Cedar Grove Brook Watershed Restoration and Protection Plan

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I. ACKNOWLEDGEMENTS

This project was a collaborative effort of the New Jersey Water Supply Authority, the New Jersey Department of Environmental Protection, Franklin Township, Somerset County and the project committee. TRC Omni Environmental was contracted to perform water quality sampling, investigate best management practices, and develop potential projects. SWM Consulting, P.A. was retained as a subconsultant by TRC Omni.

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II. Executive Summary

A. Project Background/Development

The Delaware and Raritan (D&R) Canal transfers water from the Delaware River Basin to the Raritan River Basin, where the raw water is treated to become drinking water for approximately 600,000 customers living in and near the Raritan Basin. Since 1997, several of the Canal's water purveyors have reported increased concentrations of total suspended solids in the raw water during and immediately after precipitation events, requiring increased chemical use for treatment and increasing residual sludge generation. In addition, a 1999 study by the United States Geological Survey (USGS) reported that turbidity does not decrease in the Canal reach between Ten Mile Lock and the Route 18 spillway (the final 11 miles of the Canal) as would be expected due to low water velocities in this reach, indicating that settling solids are replaced by particulates from influent streams and stormwater discharges to the Canal. Field observations downstream of the Canal's confluence with Cedar Grove Brook confirm this, noting the formation of a sand bar indicating that Cedar Grove Brook contributes sediment-laden stormwater to the Canal.

The New Jersey Water Supply Authority (NJWSA) identified a total of 68 infalls or stream and stormwater discharges to the Canal between Amwell Road and Landing Lane, where the Canal discharges into the Raritan River. The report titled "Delaware and Raritan Canal Tributary Assessment and Nonpoint Source Management Project: Watershed Restoration and Protection Plan" [1] described those infalls, estimated pollutant loads and provided preliminary recommendations for best management practices. Implementation of those recommendations is now underway.

The Cedar Grove Brook (also known as Al's Brook) watershed drains 1,788 acres in northeastern Franklin Township, Somerset County and discharges directly into the Canal approximately three miles upstream of the Canal's terminal spillway located near Landing Lane in the City of New Brunswick. The Cedar Grove Brook watershed is the fourth largest direct drainage to the Canal, and the largest within the last eleven miles of the Canal. The Cedar Grove Brook watershed was excluded from the original D&R Canal NPS study due to its size, and was made the focus of a separate nonpoint source management project.

The Cedar Grove Brook Stormwater Management and Watershed Restoration Project began as a regional stormwater management plan funded by a Section 319(h) Nonpoint Source Pollution Control Grant from the New Jersey Department of Environmental Protection (NJDEP). One aspect of a regional stormwater management plan is the development of new municipal ordinances or design standards if additional stormwater management is required to protect water resources. During the characterization and assessment phase of the project it became evident that the watershed is essentially built-out. In addition, the 2004 NJDEP stormwater regulations and strict development controls imposed by the Delaware and Raritan (D&R) Canal Commission are

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[1] A major restoration project (Delaware and Raritan Canal Nonpoint Source Implementation Project) is currently underway by NJWSA to reduce sediment loads to the Canal from the many stormwater infalls between Amwell Road and the Route 18 spillway.

expected to be protective of water quality from the impacts of future development. Lastly, the watershed is relatively small and located wholly within Franklin Township, Somerset County which has adopted ordinances and land use regulations which are protective of water resources.

As a result, the project focus was shifted from the development of additional performance standards for new development to the identification of management measures to address impacts from existing nonpoint source pollution problems concentrating on stormwater issues. The work included inventorying stream conditions, evaluating existing management practices and determining retrofit opportunities and remedial actions for existing stormwater problems. In addition, a monitoring program was implemented to track down sources of turbidity and identify best management practices (BMPs) to address likely sources of sediment.

B. Project Committee

A project committee of interested stakeholders was formed at the beginning of the project. The stakeholders included representatives from the NJDEP, Somerset/Union Soil Conservation District, Somerset County, Franklin Township, D&R Canal Commission, and NJWSA. The group met periodically throughout the project to provide feedback on various issues, including project identification.

C. Water Quality Monitoring and Modeling

Water quality monitoring and WinSLAMM modeling were used to help identify potential sources of sediment in the Cedar Grove Brook watershed. A series of stream visual assessments was also performed. The continuous turbidity monitoring results suggest that Cedar Grove Brook can significantly increase the turbidity peaks in the D&R Canal that occur during larger storm events. Water quality sampling in both Cedar Grove Brook and the D&R Canal demonstrate that high values of turbidity occur together with high values of total suspended solids (TSS); it is therefore likely that measures to reduce TSS loads to the Canal will also reduce turbidity.

There are three significant pond structures in the watershed – the Golf Coruse Pond, the Ukrainian Village Pond and the Lower Pond. The WinSLAMM analysis indicated that these ponds are providing significant sediment removal during normal and low flow conditions, resulting in Cedar Grove Brook currently discharging far less sediment to the D&R Canal than it would without the presence of those structures. These pond structures also act as sediment sources due to the resuspension of accumulated sediment under certain high flow storm conditions.

D. Recommended Management Measures

Several potential structural and non-structural nonpoint source management measures were evaluated for the Cedar Grove Brook watershed. The recommended measures include:

Structural Management Measures:

- Quail Brook Golf Course Pond – Outlet structure modification and addition of flowpath baffles
- Ukrainian Village Pond – Outlet structure modification
- Lower Pond – weir modification
- Riparian Restoration (multiple locations)
- Stormwater Basin Retrofits (multiple locations)
- Residential Stormwater Management – Rain barrels and rain gardens

Non-structural Management Measures

- River-Friendly Programs – Golf courses, businesses, schools and residents
- River-Friendly Communities

Detailed information on each of these proposed projects can be found in Section VIII.

E. Nine Minimum Elements of a Watershed Restoration Plan

The United States Environmental Protection Agency (EPA) identified nine significant elements that are critical for achieving improvements in water quality and that must be included in all watershed restoration plans funded with Clean Water Act Section 319(h) funding. The nine elements are listed below with a discussion of pertinent points from the Cedar Grove Brook watershed restoration plan that relate to each specific element. The elements do not occur sequentially.

Element 1: Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan.

Element 1 includes mapping, characterization and assessment of the watershed (**Section IV Watershed Characterization and Assessment** and **Section V Visual Assessment**) and an accounting of nonpoint sources that cause impairment in the watershed (**Section VI Pollutant Source Assessment**). A correlation shall be made between the sources of pollution and the extent to which they cause water quality impairment.

The relative contribution from any land use type is a function of:

1) the percent of the watershed comprised of the land use type; and

2) the contribution (pounds per acre) generated by the land use type in terms of pollutant load.

The dominant developed land use in the Cedar Grove Brook watershed is residential, comprising 43% of the watershed. Commercial, industrial and institutional land uses comprise small amounts of the developed land area, forest and brush/shrub land comprise 20%, wetlands comprise 18% and agriculture approximately 1% of the watershed.

The WinSLAMM modeling indicated that approximately 38% of the solids load originates on residential properties, and the majority of that load is generated by vegetated areas. Although vegetation such as lawn and forest is generally considered to be more protective of water resources than impervious areas such as driveways and roofs, these areas do generate sediments and other pollutants.

An additional sediment source that must be considered is the resuspension of sediment from the three existing pond structures during large storm events.

Element 2: An estimate of the load reductions expected from management measures.

A total maximum daily load (TMDL) has not been prepared for Cedar Grove Brook, and the watershed is not identified on the State's 2008 List of Impaired Waters. The watershed has been observed to contribute TSS and associated turbidity to the D&R Canal and water purveyors with downstream water intakes have reported higher treatment needs during and after storm events.

As the Canal and Cedar Grove Brook are not listed as impaired for sediment, a targeted endpoint or specific load reduction for the watershed was not identified. The goal of this project is to reduce the sediment load in the stream and thereby reduce sediment loads in the Canal. The anticipated load reduction from each recommended management measure is, however, specified in the restoration plan (**Section VIII Nonpoint Source Management Measures** and **Appendix G Project Detail Sheets**).

Element 3: A description of the nonpoint source management measures that will need to be implemented to achieve load reductions and a description of the critical areas in which those measures will be needed to implement this plan.

This restoration plan describes the management measures that are recommended in order to achieve the reduction of sediment entering Cedar Grove Brook and ultimately the D&R Canal. These measures include:

Structural Management Measures:

- Quail Brook Golf Course Pond – Outlet structure modification and addition of flowpath baffles
- Ukrainian Village Pond – Outlet structure modification
- Lower Pond – weir modification
- Riparian Restoration (multiple locations)
- Stormwater Basin Retrofits (multiple locations)
- Residential Stormwater Management – Rain barrels and rain gardens

Non-structural Management Measures

- River-Friendly Programs – Golf courses, businesses, schools and residents
- River-Friendly Communities

Details on each of these projects are included in **Section VIII Nonpoint Source Management Measures** and **Appendix G Project Detail Sheets.**

Element 4: Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.

This section describes the financial and technical assistance necessary to implement the entire watershed restoration plan. Items that are included are implementation, construction, maintenance, monitoring and evaluation. Organizations that could potentially be responsible for various projects and tasks shall also be identified. In the Cedar Grove Brook watershed, these organizations may include NJWSA, Somerset County and Franklin Township. Funding opportunities that may be utilized include Section 319(h) funds, Corporate Business Tax funds, Natural Resources Conservation Service funds, Partners for Fish & Wildlife, and NJWSA's source water protection fund. A discussion of potential funding sources and lead organizations is provided in **Section IX Technical and Financial Assistance**.

Element 5: An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.

Outreach and education may occur through many different existing programs. Franklin Township's municipal stormwater management plan requires them to conduct a yearly educational event and distribute brochures provided by the NJDEP[2]. Additional information about this project can be distributed in conjunction with the required mailing. Web sites maintained by the Township, NJWSA and Raritan Basin Watershed Alliance (RBWA) can be vehicles for the dissemination of the plan and information about the management measures. The plan and resulting projects can be highlighted in the RBWA "Basin Bulletin". Both the D&R Canal Commission and D&R State Park can be a valuable ally in distributing literature on the project. See **Section XI Education**.

Element 6: Schedule for implementing the nonpoint source management measures identified in this plan.

A schedule for implementation of the management measures recommended in the plan shall be developed. The schedule will be modified depending on funding opportunities and the potential for management measures to be included in other projects. Some of the management measures recommended in this plan can be implemented with a minimum of planning and funding. For instance, NJWSA is currently implementing the River-Friendly suite of programs in this watershed, and could easily expand that work. Other projects will require the identification of a

[2] See NJPDES Master General Permit for Tier A municipalities

lead entity and funding. A tentative schedule for implementation is provided in **Section X Implementation Schedule and Milestones.**

Element 7: Milestones- A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

Information regarding the project schedule is provided in **Section X Implementation Schedule and Milestones.**

Element 8: Performance Criteria-A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.

The primary criteria to be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards will be TSS reduction (lbs/yr) as estimated by periodic reexamination of the WinSLAMM model and application of the Step-L model. Additional information regarding monitoring and performance criteria is provided in **Section XII Project Monitoring**.

Element 9: A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established above.

Direct water quality monitoring is not planned in the Cedar Grove Brook. A continuous water quality and flow data monitoring station is planned for the D&R Canal at Landing Lane, approximately three miles downstream. This new facility will be constructed and maintained by the USGS and NJWSA. Those data will be used to assess the overall success of the nonpoint source management measures implemented through the D&R Canal Nonpoint Source Implementation Project, and will also be pertinent for this project.

Additional information regarding monitoring and performance criteria is provided in **Section XII Project Monitoring**.

III. Introduction

The Delaware and Raritan (D&R) Canal transfers water from the Delaware River Basin to the Raritan River Basin, where the raw water is treated to become drinking water for approximately 600,000 customers living in and near the Raritan Basin. Three water purveyors maintain water intakes downstream of the project area on the D&R Canal: Middlesex Water Company, East Brunswick Township and the City of New Brunswick. Since 1997, several of the Canal's water purveyors have reported increased concentrations of total suspended solids in the raw water during and immediately after precipitation events, requiring increased chemical use for treatment and increasing residual sludge generation. Studies and field observations confirmed that the Cedar Grove Brook watershed is a source of sediments to the Canal.

The New Jersey Water Supply Authority (NJWSA) identified a total of 68 infalls or stream and stormwater discharges to the Canal between Amwell Road and Landing Lane, where the Canal discharges into the Raritan River. The report titled "Delaware and Raritan Canal Tributary Assessment and Nonpoint Source Management Project: Watershed Restoration and Protection Plan" [3] described those infalls, estimated pollutant loads and provided preliminary recommendations for best management practices. Implementation of those recommendations is now underway.

A. Cedar Grove Brook Watershed & Water Quality Issues

The Cedar Grove Brook watershed (Figure 1) is the fourth largest direct drainage to the Canal, and the largest within the last eleven miles of the Canal. The Cedar Grove Brook watershed was not included in the original D&R Canal NPS study due to its size, and was made the focus of a separate nonpoint source management project.

The Cedar Grove Brook (also known as Al's Brook) watershed drains 1,788 acres in northeastern Franklin Township, Somerset County and discharges directly into the Canal approximately three miles upstream of the Canal's terminal spillway located near Landing Lane in the City of New Brunswick. A1999 study by the United States Geological Survey (USGS) reported that turbidity does not decrease in the Canal reach between Ten Mile Lock and the Route 18 spillway (the final 11 miles of the Canal) as would be expected due to low water velocities in this reach, indicating that settling solids are replaced by particulates from influent streams and stormwater discharges to the Canal. Field observations downstream of the Canal's confluence with Cedar Grove Brook confirm this, noting the formation of a sediment bar indicating that Cedar Grove Brook contributes sediment-laden stormwater to the Canal.

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[3] A major restoration project (Delaware and Raritan Canal Nonpoint Source Implementation Project) is currently underway by NJWSA to reduce sediment loads to the Canal from the many stormwater infalls between Amwell Road and the Route 18 spillway, the last 11 miles of the Canal.

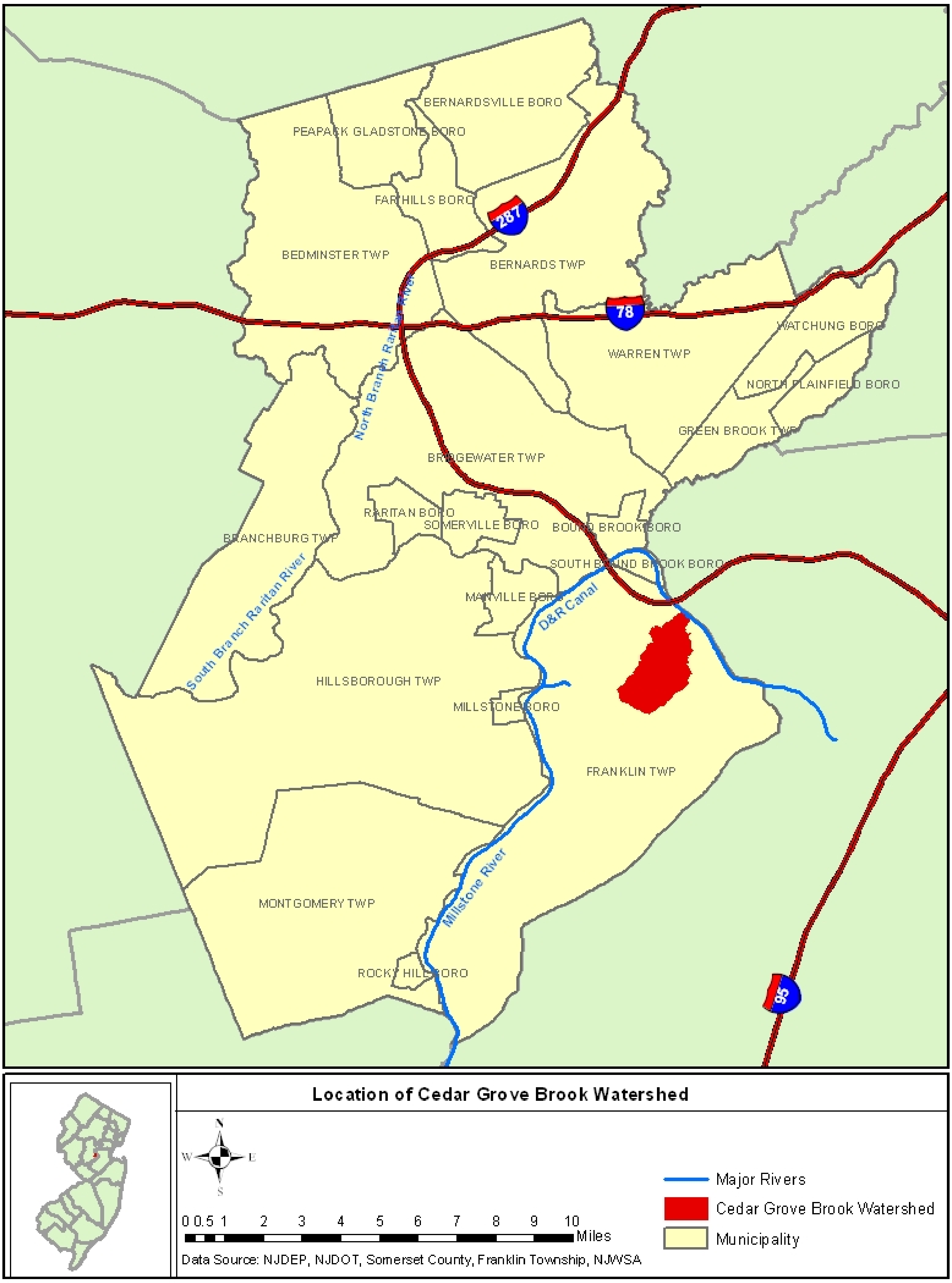

Figure 1. Location Map

The water supply purveyors reported increased levels of total suspended solids (TSS), turbidity, and total organic carbon (TOC) in the Canal during and immediately after precipitation events, requiring increased chemical use in the treatment process and increased sludge generation from residuals. There are no permitted ground water or surface water discharges in this watershed based on 2002 and 2006 NJDEP NJPDES data, so the source of pollution is 100% nonpoint. A United States Geological Survey (USGS) study from 1998 and 1999 (Appendix A) reported that turbidity and sediments were entering the Canal from influent streams and discharges to the Canal between 10 Mile Lock and Landing Lane Bridge and pointed to Cedar Grove Brook as a likely contributor.

B. Cedar Grove Brook Watershed Restoration Plan

The Cedar Grove Brook Stormwater Management and Watershed Restoration Project began as a regional stormwater management plan funded by a Section 319(h) Nonpoint Source Pollution Control Grant from the New Jersey Department of Environmental Protection (NJDEP). One aspect of a regional stormwater management plan is the development of new municipal ordinances or design standards if additional stormwater management is required to protect water resources. During the characterization and assessment phase of the project it became evident that the watershed is essentially built-out. In addition, the 2004 NJDEP stormwater regulations and strict development controls imposed by the Delaware and Raritan (D&R) Canal Commission are expected to be protective of water quality from the impacts of future development. Lastly, the watershed is relatively small and located wholly within Franklin Township, Somerset County which has adopted ordinances and land use regulations which are protective of water resources.

As a result, the project focus was shifted from the development of additional performance standards for new development to the identification of management measures to address impacts from existing nonpoint source pollution problems concentrating on stormwater issues. The work included inventorying the stream conditions, evaluating existing management practices and determining retrofit opportunities and remedial actions for existing stormwater problems. In addition, a monitoring program was implemented to track down sources of turbidity and identify best management practices (BMPs) to address likely sources of sediment.

C. Cedar Grove Brook Watershed Restoration Plan Components

1. Watershed Characterization and Assessment

A characterization and assessment of the watershed was performed. Various data were analyzed for the watershed, including hydrography, land use, land use changes, preserved lands, ground water and soils. Section IV contains the Watershed Characterization and Assessment.

2. Water Quality Monitoring and Modeling

As part of the Delaware & Raritan Canal Tributary Assessment and Nonpoint Source Management Study, NJWSA reviewed water quality data from the USGS study, New Jersey American Water Company, Middlesex Water Company and NJWSA. The data reviewed covered various portions of the time period from March 1998 to October 2004, and indicated that all of the data were below the surface water quality standard of 40 mg/l.

The average water velocity in the Canal is very low, and particles that cause turbidity are typically not transported significant distances. Turbidity is therefore expected to decrease through a particular reach as suspended solids settle out. USGS suggested that the expected decrease in turbidity within most reaches was not being observed because the expected decrease was being offset by turbid water entering the Canal from influent streams and stormwater discharges.

To examine the water quality problems reported by water purveyors and the issues found in USGS's report, NJWSA contracted with Omni Environmental, LLC (OMNI) to conduct water quality sampling and characterize sediment loads, and utilize a watershed computer model (WinSLAMM) to predict turbidity and total suspended solids (TSS) loading. These data were used to target areas within the watershed for nonpoint source management measures.

Omni prepared a Quality Assurance Project Plan (QAPP) (Appendix F), as required by the NJDEP, to obtain the necessary data for evaluating targeted pollutants with respect to flow conditions, seasonal variations and pertinent weather conditions. The sampling plan was designed to assess water quality impacts due to sediment loading. The water quality sampling was performed in accordance with the QAPP for six (6) stormwater locations, six (6) low flow locations, and eight (8) intensive stormwater locations to evaluate the targeted pollutants. The parameters measured during this study were total suspended solids (TSS) and turbidity. Omni submitted an initial report, "Cedar Grove Brook Watershed Water Quality Characterization and Assessment" (Appendix B) in July 2006.

Omni's initial report concluded the overall in-stream criteria for Cedar Grove Brook are regularly met for TSS and turbidity and concentrations and loads are relatively low throughout the watershed. When concentrations are elevated, it appears that the issue resolves itself before the stream's confluence with the Canal due to a high settling rate in the stream. The observed concentrations of TSS and turbidity were low enough that it appeared that Cedar Grove Brook may not be a large contributing factor to TSS and turbidity problems in the Canal. The sampling results indicated that the three pond structures in the watershed act as sediment sinks during low and normal flow conditions, but may act as sediment sources in high flow events.

Overall, the sampling results were not sufficient to exclude the possibility that Cedar Grove Brook delivers a substantial turbidity load affecting water quality in the Canal; nevertheless, the lack of direct sampling confirmation left open the possibility that efforts to minimize TSS and turbidity loads in the Cedar Grove Brook watershed may not address the water quality problems observed at the water supply intakes in the Canal.

To further investigate the water quality issues, turbidity was monitored continuously during a variety of flow conditions for a three week period from October 28 to November 18, 2008. Furthermore, data from the most upstream and downstream locations in the Canal (Ten Mile Lock and Route 18 Spillway at Landing Lane, respectively) were used to confirm the observations made previously by USGS (USGS, 2001) that identified Cedar Grove Brook as a likely source of turbidity to the Canal. These data at the upstream and downstream boundaries of the segment of interest in the Canal also provide a context in which to evaluate the impact of Cedar Grove Brook on the Canal. This additional data confirmed that Cedar Grove Brook is in fact, contributing a significant pollutant load to the Canal, particularly during high flow events.

3. Stream Visual Assessment

NJWSA utilized the United States Department of Agriculture-Natural Resources Conservation Service Stream Visual Assessment Protocol (SVAP) to collect baseline stream health data for this project. Fourteen SVAP locations were chosen based on preliminary visual assessments and accessibility. Various impairments were observed, including eroded streambanks, disconnection of the stream from the floodplain and degraded riparian zones. Section V provides the details of the visual assessments.

4. Recommended Management Measures

Several potential structural and non-structural nonpoint source management measures were evaluated for the Cedar Grove Brook watershed. The recommended measures include:

Structural Management Measures:

- Quail Brook Golf Course Pond – Outlet structure modification and addition of flowpath baffles
- Ukrainian Village Pond – Outlet structure modification
- Lower Pond – weir modification
- Riparian Restoration (multiple locations)
- Stormwater Basin Retrofits (multiple locations)
- Residential Stormwater Management – Rain barrels and rain gardens

Non-structural Management Measures

- River-Friendly Programs – Golf courses, businesses, schools and residents
- River-Friendly Communities

Detailed information on each of these proposed projects can be found in Section VIII.

IV. Watershed Characterization and Assessment

Appendix C contains the full Watershed Characterization and Assessment report.

A. Physical and Natural Features

Cedar Grove Brook (also known as Al's Brook), an FW2-NT (Fresh water Category 2, non trout) water body, is a significant tributary to the Delaware & Raritan Canal, one of New Jersey's major water supply facilities. The watershed encompasses a drainage area of approximately 1,788 acres and is the fourth largest direct drainage area to the Canal. The brook is located in Franklin Township, Somerset County and discharges to the Canal approximately three miles upstream from the water supply intakes for Middlesex Water Company, the Township of East Brunswick and the City of New Brunswick near Landing Lane. Figure 2 presents an aerial view of the watershed.

The Cedar Grove Brook including all its tributaries is 3.6 miles long and rises from the wooded wetlands near Amwell Road in Franklin Township. It flows northeast through residential, commercial and forested areas before discharging to the D&R Canal at Easton Avenue.

The elevation in the watershed ranges from six feet to 132 feet above mean sea level. Contour data was obtained from Franklin Township; Figure 3 presents the contours within the watershed. Inspection of the contours demonstrates the gentle slope of the watershed as well as the steeper sloped areas. Most of the banks along the Cedar Grove Brook are between five and 10 percent slope. As the gradient or percent of slope increases, the velocity of runoff water increases, which increases its erosive power.

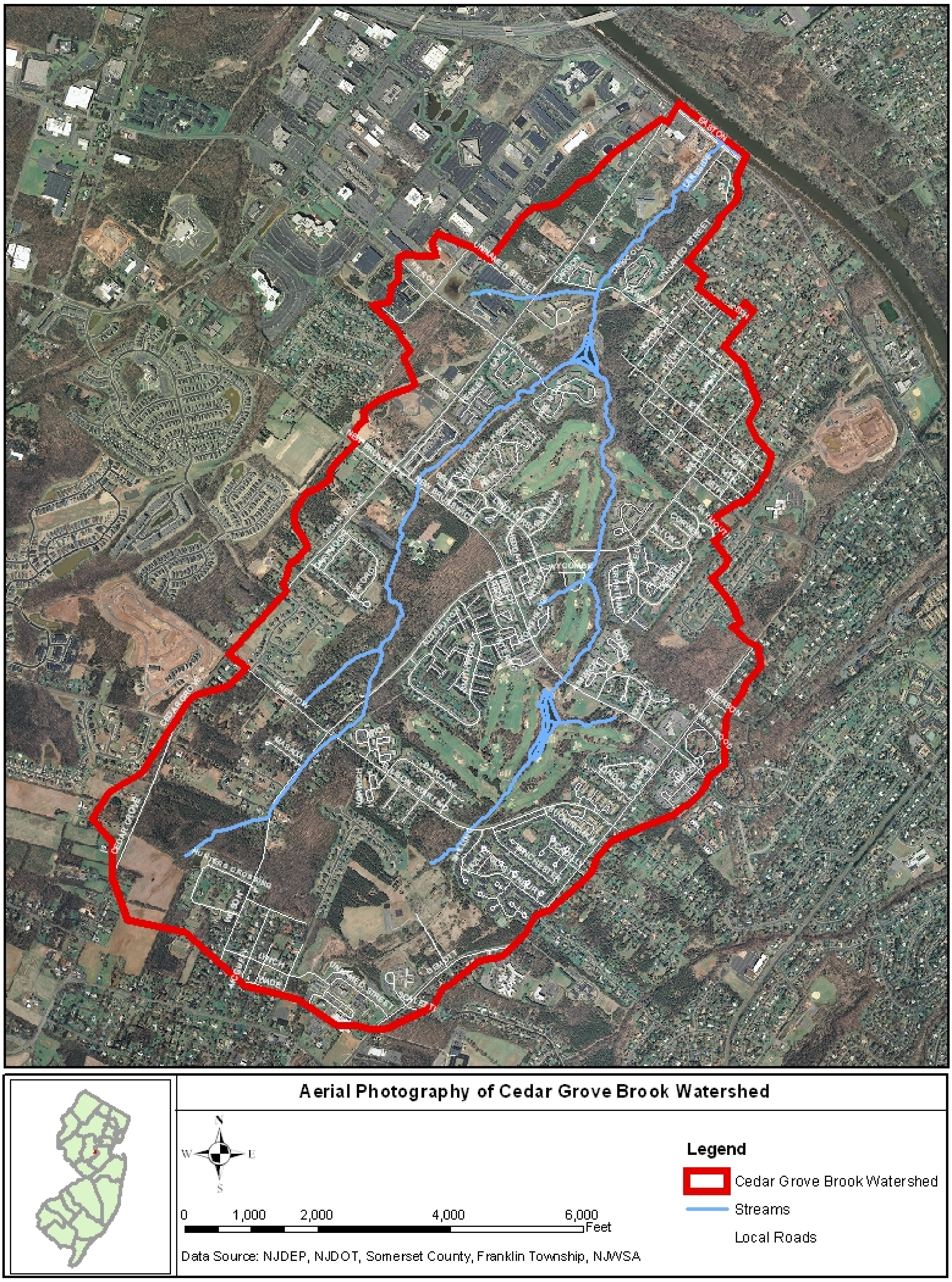

Figure 2. Aerial Map

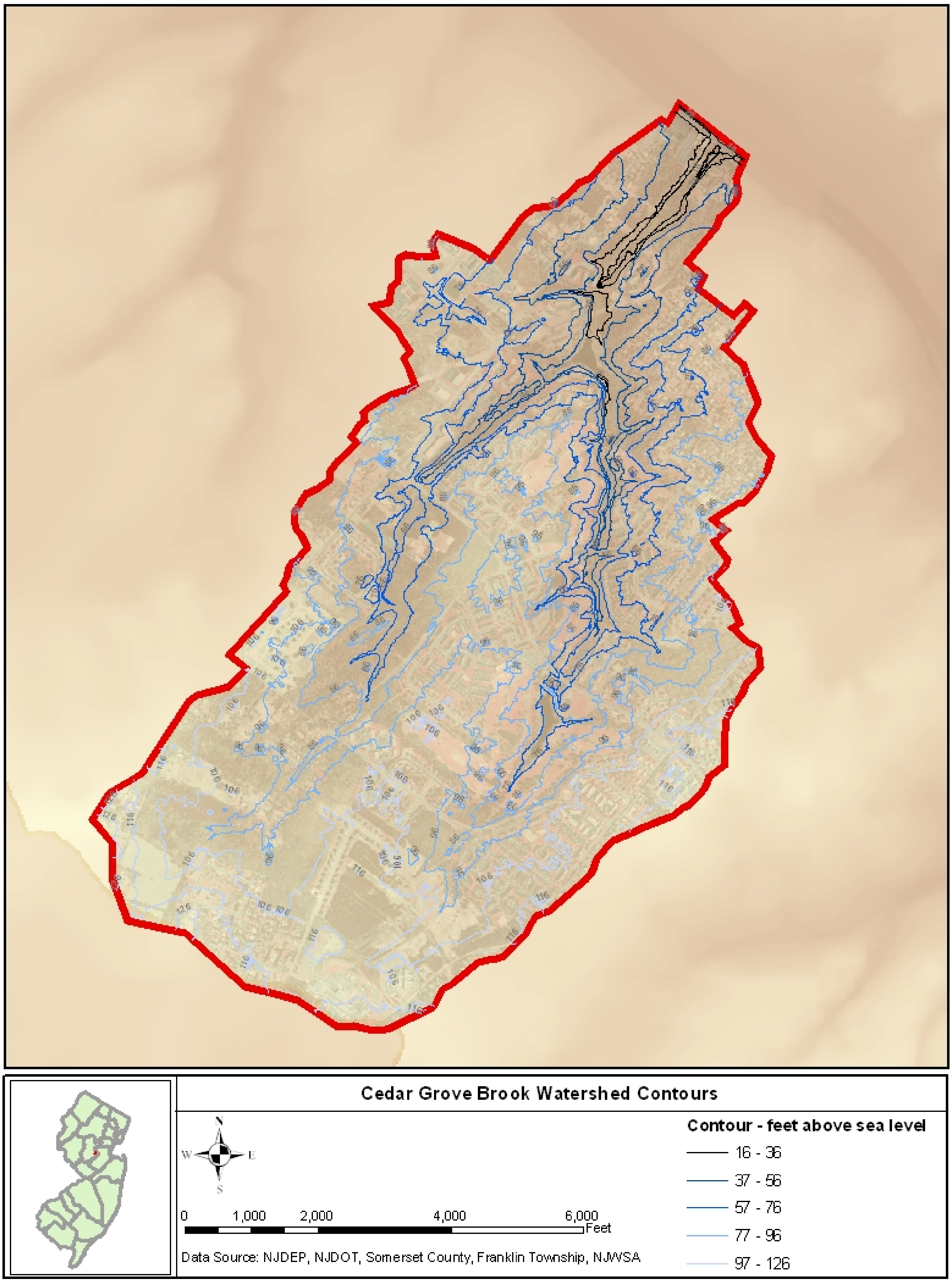

Figure 3. Watershed Contours

B. Land Use and Land Cover

NJWSA performed an analysis of land use based on the NJDEP land use/land cover data from 1986 to 2006. Additional refinement of the land use data was performed based on aerial photographs and field reconnaissance in 2009 for the D&R Canal Nonpoint Source Management Project and incorporated here. The dominant land use in the watershed was urban (60%), including residential (43%), commercial (6.6%), industrial ((0.4%) and recreational (10%) land uses. Forest and shrub/brush comprised approximately 20% of the watershed, wetland comprised approximately 18% and agriculture 1.3%.

During the 20-year period from 1986 to 2006, a total of 430.97 acres were converted to urban land. During the same period 318.02 acres of wetlands, 308.60 acres of forest, 24.56 acres of agriculture, and 7.09 acres of water were lost to development (Table 1 and Figure 4).

The pattern of land use change during that 20-year period was analyzed as well. The period between 1986 (Figure 5) and 1995 (Table 2) exhibited the most significant land use change in the watershed. Urban land use grew by 290.14 acres. All other land uses (with the exception of +2.39 ac. water[4]) lost area to development. The area experienced significant residential growth during this time period. Between 1995 and 2002 (Figure 6) development slowed; however, an additional 113.46 acres were converted to urban land use (Table 3). Additional residential growth as well as commercial development along Cedar Grove Lane was responsible for the change. Between 2002 and 2006, 27.37 acres were converted to urban land use (Table 4).

As of 2002, the impervious surface cover in the Cedar Grove Brook watershed was 19.5% , or 348 acres, based on the 2002 NJDEP land use/land cover data. According to Schueler (1992) [5], the hydrologic and pollutant loading in a watershed is directly related to the amount of impervious cover. Once the amount of impervious cover exceeds 5%, stream health is adversely impacted. Impervious surfaces also decrease natural groundwater recharge and convey a variety of pollutants that are detrimental to water quality, including sediment, nutrients, road salts, heavy metals, pathogens, and petroleum hydrocarbons.

As of 2009, the Cedar Grove Brook watershed was mostly developed (60%); however, there are opportunities for limited growth. Any additional storm water runoff is likely to have a negative impact on water quality in the watershed.

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[4] The retention pond at Quail Brook Golf Club is likely responsible for the increase to the water category.

[5] Schueler, T.R. 1992. *Mitigating the Adverse Impacts of Urbanization on Streams: A Comprehensive Strategy for Local Government*. In Watershed Restoration Sourcebook. Publication #92701 of the Metropolitan Washington Council of Governments.

Table 1. Land Use Change from 1986 to 2006

Land Use Type	Acres 1986	Percent 1986	Acres 2006	Percent 2006	Acreage Change from 1986 to 2006	Percent Change from 1986 to 2006
Agriculture	52.80	2.95	24.56	1.37	-28.24	-1.58
Forest	393.77	22.02	308.60	17.26	-85.17	-4.76
Urban	698.77	39.08	1129.74	63.18	430.97	24.10
Water	4.70	0.26	7.09	0.40	2.39	0.13
Wetlands	554.28	31.00	318.02	17.79	-236.26	-13.21
Barren Land	83.69	4.68	0.00	0.00	-83.69	-4.68
Total	1788.00	100.00	1788.00	100.00	0.00	0.00

Table 2. Land Use Change from 1986 to 1995

Land Use Type	Acres 1986	Percent 1986	Acres 1995	Percent 1995	Acreage Change from 1986 to 1995	Percent Change from 1986 to 1995
Agriculture	52.80	2.95	49.14	2.75	-3.65	-0.20
Forest	393.77	22.02	354.60	19.83	-39.18	-2.19
Urban	698.77	39.08	988.91	55.31	290.14	16.23
Water	4.70	0.26	7.09	0.40	2.39	0.13
Wetlands	554.28	31.00	384.47	21.50	-169.81	-9.50
Barren Land	83.69	4.68	3.80	0.21	-79.89	-4.47
Total	1788.00	100.00	1788.00	100.00	0.00	0.00

Table 3. Land Use Change from 1995 to 2002

Land Use Type	Acres 1995	Percent 1995	Acres 2002	Percent 2002	Acreage Change from 1995 to 2002	Percent Change from 1995 to 2002
Agriculture	49.14	2.75	24.56	1.37	-24.59	-1.38
Forest	354.60	19.83	316.39	17.70	-38.20	-2.14
Urban	988.91	55.31	1102.37	61.65	113.46	6.35
Water	7.09	0.40	7.09	0.40	0.00	0.00
Wetlands	384.47	21.50	330.08	18.46	-54.38	-3.04
Barren Land	3.80	0.21	7.51	0.42	3.71	0.21
Total	1788.00	100.00	1788.00	100.00	N/A	N/A

Table 4. Land Use Change from 2002 to 2006

Land Use Type	Acres 2002	Percent 2002	Acres 2006	Percent 2006	Acreage Change from 2002 to 2006	Percent Change from 2002 to 2006
Agriculture	24.56	1.37	24.56	1.37	0.00	0.00
Forest	316.39	17.70	308.60	17.26	-7.79	-0.44
Urban	1102.37	61.65	1129.74	63.18	27.37	1.53
Water	7.09	0.40	7.09	0.40	0.00	0.00
Wetlands	330.08	18.46	318.02	17.79	-12.07	-0.67
Barren Land	7.51	0.42	0.00	0.00	-7.51	-0.42
Total	1788.00	100.00	1788.00	100.00	N/A	N/A

Table 5. Land Use- 2009

Land Use Type	Acres 2009	Percent 2009
Agriculture	24.04	1.34
Forest	359.39	19.85
Urban	1068.74	60
Water	7.47	0.42
Wetlands	323.69	18.03
Barren Land	0	0
Total	1783.33	100.00
Note: Total acreage 2009 is slightly different due to the use of data calculated through the D&R Canal NPS Project.		

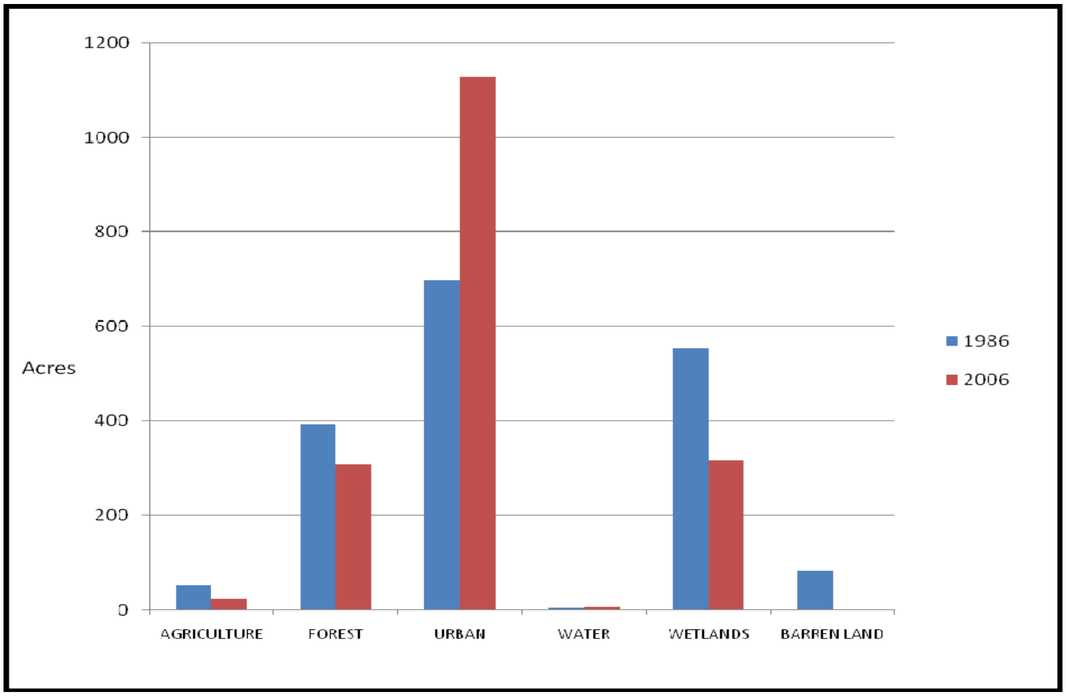


Figure 4. Land Use Comparison 1986 to 2006

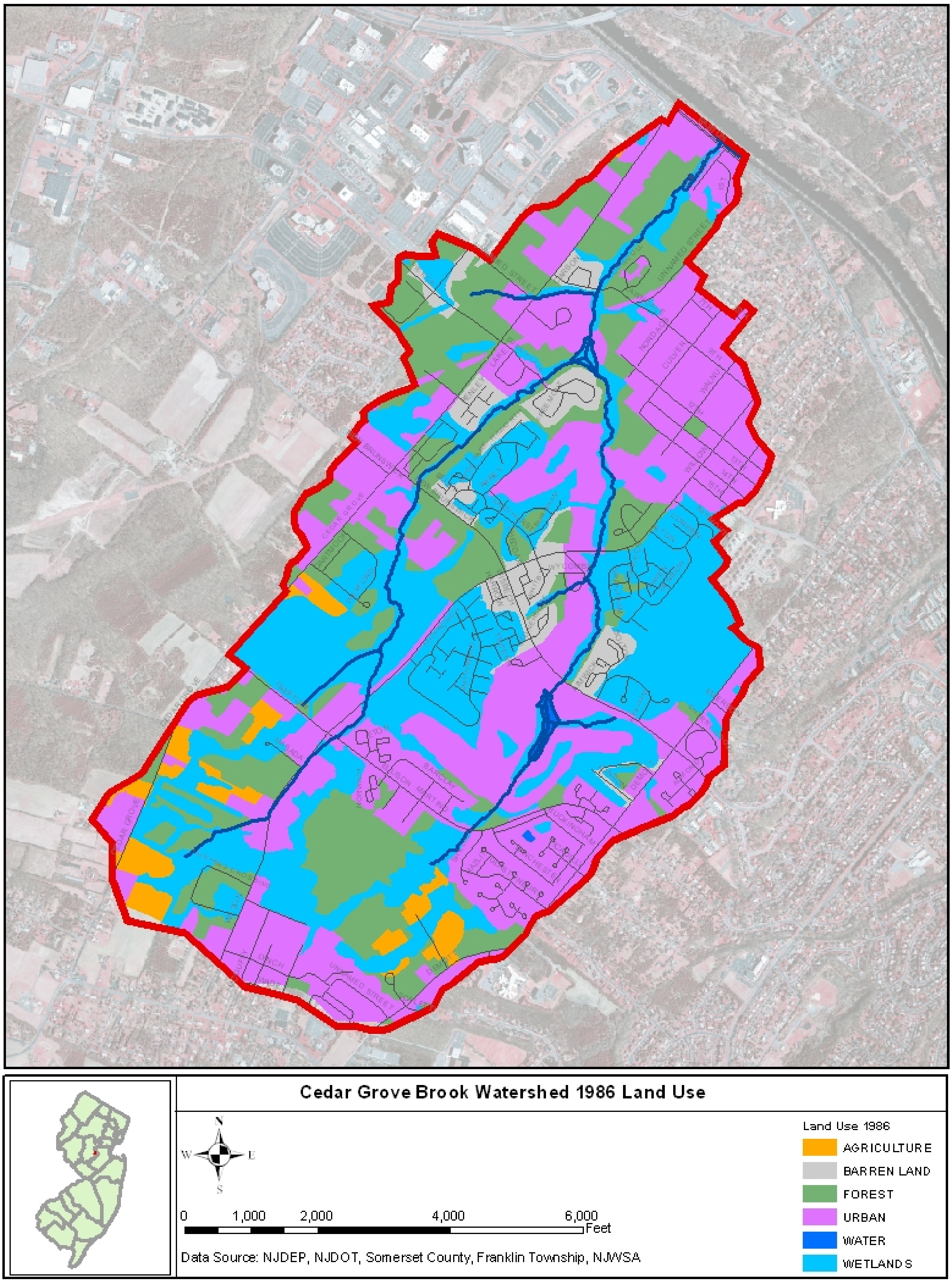


Figure 5. 1986 Land Use

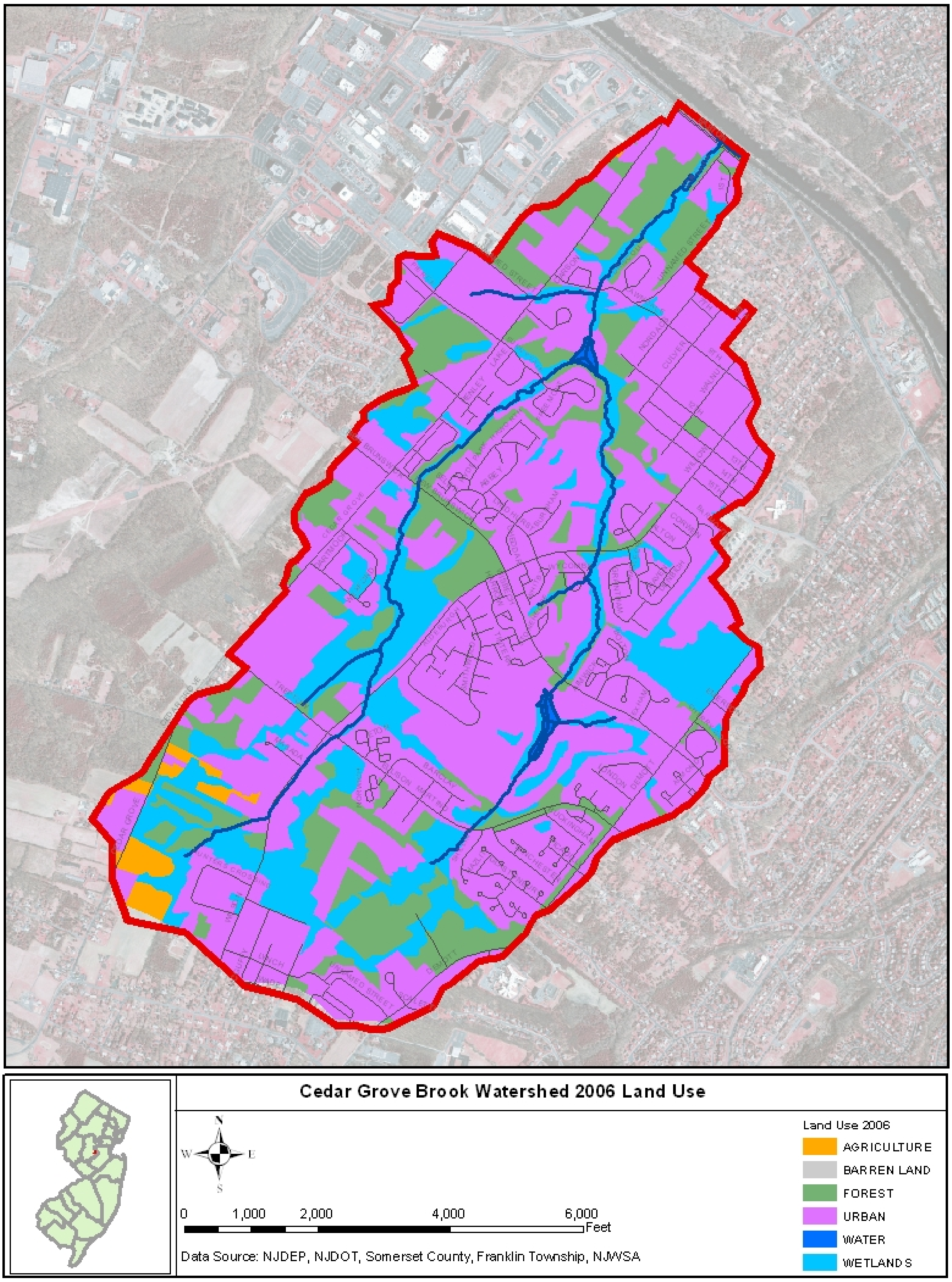


Figure 6. 2006 Land Use

C. Open Space and Preserved Lands

Preserved open space is beneficial to the health of a watershed. Open space, particularly that which is kept in a natural state, slows the movement of stormwater, provides areas for ground water recharge and can act as a filter of surface water pollutants. Preserving open space can also decrease flooding and erosion, increase biodiversity and habitat, provide recreational opportunities, enhance the quality of life and increase nearby land values.

Franklin Township and Somerset County have utilized the various open space funding programs that exist in New Jersey and have adopted open space and farmland preservation plans with a dedicated tax to finance acquisitions.

The total preserved open space in the Cedar Grove Watershed was 447 acres in 2009, or 25 percent of the total watershed area (Figure 7). Quail Brook Golf Course is owned by Somerset County, most of the rest of the open space in the watershed is owned by Franklin Township. There are isolated pockets of privately-owned open space in the larger residential developments which are maintained by homeowner associations.

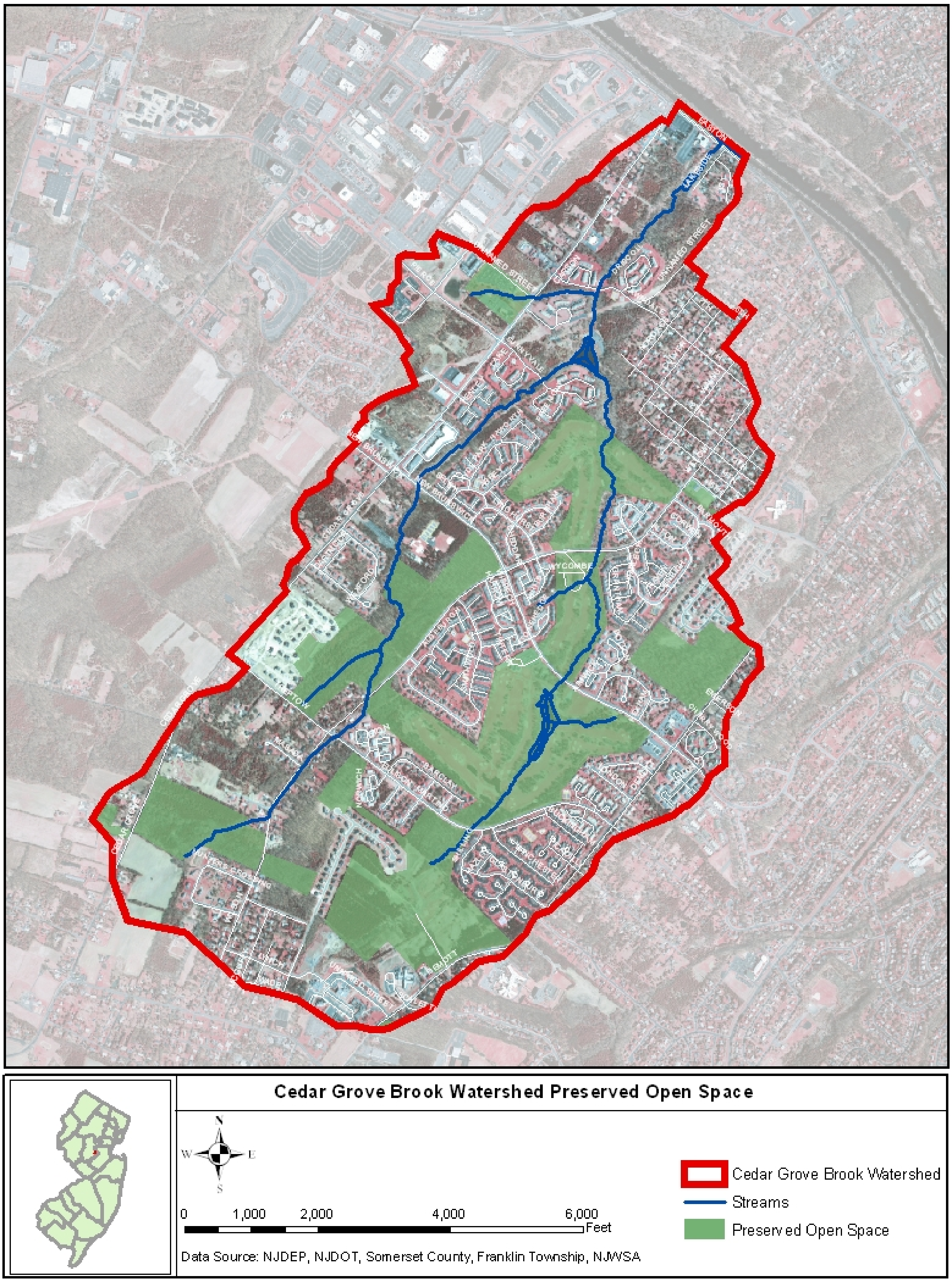


Figure 7. Preserved Lands

D. Ground Water

Cedar Grove Brook depends on ground water to maintain base flow during periods of low or no precipitation. Ground water can be contaminated by a wide variety of sources including accidental spills, and fertilizer and pesticide applications. Ground water recharge can be reduced through changes in soil permeability (e.g., impervious surfaces, soil compaction), soil aspect (e.g., slope, surface roughness), and vegetation. Relative to land use, recharge rates in forests are much higher than those in urban areas (Heath, 1983). This is because urban areas have large areas covered with impervious surfaces, hastening runoff to surface water, instead of allowing precipitation to percolate into the ground.

A ground water recharge area is the land area that allows precipitation to seep into the saturated zone. These areas are generally at topographically high areas with discharge areas at lower elevations, commonly at streams or other water bodies (i.e. the ground water returns to surface water). Groundwater recharge areas provide base flow to streams that support both aquatic ecosystems and surface water supplies. Estimating the relative recharge rates of various land areas provides a way by which the most critical ground water recharge areas can be mapped and protected through various mechanisms, including zoning, development regulation and land preservation.

Recharge rates are expressed in terms of the amount of precipitation that reaches the aquifer per unit of time (e.g. inches/year). Recharge rates vary from year to year, depending on the amount of precipitation, its seasonal distribution, air temperature, land use and other factors. The estimated recharge rates of this watershed from the NJGS 95/97 dataset indicate that the maximum recharge rate in non-drought conditions is 15.75 inches per year, with the highest infiltration rates predicted to occur in the downstream forest area along the Cedar Grove Brook (Figure 8).

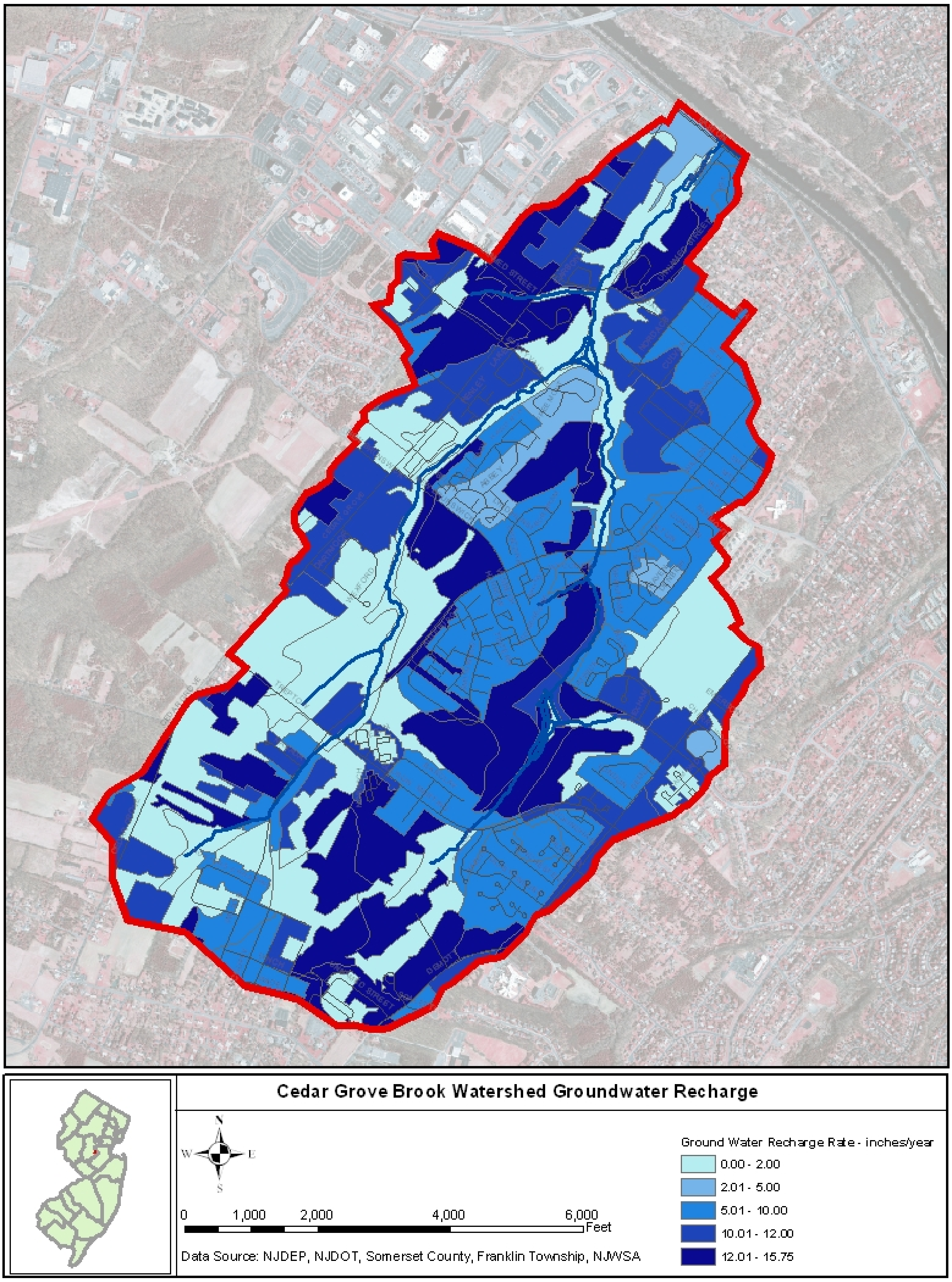


Figure 8. Groundwater Recharge

E. Soils

Soil is the unconsolidated mineral material on the immediate surface of the earth which serves as the medium for growth of land plants. The characteristics of each soil type have developed over time (usually many thousands of years) under the influence of the parent material, climate (including moisture and temperature regimes), macro- and microorganisms, and topography. Soil is a basic resource for food production, in addition to its essential role in collecting and purifying water before it enters the ground water; however, soil itself can be a pollutant as dust in the air or as sediment in water.

The US Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) develops soil surveys to determine soil characteristics and capabilities. The Somerset County soil survey was updated in 2006. The soil survey separates the landscape into segments that have similar use and management requirements. Therefore, this data set is not designed for use as a primary regulatory or management tool, but may be used as a broad scale reference source.

The soil characteristics vary from place to place in slope, depth, drainage, erodibility and other properties. The hydrologic soil grouping describes the rate that water infiltrates into the ground. The majority of the Cedar Grove Brook watershed contains Class C soils, which have slow infiltration rates (Table 6 and Figure 9).

Table 6. Hydrologic Soil Group

Class	Definition	Acres	Percent within the watershed
A	High infiltration rates. Soils are deep, well drained to excessively drained sands and gravels.	0	0%
B	Moderate infiltration rates. Deep and moderately deep, moderately well and well drained, soils that have moderately course textures.	14.7	0.8%
C	Slow infiltration rates. Soils with layers impeding downward movement of water, or soils that have moderately fine or fine textures.	1760.5	97.9%
D	Very slow infiltration rates. Soils are clayey, have a high water table, or are shallow to an impervious layer.	17.7	1%
Unknown		3.9	0.2%
Source: NRCS Soil Survey Geographic (SSURGO) Database.			

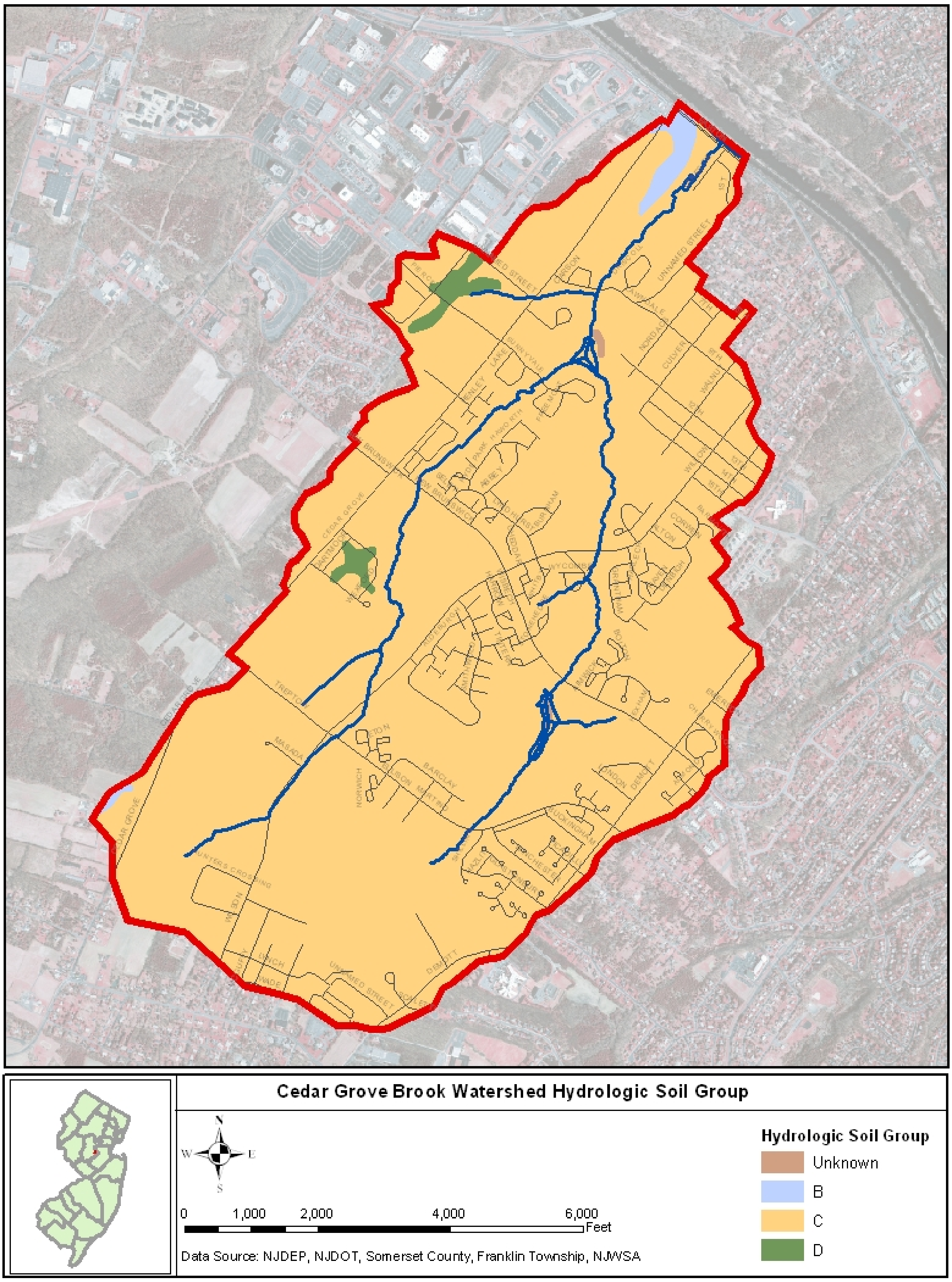


Figure 9. Hydrologic Soil Group

F. Known Contaminated Sites

A "known contaminated site" is a location where contamination of soil or ground water has been confirmed at levels greater than the applicable soil cleanup criteria, ground water quality standards and/or maximum contaminant levels of the Safe Drinking Water Standards and where remediation is either underway or pending. Contamination is typically identified at a site through sampling of the soil, sediment, surface water and/or ground water.

NJDEP maintains a master list for the cleanup of all hazardous discharge sites throughout the State. The master list, called the Contaminated Sites List (of which the Known Contaminated Sites list is a sub-list), includes an inventory of the sites that have been cleaned up, that have been identified as in need of cleanup, and that will be cleaned up. The list of sites used in this report is based on the most recent GIS coverage (April 2008 Known Contaminated Sites list) obtained from the NJDEP Site Remediation Program. Remedial levels are based on the NJDEP Site Remediation Program's 1989 Case Assignment Manual, which determines levels based on the overall degree of contamination at a site.

Table 7 and Figure 10 show three known contaminated sites within the Cedar Grove Brook watershed that are classified as level C2[6]. Known contaminated sites do not pose a significant threat to the Cedar Grove Brook watershed.

Table 7. Known Contaminated Sites within the Cedar Grove Brook Watershed

Tracking Number	Address	List Date	Type	Remediation Level & Status
162135	300 Cedar Grove Lane	8/14/2002	HO-UST	C2: Formal Design – Known Source or Release with GW Contamination – Closed 6/2006 – no detail
164971	302 Cedar Grove Lane	9/30/2002	N/A	C2: Formal Design – Known Source or Release with GW Contamination
031476	Quail Brook Golf Course – 621 New Brunswick Ave	12/17/2001	UST-Unleaded Gasoline	C2: formal Design – Known Source or Release with GW contamination. Closed – 10/1997 – 1,000 gallon tank removed
HO = Homeowner, UST = Underground Storage Tank Data from NJDEP's 2008 Known Contaminated Sites GIS coverage and Data Miner				

[6] A remedial action that consists of a formal engineering design phase, and is in response to a known source or release. Since the response is focused in scope and addresses a known, presumably quantifiable source, this remedial level is of relatively shorter duration than responses at sites with higher remedial levels. Usually involves cases where ground water contamination has been confirmed or is known to be present.

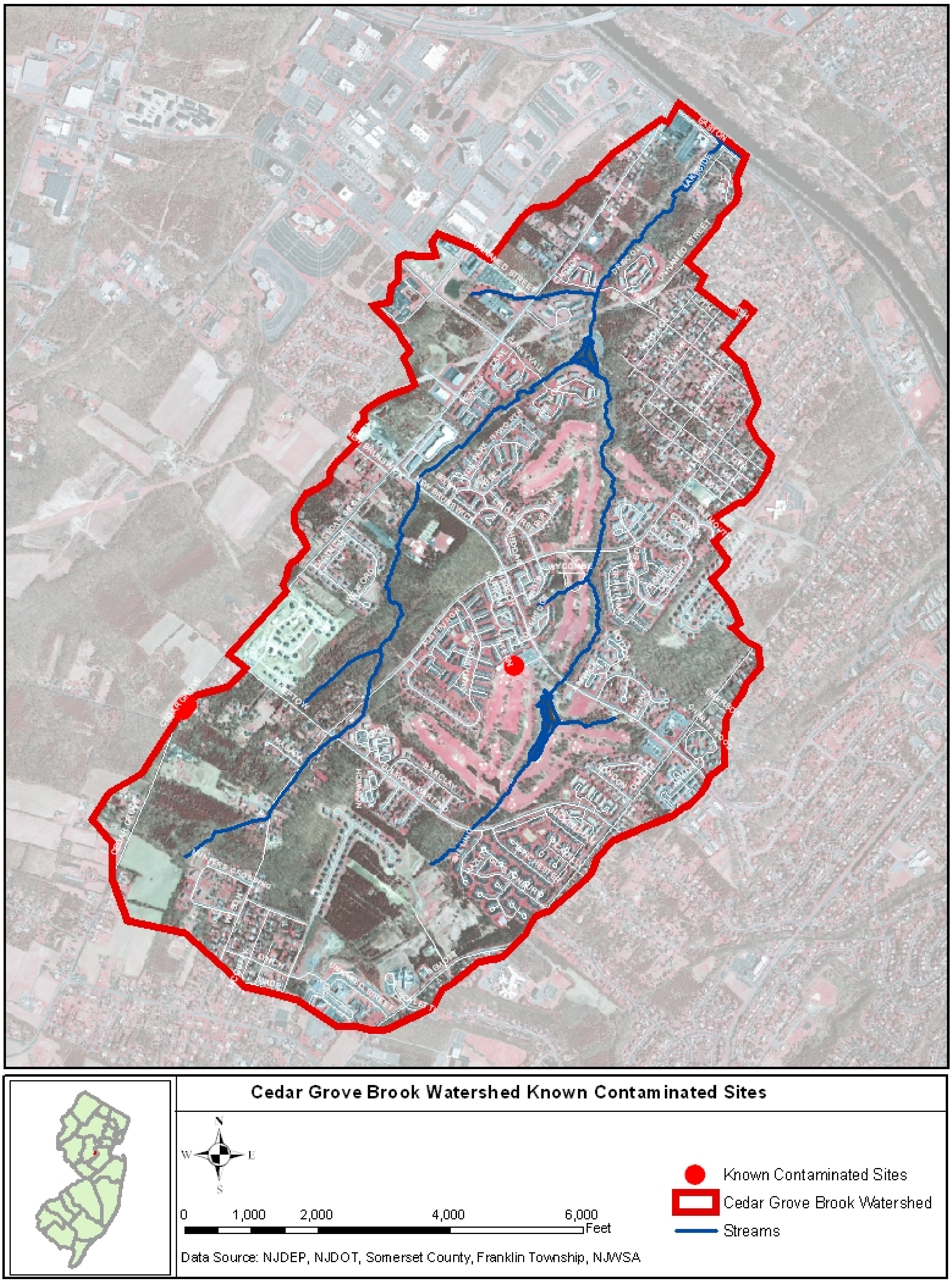


Figure 10. Known Contaminated Sites

V. Visual Assessment

A. Preliminary Visual Assessments

The Raritan Basin Watershed Alliance Road Crossing Protocol, developed by NJWSA and the Raritan Basin Watershed Alliance (RBWA), was utilized to collect information on each road crossing within the watershed. The information collected included land use, type of crossing, suitability for stream assessment (with respect to channel size, accessibility and safety) and the need for riparian buffer restoration. Photographs were taken at each crossing. From that list, NJWSA selected a subset of sites for stream visual assessment.

B. Stream Visual Assessments

In the fall of 2008 and winter of 2009, staff from the NJWSA and an ambassador from DEP's AmeriCorps program conducted a comprehensive stream visual assessment of the Cedar Grove Brook Watershed. NJWSA used the United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS) Stream Visual Assessment Protocol (SVAP) to gather baseline data for this project. The SVAP is used to score a site based on a set of 15 indicators, including:

- Channel condition: Natural vs. altered channel (e.g. channelization; installation of riprap, dikes or levees; or downcutting or incision).
- Hydrologic alteration: Connectivity to the floodplain (e.g., structures or channel incision that limit the stream's access to the floodplain).
- Riparian zone: Stream's buffer area (e.g., a perfect score requires natural vegetation to extend at least two active channel widths on each side of the stream. A lower score, for instance a 5, is given when natural vegetation extends only half the active channel width on each side of the stream).
- Bank stability: Bank condition (banks are either level with the floodplain and stable or are higher and eroding; banks have exposed roots or slope failures present within the reach).
- Water appearance: Water clarity (clear with visible bottom or cloudy/murky).
- Nutrient enrichment: Presence of dense algal and/or aquatic macrophyte growth (A stream with a diverse plant community and clear water scores a 10; a stream with greenish water and an overabundance of algae and/or macrophytes scores a 3).
- Barriers to fish movement: Withdrawals, culverts, dams or diversions both up and downstream of the reach.
- Instream fish cover: Available cover types for fish habitat (e.g., woody debris, riffles, pools, and cobble).
- Pools: Abundance and depth of pools within the reach.
- Invertebrate habitat: Number of cover types available as habitat.
- Canopy cover: Coldwater versus warmwater fisheries. The project area is considered a coldwater fishery, thus a reach that is well shaded would score high, whereas a reach that is minimally shaded would score low.
- Manure presence: Evidence of livestock in or near the stream; it was not scored for any of the project sites.
- Salinity: Non-applicable for the project watershed.

- Riffle embeddedness: Embeddedness of cobble or gravel in sediment.
- Macroinvertebrates observed: Type and diversity of species present. A site with a good diversity of pollution intolerant species received a score of 15, while a site dominated by more pollution tolerant organisms might receive a 6. It should be noted that several of the SVAPs were performed during the winter months, which are not ideal months for the observation of macroinvertebrates. This parameter was not scored at all of the sites.

Once the team chose a segment for assessment, the active channel width was measured. A reach that was 12 times the active channel width was then scored from one to 10 (one to 15 for macroinvertebrates observed and one to five for manure presence) based on the 15 parameters described above; any parameter that was not applicable to a particular site was not scored. In the project watershed, salinity was determined to be not applicable; manure presence was not identified and thus not scored at any sites. The scores for each parameter were summed and divided by the total number of parameters scored to yield the SVAP score.

The SVAP relies heavily on relative comparison of sites, rather than a rigorous quantitative analysis; it is a screening assessment tool rather than a site-specific monitoring protocol, and therefore is subjective. Each parameter is scored based on the assessor's observations of a particular reach. For this reason, NJWSA ensured consistency of assessors among all of the sites.

The SVAP provided a great deal of useful information regarding the Cedar Grove Brook watershed. The shortfall of the protocol is that it fails to provide a mechanism for identifying the cause of identified problems.

The full SVAP report is provided in Appendix D. The 14 SVAP locations were chosen based on the preliminary visual assessments, tributary patterns and accessibility. The objective was to collect enough information to assess overall stream health. The stream assessment team identified areas of impaired stream systems throughout the watershed, and documented major detention basins and associated outfalls. Observed impairments included:

- Destabilization and erosion of stream banks
- Disconnection of the stream from the floodplain due to downcutting of the stream channel and man-made embankments;
- Inadequate riparian zones and overabundance of invasive species;
- Excessive sediment deposition due to a loss of stream transport capacity;
- Presence of algae in moderate to high densities during time of assessments (December).

Detailed surveys of detention basins in the watershed were conducted using the NJDEP Volunteer Monitoring Program Visual Assessment Pipe and Drainage Ditch Inventory. Detention basins were targeted by the NJWSA staff managing the Cedar Grove Brook project. Observed impairments included:

- Concrete low flow channels in each detention basin;
- Sediment accumulation at the outlet of each detention basin;
- Abundant scat accumulation from wildlife (geese and deer) in each detention basin;
- Erosion of stream banks at the outfall of four out of six basins surveyed.

Overall scores ranged from 4.70 (Poor) to 7.80 (Good). The scores for each parameter varied widely, e.g. from a low of four in the riparian zone category to a high of nine. Figure 11 shows the 14 SVAP locations; the data are summarized in Table 8.

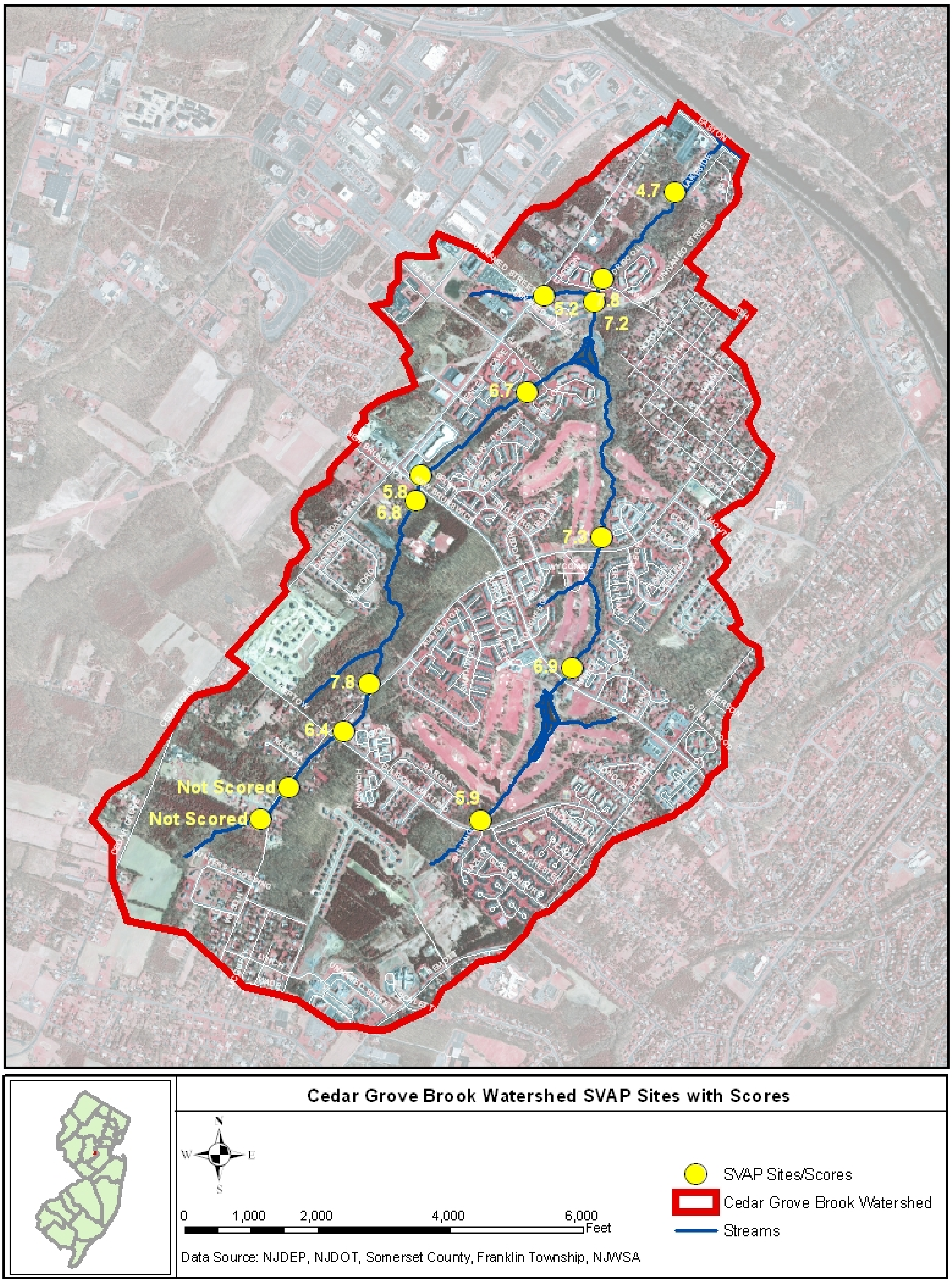


Figure 11. Stream Visual Assessment Locations and Scores

Table 8. Summary of Stream Visual Assessment Results

SVAP #	CGB-1	CGB-2	CGB-3	CGB-4	CGB-5	CGB-6	CGB-7	CGB-8	CGB-9	CGB-10	CGB-11	CGB-12	CGB-13	CGB-14
Assessment Scores:														
Channel condition	3	7	9	8	6	9			9	8	9	8	9	3
Hydrologic alteration	3	8	10	8	6	9			10	8	9	7	9	2
Riparian zone	4	6	8	6	6	4			4	6	9	8	8	6
Bank stability	5	7	7	7	6	7			10	7	8	7	9	3
Water appearance	7	7	8	6	7	7			8	7	8	7	7	7
Nutrient enrichment	7	7	4	7	6	7			8	9	3	7	8	3
Barriers to fish movement	3	1	3	3	3	3			3	3	9	3	3	5
Instream fish cover	5	8	10	5	4	8			5	10	9	5	8	8
Pools	6	8	9	8	3	7			3	5	6	3	9	3
Invertebrate habitat	8	10	10	7	7	10			7	10	10	7	10	7
Canopy cover	7	7	5	7	8	3			3	4	7	6	3	5
Manure presence	n/a	n/a	n/a	n/a	n/a	n/a			n/a	n/a	n/a	n/a	n/a	n/a
Salinity	n/a	n/a	n/a	n/a	n/a	n/a			n/a	n/a	n/a	n/a	n/a	n/a
Riffle embeddedness	3	10	10	8	7	7			n/a	6	7	3	5	4
Macroinvertebrates observed	7	na	na	na	na	na			na	na	na	na	na	na
Overall Score (Total divided by number scored) Poor = <6.0; Fair = 6.1 - 7.4; Good = 7.5 - 8.9; Excellent = >9.0	**5.2**	**7.2**	**7.8**	**6.7**	**5.8**	**6.8**	not scored	not scored	**6.4**	**6.9**	**7.8**	**5.9**	**7.3**	**4.7**
Rating	Poor	Fair	Good	Fair	Poor	Fair	na	na	Fair	Fair	Good	Poor	Fair	Poor

Four SVAP locations scored poor in the stream visual assessment process:
CGB-1: This location, with a score of 5.2, had low scores for channel condition, hydrologic alteration, riparian zone, barriers to fish movement and riffle embeddedness. The stream was confined by high banks associated with multi-family residential development on the left bank, and Lawndale Drive on the right bank. The left bank averaged 15 feet, the right bank averaged eight feet. Both banks were actively eroding. A headcut migration to bedrock provided evidence that the reach has been actively down cutting. This reach conveys considerable storm water runoff from a regional detention basin located at the southeast intersection of Pierce Street and Worlds Fair Drive.

The riparian corridor was inundated with invasive species. There was a lack of native species regeneration and virtually no native understory species population. There was an inline detention basin upstream of the Cedar Grove Lane road crossing. A large population of geese was observed. There was no riparian buffer upstream of the road crossing, only lawn. This site was identified as a potential location for riparian buffer improvement**.**

CGB-5: This location, with a score of 5.8, had low scores for barriers to fish movement and pools. The average bank height within the reach was one to two feet. The floodplain was steep and the reach was relatively straight. The upper portion of the reach was dominated by bedrock, the lower portion contained more silt and cobble. The substrate was >25% embedded at the lower end of the reach. Attached algae were moderately dense and completely covered the channel substrate.

The riparian corridor was 50 to75 feet wide on the left bank and 30 feet wide on the right bank. The corridor lacked a native understory and multi-flora rose was abundant. Land use in the vicinity of the site included commercial development and an access road.

CGB-12: This site scored 5.9, and had low scores for barriers to fish movement, instream fish cover and riffle embeddedness. The average bank height through the reach was one to two feet. The reach was dominated by small riffles and shallow pools. Sediment deposition was observed throughout the reach. A small tributary on the left bank was contributing sediment to the channel. Some erosion was occurring in proximity to a debris jam at the top of the reach.

The riparian corridor was 100 feet wide on the left bank and approximately 50feet on the right bank. The corridor contained a large population of invasive species, particularly multi-flora rose. Native species regeneration was absent. The land use in the vicinity of the site included multi-family residential and forest on the left bank, and Quail Brook Golf Course on the left bank.

CGB-14: This location had the lowest score of all the SVAP sites, a 4.7. It scored low for channel condition, hydrologic alteration, bank stability, nutrient enrichment, pools and riffle embeddedness. The stream meanders through an extensive sediment bar and may be a source of TSS during storm events.

The height of the banks within the reach ranged from one to two feet, and was as high as eight feet. The stream had access to the floodplain during storm events in some portions of the reach; in other areas the floodplain was steeply sloped.

The substrate was dominated by fine sediment in the lower portion of the reach; bedrock and cobble were observed at the upstream end where the gradient was steeper and riffles were more abundant. The upper portion of the reach had a meandering pattern with riffles, glides and shallow pools occurring frequently. Large, old sediment deposits inhabited by mature vegetation were observed. Recent deposition formed numerous sediment bars along straight areas, on the inside of meander bends and mid-channel. Bank erosion was observed on the outside of meander bends most often associated with large sediment deposits along the opposite bank.

The downstream end of the reach was dominated by large meanders, side channels and backwater pools . Large amounts of sediment were deposited within this portion of the reach. Some sediment bars were two feet above the water surface elevation and actively eroding. Attached algae were abundant and completely covered the substrate through most of the reach.

The riparian corridor on the left bank averaged less than 50 feet in width. The corridor on the right bank was approximately 50 feet wide in the lower and upper portion of the reach and greater than 100 feet mid-reach. The corridor on both banks was inundated with invasive species and lacked native species regeneration and native species in the understory. The land use in the vicinity of the site included roadway, forest and multifamily residential on the right bank and roadway, commercial development and multifamily residential on the left bank.

C. Stormwater Basin Survey

GIS layers identifying stormwater basins in the watershed were obtained from Somerset County and the Somerset-Union Soil Conservation District. A total of 15 basins were identified from the GIS layer and field observations. There may be other basins within the watershed that were not identified in this effort. General observations are included in Table 9, locations are shown in Figure 39.

Table 9. Stormwater Basins

	Basin Identifier	Street Location/ Block/Lot	Responsible Party/Owner	Notes/Observations
1	Lower Pond	1730 Easton Ave./ Block 424.02/Lot 24	Cretan Bull Restaurant Corp.	See Section VIII(A)(3)
2	Candlewood Hotel Co./ First Industrial L.P.	Block 468.09/Lot 47	First Industrial L.P. 311 South Wacker Dr., Chicago, IL 60606	Very large detention basin, 3 inlets, low flow channels, grass with some areas of exposed soil on basin floor
3	Ukrainian Village/Lakewood Townhomes	Sunnyvale Court/ Block 424.02/ Lot 11.96	Lakewood Townhouse Association 35 Clyde Road, Suite 102, Somerset, NJ	See Section VIII(A)(2)
4	Stonehenge Estates	19 Wexford Way/ Block 424.12/Lot 4.13	Stonehenge HOA, 315 Raritan Avenue, Highland Park, NJ	Low flow channels, 3 inlets, outfall 50 feet from channel, sediment source to stream, grass floor of basin
5	Franklin Twp. 1/Renoir Way	186 Cedar Grove Lane/ Block 424.12/Lot 2.32	Franklin Twp. 475 De Mott Lane	Near Renoir Way, 3 inlets with concrete low flow channels, wet basin floor, muddy, holding water after storm events
6	Hunter's Crossing	Block 423.01 Lot 40.07	Hunter's Crossing HOA, 12 Hunter's Crossing Road, Somerset, NJ 08873	Drains storm drain off Hunter's Crossing Road, 1 inlet concrete low flow channel, 3 inch hole partially blocked by sediment, sediment in low flow channel, riprap in stream at outfall, holding water after storm events – inlet under water
7	Franklin Twp. 3/Gauguin Way	Block 417.01 Lot 22.01	Franklin Twp. 475 De Mott Lane	Grass floor detention basin
8	Franklin Twp. 2	Block 417.01 Lot 5.04	Franklin Twp. 475 De Mott Lane	Very large detention basin at municipal complex. 1 inlet, 2 low flow channels, adjacent wetland area. Very wet and muddy by outlet structure
9	Somerset AL Holdings #1	473 De Mott Lane/	Somerset AL Holdings, 473	Unmowed basin – a lot of herbaceous and some woody

		Block 417.01/Lot 4.02	Demott Lane, Somerset, NJ	vegetation. Low flow channels.
10	Somerset AL Holdings #2	473 De Mott Lane/ Block 417.01/Lot 4.02	Somerset AL Holdings, 473 Demott Lane, Somerset, NJ	Small detention basin draining parking lot of assisted living facility. No low flow channel, grass mowed floor
11	Quail Brook Golf Course	625 New Brunswick Road/ Block 424.04/ Lot 63.02	Somerset County Park Commission	See Section VIII(A)(1)
12	Community Baptist Church	211 De Mott Lane/ Block 424.08/Lot 58.01	Community Baptist Church of Somerset	Receives stormwater from parking lot of Church Center via concrete swale and curb cuts. Low flow channel and mowed grass basin floor.
13	Franklin Township #4/147	Block 424.08/Lot 368	Franklin Township	Receives stormwater from approximately 35 houses on Rue Chagall and Picasso Court. Basin floor not regularly mowed
14	Paddock Estates	Block 423.01/Lot 17.10	Paddock Estates, LLC 1065 Route 22 West, Bridgewater, NJ	Two inlets with low flow channels. Mowed basin floor with some landscaping along berm. Discharges to stream along Wilson Ave.
15	Jain Center	111 Cedar Grove Lane/Block 468.07/Lot 45	Jain Center of NJ, 24A Chatham St., North Plainfield, NJ	Three concrete low flow channels.

VI. Pollutant Source Assessment

The Delaware & Raritan Canal transfers water from the Delaware River Basin to the Raritan River Basin, where the raw water is treated to become drinking water for approximately 600,000 customers living in and outside the Raritan Basin. Since 1997, several of the Canal's water purveyors reported increased concentrations of total suspended solids in the raw water during and immediately after precipitation events, requiring increased chemical use for treatment and increasing residual sludge generation.

A 1999 study by the United States Geological Survey (USGS) reported that the turbidity does not decrease in the Canal reach between Ten Mile Lock and the Route 18 spillway as would be expected due to low water velocities in this reach, indicating that settling solids are replaced by particulates from influent streams and stormwater discharges to the Canal. Field observations downstream of the Canal's confluence with Cedar Grove Brook confirm this, noting the formation of a sand bar indicating that Cedar Grove Brook contributes sediment-laden stormwater to the Canal.

The Cedar Grove Brook watershed is the fourth largest direct drainage to the Canal. NJWSA's D&R Canal Nonpoint Source Management Study focused on the last eleven miles of the D&R Canal; however, the Cedar Grove Brook watershed was excluded from that study due to its size, and was made the focus of this report.

The initial phase of this project included water quality sampling to assess the TSS and turbidity levels in Cedar Grove Brook, and to estimate watershed runoff rates and volumes and associated sediment loads. The results of this initial phase were published in the "Cedar Grove Brook Water Quality Characterization and Assessment" (Appendix B, TRC Omni, 2006).

The results of the initial sampling phase did not confirm that TSS and particularly turbidity loads from Cedar Grove Brook were substantially impacting the water quality of the D&R Canal at the water supply intakes downstream of Cedar Grove Brook. The sampling results were not sufficient to exclude the possibility that Cedar Grove Brook delivers a substantial turbidity load affecting water quality in the Canal; nevertheless, the lack of direct sampling confirmation left open the possibility that efforts to minimize TSS and turbidity loads in the Cedar Grove Brook watershed may not address the water quality problems observed at the water supply intakes in the Canal. Additional monitoring for the Cedar Grove Brook watershed was therefore designed to complement the restoration efforts that are currently underway in the Canal and to better understand the impact of Cedar Grove Brook on the turbidity in the Canal.

A. Quantification of Potential Sediment Loads – WinSLAMM Modeling

As part of the D&R Canal NPS Project, NJWSA and Princeton Hydro/SWM Consulting used the WinSLAMM source area data and results to estimate the particulate solids and particulate phosphorus loads from each infall drainage area. WinSLAMM allows the user to divide each land use (residential, commercial, industrial, other urban/open space, institutional and freeway) into source areas (parking areas, roof, landscaped areas, driveways, undeveloped, etc.). Additional information such as the length of road within the land use and a general estimate of drainage system characteristics are also entered. The model calculates how much of the pollutant load originates from each land use and each source area within the drainage area. Estimates are given for each rainfall event in the model run.

Based on the WinSLAM results, NJWSA ranked the infalls within the last 11 miles of the Canal based on the sediment and phosphorus loads. The Cedar Grove Brook watershed ranked first among all of the infalls. The WinSLAMM results based on the D&R Canal model are shown in Table 10.

Table 10. WinSLAMM Results - Sediment Load (lbs) from the Cedar Grove Brook Watershed

Land Use	Sediment load (lbs)
Residential	26,360,000
Institutional	9,042,000
Commercial	3,011,000
Industrial	121,338
Other Urban	31,700,000
Freeway	0
Total	70,230,500

For the Cedar Grove Brook project, the watershed was then divided into three subwatersheds, based on the areas draining to the Golf Course Pond, the Ukrainian Village Pond and the Lower Pond. The subwatershed delineations are shown in Figure 12.

Table 11 and Figure 13 show the results of the WinSLAMM modeling for the sediment load from each land use for the three subwatersheds. The relative contribution from any source area is a function of: 1) the percent of the watershed comprised of the source area; and 2) the potency (pounds per acre) of the source area in terms of sediment load contribution.

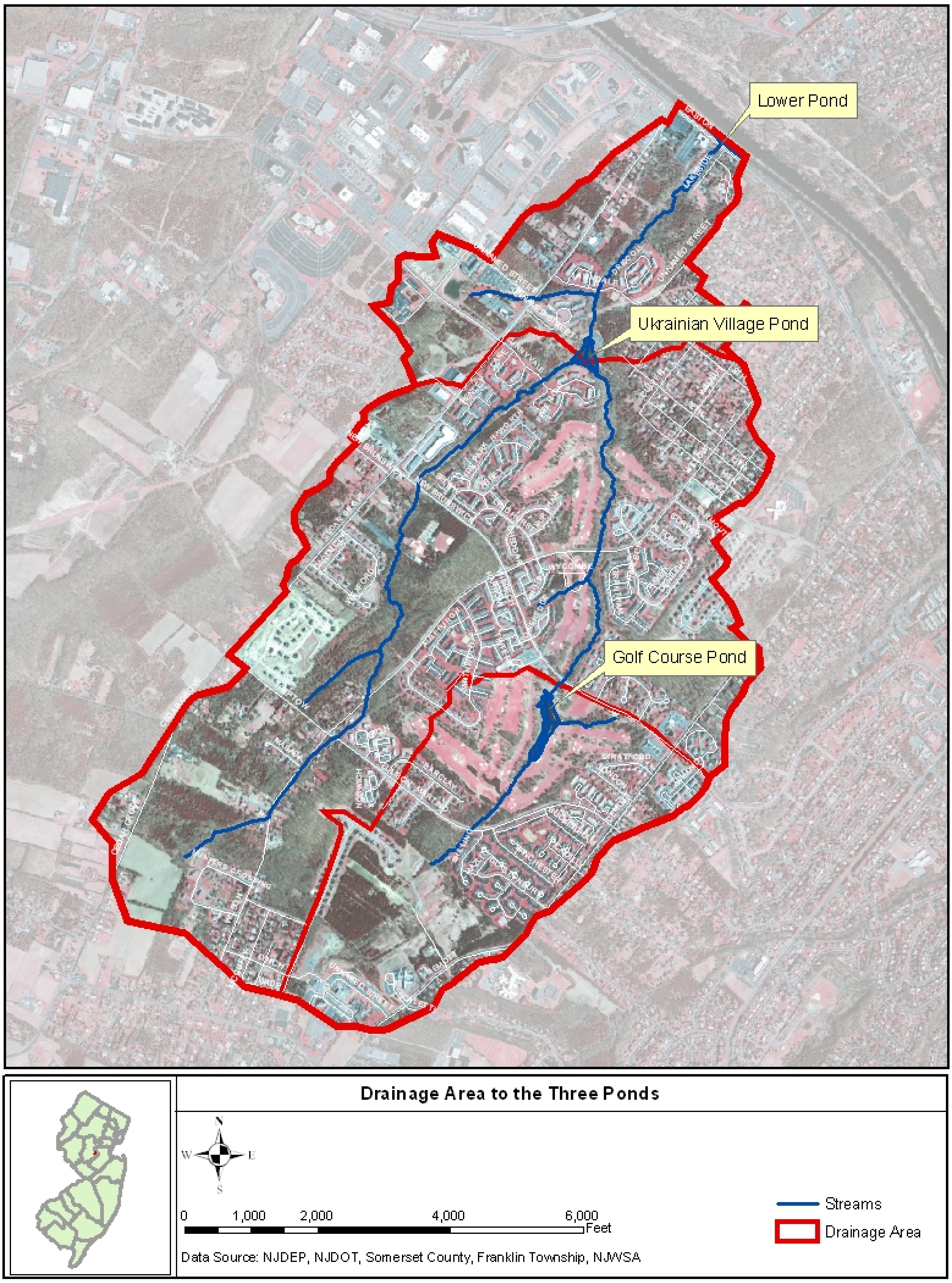


Figure 12. Subwatersheds

Table 11. Sediment Load (lbs) from the Three Subwatersheds

Land Use	Golf course Pond	Ukrainian Pond	Lower Pond	Total
Residential	3,730,000	14,410,000	2,188,000	20,328,000
Institutional	2,942,000	3,277,000	261,757	6,480,757
Commercial	1,062,000	678,539	1,562,000	3,302,539
Industrial	0	169,043	0	169,043
Other Urban	1,748,000	18,460,000	4,822,000	25,030,000
Freeway	0	0	29,910	29,910
Total	12,480,000	37,000,000	8,864,000	58,344,000
Note: The total sediment loads for the entire watershed (Table 10) and the 3 subwatersheds (Table 11) are slightly different due to slight modifications in the WinSLAMM model between the D&R Canal and Cedar Grove Brook projects.				

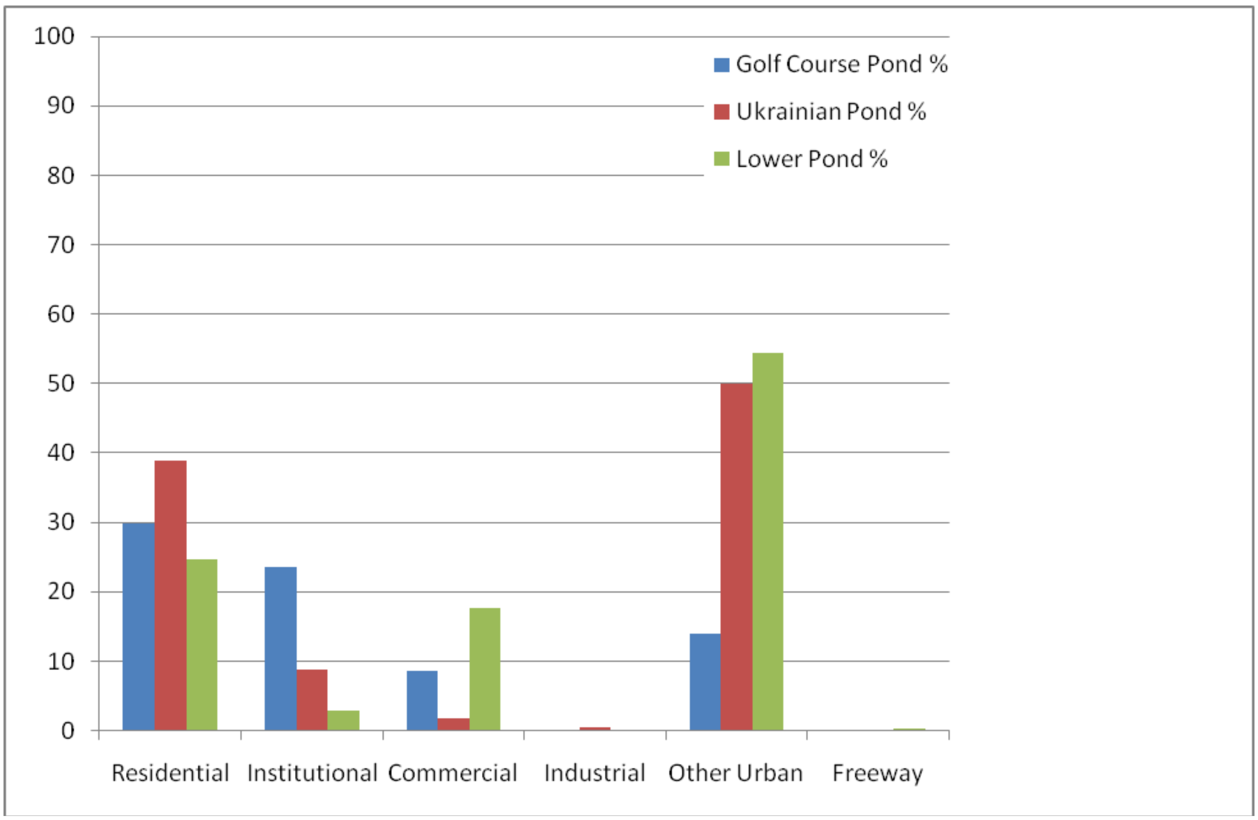


Figure 13. Percentage of Total Particulate Load by Land Use for Three Subwatersheds

The WinSLAMM modeling indicated that the largest sediment loads are typically generated from residential properties (approximately 38%) and the “other urban” land use. The “other urban” land use is the term that WinSLAMM uses for forests, brush/shrub land, wetlands and agriculture. Although vegetation such as lawn and forest is generally considered to be more protective of water resources than impervious areas such as driveways and roofs, these areas do generate sediments and other pollutants.

In order to better characterize the sediment load from the residential areas, the source areas for that land use were analyzed. WinSLAMM estimates the pollutant load coming from each source area within a land use; for residential land those source areas include roofs, driveways, paved parking areas, unpaved parking areas, streets and small landscaped areas. The results for the three subwatersheds are provided in Figure 14. The WinSLAMM modeling indicated that the majority of the residential sediment load is generated by small landscaped areas, typically lawns and gardens, with some forested areas.

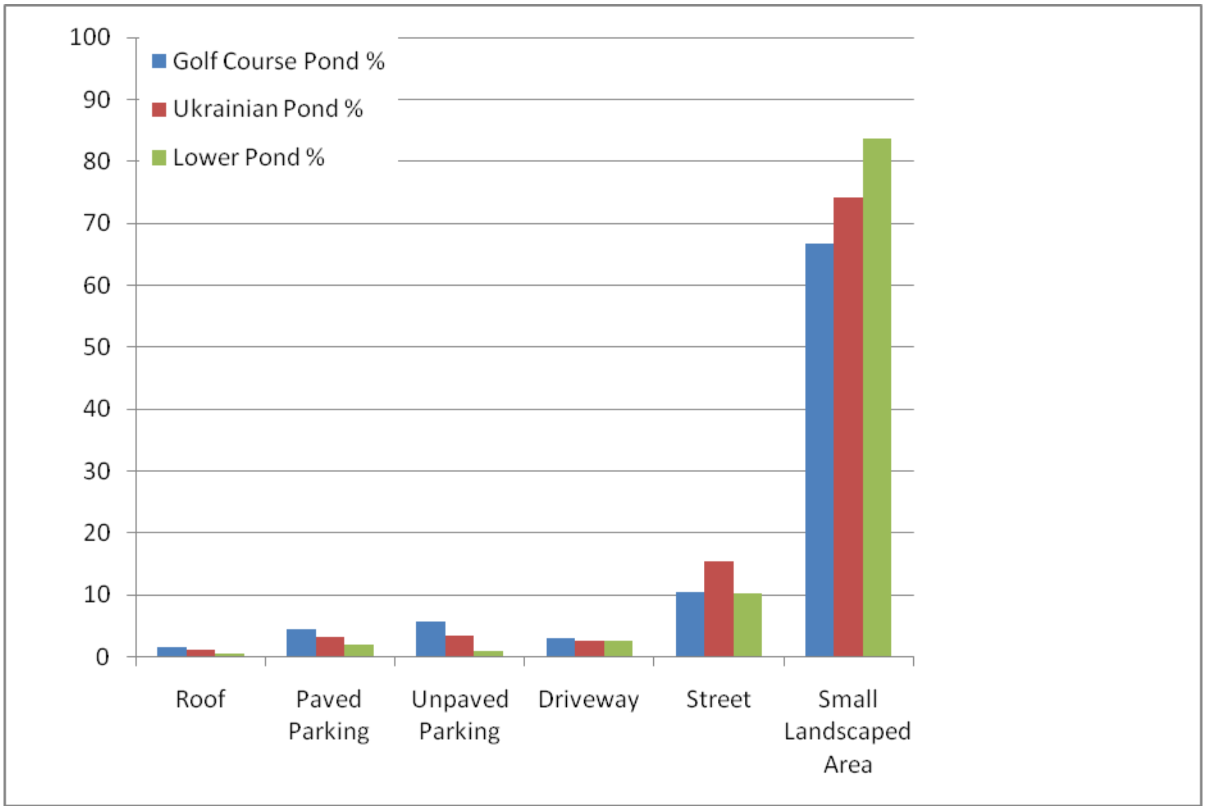


Figure 14. Percentage of Total Particulate Load by Residential Source Area for Three Subwatersheds

B. Historical Water Quality Data Summary (1998-2004)

In the late 1990's, water quality purveyors reported that after storm events, additional chemical treatment was necessary to remove suspended solids from the raw Canal water. This resulted in additional chemical costs and additional costs for removing additional sludge and/or residuals. USGS conducted a water quality study during 1998 and 1998 to determine if changes in water quality along the length of the Canal were related to storm events. USGS found that between Ten Mile Lock and the Route 18 spillway, the mean and median of measured turbidity changed very little during the study period.

The average water velocity in the Canal is very low, and particles that cause turbidity are typically not transported significant distances. Turbidity is therefore expected to decrease through a particular reach as suspended solids settle out. USGS suggested that the expected decrease in turbidity within most reaches was not being observed because the expected decrease was being offset by turbid water entering the Canal from influent streams and stormwater discharges.

USGS measured the velocity between Ten Mile Lock and the Route 18 Spillway at 0.22 ft/s, the lowest average velocity of the six reaches that were measured. The USGS study found a very small decrease in turbidity between Ten Mile Lock and the Route 18 Spillway. If there were no stormwater inputs of turbidity in this reach, a large decrease in turbidity would be expected as water travelled through the reach. Since that large decrease was not observed, USGS believed that turbidity was being added from influent streams and stormwater discharges. The Cedar Grove Brook (referred to as Al's Brook in the USGS study) drainage area was the largest in that reach, and was believed to be the source of "significant amount of stormwater runoff that carried turbidity" to the Canal (USGS, 1999). In addition, USGS observed a large sand bar just downstream of the confluence of Cedar Grove Brook with the Canal, indicating that Cedar Grove Brook has contributed stormwater-generated sediment to the Canal.

As part of the Delaware & Raritan Canal Tributary Assessment and Nonpoint Source Management Study, NJWSA reviewed water quality data from the USGS study, New Jersey American Water Company, Middlesex Water Company and NJWSA. The data reviewed covered various portions of the time period from March 1998 to October 2004, and indicated that all of the data were below the surface water quality standard of 40 mg/l. The USGS data indicated a decreasing trend in average turbidity upstream to downstream, and a similar trend for total suspended solids. The Middlesex Water Company data (4 sites) indicate that turbidity was approximately the same at all of their sampling sites. The NJWSA grab sample data indicated that average turbidity increased from Ten Mile Lock to Cedar Grove Brook and then decreased between Cedar Grove Brook and Landing Lane and Route 18. Turbidity samples taken at the Cedar Grove Brook confluence with the Canal were up to four times the levels of those taken at other locations, particularly during storm events.

C. Quantification of Potential Sediment Loads – TRC Omni Water Quality Sampling (2005)

The initial water quality data collected by TRC Omni (2005) suggested that the actual sediment loads from Cedar Grove Brook are much lower than the WinSLAMM model developed for the D&R Canal project predicted.

The three impoundments in the watershed (Golf Course Pond, Ukrainian Village Pond and Lower Pond) appear to act as sediment sinks and mitigate the potential impact of sediment generated in the Cedar Grove Brook watershed. In order to quantify the existing impact of the Golf Course Pond (Quail Brook Golf Course Pond) and Ukrainian Village Pond, a refined WinSLAMM (Version 9.3.0) simulation of the Cedar Grove Brook watershed was developed. The refined WinSLAMM simulation incorporated improved source terms from the stormwater sampling performed for the D&R Canal NPS Project in small subwatersheds that drain specific land use areas. Simulations were developed for the July 2005 and October 2005 storms (1.4 and 3.8 inches, respectively) that were sampled previously (TRC Omni, 2006). Predicted and observed loads were compared in order to understand the accuracy and limitations of both the model and the observed estimates. The refined WinSLAMM model was used then to assess the benefits of potential BMPs in terms of reduced sediment loads.

WinSLAMM simulations predict total volumes and pollutant loads to a single outlet over a storm based on individual watershed characteristics, most importantly soil type and land use. A low particle size distribution was assumed for all subwatersheds; since heavier particles settle faster, assuming a low particle size provides a conservative simulation of sediment removal rates. Predicted and observed comparisons were performed for both total runoff volumes and sediment removal rates at each of the three ponds during both 2005 storms. The predicted runoff volumes and removal rates were based on the output of the WinSLAMM simulations; the observed runoff volumes and removal rates represent best estimates based on continuous depth and discrete water quality measurements.

Estimates of the observed runoff volumes during the 2005 storms were calculated based on continuous measurements of depth over the weirs at the Golf Course Pond (CG2) and the Ukrainian Village Pond (CG5) using pressure transducers. Meaningful flow calculations could not be performed at the watershed outlet (Lower Pond, CG6) because the depth of water in the Canal was over the height of the weir, producing backwater effects. There are no significant tributaries between the Ukrainian Village Pond and the watershed outlet; the volume at CG5 (Ukrainian Village Pond) was multiplied by 1.15 to account for the increased drainage area. A comparison between the runoff volume predicted by WinSLAMM for each storm and the estimated runoff volume based on field data is provided in Figure 15. The trends and magnitudes compare reasonably well, although the field estimation of volume was significantly lower than the model predictions during the July storm. Differences can be explained by model uncertainty (runoff models often overestimate volume), field estimation uncertainty, and differences between simulated and actual local rainfall.

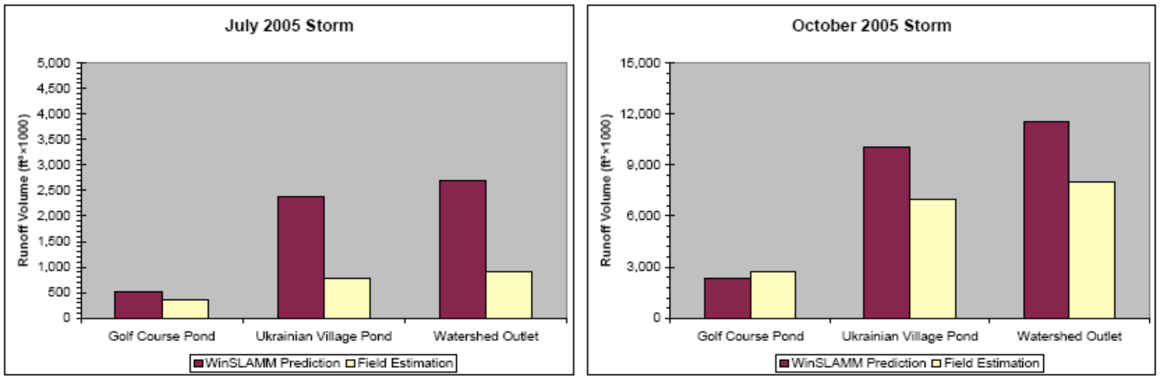
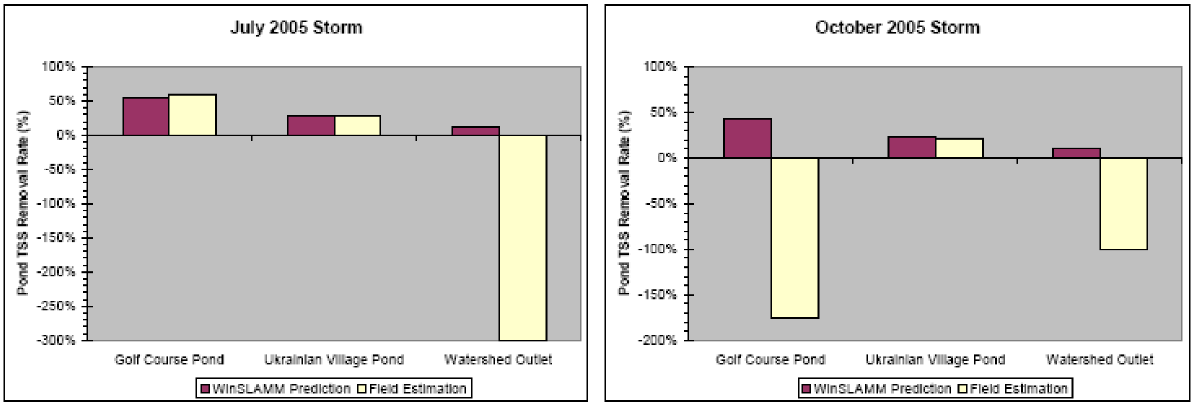


Figure 15. Runoff Volume Comparison

Estimates of the observed sediment removal rates during the 2005 storms were based on discrete water quality measurements at the inlet and outlet of each pond. The measured Total Suspended Sediment (TSS) concentrations at the inlet(s) and outlet were flow-weighted based on the estimated flow at the time of sampling in order to calculate Event Mean Concentrations (EMCs) for each storm. Since the total flow in and out of each pond is the same[7] over the course of each storm, the difference between the EMC at the outlet and the EMC at the inlet represents the pond removal rate. A comparison between the TSS removal rates predicted by WinSLAMM for each storm and the estimated removal rates based on field data is provided in Figure 16.

The removal rates compare extremely well, except that the Golf Course Pond and Lower Pond act as sources rather than sinks under certain conditions, apparently due to resuspension of bottom sediments. This is to be expected during the very large October 2005 storm event (3.8 inches); it indicates that sediment accumulates in the pond during the course of smaller, more typical events, but that large events can resuspend that sediment and cause an increase in TSS concentration. For instance, the EMC entering the Golf Course Pond at CG1 during the October 2005 storm was 4.7 mg/l of TSS; the EMC leaving the Golf Course Pond at CG2 during the same storm was 12.9 mg/l of TSS. The fact that the Lower Pond also increased TSS concentration during the much smaller July 2005 storm reflects the accumulated sediment behind the weir, leaving less than one foot of water beneath the crest of the existing weir.

[7] Hydrology for ponds is influenced by detention time that affects the amount of water evaporating as it passes through the pond, as well as the amount of rain that falls directly onto the pond. Loss of flow through evaporation, or increases from direct precipitation, may affect the outflow concentration.



*Negative "removal" rates indicate that the pond is adding TSS (due to resuspension) during a storm rather than removing it.

Figure 16. Pond TSS Removal Rate Comparison

These comparisons demonstrate the utility as well as the limitations of the WinSLAMM modeling tools for the Cedar Grove Brook watershed. Relative to all the other Canal contributions in the region, the Cedar Grove Brook represents a significant potential source of sediment and other pollutants. The three existing pond structures together are providing significant sediment removal, but also can act as sediment sources due to the resuspension of accumulated sediment under certain storm conditions.

D. Impact of Cedar Grove Brook on the D&R Canal

The D&R Canal NPS Implementation Project is focused on TSS loads, the underlying presumption being that TSS is related to turbidity and total organic carbon (TOC), both of which have been identified as water quality issues of concern for water supply uses in the Canal. Specifically, pulses of high turbidity and total organic carbon at the water supply intakes have been noted during storm events. Additional monitoring was performed in 2008 in order to understand the impact of Cedar Grove Brook on turbidity in the Canal and to understand the relationships among turbidity, TSS, and TOC under high and low flow conditions.

Continuous recording devices were equipped with turbidity sensors and installed in the following five locations (Figure 17):

- D&R Canal near Ten Mile Lock;
- Cedar Grove Brook at Easton Avenue near confluence with Canal;
- D&R Canal just upstream of Cedar Grove Brook confluence;
- D&R Canal just downstream of Cedar Grove Brook confluence; and
- D&R Canal near Route 18 spillway.

Turbidity was monitored continuously during a variety of flow conditions for a three week period from October 28 to November 18, 2008. Continuous monitoring data from Cedar Grove Brook and from the Canal upstream and downstream of Cedar Grove Brook were used to assess the impact of Cedar Grove Brook on turbidity in the Canal during a variety of flow conditions.

Furthermore, data from the most upstream and downstream locations in the Canal (Ten Mile Lock and Route 18 Spillway at Landing Lane, respectively) were used to confirm the observations made previously by USGS (USGS, 2001) that identified Cedar Grove Brook as a likely source of turbidity to the Canal. These data at the upstream and downstream boundaries of the segment of interest in the Canal also provide a context in which to evaluate the impact of Cedar Grove Brook on the Canal.

In addition to the continuous turbidity monitoring, water quality samples were collected from Cedar Grove Brook at Easton Avenue (upstream of weir near Canal confluence) and the D&R Canal at Five Mile Lock, which is near the Route 287 (Exit 10) bridge upstream of Cedar Grove Brook. Samples were collected under both low and high flow conditions, and analyzed for turbidity, TSS, and TOC. The grab sampling data were used to explore the relationships among TSS, turbidity, and TOC in Cedar Grove Brook and the Canal under various conditions. Eight grab sampling events were performed: four low-flow events, three high-flow events, and one medium flow event (two days after a rain event). Each event consisted of a single sample collected at both locations. The grab sampling in the Canal and in Cedar Grove Brook were used to assess the degree to which turbidity and TOC are related to TSS in this system. Figure 18 shows the flow and precipitation conditions prevalent during the monitoring period.

Flow was characterized using a nearby USGS stream gage (#01403150, West Branch Middle Brook near Martinsville). A small local stream was selected rather than the Canal gage at Port Mercer because the Canal gage is farther away and flow in the Canal is not as responsive to precipitation as a small stream, which would better characterize the response of Canal inlets and tributaries. Precipitation is shown in 15-minute increments based on data from the USGS rain gage in Somerville (#403410074364001). This station is approximately five miles from the sampling locations. The cumulative rainfall amounts for each storm event that occurred during the 2008 continuous monitoring period were as follows: 1.8 inches on 10/28, 0.31 inches on 11/5-11/6, and 1.27 inches on 11/13-11/15.

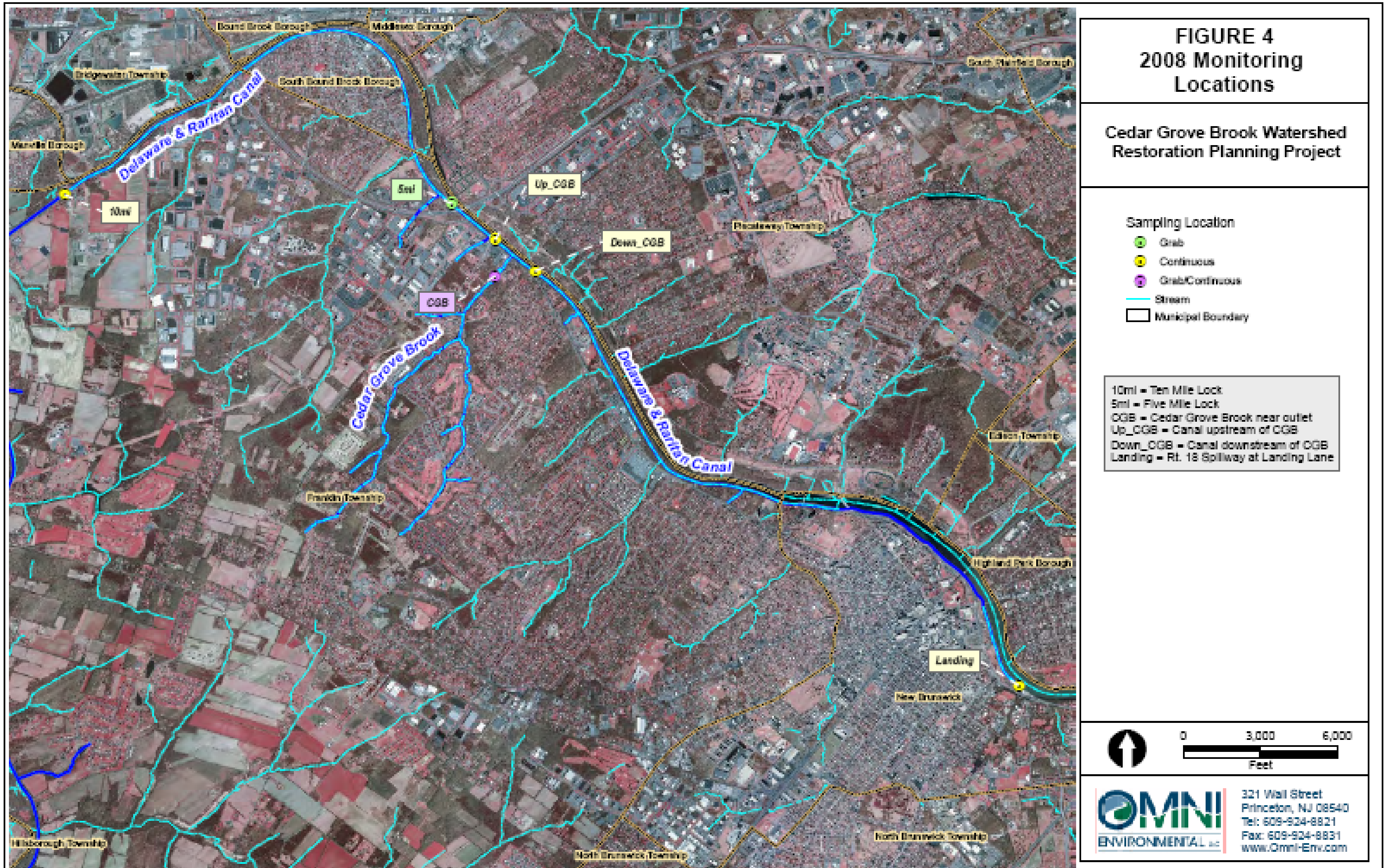


Figure 17. 2008 Monitoring Locations

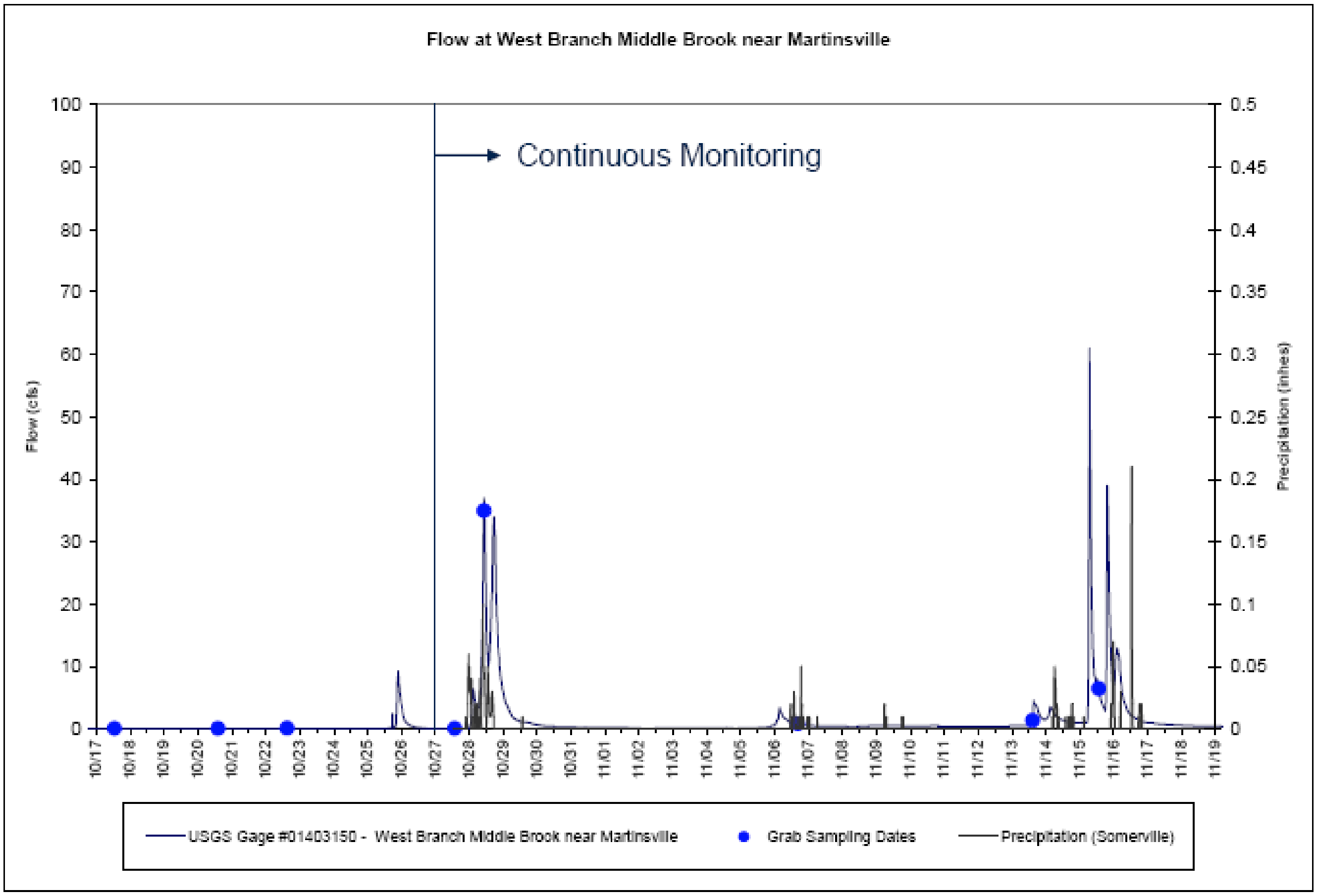


Figure 18. Flow and Precipitation Conditions During Monitoring Period

E. Turbidity Monitoring Results

Evaluating turbidity monitoring data from the four D&R Canal locations (10mi, Up_CGB, Down_CGB, and Landing) yielded some interesting results. Figure 19 zooms in on a low-flow period from November 3 to 8 and shows that at least some of the turbidity variation observed at the locations upstream and downstream of Cedar Grove Brook, as well as Landing Lane, can be explained simply by downstream propagation of the turbidity signature at the upstream study boundary at Ten Mile Lock. In fact, the turbidity peak at Ten Mile Lock was observed approximately 1.5 days later at the meters upstream and downstream of Cedar Grove Brook, and then again approximately 1 day after that at the downstream study boundary at Landing Lane (near Route 18 spillway). The total travel time of 2.5 days compares favorably with the expected travel time of 2 days 8 hours between Ten Mile Lock and the Route 18 Spillway as reported in the USGS study (USGS, 2001).

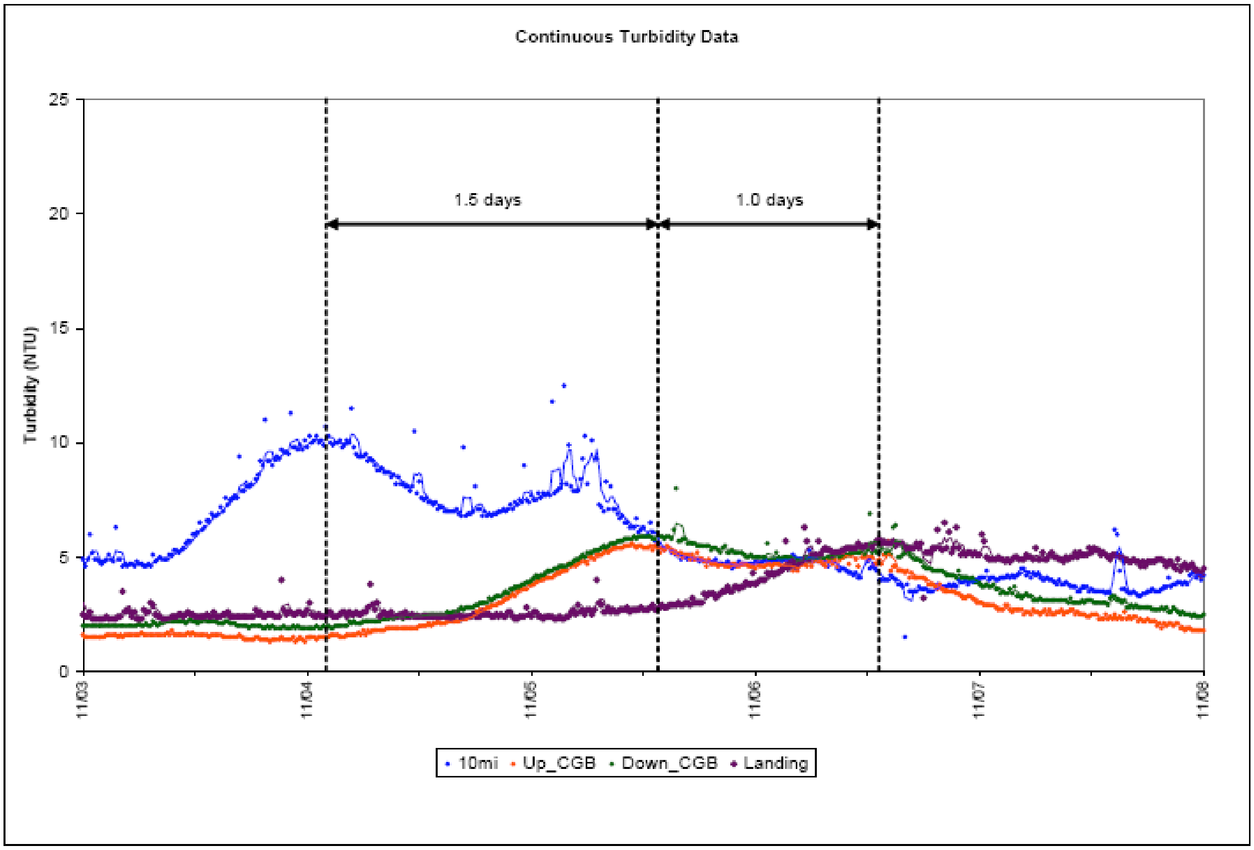


Figure 19. Travel Time of Turbidity in the D&R Canal

The continuous turbidity monitoring yielded one unexpected result: during low-flow periods, the D&R Canal at Ten Mile Lock exhibits clear diurnal turbidity variation (Figure 20) that appears to be natural in origin. The magnitude of the variation – about 1 Nephanolometric Turbidity Unit (NTU) – is not significant from a water quality perspective; however, it is consistent and definitely diurnal in nature, with peaks occurring at night (2:00–3:00AM) and troughs occurring in the mid-afternoon. Furthermore, as shown in Figure 20, the diurnal turbidity pattern exhibited at Ten Mile Lock is propagated downstream as well.

Traditionally, studies relating to diurnal variation in surface waters have focused on dissolved oxygen and pH; however, researchers are increasingly interested in diurnal variation of other surface water constituents, as evidenced by a recent symposium[8] sponsored by New Jersey Water Resources Research Institute entitled: "Diurnal (Diel) Cycling of Cedar Grove Brook Watershed Chemical Constituents in Surface Water and Related Media – Scientific and Regulatory Considerations." Researchers noted significant diurnal variations in arsenic and other metals, nutrients, hardness, organic carbon, and solids concentrations in surface waters, in addition to constituents that are more often associated with diurnal variations (e.g., temperature, pH, and

8 NJWRRI symposium: "Diurnal (Diel) Cycling of Chemical Constituents in Surface Water and Related Media – Scientific and Regulatory Considerations." Held December 12, 2008 at NJDEP in Trenton. http://www.njwrri.rutgers.edu/diurnal_cycling.html.

dissolved oxygen). The results of the continuous turbidity monitoring suggest that turbidity varies diurnally under some circumstances as well. Possible causes of diurnal variation include changes in flow, benthic macroinvertebrates activity, and temperature-related physical factors such as viscosity and sorption rates. The meter at Ten Mile Lock was deployed downstream of the lock itself, closer to the footbridge, and well past the area of turbulence associated with the lock. The smooth and consistent pattern suggests a natural diurnal phenomenon.

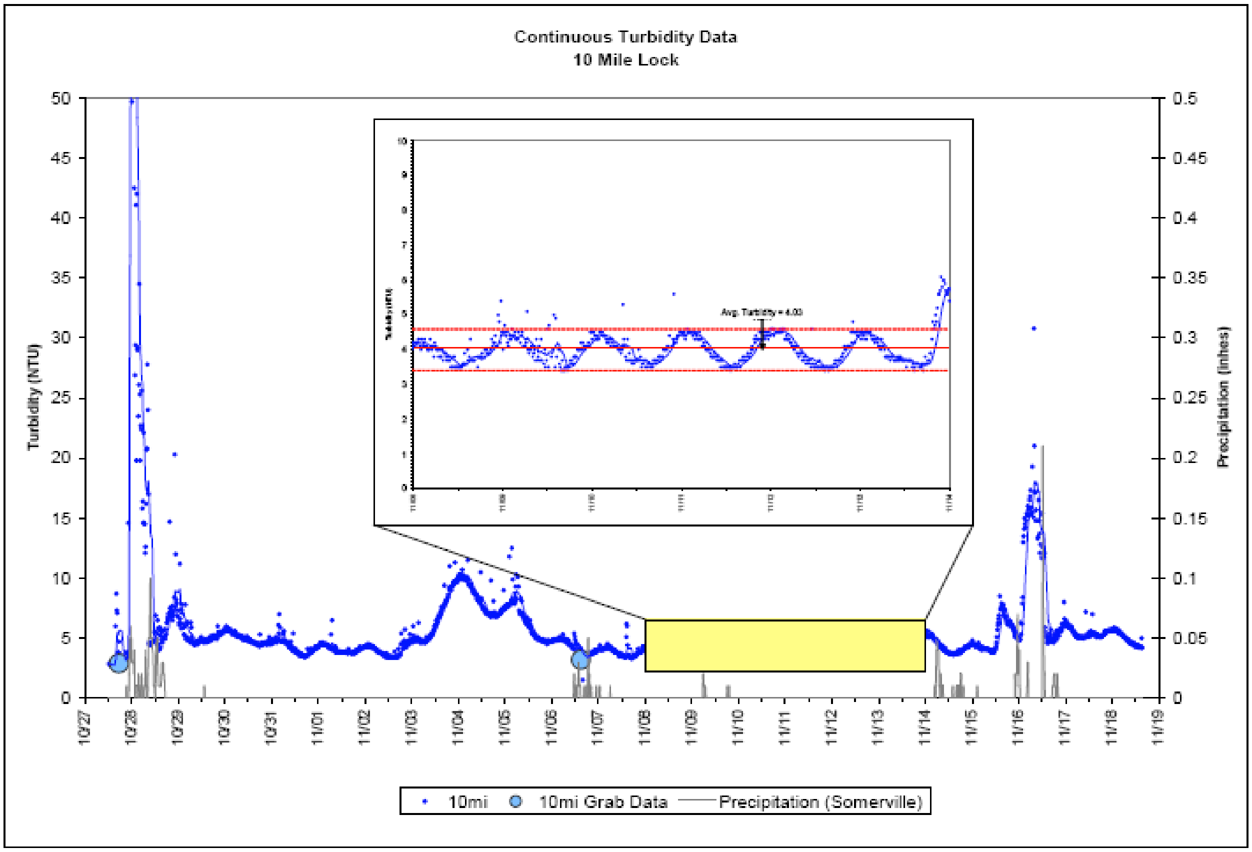


Figure 20. Diurnal Turbidity Variation Observed in the D&R Canal at Ten Mile Lock

The maximum, mean, and minimum turbidity values from the continuous turbidity data collected at the four D&R Canal locations are shown in Figure 21. The format and results are similar to that provided in the 2001 USGS study and can be compared directly. The USGS study was performed over a longer period of time (16 months), but did not include any turbidity measurements between Ten Mile Lock and the Route 18 Spillway. In terms of overall magnitude, the USGS average turbidity was approximately 9 NTU at Ten Mile Lock and the Route 18 Spillway locations, while the observed means during the 3-week survey in 2008 were 5.1 and 3.4 NTU at Ten Mile Lock and the Route 18 Spillway, respectively. The lower magnitude of the average can be attributed to the shorter time frame that included fewer major storms with high turbidity peaks. In fact, the highest maximum turbidity observed during the three-week survey in 2008 was 31 NTU at Ten Mile Lock, whereas the USGS long-term monitoring reported a maximum turbidity over 200 NTU at the same location. It is not surprising that the maximum recorded turbidity over a 16-month period would be substantially larger than that observed over a 3-month period.

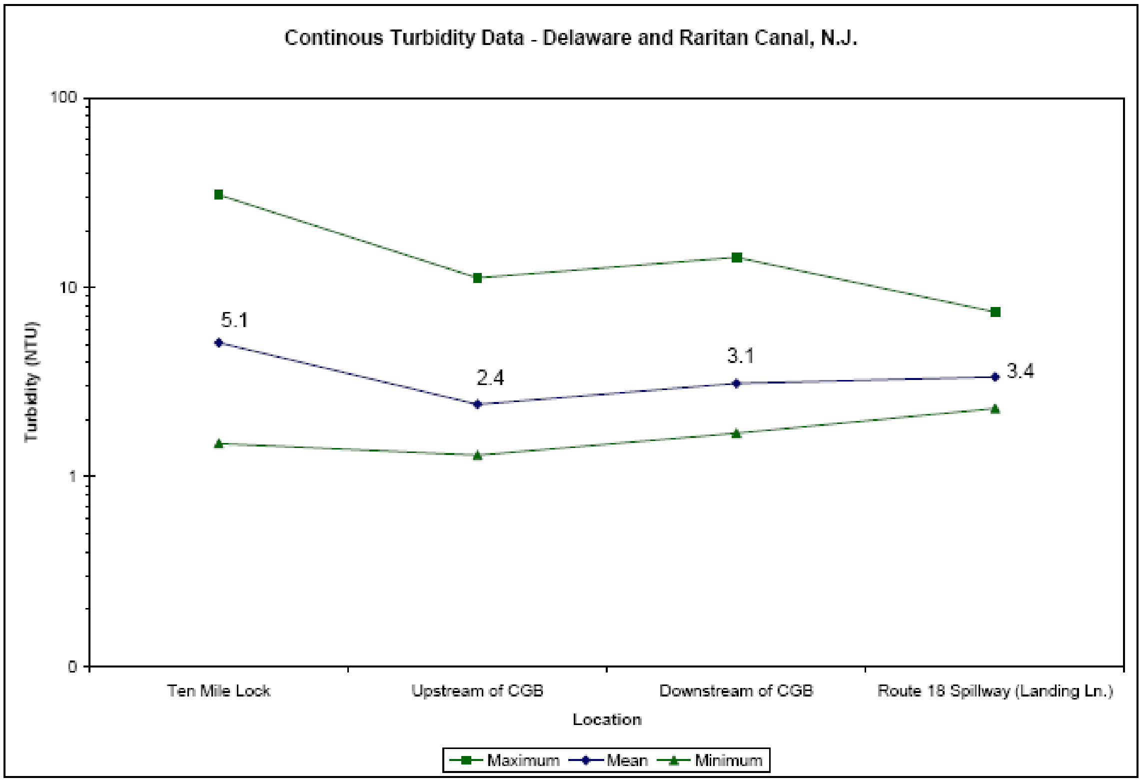


Figure 21. Turbidity Changes in the D&R Canal from Ten Mile Lock to the Route 18 Spillway

More importantly, the overall trends between Ten Mile Lock and the Route 18 Spillway were similar in both studies. The maximum recorded turbidity was significantly higher at Ten Mile Lock than at the Route 18 Spillway during both studies. Furthermore, the minimum recorded turbidity was very similar at both Ten Mile Lock and Route 18 Spillway locations during both studies. While the average turbidity during the 3-week survey in 2008 decreased by 1.7 NTU between the Ten Mile Lock and Route 18 Spillway locations (compared to only 0.1 NTU during the long term study by USGS), the observed average decrease was still much less than the 4 NTU that might be expected based on turbidity settling in other segments of the Canal (USGS, 2001). The turbidity trends at the Ten Mile Lock and Route 18 Spillway locations are similar between the two studies. It is evident from Figure 22 that Cedar Grove Brook does increase turbidity in the D&R Canal – maximum, average, and minimum turbidity all increase between the Canal monitoring locations upstream and downstream of the Cedar Grove Brook discharge point into the Canal; however, the magnitude of the increase in maximum, minimum, and average turbidity does not appear to be significant from a water quality perspective; for example, the maximum turbidity increased from 11 to 14 NTU due to the impact of Cedar Grove Brook. It is also worth noting that turbidity continues to increase between Cedar Grove Brook and the Route 18 Spillway, indicating that there may be another important discharge to the Canal in that segment.

In order to better assess the impact of Cedar Grove Brook on turbidity in the D&R Canal, it is helpful to zoom in on high and low flow periods. Figure 22 shows turbidity in the Canal upstream and downstream of Cedar Grove Brook, as well as in Cedar Grove Brook itself, during and after a storm event. Precipitation is also shown (in 15-minute intervals) along with grab turbidity sampling results that confirm the validity of the continuous turbidity results.

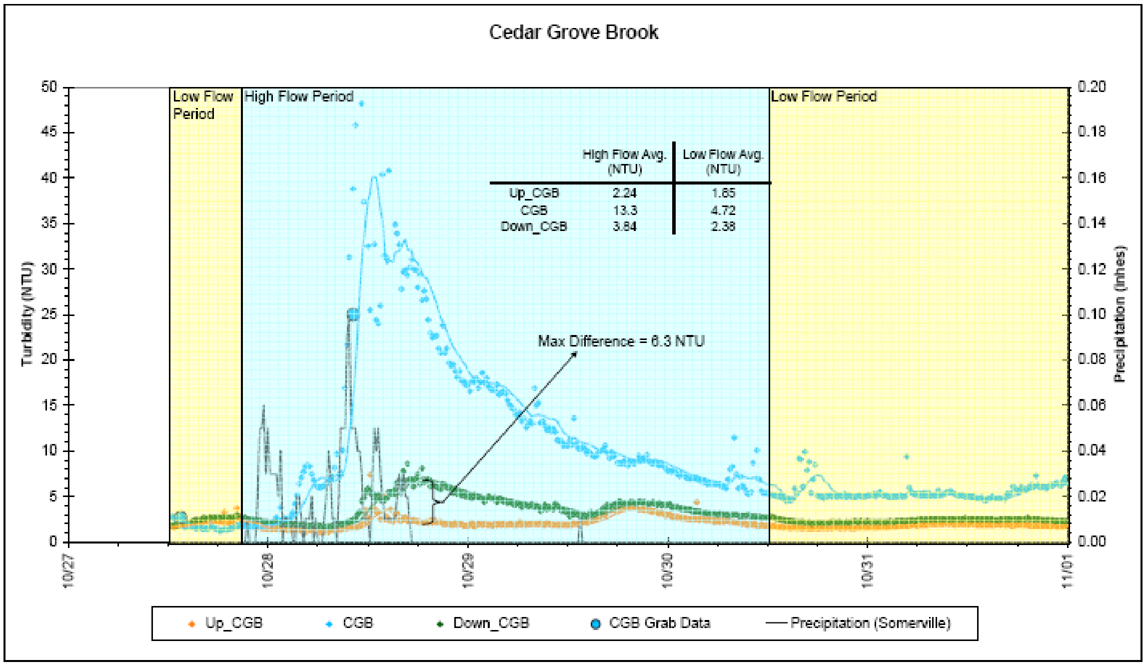


Figure 22. Turbidity Impact During High and Low Flow Periods

During the storm event, turbidity in Cedar Grove Brook peaked at over 40 NTU, whereas the turbidity in the Canal remained below 10 NTU. The maximum increase in turbidity in the Canal downstream of Cedar Grove Brook (e.g. difference between Up_CGB and down_CGB) was 6.3 NTU; furthermore, the impact of Cedar Grove Brook on the Canal was transient, with turbidity returning to pre-storm levels in about one day.

While the magnitude of the turbidity change due to Cedar Grove Brook was not that significant, it is worth noting that the turbidity peak in the Canal more than tripled during the storm due to the impact of Cedar Grove Brook. In addition, the long-term turbidity monitoring conducted by USGS recorded turbidity readings much higher than those observed during the 2008 monitoring period. Given the significant increase in the turbidity peak, the conclusion was made that Cedar Grove Brook increases the maximum turbidity peak in the Canal during large storm events.

Figure 22 also shows that the impact of Cedar Grove Brook on turbidity in the D&R Canal during low-flow periods is negligible. The difference in turbidity in the Canal immediately upstream and downstream of Cedar Grove Brook was less than 1 NTU during the low-flow period. It is clear from these data that the impact of Cedar Grove Brook on turbidity in the D&R Canal is limited to the turbidity peaks that occur during relatively infrequent, large storm events.

In summary, the continuous turbidity monitoring performed in 2008 yielded useful information regarding turbidity in the D&R Canal from Ten Mile Lock to the Route 18 Spillway and the impact of Cedar Grove Brook on this segment of the Canal. The first assessment based on the data is that turbidity in the D&R Canal from Ten Mile Lock to the Route 18 Spillway is generally fairly low in comparison to the turbidity criteria for freshwater in the Surface Water Quality Standards (N.J.A.C. 7:9B), namely a maximum 3- day average of 15 NTU and a maximum of 50 NTU at any time. Even during storm events, turbidity at the four Canal locations did not exceed these criteria during the 2008 monitoring period. The long-term monitoring performed in 1999-2000 (USGS, 2001) found a slightly higher average turbidity, likely driven by the substantially higher maximum peaks observed. It is unlikely that turbidity conditions have improved significantly between 2000 and 2008. It is more likely that the higher turbidity peaks occur during larger, less frequent storms, and perhaps also seasonally during summer phytoplankton growth periods in the Canal.

Cedar Grove Brook does appear to add some turbidity to the D&R Canal under typical and low-flow conditions, but the amount is not significant. This added turbidity is likely to reduce the amount of turbidity attenuation that occurs in this segment of the Canal. The average turbidity in the Canal at Ten Mile Lock is relatively low: approximately 5 NTU during the three-week survey in 2008 and approximately 9 NTU during the long-term monitoring performed in 1999-2000. The fact that, due to the impact of Cedar Grove Brook discharge, turbidity in the D&R Canal during typical and low-flow conditions does not decrease as much between Ten Mile Lock and the Route 18 Spillway may not be significant from a water quality perspective.

Although the typical and low-flow impact of Cedar Grove Brook on the turbidity in the Canal appears to be minimal, the continuous monitoring results do suggest that Cedar Grove Brook can significantly increase the turbidity peaks during larger storm events. This may be significant from a water treatment perspective, due to the proximity of Cedar Grove Brook to the water supply intakes. The fact that the 1.8 inch rainfall event that fell mostly on October 28, 2008 did not result in excessive turbidity in the Canal indicates that it is larger and less frequent storm events that must be driving the maximum turbidity events reported in the long-term study (USGS, 2001). To put this rainfall event in perspective, the idealized 2-year storm event for Somerset County is 3.3 inches over a 24-hour period. Furthermore, the idealized "water quality storm" is 1.25 inches of rain in a 2-hour period. While the October 28th storm totaled 1.8 inches of rain, no more than 0.5 inches fell in any 2-hour period.

F. Grab Sampling Results

As described previously, pairs of grab water quality samples from the D&R Canal (at Five Mile Lock) and Cedar Grove Brook (just upstream of the outlet to the Canal) were collected under a variety of flow conditions and analyzed for TOC, TSS, and turbidity. Results are provided in Table 12.

Table 12. Water Quality Sampling Data

Location	Flow Conditions	Date	Time	TOC (mg/l)	TSS(mg/l)	Turbidity (NTU)
D&R Canal at Five Mile Lock (5mi)	Low	10/17/2008	14:45	2.8	<2.5	2.1
		10/20/2008	15:00	3	<2.5	1.6
		10/22/2008	15:15	2.2	<2.5	2.8
		10/27/2008	14:30	6.5	<2.5	3.3
	Medium	11/6/2008	18:37	5.8	<2.5	4.2
	High	10/28/2008	12:00	2.9	3	3.1
		11/13/2008	14:30	5.6	3.5	5.8
		11/15/2008	13:40	4.9	3	3.1
Cedar Grove Brook (CGB)	Low	10/17/2008	12:50	3.9	9.5	2.2
		10/20/2008	14:00	3.1	<2.5	0.7
		10/22/2008	15:00	3	<2.5	0.9
		10/27/2008	12:00	8.7	<2.5	2.7
	Medium	11/6/2008	16:17	3.6	5	1.7
	High	10/28/2008	10"15	4.7	30	25
		11/13/2008	14:20	3.8	<2.5	2.8
		11/15/2008	13:20	5.2	5	9.7

The characterization of flow condition is qualitative. The sampling event on November 6th was intended to be a high-flow event, but the actual rainfall was less than expected and ended more than 24 hours before the sampling was performed. For this reason, the flow condition was characterized as "Medium" for that event. Eight pairs of water quality data were obtained under a variety of flow conditions that were available during the sampling period in 2008. In addition, TSS was analyzed along with confirmatory grab turbidity samples collected on November 6th at the four continuous turbidity monitoring locations in the Canal (Table 13).

Table 13. Additional TSS and Turbidity Samples at Canal Locations

Location	Date	Time	TSS (mg/l)	Turbidity (NTU)
D&R Canal at Ten Mile Lock (10mi)	11/6/2008	15:55	<2.5	3.2
D&R Canal upstream of Cedar Grove Brook (Up_CGB)		17:06	<2.5	5.9
D&R Canal downstream of Cedar Grove Brook (Down_CGB)		18:00	<2.5	5.1
D&R Canal near Route 18 Spillway (Landing)		18:15	91	11

Relationships among TOC, TSS, and turbidity were explored both in the Canal and in Cedar Grove Brook. The sample results did not include many high values, especially for TSS and turbidity; accordingly, statistical relationships were not developed. Instead, parameter values were plotted against each other and simple logarithmic regressions were fitted. Given the limited data range, the strength of the regression is not as important as the qualitative trend. For instance, Figure 23 shows turbidity versus TSS for D&R Canal locations and Cedar Grove Brook. In both cases the highest turbidity value occurred in the sample with the highest TSS concentration.

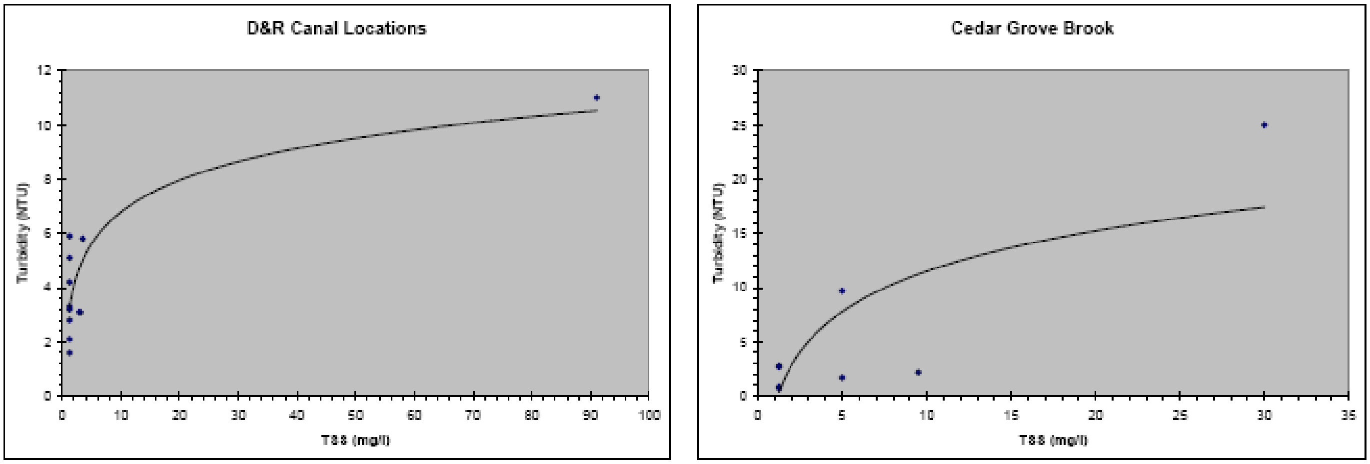


Figure 23. Turbidity vs. TSS in the D&R Canal and Cedar Grove Brook

On the other hand, TOC did not show any correlation with either turbidity or TSS, as shown in Figure 24; however, given the small number of high values, it is possible that a weak relationship exists that was not observed in this dataset.

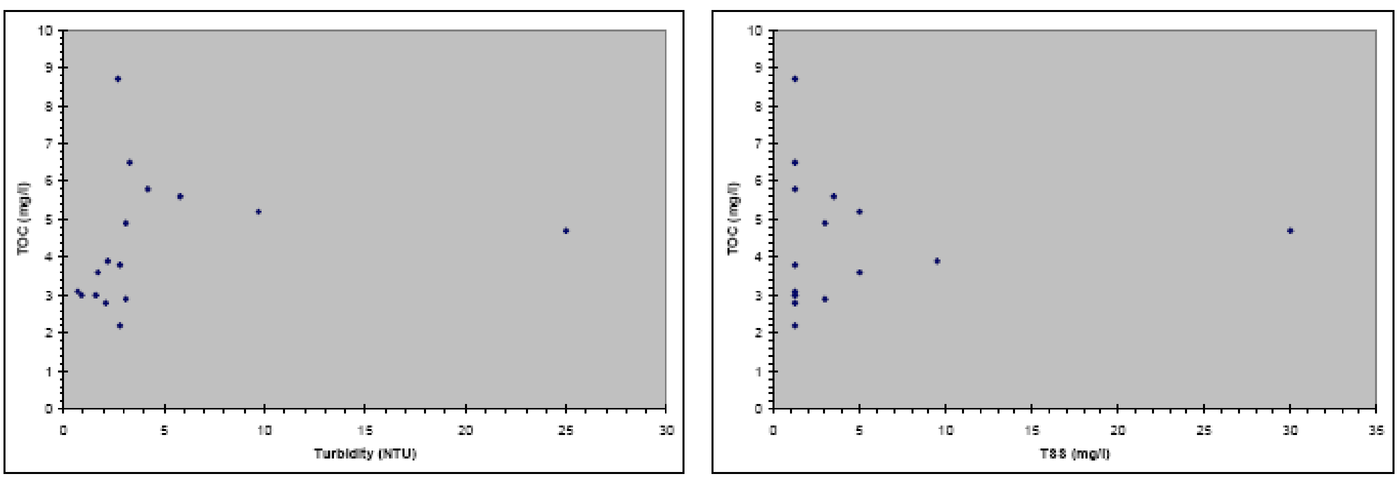


Figure 24. TOC vs. Turbidity and TOC vs. TSS

Because of the co-occurrence of high values of turbidity and TSS, it is likely that measures to reduce TSS loads to the Canal will also reduce turbidity, the parameter of concern for the D&R Canal Implementation Project. In this sense, TSS is a useful surrogate for elevated turbidity. The same cannot be said for TOC. Nothing in the data obtained for this study suggests that efforts to reduce TSS loads to the Canal will also reduce TOC.

VII. Regulatory Review

The State of New Jersey has adopted a number of rules which are designed to protect water resources. Franklin Township has also adopted a stream corridor ordinance which seeks to preserve the township's surface water resources. The existing regulations adequately protect the watershed from non-point source pollution which may result from future land development. Further, the watershed is almost entirely built-out. Accordingly, no further regulatory measures are recommended. Below are the key regulations which affect the watershed.

A. State Regulations

1. D&R Canal Commission Review Zone

http://www.dandrCanal.com/drcc/regulations.html

The entire Cedar Grove Brook Watershed is located in the D&R Canal Commission Review Zone. Areas within 1,000 feet of the Canal are within Zone A and the balance of the watershed is located within Zone B. The Cedar Grove Brook drains directly into the D&R Canal and is therefore afforded a no disturbance stream corridor protection zone which includes the 100-year flood plain plus 100 feet or a 300-foot buffer measured from the top of bank on either side of the stream, whichever is greater. The stream corridor starts from the point that the water course enters the Park at Easton Avenue, upstream to the point that the water course or its tributaries drain less than 50 acres. The Commission regulates all "major developments" in the watershed.

Major developments are reviewed for consistency with Commission regulations for stormwater runoff and water quality impact, stream corridor impact, visual, historic, and natural quality impact, as well as for traffic impact.

2. State Flood Hazard Area Rules

http://www.nj.gov/dep/landuse/se.html

The NJ Department of Environmental Protection adopted new Flood Hazard Area Control Act rules (N.J.A.C. 7:13) on November 5, 2007 in order to incorporate more stringent standards for development in flood hazard areas and riparian zones adjacent to surface waters throughout the State. The Department has adopted these new rules in order to better protect the public from the hazards of flooding, preserve the quality of surface waters, and protect the wildlife and vegetation that exist within and depend upon such areas for sustenance and habitat. Under the new rules Cedar Grove Brook is provided a 50-foot riparian zone.

3. State Freshwater Wetlands Protection Rules

http://www.nj.gov/dep/landuse/7-7a.pdf

Land disturbances in New Jersey wetlands are highly restrictive. In addition to the wetlands themselves, the regulations provide for a protective "transitional area" around identified wetlands. The wetlands in the Cedar Grove Brook watershed are generally of ordinary value which requires protection of an additional 50-foot transitional buffer adjacent to the wetland area. Field delineation may indicate other value wetlands.

4. Stormwater Management Rules

http://www.njstormwater.org/

Franklin Township is a Tier A community under NJDEP's stormwater management rules. The Tier A permit requires municipalities to develop, implement, and enforce a Stormwater Program. The stormwater program is described in the Franklin Township's written Stormwater Pollution Prevention Plan (SPPP). The Township is in compliance with the State's Stormwater Management Rules at the time of NJWSA's review.

B. Municipal Regulations

1. Franklin Township Stream Corridor Preservation Ordinance

http://www.ecode360.com/?custId=FR0703

All new lots in major and minor subdivisions and all building locations in site plans are required to provide sufficient areas outside of stream corridor preservation areas and within required setbacks to accommodate a structure for which it is being created as well as any normal accessory uses appurtenant thereto which would require disturbance. Stream corridors include four components: stream channels, floodplains, contiguous slopes of 12% or greater, and associated preservation areas.

2. Soil Removal and Deposit

http://www.ecode360.com/?custId=FR0703

In addition to the regulations of the Somerset/Union Soil Conservation District, Section 206 of the Franklin Township Codified Ordinance regulates the removal, import and disturbance of soil within the township. Permits are issued and the regulations are enforced by the Township Engineer. An exemption is provided for single family dwellings and structures accessory thereto, except on slopes of 10% or greater and within 50 feet of a stream, flood hazard area, or standing body of water or swamp.

VIII. Nonpoint Source Management Measures

Section VII discussed the WinSLAMM modeling and the water quality monitoring results. The WinSLAMM model indicated that the watershed has a significant proportion of residential land use, and that the largest sediment loads are generated from the residential land use and the "other urban" land use. The Quail Brook Golf Course is also a significant land use within the watershed. Vegetated areas within those land uses generate a significant portion of the sediment load. Although vegetated areas are generally considered to be protective of water resources, they do generate a pollutant load.

The USGS study (1999) suggested that the expected decrease in turbidity within most reaches was not occurring because the expected decrease was being offset by turbid water entering the Canal from influent streams and stormwater discharges. In the case of Cedar Grove Brook, the presence of a large sediment bar at the confluence of the stream with the Canal confirmed the stream's significance as a source of sediment to the Canal.

The TRC Omni water quality monitoring indicated that the three existing pond structures (Lower Pond, Ukrainian Village Pond and Golf Course Pond) provide sediment removal functions during normal flow and smaller storm events. These ponds appear to act as sediment sources during larger storm events, likely due to resuspension of sediment.

The TRC Omni water quality monitoring also indicated that while Cedar Grove Brook does not increase the magnitude of the turbidity in the Canal, it does impact the turbidity peaks that are observed.

Based on the land use data, WinSLAMM model, field reconnaissance and water quality monitoring results, the watershed was evaluated to identify potential nonpoint source management measures. Using those observations and the data described in the earlier sections of this report, several structural and non-structural nonpoint source management measures were identified for the Cedar Grove Brook watershed.

The recommended management measures focus on turbidity and total suspended sediment, as those two parameters were identified by the water purveyors as parameters of concern. The field observations, water quality monitoring and modeling indicated that storm events increase the turbidity peaks from Cedar Grove Brook and that the watershed is a source of sediment. The modeling that was conducted did not separate out land sources of sediment from in-stream sources (e.g. bank erosion). The recommendations contained in this restoration plan target land management, in order to reduce the amount of sediment washed from the land into streams, and also will reduce the volume of stormwater entering the streams, thereby reducing bank erosion.

The recommended management measures are described below; where appropriate, project detail sheets are provided in Appendix G.

A. Structural Measures

Seven structural management measures were identified for the watershed (Table 14).

Table 14. Summary of Structural Management Measures

Project	Estimated Load Reduction	Estimated Cost	Cost/pound sediment removal
Quail Brook Golf Course Pond Project 1- outlet modifications	40,000 lb/yr	$50,000	$1.25
Quail Brook Golf Course Pond Project 2- flowpath baffles	NA	$50,000	NA
Ukrainian Village Pond	59,941 lb/yr	$125,000	$2.08
Lower Pond	402,037 lb/yr	$500,000	$1.24
Riparian Restoration	Varies	Varies	Varies
Stormwater Basin Retrofits	Varies	Varies	Varies
Residential Stormwater Management (Rain Barrels, Rain Gardens)	Varies	Varies	Varies

Significant focus was given to improving the three primary pond structures (Golf Course Pond, Ukrainian Village Pond, and Lower Pond) to improve their water quality benefits. These ponds are providing significant sediment removal, and therefore preventing sediment from entering the D&R Canal. In some cases, such as in extreme storms, these ponds may also act as sediment sources due to the resuspension of accumulated sediments. Where appropriate, WinSLAMM was utilized to estimate sediment reductions from pond modifications.

Several additional structural management measures were also identified throughout the watershed. These measures are discussed below. In some cases, conceptual BMPs are provided; in other cases, where less information was readily available, those concepts must be developed in the future. Implementation will require detailed designs and plans. In addition, maintenance plans will be required for each management measure in order to ensure that it operates as intended. For instance, riparian buffers must be protected from mowing of adjacent areas and from animal damage. Replanting may be necessary. Stormwater basins may require maintenance such as mowing, sediment removal or cleaning of outlet structures.

1. Quail Brook Golf Course Pond

The most upstream of the pond features in Cedar Grove Brook is the Golf Course Pond (Figure 25).

Figure 25. Golf Course Pond

Two potential improvements to the Golf Course Pond were identified to increase the sediment removal rate and thereby reduce the sediment load to the downstream portion of Cedar Grove Brook:

1) modification to the outlet structure; and

2) flowpath routing baffles.

The existing outlet structure is a 3-foot long weir in the upstream side of an outlet box (Figure 26). The WinSLAMM simulation predicts an overall sediment removal rate of approximately 50%. Because the weir faces “upstream,” much of the pond volume appears to be short-circuited, which reduces the expected sediment removal rate.

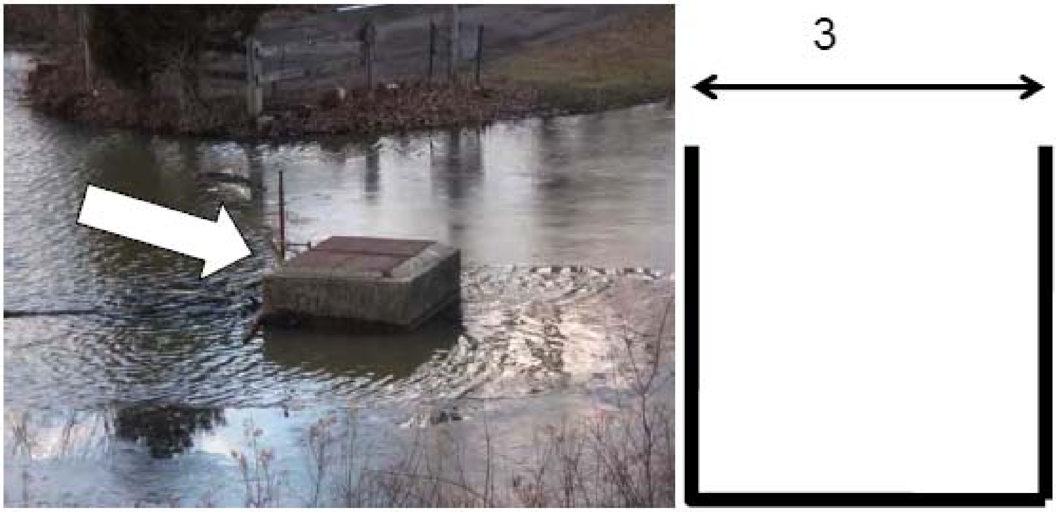


Figure 26. Golf Course Pond - Existing Outlet Structure

Two relatively simple changes to the outlet structure of the Golf Course Pond are proposed. The first is to face the outlet opening "downstream," thereby increasing residence time in the pond, and allowing more time for settling to occur. In addition, adding a smaller outlet weir at the base of the existing 3-foot weir (Figure 27) will increase the residence time and increase the overall sediment removal rate of the pond feature. Various weir heights and widths were analyzed, and their associated long term sediment removal rates were estimated using WinSLAMM. The model indicated that sediment removal is more sensitive to weir width than weir height (Figure 28). Smaller weir widths would result in higher sediment removal rates. Adding a smaller weir between 3 and 6 inches wide and 6 to 12 inches high would substantially improve the sediment removal performance of the Golf Course Pond.

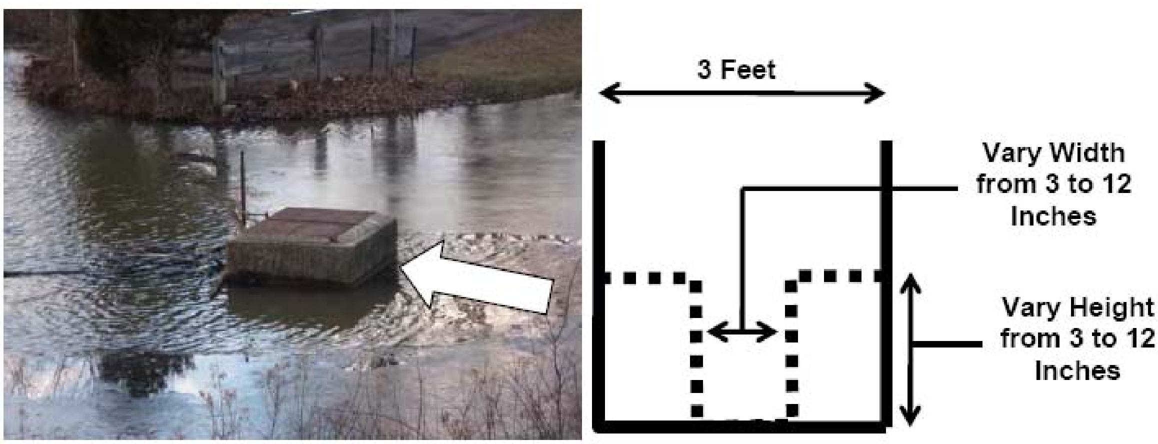


Figure 27. Golf Course Pond - Proposed Outlet Structure Modification

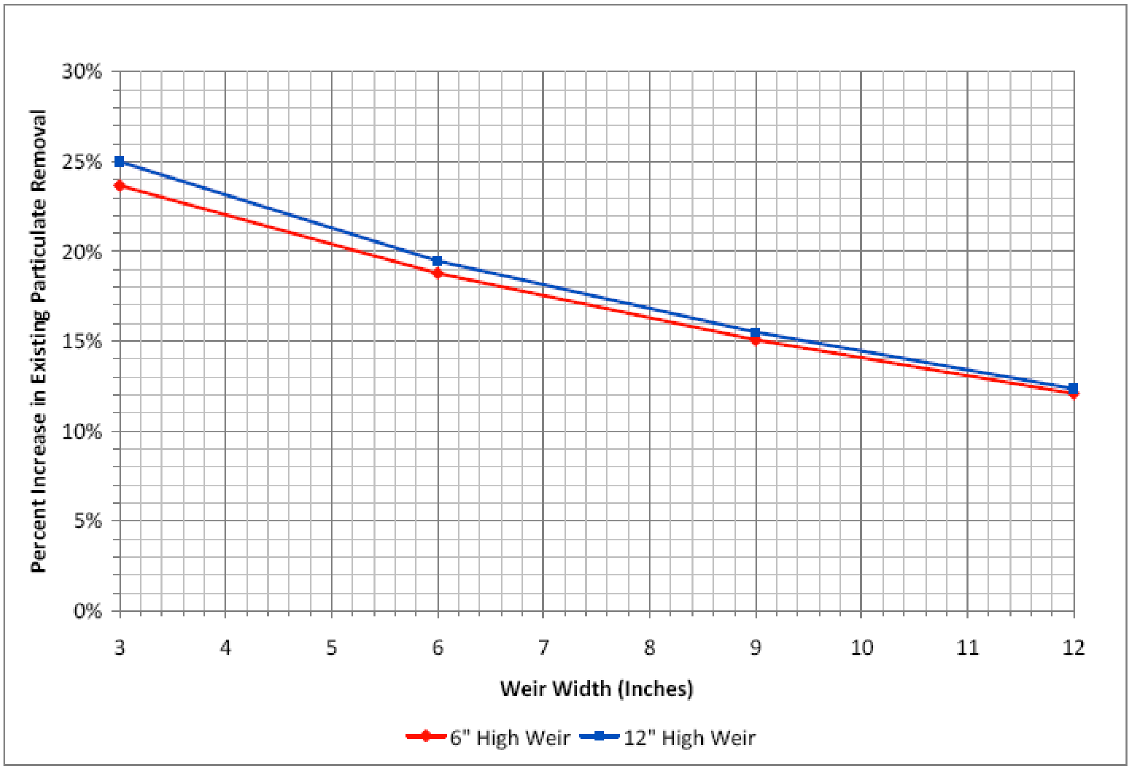


Figure 28. Golf Course Pond - Percent Change in Particulate Removal

The second proposed modification for the Golf Course Pond is to add flowpath baffles. The Golf Course Pond is somewhat linear, and the outlet is a straight flowpath from the inlet. As a result, the bulk of the pond volume is often short-circuited. The WinSLAMM modeling does not account for this phenomenon, and its importance is difficult to quantify. Adding flowpath baffles would force flow under most circumstances into more of the pond volume. This would increase residence time and therefore increase settling of sediment. Flowpath baffles, as proposed, are essentially concrete walls that extend downstream from the weir inlet in order to force water to circulate through more of the pond volume.

When improvements are made to the Golf Course Pond, sediment removal should also be performed. Stormwater basins require periodic maintenance, including sediment removal to maintain their hydrologic and water quality benefits. The stormwater monitoring results indicated that during large storm events, the TSS concentrations leaving the pond are higher than those entering the pond. This suggests that during larger storm events, accumulated sediment in the Golf Course Pond is being re-suspended and the pond is then acting as a sediment source rather than a sink.

2. Ukrainian Village Pond

The Ukrainian Village Pond (Figure 29) is downstream of the Golf Course Pond close to the center of the Cedar Grove Brook watershed. The Ukrainian Village Pond is an impoundment with two tributary inlets that discharges to Cedar Grove Brook. A relatively simple modification to the outlet structure is proposed to increase the sediment removal rate and thereby reduce the sediment load to the downstream portion of Cedar Grove Brook.

The existing outlet structure for the Ukrainian Village Pond is a 1-foot square weir within a larger 11-foot weir (Figure 30). According to the WinSLAMM simulations performed for the Ukrainian Village Pond, the existing overall sediment removal rate is approximately 33%.

Figure 29. Ukranian Village Pond

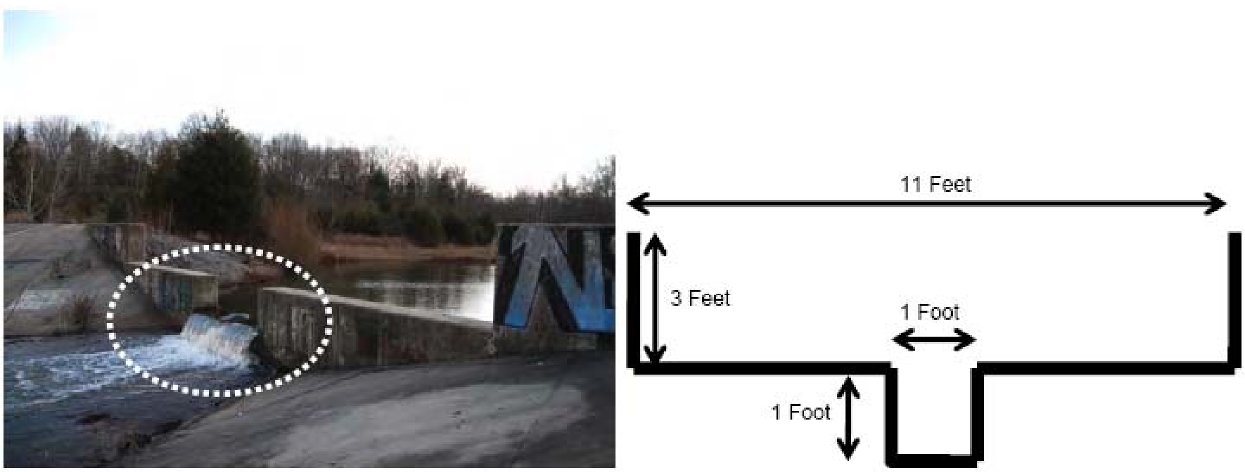


Figure 30. Ukranian Village Pond - Proposed Outlet Structure Modification

The existing 1-foot weir provides a negligible benefit in terms of sediment removal efficiency. Increasing the height of the existing weir, as shown in Figure 31, from 1 foot to 3 to 4 feet would improve the sediment removal by approximately 15% .

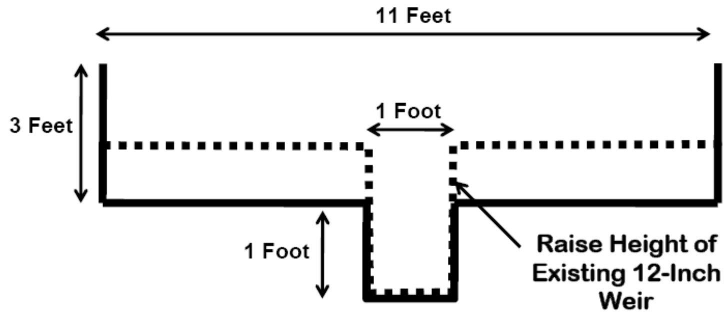


Figure 31. Ukrainian Village Pond - Proposed Modification to Outlet Structure

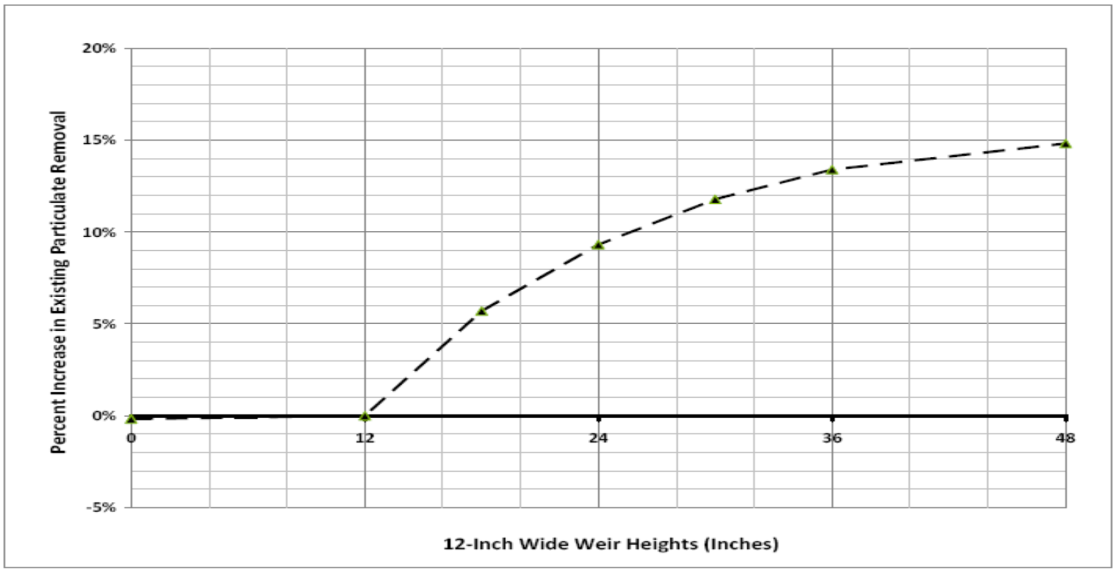


Figure 32. Ukrainian Village Pond - Percent Change in Particulate Removal

The 2005 stormwater monitoring did not show the Ukrainian Village Pond acting as a sediment source during either of the storm events that were monitored. It is possible that accumulated sediment in the pond is re-suspended and discharged to the watershed. When improvements are made to the pond, sediment removal should also be performed. This is a standard BMP maintenance action that must be performed on all stormwater ponds to maintain their hydrologic and water quality benefits.

3. Lower Pond

The outlet of Cedar Grove Brook (called "Lower Pond" for the purposes of this study) is impounded slightly by a dam structure just upstream of the Easton Avenue bridge with a weir that is generally submerged at the crest (Figure 33). Despite the dam structure, the outlet of Cedar Grove would not likely be identified by the casual observer as a pond under current conditions; one can see the bottom less than one foot below the weir crest. Nevertheless, the designation "Lower Pond" was adopted to reflect what this feature would become after the recommended restoration is complete. The reason is that the conceptual improvement identified for the outlet of Cedar Grove Brook to reduce the sediment load to the D&R Canal is a significant modification to the outlet structure. This modification would increase the height of the weir crest, resulting in a permanent pool of water 5 to 7 feet deep, thereby making it a more easily recognized pond feature.


Figure 33. Lower Pond - Cedar Grove Brook Outlet

A diagram of the existing outlet structure is shown in Figure 34. The current structure is not very useful from the standpoint of sediment removal. The WinSLAMM simulations indicate that the existing structure might be expected to remove approximately 3% of the sediment that reaches the outlet of Cedar Grove Brook. The WinSLAMM simulation does not account for the fact that the weir crest is generally submerged by Canal water, nor does it account for the resuspension of accumulated sediment. It is very likely that the outlet of Cedar Grove Brook provides a net source of sediments to the D&R Canal. The outlet structure could be improved substantially by increasing the elevation of the crest and decreasing the width of the smallest weir.

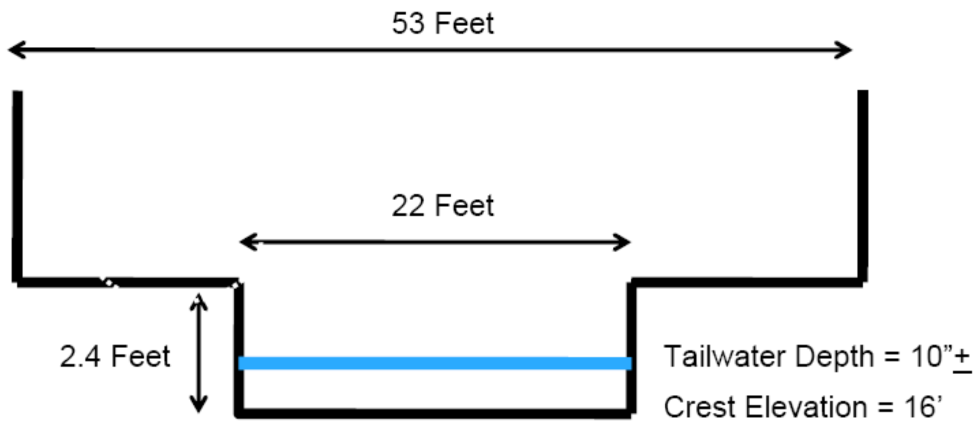


Figure 34. Lower Pond - Existing Outlet Structure

In terms of increasing the crest elevation, the flood plain at the Cedar Grove Brook watershed outlet is long and deep (Figure 35), providing plenty of room to significantly increase the crest elevation above the existing level. A new five foot wide weir (Figure 36) is proposed at a significantly higher crest elevation.

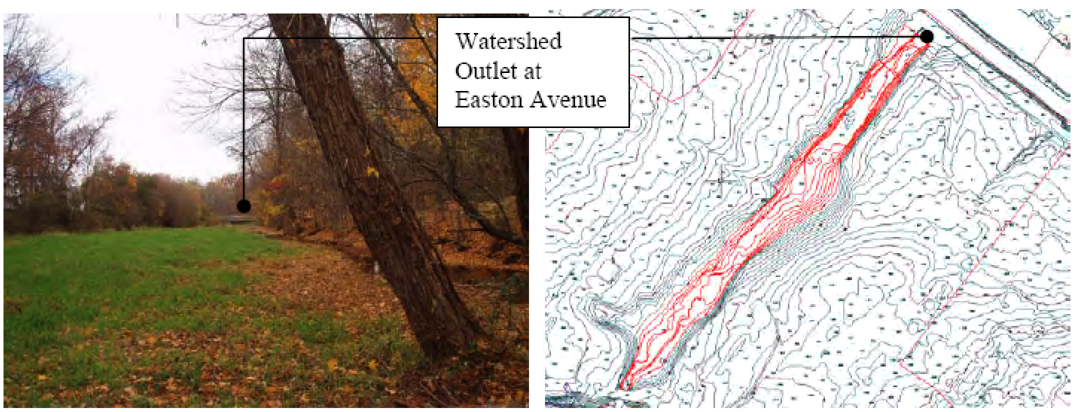


Figure 35. Lower Pond Floodplain

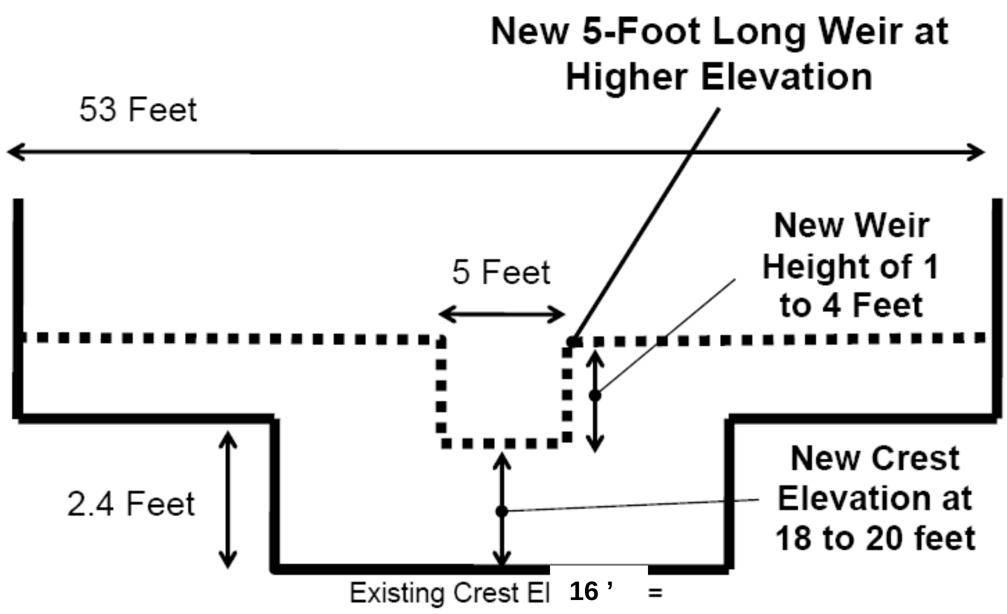


Figure 36. Lower Pond - Proposed Modification to Outlet Structure

The WinSLAMM model indicated that sediment removal is relatively insensitive to weir height at this location (figure 37). A 5-foot weir at a higher crest elevation will significantly improve the sediment removal rate of the outlet structure. Increasing the crest elevation will provide the most benefit of the elevation options explored, increasing the overall sediment removal rate to approximately 30%. This does not account for the fact that the weir crest would no longer be submerged by Canal water, or the additional benefit of reduced sediment resuspension.

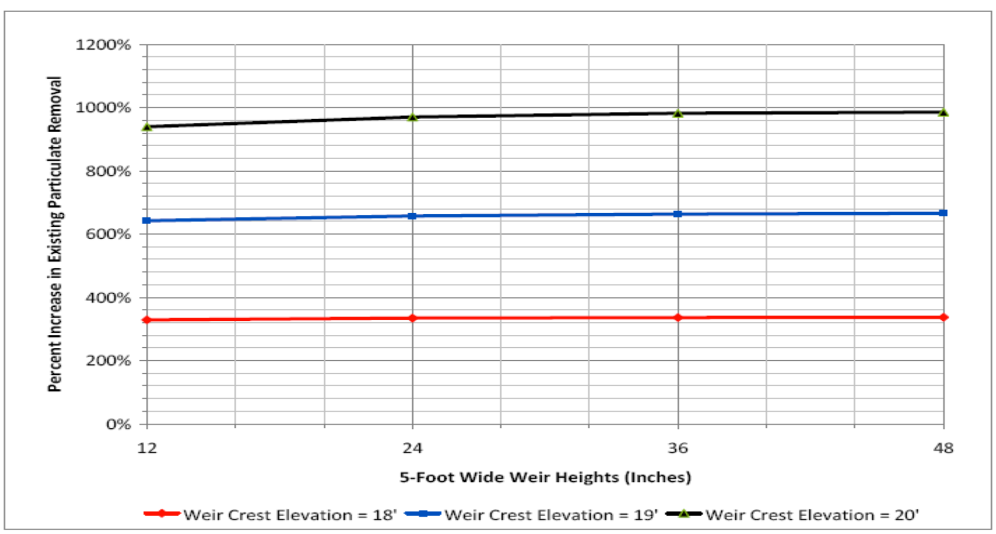


Figure 37. Lower Pond - Percent Change in Particulate Removal

4. Riparian Restoration

As detailed in Table 15 and Figure 38, eight sites were identified for riparian buffer restoration. The recommendations were developed based on the road crossing inventory and the stream visual assessments. Riparian buffer restoration may include forest and herbaceous plantings. Sediment removal rates and cost estimates were not detailed for each site, as those factors will be dependent on the width of the buffer and the plant species that are selected.

TSS removal rates for riparian buffers are reported to be 60 to 80%, depending on the width and type of vegetation. Removal rates for nutrients are typically lower than those for TSS. Riparian buffers also benefit streams from an ecological perspective, providing shade to moderate water temperature, and providing habitat and food for fish and other aquatic organisms.

A detailed planting plan must be developed for each site prior to implementation. In addition, permitting may be required for some projects.

Potential Riparian Buffer Restoration Sites

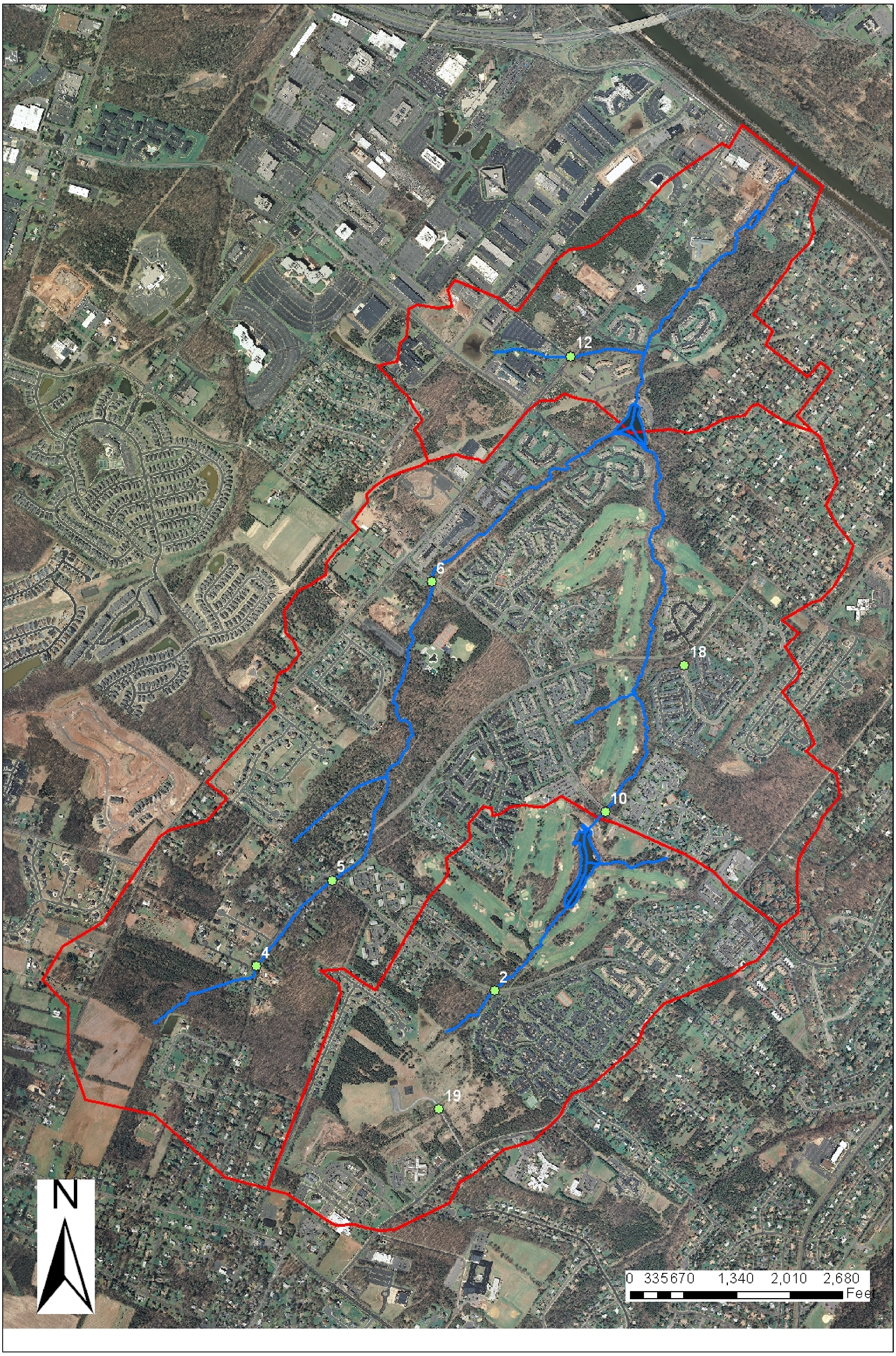


Figure 38. Potential Riparian Restoration Sites

Table 15. Cedar Grove Brook – Potential Riparian Restoration Sites

Road Crossing ID	SVAP #	Nearest Road	Notes
Cedar Grove Brook 2	NA	Martino Way	Upstream side of road crossing needs vegetation improvement near residential properties.
Cedar Grove Brook 4	CGB-7	Wilson Road	Municipal right of way present. Upstream of Wilson Road is good opportunity for buffer improvement, homeowner education.
Cedar Grove Brook 5	CGB-9	Martino Way	Canopy needs improvement to protect stream.
Cedar Grove Brook 6	CGB-6	New Brunswick Road	Upstream of road crossing needs vegetation improvement.
Cedar Grove Brook 10	NA	New Brunswick Road	Downstream of road crossing needs buffer improvement (golf course), no woody vegetation present.
Cedar Grove Brook 12	CGB-1	Cedar Grove Lane	Upstream of road crossing is good opportunity for buffer improvement – Rutgers Church on Cedar Grove Lane.
Cedar Grove Brook 18	NA	Denbigh	Area needs vegetation improvement, sections with exposed soil and no understory.
Cedar Grove Brook 19	NA	Middlebush Park Road	Good opportunity, on public property. No canopy, lawn to edge of stream. Utility line easement along right bank.

5. Stormwater Retrofits

Table 9 provides a listing of 15 stormwater basins in the watershed. That list includes the three ponds for which conceptual designs are included in this restoration plan. At this time, a detailed review of the design and function of the other 12 basins has not been performed; however, it is reasonable to anticipate that retrofits of at least some of those basins could improve their sediment removal capacity.

Many stormwater basins were designed with concrete low flow channels to force water to move quickly through the basin during smaller storm events. These channels can act as an obstacle to water quality treatment in those basins. Concrete low flow channels should, in most instances, be removed and replaced with vegetation or other stabilizing material. Most basins were also constructed with turf grass, which does not promote infiltration. By replacing turf grass with native grasses or other low maintenance vegetation, maintenance costs can be reduced (by reducing mowing needs) and infiltration can be increased.

Potential improvements include improved maintenance, removal of concrete low-flow channels and improvement of vegetation. It may also be appropriate to convert some of these basins to bioretention facilities or perform other modifications. Some of these retrofits can be accomplished at a relatively low cost, and may, in some cases reduce the required maintenance for the basin. Effective retrofits will reduce stormwater volume, increase sediment removal and can be used as a model and educational tool for township residents.

As with the riparian restoration projects, specific removal rates and costs for retrofit were not developed for these projects. Additional information, including detailed review of the existing design and the contributing drainage area for each basin must be developed in order to provide those estimates.

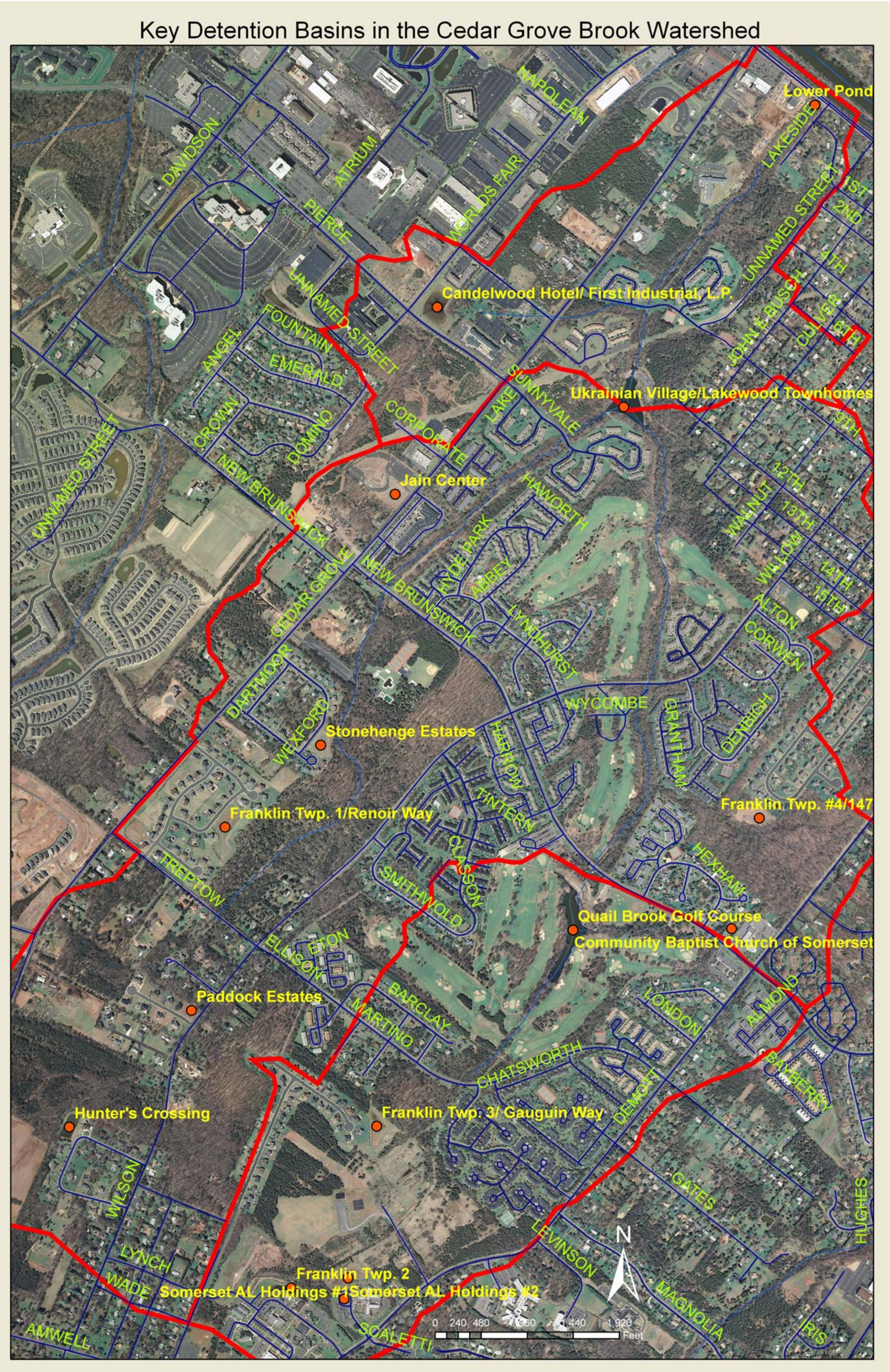


Figure 39. Key Stormwater Basins

6. Residential Stormwater Management (Rain Barrels, Rain Gardens)

Since the primary land use in the Cedar Grove Brook watershed is residential, a large impact can be made through the implementation of low-cost BMPs on private property. The installation of rain barrels and rain gardens on residential properties can help reduce the volume of runoff, promote infiltration of runoff and reduce the pollutant load entering the stormwater system. A Residential Stormwater Management Program will involve several components:

- Education and outreach for residents in targeted neighborhoods.
- Incentives to make a change in residential stormwater management.
- Technical support for installation of residential stormwater management practices.

Rain Barrels

A rain barrel can be constructed from a 55-gallon barrel, and is placed under a gutter's downspout next to a house, small sheds or other outdoor structures to collect rain water from the roof. The water can then be used in various ways including to water a garden. A rain barrel provides two important environmental functions:

- harvesting rain water provides an alternative to utilizing the drinking water supply for gardening and other uses, and
- the overflow from a rain barrel can be directed to a pervious area (an area where rain water can infiltrate into the ground) such as a lawn or garden and help replenish ground water supplies.

Rain barrels can be easily built and installed, but do require some maintenance.

1. Education & Outreach: Most residents are not familiar with the concepts of disconnecting impervious surfaces from the stormwater system and therefore rain barrels are not widely used. An educational component and support system for residents must be developed in order to provide that knowledge. This campaign could be led by Somerset County, Franklin Township, a local non-profit or NJWSA.
2. Identify target area: Targeting one sub-watershed or neighborhood within the Cedar Grove Brook watershed at a time may be a more feasible task than targeting the entire watershed at once.
3. Conduct rain barrel building workshop: Workshops can be held to assist people in building their own rain barrels for installation on their homes. The advantage of this type of system is that people are also provided with information regarding nonpoint source pollution and how they are contributing to improvement of the watershed. The disadvantage of this type of system is that it is very time intensive, from alerting residents about the workshop to obtaining barrels and conducting the workshop.
4. Develop rebate program: An alternative is to develop a rebate program, in which residents are reimbursed after they purchase and install a rain barrel. This rebate program could be coordinated with and administered through the municipality. If the rebate method is chosen, advertising and an educational presentation and program coordination meeting would still be needed to emphasize the importance of disconnecting impervious surfaces and reducing runoff.

Table 16. Cost Estimates for Rain Barrel Workshop

Item	Cost/Unit	Cost/Training
Rain Barrel	$50-$100	$1250 - $2500
Transportation of Barrels	varies	Varies
Parts (fixtures, caulk, screening)	$15-$20/barrel	$375 - $500
Tools (drill, pliers, wrench, saw)	$150-$200(purchase 1 set) $50-$75 (rental of power tools and purchase of manual tools)	$50 - $200
Direct Mailings	$.44/letter or $.29/postcard	$10-$20
Location	n/a	In-kind
Staff Time (prep time, set up, workshop, clean up)	n/a	40 hours
Total		$1700-$3500

The table estimates some of the costs associated with administering a rain barrel rebate program. The estimates assume the goal of providing rebates for approximately 300 barrels.

Table 17. Cost Estimates for Rain Barrel Rebate Program

Item	Cost
Administration of program	$500-$1000
Rebates for barrels (50% @ $100/barrel)	$15,000
Total	$16,000

Rain Gardens

Rain gardens are another example of a small scale BMP that can be implemented at the individual parcel level and have a large cumulative impact. A rain garden is a landscaped, shallow depression that allows for rain and runoff to be collected and then either infiltrated into the soil or evapotranspirated to the atmosphere. During rainstorms, much of the water quickly washes into the streets from yards, sidewalks, driveways, and parking lots. This water carries many pollutants including pesticides, fertilizers, animal waste, and chemicals. Excessive runoff can lead to flooding and can erode stream banks, adding sediment to waterways. Rain gardens reduce the quantity of water that reaches our waterways and improve the quality of water by filtering polluted runoff.

Rain gardens are designed to collect runoff from roofs, lawn, driveways, or sidewalks, or any combination of those. The size and depth of the garden will be determined by the volume of runoff that will reach the garden and the soil texture of the site. Rain garden plants should be native hardy perennial species that can survive in both wet and dry conditions. Some rain garden maintenance will be required, including weeding, pruning, and removing sediment that accumulates.

Rain gardens can treat and recharge a majority of the runoff from smaller, more frequent storms.

This will reduce stormwater runoff volume, resulting in a reduction in streambank erosion and therefore a reduction in TSS loads.

This task targets residential properties, but rain gardens can also be installed on commercial or other parcels as well.

1. Education & outreach: As with rain barrels, most residents are not aware of the concept of rain gardens. An educational component must be developed to provide that information. Rutgers Cooperative Extension, Water Resources Program has many materials that can be used for this task. Advertising a demonstration rain garden at a public location is a great way to generate interest in rain gardens. The next step would be to teach interested parties in how to properly design a rain garden.
2. Identify target area: Targeting one sub-watershed or neighborhood within the Cedar Grove Brook watershed at a time may be a more feasible task than targeting the entire watershed at once.
3. Provide technical and (if possible) financial assistance for residents who are interested in installing a rain garden.
4. Follow-up.

Several factors can affect the cost of installing a rain garden including the size of the rain garden (based on how much stormwater it will be treating), how much the soil must be amended (to improve infiltration and provide nutrients to the plants), availability of volunteer labor, and the size of plants used to establish the rain garden. A safe estimate ranges from $2/square foot to $10/square foot. The cost of a demonstration rain garden can greatly be reduced through the usage of volunteer labor and donated plants and soil amendment materials.

Increasing the implementation of rain gardens and rain barrels throughout the residential and commercial areas of the Cedar Grove Brook watershed will help to reach the goal of reducing the total amount of sediment reaching the D&R Canal. These methods will help reduce runoff by collecting stormwater closer to the source and infiltrating into the ground. This will likely have a positive impact on existing structural stormwater BMPs such as detention basins and wet ponds. Rain gardens also provide an excellent first step toward educating communities about the stormwater issues in their neighborhoods.

B. Non-Structural Measures

1. River-Friendly Programs – Golf Courses, Businesses, Schools and Residents

The New Jersey Water Supply Authority (NJWSA, www.njwsa.org) implements a suite of River-Friendly programs, including those for Golf Courses, Businesses, Schools and Residents. These programs are based on those developed by the Stony Brook-Millstone Watershed Association. Through these programs, NJWSA works with landowners to improve water quality by implementing actions in four categories: Water Quality Management & Nonpoint Source Pollution Management, Water Conservation, Native Habitat & Wildlife Enhancement, and Education & Outreach. These programs are currently being implemented in the Cedar Grove Brook watershed.

The voluntary River-Friendly Golf Course, Business and School programs are a cooperative effort between the participants and NJWSA. They provide an opportunity for landowners to become local stewards, to showcase positive environmental actions they have already taken and to work with NJWSA to implement new practices. Participating landowners receive ongoing technical information, support and guidance for implementing environmental actions tailored to their unique location, resources and needs.

NJWSA is currently working with approximately 15 golf courses and businesses in the North & South Branch Raritan and Lower Raritan watershed management areas. Example accomplishments at one business facility include establishing a buffer along the Peter's Brook; expanding no-mow areas by 10 acres and thereby reducing lawn areas by 17%; and reducing irrigated areas by 33%.

These programs are mutually beneficial and they often reduce the operational cost of the facility, improve water quality conditions, and provide good public relation opportunities for the facility.

Quail Brook Golf Course was the first course to be certified as River-Friendly by NJWSA. During their time as a participant with the River-Friendly Golf Course Program, Quail Brook Golf Course has taken several actions to reduce their impact on the Cedar Grove Brook watershed. They installed a new irrigation system that allows staff to easily check for leaks on a daily basis. No-mow and low maintenance areas have been established throughout the course, providing buffers along waterways. An on site equipment wash facility was installed at the golf course and prevents fertilizer and pesticide rinsate, as well as potentially contaminated grass clippings from being washed into the stream. An Integrated Pest Management plan for the course has also be developed, which provides staff with a pragmatic plan to assess and treat turf problems by using the least amount of harmful chemicals as possible. A brochure containing River-Friendly tips is on display in the clubhouse, providing outreach to the patrons of the course.

Although Quail Brook Golf Course is the only golf course facility in the watershed, there are several other facilities that may be appropriate for inclusion in the River-Friendly programs, including businesses, assisted-living facilities, churches and parks.

Residents can fill out a self-certification questionnaire to receive recognition as a River-Friendly Resident. The questionnaire includes questions about lawn management practices, water conservation and septic system management, and represents a resident's pledge to manage their property in a responsible manner to help protect our drinking water resources and the environment. The questionnaire can be filled out online, or can be distributed through a variety of outlets. For example, municipalities could have the questionnaire available at the municipal buildings, or could distribute it, along with other information on nonpoint source pollution, at various community events.

The River-Friendly Farm program, administered by North Jersey Resource Conservation and Development Council (www.njriverfriendlyfarm.org) and the Raritan Watershed Agricultural Committee, uses a set of five criteria, including nutrient management, pest management, riparian buffers, soil loss and irrigation water management.

For more information on any of these programs, visit: www.raritanbasin.org and www.njriverfriendly.org.

2. River-Friendly Communities

There are several residential communities within the watershed that are managed by homeowner and condominium associations, which have a range of responsibilities. Associations may manage common open space or have maintenance responsibility for roads, stormwater systems, water supply systems, wastewater treatment systems, parks and more. Nonpoint source pollution from existing residential development in the Cedar Grove Brook watershed has been identified as a significant sediment source. By working with these associations through the established River-Friendly programs (e.g. River-Friendly Resident) and a new River-Friendly Communities program, pollutant loads from these communities may be reduced.

Similar to the River-Friendly Golf Course and Business programs, each participating association will complete a detailed application regarding their community and its maintenance practices. NJWSA will then work with each individual association to design a series of unique actions for certification. While some actions will be common to all properties, many will be unique to each particular association in order to meet the characteristics, constraints and needs of each property and association. Actions may be required in each of four areas:

- Water Quality Management,
- Water Conservation Techniques,
- Wildlife and Habitat Enhancement, and
- Education and Outreach.

The program will provide ongoing technical information, support and guidance for implementing environmental projects specific to the unique location, and the resources and needs of each association.

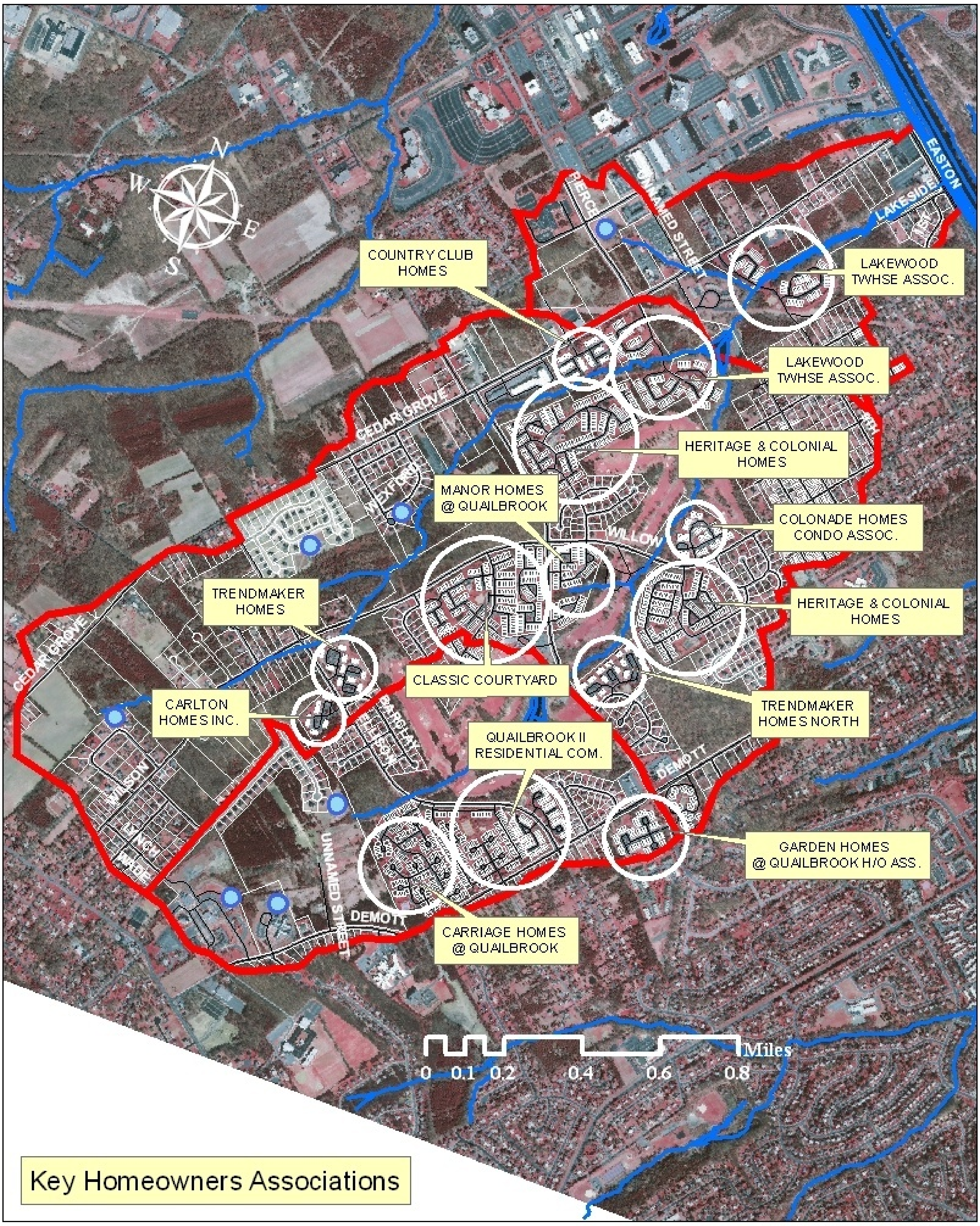
The River-Friendly Communities Certification Program will provide the following benefits:

- Protects natural resources and preserves New Jersey's native landscapes.
- Provides public recognition for achievements through receipt of a plaque, an award presentation and media announcements.
- Reduces costs by decreasing use of fertilizers, pesticides and herbicides and decreasing use of equipment in 'no-mow' zones and 'no-spray' zones.
- Creates healthier landscaping.
- Maintains community aesthetics.
- Decreases water use.
- Increases natural habitat and attracts beneficial wildlife.
- Reduces resident exposure to pesticides and other chemicals.
- Promotes a positive relationship between the surrounding community and the association.

Figure 40 details the locations of key homeowner associations in the watershed. NJWSA will develop an outline and program documents for the River-Friendly Communities program with the help of the River-Friendly Technical Advisory Committee (TAC). The program materials are likely to be similar to those developed for the River-Friendly Business and Golf Course programs; however, appropriate adaptations for residential communities will be made.

Following development of the program materials, NJWSA will begin outreach to the associations and encourage them to join the program.

Key Homeowner Groups in the Cedar Grove Brook Watershed



(NJWSA / 1-28-09 / O'Neil)

Figure 40. Homeowner Groups in the Cedar Grove Brook Watershed

C. Prioritization of Nonpoint Source Management Measures

Several methods to prioritize the recommended projects were considered. Omni prioritized the structural modifications to the three main pond structures and the residential stormwater management measure; stakeholders also prioritized several of the management measures. NJDEP then requested that the Pennsylvania "Growing Greener" criteria be used. Those criteria include:

- Measurable water quality improvement (TMDL);
- Landowner participation;
- Permitting;
- Site constraints (topography, wetlands, stream encroachment, etc);
- Anticipated costs;
- Potential funding sources;
- Expected timeframe;
- Project partners needed;
- Ecological benefits; and
- Long term maintenance/monitoring.

These criteria were placed into two groups; one set was assigned scores from 1 to 5, and the second set was assigned to an 'other considerations' group that was not scored. The final prioritization score is a sum of the six scored criteria.

Scored criteria:

- Measurable water quality improvement (TMDL):
    - 1 = minimal benefit,
    - 3 = modest benefit,
    - 5 = substantial benefit;
- Landowner participation:
    - 1 = landowner participation anticipated to be difficult,
    - 5 = landowner participation already obtained or anticipated to be easily obtained;
- Permitting:
    - 1 = permitting anticipated to be difficult,
    - 3 = permitting anticipated to be required but obtainable,
    - 5 = no permitting required;
- Site constraints (topography, wetlands, stream encroachment, etc):
    - 1 = significant site constraints that will make design difficult,
    - 5 = no site constraints present obstacles to design;
- Anticipated costs:
    - 1 = cost/benefit ratio is high, e.g. significant cost per pound of pollutant removed,
    - 5 = cost/benefit ratio is low, e.g. low cost per pound of pollutant removed;
- Ecological benefits:
    - 1 = minimal additional benefit to overall habitat or water quality/quantity;
    - 5 = significant additional benefit to overall habitat or water quality/quantity.

Table 18. Prioritization of Nonpoint Source Management Measures

	Criteria						**Other considerations (not scored)**				
Projects	Measurable water quality improvement	Landowner participation	Permit	Site constraints	Antic. Cost	Ecological Benefits	Potential Funding Sources	Expected Time Frame	Partners Needed	Long Term Maintenance & Monitoring	**Score**
Quail Brook Golf Course Pond Project 1-outlet modifications	3	5	5	5	3	1	Available	Short	No	High	22
Quail Brook Golf Course Pond Project 2-flowpath baffles	2	5	5	5	3	1	Available	Short	No	High	21
Ukrainian Village Pond	3	3	3	3	3	2	Available	Medium	No	High	17
Lower Pond	5	4	3	4	3	2	Available	Medium	No	High	21
Riparian Restoration	2	3	4	4	5	4	Available	Short to Long	Yes	Low	22
Stormwater Basin Retrofits	3	3	4	4	3	4	Available	Short to Long	Yes	Moderate to High	21
Residential Stormwater Management (Rain Barrels, Rain Gardens)	2	3	5	5	4	1	Available	Short to Medium	Yes	Low	20
River-Friendly Programs	2	4	5	3	4	4	Available	Short	Yes	None	22
River-Friendly Communities	2	4	5	5	4	3	Available	Short	Yes	None	23

Based on the prioritization scheme, the recommended management measures were ranked as follows:

1. River-Friendly Communities
2. Quail Brook Golf Course Pond Project #1 – outlet modifications
2. Riparian Restoration
2. River-Friendly Programs
3. Quail Brook Golf Course Pond Project #2 – flowpath baffles
3. Lower Pond
3. Stormwater Basin Retrofits
4. Residential Stormwater Management
5. Ukrainian Village Pond

IX. Technical and Financial Assistance

The fourth minimum element of a watershed restoration plan includes an estimate of the amounts of technical and financial assistance needed. Table 14 and the project detail sheets in Appendix G provide estimated costs for the recommended management measures.

Potential project lead entities include:

- Somerset County Park Commission
- Franklin Township
- NJWSA
- Somerset-Union Soil Conservation District
- Homeowners Associations
- Rutgers Cooperative Extension, Water Resources Program

Technical assistance may be obtained from the organizations above, as well as the Natural Resources Conservation Service (NRCS), NJDEP, US Fish and Wildlife Service.

There are a variety of sources of funding that may be utilized for the projects detailed in this plan. Deadlines, funding amounts and application requirements change often for most of these programs, and the specific program website should be checked for current information.

- The NJDEP website provides a listing of funding sources at http://www.nj.gov/dep/grantandloanprograms/Information & Education. These programs include the Section 319(h) nonpoint source program and a variety of other potential funding sources.
- Franklin Township can include the projects recommended in the plan in their stormwater mitigation plan, making them eligible for implementation with funds collected when stormwater mitigation funds are collected from entities conducting development activities. Some of the management measures may be conducted as part of Franklin Township's NJPDES permit implementation activities.
- NJWSA maintains a source water protection fund. A portion of their water rate is allocated to source water protection activities. The River-Friendly programs are funded in this manner.
- The Natural Resources Conservation Service operates several funding sources, including the Wildlife Habitat Incentives Program (WHIP). See http://www.nj.nrcs.usda.gov/programs/fundingopportunities.html for more detailed information.
- USEPA has many grant programs, including their Environmental Education Grants and Five-Star Restoration Grants, that could potentially be applied to the recommended management measures. See http://water.epa.gov/grants_funding/shedfund/watershedfunding.cfm.
- The US Fish & Wildlife Service provides grants for a variety of habitat improvements, which could be incorporated into several of the recommended management measures. See http://www.fws.gov/grants/.

X. Implementation Schedule & Milestones

The sixth minimum element of a watershed restoration plan requires the development of a schedule for implementation. This schedule will be highly dependent on the availability of funding and organizations willing to accept responsibility for project planning, implementation and long-term maintenance. Some projects may be incorporated into the ongoing D&R Canal Implementation Project, which will facilitate implementation. NJWSA's River-Friendly programs are already being implemented, and increased outreach/implementation in the Cedar Grove Brook watershed can be easily accomplished.

A potential implementation schedule is provided in Table 19. Projects at Quail Brook Golf Course are anticipated to be easy to begin once funding is available, due to their participation in the River-Friendly Golf Course program. Quail Brook GC is owned and operated by the Somerset County Parks Commission. The background investigation work for those projects should be minimal.

The Ukrainian Village Pond and Lower Pond will require work with the landowners prior to beginning any design work. In addition, funding must be obtained for the projects. Design work and permitting will take significant time as well.

The riparian restoration projects and stormwater basin retrofits will require coordination with landowners, but should not require significant design time or permitting. Once funding is available, these projects are expected to progress relatively quickly.

Residential stormwater management projects, including rain barrels and rain gardens, can be implemented through ongoing initiatives of Rutgers Cooperative Extension and NJWSA. Additional funding and expansion of those programs will be required.

NJWSA's River-Friendly Golf Course and Business programs are currently being implemented in the Cedar Grove Brook watershed. Outreach regarding the River-Friendly Resident program can be expanded to the watershed as well. The River-Friendly School program can be implemented in the watershed as funding and NJWSA staff time is available.

The River-Friendly Communities program is a new program that will be developed and implemented by NJWSA as part of the River-Friendly suite of programs. Development of the program will begin during 2011.

Table 19. Potential Implementation Schedule

Projects	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Ongoing
Quail Brook Golf Course Pond Project 1- outlet modifications		x	x	x							
Quail Brook Golf Course Pond Project 2-flowpath baffles		x	x	x							
Ukrainian Village Pond				x	x	x	x				
Lower Pond					x	x	x	x			
Riparian Restoration		x	x	x	x	x	x	x	x	x	
Stormwater Basin Retrofits			x	x	x	x	x	x			
Residential Stormwater Management (Rain Barrels, Rain Gardens)	x	x	x	x	x						
River-Friendly Programs	x	x	x	x	x	x	x	x	x	x	x
River-Friendly Communities	x	x	x	x	x	x	x	x	x	x	x
Monitoring & Maintenance			x	x	x	x	x	x	x	x	x

XI. Education

Outreach and education may occur through many different existing programs. Franklin Township's municipal stormwater management plan requires them to conduct a yearly educational event and distribute brochures provided by the NJDEP. Additional information about this project can be distributed in conjunction with the required mailing. Web sites maintained by the Township, NJWSA and Raritan Basin Watershed Alliance (RBWA) can be vehicles for the dissemination of the plan and information about the management measures. The plan and resulting projects can be highlighted in the RBWA "Basin Bulletin". Both the D&R Canal Commission and D&R State Park can be valuable allies in distributing information on the project.

XII. Project Monitoring

In order to evaluate the effectiveness of the nonpoint source management practices recommended in this plan, a monitoring plan is a necessary component.

In order to reduce overall monitoring costs, this plan will not seek to develop an end-of-pipe monitoring plan. In some cases, BMP-specific project monitoring may be recommended to determine the effectiveness of a particular BMP. For example, evaluating the residence time of stormwater in ponds before and after the recommended retrofit may provide sufficient data on whether or not it is functioning correctly and achieving the overall goal of sediment removal. Another example of site-specific monitoring could be visual inspections of naturalized detention basins. Survival rates of vegetation should be characterized and the presence or absence of erosion should be recorded. Monitoring efforts should be conducted during baseline conditions as well as during storm events.

Monitoring of the smaller BMPs such as rain gardens and rain barrels presents a challenge since these types of BMPs will generally be found on private properties. Developing a database of installed rain gardens and rain barrels where homeowners can register their small scale BMPs could provide enough data to estimate sediment reductions. Record keeping at rain barrel and rain garden trainings and outreach events will also provide information on the effectiveness of the outreach when compared to the number of rain gardens and rain barrels installed. Follow up correspondence will assist in data collection.

The WinSLAMM model that was developed as part of this project can also be utilized to help estimate load reductions achieved from the recommended management measures. Another model that can be used to document load reductions is the Spreadsheet Tool for Estimating Pollutant Load (STEPL). This simple spreadsheet model, which is approved for use by NJDEP and USEPA, can assist in quantifying the TSS reductions associated with implemented management measures and documenting progress made toward reducing TSS loads to the Canal. A USGS gauge on the D&R Canal at Landing Lane is scheduled for installation in 2011 as part of the D&R Canal NPS Implementation Project and NJWSA's overall early warning system for water purveyors. This gauge will provide overall turbidity/TSS data downstream of the Cedar Grove Brook inlet to the Canal. These data can be used to help evaluate the overall sediment and volume reduction efforts within the D&R Canal watersheds.

Lastly, the plan and the progress toward implementation of the recommended management measures should be evaluated over time. This evaluation will help to reprioritize projects, address specific shortcomings, and allow for adaptive management.

XIII. Summary

A review of existing GIS information and collection of stream visual assessment data and water quality data resulted in the identification of nine sets of nonpoint source management measures that should be implemented in the Cedar Grove Brook Watershed in order to reduce TSS loads to the Brook and ultimately to the D&R Canal. The management measures that were identified, in order of prioritization, are:

- River-Friendly Communities
- Quail Brook Golf Course Pond Project #1 – outlet modifications
- Riparian Restoration
- River-Friendly Programs
- Quail Brook Golf Course Pond Project #2 – flowpath baffles
- Lower Pond
- Stormwater Basin Retrofits
- Residential Stormwater Management
- Ukrainian Village Pond.

The United States Environmental Protection Agency (EPA) identified nine significant elements that are critical for achieving improvements in water quality and that must be included in all watershed restoration plans funded with Clean Water Act Section 319(h) funding. The nine elements are listed below with a discussion of pertinent points from the Cedar Grove Brook watershed restoration plan that relate to each specific element. The elements do not occur sequentially.

Element 1: Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan.

Element 1 includes mapping, characterization and assessment of the watershed (**Section IV Watershed Characterization and Assessment** and **Section V Visual Assessment**) and an accounting of nonpoint sources that cause impairment in the watershed (**Section VI Pollutant Source Assessment**). A correlation shall be made between the sources of pollution and the extent to which they cause water quality impairment.

The relative contribution from any land use type is a function of:

1) the percent of the watershed comprised of the land use type; and

2) the contribution (pounds per acre) generated by the land use type in terms of pollutant load.

The dominant developed land use in the Cedar Grove Brook watershed is residential, comprising 43% of the watershed. Commercial, industrial and institutional land uses comprise small amounts of the developed land area, forest and brush/shrub land comprise 20%, wetlands comprise 18% and agriculture approximately 1% of the watershed.

The WinSLAMM modeling indicated that approximately 38% of the solids load originates on residential properties, and the majority of that load is generated by vegetated areas. Although vegetation such as lawn and forest is generally considered to be more protective of water resources than impervious areas such as driveways and roofs, these areas do generate sediments and other pollutants.

An additional sediment source that must be considered is the resuspension of sediment from the three existing pond structures during large storm events.

Element 2: An estimate of the load reductions expected from management measures.

A total maximum daily load (TMDL) has not been prepared for Cedar Grove Brook, and the watershed is not identified on the State's 2008 List of Impaired Waters. The watershed has been observed to contribute TSS and associated turbidity to the D&R Canal and water purveyors with downstream water intakes have reported higher treatment needs during and after storm events.

As the Canal and Cedar Grove Brook are not listed as impaired for sediment, a targeted endpoint or specific load reduction for the watershed was not identified. The goal of this project is to reduce the sediment load in the stream and thereby reduce sediment loads in the Canal. The anticipated load reduction from each recommended management measure is, however, specified in the restoration plan (**Section VIII Nonpoint Source Management Measures** and **Appendix G Project Detail Sheets**).

Element 3: A description of the nonpoint source management measures that will need to be implemented to achieve load reductions and a description of the critical areas in which those measures will be needed to implement this plan.

This restoration plan describes the management measures that are recommended in order to achieve the reduction of sediment entering Cedar Grove Brook and ultimately the D&R Canal. These measures include:

Structural Management Measures:

- Quail Brook Golf Course Pond – Outlet structure modification and addition of flowpath baffles
- Ukrainian Village Pond – Outlet structure modification
- Lower Pond – weir modification
- Riparian Restoration (multiple locations)
- Stormwater Basin Retrofits (multiple locations)
- Residential Stormwater Management – Rain barrels and rain gardens

Non-structural Management Measures

- River-Friendly Programs – Golf courses, businesses, schools and residents
- River-Friendly Communities

Details on each of these projects are included in **Section VIII Nonpoint Source Management Measures** and **Appendix G Project Detail Sheets.**

Element 4: Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.

This section describes the financial and technical assistance necessary to implement the entire watershed restoration plan. Items that are included are implementation, construction, maintenance, monitoring and evaluation. Organizations that could potentially be responsible for various projects and tasks are also identified. In the Cedar Grove Brook watershed, these organizations may include NJWSA, Somerset County and Franklin Township. Funding opportunities that may be utilized include Section 319(h) funds, Corporate Business Tax funds, Natural Resources Conservation Service funds, Partners for Fish & Wildlife, and NJWSA's source water protection fund. A discussion of potential funding sources and lead organizations is provided in **Section IX Technical and Financial Assistance**.

Element 5: An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.

Outreach and education may occur through many different existing programs. Franklin Township's municipal stormwater management plan requires them to conduct a yearly educational event and distribute brochures provided by the NJDEP[9]. Additional information about this project can be distributed in conjunction with the required mailing. Web sites maintained by the Township, NJWSA and Raritan Basin Watershed Alliance (RBWA) can be vehicles for the dissemination of the plan and information about the management measures. The plan and resulting projects can be highlighted in the RBWA "Basin Bulletin". Both the D&R Canal Commission and D&R State Park can be a valuable ally in distributing literature on the project. See **Section XI Education**.

Element 6: Schedule for implementing the nonpoint source management measures identified in this plan.

A schedule for implementation of the management measures recommended in the plan shall be developed. The schedule will be modified depending on funding opportunities and the potential for management measures to be included in other projects. Some of the management measures recommended in this plan can be implemented with a minimum of planning and funding. For instance, NJWSA is currently implementing the River-Friendly suite of programs in this watershed, and could easily expand that work. Other projects will require the identification of a lead entity and funding. A tentative schedule for implementation is provided in **Section X Implementation Schedule and Milestones.**

Element 7: Milestones- A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

[9] See NJPDES Master General Permit for Tier A municipalities

Information regarding the potential project schedule is provided in **Section X Implementation Schedule and Milestones.** This schedule was developed based on NJWSA's experience in other watersheds. Each milestone is contingent upon funding and lead organization availability.

Milestones Year 1:

- Continue and expand existing River-Friendly programs.
- Begin development of River-Friendly Communities program.
- Begin implementation of Residential Stormwater Management Programs

Milestones Year 2:

- Begin implementation of Quail Brook Golf Course pond modification projects.
- Begin implementation of River-Friendly Communities Program.
- Begin riparian restoration projects

Milestones Year 3:

- Begin stormwater basin retrofits.

Milestones Year 4:

- Complete Quail Brook Golf Course pond modification projects.
- Begin Ukrainian Village Pond project

Milestones Year 5:

- Begin Lower Pond project.
- Complete at least one stormwater retrofit project.
- Complete Residential Stormwater Management projects.

Milestones Year 7:

- Complete Ukrainian Village Pond project

Milestones Year 8:

- Complete Lower Pond Pond project

Milestones Year 10:

- Complete riparian restoration projects.

Ongoing:

- River-Friendly Programs
- Monitoring
- Maintenance

In addition, each project will require the establishment of tasks and milestones specific to the project.

Element 8: Performance Criteria-A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.

The primary criteria that will be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards will be TSS reduction (lbs/yr) as estimated by periodic reexamination of the WinSLAMM model and application of the Step-L model. Additional information regarding monitoring and performance criteria is provided in **Section XII Project Monitoring**.

Element 9: A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established above.

Direct water quality monitoring is not planned in the Cedar Grove Brook. A continuous water quality and flow data monitoring station is planned for the D&R Canal at Landing Lane, approximately three miles downstream. This new facility will be constructed and maintained by the USGS and NJWSA. Those data will be used to assess the overall success of the nonpoint source management measures implemented through the D&R Canal Nonpoint Source Implementation Project, and will also be pertinent for this project.

Additional information regarding monitoring and performance criteria is provided in **Section XII Project Monitoring**.

APPENDICES

Appendix A Water Quality of the Delaware and Raritan Canal, New Jersey, 1998-99, United States Geological Survey (USGS), 1999

Appendix B Cedar Grove Brook Watershed Water Quality Characterization and Assessment, TRC Omni, 2006

Appendix C Characterization and Assessment of the Cedar Grove Brook, NJWSA, 2009

Appendix D Cedar Grove Brook Stream Visual Assessment Results, NJWSA, 2009

Appendix E Cedar Grove Brook Watershed Restoration Planning Project, Omni Environmental, LLC, 2009

Appendix F Approved QAPP

Appendix G Project Detail Sheets