Report

County of Morris
Department of Planning & Development

Morris County

JACKSON BROOK WATERSHED STORMWATER MANAGEMENT PLAN

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Table of Contents

Table of Contents

EXECUTIVE SUMMARY

This report documents the engineering studies performed by Killam Associates for the County of Morris to develop a stormwater management plan for the Jackson Brook Watershed. The report addresses the overall stormwater management issues within the 4.7 square mile (3010 acres) drainage area covering parts of four municipalities - the Township of Randolph, the Township of Mine Hill, the Borough of Wharton and the Town of Dover. It evaluates the impacts of future land development on existing drainage facilities and flood problem areas and recommends an area-wide stormwater management plan to achieve watershed coordinated solutions to the runoff quantity and quality problems.

The objective of the study is to provide the County of Morris with the means to assess and mitigate the stormwater impacts of both current and future land use activities and effectively manage stormwater flows to alleviate existing flooding problems while not creating any new drainage problem areas. The study also considers management measures to protect the water quality of its streams for the safety and enjoyment of its residents and for the preservation and enhancement of the drainage basin, natural streams and wetlands environment. The study utilizes the regional planning area approach to facilitate coordination of infrastructure improvements and new developments and provide the linkage between land use management and efficient stormwater management measures within the Jackson Brook watershed.

The report is organized in eight sections along with appendices and contains information on:

- The physical features of the watershed, including its geographic setting, topography, geology, soils, wetlands, climate, land use and zoning.
- Watershed hydrology, flood history, stormwater runoff peak flows for the 1-, 2-, 5-, 10-, 15-, 25-, 50-, and 100-year return intervals for existing land use and future land use conditions.

- The runoff quantity and quality control strategies, hydrologic parameters and drainage basin runoff models.

- The major drainage facilities and information on the sufficiency of the facilities under existing and future development conditions.

- The alternative stormwater management measures considered, including structural and non-structural, to meet planning objectives.

- The study findings, and includes the description of the structural and non-structural stormwater management control components of the recommended watershed stormwater management plan which provides basin-wide coordinated solutions to effectively manage the increase in runoff volumes associated with land development and land use.

The report recommends the implementation of a Stormwater Management Plan for the Jackson Brook watershed consisting of both structural and non-structural control measures. The following are the recommended structural control improvement measures:

- Reconstruction of the Hedden Pond impoundment at the confluence of Wallace Brook and Upper Jackson brook into a Regional Wet Pond Detention Basin with a new dam and outlet works, including the removal of sediment deposits.

- Installation of streambank stabilization improvements on the Wallace Brook in Hedden Park that are compatible with the existing environmental setting.

- Installation of streambank stabilization improvements and repair of retaining walls on the Lower Jackson Brook just upstream of Hurd Park.

- Reconstruction of the Brook Lane Bridge on Lower Jackson Brook.

- Improvement of the Dover Twin Reservoir Impoundment on Reservoir Road on Wallace Brook including the removal of sediment deposits.

- Reconstruction of the roadway culvert at the St. Mary.s Street crossing of Spring Brook.

The preliminary estimated probable construction cost of the above structural improvements is approximately $3,265, 000 exclusive of land easement or right-of-way costs and other engineering and legal/administrative costs associated with the implementation of recommended stormwater management improvements.

The non-structural measures consist of amendments to the existing Land Use Requirements that will include provisions to:

- Designate the Spring Brook and Upper Jackson brook major subdrainage areas as an **On-Site Stormwater Management Zone** with municipal ordinance amendments to include provisions for on-site .release rate policy. and the retrofitting of existing drainage structures with infiltration measures.

- Designate the Wallace Brook and Lower Jackson Brook major subdrainage area as a **Stormwater Management Zone** which would require all new land development and redevelopment proposals to be in compliance with the recommended structural improvements and ordinance amendments for retrofitting existing drainage structures for infiltration measures and incorporating water quality BMPs for oil/grease and sediment separation.

- Designate the Jackson Brook Watershed as the ***Jackson Brook Stormwater Management District*** to implement stormwater quality and quantity controls as recommended in the Phase II Stormwater Management Plan.

- Control the NJDEP water quality design storm at each development site.

The discussions on the recommended stormwater management plan are included in Section 8 of this report. The watershed plan map is enclosed as Plate 9 in Appendix A.

1.0 INTRODUCTION

1.1 Authority and Background

This study of the Jackson Brook Watershed has been developed at the direction of the Morris County Board of Chosen Freeholders under the supervision of the County Department of Planning and Development. It has been prepared with the technical assistance of Killam Associates in accordance with a contract for professional engineering services between Killam Associates and the County of Morris. Killam Associates was engaged by the County in January 1998, to develop a practical Phase II Stormwater Management Plan (NJAC 7:8-3.2) for the Jackson Brook Watershed that would be in compliance with the New Jersey Department of Environmental Protection (NJDEP) standards and requirements, and be consistent with the County of Morris Stormwater Management Planning Program.

The alteration of the natural land cover within the watershed associated with growth and development over the past 30 years has resulted in decreased infiltration of rainfall and increases in the rate and volume of stormwater runoff. The lack of a comprehensive and uniform stormwater control mechanism or area-wide plan to manage the increased runoff has resulted in increased occurrences of flooding problems, severe stream channel erosion and siltation, degraded water quality and reduced groundwater recharge.

The April 1989 Hydrologic Study of the Jackson Brook Watershed prepared by the North Jersey Resource Conservation and Development Area identifies a 93% increase in peak flows in Jackson Brook for a ten-year storm event over the period 1983 to 1988, as a direct result of the increased land development within the watershed, and as the cause of erosion of the stream bed and banks, resulting in siltation and sediment accumulation in both the Brook itself and the pond at Hedden Park.

The flood of July 1967 (reportedly, a 50-year frequency occurrence) caused severe damages to industrial, residential and public property and was considered at that time to be the worst in 55 years since the flood of 1912. The flood of September 1992, a 15 to 25-year frequency occurrence, caused extensive damages along Wallace Brook, Jackson Brook and within Hedden Park. Reportedly, the damages along Wallace Brook included streambank erosion, roadway embankment erosion, the toppling of large trees, undermining and washout of existing gabion lined streambanks and the deposition of large amounts of sediment in the Hedden Park Pond. Because the Hedden Park Pond and its tributaries are classified as trout production waters, the recurrent sediment accumulation and erosion of stream channels have adversely affected their habitat. Also, Hedden Park is one of the most heavily used parks within the County Parks System. Additionally, the Town of Dover reported that flood damage from the September 1992 event along Jackson Brook consisted of:

- The loss of a pedestrian bridge in Hurd Park.
- Undermining of private retaining walls along the rear of commercial and residential properties.
- Severe structural damage to the abutment of a residential access bridge near Park Heights Avenue.
- Severe stream bank erosion leaving unstable slopes and undermined trees and the migration of the eroded streambanks adjacent to the Rockaway Valley Sewerage Authority's sewer line.

The flooding and continued stream bank erosion problems were again a cause for concern to the affected municipalities and property owners during the October 18-19, 1996, storm event., approximately a 50-year event. The continuous enlargement of the stream channels, unstable stream banks, scoured channel beds and unusual sediment and debris accumulation, together with the accumulation of trash in the channel and floodplain (e.g., beer cans, shopping carts, concrete wire, lumber scraps, tombstones, etc.) caused by the recurrent flooding, have resulted in the overall degradation and visual attractiveness of the stream environment. The history of flooding and erosion damages and disruption of the natural balance of the streams' biota, as well as the continuous burden of the threat to public safety, life, property and stream pond ecosystem, serve to underscore the chronic problems in the project watershed area. More recently, the flood of September 16, 1999, approximately a 50-75 year frequency event, again caused damages along Wallace Brook and Jackson Brook within Hedden Park and along the streambanks just upstream of Hurd Park.

1.2 Objective and Purpose

The overall objective of the stormwater management study for the Jackson Brook Watershed is to provide the County of Morris with the means to address the stormwater impacts of both current and future land use, and effectively manage stormwater flows to alleviate existing flooding problems that have resulted in adverse environmental and economic impacts, while not creating any new drainage problem areas. The study also considers management measures to protect the water quality of its streams for the safety and enjoyment of its residents, and for the preservation and enhancement of the watershed environment.

The purpose of the study is to address and evaluate the stormwater situation in the watershed and prepare a Phase II Stormwater Management Plan that will meet the overall objective, be consistent with the municipalities' land use regulations, and be in conformance with applicable NJDEP and County of Morris land development standards and guidance for stormwater management controls. The intent is to utilize the regional planning area approach for the development of appropriate stormwater management measures that will allow the coordination of infrastructure improvements and new developments, and provide the linkage between land use management and efficient stormwater management within the Jackson Brook watershed.

The study approach is as follows:

- determine, based upon current land use and future land development projections, the critical areas where flood damage potential and the risks to public health and safety and stream biota are greatest,

- optimize the design of the features and functions of existing stormwater controls and natural drainage systems within the watershed, and

- evaluate watershed-wide stormwater management control measures to effectively manage the volumes, rates and timing of stormwater runoff associated with land development within the watershed.

- provide a responsible management document that recommends long-term solutions for alleviating flooding damages, reducing the risk to life and property and improving the streams' water quality.

The management measures to be considered to achieve the project purpose will include:

- the possible augmentation of existing ponds and detention basins for use as runoff attenuation and water quality improvement facilities,

- reconstruction of the Hedden Park Pond Dam to provide flood control and water quality benefits,

- retrofitting of existing stormwater/drainage facilities, together with filtering mechanisms to promote infiltration and groundwater recharge,

- reconstruction of inadequate drainage structures

- the establishment of new detention areas or water impoundment facilities on land owned by the County or land that the County would need to acquire,

- recommend Best Management Practices, BMPs, for improved water quality,
- develop computerized models for analyzing ongoing development impacts,
- and the enactment of rules to control runoff and land use, including but not limited to restrictive zoning on stream corridors, flood plains, wetlands, and designated areas, within the watershed.

1.3 Scope of Study

The scope of the study is limited to the 4.7-square mile area drained by the Jackson Brook and its tributaries, Spring Brook and Wallace Brook. The study work effort involves:

- collection, compilation and review of existing drainage basin data,
- development of aerial photographs and topographic mapping from 1998 photography, land use mapping, zoning maps, soils maps,
- conduct field investigations and surveys including verification of flood marks from prior flood events, and interviews with residents,
- development of a baseline hydrologic model for the watershed study area,
- assessment of hydrologic and hydraulic impacts through the hydrologic and hydraulic analyses of the study area for current and future land use conditions for the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year storm events,
- identification and evaluation of alternative stormwater runoff quantity and quality management improvement measures and associated cost estimates.

- conduct water quality sampling and analysis to establish baseline water quality data for the watershed,

- conduct limited water quality modeling for evaluating the effects of pollutants on Hedden Pond and the study area streams,

- the development of the final Phase II Stormwater Management Plan for the drainage basin with associated probable construction costs, and

- preparation of the Final Project Report including an Executive Summary and full text with graphics, charts and tables.

2.0 WATERSHED AREA

2.1 Location and Description

The Jackson Brook watershed is located within the central portion of Morris County and drains an area of approximately 4.7 square miles (3010 acres) covering parts of four municipalities - the Township of Randolph, the Township of Mine Hill, the Borough of Wharton and the Town of Dover.

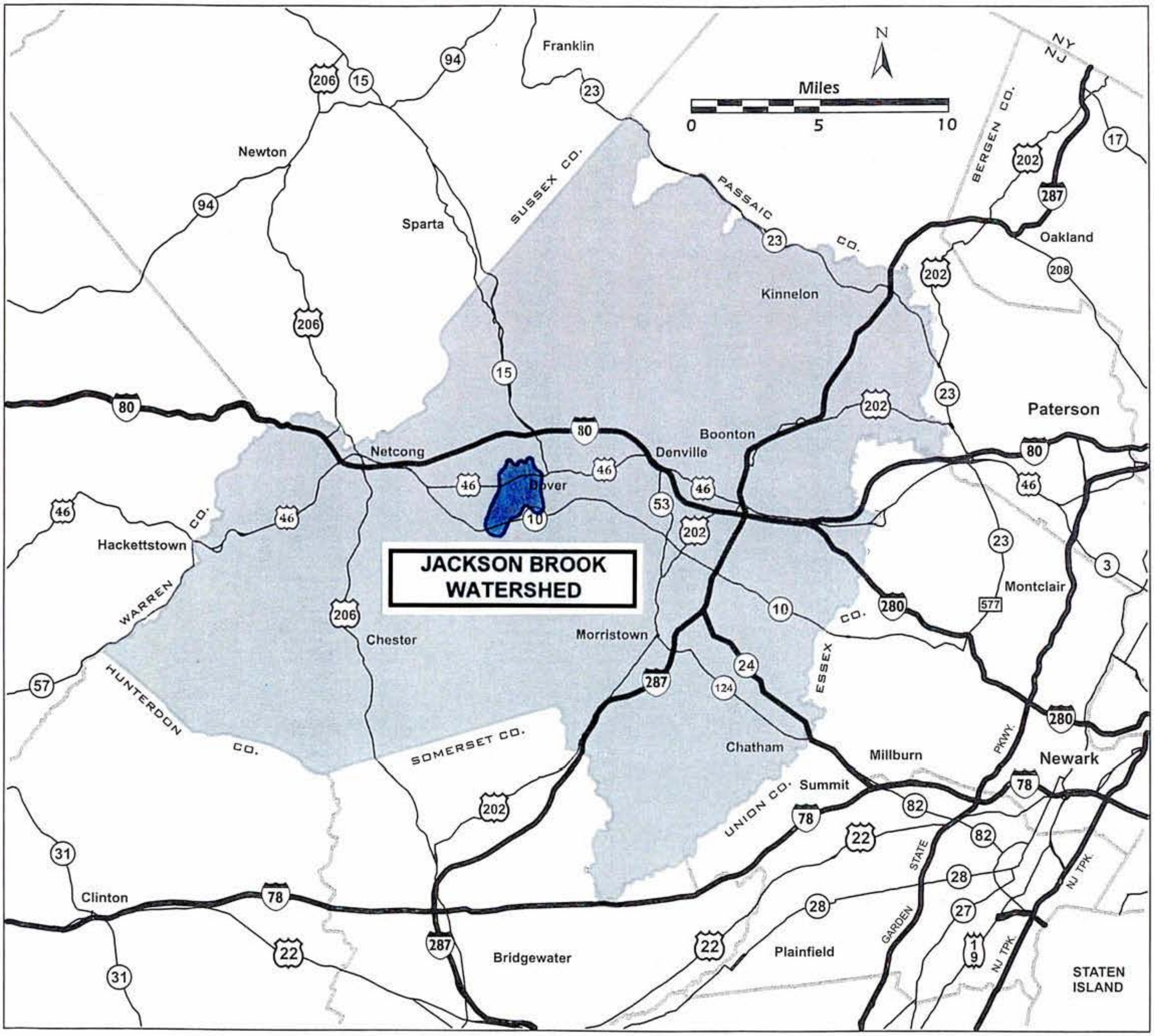
Portions of the watershed are traversed by the major roadway arteries of U.S. Highway Route 46 and N.J. State Highway Route 10. See Figure 1, Location Map. Approximately 2.1 square miles lie within Randolph, 1.6 square miles within Mine Hill, 0.5 square miles within Wharton and 0.5 square miles within Dover.

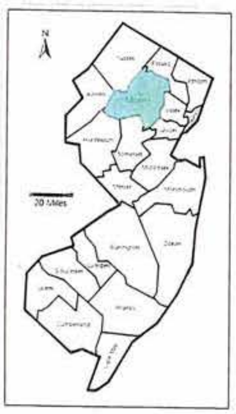
The watershed is divided into three major drainage basins (Jackson Brook, Wallace Brook and Spring Brook) which are drained by the main stem Jackson Brook, with contributory subareas of 2.9, 0.9 and 0.97 square miles, respectively. See Figure 2, Drainage Area Map.

The overall watershed boundary and major drainage sub-area divides are shown on Plate 1, Appendix A, entitled, "Topography." Plate 1 was developed from aerial photography taken on January 11, 1998 and is used as the base map for all subsequent plates which illustrate the physical features and hydrologic characteristics of the study area. The drainage area map delineating the Jackson Brook watershed sub-areas utilized in the hydrologic analysis is shown on Plate 4, entitled "Drainage Sub-Areas."

The main stem Jackson Brook sub-area encompasses approximately 2.9 square miles and flows into the Rockaway River approximately 500 feet upstream of the Route 46 bridge crossing of the Rockaway River.

The main stem flows north from the headwaters near Morris Turnpike south of Route 10 in the Township of Randolph to Hedden Pond in Hedden Park and finally to its mouth at





County of Morris
Department of Planning and Development

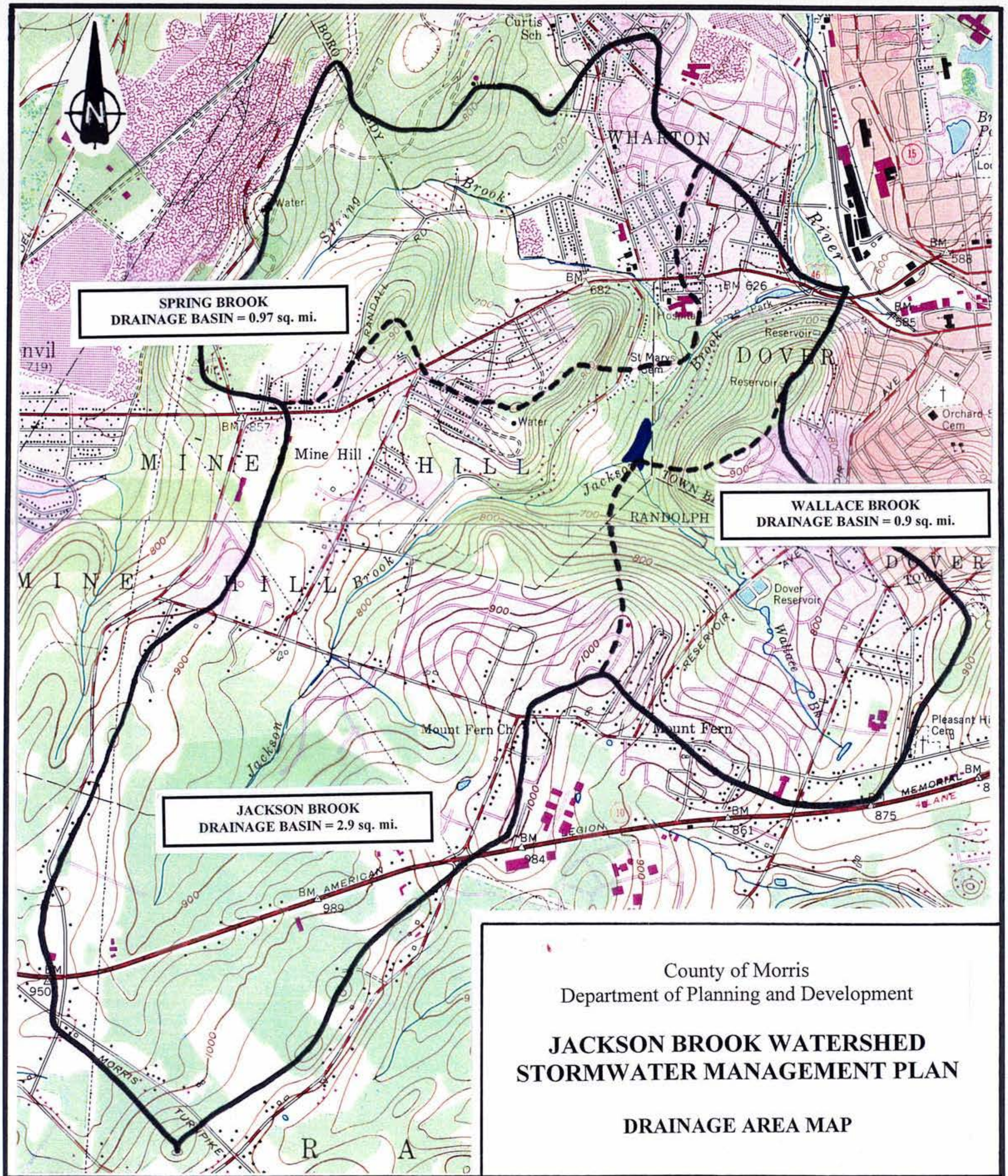
JACKSON BROOK WATERSHED STORMWATER MANAGEMENT PLAN

LOCATION MAP

Killam Associates Consulting Engineers

SOURCE: Map of Morris County New Jersey
Published by The Board of Chosen Freeholders

FIGURE 1



County of Morris
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JACKSON BROOK WATERSHED STORMWATER MANAGEMENT PLAN

DRAINAGE AREA MAP

2000 0 2000 4000

GRAPHIC SCALE IN FEET

MAP SOURCE:
USGS Topographic Survey Maps
Dover and Mendham NJ Quads

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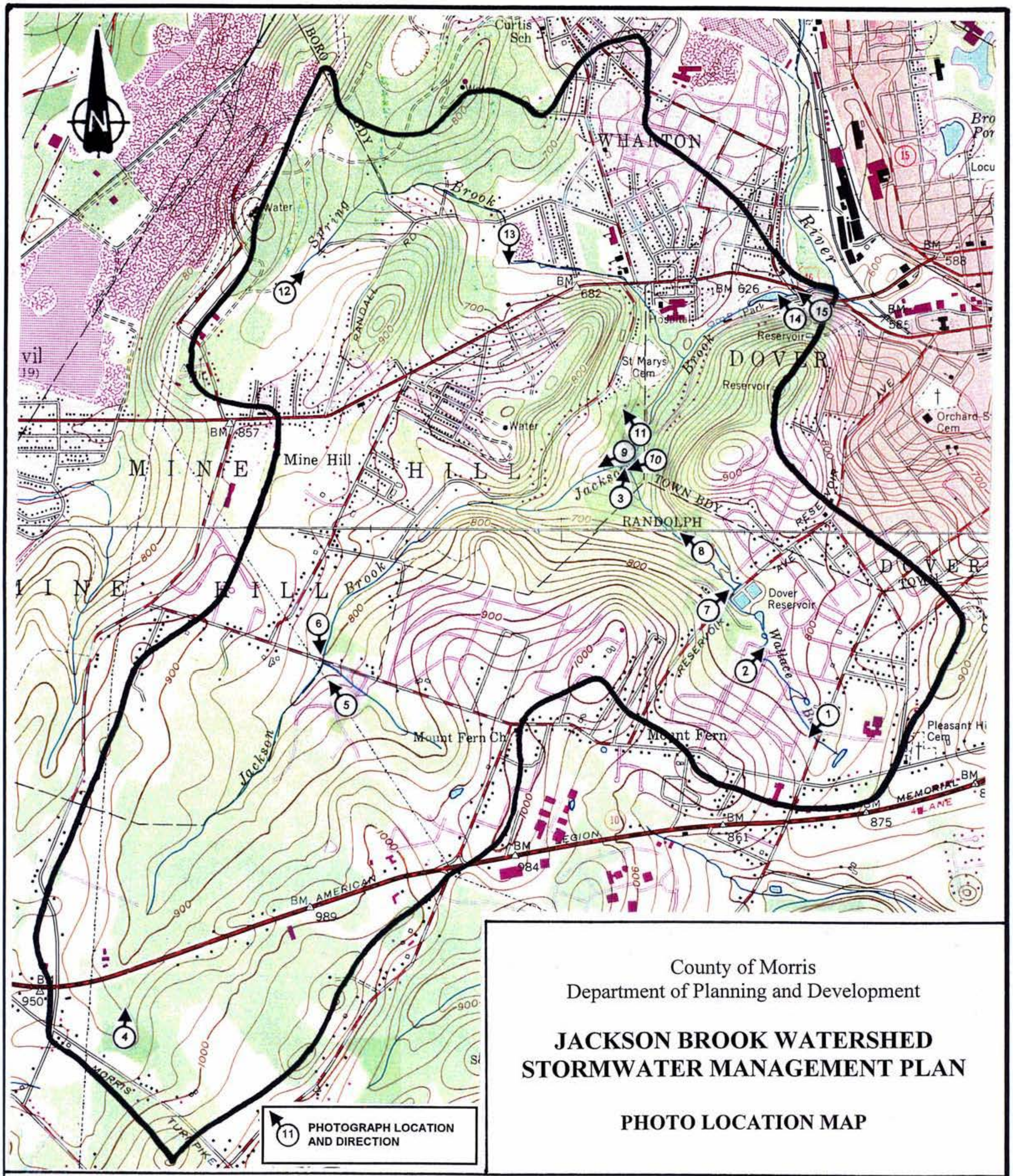
FIGURE 2

the confluence with the Rockaway River in the Town of Dover. Hedden Pond divides the main stem of the Jackson Brook drainage basin area into an upper, relatively steep portion to the south, and a lower, relatively flat portion to the north. The upper and lower portions are referred to herein as the Upper Jackson Brook and Lower Jackson Brook, respectively. The total stream channel length of the main stem Jackson Brook is approximately 2.8 miles with a relatively steep average gradient of 2.5 percent from its headwaters to Hedden Pond. Below Hedden Pond, the total stream channel length of the Lower Jackson Brook is approximately 0.8 miles with a relatively flat average gradient of 0.28 percent.

The Wallace Brook, located in the Township of Randolph, drains the area located to the north of Route 10 extending from its headwaters just east of Center Grove Road in a northwest direction to Hedden Pond. The total stream channel length is approximately 1.2 miles with a relatively steep average gradient of 3.7 percent. The portion of the brook above Reservoir Avenue consists of both open channel and piped flow. Below the Dover twin reservoirs, at Reservoir Avenue, the gradient of the brook is much steeper at 5.3 percent for a length of natural channel of approximately 2800 feet. This lower portion flows through the wooded park landscape to its mouth at the confluence of Upper Jackson Brook with Hedden Pond.

The Spring Brook major sub-area covers portions of the Township of Mine Hill and the Borough of Wharton in the northwest section of the watershed and drains a total area of approximately 1 square mile with a little over 0.7 square miles being located in the Township of Mine Hill. Spring Brook also has a relatively steep average gradient of 2.7 percent and a total stream channel length of about 1.9 miles. Spring Brook flows through both residential and wooded highlands as it winds its way through the Township of Mine Hill until it reaches its mouth at Jackson Brook approximately 1500 feet downstream of Hedden Pond near the Dover General Hospital.

Photographs taken at various locations within the watershed are illustrated on Figures 3 through 3.5. These photographs are number keyed to Figure 3, Photo Location map. Photographs . and 2 show the Wallace Brook within the urbanized upper portion of the sub-drainage basin. Photograph 3 is a view of Hedden Pond (Lake) along Jackson Brook at the entrance to the lake and shows sediment deposition, as well as the environmental features of the land, water, woodland, aesthetics and recreational amenities. Photograph 4 shows a wet pond retention basin within an industrial/commercial complex along Route 10 in the uppermost portion of the Jackson Brook. Photograph 5 is a view of a dry detention basin facility in the Upper Jackson Brook tributary subarea located in a residential development adjacent to Randolph Avenue. Photograph 6 shows the Jackson brook stream corridor at Randolph Avenue bridge just upstream of the Hedden Park area. Photograph 7 shows the Reservoir Avenue crossing over Wallace Brook at the Dover Twin Reservoir. This roadway is subject to inundation by floodwaters overflowing the Wallace Brook stream banks and the reservoir embankments. Photograph 8 shows a section of the Wallace Brook stream corridor within Hedden Park adjacent to one of the pedestrian trails, bikeway and picnic areas. Photograph 9 was taken along Jackson Brook at the entrance to Hedden Pond and illustrates the use of large boulder-type check dams and vegetation to reduce flow velocities, contain soil erosion and enhance the beauty of the pond. Photograph 10 shows the accumulation of sediment at the confluence of Jackson Brook and Wallace Brook at the pond's entrance. Photograph 11 is a view of a portion of the Hedden Pond Dam and overflow spillway at the outlet of the pond. Photographs 12 and 13 show the stream corridor of the Spring Brook near its headwaters and midway reach, respectively. Photographs 14 and 15 show the view of Hurd Park upstream of U.S. Highway Route 46 in the Park Heights Avenue vicinity. This park serves as a recreational area, as well as a stormwater retention area with its diverse wetland and upland vegetation.



County of Morris
Department of Planning and Development

JACKSON BROOK WATERSHED STORMWATER MANAGEMENT PLAN

PHOTO LOCATION MAP

2000 0 2000 4000

GRAPHIC SCALE IN FEET

MAP SOURCE:
USGS Topographic Survey Maps
Dover and Mendham NJ Quads

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FIGURE 3

Watershed Photographs

Figure 3.1

Photo No. 1
Wallace Brook

Urbanization in upper-most portion of Wallace Brook Drainage Basin

Photo No. 2
Wallace Brook

Enhanced stream corridor within urbanized area.

Photo No. 3
Jackson Brook

Hedden Pond downstream of confluence of Jackson Brook and Wallace Brook.

Figure 3.2

Photo No. 4
Jackson Brook

Urbanization development with onsite stormwater retention basin in upper-most portion of Jackson Brook watershed.

Photo No. 5
Jackson Brook

Wetland detention basin within Jackson Brook watershed.

Photo No. 6
Jackson Brook

Jackson Brook stream corridor at Randolph Avenue bridge.

Figure 3.3

Photo No. 7
Wallace Brook

Reservoir Avenue at Wallace Brook, adjacent to Dover Reservoir, which is impacted by recurrent flooding.

Photo No. 8
Wallace Brook

Wallace Brook stream corridor within Hedden Park.

Photo No. 9
Jackson Brook

Jackson Brook at entrance to Hedden Pond, with check dams and emergent vegetation to reduce flow velocities, contain soil erosion and enhance the beauty of the pond.

Figure 3.4

Photo No. 10
Jackson Brook:
Hedden Pond

Entrance to Hedden Pond with sediment deposition and accumulation.

Photo No. 11
Jackson Brook:
Hedden Pond

Hedden Pond Dam embankment and overflow spillway.

Photo No. 12
Spring Brook

Stream corridor in upper-most portion of Spring Brook drainage Basin.

Figure 3.5

Photo No. 13
Spring Brook

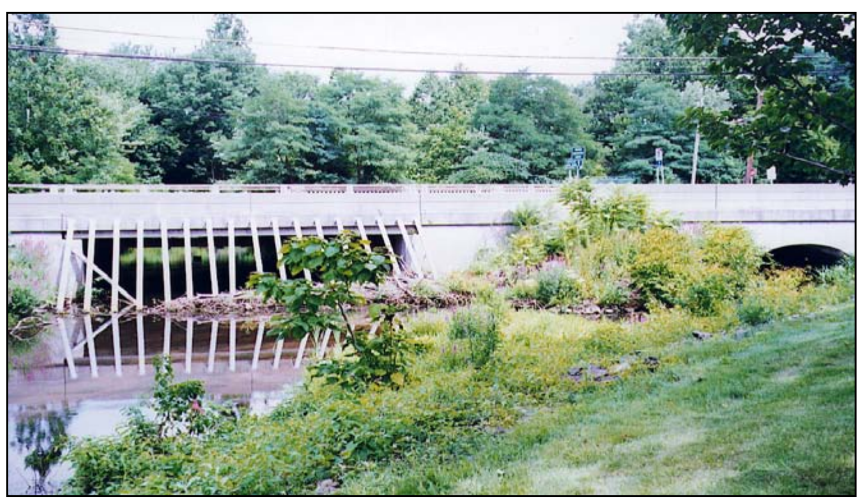
Spring Brook stream corridor.

Photo No. 14
Jackson Brook

Stream corridor within Park bordered by Route 46 and Park Heights Avenue in Dover in the lower-most portion of Jackson Brook watershed.

Photo No. 15
Jackson Brook

Route 46 bridge at Jackson Brook just upstream of its confluence with Rockaway River.



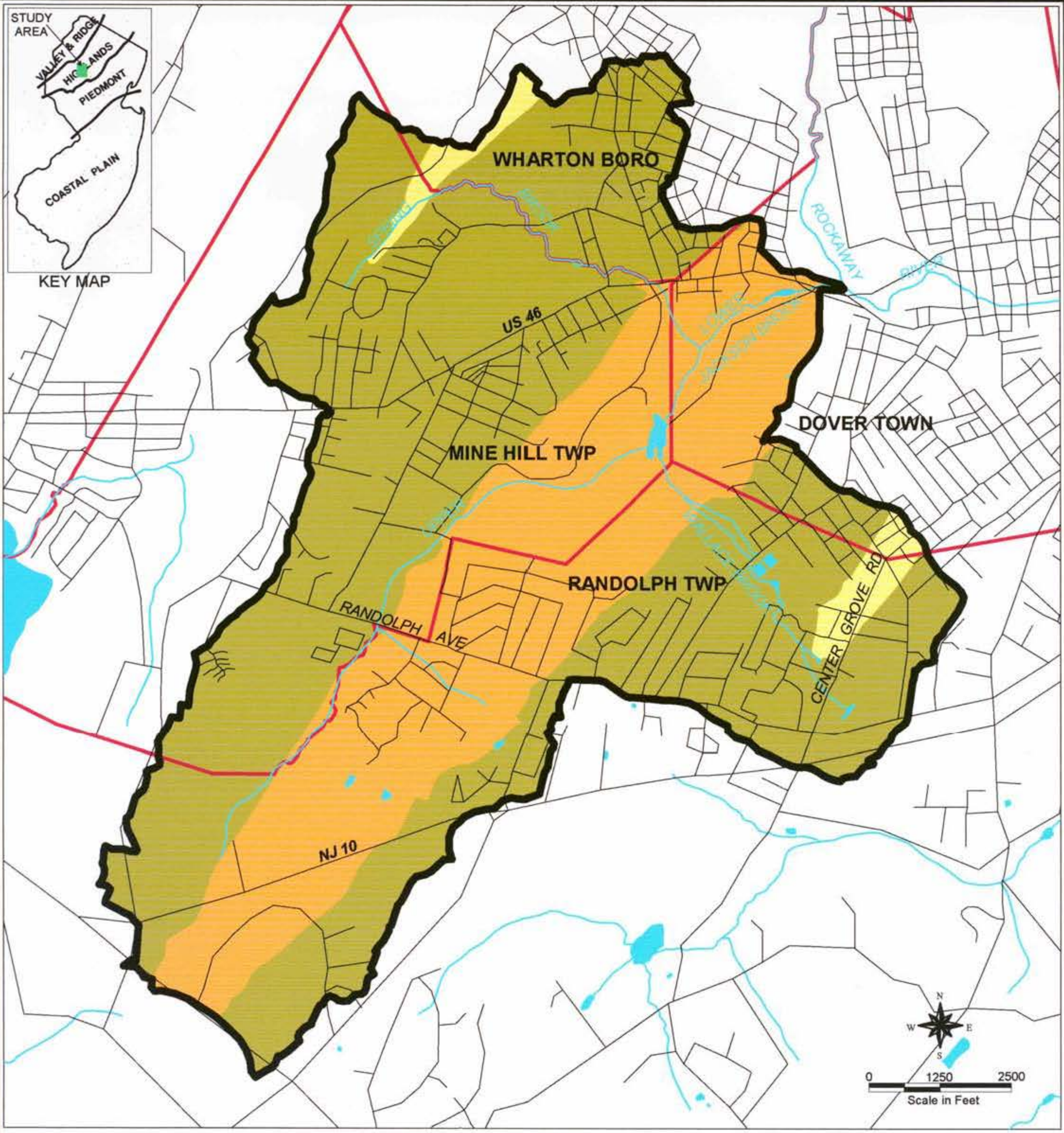
2.2 Topography

The entire study area can be classified as a steep, mountainous region containing many hills and valleys. Each of the three major streams has slightly different topographic characteristics, with mountainous ranges forming the edges of the natural valley basin and channel for the major streams. This is illustrated on Plate 1, Appendix A, entitled "Topography.

The headwaters of Wallace Brook start in a residential area where stream flow is both channeled and piped until it reaches the swampy wetland just upstream of the Dover twin reservoirs. Downstream of the reservoirs, the topography is wooded and very steep. The hills at the headwaters of Wallace Brook rise to about elevation 960 feet, North American Vertical Datum 1988 (NAVD), at the highest point, while the mouth of the stream, at Hedden Pond, the stream sits at elevation 592 feet NAVD. The Spring Brook drainage area, in the northwest corner of the watershed, ranges from high point elevations of 890, 910 and 930 feet NAVD for the highest mountain ridges to an elevation of 590 feet NAVD at the confluence with Lower Jackson Brook near the Dover General Hospital. The main stem of the Jackson Brook ranges from a high point elevation of 1060 feet NAVD in the southern portion of the watershed to an elevation of 560 feet NAVD at its mouth at the confluence with the Rockaway River. The topographic map was compiled from January 1998 aerial photography at a scale of 1" = 100 feet with 2 ft. contour intervals and digitized into ArcCad/ArcView Geographic Information System (GIS) format for use at other selected scales as appropriate.

2.3 Geology and Soils

The watershed study area falls entirely within the New Jersey Highlands Geologic Province. The Highlands are underlain predominantly by granite, gneiss and small amounts of marble of Precambrian Age. Figure 4 is a Geologic Map of the drainage basin which shows that the project area is underlain by sedimentary rocks of various types. The central portion of the watershed, which is the valley corridor, are underlain by Hypersthene – Quartz – Andesine Gneiss/Pyroxene Gneiss. The east and west portions



LEGEND

WATERSHED BOUNDARY
STREAM
WATER BODY
MUNICIPAL BOUNDARY

SEDIMENTARY ROCKS

HORNBLENDE GRANITE/MOSTLY HORNBLENDE GRANITE & GNEISS/HORNBLENDE GRANITE 7 GNEISS
HYPERSHTENE-QUARTZ-ANDESINE GNEISS/PYROXENE GNEISS; QUARTZ-ANDESINE GNEISS WITH ORTHO- & CLINOPYRO
QUARTZ-OLIGOCLASE-BIOTITE GNEISS
WATER

SOURCE: NJ Geological Survey Map
October 1999 Revision

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPEMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

GEOLOGIC MAP

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FIGURE 4

of the watershed are underlain by Hornblende Granite/mostly Hornblende Granite and Gneiss with only small amounts of Quartz – Oligoclase – Biotite Gneiss.

The soils of the study area fall within the following general soil series noted below. The descriptions of each were taken directly from the USDA Natural Resources Conservation Service (NRCS) soil survey of Morris County, dated 1976.

Alluvial - **(Ae)** Alluvial land consists of water-laid sediment along streams in all parts of the county. Drainage is variable. The material is variable.

Annandale - **(AnB)** This soil is well suited to farming and community development. The principal properties that affect the use of this gently sloping soil are adequate surface drainage, lateral seepage of water on top of the fragipan, and slow permeability in the fragipan.

Califon - **(CaB, CaC, CcB, CcC, CdB)** The Califon series consists of deep, nearly level to strongly sloping, moderately well drained and somewhat poorly drained soils. These soils are mostly in waterways or seepage areas at the base of slopes in the granitic gneiss uplands and typically contain gravel and cobbles throughout.

Carlisle - **(Cm)** The Carlisle series consists of deep, nearly level, very poorly drained organic soils. These soils are in depressions that were formerly or are now partly occupied by lakes or ponds.

Cokesbury - **(CoB, CsB)** The Cokesbury series consists of deep, nearly level to gently sloping, poorly drained soils. These soils are in waterways, depressions, and elongated areas that extend along the bases of steeper slopes in the granitic highlands. The soils are generally cobbly and stony, but in places the surface is almost free of stones.

Hibernia – **(HbC)** The Hibernia series consists of deep, gently sloping to steep, somewhat poorly drained soils in depressions, in watercourses, and at the base of steep slopes.

Netcong - **(NtB, NtC)** The Netcong series consists of deep, gently sloping to strongly sloping, well-drained soils. They formed in moderately weathered, somewhat gravelly and cobbly sandy loam glacial till that was derived mainly from granitic gneiss. Some stones and boulders are scattered on the surface and within the soil.

Parker - **(PaC, PbD, PeC, PeD, PfE)** The Parker series consists of deep, gently sloping to very steep, excessively drained soils that contain a large amount of angular granitic stones, cobbles, and gravel

Ridgebury – **(R1B)** The Ridgebury series consists of deep, nearly level to gently sloping, poorly drained very stony or extremely stony soils.

Rockaway - **(Roc, RrD, RpC)** The Rockaway series consists of deep, gently sloping to very steep, well-drained soils on uplands.

Rock Outcrop - **(Rvf)** This land type is about 50 to 90 percent outcrops of bedrock and 10 to 50 percent mostly extremely stony Rockaway soils.

Urban Land - **(Ua, UrC, Ue)** Urban land consists mostly of areas that are either paved or built upon. The soils in the remaining open spaces have been reworked to the extent that the original profile cannot be recognized. The characteristics of the material are variable.

The soils within the above listed series were separated into Hydrologic Soil Groups (HSGs) in accordance with the NRCS classification system which evaluates the runoff potential of a soil according to its infiltration and conveyance rates and consists of four groups identified by the letters A, B, C and D. Plate 3 in Appendix A, entitled "Hydrologic Soil Grouping" map shows the soil groups for the study.

As Plate 3 illustrates, the majority of the project area soils fall within the B and C soil groups. These soil groups cover approximately 80 percent of the drainage area and are well drained to moderately drained soils that are conducive to seepage of rainfall. D soils and Alluvial land are found mostly within the stream channels and their tributary areas, with Urban Land only accounting for a small percentage of the drainage area. However, it can be clearly seen that a significant percentage of the B soil area has been developed with residential and commercial properties and streets, which are now Urban Lands, causing runoff rates to be significantly greater than those when the soil survey was originally conducted circa 1976.

2.4 Climate and Flood History

The climate of the Jackson Brook watershed can be characterized as a humid and temperate continental climate that is influenced by the Atlantic Ocean. Marked changes of weather are frequent, particularly during the spring and fall. The winters are moderate with moderate snowfall, while the summers are moderate with hot, sultry mid-summer weather and frequent thunderstorms.

The average annual temperature as recorded in nearby Morristown is 53°F with extremes ranging from 13°F to 105°F. Precipitation is also moderate averaging about 46 inches annually, which is usually well distributed throughout the year. Rainfall is heaviest during summer months with much falling as thunderstorms but occasionally tropical storms, hurricanes or strong frontal storms move in from the east or south and bring along significant amounts of precipitation.

A review of past storms in the watershed area indicates that a flood may occur during any season of the year. The most outstanding flood events in recent history occurred in July 1967 and September 1992, October 1996 and September 1999. The flood of July 1967, which was estimated to be approximately a 50-year Recurrence Interval event, was equaled and exceeded by the storm events of October 1996 and September 1999, resulting in estimated damages in excess of one million dollars.

Federal Emergency Management Agency (FEMA) Flood Insurance Studies (FIS) and State of New Jersey Flood Hazard Area Delineation have only been completed for the Lower Jackson Brook branch between Hedden Pond and the confluence with Rockaway River. A map showing the approximate 100-year flood plain limits within the watershed study area is presented on Plate 8, Appendix A, entitled, "Flood Plain and Hydraulic Facilities" Map. It can be seen from this map that the most severe flooding occurs in the lower or northern portions of the watershed, more specifically in the areas along Lower Jackson Brook, Wallace Brook at and below Reservoir Avenue and Spring Brook at and below Randall Avenue/St. Mary's Street.

Flooding in the Jackson Brook occurs from a combination of backwater from the the Rockaway River, which frequently floods the low-lying region up to and above the Route 46 bridge which together with the Lower Jackson Brook branch which floods the lower portion of Jackson Brook up to Hedden Pond.

The major flood problem areas along the main stem of Jackson Brook are identified as:

- Hedden Park Pond
- Lower Jackson Brook at Brook Lane
- Lower Jackson Brook adjacent to Park Heights Drive at Route 46

The Spring Brook drainage area, located mostly in Mine Hill Township and Wharton, with a small portion in the Town of Dover, does not have a wide flood plain due to the relative steepness of the stream channel, with the exception of the relatively flat area at or below Randall Avenue/St. Mary's Street, which is the major flood problem area. However, the problems of the stream are not only limited to flooding, but also the force and speed at which the water flows during heavy rainfall which results in erosion of the stream banks.

The Wallace Brook drainage area, located mainly in Randolph Township, experiences flooding and severe erosion problems at the following locations due to the relatively steep stream gradient:

- Wallace Brook at Dover Twin Reservoir and Reservoir Avenue
- Wallace Brook stream reach in Hedden Park between Reservoir Avenue and Hedden Pond.

2.5 Zoning and Land Use

Land use maps were prepared for existing and anticipated future development conditions. These maps are presented in Appendix A on Plate 2 entitled, "Existing Land Use 1998" and on Plate 5 entitled, "Zoning and Future Land Use." The Existing Land Use map is based on January 1998 aerial photography, depicting development conditions at that time, with the 1998 Land Use categories and alphanumeric designations in accordance with Morris County Planning Board standards. As illustrated on the map, the watershed area is predominantly a residential community with commercial and industrial development next in ranking.

The Zoning and Future Land use map was prepared from the most recent zoning maps for the four municipalities in the watershed, utilizing the 1998 aerial photography planimetric map as the base. This map shows the anticipated future location, extent and intensity of development of land for varying types of residential, commercial, industrial, open space and other public and private use or combination of purposes.

Examination of the most likely future land usage shows that lands available for new development lie within residentially zoned areas mostly in Mine Hill and Randolph Townships with a few small areas available for new development in Wharton Borough. Although the land use type for a particular area may change from the present to future conditions, it is important to note that the land use zoning generally stays the same. It is anticipated that many areas within the watershed's four municipalities will undergo redevelopment in the future and the zoning is expected to remain generally as shown on the municipal zoning maps.

2.6 Wetlands

The drainage basin study area contains several regulated freshwater wetland habitats. A map illustration of the location and extent of wetlands is presented on Plate 6, Appendix A, entitled, "Existing Land use and Wetlands Map." The map was developed from the NJDEP Dover, SE&SW and Mendham NE&NW Freshwater Wetlands quarter-Quadrangles dated March 1986 and updated from the NJDEP Geographic Information System database utilizing color infrared imaging dated fall 1998.

As Plate 6 illustrates, wetland habitats are distributed contiguously throughout the entire drainage basin study area. Although there are several isolated wetlands within the drainage basin, the majority of the wetlands are located adjacent to the stream systems. The predominant wetland habitats are classified as Palustrine Forested Broad-leaved deciduous-saturated (PFO1B) deciduous-seasonal (PFOIC) deciduous-seasonal saturated (PFO1E) and Riverine-upper perennial-unconsolidated bottom gravel (R3UB1). Specifically, the classified wetland habitats located along the main stem Jackson Brook, Wallace Brook and Spring Brook are as follows:

Main Stem Jackson Brook

Upper Jackson Brook

The main stem of Jackson Brook upper portion referred to as Upper Jackson Brook, flows from south to north and begins near Morris Turnpike. The Upper Jackson Brook branch is classified as a Palustrine system. There are various wetland habitats found all along the Upper Jackson Brook with the dominant wetland type being a Palustrine Forested Broad-leaved deciduous-saturated (PFO1B) wetland habitat. There are also some small areas classified as Palustrine Emergent (PEM1B) wetland habitat, and Riverine-Upper perennial-Unconsolidated bottom- Gravel (R3UB1). The Hedden Pond where the Upper Jackson Brook branch terminates is classified as Palustrine-Open water-Permanent-Diked/Impounded.

Lower Jackson Brook

The Lower Jackson Brook branch flows north/northeast to its mouth at the confluence with the Rockaway River. The various wetland habitats found along this lower branch are predominantly Riverine-Upper perennial-Unconsolidated bottom-Gravel (R3UB1) with small areas of Palustrine-Forested-Broad-leaved deciduous-Seasonal (PFO1C) Palustrine-Forested-Broadleaved-deciduous-Saturated (PFO1B) and Palustrine-Emergent-Persistent-Saturated (PEM1B).

Wallace Brook

The Wallace Brook flows from the southeast section of the watershed in a northwest direction to Dover Twin Reservoirs and continues northwest to the Hedden Pond. The Wallace Brook headwater area is classified as a Palustrine (PFO1) wetland system which then flows through a piped system to a Palustrine-emergent-Persistent-Saturated area (PEM1B), then to the Dover Twin Reservoirs, a Palustrine-Open water-Permanent-Excavated system, bordered by Riverine-Upper perennial-Unconsolidated bottom-Gravel

(R3UB1). Upon leaving the Twin Reservoirs, the brook changes to a Riverine system, with Lower perennial flow and an unconsolidated bottom comprised of cobble and gravel until it reaches its mouth at the Hedden Pond.

Spring Brook

The Spring Brook flows from the western portion of the watershed in a northeast direction through Mine Hill Township and then changes to a more easterly direction at the border with Wharton Borough and continues on a south/southeast course to its mouth at the confluence with Lower Jackson brook. The dominant wetland habitat located along this stream corridor is Palustrine Forested Broad-leaved deciduous-saturated (PFO1B) wetland, with small areas of Broad-leaved-deciduous-seasonal (PFO1C) and Broad-leaved-deciduous-seasonal saturated (PFO1E) and an area of Palustrine-Scrub/Shrub-Broad leaved deciduous-Saturated/Palustrine-Emergent-persistent-Saturated (PSS1B/PEM1B) wetland to the southeast of St. Mary's Street in Wharton.

HYDROLOGIC ANALYSIS

3.1 Methodology

The hydrologic analysis of the 4.7 square mile drainage basin study area utilized the HEC-1 "Flood Hydrograph Package" computer program. This program, developed by the U.S. Army Corps of Engineers, was used to generate the rainfall runoff interrelationships for the major drainage sub-areas and obtain peak flows at various locations for selected storm intervals, for current land use and anticipated future land use conditions.

The HEC-1 models were based upon the hydrologic methodology of the Soil Conservation Service (SCS) as presented in their publications "National Engineering Handbook, Section 4 - Hydrology", and "Urban Hydrology for Small Watersheds, Technical Release 55 (TR55)". The 2-, 10-, and 100-year 24 hour rainfall events were selected as design storms to be analyzed in accordance with New Jersey Department of Environmental Protection standards for stormwater management. In addition, the 1-, 5-, 15-, 25-, and 50-year design storm events were selected for analysis to obtain the runoff impacts for a wide range of flows and flood recurrence intervals. Rainfall depths for the drainage basin were obtained for the selected design storms from the U.S. Weather Bureau Technical Paper 40 (TP 40), Rainfall Frequency Atlas of the United States, and the SCS Type III rainfall distribution was utilized. Runoff volumes were based upon the SCS runoff equation utilizing Runoff Curve number (RCN) to reflect the drainage area soil types and land use, and Antecedent Moisture Condition II.

Runoff hydrographs were developed based upon the Clark unit hydrograph using appropriate model time-step, sub-drainage area lag time and flood routing procedures. The time-step used in the hydrologic models was 6 minutes which is short enough to ensure mathematical stability and adequately define the peaks of the hydrographs allowing the generation of a complete hydrograph given the 300 step limit of the HEC-1 computer program.

The hydrologic models for the selected design storm rainfall events traced the volume of stormwater runoff as it flowed downstream in the four major drainage sub-areas, coordinated the timing characteristics and runoff from the contributing sub-drainage areas, and identified peak stages and discharges at various points of analysis in the drainage basin study area. The runoff model network and summary of peak discharges are described in Sections 3.7 and 3.8 herein.

3.2 Stormwater Management Control Strategies

3.2.1 Runoff Quantity Control Strategy

The stormwater runoff quantity control strategy utilized in this stormwater management study is the regional watershed planning area approach, with the goal of managing the increase in runoff volumes from development activities such that peak rates of runoff throughout the major drainage subareas are not increased to levels exceeding existing rates. This means that post development and/or most likely future development peak flow rates throughout the major subareas would have to be maintained at existing condition levels for the selected design storms, considered individually.

The strategy of the modeling is to determine the peak flow values at selected points of interest throughout the drainage basin study area for the existing base land use and anticipated future land use conditions, and to identify the relationships of peak runoff and the timing of the peak flows from the various sub-drainage areas on other downstream points. Runoff interrelationships between the various sub-drainage areas in the watershed are used to determine the appropriate method(s) of runoff control towards meeting the overall objective and purpose of the study. Key points of interest were selected at the following locations:

existing storm drainage problem areas

- bridges, culverts, dams, reservoirs and ponds identified from detailed topographic mapping, site field investigations and NJDEP Flood Hazard area delineations, and the County and Municipal Engineers' offices
- stream confluences and all sub-drainage area boundaries identified by breakdown of the drainage basin for modeling purposes

The key points of interest are designated as nodes on the runoff model network diagrams. See Figure 5, Runoff Models Flow Network Schematic in Section 3.7. Each point of interest defines a point of calculation of runoff which is summarized on Table 2 at the end of this section. Each node was selected as a flow control point.

The runoff control approach is that of optimizing the functions and features of the existing drainageways and hydraulic facility structures in conjunction with other structural and non-structural measures to effectively manage the increased peak flows resulting from "most likely" future land development for the selected range of storm recurrence events. This means that stormwater runoff volumes from anticipated "most likely" future land use conditions are to be controlled by utilizing structural and/or non-structural measures so that peak flow rates for the corresponding storm events would closely approximate the conditions currently existing at the mouths of the three major streams, namely the main stem of Jackson Brook, Wallace Brook and Spring Brook.

The *structural measures* include:

- Utilizing on-site or regional detention/retention basins and/or wet pond systems;
- Retrofitting and/or reconstruction of existing impoundments;
- Reconstruction of bridges and/or culverts;
- Stream stabilization and erosion control measures; and
- Installation of BMPs measures.

The *non-structural measures* include:

- Runoff quantity control policy involving designated allowable peak flow rates at selected points of interest, which specify the percentage of predevelopment peak flow rate that may be discharged from the subareas after development takes place;
- Ordinance and land use regulation amendments to place limitations on zoning and development to minimize the disturbance of land and/or the percentage increase in impervious cover; and
- Stream corridor and open space preservation are to be encouraged so that developments will remain outside the flood hazard areas and/or valuable open space preserved for recreation areas and parks.

3.2.2 Runoff Quality Control Strategy

Runoff from land areas resulting from rain or snowfall washes pollutants off the land into storm drainage systems and natural drainage ways and eventually into the lakes and streams of the County. This type of pollution is called "nonpoint source pollution" due to its diverse origins and dispersed outflow points. The major nonpoint source urban pollutants come from the atmosphere and human activities on land and include sediment, nutrients, trace metals, oxygen-demanding substances (i.e., street litter, pet wastes), toxic chemicals, bacteria, hydrocarbons and chloride (i.e., pavement de-icing salts). As an area becomes developed, the increase in pollutant loads to runoff are typically increased because of increased pollutant sources and increased runoff rates which accelerate the dislodgment of pollutant-laden particulate material. Also, pollutants such as roadway de-icing salts and construction site materials are typically made more available for transport in runoff as the intensity of the land use increases. The New Jersey Stormwater Management Act calls for a stormwater management program to improve the quality of runoff in addition to controlling increased rates and volumes of runoff from development activities.

The runoff quality control strategy considered in this stormwater study for land development or redevelopment is based upon the current water quality standards contained in NJDEP rules cited as NJAC 7:8-1.et seq., NJAC 7:9-4.1 et seq., NJAC 7:14A-3.1 et seq. and NJAC 8:9-5 et seq. The water quality requirements shall consider the following Best Management Pracitices (BMPs):

- Detention/retention basins, wet pond systems
- Infiltration systems such as dry wells, infiltration trenches/basins and porous pavement
- Filter systems such as grassed/vegetated swales and filter/buffer strips
- Water quality inlet/oil grit separators, such as manufactured by Stormceptoror similar provider

In addition to incorporating stormwater systems and BMPs that provide water quality storage/treatment, nonpoint source pollution from stormwater runoff can be minimized by encouraging municipal agencies to adopt community programs and ordinances that will provide:

- Public education on preventing the availability of potential pollutants at or near the sources
- Source controls for good housekeeping such as litter cleaning, inlets and catch basin cleaning, fertilizer application control and washing areas control; and
- Controls on the use of roadway de-icing compounds and pesticides

To achieve the water quality control strategy objectives for the watershed, an assessment of current water quality of the streams was conducted on an area-wide basis and evaluated to establish a baseline for the selection of BMPs for future consideration. The methodology and analysis for the assessment of the water quality of the watershed streams' is presented in Section 5.0 of this report.

3.3 Subarea Delineation

The watershed study area was separated into four major drainage sub-areas, namely the Upper Jackson Brook, Lower Jackson Brook, Wallace Brook and Spring Brook. These major drainage sub-areas were further subdivided into hydrologically independent sub-drainage areas, hereinafter referred to as subareas for modeling purposes. The 4.7-square mile watershed was subdivided into a total of 40 subareas. The Upper Jackson Brook was subdivided into 16 subareas, the Lower Jackson Brook into 4 subareas, the Wallace Brook into 11 subareas, and the Spring Brook into 9 subareas.

The 40-watershed subareas are delineated on Plate 7, Appendix A entitled "Hydrologic Model Network Map" and are defined by short-dashed lines. The subarea delineations were established on 1 inch = 100 feet scale watershed topographic maps with 2-foot contour intervals compiled from January 1998 aerial photography, and digitized. The limits of each subarea and its stream network components of nodes (point of analysis identifier) and stream links are also shown on Plate 7. Tabulations of each subarea size are presented in Table 1, entitled "Subarea Summary".

Several factors are considered in selecting the sizes and spatial distribution of the subareas. These factors included:

- Maintaining the logic of the watershed drainage pattern
- Subdividing the four major drainage sub-areas into an adequate number of discrete subareas for computer modeling purposes to simulate the interrelationship between the various parts of the watershed in terms of peak flows and the timing of the peak flows
- Utilizing drainage problem areas and drainage facilities as points of interest at subarea boundaries
- Delineating subarea boundaries at significant obstructions identified from FEMA-FIS Maps, NJDEP Flood Hazard Area Maps and field investigations.

3.4 Rainfall Distribution

The point rainfall depths for the selected design storms were obtained from the isopluvial maps contained in TP40. These depths for the study area are, respectively, 2.7", 3.3", 4.3", 5.2", 5.5", 6.0", 6.5", and 7.5" for the 1-, 2-, 5-, 10-, 15-, 25-, 50-, and 100-year 24 hour duration storms. The SCS Type III 24 hour point rainfall distribution pattern was used to distribute each storm over the drainage basin study area.

The rainfall depths were input into the hydrologic models, for the various storms, as cumulative rainfall (SCS Type III distribution ordinates) and utilized in calculating the corresponding storm runoff hydrographs.

Soils Data

Soils data for the surface soils were obtained from the Soil Survey of Morris County, dated 1976 and as updated in the NJ Geographical Information System database, and separated into Hydrologic Soil Groups (HSG's) B, C and D. As mentioned earlier, Plate 3, Appendix A, shows the limits of each HSG within the study area drainage basin. The HSG's are one of the elements used in determining the Runoff Curve Number (CN). An Antecedent Soil Moisture Condition (AMC) II, which represents average soil moisture conditions, was utilized in estimating initial abstraction and in relating soil group type to Runoff Curve Number.

Rainfall Runoff Simulation and Stream Routings

SCS Runoff Curve Numbers were determined for each subarea based on soil group, land use, and hydrologic condition. The CN's were developed for existing land use and future land use conditions based on 1998 aerial photography and municipal zoning maps, respectively, and by obtaining the weighted value from appropriate tables in the SCS, TR55 manual and allowable percentage imperious for various land use categories obtained from the County Planning Office. The CN values were input into the hydrologic models and utilized along with rainfall data to estimate the runoff volumes associated with the various storm events. Runoff hydrographs were developed based upon the SCS Clark unit hydrograph using appropriate subarea lag times.

The CN values and impervious percentages of land coverage for each subarea are compiled in Table 1 for both existing and future land use conditions and on Table 1MLF for both existing and "most likely" future land use conditions which considers that existing public parks will be preserved permanently. It must be noted that the impervious surface coverage for the existing landuse conditions was obtained using ArchInfo GIS computations directly from the January 1998 aerial photography of the watershed.

The Times of Concentration (Tc), which is the measure of the time for a particle of water to travel from the hydrologically most distant point of the subarea to the point of analysis at the subarea downstream boundary, were computed for existing and "most likely" future land use conditions. The Tc's for each subarea were computed using estimates of overland flow, shallow concentrated flow and open stream channel flow and by summing the times of flow for consecutive components of the drainage system. Channel flow lengths and surface roughness were estimated utilizing the watershed 1" = 100' scale topography mapping developed from January 1998 aerial photography and area field observations. Velocities and travel time were estimated utilizing computation procedures outlined in the SCS TR55.

Subarea streamflows resulting from the various storm events were routed through the stream channels and storage areas within the drainage basin study area stream reaches for existing and future land use conditions. The streamflow routing methods used in the hydrologic models were the Modified Puls for impoundment or Lake routings and the Muskingum and Average Lag methods for stream channel routings.

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

TABLE 1
SUBAREA SUMMARY

SUBAREA NUMBER	DRAINAGE AREA (SQ. MI.)	WEIGHTED RUNOFF CURVE NUMBER		IMPERVIOUS SURFACE PERCENTAGE		TIME OF CONCENTRATION IN HRS.	
		EXISTING	FUTURE	EXISTING	FUTURE	EXISTING	FUTURE
LOWER JACKSON BROOK MAIN STEM							
LJB-1	0.0314	63	78	11.4	40.7	0.25	0.19
LJB-2	0.2676	82	83	25.9	39.7	0.47	0.31
LJB-3	0.0658	54	80	22.5	38.0	0.32	0.17
LJB-4	0.2083	57	73	5.4	29.7	0.30	0.24
UPPER JACKSON BROOK MAIN STEM							
UJB-1	0.3266	57	68	6.6	22.1	0.52	0.40
UJB-2	0.4713	70	77	12.5	40.5	0.58	0.46
UJB-3	0.1404	72	77	9.0	34.6	0.60	0.50
UJB-4	0.3597	73	76	17.2	26.8	0.16	0.13
UJB-5	0.2875	75	87	14.0	52.2	0.43	0.34
UJB-6	0.1124	68	91	0.1	77.5	0.57	0.50
UJB-7	0.2273	72	86	12.0	65.3	0.60	0.50
UJB-8	0.0824	77	90	37.6	71.3	0.52	0.36
UJB-9	0.1427	55	81	8.3	55.8	0.51	0.39
UJB-10	0.0376	69	85	4.8	66.2	0.51	0.44
UJB-11	0.1282	75	86	13.3	66.2	0.58	0.48
SPRING BROOK							
SB-1	0.0378	73	83	23.9	48.8	0.15	0.10
SB-2	0.2403	72	80	15.9	44.5	0.42	0.32
SB-3	0.1501	67	79	5.7	43.6	0.45	0.39
SB-4	0.1165	67	76	8.5	27.9	0.33	0.26
SB-5	0.0663	68	76	2.8	25.7	0.34	0.30
SB-6	0.1838	65	77	4.0	39.1	0.40	0.35
SB-7	0.1728	71	79	19.9	42.0	0.54	0.38
WALLACE BROOK							
WB-1	0.1535	63	65	6.3	25.0	0.36	0.31
WB-2	0.0779	68	69	14.5	25.0	0.46	0.36
WB-3	0.0548	75	76	17.2	25.0	0.39	0.33
WB-4	0.1460	72	74	20.1	34.5	0.59	0.46
WB-5	0.0065	79	80	0	25.0	0.34	0.34
WB-6	0.1251	74	78	27.0	45.6	0.52	0.40
WB-7	0.0346	82	85	47.6	63.4	0.47	0.40
WB-8	0.0869	83	88	44.2	63.3	0.35	0.29
WB-9	0.0543	87	89	59.5	75.6	0.54	0.48
WB-10	0.0738	71	74	18.0	28.8	0.34	0.27
WB-11	0.0773	74	81	26.7	49.7	0.31	0.22

NOTES:
EXISTING: EXISTING LAND USE CONDITIONS.
FUTURE: FUTURE LAND USE CONDITIONS BASED UPON ZONING DATA FOR DOVER, MINE HILL, RANDOLPH AND WHARTO

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COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

TABLE 1-MLF
SUBAREA SUMMARY

SUBAREA NUMBER	DRAINAGE AREA (SQ. MI.)	WEIGHTED RUNOFF CURVE NUMBER		IMPERVIOUS SURFACE PERCENTAGE		TIME OF CONCENTRATION IN HRS.	
		EXISTING	FUTURE	EXISTING	FUTURE	EXISTING	FUTURE
LOWER JACKSON BROOK MAIN STEM							
LJB-1	0.0314	63	67	11.4	40.7	0.25	0.21
LJB-2	0.2676	82	82	25.9	39.7	0.47	0.39
LJB-3	0.0658	54	74	22.5	28.0	0.32	0.32
LJB-4	0.2083	57	68	5.4	14.8	0.30	0.30
UPPER JACKSON BROOK MAIN STEM							
UJB-1	0.3266	57	66	6.6	11.1	0.52	0.46
UJB-2	0.4713	70	76	12.5	25.0	0.58	0.49
UJB-3	0.1404	72	72	9.0	17.3	0.60	0.56
UJB-4	0.3597	73	74	17.2	26.8	0.16	0.14
UJB-5	0.2875	75	85	14.0	42.4	0.43	0.38
UJB-6	0.1124	68	90	0.1	69.7	0.57	0.50
UJB-7	0.2273	72	85	12.0	58.7	0.60	0.49
UJB-8	0.0824	77	88	37.6	64.0	0.52	0.44
UJB-9	0.1427	55	81	8.3	55.8	0.51	0.39
UJB-10	0.0376	69	85	4.8	66.2	0.51	0.44
UJB-11	0.1282	75	86	13.3	66.2	0.58	0.48
SPRING BROOK							
SB-1	0.0378	73	83	23.9	48.8	0.15	0.10
SB-2	0.2403	72	80	15.9	44.5	0.42	0.32
SB-3	0.1501	67	79	5.7	43.6	0.45	0.39
SB-4	0.1165	67	76	8.5	27.9	0.33	0.26
SB-5	0.0663	68	76	2.8	25.7	0.34	0.30
SB-6	0.1838	65	77	4.0	39.1	0.40	0.35
SB-7	0.1728	71	79	19.9	42.0	0.54	0.38
WALLACE BROOK							
WB-1	0.1535	63	65	6.3	25.0	0.36	0.31
WB-2	0.0779	68	69	14.5	25.0	0.46	0.36
WB-3	0.0548	75	75	17.2	22.5	0.39	0.34
WB-4	0.1460	72	74	20.1	34.5	0.59	0.46
WB-5	0.0065	79	79	0	5.0	0.34	0.34
WB-6	0.1251	74	77	27.0	30.0	0.52	0.49
WB-7	0.0346	82	85	47.6	63.4	0.47	0.40
WB-8	0.0869	83	87	44.2	63.3	0.35	0.29
WB-9	0.0543	87	89	59.5	75.6	0.54	0.48
WB-10	0.0738	71	74	18.0	28.8	0.34	0.27
WB-11	0.0773	74	81	26.7	49.7	0.31	0.22

NOTES: *EXISTING:* EXISTING LAND USE CONDITIONS.

FUTURE: MOST LIKELY FUTURE LAND USE CONDITIONS BASED UPON ZONING WITH PARKLANDS PRESERVED

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3.7 Runoff Models Network and Model Validation

3.7.1 Runoff Models Network

The hydrologic analyses of the drainage basin study area were conducted by developing separate runoff models for existing land use and "most-likely" future land use conditions and utilizing the Army Corps of Engineers HEC-1 Flood Hydrograph Package computer program. The runoff models were designed to simulate the surface runoff response of the major subarea drainage basins and their stream systems to selected design storm events by representing each of the four major drainage sub-areas as an interconnected network of hydrologic and hydraulic components.

The Jackson Brook watershed basin area hydrologic model network is shown in plan view on Plate 7. Each individual runoff model flow network is illustrated as a schematic diagram on Figure 5. The runoff model's components are shown on Figure 5 by:

subareas with alphanumeric code representing subareas runoff component and number

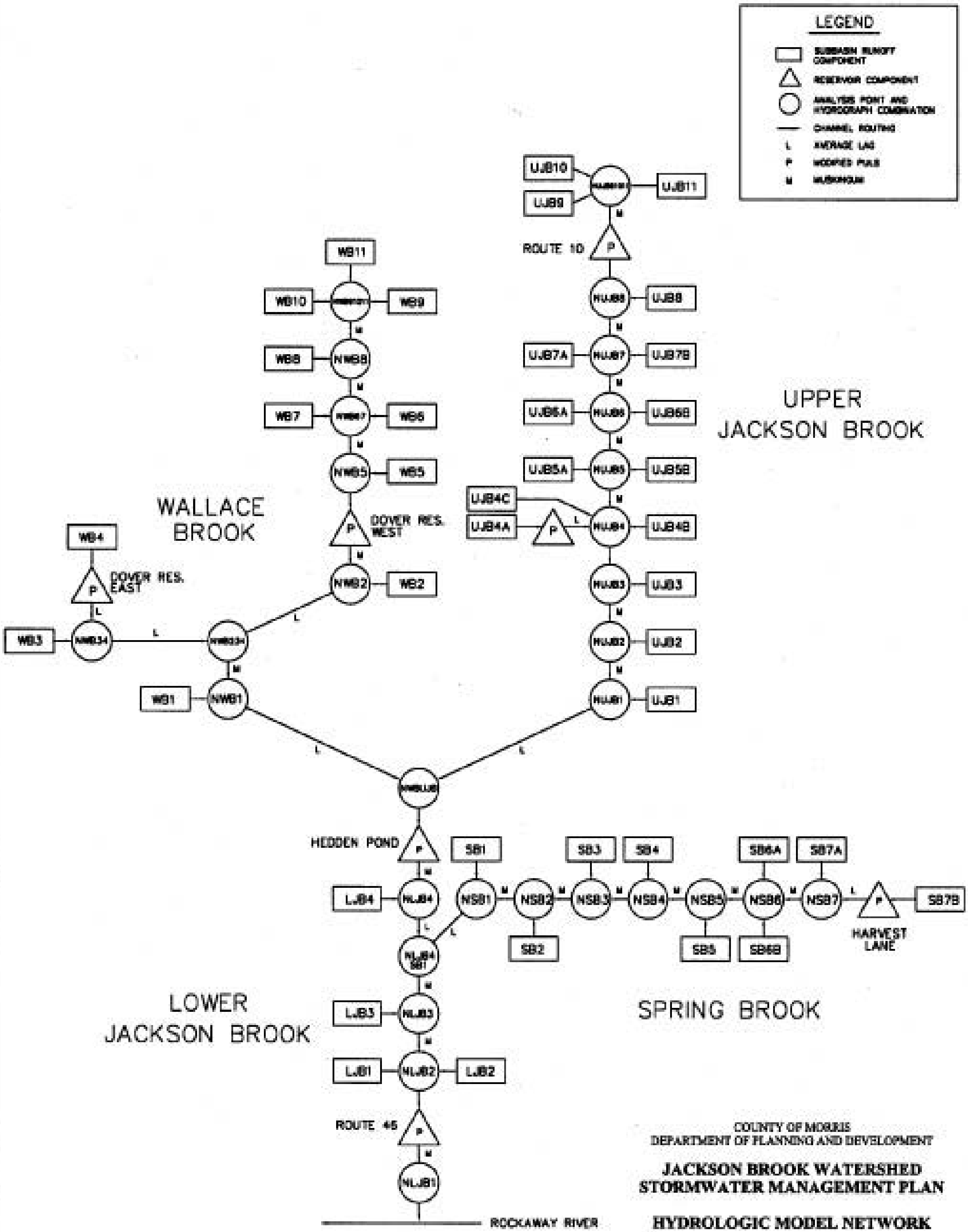
nodes with alphanumeric code representing point of interest and hydrograph combination

- stream links representing open stream channel segments connected to a node point by a solid line

routing reach with corresponding letter code

- inflow/outflow hydrograph with directional arrow

Each hydrologic and hydraulic component simulates an aspect of the rainfall-runoff process within a portion of the drainage basin, and represents subarea land surface runoff, and routing through stream channels and storage and/or impoundment areas. Parameters which specify the particular characteristics of the components and mathematical relations which describe the physical processes are utilized in the computation of streamflow hydrographs and the determination of the magnitude of the peak flows and corresponding stream stages at identified points of interest in the drainage basins.



COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED STORMWATER MANAGEMENT PLAN

HYDROLOGIC MODEL NETWORK

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Associates Consulting Engineers

FIGURE 5

The subarea land surface component is used to represent the movement of stormwater over the land surface and in the stream channels. The input is the precipitation depth over the 24-hour design storm duration. The runoff is computed by subtracting infiltration and other hydrologic abstractions such as depression storage losses based on a soil water infiltration rate function. The resulting runoff is then routed by the unit hydrograph or a streamflow routing technique to the outlet of the subarea.

The precipitation amounts for the selected design storms are input directly and the SCS runoff curve number (RCN) procedure is utilized in computing the loss rates and the resulting runoff amounts as stated previously in Section 3.6. The SCS Clark unit hydrograph is utilized along with the Modified Puls and Average Lag and Muskingum streamflow routing techniques, to establish the streamflow by hydrographs at the points of interest.

3.7.2 Model Validation

Flood peak discharges developed by the HEC-1 runoff models for existing land use conditions for the Jackson Brook drainage basin were compared with FEMA Flood Insurance Study peak discharges at corresponding points of interest.

The specific frequency flood peaks generated in the HEC-1 runoff models are based upon the assumption and use of like frequency rainfalls, the patterns of which were determined using procedures contained in TP40 and SCS TR55 as described earlier in Section 3.4. The flood peak discharge - frequency values are summarized below.

Stream Reach Location	Data Source	Peak Discharge(cfs) (2-Yr.)	(10-Yr.)	(50-Yr.)	(100-Yr)
Jackson Brook at Mouth at Confluence with Rockaway River	FEMA/FIS	*- / -	1,165 / -	1,865 / -	2,290 /-
	HEC-1 Model	**637/ 979**	**1,355 / 1,740**	**1,850 / 2,539**	**2,488 / 3,075**
Jackson Brook at West Blackwell St./ Hurd Park	**HEC-1 Model**	**645 / 988****	**1,384 / 1,841**	**2,022 / 2,577**	**2,532 / 3,216**
Jackson Brook at Hedden Pond Weir (outflow)	** * NJ RC & DA	465 / 636	1,175 / 1,475	-	-
	HEC-1 Model	**518 / 748**	**1,092 / 1,390**	**1,602 / 1,983**	**2,013 / 2,380**

Notes:

1. * Peak Discharge listed as Existing ./ Most Likely Future
2. ** Study Area HEC-1 Model values shown as bold face type
3. *** NJRC & DA is North Jersey Conservation and Development Area Executive Council, 1988

It can be seen that the magnitudes of the 10-year, 50-year and 100-year flood peak discharges for the Jackson Brook show a reasonable correlation between the published flows and the runoff model flows. At the mouth of Jackson Brook, it is noted that the HEC-1 model flows were somewhat greater than the FEMA published flows by amounts ranging from 16 percent to 8.6 percent for existing conditions during the 10-year and 100-year events, respectively.

The comparison of Jackson Brook HEC-1 Model flows with the NJRC & DA flows at the Hedden Park Pond weir show that the model 10-year peak flows are 7.5 percent lower for existing conditions and approximately the same for "most likely" future development conditions; and the model 2-year peak flows are 11 percent higher for existing conditions and approximately 18 percent higher for "most likely" future development conditions.

The differences in the above published and HEC-1 runoff model flows for the stream reaches can be attributed to the following:

- The FIS published flows were based on land use conditions (circa 1980), determined from available U.S.G.S. quadrangle topographic maps at the time of the studies; while the study runoff models flows are based on year 1998 land use conditions determined from January 1998 aerial photography.
- The runoff models utilize subareas, unit hydrograph parameters and loss rates computed from impervious areas carefully digitized from 1998 aerial photographic and topographic maps developed for the study area in conjunction with field observations.

- The runoff models flows are generated by using a short duration unit hydrograph time step to define the hydrograph peaks, and utilizing available storage versus flow discharge relationships, with hydrologic data files for the watershed streams', in the flood routing procedures to account for flow attenuation at bridges, culverts and ponds.

Additionally, validation of the runoff models peak flows was conducted by developing stage-discharge relationships at the bridge/culvert crossings and comparing observed flood mark elevation data with stream stage (height) data computed at the known flood problem areas. The resulting hydraulic models for the 2-year through 100-year recurrence interval flood stages showed good correlation to floodmark data at the flood problem areas, and reasonable consistency with both the NJDEP Flood Hazard Area Delineations and the FEMA Flood Insurance Rate Maps for the Lower Jackson Brook reach, and with the North Jersey Resource Conservation and Development area Executive Council data for the Upper Jackson Brook reach.

On the basis of the detailed development of the hydrologic models and physical parameters describing each of the major drainage basins and subareas, as well as the reasonable correlation between the models flows and the published flows, the peak flows generated throughout the watershed study area with the HEC-1 computer model can be used with confidence for watershed planning purposes.

3.8 Summary of Peak Discharges

Flood peak discharges under current conditions resulting from the 1-, 2-, 5-, 10-, 15-, 25-, 50- and 100-year design storm rainfall events are presented in Table 2 for existing and future land use conditions. The flows listed under future conditions are those flows which will result in the future due to additional impervious areas with no improvements to the existing hydraulic structures, based upon development in accordance with the adopted Zoning Maps for the municipalities in the drainage basin study area.

Table 2A lists the flood peak discharges for the selected range of storm events under existing land use and "most likely" future land use conditions. The future development conditions shown on Table 2A are somewhat lower than those presented in Table 2, and are used because they are based upon the assumption that current public open space and parklands will be permanently preserved along with future development in accordance with adopted municipal zoning.

On examination of the flows presented in Table 2A, it is seen that for "most likely" future land use conditions, the areas along the main stem of Jackson Brook and Spring Brook will experience substantial increases in stormwater flows resulting from the cumulative impacts of development. For the Spring Brook the difference between the existing and future development conditions are the greatest with average increases ranging from over 84 percent to 116 percent for the 5-year and 2 year storms, respectively; and about 45 percent on average for the 100-year storm.
For the Upper Jackson Brook reach, the 2-year flows increase by about 48 percent, except for the section above Route 10 where the flows increase by more than 100 percent.

Similarly the 5-year and 10-year flows increase by about 35 and 30 percent, respectively, except for the stream reach above Route 10 where the predicted increases are approximately 70 percent.

For the Lower Jackson Brook, during the 5-year storm event, the anticipated increases in peak flows are about 40 percent while the 100-year storm event the predicted increases are approximately 23 percent.

Along the Wallace Brook the predicted increases in peak flows range from 17 percent during the 5-year storm to 16 percent on average for the 100-year storm.

Under anticipated future development conditions, the hydraulic structures at bridge crossings in the St. Mary's Street and Brook Lane flood problem areas, and at Hedden Park Pond Dam will be overtopped more frequently and the level of flood protection will be less than that which currently exists. These reductions in the level of flood protection at the bridge crossings will only cause more extensive flooding damage in an area that currently experiences chronic flooding. Appropriate stormwater controls will be needed to provide protection against increased soil erosion and scour which will threaten the structural integrity of the bridge facilities, and increase the risk of washouts along the municipalities' roadways.

The peak discharge summary Tables show that if development is allowed to continue in the watershed without coordinated stormwater management controls, the result will be an increase in peak streamflows, which will aggravate existing flooding, and erosion problems and create significant new flooding problems during rainfall events.

The peak discharge summary tables for current and "most likely" future land use conditions with the alternative stormwater management control plans considered, are presented in Section 6 of this report.

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

TABLE 2
PEAK FLOW SUMMARY*

LOCATION	DRAINAGE AREA (SQ. MI.)	EXISTING LAND USE CONDITIONS (BASED UPON 1998 AERIAL PHOTOGRAPHY)								FUTURE LAND USE CONDITIONS WITH NO STORMWATER CONTROLS (BASED UPON 1999 ZONING MAP)								DIFFERENCE BETWEEN EXISTING LAND USE AND FUTURE LAND USE CONDITIONS WITH NO STORMWATER IMPROVEMENTS							
		RETURN INTERVAL (YEARS)								RETURN INTERVAL (YEARS)								RETURN INTERVAL (YEARS)							
		1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100
LOWER JACKSON BROOK																									
AT MOUTH	4.75	510	637	1005	1355	1484	1666	1850	2488	776	1067	1492	1810	2003	2344	2664	3197	266	430	487	455	519	678	814	709
ROUTE 46 (OUTFLOW)	4.75	510	637	1005	1356	1485	1666	1851	2491	776	1067	1493	1810	2005	2346	2666	3199	266	430	488	454	520	680	815	708
ROUTE 46 (INFLOW)	4.75	406	645	1015	1384	1513	1749	2022	2532	779	1076	1520	1948	2105	2403	2694	3216	373	431	505	564	592	654	672	684
JUST D/S OF SPRING BK. CONFL.	4.38	378	605	956	1305	1428	1649	1919	2412	741	1022	1444	1849	1998	2295	2574	3073	363	417	488	544	570	646	655	661
SPRING BROOK																									
AT MOUTH	0.97	50	81	134	190	209	245	281	351	124	170	242	310	333	374	416	494	74	89	108	120	124	129	135	143
ROUTE 46	0.93	47	76	127	181	200	234	269	336	119	163	232	298	320	360	400	475	72	87	105	117	120	126	131	139
ST. MARYS AVENUE	0.54	24	40	68	98	109	128	148	186	64	89	128	166	178	201	224	268	40	49	60	68	69	73	76	82
IRONDALE ROAD	0.42	19	31	53	77	85	100	115	145	52	71	102	131	141	159	177	212	33	40	49	54	56	59	62	67
BLUEBERRY LANE	0.36	17	27	45	65	72	84	97	122	45	61	87	112	120	135	150	179	28	34	42	47	48	51	53	57
HARVEST LANE	0.17	11	16	25	34	38	43	49	60	20	27	38	49	52	59	66	78	9	11	13	15	14	16	17	18
UPPER JACKSON BROOK																									
HEDDEN POND WEIR (OUTFLOW)	3.21	326	518	808	1092	1192	1371	1602	2013	597	821	1156	1477	1599	1849	2076	2478	271	303	348	385	407	478	474	465
HEDDEN POND WEIR (INFLOW)	3.21	327	521	811	1095	1196	1375	1610	2013	599	824	1159	1481	1603	1853	2078	2479	272	303	348	386	407	478	468	466
INDIAN FALLS ROAD	1.52	188	281	425	567	618	708	808	988	336	452	620	780	834	932	1030	1210	148	171	195	213	216	224	222	222
RANDOLPH AVENUE	1.38	175	260	391	521	567	650	740	903	314	421	575	721	769	857	944	1105	139	161	184	200	202	207	204	202
ROUTE 10	0.31	27	44	74	107	119	140	162	204	105	138	186	231	247	273	300	350	78	94	112	124	128	133	138	146
WALLACE BROOK																									
AT MOUTH	0.89	98	159	248	331	360	410	503	647	152	214	306	393	441	533	608	733	54	55	58	62	81	123	105	86
CONFLUENCE OF EAST AND WEST D/S BRANCHES BELOW RESERVOIR AVENUE	0.74	94	150	228	300	325	373	482	593	140	195	274	352	404	490	552	651	46	45	46	52	79	117	70	58
DOVER RESERVOIR (WEST)	0.46	80	130	196	253	273	308	343	410	123	173	233	294	314	350	387	454	43	43	37	41	41	42	44	44
DOVER RESERVOIR (EAST)	0.15	10	10	11	23	40	60	90	119	10	10	14	58	65	88	109	166	0	0	3	35	25	28	19	47
CENTER GROVE ROAD 1400 ft. D/S	0.21	45	63	92	120	130	147	164	197	60	81	113	143	153	171	189	222	15	18	21	23	23	24	25	25

NOTES: * *ALL FLOW VALUES IN CUBIC FEET PER SECOND (CFS).*

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COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

TABLE 2A
PEAK FLOW SUMMARY*
MOST LIKELY FUTURE

LOCATION	DRAINAGE AREA (SQ. MI.)	EXISTING LAND USE CONDITIONS (BASED UPON 1998 AERIAL PHOTOGRAPHY)								MOST LIKELY FUTURE LAND USE CONDITIONS WITH NO STORMWATER CONTROLS (BASED UPON 1999 ZONING MAP)								DIFFERENCE BETWEEN EXISTING LAND USE AND MOST LIKELY FUTURE LAND USE CONDITIONS WITH NO STORMWATER IMPROVEMENTS							
		RETURN INTERVAL (YEARS)								RETURN INTERVAL (YEARS)								RETURN INTERVAL (YEARS)							
		1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100
LOWER JACKSON BROOK																									
AT MOUTH	4.75	510	637	1005	1355	1484	1666	1850	2488	697	979	1393	1740	1844	2209	2539	3075	187	342	388	385	360	543	689	587
ROUTE 46 (OUTFLOW)	4.75	510	637	1005	1356	1485	1666	1851	2491	698	979	1394	1741	1845	2211	2541	3078	188	342	389	385	360	545	690	587
ROUTE 46 (INFLOW)	4.75	406	645	1015	1384	1513	1749	2022	2532	701	988	1420	1841	2001	2292	2577	3099	295	343	405	457	488	543	555	567
JUST D/S OF SPRING BK. CONFL.	4.38	378	605	956	1305	1428	1649	1919	2412	666	937	1348	1748	1902	2191	2465	2959	288	332	392	443	474	542	546	547
SPRING BROOK																									
AT MOUTH	0.97	50	81	134	190	209	245	281	351	124	170	242	310	333	374	416	494	74	89	108	120	124	129	135	143
ROUTE 46	0.93	47	76	127	181	200	234	269	336	119	163	232	298	320	360	400	475	72	87	105	117	120	126	131	139
ST. MARYS AVENUE	0.54	24	40	68	98	109	128	148	186	64	89	128	166	178	201	224	268	40	49	60	68	69	73	76	82
IRONDALE ROAD	0.42	19	31	53	77	85	100	115	145	52	71	102	131	141	159	177	212	33	40	49	54	56	59	62	67
BLUEBERRY LANE	0.36	17	27	45	65	72	84	97	122	45	61	87	112	120	135	150	179	28	34	42	47	48	51	53	57
HARVEST LANE	0.17	11	16	25	34	38	43	49	60	20	27	38	49	52	59	66	78	9	11	13	15	14	16	17	18
UPPER JACKSON BROOK																									
HEDDEN POND WEIR (OUTFLOW)	3.21	326	518	808	1092	1192	1371	1602	2013	532	748	1074	1390	1520	1763	1983	2380	206	230	266	298	328	392	381	367
HEDDEN POND WEIR (INFLOW)	3.21	327	521	811	1095	1196	1375	1610	2013	534	750	1076	1394	1525	1763	1984	2383	207	229	265	299	329	388	374	370
INDIAN FALLS ROAD	1.52	188	281	425	567	618	708	808	988	310	423	589	746	800	896	992	1173	122	142	164	179	182	188	184	185
RANDOLPH AVENUE	1.38	175	260	391	521	567	650	740	903	295	401	554	699	747	833	920	1081	120	141	163	178	180	183	180	178
ROUTE 10	0.31	27	44	74	107	119	140	162	204	105	138	186	231	247	273	300	350	78	94	112	124	128	133	138	146
WALLACE BROOK																									
AT MOUTH	0.89	98	159	248	331	360	410	503	647	142	205	298	384	435	526	600	723	44	46	50	53	75	116	97	76
CONFLUENCE OF EAST AND WEST D/S BRANCHES BELOW RESERVOIR AVENUE	0.74	94	150	228	300	325	373	482	593	131	186	266	348	399	483	543	641	37	36	38	48	74	110	61	48
DOVER RESERVOIR (WEST)	0.46	80	130	196	253	273	308	343	410	114	167	227	287	308	344	380	447	34	37	31	34	35	36	37	37
DOVER RESERVOIR (EAST)	0.15	10	10	11	23	40	60	90	119	10	10	14	58	65	88	109	166	0	0	3	35	25	28	19	47
CENTER GROVE ROAD 1400 ft. D/S	0.21	45	63	92	120	130	147	164	197	60	81	113	143	153	171	189	222	15	18	21	23	23	24	25	25

NOTES: * *ALL FLOW VALUES IN CUBIC FEET PER SECOND (CFS).*

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DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

TABLE 3
PEAK FLOWS AND ELEVATIONS *
HEDDEN POND DAM IMPROVEMENTS (NEW DAM)

DAM CONDITION	DESCRIPTION		EXISTING LAND USE CONDITIONS PEAK FLOWS AND ELEVATIONS RETURN INTERVAL (YEARS)								MOST LIKELY FUTURE LAND USE CONDITIONS PEAK FLOWS AND ELEVATIONS - PLAN D RETURN INTERVAL (YEARS)							
			1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100
EXISTING	50 FT. WIDE SPILLWAY AT EL. 591.5 WITH 231FT. LENGTH TOP OF DAM OVERFLOW EMBANKMENT AT MINIMUM EL. 592.0	INFLOW	327	521	811	1095	1196	1375	1610	2013	534	750	1076	1394	1525	1763	1984	2383
		OUTFLOW	326	518	808	1092	1192	1371	1602	2013	532	748	1074	1390	1520	1763	1983	2380
		POOL EL.	592.36	592.61	592.98	593.31	593.42	593.63	593.9	594.15	592.62	592.9	593.29	593.65	593.8	594.03	594.13	594.31
DAM AND SPILLWAY MODIFICATION	DROP INLET INTAKE 595 FT. EARTHEN DAM WITH 50 FT. LENGTH EMERGENCY SPILLWAY NORMAL POOL AT ELEV. 591.5	INFLOW	327	521	811	1095	1196	1375	1610	2013	534	750	1076	1394	1525	1763	1984	2383
		OUTFLOW	317	491	693	859	913	990	1070	1283	502	664	856	1003	1051	1133	1273	1784
		POOL EL.	593.17	593.91	596.17	599.13	600.21	601.93	603.82	607.48	594.02	595.7	599.08	602.23	603.35	605.41	607.42	609.31

NOTES:
1. *ELEVATIONS BASED UPON 1998 AERIAL TOPOGRAPHIC MAPPING AND SUPPLEMENTAL GROUND SURVEYS.*
2. *FLOW VALUES IN CUBIC FEET PER SECOND (CFS).*

* **WITHOUT FUTURE FLOW RELEASE RATE POLICY 50%-75%-75%**

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JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

TABLE 4
PEAK FLOWS AND ELEVATIONS * *
HEDDEN POND DAM IMPROVEMENTS (NEW DAM)

DAM CONDITION	DESCRIPTION		EXISTING LAND USE CONDITIONS PEAK FLOWS AND ELEVATIONS RETURN INTERVAL (YEARS)								PLAN -D IMPROVEMENTS PEAK FLOWS AND ELEVATIONS RETURN INTERVAL (YEARS)							
			1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100
EXISTING	50 FT. WIDE SPILLWAY AT EL. 591.5 WITH 231FT. LENGTH TOP OF DAM OVERFLOW EMBANKMENT AT MINIMUM EL. 592.0	INFLOW	327	521	811	1095	1196	1375	1610	2013	406	588	846	1091	1175	1357	1540	1854
		OUTFLOW	326	518	808	1092	1192	1371	1602	2013	405	586	844	1089	1172	1352	1535	1853
		POOL EL.	592.36	592.61	592.98	593.31	593.42	593.63	593.9	594.15	592.46	592.69	593.02	593.3	593.4	593.61	593.82	594.07
DAM AND SPILLWAY MODIFICATION	DROP INLET INTAKE 595 FT. EARTHEN DAM WITH 50 FT. LENGTH EMERGENCY SPILLWAY NORMAL POOL AT ELEV. 591.5	INFLOW	327	521	811	1095	1196	1375	1610	2013	406	588	846	1091	1175	1357	1540	1854
		OUTFLOW	317	491	693	859	913	990	1070	1283	395	542	727	879	925	996	1069	1235
		POOL EL.	593.17	593.91	596.17	599.13	600.21	601.93	603.82	607.48	593.47	594.41	596.73	599.53	600.48	602.08	603.8	607.2

NOTES:
1. *ELEVATIONS BASED UPON 1998 AERIAL TOPOGRAPHIC MAPPING AND SUPPLEMENTAL GROUND SURVEYS.*
2. *FLOW VALUES IN CUBIC FEET PER SECOND (CFS).*

*** * UTILIZES FUTURE FLOW RELEASE RATE POLICY 50%-75%-75%***

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4.0 HYDRAULIC EVALUATION

4.1 Existing Major Drainage Facilities

The major drainage facilities within the watershed study area include natural and improved channels, bridges, culverts, reservoirs and weirs/dams. These facilities are located along the main stem Jackson Brook, Spring Brook and Wallace Brook. Plate 8 in Appendix A, entitled, "Floodplain and Hydraulic Facilities Map," shows the exact locations of the principal bridges/culverts/hydraulic facilities investigated in this study. Detailed analysis of the major drainage facilities in the study area was limited to these facilities since they are located within the 100-year flood plain limit, established by the NJDEP and the Federal Emergency Management Agency (FEMA) and as developed for this study.

Bridges and Culverts

Hydraulic analyses of the major bridge/culvert facilities were conducted, for those facilities shown on Plate 8, plus the culvert located at Garden Avenue across Spring Brook, approximately 100 feet upstream of U.S. Route 46 crossing, the Brook Lane Bridge crossing of Lower Jackson Brook, approximately 500 feet downstream of the Hedden Pond weir, Blueberry Lane and Irondale Road culverts across Spring Brook, and the Arrogate development culvert on Upper Jackson Brook. Morris County owns and maintains the bridge/culvert facilities, except for the U.S. Route 46 structures located at Spring Brook (SB 140008) and Lower Jackson Brook LJB 140005, State Route 10 UJB 140001 across Upper Jackson Brook and Brook Lane bridge across Lower Jackson Brook, and the culverts located on private property.

Weir/Dam and Reservoir

The weir/dam at Hedden Park Pond and the Dover Twin Reservoirs at Reservoir Avenue were investigated in detail for possible modifications. The facilities are identified on

Plate 8, "Floodplain and Hydraulic Facilities Map." The locations on this plate are represented by solid circles identified by an alphanumeric code, indicating hydraulic performance overtopping frequency.

The Hedden Park Pond Dam is located on the Upper Jackson Brook branch and is owned and maintained by the Morris County Park Commission. The Dover Twin Reservoirs are located on the Wallace Brook branch on land owned by the Morris County Park Commission.

4.2 Existing and Future Land Use Conditions Impacts

Bridges and Culverts

The hydraulic analysis of the performance of the drainage facilities was evaluated under both existing land use and future land use conditions. Peak flows and corresponding flood elevations resulting from the 1-, 2-, 5-, 10-, 15-, 25, 50-, and 100-year storm events are listed on Table 2A for each drainage facility for existing and most likely future land use conditions included at the end of Section 3. The flows listed under the heading, "Future Land Use Conditions," are the flows that would result in the future if development were allowed to occur without implementing any stormwater management controls or drainage improvements.

The results of our analysis are summarized as follows:

UPPER JACKSON BROOK SUBDRAINAGE AREA

State Highway Route 10

Facility Size and type:	5-feet wide by 5-feet high reinforced concrete box culvert
Overtopping Flow:	Approximately 275 cfs
Overtopping Frequency:	Existing land use – 100 year; future land use – 25 year

Comment: Under future land use conditions, with no stormwater controls upstream, the capability of the structure to handle flood flows will be reduced from an existing design capacity of 100-year to the 25-year recurrence interval.

It is noted that the new concrete box culvert located approximately 800 feet downstream at the Arrogate apartment complex has sufficient capacity to handle both existing and future land use conditions 100-year flood flows.

Randolph Avenue

Facility Size and Type: Steel girder-type bridge of span 20-feet wide by 8-feet high
Overtopping Flow: Approximately 490 cfs
Overtopping Frequency: Existing land use – 100 year; future land use – 100 year
Comment: This bridge is capable of safely handling existing and future conditions 100-year flood flows without implementation of upstream stormwater controls .

Indian Falls Road

Facility Size and Type: Steel girder bridge of span 16-feet wide by 5-1/2-feet high
Overtopping Flow: Approximately 1285 cfs
Overtopping Frequency: Existing land use – 100 year; future land use – 100 year
Comment: This bridge is capable of safely passing the existing and future conditions 100-year flood flows without implementation of upstream stormwater controls.

Hedden Park Footbridge

Facility Size and Type: Timber structure of span 37 feet wide by 6 feet high
Overtopping flow: Approximately 675 cfs
Overtopping Frequency: Existing conditions – 5 year; future conditions – 2 year

Comment: The approach pathway has a low point elevation of 606 feet NAVD, which is overtopped by flood flows greater than 675 cfs. Under future conditions the 2-year event peak flow would be 750 cfs, if no stromwater controls were implemented upstream. This means that there would be a 50 percent chance of the pathway being subject to the risk of scour and erosion every year. This condition would not be desirable.

SPRING BROOK SUBDRAINAGE AREA

Harvest Lane

Facility Size and Type: 10- feet wide by 5-feet high reinforced concrete box culvert with roadway embankment serving as a dam and upstream area wetland detention system.

Overtopping Flow: Approximately 516 cfs

Overtopping Frequency: Existing land use – 100-year; future land use – 100 year

Comment: This culvert is capable of safely passing the 100-year flood flows under both existing and future land use conditions. No additional structural controls are needed because the area upstream of the culvert crossing serves as a natural wetland detention basin and flood storage attenuation area.

Blueberry Lane

Facility Size and Type: Horizontal elliptical pipe 3-feet wide by 2-feet high

Overtopping Flow: Approximately 28 cfs

Overtopping Frequency: Existing land use – 2 year; future land use – 1 year

Comments: Under both existing and future land use conditions, this culvert has inadequate hydraulic capacity and does not have sufficient capability to handle flood events equal to or greater than the 2-year storm. This culvert is situated under the unimproved section of Blueberry Lane. recommended that when this roadway is planned for improvement, a detailed analysis of this culvert crossing be conducted and the design capacity upgraded to the 25-years recurrence level or greater.

Irondale Road

Facility Size and Type: 36-inch concrete pipe

Overtopping Flow: Approximately 85 cfs

Overtopping Frequency: Existing land use – 15-year; future land use – 5 year

Comment: This culvert has inadequate hydraulic capacity under both existing and future land use conditions. Under future development conditions, flood events equal to the 5-year storm will inundate the roadway. The existing roadway over the culvert is unimproved. It is recommended that when this roadway is planned for improvement, a detailed analysis of this culvert crossing be conducted and the design capacity upgraded to the 25-years recurrence level or greater.

St. Mary's Street (Randall Avenue)

Facility Size and Type: 48-inch diameter concrete pipe

Overtopping Flow: Approximately 50 cfs

Overtopping Frequency: Existing land use – 5 year; future land use – 2 year

Comment: Under existing and future land use conditions, the facility has inadequate hydraulic capacity and flood events greater than the 2-year storm will result in the overtopping of the roadway. Since this roadway is a major artery between Wharton and Mine Hill, it is recommended that this facility be upgraded and stormwater controls implemented upstream. Our hydraulic analysis shows that a new box culvert 10-feet wide by 4-feet high with a capacity of 155 cfs, in conjunction with upstream stormwater controls, will safely pass flood flows up to and including the 50-year storm event.

Garden Avenue

Facility Size and Type: 12-feet wide by 3-feet high concrete box culvert

Overtopping Flow: Approximately 255 cfs

Overtopping Frequency; Existing land use – 100 year; future land use – 100 year

Comment: This culvert has sufficient hydraulic capacity to handle storm events of the 100-year recurrent interval under both existing and future land use conditions. No improvements outside of normal routine maintenance is needed.

U.S. Highway Route 46

Facility Size and Type: 14-feet wide by 8-feet high concrete box culvert

Overtopping Flow: Approximately 830 cfs

Overtopping Frequency: Existing land use – 100 year; future land use – 100 year

Comment: This culvert has sufficient hydraulic capacity to handle storm events of the 100-year recurrent interval under both existing and future land use conditions. No improvements outside of normal routine maintenance is needed.

LOWER JACKSON BROOK SUBDRAINAGE AREA

Brook Lane Bridge

Facility Size and Type: Steel girder 15-feet wide by 5-feet high

Overtopping Flow: Approximately 550 cfs

Overtopping Frequency: Existing land use – 5 year; future land use – 1 year

Comment: The bridge hydraulic capacity is inadequate under existing and future land use conditions. This facility is important to the residents of the area who suffer recurring losses and are unable to get out of their homes in a flood emergency during events greater than the 5-year storm. The situation will worsen in the future without bridge improvements and upstream stormwater control. This bridge is recommended for reconstruction in conjunction with upstream stormwater control. Our hydraulic analysis shows that a twin 16-feet x 5-feet concrete arch culvert with a design flow capacity of 1050 cfs will handle events greater than the 25-year storm up to the 50-year storm event, if stormwater controls and the proposed retention basin at Hedden Pond Dam are implemented.

U.S. Highway Route 46

Facility Size and Type: Two barrel concrete bridge structures with trash rack at upstream face and combined waterway opening 58-feet wide by 9-feet high.

Overtopping Flow: 1850 cfs

Overtopping Frequency: Existing land use – 50 year; future land use – 15 year

Comment: Under existing land use conditions, the bridge structure can safely handle flood flows up to the 50-year storm event. Under future land use conditions, if no stormwater controls are implemented, the bridge and roadway will be overtopped by events greater than the 15-year storm. However, if the planned new dam at Hedden Pond and upstream stormwater controls are implemented, the existing facility will be able to handle future land use conditions flood flows up to and greater than the 100-year storm events.

Weir/Dams Reservoirs

Hedden Park Pond Weir/ Dam

Facility Size and Type: 280-linear-foot embankment approximately 4 feet high

Overtopping Flow: Approximately 520 cfs

Overtopping Frequency: Existing land use – 2 year; future land use – 1 year

Comment: This facility functions as an overflow weir with little or no flood storage and attenuation capability. If stormwater controls are not implemented upstream and no flood storage improvements are made to the facility, flood flows will pass downstream and exacerbate existing flooding problems in Hurd Park and Dover. With the implementation of the recommended new dam (see Figure7) and upstream stormwater control, the 100-year flood under existing and future conditions will be controlled in Hedden Park and consequently alleviate flooding at downstream locations in Dover.

Dover Twin Reservoirs

Facility Size and Type: Twin Reservoir impoundment on Wallace Brook
East: Surface area – 0.95 acres
West: Surface area – 0.9 acres

Overtopping Flow: Approximately 250 cfs

Overtopping Frequency: Existing land use – 10-year; future land use – 5 year

Comment: The existing reservoir embankment will be overtopped by events equal to and greater than the 10-year storm. If no stormwater controls are implemented or improvements made to the reservoir to improve its flood storage capability, events greater than the 5-year storm will overtop the embankment and inundate Reservoir Avenue. It is therefore recommended that the flood storage capability of the Twin Reservoir be increased. Hydraulic analysis shows that by increasing the elevation of the existing embankment by a minimum of 2 feet, the future land use condition 50-year flood flows will pass safely through this facility. The available flood storage capacity would be increased by approximately 50 percent from 8.4 acrefeet to 12.5 acrefeet.

4.3 Problem Analysis Summary

From the discussion and results presented in Section 4.2, it is seen that the principal flood problem areas lie within the Wallace Brook, Spring Brook and Lower Jackson Brook major subdrainage areas. Although the Upper Jackson Brook facilities are sufficient to pass the existing and future land use conditions 100-year flood flows (with the exception of State Highway Route 10), stormwater controls must be provided upstream to reduce the increased peak discharges associated with new development and alleviate the recurrent flooding and erosion problems downstream.

The results of the hydraulic analyses show that the hydraulic structures along Spring Brook, Wallace Brook and Lower Jackson Brook, which currently have inadequate hydraulic capacity, will continue to have increased flooding that will be aggravated under projected future land use conditions if appropriate stormwater management controls are not implemented on a watershed-wide basis.

The flooding at the identified locations of the bridges/culverts and dams and adjacent areas has caused recurrent damages to properties and interrupted transportation and commercial activities. The recurrent nature of the flooding problems at these locations represent a continuous threat to the health and safety of those who live and work in the area. Consequently, watershed-wide stormwater controls and/or improvements must be considered for implementation to alleviate the chronic flooding and erosion problems at the locations identified herein.

5.0 WATER QUALITY DATA AND MODEL SIMULATION ANALYSIS

5.1 Watershed Management Approach

The objectives of this chapter are to assess the current water quality within the Jackson Brook watershed and to develop control alternatives that are designed to safeguard and enhance water quality of the region. To serve these objectives, the current water quality conditions have been evaluated to establish a base line for selection of the Best Management Practices (BMPs) for future consideration. For a judicious assessment of current and future water quality conditions and to describe cost/effective control measures, it is essential to adapt engineering models to the Jackson Brook Watershed that describe the major processes which control its water quality.

The assessment of water quality conditions in a stream and the ecological state of ponds can best be described using a holistic approach. Such an approach provides the best means of identifying the factors that influence both the current and future water quality and the health of the aquatic environment within a geographic area of concern.

The water quality of Jackson Brook and its two major tributaries -- Wallace Brook and Spring Brook -- is directly related to stormwater runoff and shallow aquifer quality along with the nutrient exchange processes at the sediment/water interface. Both the total volume and the quality of stormwater runoff are directly related to the land use, dominant soil types and topography of the region. Therefore, the assessment of current water quality trends in a basin and the development of judicious management plans for enhanced aquatic environment need a *watershed approach.*

The watershed approach requires (a) the implementation of a water quality monitoring plan for the streams and Hedden Pond, and (b) the development of a suite of models that incorporate all the major processes that control water quality. Additionally, this approach requires the gathering of data on the physical attributes of the watershed as listed above. The study of influences of current and future land uses becomes the basis on which changing water quality trends are assessed. This assessment, in turn, leads to the establishment of meaningful and effective mitigation measures designed to safeguard the intended uses of the aquatic system.

The analysis of current water quality data provides an initial evaluation of the conditions in the watershed, and it serves as the basis to evaluate the performance of simulation models. Such data help assure the reliability of the models in simulating water quality in the watershed.

5.2 Assessment of Current Water Quality

The Jackson Brook watershed is approximately 4.7 square miles. It includes portions of the Township of Mine Hill, Township of Randolph, Town of Dover and Borough of Wharton. The watershed consists of four major sub-basins including the upper Jackson Brook and Wallace Brook, which drain into Hedden Pond; the lower Jackson Brook, extending from Hedden Pond dam to its confluence with Rockaway River, and Spring Brook, which joins the lower Jackson Brook at Dover Township.

A detailed stream and pond sampling and analysis program was designed and implemented during 1998 to characterize the water quality of the Brooks and Hedden Pond. The sampling frequency was designed to highlight the seasonal variability in water quality. Thus, three sets of water quality samples were collected and analyzed for the period of May 14, July 30 and December 3, of 1998.

Seven monitoring stations were chosen at strategic locations within the watershed. These stations are:

1. Wallace Brook Headwater above Reservoir Avenue
2. Jackson Brook at Randolph Avenue
3. Hedden Pond South
4. Hedden Pond Center

5. Hedden Pond Dam
6. Spring Brook at confluence with Jackson Brook
7. Jackson Brook at Route 46 (Elks Club)

Water samples were collected at these stations during each of the monitoring dates mentioned above. Additionally, sediment samples were collected for various analyses to determine the potential nutrient releases from the sediments to the water column. Both sampling protocol and laboratory analysis were conducted in accordance with NJDEP guidelines. The monitoring stations are shown on Plates 5A and 5B, respectively, in Appendix A entitled, "Water Quality and Sediment Sampling Sites," illustrating the varying Land Cover and Land Use at each site.

The water samples were analyzed for the following constituents:

Total Phosphorous
Soluble Reactive Phosphorous
TKN
Ammonia-N
Nitrate-N
Chlorophyll-a
Alkalinity
Iron
Manganese
BOD
Turbidity

The sediment samples were tested for the following constituents:

Total Phosphorus
Total Nitrogen
Percent Solids
Percent Organic Solids
Iron
Manganese
Total Petroleum Hydrocarbons
Sediment Oxygen Demand

A data search of NJDEP files indicated no known point source discharges within the Jackson Brook watershed. The Rockaway Valley Sewerage Authority (RVSA) serves all of the municipalities in the area. The RVSA treatment plant discharges its effluent directly into the Rockaway River. Virtually the entire Town of Dover and the Borough of Wharton are served by municipal sewers. Nearly half of Randolph Township and a quarter of Mine Hill Township are served by sewers. The remaining areas in these municipalities are served by septic systems.

5.2.1 Review of Surface Water Quality Data

The water quality within the watershed appears to be quite good inasmuch as all parameters observed were well within established surface water quality standards. Figures 5-1 – 5-8 provide a general overview of the seasonal variability of all the conventional water quality parameters. Figure 5-1 describes the temporal and spatial variability of BOD_5 at all of the monitoring stations described above. This parameter remained below the detection limit throughout the year except in late fall when BOD_5 concentrations measured just above the analysis reliability level.

Figures 5-2 to 5-5 describe the Nitrogen series of the water quality in the watershed. Figure 5-3 shows the variation of Total Kjeldhal Nitrogen (TKN). This figure shows that only during the summer months some TKN was apparent in the mid-section of Jackson Brook and Hedden Pond. The maximum concentration of TKN in this reach of the Brook was 0.2 mg/l. The high concentration of TKN at Station 5 was due to the high concentration of Organic-N at this location as well (compare Figures 5-2 and 5-3). Figure 5-4 describes the temporal and spatial distribution of Ammonia-N in the watershed.

The Nitrate-N concentrations shown in Figure 5-5 remain below 1.4 mg/l at all locations below Station 3, the entrance to Hedden Pond, throughout the year. Finally, the concentrations in these reaches of the system do not vary seasonally. Variation in nitrate concentrations was apparent upstream of Station 3 in the upper portions of Jackson Brook. This may be related to localized effects of stormwater runoff within this section of the watershed. This hypothesis was confirmed later during the modeling endeavor of the system.

Figure 5-6 describes the concentrations of total phosphorous (TP) in the system. It is interesting to note that TP was detected only during the summer months. Elevated TP concentrations were observed at Hedden Pond dam during the Spring. This phenomenon may be attributed to spring blooms of algae that occur in the Pond. In fact, Figure 5-7 shows a commensurate increase in chlorophyll-a concentrations at this Station during the Spring as well. It is important to note that TP concentrations remain consistently below the surface water quality standard of 0.1 mg/l at all stations within the system (see Figure 5-6). A comparison of Figures 5-6 and 5-7 shows the relationship between TP concentrations and algal blooms in streams. During April 1998, there was a distinct correlation between TP and chlorophyll-a concentrations upstream of Station 5. On the other hand, in the lower reaches of Jackson Brook, downstream of Hedden Pond Dam, chlorophyll-a concentrations remained low in spite of TP concentrations comparable to those observed upstream of the dam. This demonstrates the complexity of processes that govern algal blooms in streams. Other parameters, such as sunlight, temperature, turbidity, etc. play important roles in the dynamics of algal blooms.

Finally, the data described in Figure 5-7 suggest that all the reaches of Jackson Brook and its tributaries remain oligotrophic while Hedden Pond appears to be at the threshold of becoming mesotrophic.

Figure 5-8 describes the seasonal variations of dissolved oxygen (DO) at all stations. The data suggest that the dynamics of stream DO in the watershed are influenced more by water temperatures than by biological activity. Figure 5-9 describes the temperature regime of the streams in the watershed. Elevated DO concentrations during December were the result of colder temperatures. Finally, it is important to note that observed DO concentrations remained consistently above the surface water quality standard of 5 mg/l at all monitoring stations.

Figures 5-10 – 5-13 describe the turbidity and the concentrations of alkalinity, manganese and iron in the streams. These data do not indicate any unusual concentrations, and they all point to the fact that the water quality in the Jackson Brook watershed remains quite good during an annual cycle.

5.2.2 Review of Sediment Quality Data

The monitoring program also included the collection and analysis of sediment samples at the selected stations listed earlier. Sediment analysis incorporated testing for a number of physical, organic and inorganic parameters of special interest as described below.

Figures 5-14 – 5-16 describe the temporal and spatial variation of iron, manganese and total petroleum hydrocarbons (TPHC) in the receiving streams. In general, the concentrations of these parameters are relatively low everywhere except in Hedden Pond. In fact the highest concentrations for all these parameters occur at Station 4 which is the middle of the Pond. This suggests that the Pond is acting as a retention basin with sufficient residence time for suspended and particulate matter to settle to the bottom. Relatively high concentrations of iron are related to the mineralogical characteristics of the watershed. Manganese concentrations, though elevated, are below NJDEP established standards for cleanup.

Of concern are the elevated concentrations of TPHC in the middle of Hedden Pond. These elevated concentrations are directly related to stormwater runoff from urban areas within the watershed. Although NJDEP standards for cleanup of TPHC contaminated soils is above 10,000 mg/kg; nevertheless, cleanup levels for some of the species of petroleum by-products are quite restrictive.

The spatial distribution of the organic parameters of concern in the sediments of Jackson Brook and its tributary are similar to the distribution of the inorganic parameters described above. Figures 5-17 – 5-19 show the percent mass of organic matter and the dry weight of TKN and TP in the sediments, respectively. A review of these figures shows that the highest organic and nutrient concentrations occur in the Hedden Pond. Both upstream and downstream reaches of Jackson Brook remain low in organic matter and nutrients. Data not shown here indicates that no nitrate was found in the sediment samples during all three monitoring events. Once again, it is apparent that Hedden Pond acts as a retention basin and as such, serves a useful function of ridding the stream flows from nutrients.

The nutrient pool in the sediments is not likely to be available to the water column to fuel algal blooms. The data indicates that DO concentrations in the Brooks and in the Pond remain elevated at all times, and there is no evidence to suggest that anoxic conditions will ever prevail in the Pond for any extended period.

Increasing the efficiency of the Hedden Pond as a retention basin for the watershed may warrant its dredging. In such a management scenario, it is possible to rid the sediments of all nutrients thus assuring that the Pond will serve its intended use for a long period of time.

5.2.3 Brief Description of SWMM-4 Model

The Storm Water Management Model (SWMM) was originally developed for the EPA between 1969 and 1971 and was the first comprehensive model of its type for urban runoff analysis. Version 4.4 of SWMM is the latest edition of this comprehensive computer model for analysis of quantity and quality problems associated with urban and suburban runoff.

Both single-event and continuous simulations may be performed on watersheds having storm sewers, or combined sewers and natural drainage, for prediction of flows, stages and pollutant concentrations. Using SWMM, the modeler can simulate all aspects of the urban hydrologic and quality cycles, including rainfall, snowmelt, surface and subsurface runoff, flow routing through the drainage network, storage and treatment. Statistical analyses may be performed on long-term precipitation data and on output from continuous simulation.

The model may be used for both planning and design. The planning mode is used for an overall assessment of the urban/suburban runoff problems and proposed abatement options. This mode is typified by continuous simulation for several years using long-term precipitation data. Watershed schematization is usually "coarse" in keeping with the planning level of analysis. Statistic Blocks may be used for frequency analysis of the long-term time series of hydrographs and pollutographs and for identification of individual hydrologic events that may be of special interest. A design-level event simulation also may be run using a detailed watershed schematization and shorter time steps for precipitation input. The Rain Block is used for the processing of hourly and 15-minute precipitation time series for input to continuous simulation. This Block also incorporates the statistical analysis procedures of the EPA SYNOP model for characterization of storm events. The Statistics Block may alternatively be used for statistical analysis of the precipitation time series.

For hydrologic simulation in the Runoff Block, data requirements include area, imperviousness, slope, roughness, width (a shape factor), depression storage, and infiltration parameters for either the Horton or Green-Ampt equations for up to 100 subbasins. (Number of subbasins, pipes, etc. is variable depending on the compilation). The program is driven by precipitation for up to ten gages (distributed spatially) and evaporation. Additional data are required if simulation of snowmelt, subsurface drainage, and infiltration/inflow options are employed. The subsurface drainage option is especially useful in locations where true overland flow rarely occurs because of flat, sandy soils.

Basic SWMM output consists of hydrographs and pollutographs (concentration vs. time) at any desired location in the drainage system. Additional quality output includes loads, source identification, continuity, and other parameters. The Statistics Block may be used to separate hydrographs and pollutographs into storm events and then compute statistics on parameters such as volume, duration, intensity, inter-event time, load, average concentration, and peak concentration.

The two user's manuals of SWMM-4 clearly explain all computational assumptions of the model. The model performs best in urbanized areas with impervious drainage, although it has been widely used elsewhere. Quantity simulations are enhanced by the calibration/verification process but can be expected to resemble measured data fairly accurately if reliable information is available concerning drainage area, imperviousness and rainfall. Quality simulations must be calibrated in order to be credible in terms of absolute magnitudes. Technical limitations include lack of subsurface quality routing (a constant concentration is used), no interaction of quality processes (apart from adsorption), difficulty in simulation of wetlands quality processes (except as can be represented as storage processes), and a weak scour deposition routine in the Transport Block.

5.2.4 Brief Description of PMPDR

PMPDR is an improved time variable model for long-term water quality simulation in reservoirs. It is designed to analyze the implications of various water supply operating policies in a particular reservoir in terms of eutrophication potential. The model accounts for fluctuating volumes and for variable influent and effluent flow rates. It is economical enough to simulate several to many years of reservoir operation representing various drawdown and refill strategies. The model structure contains sufficient detail to represent seasonal water quality variations while still being practical for long-term simulations.

The model is cast in two layers such that it represents a reservoir as two fully mixed layers (an epilimnion and a hypolimnion). The model is based on the assumption that phosphorus limits the algal productivity in a reservoir. Three forms of phosphorus plus dissolved oxygen are modeled in each layer. These variables were chosen as representative of the trophic state. All organic forms (e.g. phosphorus incorporated into algal cells) are combined and represented as the organic phosphorus variable. Organism growth is limited by temperature, light, and available nutrients. The particulate inorganic phosphorus is assumed to be non-reactive in the water column but settles to the sediment layer where it can be remineralized into available inorganic forms of phosphorus. Total phosphorus, a primary indicator of trophic state, is obtained by summation of the three phosphorus forms in the model.

The governing equations of the model are based on the conservation of mass of the different species of phosphorus and dissolved oxygen in the well-mixed layer of the epilimnion and the hypolimnion. A set of equations are written for each layer which incorporate the time-rate of change of the concentrations of the variables along with the rates of internal and external sources and sinks for each species. Two sets of equations were considered to adequately represent phosphorus dynamics during stratified and completely mixed conditions of the reservoir. In this specific case, due to the shallow depths of Hedden Pond, no stratification was assumed to occur in the Pond. Accordingly, the Pond was assumed to be completely mixed.

Mass conservation equations for various constituents are given below:

$$\frac{d([OP]V)}{dt} = Q_i[OP]_i - Q_o[OP] + \mu[OP]V - \beta[OP]V - v_{s_1}\frac{V}{Z}[OP]$$

$$\frac{d([DIP]V)}{dt} = Q_i[DIP]_i - Q_o[DIP] + \mu[OP]V - \beta[OP]V + S_R$$

$$\frac{d([PIP]V)}{dt} = Q_i[PIP]_i - Q_o[PIP] - v_{s_3}\frac{V}{Z}[PIP]$$

$$\mu = \mu_0\theta_\mu^T \frac{[DIP]}{K_S + [DIP]}\frac{2.718f}{(Z_1 - Z_0)K_e}$$

$$\exp[-\frac{I_0}{r}\exp(-K_eZ_1)] - \exp[-\frac{I_0}{I_{opt}}\exp(-K_eZ_0)]\}$$

$$K_e = K'_e + 0.0088[OP] + 0.054[OP]^{2/3}$$

$$\beta = \beta_{20}\theta_\beta^{(T-20)}$$

$$S_R = S_{R_{max}}\frac{K_{DO}}{[DO]_{SW} + K_{DO}}\frac{K_{DIP}}{[DIP]_{SW} + K_{DIP}} \qquad [5.7]$$

$$\frac{d([L]V)}{dt} = Q_i[L]_i - Q_0[L] - (K_D + \frac{v_{S_5}}{Z})L_NV + \beta[OP]V\alpha_1 \qquad [5.8]$$

$$\frac{d([L_N]V)}{dt} = Q_i[L_N]_i - Q_0[L_N] - (K_N + \frac{v_{s_7}}{\overline{Z}})L_N V + \beta[OP]V\alpha_2 \qquad [5.9]$$

$$\frac{d([DO]V)}{dt} = Q_i[DO]_i - Q_0[DO] - K_D[L]V - K_N[L_N]V + K_L A([DO_s]$$

$$- [DO] + \mu[OP]V\alpha_1 \qquad [5.10]$$

Where A = pond surface area; [DO] = dissolved oxygen concentration; $[DO_s]$ = dissolved oxygen saturation concentration; K_D = deoxygenation coefficient for NBOD; [L] = concentration of CBOD; $[L_N]$ = concentration of NBOD; α_1 = oxygen to phosphorus ration; and α_2 = NBOD to phosphorus ratio; D = diffusion coefficient; [DIP] = dissolved inorganic phosphorus concentration; $[DIP]_{SW}$ = dissolved inorganic phosphorus concentration at the sediment/water interface; $[DO]_{sw}$ = dissolved oxygen concentration at the sediment/water interface; f = photoperiod; I_o = light intensity at the surface layer; I_{opt} = optimum light intensity; K_{DIP} and K_{DO} = empirical constants; k_e = light extinction coefficient; K'_e = natural background light extinction coefficient; K_s = half saturation constant; [OP] = organic phosphorus concentration; [PIP] = particulate inorganic phosphorus concentration; Q = flow rate; S = source/sink of mass to epilimnion/hypolimnion due to advection between layers; S_R = sediment phosphorus release rate; S_{Rmax} = maximum sediment phosphorus release rate; T = temperature; V = volume; v_s = settling velocity, where the subscripts 1 to 4 refer to the settling velocities of [OP], [PIP], [CBOD] and [NBOD], respectively; Z_l = depth from reservoir surface to bottom of layer; β = decay rate coefficient; β_{20} = decay rate coefficient at 20° C; θ_β and θ_μ = constants; μ_o = growth rate coefficient at 0° C; and the subscripts i and o refer to influent and effluent, respectively.

The mass conservation equation for DO concentration in the original version of PMPDR ignores the contributions of CBOD and NBOD to the total sink of DO in the water column. For the present study, the DO equation has been modified to incorporate these sinks of DO in the simulation of the long-term variations of the DO concentrations in Hedden Pond. With anticipated residence in the pond for a week or so, it is expected that the bacterial decomposition of the organic masses under aerobic conditions will contribute to the overall balance of DO in the pond.

The new model, therefore, incorporates the additional mass conservation equations for CBOD and NBOD. Both of these equations are coupled to the DO equation through its source and sink terms. Figure 5-20 shows the conceptualization of the modified PMPDR model.

PMPDR requires three forms of input: (a) system stresses, (b) inherent system characteristics, and (c) exogenous system variables. The variables to be specified which cause a stress to a pond system include inflows with their corresponding concentrations of the state variables described above (e.g. loadings to a pond and the outflow rate). These variables represent those which can be controlled, to some degree, by the choice of a pond management scheme.

The second type of input includes those parameters which define the physical geometry and the biochemical processes of a pond. These are assumed to be inherent characteristics of the waterbody. Pond elevation, surface area, and storage curves define the physical geometry of the basin. Biogeochemical parameters can be defined originally from the literature and then refined through model calibration. These parameters are listed in Table 5-1.

The last form of input includes exogenous variables – those which are derived outside the pond system. These include temperature and solar radiation. By coupling PMPDR with MITEMP, the latter model provides the temperature. Solar radiation for this study was obtained from long-term records collected by the National Weather Service (NWS) at Newark Airport, Newark, NJ.

The output of PMPDR defines the state of a pond from the viewpoint of eutrophication potential. Three forms of phosphorus, dissolved oxygen, NBOD, and CBOD are provided by PMPDR as output and describe the state of the system. Organic phosphorus, dissolved inorganic phosphorus and particulate inorganic phosphorus can be summed to give total phosphorus. The two forms of inorganic phosphorus consist of both the orthophosphorus and polyphosphates.

Table 5-1 Literature Reported Range of Model Parameters

Parameter	Literature Range	Units
μ	0.2 – 3.1	1/ day
θ	1.0 – 1.1	unitless
K_S	2.0 – 80.	Ug/ 1
K_e	0.03 – 4.0	1/ m
I_{opt}	250 – 350	ly/ day
β_{20}	0.0 – 0.7	1/ day
vs_1, vs_2	0.0 – 26.	m/ day
vs_3, vs_4	0.0 – 26.	m/ day
vs_5, vs_6	0.0 – 26.	m/ day
vs_7, vs_8	0.0 – 26.	m/ day
K_L	0.0 – 2.0	1/ day
K_D	0.01 – 2.5	1/ day
K_N	0.03 – 2.5	1/ day
α_1	0.08 – 0.5	mg DO/ ug P

CBOD and NBOD represent the biochemical oxygen demand due to the oxidation of carbonaceous and nitrogenous material. For the purposes of this study, NBOD can be defined as:

$$NBOD = 4.57 \times TKN$$

Where TKN = total Kjeldahl nitrogen.

Through the use of these six state variables, the water quality of a pond is defined. Management schemes can be evaluated by simulating the variation of the state variables.

To solve the coupled set of ordinary differential equations, PMPDR employs a fourth order Runge-Kutta numerical scheme. By choosing a suitable approximation to the ordinary differential equations over a given interval, this method provides a solution by stepping through time. Once all the parameters and initial conditions are specified, the derivatives are approximated at four locations along the chosen interval. In this way solutions are obtained for the independent variables.

5.2.5 SWMM-4 Application to Jackson Brook Watershed

A detailed description of the physical characteristics and the land-use patterns of the Jackson Brook watershed were described previously in this report. It suffices to say that Killam Associates provided all the necessary input data to facilitate the application of the model to the watershed. For this application the entire watershed area of approximately 4.75 square miles (3,038 acres) was divided into four geographic sub-basins as follows:

Upper Jackson Brook -	1482 acres
Lower Jackson Brook -	367 acres
Spring Brook -	619 acres
Wallace Brook -	570 acres

The current land-use patterns in all of the municipalities were generated using GIS. The dominant land use in the watershed is low-density residential with some commercial and industrial uses with the exception of the Wallace Brook sub-basin where there is a large portion of high-density residential developments consisting of apartment dwellings. Figure 5-21 shows the percentage of various current land uses in each of the sub-basins.

In addition to land use, a detailed description of dominant slopes and different soil types in each sub-basin were described as input to the model. Using aerial photographs, natural depressions and other storage facilities within the watershed were also provided as input to the model to account for natural detention for runoff.

The model was exercised to simulate the hydraulic and water quality characteristics of streams in the watershed under current land use for a period of one year. Since data for 1998 was made available under the current study program, this year was chosen as the basis for comparative simulations of current and future conditions in the watershed with respect to its hydraulics and runoff loadings to streams and Hedden Pond. Model calibration and verification were not conducted as the monitoring program was limited in scope. Furthermore, the primary objective of the study was to generate an order of magnitude estimate for flows and loadings rather than predict actual water quality conditions in the watershed.

Figure 5-22 shows the hydraulic simulation results. The figure describes the temporal variation of flows in Jackson and Wallace Brooks at their confluence with Hedden Pond. These hydrographs clearly show the storm-event driven flows in these streams. The maximum flows in these streams occurred at different times of the year. In upper Jackson Brook the maximum simulated flow of 74.8 cu. ft/sec occurred in late June; whereas, in Wallace Brook the maximum flow of 44.9 cu. ft/sec occurred in February 1998, respectively. It is interesting to note that from July to December of 1998, the watershed experienced a drought period whereby the two Brooks had essentially no flow. During certain short-storm events that may have occurred during the summer months, the rainfall was infiltrated to the ground without running off to receiving streams. Similar hydrographs were generated for Spring Brook at its confluence with the lower Jackson Brook and at the downstream confluence of Jackson Brook and Rockaway River.

Figures 5-23 and 5-24 show the temporal variation of simulated concentrations of various water quality constituents at the same stations. As expected, the temporal changes in water quality concentrations are related to the storm events described in the hydrographs shown in Figure 5-22.

The continuous simulation of the hydraulic and water quality variations in all sub-basins of the watershed provides the means to estimate the annual loadings of the various water-quality constituents into the receiving streams and Hedden Pond. The simulations of 1998, under the current land use, resulted in annual loadings (lbs/acre) shown in Figure 5-25. Figure 5-26 shows the total contribution of loadings for each of the sub-basins and indicates that nearly 50% of loadings for TP, Ortho-P, BOD_5 and Ammonia-N originate in the upper Jackson Brook sub-basin. The annual contributions from upper Jackson and Wallace Brooks are important, particularly as they constitute the two major sources of nutrients to Hedden Pond.

The watershed simulation described above was repeated to simulate both the hydraulics and water quality of streams and Hedden Pond under a future land- use scenario. In the new simulation, it was assumed that the watershed was fully developed as per the zoning ordinances of all the municipalities. Furthermore, for this simulation, 1998 rainfall data was used as input into the model. This approach helps to compare model results under current and future land-use scenarios.

Figure 5-27 provides the percent distribution of various future land uses in the four sub-basins of the watershed. A comparison of Figures 5-21 and 5-27 shows distinct changes in future land uses. Areas designated for high-density residential development have increased substantially in all of the sub-basins considered. The loss or large reduction of open space is also apparent under future land-use scenarios in all of the sub-basins except for the Wallace Brook sub-basin where the percent of open space may increase from its current value of 12% to 23.5% in the future.

Figures 5-28 and 5-29 show the annual loadings (lbs/acre) of various constituents in the four sub-basins of the watershed. A comparison of Figure 5-25 and 5-28 shows that (a) loading rates nearly doubled in the upper Jackson Brook under current and future land-use scenarios, and (b) future loading rates in all of the other sub-basins show varying increases from 20-60%. A comparison of Figures 5-25 and 5-28 shows the increases in annual loadings of nutrients under present and future land uses within the entire watershed. Table 5.2 shows overall estimates and percent changes of these loadings for the entire watershed.

Table 5.2: Loadings under Current and Future Land Use

Constituents	Current Land Use	Future Land Use	% Change
Total Phosphorus	343	555	62
BOD_5	29,221	43,493	49
Orthophosphate	248	412	66
Ammonia-N	352	635	80

It is important to note that these estimates of loadings in the watershed were developed for a single-year hydrologic event. **These loading estimates may increase substantially during relatively wet years.** It is also important to note that the entire wasteload in the watershed consists of stormwater runoff and failing septic systems that serve the sections of the municipalities that are not served by sewer systems.

The relationship between pollutant loadings and concentrations of water quality parameters in streams and ponds is not well known. It suffices to say, however, that increased loadings of nutrients will translate into increased water quality concentrations. Currently, TP concentrations, as described above, are just at or below surface water quality standards for the Jackson Brook watershed. It is conceivable that with anticipated increases in TP loading under future land-use scenarios, regular violations of stream standards may occur. These estimates of increased nutrient loadings in the watershed warrant a serious review of water quality control alternatives. Implementation of judicious and economically viable BMP's will assure that no impairment of the designated uses of the waterbodies will occur while the planned growth proceeds in the region.

5.2.6 Application of PMPDR to Hedden Pond

The development of the continuous hydrographs for upper Jackson Brook and Wallace Brook for the hydrologic year of 1998 provided all the necessary input to simulate the nutrient and algal dynamics of Hedden Pond. In the schematization of the watershed, the Pond was designated as the terminus of the upper Jackson Brook and Wallace Brook sub-basins. A detailed description of the geometry of the Pond was also specified as input to the PMPDR model. A weir situated at the downstream end of Hedden Pond controls its hydraulics. The top of the weir is at elevation 591.5 ft. above mean sea level. At this elevation the Pond has an approximate surface area of 3.8 acres with a volume of 9.0 acre-feet and an average depth of 2.4 ft.

Hedden Pond serves the dual purposes of providing storage of stormwater runoff from the streams and as an aesthetic and recreational amenity to the communities in the watershed. Needless to say, it is quite undersized for a retention facility that receives runoff from an approximate area of 2040 acres (3.2 sq. miles). The Pond has been silted and requires dredging to increase its capacity and at the same time to rid the sediments of nutrients that have been deposited over the years.

Current model simulations of the Pond dynamics consider only the present, rather than, dredged geometry of the Hedden Pond. In addition to the input described above, the model requires detailed input with respect to meteorological conditions in the watershed. Such data was obtained from the National Weather Service for Newark Airport for 1998.

The objective of the model simulations was not to predict the long-term changes of the trophic state of the Pond, but rather to develop an estimate of the anticipated changes in the water quality of the Pond as a result of anticipated development of the watershed in the future. Simulations of the long-term changes in the trophic state of the Pond will require more extensive nutrient and physical data that span over a period of many years. Such data is not currently available. Furthermore, such simulations may be more meaningful once the final dredged geometry of the Pond is known, and baseline data on its water quality and sediments are established.

Figures 5-30 – 5-32 describe the concentration variations of BOD_5, NBOD, and Ammonia-N in Hedden Pond under current and future land-use scenarios. All of these figures show that the temporal variations of the concentrations under the two scenarios exhibit marked increases in concentrations. Episodic increases in the concentrations follow storm events that discharge pollutants from the contributing sub-basins. Under future land use, all of the concentrations reflect increasing trends as a result of increasing loads from the sub-basins. Average increases in the concentrations are substantial. Simulations for future land-use scenarios during storm events show maximum BOD_5, NBOD, and Ammonia–N concentrations increasing by 4 mg/l, 0.5 mg/l and 0.1 mg/l, respectively.

Figures 5-33 – 5-36 describe the variations of different phosphorous species in Hedden Pond over a period of one year. A review of these figures shows that the trends in these variations are similar to the ones described above. Figure 5-33 shows that under current conditions only during Summer months TP concentrations in the Pond exceed 100 ppb. However, under future land-use scenarios, TP concentrations exceed 100 ppb during early June, the Summer, and mid Fall months, with levels exceeding 140 ppb for the Summer months. It is apparent that increasing loads due to future land use result in increasing TP concentrations in the Pond.

The concentrations of PO_4 (ortho-phosphorus) in the Pond as shown in Figure 5-34 show a marked increase as a result of future land use. Average increases in such concentrations are in the order of 30 – 50 %. Increases in PO_4 concentrations are expected to enhance the dynamics of algal bloom, as it constitutes the most desirable phosphorus specie to serve as a nutrient pool for algae. A comparison of Figure 5-34 and 5-35 suggests that virtually all of the inorganic phosphorus in the Pond under both land-use scenarios is in the form of phosphate.

Figure 5-36 shows the temporal variation of organic phosphorous in the Pond. Most of the organic-P is in the form of algal biomass. Under current land use, the concentrations of organic–P appear to remain at or below 25 ppb during a substantial portion of the simulated period. Only during the summer months of June, July and August do these concentrations rise to levels close to 35 ppb. Under future land use, it is apparent that there is an approximate 25% increase in the concentration of organic-P during the critical summer months.

These estimates of phosphorous specie variations in Hedden pond under two land-use scenarios suggest that if stormwater runoff remains unabated in the future, it is expected that the Pond will become mesotrophic with algal blooms occurring more frequently. Such blooms may reduce the recreational value of the Pond and depending on the nutrient composition and the rate of deposition may accelerate the growth of submerged aquatic vegetation.

Figure 5-37 describes the variation of DO concentrations under the two scenarios of interest here. It is apparent that DO concentrations remain virtually identical under both land-use simulations. This is due to the fact that the Pond DO dynamics are driven by its temperature regime more than the algal and bacterial activity in the Pond. The Pond's shallow depth and its short residence time are two factors that contribute to a relatively healthy DO condition.

These simulations clearly show that Hedden Pond is expected to change its trophic state in the future if the watershed is developed as currently zoned and if no provisions are made to control stormwater runoff in each of the sub-basins. These estimates, however, do not reflect any alarming changes in the water quality of the streams and Hedden Pond under future land uses. They simply suggest the planning of cost/effective and judicious stormwater management that may help improve the overall water quality in the watershed, while future development of the watershed proceeds in an orderly fashion.

5.3 Water Quality Control Alternatives

Both data and simulations of water quality in the Jackson Brook watershed suggest that the current conditions are quite acceptable as no major contravention of water quality or growth of nuisance algae is apparent. This does not mean that efforts should not be invested towards improving the existing and future conditions. As data shows, the discharge of petroleum hydrocarbons from the Wallace Brook and upper Jackson Brook sub-basins is perhaps the main source of the elevated pollutant concentrations in the Hedden Pond sediments. It is also apparent that sedimentation resulting from uncontrolled runoff from these sub-basins is the source of some elevated nutrients in the sediments.

The improvement of water quality in the streams under current conditions requires a serious evaluation of stormwater control appurtenances that are in place at the present time in various developed communities and an evaluation of their efficacy. Often a simple maintenance program designed to periodically clean such appurtenances may result in substantial improvements. Wherever possible, inexpensive retrofits must be considered to further enhance the quality of runoff. Measures must be taken to reduce sediment runoff from stream banks. This could be achieved by armoring steep banks of streams and planting trees within the buffer areas of such streams. Finally, retrofitting existing storm drainage systems with stormceptors or similar types of oil and grease traps at selected locations must be planned and implemented.

Current regulations enforced by both the Soil Conservation Service and NJDEP Stormwater Management Division provide the best means to control sediment and pollutant transport to receiving streams from disturbed and densely developed areas in a watershed. To the extent practicable, use must be made of the ability of wetlands areas, in order to remove pollutants from such runoff flows. Where possible overland flow of stormwater runoff must be encouraged and use of grassed swales to direct such flows must be mandated. Local municipal ordinances must be revised to bring them in conformity with the intent and the spirit of federal and state regulations. Often, such regulations are applicable only to developments that are relatively large in scope. Municipal ordinances must, therefore, be designed to encourage the control of stormwater runoff from many of the smaller developments that may not come under federal and state jurisdictions.

The following Best Management Practices (BMPs) must be incorporated in local ordinances to help reduce the flow and loads that are associated with storm events:

Use of low check dams at selected locations.
Use of infiltration basins wherever soil conditions are favorable.
Limit runoff from developments to 75% of pre-developed conditions.
Regular maintenance schedules for stormwater runoff control appurtenances.
Periodic street sweeping.
Reduced use of deicing agents and control of highway runoff.
Controlled landscaping of new developments and reduced use of fertilizers.
Pet control at existing and future developments.
Public education and outreach programs.

These BMPs provide all the necessary steps needed to assure the maintenance of established stream water quality standards. Their rigorous implementation and adherence to scheduled maintenance further promises improvements of current water quality in the watershed.

Hedden Pond is the terminus of the upper Jackson and Wallace Brooks. The health and the trophic level changes in Hedden Pond are predicated on the water quality of these feeder streams. Additionally, the planned dredging of the Pond will rid the sediment of the nutrient pool that currently exists. The dredging of the Pond will increase its capacity thus providing for longer residence time. This in turn, will help remove some of the particulate pollutants that are discharged into lower Jackson Brook and thence to the Rockaway River. Any improvements in the water quality of the Jackson Brook watershed will help improve conditions in the Passaic River Basin that serves as one of the major sources for a potable water supply. The desired improvements in the Passaic Basin water quality may occur only if the stormwater management alternatives described above for the Jackson Brook watershed are implemented in all of its tributaries. Many of the alternatives listed above are relatively inexpensive and can be readily adapted to developing communities in the watershed.

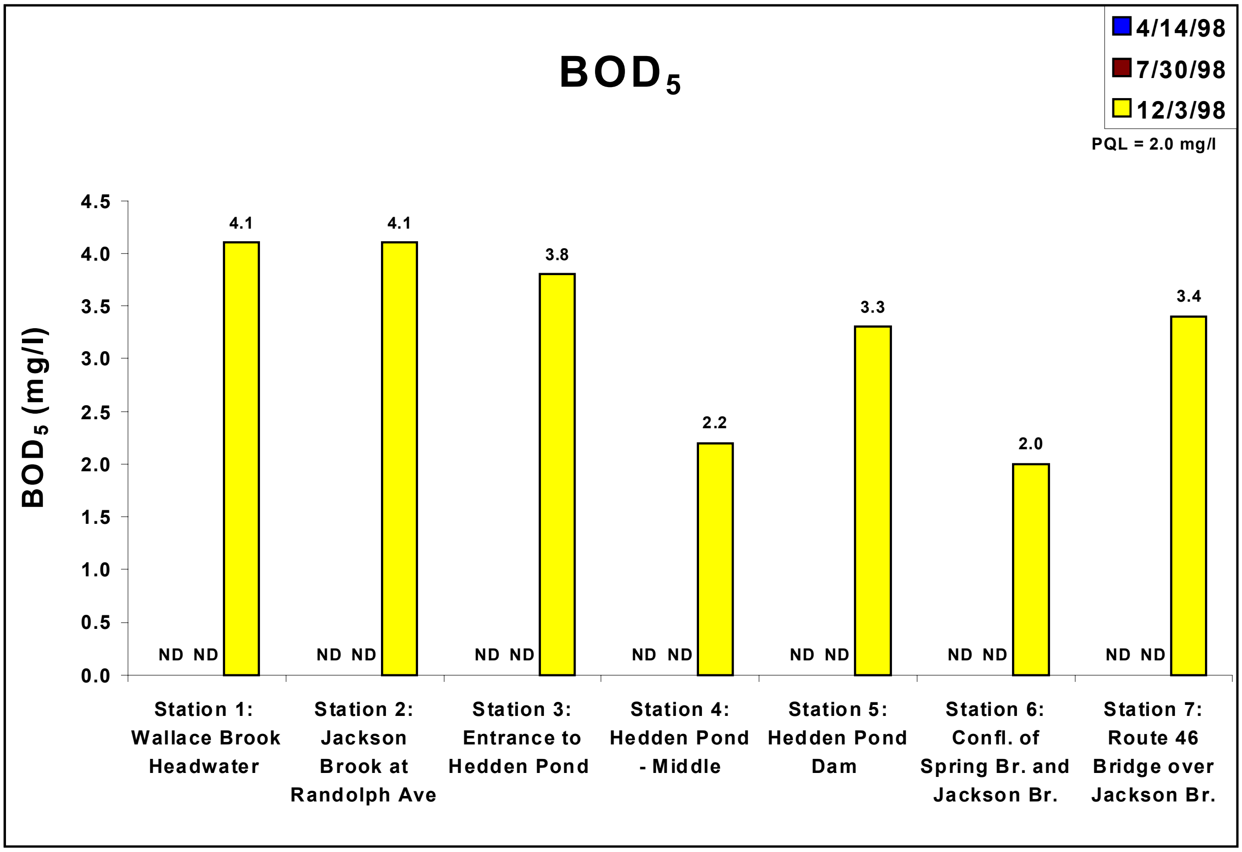


FIGURE 5-1: WATER QUALITY DATA – BOD5

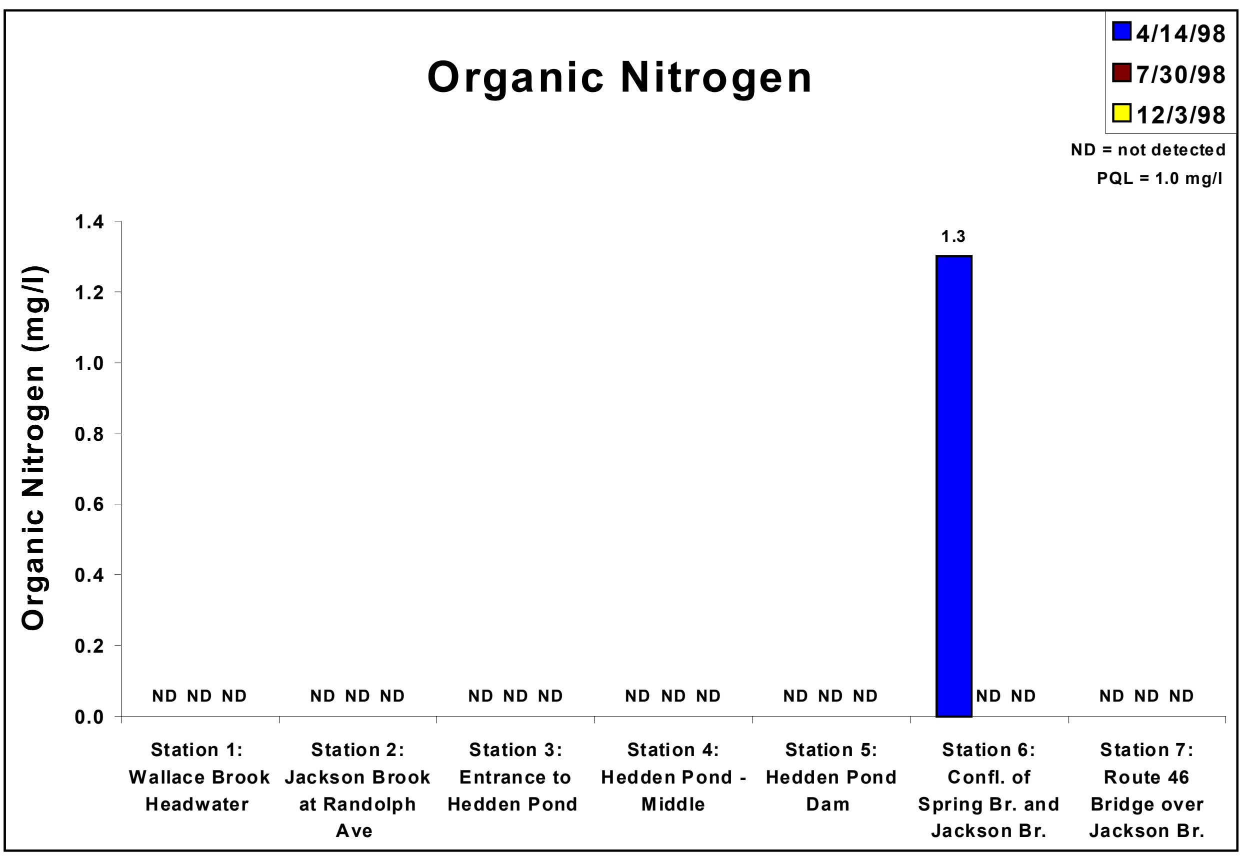


FIGURE 5-2: WATER QUALITY DATA - Organic Nitrogen

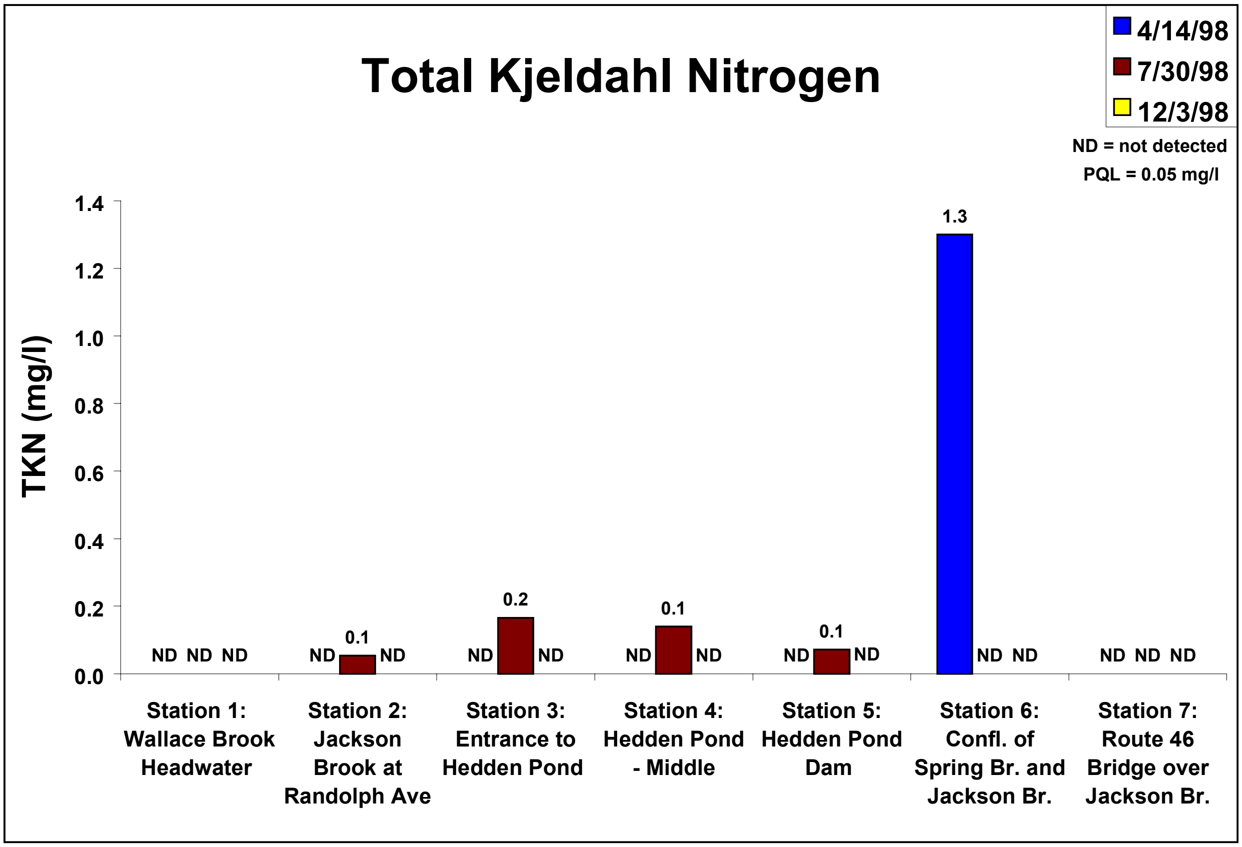


FIGURE 5-3: WATER QUALITY DATA - Total Kjeldahl Nitrogen

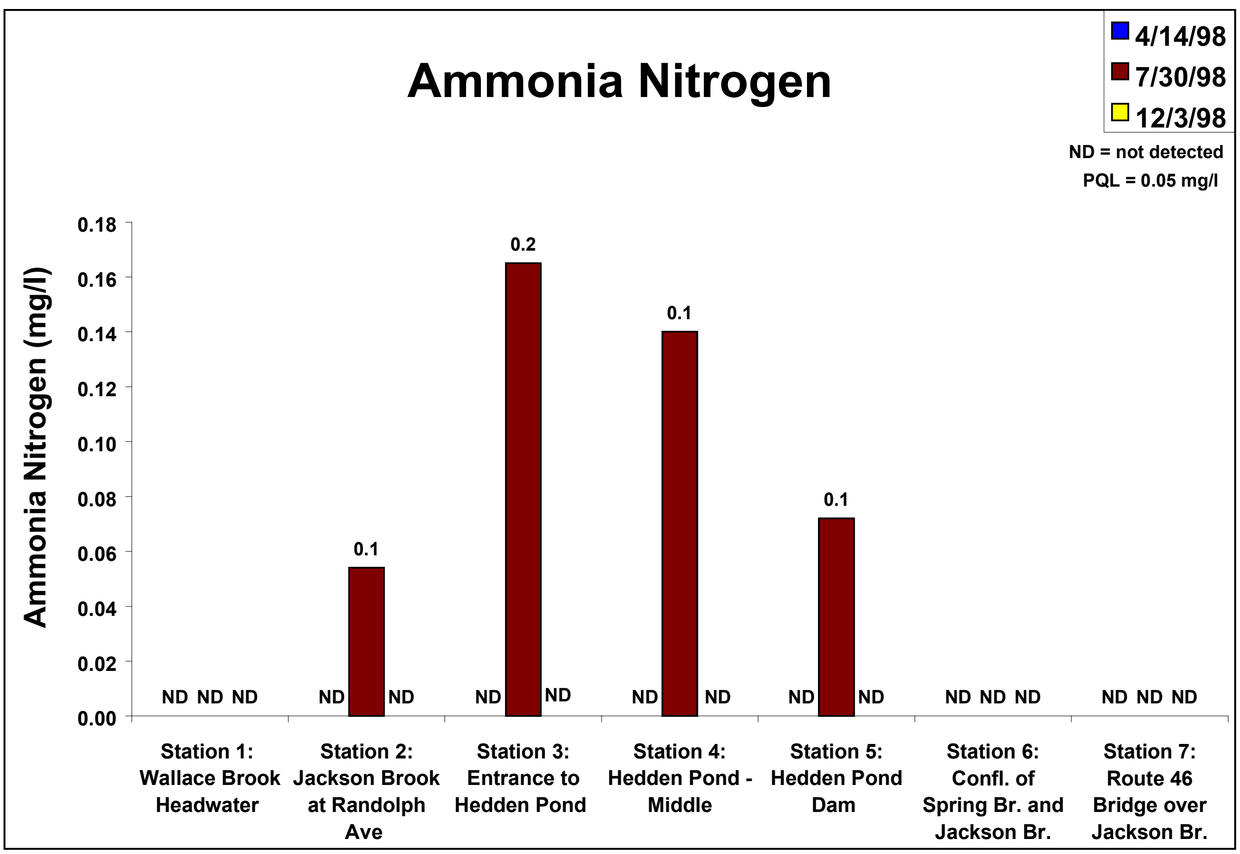


FIGURE 5-4: WATER QUALITY DATA – Ammonia Nitrogen

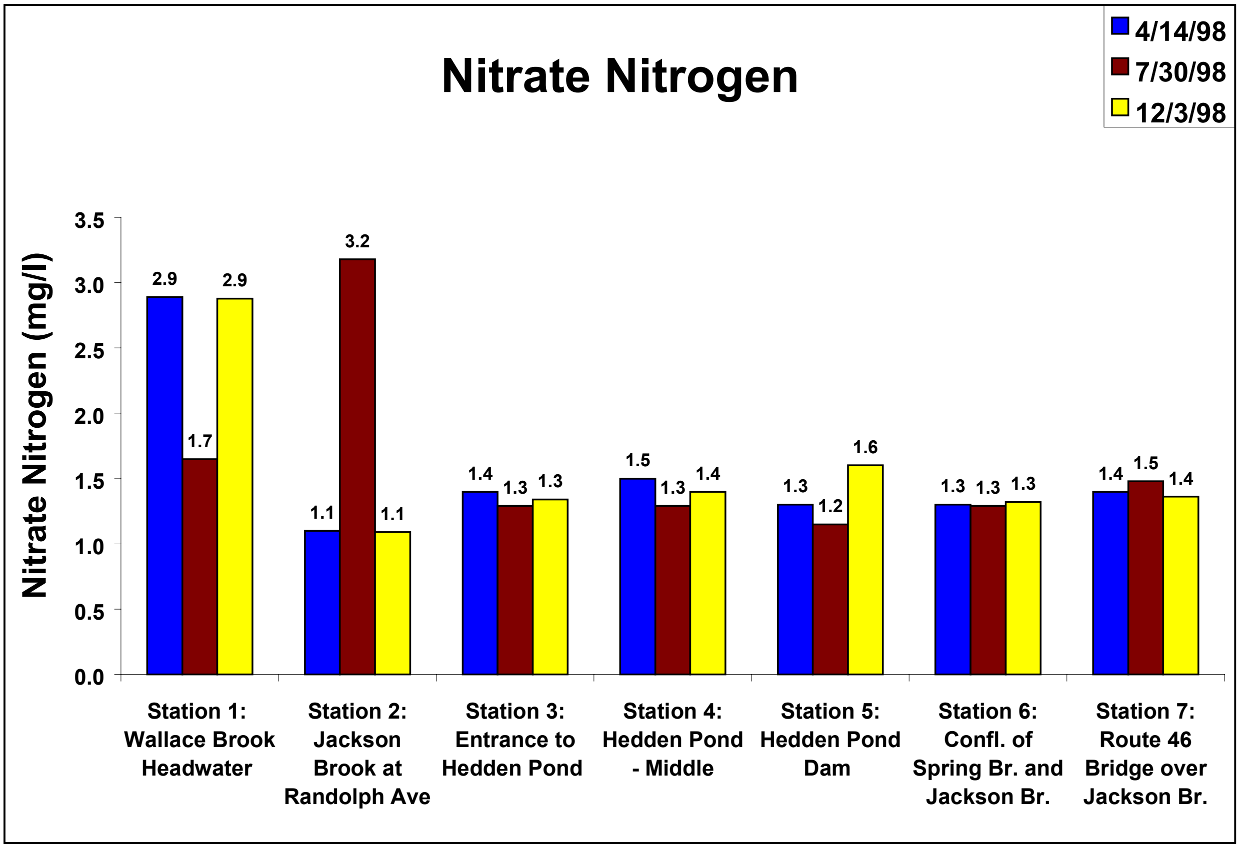


FIGURE 5-5: WATER QUALITY DATA - Nitrate Nitrogen

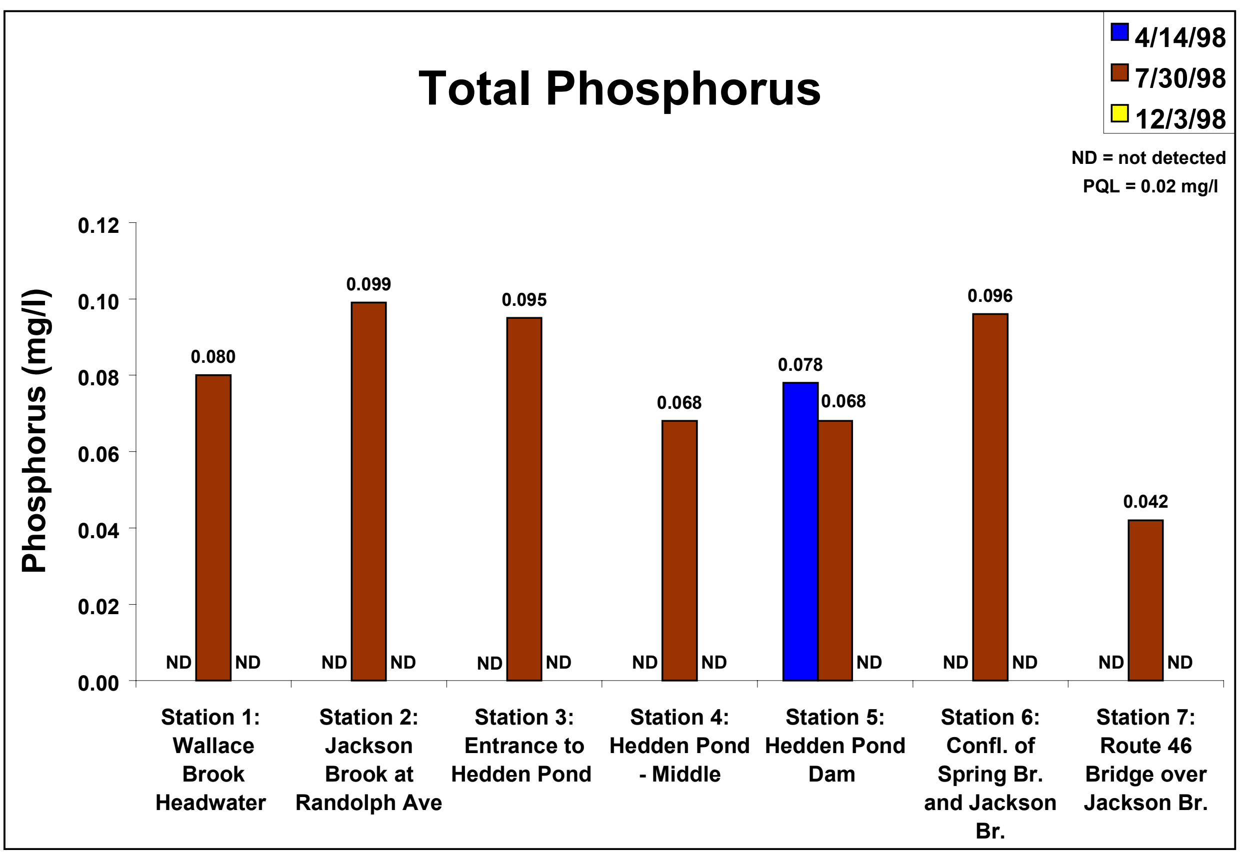


FIGURE 5-6: WATER QUALITY DATA - Total Phosphorous

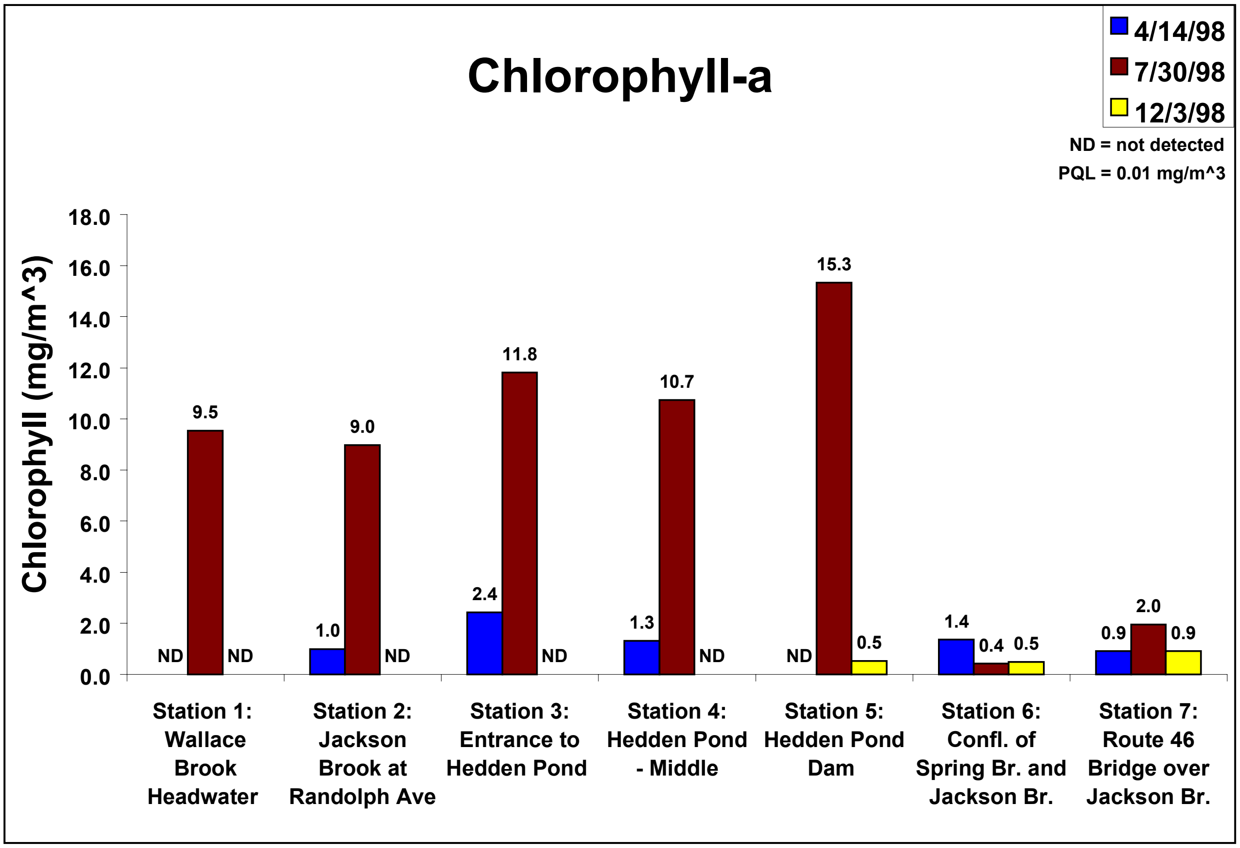


FIGURE 5-7: WATER QUALITY DATA – Chlorophyl a

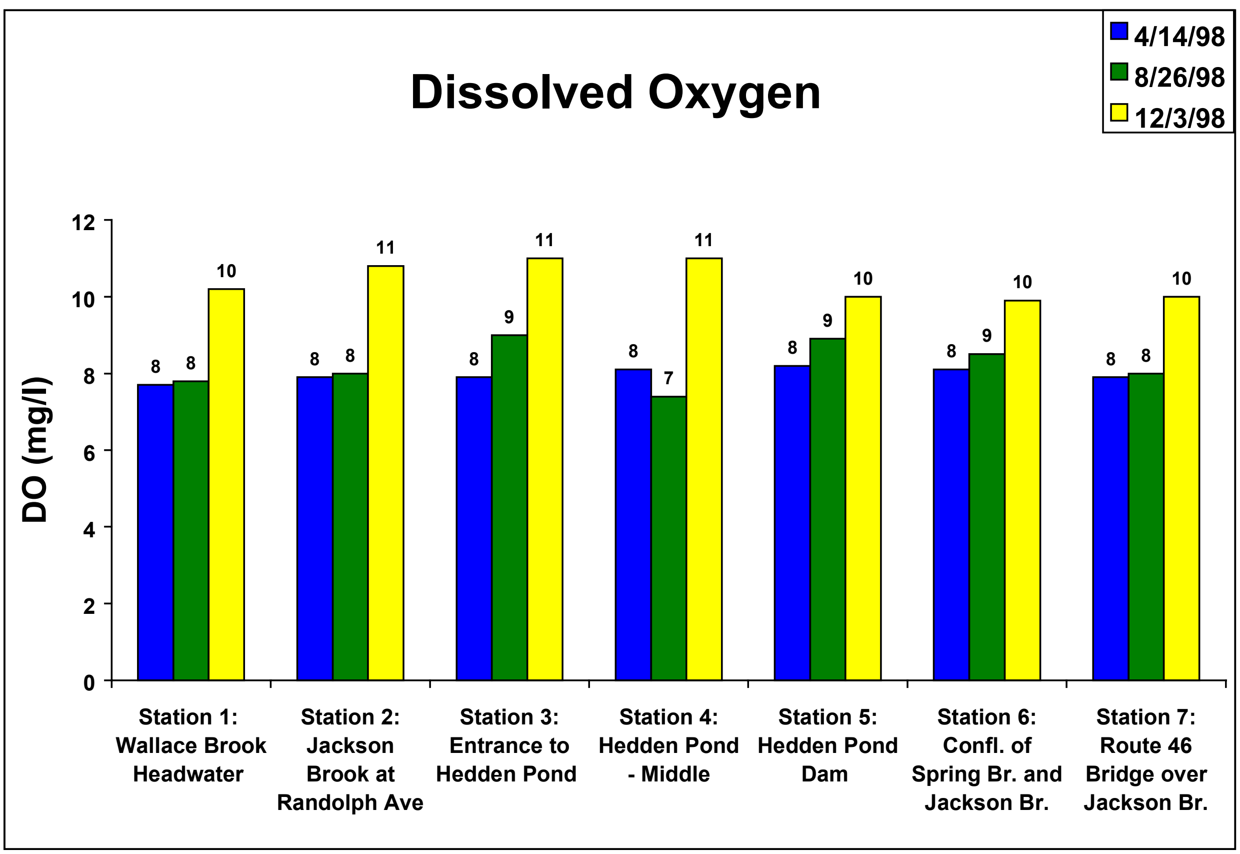


FIGURE 5-8: WATER QUALITY DATA - Dissolved Oxygen

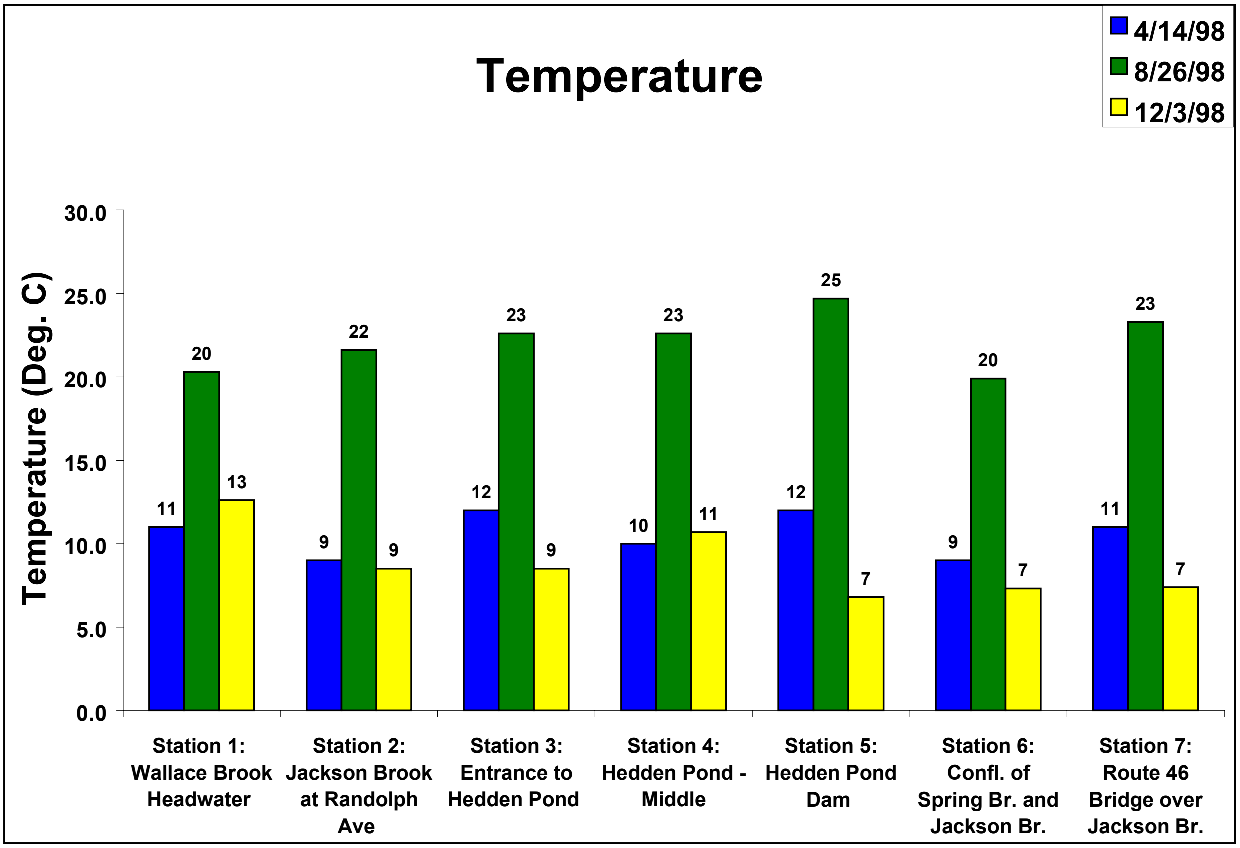


FIGURE 5-9: WATER QUALITY DATA – Temperature

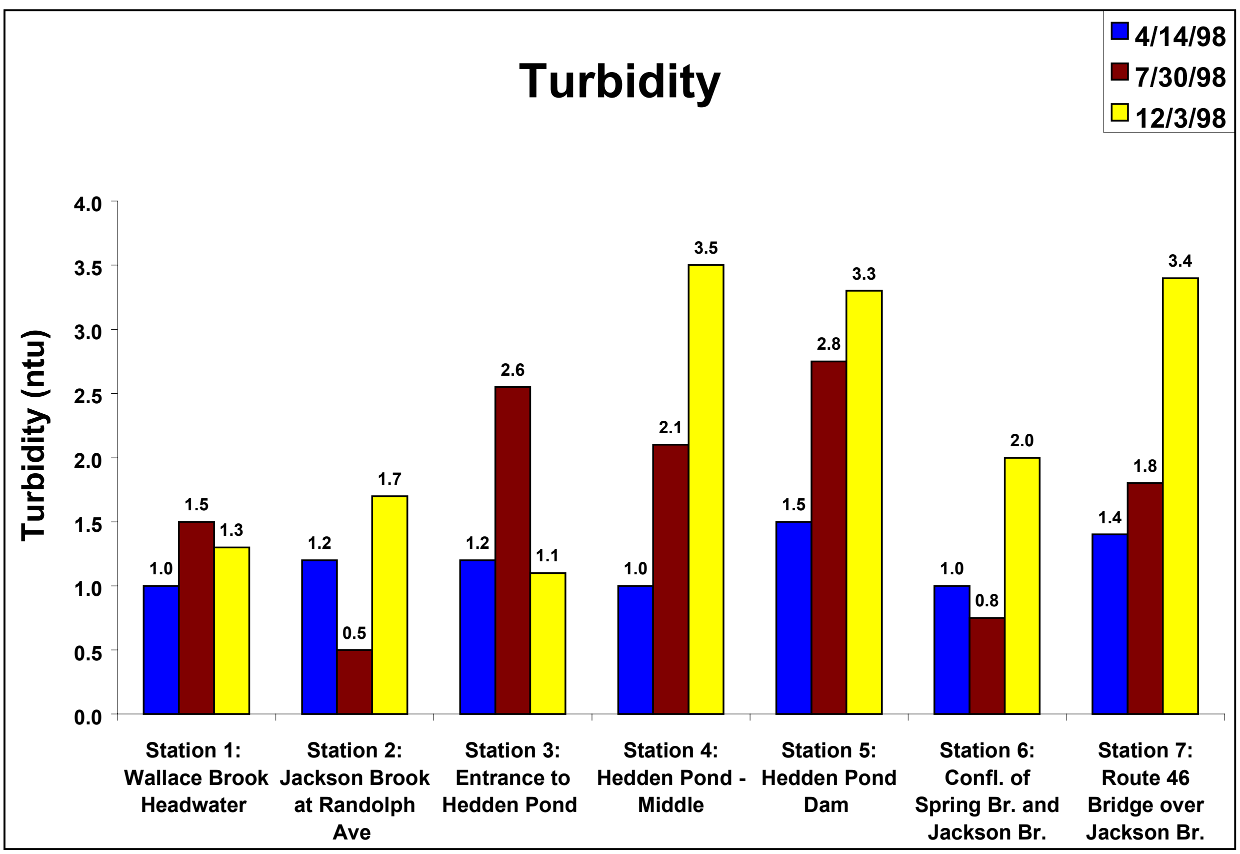


FIGURE 5-10: WATER QUALITY DATA – Turbidity

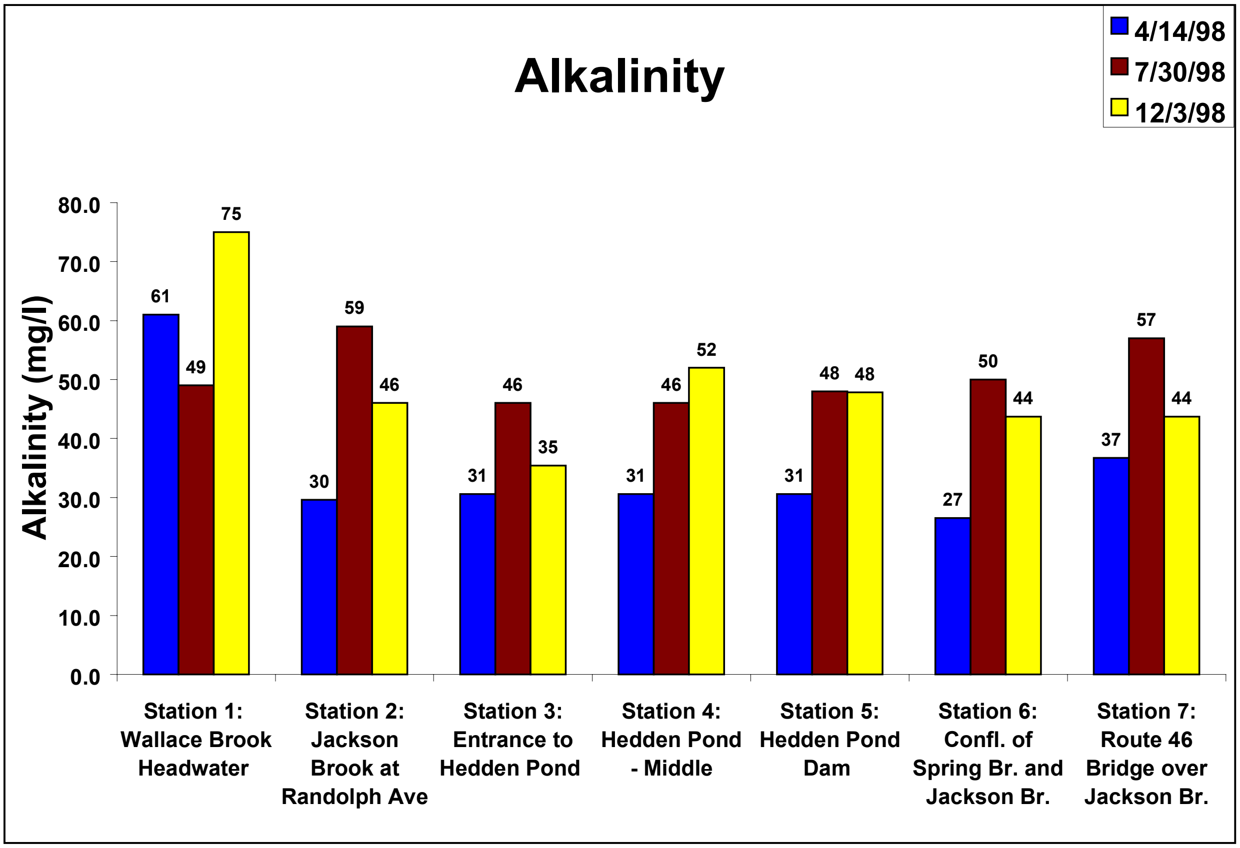


FIGURE 5-11: WATER QUALITY DATA – Alkalinity

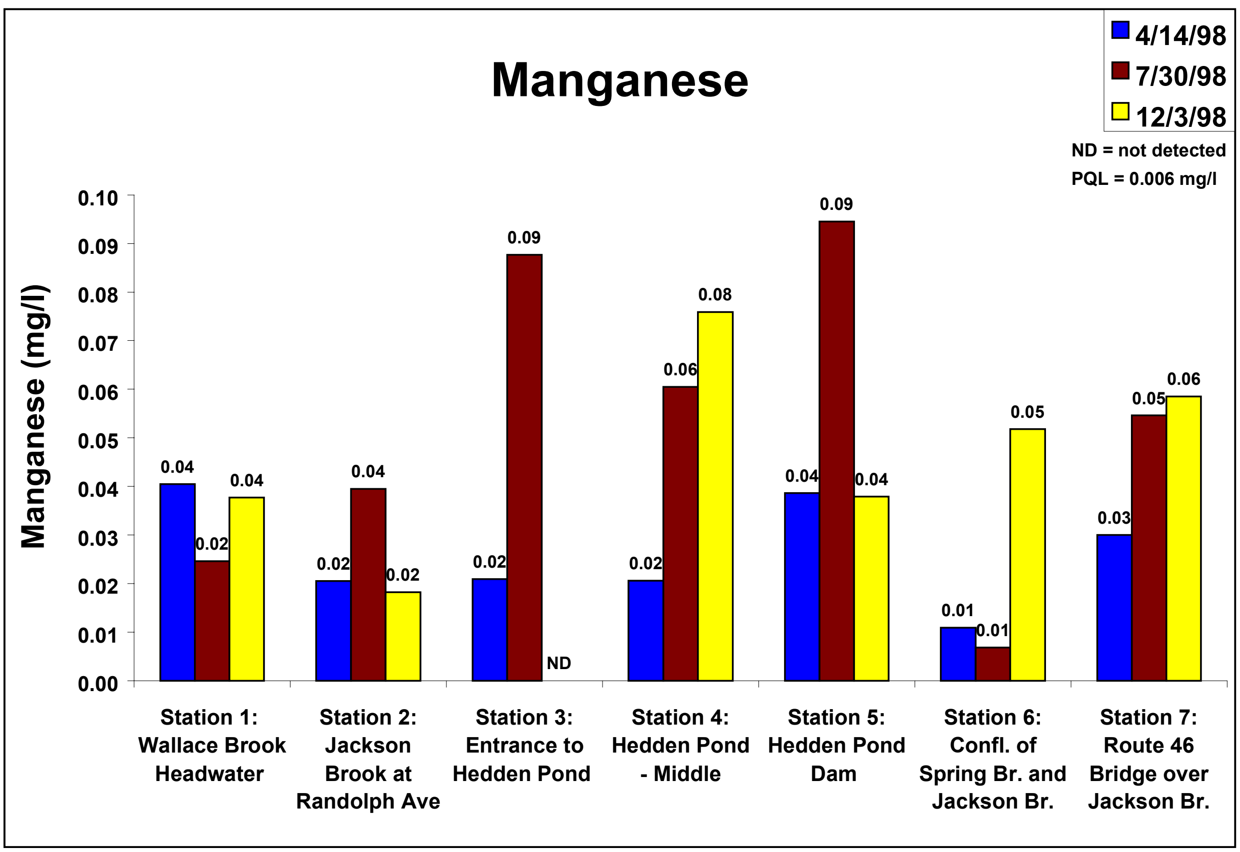


FIGURE 5-12: WATER QUALITY DATA – Manganese

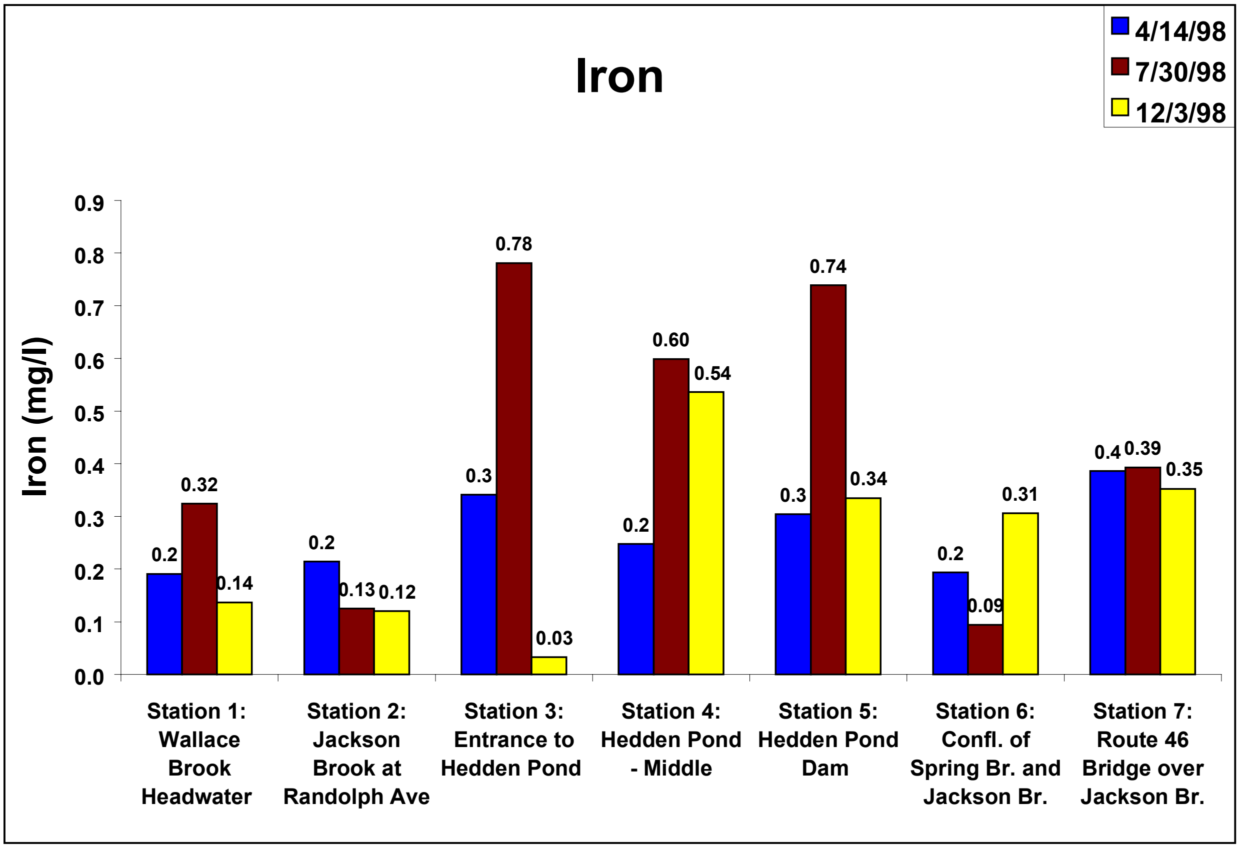


FIGURE 5-13 - WATER QUALITY DATA – Iron

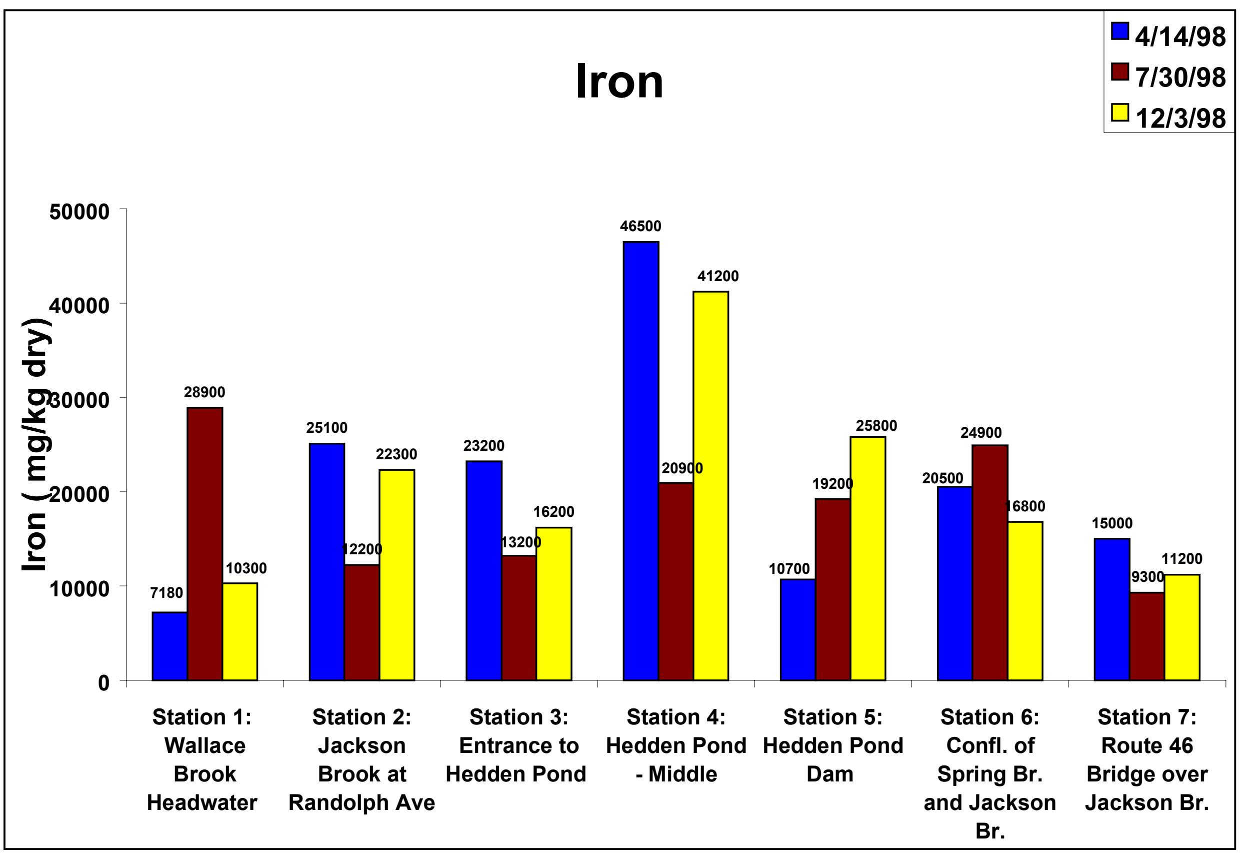


FIGURE 5-14 – SEDIMENT DATA – Iron

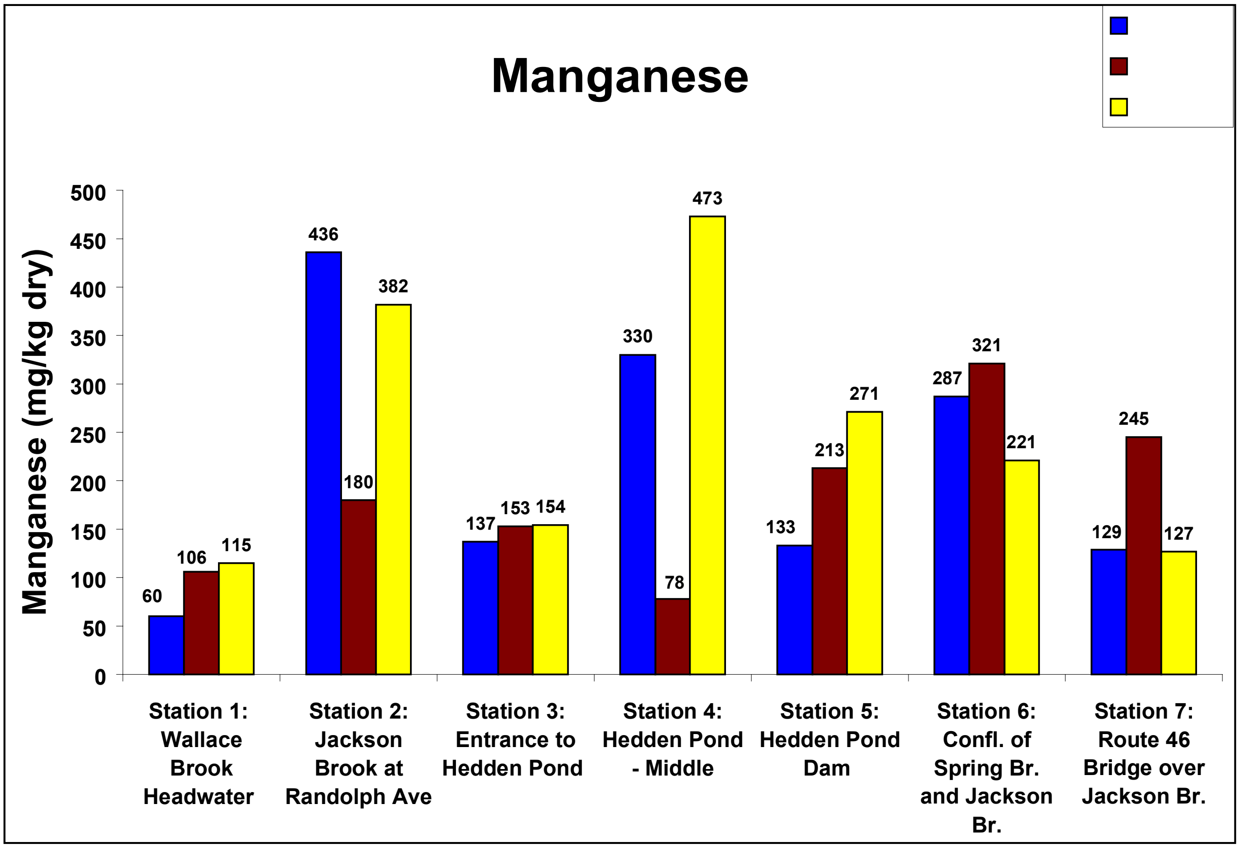


FIGURE 5-15 – SEDIMENT DATA – Maganese

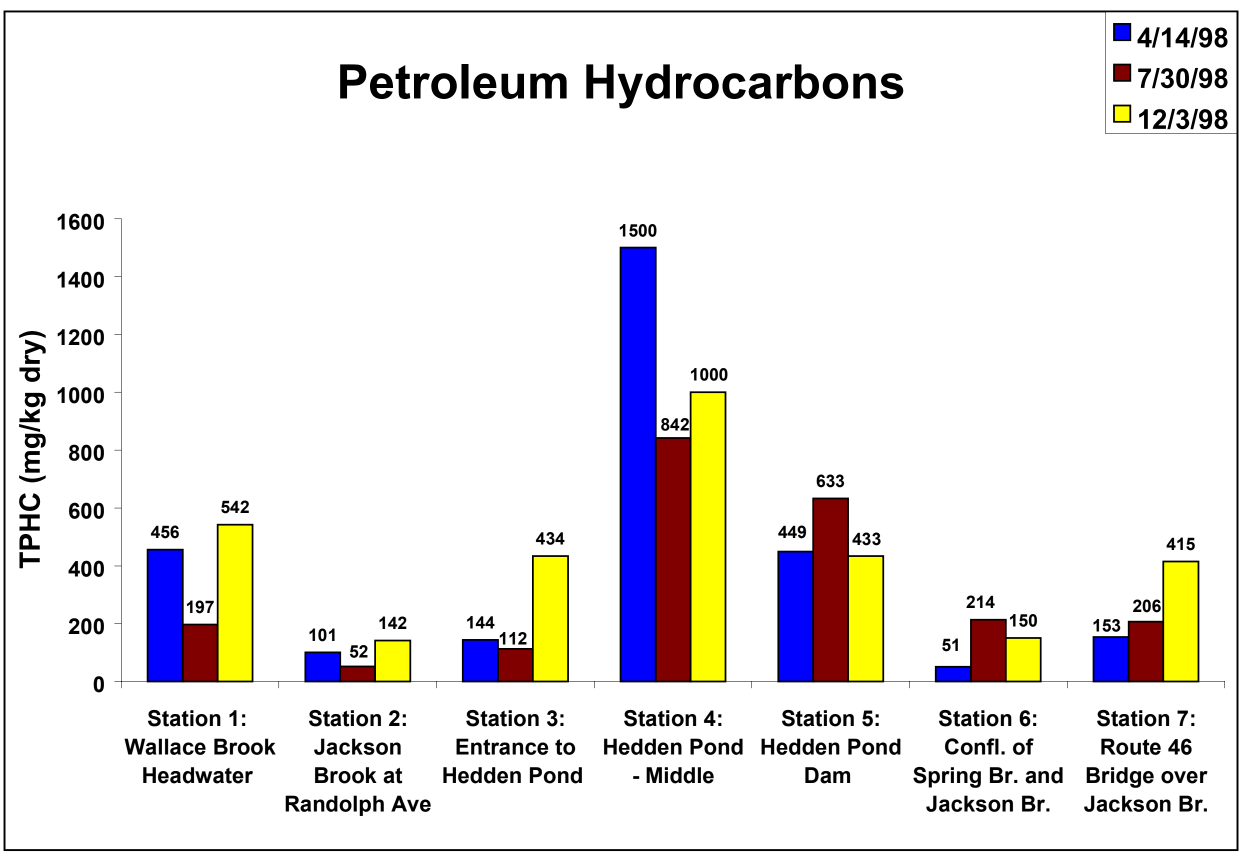


FIGURE 5-16: SEDIMENT DATA - Petroleum Hydrocarbons

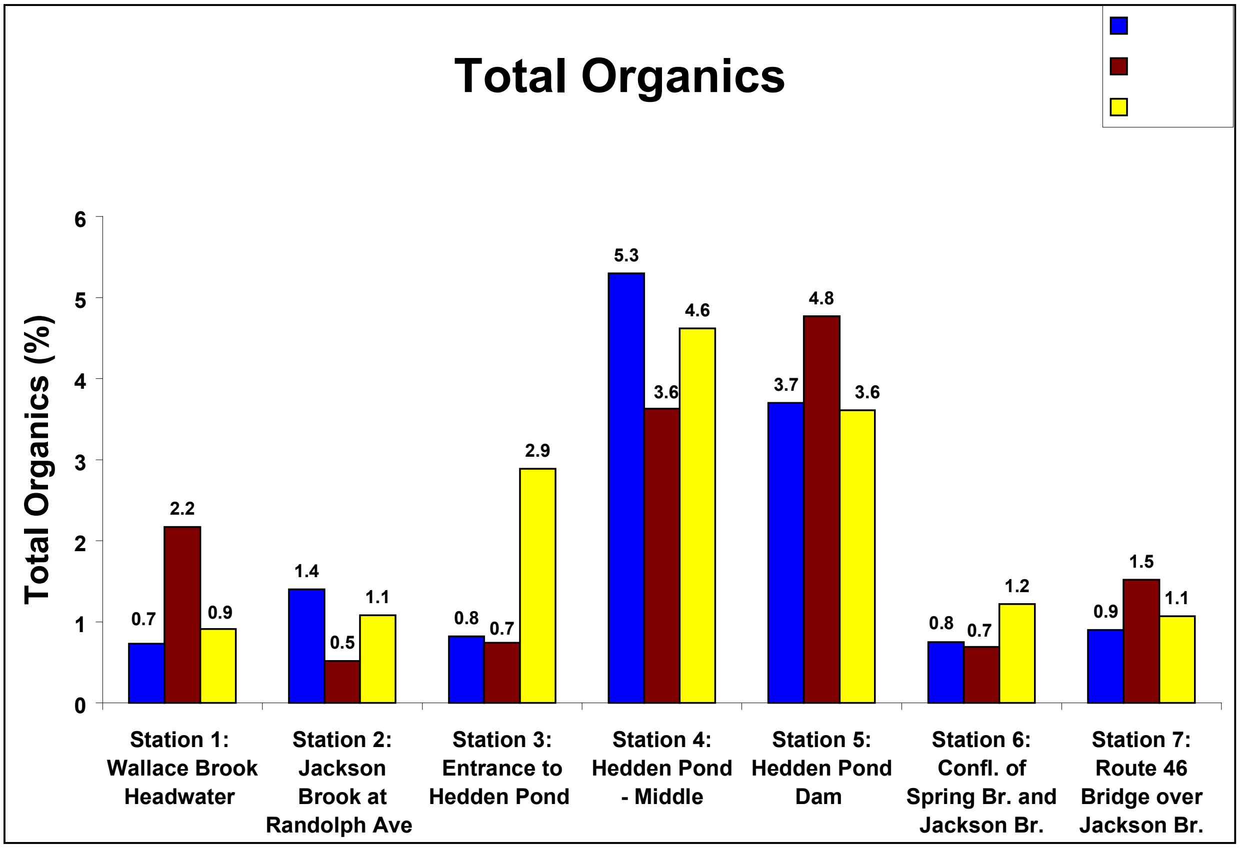


FIGURE 5-17: SEDIMENT DATA – Total Organics

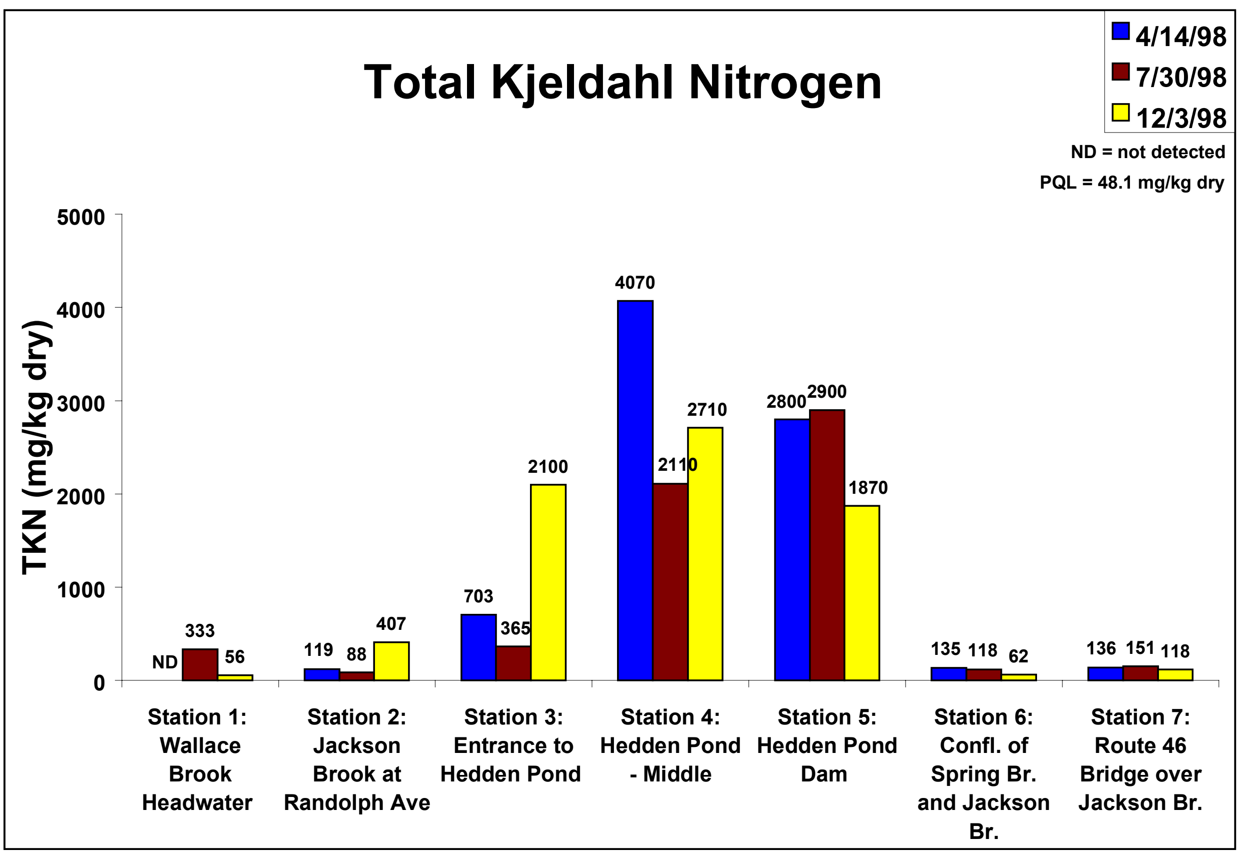


FIGURE 5-18: SEDIMENT DATA - Total Kjeldahl Nitrogen

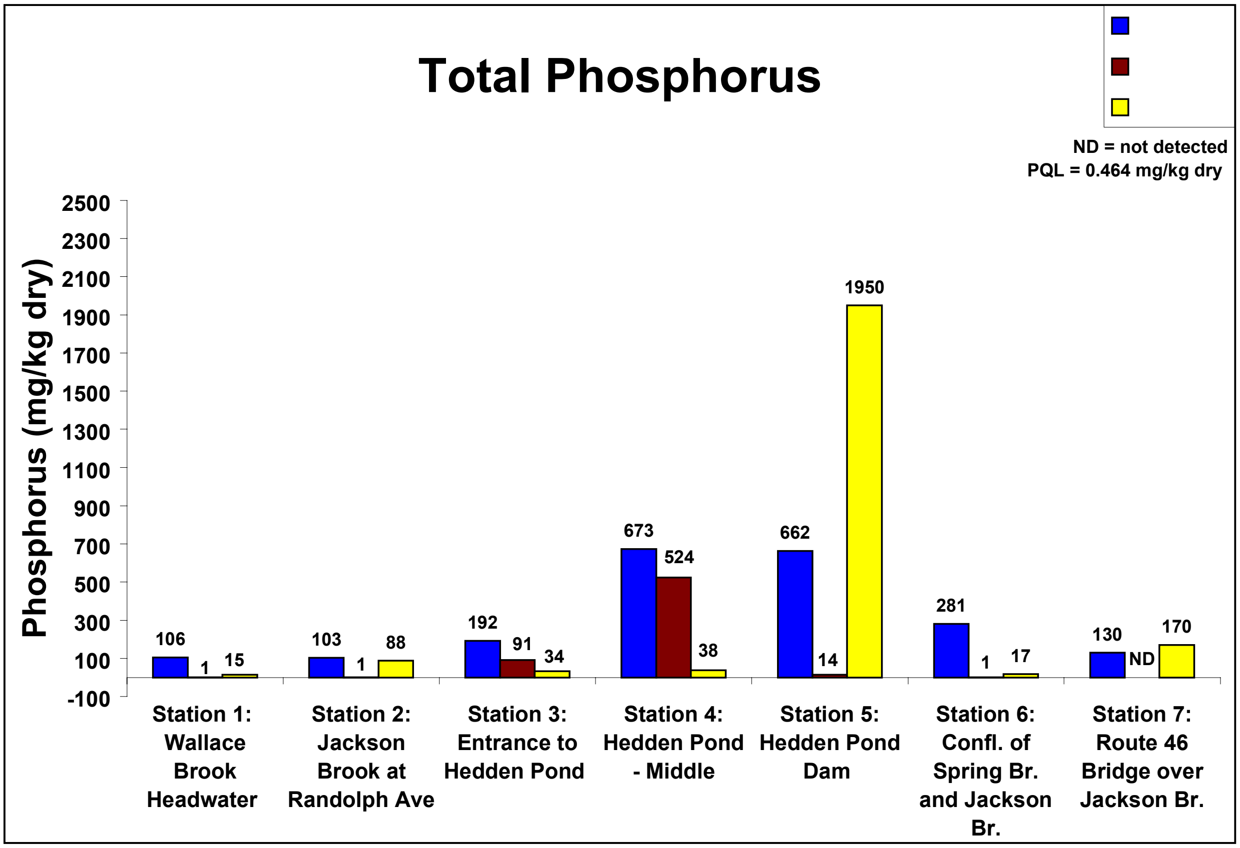


FIGURE 5-19: SEDIMENT DATA - Total Phosphorous

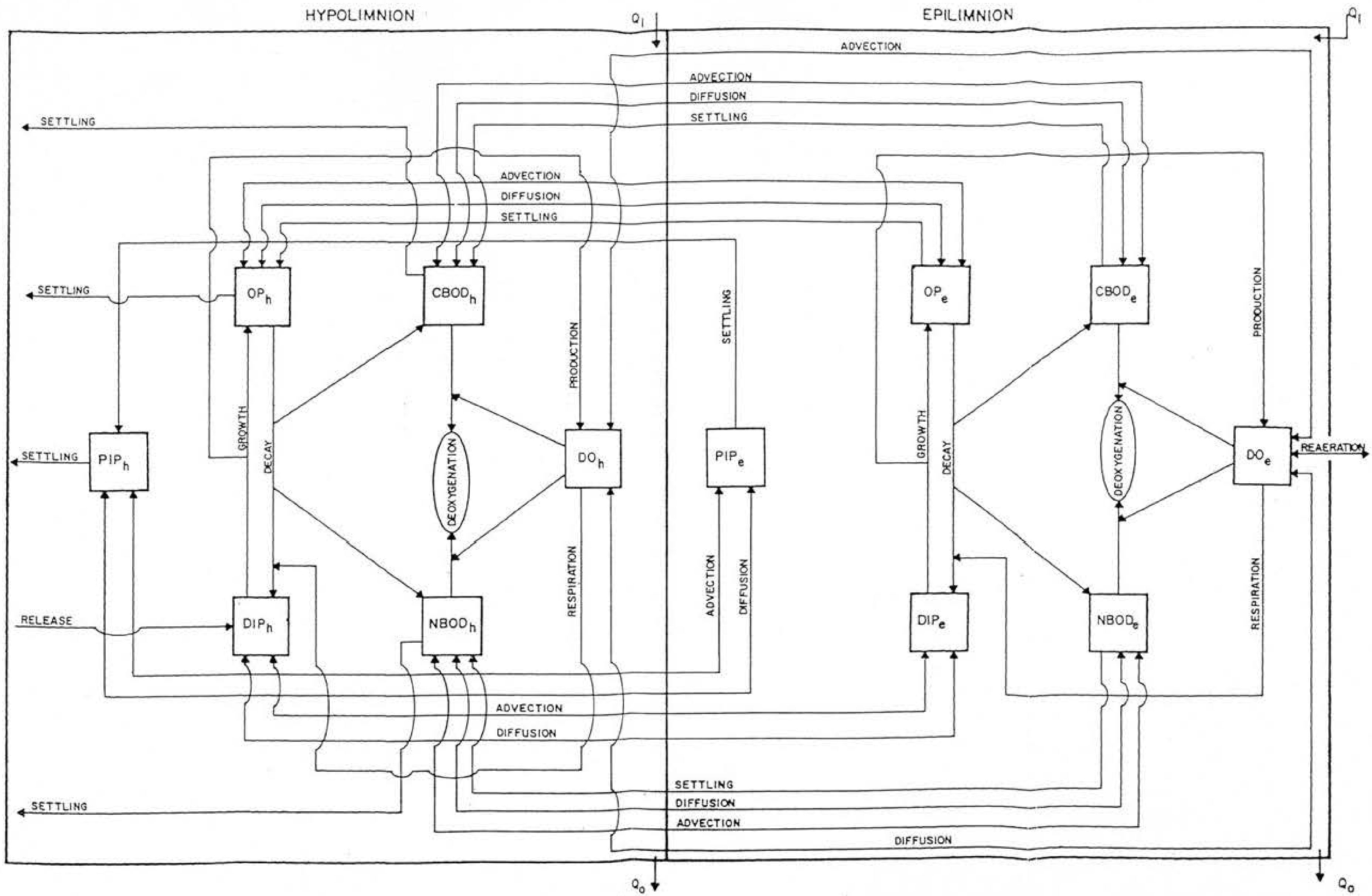


FIGURE 5.20 PMPDR Model Conceptualization

Current Drainage Basin Land Use Distribution

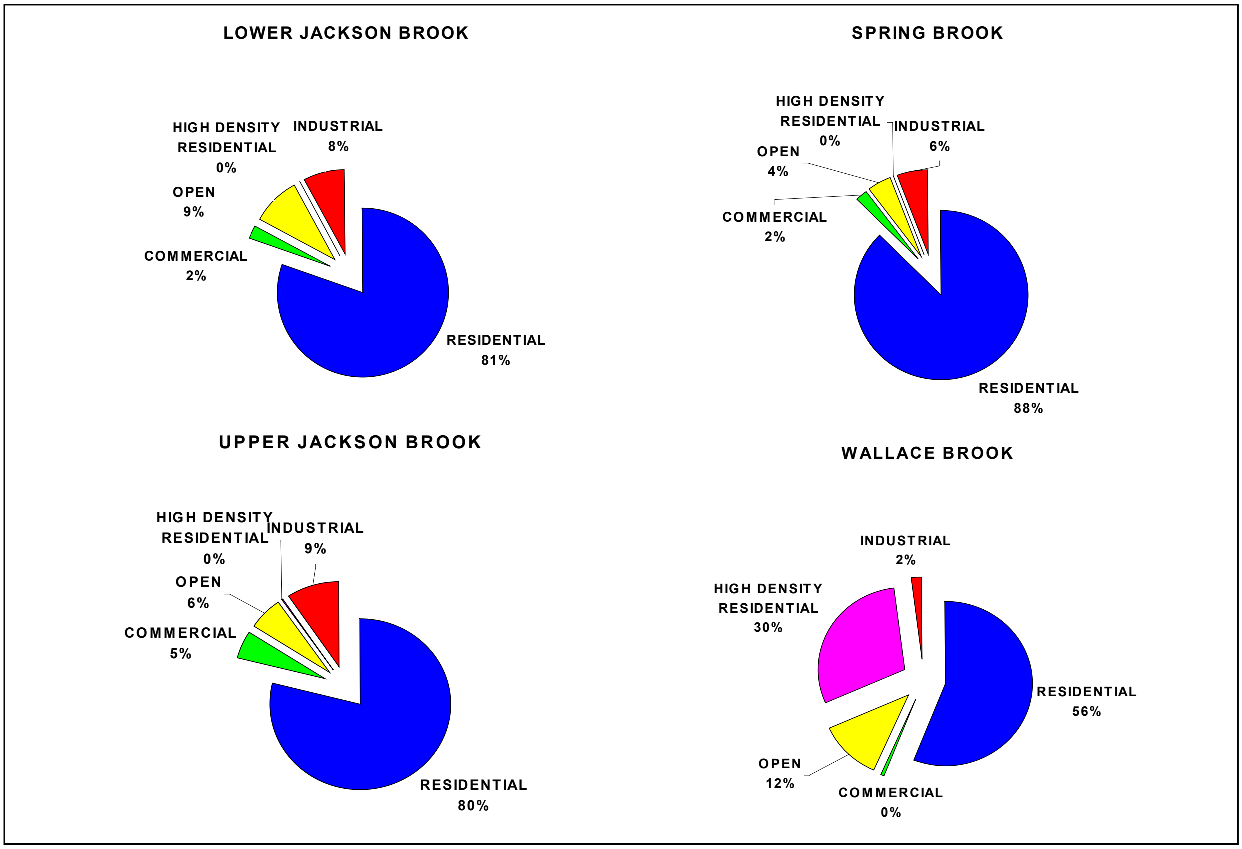


FIGURE 5-21: Jackson Brook drainage basin current land use distribution

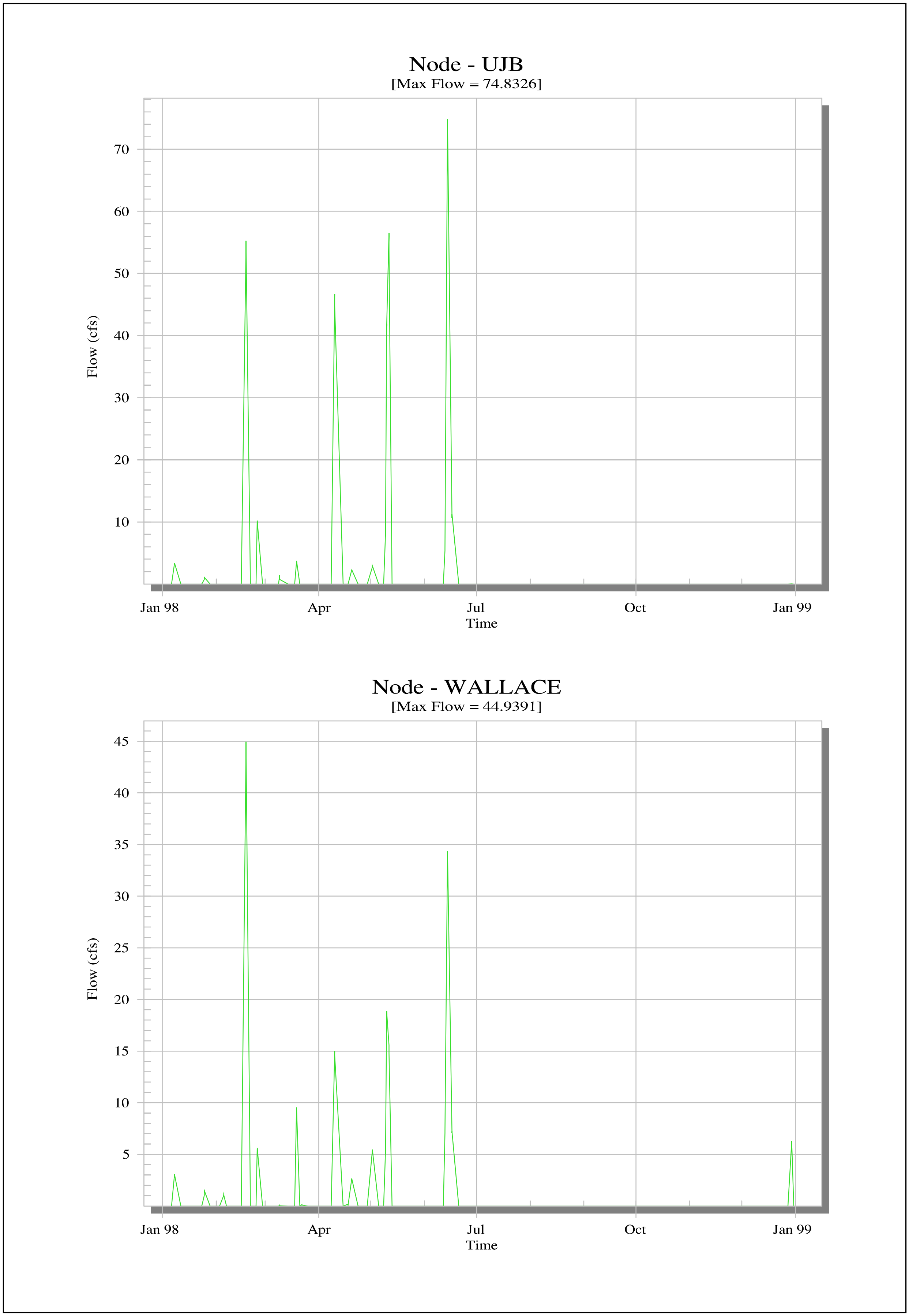


FIGURE 5-22: Computed stormwater flow rates of Upper Jackson Brook and Wallace Brook

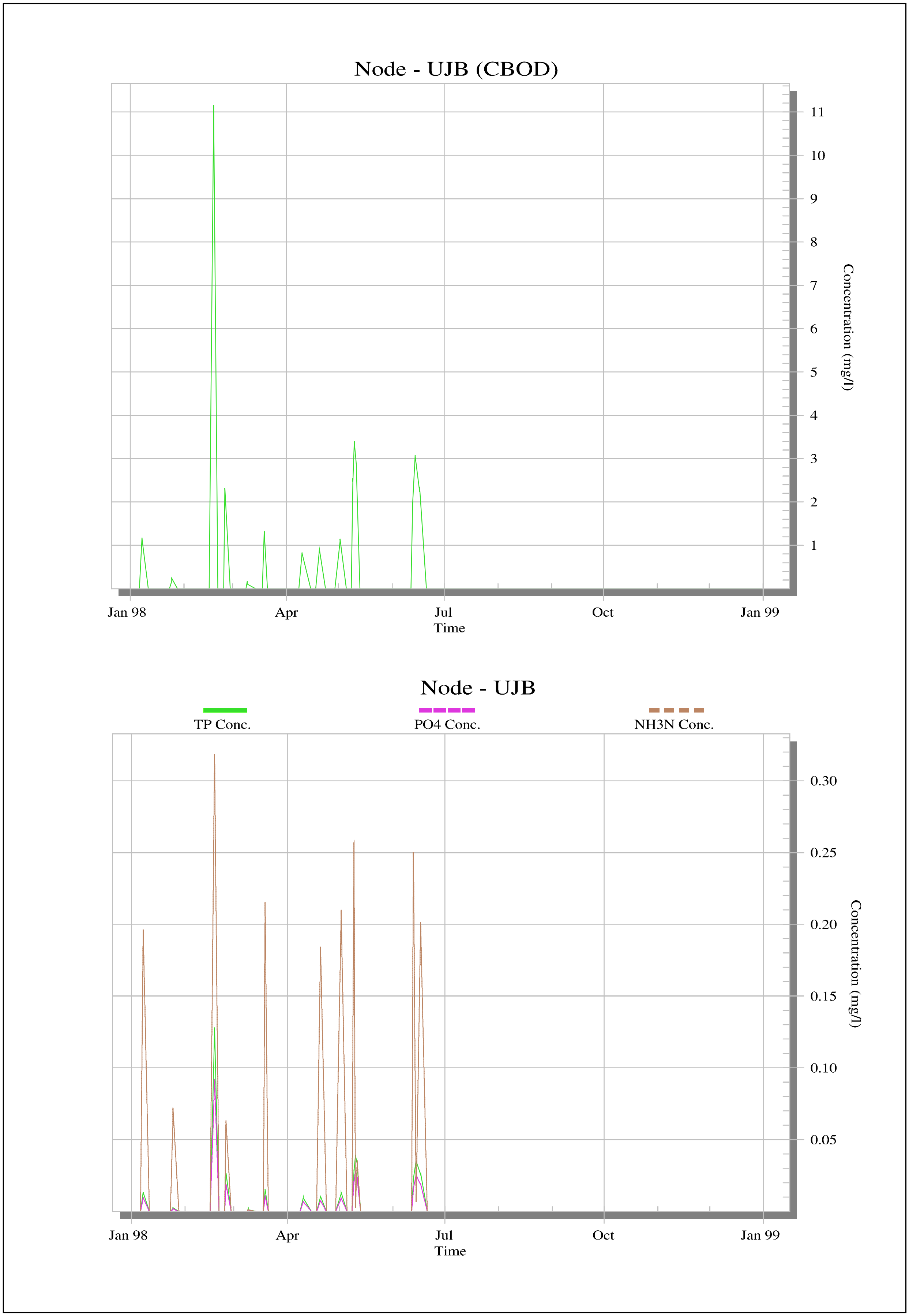
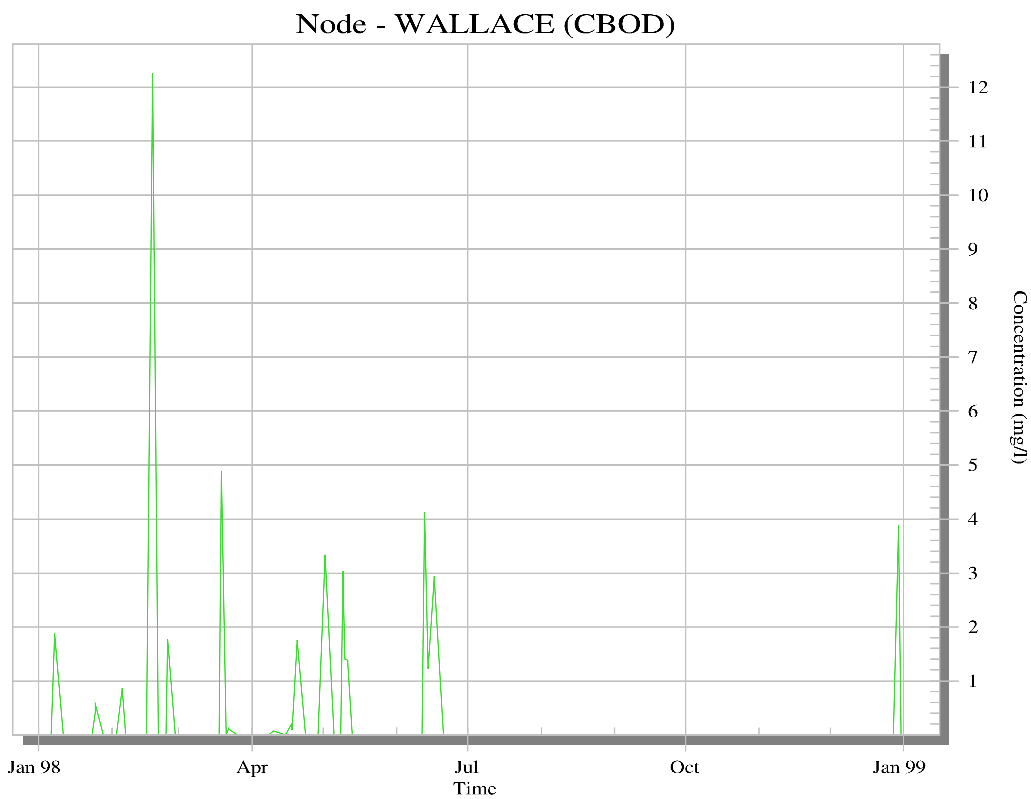


FIGURE 5-23: Computed stormwater pollutant concentrations of Upper Jackson Brook



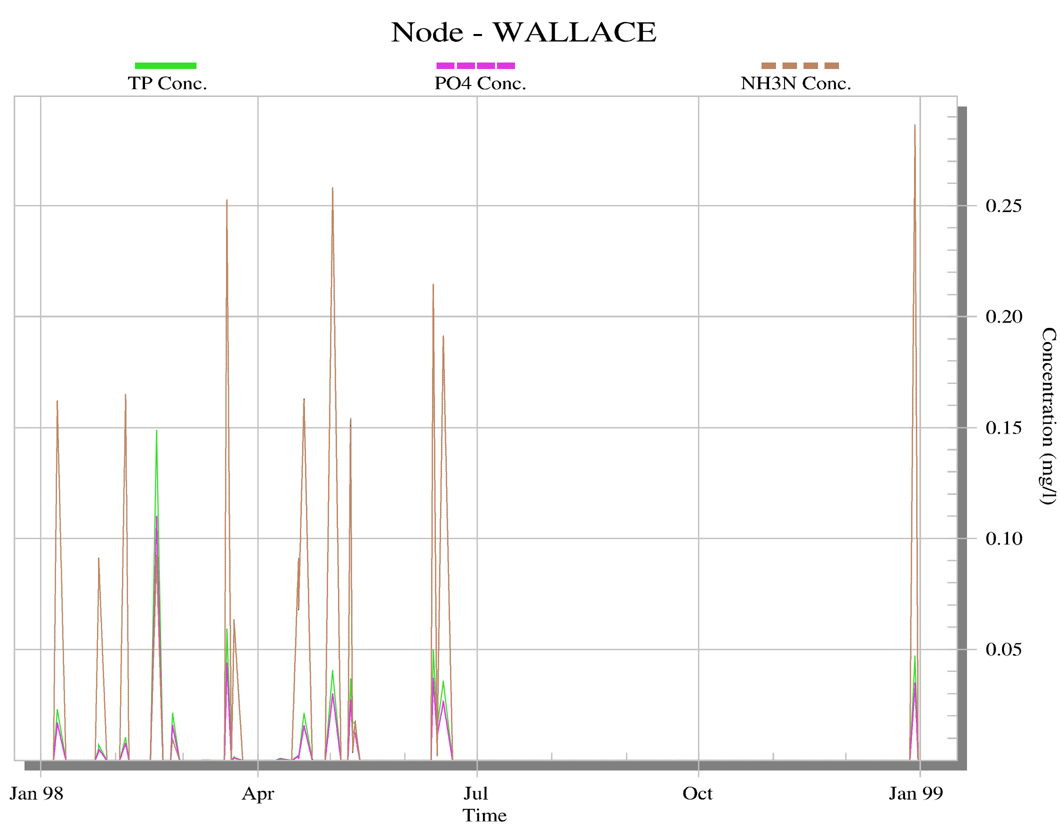


FIGURE 5-24: Computed stormwater pollutant concentrations at Wallace Brook

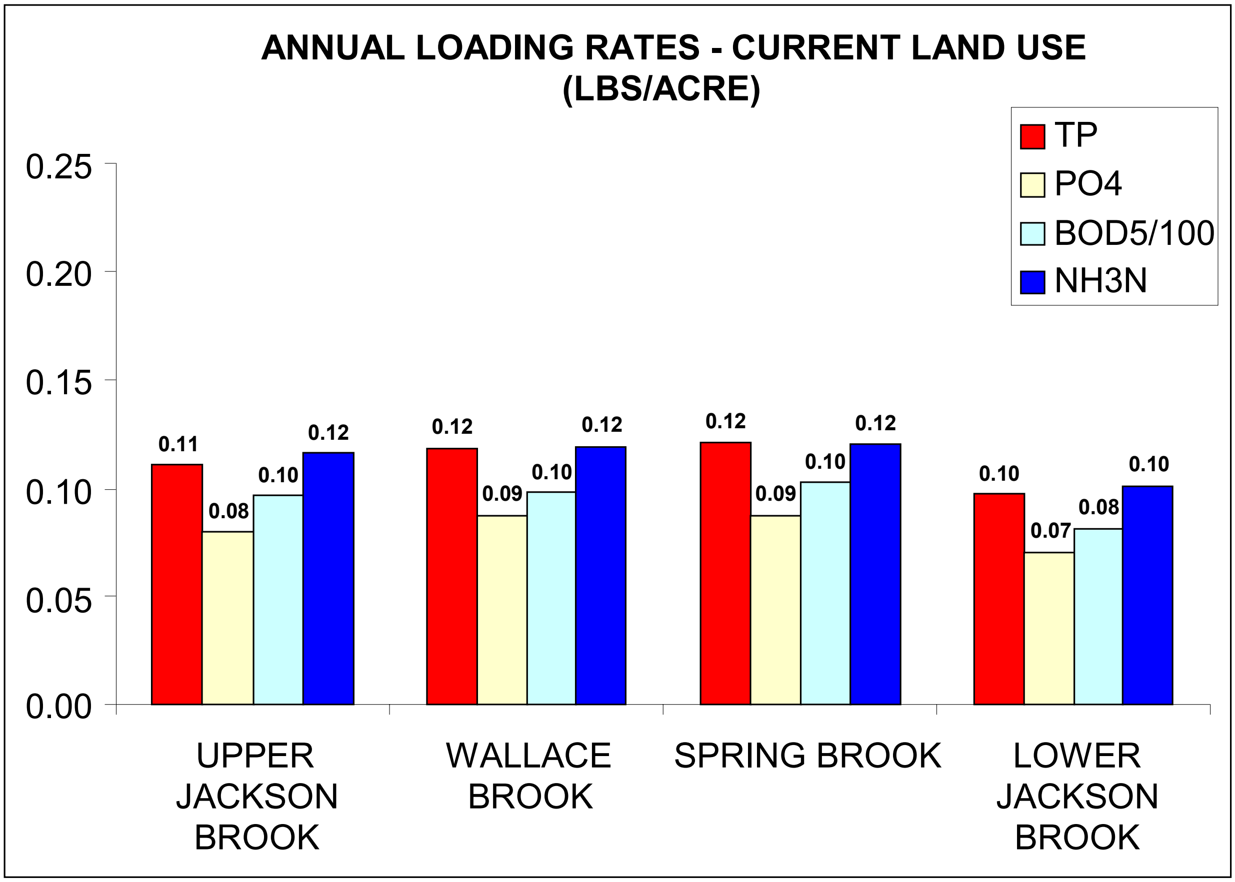


FIGURE 5-25: Annual pollutant loading rate – current land use

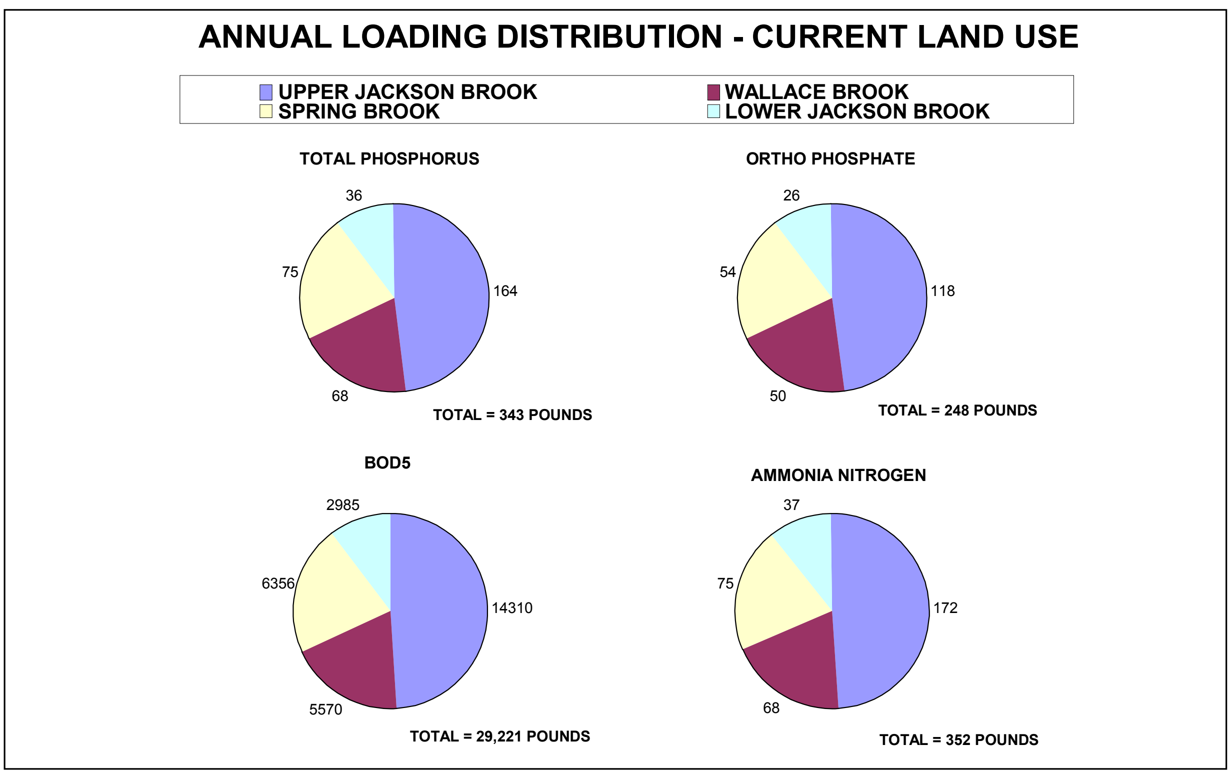


FIGURE 5-26: Annual pollutant loading distribution – current land use

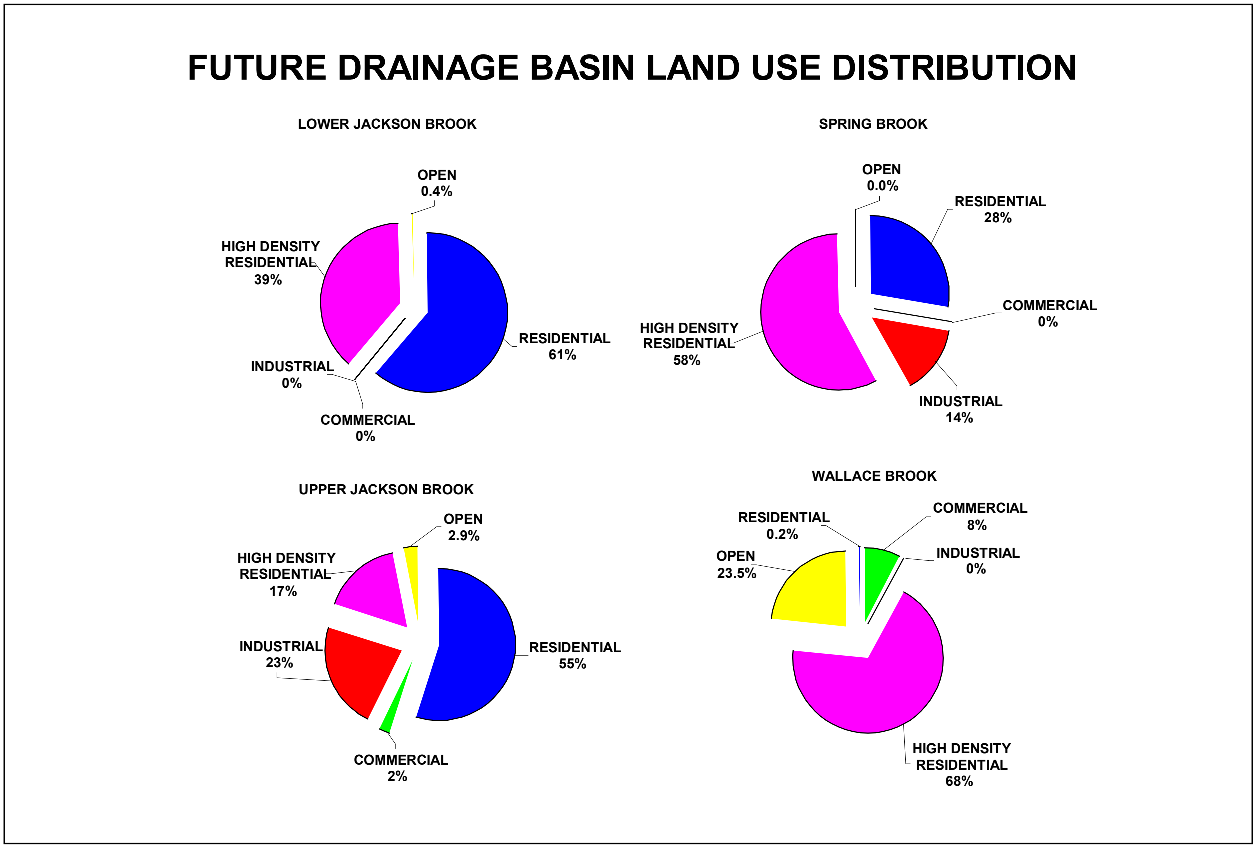


FIGURE 5-27: Jackson Brook drainage basin future land use distribution (based upon zoning build-out)

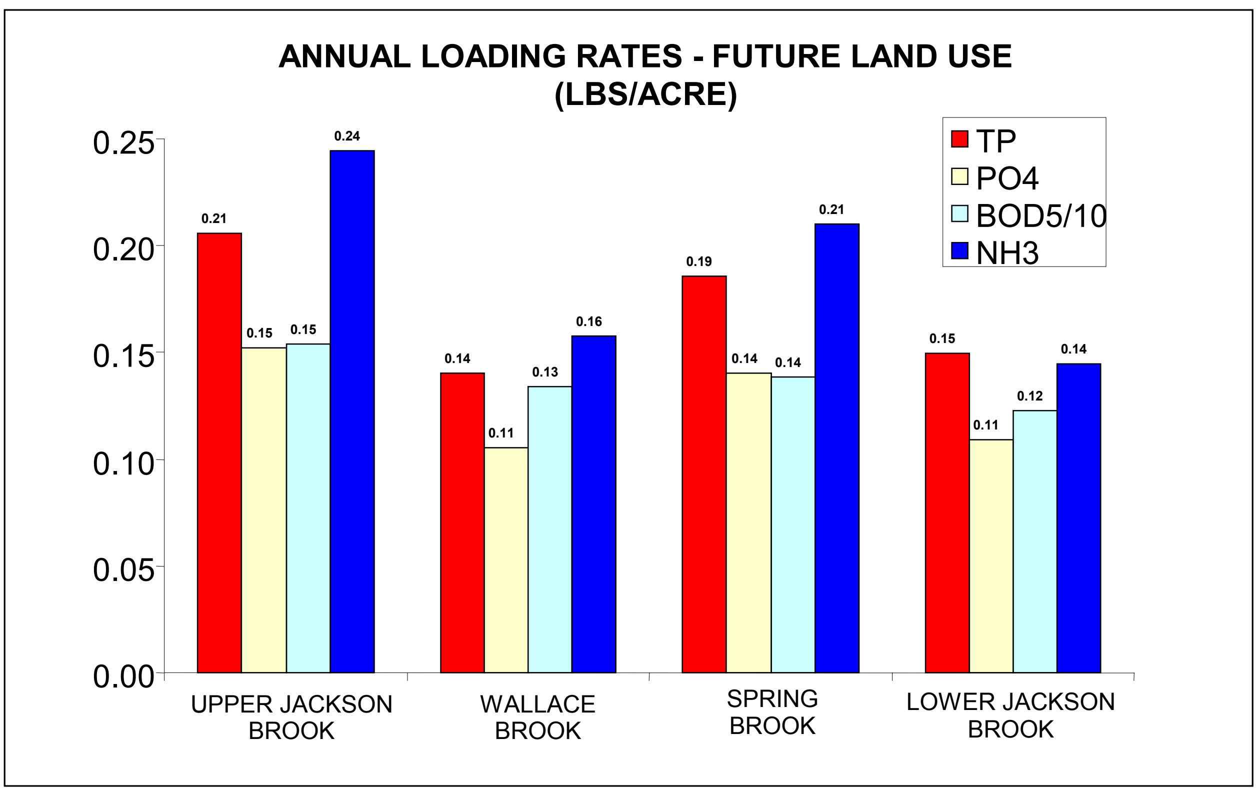


FIGURE 5-28: Annual pollutant loading rates- future land use (based upon zoning build-out)

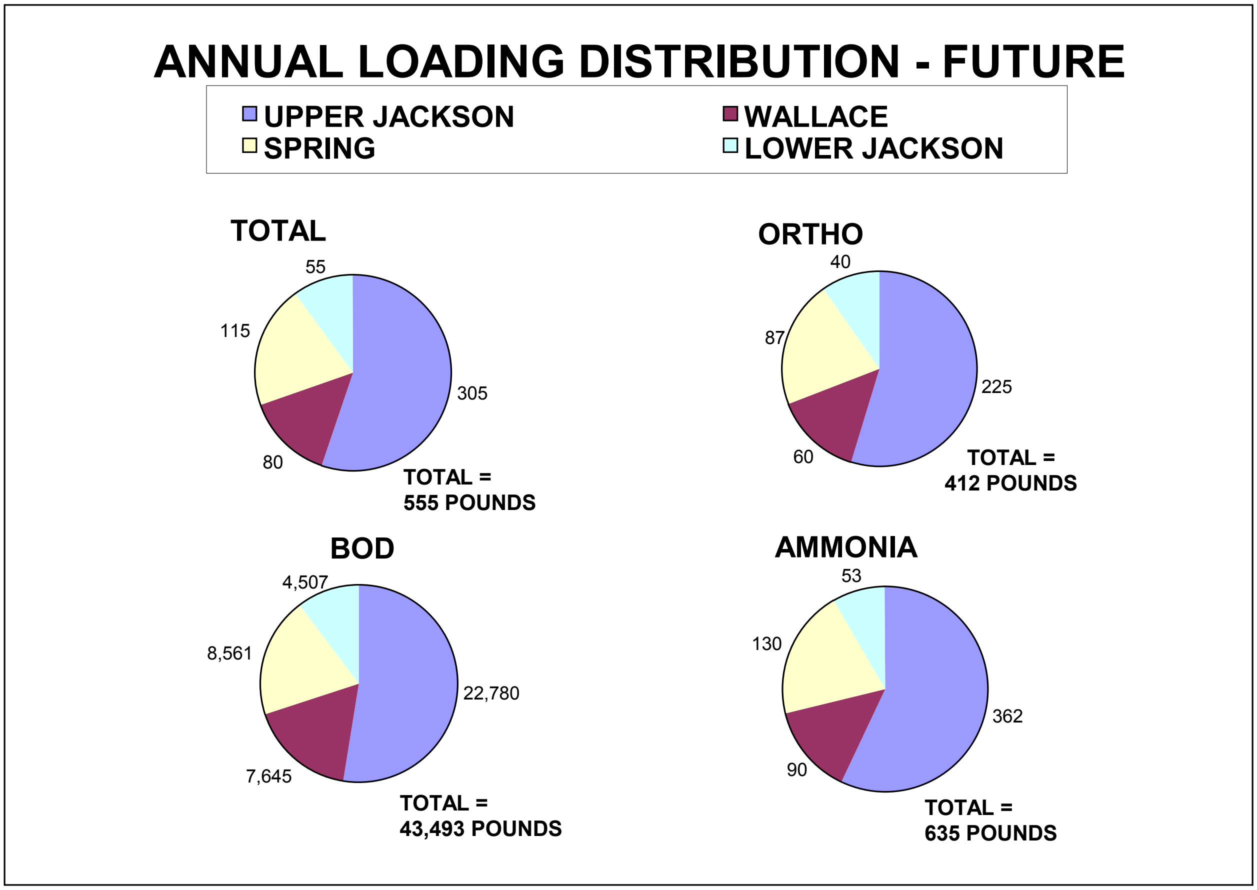


FIGURE 5-29: Annual pollutant loading distribution – future land use (based upon zoning build-out)

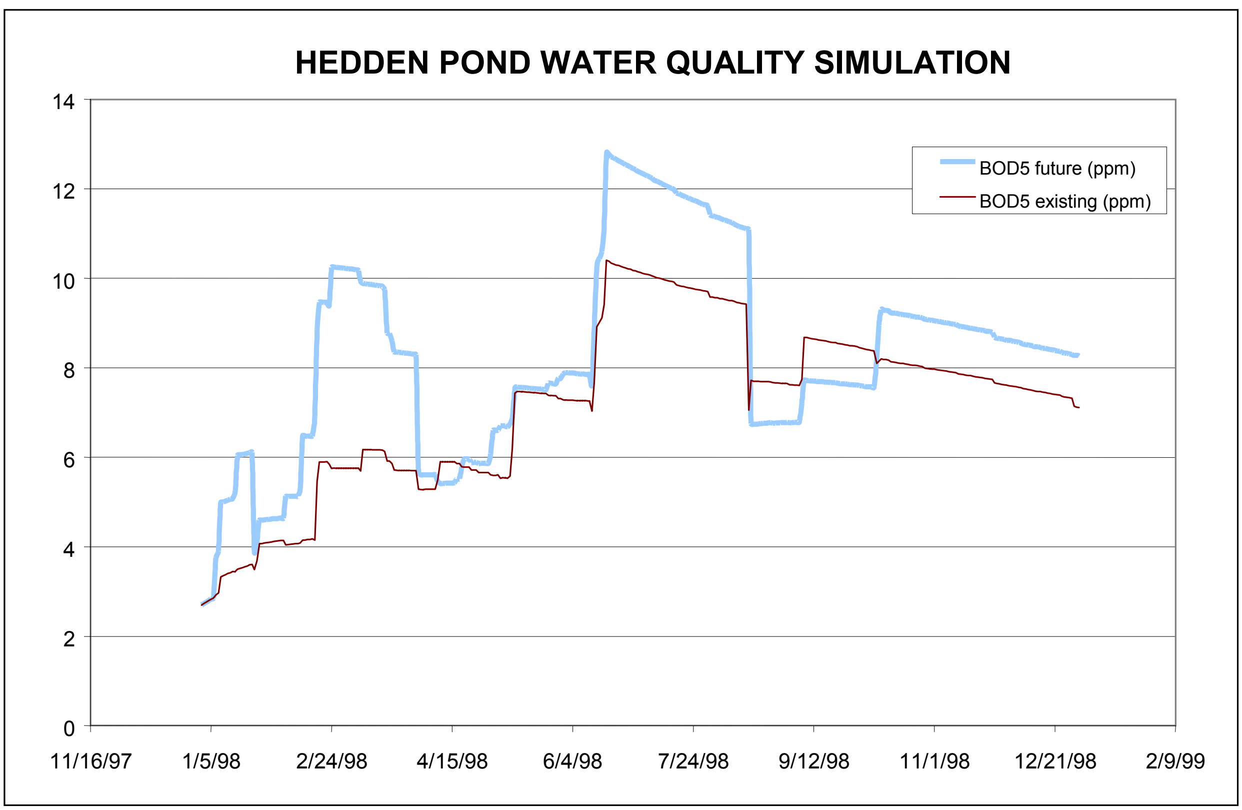


FIGURE 5-30: Simulated BOD concentrations under current and future land use (based upon zoning build-out) scenarios

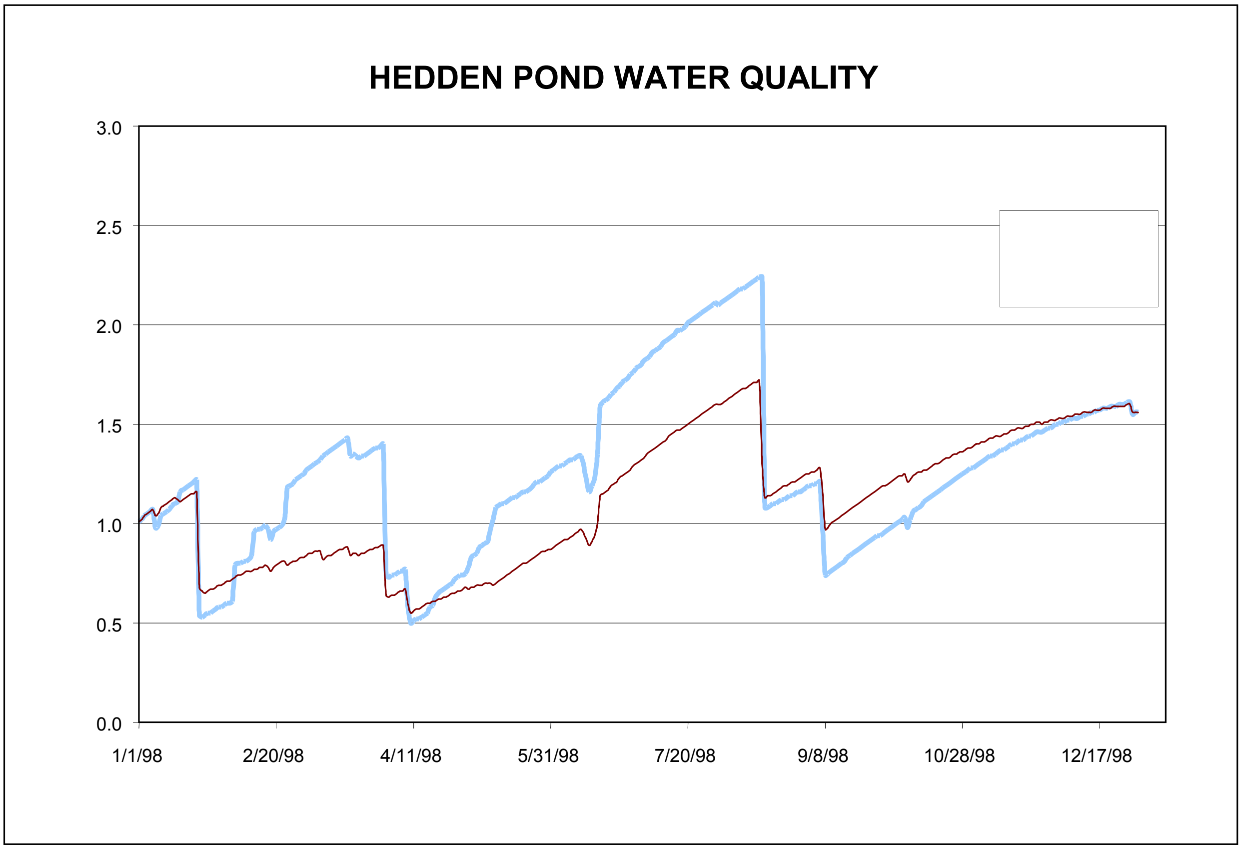


FIGURE 5-31: Simulated NBOD concentrations under current and future land use (based upon zoning build-out) scenarios

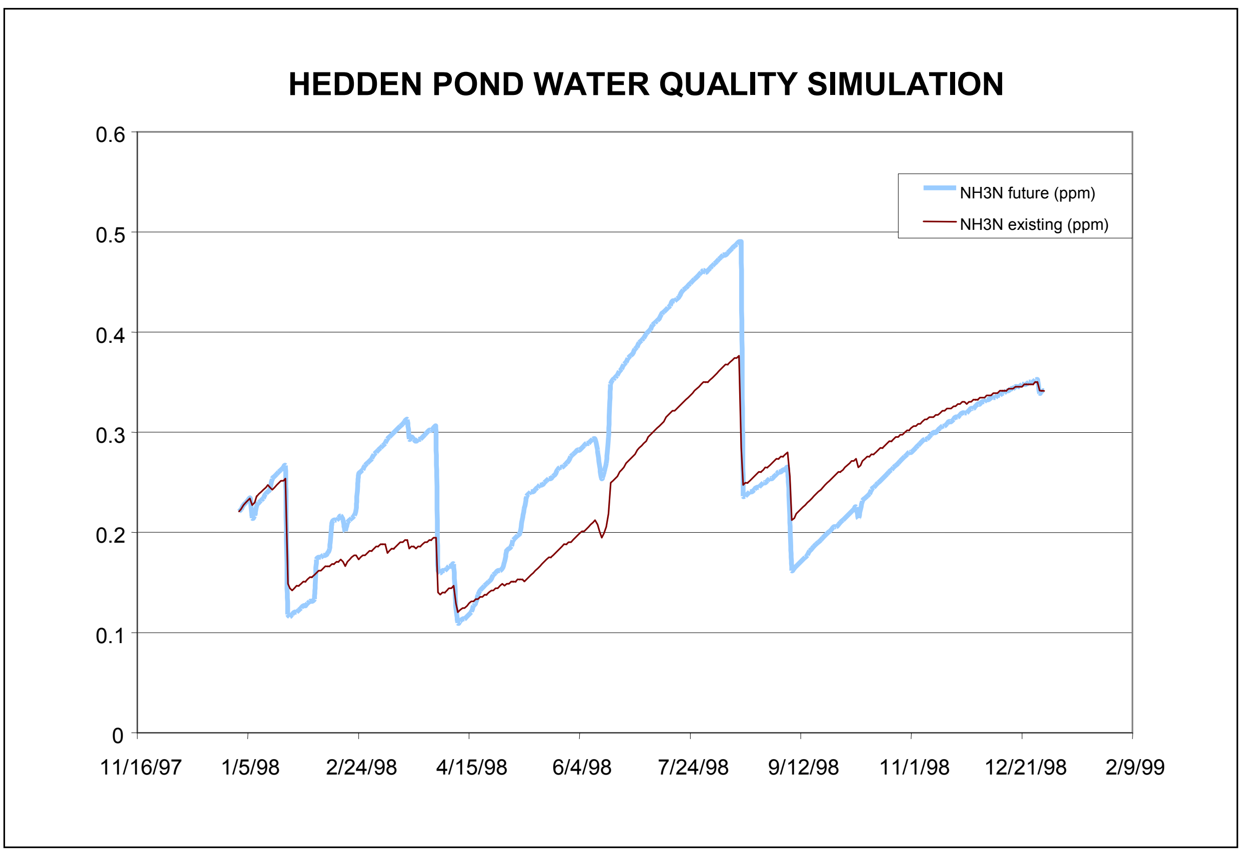


FIGURE 5-32: Simulated Ammonia Nitrogen concentrations under current and future land use (zoning build-out)

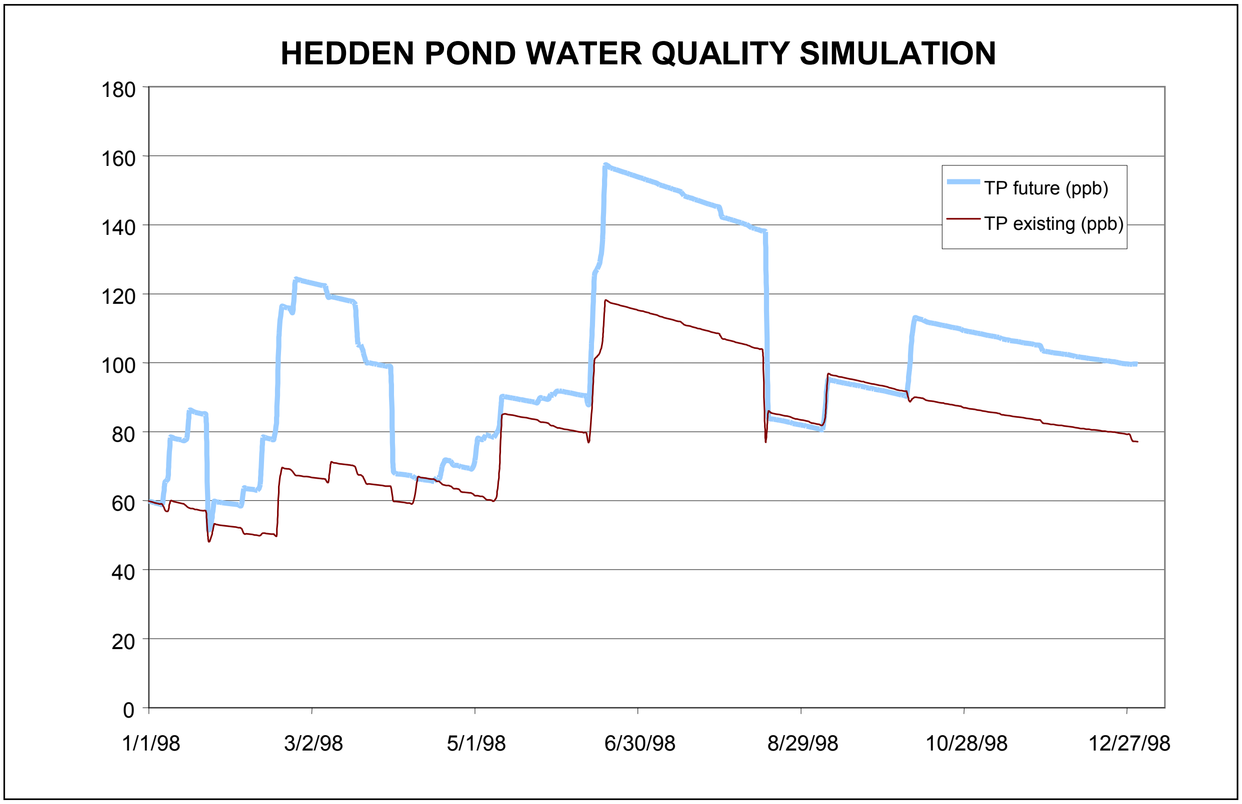


FIGURE 5-33: Simulated Total Phosphorous concentrations under current and future land use (zoning build-out)

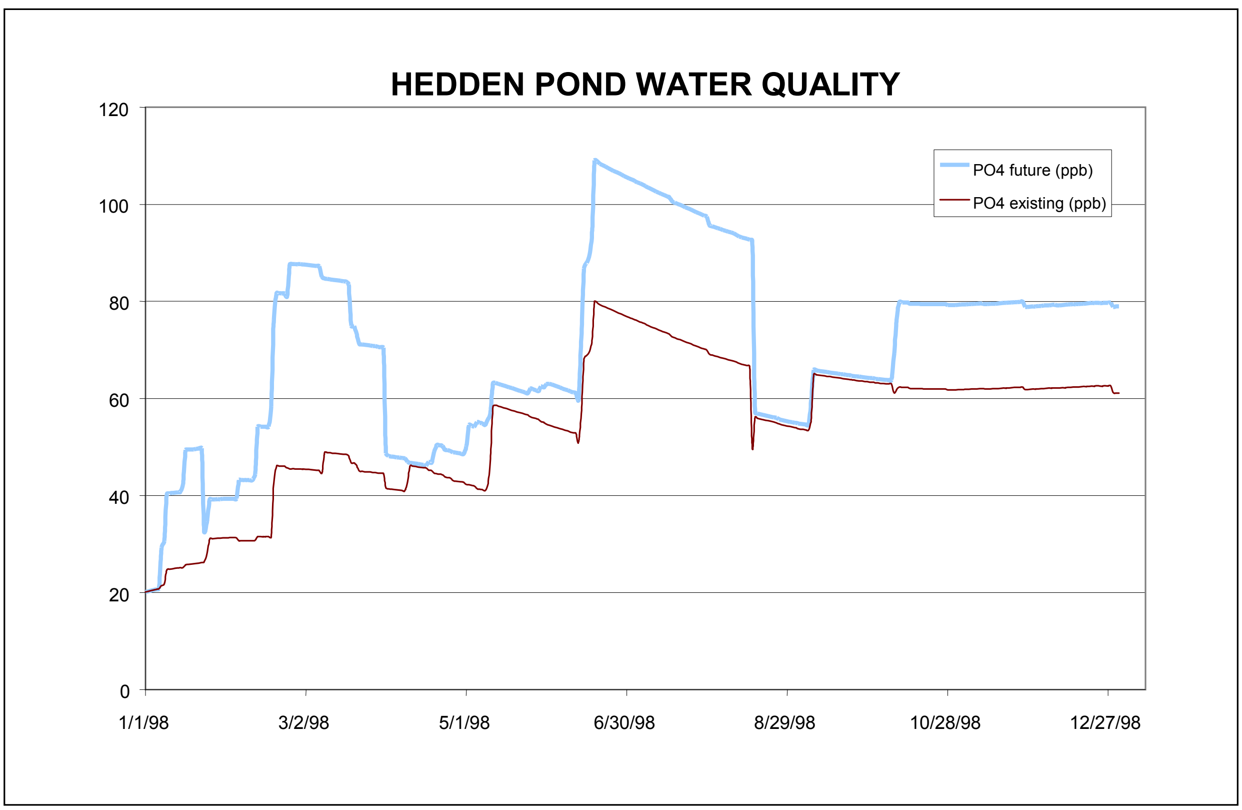


FIGURE 5-34: Simulated Ortho-Phosphate concentrations under current and future land use (zoning build-out)

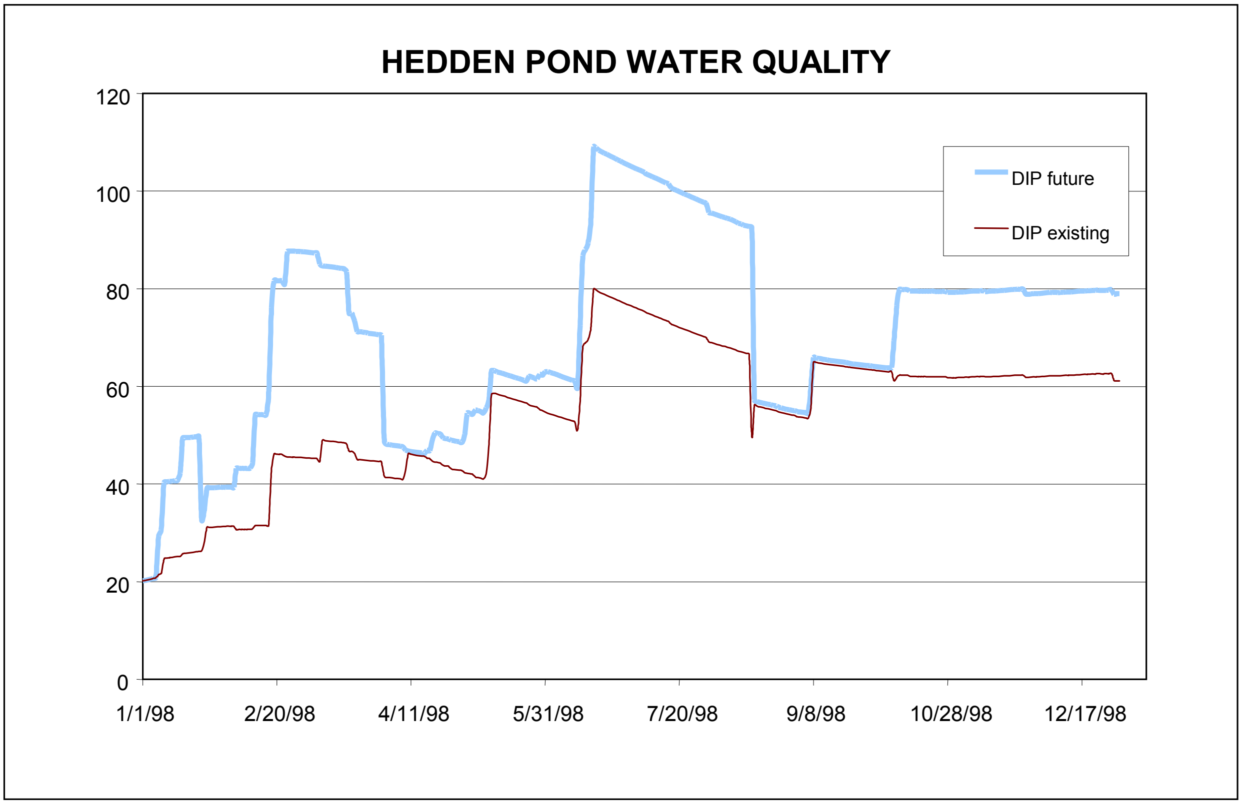


FIGURE 5-35: Simulated Dissolved Inorganic Phosphorous concentrations under current and future land use

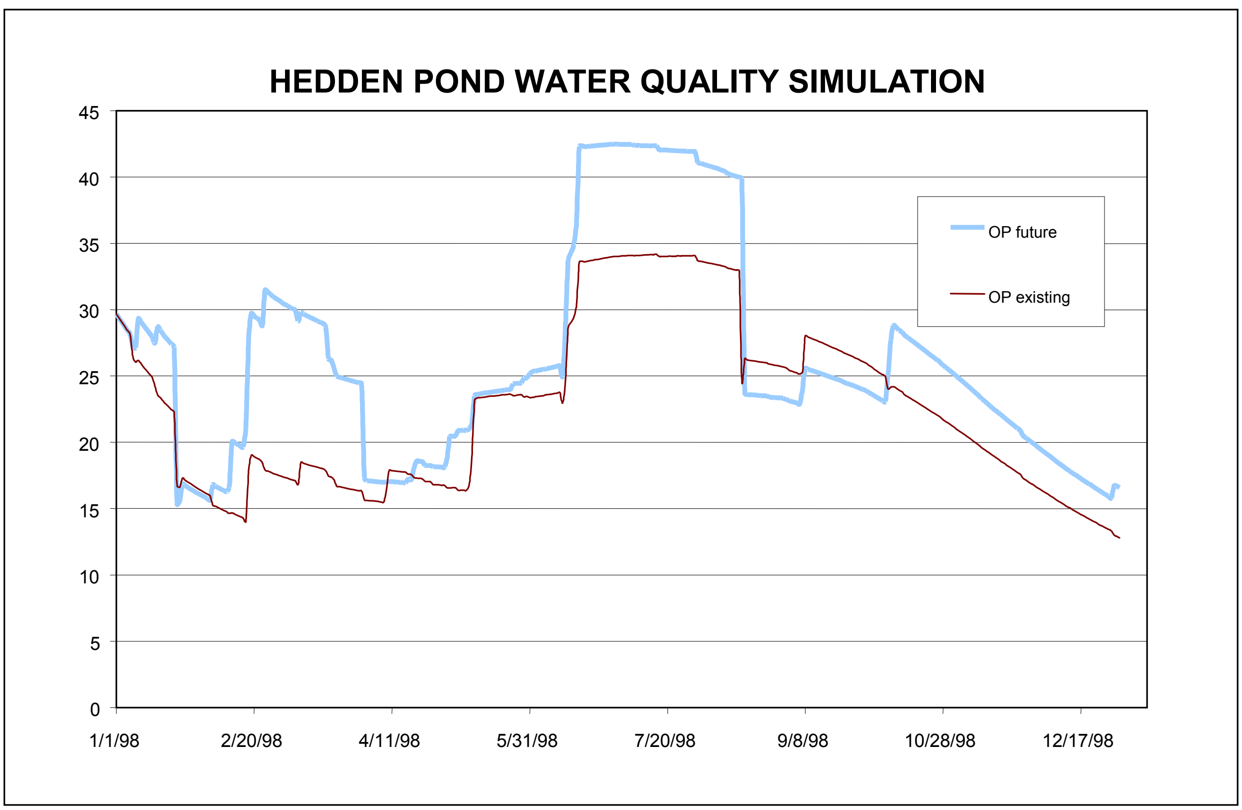


FIGURE 5-36: Simulated Organic Phosphorous concentrations uuner current and future land use (zoning build-out)

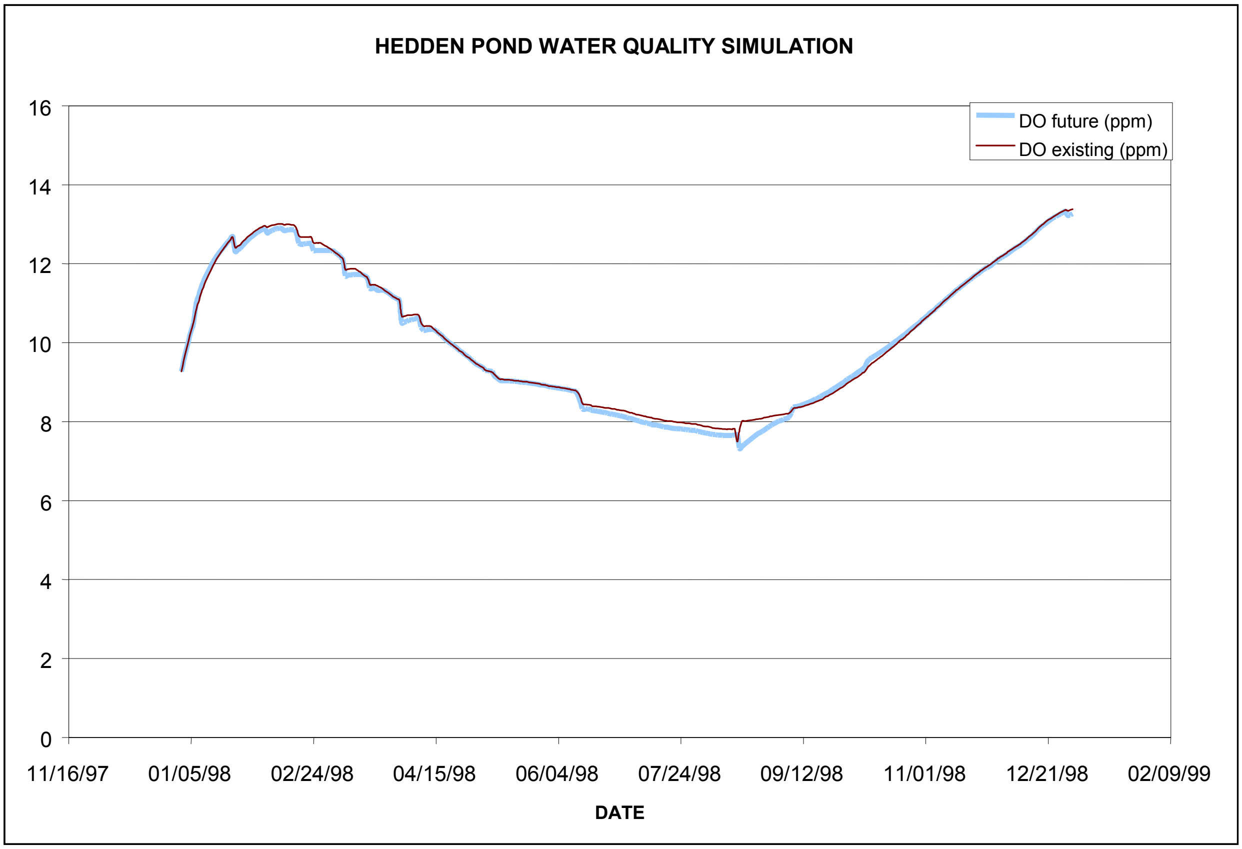


FIGURE 5-37: Simulated dissolved Oxygen concentrations under current and future land use (zoning build-out)

6.0 STORMWATER MANAGEMENT CONTROL PLANS

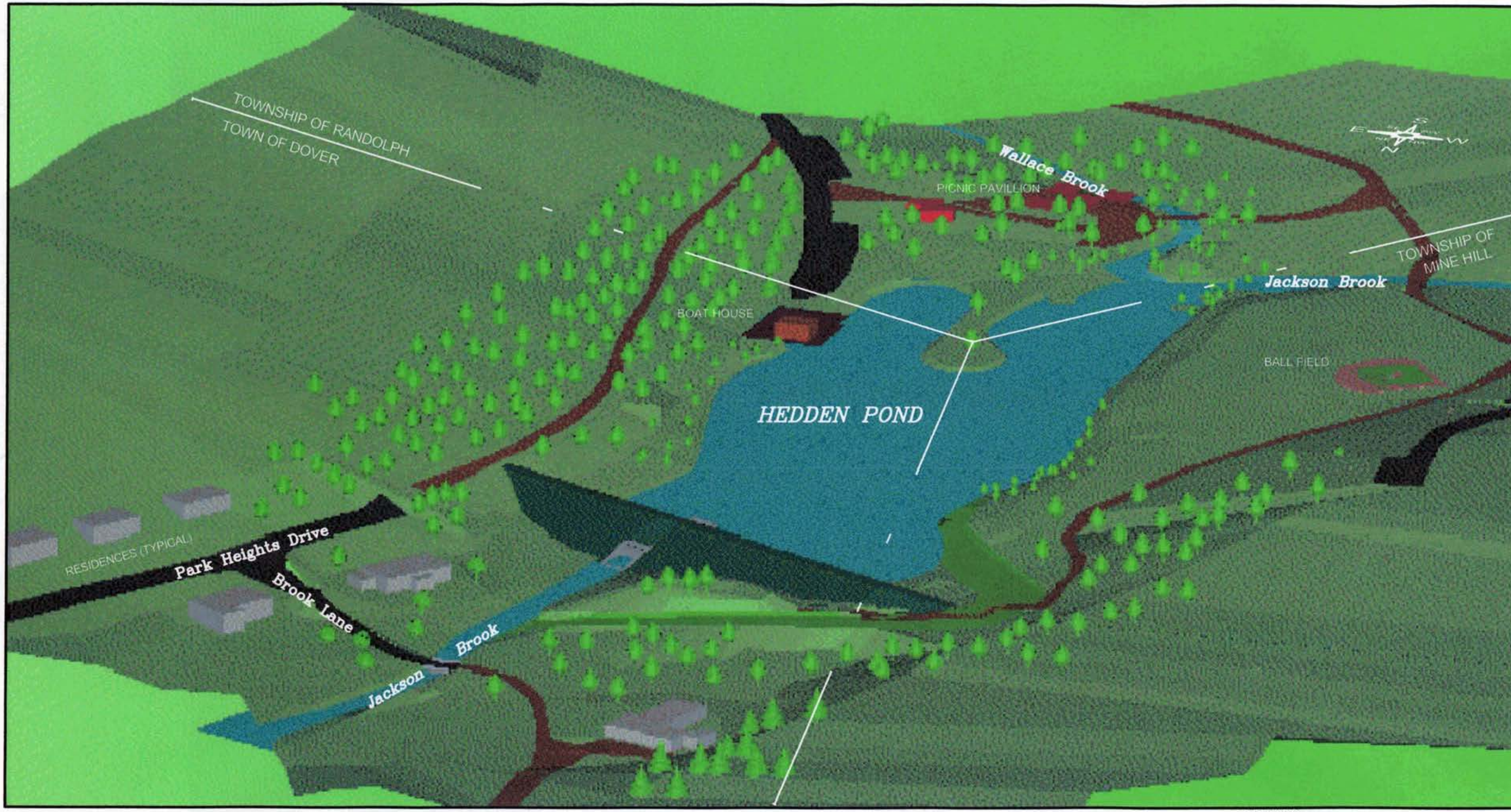
Alternative stormwater management plans were formulated for controlling the projected increases in stormwater flows and volumes resulting from future land development within the study area. The main objective of the study is to develop a stormwater management plan that will effectively manage the stormwater flows within the watershed and alleviate existing flooding problems while not creating any new drainage problem areas. The stormwater management controls considered include both structural and nonstructural improvement measures.

6.1 Structural Controls

Structural stormwater management improvements involve the construction or modification of physical facilities for stormwater and soil erosion control and flood alleviation. Structural improvement measures were considered at six locations within the watershed which are summarized below.

Improvement 1 – Reconstruction of Hedden Pond Dam and Retention Basin

Improvement 1 involves the reconstruction of the weir and the removal of accumulated sediment at Hedden Pond within Hedden Park. The existing weir has a 50-foot-wide spillway and depth of 4 feet and an earth embankment section with a concrete retaining wall of length equal to 231 feet. The new dam is an earth embankment structure approximately 595 feet long and 24 feet maximum height (above its downstream toe) complete with primary spillway outlet works and emergency spillway. A perspective view of the proposed Hedden Pond Dam within the Hedden Park setting is shown on Figure 6. The conceptual plan layout including section and elevation views are shown on Figure 7. The implementation of the proposed new dam and retention basin will provide 100-year level flood protection and alleviate the chronic flooding problems on the Lower Jackson Brook. The estimated probable construction cost of this improvement is $1,925,00.



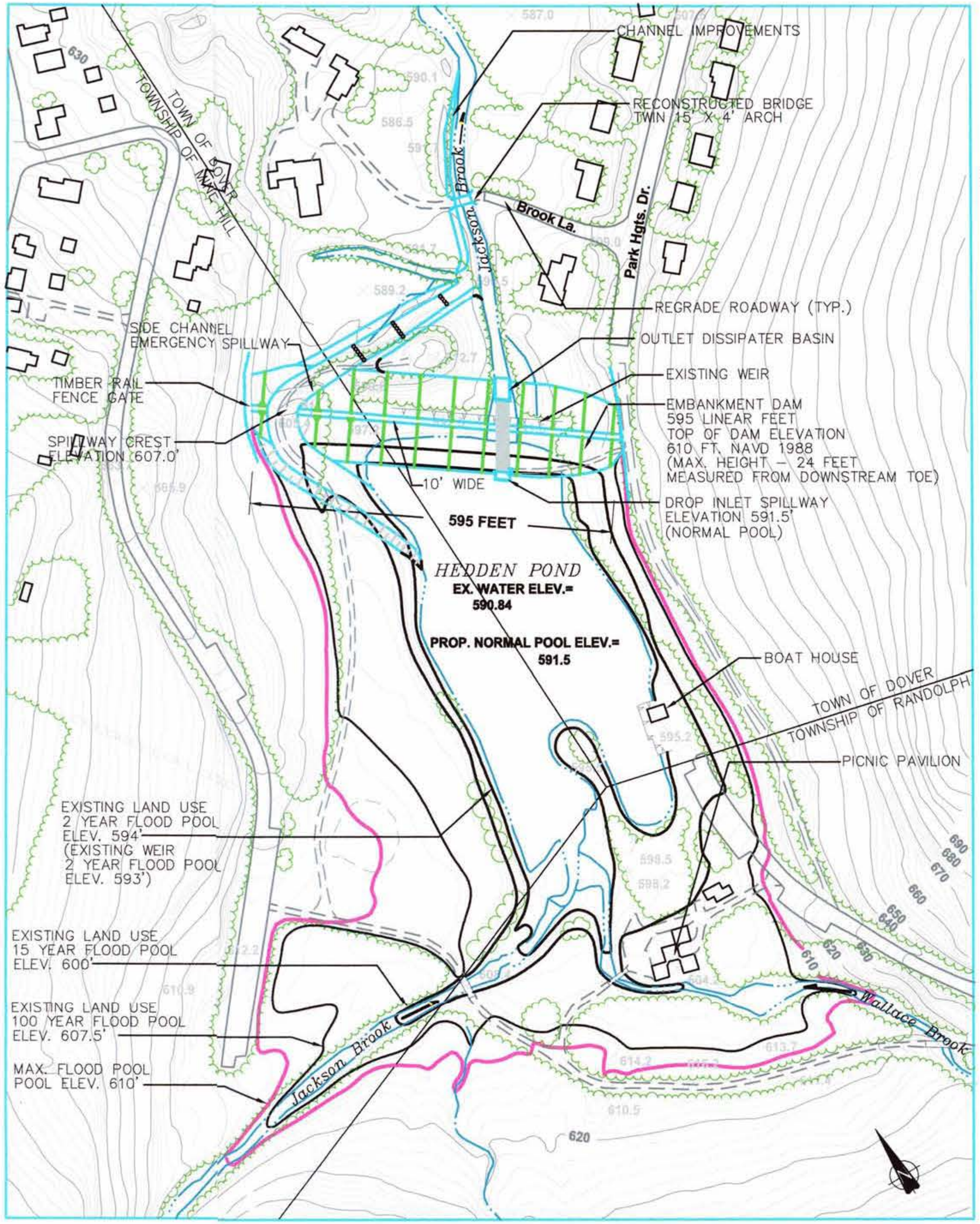
COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

PROPOSED HEDDEN POND DAM
PERSPECTIVE VIEW

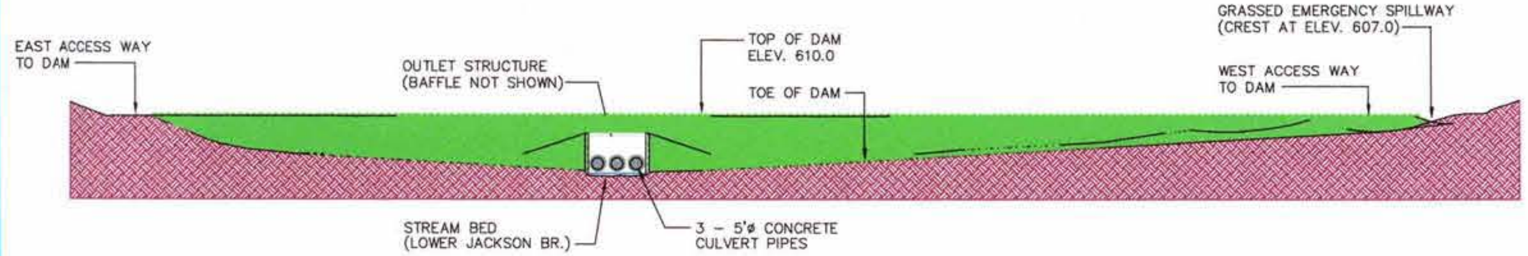
Killam Associates Consulting Engineers

FIGURE 6



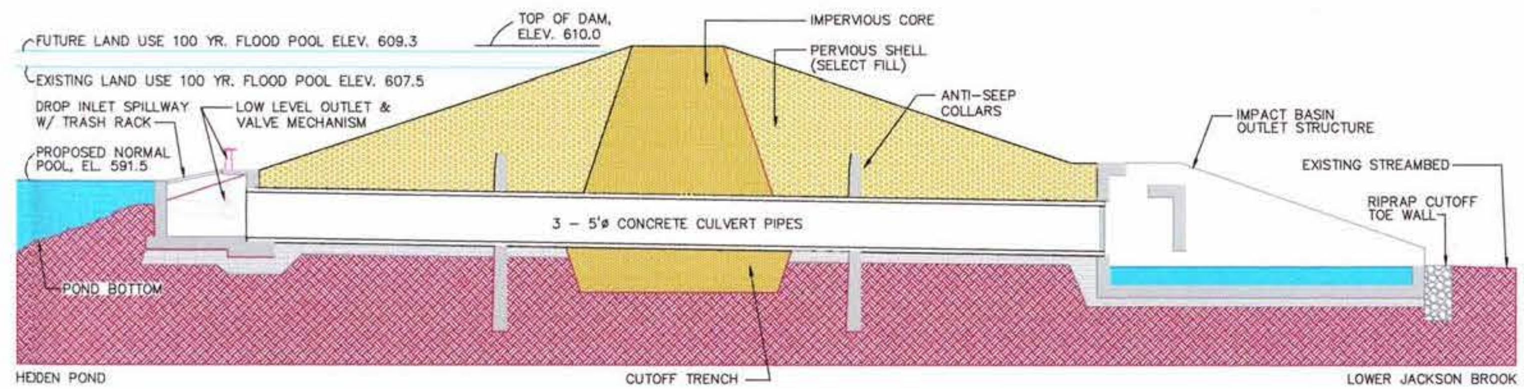
CONCEPTUAL SITE PLAN

SCALE IN FEET



ELEVATION VIEW OF HEDDEN POND DAM (LOOKING SOUTH)

SCALE IN FEET



SECTION THROUGH HEDDEN POND DAM

SCALE IN FEET

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED STORMWATER MANAGEMENT PLAN

PROPOSED HEDDEN POND DAM

CONCEPTUAL PLAN, SECTION & ELEVATION VIEW

Killam
Associates ▫ Consulting Engineers

FIGURE 7

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

TABLE 3
PEAK FLOWS AND ELEVATIONS *
HEDDEN POND DAM IMPROVEMENTS (NEW DAM)

DAM CONDITION	DESCRIPTION		EXISTING LAND USE CONDITIONS PEAK FLOWS AND ELEVATIONS RETURN INTERVAL (YEARS)								MOST LIKELY FUTURE LAND USE CONDITIONS PEAK FLOWS AND ELEVATIONS - PLAN D RETURN INTERVAL (YEARS)							
			1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100
EXISTING	50 FT. WIDE SPILLWAY AT EL. 591.5 WITH 231FT. LENGTH TOP OF DAM OVERFLOW EMBANKMENT AT MINIMUM EL. 592.0	INFLOW	327	521	811	1095	1196	1375	1610	2013	534	750	1076	1394	1525	1763	1984	2383
		OUTFLOW	326	518	808	1092	1192	1371	1602	2013	532	748	1074	1390	1520	1763	1983	2380
		POOL EL.	592.36	592.61	592.98	593.31	593.42	593.63	593.9	594.15	592.62	592.9	593.29	593.65	593.8	594.03	594.13	594.31
DAM AND SPILLWAY MODIFICATION	DROP INLET INTAKE 595 FT. EARTHEN DAM WITH 50 FT. LENGTH EMERGENCY SPILLWAY NORMAL POOL AT ELEV. 591.5	INFLOW	327	521	811	1095	1196	1375	1610	2013	534	750	1076	1394	1525	1763	1984	2383
		OUTFLOW	317	491	693	859	913	990	1070	1283	502	664	856	1003	1051	1133	1273	1784
		POOL EL.	593.17	593.91	596.17	599.13	600.21	601.93	603.82	607.48	594.02	595.7	599.08	602.23	603.35	605.41	607.42	609.31

NOTES:

1. *ELEVATIONS BASED UPON 1998 AERIAL TOPOGRAPHIC MAPPING AND SUPPLEMENTAL GROUND SURVEYS.*
2. *FLOW VALUES IN CUBIC FEET PER SECOND (CFS).*

* **WITHOUT FUTURE FLOW RELEASE RATE POLICY 50%-75%-75%**

K:\ENG\SW\208806\TABLE 3.WB3

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COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

TABLE 4
PEAK FLOWS AND ELEVATIONS * *
HEDDEN POND DAM IMPROVEMENTS (NEW DAM)

DAM CONDITION	DESCRIPTION		EXISTING LAND USE CONDITIONS PEAK FLOWS AND ELEVATIONS RETURN INTERVAL (YEARS)								PLAN -D IMPROVEMENTS PEAK FLOWS AND ELEVATIONS RETURN INTERVAL (YEARS)							
			1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100
EXISTING	50 FT. WIDE SPILLWAY AT EL. 591.5 WITH 231FT. LENGTH TOP OF DAM OVERFLOW EMBANKMENT AT MINIMUM EL. 592.0	INFLOW	327	321	811	1095	1196	1375	1610	2013	406	588	846	1091	1175	1357	1540	1854
		OUTFLOW	326	518	808	1092	1192	1371	1602	2013	405	586	844	1089	1172	1352	1535	1853
		POOL EL.	592.36	592.61	592.98	593.31	593.42	593.63	593.9	594.15	592.46	592.69	593.02	593.3	593.4	593.61	593.82	594.07
DAM AND SPILLWAY MODIFICATION	DROP INLET INTAKE 595 FT. EARTHEN DAM WITH 50 FT. LENGTH EMERGENCY SPILLWAY NORMAL POOL AT ELEV. 591.5	INFLOW	327	321	811	1095	1196	1575	1610	2013	406	588	846	1091	1175	1357	1540	1854
		OUTFLOW	317	491	693	859	913	990	1070	1283	395	542	727	879	925	996	1069	1235
		POOL EL.	593.17	593.91	596.17	599.13	600.21	601.93	603.82	607.48	593.47	594.41	596.73	599.53	600.48	602.08	603.8	607.2

NOTES:
1. ELEVATIONS BASED UPON 1998 AERIAL TOPOGRAPHIC MAPPING AND SUPPLEMENTAL GROUND SURVEYS.
2. FLOW VALUES IN CUBIC FEET PER SECOND (CFS).
***UTILIZES FUTURE FLOW RELEASE RATE POLICY 50%-75%-75%*

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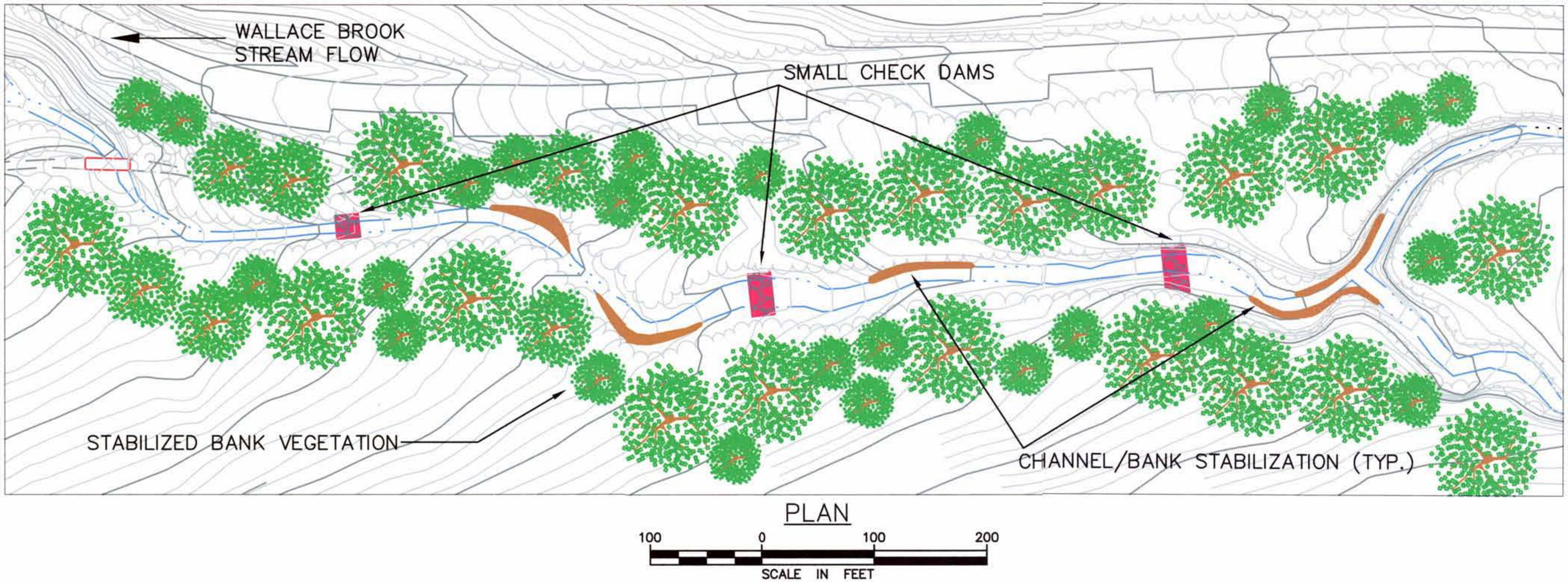
The existing weir and pond at Hedden Park provides little or no flow attenuation during storm events ranging from the 1-year through 100-year recurrence interval. The proposed new dam and retention basin provides an additional 200-acre feet of flood storage capability and will increase the level of flood protection at Hedden Park impoundment to safely pass the 100-year peak flows and consequently reduce the flood peaks, as well as the area of flood inundation at downstream locations along the Lower Jackson Brook.

Table 3 summarizes the peak flows and elevations at the facility resulting from the proposed improvements under existing and future "most likely" land use condition without considering any upstream stormwater controls.

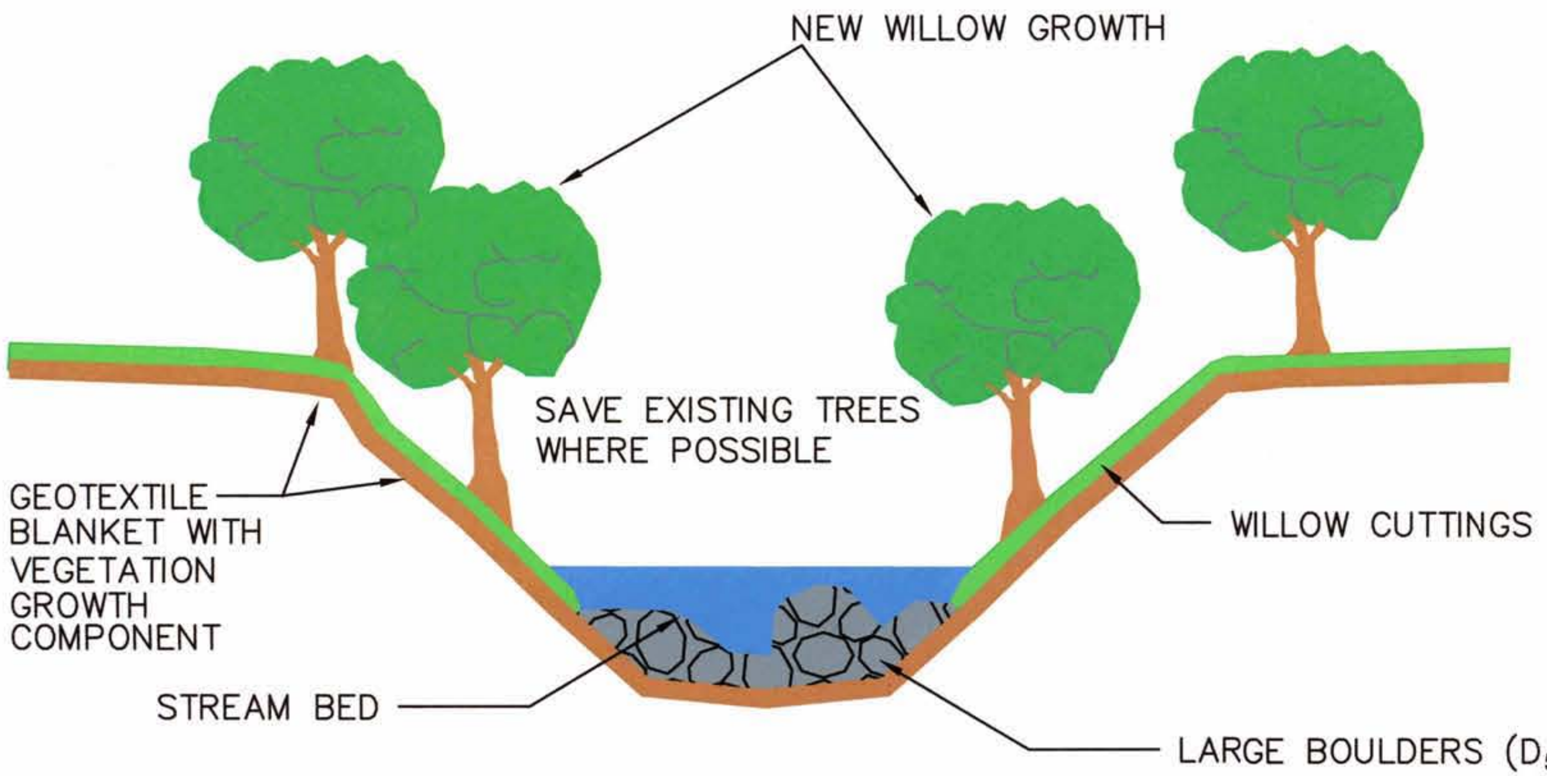
Table 4 summarizes the peak flows and elevations at the facility resulting from existing and future "most likely" land use conditions and considering stormwater controls upstream based on the 2-, 10- and 100-year future flow allowable release rate policy of 50%, 75% and 75% reduction in peak discharges.

Improvement 2 – Streambank Stabilization Improvements on Wallace Brook

Improvement 2 involves the implementation of streambank stabilization measures along the reach of Wallace Brook between Reservoir Avenue and its mouth at Hedden Pond. The conceptual streambank stabilization improvements are shown in general plan and typical sections on Figures 8 and 9. Figure 8 shows the armoring of the eroded Wallace Brook reach downstream of Reservoir Avenue with large boulders and the planting of willow trees on the banks. Also included are three low-check dams strategically placed within the stream reach. Figure 9 shows the proposed repairs to the eroded sections of Wallace Brook near its mouth adjacent to the Hedden Park recreation pavilion. These bank stabilization measures consist of armoring the left bank with large boulders and conducting repairs to the existing gabion walls on the right bank. The streambank stabilization improvements will not provide any flood control benefits but will control the continuous erosion of the Wallace Brook and the deposition of sediment in the Hedden Pond during storm events. The estimated probable construction cost of these stabilization improvements is approximately $275,000.

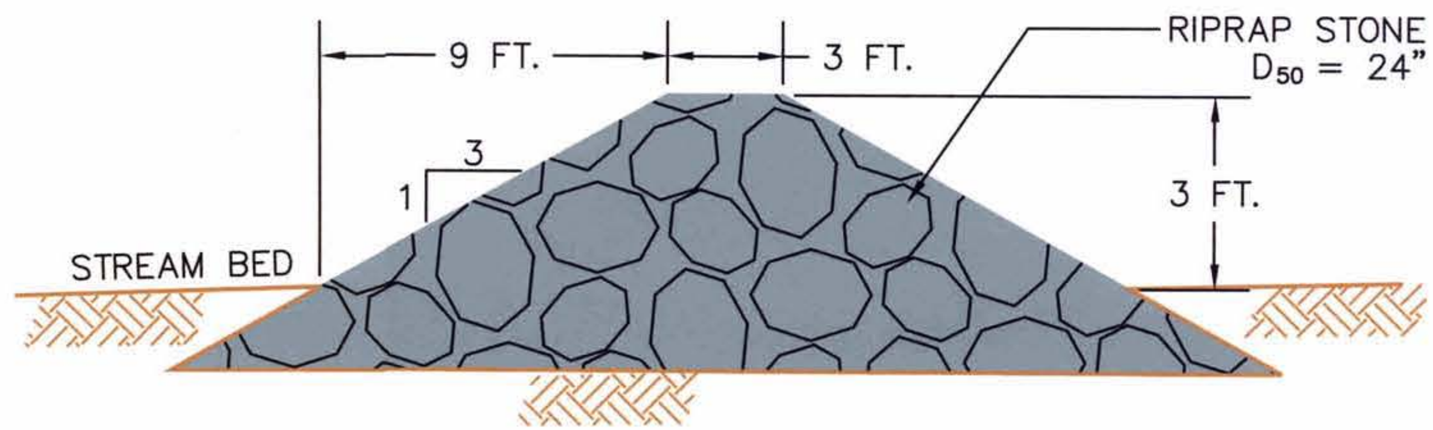


PLAN



TYPICAL SECTION–CHANNEL/BANK STABILIZATION

N.T.S.



TYPICAL SECTION THROUGH CHECK DAM

N.T.S.

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

WALLACE BROOK STREAM
STABILIZATION IMPROVEMENTS

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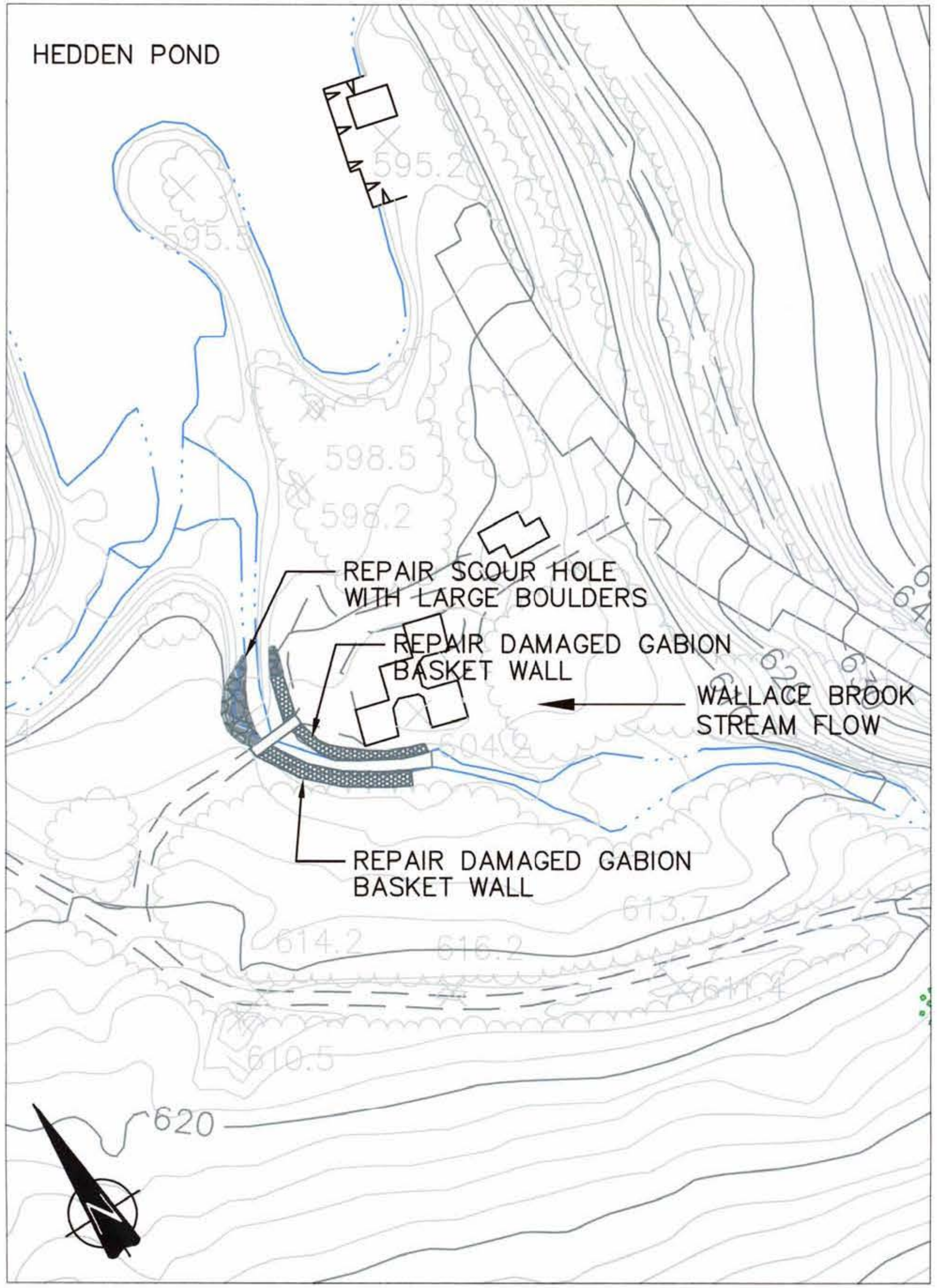
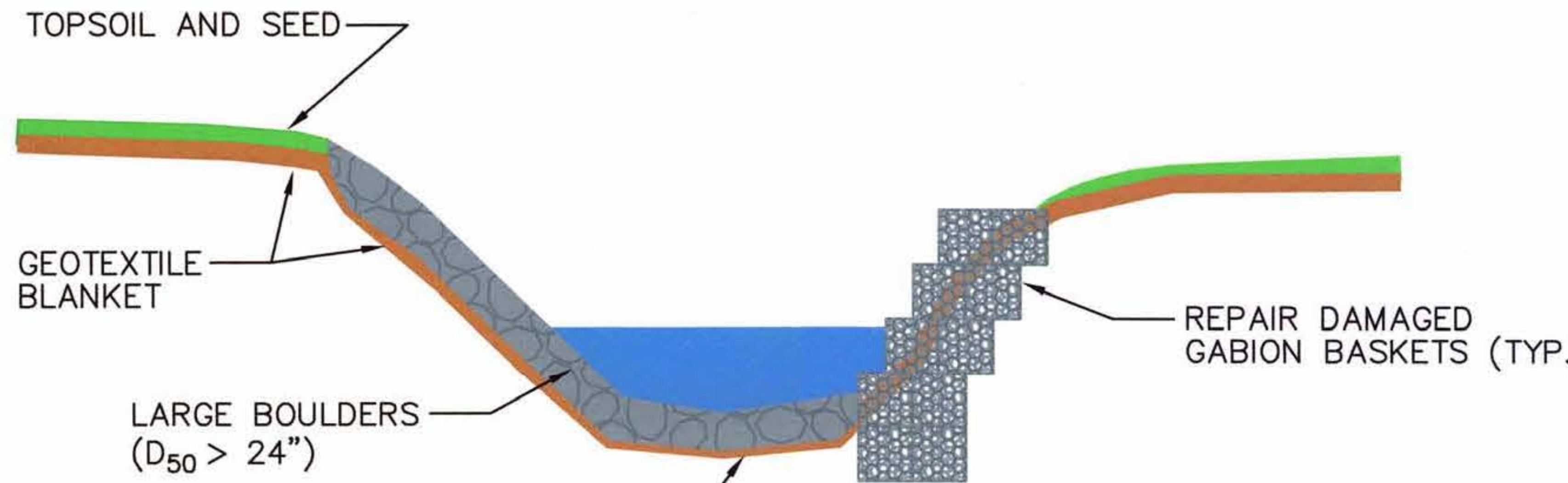
FIGURE 8



PLAN

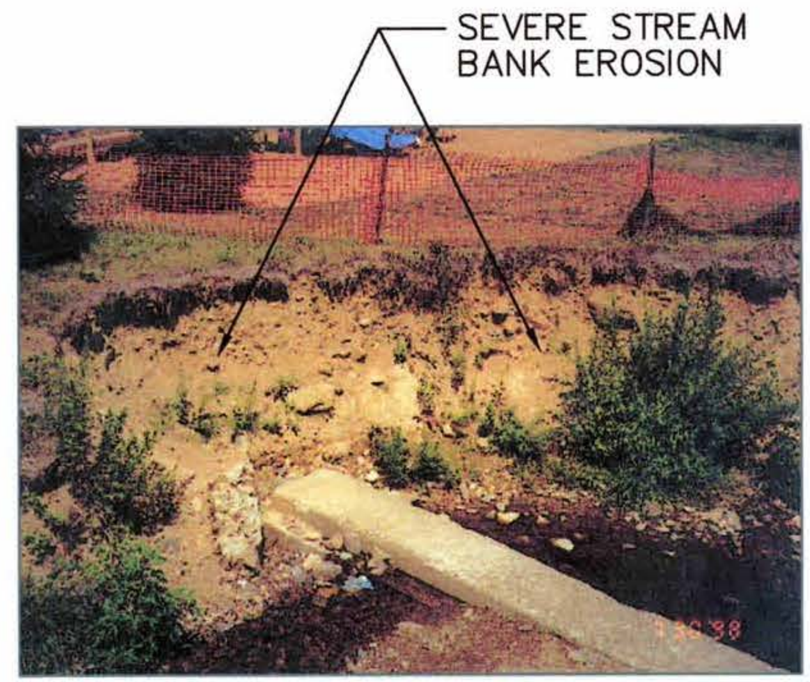
100 0 100 200

SCALE IN FEET



TYPICAL SECTION–CHANNEL/BANK STABILIZATION

N.T.S.



VIEW OF EXISTING SCOUR HOLE
TO BE REPAIRED WITH LARGE BOULDERS

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

WALLACE BROOK STREAM
STABILIZATION IMPROVEMENTS
NEAR POND

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FIGURE 9

Improvement 3 – Streambank Stabilization Improvements on Lower Jackson Brook

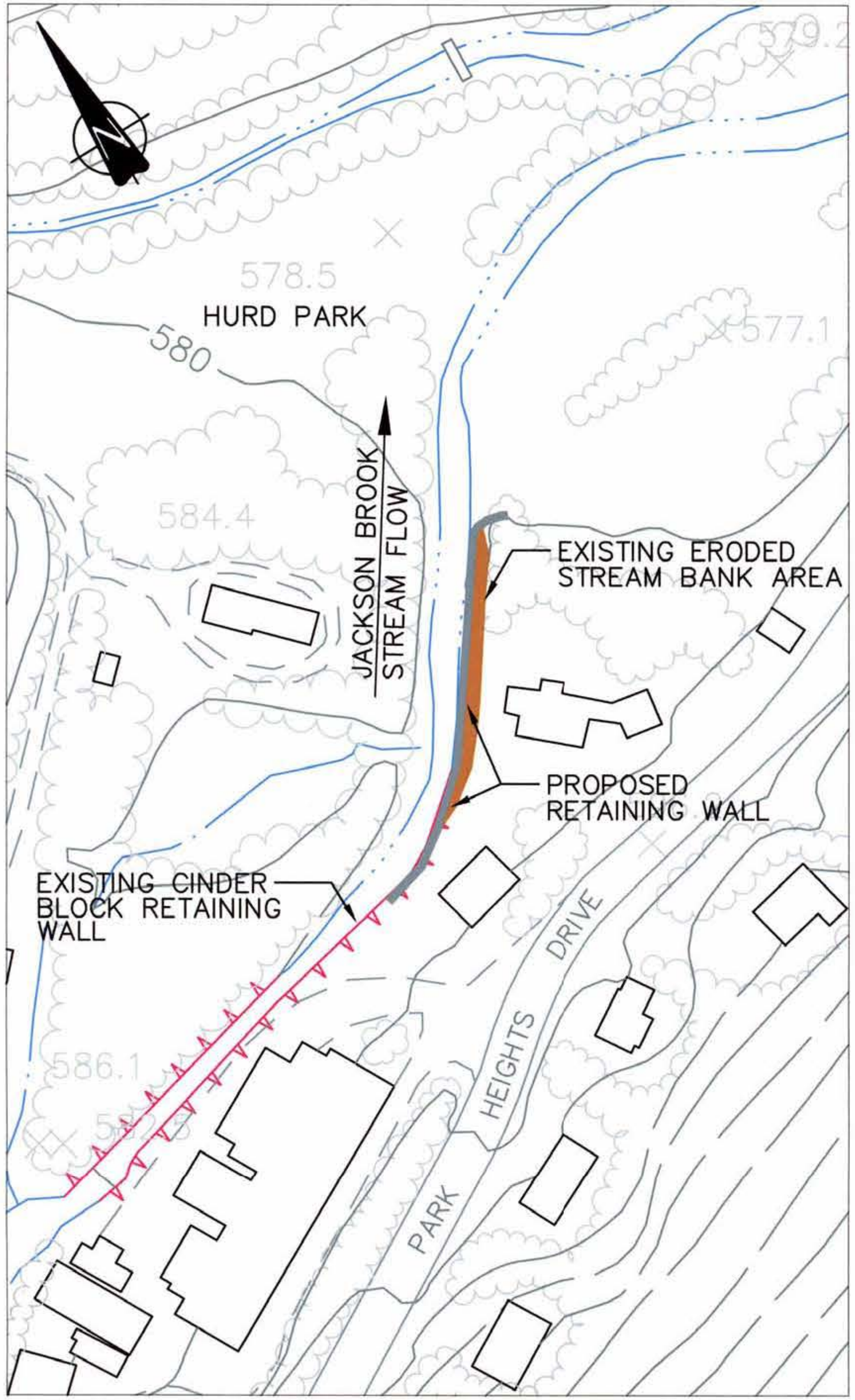
This improvement consists of the repair of the eroded and washed-out section of the right streambank adjacent to Park Heights Drive. The proposed improvement consists of constructing a new retaining wall of approximately 320 linear feet utilizing Victorian stone block construction. It is noted that the existing Rockaway Valley Regional Sewerage Authority's sanitary sewer trunk line is set back approximately 15 feet from the streambank, and the current condition of the continuous erosion of the streambank has resulted in the migration of the stream to within 5 feet of the sanitary sewer trunk line. With the implementation of the proposed improvement, the risk of washout of the sanitary sewer trunk main will be eliminated and the adjacent homes and rear yards protected from future soil erosion washouts. The layout of the general plan and typical section of the improvement is shown on Figure 10. The estimated probable construction cost of this improvement is approximately $70,000. (Constructed)

Improvement 4 – Brook Lane Bridge Improvement

Improvement 4 involves increasing the width of the bridge waterway opening from 15 feet to 32 feet and raising the roadway profile to reduce the frequency of overtopping of the roadway and to accommodate the future land use conditions flows. The Brook Lane bridge is located approximately 400 feet downstream of the Hedden Pond weir. The existing bridge which has been overtopped during the 1992, 1996 and 1999 flood events is in need of repair. The existing 15-foot span by 5-feet high bridge waterway opening will be increased to allow for passage of the flood flows with the implementation of the Hedden Pond Dam. The proposed new bridge will be a twin 16- foot by 5-foot concrete arch structure with a 50-year flood return interval design capacity. The general plan layout and typical section of the improvement is shown on Figure 11. The estimated probable construction cost is approximately $400,000.

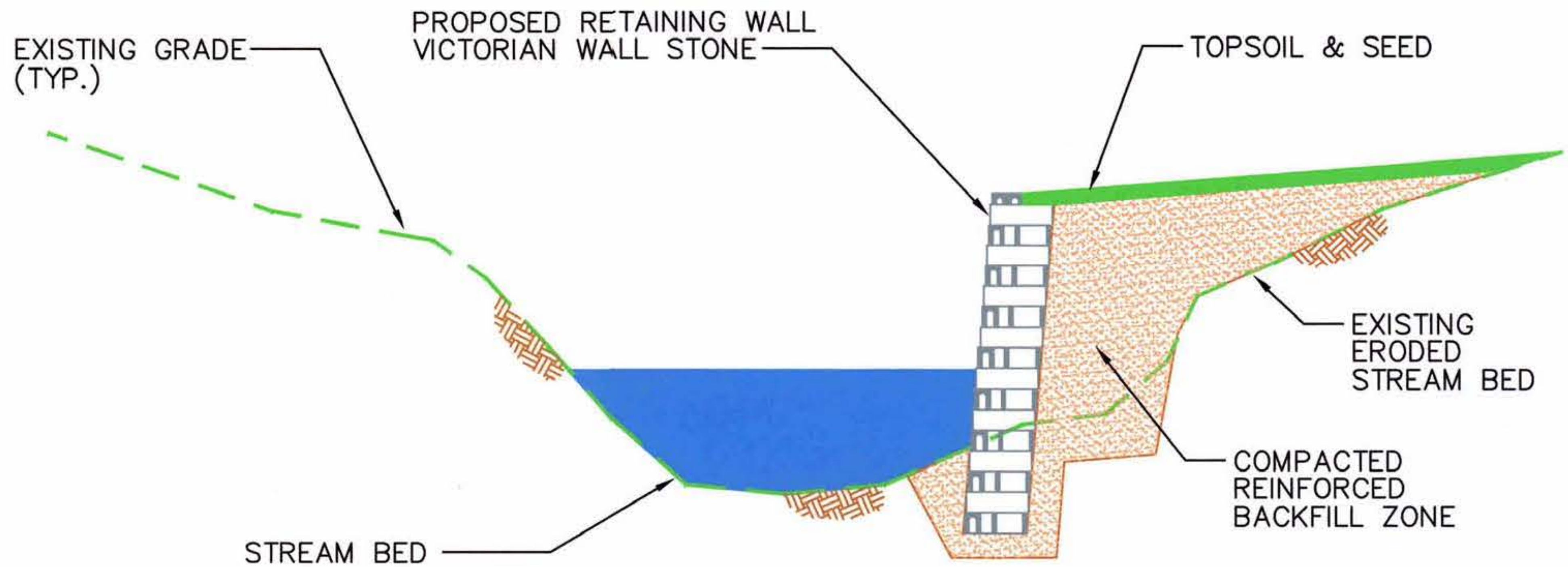
Improvement 5 – Dover Twin Reservoirs Improvement

Improvement 5 involves raising the existing impoundment embankment at the Dover Twin Reservoirs. The Dover Twin Reservoir is located at Reservoir Avenue along Wallace Brook and



PLAN

100 0 100 200
SCALE IN FEET



TYPICAL WALL SECTION—CHANNEL/BANK STABILIZATION

N.T.S.

LOOKING DOWNSTREAM AT
EXISTING ERODED STREAM BANK

VICTORIAN WALL STONE

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

JACKSON BROOK STREAM
STABILIZATION IMPROVEMENT

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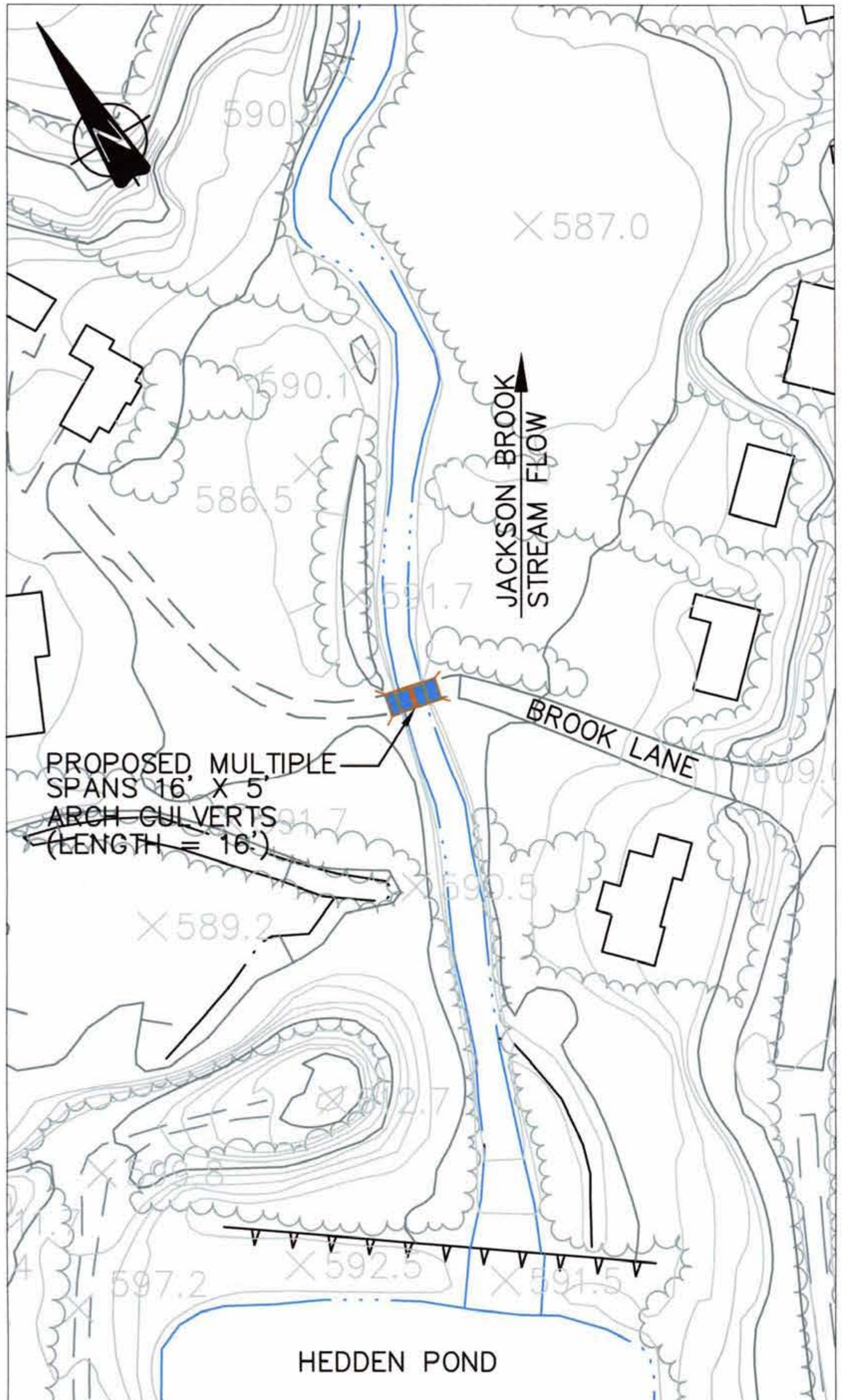
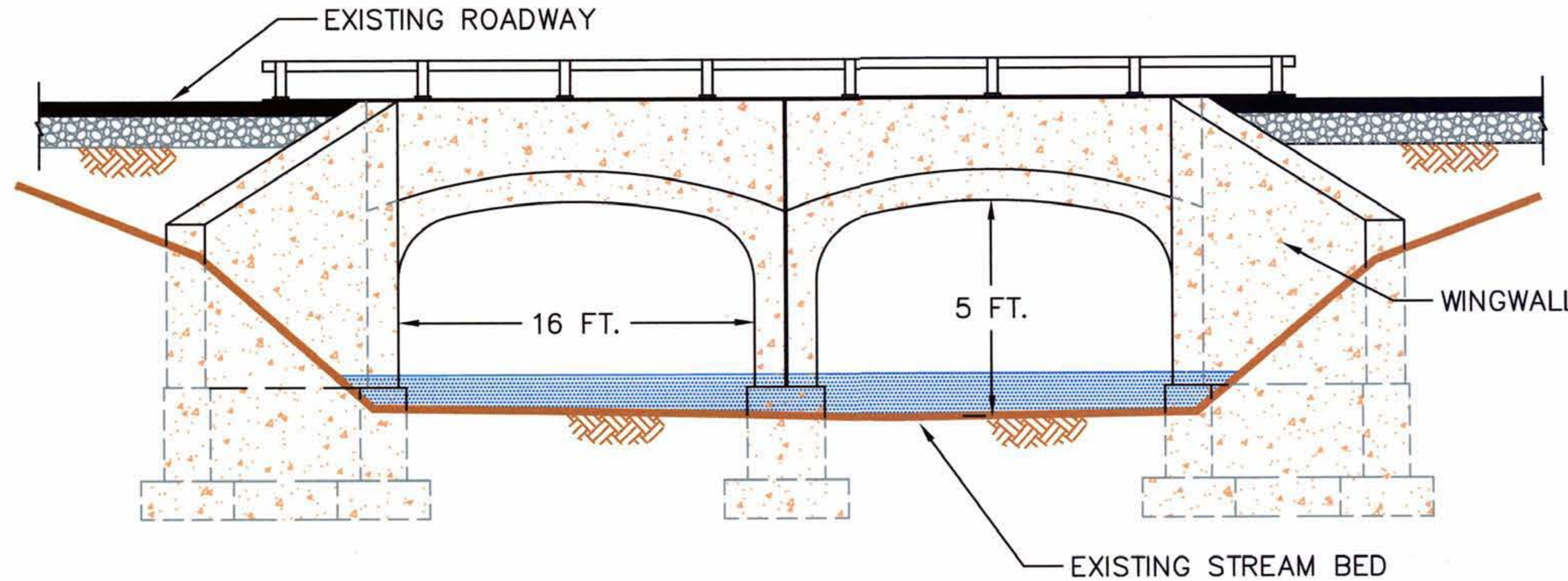
FIGURE 10



PLAN



CONCEPTUAL END SECTION – MULTIPLE SPANS 16' X 5' ARCH CULVERTS

N. T. S.

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

BROOK LANE BRIDGE IMPROVEMENT

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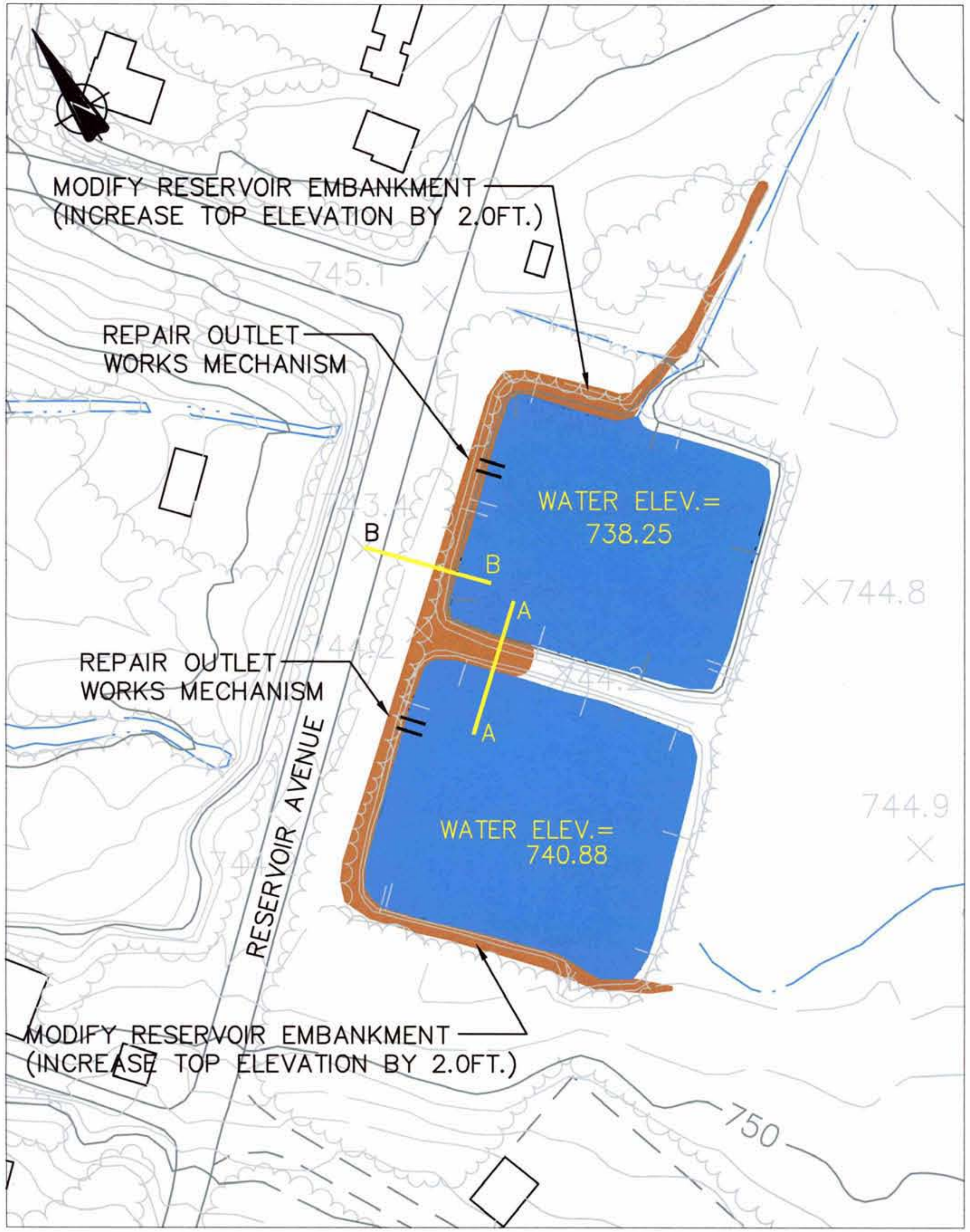
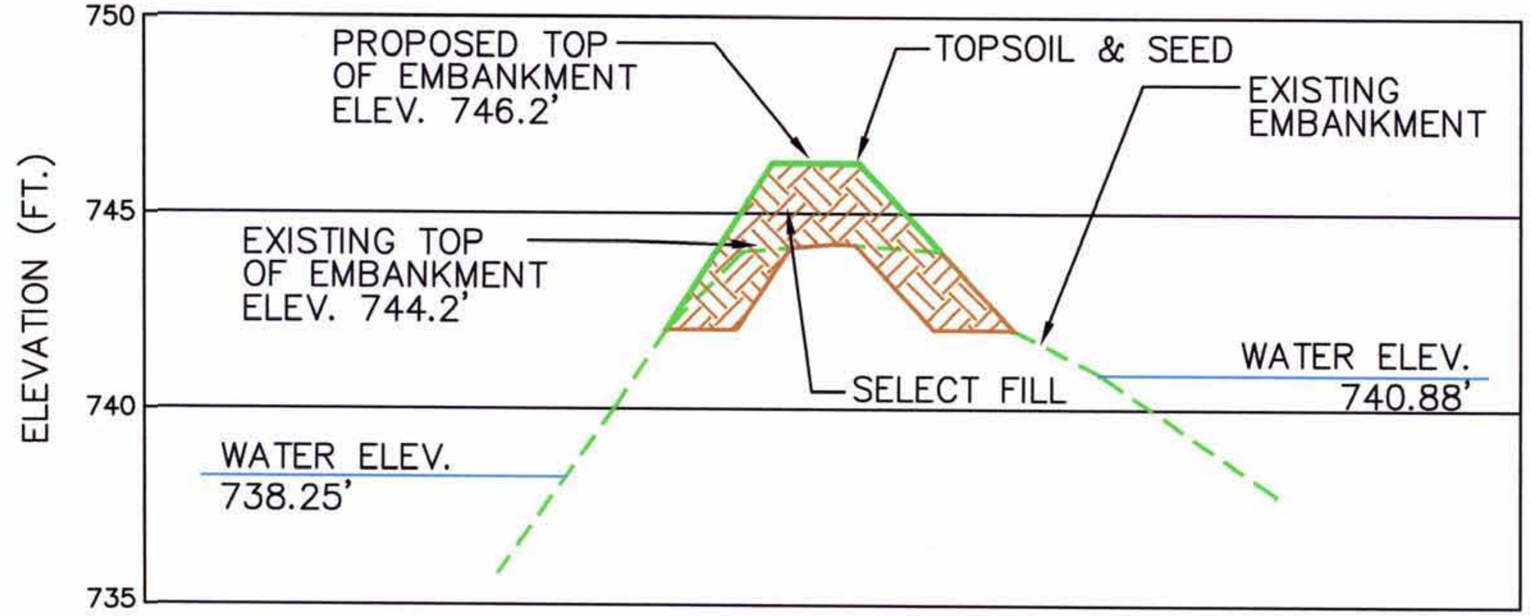
FIGURE 11

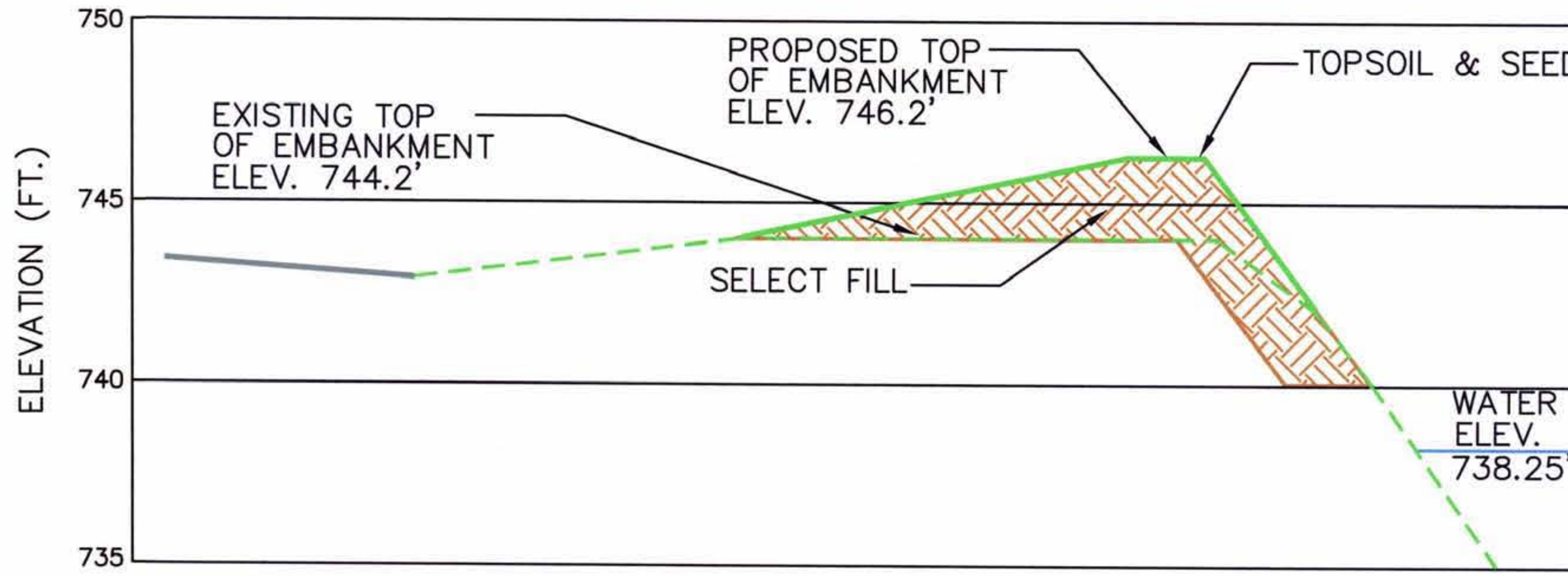


PLAN

100 0 100 200
SCALE IN FEET



SECTION A–A



SECTION B–B

10 0 10 20
SCALE IN FEET
HORIZONTAL

5 0 5 10
SCALE IN FEET
VERTICAL

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

DOVER TWIN RESERVOIRS IMPROVEMENT

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FIGURE 12

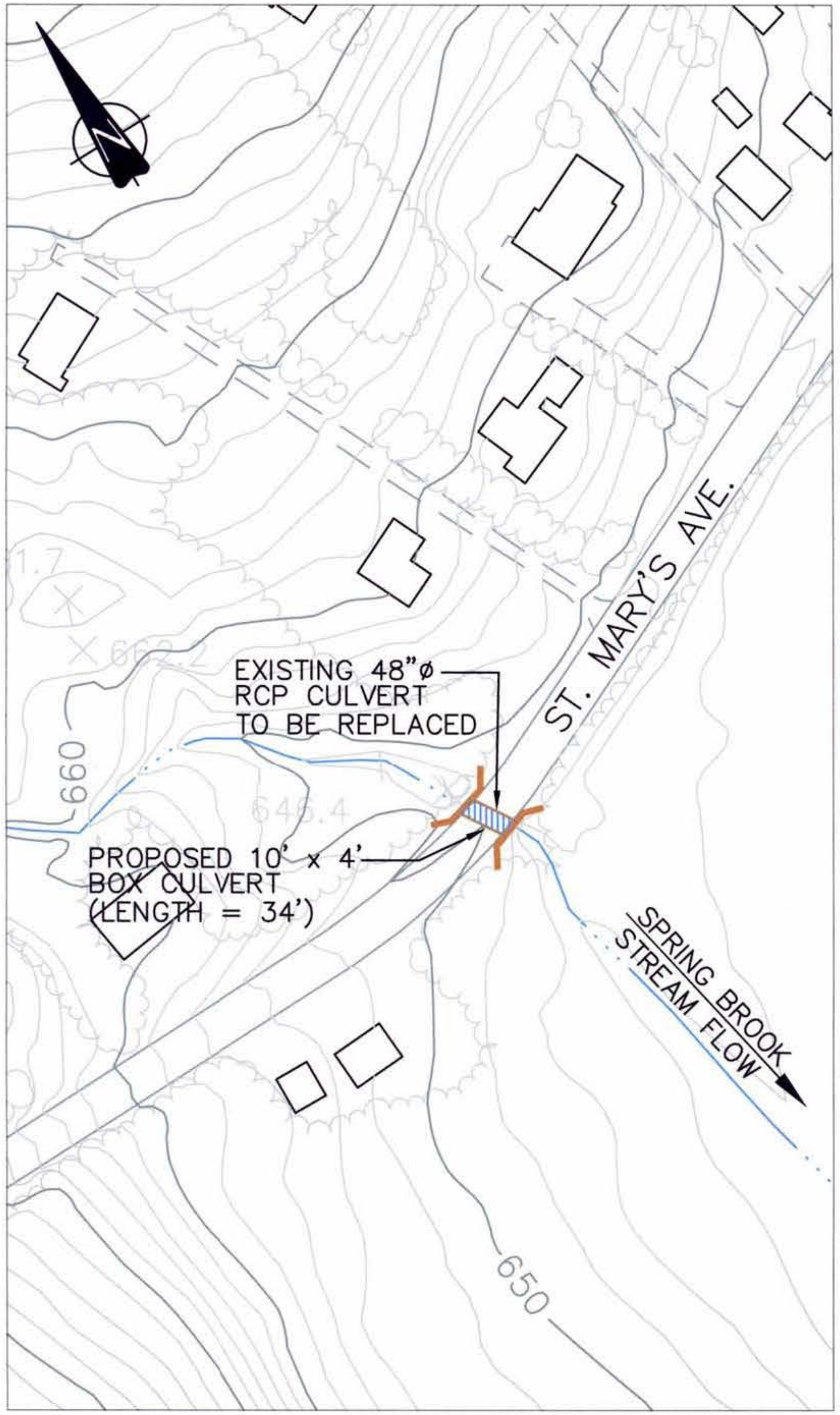
is fed by tributary branches of Wallace Brook. The proposed improvement at this facility includes the raising of the earth embankment by approximately 2 feet to provide additional flood storage and flood flow attenuation capability. The improvement also includes the repair of the existing outlet works valve mechanisms to facilitate drawdown and routine maintenance of the facility. It is estimated that based upon the evidence of erosion from the recent storm events there may be a substantial amount of sediment accumulation in the reservoir. The proposed improvement will also consider sediment removal along with the repair of the outlet works valve mechanisms. The cost for the removal of sediment deposits cannot be estimated with any degree of reliability at this time and is therefore not included in the projected improvement construction cost. The general plan layout and typical sections are shown on Figure 12. The estimated probable construction cost is approximately $250,000.

Improvement 6 – St. Mary's Street Culvert Improvement

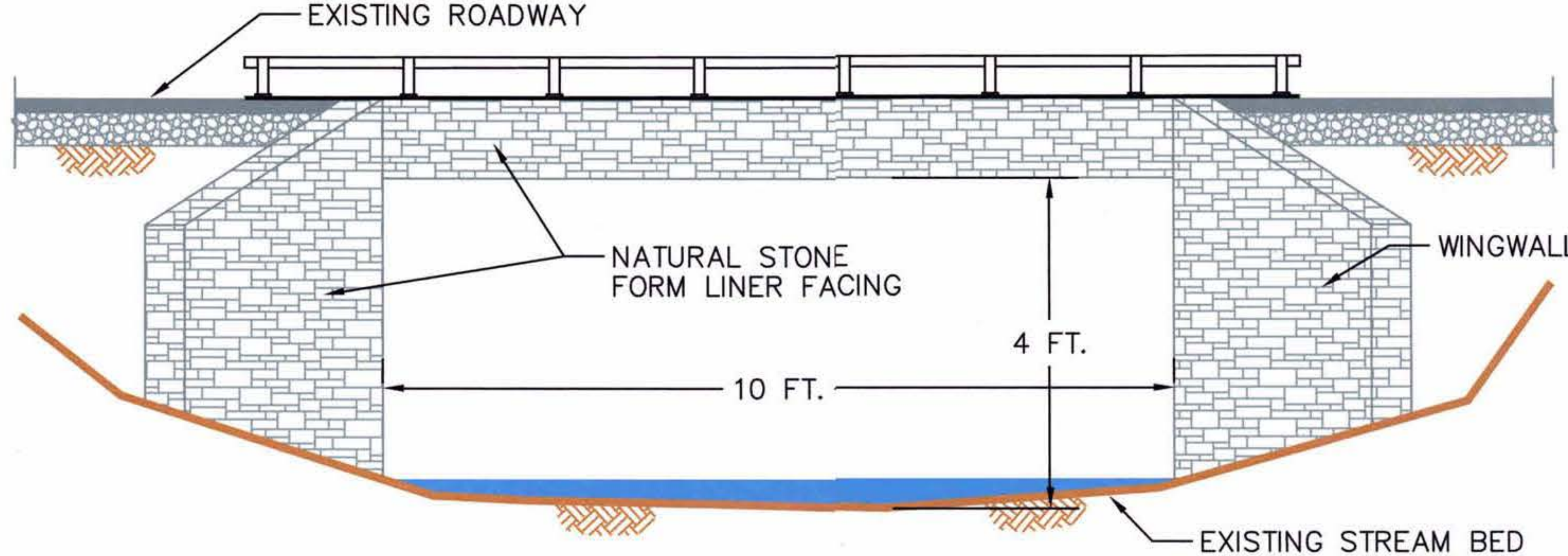
Improvement 6 involves increasing the culvert waterway conveyance capacity at the St. Mary's Street crossing of the Spring Brook. The St. Mary's Street culvert is located on the Spring Brook at the municipal border of Mine Hill and Wharton. The existing inadequate 48-inch diameter reinforced concrete pipe culvert will be replaced with a 10-foot by 4-foot concrete box culvert with formed natural stone focia. The general plan layout and section is shown on Figure 13. The existing culvert was analyzed to have a hydraulic capacity capable of passing the 5-year storm event. The proposed improvement will provide an increased level of flood protection at the roadway crossing without creating additional problems downstream. The improved culvert will have a 50-year storm design capacity. The estimated probable construction cost is approximately $345,000.

6.2 Non-Structural Controls - BMPs

Non-structural Best Management Practices (BMPs) improvements consist of measures to control stormwater flows for the protection of the individual structures or buildings against flooding in lieu of structural stream improvements and also include land ordinances, land management and legal techniques



PLAN



CONCEPTUAL END SECTION – 10' X 4' BOX CULVERT

N. T. S.

VIEW OF EXISTING UPSTREAM FACE OF ST. MARY'S AVE. 48"ø RCP CULVERT

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

ST. MARY'S AVE. CULVERT IMPROVEMENTS

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FIGURE 13

geared toward mitigating the impacts of stormwater runoff. The non-structural techniques considered herein are separated into the following three categories.

- Runoff Allowable Release Rate Policy
- Stream Corridor and Open Space Preservation
- Ordinance and Land use Regulation

Non-structural control measures are considered for the entire project area and are to be implemented in conjunction with structural improvement measures to reduce the hazard to life and property in the flood problem areas.

Runoff Allowable Release Rate Policy

The Runoff "Allowable Release Rate Policy" is a runoff control mechanism used to accomplish the runoff control strategy outlined in Section 3.2.1 of this report. This policy specifies the percentage of predevelopment peak flow rate which may be discharged from the drainage subareas after development takes place. The allowable release rates considered in the hydrologic analyses ranged from 50 percent to 100 percent depending upon the rainfall event return period. For example, a 50 percent release rate means that the peak rate of runoff leaving the subdrainage area after development may be only one-half of that prior to development and a 100 percent release rate represents that the peak rate of runoff leaving the subdrainage area after development is equal to predevelopment peak rate of runoff. A 100 percent release rate represents the conventional no increase in peak rate of runoff philosophy which is the on-site control policy that currently exists in the municipal ordinances.

The policy that accomplishes the objectives is one where the peak rates of stromwater runoff are to be controlled so that post-development peak rates will be reduced to the following percentages of pre-development peak rates, namely, 50%, 75% and 75%, respectively, for the 2-, 10- and 100-year storm events considered individually at the delineated subarea points of interest. It must be noted that the release rate of 75% reduction was utilized for all storm recurrence intervals except for the 1-year and 2-year storm events. No reduction was utilized for the 1-year storm and the 50% reduction used for the 2-year storm future land use condition peak flow control.

Stream Corridor and Open Space Preservation

The stream corridor is usually synonymous with the 100 year flood plain limits and normal zoning requirements restrict development within this area. The rules and regulations of the municipality should encourage development outside the flood plain to ensure the safest conditions as development will alter topography, create constraints in low lying flood plains and reduce the flood storage area all of which will adversely affect the levels of flood protection.

Open space preservation, can be very beneficial to stormwater management practices and can be utilized to control and store runoff without having to construct any type of structural detention system. The open space areas along the stream corridor can be utilized as recreational areas and parks. These recreational areas can be maintained to provide a vegetative buffer zone that contributes to controlling soil erosion and promotes greater settling of pollutants before they reach the waterway. Such areas are usually not in use during periods of precipitation so that ponding of stormwater for short durations will not seriously impede their primary recreational function.

Ordinance and Land Use Regulation

Land use regulations, including site plan ordinances, can also be utilized as a stormwater management planning tool. Zoning can place limitations on development, minimizing the disturbance of the land and the percentage of impervious cover so as to reduce the quantity of stormwater runoff. Nonpoint source pollution can also be controlled through site planning, to improve the quality of stormwater runoff, by regulating site design and requiring adherence to performance standards.

Stormwater and site plan ordinances should incorporate provisions for ensuring that the quantity and quality of stormwater runoff are maintained at levels that are as close as practicable to those of existing conditions, and that downstream waterways will not be degraded as a result of proposed development.

Appropriate Best Management Practices (BMPs), such as grass or vegetated swales, check dams and filter strips, can be used alone or in conjunction with other urban best management practices to control runoff velocities and downstream erosion problems. The County of Morris Stormwater Management Technical Guide and the NJDEP Stormwater Management Best Management Practices Manual should be utilized as guidance documents for selecting practical stormwater measures that are best suited to the development location. Specifically, infiltration trenches and dry wells are encouraged in the Upper Jackson Brook, Spring Brook and Wallace Brook subareas where feasible. Water quality inlets and/or oil and grease/grit separations as manufactured by Stormceptor or similar provider are encouraged for new developments and for retrofitting existing drainage systems.

The following covers the major federal, state and local laws affecting stormwater management and land related uses in the watershed municipalities.

The applicable requirements of the below regulations must be met, and permits obtained from the respective regulatory agencies, prior to the granting of final approval for any subdivision within the watershed municipalities.

Federal

The National Flood Insurance Program (NFIP)

This program adopted pursuant to the National Flood Insurance Act (1968) encourages localities to develop land use controls for areas within the 100-year flood zone as identified by the Federal Emergency Management Agency, FEMA. The long term benefit of the NFIP will be the prudent use of land resources in floodprone areas to protect individuals and communities from devastating flood losses. Specific information regarding the National Flood Insurance Program may be obtained by contacting the FEMA Regional Office.

State

The New Jersey Stormwater Management Regulations, N.J.A.C. 7:8-1.1 et seq.

These regulations adopted under the authority of the New Jersey Stormwater Management Act, P.L. 1981, C. 32; N.J.S.A. 40:55 D-1 et seq.; and N.J.S.A. 13: 1d - 1 et seq., provide requirements and controls for stormwater that are preventative in nature and which must be applied during the site plan and subdivision review process prior to obtaining a permit for development. These regulations require that every municipality prepare a stormwater management plan and a stormwater control ordinance to implement the plan. Implementation of this requirement is subject to the State making available 90 percent grant funding for developing a plan, and implementing ordinance, or to the updating of the land use element of the municipal Master Plan, whichever occurs first. Amendments to the regulations are planned for 1994 or early 1995, and will reflect the policies and technical guidance that are being promoted by the NJDEP in their "Stormwater and Nonpoint Source Pollution Control Best Management Practices Manual.

A proposed model stormwater control ordinance published by the New Jersey Department of Environmental Protection can be obtained from the Bureau of Watershed Management , CN-423, Trenton, N.J. 08625.

New Jersey Flood Hazard Area Regulations N.J.A.C. 7:13-1 et seq.

These regulations adopted pursuant to the Flood Hazard Area Control Act, N.J.S.A. 58:16A-50 et seq., Administrative code, N.J.A.C. 7:8-3.15 and covered by the 90-Day Review Law, P.L. 1975, c.232, require that a Stream Encroachment Permit be obtained prior to development. This permit is required for the construction, installation, or alteration of any structure or permanent fill along, in, or across the channel or flood plain of any stream. This permit is also required for any alteration of the stream itself. Of particular significance are the "net fill" provisions of the regulations which are built-in restrictive non-structural land use management controls.

New Jersey Dam Safety Standards N.J.A.C. 7:20-1 et seq.

These regulations implement the Safe Dam Act, N.J.S.A. 58:4-1 et seq., and require that a permit be obtained for the construction or repair of a dam. This means that a permit is required to construct or repair a dam on any stream or river in the State of New Jersey, or between New Jersey and any other State. A dam is defined as a structure which raises the water surface of a river or stream more than five feet above usual mean low-water level.

Soil Erosion and Sediment Control Plan Certification

This certification adopted pursuant to the Soil Erosion and Sediment Control Act, N.J.S.A. 4:24 et seq., requires municipalities and all other agencies to condition development project approvals upon local soil conservation district certification of a plan for soil erosion and sediment control. Certification is required for projects that disturb more than 5,000 square feet of surface area of land.

The application for soil erosion and sediment control plan (standard form) should be filed with the Morris County Soil Conservation District office along with required supporting data and fees for the Town of Dover, Township of Mine Hill and the Borough of Wharton. The Township of Randolph currently handles the certification of Soil Erosion and Sediment Control Plan for developments within the Township.

New Jersey "Freshwater Wetlands Protection Act" P.L. 1987, C 156.

This Act concerning the regulation of freshwater wetlands, amending P.L. 1977, C 74, supplementing Title 13 of the Revised Statues, was adopted by the Senate and General Assembly of the State of New Jersey on July 1, 1987.

The Act took effect on July 1, 1988, with a second phase regarding protective transition areas between proposed regulated activities and sensitive wetlands having come into effect on July 1, 1989.

The Act establishes an administrative body called The Wetlands Mitigation Council comprised of the Commissioner of the NJDEP and six members of the general public selected from building/development organizations, environmental conservation agencies, and institutions of higher learning.

The rules and regulations entitled "Freshwater Wetlands Protection Act Rules", NJAC 7:7A-1.1 et seq., developed and adopted by the NJDEP to implement the Freshwater Wetlands Act have a significant impact on developers and local authorities with regard to the site development and subdivision review process, and conducting stream improvement.

County

Site Plan and Subdivision Review Resolution

This resolution shall be known and may be cited as "The Land Development Standards of the County of Morris adopted by the Morris County Board of Chosen Freeholders September 23, 1998 as amended to date.

All ***subdivision*** applications must be submitted to the County Planning Board for review and approval in accordance with Chapter 285 of the Laws of 1968. Those subdivisions classified by the Land Development Standards as "minor subdivision" which do not front along a County road may be deemed exempt from County approval.

Prior to the issuance of any building permit, the ***site plan*** must be submitted to the County Planning Board for their review and approval in accordance with Chapter 285 of the Laws of 1968. There are two exceptions to this rule:

1 Proposed residential development consisting of less than 5 dwelling units, and

2. Any site not along a County road which involves less than one acre of impervious cover.

Municipal

The Land Use Regulations for the watershed municipalities require that all storm drainage systems be designed so that no stormwater runoff or natural drainage water will be diverted to result in creating additional drainage problems at the property boundary or on other private properties or public lands without adequate provisions to take care of the potential problems.

6.3 Alternative Stormwater Management Plans

Four alternative Stormwater Management Plans have been formulated and are identified as Plans A through D. Plans A through D utilize various combinations of the six improvements in conjunction with Runoff "Allowable Release Rate Policy." The results of implementing Plans A through D are discussed in the following paragraphs and are summarized in Tables 5 through 8 located at the end of this section.

Plan A

Plan A includes Improvement 1 – Hedden Pond Dam reconstruction along with the erosion control bank stabilization improvements Nos. 2, 3 and improvement 4. The results of the hydrologic analysis is shown on Table 5. The future "most likely" land use condition peak flows are only reduced on the Lower Jackson Brook to values equal to or less than existing conditions for the 15-year, 25-year, 50-year and 100-year storms. The Hedden Pond outflow reductions are shown on Table 3. The peak flows along spring Brook and Wallace Brook and the Upper Jackson Brook above Hedden Pond will experience no change and will be the same as those summarized in Table 2A at the end of Section 3 for future conditions without stormwater control improvements.

Plan B

Plan B incorporates Improvement 1 – Hedden Pond Dam Reconstruction and Bank Stabilization Nos. 2 and 3, and improvement 4, in conjunction with Runoff Release Rate policy on the Upper Jackson Brook. Table 4 lists the hydrologic performance of the new Hedden Pond Dam versus existing conditions with the Release Rate Policy upstream under existing and future land use conditions.

The 100-year peak inflow will be reduced from 2013 cubic feet per second (cfs) to 1283 cfs, representing a 36 percent decrease for existing land use conditions. The future land use outflow for the 100-year storm is reduced for 1854 cfs to 1235 cfs, representing a 34 percent decrease.

Table 6 shows the corresponding reductions in future condition peak flows along Wallace Brook, Spring Brook and Upper Jackson Brook. The future condition peak flows along the Upper Jackson Brook would be controlled to approximately those of existing land use conditions for storm events ranging from the 5-year to the 100-year recurrence interval.

Plan C

Plan C incorporates Improvements Nos. 1, 2, 3, 4 and Improvement 5 - the Dover Twin Reservoirs, in conjunction with the allowable release rate policy on Upper Jackson Brook.

Table 4 shows the results of the hydrologic analysis at the selected points of interest. These results are similar to those of Plan B except that the Wallace Brook peak discharges at the selected points of interest are reduced for the range of storms from 1 year through 100 years.

Plan D

Plan D consists of the Improvements Nos. 1, 2, 3, 4 5 and Improvement 6- Reconstruction of St. Mary's Street Culvert on Spring Brook, in conjunction with the allowable release rate policy along the Upper Jackson Brook and Spring Brook.

The results of the hydrologic analysis are shown on Table 8. The plan results in the largest overall reduction in peak flows under "most likely" future land use conditions at the selected points of interest and at the mouth of the main stem of Jackson Brook, Wallace Brook and Spring Brook, in addition to controlling the 100-year flood at the proposed Hedden Pond Dam Regional Retention Basin.

Our analysis shows that at the mouth of Jackson Brook and at U.S. Route 46, the existing condition peak 100-year flow of 2488 cfs will be reduced to 1688 cfs which is equivalent to the 25-year flow flow. The future condition peak flows for the 5-year through 100-year recurrence intervals are all reduced to values approximately equal to or less than those under current land use conditions.

Similarly, the future land use peak flows at the mouths of Wallace Brook and Spring Brook are reduced considerably for the range of storm events from the 5-year through 100-year recurrence intervals.

With the implementation of the structural improvements 1 through 6, in conjunction with the Allowable Release Rate policy along Upper Jackson Brook and Spring Brook, all of the bridge/culverts and dams will have increased their levels of flood protection. The Dover Twin Reservoir, Brook Lane Bridge and St. Mary's Street culvert will all provide 5-year flood level protection.

All the other bridges on the main stem of Jackson Brook and Spring Brook will provide 100-year flood level protection.

6.4 Applicable Regulatory Agency Permits

Several federal, state and local permits or approvals will be required for implementation of the structural measures. Consultations have been held with representatives of the New Jersey Department of Environmental Protection and other state and local entities. Permit applications are not required to be filed with any agency until the proposed improvements and Environmental Assessments have been approved and after preliminary design work for the proposed sites has been completed.

A listing of the required permits and approvals is as follows:

1. New Jersey Department of Environmental Protection

    a. General Permits (and/or transition area waivers) if total wetland habitat disturbance is less than 1 acre at any of the proposed site facility improvements
    b. An Individual Permit will be required if the disturbance of wetland habitat is over 1 acre at any of the proposed site facility improvements.

c. Stream Encroachment Permit - Stream Encroachment permit will be required for the reconstruction of the bridges and culverts and stream stabilization improvements.

d. Dam Construction or Repair Permit - Dam Construction or Repair Permits will be required for the modifications to Hedden Pond Dam and Dover Twin Reservoirs.

e. Water Lowering Permits will be required for the modifications to Hedden Pond Dam and Dover Twin Reservoirs.

2. Morris County Soil Conservation District Approval of the Soil and Sediment Control Plans for all recommended structural improvements.
3. Morris County Engineering Department approval to reconstruct the culverts and bridges.

6.5 Cost Estimate

The estimated probable construction cost of the structural improvements Nos. 1, 2,4,5 & 6 are summarized in Table 9. The total estimated probable construction costs for the implementation of all the structural (except Nos. 3) improvements is approximately $3,265,000 exclusive of land easement or right-of-way costs and other engineering and legal/administrative costs.

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

PLAN A
PEAK FLOW SUMMARY*
MOST LIKELY FUTURE

TABLE 5

LOCATION	DRAINAGE AREA (SQ. MI.)	EXISTING LAND USE CONDITIONS (BASED UPON 1998 AERIAL PHOTOGRAPHY) RETURN INTERVAL (YEARS)								MOST LIKELY FUTURE LAND USE CONDITIONS WITH PLAN A STORMWATER IMPROVEMENTS (BASED UPON 1999 ZONING MAP) RETURN INTERVAL (YEARS)								DIFFERENCE BETWEEN EXISTING LAND USE AND MOST LIKELY FUTURE LAND USE CONDITIONS WITH PLAN A STORMWATER IMPROVEMENTS RETURN INTERVAL (YEARS)							
		1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100
LOWER JACKSON BROOK																									
AT MOUTH	4.75	510	637	1005	1355	1484	1666	1850	2488	668	889	1166	1396	1472	1587	1731	2375	158	252	161	41	-12	-79	-119	-113
ROUTE 46 (OUTFLOW)	4.75	510	637	1005	1356	1485	1666	1851	2491	668	889	1166	1397	1472	1587	1731	2377	158	252	161	41	-13	-79	-120	-114
ROUTE 46 (INFLOW)	4.75	406	645	1015	1384	1513	1749	2022	2532	669	892	1172	1401	1477	1607	1770	2402	263	247	157	17	-36	-142	-252	-130
JUST D/S OF SPRING BK. CONFL.	4.38	378	605	956	1305	1428	1649	1919	2412	632	841	1101	1311	1381	1499	1664	2284	254	236	145	6	-47	-150	-255	-128
SPRING BROOK																									
AT MOUTH	0.97	50	81	134	190	209	245	281	351	124	170	242	310	333	374	416	494	74	89	108	120	124	129	135	143
ROUTE 46	0.93	47	76	127	181	200	234	269	336	119	163	232	298	320	360	400	475	72	87	105	117	120	126	131	139
ST. MARYS AVENUE	0.54	24	40	68	98	109	128	148	186	64	89	128	166	178	201	224	268	40	49	60	68	69	73	76	82
IRONDALE ROAD	0.42	19	31	53	77	85	100	115	145	52	71	102	131	141	159	177	212	33	40	49	54	56	59	62	67
BLUEBERRY LANE	0.36	17	27	45	65	72	84	97	122	45	61	87	112	120	135	150	179	28	34	42	47	48	51	53	57
HARVEST LANE	0.17	11	16	25	34	38	43	49	60	20	27	38	49	52	59	66	78	9	11	13	15	14	16	17	18
UPPER JACKSON BROOK																									
HEDDEN POND WEIR (OUTFLOW)	3.21	326	518	808	1092	1192	1371	1602	2013	502	664	856	1003	1051	1133	1273	1784	176	146	48	-89	-141	-238	-329	-229
HEDDEN POND WEIR (INFLOW)	3.21	327	521	811	1095	1196	1375	1610	2013	534	750	1076	1394	1525	1763	1984	2383	207	229	265	299	329	388	374	370
INDIAN FALLS ROAD	1.52	188	281	425	567	618	708	808	988	310	423	589	746	800	896	992	1173	122	142	164	179	182	188	184	185
RANDOLPH AVENUE	1.38	175	260	391	521	567	650	740	903	295	401	554	699	747	833	920	1081	120	141	163	178	180	183	180	178
ROUTE 10	0.31	27	44	74	107	119	140	162	204	105	138	186	231	247	273	300	350	78	94	112	124	128	133	138	146
WALLACE BROOK																									
AT MOUTH	0.89	98	159	248	331	360	410	503	647	142	205	298	384	435	526	600	723	44	46	50	53	75	116	97	76
CONFLUENCE OF EAST AND WEST D/S BRANCHES BELOW RESERVOIR AVENUE	0.74	94	150	228	300	325	373	482	593	131	186	266	348	399	483	543	641	37	36	38	48	74	110	61	48
DOVER RESERVOIR (WEST)	0.46	80	130	196	253	273	308	343	410	114	167	227	287	308	344	380	447	34	37	31	34	35	36	37	37
DOVER RESERVOIR (EAST)	0.15	10	10	11	23	40	60	90	119	10	10	14	58	65	88	109	166	0	0	3	35	25	28	19	47
CENTER GROVE ROAD 1400 ft. D/S	0.21	45	63	92	120	130	147	164	197	60	81	113	143	153	171	189	222	15	18	21	23	23	24	25	25

NOTES: * *ALL FLOW VALUES IN CUBIC FEET PER SECOND (CFS).*

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

PLAN B
PEAK FLOW SUMMARY*
MOST LIKELY FUTURE

TABLE 6

LOCATION	DRAINAGE AREA (SQ. MI.)	EXISTING LAND USE CONDITIONS (BASED UPON 1998 AERIAL PHOTOGRAPHY)								MOST LIKELY FUTURE LAND USE CONDITIONS WITH PLAN B STORMWATER IMPROVEMENTS (BASED UPON 1999 ZONING MAP)								DIFFERENCE BETWEEN EXISTING LAND USE AND MOST LIKELY FUTURE LAND USE CONDITIONS WITH PLAN B STORMWATER IMPROVEMENTS							
		RETURN INTERVAL (YEARS)								RETURN INTERVAL (YEARS)								RETURN INTERVAL (YEARS)							
		1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100
LOWER JACKSON BROOK																									
AT MOUTH	4.75	510	637	1005	1355	1484	1666	1850	2488	553	773	1042	1275	1350	1467	1573	1779	43	136	37	-80	-134	-199	-277	-709
ROUTE 46 (OUTFLOW)	4.75	510	637	1005	1356	1485	1666	1851	2491	553	773	1042	1275	1351	1467	1573	1779	43	136	37	-81	-134	-199	-278	-712
ROUTE 46 (INFLOW)	4.75	406	645	1015	1384	1513	1749	2022	2532	574	774	1044	1282	1357	1472	1589	1806	168	129	29	-102	-156	-277	-433	-726
JUST D/S OF SPRING BK. CONFL.	4.38	378	605	956	1305	1428	1649	1919	2413	538	723	973	1193	1261	1363	1470	1683	160	118	17	-112	-167	-286	-449	-730
SPRING BROOK																									
AT MOUTH	0.97	60	81	134	190	209	245	281	351	134	170	242	310	333	374	416	494	74	89	108	120	124	129	135	143
ROUTE 46	0.93	47	76	127	181	200	234	269	336	119	163	232	298	320	360	400	475	72	87	105	117	120	126	131	139
ST. MARYS AVENUE	0.54	24	40	68	98	109	128	148	186	64	89	128	166	178	201	224	268	40	49	60	68	69	73	76	82
IRONDALE ROAD	0.42	19	31	53	77	85	100	113	145	52	71	102	131	141	159	177	212	33	40	49	54	56	59	62	67
BLUEBERRY LANE	0.36	17	27	45	65	72	84	97	122	45	61	87	112	120	135	150	179	28	34	42	47	48	51	53	57
HARVEST LANE	0.17	11	16	25	34	38	43	49	60	20	27	38	49	52	59	66	78	9	11	13	15	14	16	17	18
UPPER JACKSON BROOK																									
HEDDEN POND WEIR (OUTFLOW)	3.21	326	518	808	1092	1192	1371	1602	2013	410	548	730	891	932	1003	1075	1250	84	30	-78	-201	-260	-368	-527	-763
HEDDEN POND WEIR (INFLOW)	3.21	327	531	811	1095	1196	1375	1610	2013	423	603	846	1112	1218	1385	1546	1854	96	72	35	17	22	10	-64	-159
INDIAN FALLS ROAD	1.53	188	281	425	567	618	708	808	988	221	305	430	547	587	659	732	873	33	24	5	-20	-31	-49	-76	-115
RANDOLPH AVENUE	1.38	175	260	391	521	567	650	740	903	210	288	403	510	546	613	679	807	35	28	12	-11	-21	-37	-61	-96
ROUTE 10	0.31	27	44	74	107	119	140	162	204	46	60	81	101	108	119	131	152	19	16	7	-6	-11	-21	-31	-52
WALLACE BROOK																									
AT MOUTH	0.89	98	159	248	331	360	410	503	647	142	205	298	384	435	526	600	723	44	46	50	53	75	116	97	76
CONFLUENCE OF EAST AND WEST D/S BRANCHES BELOW RESERVOIR AVENUE	0.74	94	150	228	300	325	373	482	593	131	186	266	348	399	483	543	641	37	36	38	48	74	110	61	48
DOVER RESERVOIR (WEST)	0.46	80	130	196	253	273	308	343	410	114	167	227	287	308	344	380	447	34	37	31	34	35	36	37	37
DOVER RESERVOIR (EAST)	0.15	10	10	11	23	40	60	90	119	10	10	14	58	65	88	109	166	0	0	3	35	25	28	19	47
CENTER GROVE ROAD 1400 ft. D/S	0.21	45	63	90	120	130	147	164	197	60	81	113	143	153	171	189	222	15	18	21	23	23	24	25	25

NOTES: * *ALL FLOW VALUES IN CUBIC FEET PER SECOND (CFS).*

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

PLAN C
PEAK FLOW SUMMARY*
MOST LIKELY FUTURE

TABLE 7

LOCATION	DRAINAGE AREA (SQ. MI.)	EXISTING LAND USE CONDITIONS (BASED UPON 1998 AERIAL PHOTOGRAPHY) RETURN INTERVAL (YEARS)								MOST LIKELY FUTURE LAND USE CONDITIONS WITH PLAN C STORMWATER IMPROVEMENTS (BASED UPON 1999 ZONING MAP) RETURN INTERVAL (YEARS)								DIFFERENCE BETWEEN EXISTING LAND USE AND MOST LIKELY FUTURE LAND USE CONDITIONS WITH PLAN C STORMWATER IMPROVEMENTS RETURN INTERVAL (YEARS)							
		1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100
LOWER JACKSON BROOK																									
AT MOUTH	4.75	510	637	1005	1355	1484	1666	1850	2488	510	765	1038	1263	1340	1458	1566	1768	0	128	33	-92	-144	-208	-284	-720
ROUTE 46 (OUTFLOW)	4.75	510	637	1005	1356	1485	1666	1851	2491	510	765	1038	1263	1340	1458	1566	1768	0	128	33	-93	-145	-208	-285	-723
ROUTE 46 (INFLOW)	4.75	406	645	1015	1384	1513	1749	2022	2532	555	766	1040	1270	1346	1463	1581	1799	149	121	25	-114	-167	-286	-441	-733
JUST D/S OF SPRING BK. CONFL.	4.38	378	605	936	1305	1428	1649	1919	2412	520	716	969	1181	1251	1394	1462	1664	142	111	13	-124	-177	-255	-457	-748
SPRING BROOK																									
AT MOUTH	0.97	50	81	134	190	209	245	281	351	124	170	242	310	333	374	415	494	74	89	108	120	124	129	135	143
ROUTE 46	0.93	47	76	127	181	200	234	269	336	119	163	232	298	320	360	400	475	72	87	105	117	120	126	131	139
ST. MARYS AVENUE	0.54	24	40	68	98	109	128	148	186	64	89	128	166	178	201	224	268	40	49	60	68	69	73	76	82
IRONDALE ROAD	0.42	19	31	53	77	85	100	115	145	52	71	102	131	141	159	177	212	33	40	49	54	56	59	62	67
BLUEBERRY LANE	0.36	17	27	45	65	72	84	97	122	45	61	87	112	120	135	150	179	28	34	42	47	48	51	53	57
HARVEST LANE	0.17	11	16	25	34	38	43	49	60	20	27	38	49	52	59	66	78	9	11	13	15	14	16	17	18
UPPER JACKSON BROOK																									
HEDDEN POND WEIR (OUTFLOW)	3.21	326	518	808	1092	1192	1371	1602	2013	395	542	727	879	925	996	1069	1235	69	24	-81	-213	-267	-375	-533	-778
HEDDEN POND WEIR (INFLOW)	3.21	327	521	811	1095	1196	1375	1610	2013	406	588	846	1091	1175	1357	1540	1854	79	67	35	-4	-21	-18	-70	-159
INDIAN FALLS ROAD	1.53	188	281	425	567	618	708	808	988	221	305	430	547	587	659	732	873	33	24	5	-20	-31	-49	-76	-115
RANDOLPH AVENUE	1.38	175	260	391	521	567	650	740	903	210	288	403	510	546	613	679	807	35	28	12	-11	-21	-37	-61	-96
ROUTE 10	0.31	27	44	74	107	119	140	162	204	46	60	81	101	108	119	131	152	19	16	7	-6	-11	-21	-31	-52
WALLACE BROOK																									
AT MOUTH	0.89	98	159	248	331	360	410	503	647	122	195	291	381	410	463	565	714	24	36	43	50	50	53	62	67
CONFLUENCE OF EAST AND WEST D/S BRANCHES BELOW RESERVOIR AVENUE	0.74	94	150	228	300	325	373	482	593	112	177	260	337	363	428	527	643	18	27	32	37	38	55	45	50
DOVER RESERVOIR (WEST)	0.46	80	130	196	253	273	308	343	410	97	156	230	288	308	344	380	447	17	26	34	35	35	36	37	37
DOVER RESERVOIR (EAST)	0.15	10	10	11	23	40	60	90	119	9	10	13	29	45	68	95	130	-1	0	2	6	5	8	5	11
CENTER GROVE ROAD 1400 ft. D/S	0.31	45	63	92	120	130	147	164	197	60	81	113	143	153	171	189	222	15	18	21	23	23	24	25	25

NOTES: * *ALL FLOW VALUES IN CUBIC FEET PER SECOND (CFS).*

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

PLAN D
PEAK FLOW SUMMARY*
MOST LIKELY FUTURE

TABLE 8

LOCATION	DRAINAGE AREA (SQ. MI.)	EXISTING LAND USE CONDITIONS (BASED UPON 1998 AERIAL PHOTOGRAPHY) RETURN INTERVAL (YEARS)								MOST LIKELY FUTURE LAND USE CONDITIONS WITH PLAN D STORMWATER IMPROVEMENTS (BASED UPON 1999 ZONING MAP) RETURN INTERVAL (YEARS)								DIFFERENCE BETWEEN EXISTING LAND USE AND MOST LIKELY FUTURE LAND USE CONDITIONS WITH PLAN D STORMWATER IMPROVEMENTS RETURN INTERVAL (YEARS)							
		1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100	1	2	5	10	15	25	50	100
LOWER JACKSON BROOK																									
AT MOUTH	4.75	510	637	1005	1355	1484	1666	1850	2488	510	715	970	1182	1250	1359	1469	1668	0	78	-35	-173	-234	-307	-381	-820
ROUTE 46 (OUTFLOW)	4.75	510	637	1005	1356	1485	1666	1851	2491	510	713	970	1182	1250	1359	1470	1668	0	78	-35	-174	-235	-307	-381	-823
ROUTE 46 (INFLOW)	4.75	406	645	1015	1384	1513	1749	2022	2532	519	716	972	1182	1256	1363	1473	1691	113	71	-43	-202	-257	-386	-549	-841
JUST D/S OF SPRING BR. CONFL.	4.38	378	605	956	1305	1428	1649	1919	2412	484	666	903	1102	1164	1262	1362	1575	106	61	-53	-203	-264	-387	-557	-837
SPRING BROOK																									
AT MOUTH	0.97	50	81	134	190	209	245	281	351	79	108	153	196	210	237	263	312	29	27	19	6	1	-8	-18	-39
ROUTE 46	0.93	47	76	127	181	200	234	269	336	75	103	146	187	201	226	252	299	28	27	19	6	1	-8	-17	-37
ST. MARYS AVENUE	0.54	24	40	68	98	109	128	148	186	43	60	85	110	119	134	149	179	19	20	17	12	10	6	1	-7
IRONDALE ROAD	0.42	19	31	53	77	85	100	115	145	36	49	70	90	97	109	122	145	17	18	17	13	12	9	7	0
BLUEBERRY LANE	0.36	17	27	45	65	72	84	97	122	32	43	61	79	85	95	106	126	15	16	16	14	13	11	9	4
HARVEST LANE	0.17	11	16	25	34	38	43	49	60	20	27	38	49	52	59	66	78	9	11	13	15	14	16	17	18
UPPER JACKSON BROOK																									
HEDDEN POND WEIR (OUTFLOW)	3.21	326	518	808	1092	1192	1371	1602	2013	395	543	727	879	925	996	1069	1235	69	24	-81	-213	-267	-375	-533	-778
HEDDEN POND WEIR (INFLOW)	3.21	327	521	811	1095	1196	1375	1610	2013	406	588	846	1091	1175	1357	1540	1854	79	67	35	-4	-21	-18	-70	-159
INDIAN FALLS ROAD	1.52	188	281	425	567	618	708	808	988	221	305	430	547	587	659	732	873	33	24	5	-20	-31	-49	-76	-115
RANDOLPH AVENUE	1.38	175	260	391	521	567	650	740	903	210	288	403	510	546	613	679	807	35	28	12	-11	-21	-37	-61	-96
ROUTE 10	0.31	27	44	74	107	119	140	162	204	46	60	81	101	108	119	131	152	19	16	7	-6	-11	-21	-31	-52
WALLACE BROOK																									
AT MOUTH	0.89	98	159	248	331	360	410	503	647	122	195	291	381	410	463	565	714	24	36	43	50	50	53	62	67
CONFLUENCE OF EAST AND WEST D/S BRANCHES BELOW RESERVOIR AVENUE	0.74	94	150	228	300	325	373	482	593	112	177	260	337	363	428	527	643	18	27	32	37	38	55	45	50
DOVER RESERVOIR (WEST)	0.46	80	130	196	253	275	308	343	410	97	156	230	288	308	344	380	447	17	26	34	35	33	36	37	37
DOVER RESERVOIR (EAST)	0.15	10	10	11	23	40	60	90	119	9	10	13	29	45	68	95	130	-1	0	2	6	5	8	5	11
CENTER GROVE ROAD 1400 ft. D/S	0.21	45	63	92	120	130	147	164	197	60	81	113	143	153	171	189	222	15	18	21	23	23	24	25	25

NOTES: * *ALL FLOW VALUES IN CUBIC FEET PER SECOND (CFS).*

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

TABLE 9

RECOMMENDED STORMWATER MANAGEMENT CONTROL MEASURES
PRELIMINARY CONSTRUCTION COST ESTIMATE

STORMWATER CONTROL PLAN	IMPROVEMENT FACILITY NO.	DESCRIPTION	LOCATION	ESTIMATED PROBABLE COST
STRUCTURAL MEASURES PLAN D	1	RECONSTRUCTION OF HEDDON POND DAM RETENTION BASIN	LOWER JACKSON BROOK	$1,925,00.00
	2	STREAMBANK STABILIZATION IMPROVEMENTS ON WALLACE BROOK	WALLACE BROOK AT HEDDON PARK	$275,000.00
	3	STREAMBANK STABILIZATION IMPROVEMENTS RETENTION WALL REPAIR ON LOWER JACKSON BROOK	LOWER JACKSON BROOK AT PARK HEIGHTS DRIVE	$70,000.00 *(CONSTRUCTED)*
	4	RECONSTRUCTION OF BROOK LANE BRIDGE ON LOWER JACKSON BROOK	LOWER JACKSON BROOK AT BROOK LANE	$400,000.00
	5	IMPROVEMENT OF TWIN RESERVOIR IMPOUNDMENT ON WALLACE BROOK	WALLACE BROOK AT RESERVOIR ROAD	$250,000.00
	6	RECONSTRUCTION OF ST. MARY STREET CULVERT ON SPRING BROOK	SPRING BROOK AT ST. MARY STREET	$345,000.00
			PLAN D TOTAL	$3,265,000.00
			STRUCTURAL MEASURES TOTAL	$3,195,000.00
NON-STRUCTURAL MEASURES		AMENDMENTS TO LAND USE AND STORMWATER ORDINANCES TO INCLUDE RETROFITTING OF EXISTING DRAINAGE STRUCTURES	NON STRUCTURAL MEASURES TOTAL	NA
			IMPROVEMENTS TOTAL	$3,195,000.00

7.0 FINDINGS AND CONCLUSIONS

Based upon the engineering studies and the evaluation of the stormwater runoff impacts, for existing and "most-likely" future land development conditions, with and without stormwater control measures, within the Jackson Brook watershed, the following findings and conclusions are presented.

1. Increases in development without adequate and coordinated stormwater management controls and improvements will result in increases in peak flows and additional soil erosion problems along the study area's streams during storm events with recurrence intervals ranging from 1 year to 100 years.

2. The "Land Development Standards" of Morris County contain provisions which state, as per section 601 et seq., that **"All subdivisions and site plans subject to County approval shall provide for the management of stormwater runoff in a manner consistent with the following policies"** starting with Item A, (in italics below) and continuing through Item G:

   A. All subdivisions and site plans shall provide adequate drainage structures in accordance with the standards established herein for the management of stormwater runoff that is generated by a development that now flows or will flow directly or indirectly to a County road or through a County drainage facility…………… continue through G. (Please refer to Land Development Standards)

   Even though the municipalities will adhere to the County's standards and enforce the above and other stormwater control requirements in their regulations and ordinances, increases in runoff rates could still occur at various points downstream of a development site because the review of site plan and subdivision applications are currently carried out on a site-by-site basis and not within the context of the entire drainage basin and also because the local ordinances do not require the applicant to conduct a hydrologic and hydraulic analysis of the watershed in which the site is located. Therefore, the cumulative impacts of new land developments and the interrelationship between the various parts of the Jackson Brook watershed in terms of peak flows and the timing of peak flows will remain unknown unless a drainage basin hydrologic analysis or database is available to quantify those impacts.

3. The hydrologic and hydraulic analysis conducted herein for the Jackson Brook watershed will provide the hydrologic database to quantify the runoff discharge impacts of new development upon downstream locations in the drainage basin area.

4. The water quality base line assessment conducted herein will provide the database to evaluate the impacts upon the stream water quality resulting from new developments within the drainage basin area.

5. Maintaining the base condition in the watershed would be to take no action to implement coordinated stormwater management control measures to mitigate the impacts of future land development or to correct existing problems. The base condition consists of reliance on the exiting stormwater control provisions in the watershed municipalities' existing stormwater control ordinances and floodplain and wetland regulations as required by Federal, State and Local laws.

The present policy of requiring the installation of an on-site stormwater detention facility within the property boundary of each development and controlling the stormwater runoff impact of the development only to the boundary of the site itself will result in increases in peak flows at locations further downstream during storm events, such as the 2-, 10- and 100-year design storm events which are required by current standards.

This means that the conventional site-by-site requirements for the control of stormwater runoff on-site, as contained in current municipal ordinances and land use regulations within the study area municipalities, will not be effective in controlling runoff at downstream locations if new development takes place in accordance with anticipated future land use projections.

6. The increases in peak flows due to uncontrolled runoff from future land development will aggravate the existing flooding problems along the main stem of Jackson Brook, Wallace Brook and Spring Brook (see Tables 2 and 2A). The increased flows will exacerbate the erosion and flooding problems in both Hedden Park and Hurd Park and will cause more frequent overtopping of the flood-prone roadways/bridge crossings, resulting in adverse impacts upon residences and transportation and business/commercial activities, all of which compromise the safety of the public and increase their inconvenience.

7. The Upper Jackson Brook and Spring Brook drainage subareas have no potential "regional detention basin" sites that can provide sufficient additional storage to attenuate 100-year flood peaks without the construction of an on-site detention basin as well. Therefore, since regional detention basin sites on these streams were not considered feasible, they are not included in the recommended watershed plan for these two major subdrainage areas.

However, non-structural stormwater management control mechanisms utilizing an **"allowable release rate policy"** can manage the increase in runoff volumes from future development such that peak rates of runoff through each of the 26 subareas in these two major subdrainage areas are not increased. The release rate policy that requires the peak rate of runoff leaving each of the 26 subareas after development to be 50%, 75% and 75% of the predevelopment peak flow for the 2-, 10-, and 100-year storm events, respectively, will meet the objectives of this study. This means joint detention facilities serving more than one subdivision or development site can be utilized to control runoff from new development within each of the 26 subareas in lieu of the conventional site-by-site detention basin.

8. The Upper Jackson Brook and Spring Brook major subdrainage areas are covered with soils, the majority of which fall into the Hydrologic Soil Grouping B, which have infiltration rates equal to or greater than 0.5 inches per hour and therefore are suitable for stormwater infiltration facilities such as infiltration trenches and dry wells.

   The existing residential and non-residential structures within these two subdrainage areas should be retrofitted with infiltration measures where feasible and new developments should be required to include stormwater infiltration measures in their design prior to approval of the site plan.

9. For the Wallace Brook subdrainage area, regional detention basin stormwater controls are not technically feasible for mitigating future conditions' peak flows. However, the proposed improvements to the existing Dover Twin Reservoir facility will provide additional flood storage capacity to alleviate existing flooding conditions downstream and increase the level of flood protection at the Reservoir Avenue crossing form the 10-year to the 50-year recurrence interval.

10. For the upper sections of the watershed area, under current land use conditions, it was determined that most of the bridges and culverts analyzed are hydraulically sufficient, as per the NJDEP definition of being able to safely pass flows during a 100-year storm event.

    The bridge/culvert structures along the Upper Jackson Brook located at U.S. Route 10, Randolph Avenue and Indian Falls Road all have the capability to handle flows equal to or greater than the 100-year storm event.

For the Spring Brook subdrainage area, the culvert structures at Harvest Lane, Garden Avenue and U.S. Route 46 are all capable of safely passing the 100-year storm flows without overtopping. However, the St. Mary's Street, Blueberry Lane, Irondale Road and Jules Farm culverts are all hydraulically insufficient and can handle only peak flows up to the 5-year storm event without overtopping.

For the Wallace Brook subdrainage area, the existing culvert combined with the Twin Reservoir outlet works at Reservoir Avenue was analyzed as capable of handling storm flows equal to or less than the 10-year storm event.

11. For the lower sections of the watershed, specifically the Lower Jackson brook subdrainage area, the existing weir at Hedden Pond allows peak flows from the 2-year through 100-year storm events to pass through the facility with little or no attenuation of flood flows and is submerged by downstream tailwater conditions during events equal to or greater than the 10-year storm.

12. With future development, the facilities along the Lower Jackson Brook will remain hydraulically insufficient and their overtopping frequencies increased if adequate stormwater controls are not implemented in the upstream subdrainage areas.

13. The implementation of Plan D, which calls for flow attenuation improvements at Dover Twin Reservoir and and a new dam at the Hedden Pond Impoundment, in conjunction with an **"allowable release rate policy"** of 50%, 75%, 75% for 2-, 10- and 100-year storms' post-development flows, and bridge culvert improvements at St. Mary's Street (Spring Brook), Brook Lane (Lower Jackson Brook), will result in the largest overall reduction in peak flows along the main stem Jackson Brook, Wallace Brook and Spring Brook. As seen in Table 8, "Plan D Peak Flow Summary," this plan reduces the majority of future land use conditions flows to levels approximately equal to or less than those that currently

exist at the mouth of the watershed streams for the selected range of storm recurrence intervals between the 5-year and 100-year events, with the exception of Wallace Brook.

14. Plan D stormwater control measures will not sufficiently reduce the future land use condition peak flows to existing land use condition levels for storms up the 2-year return interval on the main stem of Jackson Branch, Spring Brook and Wallace Brook. Consequently, control of the peak flows resulting from the 2-year storm are needed within the property boundary of each land development site within the Spring Brook and Upper Jackson Brook major subdrainage areas, where the potential for new land development is the greatest.

15. The water quality baseline data for the entire watershed area revealed pollutant loadings of total phosphorus, biochemical oxygen demand (BOD_5), orthophosphate and ammonia-nitrogen to be acceptable since no major contravention of water quality or growth of nuisance algae was apparent.

    However, it is noted that elevated concentrations of nutrients were found in the sediments at Hedden Pond with petroleum hydrocarbons being a major source.

16. Under future land use conditions the pollutant loads for total phosphorus, BOD_5,orthophosphate and ammonia-N will increase by 62%, 49%, 66% and 80%, respectively, for the entire watershed area.

    Because of this potential for increase in pollutant loadings, particularly with regard to nutrients, inexpensive retrofits of existing drainage structures should be considered to enhance the quality of runoff. The retrofitting of the existing drainage structures should consider utilizing oil and grease traps and sediment removal devices as manufactured by Stormceptor or equivalent.

17. The steep banks of the watershed streams should be armored with appropriate bank stabilization measures in accordance with the New Jersey State Standards for Soil Erosion and Sediment Control.

    Additionally, all existing severely eroded sections of the Wallace Brook and Jackson Brook must be stabilized with appropriate armoring and the planting of trees to arrest the continuous erosion and migration of the stream banks.

18. The water quality control requirement for site developments shall be in compliance with the NJDEP requirement that all runoff up to the water quality design storm be controlled by appropriate techniques which may include alternative land use, site design, source controls and structural controls individually or in combination with one another. The water quality design storm is defined as either the storm of 1.25 inch of rainfall falling uniformly in two hours or the equivalent in 24 hours using the U.S. Soil Conservation Service Type III rainfall distribution.

19. The Spring Brook and Upper Jackson Brook should be designated as an **On-Site Stormwater Management Zone** with municipal ordinance amendments to include provisions for on-site "release rate policy" and the retrofitting of existing separate drainage structure with infiltration measures. All new land development and redevelopment proposals would be required to be in compliance with the recommended stormwater control mechanism for these two major subdrainage areas.

20. The Wallace Brook and Lower Jackson Brook should be designated as a **Stormwater Management Zone**, which would require all new land development and redevelopment proposals to be in compliance with the recommended stormwater control measures for these major subdrainage areas. These measures

will include structural improvements and ordinance amendments and water quality Best Management Practices as identified in Section 6.

21. The Jackson Brook Watershed should be designated as a special ***Stormwater Management District*** consistent with the delineation of the major watersheds and drainage basins in Morris County as outlined in Appendix F of the "Morris County Stormwater Management Technical Guide" dated May 1989 and comprised of two subdistrict stormwater management zones as identified above.

The proposed ***Jackson Brook Stormwater Management District*** delineation contains the added flexibility for future alternative strormwater applications. One such application, authorized in many states, is the stormwater utility which has produced significant benefits for both flood control and water quality improvements.

A stormwater utility is a financing mechanism funded through service fees which are administered separately from the general tax fund thereby providing a stable and dedicated funding source for carrying out stormwater quantity and quality control. Stormwater utilities have also been instrumental in implementing the recommendations of watershed plans, providing for operation and maintenance of the structural facilities, providingfor the safety and enjoyment of its citizens and for the preservation and enhancement of wetlands, stream corridors and wildlife habitat.

It is important to note that the concept of the stormwater utility would require legislative authorization in New Jersey. With this in mind, NJDEP is currently investigating the applicability of stormwater utilities from an environmrntal and legal basis.

8. RECOMMENDED WATERSHED STORMWATER MANAGEMENT PLAN

On the basis of the results produced by our engineering and scientific investigations, the evaluation of various alternative stormwater control measures and regional basin site plans described herein, and consultation and coordination with Morris County project staff and the project advisory committee consisting of representatives from the municipalities of Randolph, Mine Hill, Wharton and Dover, including the Morris County Park Commission, a recommended Stormwater Management Plan for the watershed has been selected. This plan is graphically illustrated in Appendix A on Plate 9 – Recommended Watershed Stormwater Management Plan Map, which shows the location and components of the plan.

Due to the variabilities of scientific, regulatory and environmental conditions in the watershed and the availability of area-wide computer models that allow for ongoing updating of watershed conditions and analysis of alternative management measures as new developments or redevelopments are implemented, the recommended plan for the Jackson Brook watershed represents a combination of structural and non-structural stormwater management measures, which are delineated by zone. This recommended plan is comprised of the Plan D stormwater control mechanisms. The components are:

Structural

1) Reconstruction of the Hedden Pond impoundment at the confluence of Wallace Brook and Upper Jackson Brook into a Regional Wet Pond Detention Basin with a new dam and outlet works and including the removal of sediment deposits.
2) Installation of streambank stabilization Improvements on the Wallace Brook in Hedden Park that are compatible with the existing environmental setting.
3) Installation of streambank stabilization improvements and repair of retaining walls on the Lower Jackson Brook just upstream of Hurd Park.
4) Reconstruction of the Brook Lane Bridge on Lower Jackson Brook.

5) Improvement of the Twin Reservoir Impoundment on Reservoir Road on Wallace Brook including the removal of sediment deposits.
6) Reconstruction of the roadway culvert at the St. Mary's Street crossing of Spring Brook.

Table 9 summarizes the preliminary estimates of the probable construction costs of the recommended structural stormwater control measures. The total preliminary estimated construction cost of Plan D improvements' structural components is approximately $3,265,000.

Improvement 1 – Reconstruction of Hedden Pond Dam and Retention Basin

A perspective view of the proposed Hedden Pond Dam within the Hedden Park setting is shown on Figure 6. The conceptual plan layout including section and elevation views are shown on Figure 7. The implementation of the proposed new dam and retention basin will provide 100-year level flood protection and alleviate the chronic flooding problems on the Lower Jackson Brook. The new dam is an earth embankment structure approximately 595 feet long and 24 feet high (above its downstream toe) complete with primary spillway outlet works and emergency spillway. This improvement also includes the removal of accumulated sediments from Heddon Pond. The estimated probable construction cost of this improvement is $1,925,000.

Improvement 2 – Streambank Stabilization Improvements on Wallace Brook

The conceptual streambank stabilization improvements are shown in general plan and typical sections on Figures 8 and 9. Figure 8 shows the armoring of the eroded Wallace Brook reach downstream of Reservoir Avenue with large boulders and the planting of willow trees on the banks. Also included are three low-check dams strategically placed within the stream reach. Figure 9 shows the proposed repairs to the eroded sections of Wallace Brook near its mouth adjacent to the Hedden Park recreation pavilion. These bank stabilization measures consist of armoring the left bank with large boulders and conducting repairs to the existing gabion walls on the right bank. The estimated probable construction cost of these stabilization improvements is approximately $275,000.

Improvement 3 – Streambank Stabilization Improvements on Lower Jackson Brook

This improvement consists of the repair of the eroded and washed-out section of the right streambank adjacent to Park Heights Drive. The proposed improvement consists of constructing a new retaining wall of approximately 320 linear feet utilizing Victorian stone block construction. The layout of the general plan and typical section of the improvement is shown on Figure 10. The estimated probable construction cost of this improvement is approximately $70,000. (Constructed)

Improvement 4 – Brook Lane Bridge Improvement

The Brook Lane bridge is located approximately 400 feet downstream of the Hedden Pond weir. The existing bridge which has been overtopped during the 1992, 1996 and 1999 flood events is in need of repair. The existing 15-foot span by 5-feet high bridge waterway opening will be increased to allow for the passage of flood flows with the implementation of the Hedden Pond Dam. The proposed new bridge will be a twin 16-foot by 5-foot concrete arch structure with a 50-year flood return interval design capacity. The general plan layout and typical section of the improvement is shown on Figure 11. The estimated probable construction cost is approximately $400,000.

Improvement 5 – Dover Twin Reservoirs Improvement

The Dover Twin Reservoir is located at Reservoir Avenue along Wallace Brook and is fed by tributary branches of Wallace Brook. The proposed improvement to this facility includes the raising of the earth embankment to provide additional flood storage, the removal of accumulated silt deposits and the repair of the existing outlet works valve mechanisms. The general plan layout and typical sections are shown on Figure 12. The estimated probable construction cost is approximately $250,000.

Improvement 6 – St. Mary's Street Culvert Improvement

The St. Mary's Street culvert is located on the Spring Brook at the municipal border of Mine Hill and Wharton. The existing inadequate 48-inch diameter reinforced concrete pipe culvert will be replaced with a 10-foot by 4-foot concrete box culvert with formed natural stone focia. The general plan layout and section is shown on Figure 13. The estimated probable construction cost is approximately $345,000.

Non Structural

The non-structural control technique recommended for the basin is to amend the existing "Land Use Regulations" and / or "Stormwater Control Ordinances" requirements for stormwater control in the watershed's four municipalities or to enact a new municipal "Stormwater Control Ordinances" geared toward mitigating the impacts of stormwater runoff from land development within the drainage basin. The ordinance shall be applicable to any site plan or subdivision that requires site plan review.

The New Jersey Department of Environmental Protection's (NJDEP) proposed amendments to the Stormwater Management Regulations N.J.A.C. 7:8 include flood and erosion control requirements which state *"Control runoff rates and velocities from the development site for the 2-, 10- and 100-year storm events so that no increases in flow rate and velocity above existing or pre-developed levels occur at or downstream of the site. To achieve this required degree of site runoff control, the peak runoff rates for the 2-, 10- and 100-year storm events shall be controlled in accordance with a municipally approved regional stormwater management plan for the watershed in which the development site is located. In the absence of such an approved stormwater management plan, the peak runoff rates for the 2-, 10- and 100-year storm events from the site following development shall be controlled in accordance with a hydrologic and hydraulic analysis of the watershed in which the site is located. Such a study shall be in accordance with the standards and procedures adopted by the municipal engineer and shall address existing development, development proposed by the applicant and if warranted, ultimate or full development conditions in the watershed."*

The implementation of Plan D structural measures, in conjunction with the **"Allowable Release Rate Policy"** of controlling the 2-, 10- and 100-year storms' post-development flows to 50%, 75% and 75% of pre-development flows, respectively, will result in the largest overall reduction in future land use conditions peak flow rates for storm events ranging from the 5-year up to the 100-year return interval along the main stem Jackson Brook and Spring Brook. However, the recommended improvements will not reduce the increased stormwater flows under future land development condition to existing development levels along the main stem of Jackson and Spring brooks for the 1- and 2-year storm events, with the exception of Wallace Brook, where the desired reduction is not achieved.

The following are our recommendations for amendments to the Township's Land Use Regulations:

1. Plan D recommended structural stormwater management improvements shall be adopted as an integral component of the Stormwater Management Plan for the Jackson Brook watershed.

2. The Spring Brook and Upper Jackson Brook should be designated as an **On-Site Stormwater Management Zone** with municipal ordinance amendments to include provisions for on-site "release rate policy" and the retrofitting of existing separate drainage structure with infiltration measures. All new land development and redevelopment proposals would be required to be in compliance with the recommended stormwater control mechanism for these two major subdrainage areas.

3. The Wallace Brook and Lower Jackson Brook should be designated as a **Stormwater Management Zone** which would require all new land development and redevelopment proposals to be in compliance with the recommended stormwater control measures for these major subdrainage areas.

measures will include structural improvements and ordinance amendments and water quality Best Management Practices as identified in Section 6.

4. The Jackson Brook Watershed should be designated as a special ***Stormwater Management District*** consistent with the delineation of the major watersheds and drainage basins in Morris County as outlined in Appendix F of the "Morris County Stormwater Management Technical Guide" dated May 1989 and comprising two subdistrict stormwater management zones as identified above; and shall be known as the ***Jackson Brook Stormwater Management District.***

5. The proposed ***Jackson Brook Stormwater Management District*** should consider the possibility of implementing a utility structure similar to that of a water or sewer utility upon authorization by the New Jersey Legislature. The utility structure should be a financing mechanism funded through service fees which provides a stable and dedicated funding source for carrying out stormwater quantity and quality improvements. The utility structure would provide the means for implementing the recommendations of the watershed plan, providing for operation and maintenance of the structural facilities, providing for the safety and enjoyment of its citizens and for the preservation and enhancement of wetlands, stream corridors and wildlife habitat.

6. All new land development and redevelopment proposals for subdivisions and site plans that require site plan review shall be in compliance with the recommended stormwater management plan for the drainage basin.

7. Stream flow velocity or drainage discharge controls shall be provided within each subdivision site such that the stormwater discharges from the site shall not cause erosion in the downstream channel or degrade conditions in the downstream channels, within the entire drainage basin.

8. For the Spring Brook and Upper Jackson Brook **on-site** stormwater management zone, stormwater management controls shall be provided within the boundaries of each land development subdivision site sufficient to control the 2-year storm event so that no increases in flow rate and velocity above existing land use conditions occur at or downstream of the property boundary, in compliance with the Plan D stormwater management plan **'allowable release rate"** 50%, 75%-75% policy for controlling the 2-, 10- and 100-year storms and the NJDEP water quality design storm requirement.

9. For the Wallace Brook and Lower Jackson Brook **Stormwater Management Zone** water quality control requirements shall be in compliance with the NJDEP requirement that all runoff up to the water quality design storm be controlled by appropriate techniques which may include alternative land use, site design, source controls and structural controls individually, or in combination with one another. The water quality design storm is defined as either the storm of 1.25 inch of rainfall falling uniformly in two hours, or the equivalent in 24 hours using the U.S. Soil Conservation Service Type III rainfall distribution.

It is also recommended that the County and municipal agencies enter into discussions with affected property owners at the recommended structural improvement sites and pursue the administrative procedures required to implement the recommended Stormwater Management Plan for the Jackson Brook watershed.

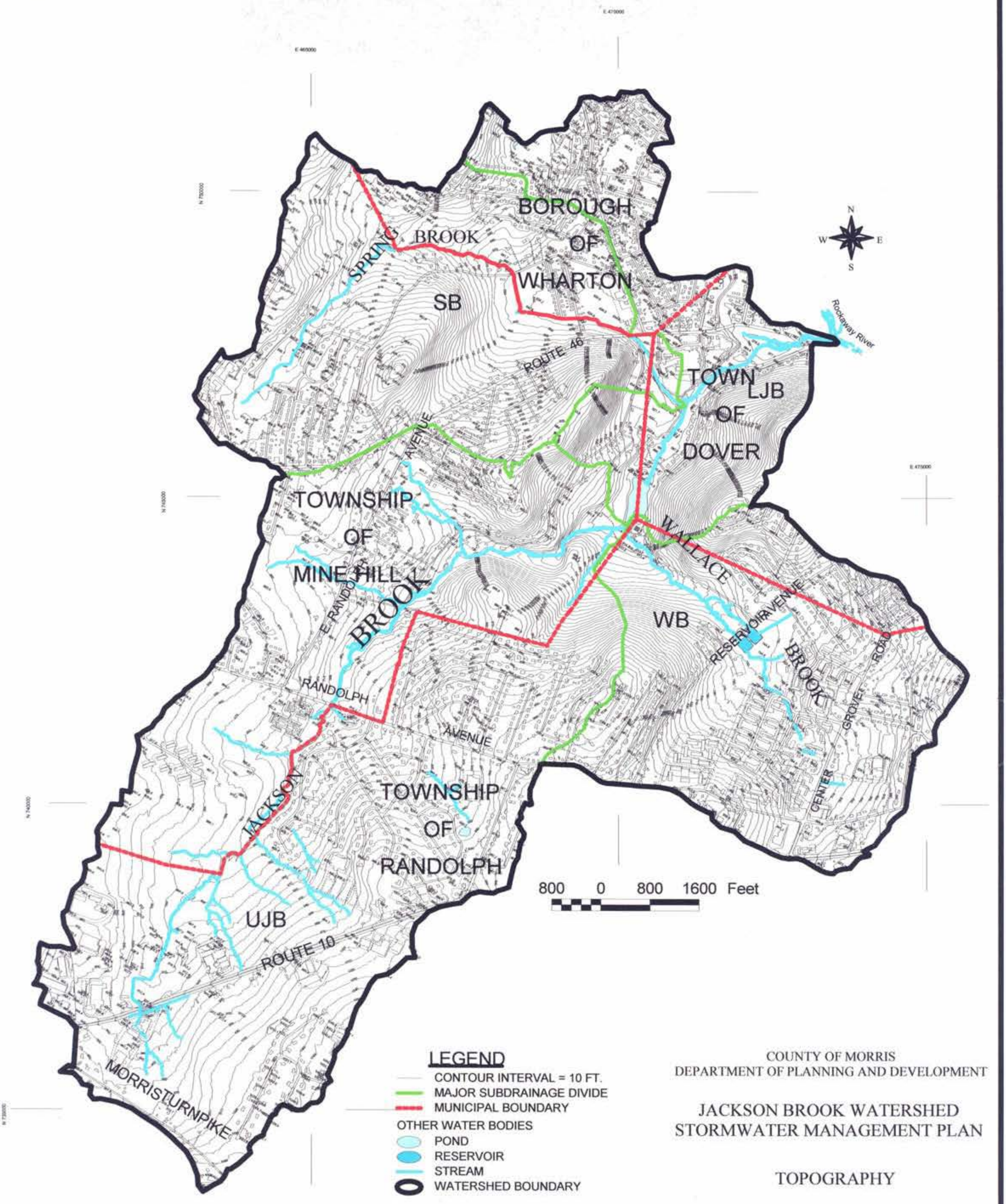
COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

TABLE 9

RECOMMENDED STORMWATER MANAGEMENT CONTROL MEASURES
PRELIMINARY CONSTRUCTION COST ESTIMATE

STORMWATER CONTROL PLAN	IMPROVEMENT FACILITY NO.	DESCRIPTION	LOCATION	ESTIMATED PROBABLE COST
STRUCTURAL MEASURES PLAN D	1	RECONSTRUCTION OF HEDDON POND DAM RETENTION BASIN	LOWER JACKSON BROOK	$1,925,00.00
	2	STREAMBANK STABILIZATION IMPROVEMENTS ON WALLACE BROOK	WALLACE BROOK AT HEDDON PARK	$275,000.00
	3	STREAMBANK STABILIZATION IMPROVEMENTS RETENTION WALL REPAIR ON LOWER JACKSON BROOK	LOWER JACKSON BROOK AT PARK HEIGHTS DRIVE	$70,000.00 *(CONSTRUCTED)*
	4	RECONSTRUCTION OF BROOK LANE BRIDGE ON LOWER JACKSON BROOK	LOWER JACKSON BROOK AT BROOK LANE	$400,000.00
	5	IMPROVEMENT OF TWIN RESERVOIR IMPOUNDMENT ON WALLACE BROOK	WALLACE BROOK AT RESERVOIR ROAD	$250,000.00
	6	RECONSTRUCTION OF ST. MARY STREET CULVERT ON SPRING BROOK	SPRING BROOK AT ST. MARY STREET	$345,000.00
			PLAN D TOTAL	$3,265,000.00
			STRUCTURAL MEASURES TOTAL	$3,195,000.00
NON-STRUCTURAL MEASURES		AMENDMENTS TO LAND USE AND STORMWATER ORDINANCES TO INCLUDE RETROFITTING OF EXISTING DRAINAGE STRUCTURES	NON STRUCTURAL MEASURES TOTAL	NA
			IMPROVEMENTS TOTAL	$3,195,000.00



LEGEND

CONTOUR INTERVAL = 10 FT.
MAJOR SUBDRAINAGE DIVIDE
MUNICIPAL BOUNDARY
OTHER WATER BODIES
POND
RESERVOIR
STREAM
WATERSHED BOUNDARY

SB - Spring Brook Drainage Area
LJB - Lower Jackson Brook Drainage Area
UJB - Upper Jackson Brook Drainage Area
WB - Wallace Brook Drainage Area

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

TOPOGRAPHY

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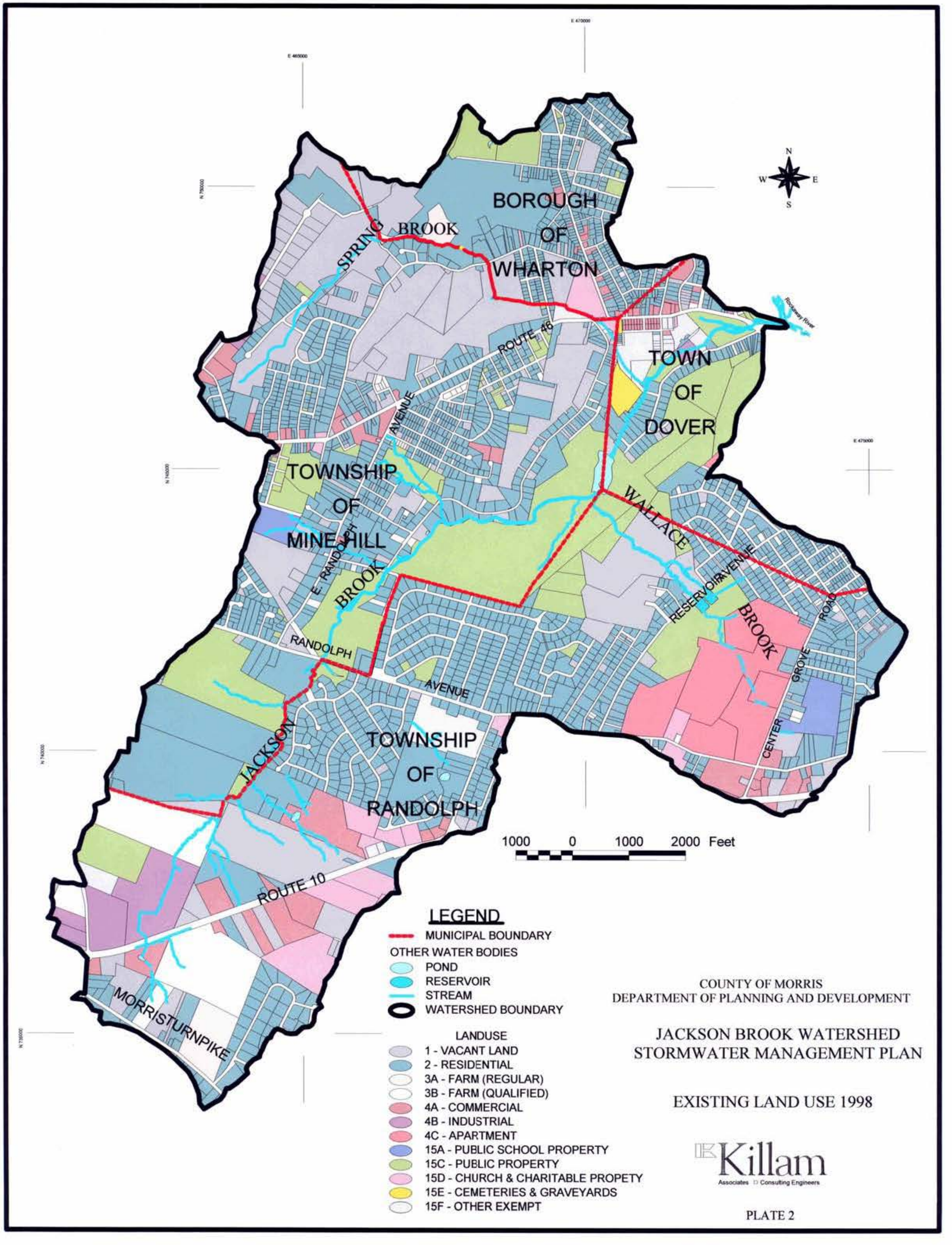
PLATE 1


BOROUGH OF WHARTON
SPRING BROOK
ROUTE 46
AVENUE
TOWN OF DOVER
Rockaway River
TOWNSHIP OF MINE HILL
E. RANDOLPH
BROOK
WALLACE
RESERVOIR AVENUE
BROOK
ROAD
GROVE
CENTER
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POND
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STREAM
WATERSHED BOUNDARY
LANDUSE
1 - VACANT LAND
2 - RESIDENTIAL
3A - FARM (REGULAR)
3B - FARM (QUALIFIED)
4A - COMMERCIAL
4B - INDUSTRIAL
4C - APARTMENT
15A - PUBLIC SCHOOL PROPERTY
15C - PUBLIC PROPERTY
15D - CHURCH & CHARITABLE PROPETY
15E - CEMETERIES & GRAVEYARDS
15F - OTHER EXEMPT
COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT
JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN
EXISTING LAND USE 1998
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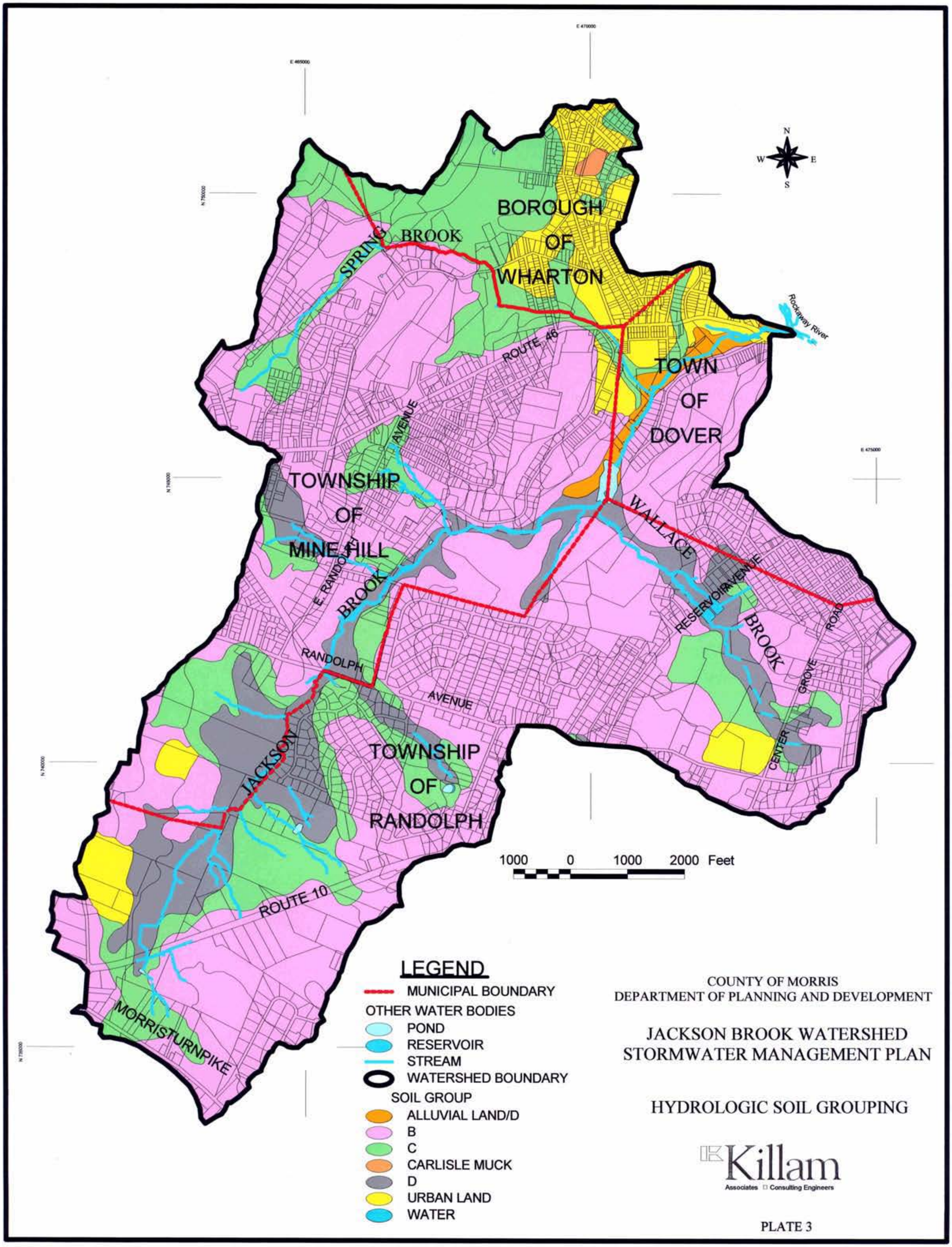
PLATE 2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JACKSON BROOK
WALLACE BROOK
Rockaway River
ROUTE 46
ROUTE 10
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OTHER WATER BODIES
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RESERVOIR
STREAM
WATERSHED BOUNDARY
SOIL GROUP
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C
CARLISLE MUCK
D
URBAN LAND
WATER
COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT
JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN
HYDROLOGIC SOIL GROUPING
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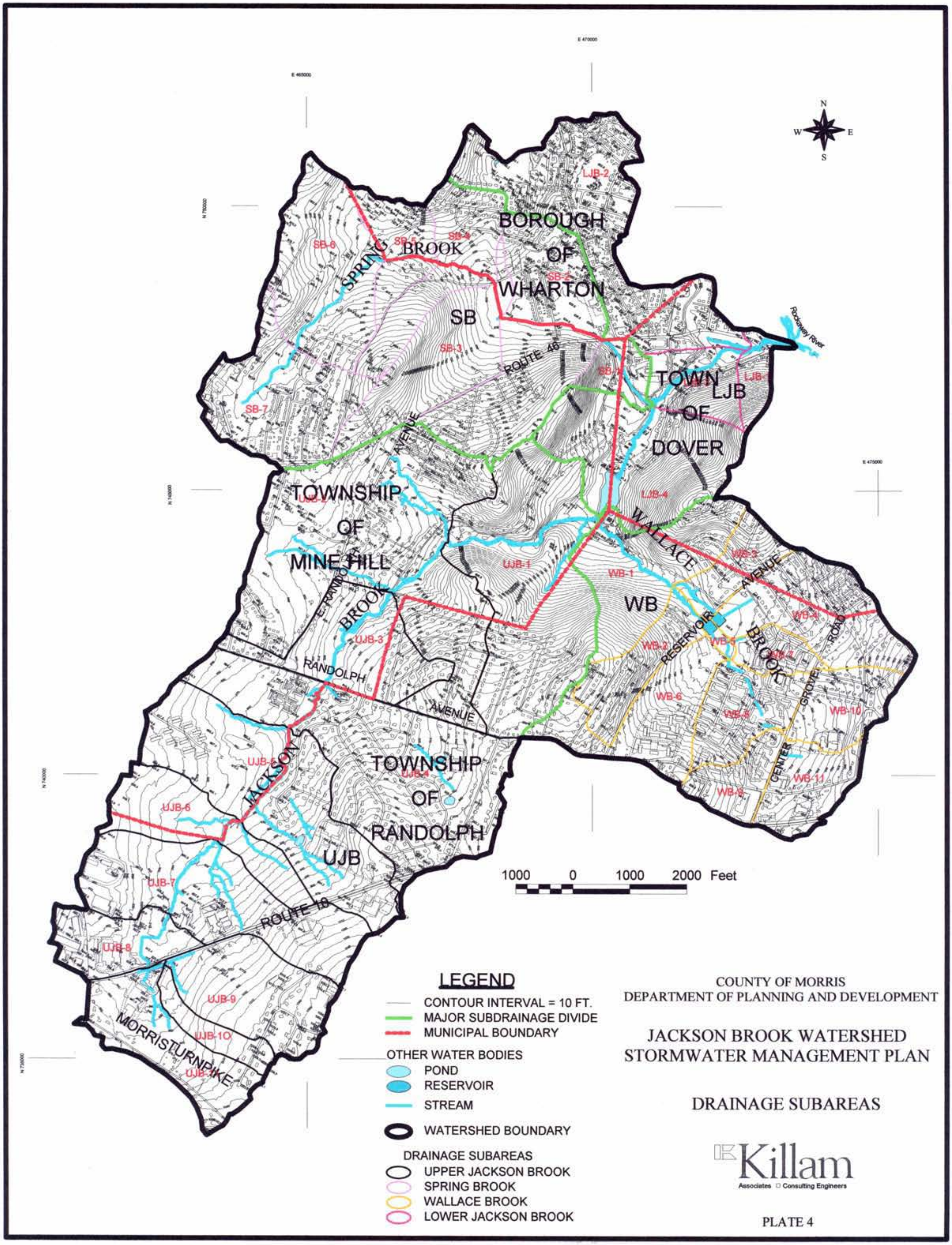
PLATE 3



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TOWN OF DOVER
TOWNSHIP OF MINE HILL
TOWNSHIP OF RANDOLPH
SPRING BROOK
WALLACE BROOK
JACKSON BROOK
SB
LJB
WB
UJB
Rockaway River
ROUTE 46
ROUTE 10
MORRIS TURNPIKE
RANDOLPH AVENUE
E. RANDOLPH AVENUE
RESERVOIR AVENUE
GROVE ROAD
CENTER
AVENUE
LJB-1
LJB-2
LJB-3
LJB-4
SB-1
SB-2
SB-3
SB-4
SB-5
SB-6
SB-7
UJB-1
UJB-2
UJB-3
UJB-4
UJB-5
UJB-6
UJB-7
UJB-8
UJB-9
UJB-10
UJB-11
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LEGEND
CONTOUR INTERVAL = 10 FT.
MAJOR SUBDRAINAGE DIVIDE
MUNICIPAL BOUNDARY
OTHER WATER BODIES
POND
RESERVOIR
STREAM
WATERSHED BOUNDARY
DRAINAGE SUBAREAS
UPPER JACKSON BROOK
SPRING BROOK
WALLACE BROOK
LOWER JACKSON BROOK
COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT
JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN
DRAINAGE SUBAREAS
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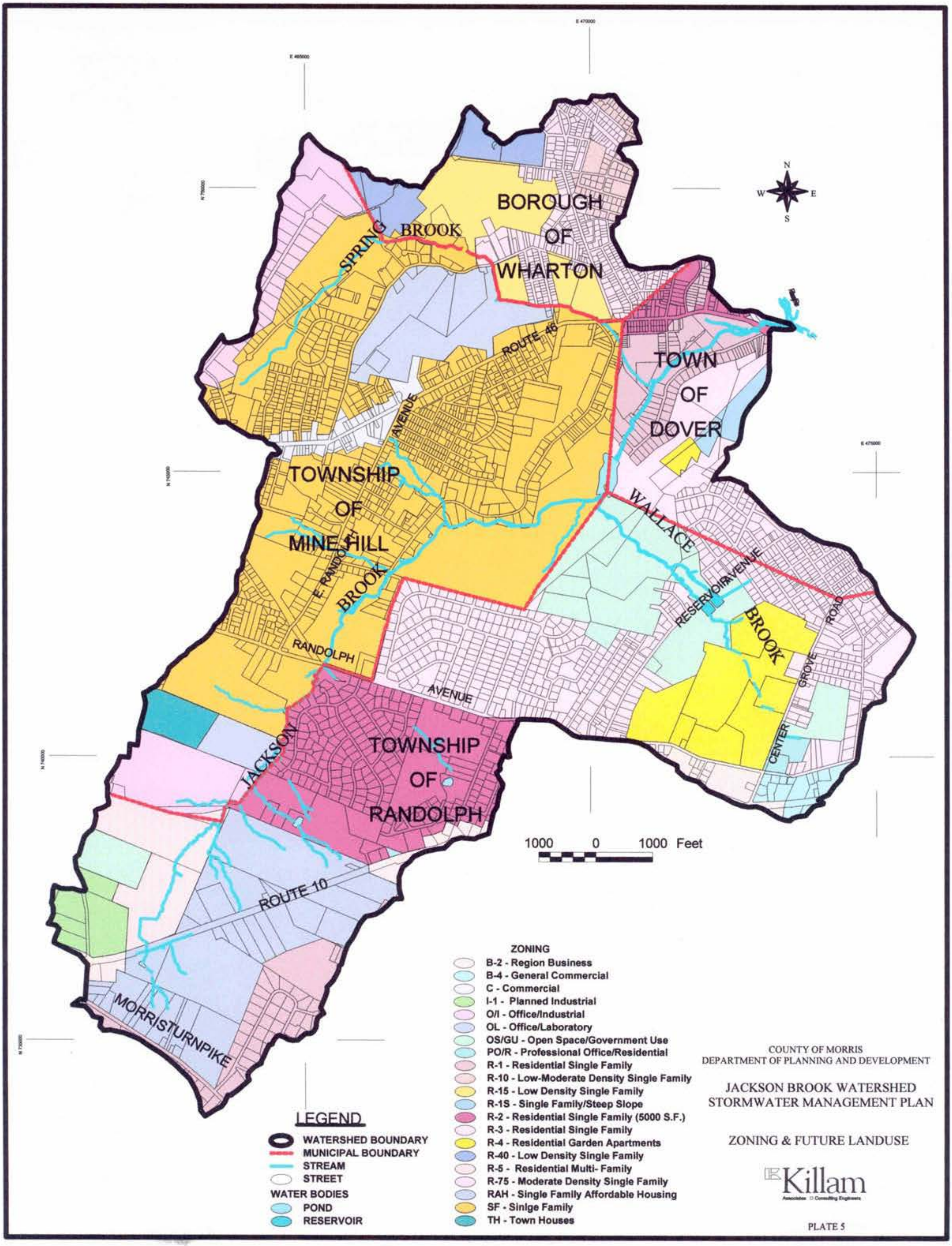
PLATE 4



COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

ZONING & FUTURE LANDUSE

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PLATE 5

NJDEP Color Infra-Red Images

This NJDEP colorinfared imagery was acquired in the fall season.

Color infra-red photographs are aquired with sensors that detect electrospectrum energy ranging from 0.4um (um stands for micrometer) to about 1um (near to mid infrared wavelengths). The range of visible light consists of the narrow portion of the spectrum, from 0.4 micrometer (blue) to 0.7 micrometer (red). Extending the range to the infrared is an enhancement to the amount of information acquired. In this imagery:

-Most deciduous vegetation appears gray due to the absence of leaves or low chlorophyll on vegetation,

-Green vegetation appears red in these images because chloryphyll reflects infrared energy.

-Clear water absorbs most of the photo (reflective) energy including infrared. Therefore, clear water appears dark. Turbid water does reflect blue energy (0.45um), as well as gravel and sand. Hence blue coloration is evident on sedimented water bodies and paved surfaces.

N

1000 0 1000 Feet

LEGEND

WATERSHED BOUNDARY

MAJOR SUBDRAINAGE BOUNDARY

MUNICIPAL BOUNDARY

STREAM

SAMPLING SITES

1 - WALLACE BROOK HEADWATER
2 - JACKSON BROOK AT RANDOLPH AVE.
3 - ENTRANCE TO HEDDEN POND
4 - MIDDLE OF HEDDEN POND
5 - HEDDEN POND WEIR
6 - CONFLUENCE OF SPRING BROOK & JACKSON BROOK
7 - JACKSON BROOK DOWNSTREAM OF ROUTE 46

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

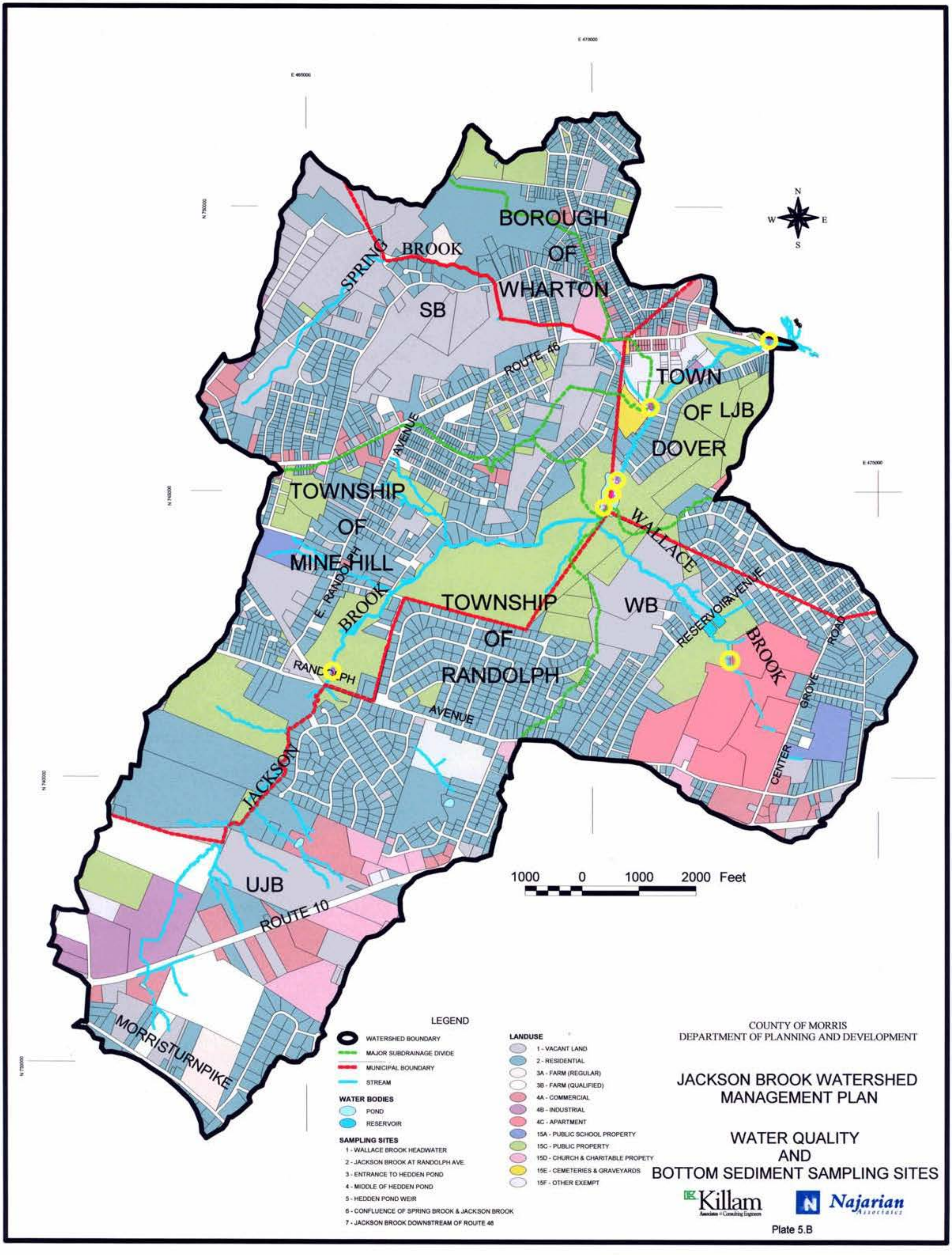
JACKSON BROOK WATERSHED MANAGEMENT PLAN

WATER QUALITY AND BOTTOM SEDIMENT SAMPLING SITES

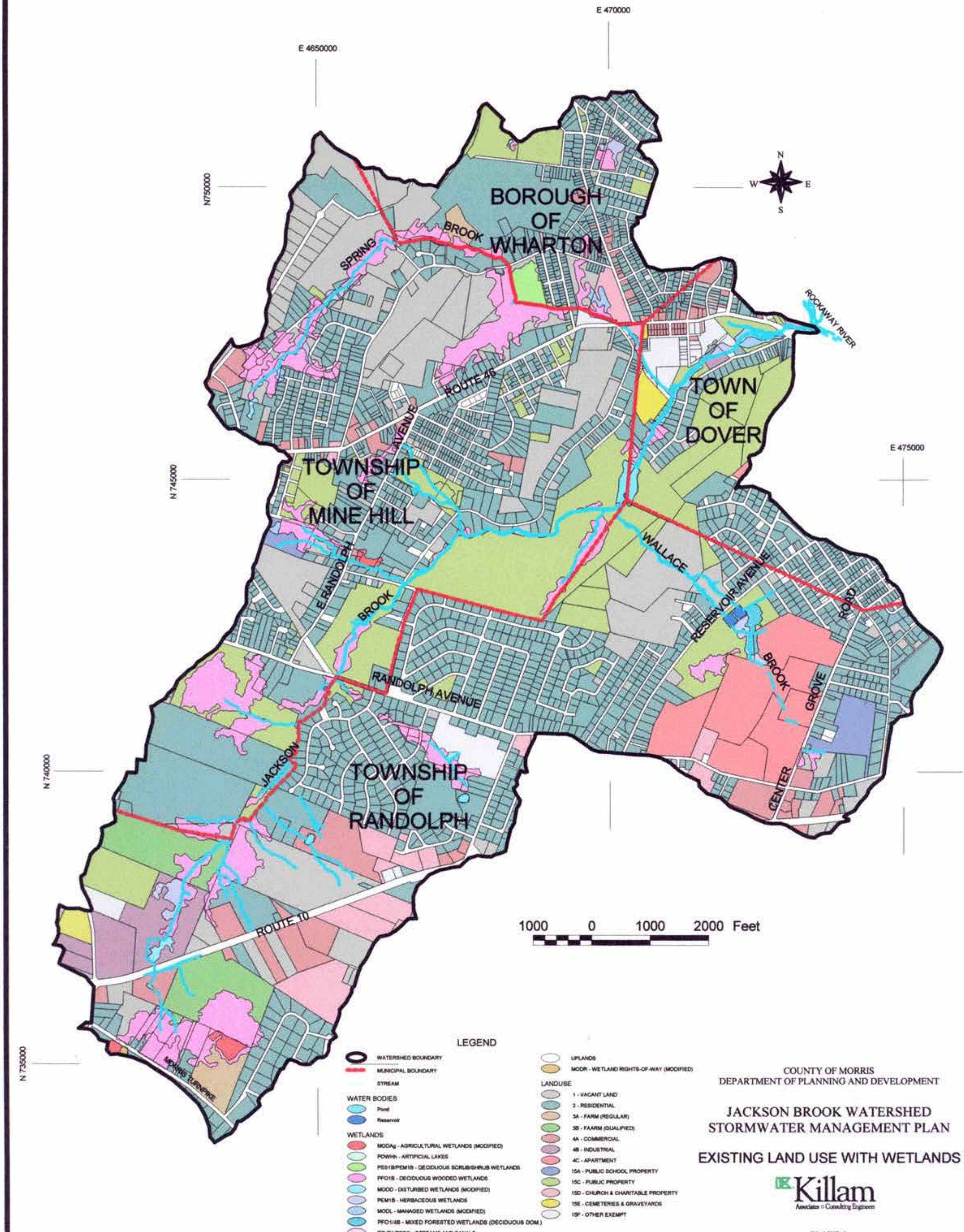
Killam Associates Consulting Engineers

Najarian Associates

Plate 5.A



BOROUGH OF WHARTON
SPRING BROOK
SB
ROUTE 46
AVENUE
TOWN OF DOVER
LJB
TOWNSHIP OF MINE HILL
E. RANDOLPH
BROOK
WALLACE
TOWNSHIP OF RANDOLPH
WB
RESERVOIR AVENUE
BROOK
ROAD
GROVE
CENTER
RANDOLPH
AVENUE
JACKSON
UJB
ROUTE 10
MORRISTURNPIKE
1000 0 1000 2000 Feet
N
W
E
S
LEGEND
WATERSHED BOUNDARY
MAJOR SUBDRAINAGE DIVIDE
MUNICIPAL BOUNDARY
STREAM
WATER BODIES
POND
RESERVOIR
SAMPLING SITES
1 - WALLACE BROOK HEADWATER
2 - JACKSON BROOK AT RANDOLPH AVE.
3 - ENTRANCE TO HEDDEN POND
4 - MIDDLE OF HEDDEN POND
5 - HEDDEN POND WEIR
6 - CONFLUENCE OF SPRING BROOK & JACKSON BROOK
7 - JACKSON BROOK DOWNSTREAM OF ROUTE 46
LANDUSE
1 - VACANT LAND
2 - RESIDENTIAL
3A - FARM (REGULAR)
3B - FARM (QUALIFIED)
4A - COMMERCIAL
4B - INDUSTRIAL
4C - APARTMENT
15A - PUBLIC SCHOOL PROPERTY
15C - PUBLIC PROPERTY
15D - CHURCH & CHARITABLE PROPETY
15E - CEMETERIES & GRAVEYARDS
15F - OTHER EXEMPT
COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT
JACKSON BROOK WATERSHED
MANAGEMENT PLAN
WATER QUALITY
AND
BOTTOM SEDIMENT SAMPLING SITES
Killam
Najarian
Plate 5.B



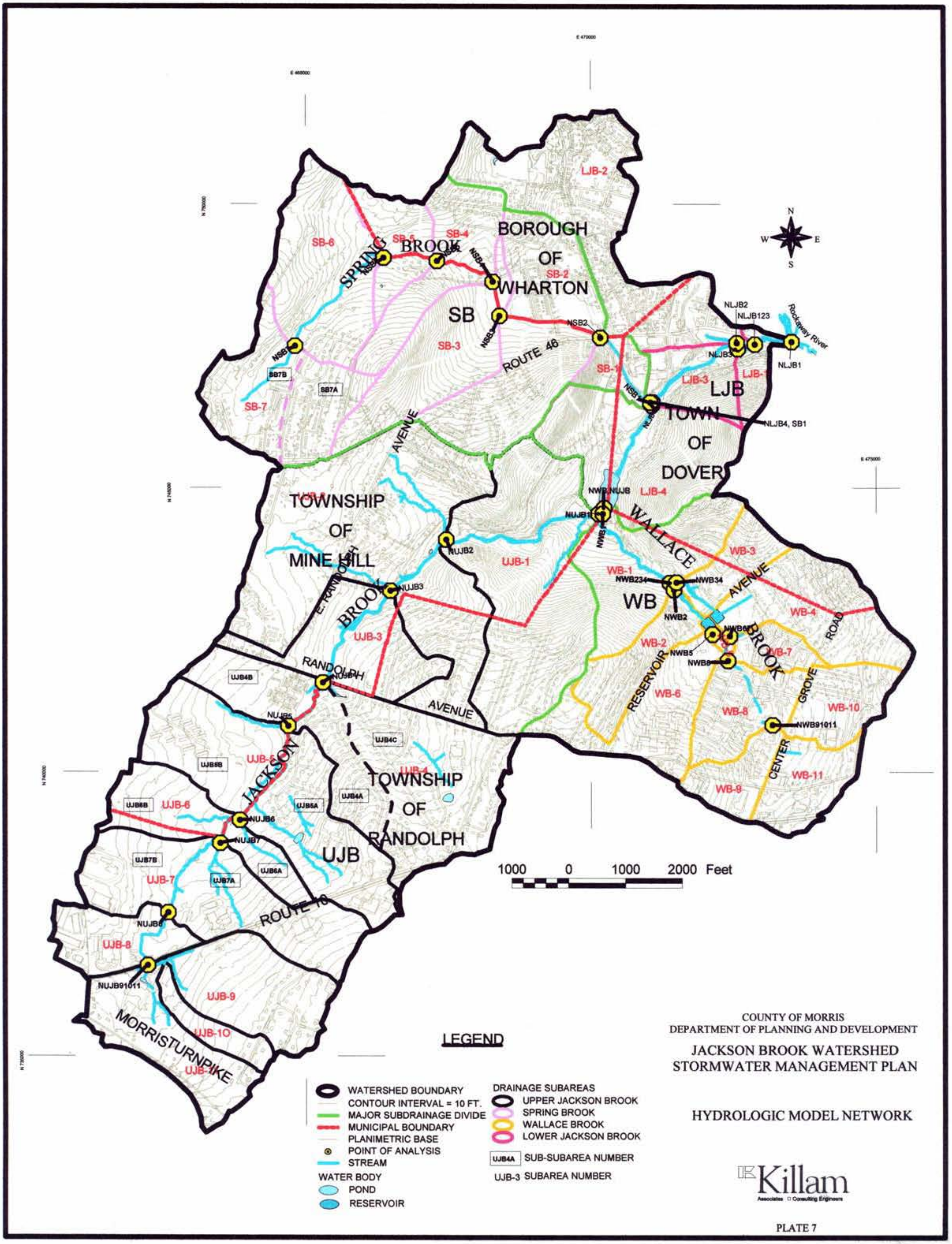
COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

EXISTING LAND USE WITH WETLANDS

Killam
Associates Consulting Engineers

PLATE 6



BOROUGH OF WHARTON
TOWNSHIP OF MINE HILL
TOWN OF DOVER
TOWNSHIP OF RANDOLPH
SPRING BROOK
JACKSON BROOK
WALLACE BROOK
ROUTE 46
ROUTE 10
MORRISTURNPIKE
RANDOLPH AVENUE
E. RANDOLPH AVENUE
RESERVOIR AVENUE
GROVE ROAD
CENTER
Rockaway River
SB
LJB
WB
UJB
SB-2
SB-3
SB-4
SB-5
SB-6
SB-7
SB-1
LJB-1
LJB-2
LJB-3
LJB-4
UJB-1
UJB-3
UJB-4
UJB-5
UJB-6
UJB-7
UJB-8
UJB-9
UJB-10
WB-1
WB-2
WB-3
WB-4
WB-6
WB-7
WB-8
WB-9
WB-10
WB-11
SB7A
SB7B
UJB4A
UJB4B
UJB4C
UJB5A
UJB5B
UJB6A
UJB6B
UJB7A
UJB7B
NSB2
NLJB1
NLJB2
NLJB3
NLJB123
NLJB4, SB1
NWB NUJB
NUJB2
NUJB3
NUJB5
NUJB6
NUJB7
NUJB91011
NWB234
NWB34
NWB2
NWB5
NWB91011
1000 0 1000 2000 Feet
LEGEND
WATERSHED BOUNDARY
CONTOUR INTERVAL = 10 FT.
MAJOR SUBDRAINAGE DIVIDE
MUNICIPAL BOUNDARY
PLANIMETRIC BASE
POINT OF ANALYSIS
STREAM
WATER BODY
POND
RESERVOIR
DRAINAGE SUBAREAS
UPPER JACKSON BROOK
SPRING BROOK
WALLACE BROOK
LOWER JACKSON BROOK
UJB4A SUB-SUBAREA NUMBER
UJB-3 SUBAREA NUMBER
COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT
JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN
HYDROLOGIC MODEL NETWORK
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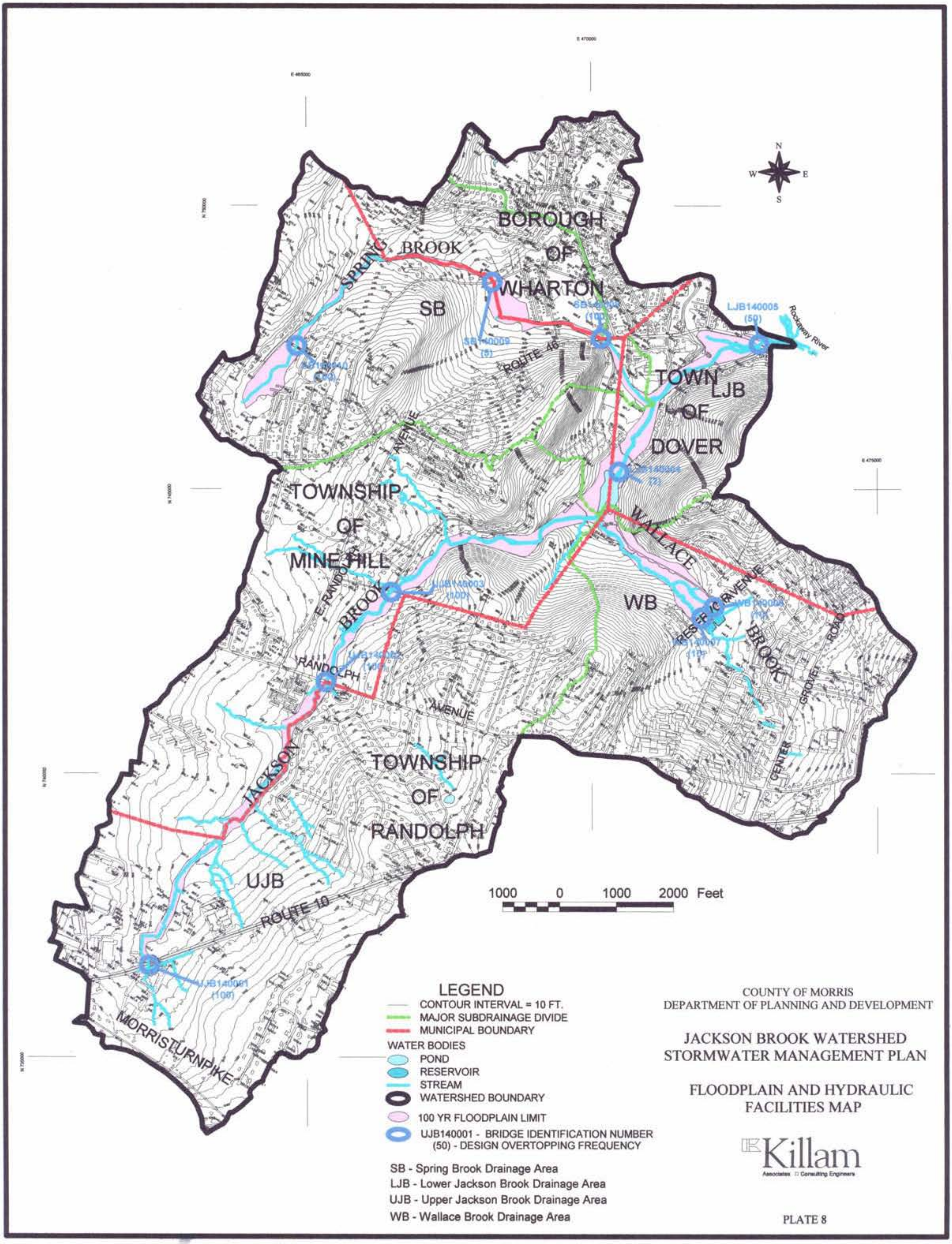
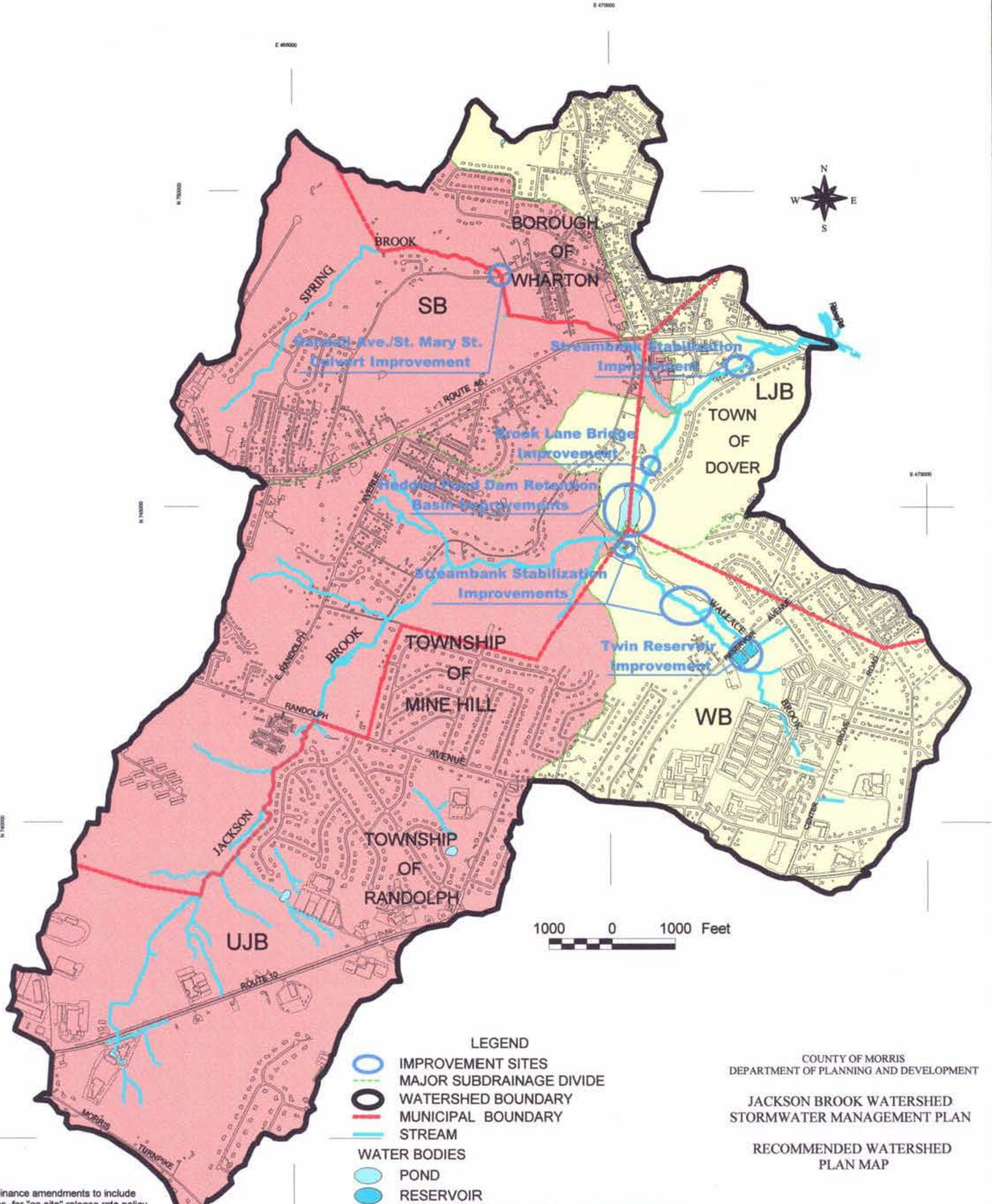
Associates Consulting Engineers
PLATE 7


BOROUGH OF WHARTON
SPRING BROOK
SB
ROUTE 46
LJB140005
(50)
Rockaway River
TOWN OF DOVER
LJB
TOWNSHIP OF MINE HILL
E. RANDOLPH AVENUE
WALLACE BROOK
WB
RESERVOIR AVENUE
GROVE ROAD
CENTER
RANDOLPH AVENUE
TOWNSHIP OF RANDOLPH
JACKSON BROOK
UJB
ROUTE 10
MORRIS TURNPIKE
1000 0 1000 2000 Feet
N
W
E
S
LEGEND
CONTOUR INTERVAL = 10 FT.
MAJOR SUBDRAINAGE DIVIDE
MUNICIPAL BOUNDARY
WATER BODIES
POND
RESERVOIR
STREAM
WATERSHED BOUNDARY
100 YR FLOODPLAIN LIMIT
UJB140001 - BRIDGE IDENTIFICATION NUMBER
(50) - DESIGN OVERTOPPING FREQUENCY
SB - Spring Brook Drainage Area
LJB - Lower Jackson Brook Drainage Area
UJB - Upper Jackson Brook Drainage Area
WB - Wallace Brook Drainage Area
COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT
JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN
FLOODPLAIN AND HYDRAULIC
FACILITIES MAP
Killam
Associates Consulting Engineers
PLATE 8



LEGEND

- IMPROVEMENT SITES
- MAJOR SUBDRAINAGE DIVIDE
- WATERSHED BOUNDARY
- MUNICIPAL BOUNDARY
- STREAM

WATER BODIES

- POND
- RESERVOIR
- WALLACE BROOK AND LOWER JACKSON BROOK STORM WATER MANAGEMENT ZONE
- SPRING BROOK AND UPPER JACKSON BROOK ONSITE STORM WATER MANAGEMENT ZONE

SB - Spring Brook Drainage Area
LJB - Lower Jackson Brook Drainage Area
UJB - Upper Jackson Brook Drainage Area
WB - Wallace Brook Drainage Area

Ordinance amendments to include provisions for "on site" release rate policy, groundwater recharge by retrofitting existing drainage and residential structures for infiltration, pollutant reduction via water quality filtering devices, and stream corridor preservation/reforestation.

Ordinance amendments to include groundwater recharge by retrofitting existing drainage and residential structures for infiltration, pollutant reduction via water quality filtering devices, and stream corridor preservation/reforestation; structural controls to include regional retention basin, reservoir impoundment up-grade, bridge and channel stabilization improvements.

COUNTY OF MORRIS
DEPARTMENT OF PLANNING AND DEVELOPMENT

JACKSON BROOK WATERSHED
STORMWATER MANAGEMENT PLAN

RECOMMENDED WATERSHED
PLAN MAP

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PLATE 9