Comprehensive Environmental Inc.

Study of Urban Non-Point Source Pollution
Pennichuck Brook to Bowers Pond Subwatershed

PENNICHUCK WATER WORKS
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1.0 PROJECT DESCRIPTION

As part of a follow-on project to a comprehensive watershed management for the Pennichuck chain pond system, Comprehensive Environmental Inc. (CEI) assisted Pennichuck Water Works in a detailed evaluation of potential threats to water quality in one of the watersheds most urban drainages. This project was jointly funded by Pennichuck Water works and the New Hampshire Department of Environmental Services (NHDES). It included evaluations of measures to minimize the threats. These recommendations have been presented in the report in a prioritized manner so that logical cost-effective implementation can occur.

From July to December 2000 CEI conducted a detailed review of an area of the Pennichuck watershed. This area is a 2,400-acre subwatershed known as the Pennichuck Brook to Bowers Pond (PBB) Subwatershed as identified in a 1998 *Watershed Management Report* (Comprehensive Environmental Inc., 1998).

Field information was gathered during the summer and fall. Many of the field efforts were conducted during first flush and/or antecedent rainfall conditions when both contaminant and runoff conditions are likely to be present.

The city and town lines of Nashua and Merrimack split the PBB subwatershed in half. The Northern portion of the subwatershed consists of a relatively low development density and vacant land. The Southwestern portion of the subwatershed represents the typical threat of high-density development and as such is best addressed through the development of remediation measures as recommended in the 1998 Watershed Management Report. The following report presents these suggested remedial measures. Overall, a blend of both structural and non-structural measures were evaluated to suit the specific character of land use found in the subwatershed and to allow for simultaneous implementation of both capital and non-capital intensive projects.

2.0 DRAINAGE DESCRIPTIONS

The Pennichuck Brook to Bowers Pond Subwatershed consists of three major drainage areas, designated A, B, and C that correspond with the general patterns of runoff to Holt and Bowers Ponds (Figure 2-1). Area A has the greatest density of development. Area A extends North of the Boston and Maine Railroad to Holt Pond and West of Thorton Road to the Western PBB Subwatershed boundary. Area B consists of less dense residential development that extends from Route 101A North to Bowers Pond and East of Thorton Road to the Eastern PBB Subwatershed boundary. Area C is the largest of the three areas, but it is also the least developed. This drainage area consists of all lands North of Holt and Bowers Ponds to the PBB Subwatershed boundaries, as outlined in Figure 2-1. Below is a more detailed description of each of the three drainage areas. Descriptions of specific sites of water quality concern within these three areas are also provided.

2.1 Area A – Southwestern Drainage Area

Figure 2-2 shows drainage area A in more detail. The southern portion of the drainage area is characterized by high-density commercial and industrial development, with medium density residential development to the North. Much of the residential development is located in close proximity to Pennichuck Brook and Holt Pond.

Land within the PBB subwatershed boundary South of the Boston and Maine Railroad is quite flat and has few impervious surfaces. One exception to this is a new Corning facility. While located within the subwatershed boundary its drainage flows via wetlands out of the subwatershed and intersects Pennichuck Brook in the Pennichuck Brook to Holt Pond subwatershed (PBH) well upstream of the PPB discharges. Its significance (as a potential water quality threat) relative to other downstream dischargers would rank it low in comparison. Because of this CEI will evaluate Corning (and surrounding land area) on a more level comparison with those sites contained in the PBH subwatershed when it is evaluated.

Drainage to the North of the Boston and Maine Railroad flows toward Route 101A and Round Pond. Much of the drainage in the Pennichuck Brook and Bowers Pond Subwatershed collected by 101A is treated by the wetland detention facility behind the N.H. Technical College. Blackstone Drive and the Western portion of 101A drain to a detention pond adjacent to Blackstone Drive. This detention pond has one outlet to a stream that flows to Holt Pond, picking up four other stormwater discharges along its meandering path. There is a detention pond

Northwest of Watersedge Drive that collects drainage from Thorton Road to Watersedge Drive and overflows through a swale to Bowers Pond during large storm events. Field investigation of drainage area A revealed the following areas of concern.

2.1.1 A-1 Amherst Park, West Discharge

Area A-1 is comprised of drainage from the perimeter of the Amherst Park property that flows over grasses and some forested land (Figure 2-3) to the stream that leaves the Blackstone Drive detention pond as well as concentrated drainage flow collected from impervious surfaces on the property discharges directly into this stream (Figure 2-4) at the Western edge of the property.

2.1.2 A-2 Amherst Park, North Discharge

Area A-2 is located in the same development as A-1, but collects a different portion of the drainage (Figure 2-5). It too has a discharge (Figure 2-6) to the Blackstone detention pond outlet stream. Although a smaller volume, the stormwater enters the stream closer to its eventual discharge into Holt Pond.

2.1.3 A-3 Blackstone Drive, Detention Pond

The detention pond (Figure 2-7) located East of Blackstone Drive serves as a point of stormwater collection for surrounding industrial and residential areas. The pond receives limited overland runoff in addition to its two major inlets from Blackstone Drive and Route 101A. The drainage area that contributes to the Blackstone pond (see hatched area on Figure 2-2) consists mainly of impervious surfaces that collect a great deal of sediment and trash. Consistent with previous studies, field staff noted substantial sediment deposits and evidence that the pond infilling may be compromising its ability to treat stormwater from such a large contributing area. Again, this detention pond is drained by the aforementioned stream, which flows to Holt Pond.

2.2 Area B – Southeastern Drainage Area

This drainage area is characterized as having medium density residential development throughout with some undeveloped land adjacent to Bowers Pond in the North. Figure 2-8 shows that most of the stormwater runoff from the residential areas throughout this drainage area generally flows Northerly and eventually discharges to Bowers Pond. The Western portion of the Kessler Farms development drains via an unnamed stream through a pond to the Northern portion of Thorton Village Mobile Home

Park and then discharges into Bowers Pond near the Holt Pond Dam. A small portion of the Thorton Village Mobile Home Park drainage immediately enters this stream and the rest of the development drains to Thorton Road where it discharges to a bermed, sandy detention area that appears to retain and recharge much of the water on site. This area is located adjacent to Greatstone Drive. The Northern portion of the Kessler Farms development drains to a dry detention pond. This treated water then combines with drainage from another "new development" in a swale that conveys these moderated flows to Bowers Pond. Drainage from the new development "Water View Homes at Bowers Pond" is collected by three detention structures before it is discharged to Bowers Pond.

Development to the North of Tinker Road is limited to a couple of short streets that drain to small swales. There is no direct conveyance of stormwater to Bowers Pond in this area. Just West of the F.E. Everett Turnpike is a stream that flows North forming a series of wetlands along its path and eventually draining to Bowers Pond. Minimal drainage from the Western half of the Turnpike reaches this wetland area via overland flow to the West. There is a large berm that runs north along the Turnpike which separates the Turnpike and the wetland area, but drainage still reaches Bowers Pond by flowing to the North along the Turnpike. The following areas of concern were noted during field investigation of the drainage area.

2.2.1 B-1 Bowers Pond Stream Outlet

Figure 2-9 shows the stream outlet into Bowers Pond near the Holt Pond Dam. The drainage area that contributes to this stream starts in the Western portion of the Kessler Farm development and continues through the Thorton Village Mobile Home Park and the Water View Homes to Bowers Pond, as mentioned earlier. The outlet of the pond adjacent to Cranleigh News marks the beginning of this stream, from which it travels along the steep gradient to Bowers Pond. There is a sediment delta that has formed where the stream enters the pond. It is likely that development activities and a floating boom (Figure 2-10) have allowed this delta to form. Nonetheless, this stream receives a great deal of water that flows considerably fast during storm events.

2.2.2 B-2 Bangor Street Detention

The stream that flows through the Thorton Village Mobile Home Park collects drainage from the Bangor Street area as it is piped under the roadway to a small detention area adjacent to Bangor Street and Larchen Lane. This overgrown detention area (Figure 2-11) is the only location where the stream is detained before it begins its last steep descent to Bowers Pond, and the Bowers Pond stream outlet described above.

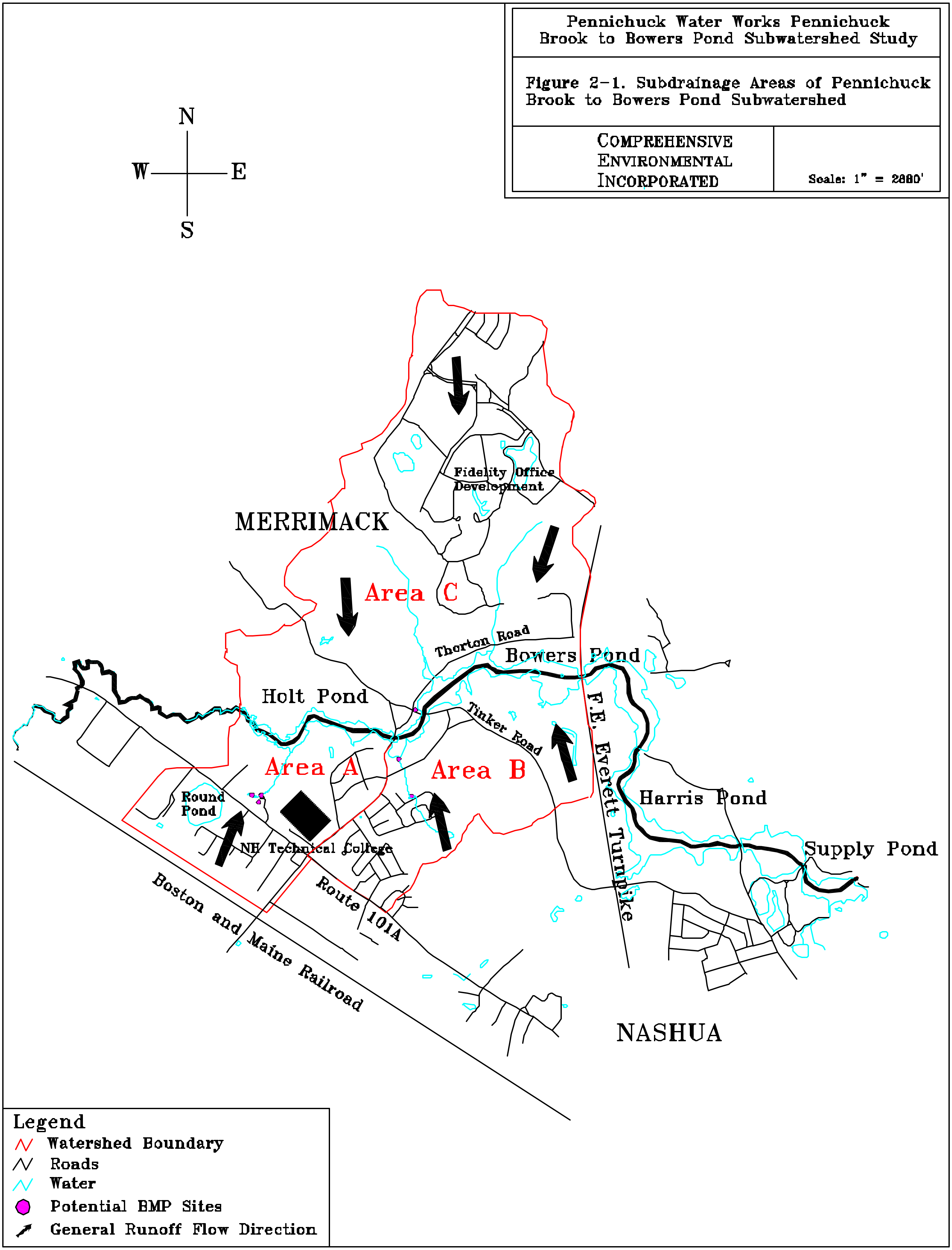
2.3 Area C – Northern Drainage Area

Drainage area C encompasses the largest portion of the PBB Subwatershed (Figure 2-12), however, development throughout the drainage area is generally low density. The Fidelity Office Development is an exception to the overall development trend and it represents a large area of high-density, light industrial land use in the Northern half of drainage area C (Figure 2-12). The drainage from this development flows to a series of detention structures and ponds that discharge to a wetland area, which flows to Bowers Pond.

The Southern half of drainage area C consists of low-density residential development. There is no development in close proximity to the Northern edge of Holt Pond, and residential development in this area is limited to a few houses along Tinker Road. Along Bowers Pond, there is low-density residential development on Thorton Road from its intersection with Stuart Drive to its end at the F.E. Everett Turnpike. This area of Thorton Road is located in close proximity to Bowers Pond, but it does not have any closed drainage systems. Runoff reaches Bowers Pond via overland flow and two stream inlets. The following area of concern was noted during field investigation of drainage area C.

2.3.1 C-1 Tinker Road Bridge

The bridge at Tinker Road is a new structure with a small drainage system that collects runoff from the bridge and the intersection of Thorton and Tinker Roads. Runoff flows from Tinker Road and from both directions of Thorton Road to three catch basins that discharge to a short swale (Figure 2-13) into Bowers Pond. This intersection (Figure 2-14) is located in very close proximity to Bowers Pond and is the site of moderate to heavy traffic given its size.



Pennichuck Water Works Pennichuck Brook to Bowers Pond Subwatershed Study

Figure 2-1. Subdrainage Areas of Pennichuck Brook to Bowers Pond Subwatershed

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

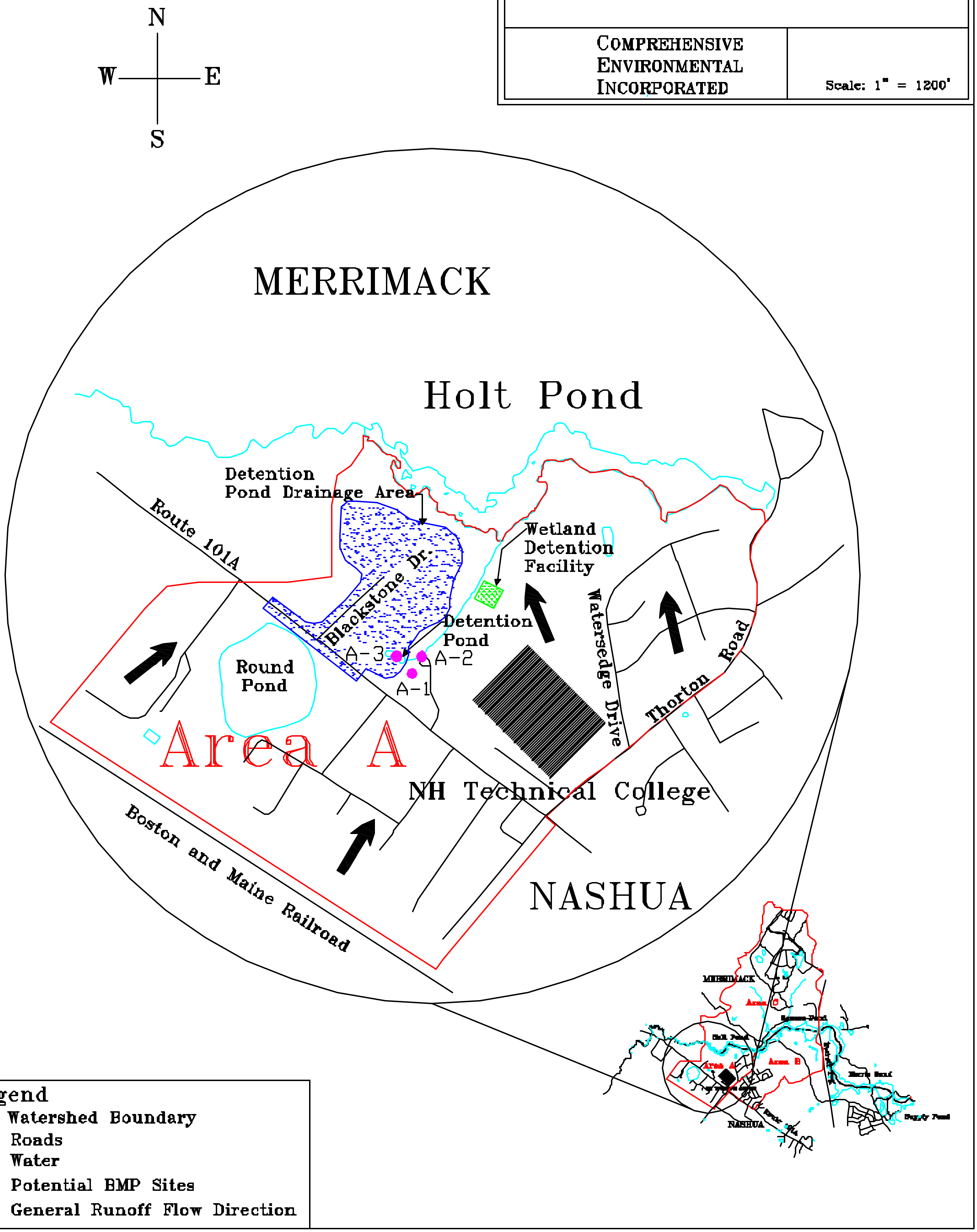
Scale: 1" = 2880'

Pennichuck Water Works Pennichuck Brook to Bowers Pond Subwatershed Study

Figure 2-2. Area A Southwestern Drainage Area

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

Scale: 1" = 1200'



A-1 Amherst Park, West Discharge

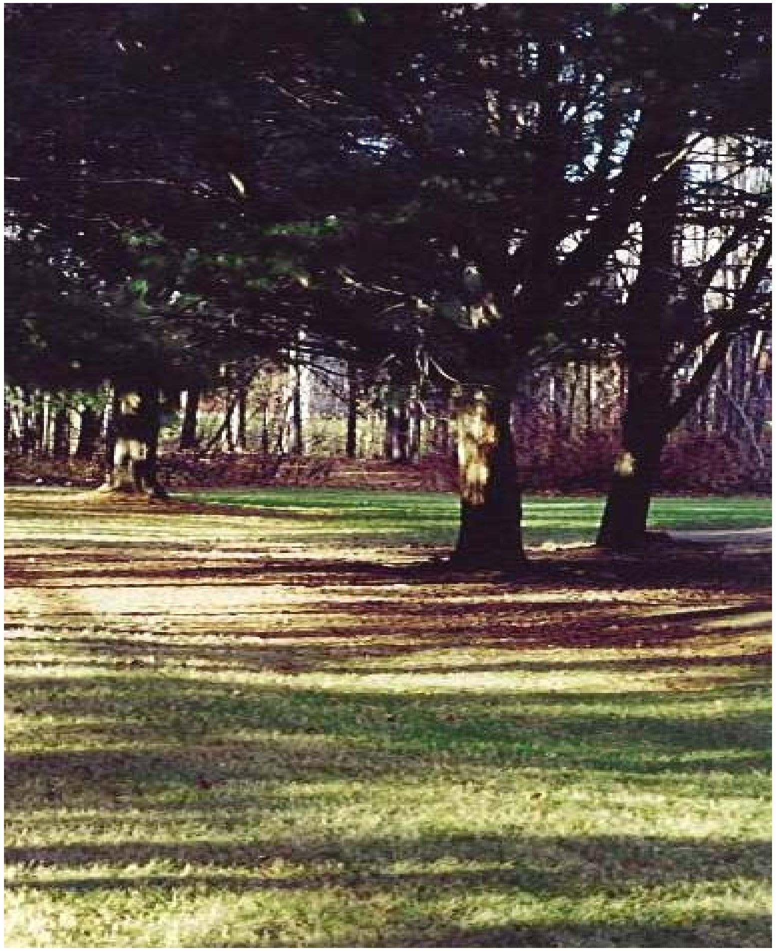


Figure 2-3. Vegetated Portion of Contributing Drainage Area.

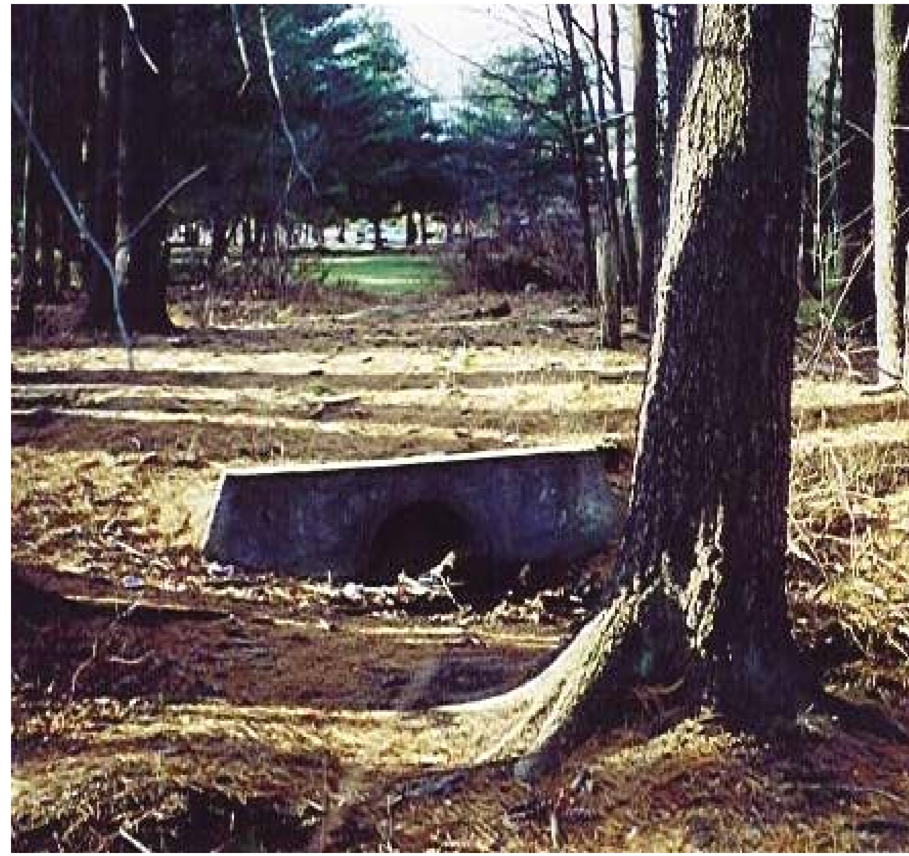


Figure 2-4. View of Discharge to Unnamed Brook Entering Holt Pond.

A-2 Amherst Park, North Discharge

Figure 2-5. View of Contributing Drainage Area to Discharge.

Figure 2-6. View of Direct Discharge to Unnamed Brook Entering Holt Pond.

A-3 Blackstone Drive Detention Pond

Figure 2-7. View of the Detention Pond from Blackstone Drive Showing the Outlet. This Marks the Beginning of the Unnamed Brook Entering Holt Pond.

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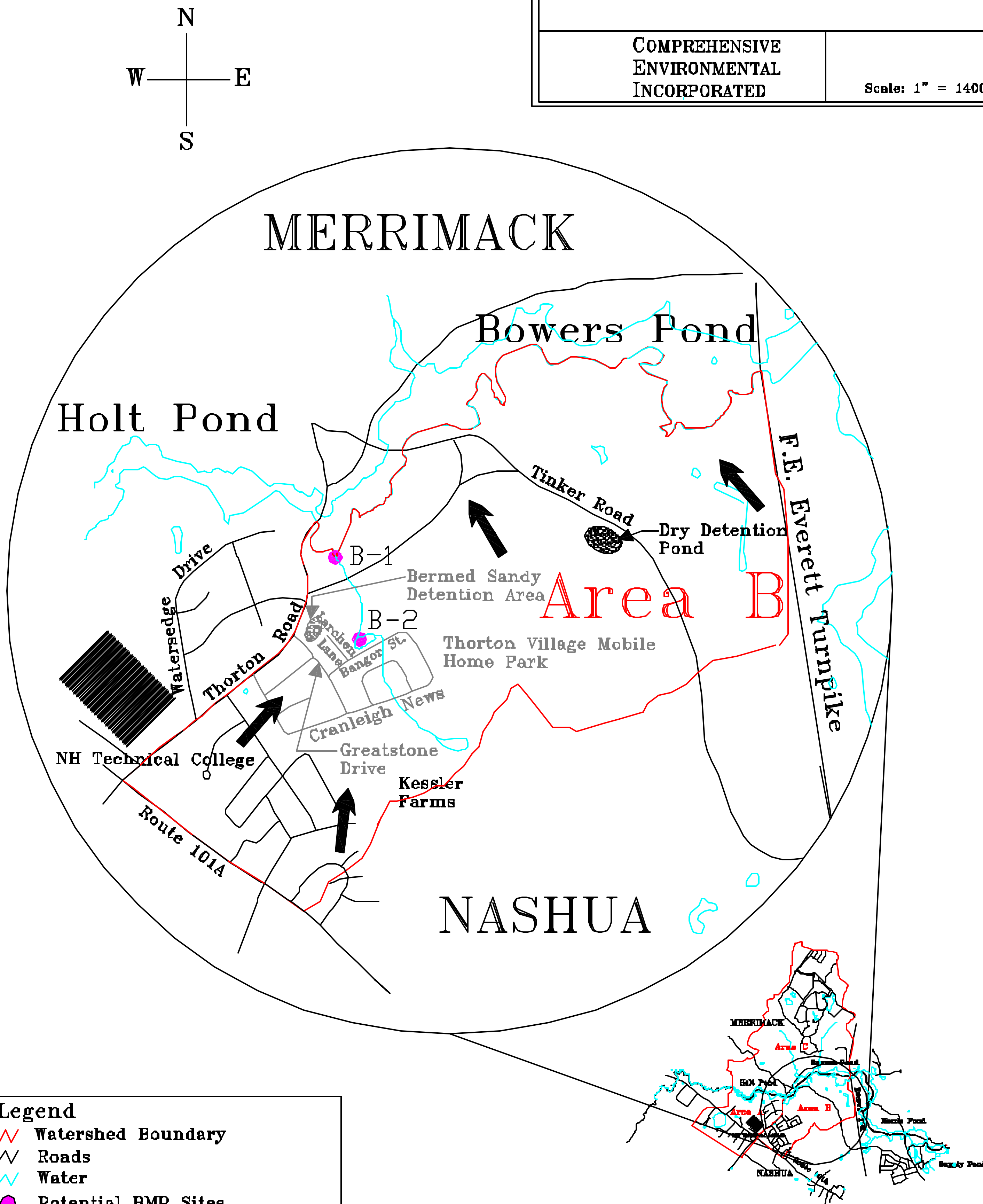
Figure 2-8. Area B Southeastern Drainage Area

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

Scale: 1" = 1400'



Legend
- Watershed Boundary
- Roads
- Water
- Potential BMP Sites
- General Runoff Flow Direction

B-1 Bower Pond Stream Inlet

Figure 2-9. View Downstream of Tributary to Bowers Pond. Note the Sediment Delta that has Formed.

Figure 2-10. Floating Silt Boom that has Created the Sediment Delta.

B-2 Bangor Street Detention Area

Figure 2-11. View of Overgrown Detention Area Adjacent to Bangor Street.

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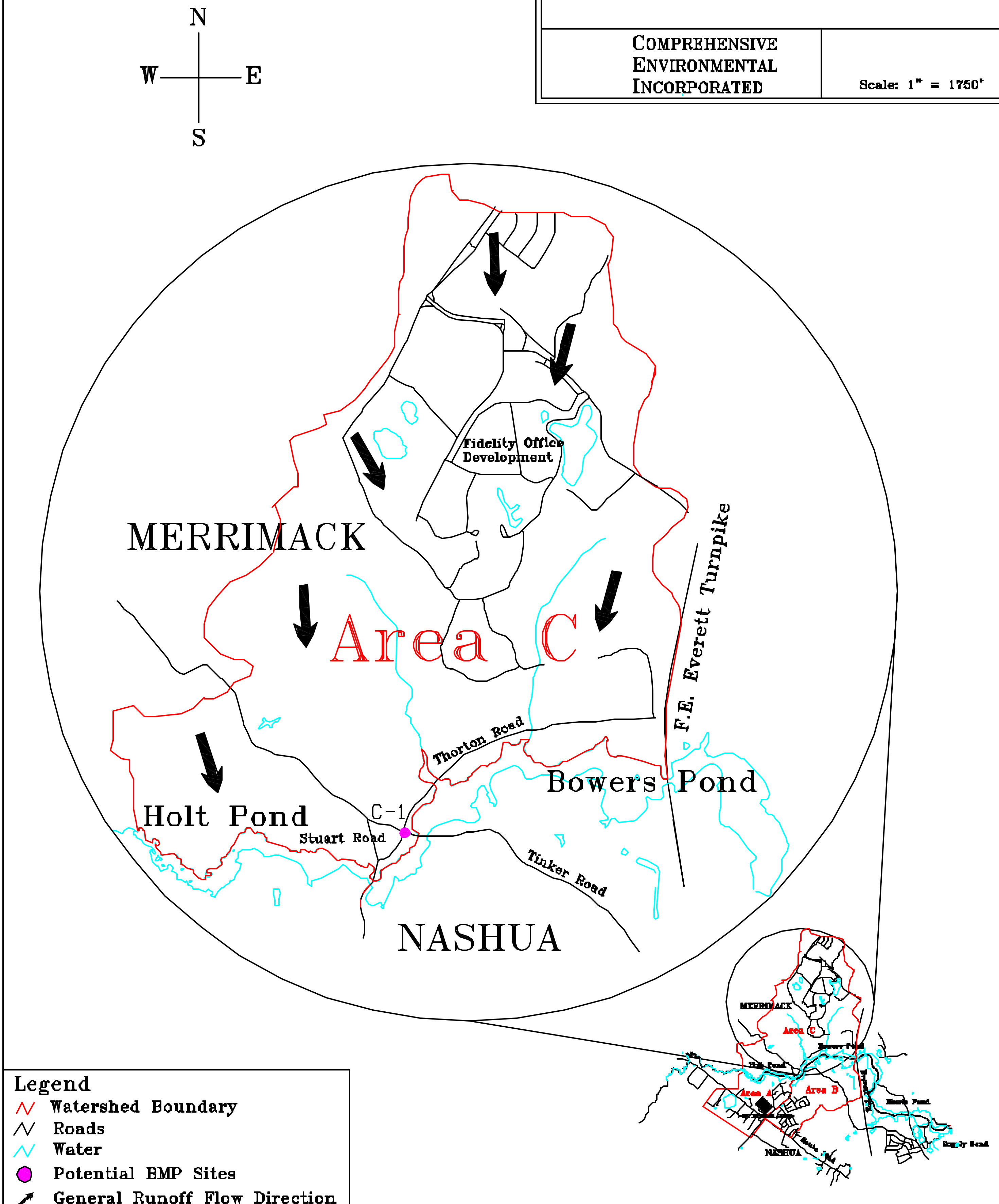
Figure 2-12. Area C Northern Drainage Area

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

Scale: 1" = 1750'



C-1 Tinker Road Bridge

Figure 2-13. View of Tinker Road Discharge Which Enters Bowers Pond.

Figure 2-14. View of Thorton and Tinker Roads Intersection. Potential Spills from Vehicle Accidents at this Intersection have a Direct Route to Bowers Pond.

3.0 RECOMMENDATIONS

Based upon a thorough review of the subwatershed and evaluation of potential problem areas, two broad categories of recommendations were developed. Primary water quality improvements are high priority projects that typically involve some design and capital expenditures. These are described in section 3.1. Secondary water quality improvements are generally smaller in size and scope and generally require reporting or investigation by Pennichuck to the City of Nashua rather than design.

3.1 Primary Water Quality Improvements

3.1.1 Site Selection Methodology

The six sites were prioritized based on the level of impact emanating from that site. Annual loadings of sediment and phosphorus flowing from the catchment areas of each of the six identified sites were estimated (see Table 3-1 for comparisons). The simple method as developed by Schueler[1] was used to derive these estimates. Sediment and phosphorus are non-point source pollutants in urban runoff and have been identified as Pennichuck Ponds' most significant threats[2] to water quality, due to their ability to infill the ponds and cause eutrophication.

A number of Best Management Practices (BMPs) were evaluated for each of the identified six sites. Anticipated sediment and phosphorus removal rates were calculated for each BMP along with installation and maintenance costs. A cost per unit of sediment removal was developed for each BMP option at each site, including a long term (20 year) cost per unit (lb) of sediment removed. The long term cost is made up of capital and maintenance expenses that accounts for inflation (present worth costing). The resulting long term cost per pound of removal as seen in Table 3-1 is a basis to rank the potential projects in terms of cost-effectiveness.

3.1.2 Recommended Water Quality Improvements

Two BMPs are the most highly recommended for implementation based on the forgoing analysis. They are described below in greater detail.

Table 3-1 BMP Comparisons

Site	Area (ft^2)	% Imp	Land Use	BMP	Removal Rates TSS/Phos	Const. Cost	Capital plus 20 yr O&M[1]	TSS Removal: Annual TSS Load (lbs)	TSS Removal: 20-yr Removal (lbs)	TSS Removal: Equalized Cost of Removal ($/lb)	Phosphorus Removal: Annual Phos Load (lbs)	Phosphorus Removal: 20-yr Removal (lbs)	Phosphorus Removal: Equalized Cost of Removal ($/lb)
A1	148,784	80	res.	None				1,654			5.6		
				Swale	30%/30%	$28,000	$32,585		9,925	$3.28		33.4	$975
				Baffle Tank	55%/30%	$12,000	$20,550		18,196	$1.13		33.4	$615
A2	48,832	75	res.	None				501			1.7		
				Forbay	50%/40%	$13,000	$26,162		5,006	$5.23		13.8	$1,894
				Infil. Trench	95%/95%	$13,000	$23,000		9,511	$2.42		32.8	$701
				Baffle Tank	70%/37%	$12,000	$20,550		7,008	$2.93		12.8	$1,609
A3	2,014,650	75	res. & com.	None (existing pond)	20%/0%[2]			28,805	*115,220*		71.2		
				Rehab Pond	50%/40%[3]	$40,000	$52,942		288,051	$0.18		569.8	$93
B1	1,692,500	15	res.	None				899			11.3		
				Silt Boom	25%/20%	$4,000	$15,259		4,495	$3.40		45.2	$338
				Ck Dam and forbay	35%/25%	$18,000	$40,519		6,292	$6.44		56.5	$717
B2	932,500	10	res.	None				488			6.4		
				Ck Dams	20%/20	$9,000	$17,394		1,953	$8.91		12.8	$1,354
C1	149,600	35	res.	None				380			2.6		
				CB Hood	10%/7%	$1,000	$4,148		759	$5.46		3.7	$1,120

[1]Present worth based on historic Constuction Cost Index 4.87% (87 years of data as published in *ENR*)

[2]Assuming existing pond's limited capacity has compromised removal to 20% TSS and 0% phos.

[3]Assume dredging allows 70% TSS removal and 40% phos. removal providing net 50% removal rate as a direct result of pond rehab expenditure.

Note: Pollutant loadings/removals are estimates and should only be used to compare drainage areas and BMPs to one another.

3.1.2a Baffle Tank at Site A1-Amherst Park

It is estimated that over 20 years site A1 may contribute the equivalent of over one dump truck load of sediment into a main tributary of Holt Pond. The installation of an underground baffle tank (see Figure 3-1) would provide an unobtrusive way to treat stormwater leaving the site, capturing this sediment in a controlled area for removal.

The baffle tank, which is constructed of a large septic tank with internal baffles, is estimated to remove 55% of the incoming sediment load and 30% of the incoming phosphorus load. The installation could be done on Pennichuck property or on the private property from where the runoff originates. Installation on the private property of Amherst Park is preferable, as it will make access for maintenance (which requires standard catch basin cleaning equipment) easier, limit permitting requirements, and reduce the likelihood of encountering groundwater during installation. This will require a permanent easement.

Estimated installation costs: $12,000

Operation & Maintenance
Annual sediment removal
Estimated cost per year (2001): $250

3.1.2b Sediment Removal in Blackstone Detention Pond

The detention pond at Blackstone Drive (refer to Figure 2-6) in drainage area A receives a great deal of stormwater from the surrounding urban environment. In addition to the visible trash floating in the pond (Figure 3-2), there are large deltas formed at the inlets to the pond, indicating that the pond is working, but it may need to be cleaned. Over a twenty year period, over 200 cubic yards of sediment are estimated to enter the pond, enough to fill over 20 dump trucks. As the pond fills in, the detention time is lessened and more sediment is passed through the pond into a brook leading to Holt Pond.

This conclusion, which is consistent with an observation made in a previous report[3], illustrates that while responsible for large amounts of sediment removal, these ponds will not work indefinitely without maintenance. Removing this sediment would help to increase the stormwater detention time in the pond and increase pollutant removal.

Dredging the pond could be done in the wet with a conventional long-arm excavator. The machinery could reach much of the material from the pond's perimeter and deposit it into waiting trucks, reducing handling costs. The pond is privately owned by Knightsbridge Arms Condominium Association and they would be an appropriate partner for this project. Direct measurements are not available, but visual evidence in the form of sediment deltas and shallow areas containing rooted aquatic plants suggest that 750-1,000 cubic yards of sediment in the pond that may be removed.

Estimated cost to dredge: $40,000

Operation and Maintenance
Maintenance dredge in yr. 2020
Estimated cost (in 2020): $10,350

3.2 Secondary Water Quality Improvements

3.21 Silt Boom Maintenance

A floating silt boom, described previously as site B1, likely installed to minimize the impacts from construction activities nearby, is in need of maintenance. Once the construction is complete, and before the City releases any bonds or issues a certificate of occupancy, the developer or his agent should be instructed to remove the accumulated sediment delta.

Pennichuck should request that the developer leave the boom in its location after the cleaning is done. The boom will serve to minimize transport of any additional sediment to the main portion of Bowers Pond. This would require follow-on inspection and maintenance activities.

3.22 Old Dump Site at Millwright Drive

During field investigation of drainage area A, an old dumping site was noticed. The site is located at the end of Millwright Drive in the bank adjacent to Holt Pond (Figure 3-3). The waste extends nearly into the pond and consists mainly of rusted metal car parts and other unidentifiable metal objects. No drums were observed. The site appears to be fairly old and probably originated during the development of the site. There is no obvious threat to water quality, but an investigation into the history of the site and its composition should be done to eliminate this uncertainty.

3.23 Detention Pond off Watersedge Drive

The detention pond located Northwest of Watersedge Drive between Fencroft and Oriole Drives receives drainage from a portion of Thorton Road and the Watersedge Drive development. There is significant stormwater flow to the pond indicated by the scoured swale inlets of the pond (Figure 3-4 and 3-5). The detention pond serves more as a retention pond and appears to adequately store and treat stormwater. During large storm events the pond overflows and discharges into Holt Pond through an overgrown swale outlet. The stormwater treatment capacity of the pond could possibly be increased by the introduction of wetland plants along the relatively barren edges of the pond.

3.24 Old Construction Materials Storage Area in Thorton Village Mobile Home Park

An abandoned construction material storage site was identified in the Thorton Village Mobile Home Park, adjacent to Greatstone Drive (Figure 3-6). Several old steel drums that contained petroleum products were noted in addition to various pipes, drainage basins and related structures, and granite curbing (Figure 3-7). All of the drums were apparently empty and undamaged. In addition to these drums a “drum bridge” was observed in the stream (Figure 3-8). The historical use of the site should be investigated to determine if there were any releases of hazardous materials, to eliminate any uncertainty of a threat posed by the site.

3.25 Existing Drainage in Thorton Village Mobile Home Park

The closed drainage system in Thorton Village flows to Thorton Road and then North past Greatstone Drive, where it exits into a retention area adjacent to the end of Larchen Lane. This drainage system is in need of maintenance. The majority of catch basin sumps were completely filled with sediment, some of which extended past the pipe invert (Figure 3-9, note the propane cylinder). The retention area serves as an adequate sump for stormwater, but the discharge from the collection system into the retention area is clogged (Figure 3-10). There is also a catch basin upgradient of the inlet that is missing a cover. This should be replaced by the owner.

3.26 Underground Storage Tank off Waterview Drive

Field inspection of the new development along Waterview Drive revealed an underground fuel oil storage tank at a residence along the shore of Bowers Pond. The tank was located in the steep bank of the pond, indicated by vent and fill pipes. The Site Manager for the development indicated that the tank was scheduled for removal and later field inspection confirmed the tank removal (Figure 3-11). It should be confirmed that the tank was removed using standard practices and the underlying soils were free of contamination.

3.27 Thorton Road Bridge

The bridge at Thorton Road is currently being reconstructed to handle two-way traffic Figure (3-12). Similar to the bridge at Tinker Road, the bridge is downgradient of Stuart Drive and both directions of Thorton Road. Drainage from the roads flows to the bridge and off of the edges of the roadway into Bowers Pond. Some of the drainage from the intersection of Stuart Drive and Thorton Road flows onto a grass strip West of Thorton Road. The edges of the roadway around the bridge currently have a narrow vegetative buffer to the pond. This minimizes the impact of stormwater to some extent by allowing for some natural attenuation. The final drainage plan for the new bridge includes two swales located on either side of the bridge (shown as Appendix A). It is recommended that the swales be inspected to ensure adequate vegetation establishment.

3.28 Logging Activities and Buffer Zones

Logging activities were noticed on land immediately adjacent to the Northern borders of both Bowers and Holt Ponds (Figure 3-13). Such activities in critical buffer zones can have significant impacts on water quality. At the time of the site visit it did not appear that the either Holt or Bowers Ponds were being impacted from the recent logging activity. The Town of Merrimack should be contacted and asked to allow Pennichuck to review proposed logging operations that will take place within 200 feet of the ponds or its tributaries. This review should take place prior to an approval of the Intent to Cut Permit.

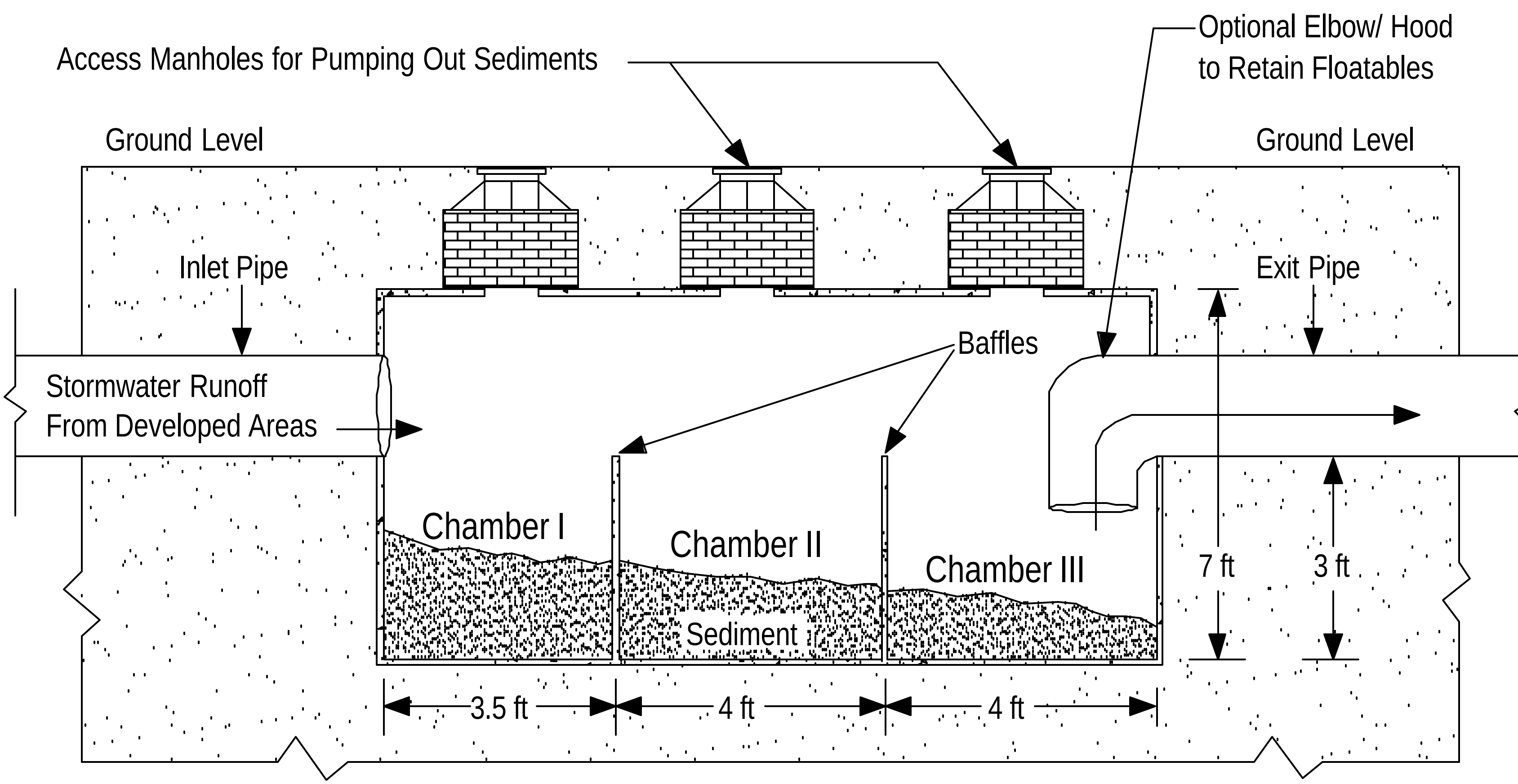


Figure 3-1. Baffled Septic Tank Conceptual Design

Not to Scale

Figure 3-2. Typical Trash Found Throughout Blackstone Drive Detention Pond.

Figure 3-3. Metal Parts and Debris at an Old Dump Site Located Along Holt Pond Near the End of Millwright Drive.

Figure 3-4. View of the Scoured Swale that Enters the Detention Pond from One Watersedge Drive Discharge.

Figure 3-5. View of Second Watersedge Drive Discharge into Detention Pond. The Swale Area Immediately Below is Scoured.

Figure 3-7. Old Construction Materials Storage Area in Thorton Village Mobile Home Park.

Figure 3-8. "Drum Bridge" Located in Stream Next to the Old Construction Materials Storage Area. This Stream is a Tributary to Bowers Pond.

Figure 3-9. Thorton Road Catch Basin Full of Sediment and in Need of Maintenance.

Figure 3-10. Clogged Discharge Near Larchen Lane. Sediment has Built Up Around the Pipe such that It is Actually Below Grade.

Figure 3-11. Former Site of Underground Storage Tank in the Bank of Bowers Pond. The Bank and Surrounding Area has been Restored to its Original Condition.

Figure 3-12. Construction of a New Bridge on Thorton Road. The New Construction Incorporates a Swale System that Handles the Runoff From Thorton Road.

Figure 3-13. Logging Activities on Lands Immediately Adjacent to Bowers and Holt Ponds (Merrimack).

REFERENCES

[1]Schueler, Thomas R. July, 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Pages 1.9-1.17.

[2]Comprehensive Environmental Inc. August 1998. Pennichuck Water Works Watershed Management Plan. Sections 5 and 9.

[3]Comprehensive Environmental Inc. Spring 2000. Study of Urban Non-Point Source Pollution. *Boire Field Brook Subwatershed*. Page 4-1.

[4] Comprehensive Environmental Inc. July 2000. Sediment Study of Pennichuck Ponds. Pages 5-7.