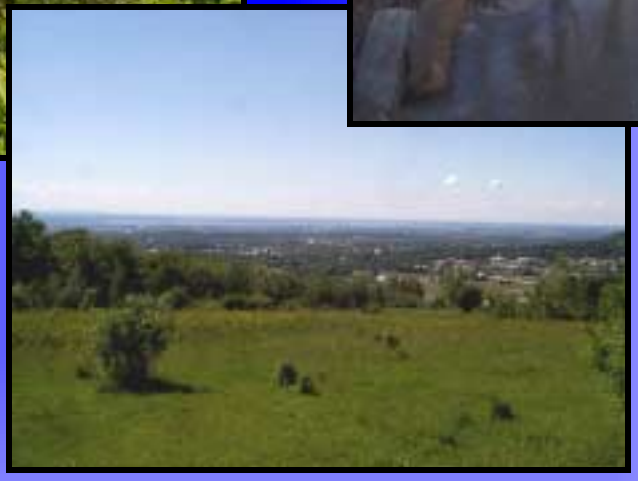
Watershed Study Report

Stevens Brook & Rugg Brook

Prepared for the

City of St. Albans, Town of St. Albans, Town of Georgia & Town of Swanton



Prepared by:

DuBois & King inc.

July 11, 2003

STEVENS/RUGG BROOKS
WATERSHED STUDY REPORT

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

1.0 INTRODUCTION

This engineering report presents the results of an investigation of the Stevens Brook and the Rugg Brook watershed. The investigation addresses long-standing concerns regarding flooding and flood-related damages as well as impaired water quality within the floodplain of these two brooks.

Primary components of this report identify and document problems within the watershed; and develop specific recommendations for implementation measures to address the problems.

The report is organized to present a background discussion on historical issues, a statement of objectives and goals, and the study methodology. The following are the results of this investigation.

1.1 Background

Stevens Brook and Rugg Brook are two separate perennial streams that flow through the Town of St. Albans and the City of St. Albans. In addition, the Stevens Brook flows through the southern corner of the Town of Swanton, near Exit 20 on Interstate 89. Rugg Brook also flows through a portion of the Town of Georgia, Vermont.

Flooding of the Collins-Perley Sports Complex on June 5, 2002.

Stevens Brook discharges into the St. Albans Bay, Lake Champlain. Rugg Brook discharges into Mill Brook, which then discharges into the St. Albans Bay. The total drainage area of the Stevens Brook, at its confluence is approximately 14.3 square miles. The total drainage area of Rugg Brook at its confluence with Mill Brook is approximately 6.4 square miles. The location of these streams, along with their respective watershed drainage boundary is illustrated on Figure 1 on page 4.

These streams are relatively small in size, and the drainage area of each one is approximately three square miles in the areas where much of the flood damages occur, notably near the western City limits. Despite this small size, there is a long history of flooding and flood related damages along their floodplain corridors. Indeed, significant out-of-bank flooding occurred several times in June 2002.

There is also a growing concern with the water quality of these two streams. Stormwater runoff, which transports many types of pollutants from the surrounding watershed, has degraded the water quality to the point where the streams are now included on the State of Vermont, Department of Environmental Conservation's (VT DEC) 303d list of impaired waters. Table 3

in Section 1.6 of this report provides detail regarding pollution type and extent of the impaired waters.

To address the two issues of flooding and water quality facing property owners within the watershed, the Northwest Regional Planning Commission (NRPC), in partnership with the City of St. Albans (City), Town of St. Albans, Town of Georgia, and Town of Swanton (Towns) initiated a study of the watershed. The objectives and goals of this study are expressed in detail later in this report, but as indicated previously, the primary purpose is to:

- Identify watershed problems and
- Identify implementation measures

The NRPC retained the professional services of DuBois & King, Inc., a consulting engineering firm in Randolph, Vermont, to assist with the development of this study and prepare the engineering report. DuBois & King's role is to provide the lead planning and engineering services associated with this project. Jeffrey W. Tucker, P.E., was the principal watershed investigator and prmiary author of this report on behalf of DuBois & King.

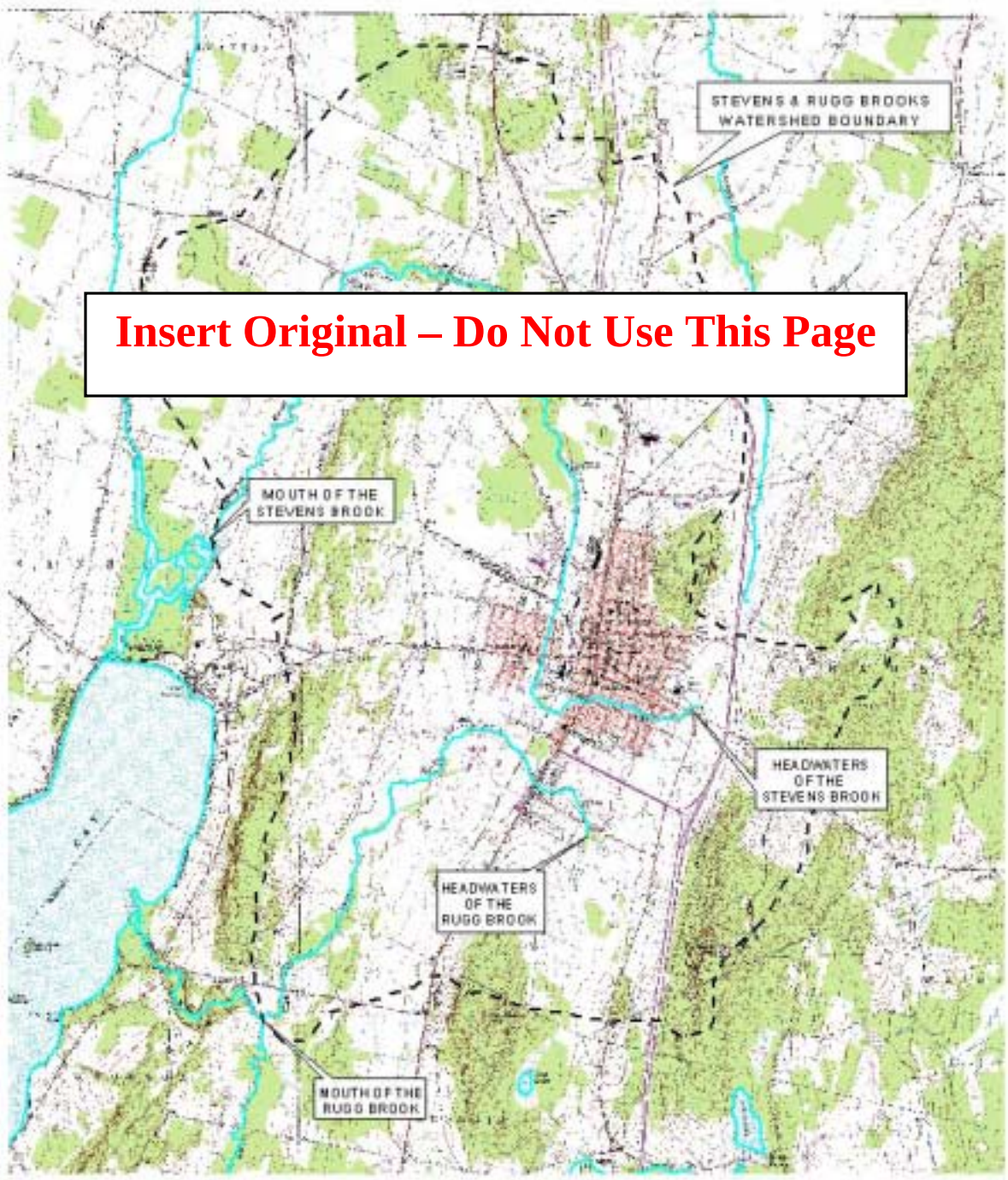
A Steering Committee was formed at the beginning of this project to provide support and overall guidance to the technical team. The role and function of the committee is discussed in greater detail in Section 3.1 of this report. Additional technical support and historical insight was provided by a number of individuals from several state and federal agencies. They include representatives from the Vermont Agency of Natural Resources (VANR) and the United States Department of Agricultural, Natural Resources Conservation Service (NRCS).

A special Thank-You is extended to each of the people who volunteered their time in the advancement of this project. The following table shows the names of the people who served on the Steering Committee.

Table 1
Steering Committee Members

Name	Organization	Title
Karen Bates	VT Dept. of Environmental Conservation	Watershed Coordinator
Jeff Bean	Mapmaker Photogrammetric Services	Owner
Dick Benoit	St. Albans City	Resident
Leon Berthiaume	St. Albans Cooperative Creamery	Manager
Jack Brigham	Farmer & Selectboard Member	Town of St. Albans
Chris Brunelle	VT Dept. of Environmental Conservation	River Management Program
Connie Burns	USDA Rural Development	
Barry Cahoon	VT Dept. of Environmental Conservation	Director, River Management Program
Fred Campbell	Town of Georgia Conservation Commission	
Bill Cioffi	City of St. Albans	Manager & Resident
Rick Hopkins	VT Dept. of Environmental Conservation	Director, Water Quality Division
Dave Hoyt	USDA Natural Resources Conservation Service	District Conservationist
Bob Johnson	Town of St. Albans	Select Board Member
Dave Kimel	Collins Perley Sports Center	Manager
Jane Kiser	City of St. Albans	Community Development Director
Kathy Lavoie	State of Vermont & Town of Swanton	State Representative & Planning Commission
Dan Lindley	Town of St. Albans	Town Administrator
Miranda Lescaze	Lake Champlain Basin Program	Technical Coordinator
Angela Magara	Vermont Emergency Management	State Hazard Mitigation Officer
Mitch Montagne	Town of St. Albans	Farmer & Planning Commission
Gil Newbury	Vermont Agency of Transportation	District 8 Transportation Administrator
William Nihan	Town of St. Albans	Planning Commission and Select Board
Jim Pease	VT Dept. of Environmental Conservation	Water Quality Division
Staci Pomeroy	VT Dept. of Environmental Conservation & Town of Georgia	Water Quality Division & Conservation Commission
Cindy Rutkowski	St. Albans City	Resident
Brian Searles	City of St. Albans	City Manager
Tim Smith	Franklin County Industrial Development Corporation	Executive Director
Dick Thompson	Town of Swanton	Town Administrator
Bonnie Waninger	Northwest Regional Planning Commission	Special Project Planner
Doug Williams	Town of Georgia	Town Administrator

Figure 1
Site Location Map



1.2 Purpose of Watershed Assessment

Historical development in the Stevens Brook and Rugg Brook watersheds has largely occurred on an individual basis, without the benefit of long-term planning and coordination. The effect of this development has been significant and has resulted in continued problems in many areas of the watershed. These problems can be seen in terms of:

- flooding
- flood damages
- threats to people and property

In addition, there has been severe environmental degradation to the riverine system and the aquatic habitat. Much of this degradation is a result of uncoordinated development in the watershed, which has resulted in a significant change in the hydrology and pollution filtering capacity.

The problems within the watershed are interrelated and historical. The short and long-term solutions require an integrated, consensus based approach. One of the first steps in addressing the problems is to identify and evaluate them on a watershed-wide basis and to identify the inter-relationships between those problems. Implementation solutions can then be developed to address specific problems, but with regard to its potential impacts on other areas of the watershed.

One of the first steps in addressing the problems is to identify and evaluate them on a watershed-wide basis and to identify the inter-relationships between those problems.

The Watershed Improvements Implementation Plan developed by this study will assist in resolving flooding and water quality problems and preserve community vitality within the watershed.

The primary purpose of this study is to evaluate the causes, effects, and extents of flooding and water quality issues within the Stevens and Rugg Brook watershed, and to develop viable solutions to these issues. The culmination of this study is the presentation of a Watershed Improvements Implementation Plan.

1.3 OBJECTIVES AND GOALS STATEMENT

The primary objective of this study is to define watershed problems and identify implementable solutions that can be used by the communities to address and correct the problems. The first step is to clearly define the goals and objectives of this study. The communities, along with support from the state and regional officials, have established the following objectives and goals:

1.3.1 Objectives

1. Identify, assess and document the causes and effects of current water resource problems in the Stevens and Rugg Brooks.

2. Identify, assess and document Watershed Implementation Measures which address and correct these causes, and which restore and repair the effects.

3. Identify the interrelationships between the implementation measures.

4. Provide opportunity for the public to provide input on this project.

1.3.2 Goals

1. Create public awareness and education of the problems within the watershed.

2. Initiate meaningful discussion at the community level regarding a short and long-term vision (goals and objectives) of how the watershed should function.

3. Create public interest and involvement in the identification of opportunities to correct the problems.

Create a Watershed Implementation Plan that can be used by City and Town officials for prioritization of watershed management and planning.

One important objective is to educate people of the direct relationship between land use activities throughout the watershed and the flooding and water quality responses that exist in the brooks.

1.4 Watershed Description

The following is a description of the watershed for the Stevens and Rugg Brooks:

1.4.1 Stevens Brook

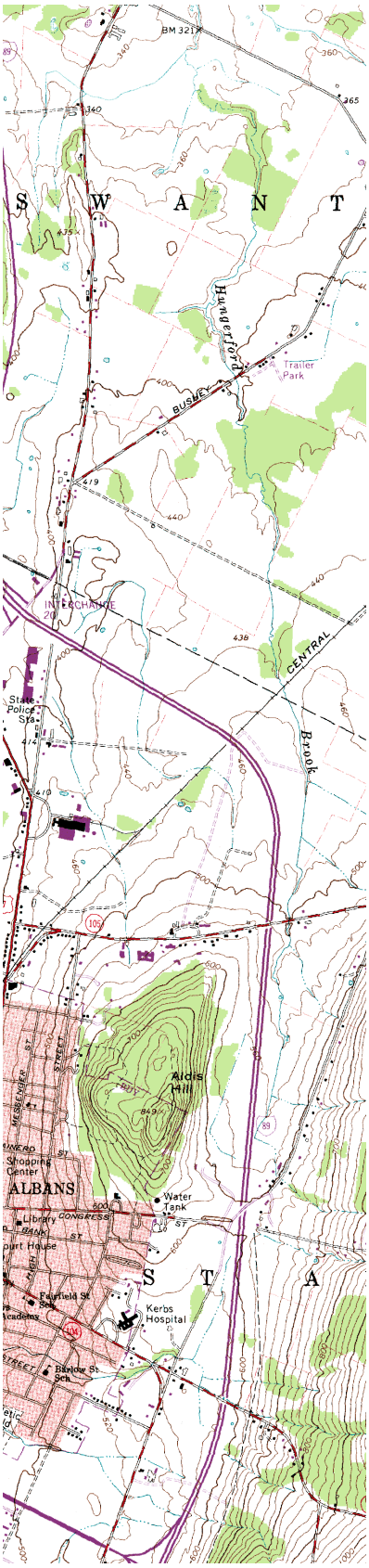
Stevens Brook Headwaters:

The Stevens Brook headwaters originate along the ridgeline located east of Interstate 89. The peak hilltop in this area is known locally as French Hill, with an approximate elevation of 1,304 feet. Two (2) primary channels convey runoff from French Hill, the main stem of Stevens Brook, and Grice Brook. Grice Brook is an intermittent tributary of Stevens Brook. VT Route 36 extends east to west through this area and approximates the divide between the upper portion of the Stevens Brook and the Grice Brook drainage areas.

The land use throughout the headwaters of the Stevens Brook is predominately rural, with some residential housing and supporting roadways. The majority of this area is wooded with some open meadow. The topography is very steep, with an approximate slope of 18 percent. At the downstream border of the headwaters defined by I-89, there is a definitive change in the slope of the terrain.

The total drainage area of Stevens Brook at its primary crossing under I-89 is approximately 1.1 square miles. The Grice Brook drainage area at I-89 is 0.3 square miles (162 acres). Therefore, the total headwater drainage area is approximately 1.4 square miles, which is 9-percent of the overall drainage area of Stevens Brook at its mouth, the confluence with Jewett Brook.

Westerly view from upper watershed



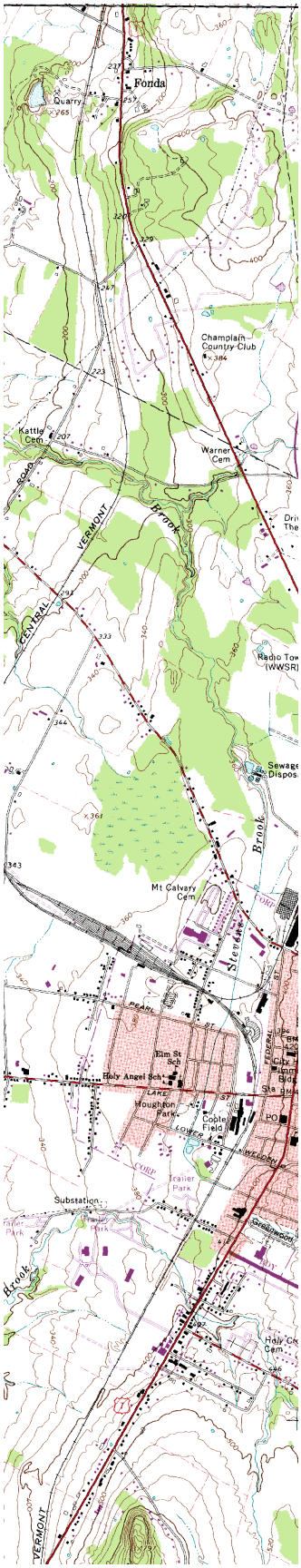
Stevens Brook Mid-watershed:

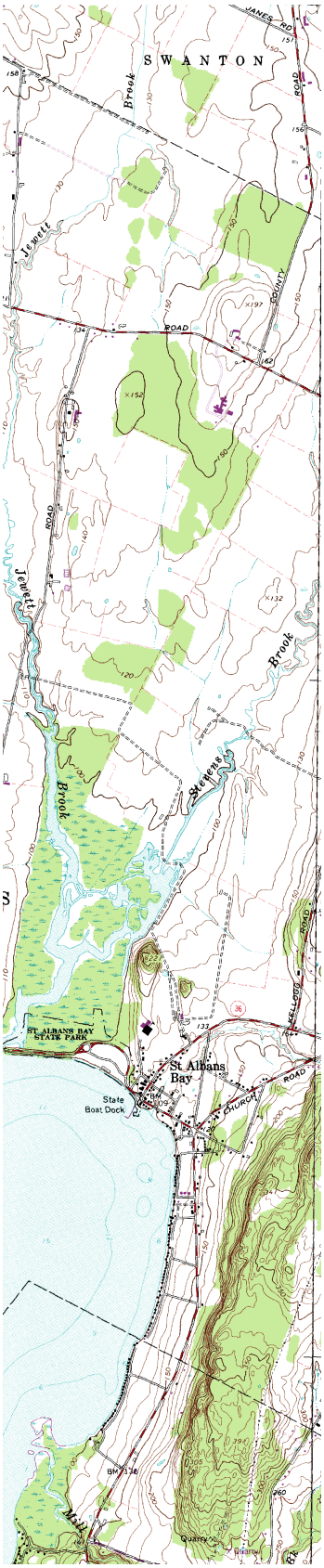
The middle section of the watershed is bounded at its upstream limit by I-89 and downstream near the St. Albans Wastewater Treatment Facility. The wastewater treatment facility is located on Rewes Road, north of the City of St. Albans limits. The vast majority of the City is located in this section of the Stevens Brook watershed. In addition, a portion of the Town of St. Albans, which is the area along the VT 104 corridor north of Exit 19 is also located within this section.

Typical developed area in the watershed.

The land use in the center section of the watershed is predominately urban. Medium to high-density residential development dominates the land use in the upstream (eastern) portion. Commercial and high-density residential land use exists from US 7 (Main Street) downstream to the wastewater treatment facility. The drainage area of Stevens Brook at Main Street is 1.8 square miles.

Also included in this section of the watershed are the lands of the Central Vermont Railroad. The railroad facilities included within this land are mainline railroad tracks, side yards, switching stations, turntables, the roundhouse, and areas for equipment and material storage. In total there are approximately five miles of railroad track within the drainage area of the Stevens and Rugg Brooks. Currently, there is an environmental remediation effort being conducted at the Central Vermont Rail Yard. The remediation efforts include a collection system comprised of drains, extraction wells, and an interception trench. The objective of this remediation system is to contain and remove the contamination while preventing it from entering the Stevens Brook. The environmental consulting engineer for Central Vermont Railroad prepares a quarterly report of the activities on the site during the previous quarter. The report discusses the volume and type of contaminant recovered on the site, as well as the maintenance and operation details for the remediation system. This report is available through the Vermont Agency of Natural Resources Solid Waste Division.





The wastewater treatment facility, located at the downstream limits of this section, processes approximately 20-million gallons of influent per day. The influent consists of a combination of sanitary wastewater from buildings, ground water infiltration into the collection lines and a portion of the stormwater collection system.

The total drainage area of Stevens Brook at the wastewater treatment facility is 3.9 square miles or approximately 2,500 acres. The Mid-watershed accounts for approximately 18-percent of the total drainage area of the Stevens Brook watershed.

Stevens Brook Lower-watershed:

The lower section of the watershed is the area located downstream of the City wastewater treatment facility. The land use is predominately agricultural, with a majority of the area used for active crop (hay, corn) fields and wood lots. Supporting infrastructure, such as roadways and low-density residential development is also located in the area. A higher density of development exists in St. Albans Bay, including the municipal offices, residences and public parks.

The topography is mild, with an average slope of less than 1-percent. The effect of the shallow slope on the stream's planform is evident by the number and frequency of meanders located in this section. In these meander sections, it is quite common for the stream to change course creating a new channel and abandoning a portion of the previously occupied channel.

Stevens Brook discharges into the marsh area that serves as the confluence of the Stevens and Jewett Brooks, approximately ½ mile upstream from the shoreline of St. Albans Bay. The marsh area and Jewett Brook were not included in this study, and therefore their drainage area is not included with the Stevens Brook drainage area. The drainage area of Stevens Brook at its mouth, upstream of the confluence of Jewett Brook, is approximately 14.3 square miles.

1.4.2 Rugg Brook

Rugg Brook Headwaters:

The Rugg Brook headwaters originate along the ridgeline located east of Interstate 89. The peak hilltop in this area is Bellevue Hill, at an elevation of 1,300 feet. Bellevue Hill is also the site of the former U.S. Air Force radar tracking facility. The headwaters extend from Bellevue Hill downstream slightly west of Interstate 89 to the housing development on Clyde Allen Drive.

Easterly view of the Rugg Brook headwaters. Note the Interstate in middleview and the abandoned radar station in the background.

There are two primary branches of the Rugg that convey runoff though the headwaters, which are referred to in this report as the North Branch and the South Branch. The North Branch collects drainage primarily from the area east of Exit 19 of I-89 and joins the South Branch at Clyde Allen Drive. The South Branch is comprised of several small tributaries originating on Bellevue Hill and the farmland located on the Town of St. Albans and Fairfield town lines.

The historical land use has been predominately agricultural. However, commercial and residential development has been rapidly expanding along VT 104, near Exit 19, and is significantly changing the land use. It is expected that within a few years, the predominate land use will be residential with supporting commercial facilities. The coverage in this area is a combination of woodland and open meadow, with scrub brush and active farming. The topography of the hillside east of I-89 is very steep, with an average slope of approximately 15-percent. The slope contributing farmland area along VT 104 is milder, with an approximate slope of less than 5-percent.

The drainage area of Rugg Brook at Clyde Allen Drive is 1.5 square miles or approximately 943 acres. The North Branch contributes 33-percent (311 acres) and the South Branch contributes the remaining 67-percent (632 acres). In total, the headwaters of the Rugg Brook account for 23-percent of the 6.4 square miles of the entire Rugg Brook watershed.

Rugg Mid-watershed:

The middle section of the watershed is bounded at its upstream limit at Clyde Allen Drive and downstream at the St. Albans Diversion Structure. The Diversion Structure is located on Nason Street south of the City of St. Albans limits. The Diversion Structure is a large earth cut and fill channel designed and built in the 1970's. The purpose and function of the Diversion Structure is to divert excess discharges from the Stevens Brook into the Rugg Brook to prevent flooding along the western portions of the City. Additional information on the diversion structure is discussed later in this Section.

The land use in the middle section of the watershed is dominated by commercial and medium to high-density residential development. Residential housing developments are located on the banks of the Rugg Brook throughout the majority of this section of the watershed. In addition, the Town of St. Albans Industrial Park is located in the middle section of the watershed. The industrial park includes the manufacturing and industrial facilities of companies such as Ben & Jerry's Homemade, Inc., Barry Callebaut, Peerless Clothing USA, Inc., and others.

The total drainage area of the Rugg Brook at the Diversion Structure is 2.9 square miles or approximately 1,858 acres. The drainage areas at several other points are tabulated below. This section accounts for approximately 45-percent of the total drainage area of the Stevens Brook watershed.

Rugg Lower-watershed:

The lower section of the watershed is the area located downstream of the Diversion Structure. The land use is predominately agricultural with a majority of the area active agricultural crop fields, with supporting infrastructure such as roadways and low-density residential development.

The topography is very mild, with an average slope of less than 1-percent. The shallow slope of the stream has a similar effect as on the Stevens Brook. Numerous meanders are located on this reach of the stream. In these meander sections, it is quite common for the stream to change course creating a new channel and abandoning a portion of the previously occupied channel.

Rugg Brook discharges into the Mill River, approximately two miles upstream from the shoreline of St. Albans Bay. The total drainage area of Rugg Brook at its mouth is approximately 6.4 square miles.

Table 2
Summary of Drainage Areas at Select Points Along the Stevens and Rugg Brooks

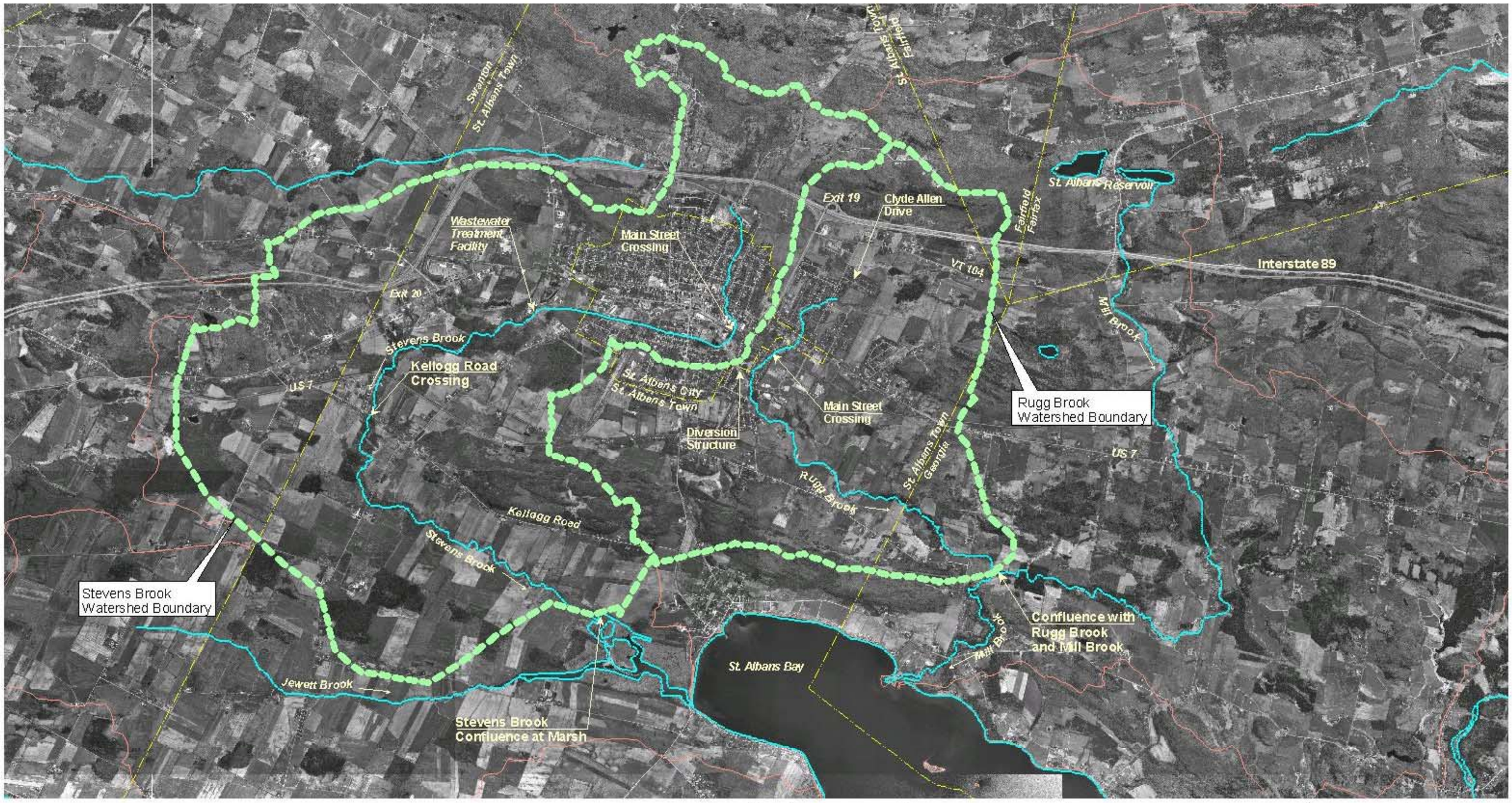
LOCATION	AREA (sq. mi)	LAND USE
Stevens Brook		
Interstate 89	1.1	Un-Developed Woodland & Meadow
VT Route 104	1.2	Agricultural
Quinton Court	1.5	Medium Density Residential & Commercial
Main Street	1.8	High Density Residential
Confluence of Grice Brook	2.4	Medium Density Residential & Commercial
Diversion Structure	2.5	Medium Density Residential & Commercial
Lower Newton Street	3.2	Medium Density Residential & Commercial
St. Albans WWTF	3.9	Agricultural
Kellogg Road	7.5	Agricultural
Mouth (St. Albans Marsh)	14.3	Agricultural
Rugg Brook		
Clyde Allen Drive	1.5	Medium Density Residential
Main Street	2.7	High Density Residential
Diversion Structure	2.9	Mix Residential & Commercial
Mouth (at Mill Brook)	6.4	Agricultural

1.5 Flooding History

There is a long history of flooding and flood related damages in the Stevens Brook floodplain corridor. As noted below, flooding and related damages were a significant enough issue over one hundred years ago, when in 1900, there was a State Legislative Action regarding the diversion of flood discharges from the Stevens into the Rugg Brook.

According to the City of St. Albans Flood Insurance Study dated December 1977, significant flooding occurs on average every 5 years. This report states that many areas in the residential section east of US 7 and the commercial section towards Newton Road are susceptible to flooding. A majority of the flooding was characterized as frequent out-of-bank flooding throughout the urban areas, associated with spring snowmelt and summer rainfall events. Larger, fluvial floods resulted in basement and first floor flooding of homes and businesses, inundation of local streets and roads, and washing out riverbanks and culverts.

Mr. William G. Cioffi, former St. Albans City Manager has indicated that the frequency of out-of-bank flooding appears to have increased significantly over time. Several examples that were cited include surcharging of the City-owned storm drain system has occurred approximately six times over the past 18-years, resulting in localized flooding. Recent storm events that resulted in significant flooding in the City include the 1998 ice storm event and the June 2002 fluvial event.



N

DATA SOURCES:
All data from VCGI except as noted.
NAD 1983 - VT State Plane Meters

0 4000 Feet

DuBois & King inc.
engineering planning management development

STEVENS AND RUGG BROOKS WATERSHED STUDY

NORTHWEST REGIONAL PLANNING COMMISSION

WATERSHED BOUNDARY MAP

DRAWN BY: JDT	DATE: 07/16/03
CHECKED BY: JWT	PROJECT NO. R17853
PROJ. ENG. SRP	SCALE: 1"=4000'

The precipitation which occurred during the June 11–12 storm event was measured to be 4.33-inches of rainfall. A 2.91-inch rainfall preceded this the week before on June 5, 2002. The June 11 – 12 storm was estimated to be between the 30-year and 40-year rainfall recurrence frequency, resulted in flood damages throughout the City and portions of the Town of St. Albans. The two adjacent graphs illustrate the temporal distribution of the rainfall.

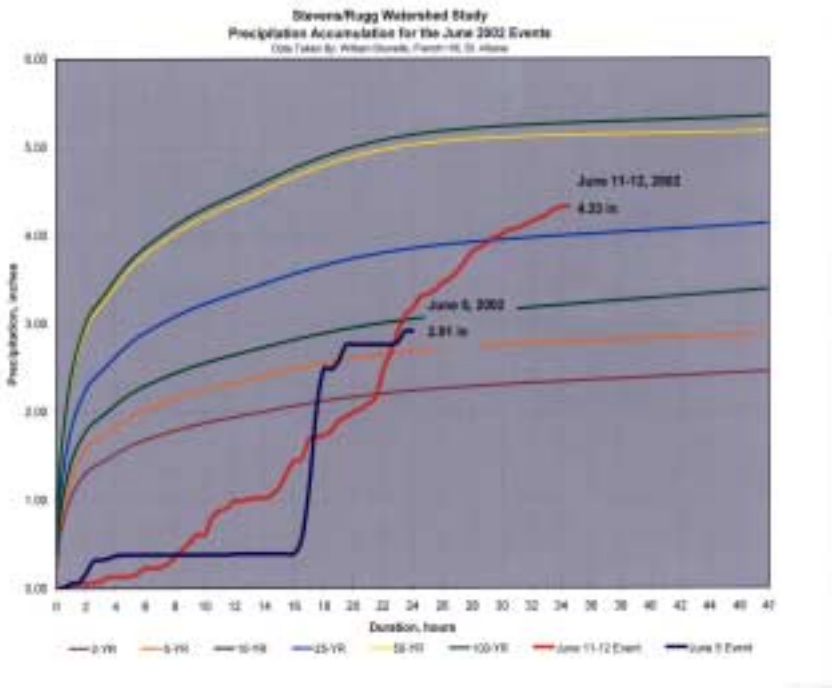
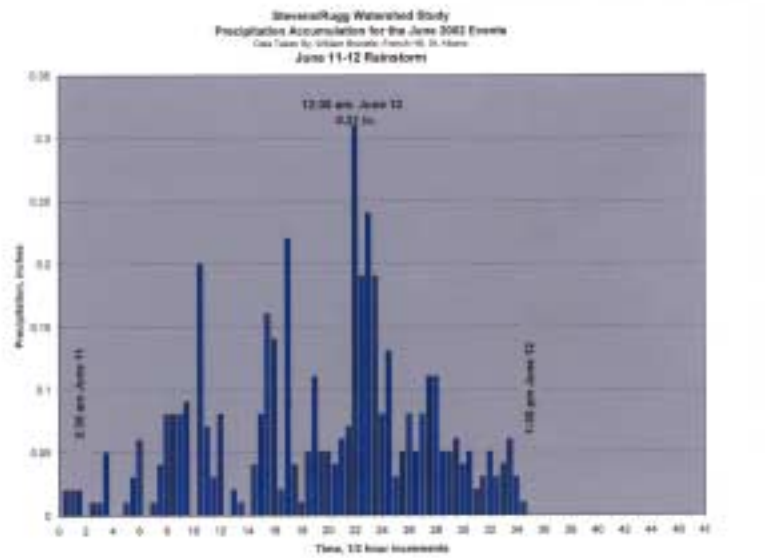


Figure 3: Precipitation Tables

During the June 2002 flood, a large number of homes experienced flooding and flood damages to basements and yards. Flooding of streets and inundation of large portions of lands also occurred. For example, Lower Weldon Street, near the intersection with North Elm, near Houghton Park was inundated as a result of out-of-bank flooding and storm sewer surcharging. Erosion and deposition of silts and gravels and flood borne debris was commonplace along the floodplain corridor following these events.



City averages expenditures of over $50,000 annually for flood related damages.

Other information sources indicate that the City has expended more than $600,000 over the past 12 years addressing flooding and flood related damages. This is approximately $50,000 on average in annual damages, and clearly demonstrates the problem has not been resolved.

1.6 Diversion Structure

According to information contained in the Stevens-Rugg Watershed Project (P.L. 566) Report dated December 5, 1972, flooding issues were a concern over 100 years ago. In 1900, the City was authorized by an act of the State Legislature to divert floodwaters from Stevens Brook into Rugg Brook; however, no action was taken for over 50 years.

Following a significant spring storm in 1955, renewed action was taken by the City, Town and the Franklin County Soil Conservation District to re-initiate the diversion of floodwaters. Planning assistance applications were made and the U.S. Department of Agriculture was authorized to initiate specific improvement studies.

Previous studies document significant flooding every five years. Storm drain systems charges, ice storms and fluvial events results in erosion and deposition of silts, gravel, and debris along the floodplain corridor.

Inlet to diversion structure

A revised work plan was developed in 1957, which detailed the project. However, the project was once again shelved, this time for nearly 10 years, because land rights could not be secured to construct the diversion structure.

Then in 1967, the SCS was again requested to restart the project. The work plan was pulled off the shelf and updated. This effort resulted in a detailed work plan, and a report was issued in 1975. This time, all issues were addressed and right-of-ways were secured. Construction of the diversion structure was completed several years after that date and it remains in operation today.

The purpose of the Diversion Structure is to divert floodwaters from the Stevens Brook to the Rugg Brook to reduce flooding along an approximate one-mile long corridor floodplain of Stevens Brook, between Lower Weldon Street and Lower Newton Street. This area includes residential and commercial development along Lake Street, Elm Street, LaSalle Street, Pearl Street and other local neighborhoods that abut the brook.

The Diversion Structure is an earth channel within an overall length of the channel is approximately 2,000 feet. Its typical cross-sectional geometry is trapezoidal, with 1 vertical to 2 horizontal side slopes, an approximate depth of 7-feet and a bottom width that varies between 45-feet to approximately 150-feet. The upstream third of the channel is contained with earth dikes on each side, and the lower two-thirds of the channel length is cut into ground.

The diversion structure represents a unique opportunity to improve stormwater in an urban area. It can be modified to function as an extended detention basin, enhanced to filter and reduce polutants. This will reduce flooding and contribute to improved water quality.

Water is diverted into the channel when flood stages at its inlet on Stevens Brook reach a certain level. Water flows along the channel until it discharges over an outlet control weir, then under Nason Street, where it then enters Rugg Brook.

Outlet from the diversion structure.

The Diversion Structure has been effective according to some local officials. The frequency of flooding has definitely been reduced in the historical flood plain since the structure was constructed. However, several City officials have stated that the structure was not installed as originally intended, and that not enough water is diverted into the channel. Conversely, others have reported that the channel is not functioning as intended because too much water is diverted into Rugg Brook, which has resulted in accelerated erosion and associated impacts to the stream banks along Rugg Brook.

City officials have stated that maintenance on the structure has been minimal to none since it was constructed. However, Mr. William Cioffi indicated that in the summer of 2002, the City of St. Albans reportedly removed several thousand cubic yards of accumulated silts and sediments from the channel.

1.7 Water Quality History

The quality of the water has been in decline for a number of years in the Stevens Brook and the Rugg Brook as well as St. Albans Bay. St. Albans Bay has long been the focus of water quality improvement studies and restoration efforts. Phosphorous and nitrates have been historical pollutant concerns, as these nutrients have caused serious problems in the Bay.

This includes a decade long (1980 to 1990) effort between the Natural Resource Conservation Service (NRCS) and individual property owners through the Rural Clean Water Program (RCWP) to install Best Management Practices (BMP's) on many of the farms in the area.

There are two (2) distinct water quality issues and sources of pollutants in this watershed:

Section 303(d) of the Clean Water Act

Under Section 303(d) of the 1972 Clean Water Act, states, territories, and authorized tribes are required to develop lists of impaired waters. These impaired waters do not meet water quality standards that states, territories, and authorized tribes have set for them, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop TMDLs for these waters.

1. Agricultural runoff that enters the Stevens and Rugg Brooks. Runoff from agricultural lands carries with it sediments rich with nutrients (phosphorus and nitrates) and organics.

2. Stormwater runoff from the urban, developed areas. Pollution of impervious areas (roads, parking lots, roof tops, etc) includes toxics (metals and organics), oil, grease, hydrocarbons and sediment.

The United States Environmental Protection Agency (EPA) has, under Section 303d of the Clean Water Act required that individual states identify water bodies (streams, lakes, etc) that do not meet Water Quality Standards. The Act also requires that the states develop a plan for cleaning up the water. The program to develop the clean up plan is called the Total Maximum Daily Load (TMDL) Program. This program provides a process for determining pollution budgets for impaired waters with the intention that once implemented, will result in meeting the Clean Water Act.

The Stevens Brook and the Rugg Brook are both identified as impaired waters and are included on the VTDEC's 303d list. The segments of the streams that are impaired are identified through sampling, testing and monitoring by the VTDEC.

The identified impairments and the location are summarized on the following table. The source of this information is the State of Vermont, Draft 303d List of Waters, July 15, 2002, Part A – Impaired Surface Waters in Need of TMDL, Interim List – Waters for Section 303d "De-Listing."

Table 3
VT DEC 303(d) List of Waters

Part A. Waters appearing below have documentation and data indicating impairment and do not meet VT Water Quality Standards. Required or needed pollution controls have yet to be fully implemented. Further pollutant loading determinations (e.g. a TMDL) are necessary - unless remediation will be completed prior to the scheduled TMDL.

Segment Name/ Description	Pollutant(s)	Use(s) Impaired	Surface Water Quality Problem(s)	Current Status/Situation	TMDL Completion Year/State Lead
Rugg Brook, from mouth to approx. 4.5 miles upstream	E. Coli, undefined	ALS, CR	Agricultural runoff, suburban runoff, land development	6/15 W/Shed farms (RCWP); poor biological condition (99); need add'l farm treatment (expansion) & mgmt; biological data (CY99 & 00) caused impairment length to be extended (2 mi to 4.5 mi); Stevens/Rugg W/Shed study by NRPC in CY2002	2010-WQ/DAF&
Stevens Brook, approx. 1 mile below Ctrl VT Rail Yard upstream to yard	Sediment, oil, grease, hydrocarbons	AES, ALS, IWS, AWS, DWS, CR	Sediment, soil & water contamination from fuel spills & management	RI/FS; SI Stage now; ST/Fed legal action; SIP 98; more RI/FS needed; poor biological condition (86-92, 98); pump & treat system installed with track pans; practices changed; leaching to brook eliminated; more investigation scheduled	2013 DEC-HM
Stevens Brook, from I-89 downstream for approx. 1.5 miles	Sediment, organic enrichment, toxics (metals & organics)	ALS	Land development, erosion/sedimentation, urban runoff, morphological instability	Poor biological condition (92 & 98); also toxicity, enrichment, habitat degradation; Stevens/Rugg watershed study by NWRPC in CY2002	2007 DEC-WQ
Stevens Brook, Mouth Upstream 4.4 Miles	Sediment, nutrient & organic enrichment, E.Coli	ALS, CR	Agricultural runoff; morphological instability	9/20 W/Shed farm (RCWP); poor biological condition (90-93, 98 & 99); Need additional farm treatment (expansion) & management; Stevens/Rugg W/Shed study by NWRPC in CY2002	210-WQ/DAF

2.0 STUDY METHODOLOGY

The process of developing an understanding of the problems and opportunities that exist in the watershed is complex, and involves social, political and technical issues. In order to advance this understanding, a Technical Work Program (study methodology) was developed at the beginning of this study. The objective was to develop a process that would result in an unbiased understanding of the issues faced in this watershed.

The work program has been framed around three (3) basic steps that allows for clear definition of the tasks to be performed with associated milestones and deliverables, as outlined below, followed by a discussion of each:

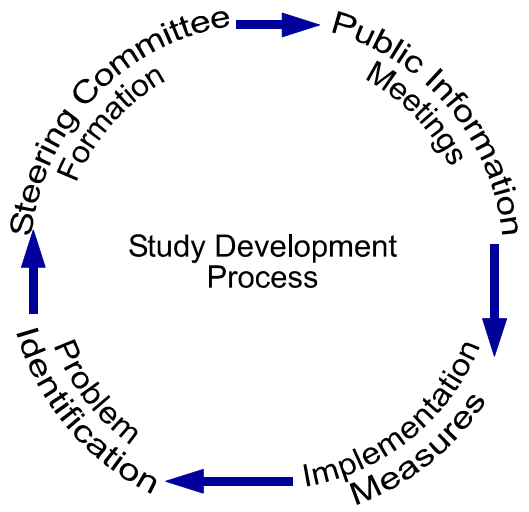
2.1 Steering Committee Formulation

The first step, prior to the initiation of the study, was the assembly of a Project Steering Committee. The purpose of this Committee was to assist in the solicitation of public and municipal input for the project, to review draft documents generated by the Principal Investigator, provide guidance and recommendations for content and provide a recommendation to the Board of Commissioners with regard to the approval of this report.

The Steering Committee assisted in soliciting project input, document review, and guidance and approval.

The Committee consisted of a number of people, resulting in a wide background and expertise variety. Community leaders from the City and Towns, concerned citizens, river management experts and watershed planners from local and state agencies, and representatives from the Natural Resource Conservation Service were the composition of the Committee. A list of the people who served on this committee is included in Section 1 of this report.

Figure 4
Interaction Diagram



The study was developed following an interactive process. Problems were identified and solutions generated. Steering Committee and Public Information meetings were held throughout the study, ensuring interaction and input from a number of sources.

Six (6) Steering Committee meetings were conducted over the course of this project. Representatives from the Northwest Regional Planning Commission chaired the meetings. DuBois & King provided a project status and initiated discussion on project issues, followed then by a round table discussion by committee members. Minutes of these meetings are available at the Regional Planning Commission's office. A brief summary of each meeting is outlined below:

Table 4
Steering Committee Meetings Summary

Steering Committee Meeting	Date	Purpose / Summary of Meeting
1	June 2002	*Discussion focused on the methodology of developing this project and represented the initiation of this project*
2	December 3, 2002	*Presentation of the Problem Identification Matrix (found in Appendix B). Discussion centered on the information contained in the matrix and the overall format.*
3	January 16, 2003	*Discuss the draft list of Watershed Implementation Measures developed by DuBois & King, which addresses the previously defined problems. Outcome was refinement of implementation measures and identification of several additional ones.*
4	March 6, 2003	*Discuss the draft Watershed Improvement Implementation Plan developed by DuBois & King, prepared following input on previously developed implementation measures. Comments were presented for incorporation into report.*
5	April 22, 2003	*Conduct initial discussions regarding priorities of the Watershed Implementation Plan that had been previously submitted. Issues such as what implementation measures would be considered to be short versus long term were discussed along with their associated priority for implementation.*
6	June 23, 2003	*Discuss priorities of the Watershed Implementation Measures.*

2.2 Public Information Meetings

Three (3) Public Information Meetings were conducted during the duration of this study. There were several objectives of these meetings, including:

- Provide a forum for the public to become informed about the watershed study, its purpose and methodology of development,
- Allow opportunity for direct public input on watershed problems and potential solutions for improvement,
- Provide project status and direct question and answer dialog with Study participants.

All meetings were held at the St. Albans Town Education Center, and were conducted between 7:00 pm and 9:00 pm. Ms. Bonnie Waninger, Special Projects Manager for the Regional Planning Commission initiated each meeting. Jeffrey W. Tucker, P.E., Principal Watershed Investigator for DuBois & King presented each study.

PowerPoint presentations and handouts were used to convey the watershed study, input, and potential solutions.

Table 5
Public Information Meeting Summary

Public Information Meeting	Date	Summary
1	September 10, 2002	*Study participants provided an overview of the project purpose and the methodology to be followed during its development. Approximately 30 people attended the meeting and significant discussion occurred throughout the meeting.*
2	January 9, 2003	*Project progress report was given to the attending public, including the presentation of the Problem Identification Matrix. Discussion of the June precipitation events and potential solutions also took place. Approximately 20 people attended and most contributed to discussion of the issues.*
3	June 5, 2003	*Primary purpose was to present the findings and conclusions of the Study to the public. A secondary objective of the meeting was to discuss the primary recommendations with the public and answer any questions that arose. Approximately 20-people attended this meeting and as with the first 2 meetings, most people in attendance contributed to the discussion of the issues.*

Each of the three meetings was well represented by City and Town officials, state and regional officials and interested local citizens. Each meeting lasted the entire scheduled two hours and many of the participants contributed to the discussion.

2.3 Phased Study Development Process

The Study Development Process occurred over three phases:

- Identification and compilation of the primary problems in the watershed and their associated impacts to the communities.
- Development of the *Watershed Improvement Implementation Plan,* which would provide short- and long-term solutions to the identified problems.
- Preparation of this report, titled *Watershed Study Report.* As indicated above, the purpose of this report is to summarize and present the results of Phases I and II as well as a overview of the Steering Committee Public Information Meetings.

The following is a discussion of each phase followed in the development of this Study.

2.3.1 *Phase I: Watershed Assessment and Problem Definition*

The purpose of Phase I is to identify and summarize the general existing condition of each watershed, and the primary problems that exist. Prior to this Study, there has been no overall compilation of information on the problems and what impacts they are having on the riverine system and to the communities within the watershed. Without a summary, it is difficult to create a vision of potential solutions on an overall watershed basis.

The watershed problems were identified and evaluated using a combination of techniques, which include:

- Site Reconnaissance to View Problems and Site Conditions
- Interviews with People having First Hand Knowledge
- Review of Historical Information
- Watershed Assessments

2.3.1.1 Site Reconnaissance and Interviews

DuBois & King water resource engineers conducted approximately six site visits as part of assessing the principal water resource problems. This included touring several key flood prone areas with City and Town officials shortly after the June 2002 flood storm events. In addition, discussions and interviews were conducted on-site with several people, including a local developer, farmer, manager of a large facility and state official in responsible charge of the state transportation system in the region. Insight to the problems facing the watershed was obtained as a result of this effort.

Straightened channels and lack of vegetated buffer reduces ability to filter pollutants from parking lots and contributes to flooding.

DuBois & King water resource engineers also walked most of the accessable areas of each brook, and observed and took photographs of the areas visited. Representatives from the State Department of Environmental Conservation, River Management Section, the City Public Works Department and the Town Selectboard also participated in several of the site reconnaissance's and provided valuable historical insight regarding the changes that have occurred and with the assessment of the existing conditions.

2.3.1.2 Review of Historical Information

DuBois & King water resources engineers conducted a comprehensive review of available historical information. The historical information was reviewed to establish background and a baseline for the Watershed Assessment. The information reviewed included:

Severely constricted channels and structures trap flood borne debris, causing flooding.

- FEMA Flood Insurance Studies for the City of St. Albans (September 1977) and the Town of St. Albans (June 1988),
- FEMA flood damage reports for recent flood events (1996 and 1998),
- Stormwater runoff studies conducted by third parties,
- Stormwater analysis conducted for recent and future commercial and residential development,
- Stormwater analysis conducted by the State of Vermont Agency of Transportation for future and current highway projects,
- Federal design documentation for the Diversion Structure.

2.3.1.3 Watershed Assessments

DuBois & King water resource engineers conducted a limited Fluvial Geomorphic Assessment with assistance from representatives of VANR-River Management Division. An estimate of basic geomorphic parameters was obtained for the Stevens Brook, using VANR Stream Geomorphic Assessment (April 2002)

protocols. The estimate of the parameters was the result of a Phase I Stream Geomorphic Assessment.

The following tasks completed the Phase I Assessment:

- Representative stream reaches were chosen for initial evaluation,
- Field measurements, including cross-section geometry, were taken during a field visit,
- The obtained field data was entered into the VANR Database,
- The database returned preliminary conclusions which was evaluated for consistency with physical observations, and
- The final conclusions were obtained from the database and confirmed by VANR personnel.

Results achieved during this assessment were used to quantify and qualify reaches of concern or reference within the watershed. The results of the analysis aided in the identification of the watershed problems. In addition, the results were considered during the development of the Watershed Improvement Implementation Plan.

2.3.1.4 Problem Identification Matrix and Project Mapping

The preparation of a *Watershed Problem Identification Matrix,* located in Appendix B was the first milestone delivery for this phase of the study.

This matrix provides a description of the watershed problems on a reach-by-reach basis along both brooks. Information on the matrix included:

- Reach identification number and landmark description
- Description of the existing land use
- Bulleted summary of problems, the morphologic condition, the riparian condition and the water quality classifications.

A Reach Identification Map of the watershed was also prepared. This map illustrates the approximate boundaries of the watershed of each brook and identifies each reach corresponding with the matrix. In addition, the map illustrates other key information such as land and natural features and political boundaries.

The Glossary of Terms, the Problem Identification Matrix and Study Base Map are located in Appendix A, B and D of this report.

A Glossary of Terms provides the reader with an explanation of most of the technical terms used in the study. Every effort was made to present Study results

(including this report) in clear, user friendly English. However, some technical terms, such as floodplain, morphology and other terms were necessary.

Although identified as a problem based matrix, many of the entries in the matrix are actually observed symptoms of a larger problem. For example, in reach five, the intersection of Lower Weldon and South Elm Street identifies a problem of street and basement flooding. This is a historical flood prone area identified by City officials as being one of the first areas to experience flooding during a storm event. Flood water backs up in the City storm sewer, then is forced up the manhole, resulting inundation of the street. This inundation requires the City to close the road and the re-routing of local traffic.

While this is an ongoing problem for the City, the reasons that the streets are inundated is simply because there is too much floodwater entering the system. Water has no place to go, except for up and into the road. The root problem is that too much water is running off the watershed during a storm event. The watershed has lost much of its ability to absorb rainfall into the ground, so the excess runoff enters the system, overwhelms it and results in street flooding.

The Problem Identification Matrix was presented to the Steering Committee for review and comment. A follow-up Steering Committee meeting was held on December 3, 2002 to discuss this information. Several revision recommendations were made and the matrix was updated to reflect the comments.

Increased development in the watershed has reduced absorption of rainfall into the ground. Excess runoff overwhelms drainage systems and results in serious flooding.

The principal watershed problems can be summarized as:

1. Excessive runoff during storm events. Excessive runoff has resulted from long-term development within the watershed, converting pervious land to impervious lands with drainage systems connected directly to the streams.

2. Land use practices. Development into the riparian buffer occurs in all segments of the watershed, including residential (mowing lawns right to the edge of brook), agricultural (plowing fields to the brooks edge), commercial and industrial (filling in floodplain)

3. Continued construction of facilities within the flood zone, thus increasing damages.

4. Inadequate (too small) bridges and culverts and supporting drainage systems.

The symptoms of the problems can be summarized as:

1. Increased flooding and flood related damages during periods of excessive runoff. Flooding of homes, public buildings, municipal infrastructure and commercial and industrial areas. Closure of local roads and bridges.

2. Degraded water quality.

3. Increased erosion from all areas of the watershed, transporting sediment and silts into the brooks. Pollutant laden sediments (runoff from parking lots, as an example) is degrading water quality.

4. Stream channel instability, severe stream bank erosion, loss of riparian buffers.

Other problems and associated systems are identified in the Problem Identification Matrix, which is included in Appendix B.

2.3.2 *Phase II: Watershed Improvement Implementation Plan*

The purpose of Phase II is to build upon the information generated in Phase I and identify and summarize areas where opportunities exist to improve or achieve sustainable watershed functions and values. The objective or output of this phase is a document that can be used by local, regional and state decision makers for the implementation of watershed improvement measures.

The result of this effort is a detailed *Watershed Improvement Implementation Plan*, which is presented in Appendix D.

This Plan includes over twenty (20) specific implementation measures, which in their own way, will provide for short- and long-term improvements to the watershed. The primary measures contained in the plan are ones that address:

- Long-term planning of the watershed, for the purpose of providing Municipalities with a way to develop criteria and review future land development proposals at sustainable levels.

Table 6
STEVENS - RUGG WATERSHED IMPLEMENTATION PLAN
Summary of Identified Implementation Measures

Implementation Measure	Priority (L/M/H)	Name	Location	Dependency on Other Implementation Measures	Immediate/ Incremental/ Long-Term	Cost	Addresses Water Quality &/or Quantity	Potential Funding Sources
1	H	Ad-Hoc Watershed Committee / Watershed Goals and Objective Statement / Development of a Detailed Stormwater Management Plan and Review and Update / Zoning Regulations / Review, Maintenance and Upgrade of Existing Stormwater Facilities and Compliance Enforcement	Watershed Basin Wide	None	Long-Term	$5,000-10,000 / Minimal or $5,000-10,000 with consultant assistance / $10,000-20,000 / Review/Compliance: $500-$2,000 per system; $10,000-50,000 est. total; Maintain/Upgrade Unknown	Both	Municipal Planning Grant & VANR
2	H	Detailed Watershed Hydrologic and Hydraulic Flood Forecasting Model	Watershed Basin Wide	1, 3	Incremental	$40,000-70,000	Quantity	FEMA, ACOE, VANR, LCBP
3	M	Stream Flow and Rainfall Gages Installation	Upstream of Diversion Structure (Stevens & Rugg)	1, 2	Long-Term	$1,000 per gage plus 1-hr recording time	Quantity	LCBP, Watershed Grants, VANR
4	M	Sediment Source Identification	Watershed Basin Wide	1	Incremental	Substantial municipal effort or $6,000-10,000 with consultant ssistance	Quality	Municipal Planning Grant, VANR, LCBP
5	M	Streambank Stabilization and Drainage Modifications	1,800-ft Reach between Main Street and Barlow Street	1, 2	Immediate	$75,000-225,000	Quality	LCBP, Watershed Grants, VANR
6	M	Re-Establishment of Riparian Buffers	Watershed Basin Wide	None	Immediate	Unknown	Quality	NRCS, LCBP, Watershed Grants, VANR
7	M	Continued Implementation of BMP for Agricultural Areas	Joint Effort between Property Owners and NRCS, with input from Watershed Development Review Board	None	Immediate	Unknown	Quality	NRCS, Farmers
8	M	Disconnection of Roof Drains into Drainage System	Mostly in developed areas (residential & commercial)	19	Incremental	~$100 per residential lot	Quantity	Private Property Owner
9	M	Removal of Unnecessary On-Site Drainage Systems & Pipes	Mostly in developed areas (residential & commercial)	8, 19	Incremental	~$500 per residential lot	Quantity	Private Property Owner

Table 6
STEVENS - RUGG WATERSHED IMPLEMENTATION PLAN
Summary of Identified Implementation Measures

Implementation Measure	Priority (L/M/H)	Name	Location	Dependency on Other Implementation Measures	Immediate/ Incremental/ Long-Term	Cost	Addresses Water Quality &/or Quantity	Potential Funding Sources
10	TBD	New Flood Control Detention Basin	East of I-89	1, 2	Long-Term	$200,000-500,000; excludes land acquisition, design, permitting	Quantity	FEMA, ACOE
11	TBD	New Flood Control Detention Basin	Grice Brook	1, 2	Long-Term	$200,000-500,000; excludes land acquisition, design, permitting	Quantity	FEMA, ACOE
12	TBD	New Flood Control Detention Basin	Upstream of VT 104 and VT 36 Intersection	1, 2	Long-Term	$200,000-500,000; excludes land acquisition, design, permitting	Quantity	FEMA, ACOE
13	TBD	Modify Diversion Structure into a Detention Basin	Stevens - Rugg Diversion Structure	1, 2, 5	Long-Term	$50,000-250,000	Quantity	FEMA, ACOE
14	TBD	New Flood Control Detention Basin	Upstream of Clyde Allen eastern Entrance Drive	1, 2, 5	Long-Term	$200,000-500,000; excludes land acquisition, design, permitting	Quantity	FEMA, ACOE
15	H	Upgrade Offsite Stormwater Management Facilities	Collins - Perley Complex	1, 2, 5	Long-Term	Not Estimated	Quantity	FEMA, ACOE
16	H	Flood Reduction at Floodwall	300-ft reach between City Fire Station & Main Street	1, 2	Long-Term	$75,000-100,000; excludes ROW acquisition, design, permitting	Quantity	FEMA, ACOE, LCBP
17	M	Drainage System Improvements	Tanglewood Drive Development	1	Long-Term	$50,000-75,000	Quantity	VTrans, FEMA
18	M	Sediment Removal from Existing Storm Sewer Systems	Large Impervious Areas (roads, parking areas)	1	Incremental	$15,000-20,000 per acre of drainage area	Both	Private Property Owner
19	H	Public Education Meetings and Outreach Programs	Watershed Basin Wide	1		Not Estimated		Stevens-Rugg Watershed Association

- Watershed hydrology, including measures to reduce existing stormwater runoff and the associated volume of water, for the purpose of reducing flooding and flood related damages.

- Flood control by protecting flood prone areas with structural measures for the purpose of reducing flood related damages.

- Water quality, for the purpose of improving existing conditions both along the brooks and also throughout the watershed to the maximum reasonable extent and for providing the municipalities with a way to maintain water quality standards in each brook.

- Public education, because it is critical that all people who live and work in the watershed understand that individual actions, even if physically far removed from the brook and flood prone areas, directly contributes to the success or failure of a sustainable, healthy and safe watershed.

Examples of quality vegetated buffers do exist on the Stevens and Rugg brooks, and should be protected from future development.

- Future watershed management, for future management of development within the watersheds, for restoration of impaired habitat and riparian buffers and for public outreach and education, with recommendations for reducing runoff from significant impervious areas (retrofit storm water systems).

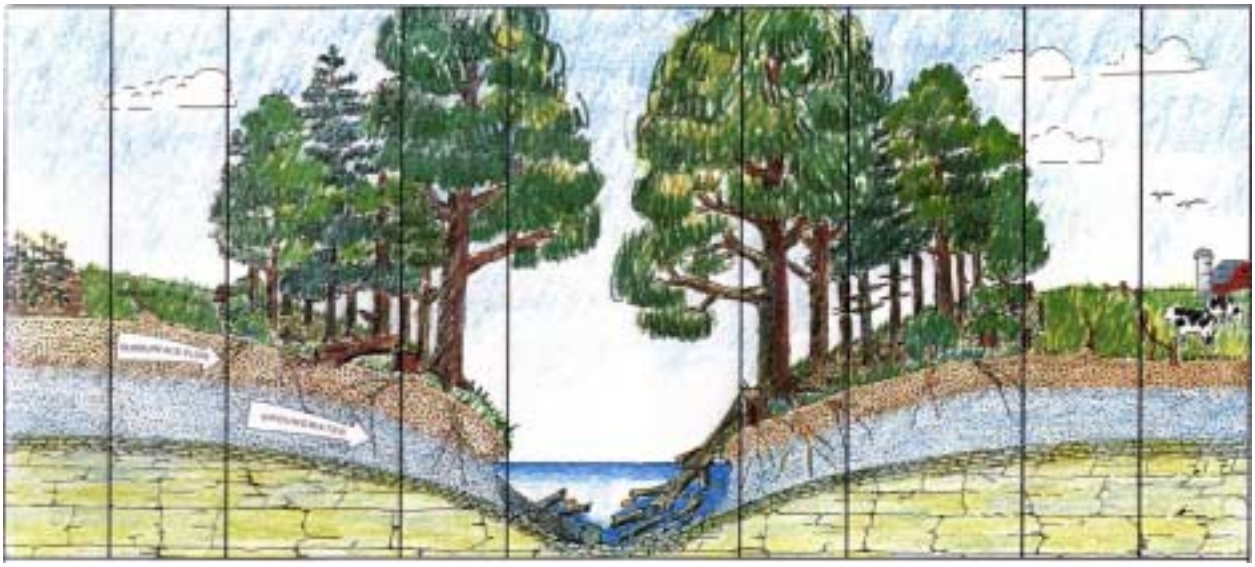
- Watershed hydrologic and hydraulic flood forecasting model. A summary of the implementation measures in presented in Table 6. This summary indicated the priority, approximate costs and time implementation of each masure.

  One implementation measure that had near universal support from the public, steering committee members and state and federal technical people is the development of a detailed watershed runoff computer model. This model, if prepared as envisioned by DuBois & King, will be a valuable tool for municipal officials in the evaluation of proposed development, and in the evaluation of proposed implementation measures, such as detention facilities.

  This model will estimate and quantify stormwater runoff under existing conditions in the watershed. Then, as new development is proposed, the municipalities can enter the proposed development into the model and estimate the impacts to runoff and flooding. This model will provide planning and

regulatory officials with specific hydrologic information regarding a development project and allow them to determine if the project will, or will not, impact flooding further downstream. This implementation measure is discussed further in Appendix D.

Figure 5
Idealized Riparian Buffer



Source: USDA

3.0 CONCLUSIONS and SUMMARY

The intent of this study is to identify problems in the watershed and to identify and evaluate solutions that will result in the short and long term resolution of the problems. The results address long standing concerns regarding flooding, flood related damages and impaired water quality. In addition to providing the results of the investigation, this report is intended to serve a planning document for Local and State planners, developing a sustainable growth plan for the St. Albans community.

This study concludes that there are a number of water resource problems in the watershed. These problems are real, well documented, and will continue to grow as development continues. As indicated above, these problems are documented in Appendix B of this report.

One critical point to make is that the problems are watershed wide, and are not restricted to the floodplain corridor along the brooks. The fact is, land use activities everywhere in the watershed contribute to the problems. It is only the symptoms that are most visible along the brooks.

Also critical is the fact that there is growing development pressures in the watershed, particularly in the middle to upper reaches in St. Albans Town. There are a number of large development projects that are expected to be presented to the Town for approval in the near future. It is very

important that these projects be located in non-flood prone areas, and that the stormwater systems be designed to mitigate the conversion of undeveloped lands to impervious areas.

This study also concludes that there are a number of specific implementation measures that can address the problems. Many of these measures are inexpensive and do not require significant expenditures of funds to implement. Changing land use habits, such as disconnection of roof drains into the drainage systems, or the restriction of most activities in the riparian buffers are several examples. Some of the implementation measures are not simple, and will require long term planning and extensive funding, such as large detention basins. However, it is the coordinated implementation of a combination of large and small measures that will result in the long term, sustainable use in this watershed.

APPENDIX A

GLOSSARY OF TERMS

STEVENS/RUGG BROOK WATERSHED STUDY

GLOSSARY OF TERMS

The definitions provided below are intended to aid the reader in a general understanding of the report and attachment text. These definitions are a compilation of terms used in science and water resources and stream morphology. While there may be several different definitions or interpretations of these terms, the definitions provided below represent the intended meaning of these terms as they appear in the report and attachment text.

TERM	DEFINITION/DESCRIPTION
Active Adjustment	The changing of the course of the stream, either horizontally by extending or avulsing meanders or vertically by head cutting.
Aggrading/Aggradation	A progressive build up or raising of the channel bed and floodplain due to sediment deposition.
Avulsion	A sudden shift in the location of the stream, typically bisecting an over extending meander.
Bankfull Discharge (Channel Forming Flow/Discharge	The discharge which by moving sediment, forming or removing bars, forming or changing bends and meanders, etc. results in the average morphologic characteristics of channel. The bankfull stage is the dominant channel-forming flow, and has a recurrence interval of approximately 1.5 years.
Best Management Practices (BMPs)	A schedule of activities, prohibitions or practices, treatment requirements, operating procedures, maintenance procedures, and other management practices to prevent, reduce or control the pollution of waters from stormwater discharges.
Channelizing / Channelized	The confining of a stream by a man-made structure, i.e. culverts, bridges, floodwalls, etc.
Degradation	A progressive lowering of the channel bed due to scour or the decrease in the value for a designated use.

TERM	DEFINITION/DESCRIPTION
Drainage Basin	The land that drains runoff to a surface water body.
EPA	The United States Environmental Protection Agency.
Floodplain	Level land adjacent to the stream, which is covered by the stream waters during flooding.
Gradient	The slope or inclination of the stream's path. High being a steep grade and low being a shallow or mild grade.
Head Cut / Head Cutting	The upstream movement of a waterfall or a locally steep, often vertical, channel bottom due to the erosion caused by rapidly flowing water.
Impervious Surface	Man-made surfaces, including, but not limited to, paved and unpaved roads and parking areas, roofs, and walkways, from which precipitation runs off rather than infiltrates.
Impaired Waters	Those waters listed on the State of Vermont List of Impaired Surface Waters Part A (Vermont 303(d) listing); waters that demonstrate documented violations of one or more criteria of the VT Water Quality Standards. A documented violation is one that can be supported or substantiated by data collected through physical, chemical, and/or biological monitoring.
Intermittent Stream	A stream that conveys open flowing water periodically throughout the year, often only during flooding and spring runoff.
Morphology/Morphologic	The form, shape or structure of a stream or organism.
Over-steepening	The increased steepening of a streambank often making it susceptible to erosion.

TERM	DEFINITION/DESCRIPTION
Oxbow	The often wet, abandoned meander of a stream channel.
Perennial Stream	A stream that conveys open flowing water consistently throughout the year.
Planform	The general course or path of the stream, marked by the meanders, bed features, gradient and banks of the stream.
Reach	A logical section of a stream, often defined by differing gradients, planform, adjacent landuse, or manmade structures confining the stream.
Riparian Buffer	An area of land and vegetation adjacent to a stream that has a direct effect on the stream. This includes woodlands, vegetation, and floodplains.
Runoff	Natural precipitation that does not infiltrate into the soil including material dissolved or suspended in it, but does not include discharges from undisturbed natural terrain or wastes from combined sewer overflows, collected from large scale developments to sensitive water quality areas (does not include natural runoff).
Stormwater	Precipitation that does not infiltrate into the soil including material dissolved or suspended in it.
Tortuous Meander	A more or less repeated pattern characterized by angles greater than 90 degrees. Relating to an extreme curving or wind of the streams course.
USGS	The United States Geological Survey.
VT 303(d) listing	A list of surface waters generated by the State of Vermont on the condition of surface waters in the State as required every two years by the EPA and the Clean Water Act.

TERM	DEFINITION/DESCRIPTION
Watershed	The total area of land contributing runoff to a specific point along a receiving water.
Wetlands	A lowland area, such as a marsh or swamp, that is saturated with moisture, especially when viewed as the natural habitat of wildlife.

APPENDIX B

PROBLEM IDENTIFICATION MATRIX

STEVENS/RUGG BROOK WATERSHED STUDY PROBLEM IDENTIFICATION MATRIX

Landmark Identification & Stream Reach	Reach Description & Land Use	Water Resource Problem	Morphologic Condition	Riparian Condition	Water Quality Classification
STEVENS BROOK					
St. Albans Bay upstream to Rt. 38 (Lower Newton Rd.)	-Shallow gradient causing tortuous meanders -Primarily Agricultural land use incl. grass and corn crops	-Slight planform instability- possibly due to inconsistent discharges -Adjustment may occur during channel forming flows, i.e. meander avulsion -Stream has adequate access to the flood plain -This reach is listed on the EPA 303(d) impaired waters list due to nutrients, pathogens, organic enrichment, and sediment.	-The Channel planform in this reach is relatively stable. -During Channel forming flows some adjustment is expected.	-Riparian buffers are generally less than 100 feet, along farm fields -In areas where farm fields are not directly adjacent to the stream the riparian buffers are greater than 100 feet	-According to the EPA 303d this reach is impaired by nutrients, pathogens, organic enrichment, and sediment. -The water quality of this reach is effected by upstream impairments
Lower Newton Rd. upstream to Kellogg Rd.	-Shallow Gradient causing tortuous meanders -Primarily Agricultural land use incl. grass and corn crops and pasture land	-Slight planform instability- possibly due to inconsistent discharges -The stream is well adjusted to the normal flows -Some adjustment may occur during channel forming flows, i.e. meander avulsion -Stream has adequate access to the flood plain	-This reach can be identified by tortuous meanders. -This stream pattern is susceptible to streambank erosion during channel forming discharges.	-Along the sections of tortuous meanders the riparian buffer is minimal.	-According to the EPA 303d this reach is impaired by nutrients, pathogens, organic enrichment, and sediment. -The water quality of this reach is effected by upstream impairments
Kellogg Rd. to St. Albans WWTF	-Steep Gradient losing 180 feet of elevation in 2 miles of stream length -Exhibits stable planform with several grade stabilizing 'hard points', i.e. ledge.	-Some adjustment may occur during channel forming flows, i.e. meander avulsion, streambank instability	-This reach can be identified by steep valley slopes -Over-steepening of the streambanks under channel forming flows is likely to occur.	-Riparian buffers in this reach range from 20 feet to 100feet	-According to the EPA 303d this reach is impaired by nutrients, pathogens, organic enrichment, and sediment. -The water quality of this reach is effected by upstream impairments
St. Albans WWTF upstream to Lower Newton Rd.	-Shallow gradient with no meanders or planform features -Primarily agricultural land use with some commercial and residential -Easy access to flood plain	-Residential development in the flood plain -Riparian Buffer is less than recommended in some areas	-This reach contains few planform features and no meanders -Streambanks are relatively stable due to the available flood plain access.	-In the sections where farm fields extend directly to the streambanks the riparian buffer is limited to less than 50 feet -The vegetation along the banks consists of tall grasses and small shrubs	-According to the EPA 303d this reach is impaired by hydrocarbons and sediment -The water quality in this reach is effected by the urban runoff and upstream impairments
Lower Newton Rd. upstream to the Diversion Structure	-Shallow gradient with no meanders or planform features -Primarily residential land use in the flood plain	-Residential development extending to the streambanks within the flood plain -Stream's access to the flood plain results in residential inundation	-The stream does not exhibit degradation, aggradation or streambank erosion	-Due to the residential development directly adjacent to the stream the riparian condition is marginal -In most areas the riparian buffer is limited to small to medium growth trees and manicured lawns	-According to the EPA 303d this reach is impaired by hydrocarbons and sediment -The water quality in this reach is effected by the urban runoff and upstream impairments

STEVENS/RUGG BROOK WATERSHED STUDY PROBLEM IDENTIFICATION MATRIX

Landmark Identification & Stream Reach	Reach Description & Land Use	Water Resource Problem	Morphologic Condition	Riparian Condition	Water Quality Classification
Intersection of Lower Weldon and South Elm St.	-This location is flooded due to the over flowing combined sanitary/stormwater system, this occurs approximately once every three years. -During severe flooding this location is impassable	-The combined system is insufficient to handle significant urban runoff during storms larger than the five year event -Flooding occurs in the street as well as in the basements of several households	-The stream channel is located several hundred feet away, therefore channel morphology does not have an influence here. -The flooding that occurs in this location is due to the overflowing of the combined sanitary/stormwater system.	-This area is effected by the combined sanitary/stormwater system -A quality riparian buffer will benefit this stream in this area by providing filtering for stormwater	-When flooding in this area occurs the flooding waters are combined sanitary and stormwater -The flood waters leave sanitary water residue that eventually makes its way into the stream untreated
Diversion Structure	-Specifically designed to divert excess discharge from the Stevens Brook to the Rugg Brook -Consists of two berms spaced approximately 200 feet apart running perpendicular to both the Stevens and the Rugg with a weir and stilling basin on the Rugg Brook end -Open land (approximately 6 acres)	-City officials feel that this structure allows too much water to pass downstream in the Stevens Brook -Town officials feel that diverted city runoff causes downstream channel instability and flooding on the Rugg Brook -As reported this structure was designed for diverting water from one watershed to another, this structure does not function as a detention basin	-Morphology does not apply for this area due to the geometry and design of the structure.	-The Diversion Structure not a channel structure, therefore riparian buffers do not apply here	-The Diversion Structure can be used to increase the water quality of the Stevens Brook if converted into a detention structure
Diversion Structure upstream to the Main St. crossing	-The confluence of the Stevens and Grice Brooks is located in this reach -Primarily residential land use in the flood plain -Concrete flood wall located in this reach	-Residential development along the stream extends to the streambanks -Out of bank flooding inundates residences and commercial buildings	-The change in slope behind the St. Albans Fire Station promotes aggradation in the channel '-The stream in this reach is channelized by the Floodwall '-The channelization has causes stream incision along the Floodwall, the foundation of the Floodwall has been exposed by this action -The frequency of channel forming discharges causes streambank erosion.	-The riparian buffer in this reach is limited due to residential development extending directly to the streambanks -The riparian buffers that do exist are less than 20 feet	-According to the EPA 303d this reach is impaired from organic enrichment, sediment and toxics (metals & organics) -The impairments are related to the volume of untreated urban runoff entering the stream with out benefit of riparian buffers.
Flood Wall at the Main St. Crossing	-Flood wall consists of a low concrete wall supplemented by concrete waste blocks stacked to add height to the wall -Flood wall installed on the right stream bank to prevent residences from becoming inundated	-Out of bank flooding inundates several houses on the right bank, this is occurring at decreasing frequencies. -At this location the floodwall was constructed to protect the houses the are in the floodplain, the flood wall is moderately successful -Several residential properties along the right streambank are inundated every spring.	-The stream is channelized due to the floodwall '-The channelization has caused significant incision and the footing of the Floodwall is now exposed -The floodwall inhibits the stream to access the floodplain only during the most extreme of events. It is at these times where the most significant damage occurs. -The discharge velocities during moderate flows are concentrated, which increase the potential for streambank erosion.	-The riparian buffer in this location consists of several houses that are less than 20 feet from the right streambank	-According to the EPA 303d this reach is impaired from organic enrichment, sediment and toxics (metals & organics) -The impairments are related to the volume of untreated urban runoff entering the stream with out benefit of riparian buffers.

STEVENS/RUGG BROOK WATERSHED STUDY PROBLEM IDENTIFICATION MATRIX

Landmark Identification & Stream Reach	Reach Description & Land Use	Water Resource Problem	Morphologic Condition	Riparian Condition	Water Quality Classification
Main St. crossing upstream to Quinton Court	-Steep stream channel gradient -Steep streambank slopes -Culverts control discharge capacity -Primarily residential land use extending to the top of the streambanks	-Streambank instability due to uncontrolled residential runoff and channel forming discharges during storm events.	-The reach morphology is controlled by several locations of ledge outcroppings and culverts. -Incision is occurring within the channel upstream of the Main St. Crossing the City sewer line crossing the stream at this location has been exposed. As a protective measure, the City has encased the sewer line. -Steep hydraulic gradient combined with channelization causes channel forming discharges at increasing frequencies.	-The riparian buffer in this reach consists of steep stream valley banks that are actively eroding -Residential development extends directly to the top of the streambanks	-According to the EPA 303d this reach is impaired from organic enrichment, sediment and toxics (metals & organics) -The impairments are related to the volume of untreated urban runoff entering the stream with out benefit of riparian buffers.
Quinton Court	-Topography suggests annual flood plain '-This area has been freqently gravel mined due to aggradation in the stream -Primarily residential land use in the flood plain extending to the top of the streambanks	-Inundation of several residences within the flood plain occurs frequently	-The change in slope in this area promotes aggradation '-The geometry of the stream channel allows for easy flood plain access, this promotes frequent out of bank flooding.	-The riparian buffer at this location consists of well manicured lawns and relatively few trees -Residential development extends directly to the top of the streambanks	-According to the EPA 303d this reach is impaired from organic enrichment, sediment and toxics (metals & organics) -The impairments are related to the volume of untreated urban runoff entering the stream with out benefit of riparian buffers.
Quinton Court upstream to I-89 Tributaries	-Intermittent reach of the Stevens Brook -Land use mix of residential and commercial	-During significant discharges, the stream floods out of its banks.	-The size of the stream is proportional to the average discharge, during channel forming flows the stream is out of bank and streambank erosion occurs.	-Reduced development along this reach is benefiting the stream by allowing for more dense riparian vegetation	-According to the EPA 303d this reach is impaired from organic enrichment, sediment and toxics (metals & organics) -The impairments are related to the volume of untreated urban runoff entering the stream with out benefit of riparian buffers.
GRICE BROOK					
Stevens / Grice Confluence upstream to I-89 Culverts	-Intermittent stream -Primarily residential land use including several new developments	-As development continues in the watershed more water resource problems, similar to the Stevens Brook, will occur.	-The stream is stable under current flow conditions. -Channel forming flows occur at relatively low discharge rates.	-Reduced development along this reach is benefiting the stream by allowing for more dense riparian vegetation	- This stream is not listed on the EPA 303(d) list of impaired waters.
6 Acre parcel at the intersection of Grice Brook Rd. and Rt. 104	-Identified location for potential detention basin. -6 Acres of open land (previously agricultural)	-Currently, this is an open site with no water resource problems.	-This area does not contribute to the morphological condition.	-This area is currently maintained as a farm field and the buffer is less than 20 feet	- This stream is not listed on the EPA 303(d) list of impaired waters.
RUGG BROOK					

STEVENS/RUGG BROOK WATERSHED STUDY PROBLEM IDENTIFICATION MATRIX

Landmark Identification & Stream Reach	Reach Description & Land Use	Water Resource Problem	Morphologic Condition	Riparian Condition	Water Quality Classification
Confluence of Mill River and Rugg Brook upstream to the Diversion Structure	-Reach characterized by the shallow gradient, tortuous meanders and well defined stream valley -Primarily agricultural land use	-During normal discharge the stream is stable. -Due to the stream's high sinuosity pattern, channel migration and streambank erosion is likely under channel forming flows	-The morphology for this reach is good to fair. -During channel forming flows some adjustment is expected.	-Riparian buffers are generally less than 100 feet, along farm fields -In areas where farm fields are not directly adjacent to the stream the riparian buffers are greater than 100 feet	-According to the EPA 303d this reach is impaired from organic enrichment, sediment and toxics (metals & organics) -The impairments are related to the volume of untreated urban runoff entering the stream with out benefit of riparian buffers.
The Industrial Park downstream of the Diversion Structure	-Industrial park (90 acres) development with only 1 detention basin of less than a 1/4 of an acre -Commercial and industrial land use	-The detention provided for development runoff is not sufficient to prevent channel forming discharges in the stream.	-The lack of detention in the Industrial Park effects the Rugg Brook downstream of the drainage outlet by causing an increased frequency of channel forming flows.	-Riparian buffers are generally less than 100 feet, along farm fields -In areas where farm fields are not directly adjacent to the stream the riparian buffers are greater than 100 feet	- This reach of the Rugg Brook is not listed on the EPA 303(d) list of impaired waters.
The Diversion Structure upstream to the confluence of tributaries near Clyde Allen Dr.	-Urban reach of the Rugg Brook -Residential land use	-Residential development along the brook limits flood plain access -The stream is confined to a narrow valley causing higher stream velocities	-Channel morphology for average flows is stable -Channel forming discharges may cause active stream adjustment.	-The riparian buffer in this reach is limited due to residential development extending directly to the streambanks -The riparian buffers that do exist are less than 20 feet	- This reach of the Rugg Brook is not listed on the EPA 303(d) list of impaired waters.
Tanglewood Development	-Development along the interstate access road with historic flooding problem -Residential land use	-Development drainage design and excess runoff from the Interstate access road causes inundation within the development. -Roof drains are piped directly into the drainage ditches. -Drainage swales through the development are insufficient in some areas to convey runoff, i.e., small culverts in place of open channels -Existing detention basin is too small and not well maintained.	-The direct connection of roof drains to the development's drainage swales cause increased discharge to the Rugg Brook. -The configuration of the development drainage exacerbates the flooding that occurs.	-The development runoff is directed into drainage swales and pipes then outlets into the stream. -The runoff flows though minimal riparian buffer prior to entering into the stream	- This reach of the Rugg Brook is not listed on the EPA 303(d) list of impaired waters.
Twin Court Development	-Development with historic flooding issues -Proposed additional development -Residential land use	-Roof drains are piped directly into the drainage ditches. -Drainage swales through the development are insufficient in some areas to convey runoff, i.e., small culverts in place of open channels -Existing detention basin is too small and not well maintained.	-The direct connection of roof drains to the development's drainage swales cause increased discharge to the Rugg Brook. -The configuration of the development drainage exacerbates the flooding that occurs.	-The development runoff is directed into drainage swales and pipes then outlets into the stream. -The runoff flows though minimal riparian buffer prior to entering into the stream	- This reach of the Rugg Brook is not listed on the EPA 303(d) list of impaired waters.

STEVENS/RUGG BROOK WATERSHED STUDY PROBLEM IDENTIFICATION MATRIX

Landmark Identification & Stream Reach	Reach Description & Land Use	Water Resource Problem	Morphologic Condition	Riparian Condition	Water Quality Classification
Clyde Allen Drive	-FEMA installed a new culvert due to flooding issues -Residential land use	-New culvert causes the detention of runoff that floods the basement of a nearby house.	-New culvert acts as a discharge controlling structure. -Increased discharge causes increased flood damages.	-The riparian buffer at this location is limited due to residential development extending directly to the streambanks -The riparian buffers that do exist are	- This reach of the Rugg Brook is not listed on the EPA 303(d) list of impaired waters.
Collins Pearly Sports Complex	-Location of a large sports complex with several play fields -Historic flooding issues -Primarily open space and recreational land use	-Runoff from the upstream watershed and from within the complex overflows the existing detention basin and inundates the play fields. -The detention basin is too small for the amount of runoff to be collected.	-Increased downstream discharges due to uncontrolled runoff causes residential flooding and channel planform instability.	-The complex is a large open area with no trees -The runoff from the complex and above watershed is collected and conveyed through pipes to the stream -The runoff flows through minimal riparian buffer prior to entering the stream	- This reach of the Rugg Brook is not listed on the EPA 303(d) list of impaired waters.
Allaire Development (Across from Baptist Church)	-Location of a proposed development -Identified as a potential location for a detention basin	-New development practices will require the runoff from impervious areas to be detained	-Increased downstream discharges due to uncontrolled runoff causes residential flooding and channel planform instability.	-Currently, this area is undeveloped meadow and farm land -Development here will require stormwater management practices satisfying the Vermont Stormwater Management Manual, which includes stream buffers	- This reach of the Rugg Brook is not listed on the EPA 303(d) list of impaired waters.
Exit 19 Commercial Development (incl. Wagon Wheel Truck stop, Mapleville Depot, etc.)	-Location of developing property -Limited existing detention	-Increased detention may be required as part of any further development.	-Increased downstream discharges due to uncontrolled runoff causes residential flooding and channel planform instability.	-The development at this location has limited stormwater management -Development here will require stormwater management practices satisfying the Vermont Stormwater Management Manual	- This reach of the Rugg Brook is not listed on the EPA 303(d) list of impaired waters.
Proposed Milk & Maple Co-Op	-Location of planned development, under Act 250 Review -Primarily agricultural use, proposed commercial development	-Runoff detention and treatment practices will be required by permitting.	-Increased downstream discharges due to uncontrolled runoff causes residential flooding and channel planform instability.	-Currently, this area is undeveloped farm land -Development here will require stormwater management practices satisfying the Vermont Stormwater Management Manual, which includes stream buffers	- This reach of the Rugg Brook is not listed on the EPA 303(d) list of impaired waters.

APPENDIX C

PHOTOGRAPHS

Upstream view of the Lincoln St. culvert. At the time it was constructed the streambed was level with the invert of the culvert. Note that within the past few years the bed has degraded approximately 3 feet.

A view of the right bank of the Stevens Brook along the reach between Lincoln Ave. and Barlow St. The stormwater runoff from this residential property flows over the bank causing streambank erosion.

A westerly view of the Collins-Perley property with Fairfax St. to the left. This photo was taken in June of 2002 when significant storms overwhelmed the stormwater drainage systems and caused localized flooding. Note the backing up of stormwater at the Fairfax Street outlet, left center of photo.

Another view of the localized flooding on the Collins-Perley property. Note the pitcher's mound in the center of the photo. This baseball field is located approximately 600 feet from the outlet at Fairfax Street.

Looking upstream from Quinton Court at the channelization of the stream. This structure concentrates discharge velocities in the stream, which impacts the stream channel downstream.

Downstream view from Quinton Court. It is in this area that flooding damage frequently occurs primarily from the limited floodplain access the stream has upstream of this location.

View looking upstream of a railroad bridge crossing the Stevens Brook. Note the debris accumulating in the stream due to the support pier.

View looking upstream of the Lake Street crossing. The stream has been confined to this narrow channel because of the encroachment.

Inlet of the control culvert on Stevens Brook. When discharges exceed capacity of this culvert, water is diverted into the diversion structure and conveyed to the Rugg Brook outlet shown in the next photo.

View of the diversion structure outlet. Here diverted water outlets into the Rugg Brook.

Upstream view of the flood wall along Lower Weldon Street. This floodwall is designed to protect the residential property at this location. Note the close proximity of the house (background) to the stream.

Another view of the floodwall along Lower Weldon Street. It is at this location that flooding frequently occurs. This area is a natural floodplain and the wall is marginally effective in containing the stream during significant discharges the stream overtops the wall and floods the property shown at the right.

View of left bank of the Stevens Brook along the reach between Lincoln Ave. and Main St. Note the significant streambank erosion caused by excessive stormwater discharge.

Another example of streambank erosion. This location is along the left bank of the Stevens Brook in the reach between Main St. and Lincoln Ave. Note that the stream-bank is vertical for approximately 6-8 feet.

An example of significant streambank erosion caused by stormwater discharging from residential developments. This streambank is approximately 15 feet in height. Note the gully that is forming due to concentrated stormwater runoff from a residential property.

Upstream view of the Barlow St. culvert. This area is frequently inundated at which time sediment is deposited on the residential property. Note the absence of any riparian vegetation. Also note the berm adjacent to the stream, which was constructed by the property owner from sediment deposited by the stream.

A view of undeveloped property at the intersection of Route 36 and 104. This is an ideal location for a community detention basin on the Stevens Brook.

Another example of undeveloped land for which a community detention basin could be constructed. This location is at the confluence of the main stem and northern tributary of the Rugg Brook upstream of Clyde Allen Drive. Fairfax Road is in the background.

An example of direct discharge of stormwater into the stream. At this location runoff from a residential development is discharged through this pipe, into a drainage swale and then into the stream.

A view of an unmaintained detention basin. Unmaintained detention basins do not operate as intended and often result in localized flooding and adverse impacts on the receiving stream.

APPENDIX D

WATERSHED IMPROVEMENT IMPLEMENTATION PLAN

Imp. Measure		
#1	**Stream:**	Stevens and Rugg Brooks
	Reach Number:	Entire Stevens / Rugg Watershed
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	Ad-Hoc Watershed Committee

Problem Statement:

Long-term growth within the watershed has occurred largely on an individual, market driven basis. Historically, there has not been a significant coordinated effort regarding the cumulative stormwater affects of development, both on-site and further downstream. This lack of coordination among development projects has contributed to the flooding and water quality problems that now exist in the watershed.

Description:

This implementation measure recommends the formation of an Ad-Hoc Watershed Committee. This Committee would consist of representatives from the City of St. Albans, the Town of St. Albans, the Town of Georgia and the Town of Swanton. The City Council and the Town's Selectboards would appoint the Committee members.

The basic function of the Committee would be to conduct site plan review of the proposed stormwater system for all new projects. This review would be with respect to system component design parameters and to assess the potential flood and water quality impacts that the project would have further downstream. The Committee would provide an advisory opinion of the proposed project, including recommendations for design modifications to prevent any anticipated impacts. The advisory opinion would be provided to the appropriate regulatory bodies within the watershed, such as Planning Commissions, Selectboards or the City Council.

Purpose:

The purpose of an Ad-Hoc Watershed Committee is to provide continuity and coordination of future development within the watershed by community members focusing on water quantity and quality. Over time, this Committee would become a significant resource of watershed issues and how development is affecting flooding and water quality.

Advantages:

- Provides a long-term mechanism for coordination and continuity for future development within the watershed.
- Will provide for sustainable, long-term growth by providing consistent review of projects specific to stormwater runoff.
- Provides a mechanism for consistent basin wide stormwater policy, planning and regulation.
- Provides for a review process which would be less susceptible to conflicting priorities

- Provides a forum for reviewing citizen complaints against existing developments with insufficient or non-existent stormwater practices, and a mechanism for requesting that non-complying development adopt stormwater best management practices for pollution prevention.
- Will involve the public in stormwater issues via press coverage of Committee decisions and actions, and thereby become an additional source of public education and outreach for these issues.

Disadvantages:

- Current difficulty in finding sufficient volunteers to fill citizen committee positions.
- Differing objectives and priorities between communities may arise.
- Potential difficulty in consensus development requires public education, outreach and participation.
- Joint government entity (multi-town sponsors) requires reporting responsibilities to municipal governments for Committee accountability, action and budget.
- Budget and funding issues constrain the Committee staffing to non-paid status.
- Training to citizen committee on stormwater management issues will be an on-going need.

Interaction and Dependency with Other Watershed Implementation Measures:

This implementation measure is not dependent on any of the other identified measures. However, it would positively affect and interact with virtually all of the other measures.

Feasibility of Implementation:

This is one of the most important measures within the Implementation Plan. If the Committee is provided with an appropriate level of review and advisory authority, then over time, it will provide the most benefit towards realizing a watershed that can tolerate additional development with decreases in flooding and improved water quality.

Theoretically, this is a simple measure to implement. The City Council and the Selectboards would create the Committee and then appoint representatives. The Committee would provide project review comments, conclusions and recommendations to the Council and Selectboards for action. The practical realities of creating a multi-municipal Committee to conduct the work described above that could potentially conflict with individual municipal priorities could make implementation of this difficult. A Committee charter would have to be written wherein the City Council, Selectboards and the Committee would have an overall accountability to each other, the watershed residents and to the environment. Training the Committee's members will not be easy and will require additional time from them.

Time Line:

The municipalities should begin exploring this implementation measure in 2003. The goal would be to create a Committee and have it operational by the calendar end of 2003.

Cost:

Members of the municipality Selectboards and City Council would take the primary lead in establishing the Ad-Hoc Watershed Committee. Town, staff and regional and state officials would provide advice and assistance to the council and Selectboards. Office space, equipment, supplies and other operating items could result in annual costs of $5,000 to $10,000.

Imp. Measure	**Stream:**	Stevens and Rugg Brooks
	Reach Number:	Entire Stevens / Rugg Watershed
#1	**Priority:**	See Summary Matrix – Main Report
	Implementation Measure Name:	Watershed Goals and Objective Statement
(continued)		

Problem Statement:

There is a need to identify and establish goals and objectives for sustainable long-term development within the Stevens / Rugg watershed. The lack of a clear and consistent plan that establishes the basis for development with respect to stormwater runoff and the level of flood protection along the flood plain have contributed to the problems that currently exist.

Description:

Develop an official Watershed Goals and Objectives Statement document to be used for the planning and management of stormwater related issues within the watershed. This document would define the vision for the future and a mission statement for the present. The Stevens – Rugg Ad-Hoc Watershed Committee would create the draft of this document. It would then be reviewed and ultimately adopted by each municipality within the watershed.

This document would clearly define several key issues;

- Stormwater review of new development relative to impacts further downstream,
- Flood frequency protection levels at primary developed locations,
- Protection of existing undeveloped stream corridors and riparian buffers
- Basin-wide stormwater design standards (integrated with state standards)

The Statement should clearly mandate the requirement for review of new development by the Ad-Hoc Watershed Committee as it relates to stormwater impacts on-site and further downstream. Stormwater systems should be designed to compliment and interact with each other. Stormwater systems should be designed so as not to result in adverse stormwater impacts both at the site and further downstream. There are many Best Management practices that can be incorporated into site development that reduce stormwater discharge rates and sediment runoff.

The level of flood protection needs to be defined at key locations in the watershed. The Statement would define the frequency of flooding that would be acceptable within developed and undeveloped areas. This will serve as the basis for the evaluation of other flood control implementation measures and for future development stormwater design. Present and future floodplain studies and regulations should be incorporated by reference as appropriate.

For example, the Committee would decide the level of flood protection along the Stevens brook within City limits. This may be defined as the 50-year flood event. Therefore, when subsequent measures are evaluated, they are evaluated to provide protection for a 50-year flood, and not something else.

The Statement should also address the protection of existing undeveloped reaches along both streams, particularly in areas where pressures for development exist. Ideally, the municipalities join together and purchase the lands, development rights, or some type of conservation easement within these corridors. This action will avoid future damages by preventing encroachment into the floodplain, and will also result in establishment of viable riparian buffers, which will contribute to the long-term reduction of erosion into the stream. State and Federal wetland and riparian buffer regulations should be incorporated by reference, as well as active zoning and planning measures to protect existing undeveloped areas along both streams.

- This statement should also recognize benefits and address potential improvements rather than the adverse impacts.

Consistent, basin-wide design standards for the design of stormwater control and treatment methods should be addressed in the Statement. The standards themselves do not need to be included, but the requirement and mechanism for their establishment should be identified. These standards should be specific to the Stevens – Rugg watershed, and can be developed using a variety of sources, including existing municipal requirements, current State stormwater regulations and other existing resources. The key is to create standards that are consistent throughout the watershed, and avoid discrepancies and conflicts.

Purpose:

The purpose of a Watershed Goals and Objectives Statement is to define the end result and to establish the overall guidelines for flood reduction and water quality improvement measures. This document would be used to identify issues, evaluate problems and in determining and evaluating many specific uses associated with the design and function of facilities.

Advantages:

- Provides a written basis for the function of flood control and water quality improvement facilities
- Provides for public input, education, consensus and support
- Provides an ideal for identifying concerns (vision)
- Provides a benchmark for evaluating non-complying elements (mission)
- Increased efficiency in implementing other solutions

Disadvantages:

- Differing objectives between the municipalities.
- Potential difficulty in consensus development.
- Preparing long-term vision statement requires a watershed perspective that disregards political boundaries.
- Preparing short-term mission statement requires specific and technical information about these streams that may not be available.

Interaction and Dependency with Other Watershed Implementation Measures:

This document is dependent on having an Ad-Hoc Watershed Committee (or a similar measure) in place (i.e.: the Committee developments the Statement). Implementation Measure No. 1 will have a direct impact on most, if not all of the other identified implementation measures. Other implementation measures may have a direct impact on this measure (i.e.: basin-wide stormwater detention standards developed are needed to complete mission statement). Similarly, it would be desirable, but not critical, for the municipalities to have a detailed hydrologic and hydraulic analysis completed, including a summary of flood frequency and flood damage information available to provide more aid in the formulation of the goals and objectives statement.

Feasibility of Implementation:

This statement of goals and objectives is a very important implementation measure because it sets the performance standard for how other measures will be evaluated. This Statement is a two-step measure to implement. The Ad-Hoc Watershed Committee creates the framework of the Statement and then forwards it to the municipalities for review and ultimate adoption. Appropriate regional and state and federal officials should be provided with the opportunity to provide input to this document.

Time Line:

The first task of the Ad-Hoc Watershed Committee would be to create a draft Statement. This document would be reviewed, and ultimately approved and adopted by each municipality. This process could take 6 to 9 months, and the goal would be to have it completed by the calendar end of 2004.

Cost:

This measure would cost approximately $5,000 to $10,000 to develop, if the Committee were to rely on outside expertise to assist in preparation of the draft and presentation at public meetings. Alternatively, if enough Committee members have experience with this issue, then there may be a nominal direct expenditure for the Town staff and Committee member time.

Imp. Measure		
#1	**Stream:**	Stevens and Rugg Brooks
	Reach Number:	Entire Stevens / Rugg Watershed
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	Development of a Detailed Stormwater Management Plan and Review and Update Zoning Regulations
(continued)		

Problem Statement:

As previously identified, there is a need for a clear and consistent, watershed-wide, stormwater management plan. Based on the historical and on-going problems within the watershed, the development and zoning regulations adopted by each municipality apparently do not adequately address downstream flooding or water quality impacts.

Description:

This implementation measure is a continuation, or expansion of measure No. 1. While the Watershed Goals and Objectives is intended to be a global document, Detailed Stormwater Management Plan should be very specific, and include appropriate objectives, standards and details. A reference to appropriate existing design standards, such as the Vermont Stormwater Manual should be incorporated into the plan.

As part of this process, each municipality in the watershed should review existing zoning and development regulations that affect stormwater runoff. These zoning regulations should be updated and modified, as appropriate, to be consistent with the Stormwater Management Plan. Several specific areas would include development limits adjacent for floodplains, storm water frequency design impacts to riparian buffers.

Purpose:

The purpose of a watershed-wide Stormwater Management Plan is to provide municipal officials, landowners, developers, regulators and other interested parties with a plan that indicates specifics for implementation of the Watershed Goals and Objectives Statement.

The purpose of review of existing zoning and other municipal regulations is to ensure that they are consistent with the Stormwater Management Plan, and provide the legal basis for its implementation and enforcement.

Advantages:

- Provides a detailed, written basis for stormwater development, regulation and enforcement.
- Will provide for long-term reduction in flooding and in improvement to water quality.

- Plan can include a suggested list of Stormwater Best Management Practices for Businesses for distribution to the business community to improve housekeeping and pollution prevention and compliance for day-to-day commercial operations.

Disadvantages:

- Differing objectives between the municipalities
- Potential difficulty in consensus development
- Incorporation of applicable state and federal requirements may be cumbersome

Interaction and Dependency with Other Watershed Implementation Measures:

This document is dependent on having Implementation Measure No. 1 (or a similar measure) in place. Implementation Measure No. 1 will have a direct impact on most, if not all of the other identified implementation measures. As with measure 2, having a detailed hydrological and hydraulic model (Measure 2) would be desirable because important information regarding discharges and flooding frequencies would be available to aid in the decision making process.

Feasibility of Implementation:

The process to develop a Stormwater Management Plan is straightforward with significant resource information available to aid in its preparation. The primary objective is for the municipalities to reach consensus on a long-term goal and objective plan, which would then be expanded and developed into a detailed Stormwater Management Plan. Having an independent Ad-Hoc Watershed Committee in place should allow for the development of this Plan.

Time Line:

Creation of a Stormwater Management Plan would occur after the Watershed Goals and Objectives have been established. Depending on the authority granted, this document may need to be approved and adopted by each municipality. It should be developed following a public process, to build consensus for the plan. This process could take 6 to 9 months, and the goal would be to have it completed by mid-2005.

Cost:

This measure would cost approximately $10,000 to $20,000 to develop, if the Committee were to rely on outside expertise to assist in preparation of the draft and presentation at public meetings. Alternatively, if enough Committee members have experience with this issue, then there may be nominal direct expenditure, except for the Town staff and Committee member time.

Imp. Measure		
#1	**Stream:**	Stevens and Rugg Brooks
	Reach Number:	Entire Stevens / Rugg Watershed
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	Review, Maintenance and Upgrade of Existing Stormwater Facilities and Compliance Enforcement
(continued)		

Problem Statement:

There appear to be a number of existing stormwater systems that have received little to no maintenance since they were originally permitted and constructed. Some systems have failed, as evidenced by broken structures, or have filled with sediment. Un-maintained stormwater systems loose their effectiveness in properly treating, attenuating and conveying surface runoff. This lack of proper maintenance clearly contributes to flooding and reduced water quality.

In addition, the frequently occurring flood damages and poor water quality in the Stevens and Rugg Brook Watershed stems from stormwater runoff. Poorly functioning stormwater management systems are contributing to increased peak runoff rates. These peak runoff rates, in turn, cause flooding, erosion and water quality impairment. Existing stormwater treatment facilities, such as private detention basins, within the watershed may not be functioning as designed and therefore exacerbating the current problems.

Description:

This implementation measure is a review of all permitted storm water systems that have been constructed in the watershed. People who have experience in the evaluation and design of stormwater systems would review original design plans and permit conditions, then conduct a site inspection with a general inspection form to determine the current condition of the systems. A brief summary of findings report would then be issued to the appropriate municipality and to the Ad-Hoc Watershed Committee.

A significant step in bringing the deficient existing systems up to current standards is a detailed inventory, inspection, and evaluation of all stormwater systems within the watershed. The investigation will include a review of the permits issued for development. Once the investigation is complete, a corrective action plan can be developed.

There are three (3) basic issues that would be addressed as part of the review process:

1. Was the system constructed in accordance with the approved design and related permit conditions? If not, then a determination would be required to assess its performance impacts and requirements to bring the system into compliance with the original permit.

2. Has the system been maintained since construction and is it still functioning as designed? If not, then a determination would be required to assess its performance impacts and requirements to bring the system into compliance with the original permit.

3. Is there an opportunity to expand or modify the system to enhance its performance in consideration of current technologies and standards? The system may have been installed and maintained as originally designed, but modifications of the system may be appropriate to increase its performance.

Purpose:

The purpose of this measure is to assess and document the current condition of each permitted stormwater system and establish a basis for enforcement of original permit conditions. In addition, this measure will allow a determination of opportunities to modify the system to increase its performance.

Advantages:

- Develops a database of existing permitted stormwater systems in the watershed
- Provides a detailed, written basis for stormwater development, regulation and enforcement.
- Develops an inventory and compliance methodology for future watershed wide assessments and updates.
- Will provide for long-term reduction in flooding and in improvement to water quality.
- Will provide an equitable basis for fair treatment of all stormwater system owners
- Increase the effectiveness of existing stormwater management systems.
- Assess and correct permit deficiencies.
- Brings systems to operational capacity they were designed for.

Disadvantages:

- Prevention, compliance and enforcement require clear definition for the public
- Differing objectives between the municipalities
- Potential difficulty in consensus development
- Need to clearly define state involvement in compliance / enforcement directions and actions early in this process
- Requires legal notification and access approval from landowners
- The upgrades to existing stormwater management systems will reduce the existing problems experienced in the watershed.
- Cost to private system owners who may not be aware of the violations.

Interaction and Dependency with Other Watershed Implementation Measures:

The initial responsible party (i.e.: project developer) may have sold all vested interests and the current landowner may be unaware of the conditions and requirements of the permit that the landowner now holds by default.

The review portion of this measure can be done independently of other measures. Each municipality can begin this process at any time. However, it is recommended that the Ad-Hoc Watershed Committee administer this measure. The primary purpose of the Committee is to

review and assess watershed wide issues. Modifications of any individual system may not have any benefit to the municipality of which it is located in, but may have significant advantages to another municipality.

Feasibility of Implementation:

This is a very feasible measure, and one that can be accomplished with little dependency on other measures. The municipalities can, at any time, begin a review of existing system design and permits and assess the construction and maintenance histories. This would be accomplished by a review of Town records for permits issued by the Town and records at the Agency of Natural Resources fro permits issued by the State. The Ad-Hoc Watershed Committee could then take that base line information and make further recommendations regarding upgrades to the systems, and understand the overall impacts resulting from these upgrades.

Time Line:

Review of existing systems and the assessment relative to construction and maintenance history can begin at once. Assessments and recommendations to modify existing systems for the purpose of increasing their performance would not occur until the Ad-Hoc Watershed Committee was able to get priority issues resolved.

Because there are not a significantly large number of systems in the watershed, it is feasible to have all reviews, inspections and assessments completed by the end of 2005, if all necessary easements and right-of-ways are granted.

Cost:

This measure would cost approximately $500 to $2,000 per system, depending upon the availability of existing information and its size and complexity, and on the level of involvement by the individual municipalities. The cost range to modify and upgrade systems may be $10,000 to $50,000 to complete depending upon the extent of permitted projects and the degree and nature of problems encountered.

Imp. Measure		
#2	**Stream:**	Stevens and Rugg Brooks
	Reach Number:	Entire Stevens / Rugg Watershed
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	Detailed Watershed Hydrologic and Hydraulic Flood Forecasting Model

Problem Statement:

Existing hydrologic and hydraulic information within the watershed is limited. Most available information consists of site specific hydrologic models associated with individual site development, preliminary hydraulic analysis at certain locations in the upper watershed for stream structure sizing, or outdated flood insurance studies which are not representative of current watershed conditions.

Evaluation of many of the implementation measures will require a detailed, watershed-wide hydrologic model, which estimates stream discharges at many locations along both brooks. An example of the need for this information is the evaluation of multiple flood control detention basins, or the expansion and modification of existing storm drain systems. To properly locate and size a detention basin, and to estimate its effectiveness in reducing discharge raters further downstream, a hydrologic model that covers the entire area is needed.

Description:

One of the first steps in the implementation of solutions is to develop a detailed, Watershed Hydrologic and Hydraulic (H&H) Model and digital mapping of the entire Stevens-Rugg watershed. This model will include the identification of the (H&H) characteristics of the watershed, including:

- Impervious area coverage,
- Runoff rates,
- Flood frequency elevations and discharges,
- Existing stormwater system inventory,
- Inventory of existing stormwater detention basins
- Physical calibration by installing field data recording devices

Once the model is calibrated with the field data, other implementation measures can be evaluated to determine priority and desired results. This model will serve as the basis for design for all structural solutions implemented within the watershed. In addition, this model can serve as an important planning tool when assessing impacts by future development because specific discharge values can be estimated to gage the impact of development. Included with this implementation measure is the preparation of low-level flight photogrammetry based mapping. This mapping would illustrate all of the key features in the watershed, such as current land use, topography and structures. The map would be in a digital format and compatible with local, regional and state mapping systems (i.e.: ArcView, etc.)

Purpose:

The purpose of an H&H model is to provide the City and Towns with site and reach specific discharge rates for existing conditions and proposed structural solutions within the watershed. This information will enable planners and engineers to determine the appropriate size for detention basins, whether in-stream or off-stream. The analysis can also be used to determine the elevations associated with flood frequencies. This allows City and Town planners to evaluate proposed developments and the potential impacts of these developments. Ultimately the H&H model combined with the mapping will aid the municipalities in the development of a long-term sustainable watershed that will reduce flood damages and improve water quality.

Advantages:

- Scientific knowledge of the watershed characteristics.
- Identification of potential trouble spots, which may be identified as potential areas to be included in a municipal construction easement program.
- Increased efficiency in the evaluation and design of other implementation measures.

Disadvantages:

So long as the model is kept up to date with current development activities, there are no known significant disadvantages to having a model that will estimate flood discharges and stages for a range of storm events for planning and design uses.

Interaction and Dependency with Other Watershed Implementation Measures:

The development of this model is paramount to the implementation of most of the structural measures, and many of the non-structural measures, particularly planning efforts. The design of any structural solution will require detailed and comprehensive parameters derived from an accurate H&H model.

Feasibility of Implementation:

This is a feasible measure to implement, as it does not directly result in construction and acquisition of property. It will require funding and an administrator to manage and implement it. The regional planning commission would be an excellent resource to assist in the procurement and management of this measure.

Time Line:

The desirable time to conduct low-level flights is in the spring or fall, once leaves are off the trees, and there is not a deep snow cover. Ideally, funding would be available to conduct the flights and produce the mapping by fall, 2003, or spring, 2004. Once the mapping was complete, the initial hydrologic model would be prepared in approximately 6 months. Updating of the

model would be a continuous effort, as development continues and additional stream and rainfall data accumulates. Ideally, the mapping and H&H model is completed by mid-2004, so that the Ad-Hoc Watershed Committee would have the information for use.

Cost:

The costs to develop a comprehensive watershed model to be used for future development and watershed management could be expected to cost within the range of $40,000 to $70,000. Much of the existing information would be gathered and incorporated, as appropriate into the model.

Imp. Measure		
#3	**Stream:**	Stevens and Rugg Brooks
	Reach Number:	Entire Stevens / Rugg Watershed
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	Stream Flow and Rainfall Gages Installation

Problem Statement:

There have not been any long-term stream flow measuring gages installed in either brook; so long-term stream flows are unknown. However, there is a rainfall gage located on French Hill that has approximately 55-years of record, and also a prior station that was discontinued in 1977. Many of the watershed implementation measures will be based on annual and flood discharge rates.

Stream flow data, particularly when combined with rainfall depth data is excellent information to use when calibrating hydrologic runoff models. As indicated in measure 5, having a hydrologic model, which has been calibrated to site specific flow data, would be very beneficial in the refinement of the appropriate implementation measures, such as flood control detention basins.

Description:

This implementation measure consists of the installation of several (2) stream gages and either reactivation of the St. Albans Bay station or establishment of a new rainfall depth gage. The stream gages would be semi-permanent, and discharges would be periodically measured by manual methods. A representative from the municipality in which the gage was constructed would likely take the measurement.

There are a number of gage types and configurations that can be selected. One that is applicable would be a V-Notch weir, which can accurately measure the low flows that occur, as well as the flood discharges. Weir can be easily fabricated from metal and concrete and should be designed to be removed and maintained.

Note: A fully automatic recording, permanent stream gage was considered, but given the small size the drainage area and the high cost of installing a device, was eliminated from further consideration. Steering committee members may wish to reconsider this conclusion.

The stream gages on both Stevens Brook and Rugg Brook should be located just upstream of the diversion structure. This will provide a more representative discharge rate than if it were downstream. Ideally, there would be a second set of gages on both brooks downstream to measure the discharge of flow that gets diverted from the Stevens to the Rugg.

There are several areas, such as bridge abutments, where it could be located. Ease of access and security should be the primary considerations for a final section. Property owner issues, channel and bank stability, depth of flow are other issues to be considered in the site selection process. Committee should walk the site, and with input from the VANR River Management Section, select the most appropriate site using the above considerations.

Purpose:

The purpose of a stream gage is to gather actual stream discharges in each brook, and use this information in the calibration of a hydrologic model and in the evaluation of implementation measures. The purpose of a second rainfall gage is to assess the variation of rainfall in storm events moving across the watershed.

Advantages:

- Watershed specific data allows for model calibration and verification and improved model predictions.
- Watershed specific data allows for refinement of implementation measures

Disadvantages:

- Some training required for data recording and validation
- Installation and maintenance costs of gages
- The time and cost for a person to record and store the date in a format that is readily retrievable and readable to others.
- Time lag of model calibration while awaiting accumulation of sufficient data over time

Interaction and Dependency with Other Watershed Implementation Measures:

The installation of several stream gages and a new rainfall depth gage is not dependent on any other implementation measure as data can be recorded and stored independently of other measures. It does, however, have direct impacts on Measure No. 2, and indirect impacts on many of the others.

Feasibility:

This measure is straightforward to implement and will not result in adverse impacts to property or environmental resources. It should not require approval from any regulatory authority except for funding approval and for the decision on who installs and maintains the gage. The Ad-Hoc Watershed Committee should take the lead on the design, location selection, construction, recording and maintenance of the gages.

Time Line:

It will take a number of years of accumulated measurements for the information to become useful for calibration of the hydrologic model. Although it is not critical that the gages be installed soon, each year in its delay represents a year of lost opportunity.

Cost:

The costs to install a semi-permanent stream gage should be less than $1,000 per gage. It would however, need to be replaced on a periodic basis. A semi-permanent stream gage can be expected to remain in service for approximately 10 –20 years. The cost for a person to record and store the discharges in a spreadsheet format would take about an hour per reading

Imp. Measure		
#4	**Stream:**	Stevens and Rugg Brooks
	Reach Number:	Entire Stevens / Rugg Watershed
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	Sediment Source Identification

Problem Statement:

A significant contributor to the water impairment and channel instability within the watershed is the sediment load in the streams. There are several reaches along both the Stevens and Rugg Brooks that have been identified as significant sources of sediment. However, off stream sources have not yet been identified. Off stream sediment sources represent a significant problem within the watershed and are considered to be a large contributor to impairment of both streams

Sediment sources range from agricultural drainage practices to construction sites to improperly maintained infrastructure. The identification of these sources will enable state, regional and municipal officials to implement solutions to mitigate the sediment sources and therefore alleviate the sediment transport load of the streams.

Description:

This measure involves the identification of significant sources of sediment entering into the streams. The identification process would be subsidiary to a geomorphic assessment. Following the identification process, potential solutions will be developed to lessen the sediment load in the streams.

Purpose:

The purpose of this implementation measure is to reduce the sediment load contributed to the Stevens and Rugg Brooks from construction sites, agricultural and commercial properties including existing stormwater infrastructure. A reduction on the sediment load will improve the water quality in the streams.

Advantages:

- Identification of sediment point and non-point source problem areas
- Reduced sediment load in the Stevens and Rugg Brooks
- Improved water quality in the Stevens and Rugg Brooks

Disadvantages:

There are no foreseeable disadvantages to identifying the significant sources of sediment either on-site or off-site. However, sediment yield from a watershed is a function of soil type and exposure, topography and structures, hydrology, stream power and energy. Therefore,

identifying a direct cause and effect relationship of implementing a mitigation measure will be difficult to quantify. Consequently, demonstrating a benefit from incurred costs will be difficult when justifying expenditures.

Interaction and Dependency with Other Watershed Implementation Measures:

This implementation measure can be conducted independently of other implementation measures. However, the initiation of Implementation Measure No. 1 should occur prior to the initiation of this measure so the objectives and goals of this measure are well defined.

Timeline:

This would be conducted early in the implementation process and used as supporting information for Improvement #5.

Cost:

This implementation measure will consist of the investigation and evaluation of a large portion of the watershed. An effort of this scale will require significant time commitments from local officials or the assistance of a private firm. The costs for such an effort for a qualified firm will range from $6,000 to $10,000.

Imp. Measure		
#5	**Stream:**	Stevens Brook
	Reach Number:	7-Main Street to Barlow Street
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	Streambank Stabilization and Drainage Modifications

Problem Statement:

The streambanks along this 1,800-foot reach are eroding, resulting in a considerable volume of sediment being washed into the stream. This reach is considered to be a high source of the sediment that is causing impairment further downstream.

Urbanization has generally resulted in higher stormwater runoff rates in this locale with numerous storm drainpipes concentrating stormwater discharges directly onto exposed soils on streambank slopes. Channel entrenchment is another key factor: the channel bottom has eroded downward through the floodplain soils over geologic time and the floodplain terrace is now abandoned approximately 20-30 feet above the stream channel. The lateral channel erosion across the floodplain is constrained by the 20-foot tall streambanks, and the normal potential for dissipation of stream energy by lateral channel migration is now impacting landowners, which can be evidenced by eroding streambanks and oversteepening. Urbanization has increased flow quantities and the flow velocities are confined within a narrow ravine that is subject to debris blockages that exacerbate the high velocities and channel scouring.

Description:

A solution to this condition is to reduce the erosion and sediment source by stabilizing the streambanks. There are a number of stabilization techniques that will work in this area, and include (but not limited to) riprap, vegetated riprap, interlocking concrete blocks and numerous types of engineered reinforced vegetated slopes. A typical design storm for stabilization projects is the 100-year flood event, which would be required in this case.

There are areas within this reach where the streambanks are stable with competent vegetative cover. These areas would be left intact, and the stabilization measures would tie into areas of stable slope.

Included with this solution is the relocation and / or removal of the many pipes and other concentrated flow devices that discharge onto the slope from residential developments. The pipes would be extended down to the channel bottom, or rerouted to more appropriate areas, such as competent storm drain systems that can handle the additional flow. Reduction of flows into the pipes could also be accomplished on a case-by-case basis.

Purpose:

The purpose of this implementation measure is to reduce the erosion of the streambanks and transport of sediment into the stream. There will be a long-term benefit to the impaired reaches located further downstream, because of the reduction in the sediment load.

Advantages:

- Soil stabilization and reduction of streambank erosion
- Reduction of sediment eroding into the stream
- Improvement of impaired reaches further downstream
- Opportunity to re-vegetate the slope above the normal high water level
- Improved habitat and water quality within the repaired reach
- Protection of neighborhood backyards from unstable slopes

Disadvantages:

- Temporary impacts to existing riparian vegetation
- Requires alteration of privately-owned storm drain systems
- Requires temporary construction easements and permanent slope easements and access for inspection and maintenance
- Cost of implementation and maintenance by the jurisdictional municipality

Interaction and Dependency with Other Watershed Implementation Measures:

Because the slopes are exposed and unstable, streambank stabilization is needed regardless of the other implementation measures. Other measures, such as detention facilities do not affect the need for this measure, and will not significantly affect the basis of the design.

The design of streambank stabilization is dependent on having a competent hydrologic analysis available. Therefore, the detailed Hydrologic and Hydraulic Flood Forecasting Model should be conducted first or concurrent with this measure.

Time Line:

This measure would be implemented once a detailed Geomorphic Assessment has been completed for the streams. During which point the streambanks would be evaluated and significant degradation would be prioritized for stabilization.

Cost Range:

The cost for installing streambank stabilization measures, such as riprap, can range from $5 to $15 per square yard of surface area protected. This is dependent on site conditions and encroachment of structures and facilities. Assuming that 50-percent of the reach requires stabilization with an average bank height of 15-feet, the surface area is approximately 15,000 square yards. This would result in a construction cost of $75,000 to $225,000.

Imp. Measure		
#6	**Stream:**	Stevens and Rugg Brooks
	Reach Number:	Entire Stevens / Rugg Watershed
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	Re-establishment of Riparian Buffers

Problem Statement:

Development within the Stevens-Rugg Brook Watershed continues to encroach upon the historical floodplain of the brooks. This encroachment often comes at the expense of the riparian buffer. The riparian buffers in residential and agricultural areas are declining, therefore, exasperating flooding impacts and water quality issues.

There are a number of residential, commercial and agricultural areas where the riparian buffer is either very minimal or non-existent. People mow their lawns directly to and across drainage swales. This allows chemicals to discharge directly into the brooks with little opportunity for infiltration, and promoting transport of sediment. Agricultural lands are disturbed to the top of the stream banks, and commercial lands have built up to the edge of the channel.

Best management practices by residential and agricultural landowners will reduce the impacts of development and land management on the stream. Riparian buffers provide several fundamental benefits to streams and developments along those streams. The mere existence of a buffer zone indicates that physical property, such as houses or infrastructure, are at a reduced risk of damage due to the location away from the stream. Additionally, the riparian vegetation provides protection to the streambanks from the erosive characteristics of the flowing water and filtering characteristics for surface runoff carrying pollutants.

Description:

This implementation measure consists of the re-establishment of vegetated riparian buffers wherever possible along each brook. The main stem and tributary drainage ways should be included. In many areas, the buffer will reestablish itself if simply left alone. The grass will grow taller, and eventually return to scrub and brush. Certainly property owners can encourage promotion of growth by planting appropriate grasses and woody vegetation.

Encourage and enforce the reestablishment of riparian buffers in accordance with current state regulations and guidelines. This implementation involves two components; education of the public and local municipal ordinances requiring a minimum setback distance for any development along the streams.

This implementation includes a public education and outreach component. There is significant opportunity for local and regional officials and citizen participation (i.e.: watershed and bay association) to continue to promote backyard best management practices.

The National Resource Conservation Service (NRCS) continues with success, to works with farmers to implement best management practices, including observing setback distances from streams and rivers. The residential landowner can also benefit from the services of the NRCS by adopting their land management practices and applying them to their own property.

The enforcement component can be achieved by passing an ordinance that no activity, whether development, harvesting, or landscaping occur within a minimum distance from the stream. Currently, the Town of St. Albans, as in many towns, restricts development to a minimum setback distance of 50 feet. However, this setback distance applies to development only and the 50 feet may not be sufficient in some reaches of the streams.

Purpose:

The implementation of best management practices for landowners along streams will aid in the mitigation of the flooding and water quality problems currently being experienced in the Stevens-Rugg Watershed. The purpose of this implementation measure is to encourage private landowners to assume some responsibility for the health the stream streams flowing through their property, which can be achieved by a public outreach and education program.

Advantages:

- Protection of water quality, aquatic and terrestrial habitat, channel and streambank stability
- Increase the streambank aesthetics
- Protect private property from flood and ice damages
- Protect intrinsic values such as natural ecosystems and biological diversity

Disadvantages:

- The loss of useable open land due to the reestablishment of vegetated riparian buffers

Interaction and Dependency with Other Implementation Measures:

This implementation measure can be conducted independently of any other. The success of this solution is not related to the completion of another nor will it be affected by the success or failure of other implementation measures.

Time Line:

This measure can be implemented upon the conclusion of this Study.

Cost:

There is little cost for this implementation measure. The costs incurred would be related to the administrative costs for implementing new ordinances. There would be no cost for the residential landowners and marginal costs for agricultural landowners due to the loss of harvestable lands.

Imp. Measure		
#7	**Stream:**	Stevens and Rugg Brooks
	Reach Number:	Entire Stevens / Rugg Watershed
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	Continued Implementation of Best Management Practices for Agricultural Areas

Problem Statement:

Currently, through significant funding from the Federal government the Natural Resources Conservation Service (NRCS) is partnering with farmers to implement and maintain a number of Best Management Practices for agricultural lands. While the Stevens-Rugg Watershed is a small watershed and has not received extensive attention in past years, positive results from BMP's are being experienced.

Description:

This implementation measure involves the continued partnership between the agricultural landowners and the NRCS. This partnership will result in solutions and improve the flood damage and water quality problems that currently exist.

Purpose:

The purpose of this implementation measure is to continue to make progress addressing the water quantity and quality issues that exist in the lower Stevens-Rugg Watershed by continuing the partnership between the agricultural landowners and the NRCS. The continued partnership will result in positive results and solutions to the problems mentioned above.

Advantages:

- Reduction of sedimentation loading due to runoff from furrowed fields
- Reduction of pollutants entering the streams from agricultural operations
- Increased stability of streambanks by established riparian buffers

Disadvantages:

- Reduction in harvestable lands due to increased riparian buffers.
- Reconfiguration of current fields to decrease direct drainage from fields into the streams.
- Lack of funding to NRCS Program limits number of program participants.

Interaction and Dependency with Other Implementation Measures:

This implementation measure is currently ongoing. The NRCS is working with farmers to implement BMP's on a site-specific basis. This implementation measure can continue independently of any other implementation measure.

Feasibility:

This implementation measure is already in operation and is therefore straightforward.

Time Line:

Continued partnering is a continuing effort.

Costs:

Costs would be part of the on-going USDA program budget.

Imp. Measure	**Stream:**	Stevens and Rugg Brooks
	Reach Number:	Watershed Basin Wide
	Priority:	See Summary Matrix – Main Report
#8	**Implementation Measure Name:**	Disconnection of Roof Drains into Drainage System

Problem Statement:

A common practice in building development (commercial and residential) is the connection of the roof gutter downspouts to stormwater drainage systems. This direct connectivity between the rooftop impervious area and the discharge end of the pipe, contributes to increased discharge rates during storm events. This practice may be acceptable if the stormwater drainage system has been designed to accommodate the flows, but can exacerbate flooding if the system was not designed to handle the flows.

There are many areas in the Stevens – Rugg watershed where the rooftop drains discharges directly into roadside ditches, which in turn feed to the streams. The overall drainage system was not designed to handle the additional flow rates. This practice is contributing to increased flows and erosion in the watershed.

Description:

Part of the overall goal of reducing watershed runoff is to disconnect roof top drains from the drainage system, and to allow the water to discharge onto lawns, or other green areas. This action will promote infiltration of the water back into the ground, thereby reducing (at least in part) increased discharges into the stream.

This implementation measure is also an excellent way for the municipalities to promote the awareness of watershed responses to development at an individual or family level scale. This, combined with other appropriate back yard Best Management Practices (BMP's) is a way for the entire community to participate in solving the flooding and water quality issues. The implementation of this BMP would consist of a public outreach component to educate the residents that there is a direct correlation between residential drainage practices and the frequent and increasing flood damages that are occurring within the watershed.

This implementation would be followed by a change in the development ordinances of the City and Town to encourage best management practices for residential property owners and developers.

Purpose:

One purpose of this implementation measure is to reduce the stormwater runoff and associated erosion rates from building developments. A second purpose is to engage, increase awareness, and to educate the community that all areas within the watershed affects flooding, not just those areas adjacent to the stream.

Advantages:

- Reduced runoff rates from building developments and reduced streambank erosion
- Public outreach and education
- Future development would be compelled to practice on-site BMP's upon the implementation of City and Town ordinances.

Disadvantages:

- Potential ponding of water in back yards during storm events. Property owners will need to manage rooftop runoff in a manner other than direct drainage into unsuitable stormwater drainage systems.

Interaction and Dependency with Other Watershed Implementation Measures:

This implementation measure can be carried out independently of any other implementation measure. However, adoption of an appropriate ordinance will be required to ensure that new developments implement this best management practice.

Implementation Cost:

The cost for this implementation measure is nominal since the resident can conduct this practice independently of any City, Town or State involvement. The costs to the property owner would vary, depending on the complexity and size of the down spouts. A standard residential lot should be able to disconnected for approximately $100, assuming that the buried pipe was left in place and not excavated and removed.

Imp. Measure		
#9	**Stream:**	Stevens and Rugg Brooks
	Reach Number:	Entire Watershed
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	Removal of Unnecessary On-Site Drainage Systems And Pipes

Problem Statement:

A common practice in residential developments is the replacement of surface drainage swales with pipes. This involves the laying of pipes in drainage swales and covering with soil to increase usable lawn area and for aesthetic landscaping.

The pipes installed are often undersized and therefore cannot convey the amount of stormwater discharge from the property. This often results in localized flooding of the streets and adjacent properties within the development, and causes negative impacts to the overall drainage system.

The installation of the pipes also contributes to increased rates of runoff of stormwater into the Stevens and Rugg Brooks. Direct piping reduces the opportunity for infiltration of the runoff back into the ground, and also maintains higher velocities. Extensive erosion occurs at the outlets of many of these pipes in the watershed.

Description:

An implementation of residential best management practices (BMP's), such as the removal of any unnecessary drainage piping and the restoration of open grass-lined swales will reduce the impact of urban stormwater drainage. The implementation of this BMP would consist of a public outreach component to educate the residents that there is a direct correlation between residential drainage practices and the frequent and increasing flood damages that are occurring, regardless of the location in the watershed.

This implementation would be followed by a change in the development ordinances of the City and Towns to encourage best management practices by residential property owners.

Purpose:

The purpose of this implementation measure is to reduce the stormwater runoff rates from residential developments. The frequent flood damages that are being experienced within the watershed can be linked to the rate in which stormwater reaches the streams. The reduction of the runoff rates will reduce the peak discharge that exacerbates flooding.

There are several purposes of this implementation measure. The first is to reduce the stormwater runoff and associated erosion rates from building developments. A second purpose is to engage, increase awareness and to educate the community that all areas within the watershed, not just adjacent to the stream, affect flooding and water quality.

Advantages:

- Reduced runoff and erosion rates from residential developments
- Public outreach and education
- Future development would be compelled to practice on-site BMP's upon the implementation of City and Town ordinances.

Disadvantages:

- The residents will have to re-landscape areas in which the pipes have been placed
- Future residential development would be compelled to practice residential BMP's upon the implementation of City and Town ordinances.
- Ignores the reason that the resident installed the pipe in the first place.

Interaction and Dependency with Other Watershed Implementation Measures:

This implementation measure would be conducted in conjunction with measure No. 8, and would also include other appropriate BMP's for residential and commercial landowners. However, adoption of an appropriate ordinance will be required to ensure than new developments implement the best management practice.

Implementation Cost:

The cost for this implementation measure is nominal since the resident can conduct this practice independently of any City, Town or State involvement. The costs to the property owner would vary, depending on the size of the subsurface drainage pipe. A standard backyard culvert on a residential lot could be removed and the yard regarded to re-establish the grass-lined swale for approximately $500.

Imp. Measure		
#10	**Stream:**	Stevens and Rugg Brooks
	Reach Number:	8 – Stevens Brook Tributaries East of Interstate 89
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	New Flood Control Detention Basin

Problem Statement:

Increased and continued development in the Stevens Brook watershed has increased the stormwater runoff rates resulting in higher flood stages and subsequent out-of-bank flooding. A possible solution to reduce the flood stages and over bank flooding is to decrease the amount of discharge from the upper undeveloped portion of the watershed. This will allow the in-channel dissipation of the peak inflows from the developed areas during storm events.

One way to reduce the discharge rates from the upper watershed is to temporarily store the water in detention basins. To be effective in reducing discharge, the detention basins need to be large enough and coordinated with similar basins in adjacent areas of the watershed.

Description:

Note: A series of flood control detention basins is described in implementation measures 11 through 14. Individual write-ups were created because of site-specific issues. However, the steering committee may wish to combine these into 1 measure.

Construct an instream flood control detention basin in the open land immediately east of the Interstate 89. The results of a watershed wide hydrologic analysis will be used to determine the appropriate size of the proposed detention basin. The function of the basin is expected to consist of limiting the discharge to approximately the 2.3-year discharge event. An additional condition of the design will be that the stream will not experience the effects of the basin for discharges less than the design discharge.

Purpose:

The purpose of this basin is to limit the discharge in the Stevens Brook (during periods of peak inflow) to the developed areas along the stream. The limiting of the discharge will reduce the potential for over bank flooding in the historically flood prone areas, such as Quinton Court. The limited discharges will also reduce the stream instability that is exacerbated during high discharges.

Advantages:

- Reduction in flood elevations and associated velocities
- Reduction of residential flood damage due to over bank flooding
- Alleviate significant sediment introduction into the stream by streambank instability and erosion.

Disadvantages:

- Requires easements or property purchases
- Design, permitting, construction and maintenance costs
- Liability of additional stormwater detention basins in remote areas
- Potential for additional streambank destabilization as a result of prolonged high-flows in the streams.

Interaction and Dependency with Other Watershed Implementation Measures:

The development and calibration of the watershed hydrologic and hydraulic model will result in a coordinated implementation plan for the recommended solutions. Therefore, the model must be operational prior to any structural implementations.

The success of any flood detention basin is dependent upon the implementation of additional flood detention basins within the watershed and their subsequent maintenances. The discharge from each basin must be coordinated to offset the peak discharges in the stream.

Feasibility of Implementation:

There are many considerations involved with the construction of a flood control detention system. Impacts to environmental resources and associated permitting, acquisition of property, costs and funding availability, type of systems, hydraulic and structural design considerations are all important issues to be addressed during the evaluation of these facilities.

However, it is believed that a properly design flood control detention system represents one of the most direct and effective ways to reduce flooding in developed areas, to provide treatment of polluted runoff, both of which will facilitate future development within the watershed. The above-identified issues can be addressed and the idea of detention advanced if there is enough support at the local, regional and state level.

Time Line:

Realistically, it will take a number of years to reach the point where construction can proceed. A feasibility analysis needs to be conducted first to quantify the reduction in discharges and therefore downstream flooding and to confirm the benefits of system-based detention. A feasibility analysis, linked with the detailed watershed hydrologic and hydraulic analysis could be completed in 6 to 9 months. Then it will take approximately several years to conduct the environmental documentation and secure needed permits and right of way acquisition, assuming that existing property owners are willing to sell the land. If initiated in 2004, construction of the basins should be ready to commence by 2006 or 2007.

Implementation Cost:

Cost data suggests that construction of a dry detention basin varies between $0.05 and $3.5 per cubic foot of water storage. This site is open with minimal site obstacles. Therefore, an approximate 5-acre site, with an average depth of 5-feet, would store approximately 1-million cubic feet of storm water. This would cost approximately, $200,000 to $500,000 to construct, excluding property acquisition, design and permitting

Imp. Measure		
#11	**Stream:**	Grice Brook (Tributary of Stevens Brook)
	Reach Number:	8 – Grice Brook, between VT 104 and Grice Brook Rd.
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	New Flood Control Detention Basin

Problem Statement:

Long-term development within the watershed has resulted in undeveloped land (pastures, wood land) being converted to developed land (buildings with supporting roads and parking lots and drainage systems). Developed lands result in greater rates of discharge causing increased flooding. In addition, development has encroached into historic floodplains, which being subject to flooding, results in flood damages.

One way to reduce the discharge rates is to temporarily store the water in detention basins. To be effective in reducing discharge, the detention basins need to be large enough and coordinated with similar basins in adjacent areas of the watershed.

Description:

This implementation measure is the construction of a new flood control detention basin (extended dry detention) in and adjacent to Grice Brook. An approximate 6-acre site may be suitable for detaining stormwater runoff and therefore reducing downstream discharges and associated flooding. The impoundment area would be created by a combination of excavation and embankment. Excavated material would be used to construct a dam at the downstream end of the basin.

This measure would be a dry-detention basin, designed to temporarily impound water during storm events exceeding the 2.3-year storm. The outlet structure would be designed to pass all flows up to and including the 2.3-year flood, thus providing for sediment transport and flushing at this frequency.

The drainage area at this site is approximately 235 acres. By contrast, the drainage area of Stevens brook at the inlet to the diversion structure is 1,472 acres. A detention basin at this location will impound approximately 16-percent of the overall drainage area.

Purpose:

The purpose of this implementation measure is to detain stormwater runoff from the upstream drainage area and reduce the discharge rates that exit from the detention basin. Reduced discharge rates would be expected to reduce the frequency of flooding at downstream locations.

Advantages:

- Reduce the downstream discharge rates
- Reduce frequency for downstream flooding
- Provide additional detention capacity for future development
- Provide opportunity for treatment of stormwater runoff, improving water quality

Disadvantages:

The detention basin will require 6 to 8 acres of land to construct. This area will not be available for other uses.

The length of time that high water levels in the downstream channel will be increased, even though the peak will be decreased. This longer time of high flows increases the potential for channel and bank erosion downstream of the outlet structure, exasperating sediment transport problems. A detailed morphologic assessment of the downstream reach along with a detailed hydraulic design will be required to minimize the erosion potential.

Interaction and Dependency with Other Watershed Implementation Measures:

This implementation is dependent on other new detention basin locations and on expansion of existing detention basins. An overall hydrologic model that accounts for all major existing and planned detention basins is a required next step in the planning and design process. This model will estimate the discharge rates from all major subcatchments, which would then be used by hydraulic engineers in evaluating the compatibility between the detention basins.

Feasibility of Implementation:

Refer to Implementation Measure No. 10

Time Line:

Refer to Implementation Measure No. 10

Implementation Cost:

Cost data suggests that construction of a dry detention basin varies between $0.05 and $3.5 per cubic foot of water storage, excluding property acquisition, design and permitting. This site is open with minimal site obstacles. Therefore, a 6 to 8 acre site, with an average depth of 4-feet, would store approximately 24 to 32 acre-feet of water, which is 1-million to 1.4-million cubic feet. This would cost approximately $200,000 to $500,000 to construct.

Imp. Measure		
#12	**Stream:**	Stevens Brook
	Reach Number:	8 – Northeast of the Route 104/36 Intersection
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	New Flood Control Detention Basin

Problem Statement:

Continued development in the Stevens Brook watershed has increased the stormwater runoff rates resulting in higher flood stages and subsequent out of bank flooding. A possible solution is to decrease the amount of discharge in the stream to allow the dissipation of the peak inflows from the development during a storm event. This is done by detaining the discharge from the upper watershed to allow dissipation of discharges further downstream to occur.

Description:

This measure consists of constructing a flood control detention basin in the open land northeast of the Route 104 / 36 intersection. The results of a watershed wide hydrologic analysis will be used to determine the appropriate size of the proposed detention basin. The function of the basin is expected to consist of limiting the discharge to approximately the 2.3-year discharge event. An additional condition of the design will be that the stream will not experience the effects of the basin for discharges less than the design discharge.

Purpose:

The purpose of this basin is to limit the discharge in the Stevens Brook during periods of peak inflow into the stream from the developed areas along the stream. The limiting of the discharge will reduce the potential for over bank flooding in the histrionically flood prone areas, such as Quinton Court. The limited discharges will also reduce the stream instability that is exacerbated during flood events.

Advantages:

- Reduction in flood elevations and associated velocities
- Reduction of residential flood damage due to over bank flooding
- Mitigation of significant sediment introduction into the stream by streambank instability and erosion

Disadvantages:

- Interruption of sediment transport during precipitation events greater than the design event
- Higher sustained discharges the could impact the streambanks downstream
- Alternate use of prime commercial / residential lands
- Increase in sustained discharges within the stream, therefore impacting the channel morphology

Interaction and Dependency with Other Watershed Implementation Measures:

Implementation measures 14 through 19 involve the construction of new flood control detention basins. It is anticipated that all, or a combination of them would be constructed as a system to maximize detention capacity and to minimize conflicts between them. The long-term success of any flood detention basin is dependent upon the coordination with these other detention basins within the watershed. The discharge from each basin must be coordinated to offset the peak discharges in the stream. In addition, a detailed watershed-wide hydrologic and hydraulic model is necessary before a detention basin can be designed.

Feasibility of Implementation:

Refer to Implementation Measure No. 10

Time Line:

Refer to Implementation Measure No. 10

Implementation Costs:

Cost data suggests that construction of a dry detention basin varies between $0.05 and $3.5 per cubic foot of water storage, excluding property acquisition, design and permitting. This site is open with minimal site obstacles. Therefore, an approximate 5-acre site, with an average depth of 5-feet, would store approximately 1-million cubic feet of storm water. This would cost approximately $200,000 to $500,000 to construct.

Imp. Measure		
#13	**Stream:**	Stevens Brook
	Reach Number:	5 – Stevens-Rugg Diversion Structure
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	Modify Diversion Structure into a Detention Basin

Problem Statement:

Historically, flooding has occurred in the Stevens and Rugg watershed causing flood damages. The P.L. 566 Stevens-Rugg Watershed Project was studied, designed and constructed to alleviate damages. In 1956, the Stevens-Rugg Watershed Project was initiated; in 1957, construction was completed. The diversion structure was a significant portion of the project.

The diversion structure is an open channel that diverts discharges greater than 70 cubic feet per second from the Stevens Brook to the Rugg Brook; this is done in order to reduce the volume of discharge downstream into the most populated areas of the City of St. Albans. It was designed to function up to and including the 100-year flood event, diverting approximately 980 of the total 1050 cubic feet per second discharging from the upper portion of the Stevens Brook watershed.

The diversion structure has been functioning as designed since its construction. However, with increased and continued development in the Stevens and Rugg Brook watersheds, since that project was completed, has increased the stormwater runoff rates resulting in higher flood stages and subsequent out of bank flooding in Rugg Brook.

The diversion structure, as it functions currently, is perceived as adversely impacting the lower reaches of the Rugg Brook. The additional water that is diverted to Rugg Brook may be exacerbating streambank instability and erosion. A balance between the flood prevention along the Stevens Brook and erosion prevention in the Rugg Brook needs to be made.

Description:

Generally, the existing diversion structure would be modified to detain water, as well as continue to divert flow from Stevens Brook to Rugg Brook. This would occur by making modifications to the outlet structure to that water is impounded to a certain elevation then released slowly. In addition, excavation of earth within the diversion channel, combined with berming near the inlet would occur, as well as reconstruction of the gate structure on Stevens Brook.

A detailed evaluation of the diversion structure is necessary, to quantify its specific operation. The geometry of the inlet and outlet, confirmation of the quantity of water being diverted and at what stage are all necessary to properly determine what impacts it may be having and what opportunities exist for its modification to detain water.
By adding the detention component to the existing diversion characteristics, the volume of water discharged downstream into the Rugg will be reduced, and therefore the instability and erosion processes will be mitigated.

Purpose:

The purpose of this basin is to detain water in the diversion structure. This would reduce the peak discharge that current is diverted into Rugg Brook, thereby reducing impacts further downstream. In addition, additional water may be able to be diverted from the Stevens as a result of detention. This would provide flood reduction benefits to areas downstream of Stevens brook.

Advantages:

- Reduction of discharge related flood damages to agricultural property downstream of the diversion structure on the Rugg Brook
- Increase stormwater management in the Stevens Brook Watershed and further reduction of flood damages

Disadvantages:

- Easement acquisition
- Costs

Interaction and Dependency with Other Watershed Implementation Measures:

The development and calibration of the watershed hydrologic and hydraulic model will result in a coordinated implementation plan for the recommended solutions. Therefore, the model must be operational prior to any structural implementations. In addition, this measure should be evaluated in conjunction with the other flood control detention basins that have been proposed.

The success of any stormwater management measure is dependent upon the coordinated implementation of additional stormwater management measures throughout the watershed. The discharge from each basin must be coordinated to offset the peak discharges in the stream. This will ensure that the discharges in the stream do not exceed sustainable levels.

Implementation Cost:

The majority of the costs for modification would consist of berming earth around the inlet to prevent out of bank flooding while water is impounded in the diversion structure, and structural modifications to the outlet structure. Modifications to the outlet structure and reconstruction of the inlet could cost between $50,000 and $250,000, depending on how extensive the repairs would be.

Imp. Measure		
	Stream:	Rugg Brook
	Reach Number:	22 – Upstream of the Eastern Clyde Allen Entrance Dr.
	Priority:	See Summary Matrix – Main Report
#14	**Implementation Measure Name:**	New Flood Control Detention Basin

Problem Statement:

The drainage area upstream of the Clyde Allen development converges to the confluence of two tributaries, which forms the main stem of the Rugg Brook. At this location, frequent out of bank flooding has occurred, resulting in flood damages to several residential properties. Although new culverts were recently installed at the Clyde Allen development entrance drives, the discharge to these new culverts can exceed their capacity. The flooding at Clyde Allen has been reduced, but the high discharge rates still contributes to flooding further downstream.

As the watersheds continue to develop, the impervious areas of the developed land will increase the rates of discharge. This increase will cause increased discharge volumes that will lead to more frequent over-bank flooding.

The installation of a flood control detention basin will be effective in reducing discharge volumes in the Rugg Brook from future development. This detention basin will require coordination with similar private, site-specific basins in upstream areas of the watershed.

Description:

A new flood control detention basin (extended dry detention) constructed adjacent to the confluence of the two tributaries that comprise the Rugg Brook. A portion of the agricultural land adjacent to the confluence of the two tributaries may be suitable for the flood control structure resulting in a reduction of downstream discharges and associated over bank flooding. The impoundment area would be created by a combination of excavation and embankment. Excavated material would be used to construct a dam at the downstream end of the basin.

This measure would be a dry-detention basin, which would temporarily impound storm water from the 915-acre drainage area upstream of this location. Any storm event exceeding the 2.3-year precipitation would be detained while all lesser events would pass without impact. The sediment transport will not be interrupted and there would be minimal impact to the stream morphology during these lesser events.

Purpose:

The purpose of this basin is to limit the discharge in the Rugg Brook during periods of peak inflow into the stream from the upper portion of the watershed. The limiting of the discharge will reduce the potential for over bank flooding in the histrionically flood prone areas, such as the Clyde Allen development. The limited discharges will also reduce the stream instability that is exacerbated during flood events.

Advantages:

- Reduction in flood elevations and associated velocities
- Reduction of residential flood damage due to over bank flooding
- Mitigation of significant sediment introduction into the stream by streambank instability and erosion

Disadvantages:

- Interruption of sediment transport during precipitation events greater than the design event
- Higher sustained discharges that could impact the streambanks downstream
- Alternate use of prime commercial / residential lands
- Increase in sustained downstream discharges within the stream, therefore impacting the channel morphology

Interaction and Dependency with Other Watershed Implementation Measures:

Hydrologic modeling and analysis that accounts for all existing and planned development upstream of the basin is required prior to the planning and design process. In addition to the hydrologic modeling and analysis, a detailed and comprehensive geomorphic stream assessment will also be required to determine the necessary channel improvements to prevent any adverse impacts to the channel morphology downstream of the basin.

The success of any flood detention basin is dependent upon the coordinated implementation of additional flood control detention basins within the Stevens and Rugg watershed. The discharge from each basin must be coordinated to offset the peak discharges in the stream. This will ensure that the discharges in the stream do not exceed maximum sustainable levels.

Feasibility of Implementation:

Refer to Implementation Measure No. 10

Time Line:

Refer to Implementation Measure No. 10

Implementation Cost:

Cost data suggests that construction of a dry detention basin varies between $0.05 and $3.5 per cubic foot of water storage, excluding property acquisition, design and permitting. This site is open with minimal site obstacles. Therefore, an approximate 5-acre site, with an average depth of 5-feet, would store approximately 1-million cubic feet of storm water. This would cost approximately $200,000 to $500,000 to construct.

Imp. Measure

#15

Stream: Rugg Brook
Reach Number: 22 – Collins Perley Sports Complex
Priority: See Summary Matrix – Main Report
Implementation Measure Name: Upgrade Offsite Stormwater Management Facilities

---

Problem Statement:

The drainage area surrounding the Collins-Perley Sports Complex converges on the site in two distinct locations, each of which receives significant discharge volumes. These locations are on the north and east sides of the property. Frequent out of bank flooding occurs at these areas, causing flood damages to the sports complex property. Recently, some work has been conducted by the Vermont Agency of Transportation to mitigate the flooding issues on the north end of the property, including re-grading the drainage ditches and installing a new culvert and stone protection. However, the majority of the flood damages stem from inundation on the east side of the property.

The flooding issues on the east side of the property are related to the existing drainage system of the sports complex and Route 104, which defines the eastern property border. Currently, there are two 36-inch culverts conveying the runoff from approximately 120 acres directly onto the sports complex site. This drainage is then conveyed through a single 36-inch by 22-inch pipe to a drainage swale to the northern most tributary of the Rugg Brook. The flooding occurs when the stormwater discharge into the site exceeds the capacity of the single on-site drainage outlet pipe.

As the development continues to occur upstream of the Collins-Perley Sport Complex, the flood damages will be exacerbated. A measure to mitigate this condition would be to increase the conveyance capacity of the existing offsite stormwater management system. The design of the upgraded system would require comprehensive hydrologic and hydraulic modeling and analysis.

Currently, a hydrologic and hydraulic model evaluation is being conducted specifically for the complex to identify opportunities to reduce both on-site flooding and potentially discharges from the site. An engineering report will be prepared that summarizes the results of the evaluation and recommendations.

Description:

New offsite stormwater management facilities (larger piping and drainage swales) constructed in place of the existing facilities. The stormwater from offsite is the primary source of the flood damages; therefore, upgraded management facilities will mitigate the on-site flooding issues.

The recommended upgrades will include replacing the existing 36-inch by 22-inch drainage pipe to one with capacity to convey both of the 36-in pipes that are draining onto the sports complex from the east. In addition to increasing pipe capacity, the grassed drainage swales would require an increase in size. Currently they do not have the capacity to convey the combined offsite stormwater and the on-site stormwater discharged from the existing detention basin.

Purpose:

The purpose of this implementation measure is to reduce the flood damages experienced by the Collins-Perley Sports Complex due to off-site stormwater inundation. By increasing the capacity of the existing facilities, the flood damages would be mitigated.

Advantages:

- Reduction of flood damage due to offsite stormwater inundation

Disadvantages:

- Construction of the new facilities will interrupt the use of several fields of play on the sports complex property

Interaction and Dependency with Other Watershed Implementation Measures:

Hydrologic and hydraulic modeling and analysis that accounts for all existing and planned development upstream of the sports complex is required prior to the planning and design process.

The successes of this implementation measure will likely cause increased discharge volumes downstream of the sports complex. Due to the nature of this implementation measure, it is likely that downstream flooding problems will be exacerbated. Therefore, coordination will be required between this implementation measure and any other implementation measures in the Rugg Brook downstream.

Implementation Cost:

Costs to upgrade the existing drainage system are to be estimated as part of the current evaluation.

Imp. Measure		
#16	**Stream:**	Stevens Brook
	Reach Number:	6 – Between Main Street and Police Station
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	Flood Reduction at Floodwall

Problem Statement:

Out of bank flooding occurs along an approximate 300-foot reach of the Stevens Brook, from the Main Street culvert outlet to an area adjacent to the City fire / police station. This flooding results in damages to buildings and public infrastructure. There are several reasons why flooding occurs. One reason is that watershed hydrology has changed over time, resulting in increased rates of discharge. Second, is the steep slope and entrenched nature of the channel upstream of Main Street, resulting in significant velocities exiting the Main Street culvert. Third, flood damages occur because the channel is restricted and because there are buildings and infrastructure located in the floodplain.

Description:

The ideal solution for this reach is to remove the buildings from the floodplain and allow controlled inundation of the historic floodplain. This should be considered a long-term objective, and structures (particularly the 3 to 4 residential units located just west of Main Street and south of Lower Weldon Street) should be removed when the opportunity presents itself.

As an interim implementation measure, raising the height of the floodwall that is located on the right bank can reduce the frequency of flooding along Lower Weldon Street, and hard armor the area to reduce the potential for scour and erosion. In addition, the existing floodwall can be moved further away from the stream, providing additional channel area. The floodwall elevation would be raised for the entire extent of the wall, approximately 300-feet.

This implementation measure would also include construction of a floodplain terrace on the left bank opposite the floodwall. The floodplain terrace would be constructed opposite the floodwall, on the left bank, extending from the outlet of the Main St. culvert downstream for approximately 200-feet.

Purpose:

The purpose of this solution is to reduce the frequency of flooding and flood damages to residential property on the upper portion of Low Weldon Street. This area would be expected to include the residences between the Fire Station and the Main Street Intersection on the south side of the street. The increased elevation of the floodwall will allow higher flood stages to remain within the channel without overtopping, reducing the potential for flood related damages. The

floodplain terrace is intended to mitigate the adverse affects on channel hydraulics resulting from raising the floodwall, by providing additional flow area. This additional area would be designed to reduce the stream power, velocity and energy gradient for flood events up to and including the 100-year event.

Advantages:

- Reduce the frequency of discharge overtopping the floodwall
- Reduce residential property damage along Lower Weldon Street
- Reduce discharge velocities along the flood wall

Disadvantages:

Possible increased deposition of sediment in the floodplain terrace and adjacent stream – The decrease in energy will cause a certain amount of sediment to drop out of the stream. This action over time may cause the channel and flood plain aggradation.

Acquisition of residential property on Lower Weldon and New Streets for the construction of the floodplain terrace and elevated floodwall. The proposed location of the floodplain terrace is entirely privately owned land. In order to implement this solution this privately owned land would need to be purchased or donated by the landowners.

Temporary loss of riparian vegetation for the construction of the floodplain terrace – Currently, the proposed location of the floodplain terrace is well vegetated with trees and shrubs, this vegetation would be temporarily removed. However, revegetation would be part of the design.

Interaction and Dependency with Other Watershed Implementation Measures:

This implementation may not be required if the flood control detention basins are implemented in the upper watershed. A detailed watershed hydrologic and hydraulic model will provide an estimate on the potential for out of bank flooding in this area. Therefore, consideration of the Raised Floodwall Implementation Measure would occur after Implementation Measure No. 2 (Detailed Watershed Hydrologic and Hydraulic Analysis) and implementation of the flood control detention basins.

Implementation Cost:

Construction of a structural floodwall could cost approximately $200 per linear foot.
Construction of a Floodplain terrace could cost approximately $50 per linear foot, excluding right of way acquisition. Therefore, a 300-foot long project could cost approximately $75,000 to $100,000 excluding right of way acquisitions, design and permitting.

Imp. Measure		
#17	**Stream:**	Rugg Brook
	Reach Number:	22 – Tanglewood Drive Development
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	Drainage System Improvements

Problem Statement:

The Tanglewood development, located south of the St. Albans Highway in the Town of St. Albans frequently experiences flooding and flood damages during storm events and heavy snow melt events. Flooding occurs as significant sheet flow across residential property and along the development roads, which has caused significant damage to residential property in the past.

Stormwater runoff and drainage has become a very complicated issue in this development, with a number of parties having conflicting priorities and approaches to resolving this issue. This implementation measure does not attempt to address these issues, but rather focuses on solutions to reduce the frequency of flooding.

A stormwater drainage assessment and evaluation of potential solutions was conducted for the Town of St. Albans in 2001. A report was issued in January 2002, which summarized the results and implementation recommendations. In general, this report recommends drainage modifications be made at the Tanglewood development and at the drainage system which crosses under the St. Albans Highway further to the east and discharges into the Collins – Perley Sports Complex.

The Vermont Agency of Transportation constructed the recommended improvements to the drainage system, which crosses under the St. Albans Highway further to the east and discharges into the Collins – Perley Sports Complex during the summer of 2002. Drainage systems improvements within and adjacent to the Tanglewood development have not been made as of February 2003.

Description:

This implementation measure is the construction of improvements at the Tanglewood development (area 2) as indicated in the January 2002 report. Of the three (3) options indicated in the report, Option 2A is recommended.

This option generally consists of constructing a new drainage swale along the southern side of the St. Albans access road, from the eastern most culvert that discharges directly into the development, behind lot 1, westerly to the existing detention basin. A small earth berm would be located along the southern side of this ditch to reduce the potential for runoff to jump the ditch and enter into the development. Runoff would then be conveyed to the detention via a new underground culvert. In addition, repairs to the existing detention basin would be made, including the outlet structure, fencing, growth and debris and dredging and removal of accumulated sediment.

Purpose:

The purpose of this implementation measure is to redirect a majority of surface runoff into a properly designed storm drain system. This should significantly reduce the potential for flooding and subsequent damage to the residences of the Tanglewood development.

Advantages:

- Reduction of flooding and flood related damages and repair costs
- Reduces the potential for injuries to people or animals during a flood event
- Decreases erosion and sediment load into the stream
- Provides increased opportunities for treatment of runoff

Disadvantages:

- A portion of the land under which the drainage collector pipe is to be installed is privately owned. Easement will need to be obtained prior to construction.

Interaction and Dependency with Other Implementation Measures:

Installation of this implementation measure can be conducted independently of all other measures. Review of the existing storm system and the associated permits would be conducted separately from implementation Measure 1.

Cost:

The cost to construct this implementation measure is approximately $50,000 to $75,000. Representatives from the VT Agency of Transportation has indicated willingness to construct the work located within their right of way (ditch, berm and associated culvert modifications under the St. Albans highway). This would significantly reduce the cost to construct the remainder of the project.

Imp. Measure	**Stream:**	Stevens Brook
	Reach Number:	4,5,6&7 – St. Albans WWTF upstream to the eastern
#18	**Priority:**	See Summary Matrix – Main Report
	Implementation Measure Name:	Sediment Removal from Existing Storm Sewer Systems

Problem Statement:

The water quality downstream of the City is listed on the EPA 303(d) list due to its impairment. The listed impairments are consistent with urban impairments, sediment, nutrient & organic enrichment, and E. coli. These contaminants are transported with sediment that enter the stream via stormwater runoff. A significant contributor of stormwater runoff entering the stream is the impervious area in the City and Town. If left untreated the stormwater runoff will continue to contribute to the impairment of this stream and hinder future development within the watershed.

Description:

As the City and Town continue to upgrade its sanitary and stormwater systems, the installation of sediment removal devices will reduce the amount of sediment being introduced into the stream from City and Town outfalls. In addition to sediment removal, these devices provide detention, which will reduce the runoff rates of the stormwater from the impervious area within the city. The decreased runoff rates will ultimate lower the flood stage elevations and therefore reduce periodic residential flood damage.

Purpose:

The purpose of installing sediment removal devices is to reduce the amount of sediment entering the stream from the City and Town stormwater system outfalls. The reductions in urban generated sediment entering the stream will initiate the process to improve the water quality of the stream.

Advantages:

- Reduce the sedimentation of the brook
- Improve the water quality of Stevens Brook
- Reduce depositional material which cause instream aggradation

Disadvantages:

- Significant construction within developed (built-out) areas
- Cost to the City for doing this.

Interaction and Dependency with Other Implementation Measures:

The implementation of sediment removal and detention devices in the existing city stormwater system can be done independently of the other implementations in the watershed. The design, however, is dependent upon the results of the watershed hydrologic and hydraulic modeling and analysis.

Cost:

The costs for such devices are estimated to range from $15,000 to $20,000 per acre of drainage area.

Imp. Measure		
#19	**Stream:**	Stevens and Rugg Brooks
	Reach Number:	Entire Stevens/Rugg Watershed
	Priority:	See Summary Matrix – Main Report
	Implementation Measure Name:	Public Education Meetings and Outreach Programs

Problem Statement:

One of the principal water resource problems is land use activities that result in increased flooding and degradation of water quality by many of property in the watershed. This includes residential, commercial, municipal, industrial, state and federal landowners. Examples of this include mowing lawns to the edge of the brook, heavy application of fertilizers to lawns, improper locations of drain pipes, connections of roof drains to drain systems, the repeated use of hydraulic structures which are too small, and include erosion.

In addition, there is wide perception that the flood and water quality issues are limited to people who live and work adjacent to the streams. The reality is that the problems are a watershed wide issue, and all people in the watershed contribute to the problems.

Description:

This implementation measure consists of conducting a series of neighborhood level public education meeting and outreach programs. There are many simple and low to no cost measures that individual property owners can take to reduce flooding and improve water quality. Some of these measures are identified in this report, including roof drains, riparian buffers and maintenance and upgrade of existing storm water systems.

Purpose:

The purpose of conducting neighborhood information meetings and a public outreach program is to inform and educate people of the interrelationship between everyone in the watershed and the response that occurs in the brooks.

A case in point: During one of the site reconnaissance's, DuBois & King noticed a large plume of milky white color in the Stevens brook. This plume was traced to the source, and found that several people were dumping water from washing paintbrushes into the road gutter. This painted water flowed directly into a catch basin, then in turn into the brook. The people had no awareness of the connection of their actions to water quality in the brook.

Advantages:

- Provides a long-term mechanism for education of people living and working in the watershed between the interrelationship between land use activities and the ultimate responses that occurs in the brooks.

- This education should result in changed habits and activities, some of which will benefit the responses in the brooks.

- Long-term changes in land use activities will aid in the reduction of flooding and flood damages, and will aid in the improvement of water quality.

Disadvantages:

- There are no significant disadvantages of informing people on the interrelationships between land use and the responses that ultimately are realized in the brooks.

Interaction and Dependency with Other Watershed Implementation Measures:

This implementation measure is not dependent on any of the other identified measures. However, it would positively affect and interact with virtually all of the other measures.

Feasibility of Implementation:

This is a very feasible measure to implement. Out reach programs can be initiated at the public school level, municipal level, civic groups, business community, and many other forums. In addition, watershed planning officials at the Vermont Agency of Natural Resources can provide valuable tools and guidance in support of this measure.

Time Line:

The municipalities should immediately begin exploring this implementation measure. Indeed, at the June 3, 2003 Public Information meeting, several students from the area high school indicated a desire to begin implementation of public education at the school.

Cost:

It is expected that this would be a volunteer based effort. Concerned citizens can easily plan, organize and implement outreach programs. Existing groups, such as the Stevens- Rugg Watershed Association is an excellent place to start. There would be some costs associated with this measure, such as newspaper notices, poster boards, etc.