STRATEGIC WATER QUALITY IMPROVEMENT PLAN FOR SURFACE WATER QUALITY IMPAIRMENTS OF THE LONG SWAMP CREEK WATERSHED

DOVER TOWNSHIP, OCEAN COUNTY, NEW JERSEY

APRIL 2003

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1.0 INTRODUCTION

This report presents Birdsall Engineering, Inc.'s (BEI) recommendations for improving surface water quality impairments of the Long Swamp Creek Watershed. BEI has prepared this plan on behalf of the Township of Dover. *Funding for this publication has been provided by the NJDEP, Division of Watershed Management through a Federal Clean Water Act Section 319(h) Grant RP01-094 for Development of a Strategic Water Quality Improvement Plan for the Long Swamp Creek Watershed.*

The recommendations presented herein are based upon the findings of a companion study that identified the root causes of the Creek's impairments (BEI, 2002). Findings were presented at multiple geographical scales that included watershed, subwatershed, and catchment levels. It is strongly recommended that the reader reference the Root Cause report when reading this study. A web-based presentation has also been developed as a companion to this report. The web presentation serves as a graphical interface to present a user-friendly summary of our findings.

The findings and recommendations presented herein are intended to serve as a blueprint for water quality improvement over the long term. Implementation of individual recommended actions are expected to have noticeable local effects, and the cumulative effect of multiple proposed action items is expected to achieve the goal of reducing the discharge of pollutants from the Creek into the Toms River.

The Water Quality Improvement Plan presented herein is composed of the following components:

- **Summary of Water Quality Impairments**
- **Summary of Root Causes**
- **Geographical Delineation of the Watershed**
- **Risk-Based Rankings**
- **Watershed Level Water Quality Improvement Plan**
- **Sub-Watershed Level Water Quality Improvement Plan**
- **Catchment Level Water Quality Improvement Plan**
- **Summary of Findings and Recommendations**

2.0 SUMMARY OF WATER QUALITY IMPAIRMENTS

This section presents a summary of the findings of the Root Cause report's (BEI, 2002) findings on water quality impairments. The reader should reference the Root Cause report for a detailed discussion of the watershed's physical, hydraulic, and hydrologic features.

Long Swamp Creek has known water quality impairments and contributes the offending pollutants to the Barnegat Bay Watershed. This section identifies the relative impairments of both of these waterbodies.

2.1 Barnegat Bay

Water quality degradation in the Barnegat Bay estuary is primarily caused by nonpoint sources of pollution (NPS pollution). The physical nature of the estuary makes it vulnerable to degradation. Its shallow water depths, relatively small amount of freshwater input from tributaries, and limited connection to the ocean cause a long residence time for pollutants that are harmful to plant and aquatic life (BBEP, 2001). Impacts have included loss of commercial and recreational fishing opportunities, closed shellfish harvesting waters and swimming areas, and oxygen-depleting algal blooms and subsequent fish kills.

According to BBEP (1999), two high priority management issues for the estuary relate to nutrient loading and pathogens, which are closely coupled with development and associated activities in the watershed, such as deforestation and construction, lawn and garden maintenance, and malfunctioning septic systems. Atmospheric deposition contributes substantially to nutrient input and stormwater discharges deliver significant concentrations of coliform bacteria. Another relatively recent pollution problem is the population explosion of Canadian geese, which directly contribute fecal matter to surface waterbodies that discharge to the estuary.

Major impacts of nutrient overenrichment (eutrophication) include increased phytoplankton production and biomass, algal blooms, elevated water column turbidity, a decline in biodiversity, and dissolved oxygen depletion. Excessive nutrient input may shift primary production from an eelgrass-dominant system to a phytoplankton and seaweed dominant system. High coliform bacteria levels directly impact water quality and adversely affect human uses of the estuary, including shellfish harvesting, swimming, and boating. The estuarine portions of the Toms River are listed as impaired under the EPA 303(d) listing for fecal coliform. These impairments cause periodic beach closings at the bathing beaches adjacent to the mouth of Long Swamp Creek (see Figure 6). In the summer of 2000, the beaches were closed 3 times for elevated fecal coliform levels.

2.2 Long Swamp Creek

The high intensity development of the Long Swamp Creek watershed makes it particularly susceptible to water quality impairments. Water quality sampling and analysis conducted by NJDEP and USGS in 1994/95 revealed that NPS stormwater runoff is likely a major contributor of nitrogen, phosphorous, suspended solids, and bacteria to the creek. The results also indicated that the Creek contributes significantly to the total annual loads of phosphorous, nitrogen and bacteria of the Toms River.

The water quality sampling program did not address other significant pollutants that may occur in the creek due to NPS pollution. Based upon the relatively developed land use in the watershed, these pollutants are likely to include petroleum products, toxics, pesticides, pathogens, salts, and heavy metals. Long Swamp Creek is specifically listed on the EPA 303(d) listing as "moderately biologically impaired."

Bacteria is a known pollutant that is of particular concern. Fecal coliform measurements in the stream near its intersection with Route 37 are know to be particularly high during storm flow. Likewise, goose populations in the Creek's impoundment lakes produce significant waste loads. The fecal coliform impairment is known to be more than a localized problem, as indicated by the frequent closing of beaches near the Creek's discharge points (see Figure 1). Suspected bacteria sources also include illicit connections between the stormwater and sanitary sewer systems; however, there is no proof to substantiate these suspicions.

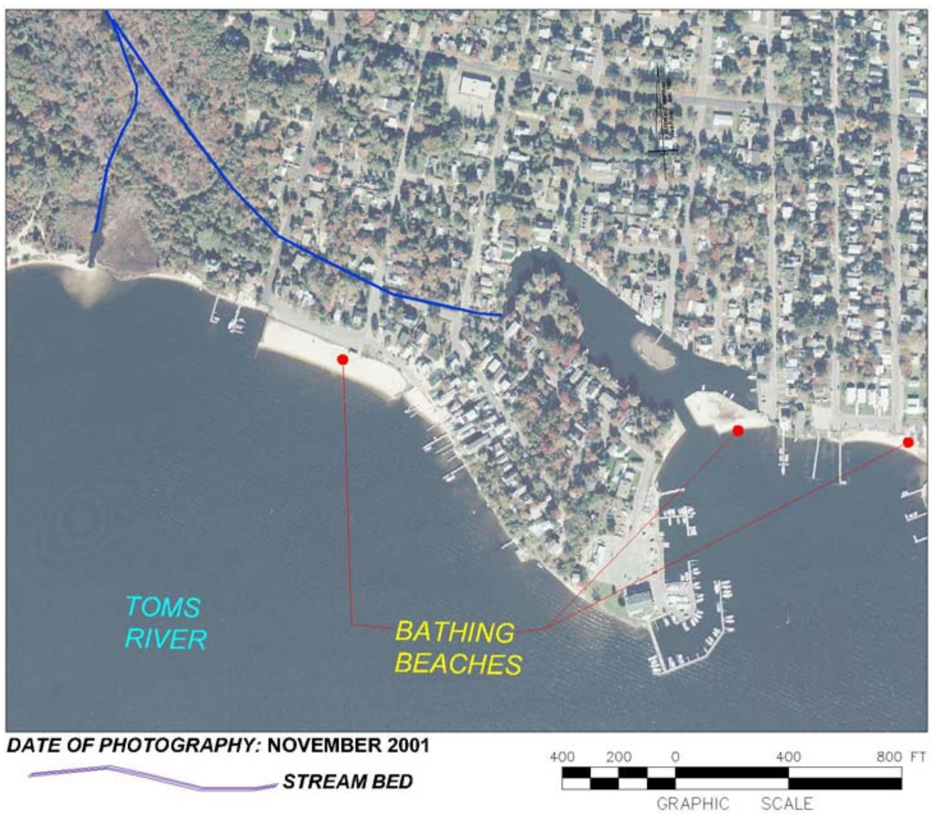


Figure 1: Public bathing beaches in the vicinity of the mouth of Long Swamp Creek.

Summary. The pollutants within Long Swamp Creek are primarily a product of NPS pollution (USGS, 1999). During stormwater events, these pollutants are discharged to the estuarine portion of the Toms River in high concentrations and contribute significantly to the annual pollutant loads of the Toms River estuary. The dominance of the stormwater-influenced pollutant load is the primary focus of this study. Typically, this dominant feature is the result of intensive development and deforestation. The water quality improvement plans contained herein are intended to reduce or eliminate the impact of the pollution sources identified in the Root Cause report.

3.0 SUMMARY OF ROOT CAUSES

This section presents a summary of the findings of the Root Cause report's (BEI, 2002) findings on the sources of pollution for Long Swamp Creek. The reader should reference the Root Cause report for a more detailed presentation.

It is well understood that the sources of water pollution in Long Swamp Creek are of a non-point source nature (NPS pollution) and are predominantly related to the extent and intensity of development that has occurred within the watershed. There are no known point sources of pollution within the watershed. These conditions significantly limit the available solutions for water quality improvement. A summary of the NPS-Pollution related conditions and sources are presented below.

3.1 Primary Land Use Features

A watershed's land use characteristics are typically the primary indicator for predicting water quality. The process of urbanization has a profound influence on the hydrology, morphology, water quality, and ecology of surface waters (Horner et al., 1996). The Long Swamp Creek watershed is heavily developed with primarily residential and commercial properties. In fact, it is the most heavily developed watershed contributing to Barnegat Bay (BBEP, 1999).

Detailed analysis of high-resolution aerial photography taken for this study yielded the following distribution of land use and impervious coverage to be as follows:

51% Residential
14% Commercial
5% Other Urbanization (roads, etc.)
4% Golf Course
<u>26% Forested/Open Space</u>
70% TOTAL DEVELOPMENT
33% IMPERVIOUS COVERAGE

The greatest concentration of development is in the lower reaches of the watershed. This distribution is indicative of a Dover Township development trend that saw urbanization begin in areas closest to the Toms River and then progress away from the river as the availability of river-proximate development parcels became limited. This trend is continuing today and is manifest through an "infilling" phenomenon that is increasing the development density of existing suburban neighborhoods.

The most influential land use feature in terms of watershed health is impervious cover. The conversion of farmland, forests, wetlands, and meadows to rooftops, roads, and lawns creates a layer of impervious surface in the urban landscape, which has a profound influence upon the hydrology, morphology, water quality, and ecology of surface waters (Horner et al., 1996). Research has shown that streams in urban watersheds such as Long Swamp Creek possess a fundamentally different character than streams in forested, rural, or even agricultural watersheds. The amount of impervious cover in the watershed can be used as an indicator to predict how severe these differences can be. In many regions of the country, as little as ten percent watershed impervious coverage has been linked to stream degradation, with the degradation becoming more severe as imperviousness increases (Schueler, 1994).

An example of the profound ecological effects that impervious coverage has is illustrated by Maxted and Shaver, 1996. Their research suggests that watershed impervious levels of 10% to 15% result in a loss of about 90% of all sensitive aquatic insects. The Center for Watershed Protection (CWP) has produced a manual entitled the “Rapid Watershed Planning Handbook” (CWP, 1998). This manual, produced for the USEPA, contains a simple model that defines a relationship between impervious cover and subwatershed quality. Considering a broad range of existing research, the CWP classified urban streams based upon impervious coverage percentage (see Table 1).

The vast majority of Long Swamp Creek is defined as “Non-Supporting” based upon this criterion. In fact, the overall impervious coverage for the watershed is 33%, which is well above the lower limit of the Non-Supporting category. Table 2 summarizes the land use within the watershed and its subwatersheds.

Table 1 Center for Watershed Protection Simple Impervious Coverage Model.

Stream Classification	Typical Impervious Coverage	Stream Characteristics
Sensitive	0 – 10%	High quality streams typified by stable channels, excellent habitat structure, good to excellent water quality, and diverse communities of both fish and insects. Low impervious coverage limits frequency of flooding and other hydrological changes that typically accompany urbanization.
Impacted	11% - 25%	Obvious signs of degradation, including alteration of stream geometry (erosion and channel widening), unstable stream banks, noticeable habitat degradation, improvement of water quality during dry weather and storm periods, loss of most sensitive fish and aquatic insects.
Non-Supporting	>25%	Stream essentially becomes a conduit for conveying stormwater flow. Highly unstable stream channel, poor water quality, high bacteria levels, pollution-tolerant fish and insects species, and high nutrient loads.

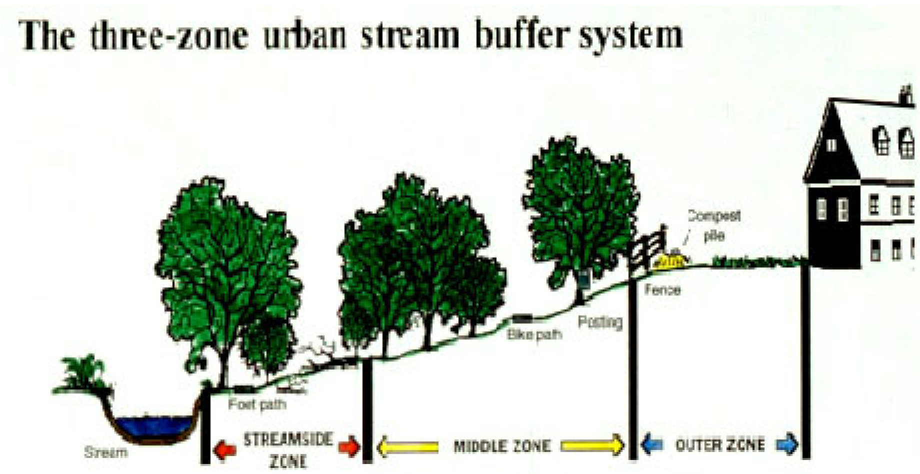
Table 2: Summary of land use within the Watershed.

Subwatershed	Percentage of Developed Land	Percentage of Impervious Coverage	Stream Classification (see Table 1)
A	84%	43%	Non-Supporting
B	74%	43%	Non-Supporting
C	54%	24%	Impacted / Non-Supporting
D	70%	23%	Impacted / Non-Supporting
Total Watershed	70%	33%	Non-Supporting

3.2 Secondary Land Use Features

Although development and impervious coverage are recognized as the dominant land use features causing water quality degradation, there are other features that are of significance in terms of their impact upon water quality.

Aquatic Buffers. An aquatic buffer is an area along a stream's shoreline where development is either restricted or has yet to occur. These buffers serve to physically protect and separate a stream. They provide a natural means of stormwater management, serve as a right of way during floods, reduce the quantity of pollutants that reach the stream, and sustain the integrity of stream ecosystems and habitats. Much of Long Swamp Creek does not meet the minimum total width of aquatic buffers as established by the "Three Zone Urban Stream Buffer System" (Center for Watershed Protection). The details of this system are described in Figure 2.



CHARACTERISTICS	STREAMSIDE ZONE	MIDDLE ZONE	OUTER ZONE
FUNCTION	Protect the physical integrity of the stream ecosystem	Provide distance between upland development and streamside zone	Prevent encroachment and filter backyard runoff
WIDTH	Min. 25 feet, plus wetlands and critical habitats	50 to 100 feet, depending on stream order, slope, and 100 year floodplain	25 foot minimum setback to structures
VEGETATIVE TARGET	Undisturbed mature forest. Reforest if grass	Managed forest, some clearing allowable	Forest encouraged, but usually turfgrass
ALLOWABLE USES	*Very Restricted* e.g., flood control, utility right of ways, footpaths, etc.	*Restricted* e.g., some recreational uses, some stormwater BMPs, bike paths, tree removal by permit	*Unrestricted* e.g., residential uses including lawn, garden, compost, yard wastes, most stormwater BMPs

Figure 2: The three-zone urban stream buffer system.
(Center for Watershed Protection web site)

High Risk Land Uses. Within the realm of commercial land use there are particular uses that pose a particular risk to stream water quality. Within the Long Swamp Creek watershed, these include auto maintenance facilities, construction materials storage yards, auto salvage yards, fueling stations, landfills, and golf courses.

Age of Development. In general, the regulatory rules governing stormwater management in New Jersey have become progressively stricter since 1970. Most development prior to the 1970's did not include measures for stormwater treatment, and many did not include *any* stormwater management. Consequently, this development did not provide the *Flood Control, Channel Protection, Groundwater Recharge,* and *Pollutant Removal* protections that modern development affords. The Long Swamp Creek watershed has a significant amount of pre-1970's development. To compound matters, the majority of this development is located close to the Creek's discharge to the Toms River.

Soil Erosion. Soil erosion is recognized as a primary contributor to poor stream water quality. Based upon field investigation, BEI has identified numerous sites that are experiencing erosion, or are likely to in the future. Typically, these sites are the product of point source discharges of stormwater; however, there are also several sites where the erosion is due to a complete absence of stabilizing vegetation.

Geese. Goose populations are recognized as a direct source of fecal coliform pollution to streams. Field inspection has revealed several goose colonies located in the ponds/lakes of Long Swamp Creek. These populations are implicitly a function of land use because their habitat (ponds/lakes) is artificially provided by the existence of stream impoundment structures.

Zoning/Ownership Issues. Although existing water quality is not a function of property ownership or future zoning requirements, these factors can significantly impact future water quality. In particular, the existing zoning of undeveloped tracts may allow for future development and increased densities. BEI has determined the location of existing undeveloped parcels within the watershed that are "at risk" and subject to potential future development based upon local zoning and a general consideration of environmental restrictions.

3.3 Hydraulic/Hydrologic Features

Streamflow. The primary impact of impervious coverage upon urban streams is a dramatic increase in surface runoff during storm events, with a proportional reduction in groundwater recharge (Schueler, 1994). In natural settings, very little annual rainfall is converted to runoff and about half is infiltrated into the underlying soils and water table. This water is filtered by the soils, supplies deep water aquifers, and helps support adjacent surface waters with clean water during dry periods. In urbanized areas such as the Long Swamp Creek Watershed this phenomenon causes less water to be available to the creek during dry periods and greater flow volumes during storms. The physical impacts of this process upon streams include the following:

- Increase in flood magnitudes and frequencies;
- Change in stream channel dimensions to accommodate extreme conditions;
- Shoreline erosion and attendant armoring;
- Degraded habitat structure and reduced aquatic diversity;

- Increase of stream crossing obstructions (e.g. bridges, pipelines, etc.);
- Water quality declines; and,
- Water temperatures increase.

As noted above, impervious coverage significantly affects stream hydraulics. Long Swamp Creek is no exception, as it has become dominated by stormwater due to the effects of development. In the upper half of the watershed (west of the Ocean County Mall), the Creek has no baseflow (it is essentially a drainage ditch in this area). In the southern half of the watershed, the Creek's baseflow is typically small or does not exist. The only appreciable waterbodies that exist along the Creek's length are the result of hydraulic impoundments (dams). The relative imbalance of base flow to storm flow is evident in 1994/95 water sampling efforts made by USGS/NJDEP. Figure 3 shows normalized flow-duration curves for Long Swamp Creek (heavily developed) and the Toms River (less developed) that illustrate this imbalance.

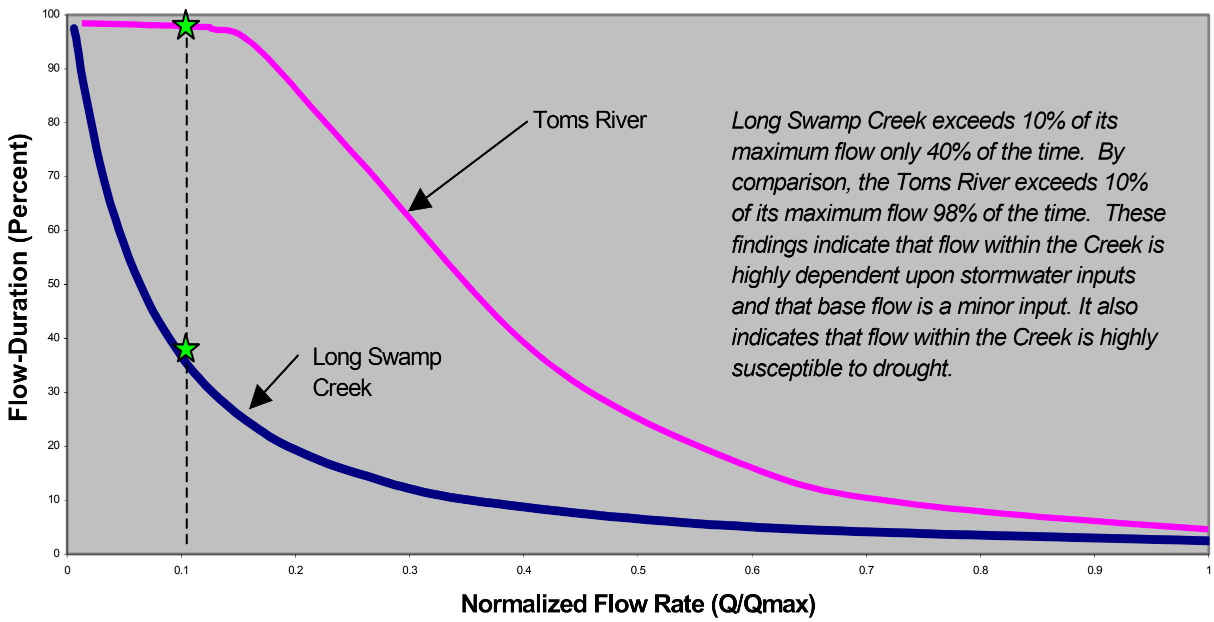


Figure 3: Flow-Duration Curve comparison of Long Swamp Creek and the Toms River.

Stormwater Outfalls. In general, most of the stormwater reaching Long Swamp Creek is delivered directly to the Creek via 50 known stormwater outfall pipes. The majority of this stormwater is untreated. Under natural conditions, most of this water would be infiltrated into groundwater. Further, the pipe networks that serve the outfalls enlarge the contributing basins to dimensions that would not be achieved under natural conditions. Consequently, stormwater from outlying areas is delivered directly to the creek without treatment *and* is delivered in greater quantities and with greater velocities.

Table 3 summarizes the magnitude of land area drained to the Creek via direct outfall stormwater pipes. As indicated in the Table, approximately 70% of the watershed is tied into the stormwater outfall delivery system.

Table 3 also indicates the percentages of land that is served by stormwater basins. As indicated in the table, about 1/3 of the watershed is served. The percentage is lowest for Subwatershed A, where development is the oldest, and is higher in Subwatersheds B and C, where development is newer and has been subject to stormwater management regulations.

Table 3: Summary of stormwater infrastructure influence in the Watershed. (*note that Subwatershed D was not analyzed because it does not contribute stormwater to Long Swamp Creek (see Section 2.7).*

Subwatershed	Percentage of Basin that is Drained via an Outfall Pipe that Delivers Directly to the Creek	Percentage of Basin Area Served by Stormwater Basins
A	91%	15%
B	93%	40%
C	50%	35%
Total Watershed	70%	33%

Long Swamp Creek has been significantly altered by the presence of hydraulic structures, including the following that affect water quality:

Impoundments. Long Swamp Creek has been impounded in eleven locations to form ponds / lakes. These features form standing water bodies in locations that would probably have only intermittent stream flow (at best) under normal conditions. The ponds serve as in-line detention basins and provide habitat for resident geese populations.

Culverts. Long Swamp Creek crosses primary roadways at nine locations. The culverts that convey water underneath the roadways have no water quality improvement function and increase local flow velocities. In several cases, the culverts act as impoundments during low-flow and drought conditions.

Diversion Structure. In the late 1970's, flow from the Long Swamp Creek was diverted to provide increased water supply to an embayment along the Toms River. Figure 4 illustrates the location and features of the structure, which lies within the undeveloped township property known as the "Brown Tract." This feature diverts the majority of dry water streamflow to an artificial drainage ditch that ultimately discharges to a tidal basin behind the Toms River Yacht Club. The drainage ditch receives direct contributions of stormwater from several catchments in addition to the water it receives as a result of the diversion. As a result, untreated stormwater is discharged directly to the enclosed tidal basin, which has poor flushing characteristics.

In an effort to characterize the impact of water discharge to the enclosed tidal basin, BEI performed a tidal flushing analysis utilizing the EPA method (USEPA, 1995). Considering local tides and the physical characteristics of the basin, it is estimated that the residence time of water within the basin is 12 days. Consequently, water that is delivered to the basin from Long Swamp Creek will not be flushed out for 12 days (based upon a 90% dilution criteria). Therefore, if the quality of the Long Swamp Creek water is poor (likely), it will have a significant impact upon water quality within the basin.

3.4 Other Root Causes

There are no confirmed additional causes for water pollution within the Long Swamp Creek watershed. The Root Causes report eliminated septic systems, groundwater, and point sources from consideration based upon credible evidence. Illicit connections or leaks of the sanitary sewer system remains a suspected source of bacteria pollution to Long Swamp Creek; however, no specific evidence is available to substantiate this theory.

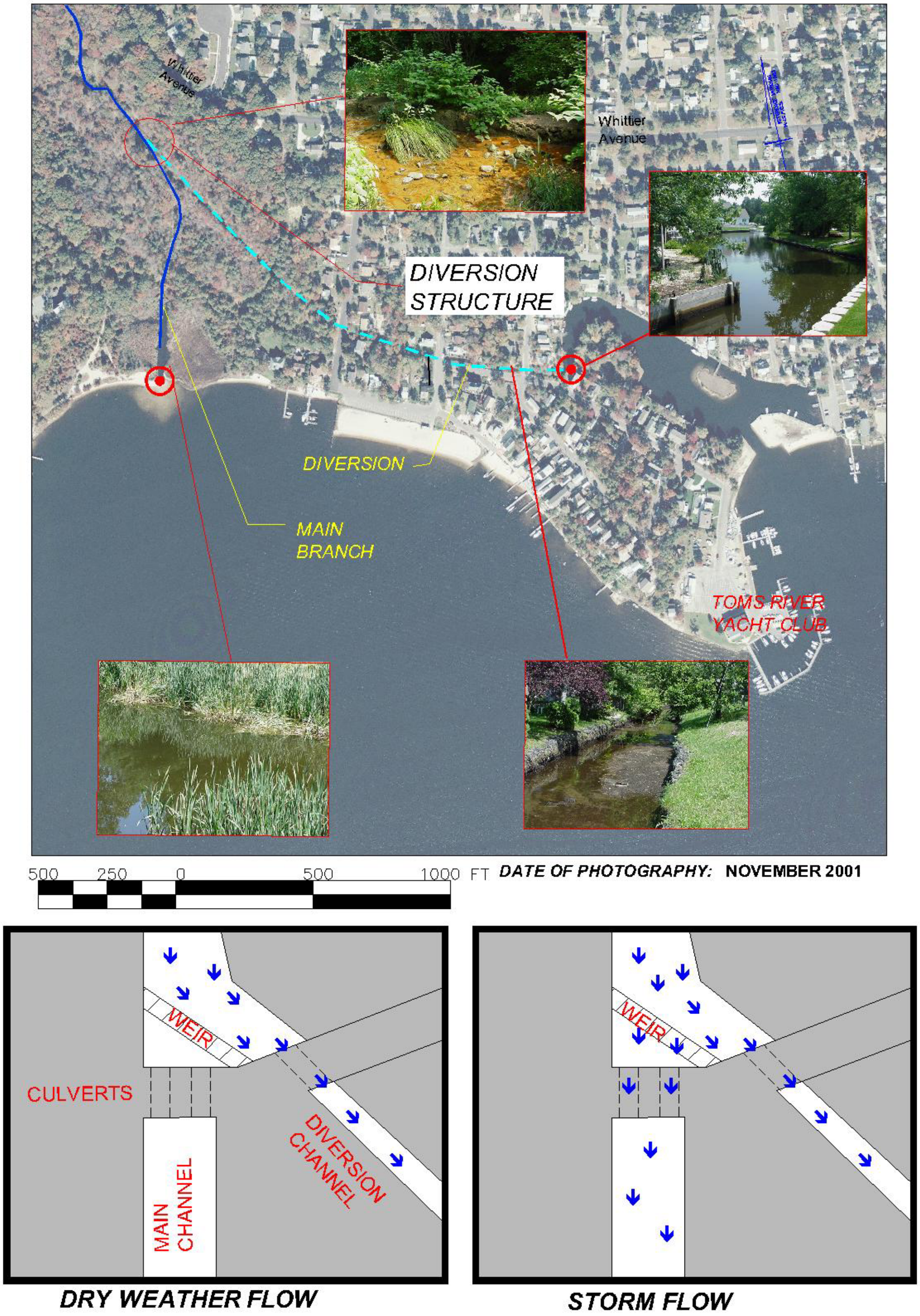


Figure 4: Summary illustration of the “Brown Tract” diversion structure.

4.0 WATERSHED DELINEATION

Objectives and strategies for water quality improvement vary significantly as a function of the watershed management unit (i.e. watershed, subwatershed, catchment, etc.). This study addresses water quality issues with respect to the following three levels of watershed resolution:

- **Watershed Level**: This level includes all land that drains to Long Swamp Creek.
- **Subwatershed Level**: Four subwatersheds have been delineated within the Long Swamp Creek watershed. Each of these units is composed of the land that drains to a physically unique reach of the Creek.
- **Catchment Level**: Each of the subwatersheds has been subdivided into community-level drainage basins (i.e. catchments). The catchments typically have well-defined drainage patterns and are of sufficiently small size to facilitate the identification of water quality impairment sources.

Detailed discussions of each of these levels are presented below.

4.1 Watershed Level Delineation

For purposes of this report, the Long Swamp Creek Watershed has been geographically defined as the area of land that drains stormwater towards the Long Swamp Creek bed. This is a typical watershed boundary definition; however, it is particularly relevant to the case of Long Swamp Creek because of the relatively insignificant role that groundwater contributes to the Creek's flow. Further, it is likely that consideration of groundwater would not significantly modify the watershed boundaries due to the fact that shallow groundwater flow in the area typically follows the general surface gradient.

The watershed boundary, which encompasses approximately 4,057 acres, is illustrated in Figure 4. The watershed's uppermost limit lies approximately 7 miles north of the Toms River; however, only the lowermost 4.5 miles of the watershed has a defined streambed. In general, this streambed lies at the center of the watershed and average watershed widths on either side of the stream are generally less than ½ mile. This configuration is narrow relative to other watersheds in the area, which is a factor that likely contributes to the lack of groundwater input to the streamflow.

4.2 Subwatershed Level Delineation

The scale of the subwatershed unit approximately divides the watershed into quarters (see Figure 5). This scale was not chosen arbitrarily. It is a result of careful investigation that revealed that the physical characteristics of the Creek and its adjacent land uses vary as a function of distance from the Toms River. This dependence is largely a result of man-made conditions. These influences include the construction of impoundments and other hydraulic structures; however, the primary factor is the chronological evolution of land development in Toms River, which proceeded from the waterfront toward the inland. Advancements in stormwater treatment regulation and technology paralleled this development trend.

Characteristics of each of the subwatersheds are described below.

Subwatershed A. This is the smallest subwatershed (599 acres); however, it is the only one that includes a regularly-flowing streambed. There are relatively few impoundment structures; therefore, stormwater that reaches the Creek may flow directly to the Toms River. In general, the Creek has a relatively large buffer in this subwatershed (compared to the other four). A mix of undeveloped private and public lands provides these buffers. The most significant buffer features include 1) a low-lying wetlands area between Route 37 and Washington Street, and 2) a large township-owned parcel between Washington Street and the Toms River. The significance of these buffers is not only related to their size and character. They are important because they present an opportunity to treat streamflow immediately before it enters the Toms River.

Subwatershed A contains the oldest and most dense development within the watershed. As noted previously, significant development within this area of Dover Township began near the Toms River and proceeded inland with time. The development within Subwatershed A is residential / commercial in nature and typically preceded the regulation of stormwater; therefore, most of the stormwater collected within the area is discharged directly to the Creek. The Route 37 corridor laterally bisects the watershed. Land use along this corridor is highly impervious and includes numerous automobile maintenance facilities and parking lots.

Subwatershed B. This is the largest subwatershed (1,519 acres). There are approximately 2.1 miles of streambed; however, the majority of it is inundated (55%) due to the presence of impoundment structures (55%). Base flow within this area appears to be negligible as evidenced by the low flow conditions observed upstream and between the impoundment structures.

The lowermost limit of the subwatershed is defined by an impoundment structure that limits the contribution of streamflow to Subwatershed A (and ultimately the Toms River). The ponds and lakes formed by the impoundment structures provide in-line storage and treatment of stormwater; however, they have also become a haven for geese. It is likely that they are net positive in terms of the water quality of discharge to the Toms River; however, they may result in locally poor stream water quality.

Subwatershed B is heavily developed with residential and commercial uses. In general, most development south of the Hooper Avenue corridor preceded stormwater management regulations; therefore, stormwater flows directly to the Creek. The Ocean County Mall, the Hooper Avenue Corridor, and the residential development located north thereof typically has stormwater detention/retention basins. Newer developments, which are “infilling” the undeveloped parcels south of Hooper Avenue generally have stormwater detention/retention basins.

Subwatershed B has the worst stream-buffering conditions of the four. Residential developments are typically sited immediately adjacent to the creek/lake shoreline.

Subwatershed C. This is the second largest subwatershed (1,007 acres). It lies predominantly between the Garden State Parkway and the Bey Lea Golf Course (inclusive). There are approximately 2.1 miles of defined streambed; however, there is no baseflow. The stream essentially acts as a drainage ditch except for the presence of several in-line ponds that are located within the Bey Lea Golf Course property.

Subwatershed C is the least developed of the four. This condition is primarily due to the presence of the Bey Lea Golf Course, which occupies approximately 15% of the total land area. The relatively low development intensity is also due to the fact that individual lot sizes in the area are large, and conservation easements have been established to provide a buffer for the Creek. These conditions are reflective of the relative youth of the area's development. Another feature of the development vintage is the presence of two regional stormwater basins and other stormwater management infrastructure.

Subwatershed D. This is the uppermost subwatershed and the third largest (932 acres). It has no defined streambed; therefore, its only apparent contribution to the streamflow of Long Swamp Creek is via groundwater contributions.

There is a relatively high percentage of developed land within Subwatershed D, and a majority of the development has occurred within the last two decades. The development is almost exclusively residential related and is of a relatively low density due to the large lot sizes. Significant open space parcels remain and are likely the target of future development. In general, stormwater management is provided for most of the recent development.

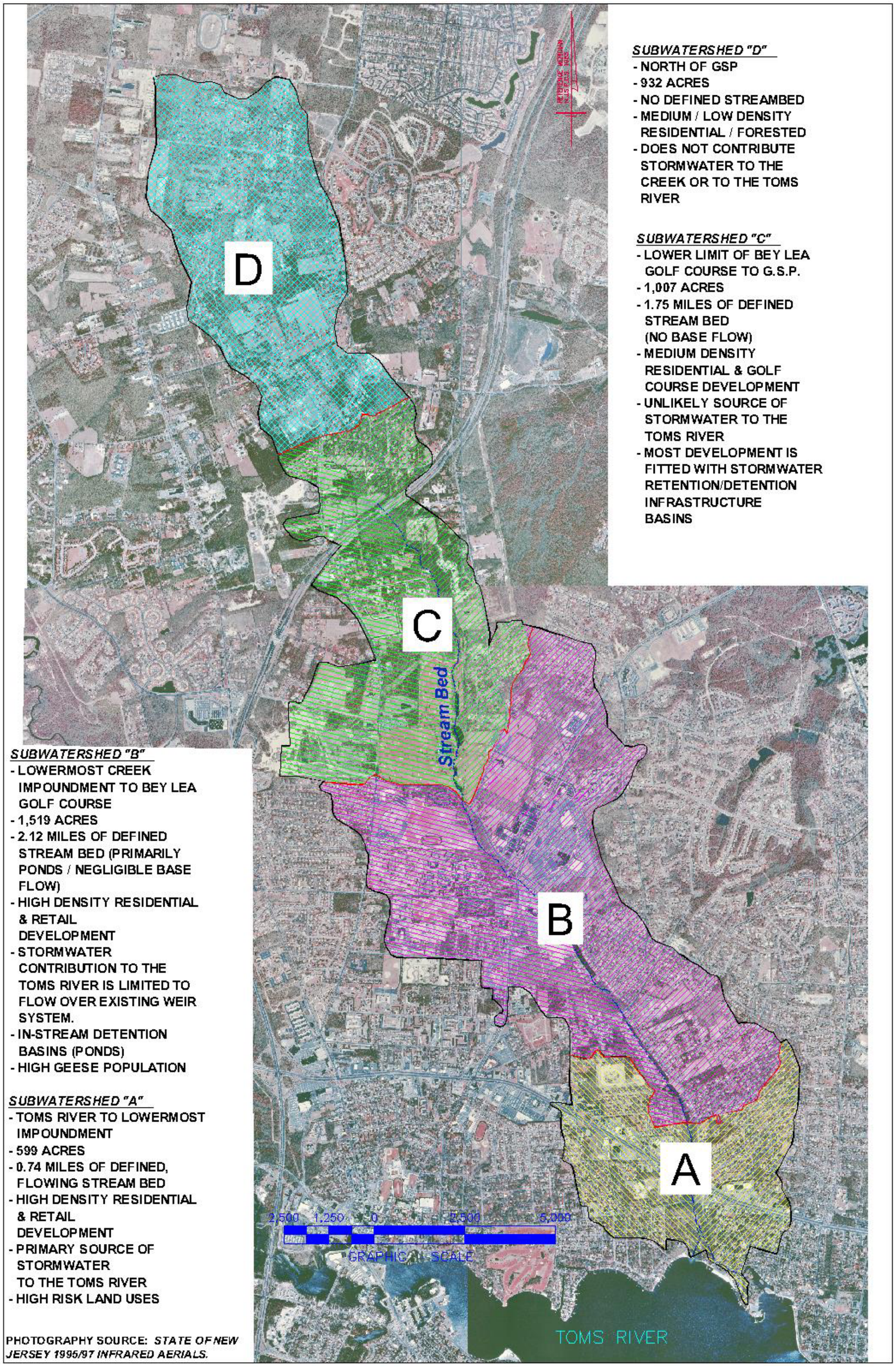


Figure 5: Subwatershed Delineation of Long Swamp Creek Watershed.

4.3 Catchment Level Delineation

Subwatersheds A, B and C have been divided into catchment units as illustrated in Figures 6, 7 and 8. The catchments are the "grass roots" component of the watershed and their boundaries have been defined with detailed fieldwork and analysis of high resolution aerial photography. The catchment unit is particularly useful for identifying "hot spot" drainage areas and for refining the scale of watershed management to a level that is manageable by local community groups and individuals. The catchment unit is also typically small enough to limit the number of unique pollutant sources; therefore, management decisions can be focused and conflicts minimized.

There are 42 individual catchments within the watershed, with typical drainage areas of 50 to 200 acres. Note that there are no catchments within Subwatershed D, due to the fact that it does not contribute stormwater flow to Long Swamp Creek. Detailed analysis presented in the Root Cause identified surface water hydrology for each catchment. Figure 9 is a typical depiction of the Root Cause hydrologic presentation of Subwatershed D. Using November 2001 aerial photography and field investigation, the land use and impervious cover within each of the catchments has been determined and was utilized to compute simplistic estimates of runoff and associated pollutant loadings. The Catchment Area base maps (see attached example Figure 10), which are included in the Root Cause report, summarize this information.

Appendix A of this report includes high resolution aerial photography and hydrologic patterns for each catchment.

4.4 Summary

As noted above, the three levels of watershed management defined herein (watershed, subwatershed & catchment) provide a means for addressing water quality improvement at various scales. The larger scales (watershed, subwatershed) facilitate the address of global issues such as the quality of the Creek's discharge to the Toms River. Solutions to these issues are likely to require efforts that are beyond the economic and logistic means of the local community and will require action by municipal, county, state and federal entities. In contrast, solutions at the catchment-level are likely to span a broad range of costs and complexity that will be inclusive of local and individual means.

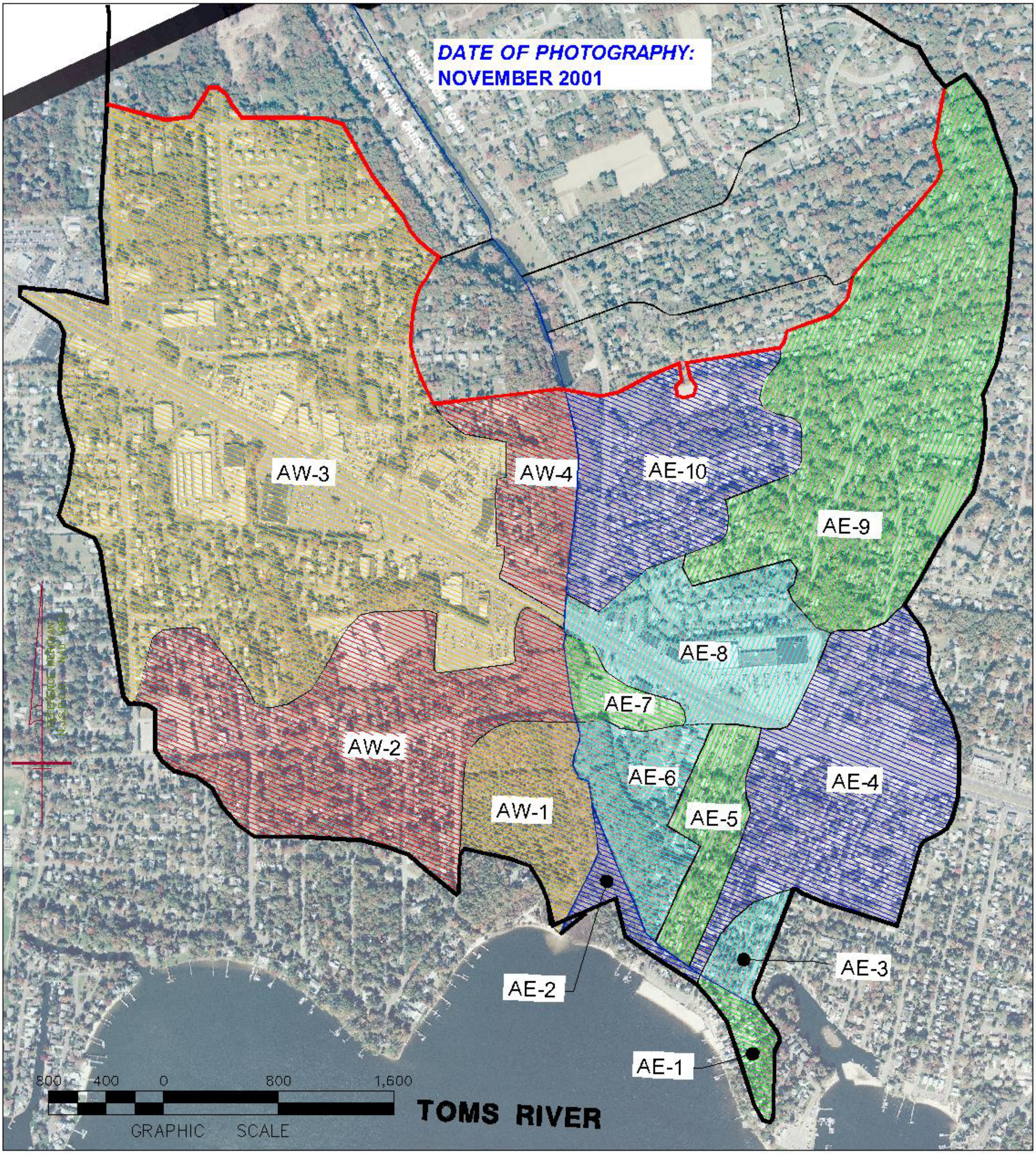


Figure 6: Catchment delineation with Subwatershed A.

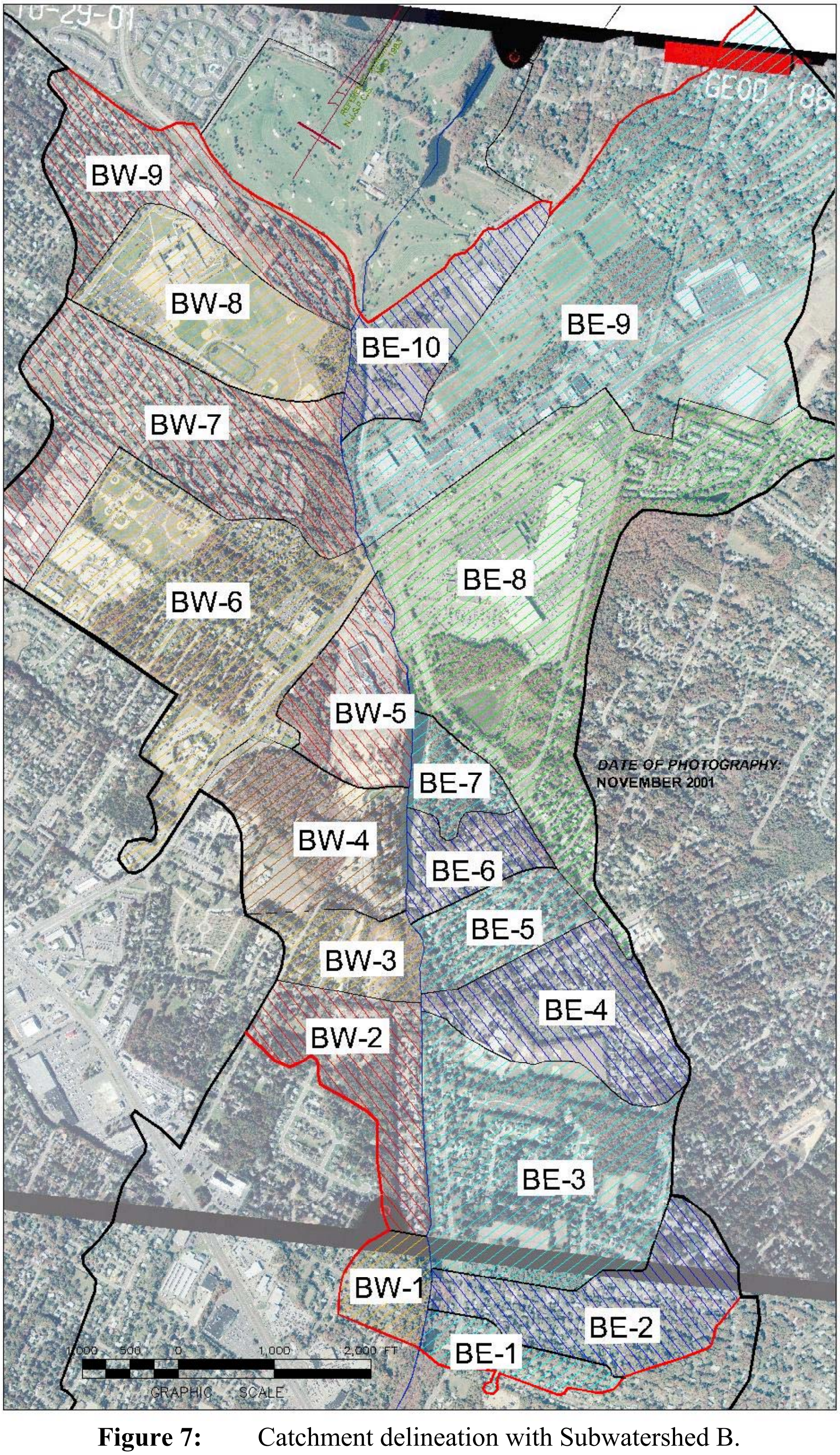


Figure 7: Catchment delineation with Subwatershed B.

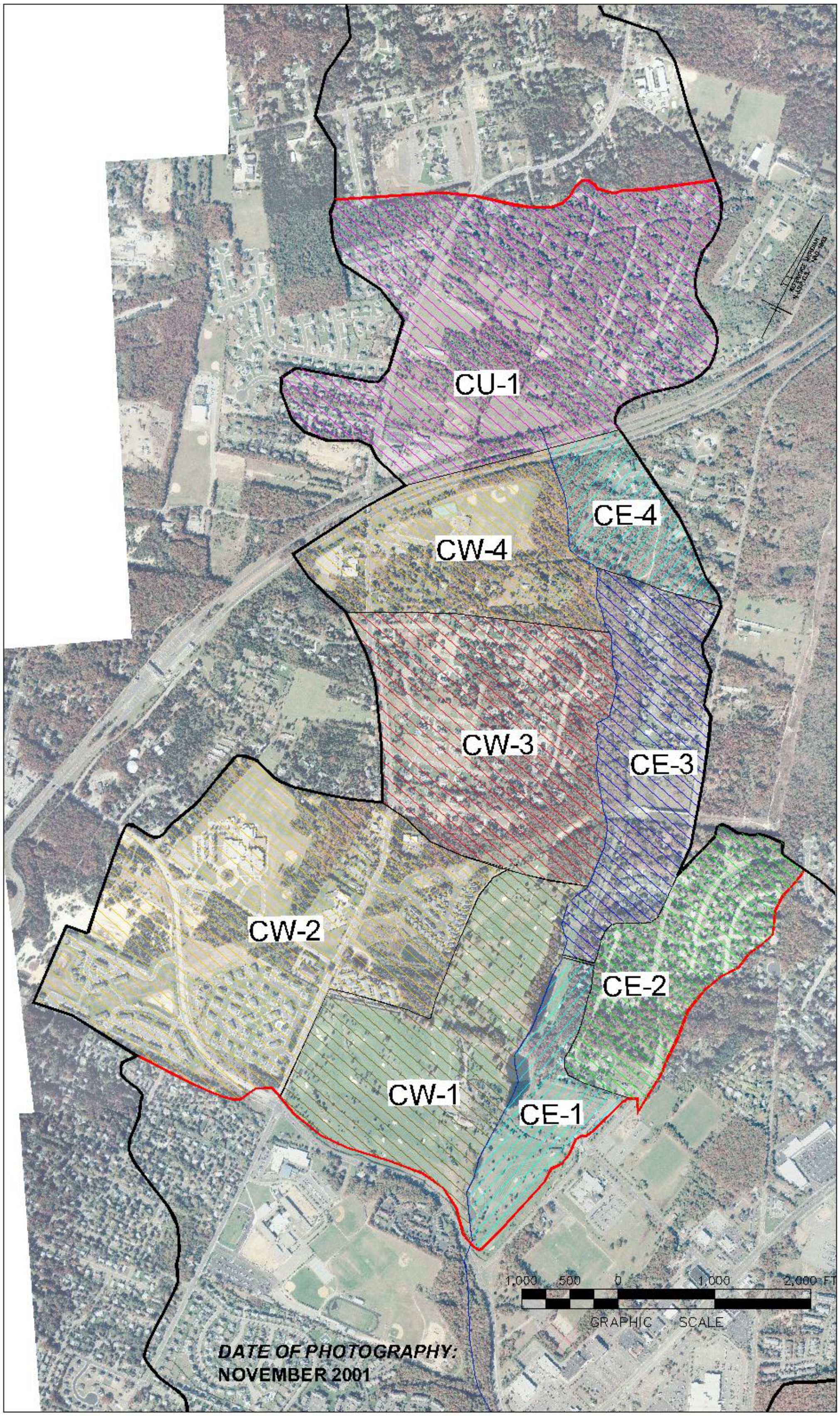


Figure 8: Catchment delineation with Subwatershed C.

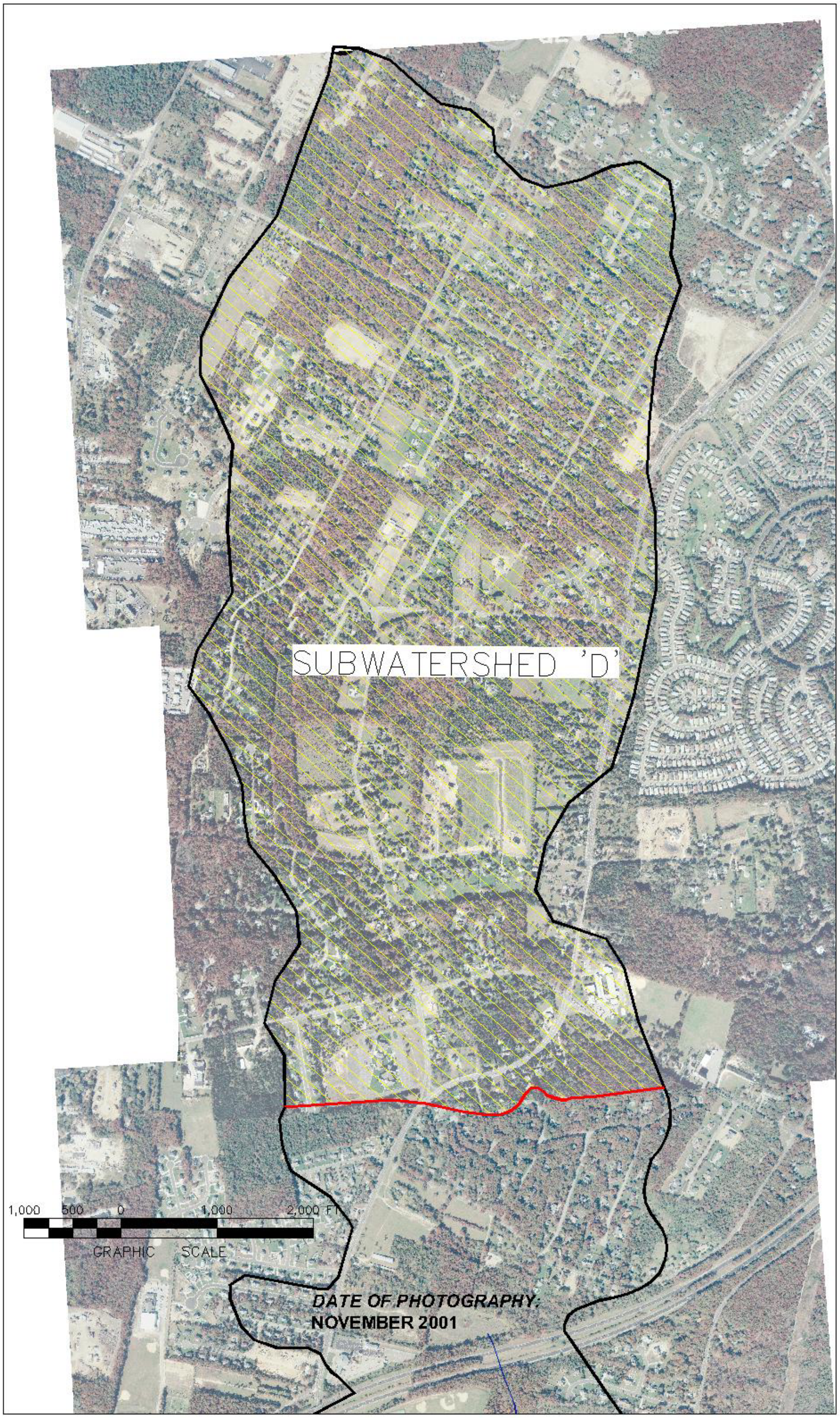
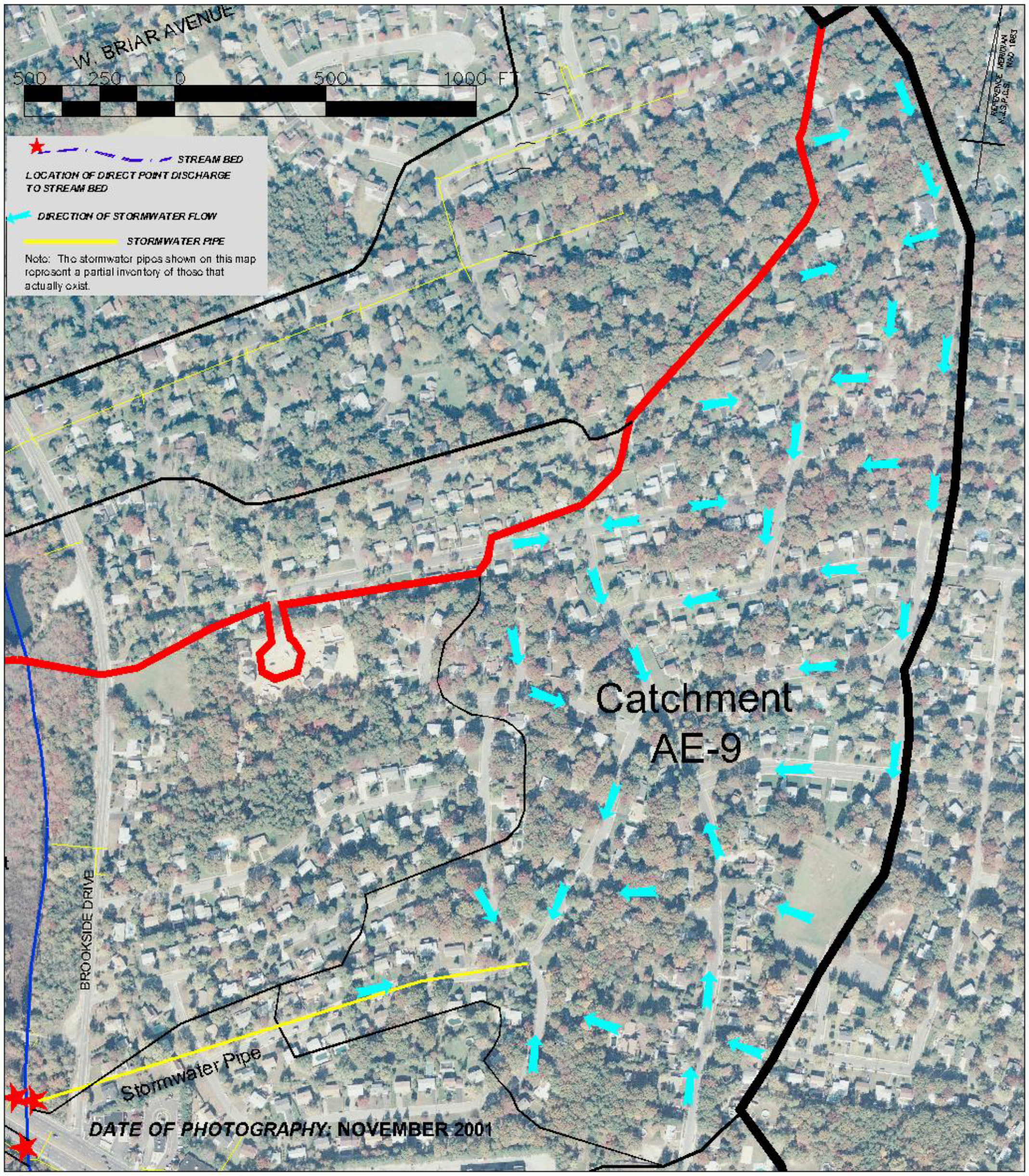


Figure 9: Subwatershed D.



NARRATIVE

Catchment AE–9 encompasses approximately 91 acres. With the exception of a 2.5 acre–park, the entire catchment is developed with medium/high density residential. The catchment has no frontage along Long Swamp Creek; however, stormwater from catchment is delivered to the Creek via a 60" dia. pipe (see photo). Stormwater is fed to this pipe via overland flow on the existing street system.

The stormwater pipe outfall exists in a small area bound by Route 37, Brookside Drive, and Batchelor Street. The outfall is located approximately 40 feet from the defined stream channel. Its discharge flows along a drainage ditch before reaching the Creek.

RISK FACTORS
Point Discharges to Streambed
Untreated Direct Discharge of Stormwater
High Development Percentage (97%)
High Impervious Coverage (34%)
No Stormwater Treatment

POSITIVE FACTORS
None

CATCHMENT AE-9
AREA = 91 ACRES
97% med./high dens. residential
3% open space
ESTIMATED TOTAL IMPERVIOUS AREA = 31 ACRES (34 %)
TOTAL DEVELOPED AREA = 88 ACRES (97 %)

Figure 10: Typical Catchment Delineation and Characterization.

5.0 RISK-BASED WATERSHED ASSESSMENT

5.1 Methodology

In order to facilitate an effective program for water quality improvement, the relative degrees of watershed impairment were identified in the Root Cause report. Specifically, an evaluation and comparison of individual catchments and subwatersheds was determined based upon the following variables.

- Proximity to the Toms River
- Impervious Coverage
- Developed Percentage
- Aquatic Buffers
- High Risk Land Uses
- Existing Water Quality Infrastructure
- Future Development Potential
- Goose Populations
- Soil Erosion
- Theoretical Pollutant Loads
- Point Discharges to Creek
- Other Variables

Ratings have been assigned to the individual catchments for purposes of comparison. These ratings are based upon the color-coded system described below:

Red – High Risk
Yellow – Median Risk
Green – Low Risk

The following sections of this report present hundreds of action items that are intended to improve water quality. The ratings presented below will serve as a tool to assist watershed management providers as they make the difficult decision of prioritizing available resources.

It is recognized that the assignment of risk ratings is largely a subjective process. BEI has assigned these ratings based upon our knowledge and study of the watershed. Other interested parties could make a similar risk-based assessment using the data presented in the Root Cause report. Further, the rating exercise can be updated in the future based upon changes in conditions. Tables 4, 5 and 6 illustrate the risk variable ratings for each of the catchments within Subwatersheds A, B and C.

Table 4 Catchment A Risk Ratings

Catchment	RISK RATINGS												
	Proximity to the Toms River	**Impervious Coverage**	**Developed Percentage**	**Adequacy of Aquatic Buffers**	**High Risk Land Use**	**Water Quality Infrastructure**	**Future Development Potential**	**Goose Population**	**Soil Erosion**	**Theoretical Pollutant Loads**	**Point Stormwater Discharge to**	**Other**	**Overall Rating**
AE-1												1,4	
AE-2												1	
AE-3												1,4	
AE-4												1,4	
AE-5												1,4	
AE-6												1	
AE-7												4	
AE-8												4	
AE-9												3	
AE-10												2,4	
AW-1												1	
AW-2												2,4	
AW-3												4	
AW-4												1	

Footnotes for "Other" Category:

1. Water quality degradation resulting from diversion of Long Swamp Creek in the "Brown Tract"
2. Water quality degradation resulting from trash and debris in the stream.
3. Site of known high fecal coliform discharge to the Creek.
4. Street crossing of the Creek.

Table 5 Catchment B Risk Ratings

Catchment	RISK RATINGS												
	Proximity to the Toms River	Impervious Coverage	Developed Percentage	Adequacy of Aquatic Buffers	High Risk Land Use	Water Quality Infrastructure	Future Development Potential	Goose Population	Soil Erosion	Theoretical Pollutant Loads	Point Stormwater Discharge	Other	Overall Rating
BE-1													
BE-2													
BE-3												1	
BE-4												2	
BE-5													
BE-6													
BE-7													
BE-8												2	
BE-9												2	
BE-10													
BW-1													
BW-2												1	
BW-3												2	
BW-4												1	
BW-5												2	
BW-6												2	
BW-7													
BW-8													
BW-9												2	

Footnotes for "Other" Category:

1. Habitat / Water Quality degradation resulting from bulkheaded shoreline.
2. Habitat / Water Quality degradation resulting from road crossing of stream.

Table 6 Catchment C Risk Ratings

Catchment	RISK RATINGS												
	Proximity to the Toms River	Impervious Coverage	Developed Percentage	Adequacy of Aquatic Buffers	High Risk Land Use	Water Quality Infrastructure	Future Development Potential	Goose Population	Soil Erosion	Theoretical Pollutant Loads	Point Stormwater Discharge	Other	Overall Rating
CE-1													
CE-2													
CE-3													
CE-4													
CW-1													
CW-2													
CW-3													
CW-4													
CU-1													

6.0 WATERSHED LEVEL WATER QUALITY ACTION ITEMS

This section presents BEI's recommended action items for water quality improvement at the watershed level. Some researchers maintain that this is the only level in which water protection initiatives can be effective (CWP, 1998).

As noted previously, addressing water quality at the watershed scale facilitates the consideration of "global" issues such as the quality of the Creek's discharge to the Toms River. Solutions to these issues are likely to require efforts that are beyond the economic and logistic means of the local community and will require action by municipal, county, state and federal entities.

BEI believes that an effective water quality improvement plan requires the specification of specific projects. Although general implementation of best management practices (BMPs) and community education are important components of a comprehensive plan, we assume that these efforts will be pursued irrespective of this study.

The following list of represents BEI's recommended action items for water quality improvements at the watershed level. It is noted that the list is expected to evolve with time as project are completed, deemed infeasible, or unnecessary. By maintaining an updated list, the community will be able to set goals and plan for works in the future.

- **RATS (River Assessment Teams) & BATS (Biological Assessment Teams)**

The DEP's Division of Watershed Management (DWM) has launched its new volunteer watershed monitoring programs, *RATS* and *BATS*, which were inspired by ongoing water monitoring programs that are performed by environmental groups and watershed associations throughout the state. *RATS* and *BATS* volunteer teams monitor New Jersey's waterways through visual assessment techniques, mapping or macroinvertebrate surveys. The formulation of *RATS* and *BATS* volunteer teams should be considered for the Long Swamp Creek watershed. The Long Swamp Creek teams must first participate in a DWM-sponsored workshop and then are able to collect data and provide it to DWM. The data that is collected will be made available to other organizations and will be used by DEP when prioritizing watershed restoration projects. This data can then be applied directly to implementation projects outlined within this report.

❖ Creek Diversion

In the late 1970's, flow from the Long Swamp Creek was diverted to provide increased water supply to an embayment along the Toms River. This feature, located within the "Brown Tract," diverts the majority of dry weather streamflow to an artificial drainage ditch that ultimately discharges to a tidal basin behind the Toms River Yacht Club. The drainage ditch receives direct contributions of stormwater from several catchments in addition to the water it receives as a result of the diversion. As a result, untreated stormwater is discharged directly to the enclosed tidal basin, which has poor flushing characteristics. An in-depth analysis of the function of this diversion structure should be conducted in order to determine mitigation measures.

❖ Regional Stormwater Plan Implementation

As described within the NJDEP Division of Watershed Management's Guidance for Regional Stormwater Management Plan Development, a regional stormwater management plan addresses stormwater related water quality and water quantity impacts of new and existing uses in a drainage area; is developed on a drainage area basis; and, is not limited to on-site stormwater management measures.

Regional stormwater plan implementation has been successful within the Long Swamp Creek watershed. Future efforts should be made, where practicable, to continue with these efforts relative to both existing and future development.

❖ TMDL Development

Total Maximum Daily Loads (TMDL) specify the maximum amount of a pollutant that a waterbody can receive and still meet State water quality standards while also allocating pollutant loadings among point and nonpoint pollutant sources. TMDL's are developed as a mechanism for identifying all the contributors to surface water quality impacts while setting goals for load reductions for pollutants of concern as necessary to meet State water quality standards. TMDL's should be established for Long Swamp Creek in coordination with TMDL efforts for the Toms River.

❖ Stormwater Basin Improvements/Maintenance

In accordance with the *Revised Manual for New Jersey: Best Management Practices for Control of Nonpoint Source Pollution from Stormwater* (BMP Manual), maintenance of existing stormwater management facilities is an issue that is too often overlooked by responsible parties. Proper construction of new, and maintenance of existing, stormwater management facilities within the Long Swamp Creek watershed will significantly increase the efficiency and reduce any inherent maintenance problems with these structures. Inspection plans and checklists should be developed in accordance with the BMP Manual for all stormwater management facilities that currently do not have such a plan.

❖ **Public Outreach and Education**

As part of the Public Outreach Program of this project, the Dover Township Environmental Commission produced a publication entitled "What You Can Do To Prevent NonPoint Source Pollution in Dover Township." The Commission printed 29,000 copies of this publication for distribution to the Township of Dover, of which 2,797 were mailed directly to each household within the Long Swamp Creek Watershed. In addition, as part of this program, the Dover Township Environmental Commission developed a study to determine the effectiveness of the nonpoint source pollution outreach materials.

As an integral part of the ongoing effort to address NPS pollution within the Long Swamp Creek watershed, it is recommended that a public education and outreach program, similar to the efforts described above, be conducted in conjunction with the future implementation of priority action items described within this report. Additional public education and outreach programs may consist of the distribution of this water quality improvement plan on CD to local library branches and/or website demonstrations to local community groups and schools.

❖ **Water Quality Sampling**

Water quality sampling is essential to the continued success of the Long Swamp Creek Water Quality Improvement Plan, both in targeting potential sources of NPS pollution and developing future implementation strategies, as well as documenting successes or failures of implementation projects conducted throughout the watershed.

Past water quality monitoring efforts performed by the NJDEP Bureau of Marine Water Quality Monitoring have identified four locations within Long Swamp Creek with elevated concentrations of pollutants.

As part of initial plan efforts, attempts were made for the NJDEP to expand its initial monitoring efforts to the remainder of the watershed. Due to budget constraints, the NJDEP was unable to perform additional monitoring in the watershed in support of on-going plan efforts.

Recognizing that supporting water quality data is essential to the continued success of this plan, it is recommended that the Township pursue additional sources that will be capable of providing strategic water quality data to target additional sources of NPS pollution, as well as continue to monitor implementation projects conducted throughout the watershed.

It is recommended that a Long Swamp Creek Water Quality Database be created in order to track all historical, current and future water quality data collected within the watershed, regardless of whom it is collected by.

The following potential sources for future water quality monitoring should be pursued:

1. Ocean County Health Department – Water Quality Summer Sampling Program;
2. NJDEP – Bureau of Marine Water Quality Monitoring; and,
3. Additional 319(h) funding for sampling in conjunction with particular implementation projects.

The following are additional sources with past water quality data for Long Swamp Creek that should be researched and input into the Long Swamp Creek Water Quality Database:

1. NJDEP – Bureau of Marine Water Quality Monitoring; and,
2. U.S.G.S.

7.0 SUBWATERSHED LEVEL WATER QUALITY ACTION ITEMS

This section presents BEI's recommendations for water quality improvement action items at the subwatershed level. Within the Long Swamp Creek watershed, the subwatershed management level facilitates improvement of in-stream water quality through implementation of action items that are of a local nature, yet are beyond the economic and logistical means of community-level organizations.

The defining goal of the *subwatershed* improvement plan is to improve local water quality. By default, local water quality improvements will aid the "global" goal of reducing pollutants discharged to the Toms River; however, the local improvements will have realizable impacts upon a neighborhood's section of the Creek. For example, a constructed wetland is proposed as part of the Watershed Level action items. This wetland will improve water quality downstream, but not have an appreciable impact in the area of the project. In contrast, control of goose populations in the in-stream lakes will have a significant impact upon water quality within those lakes.

The following lists represent BEI's recommended action items for water quality improvements at the subwatershed level. These recommended action items are not listed in order of priority and were derived from the items reoccurrence within the combined catchment areas throughout each subwatershed. More information about these action items can be found in the catchment level tables (Tables 7-9) and in the Priority Action Items/Implementation Project List located in Section 9.0. It is noted that the lists are expected to evolve with time as projects are completed, deemed infeasible, or unnecessary. By maintaining an updated list, the community will be able to set goals and plan for works in the future.

Subwatershed A Action Item Recommendations

- Litter/Debris Removal
- Public Outreach and Education
- Open Space Preservation
- Water Quality Basin Construction
- Inlet Filters

Subwatershed B Action Item Recommendations

- ❖ Litter/Debris Removal
- ❖ Public Outreach and Education
- ❖ Open Space Preservation
- ❖ Goose Management
- ❖ Inlet Filters

Subwatershed C Action Item Recommendations

- ❖ Expansion of Existing Riparian Buffers
- ❖ Public Outreach and Education
- ❖ Open Space Preservation
- ❖ Goose Management
- ❖ Exposed Soil Stabilization

8.0 CATCHMENT LEVEL WATER QUALITY ACTION ITEMS

This section presents BEI's recommendations for water quality improvement action items at the catchment level. As mentioned previously, the catchment management level provides a "grass roots" level for water quality improvement. Recommended projects can typically be implement by municipal or community organizations, and some projects can be undertaken at the individual level. The catchment level has the added benefit of identifying a local community's features and lifestyle habits that affect water quality. In this manner, the entire community can be enfranchised in the cleanup of the Creek.

The defining goal of the *catchment* action items is to reduce or eliminate the *source* of water pollutants in a community. As noted previously, the vast majority of pollutant sources for Long Swamp Creek are explicitly related to residential and commercial development. Although reversal of that development is not an option, action items can be implemented to reduce its effects.

At the catchment level, there are several action items that are valid throughout the entire watershed. These include public education, pet waste management, control of fertilizer use, and other best management practices (BMPs). However, each catchment also has unique action items that range from open space preservation to erosion control.

Tables 7 through 9 summarize BEI's recommended action items for water quality improvements at the catchment level. The reader should reference the companion web site to view more detailed photos of the individual project items.

CATCHMENT	PHOTO #	LOCATION	OBSERVED IMPACTS: Eroded Banks	Blocked Flow	Oil Sheen	Sedimentation	Dense Geese Population	Fertilizer Application	Litter	Pet Waste	Exposed Soils	Lack of Stormwater Management	IMPLEMENTATION PROJECTS
AE-1	118	Holmes and Longfellow						X	X	X			Inlet filters Litter removal Expansion of existing riparian buffer
	119	Holmes						X		X			Inlet filters Expansion of existing riparian buffer
	120	Summit Avenue and Summit Place						X	X	X			Inlet filters Litter removal
AE-2	117	Brown Tract		X		X			X				Litter and debris removal
AE-3	121	Holmes and Tennyson						X		X			Expansion of existing riparian buffer
	122	Tennyson and Bryant						X		X			Inlet filters
AE-4	20 A&B	Longfellow Discharge Point		X		X		X	X	X			Litter removal Stream bank stabilization plantings Possible minor dredging to remove accumulated silt blocking stream flow Public outreach and education
	21	Burns Avenue						X		X			Public outreach and education
	22	Partridge Road											Potential open space preservation
	23	Partridge Road											Potential for water quality basin
AE-5	19	Keats Avenue						X		X			Public outreach and education
AE-6	37 A & B	"Brown Tract" Diversion Structure		X		X							Stream cleaning Diversion structure removal Litter removal Flow redirection to natural channel Investigation of the integrity/vulnerability of sanitary sewer crossing Potential for water quality basin
AE-7	35	Wallgreens Basin							X				Litter removal Discard of grass clippings next to Creek
	36 A-C	Route 35 Culvert		X	X	X			X				Inlet filters Litter removal Oil skimmers Debris removal
AE-8	5	Bob Kislin's Sporting Goods										X	Inlet filters Retrofit parking islands for possible water quality basin construction Potential for vegetated water quality swales Parking lot litter removal Street sweeping Potential for water quality basin
	6	Kingsley Court						X		X		X	Inlet filters

CATCHMENT	PHOTO #	LOCATION	OBSERVED IMPACTS										IMPLEMENTATION PROJECTS
			Eroded Banks	Blocked Flow	Oil Sheen	Sedimentation	Dense Geese Population	Fertilizer Application	Litter	Pet Waste	Exposed Soils	Lack of Stormwater Management	
													Public outreach and education Non point Source Pollution Public Survey administered to residents
AE-9	7	Glenwood Circle						X		X			Inlet filters Public outreach and education
AE-10	1	Corner of Brookside & Batchelor						X			X		Potential for upland water quality basin Potential for vegetated water quality swales
	2	Batchelor Avenue				X					X		Inlet filters Inlet filters Increase street sweeping
	3	Residential area near Castle Drive						X		X		X	Inlet filters Non point Source Pollution Public Survey administered to residents Public outreach and education
	4	Craven Road											Potential forest open space preservation
		Brookside Drive Outlet											Water quality sampling for fecal coliform/streptococus
AW-1	114	Brown Tract	X	X									Remove diversion structure Stabilize banks
	115	Brown Tract		X									Inspect integrity and evaluate extent of exposed sanitary sewer line
	116	Brown Tract											Potential for construction of water quality basin
AW-2	16	Washington Street				X		X	X	X			Potential for constructed wetland water quality basin Potential for vegetated water quality swales
	17	Woodlands along Washington Street											Potential forest open space preservation
	18	Cedar & Holly						X		X			Public outreach and education
AW-3	10	End of Longview Drive											Potential for open space preservation
	11	Holiday Inn Jug Handle Island											Potential for water quality basin
	12	Ocean Chevrolet Commercial Area										X	Inlet filters
	13	Hollywood Avenue						X		X		X	Inlet filters Public outreach and education
	14	Washington Street Elementary School											Potential open space preservation
	15	Super Stop and Shop			X	X			X				Inlet filters Oversized parking lot could be converted to water quality basin Potential for vegetated water quality swales Litter removal
AW-4	8	Hill Road						X		X			Public outreach and education Potential riparian corridor preservation
	9	White Cedar Road									X		Potential open space preservation

CATCHMENT	PHOTO #	LOCATION	OBSERVED IMPACTS										IMPLEMENTATION PROJECTS
			Eroded Banks	Blocked Flow	Oil Sheen	Sedimentation	Dense Geese Population	Fertilizer Application	Litter	Pet Waste	Exposed Soils	Lack of Stormwater Management	
BE-1	43-47	End of Raliegh Road				X			X		X		Stabilization of exposed soils Potential for vegetated water quality swales Litter removal Expansion of existing riparian buffer Dredging to remove existing sediment plume
	48, 50-52	End of Raliegh Road		X	X	X			X				Litter removal Create pond/lake management plan Possible lake dredging
	49	End of Raliegh Road							X				Litter removal Block access through cleared area
BE-2	56	Ocean View Road	X							X		X	Inlet filters Bank stabilization Public outreach and education
	57-58	Impoundment at end of Ocean View		X	X	X	X		X				Litter removal Oil skimmers Anti goose measures
BE-3	59	Brookside Drive		X			X	X					Anti goose measures Stream bank stabilization/plantings Litter removal Public outreach and education Pond/lake management plan
	60	Brookside Drive											Potential for open space preservation
	61	Brookside Drive						X					Public outreach specifically on agricultural impacts
	62	West Briar Avenue						X		X			Public outreach and education
	63	Schoolhouse Lane											Potential for open space preservation
BE-4	64 A & B	Cedar Grove Road	X	X	X	X							Inlet filters Stream bank stabilization Litter removal Oil skimmers
	65	Cedar Grove Road						X					Public outreach specific to agricultural impacts
	66	Twin Oakes Road						X		X			Inlet filters Public outreach and education
	67	Transom Court											Potential for open space preservation
BE-5	68	Sharon Drive						X		X		X	Public outreach and education
	69 A & B	End of Sharon Drive		X		X							Debris removal Outfall reconstruction Rip-rap stabilization of discharge area
	70	End of Sharon Drive											Potential open space preservation

CATCHMENT	PHOTO #	LOCATION	OBSERVED IMPACTS										IMPLEMENTATION PROJECTS
			Eroded Banks	Blocked Flow	Oil Sheen	Sedimentation	Dense Geese Population	Fertilizer Application	Litter	Pet Waste	Exposed Soils	Lack of Stormwater Management	
	72	Lester Road		X			X	X	X	X			Inlet filters Litter removal Anti goose measures along shoreline Debris removal Expansion of existing riparian buffer Public outreach and education
BE-6	71	Lester Road											Public outreach and education
BE-7	73	Brookside Court						X		X			Public outreach and education
	74	Bay Avenue											Potential open space preservation
	75	Bay Avenue				X	X		X				Litter removal Oil skimmers at outfalls Pond/lake management plan with anti goose measures
BE-8	24	Wooded area adjacent to OC Mall											Potential for open space preservation
	25 A-C	Regional basin adjacent to OC Mall		X									Inspect drainage pipes for blockage
	26	Ocean County Mall				X			X				Inlet filters Litter removal Street sweeping
	27	Condo retention basin						X	X	X			Litter removal Inspect drainage pipes for blockage Public outreach and education
	28 A & B	Seacourt Pavilion	X	X	X	X	X						Inlet filters Soil and shoreline stabilization Litter removal Oil skimmers Inspect drainage pipes for blockage
	28 C & D	Seacourt Pavilion											Freshwater clam seeding Lake water quality monitoring
	28 E	Seacourt Pavilion											Biological control of purple loosestrife
	29	Bow Road						X		X			Public outreach and education
BE-9	85	Oak Ave south of Hooper Ave									X		Stabilization of exposed soils Potential open space preservation
	86	Feathertree Drive						X		X			Inlet filters Public outreach and education
	87	Sehenck's Mill Line Road											Potential open space preservation
	88	Oak Avenue Soccer Complex					X	X		X			Public outreach and education Pet waste disposal bag receptacles Anti goose measures
BE-10	89	Bey Lea Park					X	X		X			Anti goose measures

CATCHMENT	PHOTO #	LOCATION	OBSERVED IMPACTS										IMPLEMENTATION PROJECTS
			Eroded Banks	Blocked Flow	Oil Sheen	Sedimentation	Dense Geese Population	Fertilizer Application	Litter	Pet Waste	Exposed Soils	Lack of Stormwater Management	
													Public outreach and education
BW-1	53	Hill Road						X	X	X			Litter removal Public outreach and education
	54	End of Hill Road											Potential for open space preservation
BW-2	42	Brookside Drive		X	X	X	X	X	X	X			Litter removal Oil skimmers Pond/lake management plan including aerators and macro algae management
	55	McCormick Street						X	X	X			Inlet filters Litter removal Public outreach and education
BW-3	40	Frann Road						X		X			Inlet filters Public outreach and education
	41	Frann Road				X							Stabilization of exposed soils
BW-4	34	Across from Commerce Bank											Potential for open space preservation
	38	Lester Road											Potential for open space preservation
	39	Lester Road						X		X			Inlet filters Public outreach and education
BW-5	30	Seacourt Pavilion					X		X		X		Replenish rip-rap at outfall across from Marshall’s Anti-goose/fencing or vegetative buffer Inlet filters for parking lot Litter removal
	31	Seacourt Pavilion							X		X		Inlet filters Litter removal Either revegetate or stop mowing area to restrict goose access
	32 A & B	Seacourt Pavilion									X		Inlet filters Soil stabilization due to heavy ATV use
	33	Seacourt Pavilion											Potential open space preservation
BW-6	76	Toms River Little League						X	X		X		Litter removal Minimize fertilizer and pesticide application Stabilization of exposed soils
	77	Toms River Corporate Center			X	X			X				Inlet filters Litter removal Street sweeping
	78	Maimone Street						X	X	X			Public outreach and education Litter removal
	79	Across from Sea View Court							X				Litter removal – illegal dumping taking place Potential for open space preservation
	80	Across from Ocean County Mall		X		X			X				Inlet filters

CATCHMENT	PHOTO #	LOCATION	Eroded Banks	Blocked Flow	Oil Sheen	Sedimentation	Dense Geese Population	Fertilizer Application	Litter	Pet Waste	Exposed Soils	Lack of Stormwater Management	IMPLEMENTATION PROJECTS
													Litter/debris removal
BW-7	81	Dover Meadows						X	X	X			Street sweeping
													Public outreach and education
													Litter removal
	82	East of Dover Meadows											Potential for open space preservation
	84	Toms River North		X		X			X				Potential for water quality basin
													Potential for vegetated water quality swales
													Stream bank stabilization
													Litter removal
BW-8	83	Toms River North						X	X		X	X	Potential water quality basin
													Litter removal
													Retrofit parking area to include stormwater pre-treatment
													Stabilization of exposed soils
													Minimize fertilizer and pesticide application
BW-9	90	Ocean County VoTech School											Preservation of natural drainage ditch/buffer
	91	Hilltop Road						X		X		X	Inlet filters
													Public outreach and education

OBSERVED IMPACTS: Eroded Banks through Lack of Stormwater Management.

CATCHMENT	PHOTO #	LOCATION	OBSERVED IMPACTS										IMPLEMENTATION PROJECTS
			Eroded Banks	Blocked Flow	Oil Sheen	Sedimentation	Dense Geese Population	Fertilizer Application	Litter	Pet Waste	Exposed Soils	Lack of Stormwater Management	
CE-1	92	Bey Lea Golf Course					X	X					Update golf course BMP manual to include anti goose measures Expansion of riparian buffer along impoundments and stream
	93	Eagle Point Drive											Potential for open space preservation
CE-2	94	Bay Avenue											Potential for open space preservation
	99	Palmetto Drive						X		X		X	Inlet filters Public outreach and education
CE-3	100	Greenleaf Court											Expansion of existing riparian buffer Preservation of existing riparian buffer adjacent to residential area
	101	Craig Road											Potential for open space preservation
CE-4	102	Priscilla Court											Preservation of existing riparian buffer
CW-1	95	Bey Lea Golf Course					X	X					Update golf course BMP manual to include anti goose measures Expansion of existing riparian buffer along impoundments and stream
CW-2	96	New Hampshire Avenue											Existing BMPs are sufficient
	97	Bey Lea Road	X										Stabilization of exposed soils and steep slopes Potential open space preservation
	98	Ocean County Public Lands Trust									X		Soil stabilization
CW-3	106	LaTache Court											Preservation of existing riparian corridor
	107	Cabernet Court						X		X			Public outreach and education
	108	Golf Park View											Potential open space preservation
	109	Utility Easement											Preservation of existing riparian corridor
CW-4	103	Whitty Road											Preservation of existing riparian corridor
	104	St. Joseph Church Parish Fields					X	X		X			Public outreach and education
	105	New Hampshire Avenue											Potential open space preservation
CU-1	110	The Church of Grace and Peace											Soil stabilization due to heavy ATV use Existing BMPs are sufficient
	111	Woodchuck Drive						X		X			Public outreach and education Inlet filters
	112	Todd Road											Potential for open space preservation
	113	New Hampshire Avenue											Potential for open space preservation

9.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS

The following list represents priority action items/implementation projects derived from BEI's field work during a six month period from June 2002 through November 2002. The following list is not in order of priority.

1. Implementation of Watershed-Wide Water Quality Monitoring Plan

Water quality sampling is essential to the continued success of the Long Swamp Creek Water Quality Improvement Plan, both in targeting potential sources of NPS pollution and developing future implementation strategies, as well as documenting successes or failures of implementation projects conducted throughout the watershed.

Past water quality monitoring efforts performed by the NJDEP Bureau of Marine Water Quality Monitoring have identified four locations within Long Swamp Creek with elevated concentrations of pollutants.

As part of initial plan efforts, attempts were made for the NJDEP to expand its initial monitoring efforts to the remainder of the watershed. Due to budget constraints, the NJDEP was unable to perform additional monitoring in the watershed in support of on-going plan efforts.

Recognizing that supporting water quality data is essential to the continued success of this plan, it is recommended that the Township pursue additional sources that will be capable of providing strategic water quality data to target additional sources of NPS pollution, as well as continue to monitor implementation projects conducted throughout the watershed.

It is recommended that a Long Swamp Creek Water Quality Database be created in order to track all historical, current and future water quality data collected within the watershed, regardless of whom it is collected by.

The following potential sources for future water quality monitoring should be pursued:

4. Ocean County Health Department – Water Quality Summer Sampling Program;
5. NJDEP – Bureau of Marine Water Quality Monitoring; and,
6. Additional 319(h) funding for sampling in conjunction with particular implementation projects.

The following are additional sources with past water quality data for Long Swamp Creek that should be researched and input into the Long Swamp Creek Water Quality Database:

3. NJDEP – Bureau of Marine Water Quality Monitoring; and,
4. U.S.G.S.

2. Diversion Structure

In the late 1970's, flow from the Long Swamp Creek was diverted to provide increased water supply to an embayment along the Toms River. This feature, located within the "Brown Tract," diverts the majority of dry weather streamflow to an artificial drainage ditch that ultimately discharges to a tidal basin behind the Toms River Yacht Club. The drainage ditch receives direct contributions of stormwater from several catchments in addition to the water it receives as a result of the diversion. As a result, untreated stormwater is discharged directly to the enclosed tidal basin, which has poor flushing characteristics.

An in-depth analysis of the function of this diversion structure should be conducted in order to determine mitigation measures.

3. Stream Bank Stabilization and Re-establishment of Riparian Buffers

Several areas of exposed soils exist adjacent to Long Swamp Creek and along its banks, all varying in degrees of severity.

Main areas for potential bank stabilization and/or riparian buffer re-establishment are as follows:

1. At the intersection of Brookside Drive and Ocean View Drive (both shoreline stabilization and riparian buffers should be reestablished);
2. Property located south of the Seacourt Pavilion and west of the adjoining lake;
3. Numerous residential properties along the creek;
4. Several areas within the Bey Lea Golf Course complex; and,
5. Longfellow discharge point.

4. Catchbasin Retrofits

Most developments within the lower Long Swamp Creek Subwatershed "A" have been constructed with curb and gutter drainage and stormwater detention structures. Small storms, which are responsible for most stormwater pollution and stream bank erosion, were not addressed in the original design of these structures. It has been well documented that these existing stormwater facilities can be dramatically improved through effective retrofitting.

Existing stormdrains can be retrofitted at strategic locations with manufactured filtering devices which filter out sediment and organic matter prior to discharge to the stormwater pipe system. These retrofits could be utilized in several locations throughout the lower reaches of the existing stormwater system, of which some of the most crucial are as follows:

1. Batchelor Avenue;
2. Seacourt Pavilion;
3. Route 37 Culvert;
4. Super Stop and Shop; and,
5. Bob Kislin's.

5. Preservation of Existing Riparian Buffers

Several areas adjacent to Long Swamp Creek contain an adequate riparian buffer of mixed shrubs and forest. Existing riparian buffers serve many functions in reducing non-point source pollution, including reducing the amount of pollutant runoff, sedimentation, and nutrients entering the Creek, as well as reducing increased water temperatures through proper shading, and reducing the potential for shoreline erosion. Main sections of existing riparian buffers along Long Swamp Creek are as follows:

1. Contiguous area from the mouth of the creek upstream to Route 37;
2. Contiguous area from Route 37 upstream to the first impoundment (adequate buffers only exist on the west side of these impoundments);
3. Contiguous area from Cedar Grove Road upstream to the Seacourt Pavilion lake;
4. Contiguous area from Hooper Avenue and the southern end of the Bey Lea Golf Course; and

5. Contiguous area from the north end of the Bey Lea Golf Course upstream to the Garden State Parkway (some fragmentation exists along this segment of riparian buffer).

The preservation of these areas should be a priority.

Areas where riparian buffers are absent in the case of residential property lawn maintenance should be investigated. Residential property owners should be educated on the many values of riparian buffers and encouraged to reestablish minimum vegetative buffers where practicable. In cases where water views are desired, stiff stemmed grasses or low-lying shrubs should be recommended.

6. Stream Cleaning

Several locations within the lower reaches (Subwatershed "A") of Long Swamp Creek are littered with debris. Coincidentally, these areas are also areas which contain adequate riparian buffers to the Creek. It is well documented that riparian buffers often attract public interest and as such are often prone to litter.

In addition to litter, there are areas of debris dams which are substantially restricting stream flows. These dams consist mostly of accumulated sediment and fallen branches which contribute to substantial upstream impoundment of water.

It is recommended that the following sections of the Long Swamp Creek be scheduled for stream cleanings:

1. Area immediately south of Route 37 (area is littered with debris and will require removal of a debris dam); and,
2. Area at the intersection of Brookside Drive and Ocean View Drive.

In order to ensure that these areas remain as litter-free as possible, an education and outreach program as well as the placement of appropriate signage should be incorporated where practicable.

7. Brookside Drive Fecal Sampling

The estuarine portions of the Toms River are identified on the EPA 303(d) list of impaired streams as being impaired for fecal coliform. Excessive levels of fecal coliform within the Toms River have caused periodic beach closings at the bathing beaches adjacent to the mouth of Long Swamp Creek. In the summer of 2000, the beaches were closed 3 times for elevated fecal coliform levels. A previous study entitled "*Relation of Water Quality to Land Use in the Drainage Basins of Four Tributaries to the Toms River, New Jersey, 1994-95*" *USGS/NJDEP (Hunchak-Kariouk, 1999)* along with additional water quality data collected by NJDEP, Bureau of Marine Water Monitoring since 1995 have documented a specific stormwater outfall pipe as being a significant contributor of fecal coliform within the Long Swamp Creek Watershed. The outfall pipe is a 60-inch stormwater outfall located near the intersection of Brookside Drive and State Route 37. This outfall discharges stormwater collected from an extensive system of conduits that collect run-off from an 80+/- acre area that is comprised primarily of residential land uses.

Determining the source type (i.e. human vs. animal) of fecal coliform generated within this subwatershed should be a priority. Stormwater samples should be collected at the 60-inch outfall pipe during rainfall events and then be forwarded to a State certified laboratory for fecal coliform and fecal streptoccus analysis. The results of this analysis will help determine the source, and therefore help determine adequate implementation measures to be considered.

8. <u>Batchelor Ave./Brookside Drive Stormwater/Water Quality Retrofit</u>

A significant drainage area discharges directly to Long Swamp Creek through the existing outfall at the corner of Batchelor Avenue and Brookside Drive. This stormwater currently discharges directly to the Creek without any pretreatment. The property at this intersection, although privately owned, would possibly be an ideal candidate for the implementation of a water quality retrofit project.

A potential water quality project would consist of the construction of a vegetative filter strip or wetland basin. Constructed vegetative filter strips and/or wetland basins can be designed to maximize the removal of pollutants and stormwater runoff through wetland vegetation uptake, retention and settling prior to discharge to the Creek.

9. <u>Brown Tract Stormwater/Water Quality Retrofit</u>

The feasibility of a constructed stormwater wetland should be investigated on the property known as the "Brown Tract." This property, being located within the lower reaches of Subwatershed "A", being controlled by the Township, and consisting of substantial acreage, could potentially be ideal for the treatment of stormwater immediately prior to discharge to the Toms River.

Constructed stormwater wetlands are wetland systems designed to maximize the removal of pollutants and stormwater runoff through wetland vegetation uptake, retention and settling of sediments.

The use of constructed stormwater wetlands is limited by a number of site constraints, including soil types, topography, depth to groundwater, contributing drainage area, and available land area at the site. These factors, among others should be investigated as a part of the feasibility of a constructed stormwater wetland on the "Brown Tract."

10. Goose Management

During initial site investigations, several populations of Canada Geese were encountered. Populations were typically encountered on maintained lawns and the lakes/ponds within the watershed. However, common problem areas also include public parks, public beaches and swimming facilities, corporate business areas, golf courses, schools, private lawns, athletic fields, and residential subdivisions, all which exist within the Long Swamp Creek watershed. Substantial populations encountered within the watershed are as follows:

1. Residential lawns and ponds along Brookside Drive;
2. Lake adjacent to Seacourt Pavilion;
3. Bey Lea Golf Course;
4. Bey Lea Park; and,
5. Oak Avenue Soccer Complex.

In the last 20 years, numbers of Canada geese that nest and/or reside within the United States (resident Canada geese) have undergone dramatic population growth, increasing to populations that are imposing direct health hazards on the utilized waterbodies. Long Swamp Creek is no exception to this trend. Heavy concentrations of goose droppings are well documented to over fertilize lawns and degrade water quality resulting in eutrophication of lakes and excessive algae growth.

Priority should be given to evaluate strategies to reduce, manage and control resident Canada goose populations within the Long Swamp Creek watershed.

11. Mussel Seeding

During site inspections performed in the spring of 2001, several mussel shells and a single live mussel were encountered within the lake adjacent to the Seacourt Pavilion. Shellfish are known to be excellent biological filters of algae and suspended particulate organic matter within the water column.

Further investigations into the species of mussel encountered, their location, extent, and water-filtering capability should be conducted in order to assess the feasibility of conducting a mussel-seeding program within the lakes/ponds of the Long Swamp Creek impoundment system.

12. Pet Waste

As large majority of the Long Swamp Creek watershed consists of residential type developments, associated pet population densities should be addressed.

Potential implementation/action items to address pet waste within the watershed are as follows:

1. Strategic placement of waste receptacles around public parks and within residential developments;
2. Public education and outreach focusing on dog waste impacts to water quality; and,
3. Placement of mutt-mitt dispensers at public parks and within residential developments.

13. Public Outreach and Education

As part of the Public Outreach Program of this project, the Dover Township Environmental Commission produced a publication entitled "What You Can Do To Prevent NonPoint Source Pollution in Dover Township." The Commission printed 29,000 copies of this publication for distribution to the Township of Dover, of which 2,797 were mailed directly to each household within the Long Swamp Creek Watershed. In addition, as part of this program, the Dover Township Environmental Commission developed a study to determine the effectiveness of the nonpoint source pollution outreach materials.

As an integral part of the ongoing effort to address NPS pollution within the Long Swamp Creek watershed, it is recommended that a public education and outreach program, similar to the efforts described above, be conducted in conjunction with the future implementation of priority action items described within this report.

Additional public education and outreach programs may consist of the distribution of this water quality plan by means of CD to local library branches and/or website demonstrations to local community groups and schools.

14. Submerged Aquatic Vegetation Restoration

Seagrasses grow in shallow, subtidal or intertidal unconsolidated sediments. They bind shallow water sediments with their roots and rhizomes, while absorbing wave energy. In this manner the canopy inhibits re-suspension of fine particles and traps water-column-borne material, lowering turbidity and improving water quality. These cleansing effects extend to the water column nutrients as well. Nutrient uptake by seagrass blades and their associated epiphytes and macroalgae, as well as roots, incorporate dissolved nutrients into plant biomass, which can also improve water quality.

In the spring of 2002, Birdsall Engineering, Inc, in conjunction with Fairleigh Dickinson University, undertook an experimental submerged aquatic vegetation (SAV) planting within the Toms River, at the mouth of Long Swamp Creek. Several square meters of Widgeon grass (*Ruppia maritima)* were planted at the site. This experimental planting was conducted in accordance with a project titled "Submerged Aquatic Vegetation Restoration as a Technique for Increasing Water Quality and Reducing NPS Pollution." Ongoing monitoring of the success and/or failure of this experimental planting and its effects on reducing NPS from Long Swamp Creek will continue through 2003.

This project received an Environmental Excellence Award from the NJDEP on November 19, 2002 in the Healthy Ecosystems Category.

15. Lake/Pond Management Plans

As Long Swamp Creek proper consists of numerous man-made and natural impoundments with substantial waterbodies upstream of these features, select implementation projects should focus on the management of these features as small lakes and ponds. As such, addressing problems common to lakes and ponds such as nuisance aquatic vegetation, elevated fecal coliform levels, shallow water depths, increased water temperatures, and user conflicts, should all be a priority in addressing the water quality of Long Swamp Creek.

The creation and/or natural existence of these features within the Long Swamp Creek watershed calls for challenging approaches to their management, as well as to determining their overall health and water quality.

The feasibility of implementing an overall lake/pond management plan, or individual plans for each impoundment, should be researched. During initial site investigations, several of the above common lake problems were encountered within the watershed.

LONG SWAMP CREEK WATERSHED
COMPLETED ACTION ITEMS/IMPLEMENTATION PROJECTS
2003 WORKING DOCUMENT

ACTION ITEM/ IMPLEMENTATION PROJECTS	ITEM/ PROJECT NUMBER**	% COMPLTE	STATUS	ADDITIONAL INFORMATION
Brookside Drive Fecal Sampling	7	3 sampling events 100% complete	This site will continue to be sampled as part of the Ocean County Health Department's Summer Sampling Program	Fecal Coliform Source Type Determination – April 2003
Biological Control of Purple Loosestrife		Delineation 100% complete	Beetles to be released Spring 2003	Biological Control of Purple Loosestrife Monitoring Protocol – February 2003
"What You Can Do To Prevent NonPoint Source Pollution in Dover Township" Public Survey	13	Distribution and analysis 100% complete	Complete	Nonpoint Source Pollution Survey Results – December 2002
Ocean County Department of Health Water Quality Monitoring of 4 of 9 Site from our Recommended Water Quality Monitoring Plan	1		Sites have been selected and monitoring is to begin June 2003	Ocean County Health Department
Submerged Aquatic Vegetation Restoration	14	Plantings 100% complete	Monitoring to continue throughout 2003	
Creation of a Water Quality Database	1	100% complete	Working document. Locations should be added as sampling is conducted	Water Quality Database – April 2003
Creation of an Interactive Website Containing the "Long Swamp Creek Water Quality Improvement Plan"	13	100% complete		Dover Township Environmental Commission
10 Acres Open Space Acquisition – Milza Tract		100% complete	Dedication took place April 11, 2003	Dover Township

**NOTE: These numbers are used for tracking purposes and correspond with the action item and/or implementation project's number in the overall Priority Action Items/Implementation Projects (2003) list. Items without numbers indicate projects that are not dually listed as Priority Projects.

LONG SWAMP CREEK WATERSHED
WATER QUALITY DATABASE
WORKING DOCUMENT

Collection Date and Location	Sample No.	Parameter	Results	Units
2/11/02 Brookside Drive Outfall Pipe	1	Fecal Coliform	135	c/100ml
		Fecal	<2	col.
	2	Fecal Coliform	<2	c/100ml
		Fecal	<2	col.
	3	Fecal Coliform	<2	c/100ml
		Fecal	<2	col.
12/20/02 Brookside Drive Outfall Pipe	1	Fecal Coliform	300	c/100ml
		Fecal	30	col.
	2	Fecal Coliform	<2	c/100ml
		Fecal	24	col.
	3	Fecal Coliform	400	c/100ml
		Fecal	40	col.
02/22/03 Brookside Drive Outfall Pipe	1	Fecal Coliform	TNTC - Est.	c/100ml
		Fecal	112	col.
	2	Fecal Coliform	TNTC - Est.	c/100ml
		Fecal	52	col.
	3	Fecal Coliform	TNTC - Est.	c/100ml
		Fecal	TNTC - Est.	col.

* Laboratory Estimate

PROPOSED SAMPLE LOCATIONS

SAMPLE NO.	NORTHERNING	EASTING
1	406731.0	585769.0
2	407209.5	585420.5
3	408315.0	585808.5
4	409115.0	585735.5
5	409387.5	585735.5
6	410537.0	585672.0
7	412466.0	584556.5
8	414507.5	583065.5
9	419542.5	579454.0

DATE	REVISION	DRAWN	CAD	CHK'D	REL'D
2/28/02	MOVED PROPOSED SAMPLE LOCATIONS PER NJDEP COMMENTS		RAO		

Prepared By:

Birdsall Engineering, Inc.

Professional Engineers, Land Surveyors, Planners

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582 Plaza Terrace East
Brick, N.J. 08723
Tel: (732) 477 - 3330

Michael J. Giuliano, Jr. PE No 23314
John L. Wuestneck PE No 36698
David G. Eareckson PE No 42244

PROPOSED SAMPLE LOCATION PLAN
LONG SWAMP CREEK WATERSHED
319(h) GRANT FUNDING

SITUATED IN
DOVER TOWNSHIP , OCEAN COUNTY , NEW JERSEY

DATE	SCALE	DRAWN BY	CHECKED BY	RELEASED BY	FILE NO.	DRAWER NO.	SHEET
12/05/01	1" = 500'	RAO			0105-E530	COMPUTER	SHEET 1 OF 1

LONG SWAMP CREEK WATERSHED PILOT PROJECT IMPLEMENTATION RESERVE

FECAL COLIFORM SOURCE TYPE DETERMINATION APRIL 2003

INTRODUCTION

In June 2001, the Township of Dover was awarded a Clean Water Act 319(h) grant to develop and implement a plan for the Long Swamp Creek Watershed that would coordinate nonpoint source pollution strategies throughout the watershed. The Long Swamp Creek Water Quality Improvement Plan outlined three programs that the Township of Dover would work on, including: a Strategic Water Quality Improvement Plan; a Pilot Project Implementation Reserve; and, a Public Outreach Program. As part of the Pilot Project Implementation Reserve two major implementation projects within the watershed were proposed: Fecal Coliform Source Type Determination and Biological Control of Purple Loosestrife (*Lythrum salicaria*).

The estuarine portions of the Toms River are identified on the EPA 303(d) list of impaired streams as being impaired for fecal coliform. Excessive levels of fecal coliform within the Toms River have caused periodic beach closings at the bathing beaches adjacent to the mouth of Long Swamp Creek. In the summer of 2000, the beaches were closed 3 times for elevated fecal coliform levels. A previous study entitled "*Relation of Water Quality to Land Use in the Drainage Basins of Four Tributaries to the Toms River, New Jersey, 1994-95*" *USGS/NJDEP (Hunchak-Kariouk, 1999),* along with additional water quality data collected by NJDEP, Bureau of Marine Water Monitoring since 1995, have documented a specific stormwater outfall pipe as being a significant contributor of fecal coliform within the Long Swamp Creek Watershed. The outfall pipe is a 60-inch stormwater outfall located near the intersection of Bachelor Avenue and State Route 37 (Figure 1). This outfall discharges stormwater collected from an extensive system of conduits that collect run-off from an 80+/- acre area that is comprised primarily of residential land uses.

Figure 1

In order to determine the potential source type (human vs. animal) of the fecal coliform, BEI collected stormwater samples from the 60-inch outfall discharge point for laboratory analysis of fecal coliform and fecal streptococcus. The ratio between fecal coliform and fecal streptococcus can provide information on the possible sources of pollution. Ratios greater than 4.4 FC/FS are considered indicative of pollution derived from domestic wastes comprised of human excrement whereas rations less than 0.7 suggest pollution due to non-human sources and ratios between 0.7 and 4.4 usually indicate wastes of mixed human and animal sources.[1]

BEI obtained stormwater samples at the 60-inch outfall pipe during three separate rainfall events: December 11, 2002; December 20, 2002; and, February 22, 2003. During each event, three in-stream samples were collected at 15-minute intervals. Initiation of sample collection was timed to capture the onset of each storm's "first flush." Collected samples were then immediately forwarded to a State certified laboratory for analysis.

SUMMARY OF FINDINGS

Review of the laboratory analysis reveals that there is a wide range of results for both fecal coliform and fecal streptococcus. Fecal coliform sample results ranged from <2 colonies per 100 milliliters of water sample (c/100 ml) to results that were to numerous to count (TNTC) using the EPA analysis method (SM9222D) employed by the laboratory. However, in-house estimates for such fecal coliform samples ranged up to 20,500 c/100 ml. Sample results for fecal streptococcus also ranged between <2 c/100 ml to results that were to numerous to count (TNTC) using the employed EPA analysis method (SM9230C); in-house estimates for these samples ranged up to 21,000 c/100 ml. Table 1, below, provides a summary of the laboratory results by sampling date. Copies of the laboratory certificates of analysis are included as Appendix A.

Table 1: Summary of Laboratory Results for Stormwater Samples Collected at a 60" Outfall Pipe Discharging into Long Swamp Creek at Bachelor Avenue and S.R. 37 in Dover Township, Ocean County, New Jersey

Collection Date	Sample No.	Parameter	Results	Units
12/11/02	1	Fecal Coliform	135	c/100ml
		Fecal Streptococcus	<2	c/100ml
	2	Fecal Coliform	<2	c/100ml
		Fecal Streptococcus	<2	c/100ml
	3	Fecal Coliform	<2	c/100ml
		Fecal Streptococcus	<2	c/100ml
12/20/02	1	Fecal Coliform	300	c/100ml
		Fecal Streptococcus	30	c/100ml
	2	Fecal Coliform	<2	c/100ml
		Fecal Streptococcus	24	c/100ml
	3	Fecal Coliform	400	c/100ml
		Fecal Streptococcus	40	c/100ml
02/22/03	1	Fecal Coliform	TNTC – Est. 500*	c/100ml
		Fecal Streptococcus	112	c/100ml
	2	Fecal Coliform	TNTC - Est. 450*	c/100ml
		Fecal Streptococcus	52	c/100ml
	3	Fecal Coliform	TNTC – Est. 21,000*	c/100ml
		Fecal Streptococcus	TNTC – Est. 20,500*	c/100ml

* Laboratory Estimate

EPA guidance for evaluation of FC/FS ratios instructs the reader to not use the ratio evaluation when fecal streptococcus counts are less than 100 c/100 ml.[1] Therefore, as the majority of the fecal streptococcus sample results were below 100 c/100 ml and as samples with fecal streptococcus results greater than 100 ml were too numerous to count, ratio evaluation of the samples could not be performed.

DISCUSSION

Various bacteria, including fecal coliform, are found in the digestive tracts and feces of wild and domestic animals and humans.[2] As such, the occurrence of fecal coliform bacteria in stormwater discharge indicates contamination from either human sewage or droppings from other warm-blooded animals.[3] Sources of human related contamination include sewer cross-connections between sanitary sewers and storm drains; infiltration from aging sanitary sewer lines to storm drains; overflows at sewage pumping stations; and, septic tank and field failures.[3] Sources of animal related contamination include excrement from domestic animals and local wildlife that is transported within stormwater run-off. Although the FC/FS ratio evaluation designed to help differentiate between source types could not be performed utilizing the collected data set, information regarding the potential source type can still be inferred from the data.

Due to a combination of factors, fecal coliform levels tend to be lower during winter months. These factors include: decreased bacterial mobility; dilution from increased base flow; and, limiting growth factors such as reduced sunlight and reduced water temperatures. As such, fecal levels would not be expected to significantly exceed State Surface Water Quality Standards (N.J.A.C. 7:9B et. Seq.), which is 200 c/100 ml for fecal coliform and 33 to 35 c/100 ml for Enterococci Groups, which include fecal streptococcus for FW2/SE1* streams.[4] However, review of the laboratory results for the stormwater samples obtained under this effort revealed that five of the nine fecal coliform samples and four of the nine fecal streptococcus samples returned results that exceeded the State Water Quality Standards. Two of the stormwater samples (one fecal coliform and one fecal streptococcus) significantly exceeded the State standards. Although the reported laboratory results for these two samples were too numerous to count using the employed EPA methods, in-house laboratory estimates suggest that each of these samples exceeded 20,000 c/100 ml. Such results would suggest that an investigation to determine whether the elevated levels could be occurring as a result of a sanitary sewer cross-connection(s) or infiltration from an aging sanitary sewer line(s) to storm drains should be considered.

During discussions with a representative of the Ocean County Department of Health, it was stated that the Department has previously investigated similar situations where elevated fecal levels discharging from stormwater outfall pipes within residential land use areas were determined to be occurring as a result of human related source traced to sewer cross-connection or infiltration from an aging sanitary sewer line to a cracked stormwater conduit. As such, BEI recommends that the Township consider submitting a request to

* FW2/SE1 refers to the State general surface water quality classification for Long Swamp Creek which is applied to freshwaters that are not designated as FW1 or Pinelands Waters and saline waters of estuaries.

the State to utilize the designated 319(h) implementation reserve grant funds to conduct a video inspection of the stormwater conduit system to identify any possible cross-connections or any potential areas where aging sanitary sewer lines are infiltrating effluent into the stormwater system in combination with a stormwater conduit cleaning program and continued water quality monitoring.

REFERENCES

1. American Public Health Association, American Water Works Association, Water Environment Federation.1992. Standard Methods for the Examination of Water and Wastewater, 18th ED:903-4

2. Whitlock JE, Jones DT, Harwood VJ. 2002. Identification of the sources of fecal coliforms in an urban watershed using antibiotic resistance analysis, Water Research, 36(17):4273-82

3. Capital Regional District (CRP). 2003. Report on the Environment: Monitoring: Trends in the Capital Regional District http://www.crd.bc.ca/rte/report/p-e2.htm

4. New Jersey Department of Environmental Protection (NJDEP). 2002. Surface Water Quality Standards. New Jersey Administrative Code (N.J.A.C.) 7:9B

LONG SWAMP CREEK WATERSHED
PILOT PROJECT IMPLEMENTATION RESERVE

BIOLOGICAL CONTROL OF PURPLE LOOSESTRIFE
MONITORING PROTOCOL
FEBRUARY 2003

INTRODUCTION

In June 2001, the Township of Dover was awarded a Clean Water Act 319(h) grant to develop and implement a plan for the Long Swamp Creek Watershed that would coordinate nonpoint source pollution strategies throughout the watershed. The Long Swamp Creek Water Quality Improvement Plan outlined three programs that the Township of Dover would work on, including: a Strategic Water Quality Improvement Plan; a Pilot Project Implementation Reserve; and, a Public Outreach Program. As part of the Pilot Project Implementation Reserve two major implementation projects within the watershed were proposed: Fecal Coliform Source Type Determination and Biological Control of Purple Loosestrife (*Lythrum salicaria*).

Purple Loosestrife *(Lythrum salicaria)* is a non-native weed that is aggressively becoming dominant in freshwater wetlands in the northeast region of the United States.

This Eurasian perennial is rapidly displacing native wetlands species such as sedges, rushes and cattails. These naturally diverse, rich food source wetland habitats are being converted to monocultures with the resulting decline in habitat value for migrating birds and other wildlife species. Current research indicates that this species can be controlled by the introduction of plant-eating beetles *Galerucella calmariensis* and *Galerucella pusilla*. The goal of the biological control is to reduce, not eliminate populations of purple loosestrife.

During fieldwork for the Long Swamp Creek watershed assessment project, it was observed that purple loosestrife was, in fact, becoming dominant in a portion of a wetland corridor located just east of Route 549/Hooper Avenue and just south of Route 571/Bay Avenue in Dover Township, Ocean County, New Jersey. Additionally, on August 22, 2002 County Officials, New Jersey Department of Environmental Protection (NJDEP), Birdsall Engineering, Inc. and United States Department of Agriculture (USDA) representatives met onsite to discuss the initiation of a biological control project.

PRE-CONTROL ASSESSMENT

In January 2003, an on-site assessment was performed by Birdsall Engineering, Inc. to establish limits of the study area. Seven sub-areas (A-G) were established within the overall study area to separate different densities of coverage for naturally occurring purple loosestrife *(Lythrum salicaria)* plants. Field reference points, consisting of wooden lath with numbered surveying ribbon, were placed in the field to mark the limits of the study area and sub-areas. These points were subsequently located using Global Positioning System (GPS) to provide accurate mapping of the existing extent of purple loosestrife. These points were overlaid on an aerial photograph of the area in order to produce a pre-control survey. The pre-control survey also includes a table estimating the percent coverage of purple loosestrife in each sub-area. The percent coverage of purple loosestrife plants within each sub-area was estimated based on field measurements and visual observation.

RELEASE AND MONITORING PROTOCOL

The Dover Township Environmental Commission placed an order to purchase 6,000 plant-eating beetles, consisting of a combination of *Galerucella calmariensis* and *Galerucella pusilla*, from the USDA in December 2002. Thomas Scudder, Entomologist, USDA, under standard insect release guidelines will introduce the 6,000 beetles throughout the established study area in the spring of 2003.

The objective to monitoring purple loosestrife after beetle release is twofold: 1) to measure changes in purple loosestrife populations; and 2) to identify the changes in the overall plant community pertaining to the re-establishment of native species. The following monitoring protocol was modeled after the University of Connecticut's "Purple Loosestrife Monitoring Protocol" dated April 1997. According to this model, three monitoring events, which reflect the developmental stages of the plant, should take place each year (May-September) for a minimum of three to five years after beetle release:

- **First Monitoring**: late May to early June when purple loosestrife shoots are 8-12" tall;
- **Second Monitoring**: mid to late July when purple loosestrife is in full bloom; and,
- **Third Monitoring:** September when seed production on the plant has been completed.

The primary objective of each monitoring event is to estimate and record the percent coverage of purple loosestrife within each sub-area. A secondary objective is to record the presence of other plant species and to provide comments on their rate of re-establishment in each sub-area. It is important to provide a photographic record of purple loosestrife coverage throughout the 3-5 year monitoring period. A photographic diary of each sub-area should be taken during the second monitoring event of each year to record the extent of purple loosestrife plants in flower. Photograph locations and angle of view should be established (in relation to Field Reference Points) and made part of the monitoring records so annual photographs of each sub-area can be taken consistently from the same location, angle of view, using the same lens and camera height. This will provide a strong visual comparison of purple loosestrife coverage from year to year.

ANTICIPATED RESULTS

Depending on a variety of site conditions, precipitation and other outside factors, populations of *Galerucella calmariensis* and *Galerucella pusilla* can have devastating effects on purple loosestrife populations. In a 1999 Rhode Island Study, by Lisa Tewksbury, University of Rhode Island, beetles were released at the Roger William Park Zoo from 1994 through 1996. Within five years of the first release, by August 1999, hundreds of thousands of adult beetles were observed in the release area where virtually every purple loosestrife plant had been skeletonized. These are comparatively good results.

Biological control of purple loosestrife using *Galerucella spp*. can take many years to achieve noticeable results. A minimum recommended monitoring period is 3-5 years however, several studies recommend monitoring for a period of 15-20 years. Once food source communities of purple loosestrife have been defoliated, adult beetles will move to feed on adjacent purple loosestrife communities throughout the wetlands complex allowing re-colonization by native wetland plants in the original project area.

It is anticipated that implementation of biological control agents should have a distinct impact on purple loosestrife within the study area. Assuming a local population of *Galerucella* beetles becomes established, the beetle is likely to spread throughout the Long Swamp Creek Watershed. Hopefully the result will be a great reduction in purple loosestrife and a restoration of native plant communities.

LONG SWAMP CREEK WATERSHED PUBLIC OUTREACH PROGRAM

NONPOINT SOURCE POLLUTION SURVEY RESULTS DECEMBER 2002

INTRODUCTION

In June 2001, the Township of Dover was awarded a Clean Water Act 319(h) grant to develop and implement a plan for the Long Swamp Creek Watershed that would coordinate nonpoint source pollution strategies throughout the watershed. The Long Swamp Creek Water Quality Improvement Plan outlined three programs that the Township of Dover would work on including: a Strategic Water Quality Improvement Plan; a Pilot Project Implementation Reserve; and, a Public Outreach Program.

As part of the Public Outreach Program, the Dover Township Environmental Commission produced a publication entitled "What You Can Do To Prevent NonPoint Source Pollution in Dover Township." The State 319(h) grant provided funding to print 16,000 copies of this publication of which 2,797 were mailed directly to each household within the Long Swamp Creek Watershed. Further funding efforts undertaken by the Township of Dover provided for an additional 13,000 booklets resulting in a total of 29,000 copies that were printed and made available to the residents of Dover Township. In addition, as part of this program, the Dover Township Environmental Commission developed a study to determine the effectiveness of the nonpoint source pollution outreach materials. The following is a discussion of the methods and results of this public outreach study.

METHODS

The Dover Township Environmental Commission targeted its public outreach program toward a 200-acre subwatershed located north of Route 37 and east of Brookside Drive that is know to contribute to Long Swamp Creek's water quality problems. Birdsall Engineering, Inc. delineated this subwatershed and using a GIS database referencing current property tax records created a mailing list of residences within this subwatershed target area. On May 22, 2002 597 mailings were sent to the target area households. These mailings included an introduction letter, a booklet entitled "What You Can Do To Prevent NonPoint Source Pollution in Dover Township," as well as a postage prepaid postcard questionnaire.

The questionnaire included a total of eight yes or no questions and space to provide comment to each question. The eight questions were as follows:

1. A watershed is an area of land that drains into a common waterbody. Do you live in the long Swamp Creek Watershed?

2. In the last five years, have you noticed any changes affecting the water quality of Long Swamp Creek? If yes, please provide contact information so we can get more information.
3. Is improper handling of pollutants, such as pesticides, chemicals, automotive leaks, pet and animal wastes, winter salt and de-icers, grass clipping and yard wastes, a potential risk to the environment and your family's health?
4. When you contract with a professional lawn care service, are you aware of the products they use and do you insist on Integrated Pest Management techniques?
5. To better control water runoff, would you be willing to install a rain sensor shut-off on your lawn sprinkler?
6. Within the past year, have you made simple changes in household practices to prevent pollution and help reduce consumption of water, energy, and other resources?
7. Would you be wiling to expend municipal funds for wider circulation of this non-point source pollution prevention booklet?
8. Do you believe our town needs assistance (training for planning board, environmental commission, and municipal staff regarding environmental concerns and ecologically-based zoning/land use) to more effectively address growth issues?

Completed questionnaires were collected by the Commission for one month. All collected questionnaires were forwarded to BEI for analysis. Responses to each question were broken down into the number of yes, no, unsure, and not applicable answers. A response was considered unsure if the respondent either left the question blank or put a question mark next to the question. A response was considered not applicable if the respondent stated that the question was not applicable to them by placing a N/A next to the question. Each question's responses were totaled and given a percentage of the whole. These percentages were derived by taking the total number of a particular answer to a question and dividing that number by the total number of completed questionnaires received. This methodology was repeated for all eight questions.

RESULTS

A total of 108 questionnaires were returned however, only 107 questionnaires were legible. Therefore, any analyses performed for this study included a total of 107 returned questionnaires. The study had a 17.9% response rate and twelve, or 11% of, respondents included either their phone number or address if further information was needed regarding their responses.

79% of the respondents believed that they lived within the Long Swamp Creek Watershed. The remainder of respondents did not. 63% of respondents have not noticed changes in water quality in the last five years. The 23% of respondents that have noticed changes in water quality noted that these changes are mostly from geese in the area, litter around Long Swamp Creek, and discolored tap water.

87% of respondents believed that improper handling of pollutants were a potential risk to their family and the environment. The remainder of the respondents equally either did not think improper handling was a risk or were unsure. 50% of respondents were aware of methods that professional lawn care services use on their property. 28% do not use lawn care services or maintain their lawns themselves and 23% did not know what methods their company uses.

61% of respondents are willing to install rain sensor shut-offs on their sprinkler system. 27% of respondents do not have sprinkler systems. 5.5% of respondents would not consider sensors. 10% of respondents already have shut-off mechanisms. 93.5% of respondents have made changes in their household practices within the past year that would help reduce consumption of resources.

63.5% of respondents would be willing to expend municipal funds to circulate the "What You Can Do To Prevent NonPoint Source Pollution in Dover Township" booklet. 31% would not be willing to expend municipal funds for distribution. Several respondents mentioned that distribution to area high schools would be a better idea than distributing to resident households. 77.5% of respondents believe that the town needs assistance to address growth issues and 16% do not. A handful of respondents stated that the Township already has an Environmental Commission and that should be enough. Others mentioned that it is the responsibility of the town officials to already know how to deal with these issues.

A summary of the results can be found in Table 1 provided below.

TABLE 1: NONPOINT SOURCE POLLUTION SURVEY RESULTS

QUESTION	QUESTION #	YES	NO	UNSURE	N/A
Do you live in Long Swamp Creek Watershed?	1	79%	21%	0%	0%
Have you noticed changes in water quality in last 5 years?	2	23%	63%	11%	3%
Is improper handling of pollutants a potential risk to family & environment?	3	87%	6.5%	6.5%	0%
Are you aware of lawn care service methods?	4	50%	21%	1%	28%
Are you willing to install a rain sensor shut-off on your sprinkler?	5	61%	5.5%	6.5%	27%
Within past year, have you made changes to household practices?	6	93.5%	6.5%	0%	0%
Are you willing to expend municipal funds to circulate booklet?	7	63.5%	31%	5.5%	0%
Do you believe the town needs assistance to address growth?	8	77.5%	16%	6.5%	0%