of stormwater management options. This was done by comparing the 100-year hourly rainfall record from the NOAA Philadelphia International

Airport rain gauge station to individual quarterly records for the years 1991 through 2002. Each quarter year was evaluated against the long term record by comparing total quarterly rainfall along with the cumulative distributions of rainfall intensities and storm total depths. The resulting representative year was constructed using data from quarter 1 of 1997, quarter 2 of 1998, quarter 3 of 1996, and quarter 4 of 1997.

Table 2.1 Rainfall Data Available for the Tookany/Tacony-Frankford Watershed Gauges

Gauge Name	Available Data
RG-07	1991-2003
RG-08	1991-2001, 2003
RG-10	1991-2001
RG-11	1991-2000, 2002-2003
RG-13	1991-1998, 2001-2003
RG-14	1991-1998, 2001
RG-17	1991, 1993-2003
RG-18	1992-2003
RG-19	1991-2003

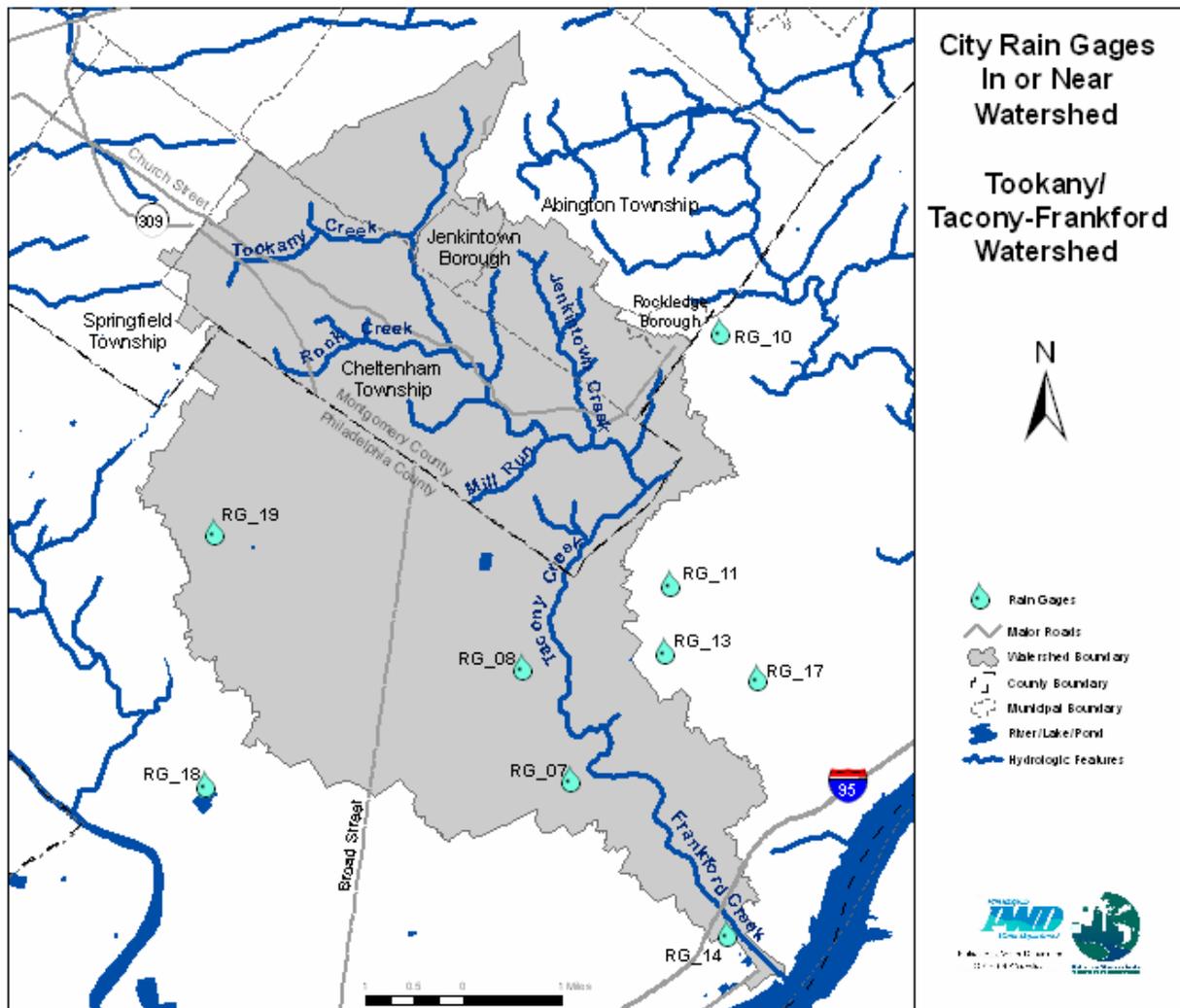


Figure 2.1 City Rain Gauges in or near the Tookany/Tacony-Frankford Watershed

Land Use

Land use information for the Tookany/Tacony-Frankford Watershed was obtained from the Delaware Valley Regional Planning Commission (DVRPC) for Montgomery and Philadelphia counties. The DVRPC land use maps are based on aerial photography from March through May of 1995. The residential areas were updated based on the 2000 Census populations. A useful representation of the existing land use information for hydrologic analyses was developed as shown in Figure 2.2.

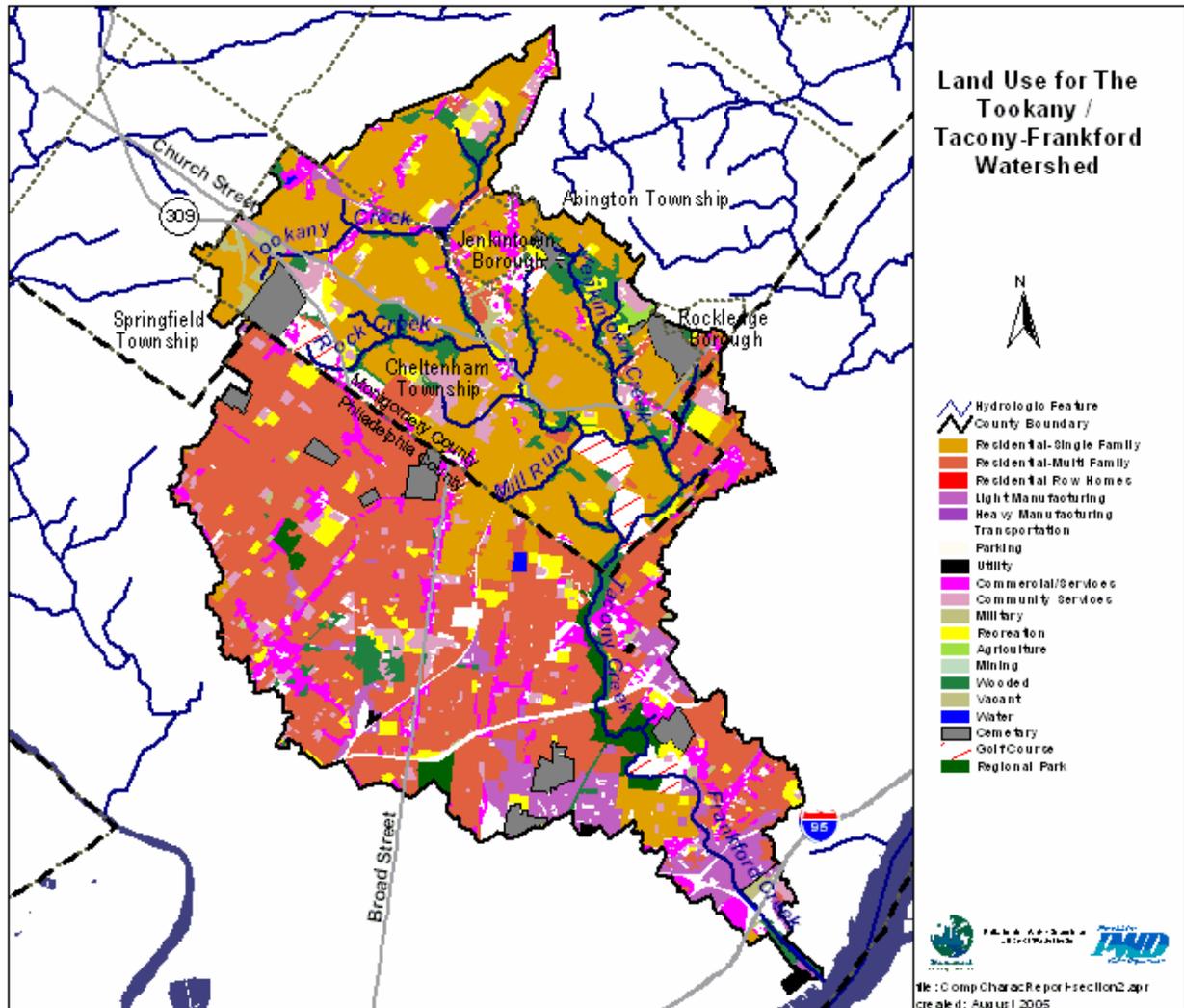


Figure 2.2 Land Use Map for the Tookany/Tacony-Frankford Watershed (Source: DVRPC)

Streamflow

During the 1960s, the United States Geological Survey (USGS), in cooperation with PWD, established streamflow-gauging stations at five locations in the Tookany/Tacony-Frankford Watershed. While only one of these gauges still is active today, the two to three decades of historic record they provided is invaluable in characterizing the hydrologic response of the watershed. The locations of the gauges are listed in Table 2.2 and shown in Figure 2.3, below. Daily streamflow records from the gauges were analyzed, and baseflow separation performed

to identify patterns along the stream of baseflow and stormwater runoff. (The results of these analyses are presented in Section 4.2.1 and Section 5.2.)

Water Quality

In the early 1970s, the Philadelphia Water Department began a study in cooperation with the U.S. Geological Survey (USGS) titled, “Urbanization of the Philadelphia Area Streams.” The purpose of this study was to quantify the pollutant loads in some of Philadelphia’s streams and document any degradation in water quality due to urbanization. The study included three sampling sites in the headwaters and two on the main stem of Tacony-Frankford Creek (see Figure 2.3, next page). Monthly discrete water quality samples were collected at each site and analyzed for a variety of water quality parameters between 1970 and 1980. The USGS established streamflow gauging stations at five locations in the Tacony-Frankford Watershed, partially as a result of its participation in the Cooperative Program. The majority of the data currently available from STORET, U.S. EPA’s water quality database, was collected as part of this study.

Table 2.2 USGS Gauges and Periods of Record

Gauge No.	Name	Drainage Area (sq. mi.)	Period of Record
01467089	Frankford Creek at Torresdale Ave.	33.8	10/1/65 - 9/30/81, 5/14/82 - 6/29/82
01467087	Frankford Creek at Castor Ave.*	30.4	7/1/82 - 9/30/98
01467086	Tacony Creek at County Line	16.6	10/1/65 - 11/17/88
01467085	Jenkintown Creek At Elkins Park	1.17	10/01/73 - 9/30/78
01467083	Tacony Creek near Jenkintown	5.25	10/1/73 - 9/30/78

* currently operating gauge

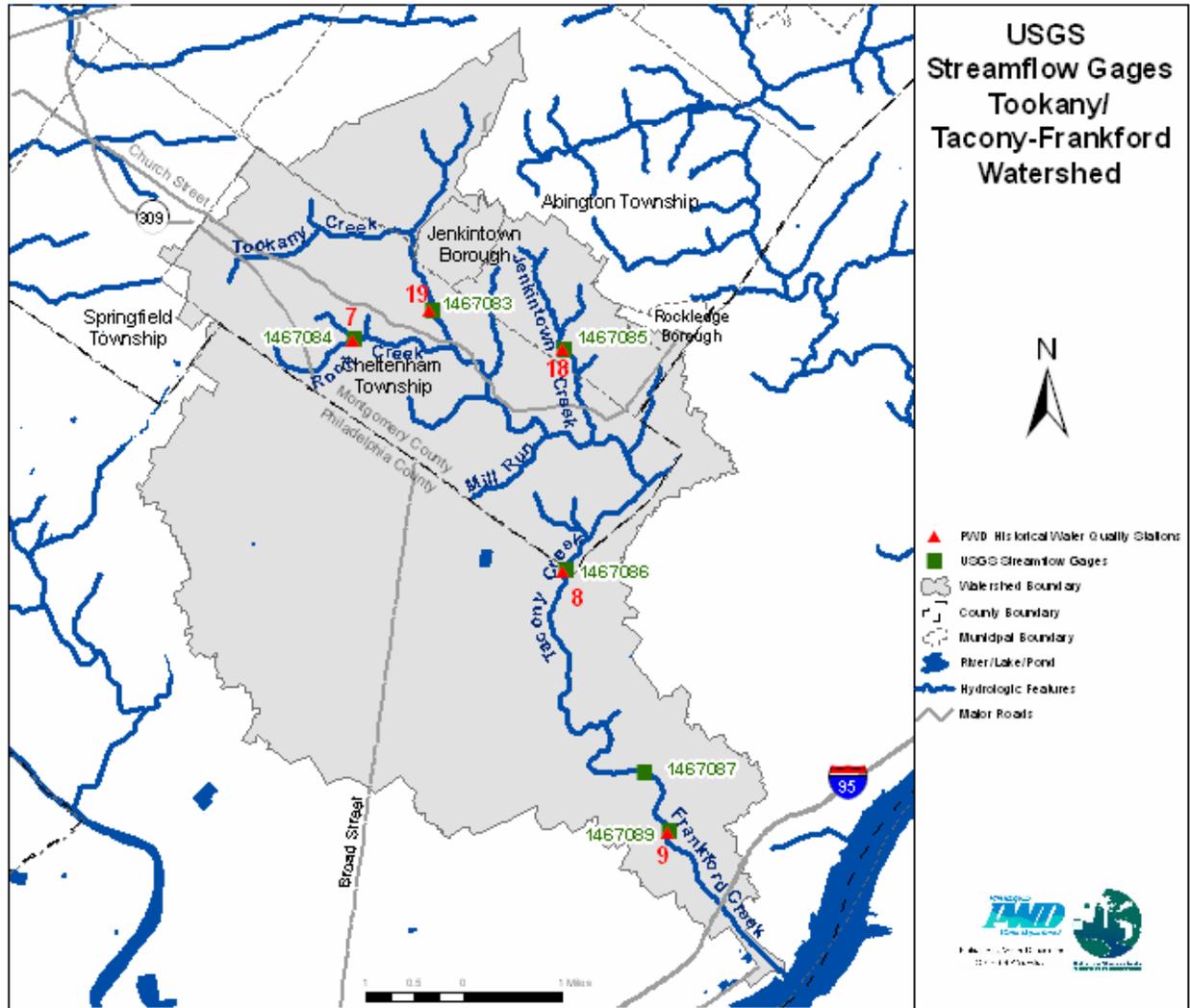


Figure 2.3 PWD/USGS Cooperative Program Water Quality and Streamflow Stations in the Tookany/Tacony-Frankford Watershed

2.2.2 Monitoring and Field Data Collection

To supplement existing data, PWD conducted an extensive sampling and monitoring program to characterize conditions in the TTF Watershed. The program was designed to document the condition of aquatic resources, to provide information for the planning process needed to meet EPA and PA DEP regulatory requirements, and to monitor trends as implementation proceeds.

Water Quality Sampling

PWD performed three types of sampling at eight sites (Figure 2.4). Discrete sampling was done from June 2000 through July 2003. Wet weather sampling involved collecting discrete samples before and during 12 wet weather events from March 2001 through October 2003, allowing the characterization of water quality responses to stormwater runoff and sanitary and combined sewer overflows. The third type of sampling was continuous monitoring, carried out by YSI 6600 and 600 XLM Sondes, shallow depth continuous water quality monitors, and probes that record dissolved oxygen, pH, and turbidity. The equipment was deployed to three locations periodically for a number of days to collect continuous data samples and observe water quality fluctuations. The Sonde data for the Tookany/Tacony-Frankford Watershed includes over 80 deployments.

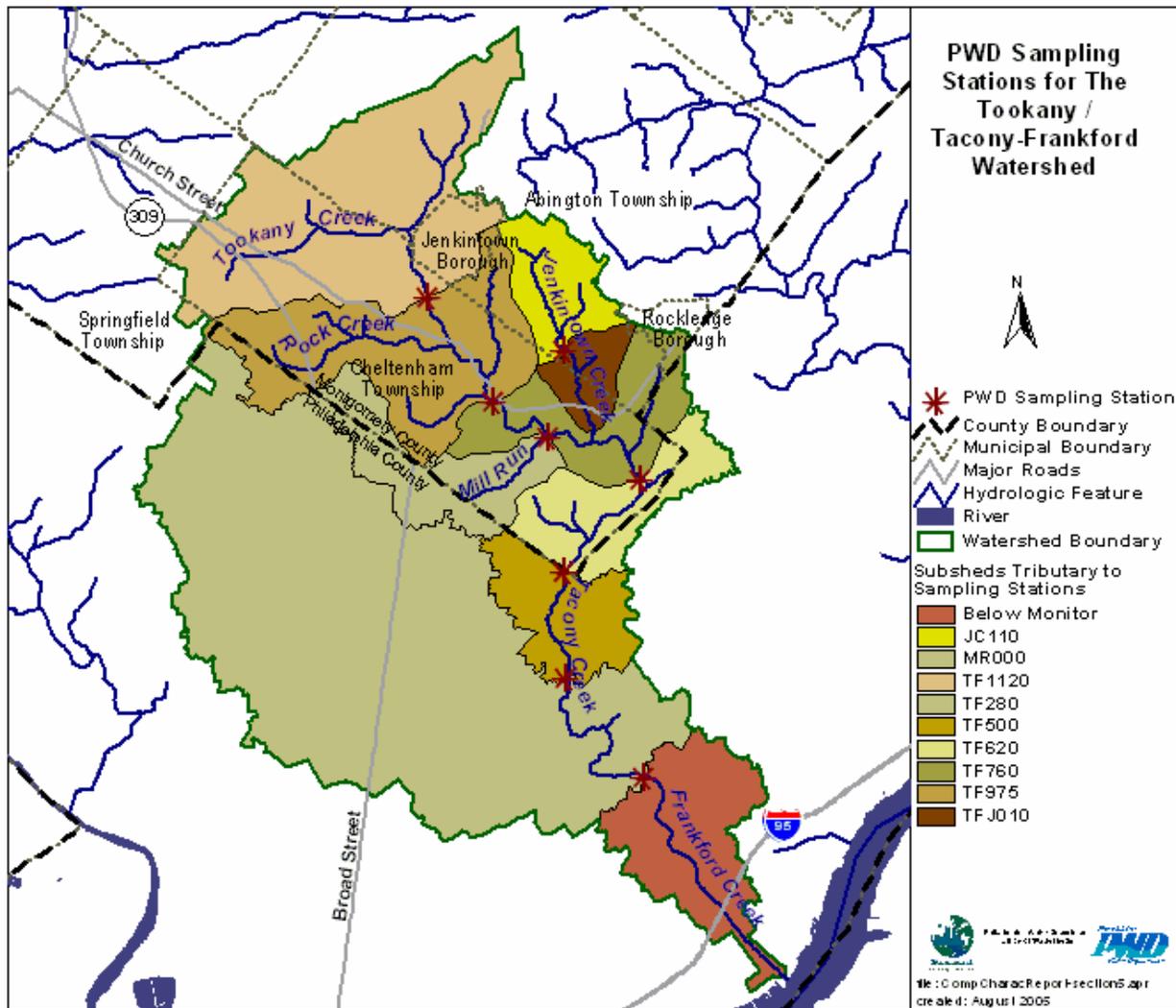


Figure 2.4 Water Quality Monitoring Locations in the Tookany/Tacony-Frankford Watershed

Biological Monitoring

Biological monitoring is a useful means of detecting anthropogenic impacts to the aquatic community. Resident biota (e.g., benthic macroinvertebrates, fish, and periphyton) in a water body are natural monitors of environmental quality and can reveal the effects of episodic and cumulative pollution and habitat alteration (Plafkin et. al. 1989, Barbour et al. 1995). The Philadelphia Water Department's Office of Watersheds and Bureau of Laboratory Services, along with the Philadelphia Academy of Natural Sciences and the Pennsylvania Department of Environmental Protection have been developing a preliminary biological database to assess the aquatic integrity of the Tookany/Tacony-Frankford Watershed. During the winter of 2000-2001, the Philadelphia Water Department conducted biological assessments (Rapid Bioassessment Protocols III and V) at seven non-tidal locations along the Tacony-Frankford Watershed to investigate the various point and non-point source stressors. Macroinvertebrate and ichthyofauna monitoring was conducted at specific locations within the watershed. Geographical Information Systems (GIS) databases and watershed maps were constructed to provide accurate locations of the sampling sites.

An ichthyofauna (fish) assessment occurred at four sampling stations on the mainstem of the Tookany/Tacony-Frankford Creek. Six metrics were used to assess the quality of the fish assemblages in the study stream.

1. Species richness
2. Species diversity
3. Trophic composition relationships
4. Pollution tolerance levels
5. Disease and parasite abundance/severity
6. Introduced (exotic) species

In addition to the fish assessment, the results of a PA DEP Rapid Bioassessment Protocol (RBP) assessment of seven sites in the Tookany/Tacony-Frankford Watershed were also compiled. PA DEP biologists used a combination of habitat and biological assessments to evaluate the Tookany/Tacony-Frankford under the Unassessed Waters Program. Biological surveys included kick screen sampling of benthic macroinvertebrates, which were identified by family and by their tolerance to pollution. Benthic macroinvertebrates mainly are aquatic insect larvae that live on the stream bottom. Since they are short-lived and relatively immobile, they reflect the chemical and physical characteristics of a stream and chronic sources of pollution. The biological integrity and benthic community composition was determined using U.S. EPA guidelines for RBP III.

Upon completion of the total biological scoring criteria, each site was compared to a reference site according to its drainage area and geomorphological attributes. The reference site chosen was French Creek, located at Coventry Road Bridge, South Coventry Township, Chester County. The comparison of the biological assessment of each site with the reference site was designed to create a baseline for monitoring trends in benthic community structure that might

be attributable to improvement or worsening of conditions over time. Several Biological Condition Categories were developed:

- Non-impaired
- Slightly impaired
- Moderately impaired
- Severely impaired

Habitat Assessment

Habitat assessments evaluate how deeply the stream substrate is embedded, the degree of streambank erosion, the condition of riparian vegetation, and the amount of sedimentation. Data from the PA DEP surveys were available for the Tookany/Tacony-Frankford Creek. Habitat assessments at seven non-tidal sites were completed based on the Stream Classification Guidelines for Wisconsin (Ball, 1982) and Methods of Evaluating Stream, Riparian, and Biotic Conditions (Platts et al., 1983). Reference conditions were used to normalize the assessment to the Tookany/Tacony-Frankford (mainstream) “best attainable” situation. Habitat parameters were separated into three principal categories to characterize the site:

- Primary or microscale habitat
- Secondary or macroscale habitat (stream channel)
- Tertiary or riparian and bank structure

Resource based Habitat Suitability Indices (HSI) were developed to add aquatic life-based habitat and flow requirement criteria to the watershed assessment. HSIs integrate the expected effects of a variety of physicochemical and hydrological variables on a target species of environmental or economic concern. Data is used to construct sets of suitability index curves, each of which relates a habitat parameter to its suitability for the species of interest. Curves rate habitat variables on a scale of 0 to 1.0, and were developed to measure food and cover, water quality, and reproduction (e.g., substrate type, percent pools, percent cover, depth of pools, pH, DO, turbidity, temperature).

Fluvial Geomorphological Assessment

For the Tacony Creek Watershed, members of the Philadelphia Water Department performed a fluvial geomorphological (FGM) assessment which included baseline determination of stream stability and habitat parameters. The measurement of geomorphic parameters and physical and hydraulic relationships were performed at both Level I and Level II using the Rosgen classification methodology (D.L. Rosgen Applied River Morphology 1996).

Level I: Desktop survey included desktop delineation of the stream using generalized major stream types based on available topographic information, geological maps, soils maps, and aerial photographs. The purpose of the inventory was to provide an initial framework for organizing and targeting subsequent field assessments of important reaches where problems are known to occur or are anticipated to occur. Available topographic information, geological maps, soils maps, and aerial photographs were reviewed.

Level II: Reach stream survey was performed for approximately 30 miles of stream including the Main Stem Tookany/Tacony-Frankford Creek and 14 tributaries within the Watershed. A field team consisting of engineers and biologists walked the designated lengths of each stream and tributary and estimated several parameters related to channel morphology:

- Bankfull elevations/widths
- Floodprone elevations/widths
- Bankfull/Floodprone discharges
- Entrenchment ratios
- Width/Depth ratios
- Sinuosity
- Channel/Water surface slopes
- Channel materials (pebble count) – D50's
- Meander pattern
- Rosgen stream types
- Velocities
- Shear stresses

Wetland Study Method

Wetlands play a significant role in ecosystem health and water quality in a watershed. For this reason, two wetland field investigations were conducted to characterize the presence and condition of wetlands in the Tookany/Tacony-Frankford Watershed. Potential wetlands within Philadelphia were evaluated in July of 2001, and potential wetlands in Montgomery County were evaluated in August 2003. The wetland field investigation was designed to survey existing wetlands, evaluate potential wetland enhancement actions, and identify potential wetland creation sites.

The field investigation plan was developed based on orthophoto basemaps, and indicator information such as National Wetlands Inventory (NWI) mapping, hydric soil information, Fairmount Park Commission (FPC) mapping, and Delaware Valley Regional Planning Commission (DVRPC) existing open space mapping.

The wetland field investigation evaluated the hydrology, vegetation, soils, general location, estimated acreage, and landscape position of the wetlands in the riparian corridors. Although wetlands were not delineated, all identified wetlands within the watershed met the criteria for jurisdictional wetlands as described in the 1987 *U.S. Army Corps of Engineers (USACE) Wetlands Delineation Manual* (Environmental Laboratory 1987). Where possible, significant and representative points were mapped using global positioning systems (GPS).

Existing wetlands located during the field survey were also evaluated for existing wetland functions using the Oregon Assessment Method. The *Oregon Freshwater Wetland Assessment Methodology* (Roth, et al. 1996) and the Human Disturbance Gradient (Gernes and Helgen, 2002) were applied to each wetland location. The Oregon Assessment Method values were calculated for Wildlife Habitat, Fish Habitat, Water Quality, Hydrologic Control, and Sensitivity to Future

Impact. An additional function, termed Wetland Improvement, was evaluated using relevant questions from other areas of the Oregon Assessment Method. The Wetland Improvement Function was intended to reflect field observations that the potential for wetland enhancement may exist without a significant buffer, so long as there was sufficient access to create the enhancement.

Water quality is a factor of both the Oregon Assessment Method and the Human Disturbance Gradient (HDG). A combination of field observations, including the location of the wetland and waterway within the watershed or sub-watershed, as well as the PA DEP's 2002 *Section 303(d) List of Impaired Waterbodies* (PA DEP 2002) was used as a measure of water quality. Four PWD monitoring stations within the Tookany/Tacony-Frankford Watershed that assess chemical, macroinvertebrate, and fish habitat data also contributed data to the Oregon and HDG analyses.

Where applicable, the redirection of outlets was considered in determining sites for streambank restoration and/or wetland restoration. Existing undeveloped areas were considered as potential wetland creation sites; factors included proximity to a waterway, the presence of stormwater outlets, the presence of existing wetlands nearby, whether these wetlands would be negatively impacted by the creation of additional wetland, and construction access and physical limitations of the site.

2.2.3 Watershed Modeling

An important tool for developing the watershed plan is a hydrologic and hydraulic model of the stream and stormwater system. In most streams in the eastern U.S., stormwater flows can range from less than 30% of total annual streamflow in less-developed watersheds to over 70% in highly urbanized settings. Modeling of stormwater flows is, therefore, a critical component of a watershed management plan. The model should, at a minimum, be built to provide storm-by-storm flows to the streams as well as estimates of pollutant loads carried by the stormwater reaching the streams.

A Stormwater Management Model (SWMM) was built for the entire Tookany/Tacony-Frankford Watershed. SWMM is a comprehensive set of mathematical models originally developed for the simulation of urban runoff quantity and quality in storm, sanitary, and combined sewer systems. The model subdivides the watershed into approximately 300 subwatersheds and estimates flow and pollutant loading from each land use type within each of the subwatersheds. It simulates the hydraulics of combined sewers, the open channel of the creek itself, and the floodplain. Thus, the model is useful for simulation of stormwater runoff quantity and quality, combined sewer overflow, and streamflow. The model was calibrated by comparing stormwater runoff to estimated runoff, calculated through hydrograph separation at the USGS gauges in the watershed. Model simulations included:

- Existing conditions using a long-term rainfall record from Philadelphia Airport;
- Annual average pollutant loads for key pollutants found in stormwater. The list of pollutants includes parameters such as nitrate, phosphorus, total suspended solids, heavy metals, biochemical oxygen demand, and dissolved oxygen;
- Numerous simulations to test the effectiveness of various BMPs within the Tookany/Tacony-Frankford Watershed. Effectiveness was judged based on reductions in stormwater discharges, CSOs, and reduced pollutant loading during wet weather.

The model results helped identify areas where stormwater runoff or pollutant loads are particularly high and in need of control. Model flow results, in combination with the results of the fluvial geomorphic assessment, provided excellent tools for identifying areas of the watershed that are undergoing stormwater-related stress and an efficient way of developing alternative integrated watershed management approaches, particularly with regard to the Wet Weather “Target C” objective (described in Section 2.2.7).

2.2.4 Goals and Objectives

Early in the planning process, project goals and objectives were developed in conjunction with the stakeholders. In general, goals represent consensus on a series of “wishes” for the watershed. Seven project goals were established that encompass the full spectrum of goals from all the relevant regulatory programs as well as the River Conservation Plans (as summarized in Table 1.3). A significant effort was made to consolidate the various goals into a single, coherent set that avoids overlap and is organized into clear categories:

1. Streamflow and Living Resources
2. Instream Flow Conditions
3. Water Quality and Pollutant Loads
4. Stream Corridors
5. Flooding
6. Quality of Life
7. Stewardship, Communication, and Coordination

Once the preliminary set of goals was established, a series of associated objectives was developed. Objectives translate the goals into measurable quantities; “indicators” (described below) are the means of measuring progress toward those objectives. This relationship is the link between the more general project goals and the indicators developed to assess the watershed and to track future improvement.

The preliminary planning goals and objectives were presented to stakeholders for initial review. However, the final, prioritized goals and objectives were subjected to final review and approval when the data analysis and modeling work were completed. (See Section 3 for more detail.)

2.2.5 Data Analysis and Indicator Development

An integral part of this plan is the assessment and description of existing conditions within the watershed and stream. This assessment has identified specific problem areas, while establishing a “watershed baseline” from which we can measure our future progress as recommendations are implemented. Based upon these existing conditions, a series of “watershed indicators” were developed so that as implementation occurs in the coming years, progress can be quantified. These indicators were developed to represent the results of the data collection efforts and the data analysis and modeling. An indicator is a measurable quantity that characterizes the current state of at least one aspect of watershed health. Every indicator is directly linked to one or more project objectives. Thus, they serve to describe the current conditions, and provide a clear method of monitoring progress and achievement of objectives as watershed management strategies are implemented over time.

The 21 indicators selected for their potential use in assessing both current conditions and future progress in improving conditions are listed in Table 2.3 (next page) and discussed in detail in Section 4.

Table 2.3 Tookany/Tacony-Frankford Watershed Indicators

The Land Use and Stream Health Relationship

Indicators	
1	Land Use and Impervious Cover

Flow Conditions and Living Resources

Indicators	
2	Streamflow
3	Stream Channels and Aquatic Habitat
4	Restoration and Demonstration Projects
5	Fish
6	Benthic Macroinvertebrates

Water Quality

Indicators	
7	Effects on Public Health (Bacteria)
8	Effects on Public Health (Metals and Fish Consumption)
9	Effects on Aquatic Life (Dissolved Oxygen)

Pollutants and Their Sources

Indicators	
10	Point Sources
11	Non-point Sources

The Stream Corridor

Indicators	
12	Riparian Corridor
13	Wetlands and Riparian Woodlands
14	Wildlife

Quality of Life

Indicators	
15	Flooding
16	Public Understanding and Community Stewardship
17	School-Based Education
18	Recreational Use and Aesthetics
19	Local Government Stewardship
20	Business and Institutional Stewardship
21	Cultural and Historic Resources

2.2.6 Development and Screening of Management Options

Clear, measurable objectives provided the guidance for developing options designed to meet the project goals. A “management option” is a technique, measure, or structural control that addresses one or more objectives (e.g., a detention basin that gets built, an ordinance that gets passed, an educational program that gets implemented).

The following example clarifies the difference among a goal, an objective, and a management option.

Goal: Improve water quality.

Objective: Maintain dissolved oxygen levels above 5 mg/L.

Management Option: Eliminate deep, poorly mixed plunge pools where low DO is detected.

Lists of management options were developed to meet each of the goals and objectives established for the Tookany/Tacony-Frankford Watershed. Only those options deemed feasible and practical were considered in the final list of management options. Options were developed and evaluated in three steps:

1. **Development of a Comprehensive Options List.** Virtually all options applicable in the urban environment were collected. These options were identified from a variety of sources, including other watershed plans, demonstration programs, regulatory programs, literature, and professional experience.
2. **Initial Screening.** Some options could be eliminated as impractical for reasons of cost, space required, or other considerations. Options that already were implemented, were mandated by one of the programs, or were agreed to be vital, were identified for definite implementation. The remaining options were screened for applicability to the TTF Watershed and for their relative cost and the degree to which they met the project objectives. Only the most cost-effective options were considered further.
3. **Detailed Evaluation of Structural Options.** Structural best management practices (BMPs) for stormwater and combined sewage were subjected to a modeling analysis. Effects on runoff volume, overflow volume, peak stream velocity, and pollutant loads were evaluated at various levels of coverage.

Detailed evaluation of structural options (step 3) used the SWMM model to assess the effectiveness of each option and used planning-level cost estimates of each option. All options that had an effect on CSOs or stormwater-related pollutant loads were modeled at several degrees of implementation. Graphs of effectiveness versus degree of implementation were developed, and the results were then combined with more accurate cost estimates to provide guidance on selecting effective options or combinations of options.

2.2.7 Development of Target Approach for Meeting Goals and Objectives

In developing a recommended watershed management alternative and discussing goals and objectives with stakeholders, it became clear that implementation could best be achieved by defining three distinct targets to meet the overall plan objectives. Targets A and B were defined so that they could be fully met with a limited set of options that are fully implemented. Target C fit better with an adaptive management approach. In other words, it was agreed to set interim objectives, recommend measures to achieve the interim objectives, implement those controls, and reassess the capability to meet the objectives or agree to raise the bar to more complete achievement of the final objectives.

These three targets represent groups of objectives that each focus on a different problem related to the urban stream system. They can be thought of as different parts of the overall goal of fishable and swimmable waters through improved water quality, more natural flow patterns, and restored aquatic and riparian habitat. The targets are specifically designed to help focus plan implementation.

By defining these targets, and designing the recommended alternative to address the targets simultaneously, the plan will have a greater likelihood of success. It also will result in realizing some of the objectives within a relatively short time frame, providing positive incentive to the communities and agencies involved in the restoration, and more immediate benefits to the people living in the watershed.

The targets for the Tookany/Tacony-Frankford Integrated Watershed Management Plan are defined as follows:

Target A: Dry Weather Water Quality and Aesthetics

Target A was defined for Tookany/Tacony-Frankford Creek with a focus on trash removal and litter prevention, and the elimination of sources of sewage discharge during dry weather. Streams should be aesthetically appealing (look and smell good), be accessible to the public, and be an amenity to the community. Access and interaction with the stream during dry weather has the highest priority, because dry weather flows occur about 60-65% of the time during the course of a year on the Tookany/Tacony-Frankford Creek. These are also the times when the public is most likely to be near or in contact with the stream. The water quality of the stream in dry weather, particularly with respect to bacteria, should be similar to background concentrations in groundwater.

In many urban streams, monitoring indicates that the water quality rarely meets the standard for bacteria, and occasionally exhibits dissolved oxygen (DO) problems, even during baseflow or dry weather conditions. Thus, the first target focuses on dry weather water quality, coupled with the visual aesthetics of the stream, primarily the removal of trash and the elimination of illegal dumping so often associated with degraded, urban waterways. Target A also includes a range of regulatory and nonstructural options that address both water quality and quantity concerns. Because the options under consideration are aimed at the total elimination of dry weather sources of trash and sewage, virtually all options related to this target were included in the implementation plan.

Target B: Healthy Living Resources

Based on the results of the water quality monitoring, habitat assessment, and biological monitoring, water quality was not identified as the primary cause of the low diversity and impaired nature of the fish population in the stream. Improvements to the number, health, and diversity of the benthic macroinvertebrate and fish species in the Tookany/Tacony-Frankford Creek need to focus on habitat improvement and the opportunity for organisms to avoid high velocities during storms. Fluvial geomorphological studies, wetland and streambank restoration/creation projects, and stream modeling should be combined with continued biological monitoring to ensure that correct procedures are implemented to increase habitat heterogeneity within the aquatic ecosystem.

Improving the ability of an urban stream to support viable habitat and fish populations focuses primarily on the elimination or remediation of the more obvious impacts of urbanization on the stream. These include loss of riparian habitat, eroding and undercut banks, scoured streambed or excessive silt deposits, channelized and armored stream sections, trash buildup, and invasive species. Thus, the primary tool to accomplish Target B is stream restoration.

Restoration will focus on improving channel stability, improving instream and riparian habitat, providing refuges for fish from high velocity conditions during storms, and managing land within the stream corridor. Restoration strategies include:

- Bank stabilization, including boulder structures, bioengineering, root wads, plantings, and log and woody structures;
- Bed stabilization, including rock/log vanes with grade control, rock/log cross vanes, and using naturally occurring boulders and bedrock;
- Realignment and relocation, used only on severely degraded stream sections;
- Dam and debris removal;
- Reforestation, with priority to floodplains, steep slopes, and wetlands;
- Invasive species management to increase biodiversity;
- Wetland creation, often used in conjunction with stream realignment to improve floodplain areas subject to annual flooding;
- Forest preservation;
- Fish holding areas, with low- to no-current zones created to provide fish with places to hold position during high flows.

Stream restoration measures to meet Target B were identified, and all options required to meet the target are planned for implementation.

Target C: Wet Weather Water Quality and Quantity

The third target is to restore water quality to meet fishable and swimmable criteria during wet weather. Improving water quality and flow conditions during and after storms is the most difficult target to meet in the urban environment. Because wet weather conditions on Tookany/Tacony-Frankford Creek occur to some degree about 35-40% of the time during the year, measures to improve wet weather quality have a somewhat lower priority than measures designed to address dry weather water quality. During wet weather, extreme increases in

streamflow are common, accompanied by short-term changes in water quality. Stormwater generally does not cause immediate DO problems.

A comprehensive watershed management approach must also address flooding issues. Where water quality and quantity problems exist, options may be identified that address both. Any BMP that increases infiltration or detains flow will help decrease the frequency of damaging floods; however, the size of such structures may need to be increased in areas where flooding is a major concern. (Reductions in the frequency of erosive flows and velocities also will help protect the investment in stream restoration made as part of the Target B.)

Target C must be approached somewhat differently from Targets A and B. Full achievement of this target means meeting all water quality standards during wet weather, as well as eliminating all flooding. Meeting these goals will be difficult. It will be expensive and will require a long-term effort. The only rational approach to achieve this target must include stepped implementation with interim goals for reducing wet weather pollutant loads and stormwater flows, along with monitoring for the efficacy of control measures.

Initial load reduction targets for parameters such as metals, total suspended solids (TSS), and bacteria were set in conjunction with the stakeholders. Based on preliminary work by PWD, a 20% reduction is a challenging but achievable initial interim target.

It is expected that changes to the approach, and even to the desired results, will occur as measures are implemented and results are monitored. This process of continually monitoring progress and adjusting the approach is known as “adaptive management.” The NPDES permit programs for stormwater and CSO outfalls can lead to a cycle of monitoring, planning, and implementation that helps define a time frame to this process.

2.2.8 Implementation Plan

Implementation plan guidelines were developed to provide Philadelphia and the upstream municipalities with a blueprint for improving water quality and habitat conditions. The guidelines (detailed in Section 8) include:

- Specific recommendations and a schedule for meeting Target A objectives;
- Specific recommendations and a schedule for meeting Target B objectives;
- Guidance on which BMPs or mixes of BMPs are most effective in Tookany/Tacony-Frankford Creek for meeting Target C objectives;
- Guidance on the needed degree of implementation to achieve Target C objectives;
- Guidance on areas of the watershed where BMPs would be most effective;
- Recommendations on Target C options for the CSO areas and separate storm sewer areas;
- Planning level cost estimates for implementation.