Section 3: Recommendations

Goals, Objectives and Activities

In the following section is a general description of the Beaver Lake Watershed and background information. Following the description are five topic headings as follows:

- Open Space, Land Use, Growth
- Water Quantity
- Water Quality
- Biological and Habitat
- Recreation

For each topic heading an introductory section is provided to offer some context or framework on the major issues that are specific to the resource of concern. For example, relative to land use and growth, background on population growth and changes in land use over time within the Beaver Lake watershed is provided. Similarly, for water quantity, long-term flow trends were evaluated relative to land use changes in the watershed. These introductory sections are subsequently followed by a series of goals, objectives, and activities that were collectively developed by the Beaver Lake Partnership through numerous meetings.

General Description of the Beaver Lake Watershed

The Beaver Lake watershed is located in southern NH, within 15 miles of both Manchester and Nashua, the state's two largest cities. As shown in Figure 1[3], the watershed covers portions of Derry, Chester, and Auburn. For purposes of this study, the Beaver Lake watershed terminates at Beaver Lake Dam, which controls the discharge from the lake. The formation of Beaver Brook starts at the dam outlet and continues southerly through Londonderry, along the town divides of Windham and Hudson, through Pelham, and empties into the Merrimack River in Lowell, MA. The drainage area of the Beaver Lake watershed is 6,756 acres (10.5 mi^2), while the drainage area of the entire Beaver Brook watershed is 94.7 mi^2. The contributing drainage area from each town within the Beaver Lake watershed is summarized in Table 1.

Table 1: Breakdown of Beaver Lake Watershed Acreage by Town

	Derry	Chester	Auburn	Total
Contributing drainage area of each town	4,945 acres (7.7 sq miles)	1,782 acres (2.8 sq miles)	29 acres (<1 sq mile)	6,756 acres (10.5 sq miles)
Percent of contributing drainage area of each town	73%	26%	< 1%	100%

Starting in the northern portion of the watershed, the 19-acre Harantis Lake is located in Chester. The Harantis Lake Property Owners Association (HLPOA) owns and operates the 13.5 feet-high, 150-foot long dam (State ID No. 044.05) that creates the lake. The HLPOA operates the dam as run-of-river, meaning the amount of water entering the lake from tributary inflow essentially equals the discharge below the dam. There are flashboards affixed to the dam that raise the lake level and remain intact year-round. The dam has no low-level outlet, thus the elevation of the lake cannot be artificially lowered. In short, the dam does not impact the timing and magnitude of natural streamflow.

Discharge from Harantis Lake flows southerly through several wetlands of varying size before emptying into Adams Pond in Derry. At the outlet of Adams Pond is a 9 foot-high, 190-feet long dam (State ID No. 063.01) that impounds the pond. Per NH Dam Safety records, the dam is privately owned. It is assumed that the dam is operated as run-of-river, similar to Harantis Lake. Besides inflow from Harantis Lake, Adams Pond receives inflow from two other unnamed tributaries as well as local runoff. Flow emanating from Adams Pond, called Manter Brook, eventually flows into Beaver Lake. Besides Manter Brook there are two other main brooks that drain into Beaver Lake including Cat-O-Brook, and Jenny Dickey Brook. The drainage areas of major tributaries to Beaver Lake and their percent contributions to the watershed are summarized in Table 2.

[3] All figures appearing in Section 3 are included at the end of Section 3.

Table 2: Drainage Areas of Tributaries to Beaver Lake

Brook Name	Drainage Area (sq miles)	Percent of Drainage at Beaver Lake Dam
Manter Brook	7.8	74%
Jenny Dickey Brook	1.2	11%
Cat-O-Brook	1.2	11%
Cat-O-Swamp, Comeau's Beach Brook, Route 102 Inlet, Development Brook, Beaver Lake Ave Culvert, Clark Brook	0.3	<4%

At the downstream end of the watershed is the Beaver Lake Dam (State ID No. 063.03), which impounds the 140-acre Beaver Lake. The dam is 8-feet high and 190-feet long and is owned and operated by the Town of Derry.

Shown in Figure 2 is a topographic map of the watershed. As the map illustrates, one of the highest elevations in the watershed is along the northern rim, in Chester. The highest elevation in this portion of the basin is 609 feet mean sea level (msl). The topography is equally high (approximately 600 feet) in the most southern portion of the watershed at "Lookout Tower" on Warner Hill in Derry. The elevation of Beaver Lake itself is approximately 287 feet msl. Overall, there is roughly 300+ feet of topographic relief in the basin.

Climate

The Beaver Lake watershed is located in Rockingham County. The climate of the region is characterized by moderately warm summers, cold snowy winters, and ample rainfall. The Atlantic Ocean which lies approximately 24 miles to the east of the Beaver Lake watershed occasionally affects the area weather, but the region is more commonly influenced by air moving from the interior due to the prevailing northwesterly winds.

The mean monthly temperature of the area is 46°F. The mean temperature of the coldest month, January, is 21°F and the mean warmest temperature is 70°F in July. Nights are very often cool and comfortable even during the summer months. Precipitation in the Beaver Lake Watershed area averages 39.4 inches per year, including the water equivalent of snowfall (averages since 1895). Snow is present usually from mid December to the end of March.

Soils

Shown in Figure 3 is a soils map of the Beaver Lake Watershed. Overlying bedrock are the soils of the region, the direct result of erosion and surficial deposition occurring since the retreat of the glacial ice sheet. The soils tend to reflect the underlying geologic types from which they were derived. The properties of these deposits, and the soils which have developed from them, affect the hydrology of the area. The most important aspects relative to hydrology are drainage and erodability. Drainage refers to the soil's ability to absorb water, while erodability refers to how easily the soil is eroded by water moving over its surface. In general, the better a soil's internal drainage, the lower is its potential for erosion.

The Beaver Lake Watershed soils are described as well drained to very poorly drained soils on glacial till, with gently rolling or nearly level topography. The composition of the soils includes Canton, Hollis, and Woodbridge types in the ratio of 45%, 25%, and 10% respectively.

Canton type soils tend to be deep, well drained and formed over glacial till. Water drains through these soils at a moderate rate. These soils are suited for vegetable or fruit gardening, if well irrigated and managed, and are fair for forestry uses. The potential for wildlife habitat is good for both open land areas and wooded. These soils also have few limitations for developmental purposes, as attested by the rash of new homes and buildings in the area.

The Hollis type of soil can be excessively drained, and is believed to have formed in a thin layer of till over bedrock. This bedrock causes the vertical migration of water to be restricted. Crops on these soils may require irrigation in times of low precipitation, and the soil is considered a poor candidate for forestry due to the closeness of the bedrock. It is also considered poor for both wooded and open land wildlife habitat, and presents severe limitations for development.

Woodbridge soils are characterized as deep, moderately well-drained, and formed in compact glacial till. This compact till has contributed to the existence of a distinct hardpan layer, which is located approximately two feet below the grounds surface, and forms a perched water table during the wet seasons. Water does move through this hardpan layer, but slowly.

These sites are considered prime farmland if they are non-stony and occur on gentle slopes, but care must be taken to prevent erosion. Good farming uses for them include hay and pasture land, corn silage, and vegetable or small fruit production. Woodbridge soils also offer good productivity for forestry practices and good wildlife habitat both in open and wooded areas. However, the presence of a high water table and hardpan layer is an important concern when considering these for development.

Open Space, Land Use, and Growth Management

One of the major changes in the Beaver Lake watershed over the last few decades has been the rapid conversion of undeveloped lands into developed lands. The conversion of undisturbed lands to urban areas has a direct bearing on several variables including water quality, water quantity, wetlands, terrestrial habitat, and aquatic habitat. To help understand changes in water quality and quantity, it is important to understand what changes have, and continue to occur, in the Beaver Lake watershed. Thus, background on population and land use trends, and how these trends impact the Beaver Lake watershed resources is provided.

Population Trends

The interstate highway system was constructed in the late 1950s (NHDOT). Interstate 93 (I-93), which passes through Derry is an important northeast transportation corridor, connecting metropolitan Boston and fast-growing cities in southern NH. The construction of I-93 changed many southern NH towns by providing better access to the nearby big cities for employment, entertainment and other needs. People from Boston and its surrounding towns became attracted to southern NH towns for its rural charm and lower taxes. However, the construction of I-93, along with other factors, contributed to a population explosion throughout southern NH.

US Census Bureau[4] data were obtained for Derry, Chester and Auburn for each decade between 1920 and 2000. Shown in Table 3 are the populations and the populations per square mile of land within each town. It should be noted that the land areas are based on the entire town, and not that portion of town within the Beaver Lake watershed.

Table 3: Population Statistics in Derry, Auburn and Chester from 1920 to 2000

	Population			Land Area in each Town (Population/Land Area)		
Decade	Derry	Chester	Auburn	Derry-35.4 mi^2	Chester- 26.0 mi^2	Auburn- 25.5 mi^2
1920	5,382	652	652	152	25	26
1930	5,131	653	736	145	25	29
1940	5,400	702	807	153	25	32
1950	5,826	807	1,158	165	31	45
1960	6,987	1,053	1,292	197	41	51
1970	11,712	1,382	2,035	331	53	80
1980	18,875	2,006	2,883	533	77	113
1990	29,603	2,691	4,085	836	104	160
2000	34,021	3,792	4,682	961	146	184

As Figure 4 shows between 1960 and 2000, there was a population surge- particularly in Derry. In Derry, the population per square mile of land escalated from 197 people/square mile in 1960 to 961 people/square mile in 2000, an increase of 388%. Along with the population growth came additional infrastructure to support the growth including: residential housing development, business development, increased numbers of roads, and other supporting infrastructure. The increased development also placed more pressure on land and water (drinking water, wastewater, etc) resources as described next.

More recently, there have been discussions about widening I-93 to permit greater traffic capacity to and from southern NH. A panel assembled by the New Hampshire Department of Transportation (NHDOT) estimates the proposed project would bring an additional 40,000 residents-above and beyond already-projected population growth trends to southern NH. Based on recent per-capita land consumption rates in NH, this population growth could eliminate 50,000 or more acres of farms, forests, wetlands, and open space. Thus, even greater pressures will ultimately be placed on undeveloped lands within the Beaver Lake watershed and throughout the southern I-93 corridor.

[4]Reference:http://en.wikipedia.org/wiki/Historical_U.S._Census_Totals_for_Rockingham_County,_New_Hampshire

Land-Use Trends

There has been, and continues to be, a shift in the land use trends in the Beaver Lake watershed. To have a sense of how land usage has changed in the watershed, historic topographic maps were reviewed for the area immediately surrounding Beaver Lake. Shown in Figure 5 is a comparison of topographic maps from 1905 and 1988 (ideally a more up-to-date topographic map is preferred, but 1988 is the most recent).

As Figure 5 shows, increased development has occurred in several areas around Beaver Lake, however, this same phenomenon exists throughout the watershed- primarily in the Derry portion. As the red circles in the figure show former wetlands are now occupied by houses and roads.

Using Geographic Information Systems (GIS) land use changes in the Beaver Lake watershed between 1962 and 1998 were quantified and mapped. Land use data is available from the national land use/land cover (LULC) database. Shown in Figure 6 are Plan maps depicting the land use classifications (forested, residential, open space, etc.) for 1962 and 1998. Land use acreages were computed for each land use classification in 1962 and 1998. The acreages were then used to determine the percentage of land use (for each land use classification) in the Beaver Lake watershed as shown in Figure 7.

Table 4 summarizes the major changes in the watershed land use characteristics. The largest change in land use is the loss of forested and agricultural land, coupled with a large increase in residential land. Between 1962 and 1998, forested land decreased by 1,111 acres, agricultural land decreased by 419 acres, while residential land increased by 1,357 acres. Whereas in 1962 residential land occupied 4% of the watershed area, in 1998 it represents 25% of the watershed. Keep in mind that the most recent land use classification data is based on 1998 data, which is over 9 years old. Thus, between 1998 and 2007, residential land use has most likely increased further based on the population growth.

Table 4: Land Use Trends in the Beaver Lake Watershed between 1962 and 1998

Land Use Classification	1962		1998	
	Land Area (acres)	Percentage of Beaver Lake Watershed	Land Area (acres)	Percentage of Beaver Lake Watershed
Forested land	4,933 acres	73%	3,822 acres	57%
Agricultural land	954 acres	14%	535 acres	8%
Residential	299 acres	4%	1,656 acres	25%

Goal 1: All watershed towns share the same vision for protecting the watershed and coordinate their approach to regulations and protections.

Objective: The Beaver Lake Watershed Partnership shall conduct a watershed planning charette to facilitate a shared vision for protecting the watershed among participating towns by 2007.

Supporting Activities

a. Initiate joint meetings between neighboring town Planning Boards and Conservation Commissions with assistance of Regional Planning Commission.
b. Conduct outreach campaign to build awareness of Beaver Lake Watershed Partnership charette.

Outcomes

- Unified vision for the Beaver Lake watershed that provides clear guidance on revising zoning ordinances and other land use regulations.

Resources

- Retain a facilitator and seek local donations and fund raising contributions.
- Community Technical Assistance Program (CTAP) funding through Regional Planning Commissions for Beaver Lake Watershed Partnership.

Goal 2: The watershed is protected through land use policies that minimize adverse impacts to the Beaver Lake watershed.

Objective: The Beaver Lake Watershed Partnership shall identify approaches to improve land use regulations and enforcement and develop recommendations for watershed towns.

Supporting Activities

a. Conduct meeting(s) with watershed code enforcement officers to provide them with information and resources to better protect shoreland areas.

Outcomes

- Improve enforcement and notify appropriate town and state officials relative to violations of town land use regulations and ordinances.
- Action taken by appropriate town and state officials to enforce violations of town land use regulations and ordinances.

Resources

- Town enforcement officers.

Objective: The Beaver Lake Watershed Partnership shall identify key areas of the watershed, particularly around streams that feed into the lakes, for the purpose of prioritizing land for acquisition and/or conservation easements, in a report submitted to the towns by June 2008.

Supporting Activities

a. By 2007, identify and develop a program for land conservation actions through easements, fee simple land purchase and/or other tools with assistance from organizations such as Seacoast Land Trust of New Hampshire, etc.
b. Identify land use activities in the watershed area to determine where to implement appropriate Best Management Practices.

Outcomes

- Report submitted to towns by June 2008.

Resources

- Obtain assistance in developing report from towns and town conservation commissions in 2007 budget process.

Goal 3: Land use in the Beaver Lake watershed is consistent with watershed protection.

Objective: By 2009, the Beaver Lake Watershed Partnership shall develop for Auburn, Chester, and Derry recommendations for long-term planning and zoning regulations designed to protect the watershed.

Supporting Activities

a. Review current land use and regulatory provisions to determine if they are effective in protecting the watershed.
b. Develop and distribute survey instrument to seek feedback from landowners. Create and implement public outreach campaign to assure that surveys are broadly distributed and completed.
c. Develop recommendations to update land use, zoning, and growth management ordinances and open space plans for Derry, Chester, and Auburn.

Objective: By 2010, the Beaver Lake Watershed Partnership shall seek consensus among stakeholders as to the appropriate buffers, setbacks, and other regulations as it relates to development in the watershed.

Supporting Activities

a. Present recommendations to Planning Boards, Zoning Boards of Adjustment, and Conservation Commissions relative to appropriate buffers, setbacks, and other watershed protection regulations.
b. Include recommendations in Master Plan and other town governance documents.
c. Draft warrant articles and land use regulations and other governance documents for consideration at Town Meeting and Council, as appropriate, by Fall of 2008.
d. Design and conduct outreach campaign to inform voters and other citizens about the purpose and intent of the warrant articles and land use regulations and other governance documents.

Outcomes

- Adopted town warrant articles to protect the Beaver Lake watershed.
- Local governance documents include recommendations from the Beaver Lake Watershed Partnership.

Resources

- Technical assistance from Town Planners and Planning Coordinators and Regional Planning Commission by Fall 2008.

Goal 4: All non-prime wetlands within the Beaver Lake watershed have greater buffer protection.

Objective: By the end of 2007 Auburn, Chester, and Derry adopt wetlands buffer ordinances

Supporting Activities

a. Map and document wetlands for watershed including vernal pools.
b. Each watershed community holds a joint workshop between Planning Boards and Conservation Commissions to discuss buffer ordinances.
c. Draft model ordinance for the watershed.
d. Assure that model ordinance is adopted by Beaver Lake watershed towns.

Outcomes

- Model ordinance that is adopted by Beaver Lake watershed towns.
- Funding and personnel for fieldwork, map production, and ordinance development and adoption.

Goal 5: Auburn, Chester, and Derry have Open Space Ordinances.

Objective: By the end of 2007, watershed towns draft and adopt Open Space Ordinances

Supporting Activities

a. Review open space ordinances throughout New Hampshire.
b. Review current zoning ordinances and land development control regulations.

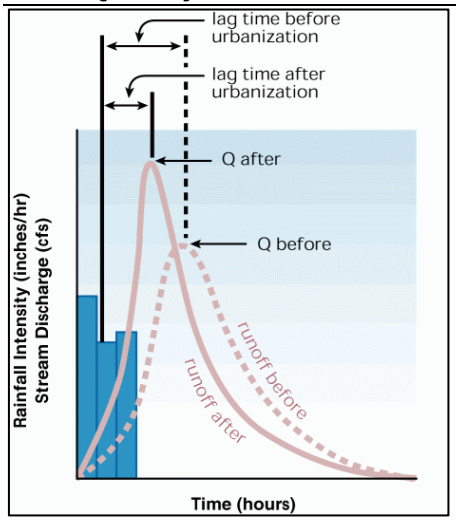
Outcomes

- Adopted open space plans and ordinances in Auburn, Chester, and Derry.

Resources

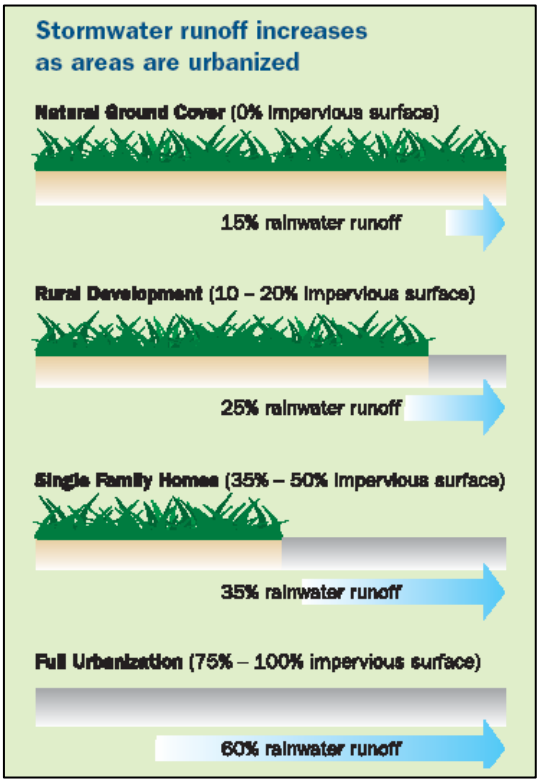
- Funding and personnel for research and development of plans and ordinances.

Water Quantity



Land use conditions in a watershed can have a direct bearing on the magnitude, volume, and attenuation of runoff. Increased urbanization in the form of paved surfaces (parking lots, driveways, roads), and buildings (roofs) leads to greater degrees of impermeability, which impacts the watershed's runoff characteristics. Impervious surfaces and impermeable soils with low infiltration rates prevent water from infiltrating into the ground, leading to an increased volume and rate of stormwater runoff. The rate of runoff increases not only due to impervious surfaces, but also the channeling of road and pavement runoff into stormwater collection systems. Stormwater systems deliver flow to a receiving stream much faster than an undeveloped watershed.

Increased development within a watershed can also result in the loss of vegetative cover, forest cover, and wetlands, which is the case in the Beaver Lake watershed. These features of the watershed provide a buffer, allowing water to infiltrate into the ground and eventually appear as base flow[5] (groundwater). A watershed that is stripped of vegetation and forested land will experience a faster rate and volume of runoff than the same "pristine" or undeveloped watershed. Less infiltration occurs reducing the amount of water available to recharge aquifers and feed streamflow during periods of dry weather. The loss or filling in of wetlands due to development (which has occurred over the years in the Beaver Lake watershed) also has a direct bearing on runoff volumes. Wetlands serve a vital role in reducing the impacts of flood flows by acting as "sponges," which store and then slowly release flood waters over time.



Increased development not only affects water quantity, but also quality. Development increases the concentration and types of pollutants carried by runoff. Runoff from roofs, parking lots, and lawns picks up and transports a variety of pollutants to downstream waterbodies. The cumulative impact of increased development has a direct impact on stream flow, stream morphology (plan, profile and dimension), degradation of aquatic habitat, and water quality impacts.

Specific to the Beaver Lake watershed the heavy development over the past few decades has reduced the amounts of rainfall infiltration while the magnitude and volume of stormwater runoff increases (these assertions will be demonstrated later). It should also be noted because the receiving streams such as Manter Brook, Jenny Dickey Brook and Cat-O-Brook are receiving higher peak flows than prior to heavy development they are continually adjusting over time. Channel adjustments occur to accommodate increased flow by eroding their streambanks. The eroded streambank sediments are transported downstream and ultimately deposit in slow moving waters such as wetlands, Adams Pond or Beaver Lake. The changes to the brooks may also impact aquatic habitats, water depths/velocities and vegetation along the stream banks.

[5] Base Flow: Base flow is that part of the stream discharge that is not attributable to direct runoff from precipitation or melting snow; it is usually sustained by groundwater.

Hydrologic regimes are vitally important in determining the composition, structure, and function of aquatic, wetland riparian ecosystems (Richter, et al). To identify the impact of human disturbance[6] on the hydrologic regime, the Nature Conservancy has developed a software program called "The Indicators of Hydrologic Alteration" (IHA) (Richter, B., Baumgartner, J., Powell, J., and Braun, D.). The IHA method assesses the degree of hydrologic alteration attributable to human influence within a watershed. The IHA software relies on long term flow data and generates various flow statistics. The flow statistics evaluate the timing, duration, frequency, magnitude and rate of change of flow conditions. The program has the ability to assess hydrologic changes associated with activities such as dam operations, flow diversion, groundwater pumping, or intensive land-use conversion.

To determine how land use changes and human disturbances have impacted streamflow, flow data from the Beaver Brook gauge (see Table 5) was used in the IHA analysis. Although the Beaver Brook gauge is located further downstream from the Beaver Lake watershed (terminating at Beaver Lake Dam), it is a good indicator of overall streamflow conditions.

Table 5: Data on US Geological Survey Gauge on Beaver Brook

Gauge No.	Gauge Name	Drainage Area	Period of Record	Gauge Elevation
010965852	Beaver Brook at North Pelham, NH	47.8 square miles	10/01/1986-current	150 feet msl

To assess long term changes in the Beaver Brook streamflow pattern, it is desirable to have an equally long period of flow data. With the population growth starting in the 1960s, having flow data on Beaver Brook dating back to the 1960s would be ideal. However, flow trends in Beaver Brook were limited to the available period of record- October 1, 1986 through September 30, 2006, 20 years.

Although the IHA software computes numerous flow statistics, some of the key findings are highlighted to illustrate trends in peak and low flows in the Beaver Brook watershed.

Instantaneous Peak Flows - Shown in Figure 8 are the annual instantaneous peak flows on Beaver Brook along with a trend line. As the figure shows, the general trend is that peak flows are increasing over time. Keep in mind that although the graph terminates in 2006, peak flows over 2,500 cfs were observed on Beaver Brook during the May 2006 "Mother's Day" flood and over 1,650 cfs during the April 2007 flood. Peak flows are likely increasing in the watershed as more open or forested land is being converted to residential housing or businesses. As noted above, conversion of forested lands to development increases the amount of impervious surfaces, which leads to greater peak flows.

Summer Low Flows - Shown in Figures 9 and 10 are the mean August flow and base flow index[7] for Beaver Brook. Based on the available period of record, the trend is showing both the mean August flow and base flow index is decreasing over time. Again, this is a function of decreased infiltration into soils (because over time impervious surfaces in the watershed have steadily increased) that appears as base flow during dry weather periods.

Goal 1: The current flow regime in the Beaver Lake watershed is maintained for the protection of aquatic, recreation, wetland, wildlife, and aesthetic resources.

Objective: By the end of 2007, quantify the annual and seasonal magnitude of flow in the Beaver Lake watershed to document the current flow regime.

Supporting Activities

a. Review existing hydrologic data sources, such as the Beaver Lake Diagnostic and Feasibility Study.

[6] Human disturbances may include: changes in land use, construction of dams, water supply withdrawals, out of basin water transfers, etc. Essentially, human disturbances represent any change in the watershed that impacts natural streamflow patterns.

[7] The base flow index is the 7-day minimum flow divided by the annual mean flow.

b. Conduct an analysis of the US Geological Survey Gage No. 010965852 Beaver Brook at North Pelham, NH. Gage Period of Record: 1986-2004. Drainage Area=47.8 sq mi. [Note: In February 2006, the USGS installed a gage on Beaver Brook at the outlet of Kendall Pond in Derry for a NHDES Total Maximum Daily Load (TMDL) study].
c. Explore feasibility of purchasing, installing, maintaining, and monitoring a flow gage (staff gage) at the outlet at Beaver Lake Dam, Meadow Dam, Eustis Memorial Dam (at Harantis Lake) or another location in the Beaver Lake watershed[8].

Objective: By the end of 2007, conduct a watershed budget[9] evaluation to determine the net loss (water leaving the watershed) or gain (water transferred out of the watershed) of water in the Beaver Lake watershed on an annual and seasonal basis[10].

Supporting Activities

a. Contact Derry Department of Public Works to determine how much water is brought into the watershed for water supply and where it is discharged (treatment plant, septic systems). Also determine what sections of town are on public water supply, estimate water use (gallons per capita per day) and estimate the amount transferred out of the watershed to the wastewater treatment plant.
b. Identify what sections of the Towns of Auburn, Chester, and Derry in the watershed are on private wells and septic systems.

Outcomes

- Quantify the current flow regime in the Beaver Lake watershed.
- Quantify the sources of water entering and leaving the Beaver Lake watershed.
- An established curriculum with PA and/or identification of "staff gage watchers" for long-term monitoring of staff gages.

Resources

- Staff gage or continuous flow monitoring gage.
- DES interns, paid staff, or volunteers to monitor and maintain staff gage or continuous flow monitoring gage.
- USGS flow monitoring gage data.

Goal 2: The current flow regime in the Beaver Lake watershed is maintained by managing development.

Objective: By the end of 2010, determine how past land use changes have impacted the Beaver Lake flow regime.

Supporting Activities

a. Evaluate historical flow data (1986 is the oldest available data) and identify any trends between the magnitude of seasonal, peak, and base flows resulting from land use changes over time.
b. Conduct literature search to document how increased development impacts the timing, magnitude, and duration of flow.
c. Using the long-term flow data coupled with long-term land use trends, develop a report quantifying the relationship with land use and stream flow.

Objective: By the end of 2008, or to coincide with the Auburn, Chester, and Derry Master Plans

[8] It should be noted that in NHDES' Diagnostic/Feasibility study of Beaver Lake nine inflowing tributaries and two outlets were monitored for streamflow. Thus, it may be possible to relocate some of the flow metering sites to ensure consistency with streamflow measurements obtained in the early 1990's.

[9] Budget refers to the net loss or gain in water in the Beaver Lake watershed. The "budget" accounts for the magnitude of water entering the Beaver Lake watershed from sources outside the watershed (such as potable water supply) resulting in a net gain of water. The "budget" also accounts for the magnitude of water leaving the watershed (such as stormwater and sewer collection facilities) resulting in a net loss of water.

[10] NHDES conducted a Diagnostic/Feasibility (D/F) study of Beaver Lake in the early 1990s. As part of the D/F a hydrologic budget was conducted relative to inflows to only Beaver Lake. The study did not address the loss of water from the Beaver Lake watershed.

development, assure that ordinances are in place to manage land development such that there is no net change in the magnitude and timing of runoff (flow) between pre- and post- development.

Supporting Activities

a. Establish a committee to recommend/develop/modify town land development rules and regulations.

Objective: By the end of 2008, or to coincide with the Auburn, Chester, and Derry Master Plans, determine how future land use changes, using build-out analysis, could impact the Beaver Lake watershed flow regime.

Supporting Activities

a. Review town build-out analysis to determine the percent of impervious surface.
b. Predict how build-out analysis could impact the flow regime via simplified runoff calculations.

Outcomes

- Town officials (Planning Boards, Zoning Boards of Adjustment, etc) understand the importance and impact of land development on flow in the Beaver Lake watershed.
- The impact of land use activities on flow is understood and town ordinances are enacted to preserve the watershed budget (magnitude, timing, frequency).

Resources

- Historical flow and land use data of the Beaver Lake watershed.
- Auburn, Chester, and Derry build-out analyses.
- Town officials, such as Zoning Board of Adjustment and Planning Board members' participation in potential development of land-use ordinances.

Goal 3: The public is aware of how their actions impact river/brook flows in the Beaver Lake watershed and what actions the public can take to improve water resources.

Objective: Initiate and continuously raise the public's awareness on the hydrologic process (where water comes from) and how human intervention (dam operations, water withdrawals, land development, etc) impacts natural streamflow.

Supporting Activities

a. Obtain historic water level data for Harantis Lake, Beaver Lake, and Adams Pond, if available, to show how gate operations impact water levels and downstream flow.
b. Obtain information on when the impoundments are purposely lowered and refilled, and compare the timing of the events with USGS gage flows on Beaver Brook. Also determine who manages the dams and gate operations.
c. Identify and modify curricula, such as Interactive Lake Ecology and Project WET, for Beaver Lake watershed schools to support water conservation.
d. Modify and adapt Watershed Steward Program and promote it within the watershed.

Outcomes

- A well-educated public.
- An established curriculum with Pinkerton Academy for long-term monitoring.

Resources

- Water level data records on Harantis Lake, Beaver Lake, and Adams Pond, if available.
- Public educational materials.

Water Quality

Land use within a watershed ultimately impacts—either positively or negatively—the quality of the runoff and, in turn, impacts streamflow and lake water quality. For example, watersheds in northern NH tend to have relatively good water quality because they have forested watersheds and relatively low rates of development. Alternatively, watersheds with heavy rates of agricultural, residential and/or commercial development tend to have poorer water quality because of large land use contributions to watershed runoff.

As watersheds are developed, runoff increases as the amount of impervious area increases. In addition, erosion and sedimentation increase as soils are distributed and vegetation is removed. Increased runoff combined with increased erosion results in an increased delivery of phosphorus—a major contributor to algal populations and decreasing water clarity—as a soil attachment.

Land use has the most direct connection to water quality in a watershed. In general, the following broad categories can directly impact water quality: faulty septic systems, agricultural use (livestock), soil erosion and sedimentation, and land use development. Relative to septic systems, as noted earlier, residential development around the periphery of Beaver Lake historically used septic systems for wastewater disposal. However, in 1989-1990, Derry expanded the sewer system to include residents around the lake. Although the sewer system brought marked improvement to the Lake, Volunteer Lake Assessment Program testing at Beaver and Harantis Lakes showed continued nutrient loading from other sources to the tributaries and the lake.

Some locations in the Beaver Lake watershed contain livestock (such as horses) that are located in close proximity to streams, lakes and ditches. Surface runoff from pastures and grazing areas is another source of pollutant loading to nearby streams and lakes. The eroded sediments carry attached phosphorus to the surface waters as an additional source of nutrients. Excessive phosphorous contributes to declining water quality because it is the limiting nutrient needed for abundant algae growth and it can upset lake ecosystems.

Soil erosion and sedimentation are major pollutants to lakes and streams and directly affect water quality. Soil erosion consists of the availability, detachment and transport of soil particles into a lake or stream. In the case of the Beaver Lake watershed increased development has resulted in sediment erosion of previously forested lands. Overland flow carrying eroded sediments pick up contaminants that are subsequently transported to receiving waters. For example, one of the major concerns is Jenny Dickey Hill Road, which continually erodes, carrying sediments and other pollutants to Beaver Lake.

Overall, development has a profound impact on water quality. As with the other land use impacts discussed above, a primary impact from development is the contribution of phosphorus and other contaminants. When attached to soil, phosphorus can be carried to water bodies from erosion and runoff from land and impervious surfaces (paved surfaces that water runs off instead of percolating through). Phosphorus is a general soil nutrient that in excess in a lake can cause severe algal blooms and oxygen depletion leading to degradation of water quality and diminished aesthetic and recreational enjoyment.

Wetlands serve many vital roles relative to diminishing high flows and filtering contaminants. However as shown earlier, some wetlands within the Beaver Lake watershed have been drained and filled to accommodate residential development. Restoring drained wetlands, or protecting existing wetlands, is a unique opportunity to reduce water quality impacts from large land areas upstream from the wetlands.

Goal: Waterbodies in the Beaver Lake watershed support their designated uses and exhibit no impairments.

Objective: By 2009, erosion and contaminant loading from development and roads in the Beaver Lake watershed is reduced by 50%.

Supporting Activities

a. Identify and quantify areas of erosion and contaminant loading from roadways in sensitive areas, such as Jenny Dickey Hill Road.
b. Prioritize highly sensitive areas and develop and implement Best Management Practices to reduce erosion and contaminant loading.

c. Develop watershed protection recommendations and ordinances for construction of new roads and driveways.
d. Develop outreach campaigns targeted to developers and homeowners to provide them with models and resources for low impact development principles.
e. Work with NH Department of Transportation, local road agents, and departments of public works to establish low-salt and alternative winter treatment for roads in sensitive areas.
f. Eliminate detention ponds' post-development runoff so that it does not exceed pre-development runoff.
g. Work with NHDES and USGS to expand pilot project, *Effects of Urbanization on Stream Quality* (see References section) to the Beaver Lake watershed.
h. Apply results of expanded pilot project to help form recommendations for stormwater management and other practices.

Outcomes

- NH Department of Transportation, local road agents, and departments of public works adopt low impact principles relative to road construction and maintenance.
- BMPs are implemented on roads and driveways in highly sensitive areas.

Resources

- Grant programs to implement BMPs.
- Grant programs to implement outreach campaigns.

Objective: By 2008, outreach campaigns will be conducted in the Beaver Lake watershed to increase awareness of and compliance with ordinances and voluntary water quality protection measures.

Supporting Activities

a. Raise community awareness of the benefits of land conservation easements and purchases for protection of water quality.
b. Develop speaker's bureau and presentations that can be provided upon request to area groups such as civic organizations, town boards, and schools.
c. Develop media materials on the importance of land use protection relative to water quality.
d. Development awareness of waterfowl feeding ordinance and encourage compliance through outreach programs

Outcomes

- More informed public relative to water quality issues
- Public feeding of waterfowl feeding is reduced or eliminated

Resources

- Funding and paid or volunteer staffing for developing presentations and media materials

Objective: By 2007, increase by 20% the quantity of contaminants and hazardous waste diverted from residential and business properties to appropriate disposal outlets.

Supporting Activities

a. Work with Beaver Lake watershed towns to increase awareness of contaminants and hazardous waste and their effects on water quality.
b. Work with Beaver Lake watershed towns to increase hazardous collection days and better advertise their availability.
c. Conduct random sampling in high-use commercial and industrial areas for hazardous materials.
d. Include contaminant sampling of waterbodies near high-use commercial and industrial areas during routine building inspections.

Outcomes

- Hazardous waste sites are remediated
- Increased municipal and homeowner participation in hazardous waste collection days

Resources

- Contractors and sites for waste disposal
- Municipal support for household hazardous waste days

Objective: By 2008, increase water quality sampling and watershed assessment by 100%, evaluate findings, and regularly publish results.

Supporting Activities

a. Increase participation in Volunteer Lake Assessment Program (VLAP) to include all Beaver Lake watershed lakes and ponds (beyond the current programs conducted in Beaver and Harantis Lakes).
b. Increase number of VLAP tributary monitoring sites in Beaver and Harantis Lakes.
c. Add bacteria sampling at VLAP monitoring sites in Beaver and Harantis Lakes.
d. Begin assessing Beaver Lake watershed rivers and streams with the Volunteer River Assessment Program.
e. Develop Beaver Lake watershed / water quality curriculum for and with Pinkerton Academy that can be transferred to other watershed schools.
f. Establish permanent monitoring stations for Stream Teams habitat assessment
g. Continue Stream Teams watershed assessment activities.
h. Implement Weed Watcher and algal observation programs in Beaver Lake watershed waterbodies.
i. Develop procedure and network for water quality impairments (such as fish kills) documentation and reporting.
j. Create online, GIS-based, data search tool for reporting water quality testing results.

Outcomes

- Greater number of monitoring sites and sampling parameters.
- Increased understanding of Beaver Lake watershed health.

Resources

- Funding and paid or volunteer staffing for conducting water quality surveys and creating data management tools.

Biological and Habitat

The rapid increase in human population and rate of development in the Beaver Lake watershed is placing significant stress on the native, aquatic and terrestrial wildlife populations. Land that was once habitat for wildlife species is being converted into residential and commercial subdivisions, roads, and other uses. The development of land and related activities impact both the quantity and quality of wildlife habitat. The loss of aquatic and terrestrial habitat through the conversion of land from its natural state to a developed landscape represents the single greatest impact of increased human activity on native wildlife within the Beaver Lake watershed.

Development eliminates or significantly changes many important habitat features found in a natural area, thus reducing or eliminating the habitat value of that area. For example, a diverse wildlife population depends upon the natural diversity of native plants found in most undeveloped areas. Development often changes the vegetative community, making it more difficult for many native species to survive. Those species able to survive in urban settings may thrive, but the rest are forced to find new territory or die.

Habitat fragmentation is a less obvious consequence of development, reducing both the quantity and quality of habitat. Fragmentation is a process whereby large tracts of the natural landscape are gradually developed and subdivided until only patches of original habitat remain. The patches are often too small and too far apart to support the basic survival and reproductive needs of many wildlife species during various stages of their life-cycle or in different times of the year. In addition to the detrimental impacts to terrestrial and aquatic wildlife within the watershed, landscape disturbances caused by development can also serve to introduce invasive species into natural habitats, further degrading the quality of remaining habitat areas.

More than 60 water bodies in the central and southern parts of the state are infested with invasive aquatic plants, such as variable milfoil, fanwort and water chestnut. Plants such as purple loosestrife, common reed and glossy buckthorn dominate many acres of the state's freshwater marshes and forested wetlands in these areas. Both Auburn and Derry have infestations of invasive aquatic plants in Lake Massabesic and Big Island Pond, respectively. Another five municipalities that border the Beaver Lake watershed have invasive aquatic infestations in lakes and ponds. The abundance of public access facilities and the increasing number of boats and trailers in New Hampshire each year increases the threat of spreading exotic, non-native species into the Beaver Lake watershed. Once invasive species are introduced, managing and controlling them is a significant challenge as well as a costly one.

In addition to the threat of introducing invasive terrestrial and aquatic species into the watershed as a result of conversion of open space, the structural habitat of aquatic systems can also be significantly degraded by modifications associated with roads and development. The roads, driveways, rooftops, and highly manicured, compacted lawns account for the increase in impervious surfaces within a watershed. Impervious surfaces are areas where infiltration of water into the underlying soil is prevented. Research in recent years has consistently shown a strong relationship between the percentage of impervious cover in a watershed and the health of the receiving stream. Scientists generally agree that stream degradation consistently occurs at relatively low levels of imperviousness (10 to 20%). Roadways and other impervious areas channel pollutants directly into streams without being filtered during transport through the soil.

The preservation of open land, including open fields, woods, wetlands, farms, and undisturbed wild areas for both terrestrial and aquatic life, is critical to assure that the Beaver Lake watershed will remain diverse, healthy, and ecologically functional for generations of watershed residents to come.

Goal 1: All aquatic habitats within the Beaver Lake watershed are free from invasive species.

Objective: By 2007 the BLWP secures six additional volunteers to participate in the Lake Host Program

Supporting Activities

a. Continue participation in Lake Host Program at Beaver Lake.
b. Actively recruit volunteers at the BLIA annual meeting.
c. Create and air a public service announcement (PSA) on Derry Community Television and other media outlets.

d. Create and post recruitment poster at relevant public and private locations throughout the Beaver Lake Watershed.

Objective: By the end of 2007 the Auburn, Chester, and Derry Conservation Commissions, as well as the Harantis Lake Homeowners Association are participating in the DES Weed Watcher Program

Supporting Activities

a. Promote Weed Watcher Program at conservation commission meetings.
b. Encourage attendance at NH Watershed Conference and NH Association of Conservation Commissions Annual Meeting where Weed Watcher Program is being promoted.

Outcomes

- Limit introductions of invasive species in the Beaver Lake watershed.

Resources

- Funding and personnel to participate in Weed Watcher and Lake Host Programs.
- Funding and personnel to create and distribute public service announcements.

Goal 2: The Beaver Lake watershed benefits from a net increase in protected land that supports wildlife connectivity and continuity and fish passage.

Objective: By the end of 2010, at least 10% of all stream crossings will support fish and wildlife passage.

Supporting Activities

a. Complete inventory of all culverts and stream crossings to assess their ability to support fish and wildlife passage using protocols being developed by The Nature Conservancy.
b. Evaluate, prioritize, and recommend Best Management Practices and designs for existing and new stream crossings in the Beaver Lake watershed.

Objective: By the end of 2007, develop criteria for identifying and prioritizing lands for protection.

Supporting Activities

a. Research Comprehensive Wildlife Strategy and identify areas in the Beaver Lake watershed named in the report that support exemplary natural communities.
b. Plan and host tri-town Conservation Commission workshop designed to work toward development of criteria.
c. Use existing data and conduct, as necessary, inventories of bird, macroinvertebrate, and other wildlife population data as indicators of pesticide use and other impacts.

Objective: By 2010, 700 acres will be conserved via an easement or fee simple purchase for the protection of fish and wildlife.

Supporting Activities

a. Relevant Auburn, Chester, and Derry land use committees will provide recommendations on prioritization on acreage to conserve.
b. Auburn, Chester, and Derry governments and nonprofits will negotiate with landowners to secure conservation easements and land conservation purchases in the Beaver Lake watershed.

Outcomes

- Conservation easements or fee simple purchase of 700 acres of land

Resources

- Funding to purchase easements or land title and to support acquisition fees
- Funding and personnel to conduct indicator species data and other surveys and inventories as necessary

Recreation

Diverse recreational opportunities are an important part of life in the Beaver Lake watershed. Activities include motorboating, waterskiing, horseback riding, paddling, fishing, bird watching, hiking, hunting, and biking. Engaging in these and other outdoor activities helps residents and visitors connect to the watershed and learn more about its ecology. These diverse recreation opportunities should be supported, developed, and well managed in the Beaver Lake watershed.

Sound watershed management is the key to maintaining access to, and the quality of, these recreational opportunities. One example is that invasive species can be introduced to lakes and streams by boats, boat trailers, and bait that are carried from one waterbody to another. For instance, non-native plants can get snagged on boat trailers, boats, and on fishing gear when used in an infested lake. When that equipment is deployed in a new waterbody, the invasive plants can take root there and propagate.

In some waterbodies, excessive boat wakes can cause erosion to shorelands and disturb loon and other birds nesting habitats as well as fish and amphibians. Well-designed and maintained boat access sites are crucial so that polluted runoff to waterbodies is eliminated or minimized.

Trails are important as access for hikers, cyclists, horseback riders, and birdwatchers. It's important to design and maintain trails so that they do not add to polluted runoff in the Beaver Lake watershed.

Goal: The waterbodies in the Beaver Lake watershed support diverse recreation opportunities that are environmentally responsible.

Objective: Work with stakeholders to develop policies, programs, and incentives that encourage environmentally responsible water recreation uses in the watershed.

Supporting Activities

a. Survey current recreational habits such as those related to boat speeds, navigation patterns, types of vessels, waste disposal.
b. Lobby the Department of Safety, Power Squadrons, and other boating trainers to include environmental education in their boater safety programs.
c. Provide opportunities for non-motorized boater use in the watershed.
d. Work with marine dealers to provide incentives to convert to four-stroke engines.
e. Work with Derry Recreation Department, Auburn Parks and Recreation Committee, Chester, Recreation Department and New Hampshire Lakes Association to design and implement education and information programs in the Beaver Lake watershed.
f. Provide support to the Derry Recreation Department, Auburn Parks and Recreation Committee, and the Chester Recreation Department, to continue their environmental programs in the watershed.

Outcomes

- Informed and environmentally responsible recreationists.
- Recommendations for new, improved, and refined water recreation policies.

Resources

- Funding and personnel to conduct surveys and produce outreach campaigns.
- Volunteers to work with boating trainers.