Nonpoint Source Pollution Assessment Report And Management Plan

MATFIELD AND SALISBURY PLAIN RIVER WATERSHEDS

PREPARED FOR

Executive Office of Environmental Affairs
Massachusetts Department of Environmental Protection
Bureau of Resource Protection

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Project No. M272-000

November 4, 2003

NONPOINT SOURCE POLLUTION
ASSESSMENT REPORT AND
MANAGEMENT PLAN
MATFIELD AND SALISBURY
PLAIN RIVER WATERSHEDS
Abington, Avon, Brockton, Bridgewater,
East Bridgewater, West Bridgewater,
Holbrook, and Whitman, Massachusetts

Prepared for:

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November 4, 2003

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ACKNOWLEDGMENT

This project has been financed partially with State Funds from the Massachusetts Department of Environmental Protection (DEP) under a Massachusetts Watershed Initiative grant. The contents do not necessarily reflect the views and policies of DEP, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

EXECUTIVE SUMMARY

The Matfield and Salisbury Plain River Watersheds Nonpoint Source (NPS) Pollution Assessment (Project) was initiated in spring 2002 at the request of local, state, regional, and federal stakeholders participating in the ongoing watershed planning process for these basins. The primary goals of the Project were to identify significant sources of NPS pollution, prioritize these sources, and design a management plan recommending specific actions to protect and improve water quality in the study area. The underlying purpose of the Project was to minimize, reduce, and prevent pollution from harming the environment while ensuring steps are taken to remove any waterbodies within project watershed from the State 303(d) List. The Project represents one component of a watershed protection process being undertaken by EOEA, MADEP, local government, non-governmental organizations, and ordinary citizens.

Situated in southeastern Massachusetts, the Matfield and Salisbury Plain River watersheds (Figure 1) include some of the most densely developed areas of the state. The Matfield and Salisbury Plain River watersheds are part of the Taunton River watershed, the second largest watershed in the state. The Project study area has a total drainage area of 71.5 square miles, and includes some or all of eight municipalities including Abington, Avon, Brockton, Bridgewater, East Bridgewater, West Bridgewater, Holbrook, and Whitman. The upper Taunton River watershed provides habitat for numerous bird species, reptiles, amphibians, and mammals and also supporting seven species of freshwater mussels (www.tauntonriver.org). Much of the Salisbury Plain watershed is in Brockton and is highly urbanized. In the northwest corner of the Salisbury Plain watershed is Brockton Reservoir (a Class A ORW), an important public water supply for much of the area, including Brockton. Many of the river and stream segments in the study area, in particular the Matfield River, were found to have impaired water and habitat quality due to extensive development, a lack of stream-side vegetation, and minimal stormwater detention or other treatment. Local residents noted strong odors from rivers and streams, water discoloration, and algae build up in many areas.

A variety of assessment methods was applied to achieve Project goals. These included historical research on past water quality data and pollution sources; field sampling of bacterial, nutrient, and physical parameters; field reconnaissance of stream corridors to determine watershed conditions and identify potential NPS pollution contribution areas; and interviews with local, state, and regional officials. As part of this study, water quality samples were collected at 33 sampling locations by ESS staff and analyzed in MADEP-certified laboratories for fecal coliform, *E. coli* bacteria (via MTEC method), TKN, total phosphorus and TSS (see Figures 2, 3 and 4 and Table 1 for sample locations). In addition, ESS staff measured specific conductance, turbidity, dissolved oxygen, temperature, pH, and flow rate in the field at all sample locations.

In the Matfield River watershed, nonpoint sources of pollution originate predominantly from stormwater and sediment runoff from highway, residential, industrial and commercial land uses; and areas where geese feed and congregate such as golf courses and ponds. Pollution also potentially originates from storm drain pipes discharging directly into the waters, housing development areas adjacent to the Matfield River and its tributaries, cranberry bogs, and improperly managed pet waste and trash in developed areas. The transmission of stormwater and sediment is controlled mainly through sheet runoff, or "country" drainage, with traditional catch basins in many areas of the watershed. The location of stormwater outfalls to surface waters is generally un-documented. Some of the waterbodies are channelized, with straightened banks and narrow or non-existent vegetated buffers in many areas throughout the watershed, particularly in the more developed areas along the sides of roads and private yard areas. In the Matfield River watershed, ESS found that water quality at 13 of the 14 sample sites (Figures 2 and 3) exceeded the Massachusetts primary contact (e.g., swimming) standard for fecal coliform, one of the 14 sites only partially supported secondary contact recreational use (e.g., fishing and boating), 12 of the 14 did not support aquatic life (due to low dissolved oxygen in most cases), and all the sites had at least one relatively high bacteria count. Nutrient levels at all sample locations exceeded EPA guidance criteria for phosphorus and nitrogen, and many sites had elevated total suspended solids (TSS) concentrations.

In the Salisbury Plain River watershed, ESS found that water quality at all of the 19 sample sites exceeded the Massachusetts primary contact (e.g., swimming) standard for fecal coliform, nine (9) of the 19 did not support secondary contact recreational use (e.g., fishing and boating), 16 of the 19 did not support aquatic life (due to low dissolved oxygen in most cases, but sometimes also turbidity and pH), and all the sites had at least one relatively high bacteria count. Nutrient levels at all sample locations exceeded EPA guidance criteria for phosphorus and nitrogen, and many sites had elevated total suspended solids (TSS) concentrations.

Several sub-basins in the Project watershed stand out as likely priority areas to address NPS pollution sources. These sub-basins tend to be located in the central western portion of the study area (i.e., the Salisbury Plain River watershed and, in particular, the City of Brockton), where there is dense residential, commercial, and industrial development; major roads and highways are present; extensive channel alteration is common place; extensive impervious areas dominate the sub-basins; numerous examples of flooding and stormwater control problems exist; roof runoff is an issue; there are potential sources of wastewater entering the streams caused by defects in sewage systems; the sub-basins golf courses and the waterfowl that frequent them are present; and stream channels are less buffered by forested and otherwise vegetated zones than they are in other parts of the watershed. Based on the findings of this study, the following sub-basins should be the focus of future NPS abatement efforts: Trout Brook, Salisbury Brook, Searles Brook, Cary Brook, Salisbury Plain River, and the Matfield River. Watershed stewards may also want to focus growth management initiatives in the eastern portion of the study area, to prevent the degradation of areas that now appear to be functioning relatively well.

In the Salisbury Plain River watershed, development densities are very high in many areas and vegetative buffers and natural stream banks are generally narrow and provide little pollutant removal capacity. These areas may benefit more from structural or end-of-pipe BMPs such as on-site detention with engineered soils and plantations, specialized catch basins that remove nutrients and TSS, and constructed wetlands that can also help address bacterial inputs. Stream bank restoration is also an option in areas that are currently channelized but for which hard walls are not required for flood and erosion control.

Further investigation into possible illicit connections and/or leaks in sewage system (especially in Brockton) and correction of these issues is also recommended. Throughout the study area, public education about the importance of NPS pollution prevention, especially pet waste management, would greatly increase the likelihood of reducing existing pollutant loads in study area waterbodies. A watershed-wide program targeted to the kinds of issues found in the study area would certainly have positive results.

If meaningful NPS pollution reductions are to be made, it will be important for communities in the study area, working in partnership with government agencies such as the MADEP and non-profit organizations such as the Taunton River Watershed Association, to identify and seek support for the priority recommendations for reducing NPS pollution identified in this report. A project kickoff was held with the Brockton mayor and other staff in June 2002. Community meetings with Brockton officials, officials from other towns in the study areas, and nonprofit organizations were held to review project findings on June 3 and 4, 2003 in Brockton. All involved indicated their interest in pursuing the goals and recommendations of this study.

Acronym List

Acronyms	Water Bodies
AWWF – Class A Warm Water Fishery	ABB Avon Beaver Brook
BCWF – Class B Cold Water Fishery	BB – Beaver Brook
BWWF – Class B Warm Water Fishery	CB – Cary Brook
CFS – Cubic Feet per Second	LB – Lovett Brook
EOEA – Executive Office of Environmental Affairs	MAB – Malfardar Brook
EPA – Environmental Protection Agency	MB – Meadow Brook
ESS – ESSGroup, Inc.	MR - Matfield River
gdp – Gallons per Day	SB –Salisbury Brook
MADEP – Massachusetts Department of Environmental Protection	SEB – Searles Brook
Mg/L – Milligrams per Liter	SHR – Shumatuscacant River
MTEC method – Water Quality Analysis for Fecal Coliform (bacteria)	SPR – Salisbury Plain River
MWI – Massachusetts Watershed Initiative	SR - Satucket River
NCDC – National Climatic Data Center	SST – Spring Street Tributary
NPS – Nonpoint Source	TB – Trout Brook
NRCS – Natural Resource Conservation Service	WT – Westdale Tributary
ORW – Outstanding Resource Waters	
QAPP - Quality Assurance Project Plan	
QA/QC – Quality Assurance/Quality Control	
SOGS – Standard Operating Guidelines	
SU – Standard Units	
TKN – Total Kjeldahl Nitrogen	
TRWA – Taunton River Watershed Association	
TSS – Total Suspended Solids	
VOC – Volatile Organic Compounds	

1.0 INTRODUCTION AND REPORT ORGANIZATION

WHAT IS A WATERSHED?
A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place. John Wesley Powell, scientist geographer, put it best when he said that a watershed is:

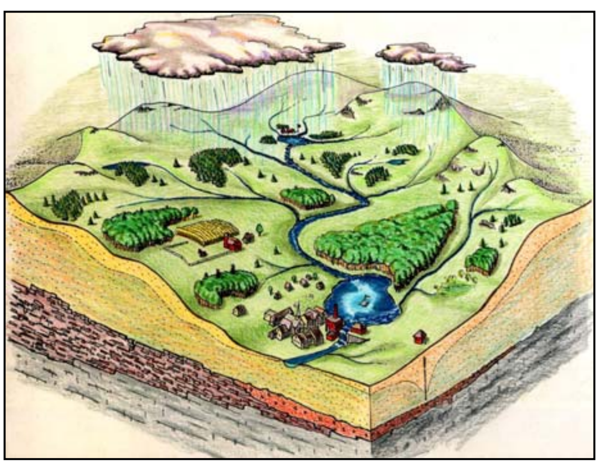
> "that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community."

Watersheds come in all shapes and sizes. They cross county, state, and national boundaries. No matter where you are, you're in a watershed!

(Source: www.epa.gov)

The Matfield and Salisbury Plain River Watersheds Nonpoint Source (NPS) Pollution Assessment (Project) was initiated in spring 2002 at the request of local, state, regional, and federal stakeholders participating in the ongoing watershed planning process for these basins. This process is centered around locally and regionally coordinated Watershed Teams comprised of representatives from watershed associations, municipalities, universities, and government agencies. The Project was funded under the Massachusetts Watershed Initiative (MWI), a former program of the Massachusetts Executive Office of Environmental Affairs (EOEA). The MWI grant that supported this Project was administered through the Massachusetts Department of Environmental Protection (MADEP), which was also a key manager and technical advisor to the Project.

MADEP has monitored water quality in portions of the study area for many years. Based on previous assessments, several waterbody segments in the study area appear on the state's 303(d) List of impaired waterbodies, including segments in the Matfield River, the Salisbury Plain River, Trout Brook, and Salisbury Brook. Conversely, Beaver Brook in Avon is designated as a Class A outstanding resource water (ORW) as it is immediately upstream of Brockton Reservoir, a public water supply which has socioeconomic, recreational, and aesthetic values.



Historically, water and sediment quality studies have focused on the control of point sources of pollutants (i.e., discharges from pipes and other structural conveyances) that discharge directly into lakes, ponds, or river segments. While this localized approach may be appropriate under certain situations, it typically fails to characterize the more subtle and chronic sources of pollutants that are widely scattered throughout a broad geographic region such as a watershed (e.g., roadway runoff, failing septic systems in high groundwater, areas of concentrated wildfowl use, fertilizers, pesticides, pet waste, and certain agricultural sources). These so called "nonpoint sources" of pollution significantly contribute to the decline of water quality through their cumulative impacts. A watershed-level approach that uses the surface drainage area as the basic study unit enables managers to gain a more complete understanding of the potential pollutant sources impacting a waterbody and increases the precision of identifying local problem areas or "hot spots" which may detrimentally affect water and sediment quality. It is within this watershed-level framework that ESS Group, Inc. (ESS) presents this NPS Pollution Assessment and Management Plan for the Matfield and Salisbury Plain River watersheds.

Numerous efforts to monitor and assess water quality and identify and address potential sources of NPS pollution in the study area (see Section 2.1) have been conducted over the years by non-profit watershed associations, municipalities, regional planning associations, and the Commonwealth of Massachusetts. Much of this data was collected for specific purposes related to the immediate goals of the organization involved (e.g., monitoring wastewater treatment efficacy). While all of the data collected as part of these studies was reviewed as part of this assessment, only some of this data was determined to be applicable to the primary goal at hand: to identify significant NPS pollution contribution areas, prioritize these areas, and develop a management plan to protect and improve water quality in the study watersheds. Therefore, a work program including water quality monitoring, field reconnaissance, consultations with municipal officials and others with knowledge of the watersheds, historical data research, data mapping, and local capacity assessment was developed to provide a comprehensive assessment of water quality issues related to bacterial and nutrient pollution in the study area.

WHAT IS NONPOINT SOURCE POLLUTION?

Nonpoint source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water. These pollutants include:

- Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas;
- Oil, grease, and toxic chemicals from urban runoff and energy production;
- Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks;
- Salt from irrigation practices and acid drainage from abandoned mines;
- Bacteria and nutrients from livestock, pet wastes, and faulty septicsystems;

Atmospheric deposition and hydromodification are also sources of nonpoint source pollution.
(Source: www.epa.gov)

Report Organization

This report is organized by geographical unit. In order to maximize the utility of the report to local, state, and regional watershed stakeholders, results are presented both by watershed and by town. Maps and data tables and charts are linked by common sub-basin and site code numbers that were specifically developed for this assessment.

Section 2.0 of this report provides a detailed project description, including a description of the study area, project goals, and the project approach for meeting those goals. Section 3.0 presents findings and prioritizations as well as management recommendations by watershed and by town. Section 4.0 summarizes the cumulative findings of the report and provides a discussion of recommended focus areas and priority actions.

2.0 PROJECT DESCRIPTION

2.1 Study Area

> **ASSESSMENT GOALS**
>
> A primary purpose of this project is to identify and prioritize nonpoint source pollution contribution areas in the study area and encourage the control of pollution from these areas. EOEA and MADEP are working proactively with local communities, watershed associations, and other watershed stakeholders to address these issues.

Situated in southeast Massachusetts, the Matfield and Salisbury Plain River watersheds (Figure 1) include some of the most densely developed areas of the state. The Matfield and Salisbury Plain River watersheds are part of the Taunton River watershed, the second largest watershed in the state. The upper Taunton River watershed provides habitat for numerous bird species, reptiles, amphibians, and mammals and also supporting seven species of freshwater mussels (www.tauntonriver.org). Much of the Salisbury Plain watershed is in Brockton and is highly urbanized. In the northwest corner of the Salisbury Plain watershed is Brockton Reservoir (a Class A ORW), an important public water supply for much of the area, including Brockton. Many of the river and stream segments in the study area, in particular the Matfield River, were found to have impaired water and habitat quality due to extensive development, a lack of stream-side vegetation, and minimal stormwater detention or other treatment. Local residents noted strong odors from rivers and streams, water discoloration, and algae build up in many areas.

The Project study area has a total drainage area of 71.5 square miles, including the Matfield, Satucket, Shumatuscacant, and Salisbury Plain Rivers; a variety of brooks, lakes, and wetlands; and some or all of eight municipalities including Abington, Avon, Brockton, Bridgewater, East Bridgewater, West Bridgewater, Holbrook, and Whitman. Project sample locations are depicted in Figure 2 and listed in Table 1.

The Matfield River sub-watershed (Figure 3) and Salisbury Plain River sub-watershed (Figure 4) effectively split the study area in two (see Sections 2.1 and 3.2). The Salisbury Plain River drains much of Brockton as well as parts of Avon and East Bridgewater before discharging into the Matfield River. The mainstem of the Matfield River drains some of the more rural parts of the watershed in Abington, Holbrook, Whitman, and East Bridgewater before discharging into the Town River. In 1999, the Matfield River was placed on the Massachusetts 303(d) List of Impaired Waters for pathogens (#MA62-32 confluence of Beaver Brook and Salisbury Plain River, East Bridgewater to confluence with Town River, Bridgewater). The Salisbury Plain River was also placed on the 303(d) List for siltation, suspended solids, pathogens, and other habitat alterations (#MA62-05 confluence of Trout Brook and Salisbury Brook, Brockton to Brockton WWTP and #MA62-06 Brockton WWTP, Brockton to confluence with Matfield River, East Bridgewater). In addition, sections of both Trout Brook (#MA62-07) and Salisbury Brook (#MA62-08), both of which are tributaries of the Salisbury Plain River, are on the 303(d) List for siltation and pathogens, and Trout Brook was also listed for organic enrichment. The 303(d) listings for pathogens were based on the results of ambient water sampling for fecal coliform, which is used by the State of Massachusetts as an indicator of pathogen contamination.

The Salisbury Plain River converges with Beaver Brook in the town of West Bridgewater, to form the Matfield River. Based on the greater degree of urbanization and the inclusion of three of its segments on the 303(d) List, the Salisbury Plain River sub-watershed was more intensively targeted for monitoring and assessment than other parts of the study area. All the major tributaries of the Salisbury Plain River were targeted for extensive sampling and characterization as well as sections of the Salisbury Plain River itself, above and below the Brockton wastewater treatment plant. The Matfield River originates at the confluence of the Salisbury Plain River and Beaver Brook in the town of West Bridgewater. It is fed by Meadow Brook from the north and Satucket River from the east before discharging into the Town River in the Town of Bridgewater. The four major tributaries of the Matfield River sub-watershed were also assessed, as well as the mainstem of the Matfield River. The results of the Matfield and Salisbury Plain bacterial and nutrient assessments are presented in Section 3.

2.2 Project Goals

The primary goals of the Project were to identify significant sources of NPS pollution, prioritize these sources, and design a management plan recommending specific actions to protect and improve water quality in the study area. The underlying purpose of the Project was to minimize, reduce, and prevent pollution from harming the environment while ensuring steps are taken to remove any waterbodies within project watershed from the State 303(d) List. The Project represents one component of a watershed protection process being undertaken by EOEA, MADEP, local government, non-governmental organizations, and ordinary citizens.

Special effort was dedicated to identifying specific reaches and tributaries of the Matfield River and Salisbury Plain Rivers that are not currently meeting state water quality standards and identify significant sources of bacterial and nutrient pollution and sedimentation. Total suspended solids (TSS) were targeted for assessment because the Salisbury Plain River is on the 303(d) List for TSS, and both Salisbury and Trout Brooks are listed due to their high levels of siltation. Phosphorus and total Kjeldahl nitrogen (TKN) concentrations were targeted for assessment since elevated levels of these nutrients are generally associated with increases in algal production and a subsequent decrease in dissolved oxygen levels, conditions which detrimentally affect aquatic habitat quality.

2.3 Approach

A variety of assessment methods was applied to achieve Project goals. These included historical research on past water quality data and pollution sources; field sampling of bacterial, nutrient, and physical parameters; field reconnaissance of stream corridors to determine watershed conditions and identify potential NPS pollution contribution areas; and interviews with local, state, and regional officials. The study methods and where they were applied are described in greater detail below.

2.3.1 NPS Pollution Contribution Area Prioritization Process

Assessment results were mapped (see Figures 2-4 and Section 2.3.4) and analyzed in order to prioritize potential NPS contribution areas. Prioritization was based on relative water and habitat quality as indicated by sample results and field reconnaissance (see Tables 3, 9, and 10). Prioritizations are presented separately for wet- and dry-weather conditions. These results and prioritizations are presented in Section 3.

2.3.2 Historic Research and Comparisons

An effort was made to review previous monitoring studies carried out in the study area applicable to the Project. These include studies conducted by the Taunton River Watershed Association (TWRA) in 1999 and 2000 as well as a MADEP study of the Matfield River in 1989. The findings of these studies were used in conjunction with ESS site assessments and study data to locate potentially significant nonpoint source sites and contribution areas.

2.3.3 Local Capacity Inventory

Interviews were conducted with local, state, and regional officials and others with knowledge of the watersheds in the study area. Where applicable, information was mapped (see Section 2.3.4) and analyzed with other study data in order to prioritize potential NPS contribution areas. These results and prioritizations are presented in Section 3. Local capacity findings and recommendations for enhancing local capacity to manage NPS pollution are discussed in Section 3.3.

2.3.4 Mapping and Planning

Extensive GIS mapping was conducted by ESS as part of this Project (see Figures 1-4). Watershed boundaries, custom delineated by ESS, as well as areas of concern regarding NPS pollution provided by municipal officials, imperviousness percentages, land use, and water quality sampling locations are included in these maps. Water quality data is expressed in "stop light" format (red=worst, green=best) for easy interpretation of potential sources of water quality impairment. Data, including water quality results and source area locations, are linked through a database to GIS points, allowing for future analyses. The maps developed for the Project represent a widely accessible format for viewing potential NPS pollution sources and evaluating priorities for future response actions.

2.3.5 Field Water Quality Sampling

As part of this study, water quality samples were collected at 33 sampling locations by ESS staff and analyzed in MADEP-certified laboratories for fecal coliform, *E. coli* bacteria (via MTEC method), TKN, total phosphorus and TSS (see Figures 2, 3 and 4 and Table 1 for sample locations). In addition, ESS staff measured specific conductance, turbidity, dissolved oxygen, temperature, pH, and flow rate in the field at all sample locations.

Field sampling methods are described in the Quality Assurance Project Plan (QAPP) for the Project (ESS, 2002). Deviations from the QAPP are presented in Section 2.3.5.7. Dry-weather sampling dates were defined as those dates on which no rainfall occurred during sampling or within the previous 72 hours, and wet-weather sampling dates were defined as those dates on which total precipitation for the event was equal to or greater than ¼ inches and occurred at least 72 after the previous measurable rain event. Wet-weather sampling occurred during the early stages of a storm event, as close to first flush as possible. Daily precipitation totals used in the analysis were obtained from the National Climatic Data Center (NCDC, 2001).

Typically, "point source" pollutants (i.e., those pollutants which come from a concentrated originating point such as end-of-pipe discharge or other concentrated source, sometimes including failing septic systems) are observed more readily during dry-weather (base flow) conditions, whereas NPS pollutants (i.e., those pollutants which often do not come from a confined, definable source but are instead transported via surface runoff resulting from precipitation or snow melt over a wider geographical area) are typically associated with wet-weather (storm-flow) conditions. Sites sampled as part of this Project were sampled during both dry- and wet-weather in order to capture contributions from point and nonpoint sources and differentiate between potential pollutant sources.

Sample results were compared to approved or proposed state and federal surface water quality standards, where available and applicable, to indicate which sites and their upstream sub-watersheds exceeded standards and may be prioritized for remedial action. Wherever possible, analytical results were compared to Massachusetts Surface Water Quality Standards (MADEP, 1998; Table 2). Findings based in part on these comparisons are presented in Section 3, both by sub-watershed and town. Bacteria, nutrient, and physical parameter results are presented in the tables that accompany this report. Parameters which exceed comparison standards are indicated by shading. Further discussion of the applicability of selected standards is presented below.

Evaluation of water quality results was based on standards defined in the Massachusetts Surface Water Quality Standards for Class BCWF, BWWF, and AWWF waterbodies and Aquatic Life Use (MADEP, 1998), which indicate conditions that would be beneficial for the establishment and maintenance of native, naturally diverse communities of aquatic flora and fauna (Table 8). All the assessed rivers and streams of the study area are classified as Class B Warm Water Fishery (BWWF), except for one waterbody at the northern portion of the watershed in Avon on Beaver Brook (site ABB1 Figures 2 and 4) which is classified as Class A Warm Water Fishery (AWWF), because it is immediately upstream of Brockton Reservoir, which is used as a public drinking water supply. Brockton Reservoir is also Class A. Class A waters have more stringent water quality standards than Class B waters (MADEP, 1998).

With regard to bacteria levels, "impaired" sites (i.e., those not supporting designated use(s)) for the purposes of this study were defined as sites with dry- or wet-weather fecal coliform levels found to exceed 200 colonies/100mL (see Table 2). This bacteriological threshold was selected because the Massachusetts Standard for fecal coliforms in Class B Cold Water Fisheries (Class BWWF) is a geometric mean of <200 colonies/100 ml.

There are no Massachusetts State Standards for the nutrient parameters assessed as part of this study. As a consequence, the guidelines by which nutrient-impairment was defined were based on *Ambient Water Quality Criteria Recommendations, Rivers and Streams in Aggregate Nutrient Ecosystem XIV* (EPA, 2000) and *Connecticut Lakes: A Study of the Chemical and Physical Properties of Fifty-six Connecticut Lakes* (Canavan and Siver, 1995). The EPA (2000) standards employed represent levels of nutrients that "protect against the adverse effects of nutrient over-enrichment." Similar values have been used by ESS for other sampling efforts conducted through the MWI for MADEP. It is important to note that Canavan and Siver (1995) was a lake assessment and, therefore, the standards included in that study may not precisely apply to river and stream systems. However, these standards represent the best data available with which to assess in stream nutrient levels, allowing at least relative comparisons to be made between sampling locations and sub-basins.

Phosphorus and nitrogen are essential plant nutrients. Excessive concentrations of these nutrients often fuel undesirable growths of algae in the water column (blocking light, reducing dissolved oxygen levels, and reducing biodiversity), and nutrient accumulations in the bottom sediments in depositional areas will promote the growth of rooted plants. The input of excessive nutrients (particularly phosphorus in freshwater systems) promotes the growth of aquatic plants. The growth and death of these plants and the resultant accumulation of organic sediments in a waterbody is known as eutrophication. Although no state or federal standards have been established, phosphorus values less than 0.025 mg/L are desirable for maintaining low algal biomass and high water clarity. Similar aquatic life limits for nitrogen have not been established (since phosphorus is typically the limiting nutrient in freshwater systems). However, nitrogen values over 1.0 mg/L are unusual without some form of urban or agricultural influence.

In urban areas, phosphorus and nitrogen in runoff are typically derived from atmospheric deposition onto impervious surfaces, lawn fertilizers, vehicle washing, illicit discharges, and sewage exfiltration. Impervious surfaces prohibit infiltration and subsequent uptake by plant roots and removal processes within the soil. Consequently, during wet-weather, these nutrients can become elevated downgradient of any area with a substantial amount of impervious surface or downgradient of improperly managed agricultural lands. In contrast, during dry-weather the source of phosphorus and nitrogen in streams can be the result of internal processes or the result of anthropological inputs entering the stream system as either a point source or via groundwater infiltration. Phosphorus readily adsorbs (binds) to fine sediments within stormwater runoff before it reaches critical waterbodies. The various forms of nitrogen are typically dissolved, and as such, control of nitrogen typically is achieved by encouraging infiltration and subsequent uptake by vegetation.

TSS within a water column can greatly affect water clarity. Sources of TSS are typically surface runoff and re-suspended bottom sediments in flowing waters; however, pollen, algal production, and other natural processes can also contribute to high TSS values. Road sanding, agriculture, and construction activities can also be sources of TSS. TSS values of less than 25 mg/L are believed to be generally acceptable for aquatic life in the study area.

Dissolved oxygen is the amount of molecular oxygen (O_2) dissolved in water. The Massachusetts Surface Water Quality Standards (MADEP, 1996) state that for Class B warm waters, dissolved oxygen standards must be $\geq$5 mg/L and $\geq$60% saturation unless background conditions are lower. Low dissolved oxygen can result in fish kills and reduced biodiversity. Low dissolved oxygen is typically associated with eutrophic conditions brought on by excessive nutrient inputs to a waterbody.

With regard to temperature, the Massachusetts Surface Water Quality Standard for Class B warm waters is $\leq 28.3^{o}$C. Ambient water quality temperatures in excess of this standard can result in fish kills and reduced biodiversity. High temperature is generally related to clearing of riparian, or riverside, vegetation and discharges from industrial facilities. Runoff from impervious surfaces such as roads, parking areas, driveways, and roofs can also contribute to elevated ambient water temperatures.

The pH value is a measure of acids and bases dissolved in water. The Massachusetts Surface Water Quality Standard for pH in Class B waters is a range between 6.5 and 8.3 Standard Units

(SU). Waterbodies with pH much above or below this range generally have less biodiversity as they are too acidic or basic to support a wide range of species. Geologic conditions in a watershed as well as human influences like wastewater treatment plant discharges typically influence pH levels in rivers.

In addition, there are no Massachusetts Surface Water Quality Standards for conductivity. However, ESS has found that conductivity values of 50 to 500 μmhos/cm, are typical of Massachusetts rivers and streams, and conductivity values >500 μmhos/cm were therefore focused upon for the purposes of this study. It is important to note that elevated conductivity values may simply indicate the presence of dissolved solids in waters and/or the presence of a saline waterbody rather than "impaired" water quality conditions. Road salt in stormwater runoff can lead to elevated conductivity and reduce the ability of a waterbody to support fish and wildlife.

2.3.5.1 Bacteriological and Nutrient Assessment

In order to identify reaches and tributaries of the Matfield and Salisbury Plain Rivers that are not meeting water quality standards and constitute potential sources of bacterial and nutrient pollution to the rest of the project watershed, ESS conducted a water quality investigation consisting of two sampling rounds (see Table 1 and Figures 2-4 for sample site locations).

- **Round I** included one (1) wet and one (1) dry-weather sampling effort at 21 sampling locations within the Matfield and Salisbury Plain River Watersheds. These sampling locations were assigned to areas suspected of NPS pollution based on assessment of maps of current land use/cover, topography, zoning and drainage. The water quality results at these locations were used to identify initial areas of concern for NPS pollution. Round I dry-weather sampling was conducted on June 20 and June 24, 2002, and wet-weather sampling was conducted on June 6 and July 10, 2002. Data from Round I are presented in Tables 4-7.
- **Round II** included two (2) wet- and one (1) dry-weather sampling effort at 12 new sampling locations plus at the initial 21 sampling locations. This resulted in a total of 141 samples at 33 sampling locations for the Project. The 12 new (source bracketing) sampling locations were selected based on the results from the initial sampling round. Where Round I sampling locations were found to have particularly high concentrations of bacteria or nutrients, one or two of the new bracketing sampling sites were assigned to the same waterbody to try and narrow down the search for the source of pollution. Round II dry-weather sampling was conducted on August 1, August 7 and August 8, 2002 and wet weather sampling was conducted on July 16, July 24, August 20, August 30, September 16, and November 6, 2002. Data from Round II are presented in Tables 4-7.

2.3.5.3 Habitat Assessment

To characterize stream habitat within the selected reaches of the 33 sampling locations for the Project, ESS followed the MADEP habitat assessment guidelines (MADEP Method 004/11.20.95) which included an assessment of both in-stream and riparian habitat. Table 4 provides a summary of habitat assessment scores and categorizations (refer to Appendix A for methodology and completed forms). The habitat assessments performed included a general description of the site, a physical characterization, and a visual assessment of in-stream and riparian habitat quality. Parameters assessed to complete the Habitat Field Data Sheet include the following:

- **Instream cover:** a measure of the relative quantity and variety of natural structures in the stream, such as fallen logs, that are available as refugia, feeding sites or egg laying sites.
- **Epifaunal substrate:** Microhabitat diversity of hard substrates (rocks, snags etc.) available for insects and snails, many of which attach to rocks and other submerged substrates.
- **Embeddedness:** Extent to which rocks arte covered or sunken into the silt, sand or mud of the stream bottom.
- **Channel alteration:** A measure of large-scale changes in the shape of the stream channel. Many urban and agricultural stream channels have been straightened, deepened or diverted for flood control purposes.
- **Sediment deposition:** Measures the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result.
- **Frequency of riffles:** Riffles are a source of high quality habitat and diverse fauna; therefore, an increased frequency of occurrence greatly enhances the diversity of the stream community.
- **Channel flow status:** Degree to which the channel is filled with water. The flow status will change as the channel enlarges or as flow decreases as a result of the obstructions, diversion or drought.
- **Bank vegetative protection:** Measures the amount of the streambank that is covered by vegetation. The root systems of plants growing on streambanks helps hold soil in place and reduces erosion.
- **Bank stability:** Measures whether the stream bansk are eroded or have a potential for erosion.
- **Riparian vegetation zone width:** Measures the width of natural vegetation from the edge of the stream bank out through the riparian zone.

Each parameter was scored on a scale from 0 to 20 with 16-20 being optimal, 11-15 being sub-optimal, 6-10 being marginal and 0-5 being poor. See the Habitat Assessment Field Data Sheets (Appendix A) for further details.

Each stream reach was classified in terms of the condition of its habitat into one of four categories: Optimal, sub-optimal, marginal or poor. Table 3 illustrates a list of the stream segments assessed for the Project, ranked according to their total Habitat Assessment Scores as indicated in the MADEP Habitat Assessment Field Data Sheets. ESS personnel were further able to utilize the habitat data towards developing recommendations by noting the extent of sediment deposition and substrate embeddedness, thus determining the degree and likely sources of water quality impairment. In addition, the habitat data along with digital photographs of each site may assist future discussions with watershed stewards and MADEP regarding potential management options. Habitat assessments were carried out during dry weather conditions, at the time of dry-weather water quality sampling.

2.3.5.4 Field Reconnaissance

ESS conducted an extensive field reconnaissance program to identify potential sources of NPS pollution in the study area and ground-truth water quality sampling results. Field reconnaissance was conducted on January 15th, 17th, and 29th, 2002 after Rounds I and II of the field sampling program were completed. The reconnaissance effort consisted of ESS personnel walking the stream corridors upstream of all sample locations and recording general field observations including: the presence of flowing storm drains, farms in close proximity to the water, industrial areas in close proximity to the water, conditions surrounding catch basins upstream of sampling locations, country drainage upstream of sample locations, large areas of impervious ground such as parking lots, open dumpsters, golf courses or playing fields with congregating geese, obvious signs of pollution in the water such as trash and oil sheens, and poor vegetation buffers along stream and river banks.

During field reconnaissance, landscape characteristics such as land use practices which represent potential bacteriological and nutrient sources to waterbodies were noted, and suspected sources were photographed and mapped onto a USGS map in the field (Figures B-1 and B-2). Field reconnaissance observations are presented in Section 3 (by sub-basin). A photographic log of selected field reconnaissance is also presented in Appendix B.

2.3.5.6 Field and Laboratory Quality Control

ESS adhered to Quality Assurance/Quality Control (QA/QC) guidelines as outlined in the DEP-approved QAPP for the Project (ESS, 2002). Similarly, laboratory quality control measures were followed according to Laboratory Quality Assurance Plans presented in the QAPP. The following QA/QC review was conducted to ensure that collection, reporting, and analysis of data followed approved standard operating guidelines (SOGs) and that data quality objectives as outlined in the QAPP were met. Data subjected to this QA/QC review include the following: field water quality measures and laboratory water quality measures. Data that fell outside of established QA/QC acceptance criteria were investigated and have been described below. In addition, these data may have been subject to censoring or may have been omitted from any analyses.

- Several water quality sampling locations were not found to be flowing during sampling events and, therefore, no sample collection was performed at these times. Mention of these sampling sites has been included in the attached tables in order to document that attempts were made to characterize water quality at these locations. However, these sampling locations were all sampled at least once due to resumed flow conditions on that day. These sites were: SEB1 (Searles Brook at Vine Street, Brockton), SST1 (Small unnamed tributary known as "Spring Street Tributary" for the Project, at Spring Street, East Bridgewater), and WT1 (Small unnamed tributary known as "Westdale Tributary" for the Project, at West Street, East Bridgewater).
- In rare instances, water quality was assessed from residual pools of water and/or extremely slowly flowing waterbodies, which had effectively imperceptible flow rates. In such instances, data is reported for in-field, bacteria, and nutrient parameters despite NO FLOW conditions in the Flow (cfs) column.
- On the June 6th, 2002 sampling date, the dissolved oxygen meter reported widely fluctuating readings. As a consequence, the data obtained from this sampling event was deemed unreliable by ESS Water Resource Scientists and has been omitted from the present analysis.
- Agricultural information (type and location for various agricultural practices (piggeries, horse farm, cattle farm, etc.) was requested from all of the Towns in the study area. Two towns in the study area, Avon and Abington, did not respond to this request and, as a result, no agricultural data are presented on the attached GIS maps for portions of the study area in these towns.
- Halfway through the study, ESS changed the laboratory employed to carry out bacteria analysis, from BAL laboratory to a more local laboratory, Rhode Island Analytical, Inc. This change was incurred due to the closer proximity of R.I. Analytical, making it easier to complete a full day of sampling and still meet the six-hour hold times required for bacteria analysis. BAL was employed for sampling dates from 6/6/02 to 8/8/02. R.I. Analytical was employed for sampling dates from 8/20/02 through to the end of the study.

Sampling/Analysis Holding Time

Each laboratory analyte has a standard holding time that has been established to ensure sample/analysis integrity. Refer to the DEP approved QAPP (ESS, 2002) for a complete listing. If the standard holding time was exceeded, this objective is violated and data are censored. All holding times for water were met throughout the entirety of the study.

Duplicate and Replicate Analysis

As stated in the QAPP (ESS, 2002), one duplicate sample was supposed to be collected for every 20 water quality samples (a frequency representing at least 5% of the total number of samples delivered to the laboratory on any given date). This requirement was met throughout the entirety of the study.

All duplicate samples were found to be <20% different from each other for log-transformed bacteria data, thereby conforming to the criteria as stated in the QAPP (ESS, 2002). This is generally considered a satisfactory level of deviation for these parameters.

Out of the 10 duplicate samples collected throughout the study, six (6) of them did not meet the QC criteria as stated in the QAPP (ESS, 2002) for nutrient testing, i.e. there was at least a 20% difference between the data and duplicate for TSS and/or at least a 10% difference between the data and the duplicate for TKN and total phosphorus. However, in all cases the differences observed between data and duplicate data did not affect the overall assessment of the site's water quality and, on reflection, it is likely that the ESS criteria for these parameters were too stringent to allow for the natural variability in the concentrations of these nutrients.

In addition to the duplicate sampling described above, the contract laboratories for this study also conducted internal QC testing, however, all of the laboratories reported that there were no problems with the analyses and all data for associated QC met EPA or laboratory specifications.

None of these issues mentioned above appear to represent a significant problem in terms of the overall quality of the assessment or collected data.

3.0 FINDINGS, NPS CONTRIBUTION AREA PRIORITIZATIONS AND MANAGEMENT RECOMMENDATIONS BY WATERSHED AND MUNICIPALITY

This section presents findings and prioritizations by watershed and by town. Findings and prioritizations based on historic water quality data, water quality monitoring, habitat assessments, reconnaissance, field and laboratory data analysis, and interviews with municipal officials and others with knowledge of the watershed are presented for the Matfield and Salisbury Plain watersheds.

3.1 Overall Study Area Findings and Prioritizations

The primary NPS pollution constituents in the Matfield River and Salisbury Plain River watersheds include bacteria, nutrients, and suspended sediments. The ability of these pollutants to travel through the watershed via impervious surfaces, overland runoff, and directly to surface waters through outfalls and drainage ditches makes for a diffuse set of problems, each with its own specific remedial requirements. In many areas, the watershed has limited natural processes to control NPS pollution in riparian zones because vegetation has been removed or impacted by erosion and land use, parts of the rivers have been hardened or channelized, and development has occurred in environmentally constrained situations (e.g., high groundwater table and poor soils). The most significant problems vary sub-watershed to sub-watershed and town to town. However, based on the information compiled as part of this study, it was possible to identify a set of key problems that occur commonly across the study area as well as water quality "hot spots" fed by priority NPS contribution areas.

3.1.1 Matfield River Watershed

During June and July 2002, Round I of the ESS sampling effort was conducted. A preliminary visit to each sampling site was made in order to characterize stream habitat within the selected reaches. ESS completed a MADEP habitat assessment field sheet for each Round I sampling site in June 2002 (Appendix A). ESS then sampled bacteria and nutrients at a total of 10 locations in both dry- and wet-weather conditions in the Matfield River watershed (Figure 3). These sites include three (3) mainstem sites and seven (7) tributary sites. Based on the results of laboratory analysis of bacteria and nutrient samples collected during Round I, a further four (4) tributary sites (Figure 3) were sampled during Round II (July, August, September, November, 2002) in order to bracket potential sources of bacterial pollution which were identified during Round I and other data gathering efforts conducted as part of the Project. The rationale for selecting Round II sites is discussed in section 2.3.5.1. Once again, in advance of sampling (July and August, 2002), a habitat assessment sheet was completed for each Round II sampling site. During both rounds on every sampling date, additional water quality parameters were tested in the field, namely: specific conductance, turbidity, dissolved oxygen, temperature, pH, and flow rate. The results of the laboratory analysis of bacteria and nutrient samples, the rest of the water quality data, and the habitat assessment data collected from the Matfield Watershed throughout the study are presented in the sections below. Refer to Table 3 and Appendix A for raw habitat assessment data, Table 4 for a summary of all nutrient and bacteria data, Tables 5a-5G for a breakdown of the bacteria data per sub-basin, Tables 6A-6G for a breakdown of the nutrient data per sub-basin, and Table 7 for a summary of all remaining water quality data collected by ESS in the field.

In the Matfield River watershed, nonpoint sources of pollution originate predominantly from stormwater and sediment runoff from highway, residential, industrial and commercial land uses; and areas where geese feed and congregate such as golf courses and ponds. Pollution also potentially originates from storm drain pipes discharging directly into the waters, housing development areas adjacent to the Matfield River and its tributaries, cranberry bogs, and improperly managed pet waste and trash in developed areas. The transmission of stormwater and sediment is controlled mainly through sheet runoff, or "country" drainage, with traditional catch basins in many areas of the watershed. The location of stormwater outfalls to surface waters is generally un-documented. Some of the waterbodies are channelized, with straightened banks and narrow or non-existent vegetated buffers in many areas throughout the watershed, particularly in the more developed areas along the sides of roads and private yard areas.

3.1.1.1 Matfield Bacteria

Water Quality Monitoring Findings

ESS found that water quality at 13 of the 14 sample sites (Figures 2 and 3) exceeded the Massachusetts primary contact (e.g., swimming) standard for fecal coliform, one of the 14 sites only partially supported secondary contact recreational use (e.g., fishing and boating), 12 of the 14 did not support aquatic life (due to low dissolved oxygen in most cases), and all the sites had at least one relatively high bacteria count. Refer to Table 2 for a list of the water quality screening standards, Table 8 for a listing of the Massachusetts surface water quality designated uses for each site sampled and Summary Table A for an explanation of which sample sites did not meet the state standards for fecal coliform bacteria. Additionally 13 of the 14 sample sites failed the federal *E. coli* standard (see Table 2). In general, the results for *E. coli* were similar to those for fecal coliform.

The "worst" sub-basins with regard to wet-weather bacteria results were Beaver Brook, Shumatuscacant River, and Matfield River mainstem. The highest bacteria counts were found at sites BB2, BB3, SHR1, SHR3, SHR4, MR2, and MR3. With regard to dry-weather results, sites MR2, MR3, and MB1 were found to have the highest single event fecal coliform concentrations (1,230, 640, and 650 col/100ml, respectively). Greater detail on site and sub-basin ranking during wet- and dry-weather conditions is provided in Tables 9 and 10. In these tables, sites are ranked and scored for bacteria, nutrients, and TSS as well as being ranked based on a cumulative score reflecting overall water quality.

Potential Sources

Potential Matfield bacteria sources are discussed in detail in Section 3.2 and presented in Summary Table A and Figures 2 and 3. In general, the Beaver Brook and Shumatuscacant River sub-basins as well as the sub-basin encompassing site MR2 on the Matfield River, appear to be contributing the most bacterial pollution to the Matfield River Watershed. The reason for these contributions is not immediately obvious but may be due to the somewhat higher density of residential and commercial use in these sub-basins. Potential sources include stormwater runoff from roads and paved surfaces associated with commericial and residential areas and from golf courses, housing development pressures in close proximity to the water, wastewater input, compounded by steep slopes and flooding problems in some areas. Waterfowl and other wildlife impacts associated with ponds and recreation fields.

Inadequate streamside vegetated buffers also contribute to the problem.

The Beaver Brook sub-basin may be influenced by a potential source of wastewater in Brockton as well extensive housing development pressures to the north of the sub-basin as well as stormwater impacts. Bacteria counts in this sub-basin were highest during wet-weather conditions.

The Shumatuscacant River sub-basin may be influenced by waterfowl waste impacts as well as roof runoff and extensive stormwater runoff compounded by steep slopes and areas prone to flooding and sedimentation. Bacteria counts in this sub-basin were highest during wet-weather conditions.

3.1.1.2 Matfield Nutrients

Water Quality Monitoring Findings

ESS found that the sites with the highest average total phosphorus concentrations were SHR4, SR1, WT1, SST1, MR2, and MR3 (see Tables 4 and 6A-G), although all sampling sites on all days had concentrations of total phosphorus that exceeded EPA guidance criteria (Table 2). The sites with the highest average TKN concentrations were SHR4, WT1, SST1, MR1, and MR2 (see Tables 4 and 6A-G), although nearly all sampling sites on all sample days had concentrations of TKN that exceeded EPA guidance criteria (Table 2). The only two sites found to have concentrations of TSS that exceeded Massachusetts Class BWWF Water Quality Standards were BB3 and MR2, but only on one sampling day each. Site SR1 also had high concentrations of TSS on many days although never exceeding the standards. Greater detail on site and sub-basin ranking during wet- and dry-weather conditions is provided in Tables 9 and 10.

Potential Sources

Potential Matfield nutrient sources are discussed in detail in Section 3.2 and presented in Summary Table A and Figures 2 and 3. Those sites with high nutrient concentrations mentioned above are also discussed generally here.

Nutrient levels at site SHR4 are potentially influenced by stormwater runoff from surrounding roads, parking lots, and densely populated residential and commercial areas. Roof runoff from buildings adjacent to the river and storm drains discharging directly into the water are also potential sources. A solid waste facility adjacent to the river, upstream of the site, could also be a potential source of pollutants, especially during wet-weather conditions when stormwater runoff may transport nutrients to area waterbodies.

Nutrient levels at site WT1 are potentially influenced by stormwater runoff from the adjacent street and from two stormdrain pipes discharging directly into the water. Wildlife waste associated with the extensive forest and wetland areas upstream of the site is another potential source.

Nutrient levels at site SR1 are potentially influenced by stormwater runoff from catch basins on the adjacent streets and from gardens backing closely on to the river, compounded by a narrow or nonexistent vegetated buffer.

Nutrient levels at site SST1 are potentially influenced by the thick forest/wetland area immediately upstream of the sample site which could introduce relatively large amounts of rotting vegetation into the waterbody as well as wildlife waste associated with the forest area.

Sites MR1, MR2, and MR3 are the most downstream sites in the study area and, therefore, may receive nutrient inputs from some or all of the sources in the watershed. Potential sources of nutrient inputs within the Matfield sub-basin itself include waterfowl, stormwater runoff from surrounding roads and yards via sheet runoff, catch basins and country drainage, and direct runoff from storm drains.

TSS concentrations may be influenced at site SR1 by the eroding river banks upstream of the site, and at site BB3 by stormwater runoff from gardens and yards adjacent to the brook.

3.1.1.3 Matfield Habitat Assessments

A complete summary of the habitat scores and categorizations of each stream reach assessed in the Matfield River watershed can be found in Table 3, and completed MADEP habitat assessment field sheets can be found in Appendix A. In general within the Matfield watershed habitat scores ranged between 85, at a site on the Shumatuscacant River (SHR3) which is marginal, to a score of 170, at a site on the Matfield River (MR3) which is optimal. These scores reflect the wide variety of habitat conditions found within the watershed. Two (2) of the sites in the Matfield River watershed had optimal conditions, nine (9) had sub-optimal conditions and three (3) had marginal conditions. No sites were characterized as having poor conditions. Habitat assessment findings are discussed in more detail in section 3.2.

3.1.2 Salisbury Plain River Watershed

During June and July 2002, Round I of the ESS sampling effort was conducted. A preliminary visit to each sampling site was made in order to characterize stream habitat within the selected reaches. ESS completed a MADEP habitat assessment field sheet for each Round I sampling site in June 2002 (Appendix A). ESS then sampled bacteria and nutrients at a total of 11 locations in both dry- and wet-weather conditions in the Salisbury Plain River watershed (Figures 2 and 4). These sites include two (2) mainstem sites and nine (9) tributary sites. Based on the results of laboratory analysis of bacteria and nutrient samples collected during Round I, a further one (1) mainstem site and seven (7) tributary sites (Figure 4) were sampled during Round II (July, August, September, November, 2002) in order to bracket potential sources of bacterial pollution which were identified during Round I and other data gathering efforts conducted as part of the Project. The rationale for selecting Round II sites is discussed in section 2.3.5.1. Once again, in advance of sampling (July and August, 2002), a habitat assessment sheet was completed for each Round II sampling site. During both rounds on every sampling date, additional water quality parameters were tested in the field, namely: specific conductance, turbidity, dissolved oxygen, temperature, pH, and flow rate. The results of the laboratory analysis of bacteria and nutrient samples, the rest of the water quality data, and the habitat assessment data collected from the Salisbury Plain River Watershed throughout the study are presented in the sections below. Refer to Table 3 and Appendix A for raw habitat assessment data, Table 4 for a summary of all nutrient and bacteria data, Tables 5H-5O for a breakdown of the bacteria data per sub-basin, Tables 6H-6O for a breakdown of the nutrient data per sub-basin, and Table 7 for a summary of all remaining water quality data collected by ESS in the field.

In the Salisbury Plain River watershed, nonpoint sources of pollution originate predominantly from stormwater runoff and sedimentation from impervious surfaces associated with highways, railroads, residential areas, industrial areas and commercial areas, due to the extremely urbanized nature of much of the watershed, a large portion of which falls within Brockton. However there are also many locations where abandoned unplugged sewer reaches, damaged sewer lines, illicit connections to drain systems, and other sources of wastewater are likely potential sources of NPS pollution. Pollution also potentially originates from areas where geese and gulls feed and congregate such as park land and ponds, from storm drain pipes discharging directly into the waters, housing development areas adjacent to the Salisbury Plain River and its tributaries, and from improperly managed pet waste and trash in developed areas especially in urban parks. The location of stormwater outfalls to the surface waters is generally undocumented. Some of the rivers and streams are channelized, having straightened banks and narrow or non-existent vegetated buffers in many areas throughout the watershed, particularly in the more developed areas along the sides of roads and private yard areas.

3.1.2.1 Salisbury Plain Bacteria

Water Quality Monitoring Findings

ESS found that water quality at all of the 19 sample sites exceeded the Massachusetts primary contact (e.g., swimming) standard for fecal coliform, nine (9) of the 19 did not support secondary contact recreational use (e.g., fishing and boating), 16 of the 19 did not support aquatic life (due to low dissolved oxygen in most cases, but sometimes also turbidity and pH), and all the sites had at least one relatively high bacteria count. Refer to Table 2 for a list of the water quality screening standards, Table 8 for a listing of the Massachusetts surface water quality designated uses for each site sampled, and Summary Table A for an explanation of which sample sites did not meet the state standards for fecal coliform bacteria. Additionally, all of the 19 sample sites failed the federal *E. coli* standard (see Table 2). In general, the results for *E. coli* were similar to those for fecal coliform.

The "worst" sub-basins with regard to wet-weather bacteria results were Searles Brook, and Salisbury Brook. The highest bacteria counts were found at sites SEB1, SEB2, SB1, and TB1 on Trout Brook. With regard to dry-weather results, sites TB3, SB2 and TB1 were found to have the highest single event fecal coliform concentrations (48,000, 18,000, and 64,000 col/100ml, respectively). Greater detail on site and sub-basin ranking during wet- and dry-weather conditions is detailed in Tables 9 and 10.

Potential Sources

Potential Salisbury Plain bacteria sources are discussed in detail in Section 3.2 and presented in Summary Table A and Figures 2 and 4. In general, all of the sub-basins in the Salisbury Plain watershed are significant contributors of bacteria to the watershed as a whole, either during wet-weather conditions, dry-weather conditions, or both. However, the Searles Brook and Salisbury Brook sub-basins appear to be the most significant contributors of bacterial pollution to the Salisbury Plain River Watershed. This may be due to the fact that these sub-basins are located in some of the most residentially and commercially developed areas of the city of Brockton, so that potential sources such as stormwater runoff, are even more extreme due to the extensive amounts of impervious (e.g., paved) surfaces associated with streets, malls, and parking lots. In addition, these surfaces are likely to be coated with a relatively large amount of trash, dirt, and waste which can wash into the waters during wet-weather events. These effects are compounded by the lack of vegetative buffers along streams and rivers and flooding and stormwater control problems in many sections of these sub-watersheds. Other important potential sources of NPS pollution in these two sub-basins include: wastewater associated with sewer defects, roof runoff from houses built close to the water's edge, as well as wildlife waste impacts associated improperly managed trash and parks with poor vegetative buffers adjacent to the water.

The Searles Brook sub-basin may be influenced by extensive stormwater runoff and the extensive impervious areas associated with the surrounding high density residential land, including schools and housing complexes. Sewer defects are suspected though not proven. Bacteria counts in this sub-basin were highest during wet-weather conditions.

The Salisbury Brook sub-basin may be influenced by extensive stormwater runoff and extensive impervious areas associated with the surrounding high density residential, commercial, and industrial land, compounded by some areas being particularly prone to flooding and having stormwater control problems. In addition, there are potential sources of wastewater that may be associated with sewer defects in this sub-basin. In general, bacteria counts in this sub-basin were highest during wet-weather conditions.

3.1.2.2 Salisbury Plain Nutrients

Water Quality Monitoring Findings
ESS found that the sites with the highest average total phosphorus concentrations were SEB2, SPR1, SB2, and MAB1(see Tables 4 and 6H-O), although all sampling sites on the majority of days had concentrations of total phosphorus that exceeded EPA guidance criteria (Table 2). The sites with the highest average TKN concentrations were CB1, SPR1, SB2, and TB3 (see Tables 4 and 6H-O), although all sampling sites on the majority of days had concentrations of TKN that exceeded EPA guidance criteria (Table 2). The sites found to have concentrations of TSS that exceeded Massachusetts Class BWWF Water Quality Standards were TB1, TB2, CB1, and SB3, but only on one sampling day each. Other sites also had high concentrations of TSS on many days, although never exceeding the standards (see attached tables). Greater detail on site and sub-basin ranking during wet- and dry-weather conditions is detailed in Tables 9 and 10.

Potential Sources
Potential Salisbury Plain nutrient sources are discussed in detail in Section 3.2 and presented in Summary Table A and Figures 2 and 4. Those sites with high nutrient concentrations mentioned above are also discussed generally here.

Nutrient levels at site SEB2 are potentially influenced by stormwater runoff from surrounding roads, residential, and commercial areas. Wildlife waste impacts associated with the forest land surrounding this section of the brook and the open park land upstream of the site are also potential sources.

Nutrient levels at site TB3 are potentially influenced by stormwater runoff from surrounding roads, parking lots, and densely populated residential and commercial areas. All these sources stand to be compounded by the flooding and stormwater control problems in some parts of the Trout Brook sub-basin.

Nutrient levels at site MAB1 are potentially influenced by stormwater runoff from the surrounding high density residential streets. Wildlife waste associated with waterfowl observed in areas upstream of the site is another potential source.

Nutrient levels at site CB2 are potentially influenced by stormwater runoff from the surrounding high density residential streets via catch basins and country drainage as well as sheet runoff from gardens and yard areas backing closely onto the brook and impervious areas associated with two schools upstream of the site.

Nutrient levels at site SB2 are potentially influenced by stormwater runoff from surrounding roads, pavements and parking lots all heavily used, compounded by poor vegetation buffers and poorly managed trash in the area.

Sites SPR1 is the most downstream site in the Salisbury Plain watershed and therefore, may receive nutrient inputs from some or all of the sources in the watershed. Potential sources of nutrient inputs within this sub-basin for this site include stormwater runoff from the surrounding residential streets and industrial areas, direct discharge of stormwater pipes into the river, and a sewage disposal plant upstream of site SPR1.

TSS concentrations may be influenced at site SB3 by the presence of Cross Pond just upstream of the site, which could contribute phytoplankton and zooplankton to the brook. In addition, the heavy channelization at this site would compound any stormwater runoff from the surrounding impervious areas and also the roofs overhanging sections of the brook upstream of the site.

3.1.2.3 Salisbury Plain Habitat Assessments

A complete summary of the habitat scores and categorizations of each stream reach assessed in the Salisbury Plain River watershed can be found in Table 3, and MADEP habitat assessment field sheets can be found in Appendix A. In general within the Salisbury Plain watershed scores ranged between 86, at a site on the Trout Brook (TB3) which is marginal, to a score of 160, at a site on the Salisbury Plain river (SPR1) which is optimal. These scores reflect the wide variety of habitat conditions found within the watershed. One (1) of the sites in the Salisbury Plain River watershed had optimal conditions, 11 had sub-optimal conditions and seven (7) had marginal conditions. No sites were characterized as having poor conditions. Habitat assessment findings are discussed in more detail in section 3.2.

3.1.3 Site Prioritizations

All sites sampled in the Project watershed were ranked according to the water quality parameters tested, thus providing a priority list of sites (i.e., the recommended order of sites for site management actions). The parameters taken into account in the ranking were fecal coliform, TSS, TKN, and total phosphorus. Each parameter was separately ranked for each site according to the extent of its impairment. These ranks were added together to produce an overall rank score for each site. The prioritizations have been divided into two lists, "Recommended Priority for Site Management during Wet-Weather" and "Recommended Priority for Site Management during Dry-Weather" due to the differences in the NPS sources that can come into play during wet and dry conditions. The data set for site ranking is included in Tables 9 and 10. Based on these tables, the lists below introduce the Top 10 sites recommended for management during both wet- and dry-weather conditions, in order of priority. (Where sites ranked equally, they were placed on equal priority footing for recommended management.) Conceptual designs and cost estimates for management actions (i.e., best management practices) at the Top 5 wet- and dry-weather sites are included in Appendix C.

Sites Recommended for Management during Wet-Weather Conditions	Sites Recommended for Management during Dry-Weather Conditions
TB3/SEB2	**SB2**
SEB1	**MR2**
TB1	**CB1**
MR2	**CB2/SPR1/TB3**
SB3	**TB1**
SB5	**SB1**
SPR1	**ABB1**
BB3/SHR3	**MR3**
CB1	**SPR3**
TB2/SB2	**MB1**

3.2 Findings and Observations by Sub-Watershed

This section presents a general overview of each studied sub-basin within the study area (Figure 1). For the sake of discussion, the study area has been split into two sections: 1) the Salisbury Plain River watershed, which incorporates all those tributaries draining to the Salisbury Plain River as well the river itself (Figure 4), and 2) the Matfield River watershed, which incorporates all those tributaries draining to the Matfield River (except for the Salisbury Plain River) as well as the river itself (Figure 3). Watershed sub-basins were delineated for each river and brook sampled during the study. Each sub-basin is referred to as the name of the river or brook sampled within it, and each sub-basin overview incorporates only the sampling locations for that body of water. Findings are based on review of historic water quality data, water quality monitoring, field reconnaissance, geographical and land use data analysis, and interviews with municipal officials and others with knowledge of the watershed. When potential nonpoint sources of concern (identified by ESS during field reconnaissance) are initially mentioned in the following text they are accompanied by a reference to the appropriate location point recorded on Figure 5 and the number of the appropriate photograph (if available) in the photo log (Appendix 2).

3.2.1 Matfield River Watershed

The Matfield River watershed falls within the municipalities of Brockton, Abington, Whitman, Hanson, East Bridgewater, and Bridgewater Massachusetts (Figure 1, 2, and 3). The entire watershed is approximately 29,098 acres in area. The predominant land use in the watershed is forest (47%) followed by medium to low density residential areas (23%). The mainstem of the Matfield River runs in a southeasterly direction down to its confluence with the Town River in Bridgewater. It is fed by four major tributaries:

1. Beaver Brook, running south from its origin in Abington down to its confluence with the Matfield in East Bridgewater.
2. Shumatuscacant River, running south from its origin in Abington down to its confluence with Poor Meadow Brook and then ultimately to the Satucket River in East Bridgewater at the bottom of the Matfield River watershed.
3. Meadow Brook, running south from its origins in the Locust hill area of Whitman down to its confluence with the Matfield River in East Bridgewater.
4. Satucket River, running west from its origin at Robbins Pond in East Bridgewater converging with Poor Meadow Brook and Black Brook before its confluence with the Matfield River.

Minor tributaries draining to the Matfield River were also sampled during this study and will be discussed in following sections of the report.

The Matfield River provides recreational opportunities, plays a role in flood retention, and is a receiving waterbody for stormwater and overland runoff. Urban and suburban, commercial and residential land uses play a major role in the amount of nonpoint source pollution that goes to the river. NPS impacts are typically exacerbated in areas where vegetated buffers along riverfronts have been removed or destroyed because of adjacent land uses.

Matfield River Sub-Watersheds

Following is a general overview of the water quality and other field and laboratory results in each Matfield River sub-watershed. This section also includes a description of potential sources of NPS pollution in each sub-watershed. Watersheds were delineated for each river or brook sampled during the study. Each sample location was assigned a code number (Table 1). The data presented below is based on field sampling efforts, field reconnaissance, information obtained during meetings and site visits with local officials, and information available from state and federal agency water quality reports.

3.2.1.1 Beaver Brook

The total area of the Beaver Brook sub-watershed is approximately 3,995 acres with an impervious area of 7%. The brook runs through a large waterbody known as Cleveland Pond in Ames Norwell State park and through two smaller ponds known as Cushing Pond and Hunts Pond. The predominant land use is forest (52%), followed by medium density residential areas (26%). One site (BB3), at the top of the sub-basin on Plymouth Street in Holbrook, ranks as number 8 on the "Recommended Priority for Site Management during Wet-Weather" list developed as part of this study (see Section 3.1.3 and Table 9), which means overall the water quality at this site was relatively poor during wet weather conditions. Runoff from roads and other impervious areas such as parking lots, compounded by poor vegetation buffers along the edge of the brook and housing development pressures in the Cleveland pond area, are the major factors influencing NPS pollution in this sub-watershed.

Bacteria

- All sites sampled on Beaver Brook (BB1, BB2, and BB3) did not meet Massachusetts Class B standards for fecal coliform bacteria (Tables 4 and B-1). In addition, on all days sampled during wet weather conditions the Fecal coliform peak standard of 400 col/100ml was exceeded. All sites met the bacteria standard during dry weather, indicating a potential wet weather source of bacteria in the Beaver Brook watershed. The highest wet weather levels of bacteria were found in the upper watershed at site BB3 on Plymouth Street in Abington (a peak of 16,000 col/100ml on 7/10/02), the concentrations diminished downstream with the lower average concentrations being found at site BB1. The site BB3 may therefore be influenced by a local source that has a maximum impact during wet weather events. However, it is clear that further sources exist in the lower reaches of the watershed which contribute to the elevated levels of bacteria found at BB2 and BB1. Such sources will be discussed in the relevant "Potential NPS Sources" section later in the report.

Nutrients and TSS

- All sites sampled on Beaver Brook did not meet EPA guidance criteria for total phosphorus and TKN during wet and dry weather conditions for all the sampling dates (Tables 4 and 6A). Site BB2 exhibited the highest average TKN levels and site BB3 exhibited the highest average total phosphorus levels. Elevated levels of both nitrogen and phosphorus at these sites, suggests the Beaver Brook watershed may be experiencing elevated nutrient loads. Elevated levels of these nutrients can promote algal blooms, excessive weed growth and reduced dissolved oxygen levels which can cause the loss of species diversity in these waters. High levels of phosphorus can result from erosion, discharge of sewers or detergents, urban runoff and rural runoff containing fertilizers, animal and plant matter. High levels of Nitrogen can result from the natural breakdown of vegetation, runoff from lawn and crop fertilizers and feedlots. In addition, inadequately treated sewage and poor septic tank systems can increase levels of nitrogen in waterways.

- Site BB3 was the only site to exhibit TSS levels exceeding the Massachusetts aquatic life use standard, but during just one wet weather sampling day (7/16/02) (Tables 4 and 6a).

Field Parameter Findings of Special Concern

- All sites sampled on Beaver Brook exhibited some examples of below standard levels of dissolved oxygen on wet and dry sampling days (Table 7). The average value for each site also failed the Massachusetts Class B standard. Low levels of dissolved oxygen can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Low dissolved oxygen levels can be caused by excessive amounts of rotting vegetation, (that can come about through plant and algae blooms) and other organic wastes, as aerobic bacteria consume oxygen in the process of decomposition. This process can be compounded by high nutrient concentrations e.g. fertilizers contained in stormwater runoff, as well as by hot weather and low flows.
- High turbidity values were exhibited at sites BB1 and BB2 on one dry weather sampling day. These values exceeded the best professional judgment standard adopted by ESS scientists for Class B waters. High levels of turbidity can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. High turbidity levels can be caused by silt washed in during high rainfall, effluent discharge and runoff. Bank erosion/degradation can also increase turbidity as can algae and natural tannins. However very high levels of turbidity for a short period of time may not be significant and may even be less of a problem than a lower level that persists longer. In this case, due to the fact that exceeding values were seen during dry weather conditions, effluent discharge or bank erosion are the more likely causes.

Habitat Assessment Findings

Overall the assessment scores at the three sites assessed along Beaver Brook were marginal to sub-optimal (Table 3). At all three sites substrate embeddedness scored marginally i.e. gravel, cobble and boulder particles were 50-75% surrounded by fine sediment, however sediment deposition was close to optimal at the more upstream sites: BB3 and BB2, though marginal at site BB1. In addition, the amount of bank vegetative protection, the bank stability and the riparian vegetative zone width all scored "marginally" at site BB1: the most downstream of the sites sampled on Beaver Brook, as opposed to "optimal" at the other two sites, which may be due to the greater degree of development lower in the Beaver Brook sub-basin. See section 2.3.5.3 for a description of all habitat parameters assessed for the MADEP habitat assessment.

Potential NPS Sources

(Information Obtained from Research, Reconnaissance, Field Data Analysis, and Interviews with Municipal Officials and Others with Knowledge of the Watershed)

Field Reconnaissance Observations

- BB1 (Beaver Brook at Crescent Street bridge, Brockton) was sampled on five dates and exhibited elevated levels of bacteria on all wet weather sampling dates, with a peak level of 2,300 col/100ml on 6/6/02. Potential sources at this site include stormwater runoff from the extensive surrounding impervious areas in the form of roads and parking lots, compounded by narrow or nonexistent vegetation buffers along the brook edge and a channelized brook corridor. In addition, a catch basin observed on Crescent Street could be a potential source of runoff directly to the brook (*Point 40-Figure* B-1). Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem. The presence of DEP 21E tier classified sites upstream of the site could also have some impact, further investigations may be necessary to determine the significance of these sites on the water quality of Beaver Brook and the rest of the watershed. Trash observed dumped in the water could also have an effect on water quality.
- BB2 (Beaver Brook at Groveland Street bridge, Brockton/Abington border) was sampled on five dates and exhibited elevated levels of bacteria on all wet weather sampling dates, with a peak level of 9,600 col/100ml on 7/10/02. Potential sources at this site include stormwater runoff from surrounding roads via observed catch basins (*Point 41-Figure B-1*) and wildlife waste impacts associated with upstream wetland areas and surrounding conservation land. In addition, another potential source could be the extensive housing development pressures around Cleveland Pond. Although not a non point source the dam at Chestnut Street, on a stream flowing into Cleveland Pond can impact the waters above and below it, although in this case it is unlikely site BB2 would be greatly affected due to its distance from the dam.
- BB3 (Beaver Brook at Chestnut Street, Abington) was sampled on five dates and exhibited elevated levels of bacteria on all wet weather sampling dates, with a peak level of 16,000 col/100ml on 7/10/02. This site ranks as number 8 on the "Recommended Priority for Site Management (during wet weather). Potential sources at this site include stormwater runoff from surrounding roads via observed country drainage structures (*Point 2-Figure B-1 and Photo 4-Appendix 2*) and catch basins (*Point 1-Figure B-1 and Photo 5 Appendix 2*), as well as from adjacent gardens in the extensive residential area upstream of the site and waterfowl observed associated with surrounding forested areas. Well developed vegetation buffers observed at the site would likely protect from extensive runoff impacts. Copious amounts of aquatic macrophytes observed at the site may be a result of the observed high nutrient levels. A more extensive survey of all storm drains and sewer lines in this area is recommended to try and trace the source of pollution in this sub-basin.

Summarized Observations

The following potential source areas of NPS pollution were identified within this sub-watershed:

- Stormwater runoff from roads and residential areas on Plymouth Street and Abington Avenue, Abington.

- Stormwater runoff from Groveland Street, Abington.
- Wildife impacts associated with wetland area upstream of Groveland Street, Abington.
- Housing development pressures surrounding Cleveland Pond area in Ames Norwell State Park, including 200 units off of Summer Street, 200 units west of Cleveland Pond, and subdivision off of Hancock Street close to an unnamed tributary.
- Stormwater runoff from Crescent Street (Rt.27) and Quincy Street and surrounding residential and commercial areas, Brockton.
- Dam at Chestnut Street on the stream that flows into Cleveland Pond, Abington.
- Poorly vegetated buffer zone in the area of Crescent Street on Beaver Brook, Brockton.
- Potential source of wastewater on Court Street, Brockton. Contamination in a tributary to Beaver Brook off of Court Street, Brockton, was confirmed by scientists (not ESS) through water quality sampling. No defects or sources of pollution were identified but possible defects in the system were thought to be the cause. Further investigation is recommended.

3.2.1.2 Shumatuscacant River

The total area of the Shumatuscacant river sub-watershed is approximately 6,360 acres with an impervious area of 12%. The brook runs through a large waterbody known as Island Grove Pond in Island Grove Park, Abington, and through a smaller pond known as Hobart pond which is dammed at the outlet. The predominant land use is forest (37%), closely followed by medium density residential areas (32%), wetland also ranks highly (5%). One site (SHR3) on a small tributary feeding into the river on South Avenue, Whitman ranks as number 8 on the "Recommended Priority for Site Management during Wet-Weather)" list developed as part of this study (see Section 3.1.3 and Table 9), which means overall the water quality at this site was relatively poor during wet weather conditions. This relatively large sub-basin, diverse in its land use, exhibits many potential sources of NPS pollution such as stormwater runoff from roads, parking lots, residential and commercial areas and golf courses compounded by narrow or nonexistent vegetation buffers along the banks of some sections of the brook. Wildlife waste impacts and dams also rank as important non-point sources in this sub-watershed.

Bacteria

- Three of the sites sampled on Shumatuscacant River (SHR2, SHR3 and SHR4) did not meet Massachusetts Class B standards for fecal coliform bacteria (Tables 4 and 5b). In addition, the peak standard of 400 col/100ml was exceeded on 2 out of 3 wet weather sampling dates at sites SHR1 and SHR2, then 2 out of 2 wet weather sampling dates at site SHR3 and 1 out of 2 at site SHR4. All sites met the standard for bacteria during dry weather, indicating a potential wet weather source of bacteria in the Shumatuscacant river watershed. The highest wet weather levels of bacteria were found at site SHR3 (a peak of 60,000 col/100ml on 9/16/02) which is located approximately mid-watershed off of South Avenue (Route 27) in Whitman, on a small tributary feeding the main stem of the river. The other three sites exhibit similarly high levels of bacteria during wet weather conditions but none as high as those seen at SHR3. The site SHR3 may therefore be influenced by a local source within its small sub-watershed that has a maximum impact during wet weather events. However, it is clear that further sources exist in the lower and upper reaches of the watershed which contribute to the elevated levels of bacteria found at sites SHR2 and SHR4. Such sources will be discussed in the relevant "Potential NPS Sources" section later in the report.

Nutrients and TSS

- All sites sampled in the Shumatuscacant River sub-watershed did not meet EPA guidance criteria for total phosphorus during wet and dry weather conditions for all the sampling dates (Tables 4 and 6b). Additionally, all sites exceeded EPA guidance criteria for TKN for most sampling dates (SHR1 on 7/24/02 and SHR3 on 8/1/02 exhibited TKN levels that satisfied the standards). Sites SHR3 and SHR4 exhibited the highest average TKN and total phosphorus levels with site SHR1 (the most downstream site in the watershed) falling closely behind. Elevated levels of both nitrogen and phosphorus at all the sites in the Shumatuscacant River sub-watershed suggest the sub-watershed may be experiencing elevated nutrient loads. It is possible that the sources of these nutrients are greatest in the mid to lower reaches of the watershed, since nutrient levels are lowest at SHR2, the most upstream site in the watershed. Elevated levels of these nutrients can promote algal blooms, excessive weed growth and reduced dissolved oxygen levels which can cause the loss of species diversity in these waters. High levels of phosphorus can result from erosion, discharge of sewers or detergents, urban runoff and rural runoff containing fertilizers, animal and plant matter. High levels of Nitrogen can result from the natural breakdown of vegetation, runoff from lawn and crop fertilizers and feedlots. In addition, inadequately treated sewage and poor septic tank systems can increase levels of nitrogen in waterways.
- All sampling dates met the Massachusetts aquatic life use standard for TSS (Tables 4 and 6b).

Field Parameter Findings of Special Concern

- Sites SHR1 and SHR3 exhibited below (Massachusetts Class B) standard levels of dissolved oxygen on the majority of sampling days, and the average values also failed the standard at these sites (Table 7). Sites SHR2 and SHR4 were both relatively healthy in this respect. Low levels of dissolved oxygen can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Low dissolved oxygen levels can be caused by excessive amounts of rotting vegetation, (that can come about through plant and algae blooms) and other organic wastes, as aerobic bacteria consume oxygen in the process of decomposition. This process can be compounded by high nutrient concentrations e.g. fertilizers contained in stormwater runoff, as well as by hot weather and low flows.
- Turbidity standards were only exceeded at site SHR4 on 11/6/02, a wet weather sampling day (Table 7). This value exceeded the best professional judgment standard adopted by ESS scientists for Class B waters. High levels of turbidity can have an effect

on the water body's ability to support aquatic life, and thus on its overall water quality. High turbidity levels can be caused by silt washed in during high rainfall, effluent discharge and runoff. Bank erosion/degradation can also increase turbidity as can algae and natural tannins. However very high levels of turbidity for a short period of time may not be significant and may even be less of a problem than a lower level that persists longer. It is possible in this case that the high levels of turbidity were caused by the erosion associated with seasonal high water flows compounded by the wet weather event.

- The Massachusetts standard for Class B WWF (warm waters) for temperature was exceeded at SHR4 on 8/1/02 (Table 7). The temperature at all other sites sampled on the Shumatuscacant River did not exceed the State standard. High water temperatures can stress aquatic ecosystems by reducing the ability of water to hold essential dissolved gasses like oxygen, which in turn impacts the distribution and number of aquatic species found in the waterbody. Temperature is highly dependant on the depth of the water, season, time of day, and air temperatures. Industrial discharges can also affect water temperature.
- Specific conductance standards were greatly exceeded at SHR3 on 8/1/02, a dry weather sampling day (Table 7). The value on this sampling day (693 ųmhos/cm) exceeded the best professional judgment standard adopted by ESS scientists for Class B waters. The specific conductance at all other sites sampled on the Shumatuscacant River did not exceed the State standards. High levels of specific conductance can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Elevated levels of specific conductance can be caused by agricultural and sewage effluent and stormwater runoff, as well as the natural geology of the river bed

<u>Habitat Assessment Findings</u>

Overall the assessment scores at the four sites assessed along the Shumatuscacant River were marginal to sub-optimal (Table 3). The two sites (SHR3 and SHR4) in the middle of Whitman scored more poorly than those outside overall. In addition these two sites scored very poorly for sediment deposition i.e. there were heavy deposits of fine material, and substantial bar development, as well as embeddedness scoring borderline "sub-optimal/marginal". The site further upstream (SHR2) scored "marginally" on both embeddedness and sediment deposition as well as bank stability. In addition, at sites SHR3 and SHR4 the scores for the riparian vegetative zone width were "marginal", which reflects the level of development found in the center of Whitman. See section 2.3.5.3 for a description of all habitat parameters assessed for the MADEP habitat assessment.

<u>Potential NPS Sources</u>

(Information Obtained from Research, Reconnaissance, Field Data Analysis, and Interviews with Municipal Officials and Others with Knowledge of the Watershed)

Field Reconnaissance Observations

- SHR1 (Shumatuscacant River at Franklin street bridge, Whitman/Hanson border) was sampled on five dates and exhibited elevated levels of bacteria on two out of the three wet weather sampling days, with a peak level of 6,500col/100ml on 7/10/02. Potential sources at this site include storm runoff via country drainage from Franklin street (Route 27), and possible nutrient rich stormwater runoff from the Ridder Country Club (*Point 3-Figure B-1 and Photo 8 Appendix 2*), upstream of the site on the west side of the river, which includes a golf course which may be a source of nutrients from fertilizers in runoff. The presence of well established vegetation buffers on both sides of the river up-stream and down-stream of the site may mitigate runoff impacts.
- SHR2 (Shumatuscacant River at Summer Street bridge, Abington) was sampled on five dates and exhibited elevated levels of bacteria on two out of the three wet weather sampling days, with a peak level of 3,000col/100ml on 9/16/02. Potential sources at this site include stormwater runoff from surrounding roads via observed catch basins (*Point 5-Figure* B-1) including on Center Street (Route 123) and wildlife waste impacts associated with waterfowl observed on Island Grove Pond upstream of the site (*Point 4-Figure B-1 and Photo 10 Appendix 2*) and other wildlife associated with the pond and the surrounding park area. In addition, there are a number of resident or semi-resident goose populations that inhabit areas upstream of the site, which could have a wildlife waste impact as well as areas with known stormwater runoff issues throughout the sub-watershed. Although not a non point source, the dam at the base of Island Grove Pond on Route 123 is another source of pollution at site SHR2. Dams have the potential to release waters concentrated with pollutants, sediments and with decreased oxygen levels and can also affect the temperatures of waters downstream when water is released. Several DEP tier-classified 21E sites in the upper watershed could also have a limited impact on the site, further investigations may be necessary to determine the significance of these sites on the water quality of the Shumatuscacant River and the rest of the watershed.
- SHR3 (Unnamed tributary to Shumatuscacant River at South Avenue bridge, Whitman) was sampled on three dates and exhibited elevated levels of bacteria on two out of the two wet weathers sampling days, with a peak of 60,000col/100ml on 9/16/02. This site ranks as number 8 on the "Recommended Priority for Site Management during Wet-Weather" list developed as part of this study (see Section 3.1.3 and Table 9), which means overall the water quality at this site was relatively poor during wet weather conditions. Potential sources at this site include extensive stormwater runoff (observed as a gray plume exuding from a culvert on 11/6/02) from the surrounding roads and residential and commercial areas, into the river via a number of storm drains and culverts observed at the site. One such commercial area was "The Body Magic Repair Shop" adjacent to the site (to the south-east of it) (*Point 8-Figure B-1)*. A large impervious lot area around the shop could be a potential source of runoff during wet weather conditions. A number of catch basins were observed where the river crosses at South Avenue (*Point 7-Figure B-1 and Photo 14 Appendix 2))* and on Plymouth Street. Country drainage was also observed on Plymouth Street. Another potential pollution source at the site is improperly managed pet waste, of which numerous examples were observed on a grassy area just upstream of the site (*Point 10-Figure B-1)*. Trash bags were observed out of dumpsters (*Point 9-Figure B-1 and Photo 13 Appendix 2)* outside a video store just upstream of the site, which can encourage wildlife congregation and thus cause additional wildlife waste impacts. Known horse populations inhabiting areas

upstream of the site could also have an impact on the amounts of animal waste entering the waterbody. Additionally, a hose from a private swimming pool directly draining to the river was observed behind the house named "Turnesia" (*Point 6-Figure B-1 and Photo 12 Appendix 2*). Such an arrangement could impact the river with chemicals and wastes released from the pool during cleaning and seasonal closure.

- SHR4 (Shumatuscacant River at South Avenue bridge, Whitman) was sampled on three dates and exhibited elevated levels of bacteria on one out of the two wet weather sampling days, with a peak of 4,000col/100ml on 9/16/02. Potential sources at this site include stormwater runoff from surrounding roads, parking lots (*Point 11-Figure B-1*), and densely populated residential and commercial areas, compounded by narrow or nonexistent vegetation buffers on the east side of the river where buildings come almost right up to the edge. Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem. Roof runoff from these buildings is also a possible source. Numerous catch basins draining to Hobarts Pond were observed in a large parking lot area on Colebrook Boulevard (*Point 14-Figure B-1*). Catch basins were also observed upstream from the site on Essex Street (*Point 15-Figure B-1*). Observed metal and rubber trash in the water and on the waters edge could also be a source of some pollutants, and also reflects the general water quality. A flowing storm drain was observed on the east bank of the river (*Point 13-Figure B-1 and Photos 17-Appendix 2*) which was likely draining the runoff from the railway track area opposite the river at that point, which is a possible source of pollutants. Upstream of the site on the west bank, a small tributary appeared to flow from underneath a large red brick building (a boxing gym), and directly into the river (*Point 12-Figure B-1 and Photo 16-Appendix 2*). It is our guess that this water body is the remnant of a historic diversion for a mill, and is somehow hydrologically linked to Hobart Pond just upstream of this location. The water showed obvious signs of pollution, being full of metal and rubber debris and the stream bottom covered with a bright orange coating. Such a coating results from bacterial (*Thiobacillus ferrooxidans*) action on iron resulting in iron precipitating out of the water and appearing as an orange sludge. This can indicate an anoxic condition upstream or runoff from industrial areas or landfills. Visible sedimentation bars were observed at the site, and a solid waste facility was observed upstream of the site off of Essex Street behind Parker W. Bates Memorial field (*Point 16-Figure B-1*). As previously mentioned it is possible that the poor vegetation buffer observed at the river's edge adjacent to the waste facility may not fully protect the river from any solid waste running off during wet weather events. Copious amounts of aquatic macrophytes observed at the site may be a result of elevated nutrient levels found at this site. Although not a non point source, the dam at the South end of Hobart Pond is another source of pollution at site SHR2. Dams have the potential to release waters concentrated with pollutants, sediments and with decreased oxygen levels and can also affect the temperatures of waters downstream when water is released. DEP tier-classified 21E sites in the upper watershed could also have a limited impact on the site, further investigations may be necessary to determine the significance of these sites to the water quality of the Shumatuscacant River and the rest of the watershed.

Summarized Observations

The following potential source areas of NPS pollution were identified within this sub-watershed:

- Stormwater runoff via country drainage from Franklin Street (Route 27), Whitman.
- Stormwater runoff from the Ridder Country Club (Entrance on Oak street, Whitman), golf course off of Rt. 18 on Whitman town border and driving range west of the solid waste facility off of Groveland Street.
- Stormwater runoff from Center Street (Rt. 123), Abington.
- Stormwater runoff from South Avenue and Plymouth Street via catch basins and country drainage, Whitman.
- Stormwater runoff from commercial area and parking lot adjacent to river on Pond Street, compounded by lack of vegetation buffer on this side, Whitman.
- Stormwater runoff from railway line area running parallel to Pond Street, into river via visibly flowing storm drain off of Pond Street, Whitman.
- Stormwater runoff into catch basins on Colebrook Boulevard and Essex Street, Whitman.
- Roof runoff from buildings on Pond Street compounded by lack of vegetation buffer.
- Stormwater runoff from Abington Center at Junction of Route 18 and Route 123, Stop and Shop at intersection of Route 58 and Route 123, and the commercial area near Oak Street and Route 58.
- Stormwater problem areas such as steep slopes, flooding and sedimentation on a steep driveway off of Rockland street, at the corner of Blueberry and Summit Roads, Wales Street near the river and Andrew Ford Way where it intersects the main road to Abington Center.
- Wildlife waste impacts associated with waterfowl observed on Island Grove Pond, including known goose populations on the lake and off of Lake Street
- Wildlife waste impacts associated with goose populations and stormwater runoff at school off of Ralph G. Hamlin Lane.
- Wildlife waste impacts associated with improperly managed pet wastes and exposed trash bags on Plymouth Street and South Avenue, Whitman.
- Dam at the South end of Hobart Pond.
- Dam at base of Island Grove Pond on Route 123.
- Sedimentation problems on Alden Street, Dewey Street and at the bottom of Jenkins Avenue.
- Iron precipitate in small unnamed water body flowing into river from underneath boxing gym building, off of South Avenue behind Whitman furniture store.
- Housing: Lincoln Woods subdivision off of Route 18 with two new subdivisions expected adjacent to Lincoln Woods. Also a new development East of route 14 and South of Commercial street.

- Close proximity of solid waste facility off of Essex Street behind Parker W. Bates Memorial field, compounded by a narrow or nonexistent vegetation buffer, Whitman.

3.2.1.3 Meadow Brook

The total area of the Meadow Brook sub-watershed is approximately 4752 acres with an impervious area of 9%. The brook runs through a small waterbody known as Hardings Pond right at the headwaters of the sub-watershed off of Pine Street in Whitman and then through Forge Pond in East Bridgewater right before its confluence with the Matfield river. The brook also runs through extensive wetland areas in sections along its length. The predominant land use is forest (47%), followed by medium density residential areas (26%), then wetland (4.7%). The brook was only sampled at one location, (MB1) on the West Union Street bridge right at the bottom of the sub-watershed. This site ranks as number 10 on the "Recommended Priority for Site Management during Dry-Weather" list developed as part of this study (see Section 3.1.3 and Table 10), which means overall water quality was relatively poor during dry weather conditions. The potential sources of NPS pollution in this sub-watershed are stormwater runoff from roads compounded by narrow or nonexistent vegetation buffers along some sections of the brook, and new housing developments in close proximity to the brook. Wildlife waste impacts also rank as important non-point sources in this sub-watershed.

Bacteria

- The site sampled on Meadow Brook (MB1) did not meet Massachusetts Class B standards for fecal coliform bacteria (Table 4 and 5c). In addition, the peak standard of 400 col/100ml was exceeded (except on 8/30/02-wet and 8/8/02-dry). This indicates there is a potential weather independent source of bacteria in the Meadow Brook watershed. However, the highest levels of bacteria were found during wet weather conditions (a peak of 1,600 col/100ml on 7/24/02) which suggests wet weather conditions may exacerbate the bacteria problem slightly at this site.

Nutrients and TSS

- The site sampled on Meadow Brook did not meet EPA guidance criteria for total phosphorus and TKN during wet and dry weather conditions for all the sampling dates (Table 4 and 6c). The highest levels found for both parameters were during dry weather conditions on (6/24/02) although total phosphorus was similarly high on 8/30/02 and 8/8/02. Elevated levels of both nitrogen and phosphorus at this site suggest the Meadow brook watershed may be experiencing elevated nutrient loads. Elevated levels of these nutrients can promote algal blooms, excessive weed growth and reduced dissolved oxygen levels which can cause the loss of species diversity in these waters. High levels of phosphorus can result from erosion, discharge of sewers or detergents, urban runoff and rural runoff containing fertilizers, animal and plant matter. High levels of Nitrogen can result from the natural breakdown of vegetation, runoff from lawn and crop fertilizers and feedlots. In addition, inadequately treated sewage and poor septic tank systems can increase levels of nitrogen in waterways.

- All the sampling dates met the Massachusetts aquatic life use standard for TSS (Table 4 and 6c).

Field Parameter Findings of Special Concern

- Site MB1, on two of the sampling days exhibited just below (Massachusetts Class B) standard levels of percent saturation of dissolved oxygen, the corresponding concentrations of dissolved oxygen in mg/L on those same sampling dates did not fail the standard (Table 7). The average value for dissolved oxygen as a percentage and in mg/L also met the standard. A slight error in judgment when reading the dissolved oxygen meter could well explain such values. However, these levels are relatively low and may still indicate excessive amounts of rotting vegetation and other organic wastes which can be compounded by fertilizers contained in stormwater runoff. Low levels of dissolved oxygen can have an effect on the water body's ability to support aquatic life, and thus on its level of biodiversity and overall water quality.
- Specific conductance standards were exceeded on two of the sampling dates at site MB1, during wet weather conditions on 8/30/02 and during dry weather conditions on 8/8/02 (Table 7). The values on these days (605 ųmhos/cm and 515 ųmhos/cm respectively) exceeded the best professional judgment standard adopted by ESS scientists for Class B waters. High specific conductance can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Elevated levels of specific conductance can be caused by agricultural and sewage effluent and stormwater runoff, as well as the natural geology of the river bed

Habitat Assessment Findings

At the one site assessed on Meadow Brook the overall assessment score was "Optimal" (Table 3). The only parameters to score less than "optimal" were epifaunal substrate and the frequency of riffles, which can be impacted by human development when stream banks are cleared for easy access. See section 2.3.5.3 for a description of all habitat parameters assessed for the MADEP habitat assessment.

Potential NPS Sources

(Information Obtained from Research, Reconnaissance, Field Data Analysis, and Interviews with Municipal Officials and Others with Knowledge of the Watershed)

Field Reconnaissance Observations

- MB1(Meadow Brook at West Union Street bridge, East Bridgewater) was sampled on five dates and exhibited elevated levels of bacteria on two out of the three wet weather sampling days and one out of the two dry weather sampling days, with a peak level of 1,600col/100ml on 7/24/02 during wet weather conditions. Potential sources at this site include stormwater runoff via country drainage from Union street, and a storm drain located in the wall under the bridge itself which was flowing on all days the site was visited (*Point 17-Figure B-1 and Photo 19 Appendix 2*). There were also catch basins and country drainage observed on North Central Street (*Point 19-Figure B-1*) close to the brook and the potential for road and garden runoff directly into the brook along Willow Avenue due to the almost nonexistent vegetation buffer (*Point 18-Figure B-1 and Photo 20 Appendix 2*). Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem. A small parking area at the top of Willow avenue; is also a potential source for stormwater runoff directly into the stream, due to the nonexistent vegetation buffer there. A large parking area in front of and behind the Alloy casting business on Union street adjacent to the brook could be a potential source, however the presence of well developed vegetation buffers on both sides of the river up and down stream of the site would likely mitigate extensive runoff impacts from this lot. Another potential source is wildlife waste impacts associated with the ducks observed upstream of the site and wildlife associated with the small wetland area observed upstream of the site. In addition, there are a number of resident or semi-resident goose populations and horse farms upstream of the site, which could have a wildlife waste impact. DEP tier-classified 21E sites and housing developments in the upper watershed could also have a limited impact on the site, further investigations may be necessary to determine the significance of these sites on the water quality of Meadow Brook and the rest of the watershed.

Summarized Observations

The following potential source areas of NPS pollution were identified within this sub-watershed:

- Stormwater runoff via country drainage from Union Street, East Bridgewater.
- Stormwater runoff via country drainage and catch basins from North Central Street, East Bridgewater.
- Stormwater runoff directly from Willow Avenue, compounded by poor vegetation buffer, East Bridgewater.
- Continuously running storm drain under the Union Street bridge, East Bridgewater.
- Stormwater runoff area between Route 18 and School Street next to an unnamed tributary of Meadow Brook, Whitman.
- Stormwater runoff area in the commercial area and bus depot between route 18 and Diane Terrace, Whitman.
- Stormwater runoff area at the end of Pond street.
- Stormwater runoff in the commercial area off of route 123 on Meadow Brook.
- Waste impacts associated with waterfowl observed upstream of the site and wildlife associated with the small wetland area upstream of the Union Street bridge

- Wildlife waste impacts associated with goose populations along Meadow Brook just before it enters Forge Pond as well as on Hardings Pond at the very top of the watershed.
- Housing: New development close to unnamed tributary to Meadow Brook off of Walnut Street and Route 14. Also, another new development West of Meadow Brook, north of Temple Street near the Abington border.
- Sedimentation problems on East Avenue, Temple Street (Route 27) and Whiting, Loring, and Beal Avenues.

3.2.1.4 Satucket River

The total area of the Satucket river sub-watershed is approximately 8326 acres, making it the largest sub-watershed in the study, with an impervious area of 5%. The river generally runs East to West to its confluence with the Matfield River and is fed by two main tributaries that come in from the North, namely Black Brook and Poor Meadow Brook. To the far East of the sub-watershed the river originates at a large standing waterbody known as Robbins Pond in East Bridgewater as well as a wetland/cranberry bog area even further East in the town of Halifax. The predominant land use is forest (55%), followed by medium density residential areas (14%). The brook was sampled at one location (SR1), on the Plymouth Street bridge at the Western corner of the sub-watershed. This relatively large sub-basin, diverse in its land use shows markedly few potential sources of NPS pollution, those being stormwater run off from surrounding roads and gardens compounded by narrow or nonexistent vegetation buffers along some sections of the brook, and cranberry bogs in close proximity to some sections of the brook. Wildlife waste impacts also rank as important non-point sources in this sub-watershed.

Bacteria

- The site sampled on Satucket River (SR1) met the Massachusetts Class B standards for fecal coliform bacteria; the site was relatively clean in comparison to many of the other sites sampled during this study (Table 4 and 5d). However, on one out of the five days the peak standard of 400 col/100ml was exceeded (2,000col/100ml on 9/16/02 during wet weather conditions). The site (SR1) may therefore be influenced by a local source within its sub-watershed that has a maximum impact during wet weather events; however more sampling is recommended to be sure that the data from 9/16/02 was not a fluke, as it was so much higher than any of the other values recorded at this site.

Nutrients and TSS

- The site sampled on Satucket River did not meet EPA guidance criteria for total phosphorus and TKN during wet and dry weather conditions for all the sampling dates (Table 4 and 6d). The highest level found for both parameters was during dry weather conditions on 6/24/02, which indicates a potential dry weather source of pollution to the river. Elevated levels of both nitrogen and phosphorus at this site suggest the Satucket

River watershed may be experiencing elevated nutrient loads. Elevated levels of these nutrients can promote algal blooms, excessive weed growth and reduced dissolved oxygen levels which can cause the loss of species diversity in these waters. High levels of phosphorus can result from erosion, discharge of sewers or detergents, urban runoff and rural runoff containing fertilizers, animal and plant matter. High levels of Nitrogen can result from the natural breakdown of vegetation, runoff from lawn and crop fertilizers and feedlots. In addition, inadequately treated sewage and poor septic tank systems can increase levels of nitrogen in waterways

- All of the sampling dates met the Massachusetts aquatic life use standard for TSS (Table 4 and 6d).

<u>Field Parameter Findings of Special Concern</u>

- At no time during the study did any of the measured field parameters fail to meet Massachusetts Class B or ESS Best Professional standards at site SR1 (Table 7). This indicates that the site and the river itself are relatively healthy in terms of the field parameters measured, compared to many of the others sampled during this study.

<u>Habitat Assessment Findings</u>

At the one site assessed on Satucket River the overall assessment score was sub-optimal (Table 3). Embeddedness and sediment deposition both scored "marginally" at the site. In addition bank stability and bank vegetative protection were especially "poor". In this case the lack of streambank vegetation probably is causing or at least contributing to the lack of bank stability. See section 2.3.5.3 for a description of all habitat parameters assessed for the MADEP habitat assessment.

<u>Potential NPS Sources</u>

(Information Obtained from Research, Reconnaissance, Field Data Analysis, and Interviews with Municipal Officials and Others with Knowledge of the Watershed)

Field Reconnaissance Observations

- SR1 (Satucket River at Plymouth Street bridge, East Bridgewater) was sampled on five dates and exhibited elevated levels of bacteria on one out of the five, with a peak level of 2,000col/100ml on 9/16/02. Potential sources at this site include stormwater runoff into storm drains from catch basins all along Plymouth Street and from gardens adjacent to the river on Allen Street (upstream of the bridge), compounded by a nonexistent vegetated buffer upstream of the bridge (*Point 21-Figure B-1*). Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem. Another potential source observed at the site was eroding river banks compounded by the lack of a rooted vegetation buffer along this stretch of the river (*Point 20-Figure B-1 and Photo 21-Appendix 2*). On low flow days during the summer months sedimentation bars were observed within the river, in particular around the concrete columns of the Plymouth Street bridge. Another potential source is wildlife waste impacts associated with the E.B. Town Conservation Land just to the West of the site at the back of Bennett Lane; additionally there is a cattle population up on a small tributary to Black Brook that may have a limited impact on the main stem of the Satucket River. Numerous cranberry bogs scattered within the sub-watershed are also likely to be potential sources, studies have shown that cranberry operations often increase levels of nutrients and phosphorus downstream which can cause excessive weed and algae growth and reduce dissolved oxygen, sediment load can also be increased to waters downstream of the bogs and there is potential for pesticides applied to cranberry beds to be discharged to downstream waters. In addition, studies have shown that there is the potential for increased water temperature in waters downstream from cranberry bogs and that diversion of water for irrigation use in the bogs can cause temporary reductions of downstream flows, possibly increasing temperatures and reducing suitable habitat for existing aquatic life. Copious amounts of aquatic macrophytes observed at the site may be a result of the elevated nutrient levels found at this site. DEP tier-classified 21E sites and housing developments in the watershed could also have a limited impact on the site, further investigations may be necessary to determine the significance of these sites on the water quality of the Satucket River and the rest of the watershed.

Summarized Observations

The following potential source areas of NPS pollution were identified within this sub-watershed:

- Stormwater runoff from Plymouth Street and Allen Street, compounded by nonexistent vegetation buffer, East Bridgewater.
- Eroding river banks upstream of Plymouth street bridge, compounded by nonexistent vegetation buffer, East Bridgewater.
- Potential wildlife waste impacts associated with the E.B. Town Conservation Land just to the West of the site at the back of Bennett Lane, East Bridgewater.
- Cranberry bogs located of Route 106 near Satucket River and within the Zone II well head protection area off of Washington street near Black Brook.
- Housing developments: A large subdivision closer than 100 feet to a small unnamed tributary of the Satucket River off of Eliab Latham Way, in proximity to a town well and within the Zone II well head protection area.

3.2.1.4 Spring Street Tributary

The total area of the Spring Street tributary (named by ESS) sub-watershed is 260 acres with an impervious area of 16%. The site sampled was downstream of Spring Street by the culvert for a small channel draining a small forested wetland area on the north side of Spring Street, to the Spring Street tributary. The Spring Street tributary runs a short distance east from its origins just east of Aaundreas Way, East Bridgewater, to its confluence with Matfield

River a short distance east of Spring Street. The predominant land use is forest (30%) followed by medium density residential areas (23%) then Industrial land (15%). The sample site only contained water once out of the three times it was visited on 11/6/02, so it was only sampled and tested once. The potential sources of NPS pollution in this sub-watershed are stormwater run off and country drainage from Spring Street and the industrial area off of Laurel street. Wildlife waste impacts are also potential non-point sources in this sub-watershed.

Bacteria

- The site sampled (draining to the Spring Street Tributary) did not meet Massachusetts Class B standards for fecal coliform bacteria (Table 4 and 5e). The one value recorded for Fecal coliform bacteria did not exceed the peak standard of 400 col/100ml, but was very close being exactly 400 col/100ml. The site sampled may be influenced by a local source within its sub-watershed, however more sampling is recommended to clarify any potential NPS source issues.

Nutrients and TSS

- The site sampled did not meet EPA guidance criteria for total phosphorus and TKN on 11/6/02 (Table 4 and 6e). Elevated levels of both nitrogen and phosphorus at this site suggest the site may be experiencing elevated nutrient loads. Elevated levels of these nutrients can promote algal blooms, excessive weed growth and reduced dissolved oxygen levels which can cause the loss of species diversity in these waters.
- The site met the Massachusetts aquatic life use standard for TSS (Table 4 and 6e).

Field Parameter Findings of Special Concern

- On the day the site was sampled it failed the Massachusetts Class B standards for dissolved oxygen (Table 7). Low levels of dissolved oxygen can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Low dissolved oxygen levels can be caused by excessive amounts of rotting vegetation, (that can come about through plant and algae blooms) and other organic wastes, as aerobic bacteria consume oxygen in the process of decomposition. This process can be compounded by high nutrient concentrations e.g. fertilizers contained in stormwater runoff, as well as by hot weather and low flows.
- On the day the site was sampled it also failed the Massachusetts Class B standard for pH i.e. it was less then 6.5 SU (Table 7). Low pH levels in water can be caused by run-off from acid affected soils, sewage or discharge from old mines. Low pH can have the effect of mobilizing toxins in the water column, which can then enter the food chain. Outside what is considered the normal pH range sensitive species can be lost.

Habitat Assessment Findings

At the one site assessed on Spring Street Tributary the overall assessment score was sub-optimal (Table 3). The main reason for the apparent poor quality habitat was the lack of water in the stream channel. The reason for this was that the site sampled (SST1) was not the originally intended site location. Also, it was not an extended body of water, but rather a drainage ditch from the forested area on the other side of Spring Street culverted under the road.

Potential NPS Sources

(Information Obtained from Research, Reconnaissance, Field Data Analysis, and Interviews with Municipal Officials and Others with Knowledge of the Watershed)

Field Reconnaissance Observations

- The channel (draining to the Spring Street Tributary) on Spring Street, East Bridgewater was sampled on 11/6/02. Potential sources at this site include stormwater runoff via country drainage on Spring Street and from the industrial area off of Laurel Street. Another potential source is wildlife waste impacts associated with the thick forest/wetland area upstream of Spring Street. The thick vegetation buffer on both sides of the road may mitigate runoff impacts.

Summarized Observations

The following potential source areas of NPS pollution were identified within this sub-watershed:

- Stormwater runoff from Spring Street, East Bridgewater.
- Stormwater runoff from the industrial area off of Laurel Street, East Bridgewater.
- Wildlife waste impacts associated with the thick forest/wetland area north-west of Spring Street.

3.2.1.5 Westdale Tributary

The total area of the Westdale Tributary (named by ESS) sub-watershed is approximately 572 acres with an impervious area of 7%. The tributary runs in a semi-circle from its origins at a small enclosed water body off of East Center Street in Westdale, East Bridgewater. It crosses East Center Street just East of the commuter rail line then curves down and around through an extensive wetland area to come up and cross West Street (where it was sampled) just west of the old railway bed. The tributary then runs on in a generally north-east direction to its confluence with the Matfield River. The predominant land use is forest (63%) followed by low density residential areas (13%). The brook was only sampled at one location (WT1) on West Street, downstream of the road just before a small wetland area. The site was sampled twice out of the three times the site was visited due to no water being present in the channel on 8/1/02. The potential sources in this sub-watershed are stormwater runoff directly from West Street and storm drains (origins unknown) draining into the tributary upstream and downstream of the road. Sedimentation and wildlife waste impacts are also potential non-point sources in this sub-watershed.

Bacteria

- The site sampled on Westdale Tributary (WT1) did not meet Massachusetts Class B standards for fecal coliform bacteria (Table 4 and 5f). In addition, one out of the two days sampled during wet weather conditions exceeded the peak standard of 400 col/100ml. The site was not sampled during dry weather so it is impossible to tell if the sources of bacteria in the sub-watershed are wet and dry or just wet. However it can be concluded that there is at least a potential wet weather source of bacteria within the sub-watershed. The highest wet weather levels of bacteria were 1,900 col/100ml on 9/16/02. The small amount of data collected for this site makes it easy for the geometric mean to be skewed by one day with high values, so more sampling is recommended to clarify any potential NPS source issues.

Nutrients and TSS

- The site did not meet EPA guidance criteria for total phosphorus and TKN for both the sampling dates (Table 4 and 6f). The highest level found for TKN was on (11/6/02) and for total phosphorus on (9/16/02). Elevated levels of both nitrogen and phosphorus at this site suggest the Westdale Tributary watershed may be experiencing elevated nutrient loads. Elevated levels of these nutrients can promote algal blooms, excessive weed growth and reduced dissolved oxygen levels which can cause the loss of species diversity in these waters.
- All of the sampling dates met the Massachusetts aquatic life use standard for TSS (Table 4 and 6f).

Field Parameter Findings of Special Concern

- On both days the site was sampled it failed the Massachusetts Class B standards for dissolved oxygen (Table 7). Low levels of dissolved oxygen can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Low dissolved oxygen levels can be caused by excessive amounts of rotting vegetation, (plentiful with the surrounding forest at this site) and other organic wastes, as aerobic bacteria consume oxygen in the process of decomposition. This process can be compounded by high nutrient concentrations e.g. fertilizers contained in stormwater runoff, as well as by hot weather and low flows.
- On one day (11/6/02) the site failed the Massachusetts Class B standard for pH i.e. it was less then 6.5 SU (Table 7). In this case the pH was so low (3.7SU) it was the lowest level seen anywhere throughout the entire course of the study. Low pH levels in water can be caused by run-off from acid affected soils, sewage or discharge from old mines. Low pH can have the effect of mobilizing toxins in the water column, which can then enter the food chain. Outside what is considered the normal pH range sensitive species can be lost.

Habitat Assessment Findings

At the one site assessed on Westdale tributary the overall assessment score was sub-optimal (Table 3). Similarly to site SST1 on the Spring Street tributary, the main reasons for the overall poor judgment of the habitat quality were not directly caused by human impacts but rather a factor of the channel itself. The parameters scoring especially poorly were channel flow status, (which can be affected by the weather conditions), epifaunal substrate (which could be a factor of the relatively small amount of water that usually fills the channel) and the frequency of riffles (also a factor of the amount of water that flows through the channel over the year). See section 2.3.5.3 for a description of all habitat parameters assessed for the MADEP habitat assessment.

Potential NPS Sources

(Information Obtained from Research, Reconnaissance, Field Data Analysis, and Interviews with Municipal Officials and Others with Knowledge of the Watershed)

Field Reconnaissance Observations

- WT1 (Westdale Tributary at West Street, East Bridgewater) was sampled on two dates and exhibited elevated levels of bacteria on one out of the two, with a peak level of 1,900col/100ml on 9/16/02. Potential sources at this site include direct stormwater road runoff from West Street, and two storm drain pipes. One pipe was on the right hand bank of the tributary (looking upstream) right next to the road (*Point 22-Figure B-1 and Photo 25 Appendix 2*), frozen effluent was observed exuding from the pipe on 1/29/02. The second storm drain pipe was on the downstream side of the road on the left hand bank right next to the road (looking downstream) (*Point 23-Figure B-1*), water gray in color and with a "sewage" like odor was observed flowing down from the pipe into the tributary on 11/6/02. Another potential source observed at the site was a pipe embedded in the ground on the south-east side of the tributary set back about 15 feet from the waters edge, with a channel/depression in front of it running down to the water. The origin of the above mentioned storm drain pipes was not clear. The presence of well established vegetation buffers on both sides of the tributary upstream and downstream of the site may mitigate runoff impacts unless the runoff drains directly into the water body, as most of the storm drains mentioned above did. Another potential source was wildlife waste impacts associated with the extensive forest and wetland areas upstream of the site such as from raccoons, skunks, rats and feral cats. Excessive sedimentation was observed upstream of the site, the sediment was observed to have built up in front of the upstream side of the culvert to the point where it was almost no longer visible. The source of this sediment was not clear.

Summarized Observations

The following potential source areas of NPS pollution were identified within this sub-watershed:

- Stormwater runoff from West Street , East Bridgewater.
- Stormwater runoff from two storm drain pipes on the upstream and downstream side of West Street draining directly into Westdale Tributary, East Bridgewater.
- Wildlife waste impacts associated with the extensive forest and wetland area upstream of West Street, East Bridgewater.

3.2.1.6 Matfield River

The total area of the Matfield river sub-watershed is approximately 4,833 acres with an impervious area of 7%. The main stem of the river runs in a south-easterly direction from its origin (at its confluences with the Salisbury Plain River and Beaver Brook directly north from the end of Pleasant Avenue, East Bridgewater) down to its confluence with the Town River in Bridgewater. The predominant land use is forest (42%), followed by medium density residential areas (21%). Two out of the three sites sampled on the Matfield River ranked very low on the "Recommended Priority for Site Management" lists developed as part of this study. Site MR2 on Bedford Street, East Bridgewater ranks as number 4 on the "wet weather list" (Table 9) and 2 on the "dry weather list" (Table 10). Site MR3 on West Union Street, East Bridgewater ranks as number 8 on the "dry weather list" (Table 10). This indicates that overall the mid to upper reaches of the Matfield River sub-watershed was one of the worst areas in terms of water quality during wet and dry weather conditions. This sub-basin shows only a small number of potential sources of NPS pollution despite its size, i.e. runoff from major and minor roads via country drainage and catch basins, runoff from gardens adjacent to the river, and wildlife waste impacts associated with gardens, forest and wetland areas in the sub-watershed. However in addition to these sources it is likely that the input of impaired waters from the Salisbury Plain River and Beaver Brook will affect the water quality of the Matfield river accordingly and thus may explain the poor quality of the water on the Matfield River.

Bacteria

- All three of the sites sampled on Matfield River (MR1, MR2 and MR3) did not meet Massachusetts Class B standards for fecal coliform bacteria (Table 4 and 5g). In addition, the peak standard of 400 col/100ml was exceeded on 2 out of 3 wet weather sampling dates' at all three sites. The peak standard was also exceeded during dry weather conditions on 1 out of 2 days at both sites MR2 and MR3. This indicates there is a potential wet and dry weather source of bacteria in the Matfield river watershed, although wet weather events appear to exacerbate the problems. The highest wet weather levels of bacteria were found at site MR2 (a peak of 18,000 col/100ml on 7/10/02) which is located approximately mid-watershed. The other two sites exhibit similarly elevated average bacteria levels during wet weather conditions but none as high as those seen at MR2. The site MR2 may therefore be influenced by an extra local source within its small sub-watershed that has a maximum impact during wet weather events. However, it is clear that further sources exist in the lower and upper reaches of the watershed which contribute to the elevated levels of bacteria found at sites MR3 and MR1. Such sources will be discussed in the relevant "Potential NPS Sources" section later in the report.

Nutrients and TSS

- All sites sampled in the Matfield River sub-watershed did not meet EPA guidance criteria for total phosphorus and TKN during wet and dry weather conditions for all the sampling dates (Table 4 and 6g). The average concentrations of total phosphorus were found to decrease slightly going downstream. This seems to indicate that sources of total phosphorus are more prevalent in the upper reaches of the watershed. Elevated levels of both nitrogen and phosphorus at all the sites in the Matfield River sub-watershed suggests the sub-watershed may be experiencing elevated nutrient loads. Elevated levels of these nutrients can promote algal blooms, excessive weed growth and reduced dissolved oxygen levels which can cause the loss of species diversity. High levels of phosphorus can result from erosion, discharge of sewers or detergents, urban runoff and rural runoff containing fertilizers, animal and plant matter. High levels of Nitrogen can result from the natural breakdown of vegetation, runoff from lawn and crop fertilizers and feedlots. In addition, inadequately treated sewage and poor septic tank systems can increase levels of nitrogen in waterways
- Site MR2 was the only site not to meet the Massachusetts aquatic life use standard for TSS, but during just one wet weather sampling day (9/16/02) (Table 4 and 6g).

Field Parameter Findings of Special Concern

- All the sites sampled on the Matfield River exhibited below (Massachusetts Class B) standard levels of dissolved oxygen on the majority of sampling days, and the average values also failed the standard at these sites (Table 7). Even those sampling dates that did not fail the standard exhibited very low/borderline failing levels of dissolved oxygen. Low levels of dissolved oxygen can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Low dissolved oxygen levels can be caused by excessive amounts of rotting vegetation, (that can come about through plant and algae blooms) and other organic wastes, as aerobic bacteria consume oxygen in the process of decomposition. This process can be compounded by high nutrient concentrations e.g. fertilizers contained in stormwater runoff, as well as by hot weather and low flows. In this case, the low levels of dissolved oxygen in the Matfield River could also be caused by the input of impaired waters from the Salisbury Plain River and Beaver Brook, in addition to any sources in the Matfield River sub-watershed.
- The best professional judgment standard for specific conductance, adopted by ESS scientists for Class B waters was exceeded at least once at all three sites sampled on the Matfield River (Table 7). The level of impairment increased going downstream with site MR1 (the most downstream site) exhibiting the highest average as well as the greatest percentage of failing days (4 out of 5), Site MR3 (the most upstream site) failed on 1 out of 5 days. High levels of specific conductance can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Elevated levels of specific conductance can be caused by agricultural and sewage effluent and stormwater runoff, as well as the natural geology of the river bed.

Habitat Assessment Findings

Overall the assessment scores at the three sites assessed along the Matfield River ranged from sub-optimal to optimal (Table 3). The habitat quality appears to decrease moving downstream from MR3, to MR2 to MR1. The parameters scoring badly at the most downstream site (MR1) were mostly a factor of the waterbody being wide and deep and quite slow moving, i.e. riffles and runs were virtually non existent, there was a high percentage of embeddedness, and few velocity depth patterns. In general, the other two sites scored well for all the assessed parameters. See section 2.3.5.3 for a description of all habitat parameters assessed for the MADEP habitat assessment.

Potential NPS Sources

(Information Obtained from Research, Reconnaissance, Field Data Analysis, and Interviews with Municipal Officials and Others with Knowledge of the Watershed)

Field Reconnaissance Observations

- MR1 (Matfield River at High Street bridge, Bridgewater) was sampled on five dates and exhibited elevated levels of bacteria on two out of the three wet weather sampling days, with a peak level of 2,300 col/100ml on 9/16/02. Potential sources of NPS pollution at this site include stormwater runoff via catch basins from High Street into storm drains observed in the bank on the downstream side of the High Street Bridge. Catch basins and county drainage in close proximity to the river were also observed upstream on Bridge Street. The presence of well established vegetation buffers on both sides of the river up-stream and down-stream of the site may mitigate runoff impacts. Strong sewage/musty odors (when close to the water) were noted during every visit to the site, which can be an indication of untreated sewage, livestock waste or algae. The presence of a small pumping station just up-gradient from the site could also be a potential source. Pump station by-passes may contribute fecal coliform concentrations which are likely to be similar to those from combined sewer overflows. Such by-passes, if they occur in this area, may require further investigation or correction. Copious amounts of macrophytes and algae were observed at the site which could be a result of the elevated nutrient levels found at this site. Strong chlorine odors were also noted during every visit to the site, which can be an indication of over chlorination by a sewage treatment plant or chemical industry, or discharge of swimming pool water. Evidence of primary recreation was noted at the site in the form of a rope swing (*Photo 27 Appendix 2*). It is advised that such activities should be actively prohibited.
- MR2 (Matfield River at Bedford Street bridge, (Route 18), East Bridgewater) was sampled on five dates and exhibited elevated levels of bacteria on two out of the three wet weather sampling days and one out of the two dry weather sampling days, with a peak level of 18,000 col/100ml on 7/10/02 during wet weather conditions. This site ranks as number 4 on the "Recommended Priority for Site Management (during wet weather)" list (Table 9) and number 2 on the "Recommended Priority for Site Management (during dry weather)" list (Table 10), which means overall this site was one of the worst in terms of water quality during wet and dry weather conditions. Potential sources of NPS pollution

at this site include stormwater runoff from catch basins on Broad Street (Route 18) and other surrounding roads. Runoff observed from a stormdrain draining to the river is another potential source of NPS pollution at this site. The stormdrain was located on the downstream side of the road approximately 25m north of the river along the side of the road (*Point 24-Figure B-1 and Photo 29 Appendix 2*), a small channel led from the stormdrain down to the river. The origin of the stormdrain was not confirmed. The sediment in the channel and the bottom of the stormdrain pipe were covered with a bright orange coating. Such a coating results from bacterial (*Thiobacillus ferrooxidans*) action on iron resulting in iron precipitating out of the water and appearing as an orange sludge. This can indicate an anoxic condition upstream or runoff from industrial areas or landfills. Another potential source upstream of the site is stormwater runoff from the numerous gardens on Keene Lane in close proximity to the south side of the river, just upstream of the bridge, compounded by a narrow vegetation buffer (*Point 25-Figure B-1*). Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem. In contrast, the vegetation buffer on the north side of the river upstream of the bridge is thick and well established due to the lack of residential development. Another potential source at the site is wildlife waste impacts associated with waterfowl such as wild ducks, farm ducks and Canadian geese. The presence of farm ducks observed on the water indicates the possibility that a small farm may exist upstream of the site, but this could not be confirmed. Several DEP tier-classified 21E sites in the upper watershed could also have a limited impact on the site, further investigations may be necessary to determine the significance of these sites on the water quality of the Matfield River and the rest of the watershed. In addition there is a large shopping mall off of Route 18 which is within the Zone II for a town well located near the Matfield River. Strong sewage/musty odors (when close to the water) were noted during every visit to the site, which can be an indication of untreated sewage, livestock waste or algae. Copious amounts of macrophytes and algae were also observed which could be a result of the elevated nutrient levels found at this site.

- MR3 (Matfield River at West Union Street bridge, East Bridgewater) was sampled on five dates and exhibited elevated levels of bacteria on two out of the three wet weather sampling days and one out of the two dry weather sampling days, with a peak of 3,900 col/100ml on 6/6/02 during wet weather conditions. This site ranks as number 8 on the "Recommended Priority for Site Management during Dry-Weather" list developed as part of this study (see Section 3.1.3 and Table 10), which means overall the water quality at this site was relatively poor during dry weather conditions. Potential sources at this site include stormwater runoff via country drainage on West Union Street (*Point 26-Figure B-1 and Photo 31 Appendix 2*) and from a number of catch basins observed in close proximity to the river upstream from site on the North Central Street bridge. The presence of well established vegetation buffers on both sides of the river up-stream and down-stream of the site may mitigate runoff impacts. Strong sewage/musty odors (when close to the water) were noted during every visit to the site, which can be an indication of untreated sewage, livestock waste or algae. Copious amounts of macrophytes and algae were observed at the site which could be a result of the elevated nutrient levels found at this site. Site MR3 is the closest (of the three sites sampled on the Matfield River) to the confluence with the Salisbury Plain River and Beaver Brook, input of impaired waters from the Salisbury Plain River and Beaver Brook may be a reason for some degree of the elevated nutrient and bacteria levels seen at the site in addition to any further sources in the sub-watershed for site MR3

Summarized Observations

The following potential source areas of NPS pollution were identified within this sub-watershed:

- Stormwater runoff via catch basins from the High Street bridge, Bridgewater, into a storm drain observed in the bank on the downstream side of the bridge.
- Stormwater runoff into catch basins and county drainage in close proximity to the river on Bridge Street, Bridgewater.
- Stormwater runoff into catch basins on Bedford Street (Route 18), East Bridgewater.
- Runoff from a stormdrain (origins unknown) draining to the river, downstream side of Bedford Street, 25m north of the river along the side of the road, East Bridgewater.
- Stormwater runoff from gardens on Keene Lane, compounded by a narrow vegetation buffer on the south side of the river, East Bridgewater.
- Stormwater runoff via country drainage on West Union Street, East Bridgewater.
- Stormwater runoff into a number of catch basins on the North Central Street Bridge in close proximity to the river, East Bridgewater.
- Wildlife waste impacts associated with waterfowl such as wild ducks, farm ducks and Canadian geese on the water upstream of Bedford Street and in gardens on Keene Lane, East Bridgewater.
- A large shopping mall off of Route 18, within the Zone II for a town well located near the Matfield River, East Bridgewater.

3.2.2 Salisbury Plain River Watershed

The Salisbury Plain River watershed falls within the municipalities of Avon, Brockton and East Bridgewater, Massachusetts (Figure 1, 2 and 4). The entire watershed is approximately 16,641 acres in area. The predominant land use in the watershed is medium density residential areas (22%) followed by forest (16%) then high density residential areas (10%). The mainstem of the Salisbury Plain River runs in a southerly direction then curves round in an easterly direction to its confluence with the Matfield River in EastBridgewater. It is fed by 2 major tributaries:

1. Salisbury Brook, running in a south-easterly direction from its origin at the outlet of Cross Pond (which drains Ellis Brett Pond which drains Thirty acre pond which drains Upper and Lower Porter Pond, which drains Waldo Lake, which drains Brockton Reservoir) in Brockton down to its confluence with the Salisbury Plain River just south of Crescent Street (Route 27) in Brockton.

2. Trout Brook, running in a southerly direction from its origin near West Main Street in the Center of Avon down to its confluence with the Salisbury Plain River and Salisbury Brook just south of Crescent Street (Route 27) in Brockton.

Minor tributaries draining to Salisbury Brook and Trout Brook were also sampled during this study and will be discussed in following sections of the report.

The Salisbury Plain River provides recreational opportunities, plays a role in flood retention, and is receiving water from stormwater and overland runoff.

Urban and suburban, commercial and residential land uses play a major role in the amount of non-point source pollution that goes to the River. NPS impacts are typically exacerbated in areas where vegetated buffers along river fronts have been removed or destroyed because of adjacent land uses.

Salisbury Plain River Sub-Watersheds

Following is a general overview of the water quality and other field and laboratory findings/results in each Salisbury Plain River sub-watershed. The overview will also include a description of any potential sources of NPS pollution in each sub-watershed. Watersheds were delineated for each river or brook sampled during the study. Each sample location was assigned a code number (Table 1). The data presented below is based on field sampling efforts, field reconnaissance, information obtained during meetings and site visits with local officials and information available from state and federal agency water quality reports.

3.2.2.1 Avon Beaver Brook

The total area of the Avon Beaver Brook sub-watershed is approximately 669 acres with an impervious area of 40%. The brook runs through a small unnamed water body off of Stockwell Drive in Avon then through a clover leaf off ramp for Route 24 exit 19 to another small pond to the north of Pond Street in D.W. Field Park ultimately draining to Brockton Reservoir. The predominant land use is forest (32%), followed by Industrial (25%). This brook was the only Class A water supply studied in the Matfield River Watershed, which means the waters are designated as a source of public water supply. Such waters are designated for protection as Outstanding Resource Waters under 314 CMR 4.04(3). The site sampled on this brook (ABB1) ranked as number 7 on the "Recommended Priority for Site Management during Dry-Weather" list developed as part of this study (see Section 3.1.3 and Table 10), which means overall the water quality at this site was relatively poor during dry weather conditions. Runoff from major and minor roads and other impervious areas such as the Avon Industrial Park, and wildlife waste impacts associated with the wetlands, forest and standing water bodies in the watershed are the major factors influencing NPS pollution in this sub-watershed.

Bacteria

- The site sampled on Avon Beaver Brook (ABB1) (named by ESS) did not meet Massachusetts Class A standards for fecal coliform bacteria (Table 4 and 5h). In addition, the peak standard of 400 col/100ml was exceeded on 2 out of 3 wet weather sampling dates and 1 out of 2 dry weather sampling dates. This indicates there is a potential weather independent source of bacteria in the Avon Beaver Brook watershed. However, the highest levels of bacteria were found during wet weather conditions (a peak of 13,000 col/100ml on 8/20/02) which suggests wet weather conditions may exacerbate the bacteria problem in some cases at this site.

Nutrients and TSS

- The site sampled in the Avon Beaver Brook sub-watershed did not meet EPA guidance criteria for total phosphorus and TKN during wet and dry weather conditions for most sampling dates (Table 4 and 6h) (TKN levels met the standard on 8/7/02 and total phosphorus levels met the standard on 6/6/02). The highest levels of TKN was exhibited on 8/20/02 and the highest levels of total phosphorus on 7/16/02, both during wet weather conditions. Elevated levels of both nitrogen and phosphorus site (ABB1) suggests the sub-watershed may be experiencing elevated nutrient loads. Elevated levels of these nutrients can promote algal blooms, excessive weed growth and reduced dissolved oxygen levels which can cause the loss of species diversity. High levels of phosphorus can result from erosion, discharge of sewers or detergents, urban runoff and rural runoff containing fertilizers, animal and plant matter. High levels of Nitrogen can result from the natural breakdown of vegetation, runoff from lawn and crop fertilizers and feedlots. In addition, inadequately treated sewage and poor septic tank systems can increase levels of nitrogen in waterways
- The site (ABB1) met Massachusetts aquatic life standard for TSS (Table 4 and 6h).

Field Parameter Findings of Special Concern

- The site sampled on Avon Beaver Brook exhibited below (Massachusetts Class A) standard levels of dissolved oxygen on all of the sampling days (Table 7); consequently the average values also failed the standard at these sites. The average dissolved oxygen levels at this site were in fact the lowest seen at any site throughout the entire study. Low levels of dissolved oxygen can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Low dissolved oxygen levels can be caused by excessive amounts of rotting vegetation, (that can come about through plant and algae blooms) and other organic wastes, as aerobic bacteria consume oxygen in the process of decomposition. This process can be compounded by high nutrient concentrations e.g. fertilizers contained in stormwater runoff, as well as by hot weather and low flows.
- Turbidity standards were exceeded on 8/20/02, a wet weather sampling day and 8/7/02, a dry weather sampling day (Table 7). The values on these days exceeded the best

professional judgment standard adopted by ESS scientists for Class A waters. The value exhibited on 8/7/02 (42.8 STU) was the highest seen at any site throughout the entire study and could have been a result of its close proximity to a pond. Ponds can often deliver high concentrations of phytoplankton, zooplankton and other organic particles to waters downstream. High levels of turbidity can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. High turbidity levels can be caused by silt washed in during high rainfall, effluent discharge and runoff. Bank erosion/degradation can also increase turbidity as can algae and natural tannins. However very high levels of turbidity for a short period of time may not be significant and may even be less of a problem than a lower level that persists longer.

- On one day (8/20/02) the site failed the Massachusetts Class A standard for pH (it was less then 6.5 SU) (Table 7). In this case the pH was not excessively low and only just failed the standard; therefore it is doubtful that there would be any serious impacts on the brook from low pH.
- The best professional judgment standard for specific conductance, adopted by ESS scientists for Class A waters was exceeded on two out of the three wet weather sampling days and one out of the two dry weather sampling days (Table 7). In addition the average value of specific conductance for the site also failed the standard. High levels of specific conductance can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Elevated levels of specific conductance can be caused by agricultural and sewage effluent and stormwater runoff, as well as the natural geology of the river bed.

Habitat Assessment Findings

At the one site assessed on Avon Beaver Brook the overall assessment score was sub-optimal (Table 3). The slightly low overall habitat score at the site was probably not directly caused by human impacts but is rather a factor of the channel itself. The parameters scoring especially poorly were: epifaunal substrate (which could be a factor of the relatively small amount of water that usually fills the channel) and the frequency of riffles (also a factor of the amount of water that flows through the channel over the year). The brook was relatively small and the water was often not flowing when the site was visited, which explains those poorly scoring parameters mentioned above. See section 2.3.5.3 for a description of all habitat parameters assessed for the MADEP habitat assessment.

Potential NPS Sources

(Information Obtained from Research, Reconnaissance, Field Data Analysis, and Interviews with Municipal Officials and Others with Knowledge of the Watershed)

Field Reconnaissance Observations

- ABB1 (Avon Beaver Brook at Pond Street bridge, D.W. Field park, Avon) was sampled on five dates and exhibited elevated levels of bacteria on two out of the three wet weather sampling days, and one out of the two dry weather sampling days with a peak level of 13,000 col/100ml on 8/20/02. Potential sources of NPS pollution at this site include extensive stormwater runoff from Avon Industrial Park which has stormwater drains that feed into drainage ditches and a wetland, that are hydrologically connected to the Brockton Reservoir. There is also the potential for stormwater runoff from Route 24 which crosses Avon Beaver Brook near the industrial park in the form of a clover leaf shaped on/off ramp. Another important potential source of NPS pollution in this sub-watershed is wildlife waste impacts associated with the forest and wetland areas upstream of site ABB1 and in the headwater area for the brook, from animals such as raccoons, skunks, rats or feral cats. In addition wildlife waste impacts could potentially be associated with the waterfowl and other wildlife inhabiting the small ponds upstream of site ABB1.

Summarized Observations

The following potential source areas of NPS pollution were identified within this sub-watershed:

- Stormwater runoff from Avon Industrial Park, Avon.
- Stormwater runoff from Route 24-exit 19 clover leaf on/off ramp, Avon.
- Wildlife waste impacts associated with waterfowl on a small unnamed pond immediately upstream of site ABB1, north of Pond Street, and a small unnamed pond upstream of site just north-west of Route 24.
- Wildlife waste impacts associated with wetland and forest areas upstream of the site, north of Pond Street and north-west of Route 24, Avon.

3.2.2.2 Trout Brook

The total area of the Trout Brook sub-watershed is approximately 3,383 acres with an impervious area of 26%. The brook runs in a southerly direction from its origin at Lake Holbrook in the Town of Holbrook, parallel with and at some times closely adjacent to the MBTA line for much of its length, down to its confluence with the Salisbury Plain River in Brockton just south of Route 27 and a short distance west of Thatcher street. The predominant land use is medium density residential areas (40%), followed by forest (16%) and then high density residential areas (13%). Three out of the four sites sampled on Trout Brook ranked low on the "Recommended Priority for Site Management" lists developed as part of this study. Sites TB1 on Crescent Street (Route 27), TB3 on Court Street and TB2 on East Ashland Street, ranked as number 3, number 1 and number 10 respectively on the "wet weather list" (Table 9) and sites TB1 and TB3 ranked as number 5 and number 4 respectively on the "dry weather list" (Table 10). Sites TB3 and TB1 are the most downstream locations sampled on Trout Brook, which indicates that overall the lower reaches of the Trout Brook sub-watershed was one of the worst areas in terms of water quality during wet and dry weather conditions. This sub-basin, running through the heart of City of Brockton, consequently shows many potential sources of NPS pollution largely associated with stormwater runoff from major and minor roads via country drainage and catch basins and the other numerous impervious areas in close proximity to the brook such as parking lots, railway tracks, shopping malls, industrial work lots and construction sites. Flooding and stormwater control problems are also a potential source due to improper street drainage in some areas. In addition there are potential sources associated with damaged sewer lines and illicit drain connections allowing wastewater to enter the brook. Some wildlife waste impacts are also possible associated with pet waste on park lands and wildlife in the park and wetland areas in the sub-watershed. All the above potential sources of NPS pollution are likely to be compounded by the narrow to nonexistent vegetation buffers along some sections of the brook and sections where the brook has been channelized.

Bacteria

- All four of the sites sampled on Trout Brook (TB1, TB2, TB3, TB4) did not meet the Massachusetts Class B standard for fecal coliform bacteria (Table 4 and 5i). In addition, the peak standard of 400 col/100ml was exceeded on nearly all of the sampling dates (wet and dry conditions) at all four sites. The only exception was at site TB2 where the bacteria concentrations did not exceed the peak standard on either of the sampled dry weather days. The average bacteria concentrations for each site once again suggest the sources of NPS pollution are more numerous and/or more serious in the lower reaches of the Trout Brook watershed i.e. at sites TB3 and TB1. The big difference in the average bacteria values between TB2 on East Ashland Street and TB3 on Court Street (a short distance downstream of it) indicates a serious potential wet and dry weather source of bacteria somewhere in the section between these two streets. Such a source could well be a damaged sewer pipe in close proximity to the brook or even some illicit connection to the drain system. A focus on the sampling of any stormdrains in this area is recommended in order to trace the source of NPS pollution in this section of the watershed. Site TB1 on Crescent Street (downstream of site TB3) exhibits a relatively similar (though slightly lower) average bacteria concentration, which indicates there are not many new sources of NPS pollution between the two sites. The high levels of bacteria seen at site TB1 could simply be a result of its close proximity to site TB3. The highest level of bacteria was found at site TB1 (a peak of 64,000 col/100ml on 8/7/02) followed by site TB3 (a peak of 48,000 col/100ml on 8/1/02). Both were dry weather sampling dates which indicates that dry weather must somehow exacerbate the pollution problem. It is clear that further sources of NPS pollution exist in the upper reaches of the watershed which contribute to the elevated levels of bacteria found at sites TB4 and TB2. All potential sources for the sub-watershed will be discussed in the relevant "Potential NPS Sources" section later in the report.

Nutrients and TSS

- All sites sampled in the Trout Brook sub-watershed did not meet EPA guidance criteria for total phosphorus during wet and dry conditions for all the sampling dates and nearly all the sampling dates for TKN (Table 4 and 6i), the exceptions being: Site TB2 during dry weather conditions on 6/20/02 and 8/7/02 and site TB1 during dry weather conditions on 6/20/02.
- The average values of total phosphorus for each site increase going downstream from TB4 to TB2 to TB3 (Table 4 and 6i) but then decrease slightly at the most downstream

site (TB1) which indicates (as with bacteria) that sources of total phosphorus are more numerous or more serious in the lower reaches of the Trout Brook watershed and the most serious sources are between sites TB2 and TB3. The highest concentrations for each site were found during wet weather conditions, which suggests the source has a maximum impact during wet weather events.

- The average values of TKN show a slightly different pattern (Table 4 and 6i). The highest average value is once again at site TB3 but the second highest average value is at the top of the watershed at site TB4. This indicates there are more numerous or more serious potential sources of nitrogen in the upper reaches and mid reaches of the Trout Brook watershed during wet and dry weather conditions for all the sampling dates. The highest concentrations for each site were found during wet weather conditions which suggests the source has a maximum impact during wet weather events.
- Elevated levels of both nitrogen and phosphorus at all the sites in the Trout Brook sub-watershed (Table 4 and 6i) suggests the sub-watershed may be experiencing elevated nutrient loads. Elevated levels of these nutrients can promote algal blooms, excessive weed growth and reduced dissolved oxygen levels which can cause the loss of species diversity. High levels of phosphorus can result from erosion, discharge of sewers or detergents, urban runoff and rural runoff containing fertilizers, animal and plant matter. High levels of Nitrogen can result from the natural breakdown of vegetation, runoff from lawn and crop fertilizers and feedlots. In addition, inadequately treated sewage and poor septic tank systems can increase levels of nitrogen in waterways
- Site TB1 was the only site to exhibit TSS concentrations exceeding the Massachusetts aquatic life use standard (Table 4 and 6i), but during just one wet weather sampling day (8/20/02).

<u>Field Parameter Findings of Special Concern</u>

- All the sites sampled on Trout Brook did not meet (Massachusetts Class B) standard levels of dissolved oxygen on the majority of sampling days, and the average values also failed the standard at three of the sites (TB2, TB3, TB4) (Table 7). In general the sampling date earliest in the year (6/20/02) exhibited the healthiest dissolved oxygen concentrations, the rest of the sampling dates that did not fail the standard exhibited very low/borderline failing levels of dissolved oxygen. Low levels of dissolved oxygen can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Low dissolved oxygen levels can be caused by excessive amounts of rotting vegetation, (that can come about through plant and algae blooms) and other organic wastes, as aerobic bacteria consume oxygen in the process of decomposition. This process can be compounded by high nutrient concentrations e.g. fertilizers contained in stormwater runoff, as well as by hot weather and low flows.
- Turbidity standards were not met at sites TB3 and TB1, (the most downstream sites sampled on Trout Brook) (Table 7). Site TB1 failed on 6/6/02 and 8/20/02 both wet weather sampling days. Site TB3 also failed on 8/20/02. The values on these days exceeded the best professional judgment standard adopted by ESS scientists for Class B waters. High levels of turbidity can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. High turbidity levels can be caused by silt washed in during high rainfall, effluent discharge and runoff. Bank

erosion/degradation can also increase turbidity as can algae and natural tannins. Very high levels of turbidity for a short period of time may not be significant and may even be less of a problem than a lower level that persists longer.

- Sites TB1 and TB2 failed the Massachusetts Class B standard for pH on 6/6/02 (both sites) and 8/20/02 (TB2 alone) (Table 7). Low pH levels in water can be caused by run-off from acid affected soils, sewage or discharge from old mines. Low pH can have the effect of mobilizing toxins in the water column, which can then enter the food chain. Outside what is considered the normal pH range sensitive species can be lost. In this case the pH was not excessively low and only just failed the standard in most cases, therefore it is doubtful that there would be any serious impacts on the brook from low pH.
- The Massachusetts standard for Class B WWF (warm waters) for temperature was exceeded at TB4 on 8/1/02 (Table 7). The temperature at all other sites sampled on Trout Brook did not exceed the State standard. High water temperatures can stress aquatic ecosystems by reducing the ability of water to hold essential dissolved gasses like oxygen, which in turn impacts the distribution and number of aquatic species found in the waterbody. Temperature is highly dependant on the depth of the water, season, time of day, and air temperatures. Industrial discharges can also affect water temperature.

<u>Habitat Assessment Findings</u>

Overall the assessment scores at the four sites assessed along Trout Brook ranged from marginal to sub-optimal (Table 3). At the Trout brook site with the worst score overall (TB3), the parameters scoring badly were mostly a factor of human development which is not surprising seeing as the site was located in one of the most developed sections of the city of Brockton. At site TB3 the channel alteration score was low i.e. much of the stream reach was disrupted, there was very little in-stream cover, also the bank vegetative protection score and riparian vegetative zone width score was very low due to clearing of stream banks to make way for human developments i.e. roads, buildings and parking lots. In addition most of the other parameters assessed at this site scored poorly or marginally. Site TB4 also scored "marginal" overall, with most of the same parameters being scored low and for the same reason i.e. development, although bank stability was more of an issue at this site. Sites TB1 and TB2 scored slightly better in general for most parameters although both sites scored "poor" for riparian zone width i.e. the width of the zone was less than 6 meters due to human activities. See section 2.3.5.3 for a description of all habitat parameters assessed for the MADEP habitat assessment.

<u>Potential NPS Sources</u>

(Information Obtained from Research, Reconnaissance, Field Data Analysis, and Interviews with Municipal Officials and Others with Knowledge of the Watershed)

Field Reconnaissance Observations

- TB1 (Trout Brook at Crescent Street bridge (Route 27), Brockton) was sampled on five dates and exhibited elevated levels of bacteria on all of the sampling days, with a peak level of 64,000 col/100ml on 8/7/02. This site ranks as number 3 on the "Recommended Priority for Site Management (during wet weather)" list (Table 9) and as number 5 on the "dry weather" list (Table 10). Potential sources of NPS pollution at this site include stormwater runoff via catch basins on Crescent Street and stormdrain pipes draining directly into the brook in close proximity to the bridge (*Point 28-Figure B-2 and Photo 35 Appendix 2*). During interviews with Town officials a potential sources of wastewater were identified upstream of site TB1 in drain pipes at the bridge crossing on Center Street, and also two sewer reaches on Court Street that were abandoned and not plugged. In addition, inspections were performed at the intersection of Center Street and Manchester Street where damage to the sewer line was identified. Another potential source at this site is the large poorly buffered parkland area known as "Snow Park" (*Point 27-Figure B-2 and Photo 34 Appendix 2*) just upstream of the Crescent Street bridge. This area running adjacent to the brook, with a narrow to nonexistent vegetation buffer, is prime habitat for Canadian Geese. Although none were observed on the days the site was visited, wildlife waste impacts associated with this piece of land are likely. The presence of a heavily channelized section of brook downstream of the bridge is likely to compound the effects of any stormwater runoff in the area on the site. Several DEP tier-classified 21E sites in the watershed could also have a limited impact on the site, further investigations may be necessary to determine the significance of these sites on the water quality of Trout Brook and the rest of the watershed. The peak bacteria concentration at this site was exhibited during dry weather conditions which suggests stormwater runoff impacts, such as those mentioned above, may have limited impact at this site. However in this case it is possible the high levels of bacteria seen at site TB1 could simply be a result of its close proximity to site TB3.
- TB2 (Trout Brook at East Ashland Street bridge, Brockton) was sampled on five dates and exhibited elevated levels of bacteria on three out of the three wet weather sampling days but neither of the two dry weather sampling days, with a peak level of 16,000 col/100ml on 8/20/02. Potential sources of NPS pollution at this site include stormwater runoff from catch basins on East Ashland Street bridge draining directly to the brook via observed stormdrains downstream of the bridge. In addition, country drainage observed on the roads in the high density residential areas upstream of the site are a potential source. Another potential problem area for stormwater runoff is from the large impervious area (mall (*Point 30-Figure X*) and parking lot (*Point 31-Figure B-2 and Photo 37 Appendix 2*)) just upstream of the site, adjacent to the large wetland area bordering the brook. A number of catch basins were observed in the parking lot. Improperly managed pet waste and wildlife waste impacts associated with the park/playground area off of Melrose Street (*Point 32-Figure B-2*) upstream of the site is another potential source of NPS pollution at the site, although none was observed during any visits to the this area. It should be noted that the extensive wetland area (*Point 29-Figure B-2*) adjacent to the section upstream of the site would be likely to mitigate any excessive runoff impacts in the sub-watershed by acting as a filter to any pollutants moving downstream, which is probably why the site is one of the cleanest of those sampled on Trout Brook. Several DEP tier-classified 21E sites in close proximity to the site could also have a limited impact, further investigations may be necessary to determine the

significance of these sites on the water quality of Trout Brook and the rest of the watershed. Copious amounts of macrophytes (including duckweed) were observed at the site which could be a result of the elevated nutrient levels found at this site.

- TB3 (Trout Brook at Court Street bridge, Brockton) was sampled on three dates and exhibited elevated levels of bacteria on all of them, with a peak of 48,000 col/100ml on 8/1/02 during dry weather conditions. This site ranks as number 1 on the "Recommended Priority for Site Management (during wet weather)" list (Table 9) and number 4 on the "dry weather" list (Table 10), both developed as part of this study, which means overall the water quality at this site was extremely poor during wet weather conditions and relatively poor during dry weather conditions. Potential sources at this site include stormwater runoff via catch basins on Court Street and on the parking lot for the large brick building at #204 Court Street (*Point 33-Figure B-2*). In addition, stormdrains appearing to drain the large impervious area behind #204 directly into the brook were observed just upstream of the site on the west bank. Another potential source is stormwater runoff from the large impervious area associated with "Brockton Iron and Steel" just upstream of the site (*Point 35-Figure B-2*), as well as country drainage observed in the high density residential areas upstream. Town officials identified specific flooding and stormwater control problems in this sub-watershed, specifically speaking near Carter Street, south of Cary Brook.
- Improperly managed pet waste associated with a dog pen built immediately adjacent to the brook in a private yard area (*Point 34-Figure B-2*), could also have an impact at the site. The runoff from Court Street, the gardens adjacent to the brook on its east side and the area adjacent to and behind #204 Court Street are likely to be compounded by the narrow to nonexistent vegetation buffer on this section of the brook. Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem. The water was always observed to be especially murky water during site visits. Several DEP tier-classified 21E sites in close proximity to the site could also have a limited impact, further investigations may be necessary to determine the significance of these sites on the water quality of Trout Brook and the rest of the watershed. The peak bacteria concentration at this site was exhibited during dry weather conditions which suggests stormwater runoff impacts such as those mentioned above may have limited impact at this site. A focus on the sampling of any stormdrains and a survey of sewer lines in this area is recommended in order to trace the source of NPS pollution in this section of the watershed.
- TB4 (Trout Brook, West of Studley Avenue, Brockton) was sampled on three dates and exhibited elevated levels of bacteria on all of them, with a peak of 9,600 col/100ml on 9/16/02 during wet weather conditions. Potential sources at this site include stormwater runoff directly from the MBTA railroad which lies east immediately adjacent to the site (*Point 36-Figure B-2*), compounded by nonexistent vegetation buffer on the east bank. Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to

ultimately cause harm to the ecosystem. During the study the west bank was cleared for some construction work, leaving little vegetation buffer behind to protect the brook (*Photo 40 Appendix 2*). Other stormwater impacts are likely from Connelly Road and Argyle Avenue (upstream of the site off of Route 28 in Avon) via a catch basin observed at the crossroads of these streets in close proximity to the brook (*Point 38-Figure B-2*). Town officials also identified older homes with cesspools on these streets, which are also in close proximity to the public water supply wells for Avon. The large Walmart and its surrounding impervious areas (*Point 39-Figure B-2*) upstream of the site (just off of Route 28) comes in close proximity to some sections of Trout Brook, stormwater runoff impacts are a potential source in this area.

- There are a number of additional sources of potential NPS pollution identified by Town officials in this sub-watershed. One is a gas station with failing tanks along West Trout Brook at the corner of Ladge Drive, Avon and East Main Street, Avon. Also on Ladge Drive at #100 there is an unused former jewelry plating factory near Trout Brook which has contaminated the groundwater with chlorinated volatile organic compounds (VOCs). This contamination is also within the Massachusetts Department of Environmental Protection (MADEP) approved Zone II for the Avon public water supply wells.
- A potential source of wastewater was identified by officials on Wilder Street, Brockton where there is an illicit connection to the drain system on that street. The study completed by CDM did not state if the drain pipe was connected to Trout Brook, which is located to the east.
- A large wetland area upstream of Connelly road in Avon (*Point 37-Figure B-2 and Photo 39 Appendix 2*) may mitigate runoff impacts from the Walmart and any other areas upstream of the wetland. Wildlife waste impacts associated with the wetland is another potential source of NPS pollution at the site.
- Several DEP tier-classified 21E sites in the upper watershed could also have a limited impact on the site, further investigation may be necessary to determine the significance of these sites on the water quality of Trout Brook and the rest of the watershed.
- Copious amounts of macrophytes were observed at the site which could be a result of the elevated nutrient levels found at this site.

Summarized Observations

The following potential source areas of NPS pollution were identified within this sub-watershed:

- Stormwater runoff via catch basins on the Crescent Street Bridge, Brockton, into a stormdrain observed in the bank on the downstream side of the bridge.
- Potential source of wastewater from stormdrain pipes at Center Street Bridge, Brockton.
- Stormwater runoff via catch basins on East Ashland Street, into stormdrains observed in the bank on the downstream side of the bridge, Brockton.
- Stormwater runoff via catch basins on Court Street, Brockton
- Stormwater runoff via catch basins from impervious area surrounding building #204 Court Street, Brockton.

- Stormwater runoff from impervious areas associated with Brockton Iron and Steel Company, North of Court Street, Brockton.
- Stormwater runoff from MBTA railroad adjacent to Trout Brook, east of Studley Avenue, Brockton.
- Stormwater runoff via country drainage in high density residential areas upstream of site TB2, Brockton.
- Stormwater runoff from impervious areas associated with a mall just to the east of the brook off of East Ashland Street, Brockton.
- Stormwater runoff from impervious areas associated with large Walmart off of Route 28, Brockton.
- Stormwater runoff from Connelly Road and Argyle Avenue, Avon, via a catch basin on the corner of these two streets.
- Older homes with cesspools on Connelly Road and Argyle Avenue, Avon.
- Gas station with failing tanks at the corner of Ladge Drive and East Main Street, Avon.
- Contaminated groundwater at #100 Ladge Drive, Avon.
- Flooding and stormwater control problems near Carter street, south of Cary Brook, Brockton.
- Illicit connection to the drain system on Wilder Street, Brockton.
- Two abandoned unplugged sewer reaches on Court Street, Brockton.
- Damaged sewer line at intersection of Center Street and Manchester Street, Brockton.
- Wildlife waste impacts associated with Snow Park, Brockton, compounded by nonexistent vegetation buffers along the section of the brook running through the park.
- Wildlife waste impacts associated with a park/playground area off of Melrose Street, Brockton.

3.2.2.3 Lovett Brook

The total area of the Lovett Brook sub-watershed is approximately 1006 acres, with an impervious area of 34%. The brook generally runs in a south-easterly direction from its origins in wetland areas off of South Street in Stoughton to its confluence with Ellis Brett Pond (and thus to Salisbury Brook) in Brockton. The predominant land use is forest (27%), followed by medium density residential areas (22%). The brook was sampled at one location (LB1), on D.W. Field Park Drive just west of Ellis Brett Pond. The main potential source of NPS pollution at this site is stormwater runoff from impervious areas associated with an extensive industrial/commercial complex just upstream of the site and also from the clover leaf on/off ramp for exit 18-Route 24.

Bacteria

- The site sampled on Lovett Brook (LB1) did not meet Massachusetts Class B standards for fecal coliform bacteria (Table 4 and 5j). In addition, on both the days sampled during wet weather conditions the peak standard of 400 col/100ml was exceeded. The site did not meet the bacteria standard during dry weather, indicating a potential wet weather source of bacteria in the Lovett Brook watershed. The highest wet weather levels of bacteria were found on 8/20/02 (12,000 col/100ml). The site may therefore be influenced by a local source that has a maximum impact during wet weather events.

Nutrients and TSS

- The site sampled on Lovett Brook did not meet the EPA guidance criteria for total phosphorus and TKN during wet and dry weather conditions for all the sampling dates (Table 4 and 6j) (except for total phosphorus on dry weather day 8/1/02). The highest level found for both parameters was during wet weather conditions on 8/20/02. Elevated levels of both nitrogen and phosphorus at this site suggests the Lovett Brook watershed may be experiencing elevated nutrient loads. Elevated levels of these nutrients can promote algal blooms, excessive weed growth and reduced dissolved oxygen levels which can cause the loss of species diversity in these waters. High levels of phosphorus can result from erosion, discharge of sewers or detergents, urban runoff and rural runoff containing fertilizers, animal and plant matter. High levels of Nitrogen can result from the natural breakdown of vegetation, runoff from lawn and crop fertilizers and feedlots. In addition, inadequately treated sewage and poor septic tank systems can increase levels of nitrogen in waterways
- All of the sampling dates met the Massachusetts aquatic life use standard for TSS (Table 4 and 6j).

Field Parameter Findings of Special Concern

- Turbidity standards were exceeded on just one day (8/20/02) during wet weather conditions (Table 7). The value on this days exceeded the best professional judgment standard adopted by ESS scientists for Class B waters. High levels of turbidity can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. High turbidity levels can be caused by silt washed in during high rainfall, effluent discharge and runoff. Bank erosion/degradation can also increase turbidity as can algae and natural tannins. Very high levels of turbidity for a short period of time may not be significant and may even be less of a problem than a lower level that persists longer.
- The best professional judgment standard for specific conductance, adopted by ESS scientists for Class B waters was exceeded on 8/1/02, the only dry weather sampling day for the site (Table 7). This value (706 ųmhos/cm) was one of the highest seen at any site throughout the entire study. However the average value of specific conductance for the site did not fail the standard. High levels of specific conductance can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Elevated levels of specific conductance can be caused by agricultural and sewage effluent and stormwater runoff, as well as the natural geology of the river bed.

Habitat Assessment Findings

At the one site assessed on Lovett Brook the overall assessment score was sub-optimal (Table 3). No one parameter in particular scored poorly at this site, rather all aspects of the habitat were just a little below optimal. However, the width of the riparian vegetative zone was slightly narrow at the sample site itself scoring marginally, although it should be noted that the width of this zone did increase up and downstream of the site. See section 2.3.5.3 for a description of all habitat parameters assessed for the MADEP habitat assessment.

Potential NPS Sources

(Information Obtained from Research, Reconnaissance, Field Data Analysis, and Interviews with Municipal Officials and Others with Knowledge of the Watershed)

Field Reconnaissance Observations

- LB1 (Lovett Brook at DW Field Park Drive, Brockton) was sampled on three dates and exhibited elevated levels of bacteria on two out of the three, with a peak level of 12,000col/100ml on 8/20/02. The main potential source at this site is stormwater runoff from impervious areas associated with an extensive industrial/commercial complex known as "Westgate Mall and Plaza" just upstream of the site. Interviews with town officials confirmed ESS field reconnaissance observations by having previously identified this area as having specific flooding/stormwater control problems. The building in closest proximity to the site within this complex is a "Lowes superstore" (*Point 43-Figure B-2 and Photo 43 Appendix 2*). The Lowes superstore lays just up-gradient of the brook, a small detention basin (MADEP File # SE118-468) (*Point 42-Figure B-2 and Photo 42 Appendix 2*) was observed adjacent to the brook at the bottom of a small hill leading up to the Lowes. This detention basin likely manages runoff from the impervious areas surrounding Lowes, it was in relatively good condition except there was some damage to silt fences observed and also some plastic trash in and around the basin. The impact of the detention basin on the site is expected to be limited based on the good condition of the basin and its distance from the site.
- Town officials identified a potential source of wastewater in the Christy's Drive area. Surface water contamination was identified on Lovett Brook, investigations indicated that the source of contamination is located between the outlet pipe and the end of Keene Street, Brockton.
- Other potential sources of stormwater runoff upstream of the site are the clover leaf on/off ramp for exit 18-Route 24, other residential/industrial areas upstream of Route 24 and also impervious surfaces associated with the Good Samaritan Medical Center which lies in close proximity to the brook just upstream of Route 24.
- DEP tier-classified 21E sites higher in the watershed could also have a limited impact on the site, further investigations may be necessary to determine the significance of these sites on the water quality of Lovett Brook and the rest of the watershed.

Summarized Observations

The following potential source areas of NPS pollution were identified within this sub-watershed:

- Stormwater runoff from impervious areas associated with Westgate Mall and Plaza, Brockton.
- Stormwater runoff from the clover leaf on/off ramp for exit 18-Route 24, Brockton.
- Stormwater runoff from residential areas on Oak Street, Brockton.
- Stormwater runoff from Park Plaza Shopping center, Stoughton.
- Stormwater runoff from impervious areas associated with the Good Samaritan Medical Center, Brockton.
- Potential source of wastewater in the Christy's Drive area. Source of contamination is located between the outlet pipe and the end of Keene Street, Brockton.

3.2.2.4 Salisbury Brook

The total area of the Salisbury Brook sub-watershed is approximately 2,433 acres with an impervious area of 29%. The brook runs in a south-easterly direction from its origin at the outlet of Cross Pond in the City of Brockton, through and under the heart of the City down to its confluence with the Salisbury Plain River in Brockton just south of Route 27 and a short distance west of Thatcher Street. The predominant land use is medium density residential areas (25%), followed by forest (23%) and then high density residential areas (14%). Four out of the five sites sampled on Salisbury Brook ranked very low on the "Recommended Priority for Site Management" lists developed as part of this study. Site SB5 on Belmont Avenue, Brockton ranked as number 6 on the "wet weather list" (Table 9) and sites SB2 on Belmont Street and SB3 on Elmwood Avenue rank as 10 and 5 respectively. In addition, sites SB1 on Otis Street, Brockton and SB2 on Belmont Street, Brockton ranked as numbers 6 and 1 respectively on the "dry weather list" (Table 10). Sites SB1 and SB2 are the most downstream locations sampled on Salisbury Brook, which indicates that overall the lower reaches of the Salisbury Brook sub-watershed was one of the worst areas in terms of water quality during dry weather conditions. Sites SB3 and SB5 are the most upstream sampling locations, which indicates overall the water quality of the upper reaches of the Salisbury Brook sub-watershed was relatively poor during wet weather conditions. This sub-basin, running through the heart of City of Brockton, consequently shows many potential sources of NPS pollution largely associated with stormwater runoff from major and minor roads via country drainage and catch basins and the other numerous impervious areas in close proximity to the brook such as gardens, parking lots, railway tracks, shopping malls, industrial work lots and construction sites. Flooding and stormwater control problems are also a potential source due to improper street drainage in some areas. In addition there is the potential for wastewater to enter the brook due to structural defects. Some wildlife waste impacts are also possible associated with the numerous ponds and reservoirs upstream of the brook. All the above potential sources of NPS pollution are likely to be compounded by the narrow to nonexistent vegetation buffers along some sections of the brook and sections where the brook has been channelized.

Bacteria

- All five of the sites sampled on Salisbury Brook (SB1, SB2, SB3, SB4, SB5) did not meet Massachusetts Class B standards for fecal coliform bacteria (Table 4 and 5k). In addition, the peak standard of 400 col/100ml was exceeded on nearly all of the sampling dates (wet and dry conditions) at all five sites. The only exceptions were at sites SB3 and SB4 where the bacteria concentrations did not exceed the peak standard during dry weather conditions.
- The average bacteria concentrations for each site suggest the sources of NPS pollution are more numerous and/or more serious in the area of the watershed between sites SB3 and SB5, then also between sites SB4 and SB2. The big difference in the average bacteria values between SB4 on Ellsworth Street and SB2 on Belmont Street (Route 123) (a short distance downstream of it) indicates a serious potential wet and dry weather source of bacteria somewhere in the section between these two streets although it is more likely to be a dry weather source as indicated by the site ranking of 1 on the "dry weather list" (Table 10). The brook runs underground for the entire distance between these two sites. Such a source could well be a damaged sewer pipe in close proximity to the brook or even some illicit connection to the drain system. A focus on this stretch of underground brook and any drains/pipes that feed it is recommended in order to trace the source of NPS pollution in this section of the watershed.
- A similar though less serious condition exists between sites SB3 on Elmwood Street and SB5 on Belmont Avenue. The relatively big difference in the average bacteria values at these sites indicates a serious potential wet and dry weather source of bacteria somewhere in the section between these two streets, although it is more likely to be a wet weather source as indicated by the site ranking of 6 on the "dry weather list" (Table 10). Such a source could be damaged sewer pipes or illicit connections but also could be flooding and stormwater control problems that exist just upstream of SB5 (discussed in more detail in the "Potential NPS Sources" section to follow).
- Sites immediately downstream of SB5 and SB2 i.e. sites SB4 and SB1 respectively, exhibit lower average bacteria concentrations, which indicates there are not many new sources of NPS pollution between sites SB5 and SB4 as well as between sites SB2 and SB1 in the sub-watershed.
- The highest level of bacteria were found at site SB2 (a peak of 44,000 col/100ml on 7/24/02) followed by both sites SB1 and SB5 (a peak of 20,000 col/100ml on 6/6/02 and 8/20/02 respectively). All were wet weather sampling dates which indicates that overall wet weather must somehow exacerbate the pollution problem in this sub-watershed. It is clear that further sources of NPS pollution exist in other areas of the sub-watershed which contribute to the elevated levels of bacteria found at sites SB3 and SB4. All potential sources for the sub-watershed will be discussed in the relevant "Potential NPS Sources" section later in the report.

Nutrients and TSS

- Three out of the five sites sampled in the Salisbury Brook sub-watershed (SB1, SB2 SB5) did not meet EPA guidance criteria for total phosphorus and TKN for all the sampling dates (Table 4 and 5k). The other two sites (SB3 and SB4) did not meet EPA guidance criteria on some of the sampling dates. Site SB3 met guidance criteria for total phosphorus on all dry weather sampling dates and TKN on one dry weather sampling date (8/7/02). Site SB4 met guidance criteria for TKN on one dry weather sampling day (8/1/02).
- The average values of total phosphorus and TKN are slightly higher at sites SB5 and SB2 than at sites SB4 and SB3, indicating (as with bacteria) that sources of total phosphorus and TKN are a little more numerous and/or or more serious in the sections of the watershed between sites SB3 and SB5 as well as between sites SB4 and SB2. Once again, the highest concentrations of these nutrients for each site were found during wet weather conditions; which suggests that any potential source has a maximum impact during wet weather events.
- Elevated levels of both nitrogen and phosphorus at all the sites in the Salisbury Brook sub-watershed suggests the sub-watershed may be experiencing elevated nutrient loads. Elevated levels of these nutrients can promote algal blooms, excessive weed growth and reduced dissolved oxygen levels which can cause the loss of species diversity. High levels of phosphorus can result from erosion, discharge of sewers or detergents, urban runoff and rural runoff containing fertilizers, animal and plant matter. High levels of Nitrogen can result from the natural breakdown of vegetation, runoff from lawn and crop fertilizers and feedlots. In addition, inadequately treated sewage and poor septic tank systems can increase levels of nitrogen in waterways
- Site SB3 was the only site not to meet the Massachusetts aquatic life use standard for TSS, (Table 4 and 6k) but during just one wet weather sampling day (7/16/02).

Field Parameter Findings of Special Concern

- Four out of the five sites (SB2, SB3, SB4, SB5) sampled on Salisbury Brook exhibited below (Massachusetts Class B) standard levels of dissolved oxygen on a minority of sampling days, however the average values did not fail the standard at three out of these four (Table 7). The levels were below standard at sites SB3, SB4 and SB5 during the august dry weather sampling days. Site SB2 failed the standard on both 7/24/02 and 8/7/02 and the average concentration in mg/L failed the standard for this site also. In general the sampling dates earliest and latest in the year (6/20/02 and 11/6/02) exhibited the healthiest dissolved oxygen concentrations. Low levels of dissolved oxygen can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Low dissolved oxygen levels can be caused by excessive amounts of rotting vegetation, (that can come about through plant and algae blooms) and other organic wastes, as aerobic bacteria consume oxygen in the process of decomposition. This process can be compounded by high nutrient concentrations e.g. fertilizers contained in stormwater runoff, as well as by hot weather and low flows.

- Turbidity standards were only exceeded at site SB2 during wet weather conditions on 8/20/02 (Table 7). The value on this day exceeded the best professional judgment standard adopted by ESS scientists for Class B waters. High levels of turbidity can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. High turbidity levels can be caused by silt washed in during high rainfall, effluent discharge and runoff. Bank erosion/degradation can also increase turbidity as can algae and natural tannins. Very high levels of turbidity for a short period of time may not be significant and may even be less of a problem than a lower level that persists longer.
- The Massachusetts Class B standard for pH was also only failed by one site on day, SB2 during wet weather conditions on 7/24/02 (Table 7). Low pH can have the effect of mobilizing toxins in the water column, which can then enter the food chain. Outside what is considered the normal pH range sensitive species can be lost. In this case the pH was not excessively low and only just failed the standard, therefore it is very doubtful that there would be any serious impacts on the brook from this one example of slightly low pH.
- The best professional judgment standard for specific conductance, adopted by ESS scientists for Class B waters was exceeded on three out of the five sites during the June dry weather sampling dates (Table 7). In addition the average value of specific conductance did not fail the standard at any of the sites sampled on Salisbury Brook. High levels of specific conductance can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. In this case the specific conductance was not excessively high at any site and only just failed the standard in each case, therefore it is very doubtful that there would be any serious impacts on the brook from high specific conductance. Elevated levels of specific conductance can be caused by agricultural and sewage effluent and stormwater runoff, as well as the natural geology of the river bed.

Habitat Assessment Findings

Overall the assessment scores at the five sites assessed along Salisbury Brook ranged from marginal to sub-optimal (Table 3). The Salisbury Brook site with the worst score overall (SB1) also had the lowest score of any site assessed throughout the study, nearly every parameter scored badly i.e. was judged to be in the "poor" category. The low scores at this site were mostly a factor of human development which is not surprising seeing as the site was located in one of the most developed sections of the city of Brockton. At site SB1 the channel alteration score was low i.e. much of the stream reach was disrupted and the stream corridor was severely channelized both up and downstream of the sample site, there was very little in-stream cover or epifaunal substrate, the degree of embeddedness was extreme as was the sediment deposition, also the bank vegetative protection score and riparian vegetative zone width score was very low due to clearing of stream banks to make way for human developments i.e. roads and houses. Sites SB4 and SB5 also scored "marginal" overall, with most of the same parameters being scored low and for the same reason i.e. human development, in particular the width of the riparian zone was very narrow and was scored as "poor" at both sites and there was heavy channelization (channel alteration) at site SB4. Sites SB2 and SB3 scored slightly better in general for most parameters although both sites scored low for riparian zone width and site SB3 scored low for channel alteration due to channelization of the brook corridor upstream of the site. See section 2.3.5.3 for a description of all habitat parameters assessed for the MADEP habitat assessment.

Potential NPS Sources

(Information Obtained from Research, Reconnaissance, Field Data Analysis, and Interviews with Municipal Officials and Others with Knowledge of the Watershed)

Field Reconnaissance Observations

General Note: Although potential sources of NPS pollution are discussed on a site by site basis thus introducing any sources within the sub-watershed for that site, it should not be forgotten that due to the close proximity of some of the sites, a major source of pollutants at some sites could be from sites and sub-watersheds upstream and not necessarily from sources of NPS pollution within their own sub-watershed. This is often likely the case when sites in close proximity and downstream of highly impaired sites show lower levels of impairment.

- SB1 (Salisbury Brook at Otis Street bridge, Brockton) was sampled on five dates and exhibited elevated levels of bacteria on all of the sampling days, with a peak level of 20,000 col/100ml on 6/6/02. This site ranks as number 6 on the "Recommended Priority for Site Management (during dry weather)" list (Table 10). Potential sources of NPS pollution at this site include stormwater runoff via catch basins on Otis Street and directly from the commuter rail line where it crosses the brook upstream of Perkins Street. Stormwater runoff is also likely from other surrounding streets such as Perkins Street, Reed Avenue and Montello Street (Route 28). There is also the potential for stormwater runoff from impervious areas associated with an Auto-body shop "DandG Autobody" car holding lot (*Point 45-Figure B-2 and Photo 46 Appendix 2*) adjacent to the brook just upstream of the site. Oily/colored sheens were observed on the water surface many times during site visits which may indicate the presence of oil in the water possibly caused by oil rich runoff from the autobody lot.
- During a reconnaissance visit to the site on 1/15/03 a new construction site had been established immediately upstream of the site (MADEP #118473) with access from Perkins Street, visible from the Otis Street bridge, large piles of sediment were in place on the site adjacent to the brook. The potential exists for wet weather events to cause sediment to runoff into the brook so a close watch should be kept on the site. However, sediment deposition was previously observed at the site during all visits before this construction started, in the form of sand banks within the water channel.
- During interviews with Town officials a potential source of wastewater was identified on Otis Street in the form of an outfall pipe draining to Salisbury Brook, however no source identification was possible; television inspection was recommended.
- Another potential source at this site is poorly managed pet waste from a dog pen built immediately adjacent to the edge of the brook (*Point 44-Figure B-2 and Photo 45*

Appendix 2). Two dogs were observed in the pen during a field reconnaissance visit on 1/15/03.

- All the above mentioned stormwater runoff impacts are likely to be compounded by the nonexistent vegetation buffer and the presence of heavy channelization of the brook upstream and downstream of the bridge. Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem.
- Many DEP tier-classified 21E sites in the watershed could also have an impact on the site, further investigations may be necessary to determine the significance of these sites on the water quality of Salisbury Brook and the rest of the watershed. Trash observed dumped in the water could also have an effect on water quality.
- SB2 (Salisbury Brook at Belmont Street bridge (Route 123), Brockton) was sampled on five dates and exhibited elevated levels of bacteria on all of the sampling days with a peak level of 44,000 col/100ml on 7/24/02. This site ranks as number 1 on the "Recommended Priority for Site Management (during dry weather)" list (Table 10) and number 10 on the "Recommended Priority for Site Management (during wet weather)" list (Table 9). The main potential source of NPS pollution at this site is stormwater runoff from the large impervious areas surrounding the site in the form of major roads and parking lots. Belmont Street (Route 123) runs over the brook just upstream of the site. A large paved parking and drive through area for Rockland Trust Bank is also situated just upstream from the site adjacent to the brook, it can be accessed from Belmont Street (Route 123). A silt fence was observed to have been erected along the edge of the lot for the bank adjacent to the brook, sediment was compiled against it. Another public parking lot flanks the sampling site from the opposite bank a little downstream from Rockland Trust Bank, which can be accessed from North Warren Avenue. A third parking lot adjacent to the sampling site is found next door to the bank, off of Chester Street, behind Law Office of Robert Clark. This lot is used by the law office and also by the tenants of an apartment building next door. A narrow to non-existent vegetation buffer along this stretch of the brook is likely to compound any stormwater runoff impacts from the above mentioned impervious areas. Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem.
- Another potential source of NPS pollution at the site is runoff observed draining from a number of small pipes sticking out of the back of the vacant "Columbia Electric" building (*Point 47-Figure B-2 and Photo 48 Appendix 2*). The back of this building lies adjacent to the brook just before it runs under the Route 123 Bridge. The front of the building can be accessed from North Warren Avenue, being adjacent to the parking lot previously mentioned on that street. The whole ground area in front of the pipe was a bright orange color, much of the water and the ground was frozen due to the season so actual flow was not observed although it was clear where the water had originated from. Such an orange coating results from bacterial (*Thiobacillus ferrooxidans*) action on iron

resulting in iron precipitating out of the water and appearing as an orange sludge. This can indicate runoff from industrial areas or landfills. Two storm drains were also observed at this location in the bank (channelized with rocks) above the brook, frozen water structures caked the wall from these pipes but the origins of the pipes are unknown.

- Numerous examples of trash and open dumpsters (*Point 46-Figure B-2 and Photo 49 Appendix 2*) were observed during site visits and during field reconnaissance in the parking lot for the law office and the apartment building. Rats have been noted to live around the brook and the apartment building previously (information from conversation with a tenant). Wildlife waste impacts are possible from the rats and other wildlife encouraged to congregate in the area by the open dumpsters, other trash in the lot and trash dumped on the hill side leading down to the brook. Trash such as old shopping trolleys, musical instruments and other metallic objects were observed in the water of the brook.
- Wildlife waste impacts associated with the park/playground area known as Keith Memorial Field, off of Belmont Street upstream of the site, is another potential source of NPS pollution. A lack of vegetation buffer along the park-side bank of the brook could encourage the congregation of water fowl as well as compound runoff impacts from the grass area which is probably fertilized, possibly introducing nutrients to the brook.
- A potential waste water source was identified by town officials just upstream of the site in a culvert that conveys the brook for approximately 300 feet. A sewer manhole adjacent to the culvert at the intersection of Ellsworth and North Arlington Street (just downstream of site SB4) was identified as the possible problem due to defects.
- Several DEP tier-classified 21E sites in close proximity to the site could also have a limited impact, further investigations may be necessary to determine the significance of these sites on the water quality of Salisbury Brook and the rest of the watershed.
- SB3 (Salisbury Brook at Elmwood Avenue bridge, Brockton) was sampled on five dates and exhibited elevated levels of bacteria on all of the wet weather sampling days (but none of the dry weather days) with a peak of 10,000 col/100ml on 8/20/02 during wet weather conditions. This site was generally the cleanest i.e. with the best water quality, of those sampled on the Salisbury Brook during this study. The main potential sources at this site were wildlife impacts associated with Cross Pond immediately upstream of the site. The nonexistent vegetation boundary on the north side of the pond (*Point 50-Figure B-2*) could facilitate the use of the pond by water fowl such as Canadian Geese, although none were observed on the water during any site visits. In addition, poorly managed pet waste is a potential source of NPS pollution at the site. Numerous examples were observed on the grassy banks adjacent to Cross Pond along Elmwood Avenue. At the south-western end of the pond an open dumpster was observed in the car park area (*Point 49-Figure B-2 and Photo 51 Appendix 2*) for Honeydew donuts, off of Pleasant Street. This could potentially exacerbate wildlife impacts by attracting further foraging wildlife to the banks of the pond. In addition, geese and ducks on the east side of Upper Porter Pond and the west side of Waldo Lake (South), have been identified as a problem by Town officials and could impact site SB3. The distance of SB3 from these ponds may well mitigate excessive impacts however.

- Another potential source of NPS pollution at the site is roof runoff from a number of buildings lying immediately adjacent to brook (*Point 48-Figure B-2 and Photo 50-Appendix 2*). The buildings are so close that anything running off the roof would directly enter the water. Substances such as accumulated atmospheric pollutants and bird waste could wash off into the water during a wet weather event, having a subsequent impact on the brook. The non-existent vegetation buffer and the presence of heavy channelization on upstream sections of the brook from the site are likely to compound any runoff impacts. Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem.
- The copious amounts of aquatic macrophytes observed at the site may be a result of the observed high nutrient levels.
- One DEP tier-classified 21E sites in close proximity to the site could also have a limited impact, further investigations may be necessary to determine the significance of these sites on the water quality of Salisbury Brook and the rest of the watershed
- SB4 (Salisbury Brook, end of Montgomery Avenue, Brockton) was sampled on three dates and exhibited elevated levels of bacteria on all of the wet weather sampling days (but not the dry weather one) with a peak of 13,000 col/100ml on 8/20/02 during wet weather conditions. The main potential source of NPS pollution at this site is stormwater runoff directly from Montgomery Avenue into the brook via a form of country drainage structured like a chute at the end of the street to where the brook runs. Water and sediment has been observed washing into the stream from this chute during visits to the site. There is the potential for more stormwater runoff impacts from the high density residential streets surrounding the brook and also specifically via country drainage on Ellsworth Street (*Point 51-Figure B-2 and Photo 5-Appendix 2*). All stormwater runoff impacts will be compounded by the extreme cases of bank alteration in this area. The brook is heavily channelized along much of its length in this section as well as suffering from a complete lack of a vegetation buffer along much of the bank. Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem.
- There is also the potential for wildlife impacts from some waterfowl observed on the brook at the site.
- A small number of DEP tier-classified 21E sites in close proximity to the site could also have a limited impact, further investigations may be necessary to determine the significance of these sites on the water quality of Salisbury Brook and the rest of the watershed
- SB5 (Salisbury Brook, Belmont Avenue Bridge, Brockton) was sampled on three dates and exhibited elevated levels of bacteria on all of them with a peak of 20,000 col/100ml on 8/20/02 during wet weather conditions. The main potential source of NPS pollution at this site is stormwater runoff from the high density residential areas and roads

surrounding the brook in this area. Catch basins (likely draining to the brook) were observed on, Park Road; country drainage structures were also observed directly draining to the brook on the Belmont Avenue Bridge and North Ash Street Bridge (*Point 53-Figure B-2 and Photo 55 Appendix 2*). In addition, stormdrains were observed draining Pleasant Street (Route 27) (*Point 54-Figure B-2*) and Malvern Road into the brook, where the brook runs under or close to these streets. Another potential source of stormwater runoff impacts is private gardens and lawns adjacent to the edge of the brook upstream of the site (*Point 52-Figure B-2 and Photo 54 Appendix 2*), the narrow to non-existent vegetation buffers along the brook at the edge of these gardens is likely to compound any runoff from the gardens, which can contain fertilizers and other chemicals. Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem.

- The extreme channelization of the brook upstream of the site, especially at the North Ash Street Bridge, is also likely to compound any stormwater runoff impacts.
- Town officials also identified a specific flooding/stormwater control problem in the sub-watershed for site SB5. The area of concern is between Silver road, Sycamore Avenue and Belmont Avenue in Brockton. This problem area may also fall partly into the sub-watershed for site SB4 and thus may directly affect this site also.

Summarized Observations

The following potential source areas of NPS pollution were identified within this sub-watershed:

- Stormwater runoff via catch basins on the Otis Street bridge, Brockton.
- Stormwater runoff from car holding lot for "DandG Auto-body shop" on Perkins Street, Brockton. Stormwater runoff via catch basins on Court Street, Brockton.
- Stormwater runoff from parking/drive through lot for Rockland Trust Bank, Belmont Street, Brockton.
- Stormwater runoff from public parking lot (back adjacent to brook) 1st lot on right side of North Warren Avenue, Brockton.
- Stormwater runoff from parking lot for Law office of Robert Clark and apartment building next door, 1st left off of Chester Street, Brockton.
- Stormwater runoff via country drainage at end of Montgomery Avenue, Brockton.
- Stormwater runoff via country drainage on Ellsworth Street, Brockton.
- Stormwater runoff via country drainage on Belmont Avenue and North Ash Street.
- Stormwater runoff from stormdrain pipes draining Pleasant Street and Malvern Road, Brockton.
- Stormwater runoff from catch basins on Park Road, Brockton.

- Stormwater runoff from gardens adjacent to brook with no vegetation buffer, upstream of Belmont Street, Brockton.
- Flooding and stormwater control problems between Silver Road, Sycamore Avenue and Belmont Avenue, Brockton.
- Runoff from pipes in the back of the "Columbia Electric Building", on North Warren Avenue, Brockton.
- Roof runoff from buildings adjacent to brook, on Prospect Street, Brockton.
- Potential stormwater runoff from new construction site on Perkins Street, adjacent to brook, Brockton.
- Potential source of wastewater from an outfall pipe on Otis Street, Brockton.
- Potential source of wastewater at a sewer manhole with defects, located at the intersection of Ellsworth and North Arlington Street.
- Pet waste impacts from a dog pen built adjacent to brook, off of Perkins Street, Brockton, part of "DandG Auto-body shop".
- Pet waste impacts from the grassy verge of Cross Pond off of Elmwood Avenue, Brockton.
- Wildlife waste impacts associated with open dumpsters and loose trash on the banks of brook in the parking lot for Law Office of Robert Clark, Chester Street, Brockton.
- Wildlife waste impacts associated with Keith Memorial Field, Belmont Street, Brockton.
- Wildlife waste impacts associated with potential waterfowl habitat on Cross Pond.
- Wildlife waste impacts associated with an open dumpster in the parking lot for Honey Dew Donuts, Pleasant Street, Brockton.

3.2.2.5 Searles Brook

The total area of the Searles Brook sub-watershed is approximately 549 acres, with an impervious area of 25%. The brook generally runs in a south-easterly direction from its origins in wetland areas off of South Street in Avon to its confluence with Trout Brook (and thus to Salisbury Plain River) in Brockton. The predominant land use is forest (22%), followed by high density residential areas (18%). Site SEB1 was only sampled four out of the five times the site was visited due to no water being present in the channel on 8/7/02. Both sites rank low on the "Recommended Priority for Site Management during Wet-Weather" list developed as part of this study (see Section 3.1.3 and Table 9). Site SEB1 on Vine Street, Brockton ranks as number 2 and SEB2 off of Village Way, Brockton ranks as number 1, which means overall Searles Brook is one of the worst waterbodies in terms of water quality during wet weather conditions. The brook runs underground in places and runs completely underground from just south of Upland Street to where it converges with Trout Brook. The potential sources of NPS pollution at this site are stormwater runoff from impervious areas associated with schools, housing complexes and high density residential areas surrounding the brook, also wildlife impacts associated with areas of well developed forest land and some open land, compounded by narrow to nonexistent vegetation buffers along the residential sections of the brook.

Bacteria

- Both sites sampled on Searles Brook (SEB1 and SEB2) did not meet the Massachusetts Class B standards for fecal coliform bacteria (Table 4 and 5l). In addition, on all the days sampled during wet weather conditions the peak standard of 400 col/100ml was greatly exceeded at both sites. Site SEB2 did not exceed the bacteria standard during dry weather but site SEB1 exceeded it slightly on one out of the two days, although it should be noted that during the second dry weather sampling visit there was no water in the brook channel. These findings indicate a potential wet weather source of bacteria in the Searles Brook watershed. The highest wet weather levels of bacteria were found at site SEB2 on 8/20/02 (38,000 col/100ml) although at site SEB1 (downstream of SEB2) on the same date the bacteria concentration was 37,000 col/100ml. This indicates there may not be any new substantial sources of NPS pollution in the watershed between the two sites.

Nutrients and TSS

- Both sites sampled on Searles Brook did not meet EPA guidance criteria for total phosphorus and TKN during wet and dry weather conditions for all the sampling dates (Table 4 and 6l) (except for TKN at site SEB1 during dry weather conditions, 6/20/02). The highest level found for both parameters was during wet weather conditions on 8/20/02. Elevated levels of both nitrogen and phosphorus at this site suggests the Searles Brook watershed may be experiencing elevated nutrient loads. Elevated levels of these nutrients can promote algal blooms, excessive weed growth and reduced dissolved oxygen levels which can cause the loss of species diversity in these waters. High levels of phosphorus can result from erosion, discharge of sewers or detergents, urban runoff and rural runoff containing fertilizers, animal and plant matter. High levels of Nitrogen can result from the natural breakdown of vegetation, runoff from lawn and crop fertilizers and feedlots. In addition, inadequately treated sewage and poor septic tank systems can increase levels of nitrogen in waterways
- All of the sampling dates met the Massachusetts aquatic life use standard for TSS (Tables 4 and 6).

Field Parameter Findings of Special Concern

- Both of the sites sampled on Searles Brook exhibited below (Massachusetts Class B) standard levels of dissolved oxygen on some of the sampling days (Table 7); however the average values did not fail for either site. The levels were below standard at site SEB1 on one out of two wet weather sampling days (the meter malfunctioned on the third day) and at site SEB2 on one out of two wet days (borderline fail) and the one dry day. Low levels of dissolved oxygen can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Low dissolved oxygen levels can be caused by excessive amounts of rotting vegetation, (that can come about through plant and algae blooms) and other organic wastes, as aerobic bacteria consume oxygen in the process of decomposition. This process can be compounded by high nutrient concentrations e.g. fertilizers contained in stormwater runoff, as well as by hot weather and low flows.

- The Massachusetts Class B standard for pH was failed by site SEB2 on two out of the three sampling days (Table 7), both during wet weather conditions, the average value for the site also failed the standard. This indicates wet weather conditions may exacerbate the source of low pH concentrations in this part of the Searles Brook watershed. Low pH levels in water can be caused by run-off from acid affected soils, sewage or discharge from old mines. Low pH can have the effect of mobilizing toxins in the water column, which can then enter the food chain. Outside what is considered the normal pH range sensitive species can be lost. In this case the pH was not excessively low and only just failed the standard in both cases; therefore it is very doubtful that there would be any serious impacts on the brook.

Habitat Assessment Findings

Overall the assessment scores at both Searles Brook sites were "sub-optimal" (Table 3). No one parameter in particular scored poorly at these sites, rather all aspects of the habitat were just a little below optimal. However, at site SEB1 the width of the riparian vegetative zone was narrow and at site SEB2 the channel flow status was low at the time of assessment plus the epifaunal substrate and embeddedness scored a little low. The reasons for the slightly low overall scores are different at the two sites, site SEB1 being subject to more human impacts than site SEB2 which scored low on habitat parameters more as a function of the channel itself. See section 2.3.5.3 for a description of all habitat parameters assessed for the MADEP habitat assessment.

Potential NPS Sources

(Information Obtained from Research, Reconnaissance, Field Data Analysis, and Interviews with Municipal Officials and Others with Knowledge of the Watershed)

Field Reconnaissance Observations

- SEB1 (Searles Brook at Vine Street bridge, Brockton) was sampled on four dates and exhibited elevated levels of bacteria on all of them, with a peak level of 37,000col/100ml on 8/20/02. This site ranks as number 2 on the "Recommended Priority for Site Management (during wet weather)" list (Table 9). The main potential source of NPS pollution at this site is stormwater runoff from impervious areas associated with the high density residential land surrounding this section of the brook. Country drainage was observed on Vine Street draining directly to the brook (*Point 55-Figure B-2 and Photo 56 Appendix 2*). Houses upstream of the Vine Street Bridge were built immediately adjacent to the brook so that the roofs overhang the water, roof runoff into the water from these houses upstream of the brook is likely, such runoff can contain atmospheric deposits and bird waste which can have a negative impact on water bodies. Landscaping debris and other trash was observed in the waters of the brook on a regular basis, which can also have an impact on water quality. The runoff impacts at this site are compounded by the extreme channelization of the brook (*Point 56-Figure B-2 and Photo 58 Appendix 2*) and the non-existent vegetation buffer along most sections. Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem.

- Further upstream, potential sources are associated with the Battles Farm Village Housing Complex, off of Rutland Street. Numerous catch basins were observed in the parking lot area for the complex (*Point 57-Figure B-2*) in close proximity to the brook. The brook is also culverted under some sections of the complex (*Photo 57 Appendix 2*). Upstream of the housing complex the brook runs under the playing field for the North Junior High School, originating from the West side of North Warren Avenue. Stormwater runoff from the impervious area associated with the school grounds (*Point 58-Figure B-2*) is another potential source of NPS pollution in the SEB1 sub-watershed.
- There is also the potential for wildlife waste impacts associated with the high school playing field, numerous gulls were observed congregating in the area during reconnaissance visits.
- SEB2 (Searles Brook at end of Village Way, Brockton) was sampled on three dates and exhibited elevated levels of bacteria on two out of the three (both during wet weather conditions), with a peak level of 38,000col/100ml on 8/20/02. This site ranks as number 1 on the "Recommended Priority for Site Management (during wet weather)" list (Table 9). The main potential source of NPS pollution observed at this site is wildlife waste impacts associated with the forest land surrounding this section of the brook from animals such as raccoons, skunks, rats or feral cats. Evidence of possible beaver activity was observed as well direct observation of raccoons inhabiting areas close to the brook. Additional wildlife waste impacts are possible associated with D.W. Field Park immediately upstream of the site, the brook also runs through the park further upstream Open land like this is often is lure to congregating birds such as geese and gulls, although non were observed during field reconnaissance visits.
- However, as the site SEB2 ranks so low (number 1) on the "wet weather list" (Table 9) it seems unlikely that wildlife waste impacts could be responsible for the brunt of the extremely high bacteria concentrations exhibited. In addition, strong sewage/musty smelling odors were observed during some visits to the site which can suggest the presence of untreated sewage in the water. Other potential sources could be the stormdrain pipe (observed flowing during dry weather conditions) just upstream of the site on the west bank of the brook (*Point 59-Figure B-2 and Photo 60 Appendix 2*), possibly draining the parking lot for the condominium complex on Village Way. Further upstream the brook runs in close proximity to high density residential areas west of North Main Street e.g. Manners Avenue, Mellen Street and Addison Street in Brockton. It also runs through a built up area south of South Street which includes a school (Butler Elementary) and a street called "Leo's Lane" which runs parallel to the brook. Stormwater runoff from these streets and the impervious area associated with the school or even a possible illicit connection to a drain in the area could be potential sources, however close study of the area upstream would be needed to confirm this theory.

Summarized Observations

The following potential source areas of NPS pollution were identified within this sub-watershed:

- Stormwater runoff via country drainage at edge of Searles Brook on Vine Street, Brockton.
- Stormwater runoff from catch basins and impervious areas associated with Battles Farm Village Housing Complex, Rutland Street, Brockton.
- Stormwater runoff from impervious areas associated with North Junior High school, North Warren Avenue, Brockton.
- Roof runoff from houses adjacent to brook upstream of Vine Street bridge, Brockton.
- Runoff from stormdrain pipe on west bank upstream of site SEB2, origins unknown.
- Potential stormwater runoff from residential areas adjacent to the brook west of North Main Street and south of South Street, Brockton.
- Wildlife waste impacts associated with playing fields for North Junior High School, North Warren Avenue, Brockton.
- Wildlife waste impacts associated with well developed forest land surrounding the brook up and downstream of site SEB2.
- Wildlife waste impacts associated with D.W. Field park, Brockton.

3.2.2.6 Malfardar Brook

The total area of the Malfardar Brook sub-watershed is approximately 419 acres, (one of the smallest sub-watersheds studied for the Matfield project), with an impervious area of 15%. The brook generally runs in a westerly direction from its origins in the residential area east of Calvary cemetery, to its confluence with Trout Brook just south of East Ashland Street, Brockton. The outstandingly predominant land use is medium density residential areas (65%). The brook was sampled at one location (MAB1), on North Cary Street in Brockton. The main potential source of NPS pollution at this site is stormwater runoff from impervious areas associated with high density residential areas upstream of the site, some wildlife waste impacts are also possible associated with waterfowl observed on the brook. The above mentioned sources of NPS pollution are likely to be compounded by narrow to nonexistent vegetation buffers along some sections of the brook.

Bacteria

- The site sampled on Malfardar Brook (MAB1) did not meet the Massachusetts Class B standards for fecal coliform bacteria (Table 4 and 5m). In addition, on two out of the three days sampled during wet weather conditions the peak standard of 400 col/100ml was exceeded. The site met the bacteria standard during dry weather, indicating a potential wet weather source of bacteria in the Lovett Brook watershed. The highest wet weather levels of bacteria were found on 7/16/02 (3,600 col/100ml). The site may therefore be influenced by a local source that has a maximum impact during wet weather events.

Nutrients and TSS

- The site sampled on Malfardar Brook did not meet the EPA guidance criteria for total phosphorus and TKN during wet and dry weather conditions for all the sampling dates (Table 4 and 6m). The highest level found for both parameters was during wet weather conditions. Elevated levels of both nitrogen and phosphorus at this site suggests the Malfardar Brook watershed may be experiencing elevated nutrient loads. Elevated levels of these nutrients can promote algal blooms, excessive weed growth and reduced dissolved oxygen levels which can cause the loss of species diversity in these waters. High levels of phosphorus can result from erosion, discharge of sewers or detergents, urban runoff and rural runoff containing fertilizers, animal and plant matter. High levels of Nitrogen can result from the natural breakdown of vegetation, runoff from lawn and crop fertilizers and feedlots. In addition, inadequately treated sewage and poor septic tank systems can increase levels of nitrogen in waterways
- All of the sampling dates met the Massachusetts aquatic life use standard for TSS (Table 4 and 6m).

Field Parameter Findings of Special Concern

- Overall, the site on Malfardar Brook is one of the healthiest sites sampled during the Matfield project in terms of the field parameters recorded by ESS (Table 7). The only parameter to fail standards at this site was pH, which failed to pass the Massachusetts Class B standard on one out of the five sampling days, during wet weather conditions on 6/6/02. This indicates wet weather conditions may occasionally exacerbate a source of low pH concentrations in the Malfardar Brook watershed. However, in this case the pH was not excessively low therefore it is very doubtful that there would be any serious impacts on the brook.

Habitat Assessment Findings

At the one site assessed on Malfardar Brook the overall assessment score was "marginal" and one of the lowest scores seen at any site throughout the study (Table 3). Most parameters scored poorly at this site, some linked to human impacts i.e. embeddedness, riparian vegetative zone width and bank vegetative protection score and some to the nature of the channel i.e. the frequency of riffles and the epifaunal substrate. See section 2.3.5.3 for a description of all habitat parameters assessed for the MADEP habitat assessment.

Potential NPS Sources

(Information Obtained from Research, Reconnaissance, Field Data Analysis, and Interviews with Municipal Officials and Others with Knowledge of the Watershed)

Field Reconnaissance Observations

- MAB1 (Malfardar Brook at North Cary Street, Brockton) was sampled on five dates and exhibited elevated levels of bacteria on two out of the five, with a peak level of 3,600col/100ml on 7/16/02. The main potential source at this site is stormwater runoff from impervious areas associated with high density residential land upstream of the site. Catch basins draining to the brook were observed on Anawan Drive and Ashfield Drive, and country drainage structures were observed adjacent to the brook upstream of the site on Moncrief Street (*Point 61-Figure B-2 and Photo 63 Appendix 2*). Sediment deposition was observed in the brook where the country drainage structure emptied. In addition, storm drain pipes were observed along the northern bank of the brook also appearing to drain Ashfield Drive (*Point 60-Figure B-2 and Photo 62 Appendix 2*). The stormwater runoff from these areas are likely to be compounded by the narrow vegetation buffer observed along many of the upstream sections of the brook, as well as the complete lack of a buffer on the southern bank adjacent to the site. Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem.
- The copious amounts of macrophytes observed at the site (in particular duckweed which covered the surface of the water completely during every visit to the site during the spring and summer) may be a result of the high nutrient levels, fine sediments and shallow water there.
- Another potential source of NPS pollution at the site is wildlife waste impacts associated with ducks and other waterfowl observed on the waters of the brook. The small forest area upstream of the site would serve to shelter and thus encourage such wildlife as well as other types of wildlife using the trees.
- A couple of DEP tier-classified 21E sites higher in the watershed could also have a limited impact on the site, further investigations may be necessary to determine the significance of these sites on the water quality of Malfardar Brook and the rest of the watershed

Summarized Observations

The following potential source areas of NPS pollution were identified within this sub-watershed:

- Stormwater runoff from catch basins on Anawan Drive and Ashfield Drive, Brockton.
- Stormwater runoff via country drainage structures on Moncrief Street, Brockton.
- Storm drain pipes along the northern bank of the brook, upstream of the site, draining Ashfield Drive, Brockton.
- Wildlife waste impacts associated with ducks and other waterfowl observed on the waters of the brook and a small forested area upstream of the site.

3.2.2.7 Cary Brook

The total area of the Cary Brook sub-watershed is approximately 194 acres, with an impervious area of 9%. The brook generally runs in a north-westerly direction from its origins in the middle of a residential area west of Sheridan Street in Brockton, to its confluence with Trout Brook (and thus to Salisbury Plain River) in Brockton. The predominant land use is medium density residential areas (51%), followed by urban open land (18%). Both sites rank low on the "Recommended Priority for Site Management lists developed as part of this study (Tables 9 and 10). Site CB1 on Elliot Street, Brockton, ranks as number 9 and number 3 on the "wet weather" and "dry weather" lists respectively. Site CB2 on Court Street, Brockton, ranks as number 4 on the "dry weather" list. This means that overall Cary Brook is relatively poor in terms of water quality during wet weather conditions, and is one of the worst waterbodies of the entire project in terms of water quality during dry weather conditions. The sub-watershed for Cary Brook is the smallest of those studied for the Matfield project and has few recognizable potential sources of NPS pollution. The potential sources are stormwater runoff from impervious areas associated with residential areas, schools, parking lots and also from gardens adjacent to the brook, compounded by narrow vegetation buffers along the residential sections of the brook. Another potential source is wildlife impacts associated with areas of well developed forest upstream of site CB2 (the most upstream sampling site).

Bacteria

- Both sites sampled on Cary Brook (CB1 and CB2) did not meet the Massachusetts Class B standards for fecal coliform bacteria (Table 4 and 5n). In addition, on all the days sampled during wet and dry weather conditions the peak standard of 400 col/100ml was exceeded at both sites (the only exception being during dry weather conditions at site CB1 on 6/20/02). The highest wet weather levels of bacteria were found at site CB2 on 11/6/02 (6,500 col/100ml) however at this site the dry weather peak is also high (3,900 col/100ml), which indicates there are both dry and wet weather sources of NPS pollution in the watershed but that wet weather conditions likely exacerbate the problem. Site CB2 is the most upstream sampling site on Cary Brook and the sub-watershed area draining to the site is very small (10B-1cres). This indicates there must be a serious source of NPS pollution in the sub-watershed for site CB2 and it is likely that there are no new substantial sources in the sub-watershed for CB1 as the average values at this site are markedly less.

Nutrients and TSS

- Both sites sampled on Cary Brook did not meet the EPA guidance criteria for total phosphorus and TKN during wet and dry weather conditions for all the sampling dates (Table 4 and 6n). The highest level found for both parameters at site CB1 was during dry weather conditions on 8/7/02. The highest levels found for both parameters at site CB2 was during wet weather conditions on 11/6/02 and 8/30/02. As with bacteria concentrations, the higher average values for total phosphorus and TKN are found at the top of the sub-watershed at site CB2. This supports the theory that there is a serious source of NPS pollution in the sub-watershed for site CB2 and it is likely that there are no new substantial sources in the sub-watershed for CB1 as the average values at this site are markedly less. Elevated levels of both nitrogen and phosphorus at this site suggests the Cary Brook watershed may be experiencing elevated nutrient loads. Elevated levels of these nutrients can promote algal blooms, excessive weed growth and reduced dissolved oxygen levels which can cause the loss of species diversity in these waters. High levels of phosphorus can result from erosion, discharge of sewers or detergents, urban runoff and rural runoff containing fertilizers, animal and plant matter. High levels of Nitrogen can result from the natural breakdown of vegetation, runoff from lawn and crop fertilizers and feedlots. In addition, inadequately treated sewage and poor septic tank systems can increase levels of nitrogen in waterways

- Only one of the weather sampling dates (site CB1 on 6/6/02) did not meet the Massachusetts aquatic life use standard for TSS (Table 4 and 6n).

Field Parameter Findings of Special Concern

- Both of the sites sampled on Cary Brook exhibited below (Massachusetts Class B) standard levels of dissolved oxygen on the majority of the sampling days, the average values also failed at both sites (Table 7). The levels were below standard on every sampling day at site CB1 and on two out of three sampling days at site CB2. The average levels of dissolved oxygen at site CB1 were some of the worst seen at any site during the entire Matfield project. Low levels of dissolved oxygen can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Low dissolved oxygen levels can be caused by excessive amounts of rotting vegetation, (that can come about through plant and algae blooms) and other organic wastes, as aerobic bacteria consume oxygen in the process of decomposition. This process can be compounded by high nutrient concentrations e.g. fertilizers contained in stormwater runoff, as well as by hot weather and low flows.
- Turbidity standards were only exceeded at site CB1 during dry weather conditions on 8/7/02 (Table 7). The value on this day exceeded the best professional judgment standard adopted by ESS scientists for Class B waters. High levels of turbidity can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. High turbidity levels can be caused by silt washed in during high rainfall, effluent discharge and runoff. Bank erosion/degradation can also increase turbidity as can algae and natural tannins. Very high levels of turbidity for a short period of time may not be significant and may even be less of a problem than a lower level that persists longer. Due to the fact that the high turbidity level was exhibited during dry weather conditions, it may be more likely to have been caused by effluent discharge or by an error in sampling/measurement of that parameter.
- The Massachusetts Class B standard for pH was failed at site CB1 on just one out of the five sampling days (Table 7), during wet weather conditions. This indicates wet weather conditions occasionally may exacerbate the source of low pH concentrations in the lower reaches of the Cary Brook watershed. Low pH levels in water can be caused by run-off from acid affected soils, sewage or discharge from old mines. Low pH can have the effect of mobilizing toxins in the water column, which can then enter the food chain. Outside what is considered the normal pH range sensitive species can be lost. In this

case the pH was not excessively low; therefore it is doubtful there would be any serious impacts on the brook.

Habitat Assessment Findings

Overall the assessment scores at both Cary Brook sites were "sub-optimal" (Table 3). At site CB1 the frequency of riffles scored particularly low i.e. all the water was generally flat, plus the instream cover and epifaunal substrate parameters scored very low also. At site CB2 embeddedness and sediment deposition scored particularly low which is often a result of human impacts, for example solid waste building up on impervious surfaces and then getting washed into the water during a storm event. See section 2.3.5.3 for a description of all habitat parameters assessed for the MADEP habitat assessment.

Potential NPS Sources

(Information Obtained from Research, Reconnaissance, Field Data Analysis, and Interviews with Municipal Officials and Others with Knowledge of the Watershed)

Field Reconnaissance Observations

- CB1 (Cary Brook at Elliot Street bridge, Brockton) was sampled on five dates and exhibited elevated levels of bacteria on four out of the five with a peak level of 1,800col/100ml on both 6/6/02 and 7/16/02. This site ranks as number 9 and 3 on the "Recommended Priority for Site Management (during wet and dry weather respectively)" list (Tables 9 and 10). The only potential source of NPS pollution observed at this site is stormwater runoff from impervious areas associated with the high density residential areas upstream of the site. In addition, there are areas upstream of the site (on North Cary Street), that have lawns/gardens backing closely onto the banks of the brook (*Point 62-Figure B-2*). All stormwater runoff from the above mentioned areas will be compounded by the narrow vegetation buffers also observed along some sections of the brook upstream of the site. Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem.
- CB2 (Cary Brook on Court Street bridge, Brockton) was sampled on three dates and exhibited elevated levels of bacteria on all of them, with a peak level of 6,500/100ml on 11/6/02. This site ranks as number 4 on the "Recommended Priority for Site Management (during dry weather)" list (Table 10). Despite the poor water quality at this site few potential sources were observed. However, there is the potential for NPS pollution impact from wildlife impacts associated with the well developed forest land upstream of site CB2 from animals such as raccoons, skunks, rats or feral cats. Evidence of beaver activity was directly observed in the forest. There is also the potential for stormwater runoff impacts from impervious areas and gardens associated with the residential areas to the south and east of the site and from impervious areas associated with the two schools in the watershed, i.e. Cardinal Spellman High off of Court Street and East Junior High off of Centre Street (Route 123).

Summarized Observations

The following potential source areas of NPS pollution were identified within this sub-watershed:

- Potential stormwater runoff from impervious areas associated with the high density residential streets upstream of the site i.e. Boyden Street, Moody Street and North Cary Street, Brockton.
- Stormwater runoff from gardens adjacent to Cary Brook on North Cary Street, Brockton.
- Wildlife impacts associated with the well developed forest land upstream of site CB2, east of Court Street, Brockton.
- Potential stormwater runoff impacts from impervious areas and gardens/lawns associated with the residential areas to the south and east of the site i.e. Provost Street, Benham Street, Rainville Street, Frederick Street, Marie Avenue and Budd Avenue, Brockton.
- Potential storm water runoff impacts from impervious areas associated with Cardinal Spellman High School off of Court Street and East Junior High School off of Centre Street (Route 123), Brockton.

3.2.2.8 Salisbury Plain River

The total area of the Salisbury Plain River sub-watershed is approximately 3,314 acres with an impervious area of 26%. The main stem of the river runs in a southerly direction for most of its length from its origins where Salisbury Brook and Trout Brook converge (just south of Crescent Street in Brockton) but it then curves east to meet its confluence with the Matfield River in East Bridgewater. The predominant land use is medium density residential areas (27%) followed by forest (25%) and then high density residential areas (20%). Two out of the three sites sampled on the Salisbury Plain River ranked low on the "Recommended Priority for Site Management" lists developed as part of this study. Site SPR1 on Belmont Street, East Bridgewater ranks as number 7 on the "wet weather list" (Table 9) and 4 on the "dry weather list" (Table 10). Site SPR3 on Main Street, Brockton ranks as number 9 on the "dry weather list"(Table 10). This indicates that overall the lower reaches of the Salisbury Plain River sub-watershed are relatively poor in terms of water quality during wet and dry weather conditions. There are many potential sources of NPS pollution in this sub-watershed due to the diversity of its location both in some of the more developed areas of Brockton but also more rural areas in the lower reaches of the watershed. These sources include stormwater runoff from the large amounts of impervious land associated with major and minor roads, industrial and commercial developments, parking lots and railway lines in the city via catch basins and storm drain pipes. Defects in sewers drain pipes and septic systems, is another potential source in the developed areas of the watershed. In the more rural parts of the watershed, runoff from farmland and gardens and wildlife impacts associated with the larger areas of forest and wetland, are also potential sources of NPS pollution.

In addition to the above mentioned sources it is possible that the input of impaired waters from Salisbury Brook and Trout Brook can also affect the water quality of the Salisbury Plain River. The average values for bacteria and nutrients at each site (Tables 5o and 6o) indicate that a major source of bacteria in the upper reaches of the Salisbury Plain River watershed is the waters of Salisbury Brook and Trout brook, (average bacteria values at sites TB1, SB1 and SPR2 are similarly high and the values decrease going down the Salisbury Plain river) whereas the major sources of nutrients are located in the lower reaches of the watershed (average values for total phosphorus and TKN increase downriver).

Bacteria

- All three of the sites sampled on Salisbury Plain River (SPR1, SPR2 and SPR3) did not meet the Massachusetts Class B standards for fecal coliform bacteria (Table 4 and 5o). In addition, the peak standard of 400 col/100ml was exceeded on all sampling dates at sites SPR2 and SPR3. Site SPR1 did not meet the standard on three out of the five sampling days during wet and dry weather conditions. This indicates there is a potential wet and dry weather source of bacteria in the Salisbury Plain River watershed, although wet weather events appear to exacerbate the problems. The highest wet weather level of bacteria was found at site SPR2 (a peak of 20,000 col/100ml on 6/6/02) which is the most upstream of the sampling locations on the river, and thus closest to the Salisbury Brook and Trout Brook confluence. The average value at site SPR2 is similar to the sites at the bottom of Salisbury Brook and Trout Brook i.e. SB1 and TB1 respectively. The fact that the average values at sites SPR3 and SPR1 decrease incrementally going downstream indicates that the main source of bacteria is at the top of the watershed, i.e. possibly from the waters of Trout Brook and Salisbury Brook. In general it takes at least 3 days for bacteria to decay to 10% of its original concentration (Easton et al., 2001), and the speed of the water at these sites is fast enough for water to travel between them in less than a day, therefore it is possible for concentrations of bacteria to accumulate moving downstream, or at least maintain a constant concentration. However, it is likely that some other potential sources of bacteria also exist in the upper and lower reaches of the sub-watershed to supplement the effect of impaired waters from Salisbury Brook and Trout Brook. Such potential sources will be discussed in the relevant "Potential NPS Sources" section later in the report.

Nutrients and TSS

- All sites sampled in the Salisbury Plain River sub-watershed did not meet the EPA guidance criteria for total phosphorus and TKN during wet and dry weather conditions for all the sampling dates except for 6/20/02 at site SPR2 (Table 4 and 6o). The average concentrations of total phosphorus and TKN were found to increase markedly going downstream (SPR2 to SPR3 to SPR1). This seems to indicate that sources of total phosphorus and TKN are more prevalent in the lower reaches of the watershed. Elevated levels of both nitrogen and phosphorus at all the sites in the Salisbury Plain

River sub-watershed, suggests the sub-watershed may be experiencing elevated nutrient loads. Elevated levels of these nutrients can promote algal blooms, excessive weed growth and reduced dissolved oxygen levels which can cause the loss of species diversity. High levels of phosphorus can result from erosion, discharge of sewers or detergents, urban runoff and rural runoff containing fertilizers, animal and plant matter. High levels of Nitrogen can result from the natural breakdown of vegetation, runoff from lawn and crop fertilizers and feedlots. In addition, inadequately treated sewage and poor septic tank systems can increase levels of nitrogen in waterways

- All of the sites on all sampling days met the Massachusetts aquatic life use standard for TSS (Table 4 and 6o).

Field Parameter Findings of Special Concern

- All the sites sampled on the Salisbury Plain River exhibited below (Massachusetts Class B) standard levels of dissolved oxygen on at least one sampling day (Table 7). On 6/6/02 the meter malfunctioned so readings were not recorded on that day. Site SPR1 (the most downstream sampling location on the river) exhibited below standard levels of dissolved oxygen on all sampling days and the average value also failed the standard at this site. The average values at site SPR1 were some of the worst see at any site throughout the entire study.
- Sites SPR2 and SPR3 exhibited failing levels of dissolved oxygen on two out of four and one out of three sampling days respectively.
- Low levels of dissolved oxygen can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Low dissolved oxygen levels can be caused by excessive amounts of rotting vegetation, (that can come about through plant and algae blooms) and other organic wastes, as aerobic bacteria consume oxygen in the process of decomposition. This process can be compounded by high nutrient concentrations e.g. fertilizers contained in stormwater runoff, as well as by hot weather and low flows. In this case, the low levels of dissolved oxygen at the most downstream site on the Salisbury Plain River could be caused by the input of impaired waters from the rest of the Salisbury Plain River upstream of that site.
- The best professional judgment standard for specific conductance, adopted by ESS scientists for Class B waters was exceeded only by site SPR1 (Table 7), the most downstream site sampled on the river. The standard for specific conductance was exceeded on three out of the five sampling days for this site and the average value also failed the standard. High levels of specific conductance can have an effect on the water body's ability to support aquatic life, and thus on its overall water quality. Elevated levels of specific conductance can be caused by agricultural and sewage effluent and stormwater runoff, as well as the natural geology of the river bed. Once again, the high levels of specific conductance at the most downstream site on the Salisbury Plain River could be caused by the input of impaired waters from the rest of the Salisbury Plain River upstream of that site.
- The Massachusetts standard for Class B WWF (warm waters) for temperature was exceeded at site SPR3 on 8/1/02 (Table 7). The temperature at all other sites sampled on the Salisbury Plain River did not exceed the State standard. High water temperatures can stress aquatic ecosystems by reducing the ability of water to hold essential dissolved

gasses like oxygen, which in turn impacts the distribution and number of aquatic species found in the waterbody. Temperature is highly dependant on the depth of the water, season, time of day, and air temperatures. Industrial discharges can also affect water temperature. In this case, the temperature was not excessively high and in fact only just exceeded the standard; therefore it is doubtful there would be any serious impacts on the river.

Habitat Assessment Findings

Overall the assessment scores at the three sites assessed along Salisbury Plain River vary widely ranging from marginal to optimal (Table 3). The Salisbury Brook site with the worst score overall (SPR3) scored particularly badly on the degree of embeddedness and sediment deposition which can be factors of human impacts as well as bank stability which was also marginal at this site. The width of the riparian vegetative zone also scored low at this site which is also a sign of human development impacts. At site SPR2 no one parameter scored particularly low, all habitat parameters were generally sub-optimal at the site although epifaunal substrate and frequency of riffles scored on the low side. Site SPR1 was optimal for most habitat parameters although the bank vegetative protection score and riparian zone width was low in places. See section 2.3.5.3 for a description of all habitat parameters assessed for the MADEP habitat assessment.

Potential NPS Sources

(Information Obtained from Research, Reconnaissance, Field Data Analysis, and Interviews with Municipal Officials and Others with Knowledge of the Watershed)

Field Reconnaissance Observations

- SPR1 (Salisbury Plain River at Belmont Street bridge, East Bridgewater) was sampled on five dates and exhibited elevated levels of bacteria on two out of the three wet weather sampling days and one out of the two dry weather sampling days, with a peak level of 14,000 col/100ml on 6/6/02. This site ranks as number 7 on the "Recommended Priority for Site Management (during wet weather)" list (Table 9) and number 4 on the "Recommended Priority for Site Management (during dry weather)" list (Table 10), which means overall this site was relatively bad in terms of water quality during wet and dry weather conditions. Potential sources of NPS pollution at this site include stormwater runoff from Matfield Street and Belmont Street compounded by a narrow vegetation buffer along sections of the river close to the roads. Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem.
- In addition, a horse stable (Stonecroft farm #108 Belmont Street) was located immediately adjacent to the site, a paddock for the horses was located along the bank

adjacent to/downstream of the site (*Point 64-Figure B-2*), where only two horses were ever observed at one time. There is the potential for stormwater runoff from this paddock down the bank into the river, compounded by the narrow vegetation buffer along that section.

- Another potential source of runoff is a storm drain pipe (origins unknown) on the Northern bank of the river at the sampling site (*Point 63-Figure B-2 and Photo 67 Appendix 2*), which was observed to flow during dry weather conditions. Wildlife waste impacts associated with the extensive areas of forest and wetland upstream is also a potential source, from animals such as raccoons, skunks, rats or feral cats. Another possible source of pollutants is the sewage disposal plant, upstream of the site on Industrial Boulevard, Brockton. In addition, town officials identified a potential area of concern for NPS pollution along Pinecrest Road, where there are residences with septic systems within a Zone II well head protection area for town wells. Strong sewage/musty odors (when close to the water) were noted during every visit to the site, which can be an indication of untreated sewage, livestock waste or algae (which was also observed). The copious amounts of macrophytes and algae observed at the site could be a result of the elevated nutrient levels found at this site. A small number of DEP tier-classified 21E sites in the sub-watershed could also have a limited impact on the site, further investigations may be necessary to determine the significance of these sites on the water quality of Salisbury Plain River and the rest of the watershed.

- SPR2 (Salisbury Plain River at Plain Street bridge, Brockton) was sampled on five dates and exhibited elevated levels of bacteria on all of them, with a peak level of 20,000 col/100ml on 6/6/02 during wet weather conditions. The main potential source of NPS pollution at this site is stormwater runoff from the large areas of impervious land around and upstream of the site. A stormdrain, likely draining Plain Street (no catch basins were observed), was observed downstream of the Plain Street bridge on the south-east side of the river built into the concrete structure for the bridge (*Point 67-Figure B-2*). There is also the potential for stormwater runoff from the large parking lot for the Campello T-Stop (*Point 66-Figure B-2*) immediately upstream of the Plain Street Bridge. A stormdrain likely draining this area was observed on the south-east bank of the river (*Point 65-Figure B-2 and Photo 69 Appendix* 2) in between the section running underneath the train track and the Plain Street Bridge. Further upstream (after the river runs under the tracks) there is the potential for stormwater runoff from the impervious grounds associated with the "Trojan Recycling Transfer Station". Two stormdrains were observed on the south-east side of the river draining from this area into the river. Upstream of the transfer station is literally a sea of pavement and parking lots, where there is enormous potential for excessive stormwater runoff. The majority of this section of the Salisbury Plain River is heavily channelized and has a narrow to non-existent vegetation buffer, both which will compound the stormwater runoff from the surrounding highly industrialized impervious areas. Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem.

- In addition, a potential source of wastewater was identified by town officials associated with defects in the sewer and drain pipes between Montello and Clinton Streets, linked to an outfall on Clinton Street draining to a tributary of the Salisbury Plain River. More television inspection was recommended to get a full understanding of the problems. A large number of DEP tier-classified 21E sites in the sub-watershed could also have a limited impact on the site, further investigations may be necessary to determine the significance of these sites on the water quality of Salisbury Plain River and the rest of the watershed.

- SPR3 (Salisbury Plain River at Main Street bridge, Brockton) was sampled on three dates and exhibited elevated levels of bacteria on all of them with a peak of 5,800 col/100ml on 11/6/02 during wet weather conditions. This site ranks as number 9 on the "Recommended Priority for Site Management (during dry weather)" list (Table 10), which means overall this site was relatively bad in terms of water quality during dry weather conditions. The main potential source of NPS pollution at this site is stormwater runoff from the large areas of impervious land around and upstream of the site. Numerous catch basins (likely draining to the river) were observed on Sargents Way, (*Point 68-Figure B-2*) which crosses the river upstream of the site and also on Meadowbrook Road (*Point 69-Figure B-2*) which runs parallel to the river for a short distance upstream of Sargents Way. The whole of Meadowbrook Road and Sargents Way is heavily industrialized; any stormwater runoff from these roads would be compounded by the very narrow vegetation buffer along this section of the river. Vegetation buffers tend to act as a filtering strip, in their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff. In their absence all of the potential pollutants present in stormwater runoff (such as bacteria, nutrients and sediments), run unhindered and undiluted directly into the water body to ultimately cause harm to the ecosystem.
- A stormdrain (likely draining from the observed catch basins) was observed off of Meadowbrook Road opposite the brick and stone dealership called "Lee's Stone". Stormwater runoff is also a potential source from other streets in close proximity to this section of the river, upstream of the site i.e. Watson Street, Holmes Street, Meadow Lane and even Main Street (Route 28) itself (although this is a little further away). In addition, site SPR3 is in very close proximity to site SPR2, so it is likely that any NPS pollution in the river at site SPR2 will impact the water quality at site SPR3. A small number of DEP tier-classified 21E sites in the sub-watershed could also have a limited impact on the site, further investigations may be necessary to determine the significance of these sites on the water quality of Salisbury Plain River and the rest of the watershed.

Summarized Observations

The following potential source areas of NPS pollution were identified within this sub-watershed:

- Stormwater runoff from Matfield Street and Belmont Street, East Bridgewater, compounded by narrow vegetation buffers.
- Stormwater runoff from horse paddock at Stonecroft farm, #108 Belmont Street, East Bridgewater, compounded by narrow vegetation buffers.
- Stormwater runoff from the Plain Street area via a stormdrain pipe downstream of the bridge on the south-east side, Brockton.

- Stormwater runoff from the impervious area associated with Campello T-stop, via a stormdrain pipe upstream of the Plain Street bridge, on the south-east bank, Brockton.
- Stormwater runoff from the impervious area associated with the Trojan Recycling Transfer Station, via two stormdrain pipes located on the south-east side downstream of the railroad, Brockton.
- Stormwater runoff via catch basins on Sargents Way and Meadowrook Road, compounded by very narrow vegetation buffers, Brockton.
- Stormwater runoff from a stormdrain on Meadowbrook Road, opposite "Lee's Stone" brick and stone dealership, Brockton.
- Dry weather runoff from stormdrain on North bank of river, off of Belmont Street, East Bridgewater.
- Potential stormwater runoff from Watson Street, Holmes Street, Meadow Lane and Main Street, Brockton.
- Wildlife waste impacts associated with forest and wetland upstream of Belmont Street, East Bridgewater.
- Residences with septic systems on Pinecrest Road, within a Zone II well head protection area for town wells, West Bridgewater.
- Potential source of wastewater in sewer and drain pipes between Montello Street and Clinton Street linked to an outfall on Clinton Street draining to a tributary of the Salisbury Plain River, Brockton.

3.3 FINDINGS AND OBSERVATIONS BY MUNICIPALITY

This section presents findings and prioritizations by town. Findings and prioritizations based on historic water quality data, reconnaissance, field data analysis, and interviews with municipal officials and others with knowledge of the watershed were used to develop the recommendations presented below.

The Massachusetts cities and towns that make up the Matfield River and Salisbury Plain River watersheds are protecting their water resources and are pursuing NPS control measures through local ordinances. The local governments with substantial portions of the study area within their borders include the Towns of Avon, West Bridgewater, East Bridgewater, Abington, Whitman, and the City of Brockton. There are many tools that are utilized by these towns, including zoning by-laws to control housing density, conservation commission wetland bylaws to protect water resources, surface and groundwater district overlays, open space purchases, septic system repairs and pump-out and storm drain catch basin maintenance street sweeping and catch basin clean out, town ordinances that manage nonpoint sources of pollution and impacts from stormwater. A survey of 12 municipal officials and follow-up interviews was conducted to determine what types of regulations local authorities use to manage nonpoint sources of pollution and opportunities to improve such management. The feedback has been incorporated into a summary for each municipality.

3.3.1 Town Management Measures to Control Nonpoint Sources of Pollution

3.3.1.1 Avon

Two of the main tributaries to the Salisbury Plain River have their headwaters in Avon, Trout Brook, and Beaver Brook. The Town of Avon public water supply is from wells located in the southeastern part of the town. Only a few businesses have sewers which are connected to the Brockton sewer infrastructure. Avon is currently completing a comprehensive water management plan to assess storm water and sewer needs. The Avon Highway Department completes street sweeping and catch basin clean-out annually.

The Town of Avon's Water Supply District covers a large portion of the town, and Zoning regulations prohibit certain types of activities from the district including the following:

- On-site disposal systems are prohibited unless limited to disposal of 110 gallons/quarter acre or 440 gallons/acre which ever is greater
- Land filling or storing of sludge
- Storage of animal manures, de-icing chemicals
- Permanent removal of earth to within 6 feet of the historical high water table
- Storage of liquid hazardous materials
- Motor vehicle graveyards and junkyards
- Treatment or disposal works for non-sanitary wastewaters
- Storage of commercial fertilizers and soil conditioners
- Use of septic system cleaners toxic or hazardous materials.

3.3.1.2 Brockton

Brockton contains the largest number of river and tributary miles to the Matfield River of all the towns in the project watershed. The Salisbury Plain River headwaters are in Brockton and flow from the Salisbury Brook. The Salisbury Brook in turn is fed by a series of ponds south of the Brockton Reservoir (Upper Porter Pond, Lower Porter Pond, Thirty-Acre Pond, Ellis Brett Pond, and Cross Pond). Lovett Brook also flows into Ellis Brett Pond from the west. From the east, Trout Brook has its headwaters in Lake Holbrook in the Town of Holbrook and the Malfardar Brook and Cary Brook flow into Trout Brook before it merges with the Salisbury Plain River and Salisbury Brook. The Brockton Reservoir is located in Avon but the majority of the public water supply comes from Silver Lake in the Town of Halifax.

Brockton has a floodplain, watershed, and wetland protection zone which has the following prohibited uses:

Dumping, filling, excavating, or transferring of any material that will reduce the natural water storage capacity, interfere with the natural drainage pattern of any watercourse, or otherwise effect the natural hydrology of the area; erection, construction, alteration, addition or other creation or installation of any building, wall, dam or other structure, except as where otherwise provided, and dumping of waste material, permanent and/or temporary storage of buoyant, flammable, toxic or explosive materials in the floodplain, construction of on-site sewage disposal systems in the floodplain, and development of a private well for water supply in a floodplain except for irrigation purposes.

3.3.1.3 West Bridgewater

Only a small portion of the Matfield River watershed falls within the Town of West Bridgewater in the northeast corner where the Salisbury Plain River crosses between Brockton and East Bridgewater. Much of this area is covered by the West Bridgewater Zone II and a portion of the East Bridgewater Zone II.

West Bridgewater has a Watershed Resource Protection District which is designed to protect the public health of the residents of the town from contamination of existing and potential public groundwater supplies and recharge areas. The town's zoning regulations specify prohibited activities and requirements for special permission from the Board of Health or Planning Board. The watershed district is divided into three water resource protection zones and activities are allowed or prohibited by zone. The zones include Subzones I-III:

- Subzone I: The area within a 400-foot radius of an existing public well
- Subzone II: The area above that portion of any aquifer that will contribute water to an existing public well, as determined by standard geologic and hydrogeologic investigation, under the most severe recharge and pumping conditions that can be realistically anticipated, that is, pumping at maximum safe yield for 180 days without recharge.
- Subzone III: The recharge area to an existing public well or the area that is expected, based on current information derived from standard geologic and hydrogeologic investigation to recharge a future public well.

The West Bridgewater subdivision regulations require an environmental assessment for subdivisions of twenty (20) units or more which can include up to two major alternatives to the plan proposed. The Planning Board can require the environmental assessment to include discussions of the impact upon surface water quality and levels, groundwater quality and levels, effects on wildlife habitats, vegetation, soils, water supply systems and nutrient loading. Storm water runoff is required to be minimized to the extent feasible with no increase in peak flows for the 10-year frequency storm. The subdivision regulations also have standards for the construction of storm drains and drainage from the building lot.

The West Bridgewater Conservation Commission Wetlands Protection By-Laws apply to any bank, beach, flat, freshwater wetland, meadow, bog, or swamp; any lake, pond, river or stream; and any land subject to flooding or inundation by groundwater or surface water. A 50-foot setback is required for activities occurring adjacent to inland banks and vegetated wetlands, except for maintenance of an already existing structure. No activities other than maintenance of an already existing structure are permitted for land subject to flooding and land under water bodies. The Conservation Commission can issue variances, but only if the applicant can show there is no adverse affect upon the resources protected by the by-law.

3.3.1.4 East Bridgewater

The Salisbury Plain River and Beaver Brook converge to form the Matfield River in East Bridgewater. Route 18 travels through the middle of East Bridgewater and there are several cranberry bogs that fall within the Zone II wellhead protection areas. East Bridgewater has high water tables throughout most of the town and does not have a central sewer system. The town does not have any conservation commission by-laws that go beyond the Wetlands Protection Act, but there is a Flood Plain and Wetlands Protection District and the Conservation Commission also typically requests a 25-foot setback from wetlands and conservation covenants with properties proposing development within 100 feet of a wetland or waterbody. The East Bridgewater Watershed Protection District restricts sodium chloride use for snow removal and above and below ground storage of petroleum products.

There are 1300 catch basins in East Bridgewater that are cleaned annually. Street sweeping also occurs annually. The town is mapping their storm drain system.

3.3.1.5 Abington

Beaver Brook and the Shumatuscacant River flow through the Town of Abington. Route 123 crosses the town in the south and Route 139 in the north. Route 18 runs north and south through the central-eastern part of the town. Abington is almost completely sewered with a permit to pump 1,000,000 gallons a day to Brockton and 110,000 gallons a day to Rockland (town to the east). Typically, septic systems are pumped and filled in after the sewer system is completed for a section of town. The town has between 1500 and 1600 catch basins that are cleaned out every spring. Street sweeping is usually done before the catch basin clean out and sometimes more frequently depending on build-up. The Department of Public Works is presently using a software package called Pavement Plus to enter stormdrain information including width of streets, curb, berm and sidewalk information, water and sewer line, hydrants and storm water drains. Approximately two thirds of the town is completed. Outfall pipes to streams and ponds are not necessarily indicated in this mapping. Stream maintenance is undertaken in December to clean out trash, large trees, and siltation from erosion where pipes are located.

Abington has town ordinances that manage nonpoint sources of pollution and impacts from storm water. The Subdivision Regulations require that building design and resulting building sites reduce to the extent reasonably possible the following nonpoint source related impacts:

- The volume of the cut and fill
- The area over which existing vegetation will be disturbed, especially if within two hundred feet of a river, pond, wetland or stream, or having steep slopes
- The number of tress greater than 10 inches in diameter (at 6 feet above the ground) removed
- The increase in peak rates of storm water runoff
- Soil loss or instability during and after construction

The Subdivision Regulations also require that the Definitive Plans for subdivisions contain the watershed area with total acreage, storage areas, and runoff controls.

Abington has two overlay districts in the Zoning By-Laws, the Flood Plain and Wetlands Protection District, and the Watershed Protection District that have requirements for storm water controls, and prohibit certain types of development. The Flood Plain and Wetlands Protection District requires applications for Special Permits to include a Site Plan and Environmental Impact Statement that describes the impact with respect to drainage, sewage, groundwater, surface water pollution and other parameters determined necessary. The Watershed Protection District prohibits certain land uses including on-site sewage disposal systems with flows greater than 10,000 gallons per day and development that renders a lot area more than 15% impervious or 2,500 ft^2 impervious area except by Special Permit. Commercial and industrial districts cannot be greater than 50% impervious with a Special Permit.

The Zoning By-Laws also has environmental performance policies and standards for all development regulated by the zoning code including surface water drainage to control runoff, erosion control and restrictions on vegetation removal.

3.3.1.6 Whitman

There are two main hydrologic features in Whitman, the Shumatuscacant River, and Meadow Brook. The Shumatuscacant River flows from Abington through Hobart Pond in Whitman and south to the Town of Hanson. Meadow Brook begins in Abington and flows through Whitman. Routes 14, 18, 27, and 58 all crisscross through Whitman. The town is 95% sewered and sewage is treated at the Brockton facility. Mandatory sewer hook-ups are not required unless there is a septic system problem and some areas (Carver Street) still utilize on-site septic systems. Whitman purchases its water from the City of Brockton, most of the water supply comes from Silver Lake in Halifax. The town recently purchased a street sweeper and catch basin cleaning truck and 100% of the town is completed annually. The catch basins in Whitman are older and most do not have oil and grease traps.

3.3.2 Findings and Prioritizations by Town

Town	Waterbody	Site Code	Recommended site management priority rank during wet weather, based on water quality (Also see Table 9)	Recommended site management priority rank during dry weather, based on water quality (Also see Table 10)	Reference sections in this report for recognized NPS contribution areas
Abington/Brockton	Beaver Brook	BB2	21	22	Pg 25 Section 3.2.1.1.5, Photo 2-Appendix B
Abington	Shumatuscacant River	SHR2	25	13	Pg. 29 Section 3.2.1.2.5 Point 4 and 5-Figure B-1, Photos 9-10 Appendix B
Avon	Avon Beaver Brook	ABB1	22	7	Pg. 51 Section 3.2.2.1.5, Photos 32-33 Appendix B
Bridgewater	Matfield River	MR1	15	11	Section 3.2.1.7.5 Photos 26-27 Appendix B
Brockton	Beaver Brook	BB1	25	12	Pg. 25 Section 3.2.1.1.5, Photo 1-Appendix B
Brockton/Abington	Beaver Brook	BB2	21	22	Pg. 25 Section 3.2.1.1.5, Photo 2-Appendix B
Brockton	Trout Brook	TB1	3	5	Pg. 55 Section 3.2.2.2.5 Points 27 and 28-Figure B-2, Photos 34 and 35- Appendix B
Brockton	Trout Brook	TB2	10	13	Pg. 55 Section 3.2.2.2.5 Points 29, 30, 31, 32-Figure B-2, Photo 36 and 37- Appendix B

Town	Waterbody	Site Code	Recommended site management priority rank during wet weather, based on water quality (Also see Table 9)	Recommended site management priority rank during dry weather, based on water quality (Also see Table 10)	Reference sections in this report for recognized NPS contribution areas
Brockton	Trout Brook	TB3	1	4	Pg. 55 Section 3.2.2.2.5; Points 33, 34, 35-Figure B-2, Photo 38-Appendix B
Brockton	Trout Brook	TB4	19	18	Pg. 55 Section 3.2.2.2.5 Points 36, 37, 38, 39-Figure B-2, Photos 39 and 40 Appendix B
Brockton	Lovett Brook	LB1	13	21	Pg. 60 Section 3.2.2.3.5 Points 42 and 43-Figure B-2, Photos 41- 43 Appendix B
Brockton	Salisbury Brook	SB1	16	6	Pg. 65 Section 3.2.2.4.5 Points 44 and 45-Figure B-2, Photos 44-46 Appendix B
Brockton	Salisbury Brook	SB2	10	1	Pg. 65 Section 3.2.2.4.5 Points 46 and 47-Figure B-2, Photos 47-49 Appendix B
Brockton	Salisbury Brook	SB3	5	23	Pg. 65 Section 3.2.2.4.5 Points 48, 49, 50-Figure B-2, Photos 50-51 Appendix B
Brockton	Salisbury Brook	SB4	17	20	Pg. 65 Section 3.2.2.4.5 Point 51-Figure B-2, Photos 52-53 Appendix B

Town	Waterbody	Site Code	Recommended site management priority rank during wet weather, based on water quality (Also see Table 9)	Recommended site management priority rank during dry weather, based on water quality (Also see Table 10)	Reference sections in this report for recognized NPS contribution areas
Brockton	Salisbury Brook	SB5	6	15	Pg. 65 Section 3.2.2.4.5 Points 52, 53, and 54-Figure B-2, Photos 54-55 Appendix B
Brockton	Searles Brook	SEB1	2	16	Pg. 73 Section 3.2.2.5.5 Points 55, 56, 57 and 58-Figure B-2, Photos 56-58 Appendix B
Brockton	Searles Brook	SEB2	1	17	Pg. 73 Section 3.2.2.5.5 Point 59-Figure B-2, Photos 59-60 Appendix B
Brockton	Malfardar Brook	MAB1	24	12	Pg. 76 Section 3.2.2.6.5 Points 60 and 61-Figure B-2, Photos 61-63 Appendix B
Brockton	Cary Brook	CB1	9	3	Pg. 79 Section 3.2.2.7.5 Point 62-Figure B-2, Photo 64 Appendix B
Brockton	Cary Brook	CB2	11	4	Pg. 79 Section 3.2.2.7.5 Photo 65 Appendix B
Brockton	Salisbury Plain River	SPR2	18	13	Pg. 84 Section 3.2.2.8.5 Points 65, 66 and 67 Figure B-2, Photos 68-69 Appendix B

Town	Waterbody	Site Code	Recommended site management priority rank during wet weather, based on water quality (Also see Table 9)	Recommended site management priority rank during dry weather, based on water quality (Also see Table 10)	Reference sections in this report for recognized NPS contribution areas
Brockton	Salisbury Plain River	SPR3	14	9	Pg. 84 Section 3.2.2.8.5 Points 68 and 69- Figure B-2, Photo 70 Appendix B
East Bridgewater	Meadow Brook	MB1	27	10	Pg. 34 Section 3.2.1.3.5 Points 17, 18 and 19- Figure B-1, Photos 18-20 Appendix B
East Bridgewater	Satucket River	SR1	23	17	Pg. 37 Section 3.2.1.4.5 Points 21 and 21- Figure B-1, Photo 21 Appendix B
East Bridgewater	Spring Street Tributary	SST1	22	25	Pg. 42 Section 3.2.1.5.5 Photos 22-23 Appendix B
East Bridgewater	Westdale Tributary	WT1	22	25	Pg. 45 Section 3.2.1.6.5 Points 22 and 23- Figure B-1, Photos 24-25 Appendix B
East Bridgewater	Matfield River	MR2	4	2	Section 3.2.1.7.5 Points 24 and 25- Figure B-1, Photos 28-29 Appendix B
East Bridgewater	Matfield River	MR3	12	8	Section 3.2.1.7.5 Point 23- Figure B-1, Photos 30-31 Appendix B

Town	Waterbody	Site Code	Recommended site management priority rank during wet weather, based on water quality (Also see Table 9)	Recommended site management priority rank during dry weather, based on water quality (Also see Table 10)	Reference sections in this report for recognized NPS contribution areas
Holbrook	Beaver Brook	BB3	8	14	Pg. 25 Section 3.2.1.1.5 Points 1 and 2-Figure B-1, Photos 3 - 6-Appendix B
West Bridgewater	Salisbury Plain River	SPR1	7	4	Pg. 84 Section 3.2.2.8.5 Points 63 and 64-Figure X, Photos 66-67 Appendix X
Whitman	Shumatuscacant River	SHR1	26	17	Pg. 29 Section 3.2.1.2.5 Point 3-Figure B-1, Photos 7-8 Appendix 2
Whitman	Shumatuscacant River	SHR3	8	24	Pg. 29 Section 3.2.1.2.5 Points 6, 7, 8, 9, 10-Figure B-1, Photos 11-14 Appendix 2
Whitman	Shumatuscacant River	SHR4	20	19	Pg. 29 Section 3.2.1.2.5 Points 11, 12, 13, 14, 15, 16-Figure B-1, Photos 15-17 Appendix 2

3.3.3 NPS Management Recommendations by Town

3.3.3.1 Stormwater Outfall Identification

Storm drain outfalls have not been identified for the full length of any of the rivers in the study area. Identifying the location of stormwater drains with direct discharges into these rivers and prioritizing problem areas through sampling and/or sight inspection will allow the towns to pursue funding opportunities to address nonpoint source pollutants. Several storm drains were identified through site visits and are incorporated into Figure B-2.

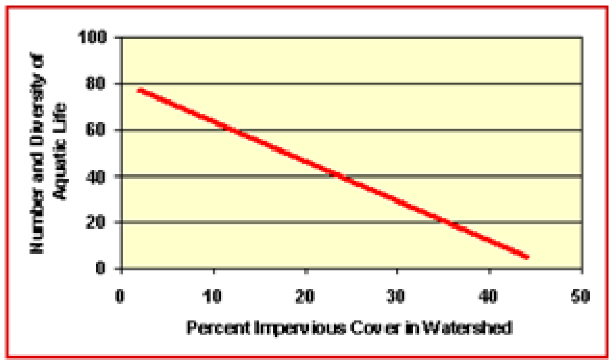
All of the towns in the Matfield and Salisbury Plain watersheds need to identify where stormwater outfalls occur to the tributaries and mainstems of the watersheds so that BMPs can be developed to address those areas listed as impaired by the State.

3.3.3.2 Stormwater Treatment/Sediment Removal

Many areas within the Study area have stormwater and sedimentation problems which were identified during field reconnaissance for water quality sampling, town site visits, and water quality reports. These sites are problem areas that should be considered for stormwater and sediment structural BMPs either because of the size of the areas they drain, the land uses they are draining, and/or the resources they are draining to. In most cases these resources are small streams that feed the main tributaries to the rivers in the Matfield and Salsibury Plain watersheds.

Because choosing a structural BMP is dependent on the characteristics of the site, it would be helpful to the communities to have a reconnaissance study completed of the stormwater problems identified in this report. The reconnaissance study could list the factors needed to determine an appropriate BMP including such physical constraints as soil conditions, watershed size, depth to water table, depth to bedrock and slope, etc.

3.3.3.3 Removal of Impervious Surfaces



Permeable pavements can be an effective means of reducing the area of imperviousness in a watershed. In cases where a community is close to full development and in urban areas, removal of impervious surfaces and replacement with permeable pavement can be a solution to stormwater runoff problems. The Center for Watershed Protection notes that porous pavements (including permeable asphalt mixes and pavers) are best suited for low traffic areas, such as parking lots and sidewalks and that the most successful use of permeable pavements are found in areas with sandy soils and flatter slopes (Center for Watershed Protection, 1998). Permeable pavements allow stormwater to infiltrate into underlying soils promoting pollutant treatment and recharge, reducing the amount of stormwater and overland runoff to drainage systems that discharge into streams and wetlands. Costs for paving blocks and stones range from $2 to $4, whereas asphalt costs $0.50 to $1 (Center for Watershed Protection, 1998). Municipalities that have extensive areas of commercial land use where parking lots and large buildings create overland runoff would benefit from requiring new development and renovations to utilize pervious surface materials where appropriate.

All the towns that make up the river basins for the Matfield and Salisbury Plain watersheds contain some land that has greater than 10% imperviousness.

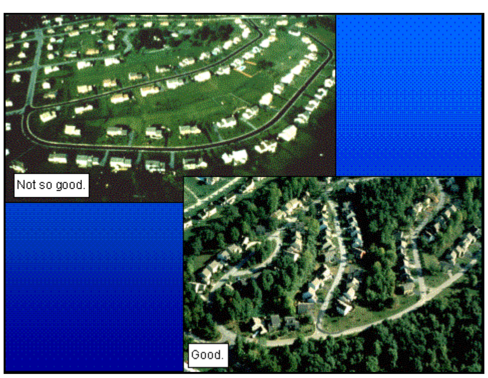
3.3.3.4 Remove Hardened Shorelines and Channelized Stream Segments and Replace with Vegetated Buffers

There is a significant amount of shoreline in the Matfield and Salisbury Plain watersheds (especially the municipality of Brockton), where the river banks were historically hardened with concrete and other materials to extend usable land and/or to control erosion due to vegetation removal. Other areas of the river are channelized where there was an attempt to straighten the river or alter its course permanently by controlling the movement of the natural channel with concrete or other permanent structures. A comprehensive study of riparian areas should be completed to estimate the total amount of channelization/hardened shoreline, what type of materials are present, adjacent land uses, critical resources, options for removal and restoration and identification of riparian areas that should be preserved through state and local conservation.

When river and stream banks are hardened, nonpoint source pollution from roadways, parking lots and adjacent development goes directly into the river untreated. Replacing hardened shorelines with vegetated buffers will restore the natural removal of pollutants so that excess nutrients, sediment and other pollutants carried along in runoff from adjacent development will be absorbed. In addition to the benefits of limiting the impacts of nonpoint source pollution, restoring riparian areas has flood retention and wildlife habitat benefits.

3.3.3.5 Adopt Wastewater Management District/Regulations

Establishing wastewater management districts through a town ordinance can ensure the proper function and maintenance of septic systems, and for certain resource areas, require alternative designs and construction features that will reduce pollutant inputs to groundwater. If properly developed and enforced, wastewater management districts can help to maintain property values and preserve and improve the quality of valuable ground and surface water resources (Dillmann, 1999). The towns of the study area, perhaps with the exception of Brockton, could potentially benefit from wastewater management districts because of the presence of failing septic systems, high groundwater tables, poorly drained soils and location within the drinking water aquifers. Areas where wastewater management districts would benefit specific towns are in many cases the areas that are not already sewered, or have already been identified by the towns as problem areas needing to be sewered. Some of these areas are listed below by city/town.



22 Design Principles that Reduce the Environmental Effects of Residential and Commercial Development

Builders for the Bay – Center for Watershed Protection

The twenty-two model development principles listed below provide design guidance for economically viable, yet environmentally sensitive development. These principles provide planners, developers, and local officials with benchmarks to investigate where existing ordinances may be modified to reduce impervious cover, conserve natural areas, and prevent stormwater pollution. These development principles are not national design standards. Instead, they identify areas where existing codes and standards can be changed to better protect streams, lakes and wetlands at the local level. The development principles are divided into the three following areas:

- Residential Streets and Parking Lots (Habitat for Cars)
- Lot Development (Habitat for People)
- Conservation of Natural Areas (Habitat for Nature)

Each principle is presented as a simplified design objective. Actual techniques for achieving the principle should be based on local conditions. A Technical Support Document and model ordinances are available for more detailed rationale for each principle at http://www.cwp.org/22_principles.htm.

Residential Streets and Parking Lots (Habitat for Cars)

1. Design residential streets for the minimum required pavement width needed to support travel lanes; on-street parking; and emergency, maintenance, and service vehicle access. These widths should be based on traffic volume.
2. Reduce the total length of residential streets by examining alternative street layouts to determine the best option for increasing the number of homes per unit length.
3. Wherever possible, residential street right-of-way widths should reflect the minimum required to accommodate the travel-way, the sidewalk, and vegetated open channels. Utilities and storm drains should be located within the pavement section of the right-of-way wherever feasible.
4. Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.
5. Where density, topography, soils, and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff.
6. The required parking ratio governing a particular land use or activity should be enforced as both a maximum and a minimum in order to curb excess parking space construction. Existing parking ratios should be reviewed for conformance taking into account local and national experience to see if lower ratios are warranted and feasible.
7. Parking codes should be revised to lower parking requirements where mass transit is available or enforceable shared parking arrangements are made.
8. Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in spillover parking areas where possible.
9. Provide meaningful incentives to encourage structured and shared parking to make it more economically viable.

10. more economically viable.
11. Wherever possible, provide stormwater treatment for parking lot runoff using bioretention areas, filter strips, and/or other practices that can be integrated into required landscaping areas and traffic islands.

Lot Development (Habitat for People)

12. Advocate open space design development incorporating smaller lot sizes to minimize total impervious area, reduce total construction costs, conserve natural areas, provide community recreational space, and promote watershed protection.
13. Relax side yard setbacks and allow narrower frontages to reduce total road length in the community and overall site imperviousness. Relax front setback requirements to minimize driveway lengths and reduce overall lot imperviousness.
14. Promote more flexible design standards for residential subdivision sidewalks. Where practical, consider locating sidewalks on only one side of the street and providing common walkways linking pedestrian areas.
15. Reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together.
16. Clearly specify how community open space will be managed and designate a sustainable legal entity responsible for managing both natural and recreational open space.
17. Direct rooftop runoff to pervious areas such as yards, open channels, or vegetated areas and avoid routing rooftop runoff to the roadway and the stormwater conveyance system.

Conservation of Natural Areas (Habitat for Nature)

18. Create a variable width, naturally vegetated buffer system along all perennial streams that also encompasses critical environmental features such as the 100-year floodplain, steep slopes and freshwater wetlands.
19. The riparian stream buffer should be preserved or restored with native vegetation. The buffer system should be maintained through the plan review delineation, construction, and post-development stages.
20. Clearing and grading of forests and native vegetation at a site should be limited to the minimum amount needed to build lots, allow access, and provide fire protection. A fixed portion of any community open space should be managed as protected green space in a consolidated manner.
21. Conserve trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native plants. Wherever practical, manage community open space, street rights-of-way, parking lot islands, and other landscaped areas.
22. Incentives and flexibility in the form of density compensation, buffer averaging, property tax reduction, stormwater credits, and by-right open space development should be encouraged to promote conservation of stream buffers, forests, meadows, and other areas of environmental value. In addition, off-site mitigation consistent with locally adopted watershed plans should be encouraged.
23. New stormwater outfalls should not discharge unmanaged stormwater into jurisdictional wetlands, sole-source aquifers, or sensitive areas.

Source:

Builders for the Bay, Center For Watershed Protection - http://www.cwp.org/builders_for_bay.htm

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3.3.3.6 Require Alternative Technologies for Septic Systems in Densely Developed Areas

Title 5 of the State Environmental Code, 310 CMR 15.000, imposes a nitrogen loading limitation of 440 gallons per day (gpd) per acre design flow for systems serving new construction in nitrogen sensitive areas and for new residential construction where the use of both on-site systems and on-site drinking water supply wells are proposed. These areas include Zone II areas, Interim Wellhead Protection Areas and nitrogen sensitive embayments. Many of the areas in the Study area are already densely developed and nitrogen loading to groundwater is occurring from existing septic systems. Local communities should consider adopting Title V regulations for failed septic systems that need to be replaced and other densely developed areas where private wells are the source of potable water areas in proximity to surface water resources. The towns and areas listed in Section 3.4 for Wastewater Management Districts should consider adopting the Title V requirements for problem areas.

3.3.3.7 Prioritize Areas for Septic Repairs/Alternative Technologies that Coincide with Water Resource/Aquifer Overlay Districts

All of the towns in the Study area have aquifer protection overlay districts and ordinances to protect their groundwater resources. New regulations could be added to these existing ordinances to require septic system pump-outs and alternative technologies in areas where there are poorly drained soils and high water tables. Areas within the watershed that use septic systems and have high groundwater tables and poorly drained soils should also be targeted.

3.3.3.8 Restore Vegetated Buffer Zones

Vegetated buffers can remove sediment and attached pollutants from surface water runoff. The effectiveness of vegetated buffers depends on a number of variables including soil type, water table depth, type of vegetation, land-use and drainage areas (Desbonnet et al. 1994). Vegetated buffers are required by many municipal and state authorities throughout the United States. They have

been applied as BMPs for forest and agricultural land uses since the 1950s to protect in-stream habitats from degradation from sediment and nutrients (Desbonnet et. al. 1994). Avon, Abington, East Bridgewater, West Bridgewater, Brockton, and Whitman have vegetated buffer requirements of at least 25 feet. Each of the town Conservation Commissions has provisions to require wider vegetated buffers depending on the resources present.

More specific requirements for vegetated buffer sizes could be required by the municipalities that have Wetland Protection By-laws as a standard in their regulations. For instance, when there are steep slopes and/or erodible soils within close proximity to the stream. Different methods may be used to adjust buffer width for steep slopes including basing the width of the buffer on the % of slope and the type of stream use as follows:

% Slope	Width of Buffer
15%-17%	add 10 feet
18%-20%	add 30 feet
21%-23%	add 50 feet
24%-25%	add 60 feet

% Slope	Type of Stream Use	
	Water Contact Recreational Use	Sensitive Stream Habitat
0 to 14%	no change	add 50 feet
15 to 25%	add 25 feet	add 75 feet
Greater than 25%	add 50 feet	add 100 feet

(Stormwater Manager's Resource Center, Model Ordinance)

Other considerations include the following:

- Slopes exceed ten (10) % within five hundred (500) feet of the streams, wetlands, or waterbodies;

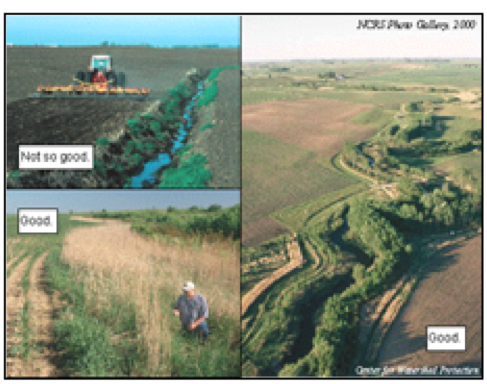
- Soil erodibility K values exceed .24 within five hundred (500) feet of the streams, wetlands, or waterbodies; or
- The vegetative cover within one hundred (100) feet of the streams, wetlands, or waterbodies is: bare soil; fallow land; crops; active pasture in poor or fair condition; orchard-tree farm in poor or fair condition; brush-weeds in poor condition; or woods in poor condition. (Baltimore County, MD, Buffer Protection and Management Ordinance, Environmental Protection and Resource Management)

The municipalities in the study area that do not have wetland protection by-laws would benefit from adopting vegetated buffer requirements in riverine, stream, lacustrine and estuarine adjacent areas. Vegetated buffers could also be installed in more developed urban areas adjacent to these resource areas where renovations and Brownfield developments are planned. Some of these areas were identified through the discussions with the municipal authorities and are highlighted above.

The benefits of vegetated buffers include sediment removal, erosion control, flood retention, pollutant removal from stormwater and overland flow (including oil, detergents, pesticides, herbicides, insecticides, wood preservatives and other domestic chemicals), and absorbing nutrients (particularly nitrogen) from surface water runoff and groundwater flow (RICRMP, 1994).

3.3.3.9 Agricultural Land Use Best Management Practices

Agricultural lands have the potential to produce nonpoint sources of pollution through runoff of fertilizers and pesticides and also animal manure. Since many New England farms are sited on tributaries of the rivers that feed estuaries, it is important that BMPs for vegetation buffer zones, animal waste management and fertilizer and pesticide control are observed. There are many resources provided through federal and state agencies for agricultural BMPs, there is also technical assistance provided by the US Department of Agriculture through the Natural Resources Conservation Service (NRCS). These programs include the Wildlife Habitat Incentives Program and the Environmental Quality Incentives Program which provide funding to existing and historical farmlands to protect water quality and improve wildlife habitat. The Wetlands Reserve Program is another program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The NRCS provides technical and financial support to help landowners with all three programs. More information on these programs is available on the



internet at http://www.nrcs.usda.gov/.

The municipalities of East Bridgewater and Whitman have farms that support animals including cows, and horses. Checks should be made to see if any of these farms include tributaries that are not fenced off from animals, lack vegetated buffer zones, and/or have erosion problems. Three areas these municipalities can focus on to improve water quality include: 1) vegetation and erosion management, 2) restricting animal access to the River, and 3) animal waste management.

Vegetation Management
Maintenance of vegetated buffer zones along the banks of waterways at the edges of crop land and grazing pastures is essential. At the edges of the crop lands, the vegetation helps to absorb nutrients (fertilizers and pesticides) from fields. At the edges of grazing pastures, along waterways, the vegetation provides a natural barrier to minimize the possibility of grazing animals from wading into the watercourse. For both crop land and grazing fields, the vegetation reduces the potential of bank erosion caused by fast-flowing water and/or trampling of the banks by animals. Different methods may be used to adjust buffer width for steep slopes including basing the width of the buffer on the % of slope and the type of stream use as specified in Section 3.3.2.8.

Waste Management
Fencing to keep farm animals out of the River will help to limit the amount of direct contributions of animal wastes entering the water column. Animal wastes can also be collected in storage or treatment impoundments outside of the riparian zone.

3.3.3.10 Community Outreach Programs

As discussed above, community outreach programs should be targeted to those areas requiring septic system maintenance, increased vegetated buffers, and mitigation for stormwater impacts from commercial, industrial, and residential land uses. These areas are documented above, and community outreach in the form of informational consultations with individual property owners, meetings and workshops, and brochures should be undertaken.

4.0 DISCUSSION

Although a great number of potential sources of NPS were identified in this study, it will be important for watershed stakeholders and managers to focus their attention on fixing those that will have the greatest benefit to the interests of both wildlife and humans using the study area. This report provides the basis for moving ahead with mitigation and restoration projects that will hopefully reduce NPS pollution, improve water quality, and enhance opportunities for boating, fishing, and swimming in the rivers, streams, and ponds of the study area.

Several sub-basins in the Project watershed stand out as likely priority areas to address NPS pollution sources. These sub-basins tend to be located in the central western portion of the study area (i.e., the Salisbury Plain River watershed and, in particular, the City of Brockton), where there is dense residential, commercial, and industrial development; major roads and highways are present; extensive channel alteration is common place; extensive impervious areas dominate the sub-basins; numerous examples of flooding and stormwater control problems exist; roof runoff is an issue; there are potential sources of wastewater entering the streams caused by defects in sewage systems; the sub-basins golf courses and the waterfowl that frequent them are present; and stream channels are less buffered by forested and otherwise vegetated zones than they are in other parts of the watershed. Based on the findings of this study, the following sub-basins should be the focus of future NPS abatement efforts: Trout Brook, Salisbury Brook, Searles Brook, Cary Brook, Salisbury Plain River, and the Matfield River. Watershed stewards may also want to focus growth management initiatives in the eastern portion of the study area, to prevent the degradation of areas that now appear to be functioning relatively well.

In the Salisbury Plain River watershed, development densities are very high in many areas and vegetative buffers and natural stream banks are generally narrow and provide little pollutant removal capacity. These areas may benefit more from structural or end-of-pipe BMPs such as on-site detention with engineered soils and plantations, specialized catch basins that remove nutrients and TSS, and constructed wetlands that can also help address bacterial inputs. Stream bank restoration is also an option in areas that are currently channelized but for which hard walls are not required for flood and erosion control.

Structural or end-of-pipe BMPs such as specialized catch basins are recommended for the Salisbury Plain River watershed and other less densely developed portions of the study area in the Matfield River watershed. Stream bank, riparian wetland, and floodplain restoration would also be appropriate in the urbanized parts of the Salisbury Plain and Matfield river watersheds. Structural BMPs, although often cost intensive, may be appropriate for large areas of imperviousness whose runoff cannot otherwise be addressed, although additional street cleaning could also help with stormwater runoff issues. Further investigation into possible illicit connections and/or leaks in sewage system (especially in Brockton) and correction of these issues is also recommended. Throughout the study area, public education about the importance of NPS pollution prevention, especially pet waste management, would greatly increase the likelihood of reducing existing pollutant loads in study area waterbodies. A watershed-wide program targeted to the kinds of issues found in the study area would certainly have positive results.

If meaningful NPS pollution reductions are to be made, it will be important for communities in the study area, working in partnership with government agencies such as the MADEP and Massachusetts Department of Food and Agriculture and non-profit organizations such as the Taunton River Watershed

Association, to identify and seek support for the priority recommendations for reducing NPS pollution identified in this report.

5.0 REFERENCES

Baltimore County, MD, Buffer Protection and Management Ordinance, Environmental Protection and Resource Management, Baltimore, MD.

Canavan and Siver, 1995. *Connecticut Lakes: A Study of the Chemical and Physical Properties of Fifty-six Connecticut Lakes*.

Center For Watershed Protection, 1998. Better Site Design: A Handbook for ChangingDevelopment rules in Your Community.

Desbonnet, Alan, Pam Pogue, Virginia Lee and Nicholas Wolff, 1994, Vegetated Buffers in the Coastal Zone: A Summary Review and Bibliography, URI Coastal Resources Center, Narragansett, RI.

Dillmann, Brenda Asher, Town of Charlestown On-Site Wastewater Management Plan, 1999, Town of Charlestown, RI.

EPA, 2000. *Ambient Water Quality Criteria Recommendations, Rivers and Streams in Aggregate Nutrient Ecosystem XIV*.

ESS, 2002. *Quality Assurance Project Plan for the Matfield River Sub-Watershed Stormwater Assessment and Plan*. ESS Group, Inc., Wellesley, MA.

MADEP, 1999. Final Massachusetts Section 303(d) List of Waters 1998. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA.

MADEP, 1998. Massachusetts Surface Water Quality Standards. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA.

National Climatic Data Center, 2001. Daily surface data. http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwAW~MP.

RICRMC, 1994. Rhode Island Coastal Resources Management Council, State of Rhode Island Coastal Resources Management Program, As Amended, Wakefield, RI.