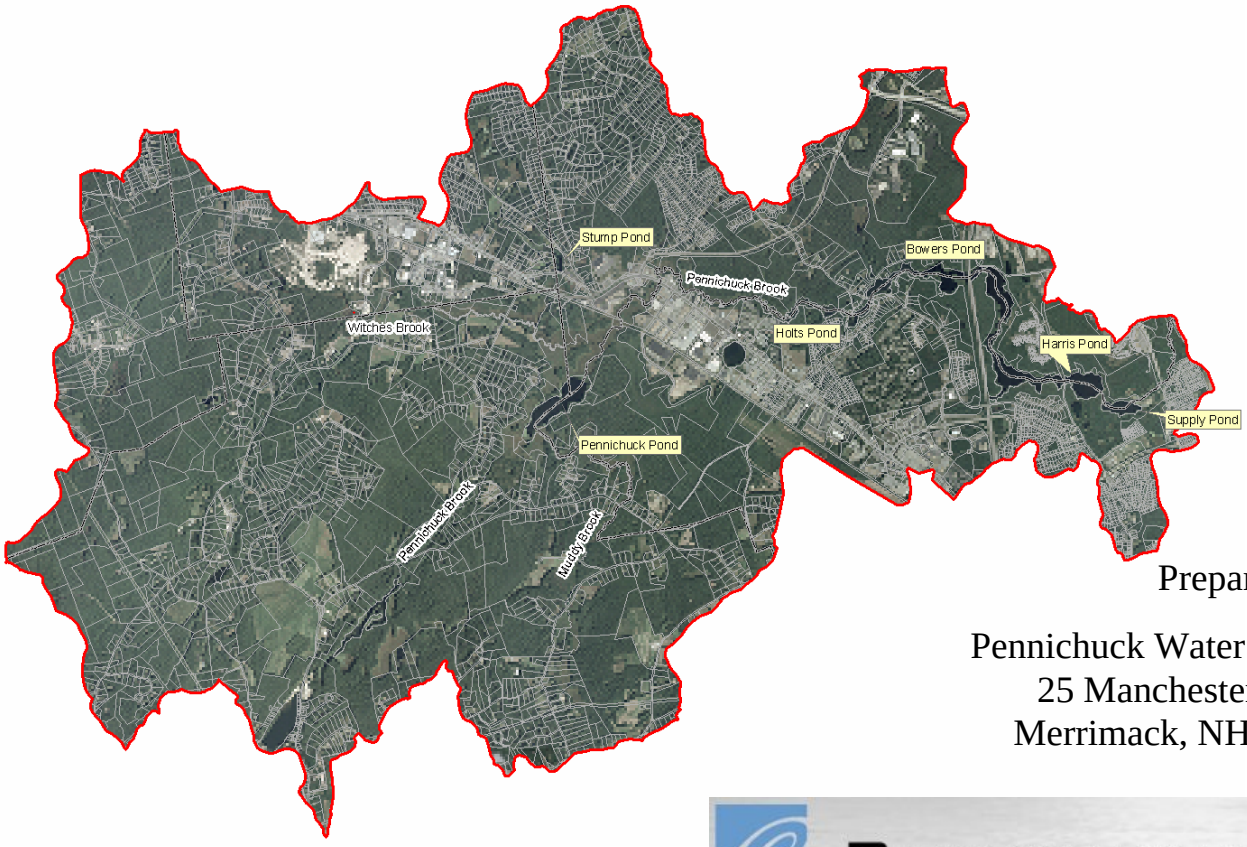
Pennichuck Water Works
Pennichuck Brook
Watershed Restoration Plan

Final Report
February 7, 2008



Prepared for:

Pennichuck Water Works
25 Manchester Street
Merrimack, NH 03054

Prepared by:

State of New Hampshire
Department of Environmental Services
29 Hazen Drive, P.O. Box 95
Concord, NH 03302

Comprehensive Environmental Inc.
21 Depot Street
Merrimack, NH 03054

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Executive Summary

This ten-year watershed restoration program was created by Pennichuck Water Works, Inc. following the completion of the 1998 Watershed Management Plan and implementation program. The implementation of the Watershed Management Plan was highly successful, occurring from 1998 until 2007; however, the effectiveness was not quantified due to a lack of monitoring and other data. The purpose of this 10-year watershed restoration program is to provide that quantification.

The 10-year program was developed over a two-year period from 2006 to the end of 2007. During that time, considerable water quality and flow data was collected throughout the watershed for both dry and wet weather precipitation events. Based on that data and other available historical data, Pennichuck evaluated flows and pollutant loads throughout the watershed. Pennichuck's consultant Comprehensive Environmental Inc. (CEI) used the data to develop and calibrate the model that mimics flow and quality of Pennichuck Brook at various locations throughout the watershed. The model was calibrated such that 'what if' scenarios could then be evaluated as to how to meet water quality goals.

Based on the morphometry of the Pennichuck ponds, which are shallow, riverine ponds with a high flow rate, and based on typical phosphorous levels for that type of pond, a target water quality goal was set. Various improvements were then modeled to determine how best to meet that water quality goal.

The end result of the modeling and monitoring is a 10-year capital improvement plan that is tied to pollutant load reductions. This is unique in that most watershed restoration programs do not take the final step of quantifying potential pollutant removals from various stormwater practices to match the target goal, nor do they tie it into a capital improvement program (CIP) and schedule.

The capital improvement plan covers a 10-year period from 2008-2017 at a cost of $2.7 million dollars. These expenditures are estimated to reduce phosphorous loadings by some 2,300 pounds per year, enough to meet the 30 micrograms per liter target goal. At least $600,000 and possibly more of the cost is potentially reimbursable by grants.

The recommendations under the 10-year program are comprehensive and designed to address nearly every source of phosphorus, including widespread loadings from commercial/industrial parking lots, roadways, residential areas, internal pond loadings, and sediment sources. Several other problems, including potential sources of bacteria and suspended solids, are also addressed although not modeled. The recommendations include:

- extensive public education;
- increased street sweeping and catch basin cleaning in private commercial areas to be performed by Pennichuck;
- the retrofitting of key detention basins including the Tinker Road detention basin retrofit;
- encouragement of low impact development (LID) practices throughout the watershed via a grant program to watershed communities;
- encouragement of local adoption of new state storm water standards at a reduced threshold;
- evaluation of groundwater phosphorous levels;
- evaluation of sediment accumulation over time;
- a Stormwater Utility Feasibility Study for the region;
- continuation of Harris Pond aeration; and
- continuation of the long-term monitoring program.

In addition to the capital costs outlined above, significant operational costs will also be born including staffing for equipment operation, continued monitoring of the watershed, and inspection of stormwater practices.

After the 10-year watershed program is complete, the results should be revaluated and adjustments made for further improvements where possible.

1.0 Introduction

This report describes the results and evaluation of the Pennichuck Brook Watershed to develop a Watershed Restoration Program to address excess algal growth and cyanobacteria in Harris Pond. Harris Pond is currently listed on the 2006 305(b)/303(d) Surface Water Quality Assessment for cyanobacteria. Cyanobacteria or "blue-green" algae blooms are caused by excessive nutrient loadings into the ponds, particularly phosphorus, which is the limiting nutrient in fresh water systems. This plan focuses on implementation actions to reduce phosphorus loadings into Harris Pond. A cyanobacteria bloom occurred in the pond as recently as September 2007.

The Pennichuck Brook watershed occupies more than 17,000 acres in rapidly developing southern New Hampshire. It provides a major portion of the drinking water supply for Nashua and some surrounding communities, supplied by Pennichuck Water Works Corporation, a private water supply company.

The restoration plan is described in six sections beginning with this introduction. Section 2.0 describes the watershed source analysis of pollutants using a watershed model developed to evaluate stormwater impacts and issues. Section 3.0 lays out the numeric targets or goals for water quality. The necessary reductions needed by community are then described in Section 4.0 on wasteloads. Section 5.0 describes options and control strategies plus the restoration plan and overall schedule.

1.1 Background

Pennichuck Brook has long been the primary source of water supply for a significant portion of southern New Hampshire. The water supply is operated by Pennichuck Water Works Corporation located in Merrimack, NH, with peak summer demands sometimes supplemented by the Merrimack River. Over the last 100 years, extensive development throughout the 17,000+ acre watershed has resulted in declining yields and water quality, a common phenomenon in urbanizing areas of New Hampshire and elsewhere. This has caused increased algal blooms in Harris Pond, due to excessive phosphorus loadings. Contributing factors include major highways, urban traffic and dense commercial/industrial land uses that have developed throughout a large segment of the watershed, much of it since 1950.

In recognition that watershed protection for the five town watershed needed a multi-faceted approach, Pennichuck Water Works Corporation (Pennichuck) developed a Comprehensive Watershed Management Plan (CEI, August 1998). The Watershed Management Plan identified 10 of the most significant problems in the watershed and proposed recommendations for improvement. The most significant threat was identified as urban stormwater. Recommendations for improvement

included increasing buffer zones; evaluating sediment accumulations in the ponds; working to ease transportation impacts; providing public educational outreach; developing and distributing focused educational materials targeting agricultural land uses as well as other "hot spots" such as gas stations and repair shops; gaining regulatory authority through the State of New Hampshire; and the development of a comprehensive database that can be used to track progress.

Following development of the Comprehensive Watershed Management Plan, Pennichuck sought funding from NH Department of Environmental Services (DES) for implementation of the key recommendations. Where outside funding was unavailable, Pennichuck provided funds directly or provided matching funds. Step by step, the recommendations were implemented. In some cases the scope of the recommendations was refined during implementation.[1] A graphic representation of the follow-on studies, designs and construction projects is shown on Figure 1-1.

Following substantial completion of the recommended measures, Pennichuck initiated an effort to update the Watershed Management Plan and in the process to reevaluate and reprioritize its efforts. Since watershed management is always a work in progress, it is helpful to complete periodic updates and adjust methods, goals and actions to match the latest scientific understanding of the best watershed management techniques. This report presents the update completed in 2006/2007.

1.2 Purpose of the Watershed Restoration Plan

This Watershed Restoration Plan provides an update and reevaluation of the Watershed Restoration Actions performed by Pennichuck and others. A quantitative approach was used that included the development of a computer model to evaluate existing sources of pollution and to further evaluate how proposed watershed restoration actions would affect the total pollution load. The objectives were:

1) to identify water quality goals based on the latest information and water quality data;
2) to calibrate the data to match the flows in Pennichuck Brook and its tributaries; and
3) to match proposed future projects to the restoration goals for the watershed.

This report presents the findings, modeling results and actions proposed for improving water quality in the watershed. Consistent use of

[1] For example, Recommendation #4 on Transportation Impacts included a subtask to develop a monitored demonstration roadway for comparison to an old style roadway. This recommendation turned out to be infeasible and was replaced with a demonstration parking lot which was retrofitted with Low Impact Development techniques.

quantified loadings provides a basis to evaluate the effectiveness of projects towards achieving water quality goals.

1.3 General Watershed Information

The Pennichuck Brook Watershed occupies land in five southern New Hampshire towns, including Nashua, Merrimack, Amherst, Milford and Hollis. The primary water supply consists of about 351 acres of water in a series of chain ponds that includes Supply Pond, Harris Pond, Bowers Pond, Holts Pond, Stump Pond, Pennichuck Pond and many smaller ponds. However, the total pond acreage is just under 2% of the total watershed area, as shown on Figure 1-2. Figure 1-3 shows the overall watershed, which is 17,984 acres in total with 10 subwatersheds of roughly 1,200-3,200 acres each.

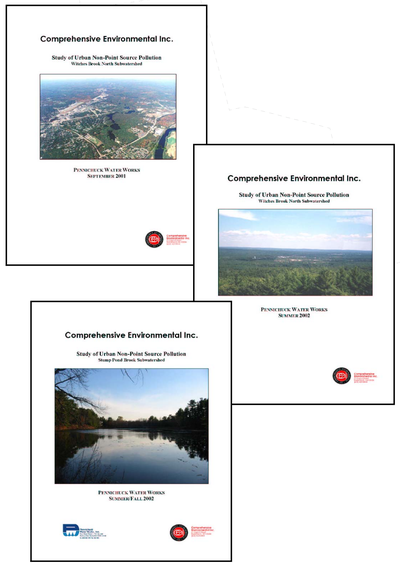
The populations of each of the watershed towns have grown considerably, particularly between the 1960 and 1990 censuses when the population in Nashua alone more than doubled. Table 1-1 shows watershed population by town from 1940 through 2000, showing the dramatic increase in population. Although the watershed is threatened by this continuing population explosion, there are also some features that help to minimize the extent of water quality degradation in the near term. These factors include:

1) much of the watershed has relatively sandy, well drained soils;
2) one of the watershed communities (Hollis) contains a large proportion of the watershed yet is only lightly developed and zoned to stay that way; and
3) Pennichuck has been promoting Low Impact Development (LID) on many projects in the watershed. LID is geared to protect the natural hydrology of each site.

In addition, both water quality and quantity benefit significantly from the large network of wetlands that occur in some areas of the watershed. These wetlands store and purify large quantities of water, providing immense benefits in terms of flood storage, water purification and aquatic habitat. Some of the most significant wetland areas are shown on Figure 1-4. In the next section, flow and water quality data are described further along with the development of the water quality model.

Table 1-1. Watershed Community Populations 1940-2000[2]							
	Year						
City/Town	**1940**	**1950**	**1960**	**1970**	**1980**	**1990**	**2000**
Amherst	---	---	2,051	4,605	8,243	9,068	10,769
Hollis	---	---	1,720	2,616	4,679	5,705	7,015
Merrimack	---	---	2,989	8,595	15,406	22,156	25,119
Milford	---	---	4,863	6,622	8,685	11,795	13,535
Nashua	32,927	34,669	39,096	55,820	67,865	79,662	86,605

[2] Note that the data represents each community as a whole and not just the watershed area. Source: http://www.nh.gov/oep/programs/DataCenter/Population/documents/Munipop60-00.doc



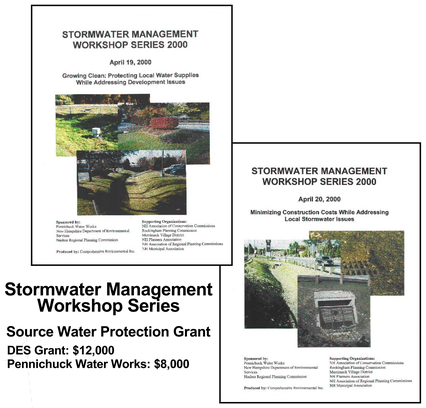
Studies of Urban Non-Point Source Pollution

Source Water Protection Grants
- Boire Field Brook: $14,680
- Pennichuck Brook to Bowers Pond: DES Grant $13,700, Pennichuck Water Works $9,200
- Stump Pond Brook: DES Grant $15,000, Pennichuck Water Works $3,750
- Witches Brook East: DES Grant $15,000, Pennichuck Water Works $4,600
- Witches Brook North: DES Grant $15,000, Pennichuck Water Works $3,900
- Sediment Study: DES Grant $14,840, Pennichuck Water Works $8,000

319 Watershed Assistance Grant
- Remaining Five Sunwatersheds:

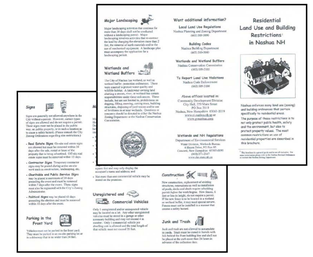
Muddy Brook,
Pennichuck Brook to Holts Pond,
Pennichuck Brook to Pennichuck Pond,
Pennichuck Brook to Supply Pond,
Witches Brook South

DES Grant $19,100
Pennichuck Water Works $28,600

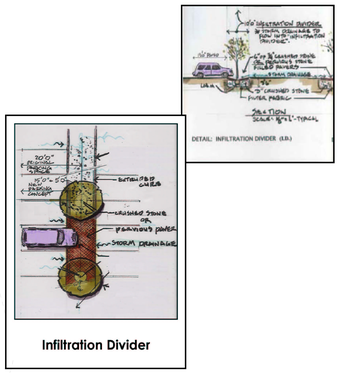


Stormwater Management Workshop Series

Source Water Protection Grant
DES Grant: $12,000
Pennichuck Water Works: $8,000



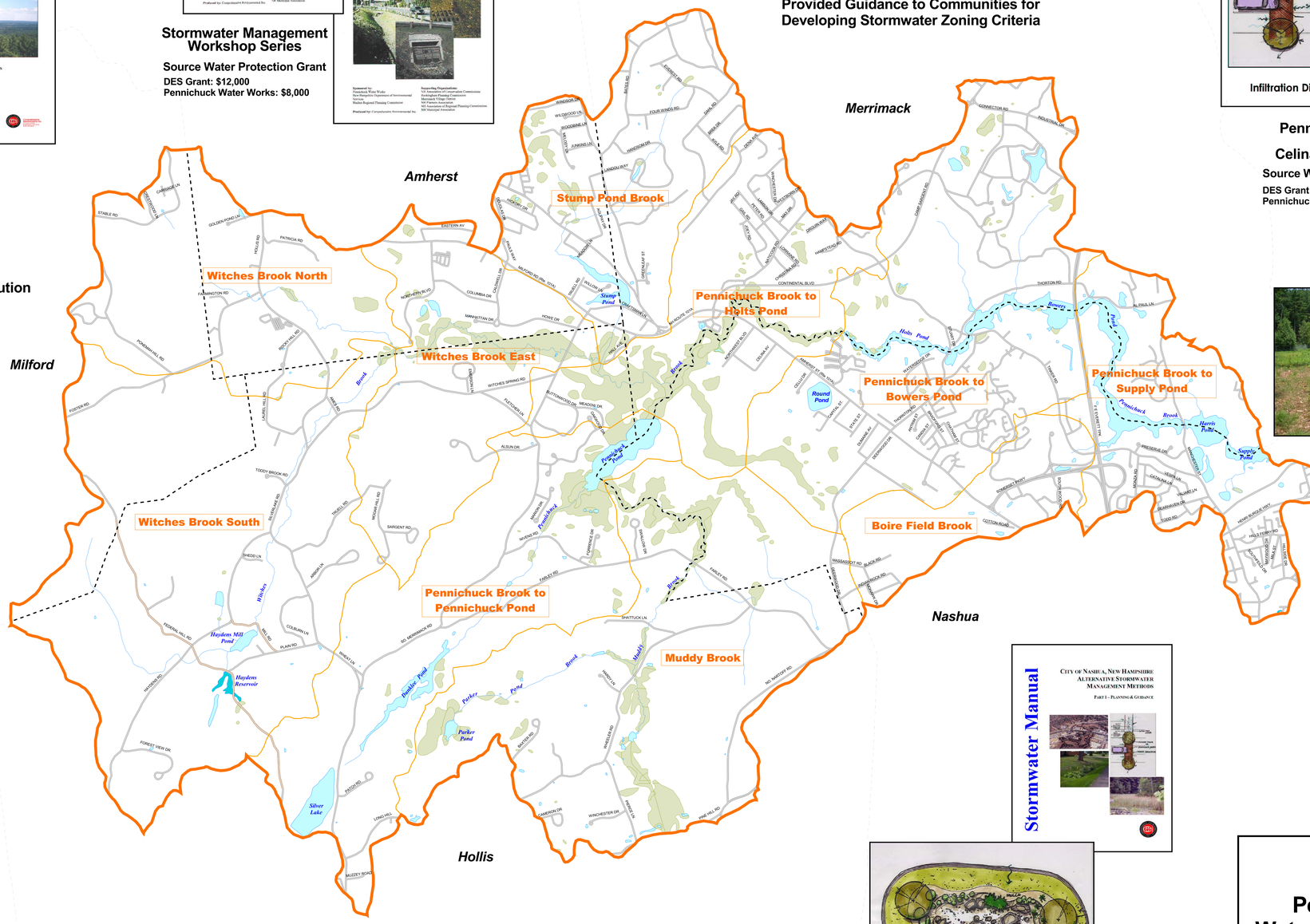
Provided Guidance to Communities for Developing Stormwater Zoning Criteria



Infiltration Divider

Pennichuck Square and Celina Avenue BMPs

Source Water Protection Grant
DES Grant: $28,500
Pennichuck Water Works: $27,500



Nashua Community Technical College Wet Detention

Pennichuck Water Works: $175,000

Hot Spots Program

319 Watershed Assistance Grant
DES Grant: $15,000
Pennichuck Water Works: $9,300

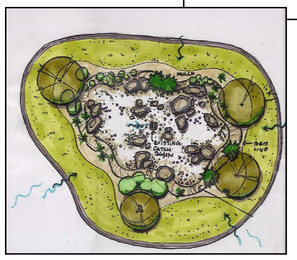
LET ONLY RAIN GO DOWN THE STORM DRAIN
DRAINS TO WATER SUPPLY

Storm Drain Mapping & Marking Program

Source Water Protection Grant
DES Grant: $15,000
Pennichuck Water Works: $19,000

Cornerstone Site Structural BMP/ Post Office Treatment Swale & Biolog

319 Watershed Assistance Grant
DES Grant: $21,000
Pennichuck Water Works: $14,000



Alternative Stormwater Management Manual

319 Watershed Assistance Grant
DES Grant: $40,000
Matching Contribution $58,500 by:
Pennichuck Water Works: $25,000
City of Nashua: $25,000
Comprehensive Environmental Inc.: $8,500

Figure 1-1

Pennichuck Water Works Watershed Management Projects

Pennichuck Brook Watershed
Southern New Hampshire

PENNICHUCK CORPORATION

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

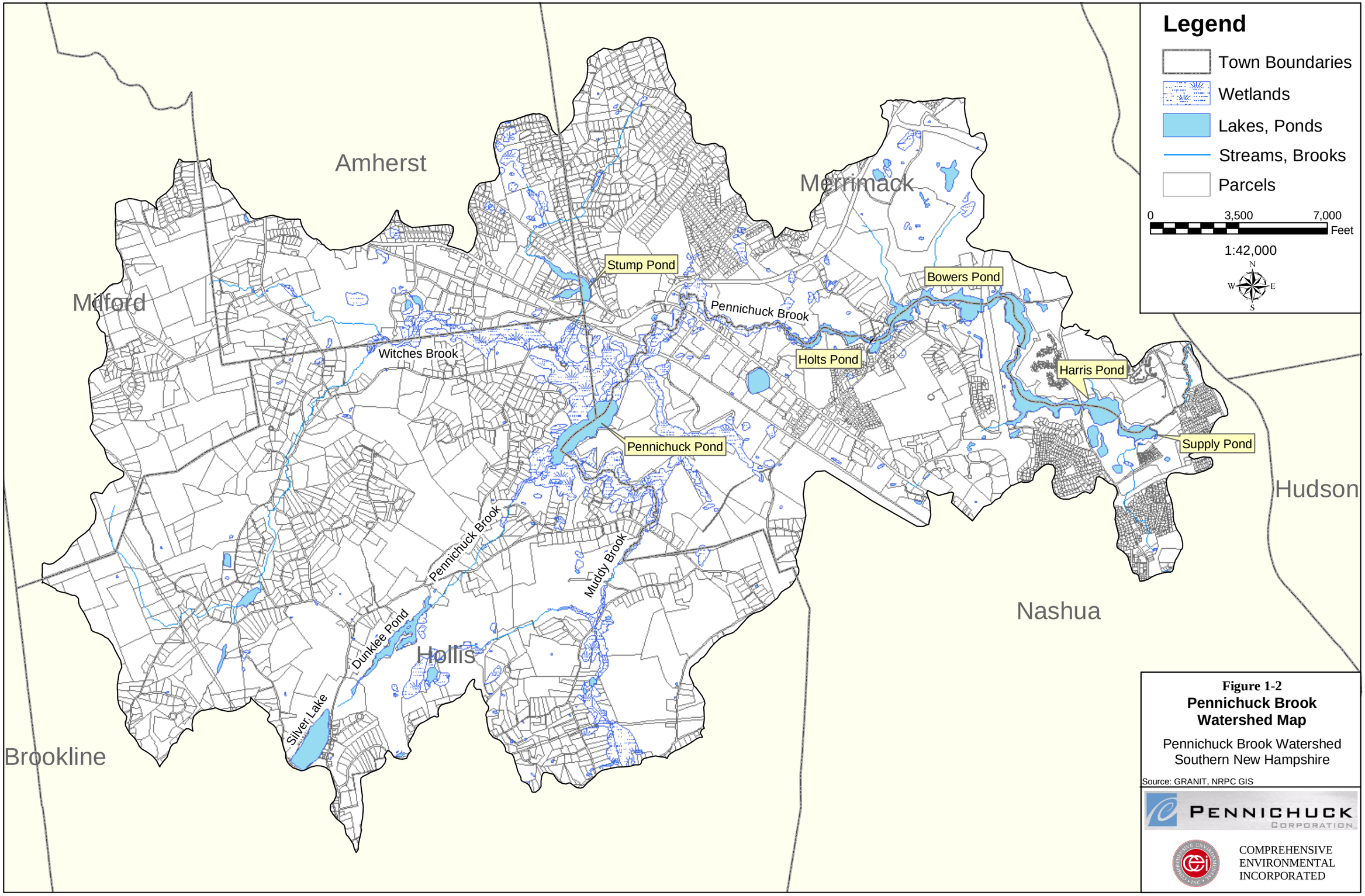


Figure 1-2
Pennichuck Brook Watershed Map

Pennichuck Brook Watershed
Southern New Hampshire

Source: GRANIT, NRPC GIS

PENNICHUCK CORPORATION

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

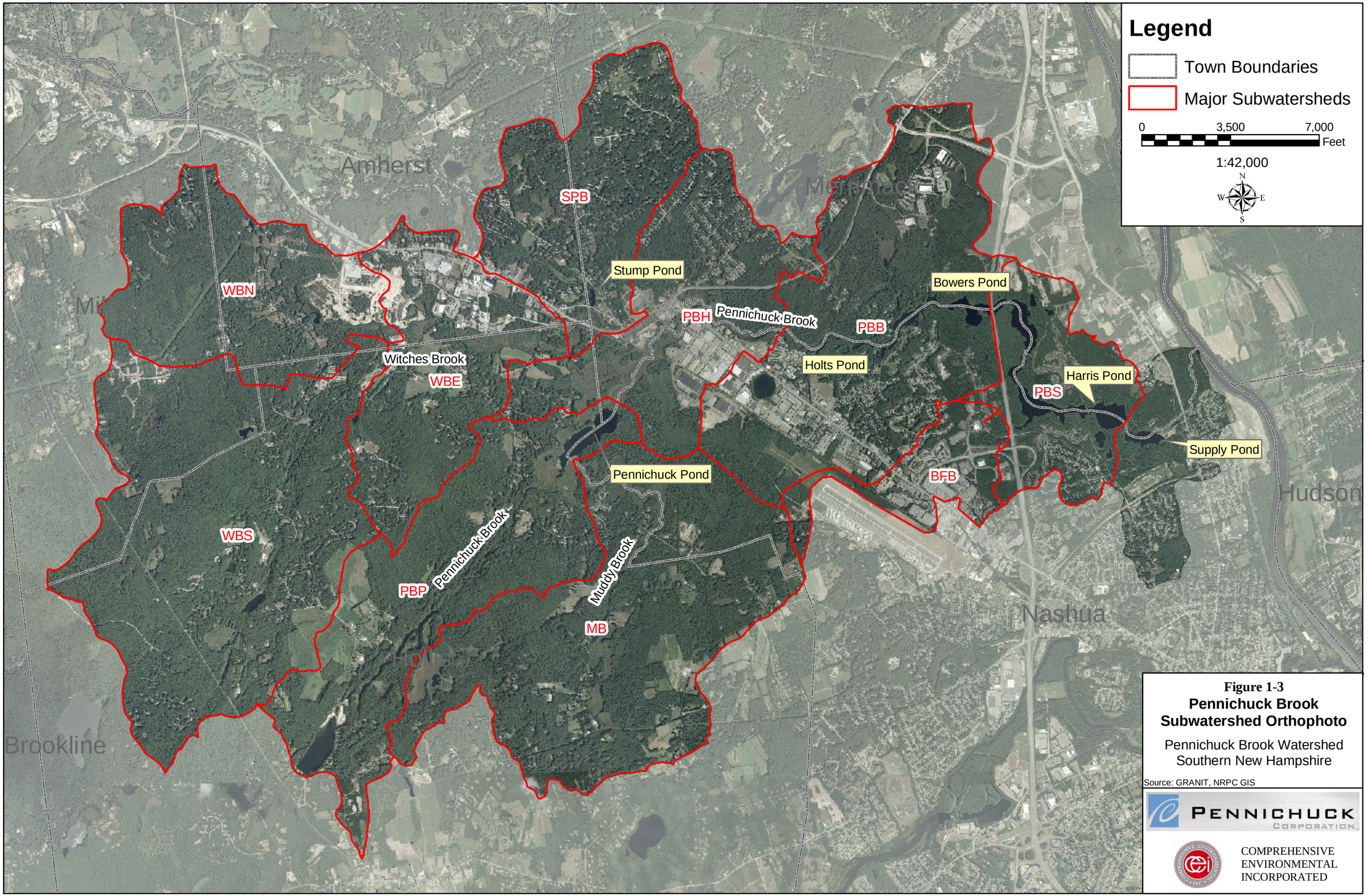


Figure 1-3
Pennichuck Brook Subwatershed Orthophoto

Pennichuck Brook Watershed
Southern New Hampshire

Source: GRANIT, NRPC GIS

PENNICHUCK CORPORATION

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

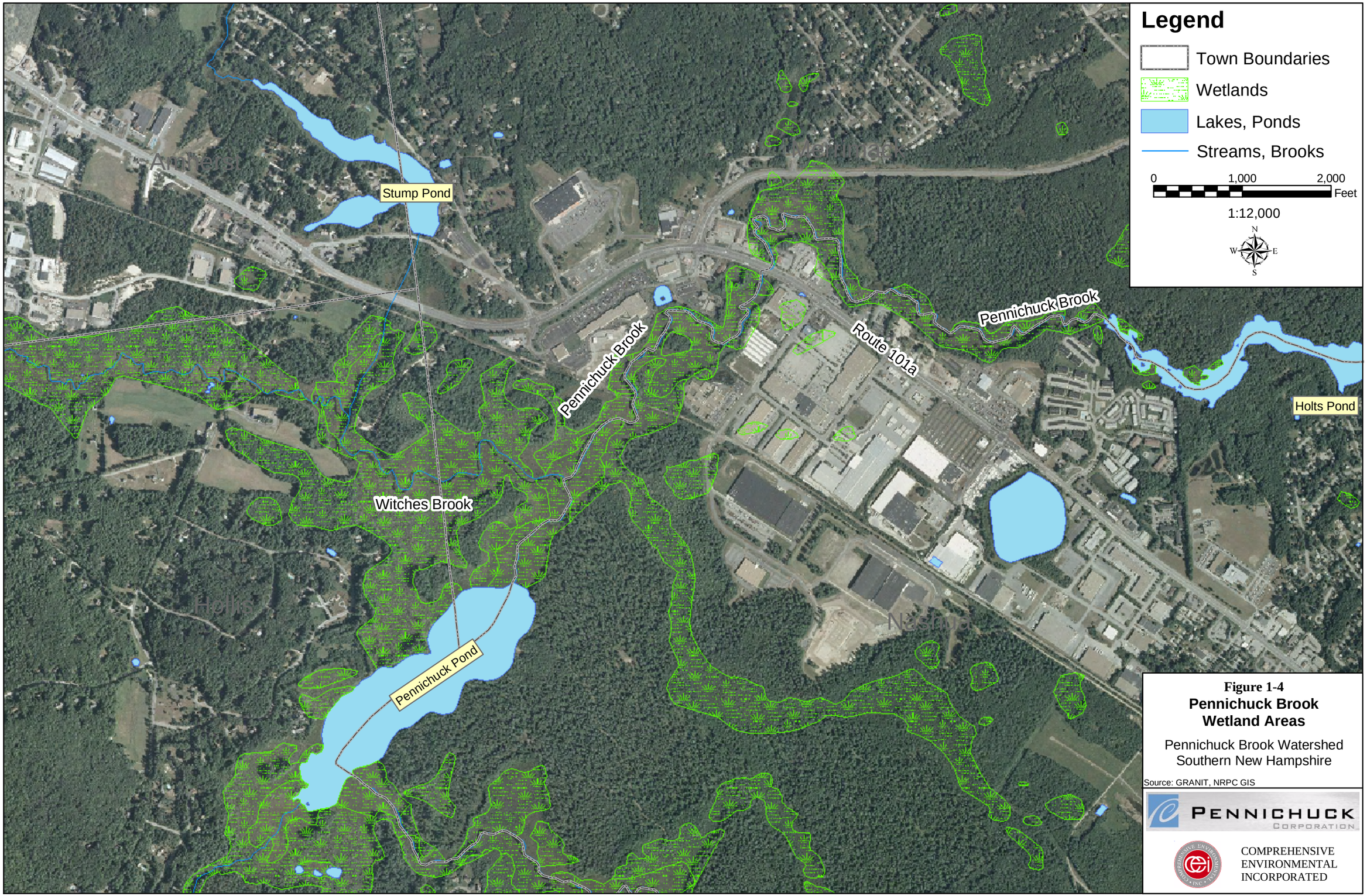


Figure 1-4
Pennichuck Brook Wetland Areas

Pennichuck Brook Watershed
Southern New Hampshire

Source: GRANIT, NRPC GIS

PENNICHUCK CORPORATION

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

2.0 Source Analysis

Setting water quality goals for the Pennichuck Watershed and developing action items to achieve those goals requires an understanding of existing pollutant loadings. To account for the multiple parameters involved in estimating pollutant loadings from the watershed, the study team selected EPA's Storm Water Management Model (SWMM) Version 5.0 (Rossman, 2005) to assist with the development of pollutant estimates. The model allows for the evaluation of stormwater practices and their impact on water quality. Although the primary function of this model for the Pennichuck watershed is to evaluate water quality within the water supply ponds, a detailed flow assessment was also performed to calibrate phosphorus loads to match observed in-pond concentrations. The Reckhow and Vollenweider models were also used to convert pollutant loadings calculated in SWMM to estimated concentrations in the ponds.

2.1 Flow Assessment

The first step in setting up the model was to evaluate tributary flows in the watershed and their response to precipitation events to better quantify flows associated with stormwater runoff and those associated with baseflow.

The model includes a surface runoff/infiltration component and an aquifer/streamflow component (Figure 2-1). Precipitation falls on the ground surface and either evapotranspires, infiltrates or runs off, depending on several variables (e.g., land use, soil type, depression storage). In the model, the study team developed a simple aquifer below the surface of each subwatershed. As configured for this study, the model assumes that this shallow aquifer collects the water that percolates through the surficial soils and conveys this water to the streams as groundwater baseflow.

Deep aquifer recharge is assumed to be insignificant, however, there may be deep aquifer discharge to the streams. The basis for this assumption is: 1) the observed flow data that was collected from the streams for several months in 2005 and 2006 shows that the streams are supported by groundwater discharge as seen by the observed peaks during and after a precipitation event; and 2) using these assumptions, the model predicted less flow in the streams than was observed in the field, which indicates that the deeper aquifer may also be providing water to the streams. An in-depth geological and hydrological analysis was not performed to confirm these assumptions, as the model calibrated well with the existing data and the primary focus of the modeling effort was stormwater runoff and the associated pollutants.

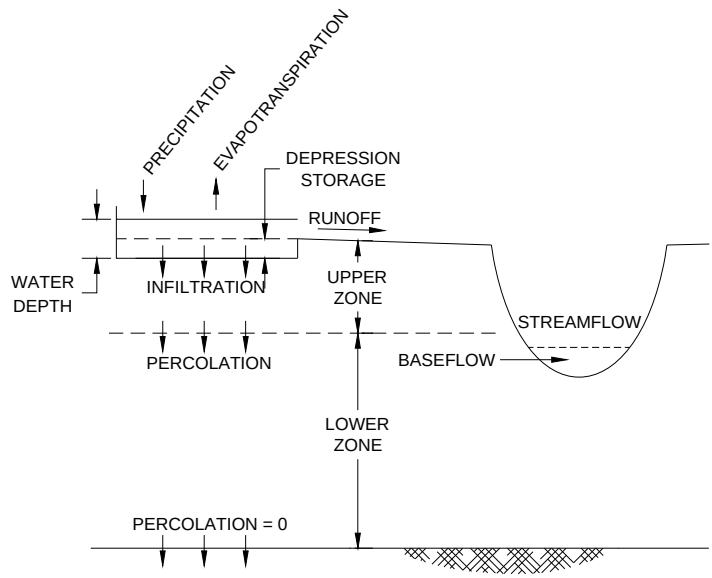


Figure 2-1. EPA SWMM Model Water Balance Schematic

The following summarizes the data used in the model and the results of the flow assessment.

2.1.1 Input Data and Assumptions

The majority of the model input data was available as spatial data in a Geographic Information System (GIS). GIS data was available from NRPC and the State of New Hampshire GIS (GRANIT). The layers available for use, and a description of their purpose in the model, are described in Table 2-1 below.

Table 2-1. Existing GIS Data

GIS Layer	Model Use	Type	Source
Subwatersheds	Subcatchments	Vector-Polygon	(CEI, 2005)
Parcels	Mapping	Vector-Polygon	(NRPC, 2005)
Land Use	Land Use, Imperviousness	Vector-Polygon	(NRPC, 2005)
Landcover	Evapotranspiration Cover Coefficients	Vector-Polygon	(GRANIT, 2001)
Soils	Infiltration Rates, Soils Parameters	Vector-Polygon	(GRANIT, 2006b)
Hydrography	Streams, Ponds, Reservoirs	Vector-Polygon/Polyline	(GRANIT, 2006a)
Orthophotos	Mapping	Raster-Image	(GRANIT, 2005)
USGS Topographic Maps	Elevation Data	Raster-Image	(GRANIT, 2004)

Subwatersheds

The Pennichuck water supply watershed was divided into 24 subwatersheds or subdrainage areas for modeling purposes (Figure 2-2). This allows for evaluation of each subarea for impacts to tributaries and the larger receiving streams and provides a more manageable scale to evaluate the area, providing more localized information on which to base decisions.

The subwatershed boundaries are natural boundaries dictated by the local topography. These boundaries generally follow ridgelines or high points and represent the area that drains to the furthest downgradient point, which was typically chosen where a stream intersected another stream. The original ten subwatershed boundaries included in the 1998 Watershed Management Plan[1] were broken up further to reflect the area draining to locations where water quality data existed, which would allow for better calibration of pollutant loadings.

USGS topography was also used to determine the average surface slope of each subcatchment area, which is used in runoff estimations in the model.

Hydrography

Hydrography data includes streams, ponds and reservoirs. This information is used to estimate stream lengths and pond areas used in the model. Stream cross-sections were measured in the field for select locations. Hydrography data was obtained from the State of New Hampshire GIS GRANIT database.

Land Use and Landcover

The type of land use within the watershed has a direct relationship with the amount of runoff and pollutant loadings to the water supply. Land uses with greater levels of impervious area will result in greater runoff than forested areas. The steepness of the land also plays a role in the amount of runoff generated, with steeper areas producing more runoff than flat areas. Generally, the same holds true for pollutant loadings, with greater levels of pollutants associated with more developed areas.

Land use data within the Pennichuck watershed was obtained from NRPC. The NRPC database consisted of multiple land uses throughout the watershed. This data was consolidated into eight land uses as shown in Table 2-2, which also includes the percent impervious area associated with each land use.

The NRPC land use layer is parcel based, which results in some degree of error in the model because of the assumption that the entire parcel is one

[1] Comprehensive Environmental Incorporated. Pennichuck Water Works Watershed Management Plan. August 1998.

consistent land use. For example, a 100-acre lot may have only one house on it, which classifies the parcel as residential, when in actuality the majority of the parcel remains forested. This study assumes that this degree of error would be consistent throughout the model, and since the computed runoff and water quality parameters would be calibrated to measurements of observed conditions, this data constraint is not anticipated to introduce significant error in the model.

Table 2-2. Land Use Types and Parameters

Model Land Uses	NRPC Land Use	Impervious[2]
Commercial	Commercial Institutional Municipal Facility School	85%
Forest	Permanent Open Space Recreation Vacant	1.6%
High Density Residential	Multi Family Residential Mixed Use	44%
Industrial	Industrial	72%
Low Density Residential	Single Family Residential Manufactured Housing	19%
Open Space	Agricultural ROW	2.8%
Road	Road	66%
Water	Water	100%

Figure 2-3 shows the existing land uses throughout the watershed. Existing land use within the watershed by town is tabulated in Table 2-3 by acreage and in Table 2-4 as a percentage.

Table 2-3. Existing Land Use by Town (acres)

Town	Commercial	Industrial	High Density Residential	Low Density Residential	Open Space	Forest	Road	Water	Total
Amherst	154	366	29	726	23	402	118	-	1,800
Hollis	68	46	22	3,391	647	3,106	230	107	7,600
Merrimack	336	441	208	1,238	0	785	254	100	3,400
Milford	-	-	47	493	-	750	40	-	1,300
Nashua	468	332	329	440	83	1,123	236	172	3,200
Total	1,026	1,186	634	6,289	753	6,166	877	379	17,300

Note: This represents the drainage area to Harris Pond only since this is the location of the water supply intakes.

[2] Impervious values based on USDA NRCS Technical Release-55 and Sleavin, W.J., Civco, D.L., Prisloe, S., Giannotti, L. 2000. Measuring Impervious Surfaces for Non-Point Source Pollutant Modeling. University of Connecticut.

Soils

Soils data is necessary to determine percolation rates throughout the watershed. These percolation rates help establish the amount of precipitation that is infiltrated through the soils into the groundwater. Soils data was obtained from the U.S. Department of Agriculture, Natural Resources Conservation Service soils layer from GRANIT. Figure 2-4 shows the hydrologic soil groups throughout the watershed.

Table 2-4. Existing Land Use by Town as a Percent of Watershed Area

Town	Commercial	Industrial	High Density Residential	Low Density Residential	Open Space	Forest	Road	Water
Amherst	9%	20%	2%	40%	1%	22%	7%	0%
Hollis	1%	1%	0%	45%	9%	41%	3%	1%
Merrimack	10%	13%	6%	36%	0%	23%	7%	3%
Milford	0%	0%	4%	38%	0%	58%	3%	0%
Nashua	15%	10%	10%	14%	3%	35%	7%	5%

Precipitation

Precipitation data is necessary to determine infiltration, runoff and evapotranspiration volumes in the model. SWMM is able to process precipitation data at frequent intervals (e.g., hourly) to simulate individual rain events. This is useful in calibration of the flow data to match modeled flow data with observed flow data.

Precipitation data was obtained from the National Climatic Data Center (NCDC, 2006). This consisted of hourly data for the Concord Municipal Station 271683 from June 1, 1995 through September 29, 2005. This is the closest station with a continuous period of record. The weather station located in Nashua did not have any significant periods of continuous precipitation data available. In addition to this station, data from several personal weather stations in the area were examined. Weather data from KNHNASHU10 in South Nashua was also used in the model for the period from October 1, 2005 to May 1, 2006. This station seemed to best fit the runoff events of the watershed and was combined with the Concord precipitation data in an hourly format to form the precipitation inputs for the model. A composite precipitation file was created from these two sources from June 1, 1995 to May 1 2006 (Appendix A).

Snowfall accumulation, and snowmelt were not modeled, since there was little snowfall or snow accumulation during the period of the runoff calibration when this could cause significant error. It is noted that spring snow melt can result in slugs of accumulated pollutant loadings. However, because the study focused on average annual loadings rather than seasonal variations, this phenomenon was not considered to be a relevant factor.

2.1.2 Flow Monitoring and Data Collection

Stream Levels

Nine tributary locations, T-1 through T-9 (Figure 2-5), were monitored for flow to obtain an overall understanding of tributary response to precipitation throughout the watershed. These locations were chosen to represent the major tributaries to Pennichuck's surface water supply and allowed for comparison of the impacts of varying levels of development (i.e., ranging from rural to urban areas) on flows.

Staff gages and water level transducers with dataloggers were installed at each of these nine locations during September and October 2005. The Model WL15X dataloggers (Global Water Instrumentation, 2002) are capable of reading depths from zero to 15 feet. The transducer and datalogger are built into the unit and the data can be retrieved using any computer or laptop with the appropriate software. The dataloggers can retain 24,000 readings (Global Water Instrumentation, 2002). The dataloggers are vented, which provides automatic barometric pressure compensation to prevent reading errors. A typical configuration of the staff gage with datalogger installed in the stream channel is shown below in Figure 2-6.

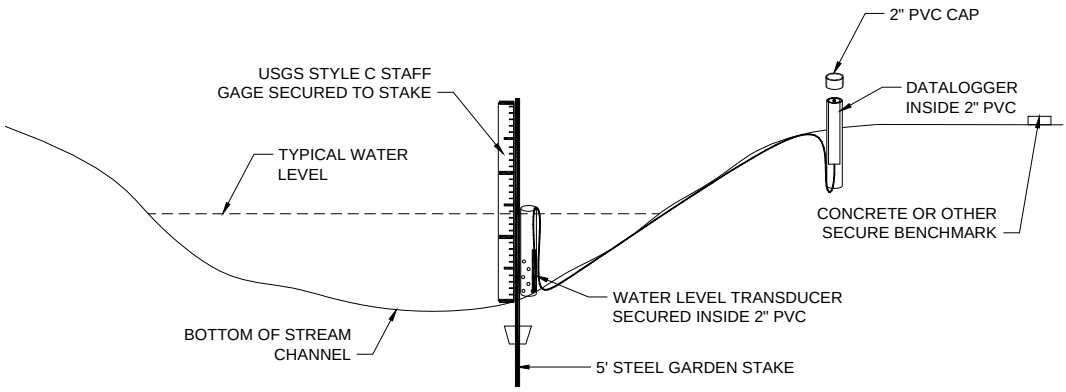


Figure 2-6. Typical Data Logger Installation.

Stage-Discharge Curves

Since the data loggers only provide water elevations, stage-discharge curves were developed for each of the nine locations to convert stream elevations into flows. This involved measuring stream cross-sections and flow velocities under multiple flow conditions to establish flows for various water levels in the stream. Nearly all monitoring locations are located at road crossings where defined cross-sections facilitate streamflow measurements. Based on field observations, it was determined that tailwater effects at the monitoring locations would be insignificant.

The stream bottom cross-section was surveyed using a laser level. The stream bottom was divided into discrete segments and the elevation of each was recorded. A measuring guide was permanently installed at each site to identify where each of these depths were recorded. Each interval was marked for future reference to expedite streamflow measurements. As shown on Figure 2-7, each stream cross-section was divided into about 20 intervals for velocity measurements (Standard Operating Procedure, Flow Measurement, Division of Watershed Management, 2003), with intervals varying from about six inches to two feet depending on the stream width. In some locations, culvert dimensions were used to generate stage-discharge curves. The staff gage, water level, and benchmark were also surveyed. The datalogger water level was recorded during surveying which allowed staff gage readings and/or datalogger readings to be correlated to the geometry of the stream channel.

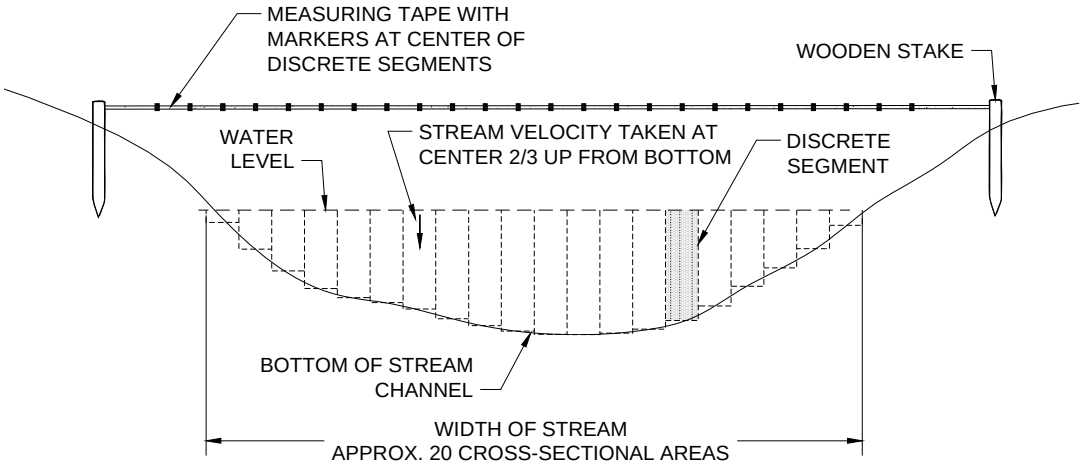


Figure 2-7. Stream Cross-Section Discretization.

Stream velocities were measured at each location where the stream elevation was recorded, using a Marsh McBirney 2000 Flo-Mate electromagnetic velocity meter (Marsh-McBirney Incorporated, 1990). A propeller type flow meter could not be used because of the low velocities associated with many of these streams during low flow. The flow meter used has a range of –0.5 to +19.99 ft/sec, which is consistent with the observed stream velocities (Marsh-McBirney Incorporated, 1990). Velocities were recorded by standing downstream of the meter and holding it approximately 2/3 up from the bottom of the stream. Once the velocity stabilized on the meter, the velocity was recorded. This was repeated at each interval at each site. Three to five stream velocity rounds were completed at each site during different stream levels.

The streamflows were determined in accordance with the Quality Assurance Project Plan (QAPP) developed by CEI for this project.[3]

[3] Comprehensive Environmental Inc. (January 2006). *Pennichuck Watershed Restoration Project: Water Quality Assessment Quality Assurance Project Plan*. (Report) Merrimack, NH: Comprehensive Environmental Inc.

Streamflows were calculated by summing the streamflows at each discrete segment across the stream profile. The width of each segment is defined as the cross-sectional area bounded on each side of the vertical velocity measurement by a distance halfway to the preceding vertical and halfway to the following vertical. The stream channel was assumed to remain unchanged while the water level and velocities varied due to time. This was consistent with field observations. The depth of water at each segment and the width of each segment are used to determine the flow area in each section.

The data described above was then used to develop stage-discharge curves so that stream elevations could be converted into flows. A unique curve was developed for each site to correlate stream levels recorded by the data logger to measured streamflows (Appendix B). Using Microsoft Excel 2002, the equation of a best-fit line was obtained for each site. The remaining water levels recorded at each site were then input into this equation to develop a continuous streamflow database (Appendix C). These flows were input into the model where they could be compared directly to modeled results.

2.1.3 Flow Calibration/Validation

Calibration Method

Data loggers were used to record stream elevations and enable estimation of flows at the nine tributary locations between September 29, 2005 and May 4, 2006. This is the only available flow data for the watershed and was used to calibrate modeled tributary flow data. The continuous observed flow data for each location was input into the model, allowing for direct comparison of modeled flow to observed flow.

The percent of impervious area directly connected to the drainage system and the groundwater interaction equation parameters, specifically the groundwater flow coefficient and exponent, were the key flow calibration parameters within the model. These parameters had the greatest influence on the peaking of stormwater runoff and the shape of the streamflow curve, to obtain the best match with calibrated flows. Variation of other parameters was determined to have less influence on the model results. To simplify the calibration process, it was assumed that the aquifers are homogeneous throughout each subwatershed; therefore, these parameters were adjusted uniformly to calibrate the model to the measured streamflows. Stream flow lengths were also adjusted where there were extensive wetlands. This adjustment was made to replicate the attenuation provided by the wetlands.

Calibration Results

The correlation coefficient represents how well the observed data fits the calibrated data. A value of zero indicates there is no correlation between the data while a value of one represents a perfect correlation between the data. Modeled flows were successfully calibrated to observed flows with

a correlation coefficient of 0.86. The results of the calibration for each location are shown graphically in Appendix D.

In the more rural areas, the measured stream flows showed a delay in peak flow of nearly two days from the precipitation event, indicating significant infiltration and contribution by groundwater flow. Some of the more urban areas, such as monitoring station T-1, do not show significant contributions from baseflow, likely due to the large impervious area in its watershed.

Flow calibration was achieved more easily in the upper watershed, especially for single tributaries. However, as tributaries began to merge and enter large wetland areas, the flows were more difficult to calibrate. This was especially true in the wetlands area that lies over the extensive Silver Lake Fault Zone and the Witches Spring Brook. Figure 2-5 shows tributary monitoring locations and the large expanse of wetlands at the confluence of Pennichuck Brook and Witches Spring Brook. Beginning at monitoring locations T-3 and T-2, the modeled flows were estimated to be significantly higher than the observed flows. This is likely due to the large expanse of wetlands. In reality, these extensive wetlands attenuate flows and result in a slower release than the modeled tributary. The creation of a pond or adjustment of stream flow lengths is required in the model to account for this attenuation. The tributaries feeding location T-3 were lengthened to represent a longer flow path with greater flow attenuation. This allowed for a closer correlation with data measured.

The model also provides estimates of the amount of evapotranspiration; the amount that evaporates from surface depressions and surfaces; infiltrates through the soils becoming groundwater flow; and that which becomes surface runoff. Evaporation is calculated based on a depth of depression in the land surface for water storage, which is entered by the modeler. Evapotranspiration is calculated as a percent of the unsaturated zone that is available for evapotranspiration. This value was adjusted until the combined evapotranspiration and evaporation figures were 40% of the precipitation budget, which is typical for the Northeast.[4] The adjustment of evapotranspiration is balanced with the groundwater flow. For example, if evapotranspiration is increased, groundwater flow is decreased by the same volume. Figure 2-8 on the next page shows the breakdown of the average annual water budget. This budget was used to estimate pollutant loads from runoff and groundwater baseflow. Average annual water budgets by subwatershed are included in Table 2-5.

[4] Hanson, R.L., 1991, Evapotranspiration and Droughts, in Paulson, R.W., Chase, E.B., Roberts, R.S., and Moody, D.W., Compilers, National Water Summary 1988-89--Hydrologic Events and Floods and Droughts: U.S. Geological Survey Water-Supply Paper 2375, p. 99-104.

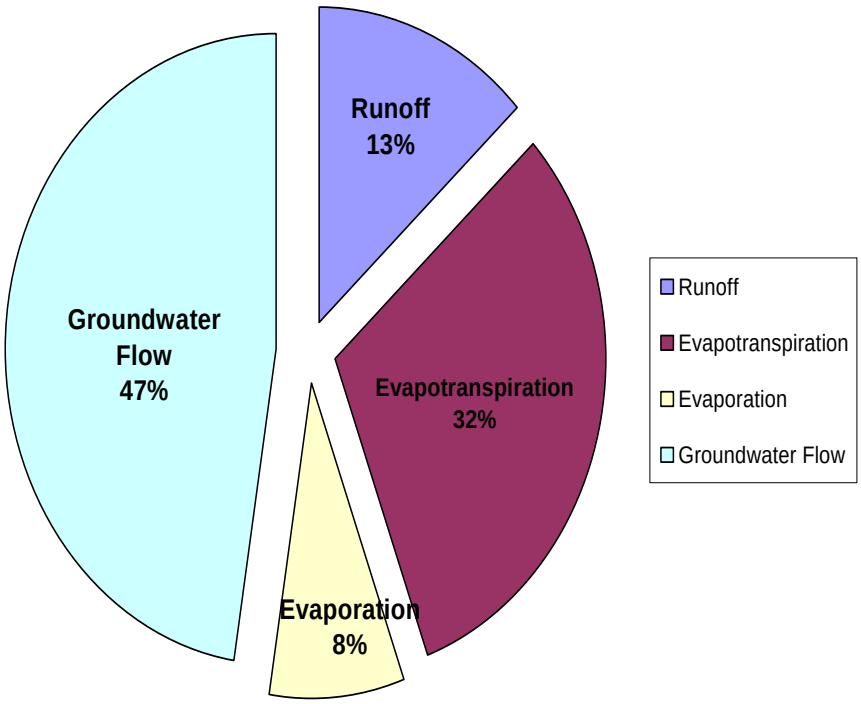


Figure 2-8. Pennichuck Brook Watershed Average Annual Water Budget

Table 2-5. Water Budget by Subwatershed				
Subwatershed	**Runoff**	**Evapotranspiration**	**Evaporation**	**Groundwater Flow**
1	25%	20%	8%	47%
2	30%	18%	9%	43%
3	33%	17%	10%	41%
4	52%	9%	12%	27%
5	14%	79%	7%	0%
6	26%	17%	10%	47%
7	32%	55%	13%	0%
8	26%	18%	10%	46%
9	26%	18%	10%	46%
10	8%	35%	7%	50%
11	8%	36%	7%	48%
12	5%	40%	6%	49%
13	1%	40%	6%	52%
14	2%	60%	7%	31%
15	1%	32%	6%	60%
16	4%	25%	8%	62%
17	17%	23%	8%	52%
18	21%	21%	9%	49%
19	4%	26%	7%	63%
20	14%	21%	9%	55%
21	6%	19%	10%	65%
22	1%	39%	6%	53%
23	1%	38%	7%	54%
24	2%	34%	7%	57%

2.2 Water Quality Assessment

Two pollutants, total phosphorus (TP) and total suspended solids (TSS) were modeled within the Pennichuck watershed using the SWMM buildup and washoff functions. Total phosphorus was selected as a key pollutant since the impairment in Harris Pond is 'excess algal growth', which is a function of excess nutrient loadings to the ponds. Since phosphorus is the limiting nutrient for algal growth in fresh water systems, often leading to eutrophication and algal blooms, it was selected as the primary pollutant of concern and the basis for setting and implementing water quality goals.

The Reckhow and Vollenweider in-pond models were used to approximate modeled in-pond phosphorus concentrations for comparison to observed in-pond concentrations. This model represents an average in-pond concentration that accounts for nutrient cycling within the ponds. This was used to aide in calibrating the TP loads in runoff. Sediment could not be calibrated against observed sediment levels since there was little TSS data available for the watershed. Additionally, SWMM calculates pollutant loads associated with stormwater runoff and there are likely other more significant sources of sediment loadings to the ponds, such as stream bank erosion from large precipitation events and high sediment loadings from construction sites. As a result, the restoration plan focuses on a phosphorus water quality goal, with recommendations that will also help address sediment loadings.

2.2.1 Input Data and Assumptions

Pollutant Loadings

In addition to the input data necessary to model stream flows within the watershed, input on pollutant loading factors was also required. SWMM models pollutants associated with groundwater baseflow and stormwater runoff.

Existing dry weather streamflow data was used to approximate a groundwater baseflow concentration. Based on the existing sampling data, which was available for various locations from July 2004 to August 2006, an average dry weather tributary phosphorus concentration of about 20 ug/l (micrograms per liter) was estimated. For modeling purposes, this was assumed to represent groundwater baseflow and a uniform concentration was applied to all aquifers. However, no groundwater samples were available within the watershed to confirm this assumption.

The dry weather tributary data implies a widespread relatively high groundwater concentration of phosphorus in comparison to what is typical, however, the actual groundwater concentration is unknown as is its' source. Some possibilities include 1) naturally high levels of phosphorus in the soils in the watershed; 2) gravelly soils that allow high

phosphorus stormwater and wastewater to enter groundwater without the typical attenuation of finer soils; and/or 3) some large but yet unknown point source. Further study is recommended to evaluate the source of this phosphorus to determine how it may be addressed.

SWMM offers three options for estimating pollutant loadings associated with stormwater runoff. One is the direct entry of event mean concentrations (EMCs), which can be obtained from literature for various land uses and represent the average concentration of the pollutant in stormwater runoff. The other two methods incorporate pollutant buildup functions, which account for the time between storm events, with pollution accumulating on surfaces during this time. These can be entered as a function of land use (e.g., lb/acre/day) or as a function of curb length (e.g., lb/curb mile/day). A combined land use based with buildup function was used. The power buildup function assumes that the incremental increase in buildup will decrease as the amount of pollutant on the surface increases. An exponential washoff function was assumed to represent the pollutant washoff.

The advantages of the pollutant buildup and washoff functions are that they allow for evaluation of pollutant concentrations through the duration of a storm event and account for actual buildup of pollutants between storm events rather than just assuming that every precipitation event results in the same concentration of pollutants in the stormwater runoff. This is useful for evaluating the effects of street sweeping at different frequencies. Buildup and washoff functions also allow for evaluation of pollutant concentrations in stormwater throughout the duration of a storm, which may be useful when incorporating grab samples into the model. Table 2-6 shows the initial phosphorus and TSS buildup parameters used in the SWMM model by land use.

Bathymetric Data

Bathymetric data was obtained from a sediment study of the ponds conducted by CEI in 2000[5]. This information is needed to determine the mean depth and water storage capacity of each pond, which is in turn used to determine the in-pond phosphorus concentrations resulting from the estimated phosphorus loadings.

The reservoirs were modeled as having their respective surface area and an average depth based on storage capacity.

[5] Comprehensive Environmental Incorporated. Sediment Study of Pennichuck Ponds Pennichuck Water Works July 2000.

Table 2-6. Initial Phosphorus and TSS Buildup Parameters Used in SWMM		
Land use	**Initial Buildup (lb/acre/day)**	**Source**
	TP	
Commercial	0.00690	Northern Virginia (Kuo, 1988)
Forest	0.00055	Reckhow
High Density Residential	0.00830	Northern Virginia (Kuo, 1988)
Industrial	0.00580	Northern Virginia (Kuo, 1988)
Low Density Res.	0.00120	Northern Virginia (Kuo, 1988)
Open Space	0.00160	Reckhow Avg. of Ag/Forest
Road	0.03450	Factor * Commercial
Water	0.00000	None (associated with rainfall only)
	TSS	
Commercial	2.19	Northern Virginia (Kuo, 1988)
Forest	0.17	Ratio from Com/Forest Above
High Density Res.	3.53	Northern Virginia (Kuo, 1988)
Industrial	1.60	Northern Virginia (Kuo, 1988)
Low Density Res.	1.32	Northern Virginia (Kuo, 1988)
Open Space	0.49	Ratio from Com/Forest Above
Road	10.95	Factor * Commercial
Water	0.00	None (associated with rainfall only)

Very few models are available to estimate in-pond phosphorus concentrations. The most common model, the Reckhow steady-state lake model was used to estimate in-pond concentrations. The most important component of this model is the "apparent settling velocity" of phosphorus within the pond. In actuality, this represents the net effect of phosphorus deposition and resuspension from the bottom surface. To use this model, it is essential that the simulated water body is representative of the basis of the model (Reckhow, 1983), as shown on Table 2-7. This table shows the minimum and maximum data set levels that fit the model, along with the levels of each pond. Both Holts Pond and Supply Pond exceeded the ranges of this model, so the generic Vollenweider lake model was used to simulate these ponds. This model is more representative because it uses a lower "apparent settling velocity" for phosphorus than the Reckhow model. Both of these ponds experience a very large hydraulic loading compared to their overall size. However, the Reckhow model was used for Bowers and Harris Ponds.

Table 2-7. Reckhow Model Limitations (Reckhow 1979d)					
	Reckhow Acceptable Range	**Holts Pond**	**Bowers Pond**	**Harris Pond**	**Supply Pond**
Phosphorus Concentration – P (ug/l)	4 – 135	47	43	40	42
Annual Area Phosphorus Loading – L (g/m2-yr)	0.07 – 31.4	19	7	8	32
Areal Water Loading – qs (m/yr)	0.75 – 187	388	116	146	746

2.2.2 Monitoring Data

A wide range of samples have been collected in the Pennichuck water supply watershed between 1996 and the present. Data has been collected by the Nashua Regional Planning Commission (NRPC), consultants working for Pennichuck Water Works and by Pennichuck Water Works directly. The focus has been on the tributaries feeding the water supply ponds and on the ponds themselves.

This data has been compiled in a searchable format for use by Pennichuck Water Works and for incorporation by DES into their state database of water quality data. Nearly all of the available data is associated with dry weather sampling events, with a few wet weather-sampling events specifically targeting the performance of stormwater practices within the watershed.

Dry-Weather Tributary Sampling

As previously discussed, the data collected from the tributary dry weather sampling events was used to determine a groundwater baseflow phosphorus contribution. The data also consisted of other nutrient sampling, such as TKN, nitrate-nitrogen and ammonia nitrogen. This data was evaluated to determine whether septic systems may be contributors to the elevated phosphorus concentrations observed in the tributaries. The data revealed non-detect levels of nitrate-nitrogen in all dry weather events, suggesting that septic systems may not be a major pollutant load since nitrogen is typically quite high from septic systems. However, additional data will be needed in the future to confirm this and to identify source(s) of excess phosphorus in 'baseflow'.

Stormwater Practice Sampling Data

A variety of both common and more innovative stormwater practices in the watershed were sampled under wet weather conditions to assess their performance. Data from other sources was also collected, including:

- an infiltration system at the Department of Transportation Park and Ride Facility off of Somerset Parkway (Exist 8 of the FE Everett Turnpike) on North Southwood Drive;
- a swale located along Amherst Street (Route 101A) in the Somerset Plaza;
- a combination wet pond and constructed wetlands at the Nashua Technical Community College.

In addition, six other stormwater practices were sampled as a part of this study. These included:

- a swale at Conway Office Products in Nashua,
- a grass detention pond at Home Depot in Merrimack,
- Low Impact Development (LID) techniques at Pennichuck Square in Merrimack,
- a sediment forebay at Celina Avenue in Nashua,

- a detention pond with wetland plantings off White Oak Drive near Thornton Road in Nashua, and
- a dry detention basin that is grown in with natural vegetation off White Oak Drive near Tinker Road in Nashua.

The locations of the stormwater practices sampled are shown on Figure 2-9. The purpose of the sampling was to obtain information on the performance of various types of stormwater practices throughout the watershed, to establish whether and to what degree existing stormwater practices were contributing to water quality improvements, as well as obtain some information on loadings from various land use types in the watershed. The information was also used to determine whether there is a need or benefit associated with stormwater practice retrofits in the watershed.

Sampling results showed that most of the traditional practices like detention basins appear to achieve little phosphorus removal and in some cases contributed phosphorus. Most of these stormwater practices are designed for peak control, rather than water quality unlike the newer practices and Low Impact Development practices built by Pennichuck.

Results were highly variable for the two locations sampled by NRPC and the six locations sampled as a part of this study. Four of the six stormwater practices sampled under this study did not have outlet flows with 0.25 inches of precipitation or less, indicating that the smaller storms are typically fully infiltrated due to the high permeability of the soils. The largest stormwater practice in the watershed collects stormwater runoff from the streets, residential neighborhoods and parking lots of roughly 60 businesses located in the approximate 79 acre drainage area. The BMP, which was designed by Pennichuck Water Works Company, incorporates sediment forebays, oil/water separators, wetlands and wet pond treatment and is located on the NH Technical College property. This practice achieved relatively good removal of TSS and phosphorus. Other up-to-date designs such as the LID practices at Pennichuck Square also did quite well at removing all pollutants. A summary of the sampling results is included in Appendix E.

The results of the sampling helped verify that the traditional stormwater practices do not appear to be providing much if any water quality protection. This emphasizes the need to either provide additional stormwater practices or retrofit the existing stormwater practices to obtain some pollutant removal from existing practices such as detention basins.

In-Pond Sampling

Some in-pond data was available, dating as far back as 1996. This data was the most useful for calibrating pollutant loadings calculated in the model as it allowed for a direct comparison of modeled phosphorus concentrations to observed phosphorus concentrations.

The ponds are typically sampled under stratified conditions, with samples collected from the top and bottom water layers of the pond. As expected, the bottom layer has a much higher phosphorus concentration than the top, since low oxygen levels allow for the release of phosphorus from bottom sediments back into the water column. However, this only occurs for a portion of the year. As a result, a representative average in-pond concentration was calculated by averaging the top and bottom samples, assuming that the bottom samples only contributed to the in-pond concentration 3 months out of the year and the top samples contributed all 12 months of the year. The average in-pond concentrations for each sampling date, using the method just described is provided in Table 2-8.

Table 2-8. Observed In-Pond Phosphorus Concentrations (ug/l)

Date	Holts Pond	Bowers Pond				Harris Pond		Supply Pond*
	09-PEN	08-PEN	07P-PEN	07F-PEN	07-PEN	06-PEN	04-PEN	02-PEN
10/11/2006		26	31	16		16	13	
8/8/2006	40							
7/25/2006	40							
6/27/2006	5							
5/9/06-6/1/06		44	216	28		144	33	
9/8/2005		36	47	29		13	13	
8/4/2005		15	13	36		22	25	
6/23/2005		37	23	28		51	28	
8/26/2004		16	15	5		39	73	
6/30/2004		17	6	14		14	6	
10/28/2003		39	17	35		45	39	19
7/23/2003		14	019	18		17	13	9
9/28/1999	110	15			168		158	114
9/14/1999	5	22			5		5	5
8/26/1999	14	5			5		5	12
8/28/1996	130	4,530*			290		120	190
7/17/1996	49	26			16		46	3
7/9/1996	210				10		60	
6/26/1996	60				60		40	
6/13/1996	90						50	30
5/30/1996	30				12		10	16
5/15/1996	40						16	14
5/1/1996	10				254		36	
4/18/1996	25						20	40
11/15/1995	10				20		10	
11/14/1995	10				10		20	
Station	51	35	43	23	77	40	37	41
Pond Average	**51**	**45**				**38**		**41**

* Ignored because value is an outlier that is unreasonably high

Notes: All Phosphorus Concentrations in ug/l

Where top and bottom samples were available, used weighted average for sampling date (3*bottom + 12*top / 15). Middle samples were not used.

Where sample was non-detect, 5 ug/l was used

2.2.3 Pollutant Calibration/Validation

The model was calibrated to the 10-year analysis period from January 1, 1996 through December 31, 2005. The average pollutant loadings, runoff rates, and baseflow from SWMM through this duration were input into the in-pond models. Calibration involved adjusting the pollutant loading factors until estimated in-pond concentrations matched the observed in-pond concentrations with minimal error.

SWMM allows for estimation of pollutant loadings based on either an event mean concentration or a buildup function. The event mean concentration method assumes one stormwater concentration for all storms throughout the duration of the storm. The buildup function represents pollutant buildup on the land surface between precipitation events with a higher initial buildup which levels off to an insignificant buildup rate. The advantage to the buildup function is that it allows for evaluation of pollutant loadings associated with a particular storm event. This would allow for direct comparison to sampled pollutant levels for more detailed calibration. Although this project focused on annual pollutant loadings rather than individual storm events, the buildup function was used to allow more detailed analysis under future modeling efforts if desired.

The initial pollutant buildup coefficients were based on daily accumulation rates since typical values for use in SWMM were not available. These were then adjusted upward to account for the buildup function (e.g., higher initial pollutant buildup). All of the buildup values were adjusted by the same percentage initially, with some additional adjustment, made to specific land uses to achieve good calibration to in-pond concentrations. Since the adjustments primarily focused on normalizing the data set to account for the buildup function, the TSS data set was scaled up by the same percentages. It was assumed that the groundwater baseflow concentrations remained at 20 ug/l throughout the analysis, with adjustments only provided for phosphorus buildup on land surfaces. A comparison of the initial buildup values with the final buildup values to achieve calibration is provided in Table 2-9.

Table 2-9. Phosphorus and TSS Calibrated Buildup Parameters Used in SWMM		
Land use	**Initial Buildup (lb/acre/day)**	**Calibrated Buildup (lb/acre/day)**
Total Phosphorus		
Commercial	0.00690	0.0121
Forest	0.00055	0.0010
High Density Residential	0.00830	0.0111
Industrial	0.00580	0.0102
Low Density Res.	0.00120	0.0021
Open Space	0.00160	0.0027
Road	0.03450	0.0604
Water	0.00000	0.0000
Total Suspended Solids		
Commercial	2.19	3.83
Forest	0.17	0.31
High Density Res.	3.53	3.32
Industrial	1.60	2.80
Low Density Res.	1.32	2.31
Open Space	0.49	0.86
Road	10.95	19.16
Water	0.00	0.00

The modeled in-pond concentrations (Appendix F) using the calibrated values above are compared to observed in-pond concentrations in Table 2-10. Water quality goals will focus on Harris Pond, since this is the primary withdrawal point for the water supply system.

Table 2-10. Calibrated Modeled In-Pond Phosphorus Concentrations vs. Observed In-Pond Phosphorus Concentrations (ug/l)				
	Pond/Reservoir			
	Holts	**Bowers**	**Harris**	**Supply**
Calibrated Modeled Concentration	47	43	40	42
Average Observed Concentration	51	45	38	41

2.2.4 Pollutant Loadings

Based on the calibrated modeling runs, the phosphorus loadings by subwatershed were estimated. These are presented in Table 2-11 and shown graphically in Figure 2-10.

Table 2-11. Annual Phosphorus Loadings by Subwatershed				
Subwatershed	**Existing TP Loading (lbs/year)**	**Additional TP Load at Buildout (lbs/year)**	**Total TP Loading (lbs/year)**	**Tributary to:**
Sub 1*	201	22	222	Pennichuck Brook and Merrimack River
Sub 2*	292	13	304	Supply Pond
Sub 3	642	83	725	Harris Pond
Sub 4	304	18	322	Bowers Pond
Sub 5	10	7	17	Harris Pond
Sub 6	874	81	954	Bowers Pond
Sub 7	433	77	510	Harris Pond
Sub 8	650	59	710	Holts Pond
Sub 9	617	22	639	Holts Pond
Sub 10	71	4	75	Holts Pond
Sub 11	87	8	95	Pennichuck Pond
Sub 12	60	14	74	Pennichuck Pond
Sub 13	27	5	33	Pennichuck Pond
Sub 14	27	2	29	Pennichuck Pond
Sub 15	0	0	0	Holts Pond
Sub 16	2	0	2	Holts Pond
Sub 17	558	24	582	Stump Pond
Sub 18	470	57	526	Holts Pond
Sub 19	20	0	21	Holts Pond
Sub 20	215	12	227	Holts Pond
Sub 21	14	0	14	Holts Pond
Sub 22	23	7	29	Holts Pond
Sub 23	28	8	36	Holts Pond
Sub 24	16	9	25	Holts Pond
Total	5,149	497	5,646	

*Subwatersheds 1 and 2 are not included in the total, as they are located downstream of Harris Pond and do not contribute phosphorus loadings to Harris Pond.

Phosphorus loadings were also determined by town to provide a basis for recommendations and to identify responsibility for each action. Phosphorus loadings by town are included in Table 2-12. Phosphorus loadings by land use are included in Table 2-13.

Table 2-12. Annual Phosphorus Loadings by Source	
Town	**Existing TP Loading (lbs/year)**
Phosphorus from Stormwater	
Amherst	776
Hollis	345
Merrimack	1988
Milford	53
Nashua	1987
Subtotal Stormwater Contribution	5,149
Phosphorus from Other Sources	
Groundwater	1,523
Merrimack River	288
Subtotal Other Sources	1,812
Total	**6,960**
Harris In-Pond TP Conc. (ug/l)	40

Table 2-13. Total Phosphorus Loadings by Land Use (lbs/year)	
Land Use	**Existing TP Loading**
Commercial	1,085
HD Residential	373
Industrial	968
LD Residential	422
Roads	2,107
Forest	27
Open Space	4
Water	163
Total	5,149

2.3 Buildout

A gross buildout evaluation was also performed to determine potential pollutant loadings and in-pond concentrations at buildout. This allows for planning to prevent loadings associated with new development.

The Region-Wide Buildout Impact Analysis performed by the Nashua Regional Planning Commission in October 2005[6] was used to evaluate buildout conditions in the Pennichuck Watershed. The NRPC buildout evaluation assumes that all water, wetlands, riparian buffers, 100-year flood plains and slopes greater than 25% are not buildable.

An electronic GIS layer of developable land in the region was obtained from NRPC and used in the Pennichuck watershed analysis. The developable areas were color-coded based on the zoning and type of development that would occur on these lands. This data layer was cropped to fit within the Pennichuck watershed and used to determine

[6] Nashua Regional Planning Commission. (October 2004). Region-Wide Buildout Impact Analysis.

what a buildout condition would look like in the watershed. Figure 2-11 shows the additional developable land in the watershed. Figure 2-12 shows the total watershed land uses at buildout.

Land uses at buildout for each Town are provided in Table 2-14. Based on the buildout analysis, the additional phosphorus loadings associated with buildout are shown in Table 2-15 by Town and in Table 2-16 by land use.

Table 2-14. Land Use at Buildout (acres)

	Commercial	Forest	HD Res	Industrial	LD Res	Open Space	Road	Water	Total
Amherst	178	197	29	393	880	23	118	0	1,800
Hollis	69	2615	23	47	4053	474	230	107	7,600
Merrimack	353	391	208	469	1575	0	254	100	3,400
Milford	0	296	74	0	919	0	40	0	1,300
Nashua	521	845	388	349	568	83	236	172	3,200
Total	1,120	4,345	722	1,258	7,995	580	877	379	17,300

Table 2-15. Total Phosphorus Loadings by Source at Buildout

Town	Existing TP Loading	Additional TP Loading at Buildout	Total TP Loading at Buildout	Percent of TP Budget
Phosphorus from Stormwater				
Amherst	776	84	861	11%
Hollis	345	29	374	5%
Merrimack	1,988	164	2,151	29%
Milford	53	16	69	1%
Nashua	1,987	205	2,192	29%
Subtotal Stormwater Contribution	5,149	497	5,646	75%
Phosphorus from Other Sources				
Groundwater	1,524	(1)	1,523	20%
Merrimack River	288	---	335	4%
Subtotal Other Sources	1,812	(1)	1,858	25%
Total	**6,961**	**496**	**7,504**	**100%**
Harris In-Pond TP Conc. (ug/l)	40		43	

Table 2-16. Total Phosphorus Loadings by Land Use (lbs/year)			
Land Use	**Existing TP Loading**	**Additional TP Loading at Buildout**	**Total TP Loading at Buildout**
Commercial	1,085	143	1,228
HD Residential	373	57	430
Industrial	968	96	1,064
LD Residential	422	131	553
Roads	2,107	74	2,182
Forest	27	(9)	19
Open Space	4	0	4
Water	163	6	168
Total	5,149	497	5,646

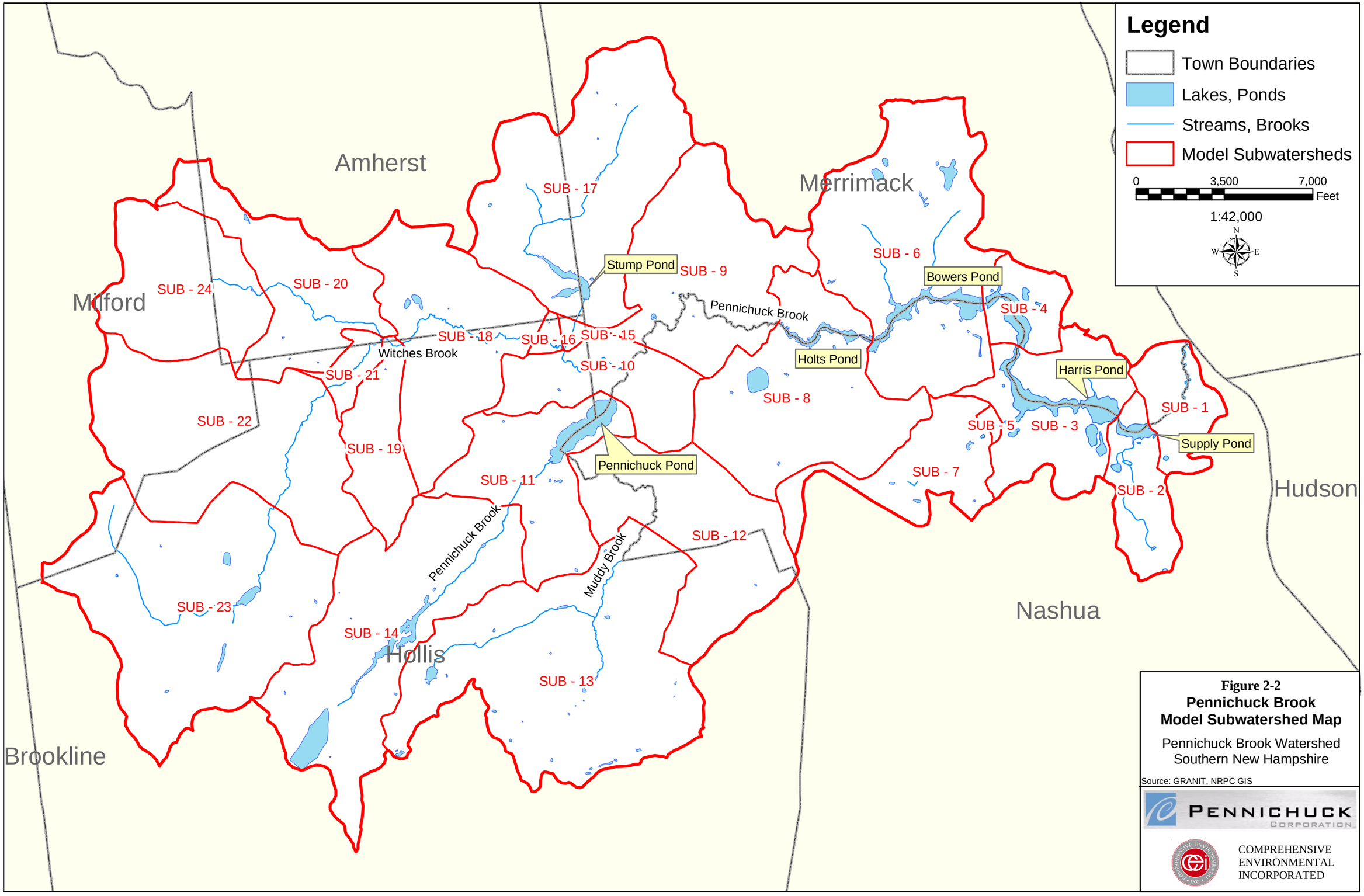


Figure 2-2
Pennichuck Brook
Model Subwatershed Map

Pennichuck Brook Watershed
Southern New Hampshire

Source: GRANIT, NRPC GIS

PENNICHUCK CORPORATION

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

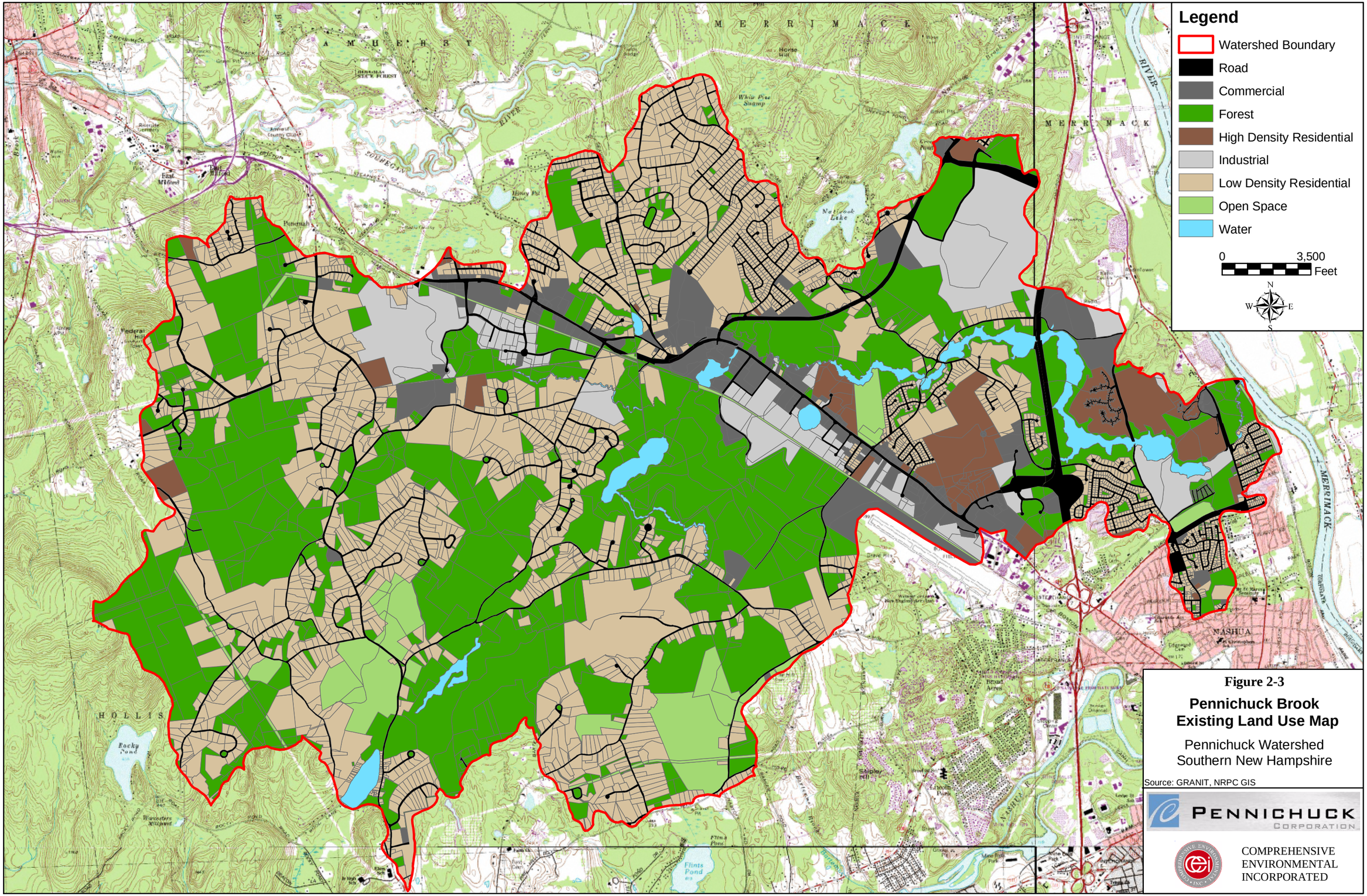


Figure 2-3

Pennichuck Brook Existing Land Use Map

Pennichuck Watershed
Southern New Hampshire

Source: GRANIT, NRPC GIS

PENNICHUCK CORPORATION

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

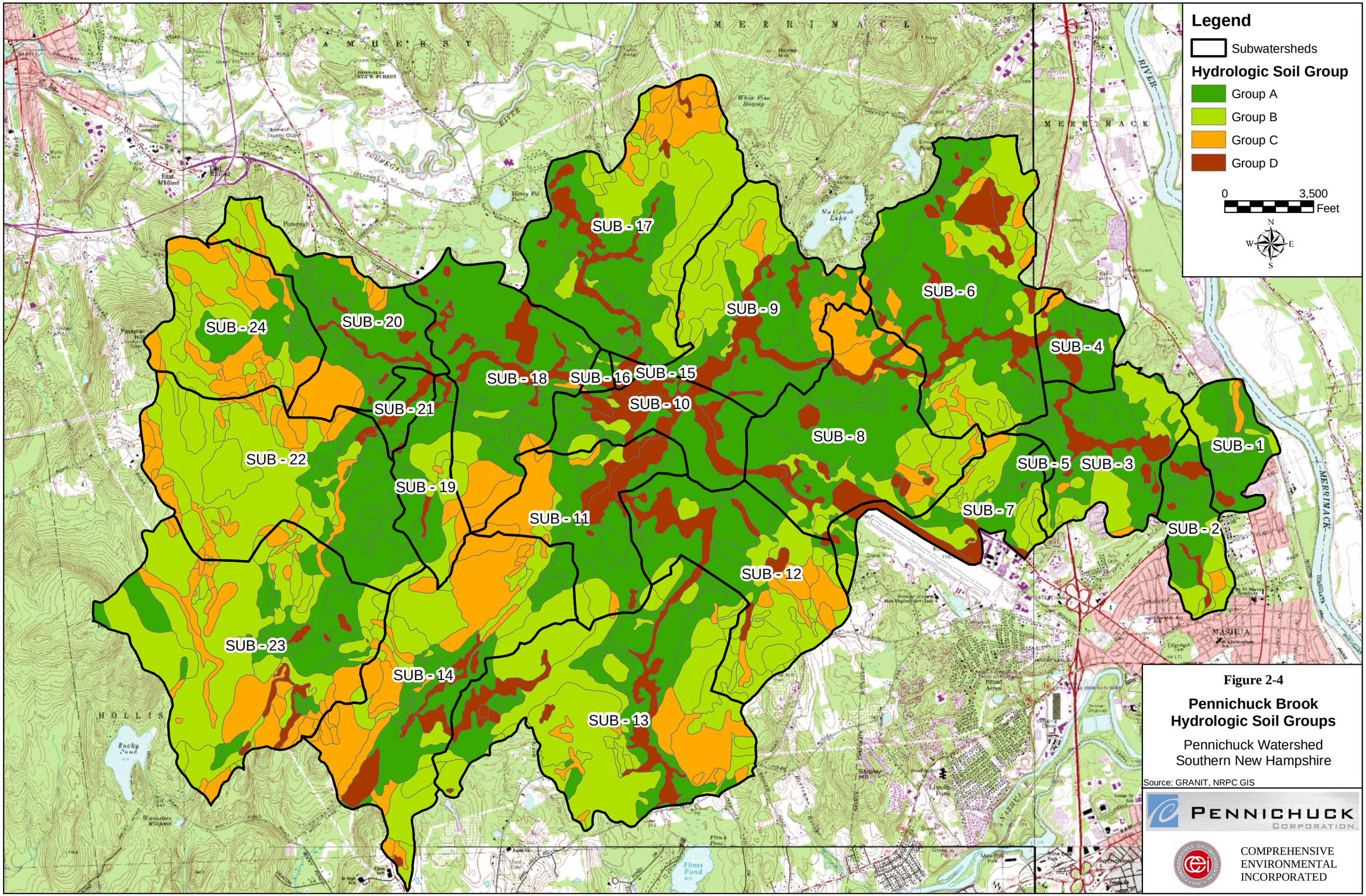

Legend
Subwatersheds
Hydrologic Soil Group
Group A
Group B
Group C
Group D
0
3,500
Feet
N
W
E
S
SUB - 1
SUB - 2
SUB - 3
SUB - 4
SUB - 5
SUB - 6
SUB - 7
SUB - 8
SUB - 9
SUB - 10
SUB - 11
SUB - 12
SUB - 13
SUB - 14
SUB - 15
SUB - 16
SUB - 17
SUB - 18
SUB - 19
SUB - 20
SUB - 21
SUB - 22
SUB - 23
SUB - 24
A M H E R S T
M E R R I M A C K
M E R R I M A C K
H O L L I S
NASHUA
MERRIMACK
RIVER
SOUHEGAN
Pennichuck Brook
Hydrologic Soil Groups
Pennichuck Watershed
Southern New Hampshire
Source: GRANIT, NRPC GIS
PENNICHUCK
CORPORATION
COMPREHENSIVE
ENVIRONMENTAL
INCORPORATED

Figure 2-4

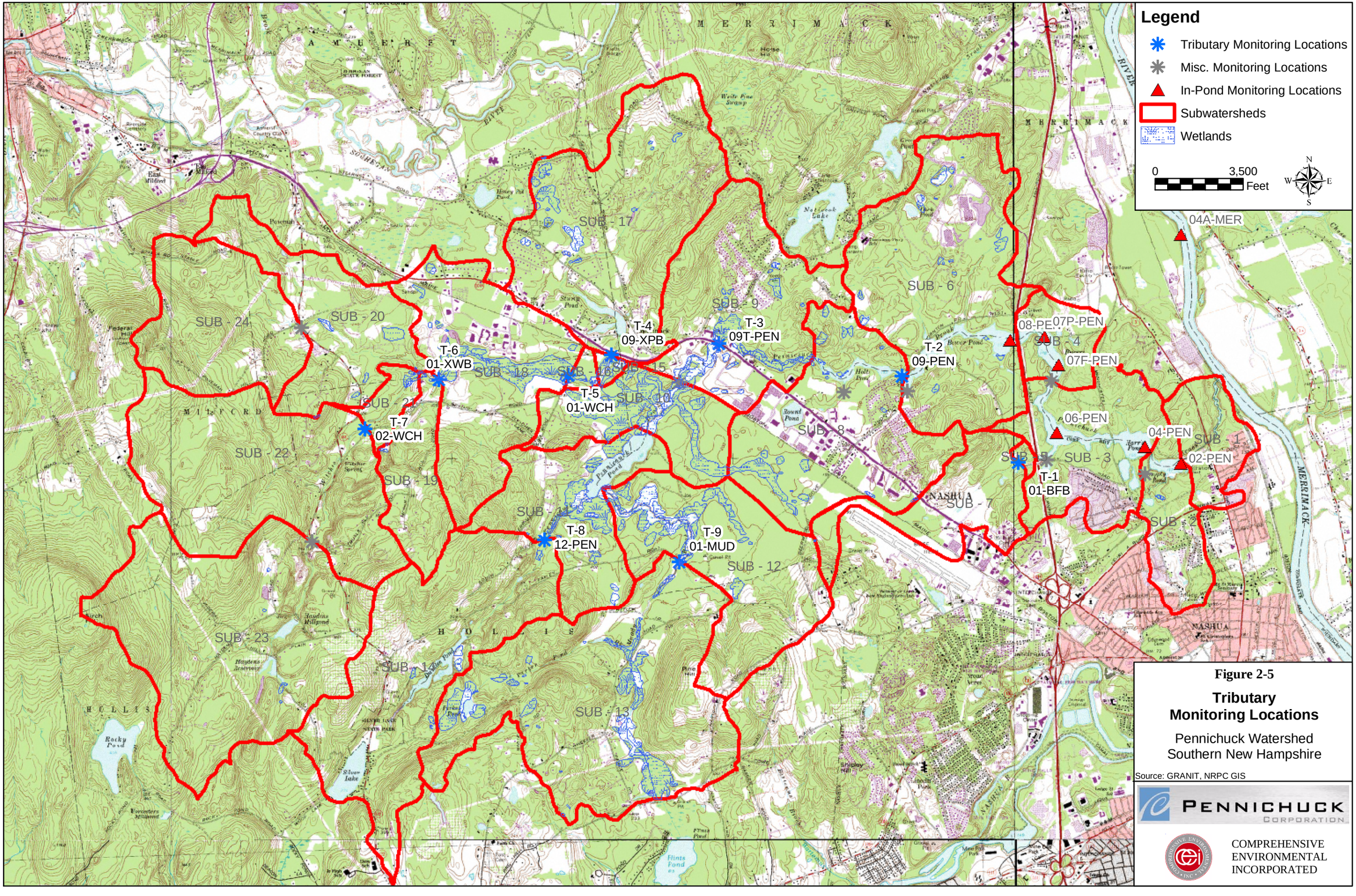


Figure 2-5

Tributary Monitoring Locations

Pennichuck Watershed
Southern New Hampshire

Source: GRANIT, NRPC GIS

PENNICHUCK CORPORATION

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BMP Site	Parcel	Address	Town/City
1. Swale	H-158;	10 Capitol St	Merrimack
2. Home Depot	Map 2B Lot 30	721 Milford Rd	Merrimack
3. Pennichuck Square	Map 2B Lot 36	709 Milford Rd	Merrimack
4. Sed. Trap/Forebay	I-42, I-53	29 Northwest Boulevard	Nashua
5. Detention Pond-Wetland	H-630	L White Oak Drive	Nashua
6. Detention Pond-Natural	H-631	L White Oak Drive	Nashua

Figure 2-9

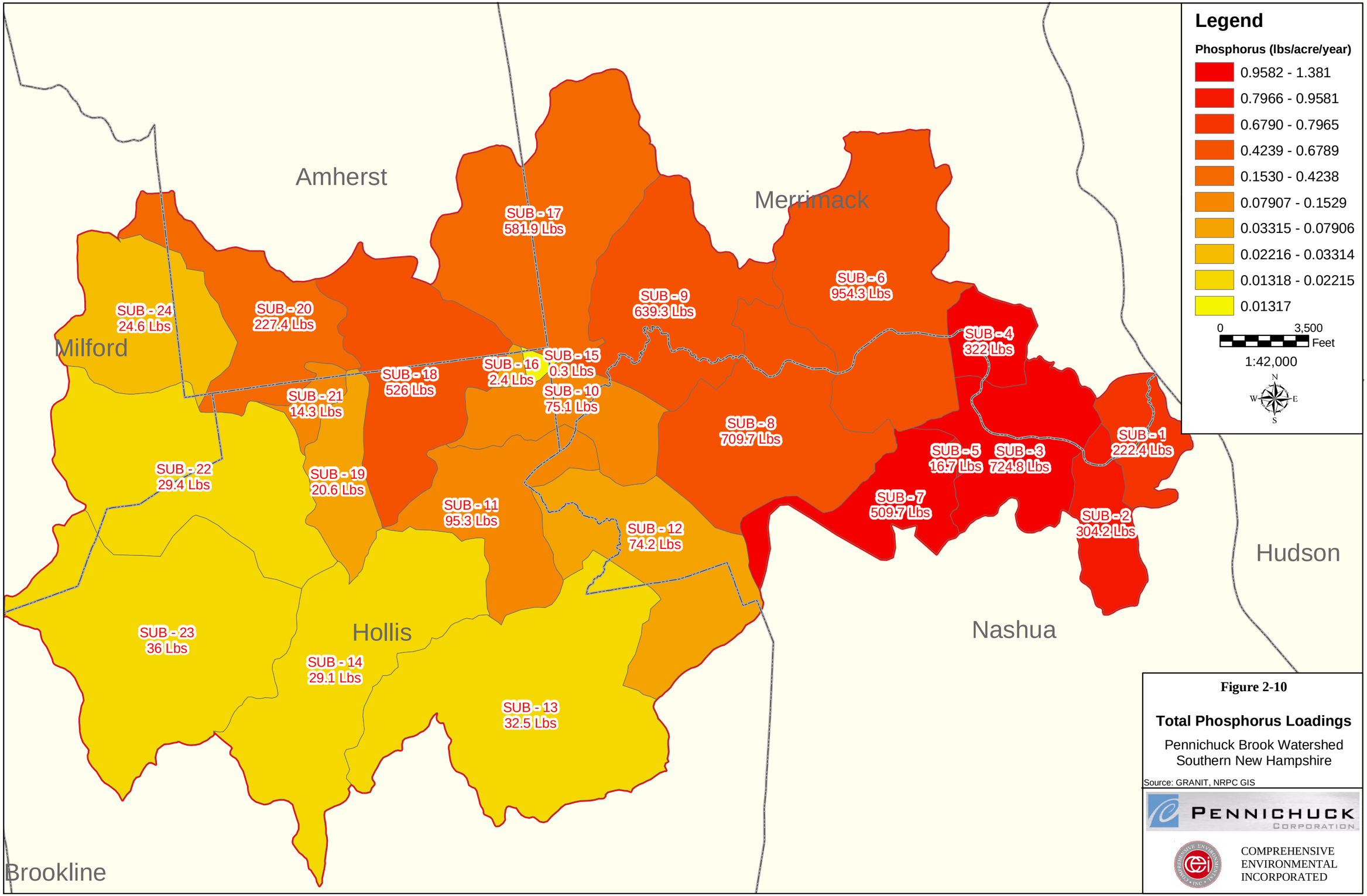
BMP Sampling Locations

Pennichuck Brook Watershed
Southern New Hampshire

Source: GRANIT, NRPC GIS

PENNICHUCK CORPORATION

COMPREHENSIVE ENVIRONMENTAL INCORPORATED


Legend
Phosphorus (lbs/acre/year)
0.9582 - 1.381
0.7966 - 0.9581
0.6790 - 0.7965
0.4239 - 0.6789
0.1530 - 0.4238
0.07907 - 0.1529
0.03315 - 0.07906
0.02216 - 0.03314
0.01318 - 0.02215
0.01317
0
3,500
Feet
1:42,000
N
W
E
S
Amherst
Merrimack
Milford
Hollis
Nashua
Hudson
Brookline
SUB - 17
581.9 Lbs
SUB - 6
954.3 Lbs
SUB - 9
639.3 Lbs
SUB - 24
24.6 Lbs
SUB - 20
227.4 Lbs
SUB - 4
322 Lbs
SUB - 15
0.3 Lbs
SUB - 16
2.4 Lbs
SUB - 18
526 Lbs
SUB - 10
75.1 Lbs
SUB - 21
14.3 Lbs
SUB - 8
709.7 Lbs
SUB - 1
222.4 Lbs
SUB - 5
16.7 Lbs
SUB - 3
724.8 Lbs
SUB - 22
29.4 Lbs
SUB - 19
20.6 Lbs
SUB - 7
509.7 Lbs
SUB - 11
95.3 Lbs
SUB - 2
304.2 Lbs
SUB - 12
74.2 Lbs
SUB - 23
36 Lbs
SUB - 14
29.1 Lbs
SUB - 13
32.5 Lbs
Figure 2-10
Total Phosphorus Loadings
Pennichuck Brook Watershed
Southern New Hampshire
Source: GRANIT, NRPC GIS
PENNICHUCK
CORPORATION
COMPREHENSIVE
ENVIRONMENTAL
INCORPORATED

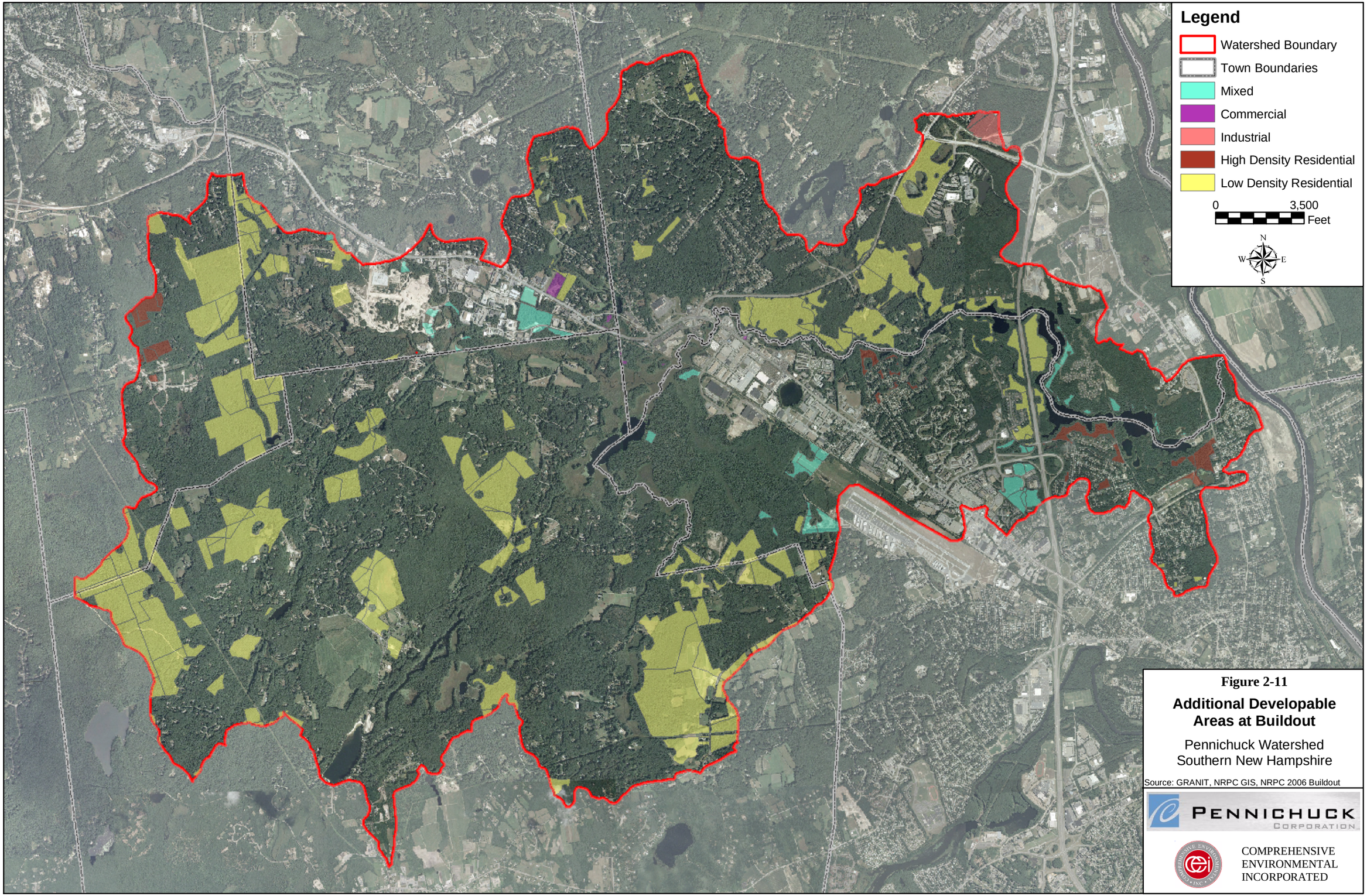


Figure 2-11

Additional Developable Areas at Buildout

Pennichuck Watershed
Southern New Hampshire

Source: GRANIT, NRPC GIS, NRPC 2006 Buildout

PENNICHUCK CORPORATION

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

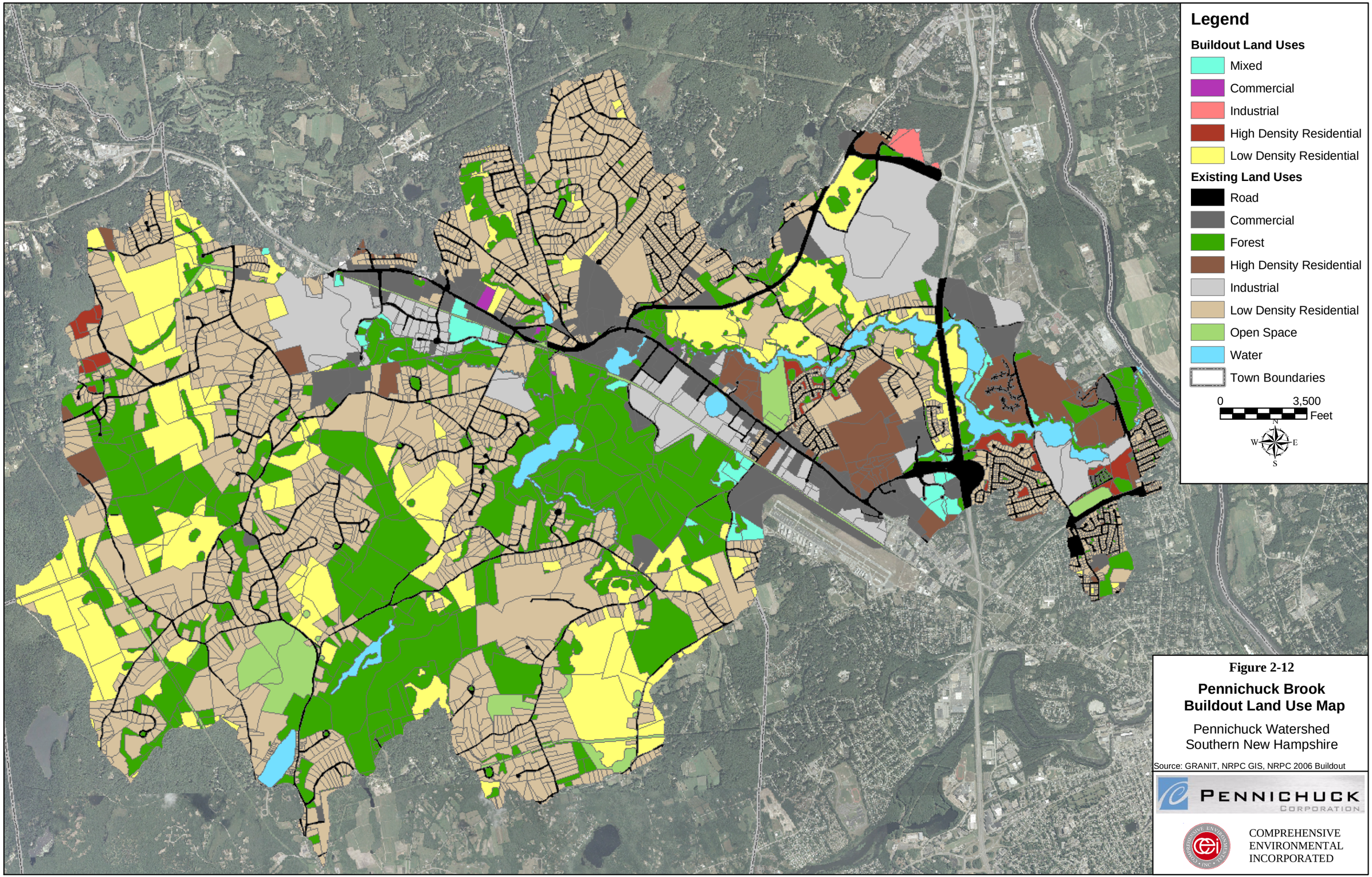


Figure 2-12

Pennichuck Brook Buildout Land Use Map

Pennichuck Watershed
Southern New Hampshire

Source: GRANIT, NRPC GIS, NRPC 2006 Buildout

3.0 Numeric & Other Targets

The purpose of setting numeric targets or goals for water quality is to use achievable, measurable benchmarks to promote the desired outcomes over time. There are several steps to effective water quality goals:

1) measure or estimate existing water quality and pollutant loadings;
2) identify the most critical measurement point;
3) identify the appropriate water quality surrogates or indicators[1];
4) identify the desired water quality;
5) compare the existing pollutant loadings to desired water quality goals; and
6) identify how pollutant loads can be addressed to achieve the goals.

The first step was described in Section 2.0, and Steps 2-4 are described below in this section. A comparison of the loadings to the goals (Step 5) is then discussed in Section 4.0. The alternative strategies to address loadings and a recommended overall strategy (Step 6) is then detailed in Sections 6.0.

3.1 Critical Measurement Point

Although data was collected throughout the watershed as a part of this project and others, it is important to identify one critical point where watershed efforts can be measured. This allows a clear indication of how much progress has been made towards a goal, although in reality reaching the goals may take years and can vary widely from year to year due to climatic factors. In Pennichuck Brook, the measurement point for setting goals is Harris Pond due to the location of the drinking water intakes.

3.2 Water Quality Surrogates & Indicators

Pollutant loadings from the watershed were estimated using the modeling protocol described in Section 2.0. As discussed in that section, phosphorus was chosen as the primary indicator of overall water quality because it is considered a limiting nutrient for plant life in fresh water systems. Excess phosphorus can cause excess algae blooms and die off, which can lead to taste and odor problems in drinking water and may cause anaerobic conditions and filling in of ponds over time due to the excess production and die off of plant material including algae. Generally, phosphorus levels under 20-30[2] ug/l will not lead to eutrophication or algae blooms, although this tends to vary with different water bodies. In other words, what is achievable in some water bodies

[1] A 'surrogate' or 'indicator' parameter is something that represents the general water quality of the stream/ponds and that can be reliably measured and tracked.
[2] Vollenweider, R. A. 1975. Input-Output Models with Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol. 37:53-83.

may not be realistic for others due to existing land uses, geologic or soil pre-conditions, or other factors.

Another frequently used indicator of water quality is total suspended solids (TSS). TSS loadings typically represent erosion of the streambed or streambanks, with lesser loads from various land uses and roadways. Elevated levels of TSS could also be caused by uncontrolled construction sites. TSS was not selected as a surrogate for this watershed, but some of the control strategies described in Sections 5.0 do address streambank and other erosion.

3.3 Desired Water Quality

Streams and rivers typically have phosphorus levels that depend on their urbanization level, and may range from 20 - 40 ug/l or even higher if there are wastewater discharges in proximity. Large lakes and ponds tend to have lower phosphorus levels since they have longer residence times and fewer point sources. Oligotrophic lakes, characterized by great depth, cold water and purity, may have levels as low as 0.005 mg/l, while small shallow ponds with short residence time are typically on the higher side, with levels greater than 30 ug/l more typical with the highest levels in urban ponds. For example, Dorrs Pond in Manchester had average phosphorus levels ranging between 23 and 45 ug/l between 2000 and 2006.[3]

Based on all of the accumulated data (described in Section 2.0), the average phosphorus level in Harris Pond was 38 ug/l. The question is, what is a reasonable and attainable goal for phosphorus concentrations in Harris Pond? The pond is shallow, about 20 feet deep with an average depth of 13 feet and a volume of 340 million gallons (MG). The residence time of only 10 days suggests it is more riverine than pond, in comparison to a lake such as Sebago where the residence time is about 5.1 years and total volume is 995 billion gallons.[4]

Harris Pond is not a deep, coldwater lake and the watershed is far from undeveloped as major highways and developments criss-cross the 17,000+ acres of land. The brook and most of the ponds are more comparable to river run reservoirs that are characterized by rapid turnover rates and shallow conditions. This type of river run pond might realistically achieve 30+ ug/l, which is still a 21% decrease from today's estimated average levels. In addition, Pennichuck Brook appeared to

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[3] City of Manchester, New Hampshire. *Biological and Water Quality Monitoring*. Retrieved October 3, 2007 from the World Wide Web: http://www.manchesternh.gov/CityGov/DPW/EPD/SEPP/Pond/Quality.html

[4] Portland Water District. *Sebago Lake Facts*. Retrieved October 3, 2007 from the World Wide Web: http://www.pwd.org/environment/sebago/facts.php

have a rather unusual level of phosphorus in the groundwater baseflow that discharges into the stream.[5]

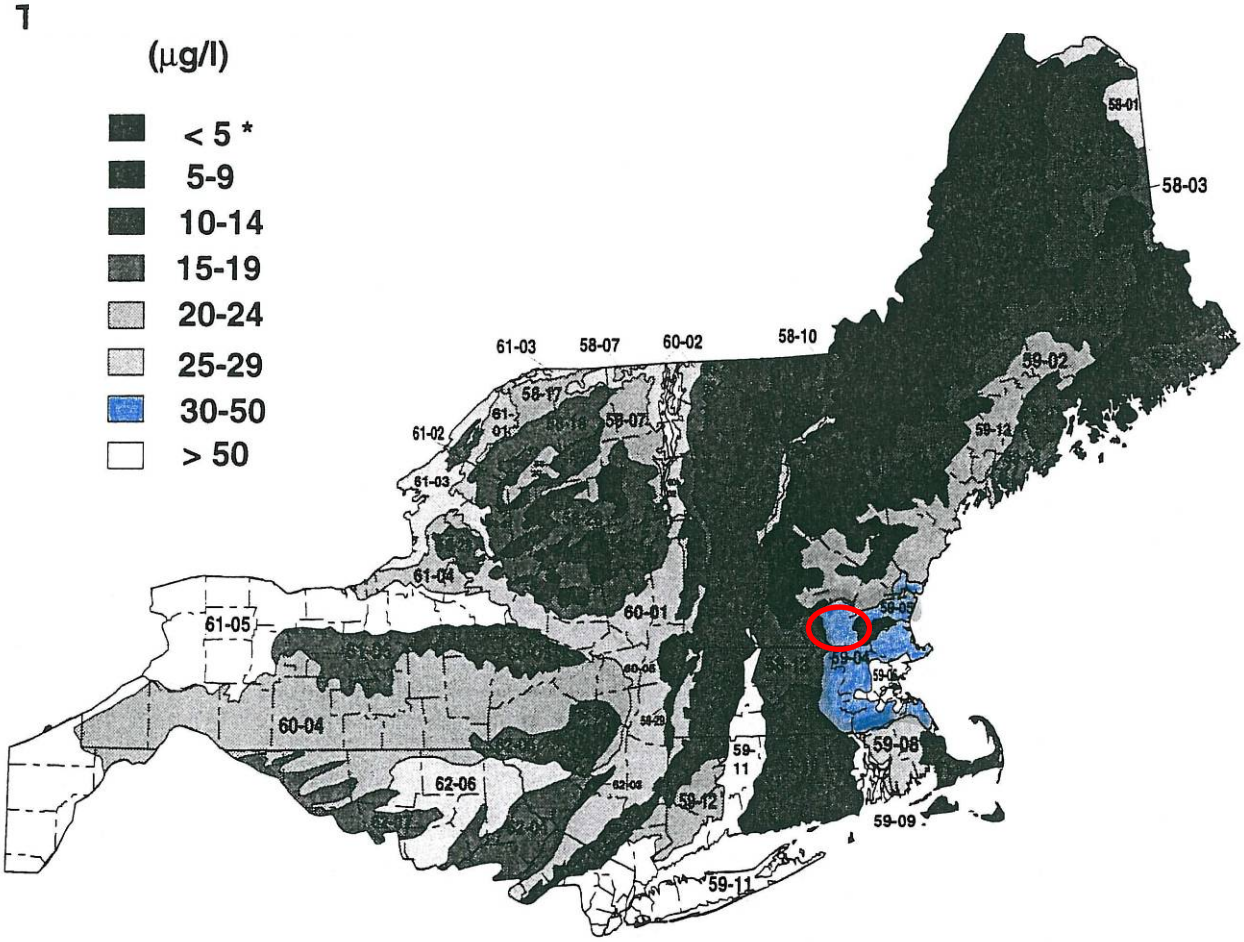
An analysis was undertaken to determine the benefit that would be realized if treatment removed 65% of phosphorus in runoff from existing developments. The results indicated that in-pond concentration would decrease to roughly 25 ug/l. However, it is unlikely that this level of retrofit can realistically be implemented. Additionally, data from a study[6] of in-pond lake phosphorus concentrations, as shown on Figure 3-1, suggests that regional in-lake total phosphorus concentrations are in the range of 30 to 50 µg/l.

Based on this information, it does not appear feasible to reduce phosphorus levels below 30 ug/l. Although this target is in the higher end of the so-called eutrophication range based on the Vollenweider analysis, it is on the lower end of the regional concentrations range. Based on this analysis, the recommended water quality target for in-pond total phosphorus concentrations is 30 ug/l. Note that these numbers are not hard and fast but are instead general indications of the health of the water body. What is more important is that the watershed is gradually improving instead of worsening over time.

[5] The levels in the stream baseflow, assumed to be from groundwater, were in the range of non-detect (detection limit of 10) – 55 ug/l. It is not known whether the source is from human development or from soils/geologic conditions, or some other source. It is also possible that it is not so unusual, but since it is so rarely sampled in groundwater, there is little to compare it with.

[6] Rohm, C. M., J. M. Omernik and C. W. Kiilsgaard. Regional Patterns of Total Phosphorus in Lakes of the Northeastern United States. Lake and Reservoir Management 11(1):1-14.

Figure 3-1. Regional Total Phosphorus Concentrations for Lakes in Northeastern United States[1]



Pollutant concentrations for TSS were also analyzed for stormwater runoff, however this is likely a small portion of the total sediment loading to the ponds, with streambank erosion likely a more significant source. Since TSS settles in the pond, an in-pond concentration target is not a reasonable goal. Instead, the more important issue is the filling in of the pond with the attendant potential for release of phosphorus from the sediments themselves as decomposition of dead plants and algae occur. Rather than setting a separate goal for sediment in the pond, sediment removal will rely on the same techniques used to remove phosphorus. Nearly all of the proposed stormwater practices for phosphorus removal will also remove significant quantities of sediment. Further, the recommendations in Section 6.0, particularly Recommendation 5 Encourage Local Adoption of State Stormwater Standards and Recommendation 8 Evaluate Sediment Accumulations, will address control of streambank erosion through better control of peak flow attenuation that causes streambank erosion and other measures as deemed necessary.

4.0 Pollutant Load Analysis

Pollutants loadings to the ponds must be removed or suppressed to achieve the proposed water quality goals. Since the Pennichuck water supply watershed encompasses several communities, phosphorus loadings were estimated by community instead of by subwatershed to encourage local control and coordination. Table 4-1 shows phosphorus loadings under buildout conditions and the amount of phosphorus that needs to be removed to achieve the water quality goal of 30 ug/l by each of the five communities within the watershed. The target of 30 ug/l was used because it is just below the point of eutrophication and is aggressive but achievable.

Table 4-1: Proposed Total Phosphorus Loading Goals

Community	Existing TP Loading	Additional TP Load at Buildout	Total TP Loading	Percent of TP Budget	Target TP Removal	Target TP Loading
Phosphorus from Stormwater						
Amherst	776	84	861	11%	344	516
Hollis	345	29	374	5%	149	224
Merrimack	1,988	164	2,151	29%	861	1,291
Milford	53	16	69	1%	28	41
Nashua	1,987	205	2,192	29%	877	1,315
Subtotal Stormwater Contribution	5,149	497	5,646	75%	2,258	3,388
Phosphorus from Other Sources						
Groundwater	1,524	(1)	1,523	20%	---	---
Merrimack River	288	---	335	4%	---	---
Subtotal Other Sources	1,812	(1)	1,858	25%	---	---
Total	**6,961**	**496**	**7,504**	**100%**	**2,258**	**3,388**
Harris In-Pond TP Conc. (ug/l)	40		43			30

The distribution of the pollutant loads by land use is shown on Table 4-2.

Table 4-2. Total Phosphorus Loadings by Land Use (lbs/year)			
Land Use	**Existing TP Loading**	**Additional TP Loading at Buildout**	**Total TP Loading at Buildout**
Commercial	1,085	143	1,228
HD Residential	373	57	430
Industrial	968	96	1,064
LD Residential	422	131	553
Roads	2,107	74	2,182
Forest	27	(9)	19
Open Space	4	0	4
Water	163	6	168
Total	5,149	497	5,646

5.0 Recommendations

5.1 Introduction

The Pennichuck Water Works water supply pond network currently has moderate phosphorus concentrations associated with phosphorus loadings, largely from stormwater runoff and to some degree groundwater baseflow. Currently, average phosphorus concentrations near the intake in Harris Pond are 38 ug/l. This is associated with a total average annual phosphorus loading of 6,960 lbs from the watershed from the following sources:

- 5,149 lbs from stormwater runoff,
- 1,523 lbs from groundwater baseflow, and
- 288 lbs from the Merrimack River.

At buildout, the in-pond phosphorus concentration in Harris Pond could increase to 43 ug/l if no actions are taken; suggesting that water quality could become significantly worse than present over time if measures are not taken to address these loadings and particularly those from future development. The projected future load at buildout (without new measures) could be 7,504 lbs: 5,646 lbs from stormwater runoff, 1,523 lbs from groundwater baseflow and 335 lbs from the Merrimack River (accounting for a slight increase associated with a greater withdrawal at buildout).

A target in-pond water quality goal of 30 ug/l was established based on typical regional in-pond phosphorus concentrations for the area, and what can realistically be achieved through the implementation of effective stormwater practices with a Margin of Safety. To get to this goal, a total of 2,258 pounds of phosphorus needs to be prevented from entering the ponds under buildout conditions. Stormwater treatment is targeted for phosphorus removal since it is easier to address than groundwater baseflow and because it represents about 75% of the total loadings. Flow from the Merrimack River does not present a significant loading and would also be difficult to address due to the large watershed, so it is not addressed herein.

Section 4 described how much phosphorus needs to be removed to protect the Pennichuck ponds and watershed from further eutrophication. This section describes an implementation program that will achieve those strategies in conjunction with town-specific actions. Recommendations are presented below and shown on Table 5-1 in terms of costs and phosphorus removal rates. A schedule for these recommendations is provided in Figure 5-1. Note that although most recommendations relate

to phosphorus removal, some recommendations are critical even though they do not directly remove phosphorus.

5.2 Recommendations

#1. Public Education

Existing residential neighborhoods in the Pennichuck Brook watershed produce some 795 pounds of phosphorus (estimated at 983 lbs at buildout), largely through activities such as yard waste dumped in wetlands; uncontrolled pet wastes; lawn and garden fertilizers; erosion from recreational vehicles; car washing and uncontrolled runoff. The following components are proposed, with details to be identified further in the ongoing pilot program in the Stump Pond Subwatershed, described below. The estimated budget of $78,000 includes:

1A. Complete Part 2 of Community Based Education Program. Public education can be used to educate homeowners on actions they can take to minimize phosphorus and other pollutant loadings. Historically, many methods have been used to provide public education, but not all have been successful. For example, 'advertising' approaches would seem to be quite effective – after all, why would so many companies spend huge amounts of money on it if it didn't work? But recent research in Canada[1] has shown that advertising often does not work for changing environmental behavior because it calls for greater understanding and commitment by people than does changing to a different laundry soap, for example. Conventional marketing and education efforts that rely on media and advertising typically have little to no effect on overall behaviors as shown in a number of studies[1]. For example:

- High school students who participated in a 6-day workshop focusing on creating awareness of environmental issues were found in a follow-up to be no more likely afterward to engage in pro-environmental actions.
- Households provided with information about energy conservation did not reduce energy use.
- Households volunteering to participate in a 10-week study of water use received a state-of-the-art handbook on water efficiency. Despite great attention paid to the preparation of the handbook, it was found to have no impact upon consumption.
- Two large surveys found that environmental information, knowledge and awareness were poorly associated with environmental behavior.
- In one study, individuals who have strong energy conservation attitudes were found no more likely to conserve energy.

[1] McKenzie Mohr, Doug and Smith, William. 1999. Fostering Sustainable Behavior: An Introduction to Community-Based Social Marketing. New Society Publishers, Gabriola Island, BC, Canada.

As shown above, increasing knowledge and changing attitudes have little impact on actual behavior change. To address these findings, an approach referred to as community based social marketing was developed, which focuses on changing people's behaviors, rather than just distributing information. The approach involves surveying current behaviors and identifying barriers that keep people from performing certain actions. The survey results are used to develop an action plan to change the ratio of benefits and barriers so that the target behavior(s) becomes more attractive. Implementation elements often revolve around commitments, reminders and prompts, establishing a norm, creating a vivid message, developing goals and feedback and providing incentives.

The community based approach has been very effective in promoting sustainable behavior.[1] For example:

- Home energy auditors trained to use behavior change tools for the largest utility in the United States, Pacific Gas and Electric, persuaded three to four times as many households to weatherize their dwellings.
- When used to promote recycling, community based social marketing techniques have resulted in dramatic increases in recycling.

In the Pennichuck watershed, this newer approach to establish a scientific, stepwise education program includes a) developing an understanding of the barriers to watershed stewardship; b) identifying how people might be willing to commit to using better stewardship techniques such as composting instead of dumping yard waste into wetlands; c) developing prompts to remind people of the 'new' behaviors; d) identifying local social 'norms' and community or block leaders to encourage better watershed stewardship; and finally e) using all of these techniques to develop an effective public education program. This approach is called Community Based Education (CBE).

Pennichuck is now working with DES and the Towns of Amherst and Merrimack on Part 1 of a pilot CBE program in the Stump Pond Subwatershed. This subwatershed was chosen since it has high density housing with high phosphorus loadings. In 2007, DES awarded a grant for Part 1 of the Community Based Education Program in concert with Pennichuck and in cooperation with the Towns of Amherst and Merrimack. Part 1 consists of the development, distribution and analysis of a survey through the neighborhoods of the Stump Pond Subwatershed to identify neighborhood leaders, barriers to better stewardship, and potential prompts and education messages to get people involved in watershed activities and in understanding the issues.

Recommendation: Develop a program to encourage people to adopt environmentally friendly habits such as using compost bins[2] instead of dumping yard waste in the wetlands; diverting roof leaders to raingardens; controlling runoff from car washing and limiting fertilizer use, especially from phosphorus-based fertilizers that run off into the wetlands and waterways.

Actions:

1) Develop and distribute watershed survey to determine roadblocks to preferred environmental behaviors.
2) Establish a neighborhood working group that will pilot survey and later champion, implement and sustain education program.
3) Develop an action item plan based on survey results that will detail plan items revolving around incentives, reminders and prompts, goals and norms.
4) Implement program via NH DES Source Water Protection Grant Program.
5) Measure and evaluate the program's success through the distribution of a follow-on resident survey.

Objectives: Change the habits of people in the watershed to be more environmentally friendly. In combination with Recommendations 1B, 1C, 1D, 1E and 1F, to collectively reduce phosphorus loadings from residential areas by 30%.

Milestones: See milestone schedule.

Partners: DES

Budgeted Costs: $20,000

Funding Source: Pennichuck Water Works and potential grant funding from NH DES.

Associated Recommendations: 1B Website, 1C Door Hangers, 1D School Education Program, 1E Coordinate with Phase II Coalition and 1F Garden Clubs

Measurement: Results of the follow-on survey showing that targeted behaviors have been met by the majority of the neighborhood working group.

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[2] DES might be able to provide low cost composters that could be sold to residents at a reduced cost. Composting bins, which have been used elsewhere in New Hampshire, can provide a tidy location for residents to dispose of yard waste, and they then receive the benefit of highly beneficial compost for future gardening efforts.

1B. Website.

Recommendation: Develop and implement a watershed website including:

- information on what citizens can accomplish with small changes in how they deal with wastes and rainwater;
- advertisements for Household Hazardous Waste collection days and locations;
- advertisements for Watershed Association meetings;
- how to get low cost composters; and
- a kids' section linking to the school education program.

Actions:

1) Research tips for citizens to include on the website.
2) Contact the five communities in the watershed to obtain information on Household Hazardous Waste collection days.
3) Coordinate with Watershed Associations to obtain meeting dates and information about their programs.
4) Obtain information from the local schools on their education programs.
5) Develop a website containing the information.

Objectives: Increase awareness of residents of more environmentally friendly practices that will be more protective of water quality. In combination with Recommendations 1A, 1C, 1D, 1E and 1F, to collectively reduce phosphorus loadings from residential areas by 30%.

Milestones: See milestone schedule.

Partners: DES

Budgeted Costs: $6,000

Funding Source: Pennichuck Water Works and potential grant funding from NH DES.

Associated Recommendations: 1A Part 2 of Community Based Education Program, Website, 1C Door Hangers, 1D School Education Program, 1E Coordinate with Phase II Coalition and 1F Garden Clubs

Measurement: The number of hits to the website, indicating how often the site is visited.

1C. Door Hangers.

Recommendation: Develop and place door hangers in specific residential areas of the watershed. The door hangers will highlight how residents can improve water quality and refer to the website.

Actions:

1) Identify residential areas of the watershed to receive door hangers.
2) Develop information to be included on door hangers.
3) Print door hangers.
4) Place door hangers in identified neighborhoods.

Objectives: Increase awareness of residents of more environmentally friendly practices that will be more protective of water quality. In combination with Recommendations 1A, 1B, 1D, 1E and 1F, to collectively reduce phosphorus loadings from residential areas by 30%.

Milestones: See milestone schedule.

Partners: DES

Budgeted Costs: $12,000 for printing and distribution of materials

Funding Source: Pennichuck Water Works and potential grant funding from NH DES.

Associated Recommendations: 1A Part 2 of Community Based Education Program, 1B Website, 1D School Education Program, 1E Coordinate with Phase II Coalition and 1F Garden Clubs

Measurement: The number of hits to the website, which residents will be directed to by the door hangers.

1D. School Education Program.

Recommendation: Develop a school education program, such as *Project Wet*. In this program, a grant or grants might be provided to key schools in the watershed so that they could cover the costs of having watershed-area teachers attend a Pennichuck watershed-adapted NH DES Project Wet training program. This program is based on teaching kids to understand and improve local water quality, and has been successful in other parts of the country and elsewhere in New Hampshire.

This might include Pennichuck hosting the annual Children's Water Festival in May at a local fairgrounds or school. This is a one day event geared to fourth graders only, with exhibits from water suppliers around the region, theatre groups and a water tasting contest. Typically it hosts

700-1,000 4th graders. It is assumed that this program will be planned as part of Part 2 of the CBE program.

Actions:

1. Coordinate with NH DES Project Wet staff and local schools to bring information on the Pennichuck Brook watershed into the school curriculum.
2. Look into the Children's Water Festival in May and contact the appropriate organization to discuss hosting/sponsoring the festival.

Objectives: Educate students about the watershed/water supply and on more environmentally friendly practices that are protective of water quality. In combination with Recommendations 1A, 1B, 1C, 1E and 1F, to collectively reduce phosphorus loadings from residential areas by 30%.

Milestones: See milestone schedule.

Partners: Local schools

Budgeted Costs: $15,000 for coordination, school buses, teachers and curriculum copies

Funding Source: Pennichuck Water Works and potential grant funding from NH DES.

Associated Recommendations: 1A Part 2 of Community Based Education Program, 1B Website, 1C Door Hangers, 1E Coordinate with Phase II Coalition and 1F Garden Clubs

Measurement: Copy of the curriculum developed for the schools. Identify the number of teachers participating in the program, the number of schools where the program is implemented and the number of students involved.

<u>1E. Coordinate with Phase II Coalition</u>. The federal Phase II Stormwater Program has been ongoing since the first permit round began in 2003. That 5-year permit period will end in April 2008 and a second 5-year permit will begin. All 5 of the watershed communities – Nashua, Merrimack, Hollis, Amherst and Milford – are in the Phase II program. This has been handled in New Hampshire by the Regional Planning Agencies who have provided a regional coordination role to ease the permit burden.

Recommendation: Coordinate and work with the Nashua Regional Planning Commissions' Phase II Stormwater Coalition, which includes the 5 watershed communities, to address watershed problems that affect both Pennichuck Brook and the required stormwater management in the five communities.

Actions:

1) Identify potential areas of collaboration between Phase II and watershed problems. Examples include roof leaders that discharge directly to driveways and then to street drainage systems; dumping of leaves, grass and other yard waste in ditches and streams; wetland buffer zone disturbances; open dumping and dumping of waste materials in catch basins.
2) Contact and meet with the Nashua Regional Planning Commissions' Phase II Stormwater Coalition to discuss potential areas of collaboration and to develop a strategy for incorporating these into Phase II.
3) Participate in coalition meetings.

Objectives: Collaborate watershed protection efforts with Phase II efforts to provide an incentive to local communities to implement measures that will be protective of the water supply. In combination with Recommendations 1A, 1B, 1C, 1D and 1F, to collectively reduce phosphorus loadings from residential areas by 30%.

Milestones: See milestone schedule.

Partners: Nashua Regional Planning Commissions' Phase II Stormwater Coalition, Watershed communities

Budgeted Costs: $10,000 for attendance and coordination with the Coalition, as well as some potential seed money to participate in public education programs.

Funding Source: Pennichuck Water Works and potential grant funding from NH DES.

Associated Recommendations: 2 Increased Maintenance in Commercial Areas, 3 Retrofit Detention Basins, 4 Encourage LID in Commercial Redevelopment, Encourage Adoption of New State Stormwater Standards for New Developments, 6 Tinker Road Detention Pond, 10 Stormwater Utilities

Measurement: List of protection efforts agreed upon and implemented by the Phase II coalition participants.

1F. Garden Clubs.

Recommendation: Encourage local Garden Clubs to visit Pennichuck Square to learn about raingardens and to potentially participate in the development of demonstration raingardens elsewhere. These might be incorporated into school, municipal or other buildings. Signage can be added at the demonstration raingardens depicting plantings and benefits of raingardens at cleansing infiltration and reducing storm flows.

Actions:

1) Send a letter to each of the garden clubs describing the program, inviting them to visit Pennichuck Square and to enlist their assistance.
2) Contact the Master Gardener Program at UNH and use their community service requirements for designing, planting or maintaining raingardens at schools or other public buildings. New Master Gardeners are required to perform 50 hours of community service within a year of their graduation.
3) Identify key locations for demonstration projects and contact owners to participate in the program.
4) Provide money for landscape materials, shrubs, trees and tools necessary to implement the demonstration raingardens.

Objectives: Increase public understanding and perception of raingardens and LID techniques through the implementation of demonstration projects. In combination with Recommendations 1A, 1B, 1C, 1D and 1E, to collectively reduce phosphorus loadings from residential areas by 30%.

Milestones: See milestone schedule.

Partners: Garden Clubs in the watershed, UNH Master Gardener Program, DES

Budgeted Costs: $15,000 for landscape materials, shrubs, trees and tools.

Funding Source: Pennichuck Water Works and potential grant funding from NH DES.

Associated Recommendations: 1A Part 2 of Community Based Education Program

Measurement: Watershed garden club members understand and support the use of raingardens and incorporate these practices into their programs of mentoring new master gardeners. Design and implementation of demonstration projects at high profile sites.

#2. Increased Maintenance in Commercial Areas

Street sweeping and catch basin cleaning, along with regular maintenance of stormwater practices, has been found to remove phosphorus from watersheds quite effectively if the best equipment is used – namely either vacuum sweepers and/or regenerative air sweepers for sweeping, vacuum trucks for cleaning of catch basins and other stormwater practices such as the plunge pool at Celina Avenue and detention basins.

Although the watershed communities sweep the roadways and streets, private parking lots and commercial driveways are likely not swept as frequently or thoroughly as they could be, at least not on a widespread basis. To evaluate the potential effectiveness of Pennichuck purchasing a sweeper to use on private parking lots and driveways, CEI modeled watershed commercial and industrial parking areas to determine the phosphorus reduction that could be achieved. For the purposes of the analysis, we assumed the use of a regenerative air sweeper that would go over the most critical areas near the brook six times per year, and over less critical areas 2 times per year.

Recommendation: Continuously sweep private parking lots and commercial driveways between April and November, sweeping critical areas near the brook more frequently (e.g., 6x/year) and less critical areas 2x/year. Clean private catch basins and stormwater practices twice a year.

Actions:

1) Evaluate issues and on-going costs associated with Pennichuck Water Works sweeping parking areas and driveways and cleaning catch basins and BMPs on private property.
2) Identify critical areas in close proximity to the water supply and its tributaries for more frequent sweeping/cleaning.
3) Sweep continuously between April and November and clean private catch basins and stormwater practices associated with commercial and industrial development twice a year.
4) Track sediment collected from sweeping/cleaning operations and adjust efforts as necessary based on accumulations.

Objectives: Reduction of 96 pounds per year of phosphorus to the water supply associated with sweeping.[3] Reduction of 280 pounds per year (7.5%[4] assuming catch basins are cleaned twice a year) of phosphorus to

[3] Street sweeping assumes Pennichuck would buy a street sweeper and run it continuously in the watershed to sweep roadways and commercial parking lots. Further evaluation would be necessary to prioritize areas for sweeping, such that higher loading areas could be addressed more frequently.

[4] State of Wisconsin Department of Transportation. (January 24, 1997) Facilities Development Manual

the water supply associated with cleaning private catch basins and stormwater practices.

Milestones: See milestone schedule.

Partners: Private commercial and industrial property owners.

Budgeted Costs: $10,000 to perform a study evaluating the issues and on-going costs associated with Pennichuck performing sweeping/cleaning services. $200,000 to purchase a street sweeper. $120,000 to purchase a Vac Truck. Operations costs have not been included in this analysis.

Funding Source: Pennichuck Water Works and potential grant funding from NH DES.

Associated Recommendations: 3 Retrofit Detention Basins, 6 Tinker Road Detention Basin Retrofit

Measurement: Amount of sediment swept from designated areas. Amount of sediment removed from catch basins and stormwater BMPs.

#3. Retrofit Detention Basins

During the study portion of this project and previous subwatershed studies, over 85 stormwater practices were identified. These ranged from the latest high performance practices such as those used at the Pennichuck Square Pilot project and the Celina Avenue plunge pool, to detention basins that are completely full of sediment and small swales. The predominant feature of these practices is detention basins that are not working. Some are large, some are quite small, but most are characterized as 'full of sediment' and overflowing. Most are also on private property and are not being maintained.

The details will need to be worked out jointly town by town, since there are significant benefits to both Pennichuck Brook and to the towns to jointly promote phosphorus reduction, flooding reduction and reduced threat of oil, grease and heavy metal pollution from large areas of parking lots.

Recommendation: Evaluate the 85+ potential locations for retrofitting BMPs and prioritize the top 10, weighing heavily on those with an estimated 25 acre or more drainage site. Evaluate each for potential improvements for better performance, including permissions/easements for maintenance.

Actions:

1) Evaluate existing BMPs for potential retrofits and prioritize the top 10.

2) Design BMP retrofits for 10 sites.
3) Construct detention basin retrofits.

Objectives: Remove 50 pounds of phosphorus per year from entering the water supply. Remove sediment from entering the water supply. Provide storage and infiltration for stormwater.

Milestones: See milestone schedule.

Partners: Private landowners, watershed communities

Budgeted Costs: $855,000 to evaluate and prioritize existing BMPs and design and construct retrofits, consisting of forebays and other improvements for 10 sites. Assumes 30% for design costs to include permitting and coordination with landowners and involved municipalities.

Funding Source: Pennichuck Water Works and potential grant funding from NH DES.

Associated Recommendations: 1E Coordinate with Phase II Coalition, 4 Encourage LID in Commercial Redevelopment

Measurement: Number and types of retrofits. Revised pollutant removals based on actual area treated. Measured quantities of sediments removed from retrofits.

#4. Encourage LID in Commercial Redevelopment

One of the biggest threats in the watershed is older commercial and industrial development that produces uncontrolled stormwater runoff. Vast parking lots, in particular, pose a hazard to the water quality of Pennichuck Brook, as well as to flooding in the host communities that damages private property and public infrastructure.

Recommendation: Work with willing watershed communities and with NH DES to develop a watershed-specific grant program that encourages the use of LID in new and redevelopment projects and provide professional review of LID projects in the watershed. Grants would be provided to the planning and community development departments to assist in the extra work that would be required to incorporate Low Impact Development techniques in local projects that occur in the watershed.

There would be two components: 1) a Pennichuck professional LID review and comments on the development prior to approval by the Planning Board and/or Zoning Board; and 2) a grant to the town for encouraging developers to go through the additional review. Communities could either use the funds for staff coordination costs, or in

turn grant these to the developer to cover their costs. Actual grant amounts could be based on the percent impervious area retrofitted and/or the amount of anticipated phosphorus removal based on the controls required.

Encourage business participation by combining the retrofits and grant program with a watershed friendly "sticker" or logo that could be used in their stores/businesses and in advertisements. Businesses might get special listings encouraging residents to buy from watershed friendly businesses.

Actions:

1) Introduce the grant program in coordination with the Phase II coalition.
2) Establish a grant program/application process for communities to apply for funds to coordinate the incorporation of LID techniques in their review process. The program would also provide Pennichuck Water Works with review opportunities for proposed projects in the watershed.
3) Implement the grant program and provide review for LID projects in the watershed.
4) Develop a watershed friendly sticker or logo for use by local stores/businesses.

Objectives: Watershed communities are promoting and adopting LID requirements for redevelopment projects, ultimately resulting in the reduction of 685 pounds of phosphorus per year.

Milestones: See milestone schedule.

Partners: Watershed communities

Budgeted Costs: $937,500 for professional LID-pre-review of redevelopment site plans. Assumes a total of 25 reviews (avg. 5 per town) each year for 5 years. For budgeting purposes, it was assumed that Pennichuck would provide an average $5,000 pre-LID review, and that by adopting the recommendations, towns would receive a stipend of $2,500 on average per site plan review for the first five years to be used for their coordination efforts or however they wished.

Funding Source: Pennichuck Water Works

Associated Recommendations: 1E Coordinate with Phase II Coalition, 5 Encourage Local Adoption of State Stormwater Standards

Measurement: Communities adopt stormwater standards for redevelopment projects that promote LID.

#5. Encourage Adoption of New State Stormwater Standards for New Developments

Although the original 1998 Watershed Management Study had an evaluation of the five towns' regulatory status, nearly 10 years has passed since that evaluation. There are many new regulatory models available from NH DES for wetlands protection and in addition, new Alteration of Terrain regulations are anticipated to be finalized in the Spring of 2008. The Alteration of Terrain (AoT) Program requires that entities disturbing more than 100,000 square feet apply for a State level permit through NH DES including a fee. NH DES then reviews these projects and they can not be approved by local planning boards until the AoT permit requirements have been met. Previously, the AoT rules were relatively minimal, and over time have become outdated. The update of AoT rules is important in that it will bring New Hampshire's regulations more in line with current best management practices. Although the new rules are not expected to have huge cost consequences for developers, the environmental improvements will be dramatic and are long overdue.

Recommendation: Seek out a grant jointly with watershed communities to assist in watershed-wide adoption of the new AoT rules for all projects more than one acre, with each community adopting these rules at the local level. The adoption of these rules should also include maintenance requirements specific to private development (to be outlined in NH DES's upcoming Guidance on the new AoT rules). This would satisfy each of the Phase II communities' need to update their regulations as mandated under Phase II federal rules, and would also significantly assist in reducing future water pollution and flooding.

Try to obtain watershed-wide cooperation for new watershed regulations through DES. This could occur after the AoT rules are in place, as these will provide the most significant benefit. Pennichuck made a significant effort to implement these watershed rules in the last few years, however, some of the watershed communities declined to participate and the watershed rules can only be put in place with participation of all watershed communities, according to DES. Over time, watershed communities may come to realize that these regulations are not particularly onerous and that both public and private property within their communities can be better protected by adopting the buffers town-wide, even outside the watershed. The buffers are most important for wetland protection, in that wetlands provide considerable flood storage and storage of aquifer water.

Continue to dedicate staff to reviewing watershed projects whenever possible. Consider hiring a watershed inspector/plan reviewer or contracting it out. Although the watershed communities are not required to incorporate and consider Pennichuck's comments, many of them appreciate the additional review.

Actions:

1) Introduce local adoption of AoT rules and maintenance requirements at Phase II Coalition meeting.
2) Provide NRPC or other group with funding to help communities locally adopt state standards.
3) Approach communities about the adoption/incorporation of watershed regulations.
4) Continue to review watershed projects.

Objectives: Adoption of state stormwater standards at the local level with a threshold of 1 acre or less for all new and redevelopment. Reduction of phosphorus loads by 252 pounds per year through adoption and implementation of regulations.

Milestones: See milestone schedule.

Partners: Watershed communities

Budgeted Costs: $40,000 for a grant to NRPC or others to help watershed towns implement new AOT rules at the local level.

Funding Source: Pennichuck Water Works

Associated Recommendations: 1E Coordinate with Phase II Coalition, 4 Encourage LID in Commercial Redevelopment

Measurement: Communities adopt State stormwater standards with a threshold of 1 acre or less instead of 100,000 square feet for all new and redevelopment.

#6. Tinker Road Detention Pond

The detention pond off of Tinker Road and Exit 8 of the F.E. Everett Turnpike was identified as a potential stormwater practice retrofit area under the 2004 watershed study of Pennichuck Brook[5]. This detention area currently discharges into a tributary of Harris Pond. The intake to the water supply is in Harris Pond, which makes this project a higher priority.

Tinker Pond collects stormwater from a large watershed with many types of land uses that contribute stormwater pollution. The pond provides some detention and limited sediment removal capabilities, but does not remove nutrients, bacteria, oil & grease, and other contaminants associated with NPS pollution. The pond is also susceptible to contamination through accidental spills on the Everett Turnpike. The Harris Pond Tributary collects stormwater, through two drainage systems,

[5] Comprehensive Environmental Incorporated. (Spring 2004). Study of Urban Non-Point Source Pollution PBS, PBH, PBP, WBS & MB Subwatersheds. Merrimack, NH

from a five acre stretch of the Everett Turnpike north of Exit 8. There is a small wetland area designed for spill containment at one of the drainage outfalls, but there is no spill protection at the other outfall. In addition, the discharge locations provide very limited capability for sediment, nutrients, bacteria, oil & grease, and other contaminant removal associated with the stormwater from the Everett Turnpike.

Recommendation: Retrofit the Tinker Road Detention Pond to improve treatment of stormwater runoff from the surrounding watershed and provide treatment for stormwater runoff from the F.E. Everett Turnpike.

The proposed stormwater practices include: 1) retrofits to the inlet and outlet structures in the detention pond on Tinker Road to extend the flow length and detention time; 2) redirecting highway runoff that is currently discharged directly into Harris Pond through two existing swales, into two proposed forebays, treatment ponds and exfiltration berms; 3) installing a series of oil/water separation structures and oil sorbent booms within the proposed treatment ponds.

Actions:

1) Secure funding through the Watershed Restoration Grant Program.
2) Finalize BMP designs.
3) Obtain necessary permits for construction.
4) Develop an Operations and Maintenance (O&M) plan.
5) Construct BMPs.

Objectives: Protect Harris Pond from typical roadway contaminants and address nutrient inputs (a source of algal growth) from stormwater associated with the adjacent neighborhood to remove 70 pounds of phosphorus per year (8% of the removal goal for Nashua). This assumes a removal efficiency of 55%, which is consistent with other wet pond structures.

Milestones: See milestone schedule.

Partners: NH DES, NH DOT for access

Budgeted Costs: $351,300 for design, permitting, construction, public education and monitoring program

Funding Source: Pennichuck Water Works and NH DES

Associated Recommendations: 3 Retrofit Detention Basins

Measurement: Photo documentation of completed BMPs, as-built designs and removals based on modeling in Watershed Restoration Plan.

#7. Evaluate Phosphorus in Groundwater

Recommendation: Conduct a study to evaluate whether phosphorus loadings from groundwater are a significant source of total load to the water supply and the measures that can be taken to address it.

Actions:

1) Perform a study of groundwater phosphorus loads.
2) Implement recommendations.

Objectives: Determine whether additional recommendations are needed to address phosphorus loads associated with groundwater. Additional recommendations may include better controls on large septic systems or additional measures for treating recharged stormwater.

Milestones: See milestone schedule.

Partners: None

Budgeted Costs: $30,000 to perform an evaluation of phosphorus loadings associated with groundwater. This assumes sampling of wells in controlled and developed areas for phosphorus, with potentially 1 day of drilling microwells.

Funding Source: Pennichuck Water Works

Associated Recommendations: None

Measurement: Final report with recommendations.

#8. Evaluate Sediment Accumulations

There is some evidence that bank erosion is occurring in some areas of the stream network. This may lead to further filling in of ponds, as well as a P loading.

Recommendation: Resurvey sediment depths in the ponds for comparison to the July 2000 Sediment Study of Pennichuck Pond. This will help define the severity of sediment infill in the ponds and the course of action required to address it.

Design and install sediment depth measurement devices in each of the ponds to assess the rate that the ponds are filling in. Sites will be selected to identify three variable input conditions: urban inputs, shoal areas with vegetative inputs, and settling zones in front of dams. A control location that represents average pond accumulations will also be selected for each pond.

If sediment accumulation rates are significant, canvas the banks of tributary streams and Pennichuck Brook for erosion.

Adopt state stormwater standards locally as discussed under Recommendation 5. These new state standards incorporate requirements for channel protection that are geared towards the flow attenuation necessary to prevent channel erosion associated with stormwater runoff and will help prevent a major source of streambank erosion.

Actions:

1) Resurvey sediment depths in the pond.
2) Design sediment depth measurement devices in each of the ponds.
3) Install sediment depth measurement devices in each of the ponds.
4) Determine the need for a streambank study based on sediment accumulation rates.
5) Perform a streambank study if needed.
6) Adopt state stormwater standards at the local level as described under Recommendation 5 to incorporate peak controls that are geared towards channel protection.

Objectives: Reduce sediment loadings to the ponds through the adoption of regulations that control peak flows that cause streambank erosion and by monitoring existing loadings to determine the need for additional actions.

Milestones: See milestone schedule.

Partners: None

Budgeted Costs: $15,000 to evaluate sediment accumulation rates in the ponds. $15,000 to canvas streams for bank erosion.

Funding Source: Pennichuck Water Works and potential funds from NH DES grants.

Associated Recommendations: 5 Encourage Local Adoption of State Stormwater Standards

Measurement: Installation of sediment measurement devices and annual sediment readings. Local adoption of state stormwater standards. Final report on severity of streambank erosion and the need for additional measures to address it.

#9. Harris Pond Aeration

Some internal loading of phosphorus is anticipated in the ponds. Reduced loading from the watershed may eventually lead to reduced internal loading, but it is not expected to happen shortly after stormwater practice implementation. Aeration may be used to prevent the recycling of phosphorus from bottom sediments into the water column in the short term. Pennichuck Water Works is currently operating a hypolimnetic aeration system in Harris Pond. This type of system will aerate the bottom layer of the pond without destratifying it. The aeration system will prevent anoxic conditions from occurring in the hypolimnion layer of Harris Pond, which will prevent phosphorus from being released from the bottom sediments back into the pond.

Recommendation: Continue operation of the aeration system in Harris Pond.

Actions:

1) Continue operation of the aeration system in Harris Pond.

Objectives: Reduce treatment costs of raw water by preventing the release of phosphorus and other contaminants from the bottom sediments back into the pond. It is anticipated that the aeration system will reduce the average phosphorus concentration to 33.5 ug/l near the intake in Harris Pond, which is equivalent to about 1,160 pounds of phosphorus annually. However, in some years, phosphorus reduction associated with aeration may not be as high due to weather conditions, thus the equivalent phosphorus reduction associated with aeration was halved to 580 pounds removal annually.

Milestones: See milestone schedule.

Partners: None

Budgeted Costs: The system is already in place. Yearly operational costs are not included.

Funding Source: Pennichuck Water Works

Associated Recommendations: None

Measurement: Operation of the aeration system. Raw water quality at the intake before and after aeration.

#10. Stormwater Utilities

Stormwater Utilities are rapidly increasing in popularity in New England. Several are beginning in Massachusetts, one in Vermont and several in Maine. Most recently, the City of Manchester received legislative authorization to consider a Stormwater Utility and legislation is being considered that would allow any municipality to adopt a Stormwater Utility.

Stormwater Utilities are similar to Water and Wastewater Enterprise Funds, and can be setup in the same way or could be part of a water or wastewater Enterprise Fund. The idea is that fees collected from the generation of stormwater are dedicated to stormwater improvements and operations and maintenance activities. Since round 2 of the NPDES Stormwater Program is coming up in May of 2008, towns will now have to repeat the first five year program with an added level of work. This includes additional catch basin cleaning, street sweeping, maintenance of stormwater BMPs, considering water quality in dam projects, and so on.

In most communities, funds for their stormwater programs are quite limited and must come from general DPW or highway budgets. Since the drainage system is often "out of sight – out of mind", these programs are difficult to fund. A Stormwater Utility provides a dedicated funding source which is in all aspects fairer than funding through the general revenue sources. One reason for fairness is that commercial entities with large parking lots and high traffic counts produce the bulk of the pollution load and flooding impact on communities, yet they do not bear a proportional cost in terms of impact as do residents.

In the Stormwater Utilities that exist in New England so far, residential fees range from $25-$90 per year per household for a two family home. The most common form of charge relies on the level of imperviousness per household. For example, in Reading, Massachusetts where a Stormwater Utility was implemented in 2006, the average single or two family residential house lot has approximately 2,000 square feet of imperviousness. Commercial areas are then charged as a multiple of the "equivalent residential unit" or ERU, defined by the average residential imperviousness, in this case 2,000 square feet. Therefore, if the residential ERU is $30 per year, a commercial parking lot with 10,000 square feet of imperviousness would be charged $150 per year in the stormwater fee. Alternatively, a flat fee could be used for all commercial/industrial entities, but the fairest method is through using ERUs and multiples thereof. This allows municipalities to separate the costs for stormwater management, including catch basin cleaning, street sweeping and the like, including staffing, to be applied to the Stormwater Utility Enterprise Fund. Like a Water or Sewer Enterprise Fund, the Utility can only spend as much as it collects in fees, so only those generating stormwater are charged. Undeveloped lands are not usually

charged a fee since they typically contribute little to the stormwater problem. There is nearly always an abatement procedure that allows those who do not generate stormwater to reduce the fees substantially, and it allows communities to reduce flooding and protect water quality simultaneously while providing a more fair system of charging for stormwater management.

Recommendation: Seek funds from DES jointly with watershed communities that wish to participate to prepare a watershed-based Initial Feasibility Analysis that would consider rates, the administrative burden and whether the communities might be able to save money by developing a joint Stormwater Utility. Alternatives should include stand-alone entities for some of the larger communities (such as Nashua and Merrimack) and whether a joint entity would be feasible or administratively cost effective.

Actions:

1) Introduce the idea of a Stormwater Utility at a Phase II Coalition meeting and establish which communities are interested.
2) Seek NH DES funds to perform an Initial Feasibility Analysis for a joint Stormwater Utility.
3) Perform an Initial Feasibility Analysis.
4) Implement recommendations of the Initial Feasibility Analysis.

Objectives: Secure money for stormwater related projects through the establishment of a Stormwater Utility.

Milestones: See milestone schedule.

Partners: NH DES, Watershed communities

Budgeted Costs: $50,000 for the Initial Feasibility Study

Funding Source: Pennichuck Water Works and potential grant funding from NH DES

Associated Recommendations: 1E Coordinate with Phase II Coalition

Measurement: Final Initial Feasibility Study with recommendations on whether a Stormwater Utility is appropriate.

#11. Continue Long-Term Monitoring Program

Long-term monitoring of the in-pond water quality and tributary streams will provide information about water quality trends and how these relate to the activities within the watershed (i.e., development, implementation of BMPs). Pennichuck currently collects water samples from within the ponds two to three times a year and NRPC has headed an effort to collect

water quality data from the major tributaries in the watershed over the last two years. The monitoring programs should continue, along with some additional monitoring activities (e.g., flow measurement) to evaluate the watershed and track the progress of the proposed improvements. Data collected under a monitoring program can also be used for future modeling efforts, anticipated for future updates of the watershed plan. CEI recommends the following monitoring program in the watershed beginning in 2007. This program should be reevaluated annually based on the results of the data and need for additional information.

11A. Tributary Sampling and Flow Monitoring

Tributary sampling is useful to monitor water quality and quantity impacts to the streams from various areas of the watershed. Water quantity measurements will help develop trendlines that show how streams respond to precipitation and how this is changing over time as more development occurs. Water quality measurements will also help develop trendlines that show how water quality is responding to development and which areas of the watershed need more attention.

Recommendation: 1) Sample nine tributaries under dry and wet weather conditions.

Locations:

02-WCH	12-PEN	09T-PEN
01-XWB	01-MUD	
01-WCH	09-PEN	
09-XPB	01-BFB	

Dry Weather Sampling Schedule:

February	August
April	September
May	October
June	December
July	

Wet Weather Sampling Schedule:

Collect three wet weather-sampling rounds between the months of May and September. A composite sample during the first flush of the storm should be collected.

Additionally, consider collecting multiple samples at a tributary location throughout the duration of a single storm. For example, grab a tributary sample just before a storm event begins and then collect samples at timed intervals (e.g., every 2 hours) throughout the duration of the storm, and then decrease the sampling thereafter (e.g., every 5 hours) until the water

level in the tributary approaches the level prior to the storm. The data could then be correlated with the tributary flow hydrograph to determine the impacts from direct runoff and infiltrated runoff in the watershed. This program should be set up after a few rounds of wet weather tributary samples are collected. This will help direct which location(s) to sample and which parameters to sample for. For example, sampling may be directed at a location that sees the greatest increases in pollutant concentrations and for select parameters.

Sampling Parameters:

All samples should be analyzed for:

E. coli	pH
Nitrate-N	temperature
Ammonia-N	DO
TKN	conductivity
Total Phosphorus	turbidity
TSS	

2) Install data loggers at the tributary sampling locations on a full time basis and download data monthly. This allows for inspection of the data loggers on a frequent basis to ensure they are operating properly and to allow for corrections as needed without losing large batches of data.

Actions:

1) Sample tributaries throughout the year under dry and wet weather conditions.
2) Add the sampling results to the water quality database.
3) Evaluate long-term water quality trends to help determine the success of the Watershed Restoration Plan.

Objectives: Establish long-term trends of water quality data in the tributaries to help determine the success of the Watershed Restoration Plan.

Milestones: See milestone schedule.

Partners: NH DES, Watershed communities

Budgeted Costs: Part of Pennichuck's ongoing sampling program.

Funding Source: Pennichuck Water Works

Associated Recommendations: None

Measurement: Increasing water quality database and decreasing phosphorus concentration trends in tributary samples. Long term increase in baseflows as LID is incorporated into the watershed.

11B. Pond Sampling

In-pond sampling is useful to monitor the ponds' response to pollutant loadings from the watershed and the effects of aeration on water quality at the intake. This information is useful to develop trendlines of the health of the ponds and determine the impacts of development and the implementation of BMPs. The information can also be used for future modeling efforts to help calibrate loadings to the pond.

Recommendation: Perform in pond sampling at five locations under dry weather conditions.

Locations:

08-PEN
07P-PEN
07F-PEN
06-PEN
04-PEN

Temperature and DO should be measured at ½ meter intervals throughout the water column to define where the pond stratifies. Ponds should be sampled at the top (three feet below the surface) and the bottom (three feet above the bottom).

Dry Weather Sampling Schedule:

End of March/Beginning of April
July
September/October

Sampling Parameters:

E. coli	pH
Nitrate-N	temperature
Ammonia-N	DO
TKN	conductivity
Total Phosphorus	turbidity
Chlorophyll-a	
TSS	

Actions:

1) Sample ponds during critical periods of the year.
2) Add the sampling results to the water quality database.
3) Evaluate long-term water quality trends to help determine the success of the Watershed Restoration Plan.

Objectives: Establish long-term trends of water quality data in the ponds to help determine the success of the Watershed Restoration Plan.

Milestones: See milestone schedule.

Partners: NH DES, Watershed communities

Budgeted Costs: Part of Pennichuck's ongoing sampling program.

Funding Source: Pennichuck Water Works

Associated Recommendations: None

Measurement: Increasing water quality database and decreasing phosphorus concentration trends in Harris Pond.

5.3 Overall Plan Success Indicators

The success of the recommendations on water quality must be measurable to ensure the plan is working and to make adjustments as needed to achieve the desired results. The following monitoring program and success indicators are proposed:

1. The long-term monitoring program outlined above will be used to assess improvements in water quality in the water supply ponds and their tributaries. The ultimate goal is to reach an average phosphorus concentration of 30 ug/l in Harris Pond. The data will be used to assess long-term trendlines with a decrease in average in-pond concentrations being seen over the course of several years, as recommendations are implemented. This will be the primary measurement to assess the program as it will reflect actual water quality improvements. The trendlines will be compared with the recommendations that have been implemented to date to correlate anticipated reductions associated with the implementation of each recommendation and actual observed in-pond concentrations. If the estimated and observed data sets do not match, then revisions to the plan will be warranted to account for the observed discrepancies (e.g., a larger or lesser reduction than anticipated) and to determine whether other efforts are necessary to achieve the water quality goals.

2. The long-term tributary streamflow measurements outlined above will be used to assess improvements in water quantity in the tributaries. Several recommendations focus on infiltration for both water quantity and quality reasons. The data will be used to assess long-term trendlines that will help in evaluating the impacts of increased infiltration from existing developments, as well as impacts from new developments (e.g., whether a greater emphasis

on stormwater infiltration is required). If the data were to show that tributary base flows are decreasing, then this condition would warrant evaluation of the causes (e.g., new development) and development of actions to maintain or restore flows.

3. An in-pond sediment depth measurement program will be developed and used to assess the sediment loadings into the pond from tributaries and stormwater. This will provide some information on the rate that sediment is entering the pond, with an anticipated decrease in sediment loadings as the recommendations are implemented.

4. The amount of sediment removed from catch basin cleaning, street sweeping and BMP maintenance should be tracked by the entity performing the activities. This will allow for prioritization of areas for more frequent cleaning to better use existing resources to achieve the greatest removal.

5. Upon the implementation of new regulations for development and redevelopment projects, the number of new and redevelopment projects constructed under the regulations should be tracked including the total and impervious acreage of the site, and the controls implemented at each site with estimated phosphorus removals. This information can be used under the proposed grant reimbursement program to determine the appropriate funds to be allocated to each town for the type of development and controls being proposed. It will also provide a tally of anticipated loading reductions that can be compared with the in-pond monitoring program results to draw a correlation between construction improvements and water quality improvements.

Table 5-1: 10-Year Watershed Restoration Program Capital Improvement Program Budget									
Option	Capital Cost	Potential Offset Revenues (e)	Source	Number of Sites Addressed in 10-Year Period		Lbs Removed per Year	Lbs Removed Over 10 Years	$/lb	Year
1. Public Education									
1A. Complete Part 2 of Education Program - Stump Pond	$20,000	$20,000	grant						
1B. Develop Web site and Populate with Watershed Resources	$6,000	$6,000	grant						
1C. Door Hangar and other Public Education Recommended from 1A	$12,000	$12,000	grant						
1D. Develop School Education Program Through Teachers	$15,000								
1E. Coordinate with Phase II Coalition/NRPC	$10,000								
1F. Garden Club Coordination	$15,000								
Total	$78,000	$38,000				285	2,846	$27	1 - 10
2. Increased Maintenance in Commercial Areas									
2A. Evaluate issues and on going costs to sweep and vac	$10,000								
2B. Purchase Street Sweeper for Prioritized Operations 2-6X/year	$200,000	$120,000	grants	2,378	acres	96	959		1 - 10
2C. Purchase Vac Truck for Prioritized Cleanouts Private Areas	$120,000	$72,000	grants			280	2,798		1 - 10
Total	$330,000	$192,000				376	3,757	$88	1 - 10
3. Retrofit Detention Basins									
3A. Evaluate Existing BMPs, Prioritize Top 10	$10,000								1
3B. Design BMPs for 10 Sites (a)	$195,000								2
3C. Construct Detention Basin Retrofits	$650,000	$200,000	grants	10	BMPs				3-5
Total	$855,000	$200,000				50	501	$1,706	
4. Encourage LID in Commercial Redevelopment	$937,500			250	sites	685	6,848	$137	1 - 10
5. Encourage Local Adoption of State Stormwater Standards	$40,000					252	2,515	$16	2
6. Tinker Road Detention Basin Retrofit	$320,000	$205,000	grant			70	700	$457	2
7. Evaluate Phosphorus in Groundwater	$30,000								1
8. Evaluate Sediment Accumulations									
8A. Evaluate Sediment Accumulation Rates in Ponds	$15,000								2
8B. Study to Canvas Streams for Bank Erosion	$15,000	$9,000	grants						5
Total	$30,000	$9,000							
9. Harris Pond Aeration						580			
10. Stormwater Utility Feasibility	$50,000							---	1
11. Continue Long-Term Monitoring Program								---	1 - 10
Total for All Recommendations	$2,670,500	$644,000				2,297	17,168	$156	
Removal Goal						**2,258**			
Notes									
(a) Potential offset revenues and grants should be prioritized as they may not all materialize even though they are technically eligible.									

Figure 5-1. 10-Year Watershed Restoration Program Milestone Schedule

Option	Year									
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1. Public Education										
1A. Complete Part 2 of Education Program - Stump Pond										
Send out watershed survey										
Develop an action item plan										
Implement the action item plan										
Send out a follow-on survey										
1B. Develop Web site and Populate with Watershed Resources										
1C. Door Hanger and other Public Education Recommended from 1A										
Print and place door hangers in identified neighborhoods										
Repeat door hanger outreach periodically										
1D. Develop School Education Program Through Teachers										
Coordinate with NH DES Project Wet staff and local schools										
Host/sponsor Children's Water Festival										
Train teachers with Project Wet curriculum										
Weave Project Wet curriculum into school curriculum										
1E. Coordinate with Phase II Coalition/NRPC										
Identify potential areas of collaboration between Phase II and watershed problems										
Partner with NRPC Phase II Stormwater Coalition										
Implementation of collaborative efforts by watershed communities										
1F. Garden Club Coordination										
Train/demonstrate and partner with local garden club members										
Secure funding. Partner with Master Gardeners, design and plant raingardens										
Provide organized raingarden tours and maintenance										

Figure 5-1. 10-Year Watershed Restoration Program Milestone Schedule

Option	Year									
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
2. Increased Maintenance in Commercial Areas										
Evaluate issues and on going costs to sweep parking areas and driveways and clean catch basins and BMPs on private properties										
Implement sweeping/cleaning program to continuously sweep between April and November and clean catch basins and BMPs twice a year										
Adjust sweeping and cleaning schedule based on sediment accumulation										
3. Retrofit Detention Basins										
Evaluate Existing BMPs, Prioritize Top 10										
Design BMPs for 10 Sites (a)										
Construct Detention Basin Retrofits										
4. Encourage LID in Commercial Redevelopment										
Present grant program idea to watershed communities at Phase II Coalition meeting										
Develop application process										
Contract professional review of LID developments and issue funds to watershed communities										
5. Encourage Local Adoption of State Stormwater Standards										
Present local adoption of AoT rules and watershed regulations at Phase II Coalition meeting										
Provide funding to NRPC to assist communities with adoption of state standards. State standards adopted locally										
Review developments within the watershed										
6. Tinker Road Detention Basin Retrofit										
Secure grant funding										
Finalize BMP designs and obtain permits										
Construct BMPs										

Figure 5-1. 10-Year Watershed Restoration Program Milestone Schedule

	Year									
Option	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
7. Evaluate Phosphorus in Groundwater										
Complete study of groundwater phosphorus loads										
Implement recommendations										
8. Evaluate Sediment Accumulations										
Resurvey sediment depths in the ponds										
Install sediment depth measurement devices in each of the ponds										
Study to canvas streambanks for erosion										
9. Harris Pond Aeration										
10. Stormwater Utility Feasibility										
Present idea of stormwater utility at a Phase II Coalition meeting										
Perform an Initial Feasibility Analysis										
Implement recommendations of the Initial Feasibility Analysis										
11. Continue Long-Term Monitoring Program										

Appendix A
Precipitation Data File

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1995	06	03	0.090
South_Nash_Concord	1995	06	04	0.140
South_Nash_Concord	1995	06	07	0.170
South_Nash_Concord	1995	06	08	0.070
South_Nash_Concord	1995	06	11	0.200
South_Nash_Concord	1995	06	12	0.240
South_Nash_Concord	1995	06	14	0.240
South_Nash_Concord	1995	06	15	0.120
South_Nash_Concord	1995	06	25	0.090
South_Nash_Concord	1995	07	01	0.020
South_Nash_Concord	1995	07	08	0.130
South_Nash_Concord	1995	07	11	0.070
South_Nash_Concord	1995	07	15	0.220
South_Nash_Concord	1995	07	17	0.980
South_Nash_Concord	1995	07	18	0.040
South_Nash_Concord	1995	07	23	0.020
South_Nash_Concord	1995	07	24	0.050
South_Nash_Concord	1995	07	26	1.450
South_Nash_Concord	1995	07	28	0.900
South_Nash_Concord	1995	07	29	0.130
South_Nash_Concord	1995	08	02	0.530
South_Nash_Concord	1995	08	03	0.590
South_Nash_Concord	1995	08	04	0.490
South_Nash_Concord	1995	08	05	0.150
South_Nash_Concord	1995	08	06	0.540
South_Nash_Concord	1995	08	12	0.010
South_Nash_Concord	1995	08	27	0.110
South_Nash_Concord	1995	09	07	0.100
South_Nash_Concord	1995	09	09	0.070
South_Nash_Concord	1995	09	13	0.050
South_Nash_Concord	1995	09	14	0.110
South_Nash_Concord	1995	09	17	1.130
South_Nash_Concord	1995	09	22	0.890
South_Nash_Concord	1995	09	25	0.010
South_Nash_Concord	1995	09	26	0.340
South_Nash_Concord	1995	10	04	0.310
South_Nash_Concord	1995	10	05	0.510
South_Nash_Concord	1995	10	06	1.170
South_Nash_Concord	1995	10	07	0.030
South_Nash_Concord	1995	10	14	0.830
South_Nash_Concord	1995	10	15	0.550
South_Nash_Concord	1995	10	16	0.010
South_Nash_Concord	1995	10	21	1.710
South_Nash_Concord	1995	10	28	2.190
South_Nash_Concord	1995	11	01	0.140
South_Nash_Concord	1995	11	02	0.990
South_Nash_Concord	1995	11	07	0.700
South_Nash_Concord	1995	11	08	0.040
South_Nash_Concord	1995	11	09	0.050
South_Nash_Concord	1995	11	11	0.030
South_Nash_Concord	1995	11	12	1.580
South_Nash_Concord	1995	11	13	0.080
South_Nash_Concord	1995	11	14	0.860
South_Nash_Concord	1995	11	15	0.550
South_Nash_Concord	1995	11	18	0.050

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1995	11	19	0.300
South_Nash_Concord	1995	11	20	0.020
South_Nash_Concord	1995	11	29	0.190
South_Nash_Concord	1995	12	01	0.180
South_Nash_Concord	1995	12	02	0.020
South_Nash_Concord	1995	12	03	0.050
South_Nash_Concord	1995	12	04	0.010
South_Nash_Concord	1995	12	06	0.250
South_Nash_Concord	1995	12	09	0.450
South_Nash_Concord	1995	12	10	0.010
South_Nash_Concord	1995	12	14	0.250
South_Nash_Concord	1995	12	15	0.070
South_Nash_Concord	1995	12	16	0.280
South_Nash_Concord	1995	12	17	0.050
South_Nash_Concord	1995	12	19	0.090
South_Nash_Concord	1995	12	20	0.180
South_Nash_Concord	1995	12	21	0.020
South_Nash_Concord	1995	12	24	0.040
South_Nash_Concord	1996	01	02	0.090
South_Nash_Concord	1996	01	03	0.410
South_Nash_Concord	1996	01	04	0.020
South_Nash_Concord	1996	01	08	0.080
South_Nash_Concord	1996	01	10	0.140
South_Nash_Concord	1996	01	12	0.360
South_Nash_Concord	1996	01	13	0.010
South_Nash_Concord	1996	01	16	0.010
South_Nash_Concord	1996	01	19	1.170
South_Nash_Concord	1996	01	21	0.040
South_Nash_Concord	1996	01	24	0.710
South_Nash_Concord	1996	01	27	1.700
South_Nash_Concord	1996	01	29	0.110
South_Nash_Concord	1996	01	30	0.020
South_Nash_Concord	1996	02	03	0.080
South_Nash_Concord	1996	02	08	0.060
South_Nash_Concord	1996	02	09	0.010
South_Nash_Concord	1996	02	11	0.040
South_Nash_Concord	1996	02	14	0.110
South_Nash_Concord	1996	02	15	0.010
South_Nash_Concord	1996	02	16	0.250
South_Nash_Concord	1996	02	17	0.030
South_Nash_Concord	1996	02	20	0.100
South_Nash_Concord	1996	02	21	1.400
South_Nash_Concord	1996	02	22	0.210
South_Nash_Concord	1996	02	24	0.270
South_Nash_Concord	1996	02	28	0.010
South_Nash_Concord	1996	03	02	0.300
South_Nash_Concord	1996	03	03	0.010
South_Nash_Concord	1996	03	05	0.340
South_Nash_Concord	1996	03	06	0.010
South_Nash_Concord	1996	03	07	0.340
South_Nash_Concord	1996	03	08	0.060
South_Nash_Concord	1996	03	15	0.060
South_Nash_Concord	1996	03	20	0.340
South_Nash_Concord	1996	03	21	0.070
South_Nash_Concord	1996	04	02	0.380

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1996	04	07	0.250
South_Nash_Concord	1996	04	08	0.230
South_Nash_Concord	1996	04	09	0.150
South_Nash_Concord	1996	04	10	0.290
South_Nash_Concord	1996	04	13	0.170
South_Nash_Concord	1996	04	14	0.430
South_Nash_Concord	1996	04	16	2.400
South_Nash_Concord	1996	04	22	0.410
South_Nash_Concord	1996	04	23	0.380
South_Nash_Concord	1996	04	26	0.080
South_Nash_Concord	1996	04	27	0.020
South_Nash_Concord	1996	04	29	0.500
South_Nash_Concord	1996	04	30	0.280
South_Nash_Concord	1996	05	01	0.290
South_Nash_Concord	1996	05	03	0.140
South_Nash_Concord	1996	05	04	0.310
South_Nash_Concord	1996	05	06	0.210
South_Nash_Concord	1996	05	10	0.710
South_Nash_Concord	1996	05	11	0.890
South_Nash_Concord	1996	05	12	0.360
South_Nash_Concord	1996	05	16	0.370
South_Nash_Concord	1996	05	17	0.020
South_Nash_Concord	1996	05	18	0.270
South_Nash_Concord	1996	05	19	0.090
South_Nash_Concord	1996	05	24	0.010
South_Nash_Concord	1996	05	29	0.290
South_Nash_Concord	1996	05	30	0.710
South_Nash_Concord	1996	06	03	0.440
South_Nash_Concord	1996	06	04	0.090
South_Nash_Concord	1996	06	07	0.360
South_Nash_Concord	1996	06	08	0.130
South_Nash_Concord	1996	06	09	0.030
South_Nash_Concord	1996	06	10	0.160
South_Nash_Concord	1996	06	13	0.590
South_Nash_Concord	1996	06	14	0.310
South_Nash_Concord	1996	06	15	0.010
South_Nash_Concord	1996	06	20	0.030
South_Nash_Concord	1996	06	21	0.200
South_Nash_Concord	1996	06	22	0.270
South_Nash_Concord	1996	06	25	0.030
South_Nash_Concord	1996	06	27	0.190
South_Nash_Concord	1996	06	30	0.310
South_Nash_Concord	1996	07	04	0.220
South_Nash_Concord	1996	07	08	0.030
South_Nash_Concord	1996	07	09	0.230
South_Nash_Concord	1996	07	13	2.200
South_Nash_Concord	1996	07	14	0.690
South_Nash_Concord	1996	07	15	0.200
South_Nash_Concord	1996	07	16	0.090
South_Nash_Concord	1996	07	19	0.100
South_Nash_Concord	1996	07	20	0.020
South_Nash_Concord	1996	07	23	0.100
South_Nash_Concord	1996	07	26	0.240
South_Nash_Concord	1996	07	31	0.020
South_Nash_Concord	1996	08	21	0.020

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1996	09	02	0.210
South_Nash_Concord	1996	09	07	0.130
South_Nash_Concord	1996	09	08	0.110
South_Nash_Concord	1996	09	10	0.050
South_Nash_Concord	1996	09	16	0.180
South_Nash_Concord	1996	09	17	0.370
South_Nash_Concord	1996	09	18	0.360
South_Nash_Concord	1996	09	22	0.510
South_Nash_Concord	1996	09	23	0.150
South_Nash_Concord	1996	09	24	0.140
South_Nash_Concord	1996	09	25	0.140
South_Nash_Concord	1996	09	28	0.160
South_Nash_Concord	1996	09	29	0.300
South_Nash_Concord	1996	10	02	0.050
South_Nash_Concord	1996	10	08	0.410
South_Nash_Concord	1996	10	09	0.850
South_Nash_Concord	1996	10	10	0.180
South_Nash_Concord	1996	10	14	0.050
South_Nash_Concord	1996	10	16	0.030
South_Nash_Concord	1996	10	20	3.190
South_Nash_Concord	1996	10	21	2.480
South_Nash_Concord	1996	10	23	0.050
South_Nash_Concord	1996	10	24	0.120
South_Nash_Concord	1996	10	28	0.140
South_Nash_Concord	1996	10	30	0.090
South_Nash_Concord	1996	11	07	0.130
South_Nash_Concord	1996	11	08	0.040
South_Nash_Concord	1996	11	09	0.520
South_Nash_Concord	1996	11	19	0.030
South_Nash_Concord	1996	11	25	0.190
South_Nash_Concord	1996	11	26	0.950
South_Nash_Concord	1996	12	01	0.320
South_Nash_Concord	1996	12	02	0.990
South_Nash_Concord	1996	12	06	0.180
South_Nash_Concord	1996	12	07	0.550
South_Nash_Concord	1996	12	08	0.780
South_Nash_Concord	1996	12	12	0.350
South_Nash_Concord	1996	12	14	0.110
South_Nash_Concord	1996	12	15	0.020
South_Nash_Concord	1996	12	17	0.800
South_Nash_Concord	1996	12	19	0.360
South_Nash_Concord	1996	12	23	0.040
South_Nash_Concord	1996	12	24	0.610
South_Nash_Concord	1996	12	25	0.050
South_Nash_Concord	1996	12	28	0.130
South_Nash_Concord	1996	12	29	0.280
South_Nash_Concord	1997	01	02	0.030
South_Nash_Concord	1997	01	03	0.090
South_Nash_Concord	1997	01	04	0.010
South_Nash_Concord	1997	01	05	0.200
South_Nash_Concord	1997	01	09	0.070
South_Nash_Concord	1997	01	10	0.450
South_Nash_Concord	1997	01	16	0.680
South_Nash_Concord	1997	01	24	0.260
South_Nash_Concord	1997	01	25	0.600

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1997	01	27	0.110
South_Nash_Concord	1997	01	28	0.580
South_Nash_Concord	1997	01	31	0.090
South_Nash_Concord	1997	02	01	0.030
South_Nash_Concord	1997	02	03	0.200
South_Nash_Concord	1997	02	04	0.080
South_Nash_Concord	1997	02	05	0.950
South_Nash_Concord	1997	02	12	0.010
South_Nash_Concord	1997	02	14	0.380
South_Nash_Concord	1997	02	16	0.020
South_Nash_Concord	1997	02	17	0.010
South_Nash_Concord	1997	02	21	0.050
South_Nash_Concord	1997	02	27	0.410
South_Nash_Concord	1997	03	02	0.020
South_Nash_Concord	1997	03	04	0.010
South_Nash_Concord	1997	03	05	0.170
South_Nash_Concord	1997	03	06	0.650
South_Nash_Concord	1997	03	08	0.150
South_Nash_Concord	1997	03	10	0.200
South_Nash_Concord	1997	03	11	0.100
South_Nash_Concord	1997	03	14	0.910
South_Nash_Concord	1997	03	15	0.010
South_Nash_Concord	1997	03	20	0.100
South_Nash_Concord	1997	03	21	0.060
South_Nash_Concord	1997	03	22	0.220
South_Nash_Concord	1997	03	25	0.250
South_Nash_Concord	1997	03	26	0.470
South_Nash_Concord	1997	03	29	0.240
South_Nash_Concord	1997	03	31	0.450
South_Nash_Concord	1997	04	01	0.040
South_Nash_Concord	1997	04	06	0.110
South_Nash_Concord	1997	04	12	0.290
South_Nash_Concord	1997	04	13	0.060
South_Nash_Concord	1997	04	17	0.110
South_Nash_Concord	1997	04	18	1.270
South_Nash_Concord	1997	04	19	0.600
South_Nash_Concord	1997	04	25	0.010
South_Nash_Concord	1997	04	28	0.800
South_Nash_Concord	1997	05	01	0.060
South_Nash_Concord	1997	05	03	0.370
South_Nash_Concord	1997	05	06	0.340
South_Nash_Concord	1997	05	09	0.070
South_Nash_Concord	1997	05	10	0.130
South_Nash_Concord	1997	05	13	0.050
South_Nash_Concord	1997	05	14	0.010
South_Nash_Concord	1997	05	15	0.050
South_Nash_Concord	1997	05	16	0.110
South_Nash_Concord	1997	05	17	0.010
South_Nash_Concord	1997	05	19	0.640
South_Nash_Concord	1997	05	20	0.230
South_Nash_Concord	1997	05	21	0.030
South_Nash_Concord	1997	05	25	0.160
South_Nash_Concord	1997	06	01	0.080
South_Nash_Concord	1997	06	13	0.010
South_Nash_Concord	1997	06	18	0.530

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1997	06	19	0.080
South_Nash_Concord	1997	07	03	1.200
South_Nash_Concord	1997	07	04	0.010
South_Nash_Concord	1997	07	08	0.240
South_Nash_Concord	1997	07	09	1.550
South_Nash_Concord	1997	07	10	0.030
South_Nash_Concord	1997	07	13	0.010
South_Nash_Concord	1997	07	14	0.100
South_Nash_Concord	1997	07	15	0.460
South_Nash_Concord	1997	07	16	0.020
South_Nash_Concord	1997	07	17	0.050
South_Nash_Concord	1997	07	18	0.110
South_Nash_Concord	1997	07	21	0.030
South_Nash_Concord	1997	08	03	0.030
South_Nash_Concord	1997	08	04	0.030
South_Nash_Concord	1997	08	05	0.110
South_Nash_Concord	1997	08	11	0.110
South_Nash_Concord	1997	08	12	0.010
South_Nash_Concord	1997	08	13	0.770
South_Nash_Concord	1997	08	15	0.010
South_Nash_Concord	1997	08	18	0.040
South_Nash_Concord	1997	08	21	0.820
South_Nash_Concord	1997	08	22	0.120
South_Nash_Concord	1997	08	23	0.020
South_Nash_Concord	1997	08	27	0.350
South_Nash_Concord	1997	08	28	0.100
South_Nash_Concord	1997	08	29	1.170
South_Nash_Concord	1997	09	01	0.030
South_Nash_Concord	1997	09	03	0.080
South_Nash_Concord	1997	09	06	0.060
South_Nash_Concord	1997	09	07	0.460
South_Nash_Concord	1997	09	08	0.060
South_Nash_Concord	1997	09	11	0.400
South_Nash_Concord	1997	09	12	0.160
South_Nash_Concord	1997	09	18	0.020
South_Nash_Concord	1997	09	20	0.060
South_Nash_Concord	1997	09	23	0.010
South_Nash_Concord	1997	09	29	0.340
South_Nash_Concord	1997	10	03	0.150
South_Nash_Concord	1997	10	05	0.370
South_Nash_Concord	1997	10	09	0.010
South_Nash_Concord	1997	10	10	0.010
South_Nash_Concord	1997	10	15	0.010
South_Nash_Concord	1997	10	16	0.090
South_Nash_Concord	1997	10	25	0.320
South_Nash_Concord	1997	10	27	0.480
South_Nash_Concord	1997	11	01	1.850
South_Nash_Concord	1997	11	02	0.410
South_Nash_Concord	1997	11	04	0.470
South_Nash_Concord	1997	11	08	0.050
South_Nash_Concord	1997	11	09	0.870
South_Nash_Concord	1997	11	10	0.010
South_Nash_Concord	1997	11	14	0.480
South_Nash_Concord	1997	11	15	0.010
South_Nash_Concord	1997	11	16	0.120

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1997	11	22	0.650
South_Nash_Concord	1997	11	23	0.030
South_Nash_Concord	1997	11	26	0.110
South_Nash_Concord	1997	11	27	0.020
South_Nash_Concord	1997	11	28	0.060
South_Nash_Concord	1997	11	30	0.470
South_Nash_Concord	1997	12	01	0.240
South_Nash_Concord	1997	12	04	0.040
South_Nash_Concord	1997	12	14	0.010
South_Nash_Concord	1997	12	23	0.410
South_Nash_Concord	1997	12	25	0.570
South_Nash_Concord	1997	12	29	0.030
South_Nash_Concord	1997	12	30	0.170
South_Nash_Concord	1998	01	04	0.060
South_Nash_Concord	1998	01	05	0.010
South_Nash_Concord	1998	01	06	0.070
South_Nash_Concord	1998	01	07	0.350
South_Nash_Concord	1998	01	08	1.020
South_Nash_Concord	1998	01	09	0.090
South_Nash_Concord	1998	01	13	0.110
South_Nash_Concord	1998	01	15	0.060
South_Nash_Concord	1998	01	16	0.170
South_Nash_Concord	1998	01	18	0.100
South_Nash_Concord	1998	01	20	0.030
South_Nash_Concord	1998	01	23	0.710
South_Nash_Concord	1998	01	24	0.470
South_Nash_Concord	1998	01	30	0.080
South_Nash_Concord	1998	02	12	0.270
South_Nash_Concord	1998	02	18	0.910
South_Nash_Concord	1998	02	19	0.250
South_Nash_Concord	1998	02	24	0.490
South_Nash_Concord	1998	02	25	0.260
South_Nash_Concord	1998	03	01	0.010
South_Nash_Concord	1998	03	05	0.010
South_Nash_Concord	1998	03	07	0.020
South_Nash_Concord	1998	03	08	0.200
South_Nash_Concord	1998	03	09	1.870
South_Nash_Concord	1998	03	10	0.010
South_Nash_Concord	1998	03	14	0.100
South_Nash_Concord	1998	03	18	0.030
South_Nash_Concord	1998	03	19	0.610
South_Nash_Concord	1998	03	21	0.060
South_Nash_Concord	1998	03	22	0.500
South_Nash_Concord	1998	03	23	0.010
South_Nash_Concord	1998	04	01	0.200
South_Nash_Concord	1998	04	02	0.150
South_Nash_Concord	1998	04	03	0.020
South_Nash_Concord	1998	04	16	0.200
South_Nash_Concord	1998	04	17	0.100
South_Nash_Concord	1998	04	19	0.480
South_Nash_Concord	1998	04	20	0.500
South_Nash_Concord	1998	04	23	0.320
South_Nash_Concord	1998	04	24	0.020
South_Nash_Concord	1998	04	25	0.150
South_Nash_Concord	1998	05	02	0.260

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1998	05	03	0.020
South_Nash_Concord	1998	05	04	0.160
South_Nash_Concord	1998	05	05	0.150
South_Nash_Concord	1998	05	06	0.930
South_Nash_Concord	1998	05	07	0.230
South_Nash_Concord	1998	05	10	0.180
South_Nash_Concord	1998	05	11	0.050
South_Nash_Concord	1998	05	17	0.140
South_Nash_Concord	1998	05	20	0.020
South_Nash_Concord	1998	05	21	0.020
South_Nash_Concord	1998	05	31	1.790
South_Nash_Concord	1998	06	01	0.100
South_Nash_Concord	1998	06	02	0.130
South_Nash_Concord	1998	06	03	0.030
South_Nash_Concord	1998	06	07	0.180
South_Nash_Concord	1998	06	08	0.470
South_Nash_Concord	1998	06	12	0.400
South_Nash_Concord	1998	06	13	2.340
South_Nash_Concord	1998	06	14	0.740
South_Nash_Concord	1998	06	15	0.460
South_Nash_Concord	1998	06	16	1.050
South_Nash_Concord	1998	06	17	0.820
South_Nash_Concord	1998	06	18	0.010
South_Nash_Concord	1998	06	19	0.250
South_Nash_Concord	1998	06	20	0.020
South_Nash_Concord	1998	06	21	0.010
South_Nash_Concord	1998	06	24	0.030
South_Nash_Concord	1998	06	25	0.310
South_Nash_Concord	1998	06	26	0.240
South_Nash_Concord	1998	06	27	0.210
South_Nash_Concord	1998	06	30	0.120
South_Nash_Concord	1998	07	01	0.670
South_Nash_Concord	1998	07	05	0.150
South_Nash_Concord	1998	07	20	0.460
South_Nash_Concord	1998	07	23	0.630
South_Nash_Concord	1998	08	06	0.260
South_Nash_Concord	1998	08	07	0.030
South_Nash_Concord	1998	08	11	0.370
South_Nash_Concord	1998	08	12	0.010
South_Nash_Concord	1998	08	17	0.170
South_Nash_Concord	1998	08	18	0.070
South_Nash_Concord	1998	08	21	0.010
South_Nash_Concord	1998	08	23	0.170
South_Nash_Concord	1998	08	24	0.140
South_Nash_Concord	1998	08	25	0.160
South_Nash_Concord	1998	08	31	0.020
South_Nash_Concord	1998	09	02	0.070
South_Nash_Concord	1998	09	07	0.260
South_Nash_Concord	1998	09	09	0.130
South_Nash_Concord	1998	09	15	0.340
South_Nash_Concord	1998	09	16	0.220
South_Nash_Concord	1998	09	22	0.370
South_Nash_Concord	1998	09	26	0.010
South_Nash_Concord	1998	09	27	0.240
South_Nash_Concord	1998	10	01	0.020

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1998	10	08	0.660
South_Nash_Concord	1998	10	09	0.160
South_Nash_Concord	1998	10	10	1.660
South_Nash_Concord	1998	10	11	0.210
South_Nash_Concord	1998	10	14	0.670
South_Nash_Concord	1998	10	15	0.020
South_Nash_Concord	1998	10	28	0.180
South_Nash_Concord	1998	11	11	0.560
South_Nash_Concord	1998	11	14	0.010
South_Nash_Concord	1998	11	15	0.070
South_Nash_Concord	1998	11	16	0.020
South_Nash_Concord	1998	11	17	0.120
South_Nash_Concord	1998	11	19	0.050
South_Nash_Concord	1998	11	20	0.160
South_Nash_Concord	1998	11	21	0.020
South_Nash_Concord	1998	11	24	0.010
South_Nash_Concord	1998	11	26	1.180
South_Nash_Concord	1998	12	08	0.210
South_Nash_Concord	1998	12	17	0.110
South_Nash_Concord	1998	12	19	0.040
South_Nash_Concord	1998	12	21	0.020
South_Nash_Concord	1998	12	22	0.270
South_Nash_Concord	1998	12	29	0.110
South_Nash_Concord	1998	12	30	0.090
South_Nash_Concord	1999	01	03	1.050
South_Nash_Concord	1999	01	08	0.250
South_Nash_Concord	1999	01	09	0.390
South_Nash_Concord	1999	01	12	0.090
South_Nash_Concord	1999	01	13	0.160
South_Nash_Concord	1999	01	14	0.230
South_Nash_Concord	1999	01	15	1.000
South_Nash_Concord	1999	01	18	0.850
South_Nash_Concord	1999	01	19	0.010
South_Nash_Concord	1999	01	22	0.080
South_Nash_Concord	1999	01	23	0.040
South_Nash_Concord	1999	01	24	0.510
South_Nash_Concord	1999	01	27	0.120
South_Nash_Concord	1999	01	28	0.180
South_Nash_Concord	1999	01	29	0.040
South_Nash_Concord	1999	02	02	0.940
South_Nash_Concord	1999	02	03	0.030
South_Nash_Concord	1999	02	04	0.180
South_Nash_Concord	1999	02	12	0.130
South_Nash_Concord	1999	02	17	0.130
South_Nash_Concord	1999	02	18	0.490
South_Nash_Concord	1999	02	19	0.010
South_Nash_Concord	1999	02	28	0.700
South_Nash_Concord	1999	03	01	0.440
South_Nash_Concord	1999	03	03	0.310
South_Nash_Concord	1999	03	04	0.230
South_Nash_Concord	1999	03	06	0.170
South_Nash_Concord	1999	03	07	0.030
South_Nash_Concord	1999	03	11	0.010
South_Nash_Concord	1999	03	12	0.030
South_Nash_Concord	1999	03	14	0.020

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1999	03	15	0.220
South_Nash_Concord	1999	03	21	0.120
South_Nash_Concord	1999	03	22	0.710
South_Nash_Concord	1999	03	24	0.010
South_Nash_Concord	1999	03	28	0.460
South_Nash_Concord	1999	04	03	0.020
South_Nash_Concord	1999	04	04	0.010
South_Nash_Concord	1999	04	07	0.010
South_Nash_Concord	1999	04	16	0.280
South_Nash_Concord	1999	04	17	0.200
South_Nash_Concord	1999	04	20	0.380
South_Nash_Concord	1999	04	23	0.030
South_Nash_Concord	1999	04	26	0.020
South_Nash_Concord	1999	05	04	0.220
South_Nash_Concord	1999	05	05	0.350
South_Nash_Concord	1999	05	06	0.060
South_Nash_Concord	1999	05	08	0.130
South_Nash_Concord	1999	05	09	0.030
South_Nash_Concord	1999	05	19	1.260
South_Nash_Concord	1999	05	20	0.080
South_Nash_Concord	1999	05	23	0.070
South_Nash_Concord	1999	05	24	0.490
South_Nash_Concord	1999	05	25	0.040
South_Nash_Concord	1999	05	26	0.060
South_Nash_Concord	1999	06	02	0.030
South_Nash_Concord	1999	06	08	0.050
South_Nash_Concord	1999	06	09	0.010
South_Nash_Concord	1999	06	14	0.030
South_Nash_Concord	1999	06	15	0.010
South_Nash_Concord	1999	06	17	0.090
South_Nash_Concord	1999	06	18	0.010
South_Nash_Concord	1999	06	21	0.750
South_Nash_Concord	1999	06	23	0.040
South_Nash_Concord	1999	06	25	0.040
South_Nash_Concord	1999	06	28	0.380
South_Nash_Concord	1999	06	29	0.500
South_Nash_Concord	1999	07	01	0.020
South_Nash_Concord	1999	07	02	0.830
South_Nash_Concord	1999	07	03	0.010
South_Nash_Concord	1999	07	04	0.030
South_Nash_Concord	1999	07	06	0.310
South_Nash_Concord	1999	07	08	0.070
South_Nash_Concord	1999	07	09	0.130
South_Nash_Concord	1999	07	19	0.880
South_Nash_Concord	1999	07	22	0.460
South_Nash_Concord	1999	07	24	0.730
South_Nash_Concord	1999	07	25	0.320
South_Nash_Concord	1999	07	26	0.410
South_Nash_Concord	1999	07	27	0.180
South_Nash_Concord	1999	07	29	0.010
South_Nash_Concord	1999	08	01	0.010
South_Nash_Concord	1999	08	05	0.050
South_Nash_Concord	1999	08	06	0.130
South_Nash_Concord	1999	08	08	0.610
South_Nash_Concord	1999	08	11	0.140

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	1999	08	14	0.350
South_Nash_Concord	1999	08	15	0.190
South_Nash_Concord	1999	08	17	0.110
South_Nash_Concord	1999	08	21	0.690
South_Nash_Concord	1999	08	22	0.020
South_Nash_Concord	1999	08	27	1.110
South_Nash_Concord	1999	08	29	0.030
South_Nash_Concord	1999	09	06	0.550
South_Nash_Concord	1999	09	08	0.020
South_Nash_Concord	1999	09	10	2.690
South_Nash_Concord	1999	09	15	0.160
South_Nash_Concord	1999	09	16	1.900
South_Nash_Concord	1999	09	17	0.320
South_Nash_Concord	1999	09	21	0.780
South_Nash_Concord	1999	09	22	0.420
South_Nash_Concord	1999	09	23	0.140
South_Nash_Concord	1999	09	29	0.010
South_Nash_Concord	1999	09	30	0.710
South_Nash_Concord	1999	10	04	0.640
South_Nash_Concord	1999	10	09	0.130
South_Nash_Concord	1999	10	10	0.170
South_Nash_Concord	1999	10	14	0.160
South_Nash_Concord	1999	10	18	0.340
South_Nash_Concord	1999	10	20	0.470
South_Nash_Concord	1999	10	23	0.570
South_Nash_Concord	1999	11	02	0.360
South_Nash_Concord	1999	11	03	0.530
South_Nash_Concord	1999	11	10	0.340
South_Nash_Concord	1999	11	11	0.090
South_Nash_Concord	1999	11	12	0.080
South_Nash_Concord	1999	11	13	0.020
South_Nash_Concord	1999	11	14	0.130
South_Nash_Concord	1999	11	20	0.190
South_Nash_Concord	1999	11	23	0.010
South_Nash_Concord	1999	11	24	0.080
South_Nash_Concord	1999	11	25	0.030
South_Nash_Concord	1999	11	26	0.190
South_Nash_Concord	1999	11	27	0.610
South_Nash_Concord	1999	12	04	0.090
South_Nash_Concord	1999	12	06	0.250
South_Nash_Concord	1999	12	07	0.250
South_Nash_Concord	1999	12	10	0.070
South_Nash_Concord	1999	12	15	0.100
South_Nash_Concord	1999	12	16	0.050
South_Nash_Concord	1999	12	20	0.460
South_Nash_Concord	1999	12	21	0.080
South_Nash_Concord	2000	01	02	0.010
South_Nash_Concord	2000	01	03	0.110
South_Nash_Concord	2000	01	04	0.480
South_Nash_Concord	2000	01	05	0.010
South_Nash_Concord	2000	01	10	0.600
South_Nash_Concord	2000	01	11	0.070
South_Nash_Concord	2000	01	16	0.070
South_Nash_Concord	2000	01	20	0.020
South_Nash_Concord	2000	01	25	0.410

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2000	01	26	0.090
South_Nash_Concord	2000	01	31	0.310
South_Nash_Concord	2000	02	07	0.010
South_Nash_Concord	2000	02	11	0.130
South_Nash_Concord	2000	02	14	1.170
South_Nash_Concord	2000	02	16	0.010
South_Nash_Concord	2000	02	18	0.270
South_Nash_Concord	2000	02	19	0.180
South_Nash_Concord	2000	02	24	0.140
South_Nash_Concord	2000	02	25	0.730
South_Nash_Concord	2000	02	26	0.020
South_Nash_Concord	2000	02	28	0.160
South_Nash_Concord	2000	03	02	0.010
South_Nash_Concord	2000	03	09	0.120
South_Nash_Concord	2000	03	11	0.850
South_Nash_Concord	2000	03	12	0.360
South_Nash_Concord	2000	03	16	0.270
South_Nash_Concord	2000	03	17	0.400
South_Nash_Concord	2000	03	25	0.020
South_Nash_Concord	2000	03	26	0.030
South_Nash_Concord	2000	03	28	1.220
South_Nash_Concord	2000	03	29	0.060
South_Nash_Concord	2000	04	02	0.030
South_Nash_Concord	2000	04	03	0.350
South_Nash_Concord	2000	04	04	0.410
South_Nash_Concord	2000	04	08	0.010
South_Nash_Concord	2000	04	09	1.030
South_Nash_Concord	2000	04	11	0.090
South_Nash_Concord	2000	04	12	0.040
South_Nash_Concord	2000	04	19	0.050
South_Nash_Concord	2000	04	20	0.010
South_Nash_Concord	2000	04	21	1.060
South_Nash_Concord	2000	04	22	0.560
South_Nash_Concord	2000	04	23	0.480
South_Nash_Concord	2000	04	26	0.500
South_Nash_Concord	2000	04	27	0.080
South_Nash_Concord	2000	04	28	0.120
South_Nash_Concord	2000	05	02	0.090
South_Nash_Concord	2000	05	06	0.010
South_Nash_Concord	2000	05	08	0.010
South_Nash_Concord	2000	05	09	0.010
South_Nash_Concord	2000	05	10	0.780
South_Nash_Concord	2000	05	11	0.240
South_Nash_Concord	2000	05	13	0.140
South_Nash_Concord	2000	05	14	0.020
South_Nash_Concord	2000	05	18	0.450
South_Nash_Concord	2000	05	19	0.120
South_Nash_Concord	2000	05	20	0.010
South_Nash_Concord	2000	05	21	0.120
South_Nash_Concord	2000	05	23	0.020
South_Nash_Concord	2000	05	24	0.600
South_Nash_Concord	2000	05	25	0.210
South_Nash_Concord	2000	06	02	0.090
South_Nash_Concord	2000	06	06	0.690
South_Nash_Concord	2000	06	07	0.550

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2000	06	08	0.010
South_Nash_Concord	2000	06	09	0.020
South_Nash_Concord	2000	06	11	0.050
South_Nash_Concord	2000	06	12	0.400
South_Nash_Concord	2000	06	13	0.080
South_Nash_Concord	2000	06	14	0.030
South_Nash_Concord	2000	06	17	0.320
South_Nash_Concord	2000	06	18	0.140
South_Nash_Concord	2000	06	21	0.140
South_Nash_Concord	2000	06	22	0.220
South_Nash_Concord	2000	06	25	0.100
South_Nash_Concord	2000	06	26	0.020
South_Nash_Concord	2000	06	27	0.010
South_Nash_Concord	2000	06	29	0.260
South_Nash_Concord	2000	07	03	0.030
South_Nash_Concord	2000	07	04	0.020
South_Nash_Concord	2000	07	09	0.640
South_Nash_Concord	2000	07	10	0.080
South_Nash_Concord	2000	07	14	0.040
South_Nash_Concord	2000	07	15	0.010
South_Nash_Concord	2000	07	16	1.200
South_Nash_Concord	2000	07	17	0.070
South_Nash_Concord	2000	07	18	0.010
South_Nash_Concord	2000	07	21	0.030
South_Nash_Concord	2000	07	22	0.010
South_Nash_Concord	2000	07	26	0.270
South_Nash_Concord	2000	07	27	0.800
South_Nash_Concord	2000	07	30	0.590
South_Nash_Concord	2000	07	31	0.530
South_Nash_Concord	2000	08	01	0.020
South_Nash_Concord	2000	08	03	0.090
South_Nash_Concord	2000	08	06	0.180
South_Nash_Concord	2000	08	07	0.630
South_Nash_Concord	2000	08	09	0.020
South_Nash_Concord	2000	08	10	0.080
South_Nash_Concord	2000	08	14	0.460
South_Nash_Concord	2000	08	16	0.200
South_Nash_Concord	2000	08	18	0.060
South_Nash_Concord	2000	08	23	0.120
South_Nash_Concord	2000	09	02	0.120
South_Nash_Concord	2000	09	04	0.070
South_Nash_Concord	2000	09	13	0.590
South_Nash_Concord	2000	09	15	0.930
South_Nash_Concord	2000	09	19	0.680
South_Nash_Concord	2000	09	20	0.420
South_Nash_Concord	2000	09	23	0.550
South_Nash_Concord	2000	09	24	0.150
South_Nash_Concord	2000	09	26	0.030
South_Nash_Concord	2000	10	05	0.380
South_Nash_Concord	2000	10	06	0.670
South_Nash_Concord	2000	10	16	0.320
South_Nash_Concord	2000	10	18	0.580
South_Nash_Concord	2000	10	29	0.010
South_Nash_Concord	2000	10	30	0.290
South_Nash_Concord	2000	10	31	0.040

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2000	11	05	0.480
South_Nash_Concord	2000	11	06	0.010
South_Nash_Concord	2000	11	10	1.280
South_Nash_Concord	2000	11	11	0.190
South_Nash_Concord	2000	11	13	0.010
South_Nash_Concord	2000	11	14	0.580
South_Nash_Concord	2000	11	15	0.140
South_Nash_Concord	2000	11	26	0.660
South_Nash_Concord	2000	11	27	0.010
South_Nash_Concord	2000	11	29	0.010
South_Nash_Concord	2000	11	30	0.050
South_Nash_Concord	2000	12	12	0.220
South_Nash_Concord	2000	12	14	0.610
South_Nash_Concord	2000	12	16	0.180
South_Nash_Concord	2000	12	17	0.800
South_Nash_Concord	2000	12	19	0.020
South_Nash_Concord	2000	12	20	0.180
South_Nash_Concord	2000	12	30	0.280
South_Nash_Concord	2000	12	31	0.060
South_Nash_Concord	2001	01	05	0.070
South_Nash_Concord	2001	01	06	0.110
South_Nash_Concord	2001	01	08	0.040
South_Nash_Concord	2001	01	09	0.020
South_Nash_Concord	2001	01	15	0.060
South_Nash_Concord	2001	01	16	0.010
South_Nash_Concord	2001	01	19	0.110
South_Nash_Concord	2001	01	21	0.030
South_Nash_Concord	2001	01	30	0.530
South_Nash_Concord	2001	01	31	0.310
South_Nash_Concord	2001	02	05	0.500
South_Nash_Concord	2001	02	06	0.020
South_Nash_Concord	2001	02	09	0.270
South_Nash_Concord	2001	02	10	0.020
South_Nash_Concord	2001	02	14	0.110
South_Nash_Concord	2001	02	16	0.060
South_Nash_Concord	2001	02	22	0.010
South_Nash_Concord	2001	02	23	0.020
South_Nash_Concord	2001	02	25	0.510
South_Nash_Concord	2001	03	05	0.240
South_Nash_Concord	2001	03	06	0.420
South_Nash_Concord	2001	03	09	0.210
South_Nash_Concord	2001	03	10	0.090
South_Nash_Concord	2001	03	13	0.420
South_Nash_Concord	2001	03	18	0.010
South_Nash_Concord	2001	03	22	1.980
South_Nash_Concord	2001	03	23	0.100
South_Nash_Concord	2001	03	30	1.080
South_Nash_Concord	2001	04	06	0.070
South_Nash_Concord	2001	04	08	0.190
South_Nash_Concord	2001	04	09	0.040
South_Nash_Concord	2001	04	12	0.460
South_Nash_Concord	2001	04	21	0.020
South_Nash_Concord	2001	04	22	0.060
South_Nash_Concord	2001	05	05	0.070
South_Nash_Concord	2001	05	12	0.030

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2001	05	15	0.070
South_Nash_Concord	2001	05	16	0.020
South_Nash_Concord	2001	05	23	0.040
South_Nash_Concord	2001	05	24	0.060
South_Nash_Concord	2001	05	26	0.080
South_Nash_Concord	2001	05	27	1.310
South_Nash_Concord	2001	05	28	0.610
South_Nash_Concord	2001	05	30	0.040
South_Nash_Concord	2001	06	02	1.620
South_Nash_Concord	2001	06	03	0.600
South_Nash_Concord	2001	06	10	0.420
South_Nash_Concord	2001	06	11	1.090
South_Nash_Concord	2001	06	17	1.030
South_Nash_Concord	2001	06	20	0.430
South_Nash_Concord	2001	06	21	0.010
South_Nash_Concord	2001	06	23	0.340
South_Nash_Concord	2001	06	24	0.160
South_Nash_Concord	2001	06	30	0.030
South_Nash_Concord	2001	07	01	0.490
South_Nash_Concord	2001	07	05	0.240
South_Nash_Concord	2001	07	08	0.070
South_Nash_Concord	2001	07	09	0.390
South_Nash_Concord	2001	07	10	0.450
South_Nash_Concord	2001	07	11	0.070
South_Nash_Concord	2001	07	12	0.110
South_Nash_Concord	2001	07	14	0.040
South_Nash_Concord	2001	07	17	0.400
South_Nash_Concord	2001	07	26	1.030
South_Nash_Concord	2001	08	03	0.150
South_Nash_Concord	2001	08	12	0.230
South_Nash_Concord	2001	08	17	0.200
South_Nash_Concord	2001	08	20	0.050
South_Nash_Concord	2001	08	21	0.020
South_Nash_Concord	2001	08	24	0.030
South_Nash_Concord	2001	09	01	0.460
South_Nash_Concord	2001	09	04	0.160
South_Nash_Concord	2001	09	10	0.250
South_Nash_Concord	2001	09	14	0.280
South_Nash_Concord	2001	09	20	0.120
South_Nash_Concord	2001	09	21	0.620
South_Nash_Concord	2001	09	25	1.550
South_Nash_Concord	2001	09	28	0.070
South_Nash_Concord	2001	10	06	0.040
South_Nash_Concord	2001	10	14	0.050
South_Nash_Concord	2001	10	15	0.340
South_Nash_Concord	2001	10	16	0.190
South_Nash_Concord	2001	10	17	0.030
South_Nash_Concord	2001	10	24	0.100
South_Nash_Concord	2001	10	31	0.230
South_Nash_Concord	2001	11	01	0.050
South_Nash_Concord	2001	11	03	0.050
South_Nash_Concord	2001	11	05	0.150
South_Nash_Concord	2001	11	09	0.040
South_Nash_Concord	2001	11	14	0.010
South_Nash_Concord	2001	11	20	0.060

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2001	11	24	0.010
South_Nash_Concord	2001	11	25	0.160
South_Nash_Concord	2001	11	26	0.010
South_Nash_Concord	2001	11	28	0.010
South_Nash_Concord	2001	11	29	0.350
South_Nash_Concord	2001	11	30	0.200
South_Nash_Concord	2001	12	01	0.150
South_Nash_Concord	2001	12	05	0.020
South_Nash_Concord	2001	12	09	0.300
South_Nash_Concord	2001	12	13	0.070
South_Nash_Concord	2001	12	14	0.520
South_Nash_Concord	2001	12	15	0.100
South_Nash_Concord	2001	12	17	0.500
South_Nash_Concord	2001	12	18	0.180
South_Nash_Concord	2001	12	24	0.340
South_Nash_Concord	2002	01	06	0.020
South_Nash_Concord	2002	01	07	0.220
South_Nash_Concord	2002	01	11	0.050
South_Nash_Concord	2002	01	13	0.540
South_Nash_Concord	2002	01	15	0.020
South_Nash_Concord	2002	01	17	0.040
South_Nash_Concord	2002	01	19	0.080
South_Nash_Concord	2002	01	20	0.010
South_Nash_Concord	2002	01	21	0.120
South_Nash_Concord	2002	01	24	0.120
South_Nash_Concord	2002	01	29	0.030
South_Nash_Concord	2002	01	30	0.210
South_Nash_Concord	2002	01	31	0.380
South_Nash_Concord	2002	02	01	0.350
South_Nash_Concord	2002	02	10	0.380
South_Nash_Concord	2002	02	11	0.270
South_Nash_Concord	2002	02	17	0.100
South_Nash_Concord	2002	02	20	0.040
South_Nash_Concord	2002	02	21	0.320
South_Nash_Concord	2002	02	27	0.410
South_Nash_Concord	2002	03	02	0.010
South_Nash_Concord	2002	03	03	0.590
South_Nash_Concord	2002	03	10	0.370
South_Nash_Concord	2002	03	13	0.010
South_Nash_Concord	2002	03	16	0.040
South_Nash_Concord	2002	03	18	0.140
South_Nash_Concord	2002	03	19	0.040
South_Nash_Concord	2002	03	20	0.690
South_Nash_Concord	2002	03	24	0.050
South_Nash_Concord	2002	03	25	0.030
South_Nash_Concord	2002	03	26	0.750
South_Nash_Concord	2002	03	27	0.450
South_Nash_Concord	2002	03	30	0.130
South_Nash_Concord	2002	04	01	0.590
South_Nash_Concord	2002	04	03	0.170
South_Nash_Concord	2002	04	10	0.040
South_Nash_Concord	2002	04	13	0.120
South_Nash_Concord	2002	04	14	0.080
South_Nash_Concord	2002	04	15	0.470
South_Nash_Concord	2002	04	18	0.020

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2002	04	19	0.010
South_Nash_Concord	2002	04	20	0.030
South_Nash_Concord	2002	04	22	0.100
South_Nash_Concord	2002	04	23	0.010
South_Nash_Concord	2002	04	25	0.580
South_Nash_Concord	2002	04	28	0.390
South_Nash_Concord	2002	04	29	0.340
South_Nash_Concord	2002	04	30	0.020
South_Nash_Concord	2002	05	02	0.800
South_Nash_Concord	2002	05	03	0.010
South_Nash_Concord	2002	05	09	0.100
South_Nash_Concord	2002	05	12	0.420
South_Nash_Concord	2002	05	13	1.440
South_Nash_Concord	2002	05	14	0.260
South_Nash_Concord	2002	05	15	0.010
South_Nash_Concord	2002	05	17	0.010
South_Nash_Concord	2002	05	18	0.690
South_Nash_Concord	2002	05	21	0.010
South_Nash_Concord	2002	05	26	0.010
South_Nash_Concord	2002	05	27	0.030
South_Nash_Concord	2002	05	28	0.030
South_Nash_Concord	2002	05	30	0.010
South_Nash_Concord	2002	05	31	0.550
South_Nash_Concord	2002	06	02	0.100
South_Nash_Concord	2002	06	05	0.660
South_Nash_Concord	2002	06	06	0.600
South_Nash_Concord	2002	06	07	0.290
South_Nash_Concord	2002	06	09	0.020
South_Nash_Concord	2002	06	11	0.440
South_Nash_Concord	2002	06	12	0.650
South_Nash_Concord	2002	06	15	0.430
South_Nash_Concord	2002	06	16	0.050
South_Nash_Concord	2002	06	17	0.160
South_Nash_Concord	2002	06	22	0.850
South_Nash_Concord	2002	06	23	0.170
South_Nash_Concord	2002	06	27	0.550
South_Nash_Concord	2002	06	28	0.360
South_Nash_Concord	2002	07	09	0.080
South_Nash_Concord	2002	07	15	0.120
South_Nash_Concord	2002	07	19	0.490
South_Nash_Concord	2002	07	23	1.450
South_Nash_Concord	2002	07	27	0.020
South_Nash_Concord	2002	08	01	0.060
South_Nash_Concord	2002	08	02	0.010
South_Nash_Concord	2002	08	05	0.010
South_Nash_Concord	2002	08	16	0.060
South_Nash_Concord	2002	08	20	0.070
South_Nash_Concord	2002	08	22	0.340
South_Nash_Concord	2002	08	24	0.210
South_Nash_Concord	2002	08	29	1.100
South_Nash_Concord	2002	08	30	0.100
South_Nash_Concord	2002	09	02	0.040
South_Nash_Concord	2002	09	03	0.010
South_Nash_Concord	2002	09	04	0.210
South_Nash_Concord	2002	09	11	0.010

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2002	09	15	0.150
South_Nash_Concord	2002	09	16	1.870
South_Nash_Concord	2002	09	22	0.040
South_Nash_Concord	2002	09	23	0.340
South_Nash_Concord	2002	09	26	0.080
South_Nash_Concord	2002	09	27	0.800
South_Nash_Concord	2002	09	28	0.070
South_Nash_Concord	2002	09	30	0.010
South_Nash_Concord	2002	10	03	0.010
South_Nash_Concord	2002	10	04	0.160
South_Nash_Concord	2002	10	05	0.050
South_Nash_Concord	2002	10	07	0.020
South_Nash_Concord	2002	10	11	0.120
South_Nash_Concord	2002	10	12	0.320
South_Nash_Concord	2002	10	13	0.440
South_Nash_Concord	2002	10	16	0.670
South_Nash_Concord	2002	10	17	0.050
South_Nash_Concord	2002	10	18	0.020
South_Nash_Concord	2002	10	23	0.160
South_Nash_Concord	2002	10	26	1.070
South_Nash_Concord	2002	11	04	0.160
South_Nash_Concord	2002	11	06	0.880
South_Nash_Concord	2002	11	11	0.070
South_Nash_Concord	2002	11	12	0.820
South_Nash_Concord	2002	11	13	0.230
South_Nash_Concord	2002	11	16	0.010
South_Nash_Concord	2002	11	17	0.560
South_Nash_Concord	2002	11	18	1.000
South_Nash_Concord	2002	11	19	0.120
South_Nash_Concord	2002	11	21	0.050
South_Nash_Concord	2002	11	22	0.590
South_Nash_Concord	2002	11	23	0.010
South_Nash_Concord	2002	11	25	0.060
South_Nash_Concord	2002	11	27	0.060
South_Nash_Concord	2002	11	29	0.010
South_Nash_Concord	2002	11	30	0.030
South_Nash_Concord	2002	12	06	0.170
South_Nash_Concord	2002	12	12	0.560
South_Nash_Concord	2002	12	13	0.040
South_Nash_Concord	2002	12	14	0.790
South_Nash_Concord	2002	12	16	0.070
South_Nash_Concord	2002	12	20	0.520
South_Nash_Concord	2002	12	31	0.070
South_Nash_Concord	2003	01	01	0.250
South_Nash_Concord	2003	01	02	0.030
South_Nash_Concord	2003	01	05	0.140
South_Nash_Concord	2003	01	06	0.040
South_Nash_Concord	2003	01	08	0.160
South_Nash_Concord	2003	01	09	0.220
South_Nash_Concord	2003	01	10	0.030
South_Nash_Concord	2003	02	01	0.080
South_Nash_Concord	2003	02	02	0.660
South_Nash_Concord	2003	02	04	0.410
South_Nash_Concord	2003	02	12	0.010
South_Nash_Concord	2003	02	13	0.030

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2003	02	17	0.340
South_Nash_Concord	2003	02	18	0.240
South_Nash_Concord	2003	02	22	0.640
South_Nash_Concord	2003	02	23	0.530
South_Nash_Concord	2003	03	02	0.710
South_Nash_Concord	2003	03	05	0.130
South_Nash_Concord	2003	03	06	0.030
South_Nash_Concord	2003	03	13	0.080
South_Nash_Concord	2003	03	15	0.010
South_Nash_Concord	2003	03	20	0.390
South_Nash_Concord	2003	03	21	0.520
South_Nash_Concord	2003	03	23	0.010
South_Nash_Concord	2003	03	26	0.460
South_Nash_Concord	2003	03	29	0.390
South_Nash_Concord	2003	03	30	0.420
South_Nash_Concord	2003	04	02	0.210
South_Nash_Concord	2003	04	03	0.120
South_Nash_Concord	2003	04	04	0.730
South_Nash_Concord	2003	04	05	0.250
South_Nash_Concord	2003	04	07	0.060
South_Nash_Concord	2003	04	08	0.050
South_Nash_Concord	2003	04	11	0.470
South_Nash_Concord	2003	04	12	0.020
South_Nash_Concord	2003	04	22	1.080
South_Nash_Concord	2003	04	23	0.100
South_Nash_Concord	2003	04	24	0.030
South_Nash_Concord	2003	04	26	0.750
South_Nash_Concord	2003	05	01	0.050
South_Nash_Concord	2003	05	02	0.700
South_Nash_Concord	2003	05	08	0.280
South_Nash_Concord	2003	05	09	0.200
South_Nash_Concord	2003	05	11	0.370
South_Nash_Concord	2003	05	12	0.420
South_Nash_Concord	2003	05	13	0.100
South_Nash_Concord	2003	05	14	0.130
South_Nash_Concord	2003	05	21	0.230
South_Nash_Concord	2003	05	23	0.090
South_Nash_Concord	2003	05	24	0.240
South_Nash_Concord	2003	05	25	0.250
South_Nash_Concord	2003	05	26	1.210
South_Nash_Concord	2003	05	27	0.020
South_Nash_Concord	2003	05	28	0.160
South_Nash_Concord	2003	05	29	0.020
South_Nash_Concord	2003	05	31	0.240
South_Nash_Concord	2003	06	01	0.170
South_Nash_Concord	2003	06	05	0.230
South_Nash_Concord	2003	06	07	0.250
South_Nash_Concord	2003	06	09	0.020
South_Nash_Concord	2003	06	11	0.100
South_Nash_Concord	2003	06	13	0.320
South_Nash_Concord	2003	06	14	0.200
South_Nash_Concord	2003	06	18	0.040
South_Nash_Concord	2003	06	19	0.030
South_Nash_Concord	2003	06	20	0.010
South_Nash_Concord	2003	06	21	0.020

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2003	06	22	0.090
South_Nash_Concord	2003	06	23	0.070
South_Nash_Concord	2003	06	30	0.050
South_Nash_Concord	2003	07	09	0.080
South_Nash_Concord	2003	07	11	0.420
South_Nash_Concord	2003	07	16	1.160
South_Nash_Concord	2003	07	18	0.080
South_Nash_Concord	2003	07	19	0.050
South_Nash_Concord	2003	07	22	0.120
South_Nash_Concord	2003	08	01	1.810
South_Nash_Concord	2003	08	02	0.200
South_Nash_Concord	2003	08	03	0.240
South_Nash_Concord	2003	08	04	0.120
South_Nash_Concord	2003	08	05	1.690
South_Nash_Concord	2003	08	06	0.380
South_Nash_Concord	2003	08	07	0.030
South_Nash_Concord	2003	08	08	0.100
South_Nash_Concord	2003	08	09	0.490
South_Nash_Concord	2003	08	10	0.840
South_Nash_Concord	2003	08	11	0.030
South_Nash_Concord	2003	08	12	0.080
South_Nash_Concord	2003	08	13	0.100
South_Nash_Concord	2003	08	16	0.540
South_Nash_Concord	2003	08	18	0.130
South_Nash_Concord	2003	09	01	0.090
South_Nash_Concord	2003	09	02	0.380
South_Nash_Concord	2003	09	03	0.080
South_Nash_Concord	2003	09	04	0.530
South_Nash_Concord	2003	09	14	0.010
South_Nash_Concord	2003	09	16	1.040
South_Nash_Concord	2003	09	19	0.360
South_Nash_Concord	2003	09	20	0.010
South_Nash_Concord	2003	09	23	1.570
South_Nash_Concord	2003	09	25	0.050
South_Nash_Concord	2003	09	26	0.320
South_Nash_Concord	2003	09	27	0.020
South_Nash_Concord	2003	09	28	0.520
South_Nash_Concord	2003	09	29	0.010
South_Nash_Concord	2003	10	01	0.030
South_Nash_Concord	2003	10	02	0.040
South_Nash_Concord	2003	10	04	0.120
South_Nash_Concord	2003	10	12	0.240
South_Nash_Concord	2003	10	15	1.310
South_Nash_Concord	2003	10	21	0.120
South_Nash_Concord	2003	10	22	0.100
South_Nash_Concord	2003	10	23	0.130
South_Nash_Concord	2003	10	27	0.690
South_Nash_Concord	2003	10	28	0.010
South_Nash_Concord	2003	10	29	1.440
South_Nash_Concord	2003	11	02	0.100
South_Nash_Concord	2003	11	03	0.150
South_Nash_Concord	2003	11	04	0.230
South_Nash_Concord	2003	11	05	0.330
South_Nash_Concord	2003	11	11	0.070
South_Nash_Concord	2003	11	20	0.520

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2003	11	21	0.010
South_Nash_Concord	2003	11	25	0.060
South_Nash_Concord	2003	11	28	0.440
South_Nash_Concord	2003	11	29	0.160
South_Nash_Concord	2003	12	02	0.070
South_Nash_Concord	2003	12	06	0.460
South_Nash_Concord	2003	12	07	0.110
South_Nash_Concord	2003	12	11	0.730
South_Nash_Concord	2003	12	14	0.440
South_Nash_Concord	2003	12	15	0.370
South_Nash_Concord	2003	12	17	1.570
South_Nash_Concord	2003	12	18	0.030
South_Nash_Concord	2003	12	24	0.300
South_Nash_Concord	2003	12	25	0.050
South_Nash_Concord	2004	01	02	0.060
South_Nash_Concord	2004	01	03	0.160
South_Nash_Concord	2004	01	05	0.250
South_Nash_Concord	2004	01	12	0.130
South_Nash_Concord	2004	01	13	0.010
South_Nash_Concord	2004	01	18	0.010
South_Nash_Concord	2004	01	28	0.050
South_Nash_Concord	2004	02	03	0.370
South_Nash_Concord	2004	02	04	0.100
South_Nash_Concord	2004	02	06	0.340
South_Nash_Concord	2004	02	07	0.120
South_Nash_Concord	2004	02	21	0.110
South_Nash_Concord	2004	03	02	0.020
South_Nash_Concord	2004	03	05	0.090
South_Nash_Concord	2004	03	06	0.050
South_Nash_Concord	2004	03	08	0.090
South_Nash_Concord	2004	03	09	0.010
South_Nash_Concord	2004	03	14	0.010
South_Nash_Concord	2004	03	15	0.020
South_Nash_Concord	2004	03	16	0.210
South_Nash_Concord	2004	03	17	0.050
South_Nash_Concord	2004	03	19	0.020
South_Nash_Concord	2004	03	20	0.120
South_Nash_Concord	2004	03	21	0.130
South_Nash_Concord	2004	03	23	0.010
South_Nash_Concord	2004	03	25	0.250
South_Nash_Concord	2004	03	26	0.090
South_Nash_Concord	2004	03	27	0.300
South_Nash_Concord	2004	03	31	1.170
South_Nash_Concord	2004	04	01	1.640
South_Nash_Concord	2004	04	02	0.570
South_Nash_Concord	2004	04	04	0.330
South_Nash_Concord	2004	04	12	0.040
South_Nash_Concord	2004	04	13	1.970
South_Nash_Concord	2004	04	14	0.120
South_Nash_Concord	2004	04	15	0.150
South_Nash_Concord	2004	04	19	0.020
South_Nash_Concord	2004	04	23	0.420
South_Nash_Concord	2004	04	24	0.040
South_Nash_Concord	2004	04	25	0.250
South_Nash_Concord	2004	04	26	0.800

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2004	04	27	0.230
South_Nash_Concord	2004	05	02	0.010
South_Nash_Concord	2004	05	03	0.440
South_Nash_Concord	2004	05	04	0.600
South_Nash_Concord	2004	05	11	0.030
South_Nash_Concord	2004	05	15	0.210
South_Nash_Concord	2004	05	18	0.310
South_Nash_Concord	2004	05	20	0.070
South_Nash_Concord	2004	05	21	0.020
South_Nash_Concord	2004	05	22	0.180
South_Nash_Concord	2004	05	23	0.870
South_Nash_Concord	2004	05	26	0.110
South_Nash_Concord	2004	05	27	0.180
South_Nash_Concord	2004	05	28	0.870
South_Nash_Concord	2004	06	01	0.230
South_Nash_Concord	2004	06	02	0.020
South_Nash_Concord	2004	06	03	0.290
South_Nash_Concord	2004	06	06	0.010
South_Nash_Concord	2004	06	09	0.660
South_Nash_Concord	2004	06	10	0.060
South_Nash_Concord	2004	06	14	0.040
South_Nash_Concord	2004	06	17	0.010
South_Nash_Concord	2004	06	19	0.010
South_Nash_Concord	2004	06	22	0.020
South_Nash_Concord	2004	06	25	0.350
South_Nash_Concord	2004	06	26	0.230
South_Nash_Concord	2004	06	29	0.370
South_Nash_Concord	2004	07	02	0.040
South_Nash_Concord	2004	07	08	1.160
South_Nash_Concord	2004	07	09	0.020
South_Nash_Concord	2004	07	13	0.160
South_Nash_Concord	2004	07	14	0.040
South_Nash_Concord	2004	07	15	0.150
South_Nash_Concord	2004	07	18	0.120
South_Nash_Concord	2004	07	19	0.740
South_Nash_Concord	2004	07	20	0.060
South_Nash_Concord	2004	07	23	0.010
South_Nash_Concord	2004	07	24	0.020
South_Nash_Concord	2004	07	27	0.640
South_Nash_Concord	2004	07	28	0.550
South_Nash_Concord	2004	08	01	0.170
South_Nash_Concord	2004	08	05	0.080
South_Nash_Concord	2004	08	11	0.170
South_Nash_Concord	2004	08	12	0.340
South_Nash_Concord	2004	08	13	0.580
South_Nash_Concord	2004	08	15	0.530
South_Nash_Concord	2004	08	16	0.550
South_Nash_Concord	2004	08	20	0.130
South_Nash_Concord	2004	08	21	1.350
South_Nash_Concord	2004	08	29	0.620
South_Nash_Concord	2004	08	30	0.100
South_Nash_Concord	2004	09	08	0.990
South_Nash_Concord	2004	09	09	0.970
South_Nash_Concord	2004	09	10	0.010
South_Nash_Concord	2004	09	16	0.010

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2004	09	17	1.100
South_Nash_Concord	2004	09	18	2.420
South_Nash_Concord	2004	09	28	0.420
South_Nash_Concord	2004	09	30	0.190
South_Nash_Concord	2004	10	02	0.050
South_Nash_Concord	2004	10	14	0.050
South_Nash_Concord	2004	10	15	0.810
South_Nash_Concord	2004	10	16	0.400
South_Nash_Concord	2004	10	30	0.290
South_Nash_Concord	2004	10	31	0.010
South_Nash_Concord	2004	11	02	0.140
South_Nash_Concord	2004	11	03	0.170
South_Nash_Concord	2004	11	04	0.610
South_Nash_Concord	2004	11	05	0.060
South_Nash_Concord	2004	11	08	0.010
South_Nash_Concord	2004	11	12	0.010
South_Nash_Concord	2004	11	20	0.050
South_Nash_Concord	2004	11	21	0.100
South_Nash_Concord	2004	11	24	0.510
South_Nash_Concord	2004	11	25	0.280
South_Nash_Concord	2004	11	28	1.280
South_Nash_Concord	2004	12	01	1.000
South_Nash_Concord	2004	12	06	0.030
South_Nash_Concord	2004	12	07	0.630
South_Nash_Concord	2004	12	08	0.020
South_Nash_Concord	2004	12	10	0.470
South_Nash_Concord	2004	12	11	0.270
South_Nash_Concord	2004	12	19	0.070
South_Nash_Concord	2004	12	20	0.060
South_Nash_Concord	2004	12	23	1.090
South_Nash_Concord	2004	12	26	0.050
South_Nash_Concord	2004	12	27	0.060
South_Nash_Concord	2005	01	02	0.030
South_Nash_Concord	2005	01	03	0.050
South_Nash_Concord	2005	01	04	0.250
South_Nash_Concord	2005	01	06	0.500
South_Nash_Concord	2005	01	08	0.350
South_Nash_Concord	2005	01	12	0.350
South_Nash_Concord	2005	01	14	0.810
South_Nash_Concord	2005	01	16	0.040
South_Nash_Concord	2005	01	17	0.010
South_Nash_Concord	2005	01	19	0.080
South_Nash_Concord	2005	01	20	0.010
South_Nash_Concord	2005	01	22	0.150
South_Nash_Concord	2005	01	23	0.130
South_Nash_Concord	2005	01	26	0.170
South_Nash_Concord	2005	01	27	0.010
South_Nash_Concord	2005	02	03	0.080
South_Nash_Concord	2005	02	04	0.230
South_Nash_Concord	2005	02	08	0.020
South_Nash_Concord	2005	02	09	0.020
South_Nash_Concord	2005	02	10	1.000
South_Nash_Concord	2005	02	11	0.010
South_Nash_Concord	2005	02	13	0.110
South_Nash_Concord	2005	02	14	0.170

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	02	15	0.340
South_Nash_Concord	2005	02	16	0.260
South_Nash_Concord	2005	02	21	0.170
South_Nash_Concord	2005	02	22	0.020
South_Nash_Concord	2005	02	23	0.040
South_Nash_Concord	2005	02	24	0.020
South_Nash_Concord	2005	02	25	0.040
South_Nash_Concord	2005	03	01	0.410
South_Nash_Concord	2005	03	08	0.450
South_Nash_Concord	2005	03	11	0.090
South_Nash_Concord	2005	03	12	0.340
South_Nash_Concord	2005	03	13	0.010
South_Nash_Concord	2005	03	24	0.130
South_Nash_Concord	2005	03	28	1.540
South_Nash_Concord	2005	03	29	0.390
South_Nash_Concord	2005	04	01	0.020
South_Nash_Concord	2005	04	02	0.740
South_Nash_Concord	2005	04	03	0.890
South_Nash_Concord	2005	04	07	0.130
South_Nash_Concord	2005	04	08	0.010
South_Nash_Concord	2005	04	20	0.450
South_Nash_Concord	2005	04	21	0.390
South_Nash_Concord	2005	04	22	0.010
South_Nash_Concord	2005	04	23	1.220
South_Nash_Concord	2005	04	24	0.480
South_Nash_Concord	2005	04	25	0.210
South_Nash_Concord	2005	04	27	0.490
South_Nash_Concord	2005	04	28	0.230
South_Nash_Concord	2005	04	30	0.490
South_Nash_Concord	2005	05	01	0.020
South_Nash_Concord	2005	05	02	0.130
South_Nash_Concord	2005	05	07	0.400
South_Nash_Concord	2005	05	08	0.010
South_Nash_Concord	2005	05	15	0.170
South_Nash_Concord	2005	05	16	0.080
South_Nash_Concord	2005	05	18	0.030
South_Nash_Concord	2005	05	21	0.350
South_Nash_Concord	2005	05	22	0.470
South_Nash_Concord	2005	05	23	0.550
South_Nash_Concord	2005	05	24	0.520
South_Nash_Concord	2005	05	25	0.470
South_Nash_Concord	2005	05	26	0.300
South_Nash_Concord	2005	05	27	0.030
South_Nash_Concord	2005	05	29	0.330
South_Nash_Concord	2005	05	30	0.050
South_Nash_Concord	2005	07	01	0.230
South_Nash_Concord	2005	07	06	0.440
South_Nash_Concord	2005	07	07	0.020
South_Nash_Concord	2005	07	08	0.590
South_Nash_Concord	2005	07	09	0.450
South_Nash_Concord	2005	07	14	0.370
South_Nash_Concord	2005	07	17	0.010
South_Nash_Concord	2005	07	22	0.240
South_Nash_Concord	2005	07	27	0.280
South_Nash_Concord	2005	07	31	0.060

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	08	01	0.140
South_Nash_Concord	2005	08	09	0.010
South_Nash_Concord	2005	08	12	0.840
South_Nash_Concord	2005	08	13	0.290
South_Nash_Concord	2005	08	14	0.200
South_Nash_Concord	2005	08	15	0.250
South_Nash_Concord	2005	08	20	0.010
South_Nash_Concord	2005	08	21	0.080
South_Nash_Concord	2005	08	24	0.180
South_Nash_Concord	2005	08	28	0.170
South_Nash_Concord	2005	08	29	0.730
South_Nash_Concord	2005	08	30	0.020
South_Nash_Concord	2005	08	31	0.260
South_Nash_Concord	2005	09	15	0.290
South_Nash_Concord	2005	09	16	0.470
South_Nash_Concord	2005	09	17	0.060
South_Nash_Concord	2005	09	20	0.170
South_Nash_Concord	2005	09	26	0.870
South_Nash_Concord	2005	09	29	0.530
South_Nash_Concord	2005	10	07	0.008
South_Nash_Concord	2005	10	07	0.003
South_Nash_Concord	2005	10	07	0.015
South_Nash_Concord	2005	10	08	0.088
South_Nash_Concord	2005	10	08	0.125
South_Nash_Concord	2005	10	08	0.083
South_Nash_Concord	2005	10	08	0.036
South_Nash_Concord	2005	10	08	0.019
South_Nash_Concord	2005	10	08	0.062
South_Nash_Concord	2005	10	08	0.107
South_Nash_Concord	2005	10	08	0.144
South_Nash_Concord	2005	10	08	0.313
South_Nash_Concord	2005	10	08	0.121
South_Nash_Concord	2005	10	08	0.099
South_Nash_Concord	2005	10	08	0.309
South_Nash_Concord	2005	10	08	0.299
South_Nash_Concord	2005	10	08	0.111
South_Nash_Concord	2005	10	08	0.121
South_Nash_Concord	2005	10	08	0.338
South_Nash_Concord	2005	10	08	0.169
South_Nash_Concord	2005	10	08	0.222
South_Nash_Concord	2005	10	08	0.402
South_Nash_Concord	2005	10	08	0.573
South_Nash_Concord	2005	10	08	0.413
South_Nash_Concord	2005	10	08	0.234
South_Nash_Concord	2005	10	08	0.164
South_Nash_Concord	2005	10	08	0.062
South_Nash_Concord	2005	10	09	0.073
South_Nash_Concord	2005	10	09	0.160
South_Nash_Concord	2005	10	09	0.192
South_Nash_Concord	2005	10	09	0.258
South_Nash_Concord	2005	10	09	0.117
South_Nash_Concord	2005	10	09	0.043
South_Nash_Concord	2005	10	09	0.028
South_Nash_Concord	2005	10	09	0.002
South_Nash_Concord	2005	10	09	0.008

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	10	09	0.003
South_Nash_Concord	2005	10	09	0.001
South_Nash_Concord	2005	10	10	0.009
South_Nash_Concord	2005	10	10	0.005
South_Nash_Concord	2005	10	10	0.005
South_Nash_Concord	2005	10	10	0.008
South_Nash_Concord	2005	10	10	0.002
South_Nash_Concord	2005	10	10	0.007
South_Nash_Concord	2005	10	10	0.023
South_Nash_Concord	2005	10	10	0.011
South_Nash_Concord	2005	10	10	0.033
South_Nash_Concord	2005	10	10	0.008
South_Nash_Concord	2005	10	10	0.008
South_Nash_Concord	2005	10	10	0.015
South_Nash_Concord	2005	10	10	0.240
South_Nash_Concord	2005	10	10	0.256
South_Nash_Concord	2005	10	10	0.123
South_Nash_Concord	2005	10	10	0.048
South_Nash_Concord	2005	10	10	0.119
South_Nash_Concord	2005	10	10	0.042
South_Nash_Concord	2005	10	11	0.018
South_Nash_Concord	2005	10	11	0.067
South_Nash_Concord	2005	10	11	0.128
South_Nash_Concord	2005	10	11	0.005
South_Nash_Concord	2005	10	11	0.007
South_Nash_Concord	2005	10	11	0.003
South_Nash_Concord	2005	10	11	0.008
South_Nash_Concord	2005	10	11	0.002
South_Nash_Concord	2005	10	11	0.008
South_Nash_Concord	2005	10	11	0.013
South_Nash_Concord	2005	10	11	0.003
South_Nash_Concord	2005	10	11	0.007
South_Nash_Concord	2005	10	11	0.017
South_Nash_Concord	2005	10	11	0.023
South_Nash_Concord	2005	10	12	0.008
South_Nash_Concord	2005	10	12	0.123
South_Nash_Concord	2005	10	12	0.058
South_Nash_Concord	2005	10	12	0.065
South_Nash_Concord	2005	10	12	0.054
South_Nash_Concord	2005	10	12	0.032
South_Nash_Concord	2005	10	12	0.005
South_Nash_Concord	2005	10	12	0.005
South_Nash_Concord	2005	10	14	0.003
South_Nash_Concord	2005	10	14	0.007
South_Nash_Concord	2005	10	14	0.026
South_Nash_Concord	2005	10	14	0.040
South_Nash_Concord	2005	10	14	0.028
South_Nash_Concord	2005	10	14	0.006
South_Nash_Concord	2005	10	14	0.004
South_Nash_Concord	2005	10	14	0.006
South_Nash_Concord	2005	10	14	0.002
South_Nash_Concord	2005	10	14	0.011
South_Nash_Concord	2005	10	14	0.023
South_Nash_Concord	2005	10	14	0.023
South_Nash_Concord	2005	10	14	0.010

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	10	14	0.012
South_Nash_Concord	2005	10	14	0.045
South_Nash_Concord	2005	10	14	0.101
South_Nash_Concord	2005	10	14	0.166
South_Nash_Concord	2005	10	14	0.176
South_Nash_Concord	2005	10	14	0.133
South_Nash_Concord	2005	10	14	0.127
South_Nash_Concord	2005	10	14	0.097
South_Nash_Concord	2005	10	14	0.088
South_Nash_Concord	2005	10	14	0.233
South_Nash_Concord	2005	10	15	0.276
South_Nash_Concord	2005	10	15	0.210
South_Nash_Concord	2005	10	15	0.191
South_Nash_Concord	2005	10	15	0.273
South_Nash_Concord	2005	10	15	0.242
South_Nash_Concord	2005	10	15	0.133
South_Nash_Concord	2005	10	15	0.032
South_Nash_Concord	2005	10	15	0.014
South_Nash_Concord	2005	10	15	0.008
South_Nash_Concord	2005	10	15	0.027
South_Nash_Concord	2005	10	15	0.059
South_Nash_Concord	2005	10	15	0.182
South_Nash_Concord	2005	10	15	0.235
South_Nash_Concord	2005	10	15	0.247
South_Nash_Concord	2005	10	15	0.110
South_Nash_Concord	2005	10	15	0.043
South_Nash_Concord	2005	10	15	0.024
South_Nash_Concord	2005	10	15	0.024
South_Nash_Concord	2005	10	15	0.034
South_Nash_Concord	2005	10	15	0.003
South_Nash_Concord	2005	10	18	0.018
South_Nash_Concord	2005	10	18	0.016
South_Nash_Concord	2005	10	18	0.007
South_Nash_Concord	2005	10	22	0.002
South_Nash_Concord	2005	10	22	0.028
South_Nash_Concord	2005	10	22	0.084
South_Nash_Concord	2005	10	22	0.044
South_Nash_Concord	2005	10	22	0.030
South_Nash_Concord	2005	10	23	0.076
South_Nash_Concord	2005	10	23	0.173
South_Nash_Concord	2005	10	23	0.067
South_Nash_Concord	2005	10	23	0.049
South_Nash_Concord	2005	10	23	0.057
South_Nash_Concord	2005	10	23	0.002
South_Nash_Concord	2005	10	23	0.039
South_Nash_Concord	2005	10	23	0.068
South_Nash_Concord	2005	10	23	0.026
South_Nash_Concord	2005	10	23	0.006
South_Nash_Concord	2005	10	23	0.002
South_Nash_Concord	2005	10	23	0.015
South_Nash_Concord	2005	10	23	0.003
South_Nash_Concord	2005	10	24	0.008
South_Nash_Concord	2005	10	24	0.003
South_Nash_Concord	2005	10	24	0.002
South_Nash_Concord	2005	10	24	0.033

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	10	24	0.023
South_Nash_Concord	2005	10	25	0.041
South_Nash_Concord	2005	10	25	0.023
South_Nash_Concord	2005	10	25	0.026
South_Nash_Concord	2005	10	25	0.018
South_Nash_Concord	2005	10	25	0.033
South_Nash_Concord	2005	10	25	0.009
South_Nash_Concord	2005	10	25	0.071
South_Nash_Concord	2005	10	25	0.071
South_Nash_Concord	2005	10	25	0.054
South_Nash_Concord	2005	10	25	0.057
South_Nash_Concord	2005	10	25	0.108
South_Nash_Concord	2005	10	25	0.048
South_Nash_Concord	2005	10	25	0.087
South_Nash_Concord	2005	10	25	0.117
South_Nash_Concord	2005	10	25	0.089
South_Nash_Concord	2005	10	25	0.113
South_Nash_Concord	2005	10	25	0.041
South_Nash_Concord	2005	10	25	0.002
South_Nash_Concord	2005	10	25	0.033
South_Nash_Concord	2005	10	25	0.031
South_Nash_Concord	2005	10	25	0.004
South_Nash_Concord	2005	11	02	0.002
South_Nash_Concord	2005	11	02	0.008
South_Nash_Concord	2005	11	06	0.001
South_Nash_Concord	2005	11	06	0.009
South_Nash_Concord	2005	11	06	0.020
South_Nash_Concord	2005	11	06	0.072
South_Nash_Concord	2005	11	06	0.008
South_Nash_Concord	2005	11	09	0.012
South_Nash_Concord	2005	11	09	0.028
South_Nash_Concord	2005	11	09	0.010
South_Nash_Concord	2005	11	09	0.029
South_Nash_Concord	2005	11	09	0.020
South_Nash_Concord	2005	11	09	0.009
South_Nash_Concord	2005	11	09	0.036
South_Nash_Concord	2005	11	09	0.177
South_Nash_Concord	2005	11	10	0.071
South_Nash_Concord	2005	11	10	0.052
South_Nash_Concord	2005	11	10	0.043
South_Nash_Concord	2005	11	10	0.024
South_Nash_Concord	2005	11	15	0.023
South_Nash_Concord	2005	11	15	0.039
South_Nash_Concord	2005	11	15	0.041
South_Nash_Concord	2005	11	15	0.034
South_Nash_Concord	2005	11	15	0.008
South_Nash_Concord	2005	11	15	0.014
South_Nash_Concord	2005	11	15	0.002
South_Nash_Concord	2005	11	15	0.005
South_Nash_Concord	2005	11	15	0.009
South_Nash_Concord	2005	11	15	0.006
South_Nash_Concord	2005	11	15	0.003
South_Nash_Concord	2005	11	15	0.058
South_Nash_Concord	2005	11	15	0.036
South_Nash_Concord	2005	11	15	0.029

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	11	16	0.006
South_Nash_Concord	2005	11	16	0.008
South_Nash_Concord	2005	11	16	0.007
South_Nash_Concord	2005	11	16	0.003
South_Nash_Concord	2005	11	16	0.009
South_Nash_Concord	2005	11	16	0.001
South_Nash_Concord	2005	11	16	0.006
South_Nash_Concord	2005	11	16	0.004
South_Nash_Concord	2005	11	16	0.065
South_Nash_Concord	2005	11	16	0.093
South_Nash_Concord	2005	11	16	0.112
South_Nash_Concord	2005	11	16	0.193
South_Nash_Concord	2005	11	16	0.113
South_Nash_Concord	2005	11	17	0.123
South_Nash_Concord	2005	11	17	0.136
South_Nash_Concord	2005	11	17	0.065
South_Nash_Concord	2005	11	17	0.002
South_Nash_Concord	2005	11	21	0.023
South_Nash_Concord	2005	11	22	0.068
South_Nash_Concord	2005	11	22	0.077
South_Nash_Concord	2005	11	22	0.060
South_Nash_Concord	2005	11	22	0.028
South_Nash_Concord	2005	11	22	0.046
South_Nash_Concord	2005	11	22	0.073
South_Nash_Concord	2005	11	22	0.059
South_Nash_Concord	2005	11	22	0.035
South_Nash_Concord	2005	11	22	0.026
South_Nash_Concord	2005	11	22	0.016
South_Nash_Concord	2005	11	22	0.075
South_Nash_Concord	2005	11	22	0.105
South_Nash_Concord	2005	11	22	0.052
South_Nash_Concord	2005	11	22	0.114
South_Nash_Concord	2005	11	22	0.171
South_Nash_Concord	2005	11	22	0.043
South_Nash_Concord	2005	11	22	0.008
South_Nash_Concord	2005	11	22	0.011
South_Nash_Concord	2005	11	22	0.005
South_Nash_Concord	2005	11	22	0.006
South_Nash_Concord	2005	11	24	0.009
South_Nash_Concord	2005	11	24	0.017
South_Nash_Concord	2005	11	24	0.019
South_Nash_Concord	2005	11	24	0.011
South_Nash_Concord	2005	11	24	0.003
South_Nash_Concord	2005	11	24	0.001
South_Nash_Concord	2005	11	25	0.003
South_Nash_Concord	2005	11	25	0.004
South_Nash_Concord	2005	11	25	0.009
South_Nash_Concord	2005	11	25	0.011
South_Nash_Concord	2005	11	25	0.011
South_Nash_Concord	2005	11	25	0.002
South_Nash_Concord	2005	11	27	0.001
South_Nash_Concord	2005	11	27	0.003
South_Nash_Concord	2005	11	27	0.005
South_Nash_Concord	2005	11	27	0.005
South_Nash_Concord	2005	11	27	0.002

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	11	27	0.001
South_Nash_Concord	2005	11	27	0.003
South_Nash_Concord	2005	11	27	0.003
South_Nash_Concord	2005	11	27	0.003
South_Nash_Concord	2005	11	28	0.001
South_Nash_Concord	2005	11	28	0.003
South_Nash_Concord	2005	11	28	0.004
South_Nash_Concord	2005	11	28	0.006
South_Nash_Concord	2005	11	28	0.003
South_Nash_Concord	2005	11	28	0.003
South_Nash_Concord	2005	11	28	0.005
South_Nash_Concord	2005	11	28	0.009
South_Nash_Concord	2005	11	28	0.013
South_Nash_Concord	2005	11	28	0.014
South_Nash_Concord	2005	11	28	0.013
South_Nash_Concord	2005	11	28	0.013
South_Nash_Concord	2005	11	28	0.009
South_Nash_Concord	2005	11	28	0.015
South_Nash_Concord	2005	11	28	0.017
South_Nash_Concord	2005	11	28	0.015
South_Nash_Concord	2005	11	28	0.006
South_Nash_Concord	2005	11	28	0.003
South_Nash_Concord	2005	11	28	0.003
South_Nash_Concord	2005	11	28	0.003
South_Nash_Concord	2005	11	29	0.003
South_Nash_Concord	2005	11	29	0.003
South_Nash_Concord	2005	11	29	0.003
South_Nash_Concord	2005	11	29	0.002
South_Nash_Concord	2005	11	29	0.003
South_Nash_Concord	2005	11	29	0.003
South_Nash_Concord	2005	11	29	0.002
South_Nash_Concord	2005	11	30	0.029
South_Nash_Concord	2005	11	30	0.204
South_Nash_Concord	2005	11	30	0.167
South_Nash_Concord	2005	11	30	0.023
South_Nash_Concord	2005	11	30	0.017
South_Nash_Concord	2005	11	30	0.005
South_Nash_Concord	2005	11	30	0.021
South_Nash_Concord	2005	11	30	0.016
South_Nash_Concord	2005	11	30	0.014
South_Nash_Concord	2005	11	30	0.067
South_Nash_Concord	2005	11	30	0.083
South_Nash_Concord	2005	11	30	0.090
South_Nash_Concord	2005	11	30	0.076
South_Nash_Concord	2005	11	30	0.066
South_Nash_Concord	2005	11	30	0.003
South_Nash_Concord	2005	12	02	0.010
South_Nash_Concord	2005	12	02	0.010
South_Nash_Concord	2005	12	02	0.009
South_Nash_Concord	2005	12	02	0.001
South_Nash_Concord	2005	12	05	0.003
South_Nash_Concord	2005	12	05	0.017
South_Nash_Concord	2005	12	05	0.018
South_Nash_Concord	2005	12	05	0.004
South_Nash_Concord	2005	12	05	0.008

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	12	06	0.007
South_Nash_Concord	2005	12	06	0.003
South_Nash_Concord	2005	12	10	0.025
South_Nash_Concord	2005	12	10	0.066
South_Nash_Concord	2005	12	10	0.068
South_Nash_Concord	2005	12	10	0.051
South_Nash_Concord	2005	12	10	0.019
South_Nash_Concord	2005	12	10	0.011
South_Nash_Concord	2005	12	11	0.008
South_Nash_Concord	2005	12	11	0.016
South_Nash_Concord	2005	12	11	0.014
South_Nash_Concord	2005	12	11	0.003
South_Nash_Concord	2005	12	11	0.005
South_Nash_Concord	2005	12	11	0.005
South_Nash_Concord	2005	12	16	0.036
South_Nash_Concord	2005	12	16	0.156
South_Nash_Concord	2005	12	16	0.228
South_Nash_Concord	2005	12	16	0.393
South_Nash_Concord	2005	12	16	0.273
South_Nash_Concord	2005	12	16	0.082
South_Nash_Concord	2005	12	16	0.039
South_Nash_Concord	2005	12	16	0.013
South_Nash_Concord	2005	12	17	0.009
South_Nash_Concord	2005	12	17	0.001
South_Nash_Concord	2005	12	23	0.009
South_Nash_Concord	2005	12	23	0.001
South_Nash_Concord	2005	12	23	0.019
South_Nash_Concord	2005	12	23	0.011
South_Nash_Concord	2005	12	25	0.006
South_Nash_Concord	2005	12	25	0.054
South_Nash_Concord	2005	12	25	0.040
South_Nash_Concord	2005	12	25	0.001
South_Nash_Concord	2005	12	25	0.049
South_Nash_Concord	2005	12	25	0.087
South_Nash_Concord	2005	12	25	0.110
South_Nash_Concord	2005	12	26	0.183
South_Nash_Concord	2005	12	26	0.148
South_Nash_Concord	2005	12	26	0.043
South_Nash_Concord	2005	12	26	0.028
South_Nash_Concord	2005	12	26	0.017
South_Nash_Concord	2005	12	26	0.030
South_Nash_Concord	2005	12	26	0.006
South_Nash_Concord	2005	12	26	0.003
South_Nash_Concord	2005	12	26	0.007
South_Nash_Concord	2005	12	26	0.003
South_Nash_Concord	2005	12	26	0.007
South_Nash_Concord	2005	12	26	0.019
South_Nash_Concord	2005	12	26	0.208
South_Nash_Concord	2005	12	26	0.108
South_Nash_Concord	2005	12	26	0.320
South_Nash_Concord	2005	12	26	0.271
South_Nash_Concord	2005	12	26	0.118
South_Nash_Concord	2005	12	26	0.018
South_Nash_Concord	2005	12	26	0.010
South_Nash_Concord	2005	12	26	0.031

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2005	12	26	0.033
South_Nash_Concord	2005	12	26	0.018
South_Nash_Concord	2005	12	26	0.008
South_Nash_Concord	2005	12	27	0.003
South_Nash_Concord	2005	12	27	0.008
South_Nash_Concord	2005	12	29	0.013
South_Nash_Concord	2005	12	29	0.032
South_Nash_Concord	2005	12	29	0.011
South_Nash_Concord	2005	12	29	0.013
South_Nash_Concord	2005	12	29	0.024
South_Nash_Concord	2005	12	29	0.063
South_Nash_Concord	2005	12	29	0.032
South_Nash_Concord	2005	12	29	0.011
South_Nash_Concord	2005	12	29	0.013
South_Nash_Concord	2005	12	29	0.004
South_Nash_Concord	2005	12	29	0.006
South_Nash_Concord	2005	12	29	0.010
South_Nash_Concord	2005	12	30	0.006
South_Nash_Concord	2005	12	30	0.004
South_Nash_Concord	2006	01	02	0.031
South_Nash_Concord	2006	01	02	0.038
South_Nash_Concord	2006	01	02	0.042
South_Nash_Concord	2006	01	02	0.019
South_Nash_Concord	2006	01	02	0.001
South_Nash_Concord	2006	01	02	0.001
South_Nash_Concord	2006	01	02	0.009
South_Nash_Concord	2006	01	03	0.010
South_Nash_Concord	2006	01	04	0.008
South_Nash_Concord	2006	01	04	0.002
South_Nash_Concord	2006	01	07	0.009
South_Nash_Concord	2006	01	07	0.001
South_Nash_Concord	2006	01	10	0.007
South_Nash_Concord	2006	01	10	0.033
South_Nash_Concord	2006	01	10	0.029
South_Nash_Concord	2006	01	10	0.020
South_Nash_Concord	2006	01	10	0.011
South_Nash_Concord	2006	01	11	0.032
South_Nash_Concord	2006	01	11	0.068
South_Nash_Concord	2006	01	11	0.129
South_Nash_Concord	2006	01	11	0.026
South_Nash_Concord	2006	01	11	0.166
South_Nash_Concord	2006	01	12	0.076
South_Nash_Concord	2006	01	12	0.010
South_Nash_Concord	2006	01	12	0.004
South_Nash_Concord	2006	01	14	0.002
South_Nash_Concord	2006	01	14	0.008
South_Nash_Concord	2006	01	14	0.005
South_Nash_Concord	2006	01	14	0.005
South_Nash_Concord	2006	01	14	0.011
South_Nash_Concord	2006	01	14	0.048
South_Nash_Concord	2006	01	14	0.026
South_Nash_Concord	2006	01	14	0.047
South_Nash_Concord	2006	01	14	0.060
South_Nash_Concord	2006	01	14	0.009
South_Nash_Concord	2006	01	14	0.004

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	01	14	0.006
South_Nash_Concord	2006	01	14	0.001
South_Nash_Concord	2006	01	14	0.048
South_Nash_Concord	2006	01	14	0.118
South_Nash_Concord	2006	01	15	0.037
South_Nash_Concord	2006	01	15	0.025
South_Nash_Concord	2006	01	15	0.002
South_Nash_Concord	2006	01	17	0.015
South_Nash_Concord	2006	01	17	0.032
South_Nash_Concord	2006	01	17	0.021
South_Nash_Concord	2006	01	17	0.011
South_Nash_Concord	2006	01	17	0.005
South_Nash_Concord	2006	01	17	0.007
South_Nash_Concord	2006	01	18	0.003
South_Nash_Concord	2006	01	18	0.041
South_Nash_Concord	2006	01	18	0.060
South_Nash_Concord	2006	01	18	0.053
South_Nash_Concord	2006	01	18	0.057
South_Nash_Concord	2006	01	18	0.034
South_Nash_Concord	2006	01	18	0.029
South_Nash_Concord	2006	01	18	0.038
South_Nash_Concord	2006	01	18	0.050
South_Nash_Concord	2006	01	18	0.018
South_Nash_Concord	2006	01	18	0.103
South_Nash_Concord	2006	01	18	0.210
South_Nash_Concord	2006	01	18	0.168
South_Nash_Concord	2006	01	18	0.138
South_Nash_Concord	2006	01	18	0.020
South_Nash_Concord	2006	01	18	0.019
South_Nash_Concord	2006	01	18	0.009
South_Nash_Concord	2006	01	24	0.005
South_Nash_Concord	2006	01	24	0.102
South_Nash_Concord	2006	01	24	0.142
South_Nash_Concord	2006	01	24	0.131
South_Nash_Concord	2006	01	24	0.091
South_Nash_Concord	2006	01	24	0.055
South_Nash_Concord	2006	01	24	0.015
South_Nash_Concord	2006	01	25	0.010
South_Nash_Concord	2006	01	25	0.050
South_Nash_Concord	2006	01	25	0.049
South_Nash_Concord	2006	01	25	0.035
South_Nash_Concord	2006	01	25	0.027
South_Nash_Concord	2006	01	25	0.014
South_Nash_Concord	2006	01	25	0.005
South_Nash_Concord	2006	01	26	0.009
South_Nash_Concord	2006	01	26	0.001
South_Nash_Concord	2006	01	29	0.003
South_Nash_Concord	2006	01	29	0.054
South_Nash_Concord	2006	01	29	0.072
South_Nash_Concord	2006	01	29	0.093
South_Nash_Concord	2006	01	29	0.128
South_Nash_Concord	2006	01	29	0.030
South_Nash_Concord	2006	01	30	0.003
South_Nash_Concord	2006	01	30	0.008
South_Nash_Concord	2006	02	01	0.032

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	02	01	0.043
South_Nash_Concord	2006	02	01	0.018
South_Nash_Concord	2006	02	01	0.012
South_Nash_Concord	2006	02	01	0.006
South_Nash_Concord	2006	02	03	0.001
South_Nash_Concord	2006	02	03	0.068
South_Nash_Concord	2006	02	03	0.168
South_Nash_Concord	2006	02	03	0.121
South_Nash_Concord	2006	02	03	0.039
South_Nash_Concord	2006	02	03	0.120
South_Nash_Concord	2006	02	03	0.147
South_Nash_Concord	2006	02	03	0.049
South_Nash_Concord	2006	02	03	0.008
South_Nash_Concord	2006	02	04	0.005
South_Nash_Concord	2006	02	04	0.054
South_Nash_Concord	2006	02	04	0.042
South_Nash_Concord	2006	02	04	0.027
South_Nash_Concord	2006	02	04	0.053
South_Nash_Concord	2006	02	04	0.097
South_Nash_Concord	2006	02	05	0.149
South_Nash_Concord	2006	02	05	0.168
South_Nash_Concord	2006	02	05	0.051
South_Nash_Concord	2006	02	05	0.108
South_Nash_Concord	2006	02	05	0.018
South_Nash_Concord	2006	02	05	0.003
South_Nash_Concord	2006	02	05	0.023
South_Nash_Concord	2006	02	05	0.235
South_Nash_Concord	2006	02	05	0.098
South_Nash_Concord	2006	02	05	0.022
South_Nash_Concord	2006	02	05	0.007
South_Nash_Concord	2006	02	05	0.003
South_Nash_Concord	2006	02	13	0.013
South_Nash_Concord	2006	02	13	0.012
South_Nash_Concord	2006	02	13	0.026
South_Nash_Concord	2006	02	13	0.038
South_Nash_Concord	2006	02	13	0.012
South_Nash_Concord	2006	02	14	0.005
South_Nash_Concord	2006	02	14	0.005
South_Nash_Concord	2006	02	14	0.007
South_Nash_Concord	2006	02	14	0.009
South_Nash_Concord	2006	02	14	0.004
South_Nash_Concord	2006	02	14	0.009
South_Nash_Concord	2006	02	14	0.001
South_Nash_Concord	2006	02	17	0.029
South_Nash_Concord	2006	02	17	0.041
South_Nash_Concord	2006	02	17	0.028
South_Nash_Concord	2006	02	17	0.023
South_Nash_Concord	2006	02	17	0.009
South_Nash_Concord	2006	02	23	0.012
South_Nash_Concord	2006	02	23	0.008
South_Nash_Concord	2006	03	09	0.003
South_Nash_Concord	2006	03	09	0.008
South_Nash_Concord	2006	03	10	0.007
South_Nash_Concord	2006	03	10	0.003
South_Nash_Concord	2006	03	10	0.018

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	03	10	0.003
South_Nash_Concord	2006	03	13	0.003
South_Nash_Concord	2006	03	13	0.018
South_Nash_Concord	2006	03	13	0.016
South_Nash_Concord	2006	03	13	0.042
South_Nash_Concord	2006	03	13	0.040
South_Nash_Concord	2006	03	13	0.011
South_Nash_Concord	2006	03	13	0.017
South_Nash_Concord	2006	03	13	0.251
South_Nash_Concord	2006	03	14	0.131
South_Nash_Concord	2006	03	14	0.002
South_Nash_Concord	2006	03	14	0.016
South_Nash_Concord	2006	03	14	0.023
South_Nash_Concord	2006	03	14	0.002
South_Nash_Concord	2006	03	14	0.026
South_Nash_Concord	2006	03	14	0.008
South_Nash_Concord	2006	03	14	0.006
South_Nash_Concord	2006	04	01	0.002
South_Nash_Concord	2006	04	01	0.008
South_Nash_Concord	2006	04	01	0.014
South_Nash_Concord	2006	04	01	0.024
South_Nash_Concord	2006	04	01	0.012
South_Nash_Concord	2006	04	03	0.003
South_Nash_Concord	2006	04	03	0.017
South_Nash_Concord	2006	04	04	0.042
South_Nash_Concord	2006	04	04	0.073
South_Nash_Concord	2006	04	04	0.103
South_Nash_Concord	2006	04	04	0.052
South_Nash_Concord	2006	04	04	0.009
South_Nash_Concord	2006	04	04	0.018
South_Nash_Concord	2006	04	04	0.139
South_Nash_Concord	2006	04	04	0.362
South_Nash_Concord	2006	04	04	0.268
South_Nash_Concord	2006	04	04	0.175
South_Nash_Concord	2006	04	04	0.051
South_Nash_Concord	2006	04	04	0.076
South_Nash_Concord	2006	04	04	0.035
South_Nash_Concord	2006	04	04	0.012
South_Nash_Concord	2006	04	04	0.008
South_Nash_Concord	2006	04	05	0.007
South_Nash_Concord	2006	04	05	0.016
South_Nash_Concord	2006	04	05	0.023
South_Nash_Concord	2006	04	05	0.018
South_Nash_Concord	2006	04	05	0.034
South_Nash_Concord	2006	04	05	0.050
South_Nash_Concord	2006	04	05	0.030
South_Nash_Concord	2006	04	05	0.003
South_Nash_Concord	2006	04	06	0.010
South_Nash_Concord	2006	04	07	0.035
South_Nash_Concord	2006	04	07	0.034
South_Nash_Concord	2006	04	07	0.020
South_Nash_Concord	2006	04	07	0.017
South_Nash_Concord	2006	04	07	0.004
South_Nash_Concord	2006	04	08	0.002
South_Nash_Concord	2006	04	08	0.008

Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	04	14	0.004
South_Nash_Concord	2006	04	15	0.006
South_Nash_Concord	2006	04	18	0.007
South_Nash_Concord	2006	04	18	0.003
South_Nash_Concord	2006	04	22	0.001
South_Nash_Concord	2006	04	22	0.044
South_Nash_Concord	2006	04	22	0.065
South_Nash_Concord	2006	04	22	0.049
South_Nash_Concord	2006	04	22	0.020
South_Nash_Concord	2006	04	23	0.005
South_Nash_Concord	2006	04	23	0.007
South_Nash_Concord	2006	04	23	0.022
South_Nash_Concord	2006	04	23	0.023
South_Nash_Concord	2006	04	23	0.025
South_Nash_Concord	2006	04	23	0.058
South_Nash_Concord	2006	04	23	0.022
South_Nash_Concord	2006	04	23	0.006
South_Nash_Concord	2006	04	23	0.004
South_Nash_Concord	2006	04	23	0.056
South_Nash_Concord	2006	04	23	0.055
South_Nash_Concord	2006	04	23	0.045
South_Nash_Concord	2006	04	23	0.052
South_Nash_Concord	2006	04	23	0.085
South_Nash_Concord	2006	04	23	0.081
South_Nash_Concord	2006	04	23	0.128
South_Nash_Concord	2006	04	23	0.017
South_Nash_Concord	2006	04	23	0.066
South_Nash_Concord	2006	04	24	0.118
South_Nash_Concord	2006	04	24	0.134
South_Nash_Concord	2006	04	24	0.044
South_Nash_Concord	2006	04	24	0.034
South_Nash_Concord	2006	04	24	0.006
South_Nash_Concord	2006	04	24	0.001
South_Nash_Concord	2006	04	24	0.013
South_Nash_Concord	2006	04	24	0.006
South_Nash_Concord	2006	04	24	0.012
South_Nash_Concord	2006	04	24	0.018
South_Nash_Concord	2006	04	24	0.007
South_Nash_Concord	2006	04	24	0.013
South_Nash_Concord	2006	04	25	0.008
South_Nash_Concord	2006	04	25	0.002
South_Nash_Concord	2006	05	02	0.003
South_Nash_Concord	2006	05	02	0.033
South_Nash_Concord	2006	05	02	0.043
South_Nash_Concord	2006	05	02	0.015
South_Nash_Concord	2006	05	02	0.090
South_Nash_Concord	2006	05	02	0.068
South_Nash_Concord	2006	05	02	0.110
South_Nash_Concord	2006	05	02	0.038
South_Nash_Concord	2006	05	02	0.020
South_Nash_Concord	2006	05	02	0.028
South_Nash_Concord	2006	05	02	0.015
South_Nash_Concord	2006	05	02	0.018
South_Nash_Concord	2006	05	02	0.028
South_Nash_Concord	2006	05	02	0.013

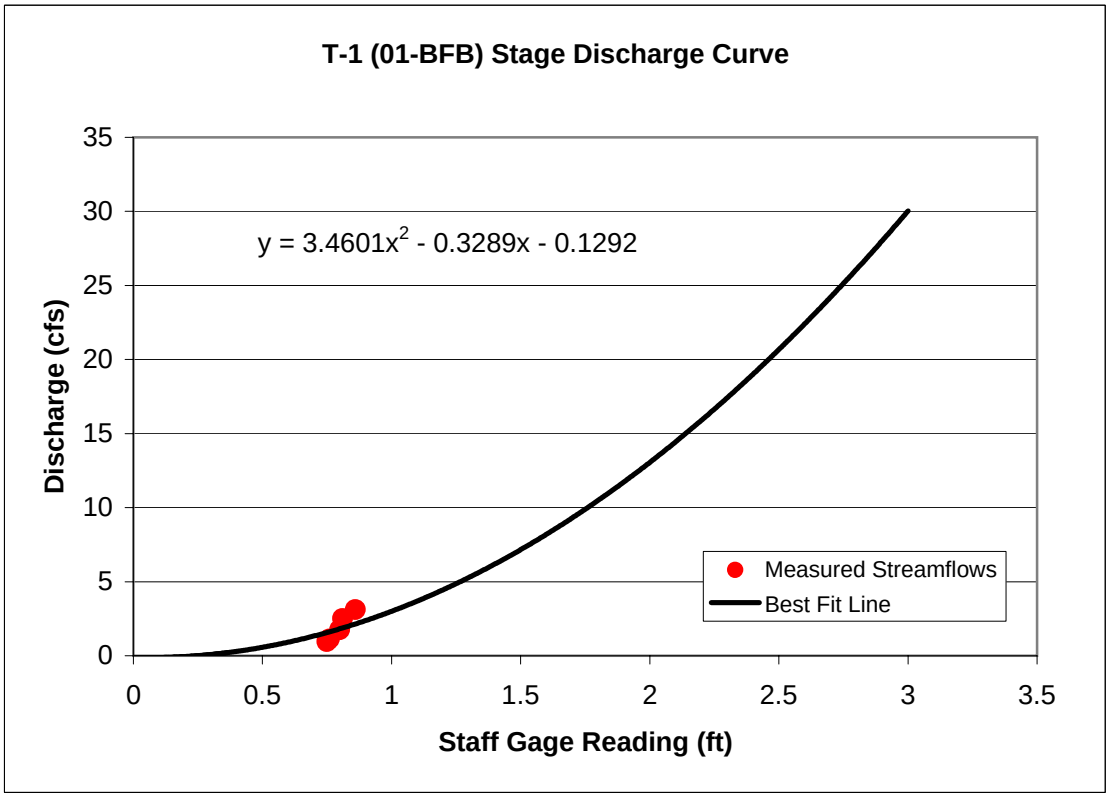
Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	05	02	0.008
South_Nash_Concord	2006	05	02	0.005
South_Nash_Concord	2006	05	02	0.005
South_Nash_Concord	2006	05	02	0.028
South_Nash_Concord	2006	05	03	0.048
South_Nash_Concord	2006	05	03	0.113
South_Nash_Concord	2006	05	03	0.045
South_Nash_Concord	2006	05	03	0.013
South_Nash_Concord	2006	05	03	0.010
South_Nash_Concord	2006	05	03	0.013
South_Nash_Concord	2006	05	03	0.010
South_Nash_Concord	2006	05	03	0.115
South_Nash_Concord	2006	05	03	0.019
South_Nash_Concord	2006	05	03	0.014
South_Nash_Concord	2006	05	03	0.012
South_Nash_Concord	2006	05	03	0.024
South_Nash_Concord	2006	05	03	0.024
South_Nash_Concord	2006	05	03	0.011
South_Nash_Concord	2006	05	03	0.008
South_Nash_Concord	2006	05	03	0.008
South_Nash_Concord	2006	05	03	0.008
South_Nash_Concord	2006	05	03	0.005
South_Nash_Concord	2006	05	09	0.013
South_Nash_Concord	2006	05	09	0.028
South_Nash_Concord	2006	05	09	0.058
South_Nash_Concord	2006	05	09	0.058
South_Nash_Concord	2006	05	09	0.025
South_Nash_Concord	2006	05	09	0.025
South_Nash_Concord	2006	05	09	0.050
South_Nash_Concord	2006	05	09	0.040
South_Nash_Concord	2006	05	09	0.018
South_Nash_Concord	2006	05	10	0.005
South_Nash_Concord	2006	05	10	0.012
South_Nash_Concord	2006	05	10	0.003
South_Nash_Concord	2006	05	10	0.008
South_Nash_Concord	2006	05	10	0.035
South_Nash_Concord	2006	05	10	0.045
South_Nash_Concord	2006	05	10	0.027
South_Nash_Concord	2006	05	10	0.087
South_Nash_Concord	2006	05	10	0.120
South_Nash_Concord	2006	05	10	0.048
South_Nash_Concord	2006	05	10	0.025
South_Nash_Concord	2006	05	10	0.057
South_Nash_Concord	2006	05	10	0.012
South_Nash_Concord	2006	05	10	0.005
South_Nash_Concord	2006	05	11	0.002
South_Nash_Concord	2006	05	11	0.007
South_Nash_Concord	2006	05	11	0.022
South_Nash_Concord	2006	05	11	0.018
South_Nash_Concord	2006	05	11	0.007
South_Nash_Concord	2006	05	11	0.002
South_Nash_Concord	2006	05	11	0.007
South_Nash_Concord	2006	05	11	0.010
South_Nash_Concord	2006	05	11	0.002
South_Nash_Concord	2006	05	12	0.007

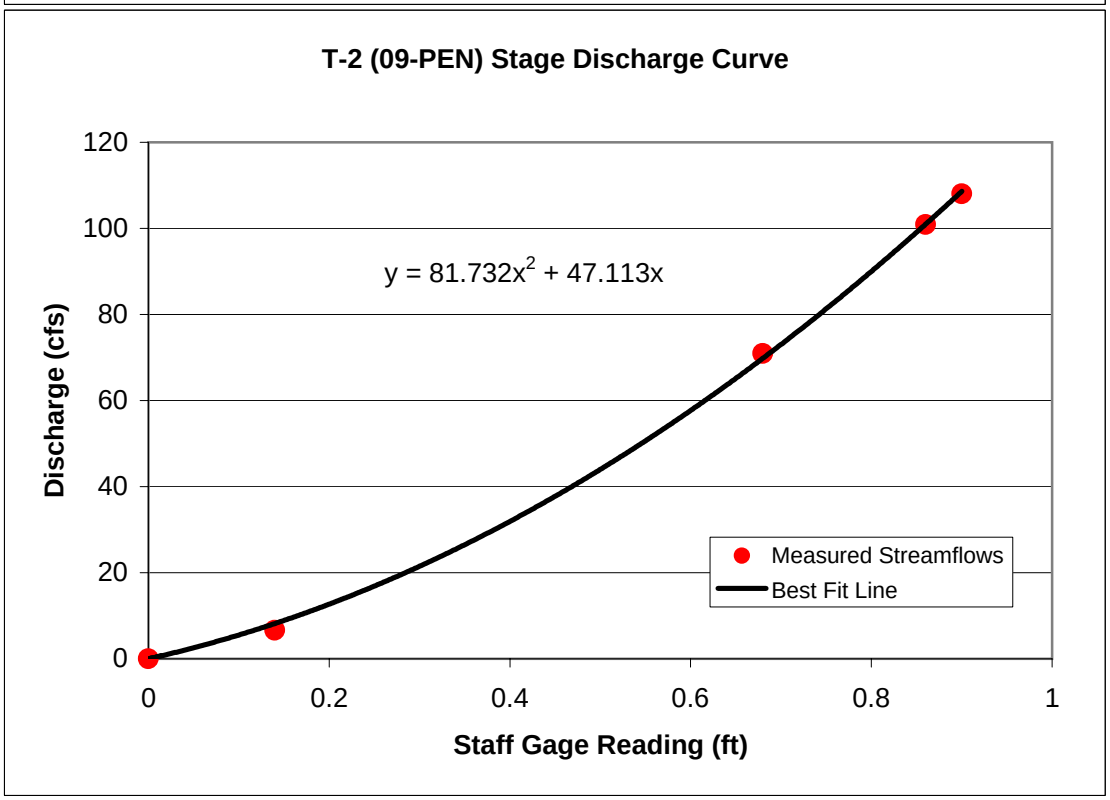
Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	05	12	0.002
South_Nash_Concord	2006	05	12	0.020
South_Nash_Concord	2006	05	12	0.050
South_Nash_Concord	2006	05	12	0.012
South_Nash_Concord	2006	05	13	0.055
South_Nash_Concord	2006	05	13	0.080
South_Nash_Concord	2006	05	13	0.017
South_Nash_Concord	2006	05	13	0.252
South_Nash_Concord	2006	05	13	0.215
South_Nash_Concord	2006	05	13	0.037
South_Nash_Concord	2006	05	13	0.005
South_Nash_Concord	2006	05	13	0.065
South_Nash_Concord	2006	05	13	0.150
South_Nash_Concord	2006	05	13	0.223
South_Nash_Concord	2006	05	13	0.175
South_Nash_Concord	2006	05	13	0.173
South_Nash_Concord	2006	05	13	0.095
South_Nash_Concord	2006	05	13	0.110
South_Nash_Concord	2006	05	13	0.219
South_Nash_Concord	2006	05	13	0.228
South_Nash_Concord	2006	05	13	0.256
South_Nash_Concord	2006	05	13	0.396
South_Nash_Concord	2006	05	13	0.263
South_Nash_Concord	2006	05	13	0.160
South_Nash_Concord	2006	05	13	0.108
South_Nash_Concord	2006	05	13	0.085
South_Nash_Concord	2006	05	13	0.057
South_Nash_Concord	2006	05	13	0.027
South_Nash_Concord	2006	05	14	0.070
South_Nash_Concord	2006	05	14	0.172
South_Nash_Concord	2006	05	14	0.193
South_Nash_Concord	2006	05	14	0.105
South_Nash_Concord	2006	05	14	0.063
South_Nash_Concord	2006	05	14	0.042
South_Nash_Concord	2006	05	14	0.130
South_Nash_Concord	2006	05	14	0.280
South_Nash_Concord	2006	05	14	0.273
South_Nash_Concord	2006	05	14	0.138
South_Nash_Concord	2006	05	14	0.302
South_Nash_Concord	2006	05	14	0.190
South_Nash_Concord	2006	05	14	0.047
South_Nash_Concord	2006	05	14	0.028
South_Nash_Concord	2006	05	14	0.015
South_Nash_Concord	2006	05	14	0.227
South_Nash_Concord	2006	05	14	0.243
South_Nash_Concord	2006	05	14	0.102
South_Nash_Concord	2006	05	14	0.102
South_Nash_Concord	2006	05	14	0.060
South_Nash_Concord	2006	05	14	0.080
South_Nash_Concord	2006	05	14	0.055
South_Nash_Concord	2006	05	14	0.008
South_Nash_Concord	2006	05	14	0.020
South_Nash_Concord	2006	05	15	0.015
South_Nash_Concord	2006	05	15	0.010
South_Nash_Concord	2006	05	15	0.005

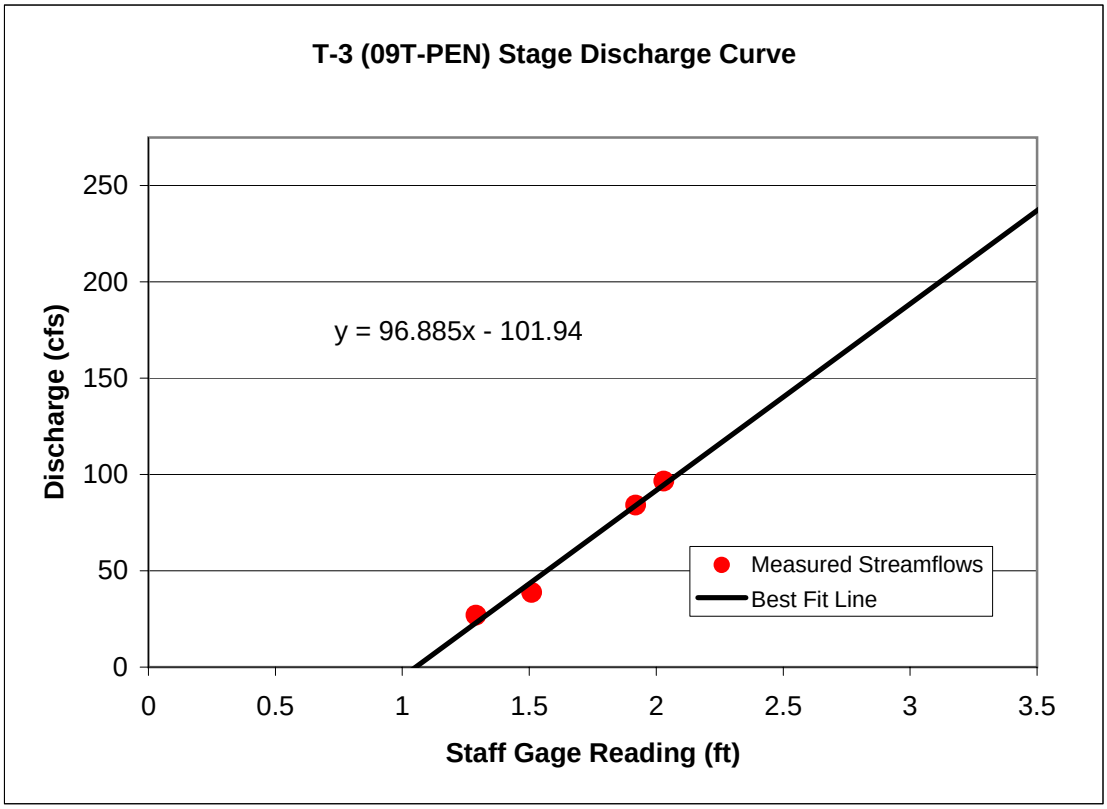
Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	05	15	0.005
South_Nash_Concord	2006	05	15	0.015
South_Nash_Concord	2006	05	15	0.008
South_Nash_Concord	2006	05	15	0.005
South_Nash_Concord	2006	05	15	0.050
South_Nash_Concord	2006	05	15	0.060
South_Nash_Concord	2006	05	15	0.008
South_Nash_Concord	2006	05	15	0.002
South_Nash_Concord	2006	05	15	0.008
South_Nash_Concord	2006	05	15	0.008
South_Nash_Concord	2006	05	15	0.012
South_Nash_Concord	2006	05	15	0.005
South_Nash_Concord	2006	05	16	0.005
South_Nash_Concord	2006	05	16	0.015
South_Nash_Concord	2006	05	16	0.080
South_Nash_Concord	2006	05	16	0.055
South_Nash_Concord	2006	05	16	0.023
South_Nash_Concord	2006	05	16	0.007
South_Nash_Concord	2006	05	16	0.015
South_Nash_Concord	2006	05	16	0.055
South_Nash_Concord	2006	05	16	0.058
South_Nash_Concord	2006	05	16	0.095
South_Nash_Concord	2006	05	16	0.075
South_Nash_Concord	2006	05	16	0.013
South_Nash_Concord	2006	05	16	0.027
South_Nash_Concord	2006	05	16	0.013
South_Nash_Concord	2006	05	17	0.045
South_Nash_Concord	2006	05	17	0.015
South_Nash_Concord	2006	05	19	0.002
South_Nash_Concord	2006	05	19	0.110
South_Nash_Concord	2006	05	19	0.088
South_Nash_Concord	2006	05	19	0.082
South_Nash_Concord	2006	05	19	0.265
South_Nash_Concord	2006	05	19	0.100
South_Nash_Concord	2006	05	19	0.030
South_Nash_Concord	2006	05	19	0.070
South_Nash_Concord	2006	05	21	0.020
South_Nash_Concord	2006	05	21	0.175
South_Nash_Concord	2006	05	21	0.025
South_Nash_Concord	2006	05	21	0.075
South_Nash_Concord	2006	05	21	0.145
South_Nash_Concord	2006	05	26	0.177
South_Nash_Concord	2006	05	26	0.050
South_Nash_Concord	2006	05	26	0.023
South_Nash_Concord	2006	06	01	0.063
South_Nash_Concord	2006	06	01	0.202
South_Nash_Concord	2006	06	01	0.153
South_Nash_Concord	2006	06	02	0.088
South_Nash_Concord	2006	06	02	0.075
South_Nash_Concord	2006	06	02	0.080
South_Nash_Concord	2006	06	02	0.008
South_Nash_Concord	2006	06	02	0.007
South_Nash_Concord	2006	06	02	0.012
South_Nash_Concord	2006	06	02	0.015
South_Nash_Concord	2006	06	02	0.007

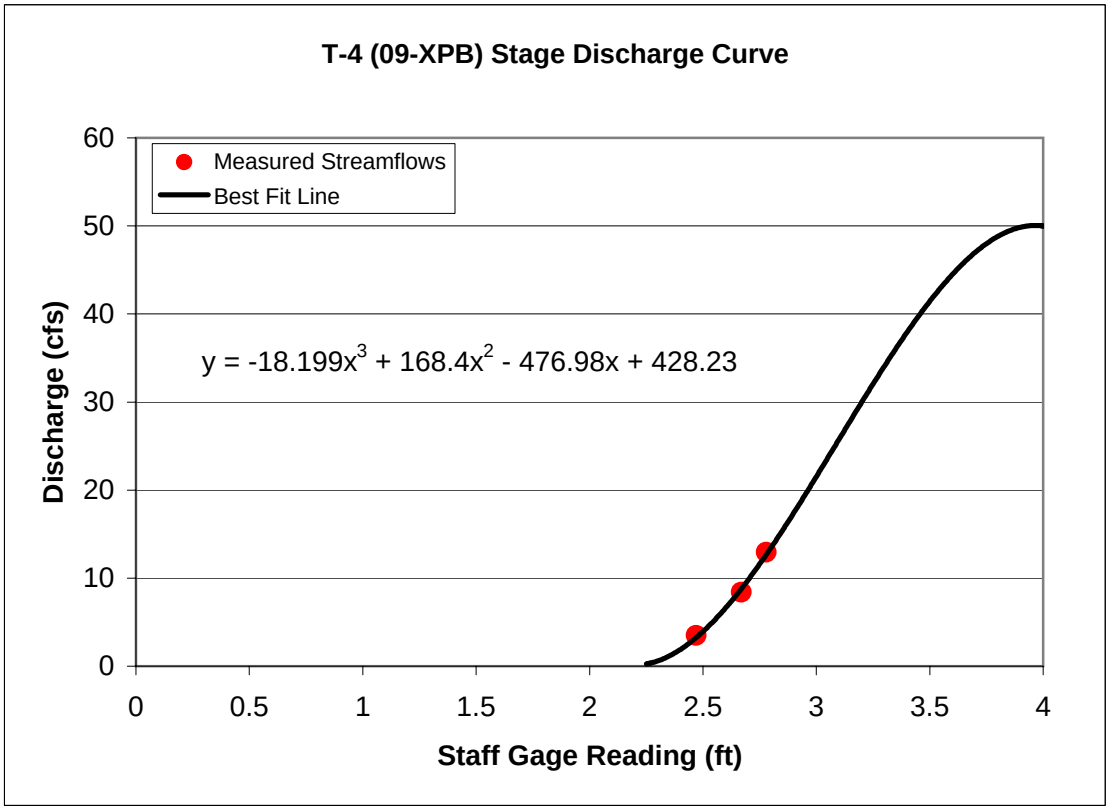
Composite Site Name	Year	Month	Day	Daily Summary of Precipitation (in)
South_Nash_Concord	2006	06	02	0.002
South_Nash_Concord	2006	06	02	0.008
South_Nash_Concord	2006	06	02	0.005
South_Nash_Concord	2006	06	02	0.010
South_Nash_Concord	2006	06	02	0.043
South_Nash_Concord	2006	06	02	0.020
South_Nash_Concord	2006	06	02	0.040
South_Nash_Concord	2006	06	03	0.008
South_Nash_Concord	2006	06	03	0.002
South_Nash_Concord	2006	06	03	0.018
South_Nash_Concord	2006	06	03	0.015
South_Nash_Concord	2006	06	03	0.057
South_Nash_Concord	2006	06	03	0.087
South_Nash_Concord	2006	06	03	0.139
South_Nash_Concord	2006	06	03	0.058
South_Nash_Concord	2006	06	03	0.084
South_Nash_Concord	2006	06	03	0.030
South_Nash_Concord	2006	06	03	0.015
South_Nash_Concord	2006	06	03	0.010
South_Nash_Concord	2006	06	03	0.030
South_Nash_Concord	2006	06	03	0.022
South_Nash_Concord	2006	06	03	0.025
South_Nash_Concord	2006	06	03	0.023
South_Nash_Concord	2006	06	03	0.040
South_Nash_Concord	2006	06	03	0.175
South_Nash_Concord	2006	06	03	0.202
South_Nash_Concord	2006	06	03	0.078
South_Nash_Concord	2006	06	03	0.068
South_Nash_Concord	2006	06	03	0.075
South_Nash_Concord	2006	06	03	0.095
South_Nash_Concord	2006	06	03	0.092
South_Nash_Concord	2006	06	04	0.138
South_Nash_Concord	2006	06	04	0.110
South_Nash_Concord	2006	06	04	0.015
South_Nash_Concord	2006	06	04	0.028
South_Nash_Concord	2006	06	04	0.008
South_Nash_Concord	2006	06	04	0.010
South_Nash_Concord	2006	06	04	0.008
South_Nash_Concord	2006	06	04	0.002

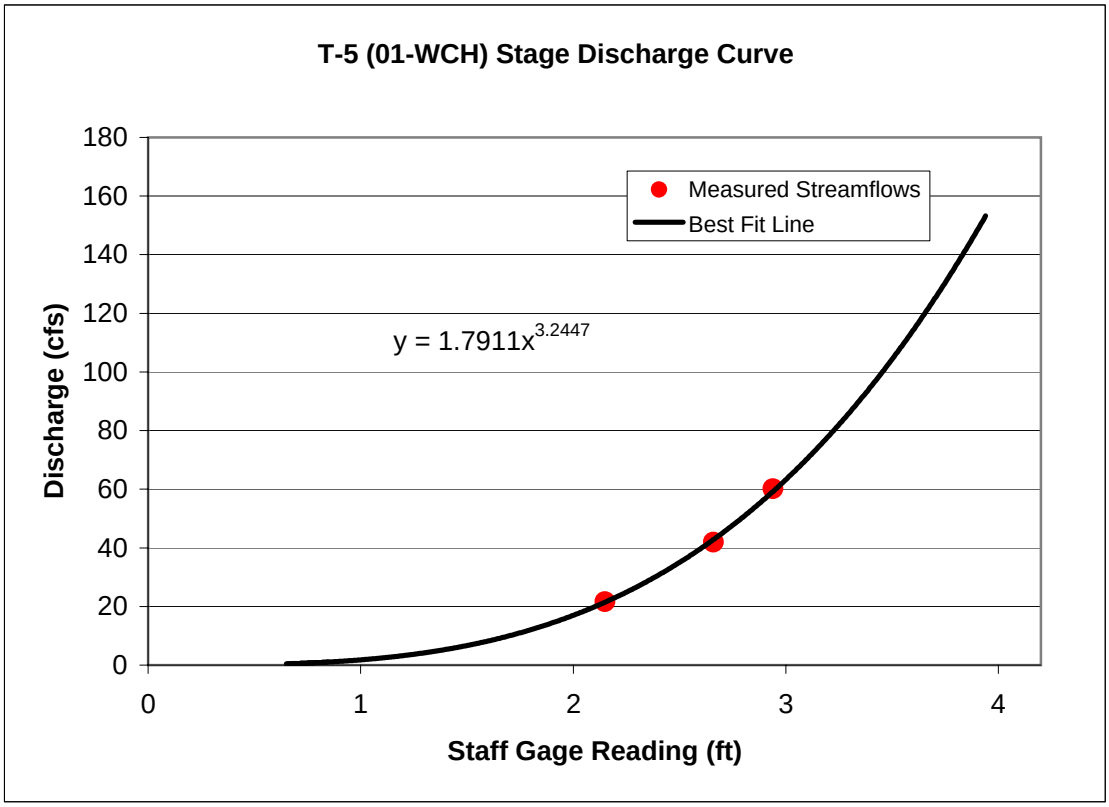
Appendix B Stage Discharge Curves

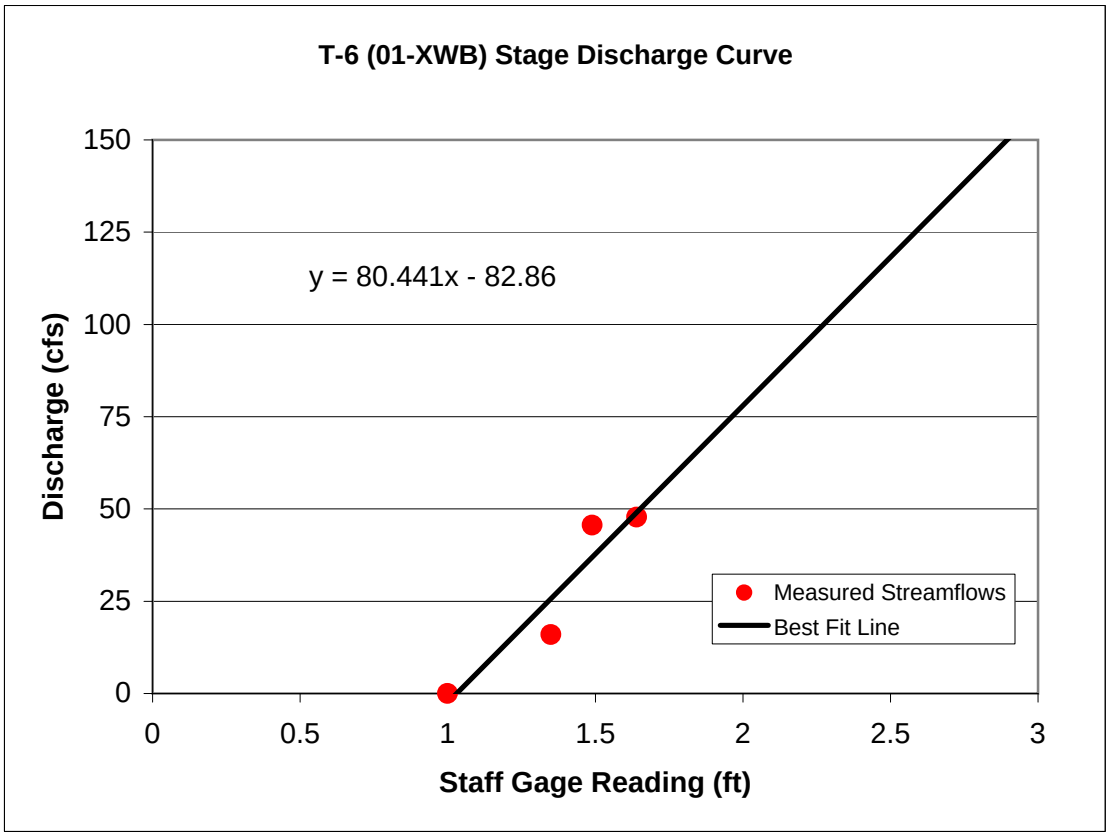

T-1 (01-BFB) Stage Discharge Curve
y = 3.4601x2 - 0.3289x - 0.1292
Discharge (cfs)
Staff Gage Reading (ft)
Measured Streamflows
Best Fit Line
0
5
10
15
20
25
30
35
0
0.5
1
1.5
2
2.5
3
3.5

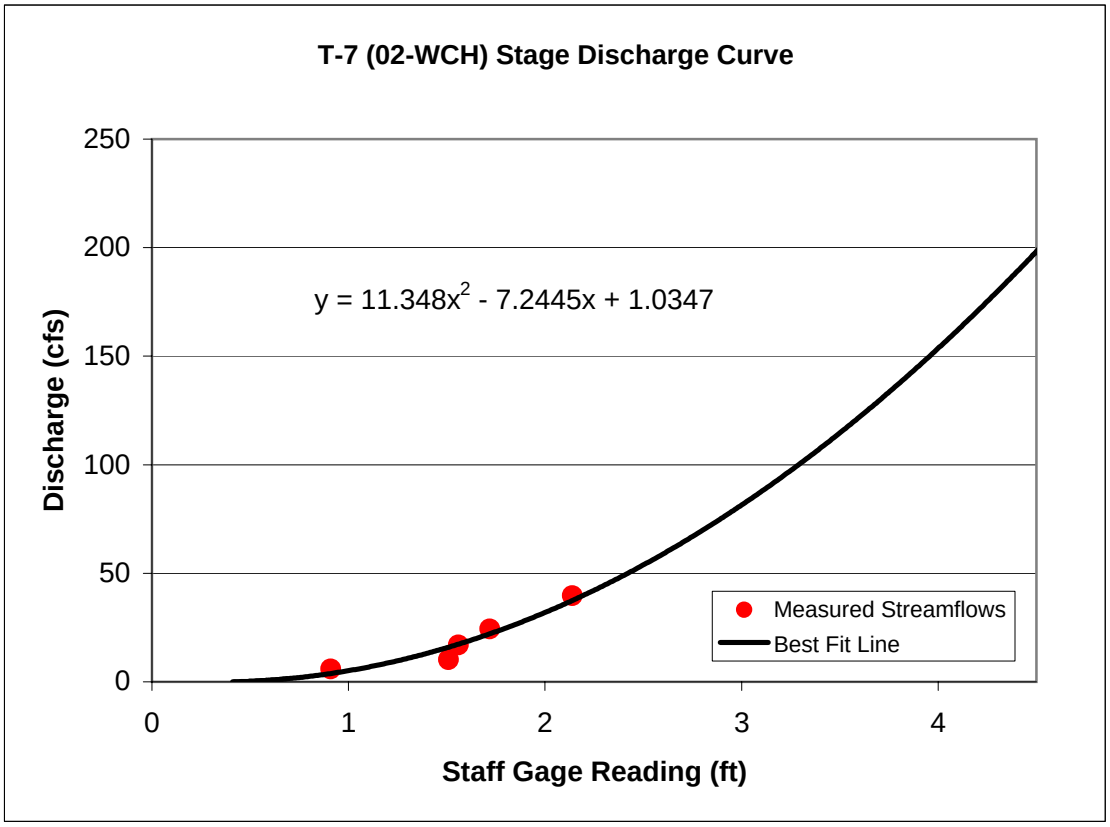

T-2 (09-PEN) Stage Discharge Curve
y = 81.732x2 + 47.113x
Discharge (cfs)
Staff Gage Reading (ft)
Measured Streamflows
Best Fit Line
0
20
40
60
80
100
120
0
0.2
0.4
0.6
0.8
1

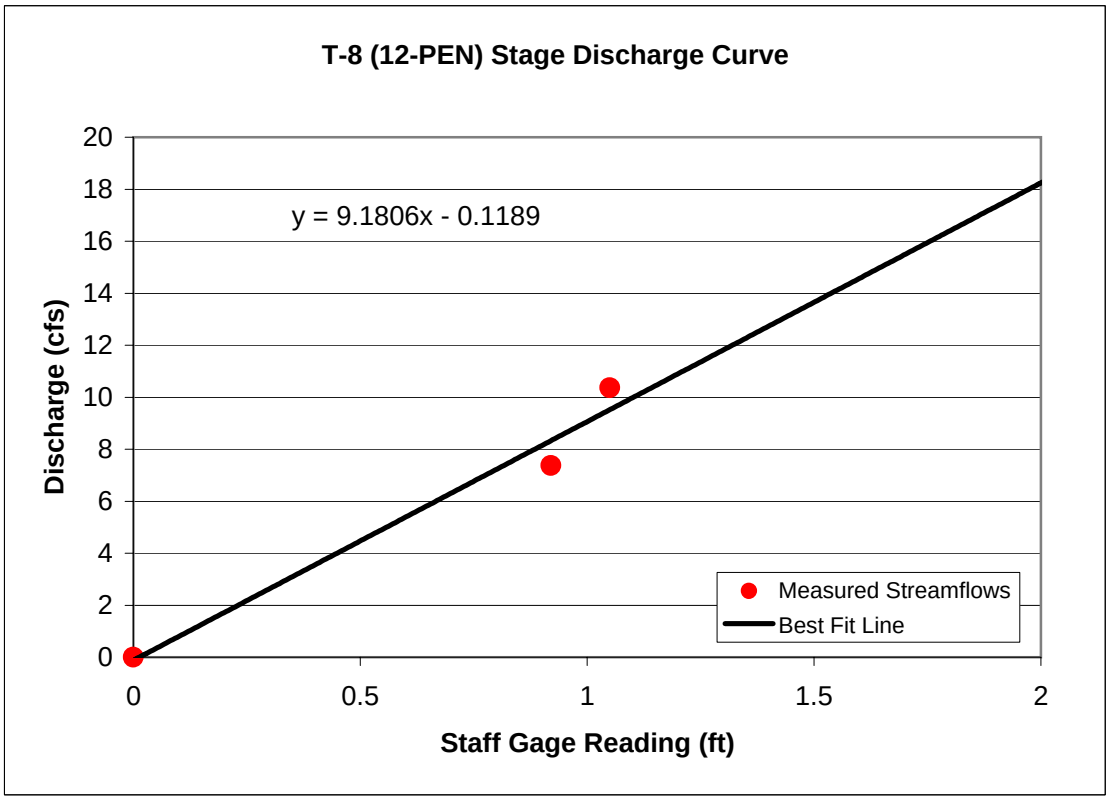

T-3 (09T-PEN) Stage Discharge Curve
Discharge (cfs)
Staff Gage Reading (ft)
y = 96.885x - 101.94
Measured Streamflows
Best Fit Line
0
50
100
150
200
250
0
0.5
1
1.5
2
2.5
3
3.5

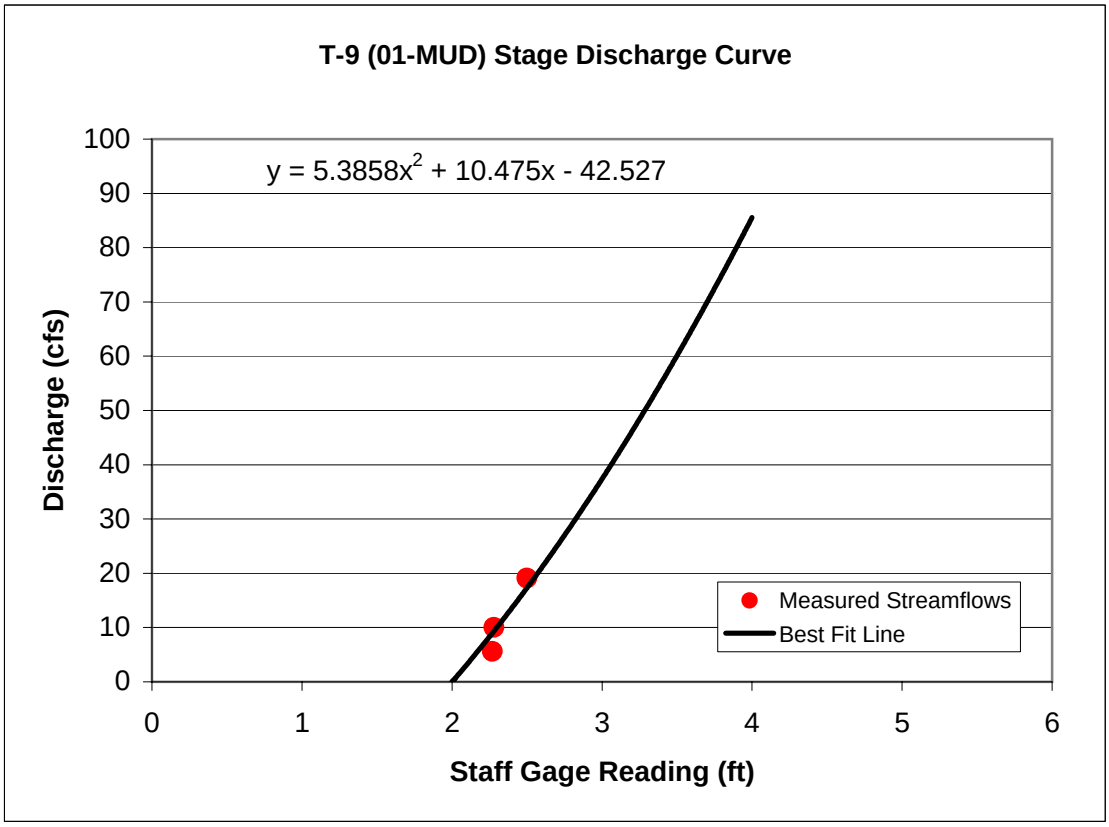

T-4 (09-XPB) Stage Discharge Curve
Discharge (cfs)
Staff Gage Reading (ft)
y = -18.199x3 + 168.4x2 - 476.98x + 428.23
Measured Streamflows
Best Fit Line
0
10
20
30
40
50
60
0
0.5
1
1.5
2
2.5
3
3.5
4


T-5 (01-WCH) Stage Discharge Curve
Measured Streamflows
Best Fit Line
y = 1.7911x^3.2447
Discharge (cfs)
Staff Gage Reading (ft)
0
20
40
60
80
100
120
140
160
180
0
1
2
3
4


T-6 (01-XWB) Stage Discharge Curve
y = 80.441x - 82.86
Measured Streamflows
Best Fit Line
Discharge (cfs)
Staff Gage Reading (ft)
0
25
50
75
100
125
150
0
0.5
1
1.5
2
2.5
3


T-7 (02-WCH) Stage Discharge Curve
y = 11.348x2 - 7.2445x + 1.0347
Discharge (cfs)
Staff Gage Reading (ft)
Measured Streamflows
Best Fit Line
0
50
100
150
200
250
0
1
2
3
4


T-8 (12-PEN) Stage Discharge Curve
y = 9.1806x - 0.1189
Discharge (cfs)
Staff Gage Reading (ft)
Measured Streamflows
Best Fit Line
0
2
4
6
8
10
12
14
16
18
20
0
0.5
1
1.5
2


T-9 (01-MUD) Stage Discharge Curve
y = 5.3858x2 + 10.475x - 42.527
Discharge (cfs)
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
Staff Gage Reading (ft)
Measured Streamflows
Best Fit Line

T-1 Streamflow Calculations Page 1										
			06/12/05 Staff Gage Reading			0.76	06/22/05 Staff Gage Reading			0.75
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow
14.5										
15	4.72	0.13	0.63	0.32	0.28	0.09	0.62	0.31	0.22	0.07
15.5	4.62	0.23	0.53	0.27	0.55	0.15	0.52	0.26	0.43	0.11
16	5.07	-0.22	0.98	0.49	0.42	0.21	0.97	0.49	0.47	0.23
16.5	5.1	-0.25	1.01	0.51	0.45	0.23	1.00	0.50	0.45	0.23
17	5.02	-0.17	0.93	0.47	0.31	0.14	0.92	0.46	0.34	0.16
17.5	5.08	-0.23	0.99	0.50	0.27	0.13	0.98	0.49	0.23	0.11
18	5.1	-0.25	1.01	0.51	0.15	0.08	1.00	0.50	0.08	0.04
18.5	4.99	-0.14	0.9	0.45	0.12	0.05	0.89	0.45	0.03	0.01
19	4.93	-0.08	0.84	0.42	0.06	0.03	0.83	0.42	0.00	0.00
19.5	4.81	0.04	0.72	0.36	0.04	0.01	0.71	0.36	0.06	0.02
20	4.66	0.19	0.57	0.29	0.02	0.01	0.56	0.28	-0.05	-0.01
20.5	4.52	0.33	0.43	0.22	0.01	0.00	0.42	0.21	-0.07	-0.01
21	4.37	0.48	0.28	0.14	0	0.00	0.27	0.14	0.00	0.00
21.5	4.3	0.55	0.21	0.11	0	0.00	0.20	0.10	0.00	0.00
22	4.2	0.65	0.11	0.06	0	0.00	0.10	0.05	0.00	0.00
22.5	4.1	0.75	0.01	0.01	0	0.00	0.00	0.00	0.00	0.00
23	3.96	0.89	0	0.00	0	0.00	0.00	0.00	0.00	0.00
23.5	3.8	1.05	0	0.00	0	0.00	0.00	0.00	0.00	0.00
24	3.5	1.35	0	0.00	0	0.00	0.00	0.00	0.00	0.00
24.5	3.72	1.13	0	0.00	0	0.00	0.00	0.00	0.00	0.00
25	2.58	2.27	0	0.00	0	0.00	0.00	0.00	0.00	0.00
25.5				5.08	Flow	1.12	cfs	5.00	Flow	0.948

Site Survey Information			
		Staff Guage Shot	4.85
		Staff Guage Reading	0.76
	Benchmark (Invert of Middle Culvert)		3.56

T-1 Streamflow Calculations Page 2											
11/16/05 Staff Gage Reading			0.80	12/1/05 Staff Gage Reading			0.86	1/13/06 Staff Gage Reading			0.81
Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow
0.67	0.67	0.13	0.09	0.73	0.73	0.53	0.39	0.68	0.68	0.44	0.30
0.57			0.00	0.63			0.00				0.00
1.02	1.02	0.53	0.54	1.08	1.08	0.88	0.95	1.03	1.03	0.78	0.80
1.05			0.00	1.11			0.00				0.00
0.97	0.97	0.51	0.49	1.03	1.03	0.64	0.66	0.98	0.98	0.51	0.50
1.03			0.00	1.09			0.00				0.00
1.05	1.05	0.37	0.39	1.11	1.11	0.46	0.51	1.06	1.06	0.49	0.52
0.94			0.00	1.00			0.00				0.00
0.88	0.88	0.22	0.19	0.94	0.94	0.45	0.42	0.89	0.89	0.28	0.25
0.76			0.00	0.82			0.00				0.00
0.61	0.61	0.09	0.05	0.67	0.67	0.22	0.15	0.62	0.62	0.18	0.11
0.47			0.00	0.53			0.00				0.00
0.32	0.32	0.00	0.00	0.38	0.38	0.09	0.03	0.33	0.33	0.06	0.02
0.25			0.00	0.31			0.00				0.00
0.15	0.15		0.00	0.21	0.21	0.02	0.00	0.16	0.16	0.01	0.00
0.05	0.05		0.00				0.00				0.00
0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00
0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00
0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00
0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00
0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00
cfs	5.72	Flow	1.76	cfs	6.15	Flow	3.12	cfs	5.75	Flow	2.50

T-2 Streamflow Calculations					
Location	D.L. Reading*	S.G.Reading**	Depth	Width	Flow
9/29/2005	1.73	0.14	0.14	38.00	6.63
11/17/2005	2.27	0.68	0.68	38.00	70.96
12/1/2005	2.49	0.90	0.9	38.00	108.04
1/13/2006	2.45	0.86	0.86	38.00	100.92

*D.L. = Datalogger Reading
**S.G. = Staff Gage Readings

T-3 Streamflow Calculations Page 1											
Site Information			06/12/05 Staff Gage Reading			1.51	06/22/05 Staff Gage Reading			1.29	
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	
55.9	start										
56	11.57	1.02	0.49	0.27	0.38	0.10	0.27	0.15	0.04	0.01	
57	11.57	1.02	0.49	0.49	0.38	0.19	0.27	0.27	0.04	0.01	
58	14.53	-1.94	3.45	3.45	0.62	2.14	3.23	3.23	0.48	1.55	
59	14.51	-1.92	3.43	3.43	0.54	1.85	3.21	3.21	0.64	2.05	
60	15.04	-2.45	3.96	3.96	1.03	4.08	3.74	3.74	0.64	2.39	
61	15.31	-2.72	4.23	4.23	1.03	4.36	4.01	4.01	0.74	2.97	
62	15.72	-3.13	4.64	4.64	1.03	4.78	4.42	4.42	0.78	3.45	
63	14.9	-2.31	3.82	3.82	1.01	3.86	3.60	3.60	0.81	2.92	
64	15.61	-3.02	4.53	4.53	0.98	4.44	4.31	4.31	0.75	3.23	
65	15.51	-2.92	4.43	4.43	0.94	4.16	4.21	4.21	0.73	3.07	
66	15.75	-3.16	4.67	4.67	1.15	5.37	4.45	4.45	0.74	3.29	
67	15.56	-2.97	4.48	3.36	1.02	3.43	4.26	3.20	0.64	2.04	
67.5	end			41.28	Flow	38.75	cfs	38.79	Flow	26.99	cfs

Site Survey Information	
Staff Guage Shot	12.59
Staff Guage Reading	1.51
BM top of steel 2.92	

T-3 Streamflow Calculations Page 2											
		1/13/06 Staff Gage Reading			2.03		2/01/06 Staff Gage Reading			1.92	
	EL	Depth	Area	Velocity	Flow		Depth	Area	Velocity	Flow	
86.5											
87.50	1.02	1.01	0.505	2.43	1.23		0.9	0.45	2.29	1.03	
88.50	1.02	1.01	1.01	2.53	2.56		0.9	0.90	1.93	1.74	
89.50	-1.94	3.97	3.97	2.34	9.29		3.86	3.86	2.02	7.80	
90.50	-1.92	3.95	3.95	2.37	9.36		3.84	3.84	1.93	7.41	
91.50	-2.45	4.48	4.48	2.35	10.53		4.37	4.37	2.03	8.87	
92.50	-2.72	4.75	4.75	2.17	10.31		4.64	4.64	2.04	9.47	
93.50	-3.13	5.16	5.16	2.27	11.71		5.05	5.05	1.97	9.95	
94.50	-2.31	4.34	4.34	2.19	9.50		4.23	4.23	1.93	8.16	
95.50	-3.02	5.05	5.05	1.77	8.94		4.94	4.94	1.79	8.84	
96.50	-2.92	4.95	4.95	1.79	8.86		4.84	4.84	1.78	8.62	
97.50	-3.16	5.19	5.19	1.88	9.76		5.08	5.08	1.63	8.28	
98.50	-2.97	5.00	2.50	1.77	4.43		4.89	2.45	1.57	3.84	
			45.855	Flow	96.47	cfs		44.645	Flow	84.00	cfs

T-4 Streamflow Calculations											
			11/16/05 Staff Gage Reading			2.47	11/16/05 Staff Gage Reading			2.78	
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	
Culvert	3.7	-1.23	3.7	11.26	0.31	3.49	4.01	11.34	1.14	12.93	
					Flow	3.49	cfs		Flow	12.93	cfs

Site Survey Information	
Staff Guage Reading	2.47

1/13/06 Staff Gage Reading			2.67	
Depth	Area	Velocity	Flow	
3.9	11.34	0.74	8.39	
		Flow	8.39	cfs

T-5 Streamflow Calculations Page 1											
			11/16/05 Staff Gage Reading			2.15	12/1/05 Staff Gage Reading			2.94	
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	
Culv A	0.78	1.37	0.78	1.64	0.15	0.25	1.57	3.30	1.5	4.95	
Culv C	0.85	1.3	0.85	1.87	0.39	0.73	1.64	3.61	1.59	5.74	
36											
37	3.66	-1.51	3.66	3.66	1.08	3.95	4.45	4.45	1.58	7.03	
38	3.45	-1.3	3.45	3.45	0.9	3.11	4.24	4.24	2.25	9.54	
39	3.45	-1.3	3.45	3.45	0.95	3.28	4.24	4.24	2.1	8.90	
40	3.38	-1.23	3.38	3.38	1.11	3.75	4.17	4.17	2.3	9.59	
41	3.68	-1.53	3.68	3.68	1.31	4.82	4.47	4.47	2.44	10.91	
42	3.65	-1.5	3.65	3.65	0.55	2.01	4.44	4.44	1.24	5.51	
43	3.36	-1.21	3.36	3.36	-0.08	-0.27	4.15	4.15	-0.48	-1.99	
44	End										
					Flow	21.62	cfs		Flow	60.17	cfs

Site Survey Information	
Staff Guage Reading	2.15

T-5 Streamflow Calculations Page 2			
1/13/06 Staff Gage Reading			2.66
Depth	Area	Velocity	Flow
1.29	2.71	1.02	2.76
1.36	2.99	1.05	3.14
4.17	4.17	1.32	5.50
3.96	3.96	1.47	5.82
3.96	3.96	1.72	6.81
3.89	3.89	1.78	6.92
4.19	4.19	1.98	8.30
4.16	4.16	0.89	3.70
3.87	3.87	-0.28	-1.08
		Flow	41.88

T-6 Streamflow Calculations Page 1							
			11/16/05 Staff Gage Reading			1.35	
Location	Reading	Elevation	Depth	Area	Velocity	Flow	
3		1.35	0	0.00	0	0.00	
4	0.45	0.9	0.45	0.45	0	0.00	
5	0.82	0.53	0.82	0.82	0	0.00	
6	1	0.35	1	1.00	0.01	0.01	
7	1.18	0.17	1.18	1.18	0.02	0.02	
8	1.39	-0.04	1.39	1.39	0.04	0.06	
9	1.55	-0.2	1.55	1.55	0.03	0.05	
10	1.49	-0.14	1.49	1.49	-0.01	-0.01	
11	1.71	-0.36	1.71	1.71	0.08	0.14	
12	1.96	-0.61	1.96	1.96	0.09	0.18	
13	2.25	-0.9	2.25	2.25	0.11	0.25	
14	2.57	-1.22	2.57	2.57	0.23	0.59	
15	2.77	-1.42	2.77	2.77	0.34	0.94	
16	2.88	-1.53	2.88	2.88	0.43	1.24	
17	2.88	-1.53	2.88	2.88	0.44	1.27	
18	2.73	-1.38	2.73	2.73	0.4	1.09	
19	2.66	-1.31	2.66	2.66	0.32	0.85	
20	2.54	-1.19	2.54	2.54	0.25	0.64	
21	2.71	-1.36	2.71	2.71	0.25	0.68	
22	2.57	-1.22	2.57	2.57	0.22	0.57	
23	3.31	-1.96	3.31	3.31	0.22	0.73	
24	3.33	-1.98	3.33	3.33	0.24	0.80	
25	2.99	-1.64	2.99	2.99	0.12	0.36	
26	3.8	-2.45	3.8	3.80	0.22	0.84	
27	3.93	-2.58	3.93	3.93	0.24	0.94	
28	4.22	-2.87	4.22	4.22	0.22	0.93	
29	4.06	-2.71	4.06	4.06	0.3	1.22	
30	3.71	-2.36	3.71	3.71	0.17	0.63	
31	3.23	-1.88	3.23	3.23	0.16	0.52	
32	2.46	-1.11	2.46	2.46	0.1	0.25	
33	1.86	-0.51	1.86	1.86	0.1	0.19	
					Flow	15.93	cfs

Site Survey Information	
Staff Guage Reading	1.35

T-6 Streamflow Calculations Page 2								
12/1/05 Staff Gage Reading			1.64	12/1/05 Staff Gage Reading			1.49	
Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	
0.29	0.29	0	0.00	0.14	0.14	0	0.00	
0.74	0.74	0	0.00	0.59	0.59	0	0.00	
1.11	1.11	0	0.00	0.96	0.96	0	0.00	
1.29	1.29	0	0.00	1.14	1.14	-0.2	-0.23	
1.47	1.47	0	0.00	1.32	1.32	0	0.00	
1.68	1.68	-0.05	-0.08	1.53	1.53	0.04	0.06	
1.84	1.84	0	0.00	1.69	1.69	0.04	0.07	
1.78	1.78	0	0.00	1.63	1.63	0.06	0.10	
2	2.00	0.12	0.24	1.85	1.85	0.06	0.11	
2.25	2.25	0.36	0.81	2.1	2.10	0.09	0.19	
2.54	2.54	0.28	0.71	2.39	2.39	0.14	0.33	
2.86	2.86	0.26	0.74	2.71	2.71	0.19	0.51	
3.06	3.06	0.39	1.19	2.91	2.91	0.23	0.67	
3.17	3.17	0.75	2.38	3.02	3.02	0.65	1.96	
3.17	3.17	0.75	2.38	3.02	3.02	0.67	2.02	
3.02	3.02	0.85	2.57	2.87	2.87	0.81	2.32	
2.95	2.95	0.95	2.80	2.8	2.80	0.83	2.32	
2.83	2.83	0.96	2.72	2.68	2.68	0.79	2.12	
3	3.00	0.83	2.49	2.85	2.85	0.8	2.28	
2.86	2.86	0.88	2.52	2.71	2.71	0.8	2.17	
3.6	3.60	0.82	2.95	3.45	3.45	0.82	2.83	
3.62	3.62	0.79	2.86	3.47	3.47	0.95	3.30	
3.28	3.28	0.68	2.23	3.13	3.13	0.9	2.82	
4.09	4.09	0.68	2.78	3.94	3.94	0.95	3.74	
4.22	4.22	0.68	2.87	4.07	4.07	0.91	3.70	
4.51	4.51	0.95	4.28	4.36	4.36	0.93	4.05	
4.35	4.35	0.53	2.31	4.2	4.20	1.02	4.28	
4	4.00	0.64	2.56	3.85	3.85	0.54	2.08	
3.52	3.52	0.58	2.04	3.37	3.37	0.42	1.42	
2.75	2.75	0.3	0.83	2.6	2.60	0.11	0.29	
2.15	2.15	0.3	0.65	2	2.00	0.05	0.10	
		Flow	47.82	cfs		Flow	45.63	cfs

T-7 Streamflow Calculations Page 1											
			06/12/05 Staff Gage Reading			1.51	06/22/05 Staff Gage Reading			0.91	
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	
71.2	start										
72	4.23	-0.62	2.13	1.38	0.68	0.94	1.53	0.99	0.22	0.22	
72.5	4.26	-0.65	2.16	1.08	0.74	0.80	1.56	0.78	0.26	0.20	
73	4.37	-0.76	2.27	1.14	0.98	1.11	1.67	0.84	0.70	0.58	
73.5	4.25	-0.64	2.15	1.08	0.9	0.97	1.55	0.78	0.75	0.58	
74	4.32	-0.71	2.22	1.11	0.7	0.78	1.62	0.81	0.72	0.58	
74.5	4.31	-0.7	2.21	1.11	0.8	0.88	1.61	0.81	0.70	0.56	
75	4.39	-0.78	2.29	1.15	0.69	0.79	1.69	0.85	0.51	0.43	
75.5	4.24	-0.63	2.14	1.07	0.51	0.55	1.54	0.77	0.51	0.39	
76	4.27	-0.66	2.17	1.09	0.45	0.49	1.57	0.79	0.35	0.27	
76.5	4.82	-1.21	2.72	1.36	0.38	0.52	2.12	1.06	0.44	0.47	
77	4.94	-1.33	2.84	1.42	0.37	0.53	2.24	1.12	0.44	0.49	
77.5	4	-0.39	1.9	0.95	0.44	0.42	1.30	0.65	0.32	0.21	
78	3.92	-0.31	1.82	0.91	0.39	0.35	1.22	0.61	0.34	0.21	
78.5	3.9	-0.29	1.8	0.90	0.28	0.25	1.20	0.60	0.30	0.18	
79	3.85	-0.24	1.75	0.88	0.22	0.19	1.15	0.58	0.14	0.08	
79.5	3.87	-0.26	1.77	0.89	0.12	0.11	1.17	0.59	0.14	0.08	
80	3.9	-0.29	1.8	0.90	0.13	0.12	1.20	0.60	0.09	0.05	
80.5	3.9	-0.29	1.8	0.90	0.14	0.13	1.20	0.60	0.12	0.07	
81	3.87	-0.26	1.77	0.89	0.15	0.13	1.17	0.59	0.16	0.09	
81.5	3.85	-0.24	1.75	0.88	0.15	0.13	1.15	0.58	0.10	0.06	
82	3.4	0.21	1.3	0.65	0.04	0.03	0.70	0.35	0.00	0.00	
82.5	3.2	0.41	1.1	0.55	0.02	0.01	0.50	0.25	0.00	0.00	
83	3.16	0.45	1.06	0.42	0	0.00	0.46	0.18	0.00	0.00	
83.3	end				Flow	10.22	cfs		Flow	5.83	cfs

Site Survey Information			
		Staff Guage Shot	3.61
		Staff Guage Reading	1.03
Benchmark bottom of concrete above staff guage -2.33			

T-7 Streamflow Calculations Page 2				
06/22/05 Staff Gage Reading			1.56	
Depth	Area	Velocity	Flow	
		0		
2.18	1.42	1.47	2.08	
2.21	1.11	1.28	1.41	
2.32	1.16	1.1	1.28	
2.20	1.10	1.06	1.17	
2.27	1.14	1.06	1.20	
2.26	1.13	0.99	1.12	
2.34	1.17	0.89	1.04	
2.19	1.10	0.89	0.97	
2.22	1.11	0.87	0.97	
2.77	1.39	0.85	1.18	
2.89	1.45	0.88	1.27	
1.95	0.98	0.81	0.79	
1.87	0.94	0.81	0.76	
1.85	0.93	0.65	0.60	
1.80	0.90	0.49	0.44	
1.82	0.91	0.22	0.20	
1.85	0.93	0.25	0.23	
1.85	0.93	0.23	0.21	
1.82	0.91	0.08	0.07	
1.80	0.90	0	0.00	
1.35	0.68	0	0.00	
1.15	0.58	0	0.00	
1.11	0.44	0	0.00	
		Flow	17.00	cfs

T-7 Streamflow Calculations Page 3										
			06/12/05 Staff Gage Reading			2.14	1/13/06 Staff Gage Reading			1.72
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow
71.2	start									
72	2.55	-0.41	2.55	1.66	2.6	4.31	2.13	1.38	2.22	3.07
72.5	2.98	-0.84	2.98	1.49	2.69	4.01	2.56	1.28	2.02	2.59
73	2.86	-0.72	2.86	1.43	2.54	3.63	2.44	1.22	1.7	2.07
73.5	2.97	-0.83	2.97	1.49	2.28	3.39	2.55	1.28	1.46	1.86
74	2.95	-0.81	2.95	1.48	2.07	3.05	2.53	1.27	1.3	1.64
74.5	3.05	-0.91	3.05	1.53	2.08	3.17	2.63	1.32	1.34	1.76
75	3	-0.86	3	1.50	1.84	2.76	2.58	1.29	1.25	1.61
75.5	2.84	-0.7	2.84	1.42	1.52	2.16	2.42	1.21	1.21	1.46
76	2.77	-0.63	2.77	1.39	1.45	2.01	2.35	1.18	1.22	1.43
76.5	2.73	-0.59	2.73	1.37	1.36	1.86	2.31	1.16	1.09	1.26
77	2.54	-0.4	2.54	1.27	1.18	1.50	2.12	1.06	1.02	1.08
77.5	2.78	-0.64	2.78	1.39	0.9	1.25	2.36	1.18	0.82	0.97
78	2.58	-0.44	2.58	1.29	0.95	1.23	2.16	1.08	0.75	0.81
78.5	2.55	-0.41	2.55	1.28	0.9	1.15	2.13	1.07	0.75	0.80
79	2.47	-0.33	2.47	1.24	0.68	0.84	2.05	1.03	0.57	0.58
79.5	2.4	-0.26	2.4	1.20	0.81	0.97	1.98	0.99	0.46	0.46
80	2.27	-0.13	2.27	1.14	0.78	0.89	1.85	0.93	0.32	0.30
80.5	2.28	-0.14	2.28	1.14	0.57	0.65	1.86	0.93	0.33	0.31
81	2.19	-0.05	2.19	1.10	0.48	0.53	1.77	0.89	0.15	0.13
81.5	2.08	0.06	2.08	1.04	0.33	0.34	1.66	0.83	0.09	0.07
82	1.94	0.2	1.94	0.97	0.02	0.02	1.52	0.76	0.07	0.05
82.5	1.86	0.28	1.86	0.93	-0.01	-0.01	1.44	0.72	0	0.00
83	1.64	0.5	1.64	0.66	-0.05	-0.03	1.22	0.49	0	0.00
	end				Flow	39.66			Flow	24.33

Site Survey Information	
Staff Guage Reading	2.14

T-8 Streamflow Calculations											
			11/16/05 Staff Gage Reading			1.1	12/1/05 Staff Gage Reading			1.05	
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	
85											
86	0.77	0.33	0.77	0.77	0.88	0.68	0.72	0.72	1.73	1.25	
87	1.09	0.01	1.09	1.09	0.55	0.60	1.04	1.04	1.88	1.96	
88	1.25	-0.15	1.25	1.25	0.61	0.76	1.2	1.20	1.93	2.32	
89	1.25	-0.15	1.25	1.25	0.87	1.09	1.2	1.20	2.1	2.52	
90	1.19	-0.09	1.19	1.19	0.8	0.95	1.14	1.14	2.04	2.33	
91	End			5.55				5.30			
					Flow	4.08	cfs		Flow	10.36	cfs

*Downed tree may have altered 11/16 readings

Site Survey Information	
Staff Gauge Reading	1.1

1/13/06 Staff Gage Reading			0.92	
Depth	Area	Velocity	Flow	
0.59	0.59	1.52	0.90	
0.91	0.91	1.69	1.54	
1.07	1.07	1.6	1.71	
1.07	1.07	1.65	1.77	
1.01	1.01	1.44	1.45	
	4.65			
		Flow	7.37	cfs

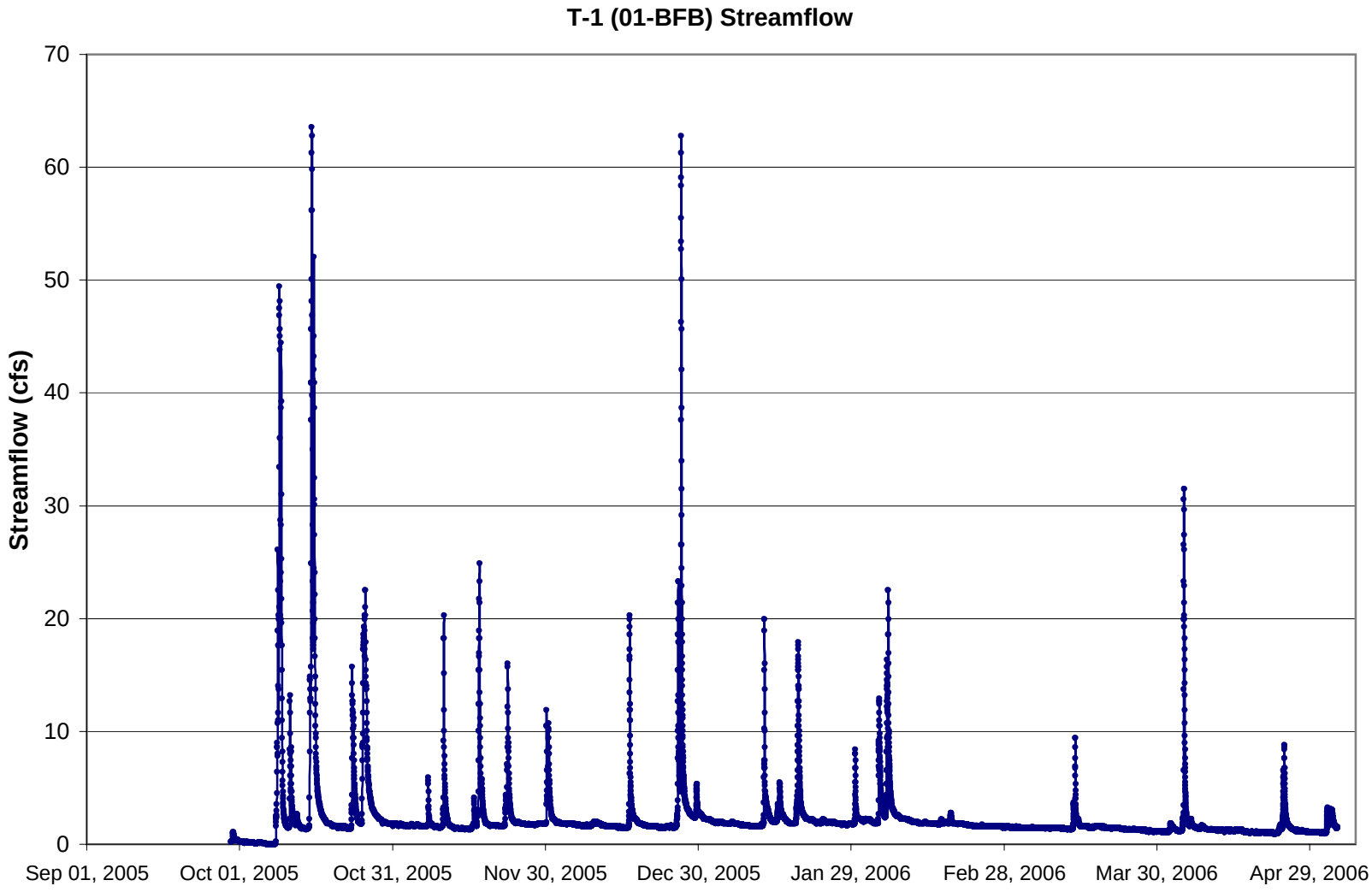
T-9 Streamflow Calculations											
			11/16/05 Staff Gage Reading			2.27	11/16/05 Staff Gage Reading			2.5	
Location	Reading	Elevation	Depth	Area	Velocity	Flow	Depth	Area	Velocity	Flow	
Culvert 1	2.16	0.11	2.16	6.92	0.45	3.11	2.39	7.83	1.19	9.32	
Culvert 2	2.16	0.11	2.16	6.92	0.36	2.49	2.39	7.83	1.25	9.79	
	End										
					Flow	5.61	cfs		Flow	19.11	cfs

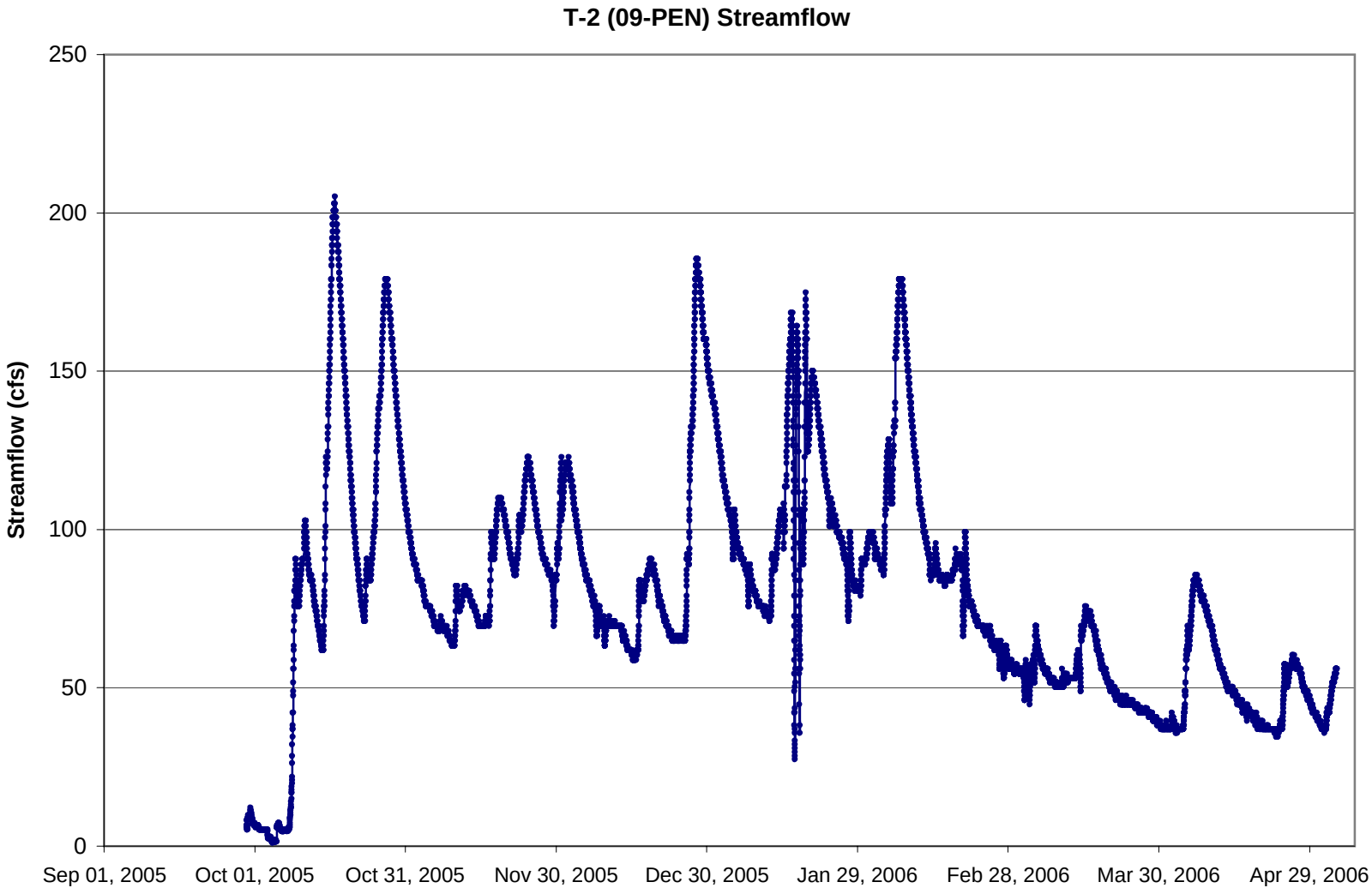
*(2) 4' dia culverts at same elevation, velocities vary based on stream orientation.

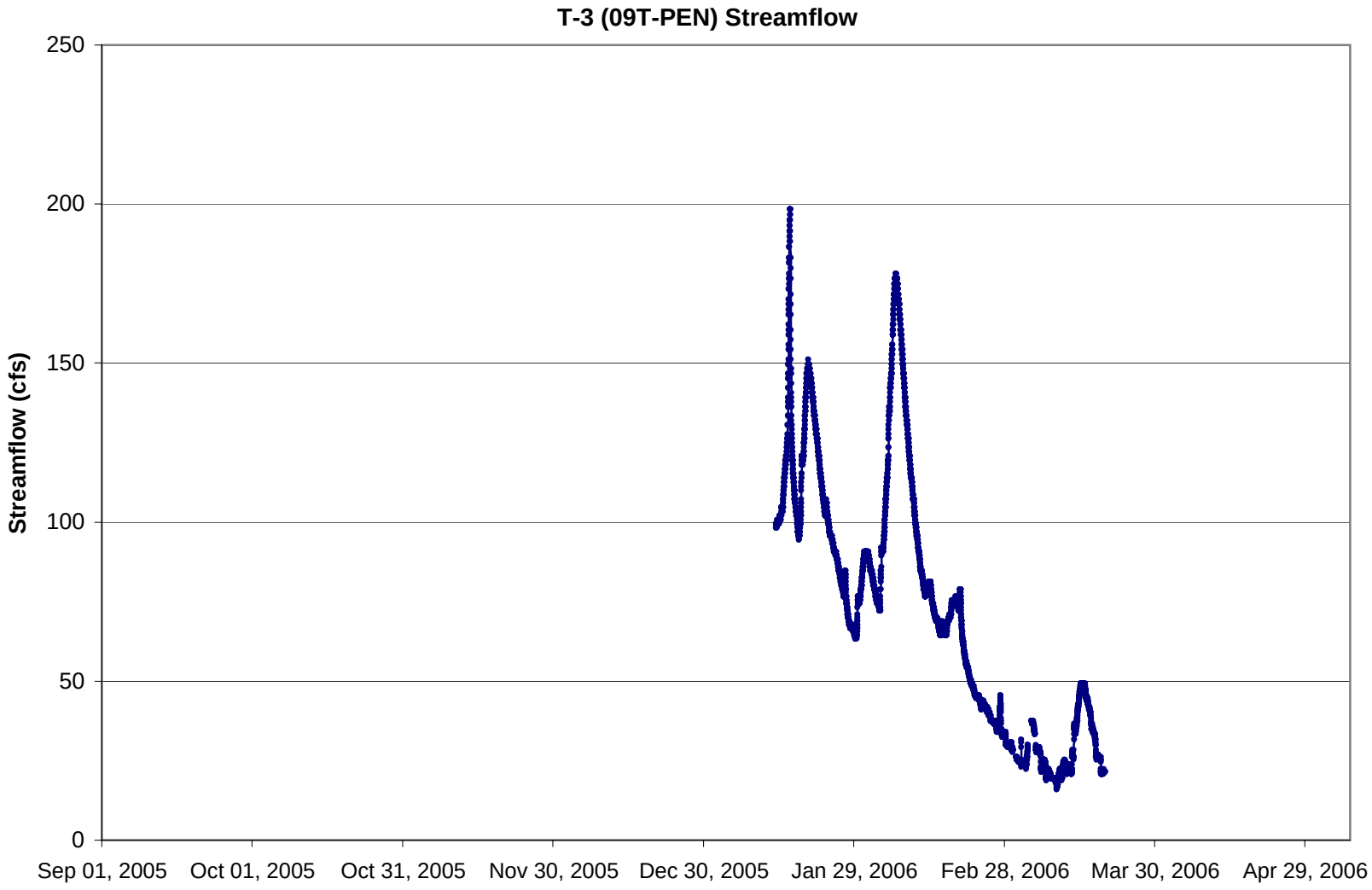
Site Survey Information	
Staff Guage Reading	2.27

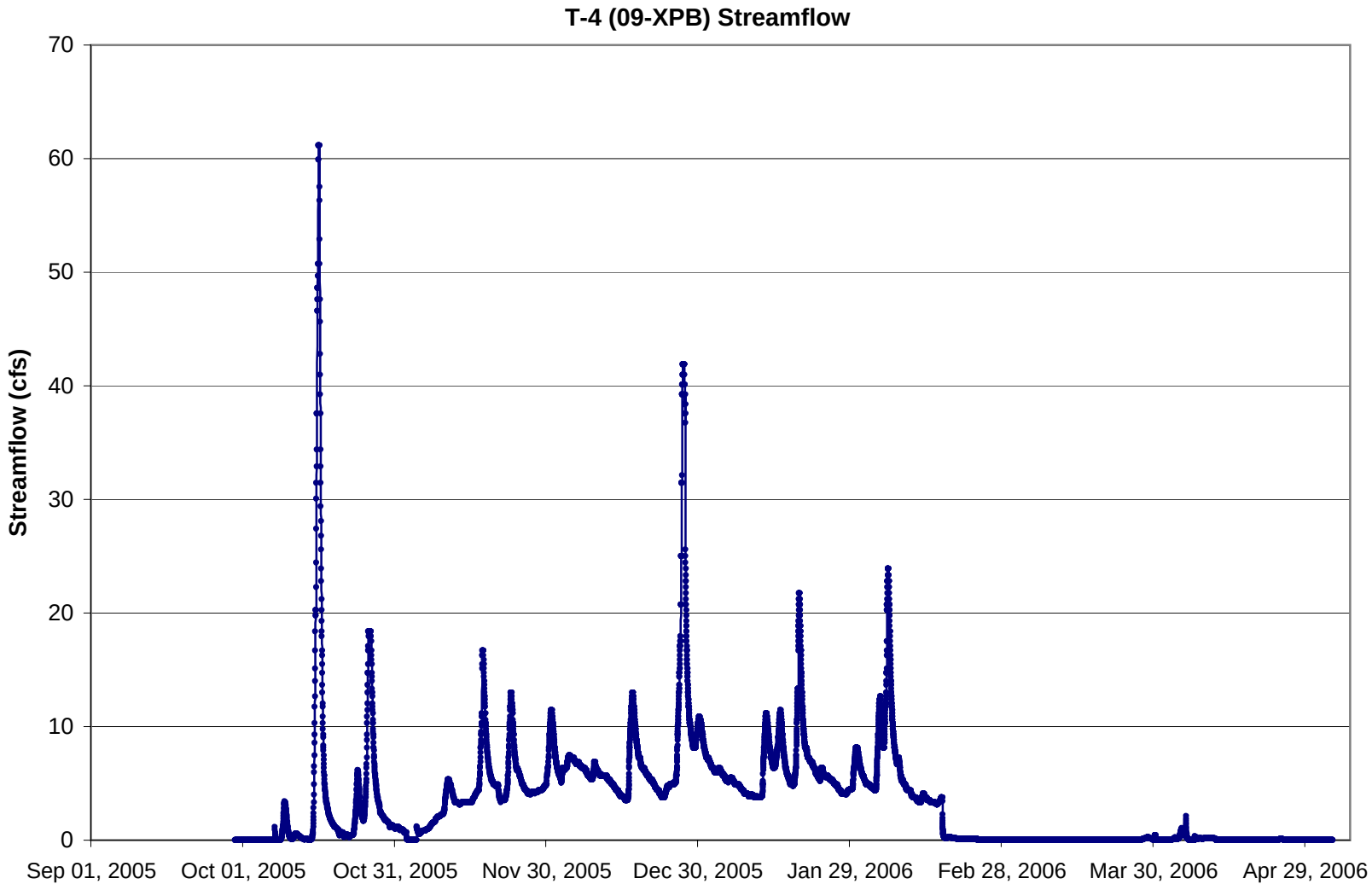
1/13/06 Staff Gage Reading			2.28	
Depth	Area	Velocity	Flow	
2.17	6.93	0.76	5.27	
2.17	6.93	0.69	4.78	
cfs		Flow	10.05	cfs

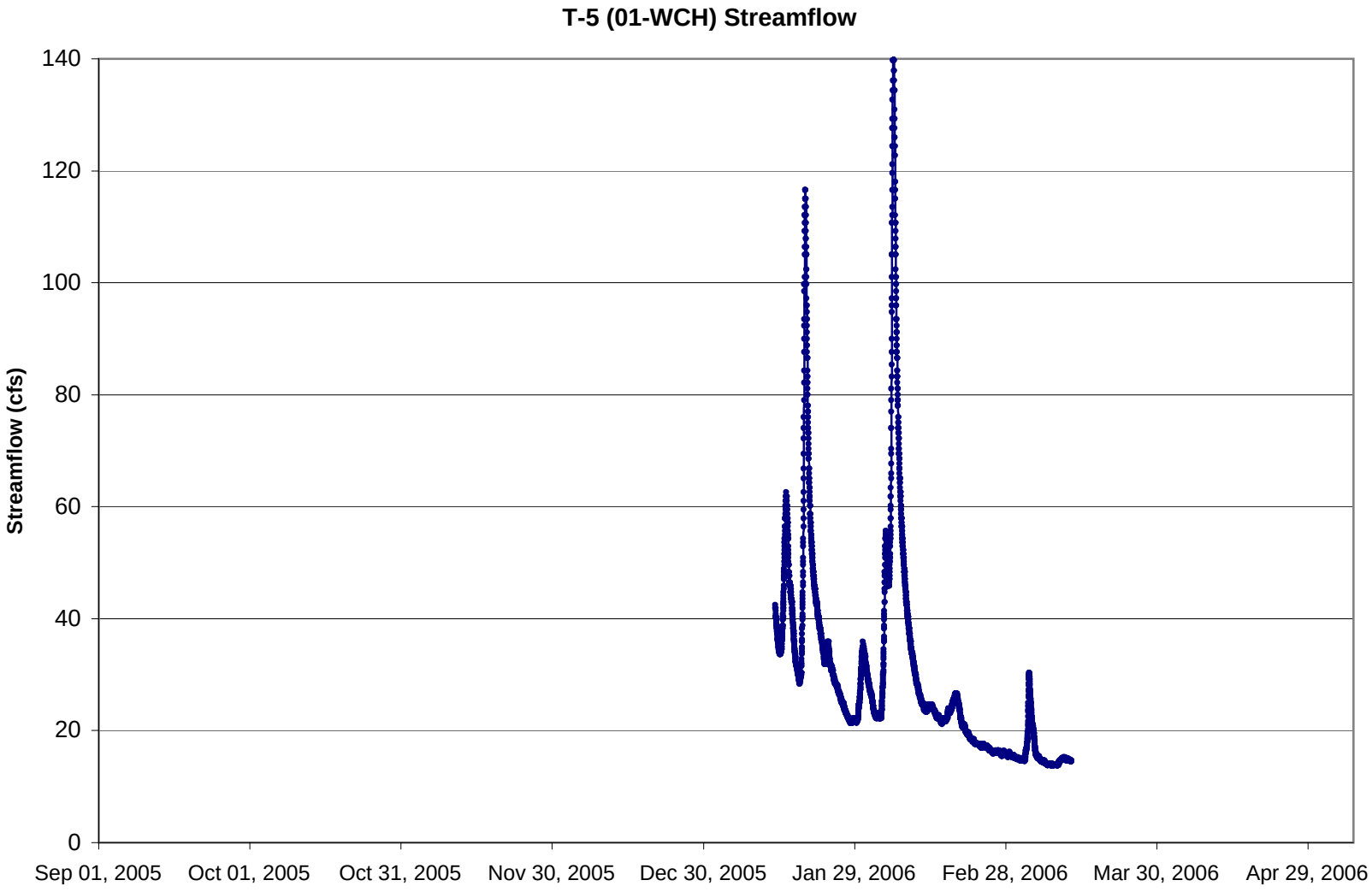
Appendix C
Measured Streamflows

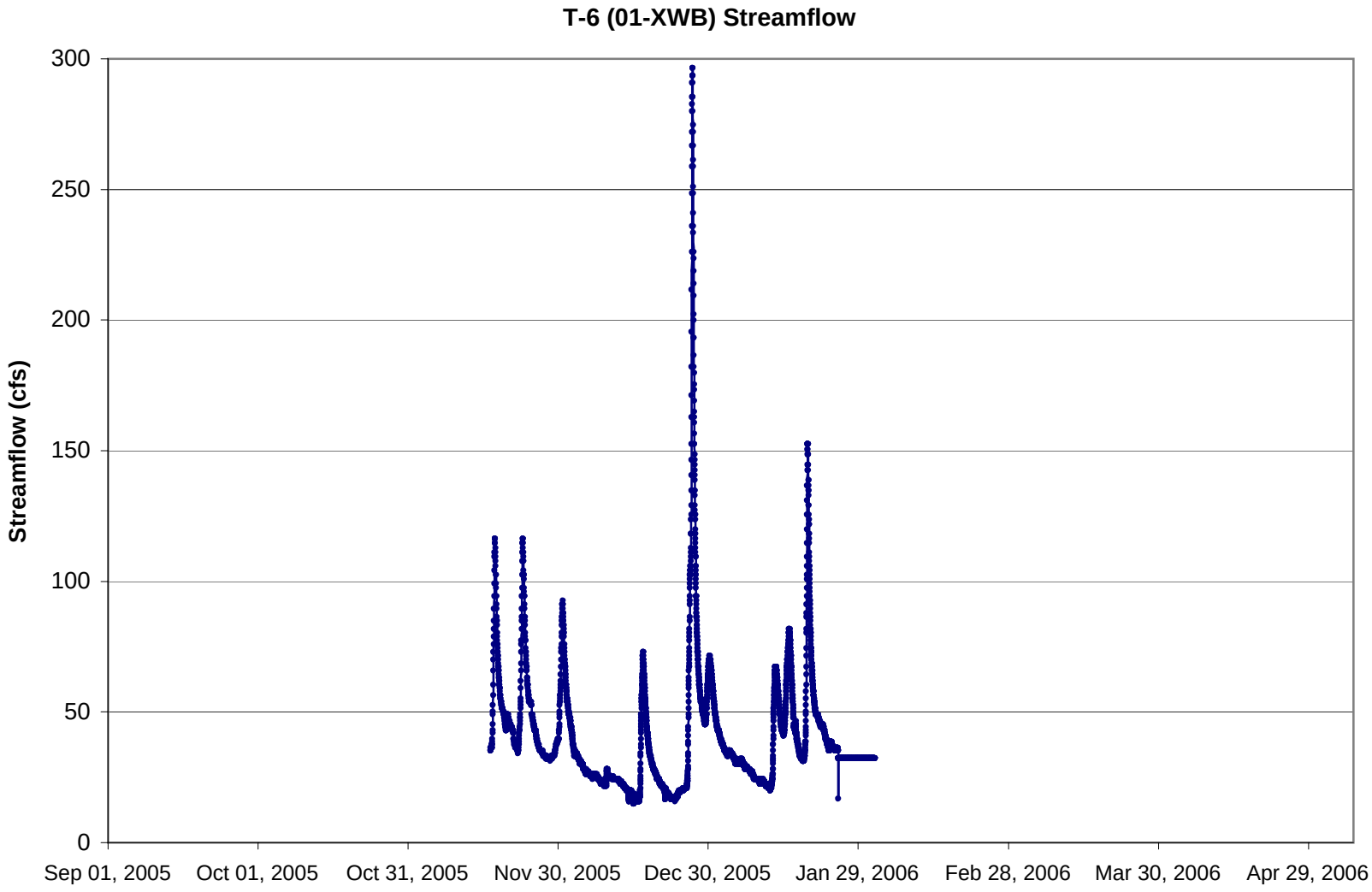

T-1 (01-BFB) Streamflow
Streamflow (cfs)
70
60
50
40
30
20
10
0
Sep 01, 2005
Oct 01, 2005
Oct 31, 2005
Nov 30, 2005
Dec 30, 2005
Jan 29, 2006
Feb 28, 2006
Mar 30, 2006
Apr 29, 2006

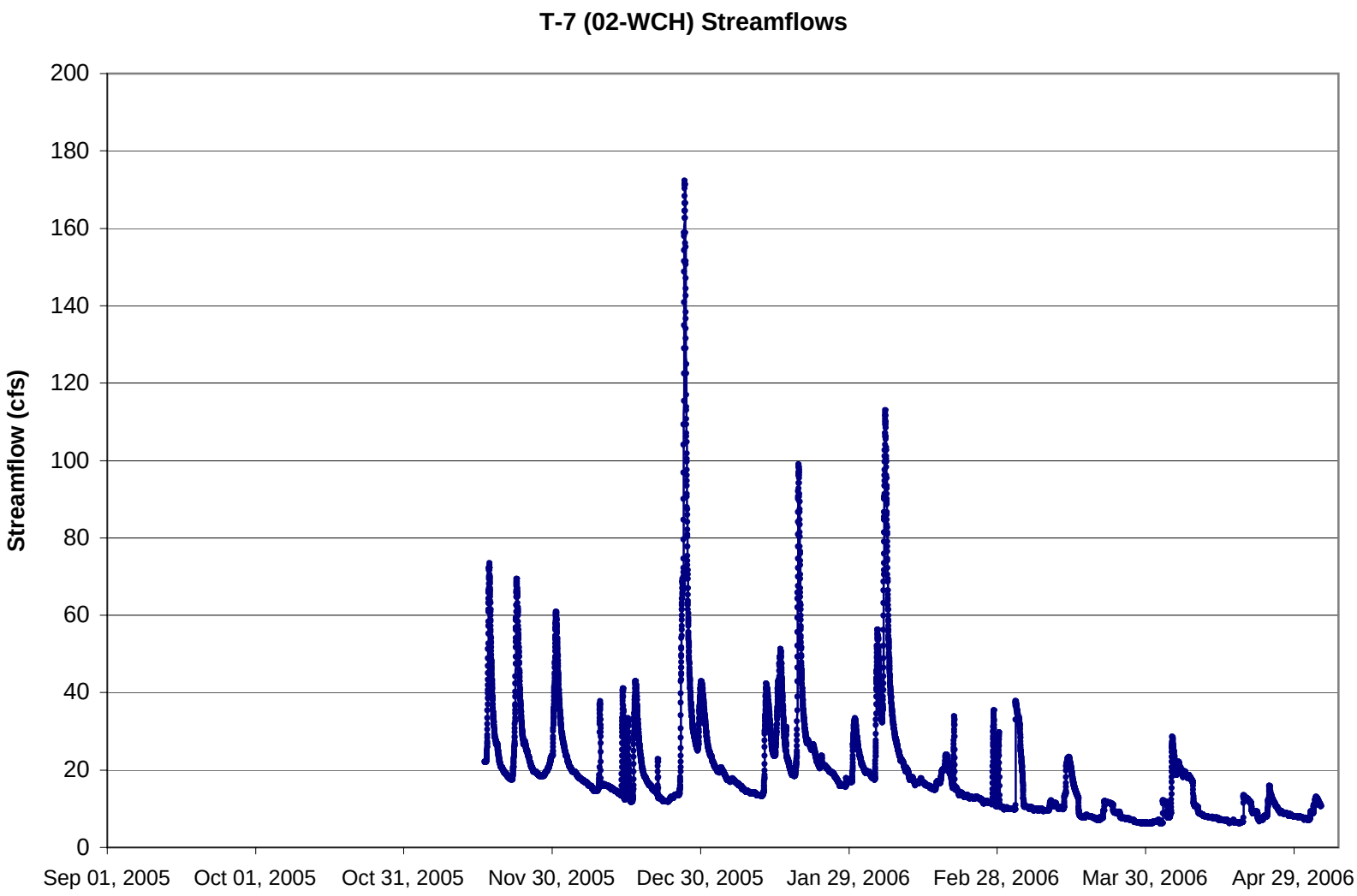

T-2 (09-PEN) Streamflow
Streamflow (cfs)
250
200
150
100
50
0
Sep 01, 2005
Oct 01, 2005
Oct 31, 2005
Nov 30, 2005
Dec 30, 2005
Jan 29, 2006
Feb 28, 2006
Mar 30, 2006
Apr 29, 2006

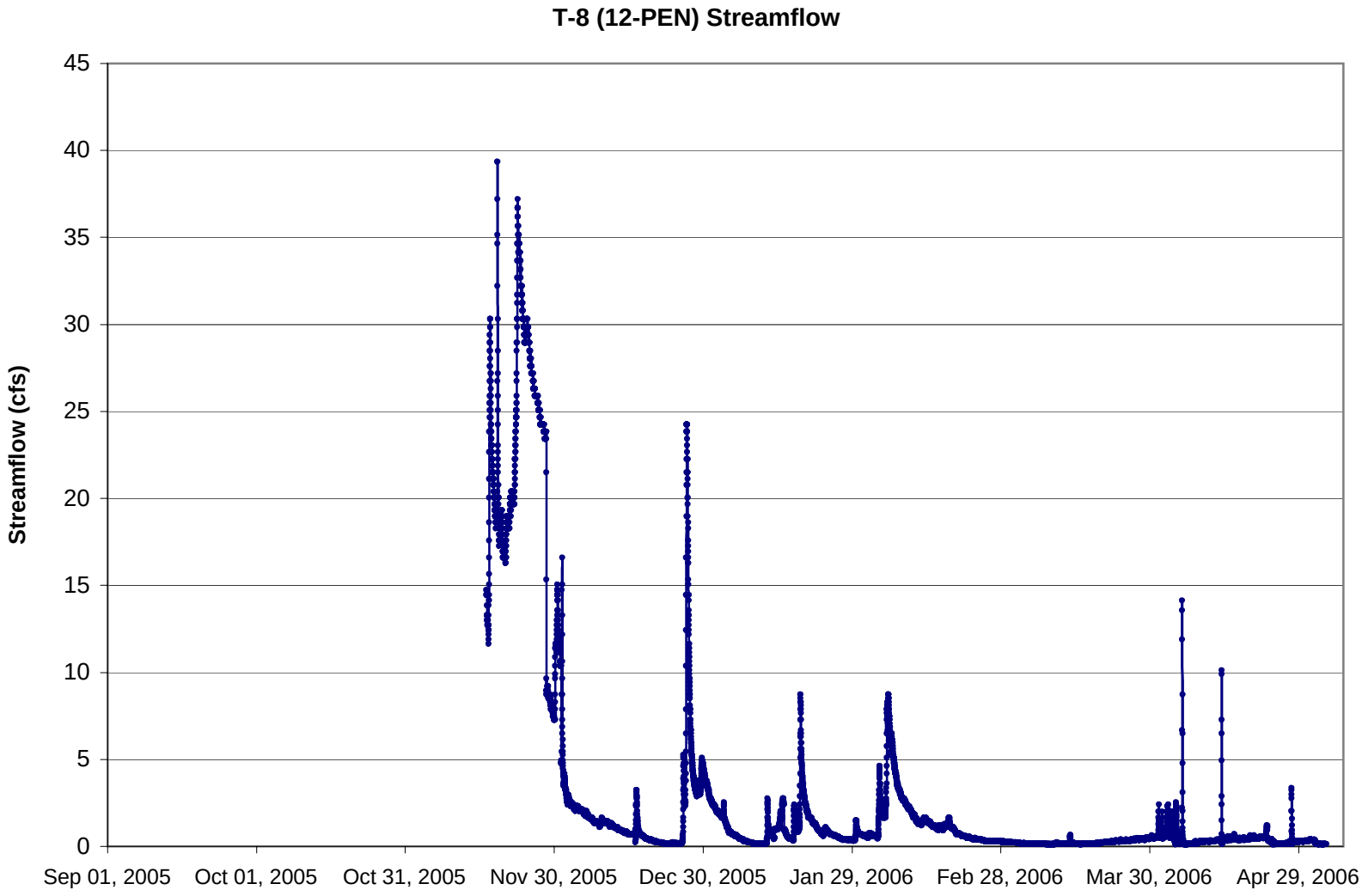

T-3 (09T-PEN) Streamflow
Streamflow (cfs)
250
200
150
100
50
0
Sep 01, 2005
Oct 01, 2005
Oct 31, 2005
Nov 30, 2005
Dec 30, 2005
Jan 29, 2006
Feb 28, 2006
Mar 30, 2006
Apr 29, 2006

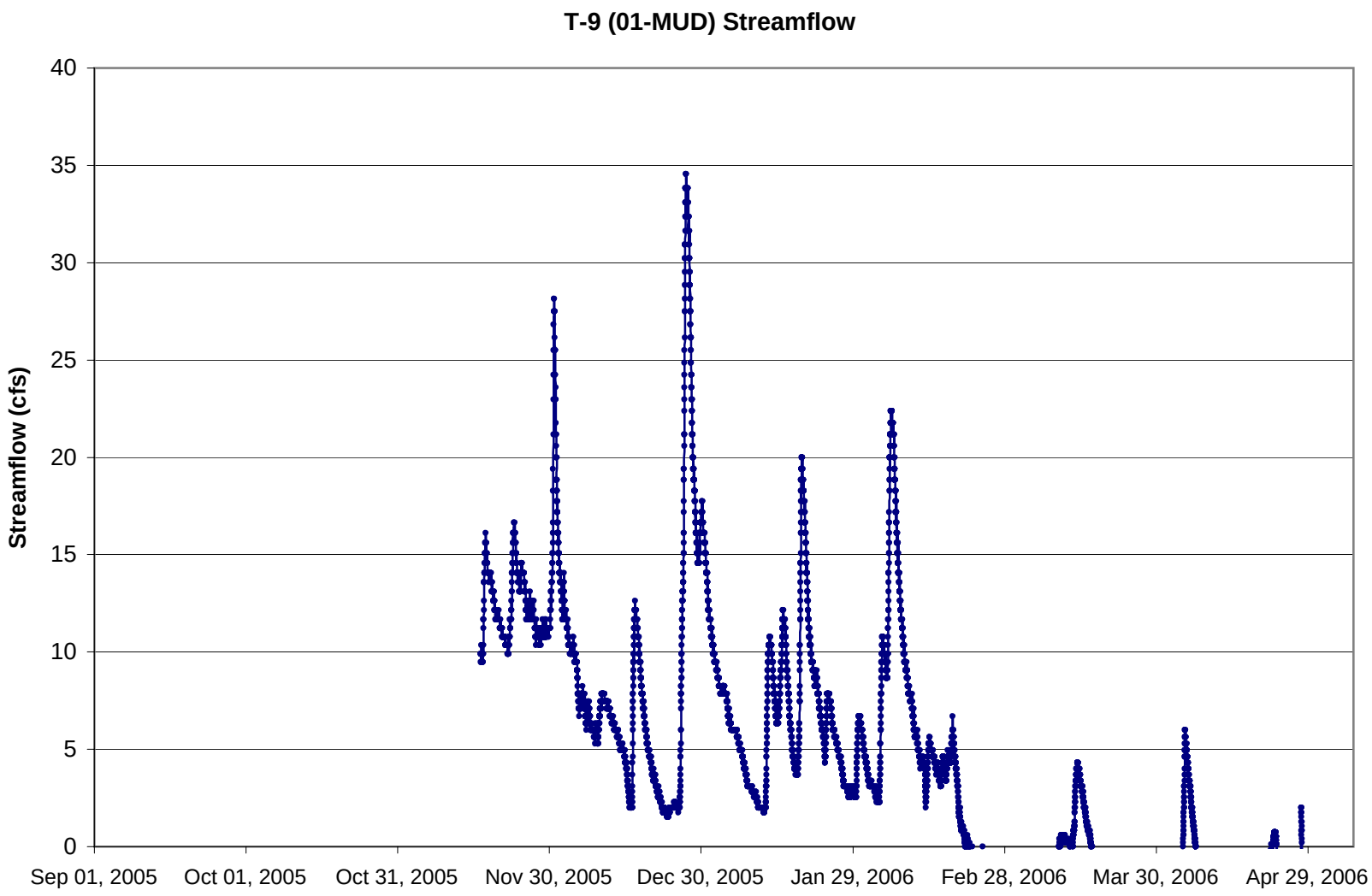

T-4 (09-XPB) Streamflow
Streamflow (cfs)
70
60
50
40
30
20
10
0
Sep 01, 2005
Oct 01, 2005
Oct 31, 2005
Nov 30, 2005
Dec 30, 2005
Jan 29, 2006
Feb 28, 2006
Mar 30, 2006
Apr 29, 2006


T-5 (01-WCH) Streamflow
Streamflow (cfs)
140
120
100
80
60
40
20
0
Sep 01, 2005
Oct 01, 2005
Oct 31, 2005
Nov 30, 2005
Dec 30, 2005
Jan 29, 2006
Feb 28, 2006
Mar 30, 2006
Apr 29, 2006

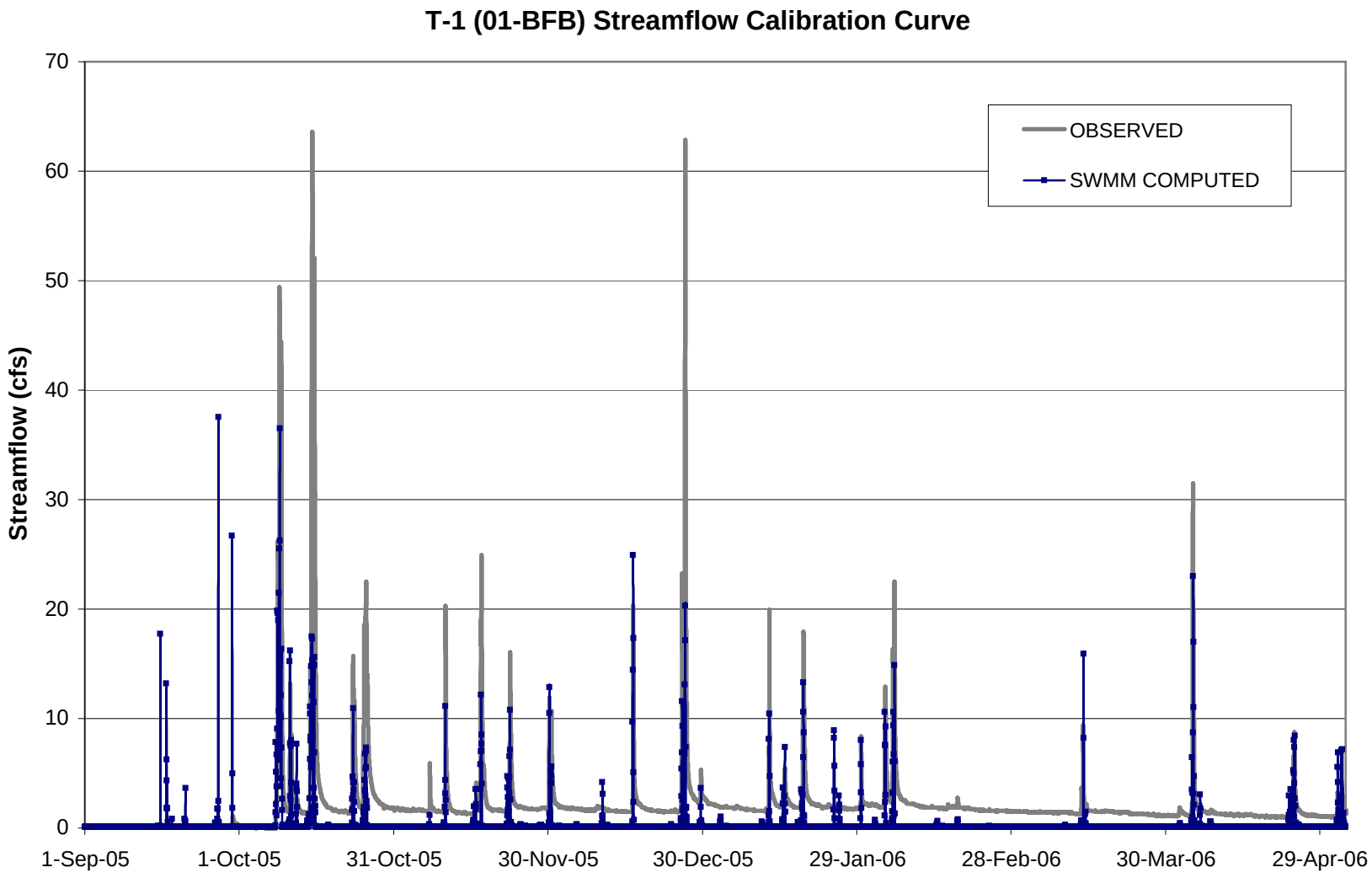

T-6 (01-XWB) Streamflow
Streamflow (cfs)
300
250
200
150
100
50
0
Sep 01, 2005
Oct 01, 2005
Oct 31, 2005
Nov 30, 2005
Dec 30, 2005
Jan 29, 2006
Feb 28, 2006
Mar 30, 2006
Apr 29, 2006

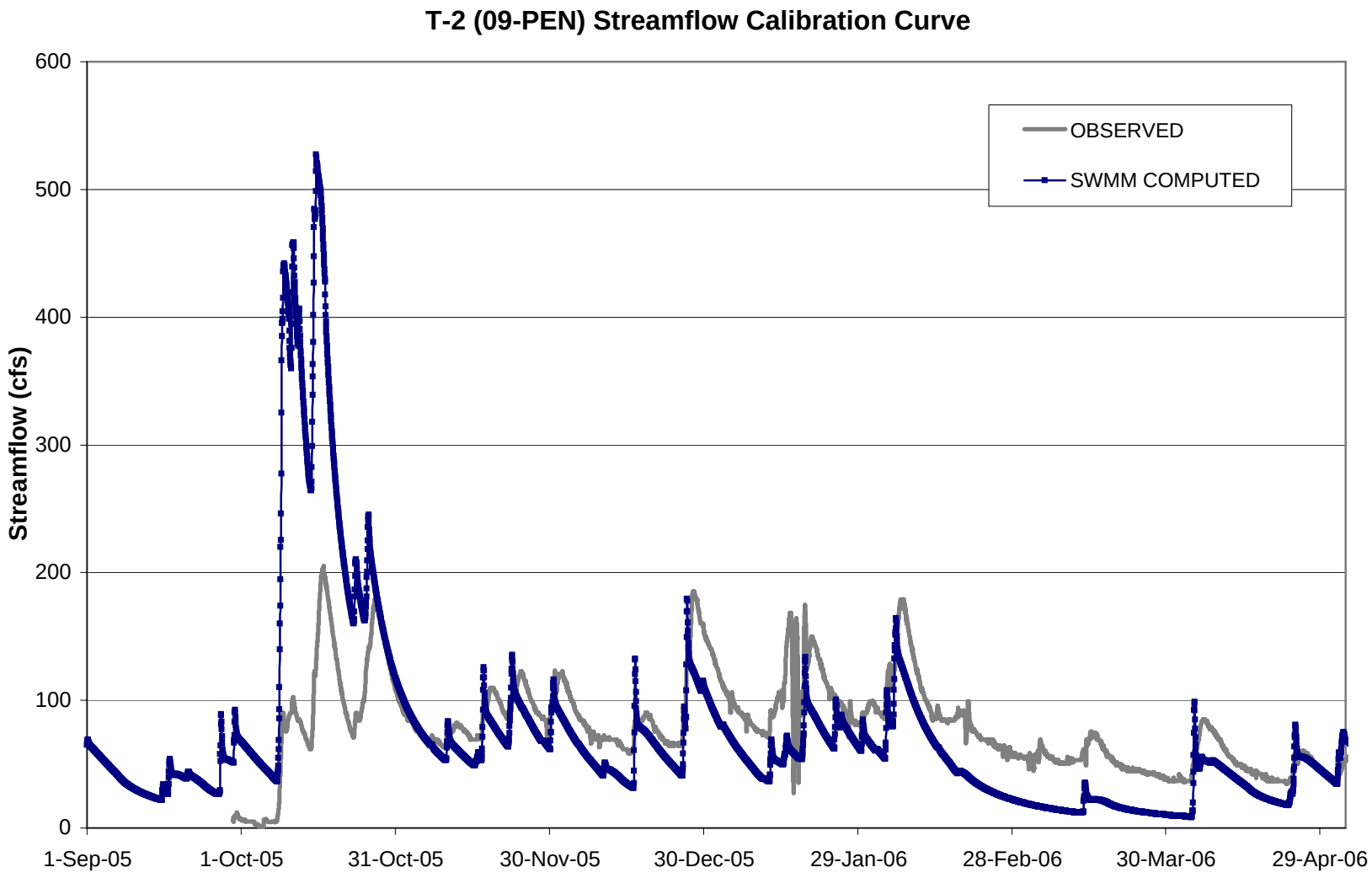

T-7 (02-WCH) Streamflows
Streamflow (cfs)
200
180
160
140
120
100
80
60
40
20
0
Sep 01, 2005
Oct 01, 2005
Oct 31, 2005
Nov 30, 2005
Dec 30, 2005
Jan 29, 2006
Feb 28, 2006
Mar 30, 2006
Apr 29, 2006

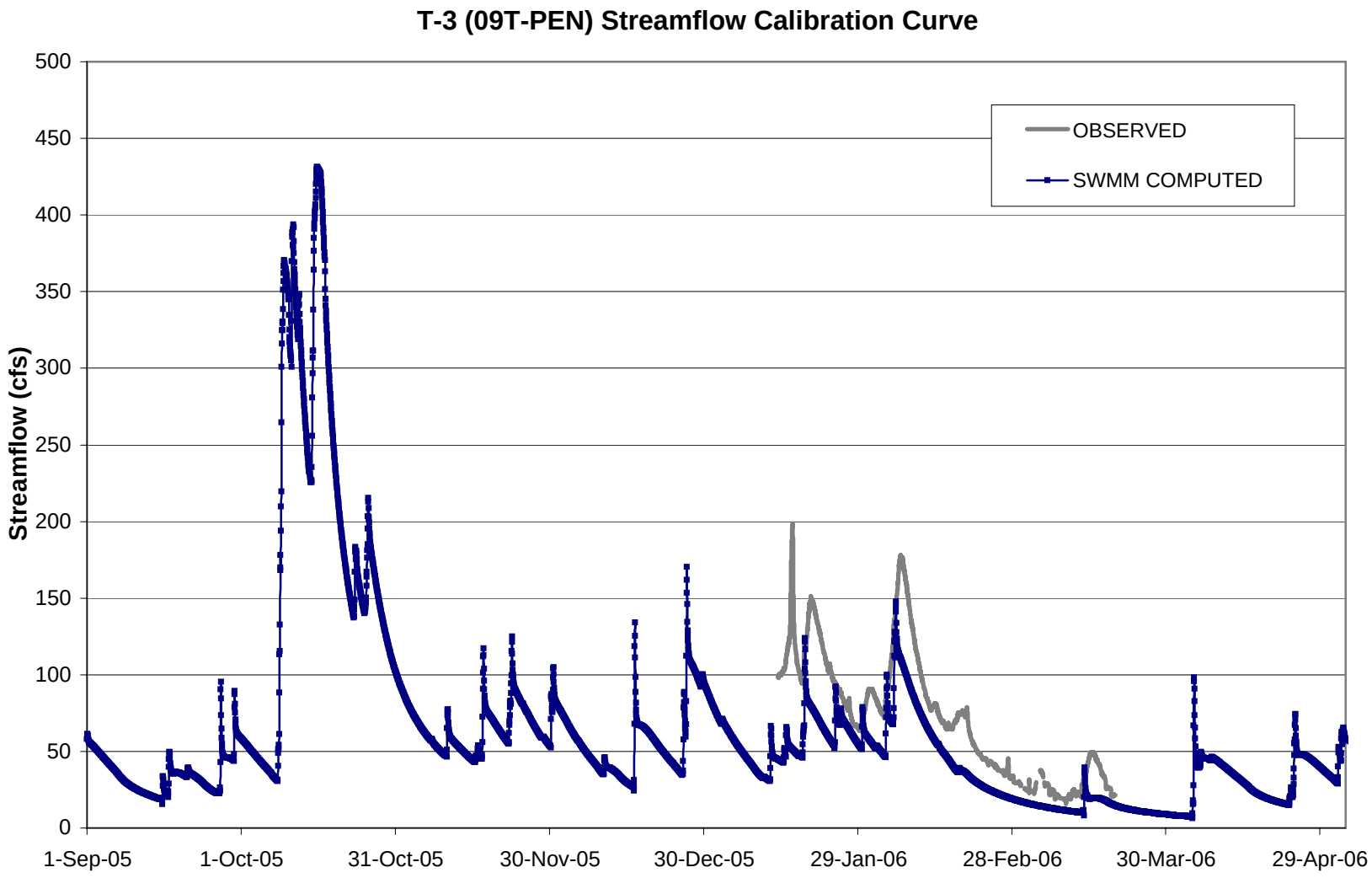

T-8 (12-PEN) Streamflow
Streamflow (cfs)
45
40
35
30
25
20
15
10
5
0
Sep 01, 2005
Oct 01, 2005
Oct 31, 2005
Nov 30, 2005
Dec 30, 2005
Jan 29, 2006
Feb 28, 2006
Mar 30, 2006
Apr 29, 2006

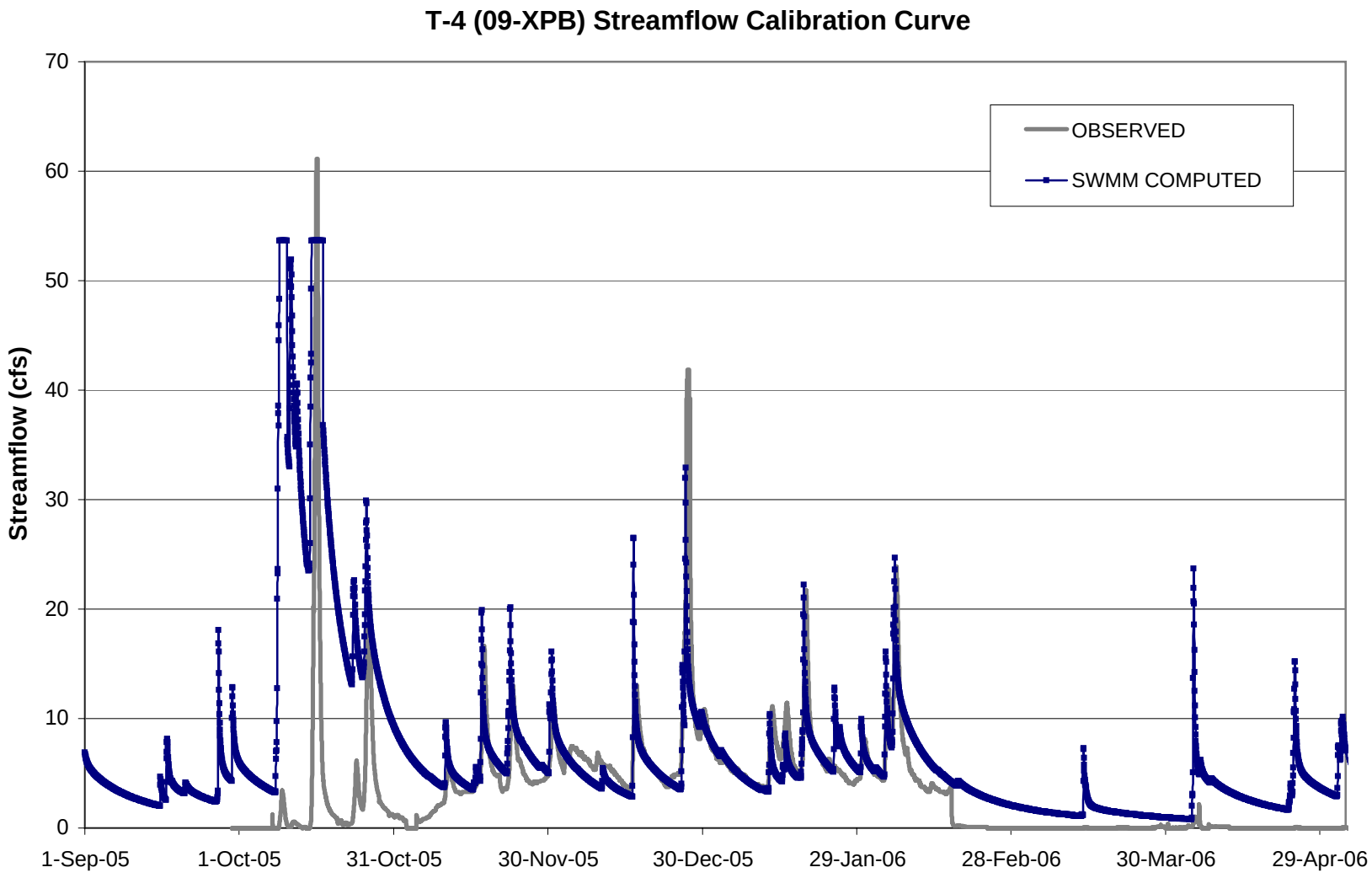

T-9 (01-MUD) Streamflow
Streamflow (cfs)
40
35
30
25
20
15
10
5
0
Sep 01, 2005
Oct 01, 2005
Oct 31, 2005
Nov 30, 2005
Dec 30, 2005
Jan 29, 2006
Feb 28, 2006
Mar 30, 2006
Apr 29, 2006

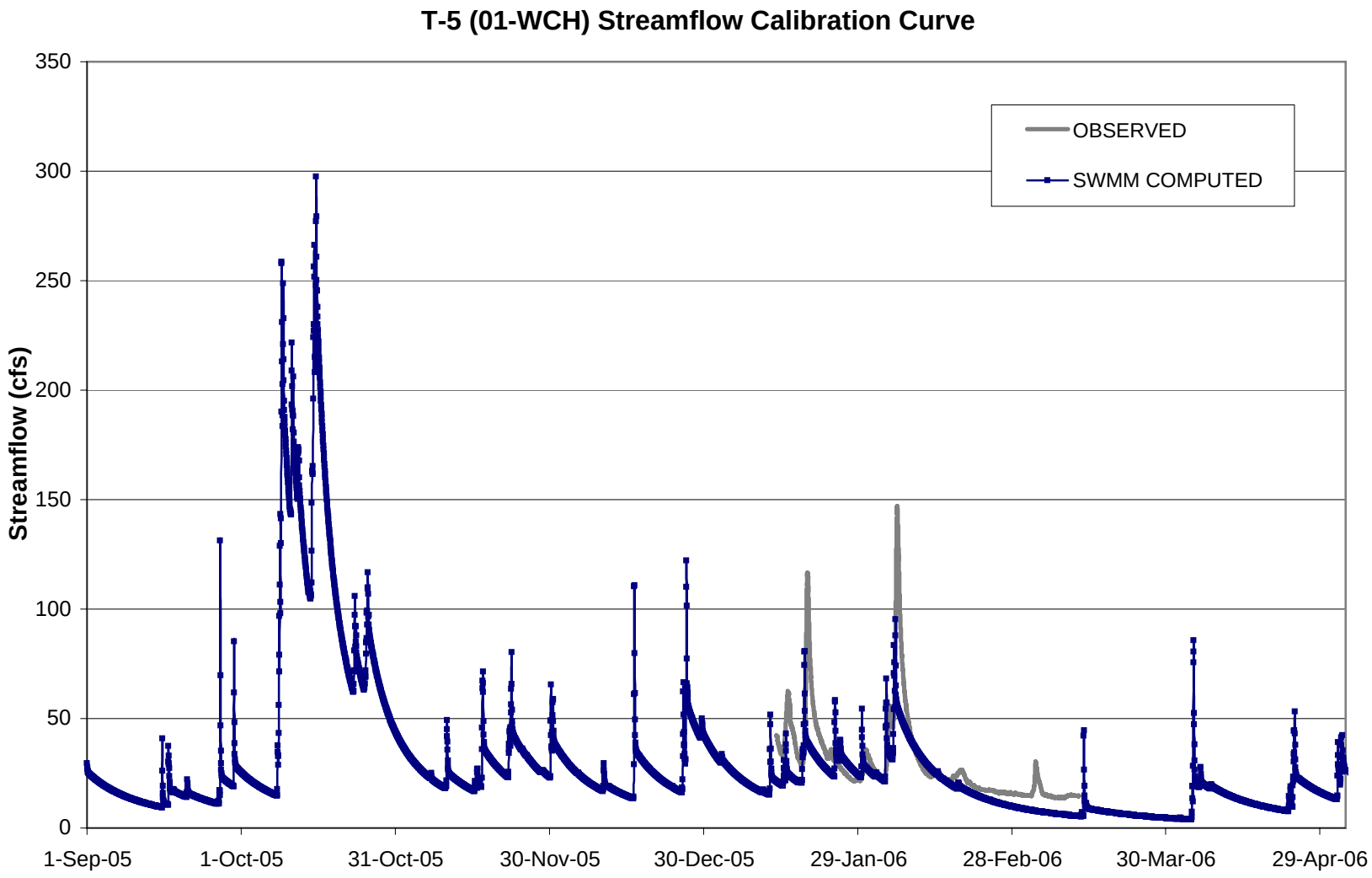
Appendix D
Streamflow Calibration Curves

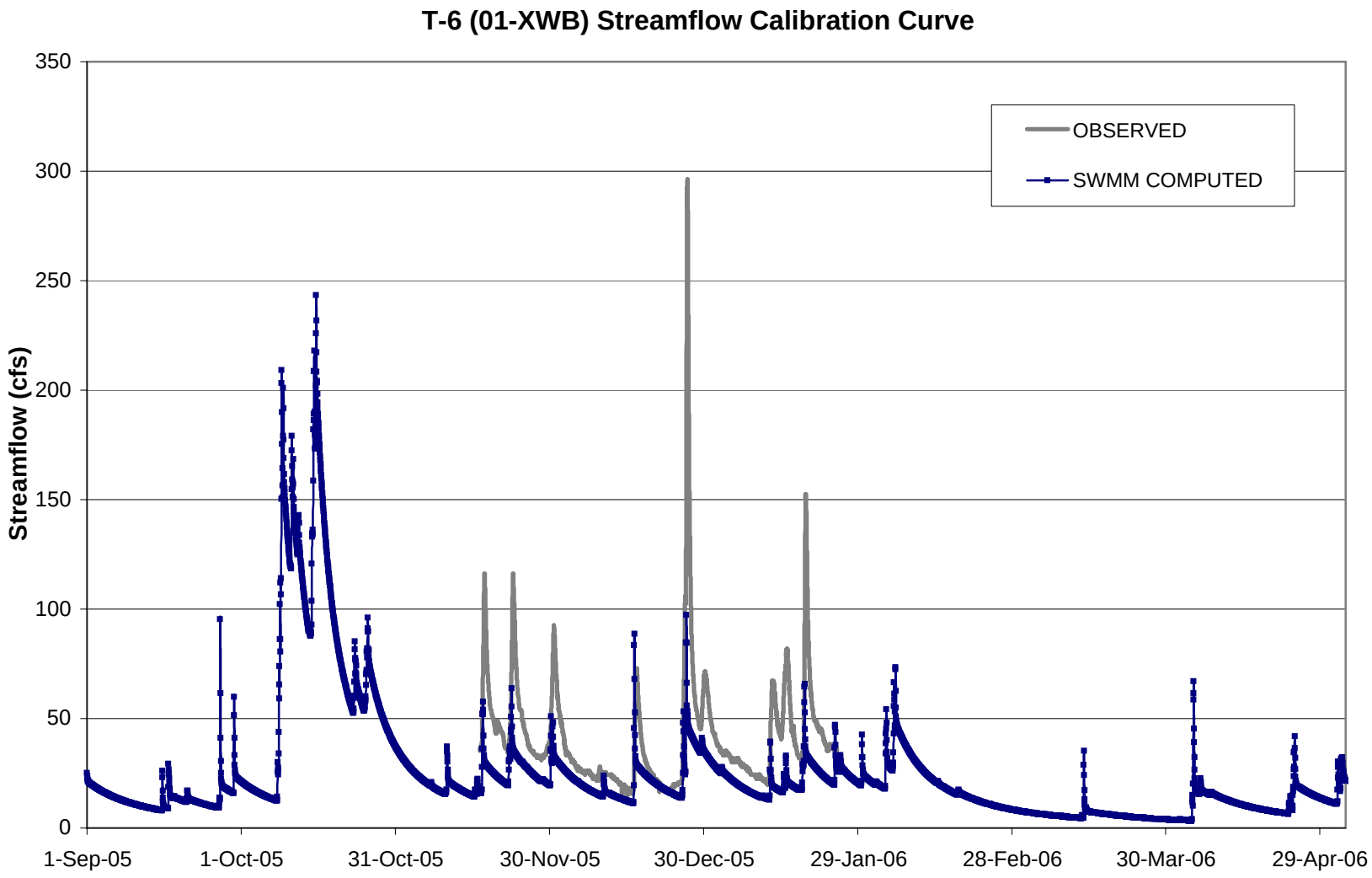

T-1 (01-BFB) Streamflow Calibration Curve
Streamflow (cfs)
70
60
50
40
30
20
10
0
1-Sep-05
1-Oct-05
31-Oct-05
30-Nov-05
30-Dec-05
29-Jan-06
28-Feb-06
30-Mar-06
29-Apr-06
OBSERVED
SWMM COMPUTED

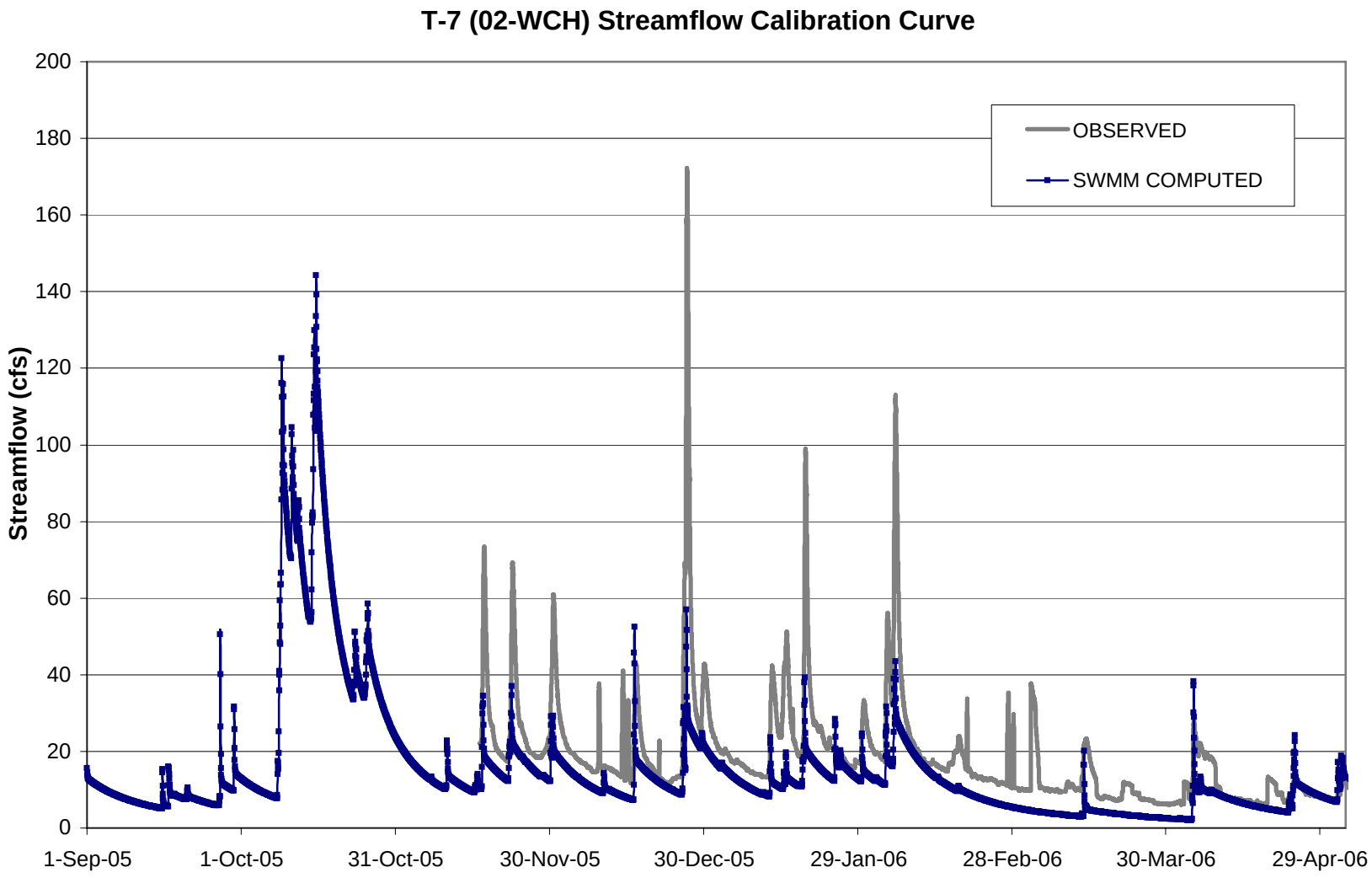

T-2 (09-PEN) Streamflow Calibration Curve
Streamflow (cfs)
600
500
400
300
200
100
0
1-Sep-05
1-Oct-05
31-Oct-05
30-Nov-05
30-Dec-05
29-Jan-06
28-Feb-06
30-Mar-06
29-Apr-06
OBSERVED
SWMM COMPUTED

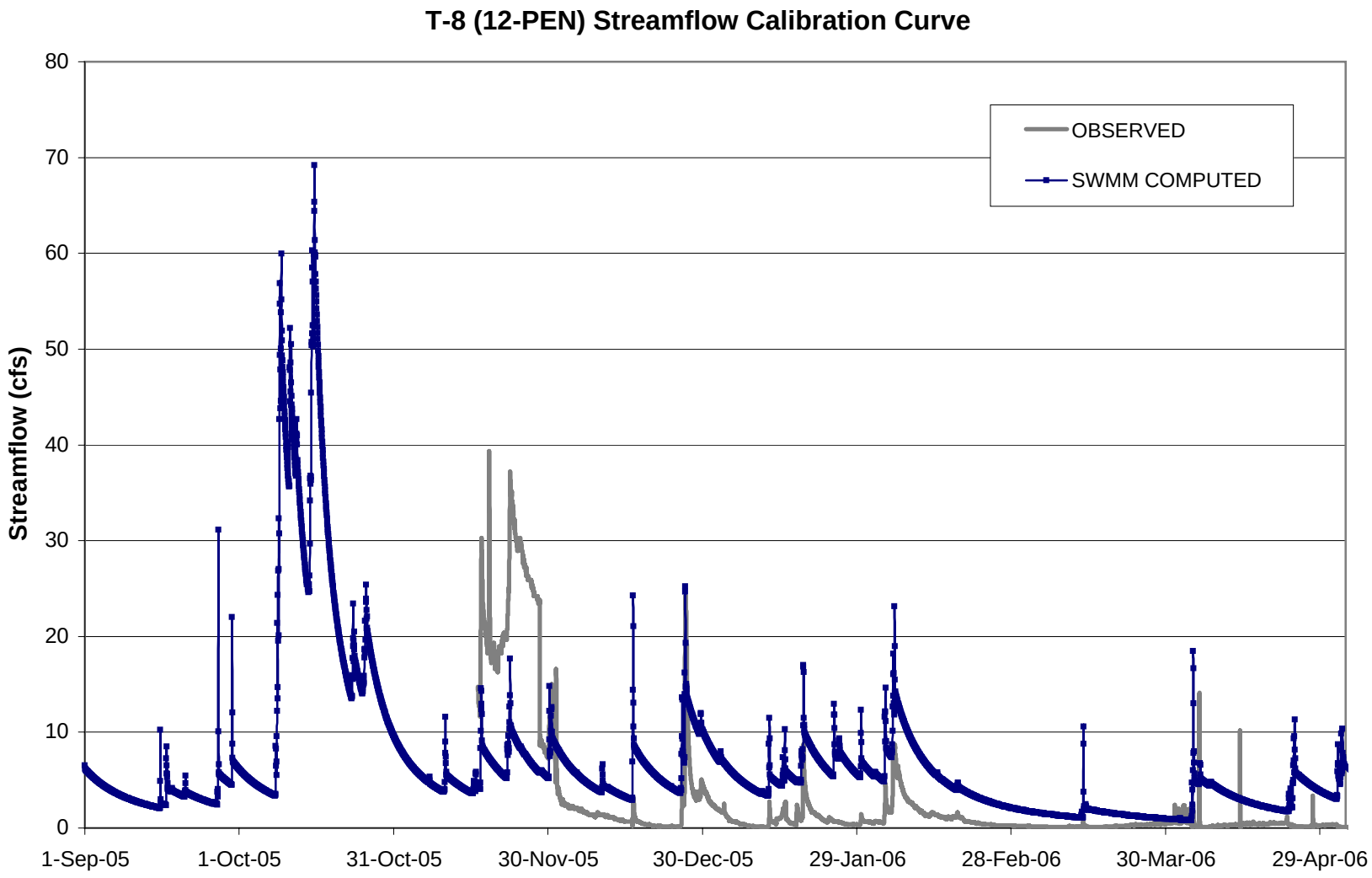

T-3 (09T-PEN) Streamflow Calibration Curve
Streamflow (cfs)
500
450
400
350
300
250
200
150
100
50
0
1-Sep-05
1-Oct-05
31-Oct-05
30-Nov-05
30-Dec-05
29-Jan-06
28-Feb-06
30-Mar-06
29-Apr-06
OBSERVED
SWMM COMPUTED

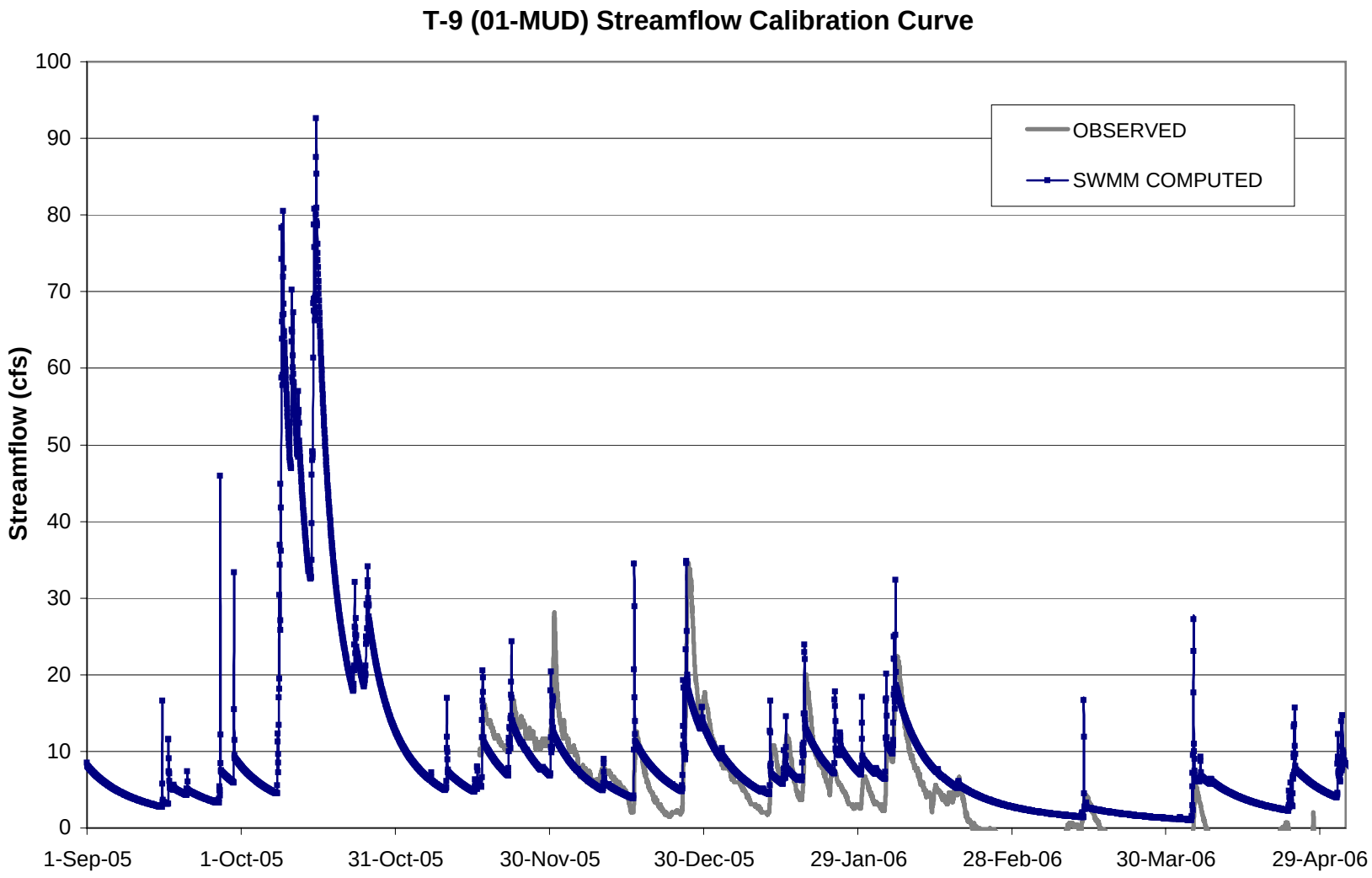

T-4 (09-XPB) Streamflow Calibration Curve
Streamflow (cfs)
70
60
50
40
30
20
10
0
1-Sep-05
1-Oct-05
31-Oct-05
30-Nov-05
30-Dec-05
29-Jan-06
28-Feb-06
30-Mar-06
29-Apr-06
OBSERVED
SWMM COMPUTED


T-5 (01-WCH) Streamflow Calibration Curve
Streamflow (cfs)
350
300
250
200
150
100
50
0
1-Sep-05
1-Oct-05
31-Oct-05
30-Nov-05
30-Dec-05
29-Jan-06
28-Feb-06
30-Mar-06
29-Apr-06
OBSERVED
SWMM COMPUTED


T-6 (01-XWB) Streamflow Calibration Curve
Streamflow (cfs)
350
300
250
200
150
100
50
0
1-Sep-05
1-Oct-05
31-Oct-05
30-Nov-05
30-Dec-05
29-Jan-06
28-Feb-06
30-Mar-06
29-Apr-06
OBSERVED
SWMM COMPUTED


T-7 (02-WCH) Streamflow Calibration Curve
Streamflow (cfs)
200
180
160
140
120
100
80
60
40
20
0
1-Sep-05
1-Oct-05
31-Oct-05
30-Nov-05
30-Dec-05
29-Jan-06
28-Feb-06
30-Mar-06
29-Apr-06
OBSERVED
SWMM COMPUTED


T-8 (12-PEN) Streamflow Calibration Curve
Streamflow (cfs)
80
70
60
50
40
30
20
10
0
1-Sep-05
1-Oct-05
31-Oct-05
30-Nov-05
30-Dec-05
29-Jan-06
28-Feb-06
30-Mar-06
29-Apr-06
OBSERVED
SWMM COMPUTED


T-9 (01-MUD) Streamflow Calibration Curve
Streamflow (cfs)
100
90
80
70
60
50
40
30
20
10
0
1-Sep-05
1-Oct-05
31-Oct-05
30-Nov-05
30-Dec-05
29-Jan-06
28-Feb-06
30-Mar-06
29-Apr-06
OBSERVED
SWMM COMPUTED

Appendix E
BMP Sampling Results

2006 Pennichuck Brook BMP Sampling Results

SW-1 Conway Office Swale				
Date	Rainfall (in.)	Location	TSS (mg/L)	Phosphorous (mg/L)
8/15/2006	0.25	Inlet	**<5**	0.16
		Outlet	None	None
8/21/2006	1.65	Inlet	**<5**	**<0.05**
		Outlet	**<5**	0.06
9/5/2006	1.20	Inlet	**<5**	**<0.05**
		Outlet	**<5**	0.06

SW-2 Home Depot Dentention Basin With Grass				
Date	Rainfall (in.)	Location	TSS (mg/L)	Phosphorous (mg/L)
9/5/2006	1.2	Inlet	**<5**	**<0.05**
		Outlet	**<5**	0.07
9/15/2006	0.35	Inlet	**<5**	0.07
		Outlet	**<5**	**<0.05**
10/2/2006	1.10	Inlet	**<5**	**<0.05**
		Outlet	**<5**	**0.056**

SW-3 Pennichuck Square Infiltration - LID				
Date	Rainfall (in.)	Location	TSS (mg/L)	Phosphorous (mg/L)
8/15/2006	0.25	Inlet	**<5**	**<0.05**
		Outlet	None	None
8/21/2006	1.65	Inlet	**<5**	**<0.05**
		Outlet	**<5**	**<0.05**
9/5/2006	1.20	Inlet	**<5**	0.06
		Outlet	**<5**	0.06

SW-4 Celina Avenue Forebay/Sediment Trap				
Date	Rainfall (in.)	Location	TSS (mg/L)	Phosphorous (mg/L)
5/27/2006	0.25	Inlet	8	0.12
		Outlet	**<5**	0.12
6/2/2006	2.90	Inlet	**<5**	0.08
		Outlet	**<5**	0.11
6/15/2006	0.40	Inlet	**<5**	0.06
		Outlet	**<5**	**0.05**
7/13/2006	1.95	Inlet	**<5**	0.20
		Outlet	**<5**	0.21

SW-5 White Oak Drive Detention Basin With Wetland Plants				
Date	Rainfall (in.)	Location	TSS (mg/L)	Phosphorous (mg/L)
5/27/2006	0.25	Inlet	18	0.37
		Outlet	None	None
6/2/2006	2.90	Inlet	**<5**	0.13
		Outlet	**<5**	0.14
7/13/2006	1.95	Inlet	90	0.18
		Outlet	70	0.12

SW-6 White Oak Drive Naturalizing Detention Basin				
Date	Rainfall (in.)	Location	TSS (mg/L)	Phosphorous (mg/L)
5/27/2006	0.25	Inlet	27	0.28
		Outlet	None	None
6/2/2006	2.90	Inlet	**<5**	0.15
		Outlet	**<5**	0.11
7/13/2006	1.95	Inlet	**<5**	0.10
		Outlet	**<5**	0.14

Appendix E:
2000 New Hampshire Technical Community College BMP Sampling

Pennichuck Brook

Urban Runoff Project

April 2000

Prepared by the

Nashua Regional Planning Commission

**This project was funded in part by a New Hampshire Department of Environmental Services
Nonpoint Source Program Local Initiative Grant
with matching funds provided by Pennichuck Water Works.**

Project Summary and Goals

The goal of the *Pennichuck Brook Urban Stormwater Project* is to decrease the impacts of urban runoff on the Holt Brook tributary and the Pennichuck Brook watershed. Accomplishing this goal involved:

- Diverting the untreated discharge through a multi-cell stormwater treatment system
- Educating the businesses in the drainage area on the negative impacts of NPS and accidental spills on the city's public water supply
- Increasing public awareness of the link between the stormwater drainage system and the public drinking water supply through a storm drain stenciling program
- Demonstrating the effectiveness of low technology urban runoff management practices on water resources
- Encouraging local planning boards to incorporate urban runoff best management practices in the designs of future development in the communities

Introduction

Through regulation and education, the impact of point sources of pollution have been reduced and the focus has shifted to nonpoint sources of pollution. The *New Hampshire Nonpoint Source Pollution Management Plan*, published in 1999 by the NH Department of Environmental Services, identifies urban runoff as the primary area of concern for impacts to water quality in the State. The Pennichuck Brook system is the major water supply source for the Nashua region and serves as Pennichuck Water Works primary source of water (approximately 75 percent). Portions of the Pennichuck Brook watershed are impacted by urban runoff from industrial, commercial and high density residential uses as well as the region's major transportation networks, the FE Everett Turnpike and NH Route 101A. This project deals with the impacts of urban runoff on the Pennichuck Brook system and includes both the construction of structural measures and educational efforts to reduce the impacts of nonpoint source pollution on the region's most important public water supply source.

The *Pennichuck Brook Urban Runoff Project* focuses on treating the discharge from the stormwater outfall with the greatest impact on water quality in the Pennichuck Brook. The outfall is located along a highly urbanized section of the NH Route 101A corridor in Nashua, more specifically on a NH Department of Transportation (DOT) easement on the NH Technical College property. The drainage area of the outfall is approximately 79 acres with an estimated impervious coverage of 60 percent. Fifty-two catch basins collect stormwater runoff from the streets, residential neighborhoods and parking lots of the roughly 60 businesses in the drainage area. See Sheet 1 of 2 in Appendix A.

The drainage area contains such varied uses as car washes, gas stations, automobile oil and lubrication services, automobile muffler and brake services, dry cleaners, restaurants and retail establishments. The threat of an accidental spill contaminating the Pennichuck Brook system is very real. In December of 1994, an accidental oil spill at the Greased Lightning facility leaked into a floor drain, which was connected to a storm drain, and was discharged to the Holt Pond tributary at the outfall behind the NH Technical College. Given the types of businesses within the drainage area and within the greater watershed, increasing awareness of the potential negative impact of business or individual actions on the public drinking water supply is an important aspect of the project. Information and educational tools developed for this project can be utilized throughout the Pennichuck Brook watershed and can also be transferred to other communities.

Development within the Pennichuck Brook watershed continues and local planning boards need to become better informed about the negative impacts of stormwater runoff on water quality. The project will provide the boards with hard evidence on the effectiveness of this particular stormwater treatment

measure. The results of the water quality monitoring will be forwarded to the Planning Boards and Health Officials when they become available. The Planning Board education component of the project aims to provide boards with better information on which to make stormwater management decisions. Nineteen people throughout the region participated in the Stormwater Management Workshop held on December 9, 1999. Subsequent workshops have been held comparing the different types and effectiveness of stormwater treatment systems. The NRPC will continue to keep municipalities apprised of new technologies through the REPP III Quarterly Water Resources meetings. The towns are also submitting projects to the NHDES Year 2000 Biomonitoring Program through the Watershed Bureau's Biology Division.

Project Tasks

Task 1. Engineering Design and Specifications: The site was surveyed by a licensed land surveyor and the treatment system was designed in conjunction with the NH DES. The treatment system is a sequence of multiple treatment cells, each with a particular treatment function. The system will treat up to a 10-year storm (40-CFS) and encompasses about .75% of the total watershed area. The system will remove pollutants via sedimentation, filtration, biological uptake and chemical reduction. See Appendix A for the location of the treatment cells and their functions.

Task 2. Construction and Inspection: West Environmental, Inc monitored the entire construction of the stormwater treatment wetland. The excavation was performed by Audrey Construction in the summer of 1998. Park Construction graded the site in September. Extensive dewatering was necessary for construction equipment in the basin areas. Twelve inches of topsoil was spread over the medium to fine subsoil to provide a good planting medium. A.J. Cameron Sod Farms, Inc. performed the landscaping at the site and plant materials were purchased from New England Wetland Plants. Planting was completed in mid-October. See Appendix B for the plant material invoice, a photo log of construction, and follow up inspection report.

Task 3. Water Quality Monitoring: Monitoring was postponed for a year to allow the wetland vegetation to take hold and give a better indication of the materials that are trapped and settled out in the system. Despite a very dry season, 80% of the vegetation planted survived. Wet weather water quality monitoring will be conducted at four sites within the treatment system. Samples will be analyzed for E-coli, dissolved oxygen, nitrates, ammonia, petroleum hydrocarbons, TKN, total suspended solids, phosphorous and drinking water detection limits for RCRA regulated metals. Pennichuck Water Works has contracted the analyses of all parameters to a certified laboratory. Ten sampling runs will be conducted by Pennichuck staff**.** A Quality Assurance Project Plan (QAPP), describing the monitoring plan and quality assurance/quality control measures has been submitted to the US EPA. See Appendix C. The results of the water quality monitoring will be forwarded as a supplemental report upon approval of the QAPP and completion of sampling.

Task 4. Education Program: The education component of the project consisted of creating a pamphlet and compiling a packet of information on non-point sources (NPS) of pollution and Best Management Practices (BMPs) developed by New Hampshire Department of Environmental Services (NH DES). The larger businesses in the stormwater drainage area were visited and presented an overview of the project and supplied with the educational packets. The majority of the 21 businesses were interested in the project and willing to read through the material provided. See Appendix D for the educational materials. The 52 public storm drain inlets in the area were stenciled "Dump No Waste/Protect Your Water" to alert the public of the fate of runoff water and materials carried with it from streets, parking areas, and landscaped areas. To increase employee awareness, NRPC will stencil drains on private property with the permission of the owner.

Task 5. Planning Board Education Program: A training workshop on NPS, BMPs, alternative technologies, and effective buffers was held on December 9, 1999 for planning boards, municipal planners, conservation commissions and enforcement officials in the Pennichuck Brook watershed. See Appendix E.

Task 6. Supplemental Final Report: A discussion of the results of the ten wet weather water quality monitoring results will be supplied upon their completion.

Appendix A

Treatment Cell Locations and Their Functions

The Treatment Cell Functions

1. ***Sediment Forebay*** - This bay of the sedimentation basin is small and readily accessible for cleaning by heavy equipment without having to enter it. This bay will capture most of the heavy grits and sands being discharged into the treatment system from the storm drainage. The presence of this forebay will extend the life of the sedimentation basin between cleanings.

2. ***Sediment Bay*** **-** This larger sedimentation follows the sediment forebay and will remove smaller particulate matter. Its detention time and depth are such that cleaning will require equipment to enter into basin. The basin is equipped with an oil water separator at its outlet, which allows the basin to drain slowly between storms.

3. ***Oil/Water Separator*** **-** This will capture the floating oils that are present in stormwater stream that are not in solution. Vac trucks can access this separator to remove the collected oils.

4. ***Marsh Channel*** **-** This part of the treatment process is a vegetated wetland and will reduce nutrient loadings through biological uptake.

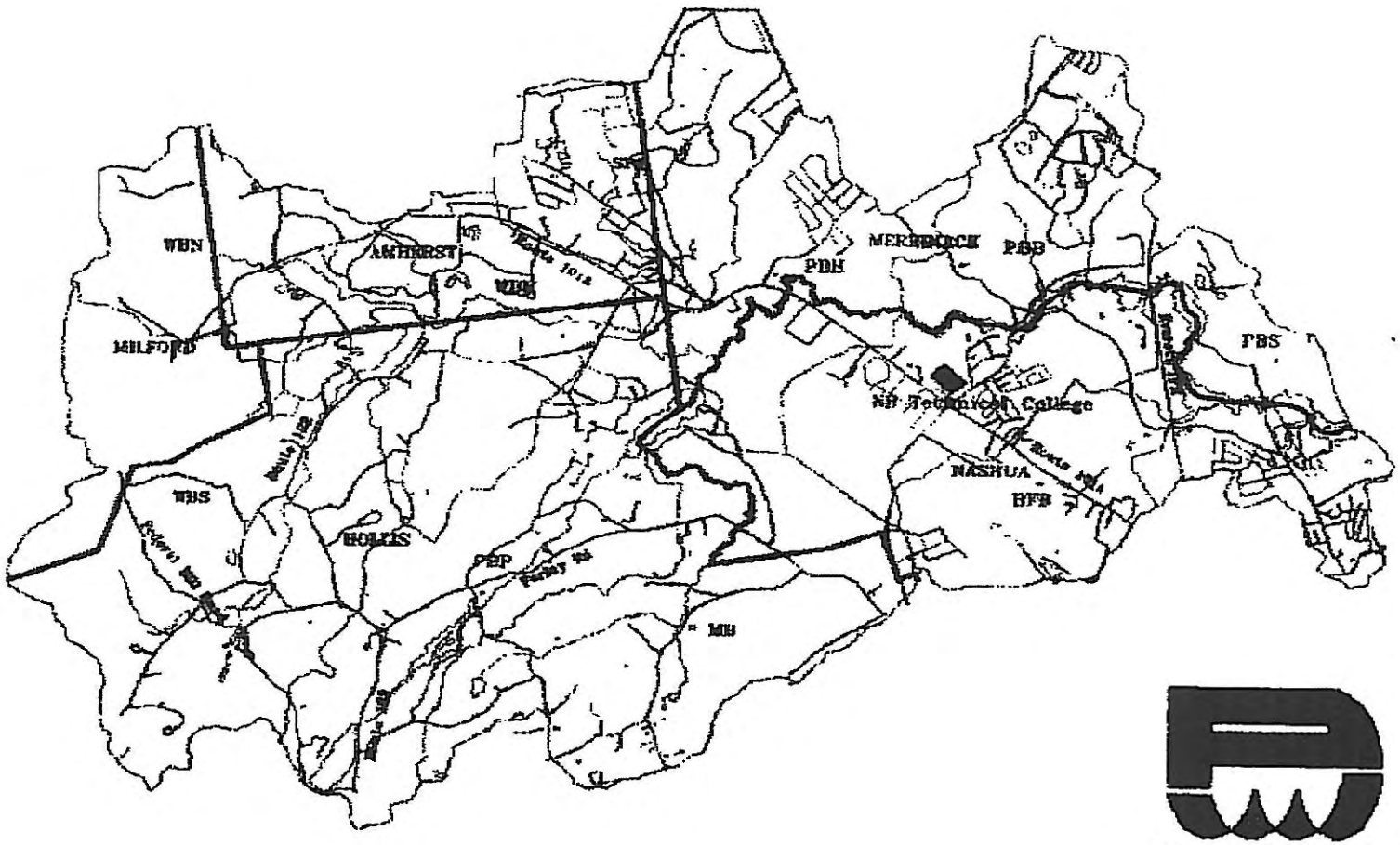
5. ***Wet Pond*** **-** The wet pond provides for additional nutrient uptake, final sedimentation, groundwater infiltration, and wildlife habitat.

6. ***Rip Rap Check Dams*** **-** These dams serve as filters as low flows can flow through them, allowing for fines to be captured in the gravel face of each check dam.

CEI
6039132379

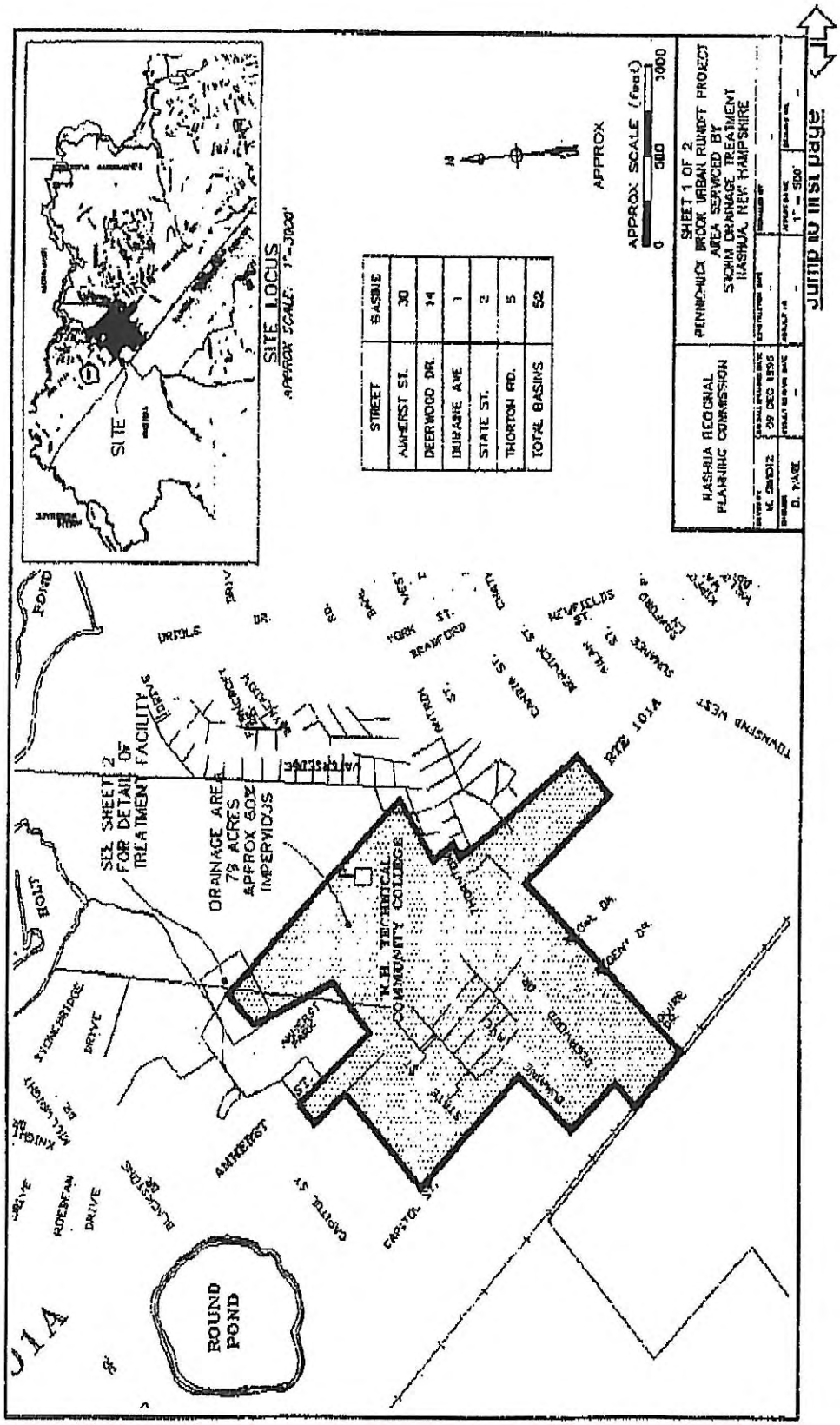
Pennichuck Brook Watershed

17,000 Acres - PWW owns 1,500

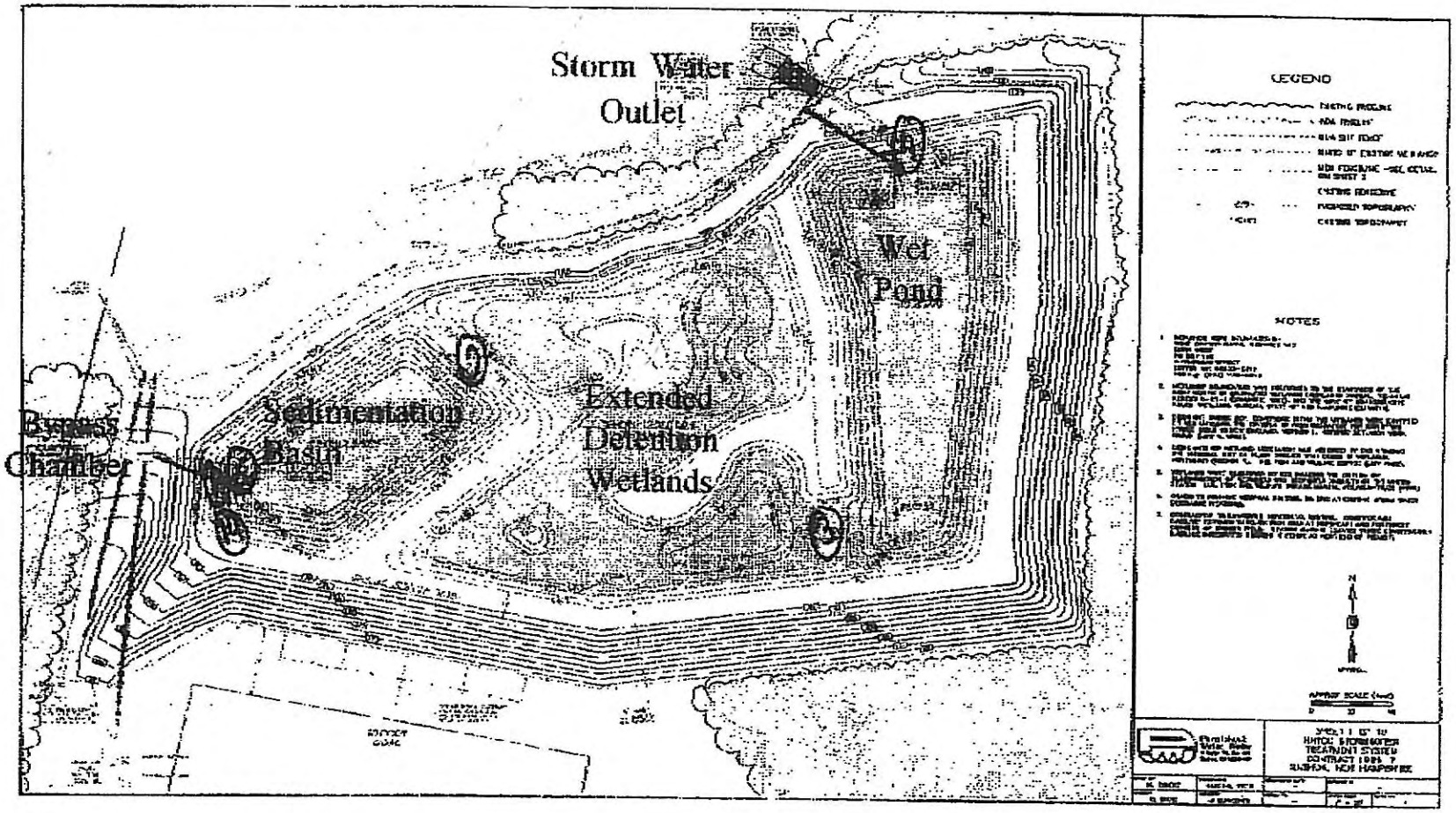


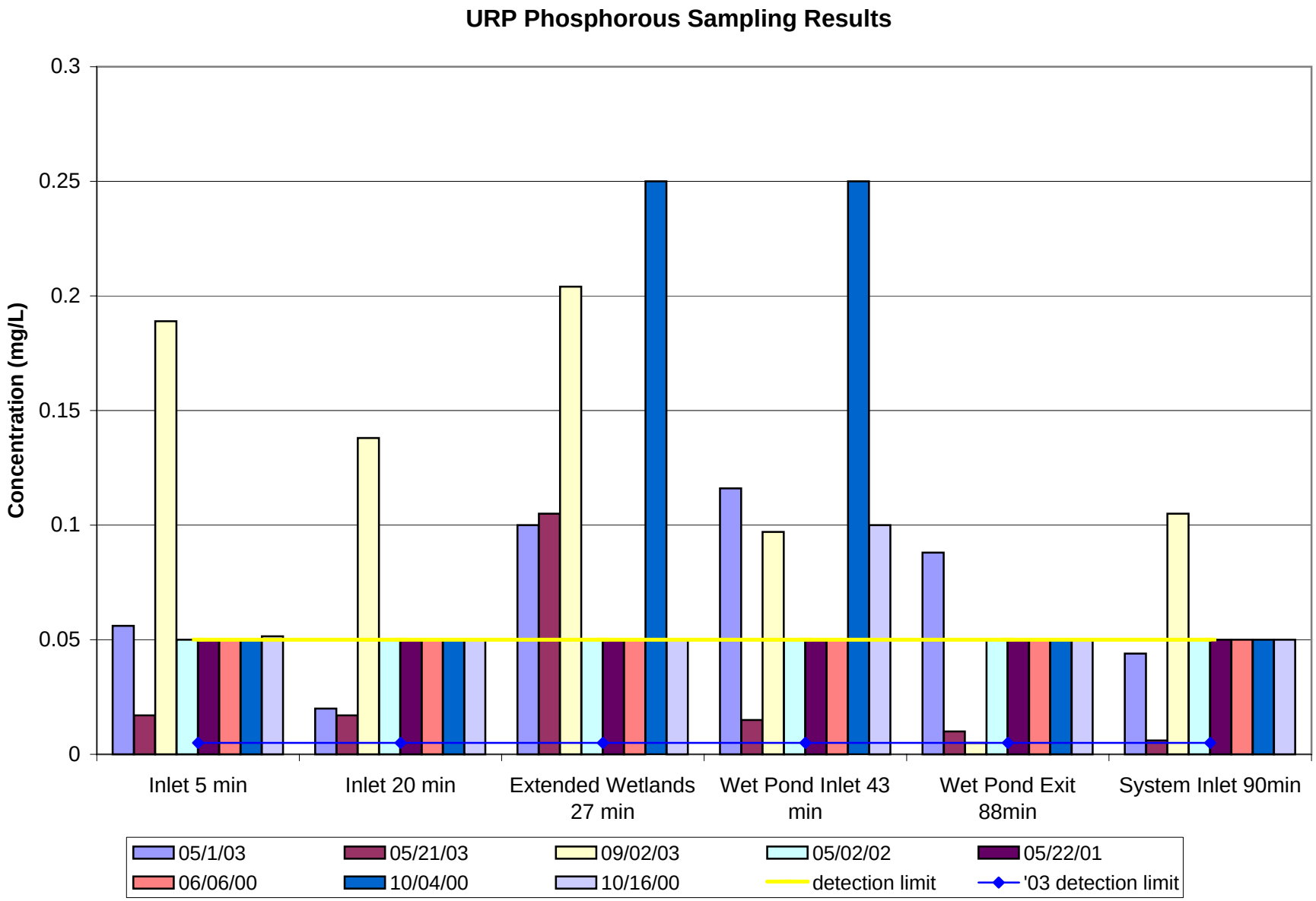
Jump to first page

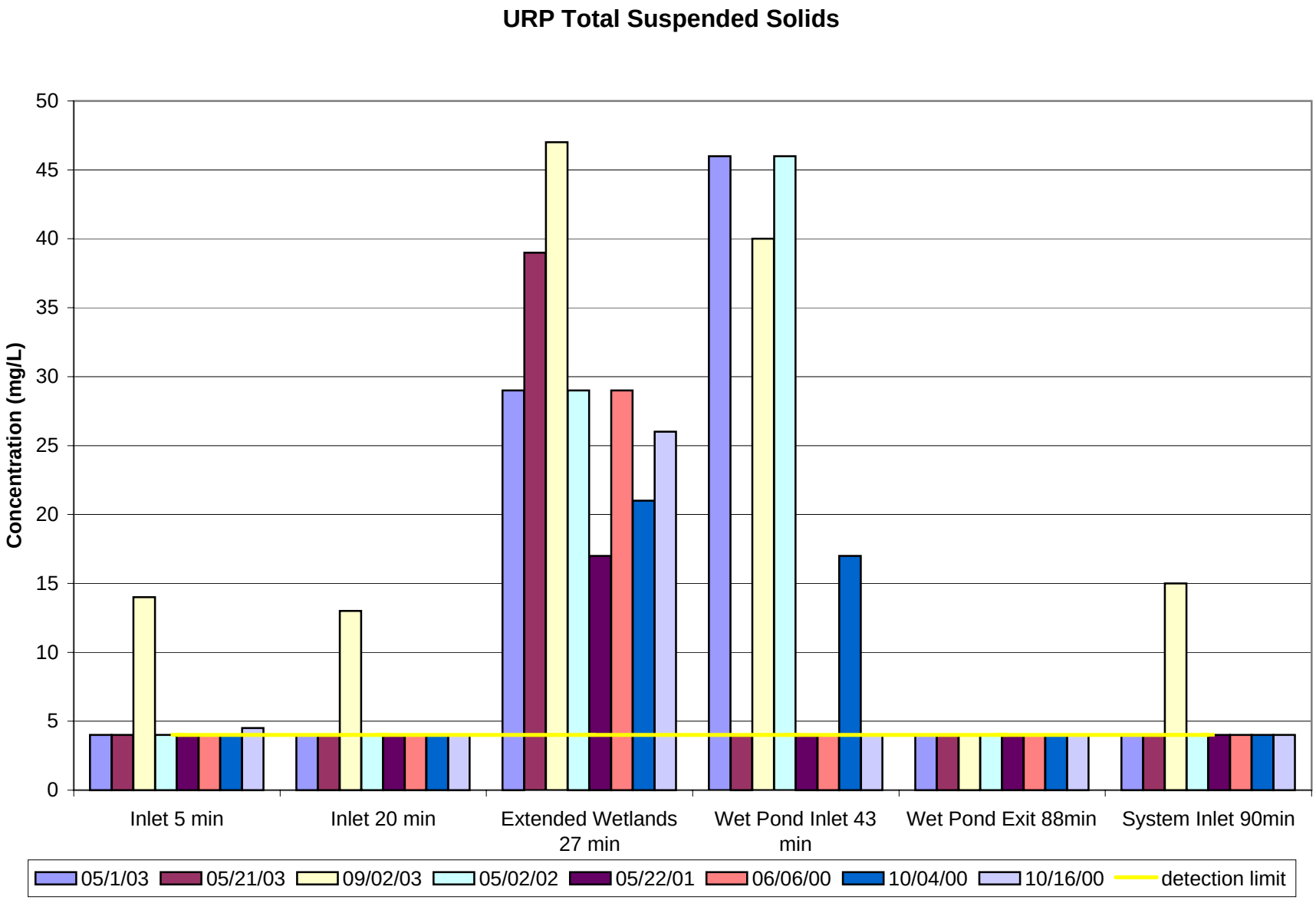
Overview of Area Treated



Treatment System Overview




URP Phosphorous Sampling Results
Concentration (mg/L)
0.3
0.25
0.2
0.15
0.1
0.05
0
Inlet 5 min
Inlet 20 min
Extended Wetlands 27 min
Wet Pond Inlet 43 min
Wet Pond Exit 88min
System Inlet 90min
05/1/03
05/21/03
09/02/03
05/02/02
05/22/01
06/06/00
10/04/00
10/16/00
detection limit
'03 detection limit


URP Total Suspended Solids
Concentration (mg/L)
50
45
40
35
30
25
20
15
10
5
0
Inlet 5 min
Inlet 20 min
Extended Wetlands 27 min
Wet Pond Inlet 43 min
Wet Pond Exit 88min
System Inlet 90min
05/1/03
05/21/03
09/02/03
05/02/02
05/22/01
06/06/00
10/04/00
10/16/00
detection limit

Sampling Results

05/1/03						
	Inlet 5 min	Inlet 20 min	Extended Wetlands 27 min	Wet Pond Inlet 43 min	Wet Pond Exit 88min	System Inlet 90min
Total suspended Solids	**4**	**4**	29	46	**4**	**4**
Nitrate	1.83	1.84	1.61	1.24	1.46	1.99
Ammonia	0.102	**0.1**	**0.1**	0.125	**0.1**	**0.1**
TKN	0.603	0.855	0.641	0.716	0.59	0.427
Phosphorous	0.056	0.02	0.1	0.116	0.088	0.044
Fecal Coliform	0	0	0	8	0	0
Arsenic	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Barium	0.088	0.086	0.099	0.088	0.071	0.098
Cadmium	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**
Chromium	0.013	**0.012**	**0.01**	0.015	**0.01**	**0.01**
Lead	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
Selenium	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Silver	**0.007**	**0.007**	**0.007**	**0.007**	**0.007**	**0.007**
Mercury	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**

05/21/03						
	Inlet 5 min	Inlet 20 min	Extended Wetlands 27 min	Wet Pond Inlet 43 min	Wet Pond Exit 88min	System Inlet 90min
Total suspended Solids	**4**	**4**	39	**4**	**4**	**4**
Nitrate	1.97	1.74	1.63	1.26	1.03	1.89
Ammonia	0.252	**0.1**	0.106	0.198	**0.1**	**0.1**
TKN	0.395	0.484	0.614	0.785	0.34	0.66
Phosphorous	0.017	0.017	0.105	0.015	0.01	0.006
Fecal Coliform	0	0	9	13	0	0
Arsenic	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Barium	0.083	0.088	0.094	0.069	0.075	0.084
Cadmium	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**
Chromium	**0.012**	**0.012**	**0.01**	**0.01**	**0.01**	**0.01**
Lead	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
Selenium	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Silver	**0.007**	**0.007**	**0.007**	**0.007**	**0.007**	**0.007**
Mercury	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**

09/02/03						
	Inlet 5 min	Inlet 20 min	Extended Wetlands 27 min	Wet Pond Inlet 43 min	Wet Pond Exit 88min	System Inlet 90min
Total suspended Solids	14	13	47	40	**4**	15
Nitrate	**1**	**1**	**1**	**1**	**1**	**1**
Ammonia	0.801	0.778	0.228	0.251	0.136	0.732
TKN	1.75	1.45	0.856	0.7	0.304	1.2
Phosphorous	0.189	0.138	0.204	0.097	0.005	0.105
Fecal Coliform	14000	13000	1490	28	91	**20000**
Arsenic	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Barium	0.041	0.043	0.073	0.059	0.06	0.038
Cadmium	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**
Chromium	0.012	0.012	**0.01**	**0.01**	**0.01**	**0.01**
Lead	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
Selenium	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Silver	**0.007**	**0.007**	**0.007**	**0.007**	**0.007**	**0.007**
Mercury	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**

Sampling Results

05/02/02						
	Inlet 5 min	Inlet 20 min	Extended Wetlands 27 min	Wet Pond Inlet 43 min	Wet Pond Exit 88min	System Inlet 90min
Total suspended Solids	**4**	**4**	29	46	**4**	**4**
Nitrate	1.71	2.00	**1**	**1**	**1**	2
Ammonia	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**
TKN	0.523	0.826	0.359	0.561	0.434	0.573
Phosphorous	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Fecal Coliform	0	0	1	3	0	0
Arsenic	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Barium	0.072	0.057	0.044	0.034	0.062	0.061
Cadmium	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Chromium	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Lead	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Selenium	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Silver	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Mercury	**0.0006**	**0.0006**	**0.0006**	**0.0006**	**0.0006**	**0.0006**

Sampling Results

05/22/01						
	Inlet 5 min	Inlet 20 min	Extended Wetlands 27 min	Wet Pond Inlet 43 min	Wet Pond Exit 88min	System Inlet 90min
Total suspe	**4**	**4**	17	**4**	**4**	**4**
Nitrate	1.68	1.62	1.58	1.19	1	1.56
Ammonia	0.172	**0.1**	0.137	**0.1**	0.122	**0.1**
TKN	0.338	0.826	0.471	0.317	0.387	0.415
Phosphoro	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Fecal Colif	0	0	29	121	0	1
Arsenic	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Barium	0.061	0.059	0.098	0.043	0.062	0.055
Cadmium	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Chromium	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Lead	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Selenium	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Silver	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Mercury	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**

Sampling Results

06/06/00						
	Inlet 5 min	Inlet 20 min	Extended Wetlands 27 min	Wet Pond Inlet 43 min	Wet Pond Exit 88min	System Inlet 90min
Total suspended Solids	4	**4**	29	**4**	**4**	**4**
Nitrate	1.87	1.80	1.4	1.07	1.1	1.77
Ammonia	0.23	0.13	0.22	0.25	0.22	0.19
TKN	0.614	0.647	0.78	0.972	0.528	0.282
Phosphorous	**0.050**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Fecal Coliform	20	3	15	220	1	1
Arsenic	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Barium	0.052	0.057	**0.05**	0.051	0.085	0.066
Cadmium	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Chromium	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Lead	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Selenium	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Silver	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Mercury	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**

10/04/00						
	Inlet 5 min	Inlet 20 min	Extended Wetlands 27 min	Wet Pond Inlet 43 min	Wet Pond Exit 88min	System Inlet 90min
Total suspended Solids	**4**	**4**	21	17	**4**	**4**
Nitrate	1.70	1.82	**1**	1.13	**1**	1.72
Ammonia	0.114	0.106	**0.1**	0.128	0.133	0.139
TKN	0.459	0.653	1.33	0.928	0.199	0.491
Phosphorous	**0.050**	**0.05**	**0.25**	**0.25**	**0.05**	**0.05**
Fecal Coliform	36.5	30	11	1	90	3
Arsenic	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Barium	0.052	0.051	**0.05**	0.058	0.061	0.05
Cadmium	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Chromium	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Lead	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Selenium	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Silver	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Mercury	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**

10/16/00						
	Inlet 5 min	Inlet 20 min	Extended Wetlands 27 min	Wet Pond Inlet 43 min	Wet Pond Exit 88min	System Inlet 90min
Total suspended Solids	4.5	**4**	26	**4**	**4**	**4**
Nitrate	1.61	1.59	1.17	**1**	**1**	1.52
Ammonia	**0.1**	0.165	**0.1**	0.132	**0.1**	**0.1**
TKN	0.579	0.394	0.582	2.29	0.433	0.549
Phosphorous	0.052	**0.05**	**0.05**	**0.1**	**0.05**	**0.05**
Fecal Coliform	35.5	33	26	30	12	32
Arsenic	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Barium	0.06	0.058	0.065	0.381	0.082	0.062
Cadmium	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**
Chromium	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Lead	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
Selenium	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Silver	**0.007**	**0.007**	**0.007**	**0.007**	**0.007**	**0.007**
Mercury	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**

Appendix E:
2001 Somerset Plaza and NH DOT Park & Ride Facility BMP Sampling

BOIRE FIELD BROOK SUBWATERSHED PROJECT

2000 Nonpoint Source Program
Local Initiative Grant

December 31, 2001

Prepared by the

NASHUA REGIONAL PLANNING COMMISSION

with funding by

NHDES

This project was funded in part by a New Hampshire Department of Environmental Services
Nonpoint Source Program Local Initiative Grant with in-kind services provided by the
City of Nashua, Pennichuck Water Works, and
NHDES Watershed Bureau.

PROJECT SUMMARY AND GOALS

The goal of the *Boire Field Brook Subwatershed Project* was to assess the impacts of stormwater runoff on a portion of the Boire Field Brook Subwatershed of the Pennichuck Brook Watershed. In addition, the project included a component to educate private landowners that maintenance of stormwater systems is their responsibility and that improperly functioning systems allow non-point source (NPS) pollutants to flow into the public drinking water supply. This study will be used as a case study to develop a citywide stormwater management program for compliance with the EPA Phase II Stormwater Regulations. Steps taken toward accomplishing this goal involved:

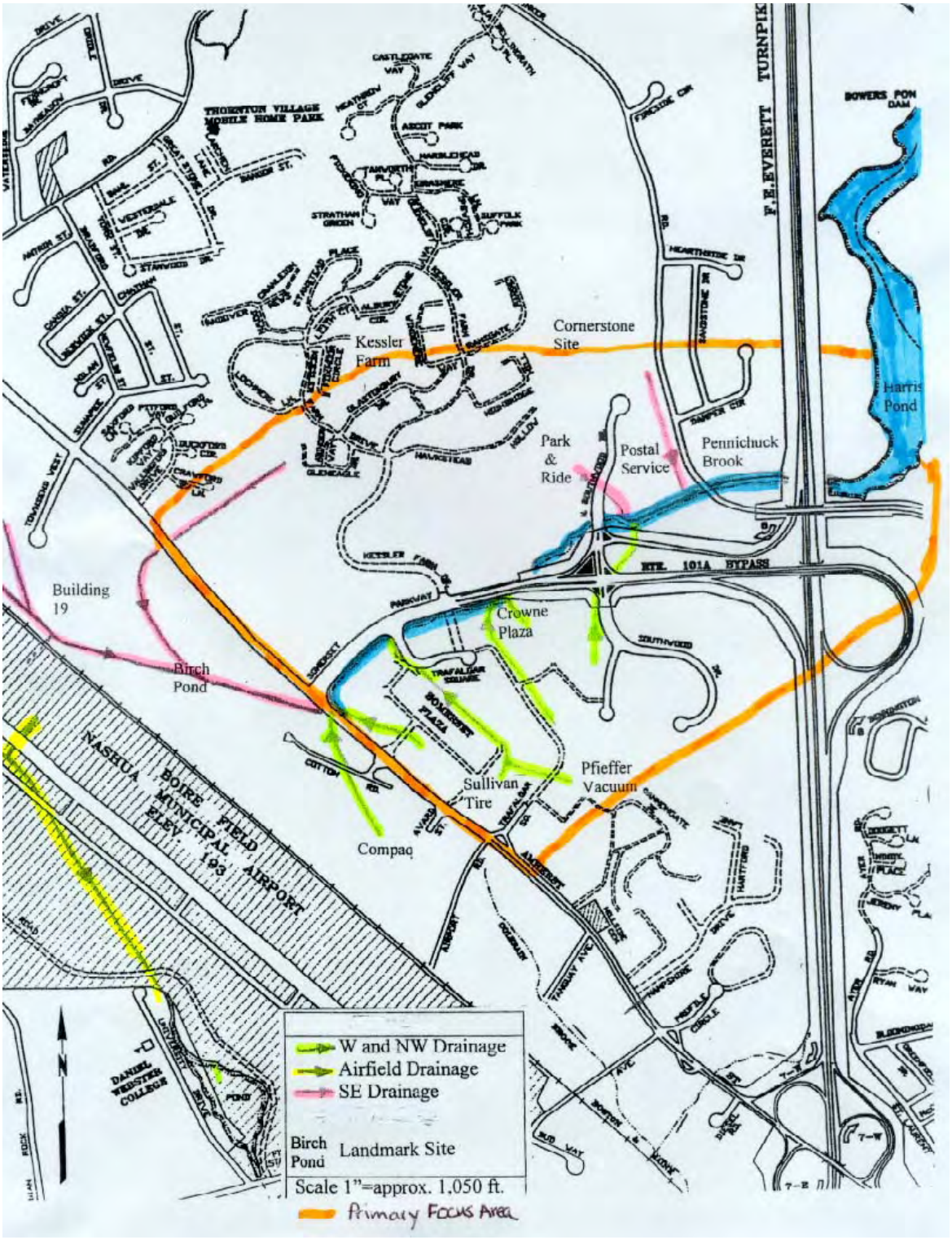
- An inventory of existing closed and open drainage systems
- Identifying data needs for planning and best management implementation
- Conducting an initial review of legal issues to enforce current regulations and improve maintenance standards
- Educating the businesses located in the drainage area on the negative impacts of NPS pollution, sedimentation and accidental spills on the City's public water supply
- Increasing public awareness of the link between the stormwater drainage system and the public drinking water supply through a storm drain stenciling program
- Encouraging local businesses to incorporate urban runoff best management practices in the designs of future development in the City
- Assisting private landowners with maintenance plans for systems on their properties

INTRODUCTION

The Pennichuck Brook system is the major water supply source for the Nashua region and serves as the primary source of water (approximately 75%) for the Pennichuck Water Works. The Boire Field Brook flows directly into Harris Pond, which is the closest pond to the Pennichuck Water Works treatment facility. The Boire Field Brook Subwatershed is impacted by urban runoff from industrial, commercial and high-density residential uses as well as the region's major transportation networks, the FE Everett Turnpike and NH Route 101A. The primary focus was along the Boire Field Brook from Amherst Street (Route 101A) along Somerset Parkway to Harris Pond (see Figure 1, Project Area).

In an effort to protect the region's water supply, the *Boire Field Brook Subwatershed Project* focused on inventorying and evaluating existing stormwater drainage systems. In 1999 and 2000, Nashua obtained new Geographic Information System (GIS) data for catch basins and other stormwater information derived from aerial photography. The existing data was field checked to verify accuracy and to account for possible omissions on the mapping. The City needed to evaluate existing data for completeness and determine what type of information will be necessary for a citywide stormwater drainage program for EPA Phase II compliance expected in 2003. The project also involved identifying areas for the construction of a larger treatment system similar to the one constructed behind the Technical College next to Holt Pond. This watershed will be used as a case study by the City of Nashua to prepare an effective citywide drainage plan.

Figure 1. Project Area



PROJECT TASKS

TASK 1 *Research, Inventory and Assessment of Existing Stormwater Drainage Systems in the Subwatershed*

Figure 2.
Sedimentation and Litter in Drainage Swale

NRPC and the City of Nashua Planning staff researched all site plans in the project area. A landowner mailing database was created and a letter was sent to the property owners/managers. The letter and mailing list is in Task 1 of the Appendix. The letter gave an overview of the project and requested permission to access the property to inspect stormwater drainage systems. The City of Nashua Planning, Pennichuck Water Works Engineering Department and NRPC reviewed the plans for potential areas to conduct wet weather water quality monitoring based on the age of the stormwater systems and their accessibility. Pennichuck and NRPC field checked the project area in April 2001. Two sites were chosen for sampling and all problems or deficiencies were noted at this time. Problems on private property were photographed and turned over to the City of Nashua Code Enforcement Department. The majority of the problems were clogged pipes, sedimentation and litter in drainage swales (Figure 2).

TASK 2 Develop Database

Assess the quality of existing data and determine what information will be needed for citywide stormwater compliance based on this sub-watershed.

A Geographic Information System (GIS) map was generated to show catch basin, flow direction, and public stormwater systems (pipes, basins and swales). Private stormwater systems were taken from individual site plans and incorporated into the map and database. A grid system was designed for the database but it proved too cumbersome and the scale was not useful. Rather, the database was designed to access property/stormwater drainage systems by the City Tax Assessors number, Sheet/Lot number or the street address. The closest street and directional indicator will identify swales. This will enable all City departments to access the information. Properties or area can be accessed by the Tax Assessors code or by Sheet/Lot number. The complete engineering summary is in Task 2 of the Appendix.

Recommendations

- Upon final approval and/or final inspection of a site plan, the Planning Department should forward the site plan to the Engineering Department for inclusion in the database before filing the plan with the Hillsborough County Registry of Deeds. This will enable the Engineering Department to automatically set a maintenance reporting schedule.
- Maintenance reports should be generated monthly to enable the enforcement entity to schedule visits or notification in the most time efficient manner.

- The City of Nashua should form a committee to discuss the role and personnel involved for enforcement of maintenance or remediation of stormwater drainage systems on private properties.
- A systematic inspection schedule of all citywide stormwater drainage systems should be developed and added to the database.
- When plans are submitted to the Department of Environmental Services (DES) for Site Specific Review, the DES project number should be reported to the Engineering Department for inclusion in the database.

TASK 3 Legal Review

An initial review of the City's rights to improve stormwater management on private property based on current regulations was completed. This includes annual maintenance (vacuuming catch basins), dredging swales or remediation measures based on field observation and water quality data collected during 2001.

This task is a brief review of the City of Nashua's legal rights to enforce existing and improved stormwater maintenance standards on private property. Existing regulatory measures, which could include stormwater maintenance standards, would apply in connection to new applications for land use control permits, such as subdivision and site plan applications. There is no means of imposing stormwater maintenance standards on unimproved land or on improved land whose improvements predate the stormwater maintenance regulations.

With respect to land approved for development since the effective date of the stormwater management regulations, stormwater management can be enforced to the extent that it has been required as a condition of the site plan approval. However, land approved for development by subdivision or site plan approval, but not yet actually improved before the enactment of the stormwater (or any other) regulations, is, to some extent, exempt from such regulations under RSA 676:12 and 674:39. The exception under RSA 674:39 is for "regulations and ordinances which expressly protect public health standards such as water quality and sewerage treatment requirements." This is a question of technical and scientific fact.

In addition to those regulations that are applicable to private development, the City may, of course, enforce stormwater management practices that are reasonably required to protect streets and other public infrastructure, provided that the City has obtained easements for that purpose. Finally, in the event that accumulations of water constitute a public nuisance, the City has the common law power to abate such a nuisance by legal action.

The City's current ordinances have been reviewed. When the City enacted ordinances concerning stormwater in December of 1998, it required stormwater management to be a part of every subdivision and site plan. For subdivisions, the applicant must submit a stormwater management report, signed by a state-registered engineer, detailing the stormwater practices used in the subdivision and their compliance with established stormwater management standards (NRO 16-107 (a)(15)). One of the subdivision approval factors is a review of the areas provided for detention, treatment, infiltration or other handling of stormwater (NRO 16-108 (b)(7)). There are also equivalent provisions for site plans, including the submission of a stormwater management report (NRO 16-122 (f)(13)) and an adequate means of handling stormwater runoff as a factor in approval (NRO 16-123 (b)(8)). Therefore, any subdivisions or site plans approved since December of 1998 should have enforceable stormwater management components in place, although they still may not be to the level or extent that may be desired in the future. The original legal summary is located in Task 3 of the Appendix.

TASK 4 Develop a Quality Assurance Protection Plan (QAPP)

The EPA final approval letter and signature sheet of the QAPP is in Task 4 of the Appendix.

TASK 5 Wet Weather Water Quality Monitoring

Wet weather water quality was measured at two (2) sites in the subwatershed. Water quality at the two sites was tested at the inlet and outfall of a new and an older open drainage system. The original results and receipts are in Task 5 of the Appendix. The new system is located at the Department of Transportation (DOT) Park and Ride Facility off of Somerset Parkway (Exit 8 of the FE Everett Turnpike) on North Southwood Drive. It was designed to be an infiltration system with an overflow pipe at the outlet (east end). Vegetation and sediment were present and therefore some trapping of sediment and nutrient uptake has occurred. The system is wide and deep and has the potential to hold water compared to the older system.

Figure 3. DOT Retention Basin Inlet

Figure 4. DOT Retention Basin Outlet (overflow)

The older system is located along Amherst Street (Route 101A) in the Somerset Plaza. The Plaza was built in the late 1980's. The swale collects water from 14 catch basins located on the main parking lot in front of the complex. The stormwater is hardpiped directly to the swale. The swale is heavily vegetated and filled with coarse-grained sediment. It is shallow, narrow and runs for approximately 100 feet before reaching the confluence of Boire Field Brook. It probably allows a great deal of sediment to flow into the Boire Field Brook due to lack of maintenance.

Figure 5. Somerset Plaza Swale Inlet

Figure 6. Somerset Plaza Swale Outlet (above confluence of Boire Field Brook)

During all sampling events, the older drainage swale at Somerset Plaza was tested first. The water moves through the system at a greater rate. Three of the four sampling runs caught the first flush.

Although petroleum hydrocarbons and metals may be a problem, we elected not to test for them due to the expense and scope of the overall grant. Rather, we wanted to get a very basic assessment of the water quality in the project area. Sampling was conducted for the following: 1) total suspended solids (TSS); 2) total Kjeldahl nitrogen (TKN); 3) total phosphorous (TP); and 4) *E. coli*. The four parameters were chosen for the following reasons:

- TSS - Large volumes of urban runoff flow from parking lots and other impervious areas in the watershed.
- TKN – Commercial fertilizer use and stagnating water is found in the subwatershed.
- TP - Commercial landscaping is prevalent and high numbers of waterfowl are found throughout the subwatershed.
- *E. coli* – The housing developments allow dogs, and waterfowl is attracted to the detention ponds near the Crown Plaza Hotel.

Total Suspended Solids (TSS)

The 1997 Stormwater Characterization study, conducted in Concord by NHDES, found a range of <1 to 146 mg/L with a study mean of 143mg/L for TSS. The samples at both sites ranged from <4 to 17mg/L which is well below the study mean of 143mg/L.

Total Kjeldahl Nitrogen (TKN)

This is a measure of inorganic ammonia nitrogen and total organic nitrogen. High readings indicate nutrient rich waters, generally characterized by high levels of biological production. In general, TKN and relative nitrogen species will be higher than phosphorus levels. Nitrogen is readily soluble and its levels usually increase as flow increases. The 1997 Stormwater Characterization study found a range of 0.53 to 13.7 mg/L with a study mean of 3.394mg/L. The samples at both sites ranged between 0.100 and 1.35mg/L, which is well below the study mean for stormwater.

Phosphorous-P

Phosphorous along with nitrogen is a plant nutrient that determines the amount of an alga growth that can occur. In freshwater in New Hampshire, phosphorus is considered the limiting nutrient. Phosphorus is not readily soluble and is more closely related to erosion. Phosphorus levels were extremely high throughout the season with a range of 0.050 – 0.211 mg/L. The level of concern established by NHDES is 0.02 mg/L. The season average at site 1 was 0.155 mg/L and site 2 was 0.074mg/L. Values >0.04 mg/L is considered excessive. The levels are indicative of the high levels of sediment and dissolved materials flowing through the swale.

E. coli

This bacteria is used as an indicator of human sewage but elevated numbers can occur in the presence of waterfowl or any other warm-blooded animal. The State of New Hampshire sets water quality standards for Class B waters. Designated uses for Class B waters includes fishing, swimming and other recreational purposes. The testing sites are not used for these purposes but are used to illustrate that the water flowing from these stormwater drainage systems enter into Class A waters which are designated drinking water supplies. Drinking water should have no *E. coli* after treatment. The acceptable level of *E. coli* is determined by risk analysis based on statistics to protect human health. *E. coli* levels at designated swimming beaches should not exceed 88 per 100 milliliter (mg/L) in any one sample, or exceed a three-sample average over a 60-day period of 47/100mL. Recreational waters that are not designated beaches should not have more than 406 *E. coli*/100mL in any one sample, or more than 126/100mL in a 60-day, three-sample average. Occasional higher numbers are not unusual, particularly after storm events and where urban or agricultural runoff occurs. These levels are generally not considered unsafe unless investigation indicates the source to be sewage. At both sites all tests exceeded 200mg/L.

September 14, 2001

This was the first rain event in approximately a month and the samples were collected late morning during the first flush. Rainfall readings at Pennichuck Water Works (Pennichuck) in Nashua registered 0.25 inches on the 14th. Due to the failure of ziplock bags during incubation, all bacteria samples for E. Coli analysis were lost. A duplicate sample for *E. coli* was taken at the Somerset Inlet but was also lost at the lab.

Analyte and Method	Somerset Inlet Pipe	Somerset Outlet Pipe	Park & Ride Inlet Pipe	Park & Ride Outlet Pipe	Detection Limit PQL
Total Suspended Solids 160.2	6 mg/L	17 mg/L	16 mg/L	9 mg/L	4 mg/L
Kjeldahl-N 351.3	0.486 mg/L	0.341 mg/L	1.23 mg/L	0.136 mg/L	0.100 mg/L
Phosphorous-P 365.2	0.209 mg/L	0.174 mg/L	0.099 mg/L	0.055 mg/L	0.050 mg/L
E. Coli SM 9213D	Lab Failure	Lab Failure	Lab Failure	Lab Failure	NA

September 21, 2001

This was the first rain event since the September 14th sampling. The samples were taken at 9 am approximately 9 hours after it started raining. Rainfall readings at Pennichuck registered 0.74 inches on the 21rst. A duplicate sample was taken at the Somerset Outlet for TKN and Phosphorous since they use the same preservative (H_2SO_4). The lab did not process the duplicates even though they were listed on the chain of custody sheet.

Analyte and Method	Somerset Inlet Pipe	Somerset Outlet Pipe	Park & Ride Inlet Pipe	Park & Ride Outlet Pipe	Detection Limit PQL
Total Suspended Solids 160.2	8 mg/L	5 mg/L	5 mg/L	5 mg/L	4 mg/L
Kjeldahl-N 351.3	1.35 mg/L	1.3 mg/L	0.119 mg/L	0.186 mg/L	0.100 mg/L
Phosphorous-P 365.2	0.211 mg/L	0.183 mg/L	<0.050 mg/L	<0.05 mg/L	0.050 mg/L
E. Coli SM 9213D	>200 mg/L	>200 mg/L	>200 mg/L	>200 mg/L	0 Colonies per 100mls

September 25, 2001

This was the first rain event since the September 21rst sampling. The samples were taken late morning during the first flush. A duplicate sample was taken at the Park & Ride Outlet for *E.coli*. Rainfall readings at Pennichuck registered a trace on the 25th and .63 inches on the 26th. The readings are generally taken in the morning, which would explain why only a trace was registered on the 25th.

Analyte and Method	Somerset Inlet Pipe	Somerset Outlet Pipe	Park & Ride Inlet Pipe	Park & Ride Outlet Pipe	Detection Limit PQL
Total Suspended Solids 160.2	<4 mg/L	5 mg/L	<4 mg/L	17 mg/L	4 mg/L
Kjeldahl-N 351.3	0.972 mg/L	1.11 mg/L	0.417 mg/L	0.769 mg/L	0.100 mg/L
Phosphorous-P 365.2	0.12 mg/L	0.124 mg/L	0.075 mg/L	0.122 mg/L	0.050 mg/L
E. Coli SM 9213D	>200 mg/L	>200 mg/L	>200 mg/L	>200 mg/L Duplicate >200 mg/L	0 Colonies per 100mls

October 15, 2001

This was the first rain event since September 14th sampling. The samples were taken at approximately 9 am. Rainfall readings at Pennichuck registered 0.21 inches.

Analyte and Method	Somerset Inlet Pipe	Somerset Outlet Pipe	Park & Ride Inlet Pipe	Park & Ride Outlet Pipe	Detection Limit PQL
Total Suspended Solids 160.2	5 mg/L	<4 mg/L	<4 mg/L	<4 mg/L	4 mg/L
Kjeldahl-N 351.3	1.28 mg/L	1.08 mg/L	<0.100 mg/L	0.643 mg/L	0.100 mg/L
Phosphorous-P 365.2	0.124 mg/L	0.091 mg/L	0.066 mg/L	0.073 mg/L	0.050 mg/L
E. Coli SM 9213D	>200 mg/L	>200 mg/L	>200 mg/L	>200 mg/L	0 Colonies per 100mls

TASK 6 Storm Drain Stenciling

The public storm drains in the project area were stenciled to increase awareness of the connection between stormwater runoff and the drinking water supply. This included all of the catch basins on Amherst Street from Sullivan Tire to Building 19. Somerset Parkway was stenciled from Amherst Street to North Southwood Drive. This accounts for 37 drains stenciled in the Project area. We did not receive any response to our offer to stencil the drains on private property. Since landowner permission was required, no drains were stenciled.

TASK 7 Landowner and Business Education Program

A packet was developed using existing information on NPS BMPs for landowners and businesses. Pennichuck Water Works developed flyers specifically for automotive and landscaping businesses. Each of the landowners and business complexes in the drainage area was mailed information on controlling NPS pollution, snow removal/storage and road salt. Specific maintenance programs were developed for the landowners based on field observations and water quality results. The mailing list is in Task 1 of the Appendix and the letter and educational materials are in Task 7 of the Appendix.

TASK 8 Identifying Sites for Future Treatment Measures

Identify sites with high sedimentation, failing systems and poor water quality for future treatment systems based on the field observations and water quality/sedimentation data.

On field visits within the Boire Field Brook Subwatershed there are three observations that relate to water quality. Most stormwater treatment devices appear to be overtaxed by sediment buildup. First, the removal of the sediment will add both longevity and treatment effectiveness (phosphorus adhering to particles) of the existing stormwater systems. There is no means of imposing stormwater maintenance standards on unimproved land or on improved land whose improvements predate the stormwater maintenance regulations of 1998. A systematic inspection schedule of private stormwater drainage systems could be developed using the existing GIS database. It is recommended that the City of Nashua should form a committee to discuss the role and personnel involved in identification of problems and enforcement of maintenance or remediation of stormwater drainage systems using health code or site plan violations.

Second, the chain of detention ponds and swales attract an abundance of waterfowl throughout the watershed. The ponds are a favorite lunch spot and workers enjoy feeding the ducks. Educational materials could be developed that explain that the waterfowl are the source of bacteria and phosphorus. Water quality is not the only issue; feeding bread to ducks is harmful to their health. Waterfowl can develop metabolic bone disease and other nutritional diseases. The City of Nashua should consider adopting an ordinance that prohibits the feeding of wildlife throughout the Pennichuck watershed.

Finally, another prevalent problem in the watershed is the improper storage and disposal of street sand. It is common practice to dump sand in a corner of a parking lot or in the drainage swales. The City of Nashua Public Works Department should undertake an educational mailing directed at contractors in the snow removal trade.

Specific problems noted for future improvements include:

- The swale on the south and east sides of Somerset Plaza needs to have the litter and sediment removed to allow for maximum nutrient uptake and retention of suspended solids in the storrmwater. The City of Nashua Code Enforcement has been notified that parking lot sand and ripped fertilizer bags have been dumped into the swale.
- The Park and Ride infiltration basin appears to be leaking water at the base of the outfall pipe. This was observed during the four sampling runs. The water seepage does not allow the basin to fill beyond half a foot for maximum infiltration.
- The Exit 8 detention area is quite large and equipped with a control valve. The gate was in the upright position, which allows the water to flow untreated directly in Boire Field Brook just above the convergence of Pennichuck Brook. This is close to the water supply uptake pond at Pennichuck Water Work's Treatment Plant. The Department of Transportation will be notified.

TASK 9 Final Report

The final report was prepared by the Nashua Regional Planning Commission and reviewed by Pennichuck Water Works and the City of Nashua Engineering, Legal and Planning Departments.

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APPENDICES NOT INCLUDED IN DIGITAL VERSION

Appendix F
In-Pond Phosphorus Calculations

Pennichuck Brook Watershed Existing In-pond Concentrations and Parameters						
	Stump Pond	**Pennichuck Pond**	**Holts Pond**	**Bowers Pond**	**Harris Pond**	**Supply Pond**
Lake area (km2)	0.08	0.23	0.09	0.37	0.32	0.06
Mean Depth (m)	1.52	1.52	0.62	1.83	4.07	3.05
Watershed area (km2)	5.56	19.06	58.74	65.37	69.99	71.28
Runoff phosphorus loadings (kg/yr)	254	92	967	535	493	133
New Streamflow Phosphorus loadings (kg/yr)	60	180	369	61	23	12
phosphorus loadings (kg/yr)	314	271	1335	597	516	144
Phosphorus loadings from Merrimack River (kg/yr)	0	0	0	131	0	0
Phosphorus loadings from preceding pond(s) (kg/yr)	0	0	401	1693	1862	1859
Total phosphorus loadings (kg/yr)	314	271	1736	2420	2378	2003
Total phosphorus loadings (g/m^2-yr)	4	1	19	7	8	32
Runoff (m/yr)	12	3	44	5	5	6
New Streamflow (m/yr)	36	39	198	8	4	9
Merrimack River Flow (m/yr)				6		
Streamflow from preceding pond(s) (m/yr)			146	97	137	730
Hydraulic Loading (m/yr)	48	42	388	116	146	746
In-pond Phosphorus (mg/l)	**0.054**	**0.019**	**0.047**	**0.043**	**0.040**	**0.042**
Average Observed P (mg/l)			**0.051**	**0.045**	**0.038**	**0.041**
P leaving pond (kg/yr)	217	184	1693	1862	1859	1976

Groundwater (Baseflow) Concentration	0.020	mg/l
Rainfall	43.58	inches

Pennichuck Brook Watershed Buildout In-pond Concentrations and Parameters						
	Stump Pond	**Pennichuck Pond**	**Holts Pond**	**Bowers Pond**	**Harris Pond**	**Supply Pond**
Lake area (km2)	0.08	0.23	0.09	0.37	0.32	0.06
Mean Depth (m)	1.52	1.52	0.62	1.83	4.07	3.05
Watershed area (km2)	5.56	19.06	58.74	65.37	69.99	71.28
Runoff phosphorus loadings (kg/yr)	264	105	1048	580	569	138
New Streamflow Phosphorus loadings (kg/yr)	56	179	377	59	21	11
phosphorus loadings (kg/yr)	320	284	1425	639	590	150
Phosphorus loadings from Merrimack River (kg/yr)	0	0	0	152.3	0	0
Phosphorus loadings from preceding pond(s) (kg/yr)	0	0	415	1795	1994	2023
Total phosphorus loadings (kg/yr)	320	284	1840	2586	2584	2172
Total phosphorus loadings (g/m^2-yr)	4	1	20	7	8	34
Runoff (m/yr)	15	3	45	6	6	7
New Streamflow (m/yr)	33	39	203	8	3	9
Merrimack River Flow (m/yr)				6.6		
Streamflow from preceding pond(s) (m/yr)			149	99	141	750
Hydraulic Loading (m/yr)	49	42	396	119	150	766
In-pond Phosphorus (mg/l)	**0.055**	**0.020**	**0.049**	**0.045**	**0.043**	**0.044**
Average Observed P (mg/l)			**0.051**	**0.045**	**0.038**	**0.041**
P leaving pond (kg/yr)	223	193	1795	1994	2023	2144

Groundwater (Baseflow) Concentration	0.020	mg/l
Rainfall	43.58	inches