Shirley Allshouse

HIGHLAND LAKE DRAINAGE STUDY

PREPARED FOR

HIGHLAND LAKE COMMISSION

OF THE

TOWN OF WINCHESTER

AND THE

CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION

MAY 1993

WENGELL, McDONNELL & COSTELLO, INC.
-Consulting Engineers-

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Table of Contents

I. Study Background and Objectives

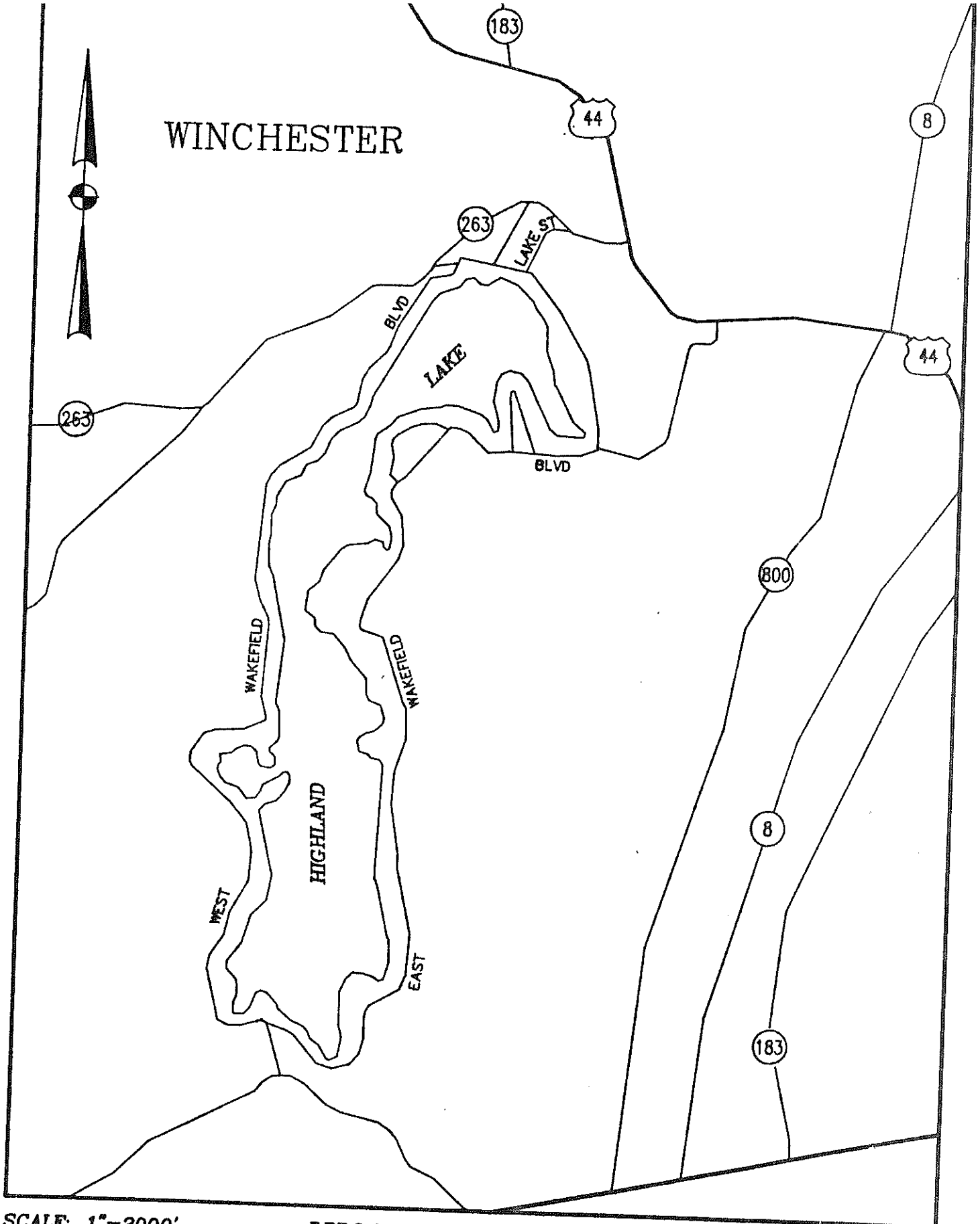
Highland Lake is a recreational water body located in the Town of Winchester which has been identified by the Connecticut Department of Environmental Protection as a priority recreational water body. A vicinity map is included on the following page.

In the recent past, Highland Lake has experienced problems with lake water quality. Investigation by the Highland Lake Commission and the State of Connecticut DEP determined that one of the potential sources of these water quality problems may be the sediments entering Highland Lake through storm runoff. According to residents living on the Lake, many coves that used to have sandy bottoms 20 to 30 years ago, are now covered with soft sediments. During the winter drawdown of the Lake, when these sediments are exposed, they wash into the central Lake area so that in the spring when Lake activity is high these sediments become suspended in the Lake water, thus reducing water quality. Additionally, it is hypothesized that these sediments contain organic materials which may be decomposing, thereby causing a reduction in oxygen levels in the Lake water.

This study represents the second part of a process for initiating water quality improvements for Highland Lake. The first step in the process was the preparation of the Highland Lake Dredging Feasibility Study completed in 1991. The final stages for improvements include final design and construction of proposed improvements.

It has been a concern of the Highland Lake Commission, the DEP and residents of the Lake area that sedimentation of the Lake resulting from inadequate storm drainage systems is reducing water quality through transportation of pollutants and sediments into the Lake. Several options for improving the existing drainage systems that serve the Lake, to enhance sediment removal, thus mitigating sedimentation to the Lake and reducing pollutant loading to the Lake are presented in this study. Identification of potential sources and possible solutions are offered so that final design can be initiated.

The use of this survey and the preceding Highland Lake Dredging Feasibility Study should assist the Highland Lake Commission, the Town of Winchester and the Connecticut Department of Environmental Protection in implementation of recommended improvements and control measures in an attempt to reduce sediment loads and associated pollutant loads to Highland Lake. By locating sources, identifying potential problems and potential solutions, the measures presented should provide a significant step towards improvement of the existing water quality of Highland Lake, contributing to the desired goals of the Highland Lake Commission and the Connecticut DEP.



SCALE: 1"=2000'

HIGHLAND LAKE

DRAINAGE STUDY

VICINITY MAP

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This study of the existing tributary drainage sy: ms to Highland Lake identifies problems with the current system of drainage and concerns about the maintenance practices on these systems. The survey portion of this study identified:

1. drainage system discharges to the Lake,
2. locations of sedimentation,
3. some areas of potential pollution within the immediate drainage area of the Lake, and
4. areas of insufficient maintenance.

II. Grant Program

In 1989, the Town of Winchester received a grant from the Connecticut Clean Lakes Program (CGS Sec. 22a-339) for a diagnostic feasibility study of Highland Lake. The Connecticut Clean Lakes Program, administered by the Connecticut Department of Environmental Protection, reimburses municipalities 75 percent of the costs for diagnostic feasibility studies that address eutrophication issues at eligible lakes.

The first study conducted with this grant was a dredging feasibility study prepared by Wengell, McDonnell & Costello, Inc. (WMC) in 1991. The dredging study concluded that significant soft sediment deposits were evident in the cove areas of the Lake, and that these sediments could be dry excavated during winter drawdown of the Lake.

III. Existing Drainage Systems

In general, the drainage systems that discharge directly to Highland Lake consist of brooks, streams, drainage swales, culverts, catch basins, paved and unpaved leakoffs from streets. These systems are, for the most part, adequate to convey normal stormwater runoff under roads to the point of discharge, namely Highland Lake. Reference should be made to Appendix I, Field Reconnaissance for exact locations and descriptions of the systems. Figure I, Base Map For The Highland Lake Drainage Survey, indicates the discharges to the Lake located by this study and should be used when referring to the Field Reconnaissance report in Appendix I.

If maintained, the existing drainage systems, in most cases, will handle frequent rainfall-runoff events that occur in the watershed. However, since the Town of Winchester Subdivision Guidelines require that storm drainage systems be capable of handling stormwater runoff from 25 year design storm (a chance of occurring once every 25 years or a 4% chance of occurring in any year), most of these same systems would be inadequate by the current Town Standards. It is important to note that the systems have been in place for many years, predating the existing regulations, and therefore should not be deemed inadequate.

The method used for analyses of existing drainage systems in this report was the Rational Method. The Rational Method is a method of estimating rainfall runoff quantities from comparable drainage areas. The method is suitable for small watershed areas, such as those tributary to the drainage systems in the Lake area, and utilizes several factors in estimating the runoff, including time of concentration (the time required for runoff from the most remote point in the drainage area to arrive at the outlet), the characteristics of the land area (ie. woodlands, lawn areas, paved surfaces etc.) and drainage area size (the area over which the rain falls, from which it flows over the land to the point of discharge).

Time of concentration for each discharge was determined with the aid of the Seelye nomograph and Kirpich nomograph, standard charts utilized for determining these factors.

Runoff coefficients used were based on two primary land uses; Residential with a C value of 0.3 and Woods & Residential (Primary Woods) with a C value of 0.2. Where a high percentage of the drainage area is woods a C value of 0.1 was used in the Rational formula.

Drainage areas were determined by first locating the discharges on a USGS topographic map and then determining the tributary areas for each discharge. Approximate drainage areas are presented in Figure II, "Drainage Areas".

Once runoff quantities were determined by the Rational Method, they were compared to the capacity of the discharge structure being studied. The structures were analyzed under inlet control conditions and a 2' maximum head since experience indicates that, given the observed conditions and construction of the discharge structures, that inlet control flow condition will likely control.

For this analysis, it was assumed that the structures were undamaged, in good condition, and clear of sediment or debris to reduce capacity. It was also assumed that maintenance of structures determined to have adequate capacity would be maintained in the future.

The existing systems provide little or no sediment or pollutant removal capabilities. These drainage systems were installed "as needed" to convey stormwater runoff to the Lake without consideration for sediment and pollutant removal prior to discharge. Thus, while they transmit stormwater discharge efficiently in most cases, significant sediment and pollutant load from tributary areas reaches the Lake.

Additionally, two main tributaries that feed Highland Lake, Sucker Brook and Taylor Brook contribute significant sediment loads to the Lake.

Tributary Streams

Sucker Brook and its' watershed are controlled by the Army Corps of Engineers flood control works at the Sucker Brook Dam, just upstream from the Lake. It has been observed that the Sucker Brook watershed contributes substantial sediment load and therefore is a significant potential pollution source to Highland Lake.

Past sedimentation has occurred on a large scale in this area of the Lake. The watersheds contribution to sedimentation can be confirmed by observation of the inlet and outlet areas of the cross culvert that conveys Sucker Brook under Wakefield Boulevard to Highland Lake, where accumulated sediment is clearly visible. Furthermore, in support of this observation, sediment probes in the Sucker Brook Cove of Highland Lake, conducted as part of the Dredging Feasibility Study for Highland Lake, indicate unconsolidated sediment depths in excess of 4 feet.

Taylor Brook's watershed contains a portion of the Paugnut State Forest which makes up a considerable percentage of the watershed. The forest is used for various recreational activities such as camping, hiking, etc. The other land use in the watershed consists of sparse residential development. This watershed also contributes significant sediments to Highland Lake. Since Taylor Brook itself appears to have a bottom and banks resistant to the erosive forces imposed upon it, it can be concluded that the observed sediments at the mouth of Taylor Brook and in the cove may be a result of brook conveyed sediment from the watershed. Observation and reference to the Dredging Feasibility Study for Highland Lake indicates unconsolidated sediment depths in excess of 4 feet in the Taylor Brook Cove of Highland Lake as well.

Catch Basins

Catch basin systems in the Lake area are generally old, in fair to poor condition and constructed of concrete block with no sump or sediment storage below outlet invert elevations. Where basins have sumps, few appear to receive sufficient maintenance to prevent sediment and organics from being discharged to the Lake. Accumulated sediment and organic debris in the basins and drains limit capacity to convey stormwater and retain only the heaviest sediment particles and debris. In many of the catch basin systems, new sediment loads pass unattenuated through to discharge points at the Lake.

The location of these catch basins with limited sediment removal capacity are evidenced by sediment deltas in the Lake at the outfall locations.

Swales

Small intermittent streams and roadside swales intercept and convey stormwater runoff from upslope areas to the inlets of cross culverts. These small streams and swales, in general, add to the sediment loads delivered to the Lake. Many of the swales erode during significant runoff events (significant meaning any event producing stormwater runoff in sufficient quantities to induce erosion in the swales).

Additionally, swales along roads collect and convey sediment washed from pavements and drives to the inlets of cross culverts. The swales are typically eroded earth ditches formed when runoff concentrates at low points, or are crudely constructed road side swales. The constructed swales typically are gravel surfaced and are not resistive to erosive forces of the stormwater runoff collected and appear to be under sized.

Sediment transported from upland areas and from erosion of the swales deposits at inlets, outlets and in the cross culverts themselves. This results in reduced stormwater capacity in culverts, as well as sediment and pollutant deposition in Highland Lake.

Leak-offs (areas where confined runoff is allowed to leave the road)

Street and road leak-offs, located at low points in the road and at other areas are, in general, unpaved, gravel mini-swales conveying street drainage down the road bank, directly or indirectly to the lake. Others are incidental leak-offs created naturally at low points in roads where stormwater has concentrated and discharged at a single point.

Occasionally, stormwater leaks off in the form of dispersed runoff along the roadsides where there are no curbs. This would be generally be preferable to leak-offs, except that the banks are not vegetated in most cases and are subject to erosion.

Many of the constructed leak-offs do not discharge to stable bases. Thus, undermining of paved leakoffs, road pavement and erosion of road banks has occurred, resulting in sedimentation of the Lake at these locations.

Cross-culverts

Cross-culverts for conveying stormwater runoff under roads to discharge points at the Lake are varied in type & size. Most stormwater culverts are 12" and 15" diameter reinforced concrete pipe (rcp) or corrugated metal pipe (cmp). Stream culverts are cast-in-place reinforced concrete box type culverts or elliptical metal pipe of various sizes. Almost all have some reduction in actual design or theoretical capacity due to the accumulation of sediment at the inlet, outlet or within the culvert. This reduced capacity, in some cases, increases the possibility of ponding at inlets, which may actually increase sediment retention.

Inlets and outlets for cross-culverts, as well as other drainage systems, are typically overburdened by sediment and other debris due to sediment loads and the need for increased maintenance. Inlets and outlets typically are unprotected, and ground cover at inlets and outlets is poorly vegetated, providing little or no protection against erosion and scour. The discharge velocities at many outlets scours or erodes downslope areas or Lake shores due to this lack of outlet protection.

Other outlets cantilever out over the Lake or are submerged in the Lake. These provide excellent protection of the Lake bed during normal Lake level periods. However, during low Lake level periods when the Lake bed is exposed, these discharges scour and erode the lake bed, increasing sedimentation to deeper portions of the Lake.

IV. Field Reconnaissance Results

A. Sediment

Discharge locations are identified by number on Figure 1. Locations of sedimentation within the Lake are detailed in the Field Reconnaissance summary of Appendix I, which in turn references Figure 1.

In summary, sedimentation entering the Lake is evident at many discharge locations and in several of the coves of Highland Lake, as documented in the Dredging Feasibility Study for Highland Lake.

Erosion is a natural process whereby soil is worn away from the land by various actions such as wind and water runoff which results in sedimentation of the Lake.

Sedimentation may be a dominant cause of phosphorus enrichment of Lake waters and a contributing factor in the eutrophication of the Lake. Sedimentation also reduces water depths, creating shoals which are conducive to the growth of aquatic plants. Associated organic matter decomposed by micro-organisms contributes to oxygen depletion in these shallower waters. In addition, sediment can be a carrier for pollutants such as salt and oil from roadways. Thus it can be seen that control of erosion and sedimentation is an important step in improving the water quality at Highland Lake for recreational uses and for ultimately improving the States' waters.

B. Maintenance

Currently, maintenance consists of spot repair of non-functional or visually damaged drainage systems, street sweeping and selective system cleaning of sediment and debris.

Locations and descriptions of areas requiring improved maintenance have been noted in Appendix I, Field Reconnaissance Summary. Inadequate maintenance was typically observed as sediment deposits at invert elevations or within discharge structures, sediment deltas at outfalls, erosion of roadside swales, road bank erosion and damaged inlet or outlet structures.

A majority of the cross culverts contained sediment and debris to a depth sufficient to affect drainage system capacity.

V. Point Sources and Non-Point Sources at Highland Lake

For this study, point sources of pollutants are defined as concentrated, localized discharges such as storm drainage outfalls or leak-offs discharging directly to the Lake.

Non-point sources are diffused (such as overland flow) and are not easily identified because they do not enter the Lake at a single point, but may enter into streams or flow overland.

Non-point sources typically include:

- scouring at outlets,
- swale erosion,
- sediment load due to land use,
- lawns, fertilizers, pesticides,
- bank and shoreline erosion,
- brook erosion,
- animal wastes,
- construction,
- recreational use of the Lake & watershed,
- residential land development and improvement resulting in reduced buffer/filter strips

Normally, drainage discharges are considered non-point source when looking at the overall tributary drainage area, however, for the purposes of this report those that discharge directly to the Lake will be considered as point discharges. A sediment source associated with the drainage systems around the Lake is the erosion of natural and manmade swales and the resultant sedimentation. Additional pollutant sources associated with road drainage systems include road sand and salt used on the roads during winter months, as well as oil from vehicles.

Shoreline Erosion

Shoreline and bank erosion are evident, to some degree, and are mainly caused by wave action on shorelines and banks in areas with reduced vegetative cover, unprotected or insufficient protection of road embankments, unprotected residential fill areas, and scouring at drainage outfalls. Limited areas of Highland Lake are experiencing bank erosion or bank undercutting which may be considered shoreline erosion. Most of the Lake is armored against normal wave action by means of manmade revetments, retaining walls, natural rock outcroppings or simply by being sheltered in coves.

Construction

Significate sediment loading occurs during new construction when erosion and sedimentation controls are improperly installed, are not maintained, or enforcement of zoning regulations requiring sediment and erosion controls is insufficient.

Development

Land development in a relatively undeveloped watershed will ensure continued sediment flow to the Lake. This occurs for reasons previously stated and will be intensified by new development which tends to reduce buffer/filter strips such as wetlands and upland vegetated areas.

Other Sources

Other watershed non-point sources of sediment and pollutant loading occurs from various land uses such as gravel surfaced driveways, intense recreation, maintenance of power equipment, lawns and fertilizers, animal wastes from pets, cattle and horses.

VI. Recommendations

The previous sections described the existing drainage systems in the watershed as either manmade or natural (streams). Their conditions, as well as their role in the sedimentation of Highland Lake was also presented. In summary, these systems typically function as conduits for stormwater, they retain limited quantities of sediment and in many cases cause increased sedimentation of Highland Lake.

As mentioned earlier, these systems are typically considered non-point sources. Experience indicates that implementation of a control program for non-point source pollutants is difficult. However this survey has identified discharge locations and these may be effectively controlled with various drainage system improvements and watershed management techniques.

General recommendations to accomplish this are presented below, while more site specific recommendations for storm drainage and outfall locations are included in the Reconnaissance Survey of Appendix I.

1) Street sweeping, although not proven to be effective in reducing nutrient loading to the Lake, reduces or minimizes the amount of sand and debris susceptible to stormwater transport to Highland Lake, if implemented frequently.

Considering economic restraints, street sweeping should be conducted at least once in the spring after the last anticipated application of street sand for traffic maintenance and again, if possible, in early summer. Additional street sweeping should be conducted throughout the year on a spot, as needed basis.

It is recommended that the basis for determining when sweeping will be utilized, be whenever sediment is tracked onto or has been deposited onto paved roads. Additionally, occasional checks of roadway surfaces in the watershed after intense rainfall events and frequent checks in the vicinity of construction activities should be implemented.

2) New sources of sediment, such as planned residential developments should be identified during the planning phase of the development. During this phase, controlled stormwater discharges from new residential areas within the watershed should be required and designed as part of the infrastructure improvements required to meet Town acceptance. The controls should implement some type of permanent sediment control, depending on the size and nature of the land disturbance and land use. Sediment basins may be required, along with the use of grass swales and retention of as much wetland buffer and wetlands that receive runoff as possible.

Additionally, the use of catch basins with sumps, hoods, and the use of gross particle separators prior to discharge should be required in conjunction with or in lieu of requiring sedimentation ponds. A gross particle separator is simply an underground structure designed to remove the larger more dense sediment particles contained in the stormwater flow.

Receiving discharge points and channels from these areas should be resistant to erosion. This may require limiting outflow velocity and flow rate or improvement of downstream areas and channels to be resistant to erosion.

During construction of such land development activities, temporary erosion and sediment controls (such as silt fences, haybales, check dams, etc.) should be installed and maintained. Inspection and enforcement during construction is key to ensuring compliance with erosion and sediment control regulations. Inspections should be conducted weekly and prior to and after rainfall runoff events. As a minimum inspections should be conducted after an inch of rainfall.

3) It is generally considered good practice to disperse discharges and filter the runoff as much as possible prior to being received by a watercourse. As an example, runoff from streets without curbs should be allowed to flow over grassed embankments along the length of the street.

In some cases, however, it is recommended to do the just the opposite. In limited areas, curbs should be added and a formal drainage system installed. Reference to Appendix I indicates specific locations where this should be done. Currently, as previously detailed, runoff typically concentrates at a point along the street and flows over the embankment to the lake, causing erosion and sedimentation of the lake.

Similarly, some outlets to the Lake should be abandoned, since these cause erosion of the bank, scouring of the Lake bottom or transport significant sediments to the Lake. These discharges should be connected to another drainage system with catch basins that discharge to a more stable location after treatment by a gross particle separator.

Repair of existing drainage systems and retaining their existing outfall location, would improve the efficiency of sediment removal for some of these systems. These systems, identified in Appendix I, could be modified by the addition of catch basins with sumps and hoods, a gross particle separator sized for the anticipated sediment load and maintenance schedule proposed. Additional structural measures in many system outfall locations should also be constructed as part of the repair or modification as described below.

New drainage systems, in locations detailed in Appendix I, should be designed and installed to reduce the erosion and sedimentation of Highland Lake. A new system would typically consist of vegetated swales to the inlet of the closed system, and possibly a small sediment basin where space and topography allow. The closed portion of the system would then consist of catch basins with hood and sumps to a gross particle separator, discharging to outfall channels or the Lake as described below.

New outfalls should be constructed in noted locations with splash pads at the outfall locations. Typically, where a drain is cantilevered over the Lake or is submerged, a splash pad to reduce scour during low Lake level periods should be installed in the fall when the Lake level is lowered.

Where feasible, vegetated swales and sediment basins should be added upstream from the inlets to closed drainage systems or prior to discharge to the Lake.

Additionally, where several swales are in proximity to each other, or where runoff flows over steep bank or erodible surfaces, diversion of the runoff to a single swale is recommended. Existing and proposed swales (as with other drainage system improvements recommended) should be designed to ensure adequate capacity, resistance to erosive stormwater runoff and effective vegetative cover. Existing swales should be increased in length where indicated and should be designed to meet the above criteria.

4) Some streams, swales and inlets that convey significant water require rip rap protection to decrease bank and bed erosion. Additionally, streamside buffers should be re-established or, required, enforced and maintained to enhance nutrient removal and to reduce sediment from the watershed. Where it is necessary to re-establish streamside buffers they should consist of select grass, trees, and shrubs. Other measures recommended below should also be designed to further the reduction of nutrients, and sedimentation of the Lake.

Where feasible, enhancement of wetland areas that receive runoff within the watershed or creation of additional wet areas is recommended.

Additional sediment removal or trapping efficiency can be achieved by the installation of stilling pools at inlets and the installation of energy dissipators along the length of proposed and existing swales and streams. Typical dissipators are check dams, pools, and structural drops or plunge pools. The installation of plunge pools at all newly constructed outlets is also recommended to reduce scour erosion and to slow discharge velocities to outlet channels or the Lake.

The U.S. Army Corps of Engineers should be contacted for assistance in removing sediment at the Sucker Brook outlet.

5) It is recommended that roadway embankments be stabilized by removing existing leakoffs and installation of catch basin systems as previously detailed. Additionally, stabilization should include vegetation of the embankment, proper grading, bank sloping and terracing.

6) Very few sections of shoreline are unprotected from the erosive force of wave action. Where areas have been indicated in this survey, the shoreline should be protected. Typical protection would depend on the exact location, however the following should be utilized to reduce this source of sedimentation: riprap banks, increased or establishment of shoreline vegetation, installation of fencing, gabions, reinforced concrete retaining walls, and precast blocks.

7) Several gravel driveways and streets within the watershed should be regraded and paved. If feasible, a porous pavement with appropriate sub-drainage should be designed for these driveways and streets. A possible alternative to paving would be to install a crushed stone surface. This alternative would not be as effective in reducing erosion and sedimentation and will require more maintenance and monitoring.

8) The Town should consider the formulation of a watershed management team which could be made up of representatives from the Highland Lake Commission, Inland Wetlands and Watercourses Commission, Public Works, Planning and Zoning Commission, etc. The watershed management team would formulate and implement Best Management Practices (BMP's) in the watershed. BMP's typically consist of:

- **erosion and runoff control,**
- **nutrient and fertilizer control,**
- **pesticide and toxins control,**
- **animal waste control, and livestock exclusion**
- **porous pavements,**
- **street cleaning,**
- **flood storage,**
- **road and skid trail maintenance, and**
- **construction area soil stabilization**

Construction area BMP's typically consist of the above, and the following:

- **disturbed area limits,**
- **surface roughening,**
- **streamside management,**
- **grassed waterways,**
- **diversion or interception,**
- **stream bank stabilization,**
- **detention, and**
- **vegetative stabilization.**

The team would also be responsible for:

- monitoring land use, development, timber harvesting, and should restrict actions inconsistent with the goal of improving and maintaining the water quality of Highland Lake.
- taking actions to prevent site specific problems, increase field inspections and enforcement of sediment control regulations.
- offering Lake area owners and recreational users educational information relative to the use of lawn and garden fertilizers, pesticide use, compost locations, effects of use on vegetative cover, water quality, gas & oil spillage form motor boats, etc.

Other actions involve implementation of the watershed management plan which should be considered during final design of any improvements to ensure structural measures work in concert with non-structural measures.

VII. Conclusion

The final stages of erosion and sediment control are the actual design and construction of recommended actions. Final designs should detail exact locations where action is recommended and should provide sufficient detail to enable construction of the recommended improvements.

The implementation of the recommendations contained in this report should have significant impacts on Lake water quality, however, there will also be significant costs associated with the design and construction of these improvements, as well as the maintenance of them in the future. Therefore, immediate action, consisting of low cost improvements resulting in the most immediate and significant improvements, coupled with long-term solutions that implement the above recommendations over several years, allowing time to plan appropriately for implementation, as well as funding are recommended.

The use of this survey and the preceding Highland Lake Dredging Feasibility Study should assist the Highland Lake Commission, the Town of Winchester and the Connecticut Department of Environmental Protection in implementation of recommended improvements and control measures in an attempt to reduce sediment loads and associated pollutant loads to Highland Lake. By locating sources, identifying potential problems and potential solutions, the measures presented should provide a significant step towards improvement of the existing water quality of Highland Lake while meeting the desired goals of the Highland Lake Commission and the Connecticut DEP.

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Appendix I

Field Reconnaissance Summary

APPENDIX I

FIELD RECONNAISSANCE SUMMARY

Highland Lake Drainage Study Field Reconnaissance Summary - Dates of Observations: May 6, 7, and 12, 1993.

DISCHARGE POINT No.	OUTLET, DISCHARGE OR OTHER DESCRIPTIONS OBSERVATIONS & RECOMMENDATIONS
EXAMPLE	
00 Description:	This is a brief description of the outfall and/or source of pollution.
Location:	This is the location of the discharge or pollution source, reference should be made to Figure I, the 1"=500' scale base map for this project.
Land Use:	This is the predominate land use associated with the tributary drainage area.
Evidence of Pollution/erosion:	This is a general description of the source and type of pollution.
Potential Sources of Pollution:	This is a description of the likely or evident cause of the observed pollution.
Recommendations:	These are recommended improvements based on field reconnaissance and the associated observations.

East Lake Street

1 Description:	CB at Resha Beach, East Lake Street with outlet to lake. Not functioning. Water in basin.
Location:	Located in front of berm at beach.
Land Use:	Gravel Parking area.
Evidence of Pollution/erosion:	None Observed.
Potential Sources of Pollution:	Parking area runoff
Recommendations:	Remove basin, regrade parking area at beach to drain away from the lake.

2 Description:	CMP outlet pipe 15" diam with end plate permits closure to prevent backflow. Submerged outlet water at top of pipe. AHW=2' TW=1.25' Sediment accumulation in tributary CB's. No apparent sedimentation at outlet of pipe.
Location:	Located on East Lake Street near boat launch at spillway.
Land Use:	Drainage area is residential land and streets.
Evidence of Pollution/erosion:	None
Potential Sources of Pollution:	Potential pollution sources: Road RO, Boat Launching activities, Gasoline spillage, fine sediments, etc.
Recommendations:	New CB's with Hoods, sumps, to Gross Particle Separators(GPS), additional CB's along East Lake Street above lake level to provide more efficient use of sumps and hoods.

West Wakefield Boulevard

3 Description:	12" RCP outlet submerged
Location:	See map
Land Use:	Limited drainage area, grassed area and road.
Evidence of Pollution/erosion:	Filled outlet channel, cross-culvert. Flat outlet channel with sediment.
Potential Sources of Pollution:	Potential sources of pollution: road runoff.
Recommendations:	Increase grass lined road side swale, increase maintenance excavate out sediment.

4 Description:	Twin 60" CMP
Location:	Sucker Brook cross culverts
Land Use:	Undeveloped grass/woods and roadway.
Evidence of Pollution/erosion:	Area has some shore line erosion due to pedestrian traffic on bank, some sediment accumulated at inlet, sediment at outlet,
Potential Sources of Pollution:	Recreational foot traffic, road runoff, sediment loading from sucker brook
Recommendations:	Add grass lined swale, paved leak offs to swales, stone shore for recreational uses, additional vegetation.
5 Description:	12" rcp cross-culvert
Location:	See map
Land Use:	Road way runoff, woods
Evidence of Pollution/erosion:	Sediment in pipe, outlet swale eroding,
Potential Sources of Pollution:	Road runoff and erosion
Recommendations:	Grass lined swale to pool at inlet, riprap inlet and outlet protection.
6 Description:	5'x4' box culvert AHW=3' does not appear to be for drainage purposes. Swale along road to culvert.
Location:	Near house #434 see map
Land Use:	Road runoff and limited drainage area residential/woods.
Evidence of Pollution/erosion:	Some sediment and leaves in culvert lack of maintenance
Potential Sources of Pollution:	Street runoff
Recommendations:	Provide limited inlet and outlet protection and maintain
7 Description:	12" square cross culvert
Location:	See map
Land Use:	Residential and road way runoff
Evidence of Pollution/erosion:	Sediment covered outlet, debris in inlet
Potential Sources of Pollution:	Erosion, runoff, lack of maintenance
Recommendations:	Provide inlet and outlet protection, increase swale length if possible, improve outlet with formal outlet (splash pad/stilling basin).

7A Description:	Shore line erosion.
Location:	See Map.
Land Use:	Residential.
Evidence of Pollution/erosion:	Bank undercutting.
Potential Sources of Pollution:	Wave erosion.
Recommendations:	Armor shore line.

8 Description:	15" rcp good condition cross culvert, outlet cantilevers over lake water, AHW=3', tw=0',
Location:	See map
Land Use:	Residential/woods, road way, substantial tributary drainage area.
Evidence of Pollution/erosion:	Shoreline erosion, sediment
Potential Sources of Pollution:	Near house #422 just up road from #8 sediment from gravel drive with 3" deep swale
Recommendations:	Add shore/bank protection, formalize bank with stone/riprap protection.

9 Description:	12" CMP cross culvert, AHW=2', outlet buried on shore side for filling beach
Location:	Near pole #1314 house #407
Land Use:	Residential/roadway
Evidence of Pollution/erosion:	Erosion and sedimentation, clogged inlet, outlet buried, beach erosion, sediment in basins.
Potential Sources of Pollution:	Erosion of lawns, beach erosion, filling for beach, lawn fertilizers and pesticides
Recommendations:	CB's with sumps and hoods to GPS, formalize outlet with riprap splash pad/plunge pool, eliminate this outlet and install grass lined swale to outlet #10 as described below.

10 Description:	12" rcp cross-culvert submerged outlet tw =12" outlet cast in retaining wall AHW=2'
Location:	See map pole #1312
Land Use:	Residential/roadways
Evidence of Pollution/erosion:	Sediment at inlet
Potential Sources of Pollution:	Lawn runoff and road runoff/sediment from roadway
Recommendations:	Add catch basins to gross particle separator (GPS), eliminate #9 above and add grass swale to c.b.'s to GPS at #10

11 Description:	Seep from high side of roadway
Location:	Near pole #1311 and House #401
Land Use:	See # 10 above for the remaining description for #11
Evidence of Pollution/erosion:	
Potential Sources of Pollution:	
Recommendations:	

12 Description:	12" rcp cross culvert to cb, cb to 12"cmp to outlet submerged at pipe top
Location:	See map, near house # 356 and pole #1309
Land Use:	Residential and roadway
Evidence of Pollution/erosion:	Sediment at inlet to invert, sediment to inverts of cb and sediment 2" above invert in outlet pipe
Potential Sources of Pollution:	Seeps from hill near pole #1309, bldg.drain from house #355,
Recommendations:	Replace system, add grass lined swale along uphill/hill side of road to cb's with sumps, hoods to GPS. Add new cb at low point near home #356 on the lake side.

13 Description:	12" cmp cantilever outfall, cb's on lake side of road AHW=2'seep at pole #1305 to basin at house #343.
Location:	See map, pole# 1305
Land Use:	Residential/roadway, woods
Evidence of Pollution/erosion:	Sediment at invert, shore/bank undercutting from wave action,erosion
Potential Sources of Pollution:	Runoff, erosion, unprotected shoreline
Recommendations:	Add cb's w/GPS, Add Shore/bank protection

13A Description:	Shore line erosion.
Location:	See Map.
Land Use:	Residential.
Evidence of Pollution/erosion:	Bank undercutting.
Potential Sources of Pollution:	Wave erosion.
Recommendations:	Armor shore line.

14 Description:	32"wx16"h cross culvert , seeps from hillside at culvert
Location:	Near pole #1300
Land Use:	Woods, roadway
Evidence of Pollution/erosion:	Sediment at inlet to 1/2 depth of culvert, Bank erosion
Potential Sources of Pollution:	Pedestrian traffic, road runoff
Recommendations:	Add cb's with high capacity inlet, sumps, to GPS prior to outfall, Omit leak offs at #14A below.

14A Description:	Paved leak off along road runoff.
Location:	See map.
Land Use:	Residential/roadway.
Evidence of Pollution/erosion:	Erosion on sides of road.
Potential Sources of Pollution:	Runoff.
Recommendations:	Curbs to leak off, curbs to cb's.

15 Description:	Inlet 15"x18"w to 12"rcp at outlet. AHW=2' outlet submerged not apparent.
Location:	See map. Near pole #1294
Land Use:	Residential/Roadway.
Evidence of Pollution/erosion:	Sediment at inlet to 1/2 height.
Potential Sources of Pollution:	Road runoff, non-point sources.
Recommendations:	Connect cb's to GPS omit #15 & #16 retain or improve outfalls.

16 Description:	cb's w/o sumps 8"pvc pipe out to lake submerged outlet 3' AHW=1'.
Location:	Opposite House #301.
Land Use:	Residential/roadways
Evidence of Pollution/erosion:	Sediment in basin up to invert elevation. see # 15 above.
Potential Sources of Pollution:	See # 15 above.
Recommendations:	See # 15 above.

17 Description:	12"hx18"w cmp cross culvert Inlet grassed w/limited pooling area collects seeps and road runoff. Submerged outlet 3', AHW=1'.
Location:	See map, vicinity of pole #3450.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment up to invert elevation.
Potential Sources of Pollution:	Road runoff, erosion.
Recommendations:	See #15 above.

18 Description:	36" cmp cross culvert with cb's AHW=3'TW=2', paved leak off on uphill side of road to brook. Pond uphill, outlet brook to culvert. Seep from stone wall area.
Location:	See map, vicinity of poles #3452,3450
Land Use:	Residential
Evidence of Pollution/erosion:	Brook with bank erosion
Potential Sources of Pollution:	Stream flow, road runoff
Recommendations:	Provide brook stabilization, inlet pool.

19 Description:	12" rcp cross culvert, AHW=2',TW=0',
Location:	Near pole # 3444
Land Use:	Residential
Evidence of Pollution/erosion:	Sediment at inlet, septic smells
Potential Sources of Pollution:	Road runoff, building drains
Recommendations:	Grass lined swale to cb's w/hood,sumps to GPS.

20 Description:	12"rcp cross culvert, up slope runoff from hill and bldg. sump pumps.
Location:	Near pole# 3442.
Land Use:	Residential.
Evidence of Pollution/erosion:	Septic smell and liquid, sediment.
Potential Sources of Pollution:	Road runoff, septage.
Recommendation:	Grass lined swale to #21 below, omit #20 replace with grass swale, protect up slope swale with rock improve outlet with riprap.

21 Description: 18"wx15"h cmp, swale from uphill areas, AHW=3',TW=0'.
Location: Near pole #3441
Land Use: Residential/roadway
Evidence of Pollution/erosion: Erosion in swale from up slope areas, sediment at outfall and inlet.
Potential Sources of Pollution: Road runoff, erosion of swale.
Recommendations: Grass lined swale, riprap swale from up slope runoff areas, install cb's w/sumps, hoods to GPS.

22 Description: 12" rcp cross culvert.
Location: Near pole #3436
Land Use: Residential
Evidence of Pollution/erosion: Sediment at inlet, Some bank erosion
Potential Sources of Pollution: Seeps from uphill side of road, road runoff, lake wave action.
Recommendations: Install grass lined swale to cb's to GPS.

23 Description: 12" rcp cross culvert, seeps from up slope, AHW=2', TW=0'.
Location: Near pole #3435.
Land Use: Residential.
Evidence of Pollution/erosion: Inlet buried with sediment, algae growth, outlet plugged with sediment
Potential Sources of Pollution: Road runoff, septage, bldg. drains.
Recommendations: Repair.

24 Description: 12" rcp with 2-drains at inlet of rcp out.
Location: Near Vons Lane.
Land Use: Residential/road
Evidence of Pollution/erosion: Sediment at inlet, at outlet sediment delta, some bank erosion and undercutting of shore.
Potential Sources of Pollution: Sediment from runoff from Vons Lane, lake wave erosion, road runoff.
Recommendations: Create pool at inlet provide splash pad at outlet.

25 Description: 12" cmp to 12"rcp outlet. AHW=2' TW=0', seeps from up slope
Location: Near House # 139.
Land Use: Residential.
Evidence of Pollution/erosion: cb's filled with sediment, sediment delta at outfall in lake.
Potential Sources of Pollution: Road runoff
Recommendations: cb's with sumps to GPS, increased maintenance.

26 Description: 12" rcp outlet from cb.
Location: Near House # 137
Land Use: Residential.
Evidence of Pollution/erosion: Sediment to inlet elevation.
Potential Sources of Pollution: Road runoff.
Recommendations: No apparent problem, increase maintenance.

27 Description: 12" cmp outlet cantilevered over lake, runoff from hill in swale.
Location: Near Pole #3427.
Land Use: Residential/woods.
Evidence of Pollution/erosion: Sediment in sump of inlet
Potential Sources of Pollution: Erosion of uphill area, runoff to swale, road runoff.
Recommendations: Riprap swale, provide sump at inlet.

28 Description: 12" rcp , seeps from hill at #28 & #29.
Location: Near Pole #2789 and driveway.
Land Use: Residential.
Evidence of Pollution/erosion: Inlet and outlet plugged with sediment, sediment delta at outfall in lake.
Potential Sources of Pollution: Road runoff, erosion.
Recommendations: Road side swale to cb's to GPS, riprap outlet, omit #28 flow to #29.

29 Description: 12" rcp and cmp, seeps from hill.
Location: Near pole #2787.
Land Use: Residential
Evidence of Pollution/erosion: Inlet with sediment to invert elevation, road shoulder eroding into lake.
Potential Sources of Pollution: Road runoff, road shoulder erosion, lake wave action.
Recommendations: Curbs with cb's to GPS, Riprap shore line.

30 Description: 12" rcp cross culvert with runoff in swale from up slope, submerged outlet, AHW=1',TW=0.5'.
Location: See Map.
Land Use: Residential.
Evidence of Pollution/erosion: Sediment at inlet to 1/2 of pipe diam., sediment at outlet, erosion at swale.
Potential Sources of Pollution: Road runoff, erosion of swale.
Recommendations: Rip rap swale and provide riprap at outlet.

31 Description: 12" rcp cross culvert to 12" cmp outlet submerged, seeps from hill, AHW=1',TW=2'.
Location: Near house #105.
Land Use: Residential.
Evidence of Pollution/erosion: Sediment at inlet to 1/2 pipe diam.
Potential Sources of Pollution: Road runoff, seep from hillside.
Recommendations: Grass swale w/cb's to GPS prior to outlet.

32 Description: Lake side of road cb w/12" cmp in from Gillett Rd. to cb out to lake.
Location: See map.
Land Use: Residential.
Evidence of Pollution/erosion: Sediment in cb over outlet pipe.
Potential Sources of Pollution: Insufficient maintenance, road runoff.
Recommendations: Cb's with sumps to GPS prior to outlet, increased maintenance.

33 Description: 12" rcp cross culvert, submerged outlet.
Location: Near house #101-3.
Land Use: Residential.
Evidence of Pollution/erosion: Sediment at inlet in basin
Potential Sources of Pollution: Road runoff, lawns.
Recommendations: Grass swale to cb's to GPS Highly recommended here.

34 Description: Cross culvert to cb to submerged 12" rcp outlet AHW=1',TW=2'
Location: See map.
Land Use: Residential.
Evidence of Pollution/erosion: Sediment at inlet up to invert elevation, trash from road,
Potential Sources of Pollution: Road runoff, lawns, gravel drives.
Recommendations: Cb's to GPS.

35 Description: 12" rcp cross culvert w/submerged outlet, Paved leak off at State boat launch area.
Location: Near State Ct. Boat Launch, See Map.
Land Use: Residential.
Evidence of Pollution/erosion: Sediment to 1/2 of inlet diam.
Potential Sources of Pollution: Road runoff, gravel drive/turnaround, lawns.
Recommendations: Cb's to GPS, pave turnaround.

East Wakefield Boulevard

36 Description: 25' concrete slab bridge, see inventory of Town drainage structures for structural condition. AHW=6',TW=0'.Seepage from dam.
Location: Down slope of Dam, see map.
Land Use: Woods, manmade land (dam area).
Evidence of Pollution/erosion: Sediment at inlet and outlet
Potential Sources of Pollution: Road runoff, seepage from dam.
Recommendations: Remove sediment, paved leak off at Pole #1333.

37 Description: Swale from gravel drive flow to road and runoff from upland areas near pole #1336.
Location: See map, Pole #1336.
Land Use: Woods, residential.
Evidence of Pollution/erosion: Sediment along road.
Potential Sources of Pollution: Erosion of swale and gravel drive.
Recommendations: Grass lined swale along uphill side flowing to Sucker Brook Culvert.

38 Description:	12" rcp cross-culvert, swale from hill with runoff.
Location:	Near pole # 1339 and house #536, (swale along house #537), outlet cantilevered over lake water. AHW=2' TW=0' Steep culvert.
Land Use:	Woods/residential.
Evidence of Pollution/erosion:	Sediment at inlet to 1/2 Diam. of pipe and at outfall, erosion evident in swale, leaves, etc.,outlet sediment.
Potential Sources of Pollution:	Erosions of swales, road runoff, lawns eroding and lawn fertilizers.
Recommendations:	Rip rap swales, or add grass lined swales to inlet, provide inlet pool for ponding of runoff to trap sediments, improve outfall with rip rap splash pad.
39 Description:	12"cmp collects uphill runoff/stream via gravel swale, submerged outlet, inlet appears crushed, AHW=2', TW=1'.
Location:	Near pole # 1341, swale near pole #1342.
Land Use:	Residential/woods.
Evidence of Pollution/erosion:	Sediment at inlet, sumps of side basins filled with sediment.
Potential Sources of Pollution:	Erosion of gravel swales, runoff along road ways, road runoff.
Recommendations:	Cb's with sumps to GPS prior to outlet, grass swales to inlets, pave gravel drives.
40 Description:	Road runoff along lake side of road way.
Location:	See Map. Area near house #554.
Land Use:	Road runoff.
Evidence of Pollution/erosion:	Slope erosion evident.
Potential Sources of Pollution:	Road runoff along lake side of road.
Recommendations:	Add curbs see map for more detailed location.
41 Description:	Shore line bank undercutting.
Location:	House #554.
Land Use:	Residential.
Evidence of Pollution/erosion:	Bank undercutting evident due to wave action.
Potential Sources of Pollution:	Erosion of bank.
Recommendations:	Armor shore line in areas where erosion is evident.

42 Description:	18" rcp cross culvert to 12" cmp submerged outlet at endwall. Outlet splashes to rocks and pool.
Location:	See Map, Near pole #1347, #1348 and house #609.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment to 1/2 of pipes' diam., sediment delta at outfall, debris in culverts, erosion of swale.
Potential Sources of Pollution:	Swale eroding, gravel drives, road runoff.
Recommendations:	Add curbing along lake side up to Forest Lane, add GPS at low point at cb's, add grass lined swale along uphill side. Improve uphill swale for short distance with formalized inlet near House #609 and pole #1348.
43 Description:	12" rcp at Forest Lane, outlet via 12"cmp.
Location:	See map, Forest Lane.
Land Use:	Residential, road
Evidence of Pollution/erosion:	Sediment at inlets, and sediment delta at outfall.
Potential Sources of Pollution:	Bare earth at inlets eroding, some bank erosion due to land use (recreational), road runoff.
Recommendations:	Cb's with connection to GPS, addition of curbing along lake side edge of road, add drop bend to level section of cmp to reduce scouring at outfall. Increased maintenance.
44 Description:	Runoff from road to low area along edge of road lakeside.
Location:	Near house #711.
Land Use:	Road/ residential.
Evidence of Pollution/erosion:	Erosion of bank , uncollected sediment from road.
Potential Sources of Pollution:	Erosion of bank, concentration of road runoff at unprotected outfall.
Recommendations:	Add curbing to Forest lane cb and cb w/GPS at Low point opposite House #711.

45 Description:	12" rcp culvert, AHW=2' TW=0'
Location:	Near Pole #1359, House #802.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment delta at outlet, erosion of bank.
Potential Sources of Pollution:	Road runoff, wave action, lack of maintenance.
Recommendations:	Cb's to GPS, addition of cubing along lake side edge of road, grass line swale along uphill side of road to inlet.

46 Description:	12" rcp cross culvert.
Location:	See map, State Park Area (Paugnut State Forest).
Land Use:	Woods, roadway.
Evidence of Pollution/erosion:	Debris at inlet, erosion of sides at inlet, sediment filled rip rap outlet.
Potential Sources of Pollution:	Road runoff, paved leak offs, unprotected inlet.
Recommendations:	Clean sediment at rip rap outlet, repair riprap outlet, add rip rap inlet protection, or add cb's to GPS., increase maintenance.

47 Description:	24" rcp cross culvert, Hill side seeps and grass lined swale to inlet,paved leak offs.
Location:	See Map, State Park area.
Land Use:	Woods/road
Evidence of Pollution/erosion:	Sediment at outlet, ends of paved leakoff.
Potential Sources of Pollution:	Road runoff.
Recommendations:	Increase maintenance of paved leak offs, possible addition of cb's to GPS. This area is a good example of the capability of a grass lined swale to handle runoff, hillside seeps and to filter sediment from the runoff prior to inlets.

48 Description:	24" rcp cross culvert.
Location:	See map, Near State Park area.
Land Use:	Woods/road.
Evidence of Pollution/erosion:	Sediment at inlet and outlet.
Potential Sources of Pollution:	Erosion of swales, road runoff.
Recommendations:	Clean sediment from inlet and outlet, increase maintenance.

49 Description:	10'wx3'h concrete bridge, rip rap swale along hill side and grass lined swale, paved leak offs.
Location:	Taylor Brook at State Forest.
Land Use:	Woods/road.
Evidence of Pollution/erosion:	Sediment in paved leak offs, sediment delta at outlet of bridge (brook mouth.
Potential Sources of Pollution:	Road runoff, erosion of upland tributary areas.
Recommendations:	Cb's w/sumps,hoods, to GPS, no channel work is recommended, restrict upland activities, implement best management practices to reduce sediment load to Taylor Brook.

50 Description:	24" rcp cross culvert, brook with gravel bottom/cobble sides, paved leak offs.
Location:	See Map, State Park area.
Land Use:	Woods/road.
Evidence of Pollution/erosion:	Sediment at inlet and outlet pool.
Potential Sources of Pollution:	Road runoff, upland area land use.
Recommendations:	Grass lined swales to larger rip rapped inlet pool, cb's to GPS, clean sediment from outlet channel and place stilling pool similar to existing or enhance existing pool at outlet.

50A Description:	Shore line erosion.
Location:	See Map, Cameron Point.
Land Use:	Residential.
Evidence of Pollution/erosion:	Bank undercutting.
Potential Sources of Pollution:	Wave erosion.
Recommendations:	Armor shore line.

51 Description:	18" rcp to 15" cmp outlet to lake, cantilevered outlet.
Location:	See map, near pole #1558.
Land Use:	Residential/woods.
Evidence of Pollution/erosion:	Sediment at inlet and sediment delta in lake at outfall.
Potential Sources of Pollution:	Road runoff.
Recommendations:	Cb's with sumps to GPS, splash pad at outfall.

52 Description:	15" rcp from basins, hillside seeps, submerged outlet.
Location:	Near pole #1556.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment in basins to invert, seep from hillside.
Potential Sources of Pollution:	Road runoff, seeps from hill.
Recommendations:	Cb's to GPS, grass lined swale along uphill side of road.

53 Description:	Seep from Driveway of House and low area in pavement
Location:	House # 829 & 832.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment at low point in road and at outfall of swale.
Potential Sources of Pollution:	Road runoff, erosion of gravel drive.
Recommendations:	Cb's to GPS to splash pad.

54 Description:	Seeps from hill flowing across road to low area then to paved leak off.
Location:	Near house #827.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment at leak off, sediment delta at low point.
Potential Sources of Pollution:	Road runoff, erosion.
Recommendations:	Add curb along lake side of road with cb/GPS, drop inlet for seep or use of swale to inlet at number 55 below.

55 Description:	15" rcp.
Location:	Near house #827.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment delta at outfall, gravel drive erosion.
Potential Sources of Pollution:	Road runoff, gravel drives eroding
Recommendations:	Cb's to GPS to outfall.

56 Description:	15" rcp to 15" cmp outlet AHW=3' TW=1.25'
Location:	Near house #817, Bristol Cove.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment delta at outlet.
Potential Sources of Pollution:	Road runoff, lack of maintenance.
Recommendations:	Cb's to GPS, increase maintenance.

57/57A Description:	18" cmp, outfall just under docks, runoff from upslope.
Location:	House # 812.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment in cb's, erosion of driveway, sediment delta at outfall.
Potential Sources of Pollution:	Road runoff, erosion of gravel drive.
Recommendations:	Repair driveway above 3-grate cb, pave, increase maintenance, connect existing drainage to GPS prior to outlet to lake. At # 57A bldg. drains to cb's, add grass lined swale to PGS at bottom of hill.

58 Description:	Lawns along Bartons Point.
Location:	See Map.
Land Use:	Residential.
Evidence of Pollution/erosion:	Land use, lawns.
Potential Sources of Pollution:	Lawns.
Recommendations:	Limit fertilizer use.

59 Description:	24" rcp to 18" rcp outlet.
Location:	Outlet between house # 674 and 670.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment in side swale, sediment at outfall.
Potential Sources of Pollution:	Road runoff, erosion of swale.
Recommendations:	Grass lined swale to sediment pools at inlet, riprap inlet and outlet, cb's to GPS new 18"rcp at outlet to splash pad.

59A Description:	8" pvc from basin.
Location:	Barton's Point Road.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment in basin to invert.
Potential Sources of Pollution:	Land use.
Recommendations:	Drywell with high level overflow to lake or cb's with sumps and hoods.
60 Description:	15" rcp to 15" cmp submerged outlet.
Location:	Near house # 656 and pole # 1529.
Land Use:	Residential.
Evidence of Pollution/erosion:	Silt in swale.
Potential Sources of Pollution:	Road runoff, erosion in swale, gravel driveways from house #659.
Recommendations:	Cb's to GPS, inlet with pool rip rap protection for swale into woods, formalize grass lined swales.
61 Description:	15" rcp cross culvert with submerged outlet.
Location:	Near house #636 and pole #1522.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment at outfall in lake.
Potential Sources of Pollution:	Road runoff, seeps from hill.
Recommendations:	Inlet at end of grass lined swale, cb's to GPS, pool at inlet, outlet splash pad for low lake level periods to reduce scour.
62 Description:	12"cmp cross culvert to cb w/ Town bench mark to lake with cantilevered over water.
Location:	Near house # 622 and 620, near pole # 1517.
Land Use:	Residential.
Evidence of Pollution/erosion:	Swales with silt, seeps from hill, erosion of swale.
Potential Sources of Pollution:	Road runoff, erosion of swale from upland areas.
Recommendations:	Inlet rip rap upland swale with pool at inlet, grass lined swales, new cb's to GPS.

63 Description:	15" rcp cross culvert.
Location:	Near house # 610 and 606.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment at inlet and outlet delta.
Potential Sources of Pollution:	Road runoff, erosion of swales.
Recommendations:	Grass lined swales to inlet, rip rap runoff swale from upland pool at inlet, riprap inlet and outlet with pools, rip rap swale to lake with pools and drops, provide outfall splash pad.
64 Description:	18" rcp cross culvert.
Location:	Opposite Pole #1508 and house # 550.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment in basins, filled drains, drains 1/2 filled w/sediment.
Potential Sources of Pollution:	Road runoff, road side swale erosion, lawns.
Recommendations:	Grass lined swale to cb's to GPS, riprap pool at inlet and grass lined swale for outlet to lake.
65 Description:	12" rcp with overland flow/uphill runoff in swale to inlet.
Location:	Opposite pole #1506, near house # 545.
Land Use:	Residential.
E vidence of Pollution/erosion:	Erosion in swale, sediment at inlet and outlet and at the outfall into the lake.
Potential Sources of Pollution:	Erosion of swales, road runoff, lawns.
Recommendations:	Rip rap or grass line swale from uphill area to inlet, riprap inlet and outlet, add grass lined swale to lake from outlet, add grass swales along road at uphill side , repair headwall, increase maintenance.
66 Description:	20" rcp, hill side seeps to edge of road.
Location:	Near Pole #1504.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment at outfall in lake, sediment at inlet in swale along road.
Potential Sources of Pollution:	Road runoff, erosion of swales for up slope runoff, hill side seeps, lack of maintenance.
Recommendations:	Add grass line swale to inlet, rip rap inlet and swale that runs uphill, provide splash pad at outfall.

67 Description:	18" rcp to 12"cmp at lake.
Location:	Near house #542.
Land Use:	Residential.
Evidence of Pollution/erosion:	Some sediment at outfall, sediment and leaves at inlet.
Potential Sources of Pollution:	Road runoff, lawns, lack of maintenance.
Recommendations:	Add grass lined swale to inlet, maintain inlet.

68 Description:	24" rcp, swale to inlet for up slope runoff stream.
Location:	Near pole # 1499S opposite Wheelers Point Rd.
Land Use:	Residential/woods.
Evidence of Pollution/erosion:	Sediment at inlet and outlet, swale erosion, leaves at inlet and outlet and swales.
Potential Sources of Pollution:	Swale bank eroding, some lawn erosion and beach erosion into lake on Wheelers Pt.
Recommendations:	Rip rap swale from inlet up slope to opposite pole #1498, grass lined swale to inlet from pole #1500, rip rap inlet and outlet, provide plunge pool at outlet, dredge swale and replace with rip rap or vegetative lining.

68A Description:	Swale erosion and lawns.
Location:	See Map.
Land Use:	Residential.
Evidence of Pollution/erosion:	Swale erosion and land use.
Potential Sources of Pollution:	Swale erosion and lawns.
Recommendations:	Grass line swale and limit fertilizer use.

69 Description:	15" rcp cross culvert.
Location:	Near house # 511 and driveway for house #523.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment and debris at inlet and outlet.
Potential Sources of Pollution:	Road runoff.
Recommendations:	Increase maintenance, add grass lined swale to inlet (both directions), riprap outlet at pool with grass lined at inlet.

70 Description:	12"x18" cmp culvert.
Location:	Near house # 450 and pole #1492.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment at inlet and outlet.
Potential Sources of Pollution:	Erosion of upland areas and swale.
Recommendations:	Add grass lined swales along both sides of road, riprap inlet and major swale from upland, provide inlet pool, grass lined swale to lake providing steps in swale to trap sediment.
71 Description:	15" cmp cross culvert, upland swale to inlet, brook 2'x2' gravel bottom with cobble sides.
Location:	Near pole #1484S
Land Use:	Woods/roads.
Evidence of Pollution/erosion:	Sediment at inlet and in swale, sediment at outlet of culvert and swale, sediment and organics at lake.
Potential Sources of Pollution:	Swale bank erosion and road runoff.
Recommendations:	Road side grass lined swale, pool at inlet, rip rap inlet and outlet, increase maintenance, add cb's to GPS to outlet for road both sides from pole #1484S to 1481, #1478 to 1475 and #1472 to 1475.
72 Description:	12" cmp cross culvert to wetland swamp area indirect discharge to lake, flow to discharge #71.
Location:	Near pole # 1475S.
Land Use:	Residential/road.
Evidence of Pollution/erosion:	Sediment in drain and at inlet and outlet, sediment in swale to lake.
Potential Sources of Pollution:	Road runoff.
Recommendations:	Increase maintenance, replace with cb's to GPS to rip rap outlet, improve swale to grass lined to wetlands.

73 Description:	15" cmp cross culvert, paved leak off, submerged outlet.
Location:	Near pole #1468 at Second Bay Cove.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment at inlet and in cb at outlet, organics and sediment at outfall at lake.
Potential Sources of Pollution:	Long gravel drive eroding, road runoff, road construction, new home construction.
Recommendations:	Add cb's to GPS to outlet, improve outfall with pipe to plunge pool submerged.

74 Description:	15" cmp to outlet swale.
Location:	Near pole #1464
Land Use:	Residential/road.
Evidence of Pollution/erosion:	Sediment and organics in basin and at outfall and in lake.
Potential Sources of Pollution:	Road runoff, lawns, gravel drives and Norcross Rd.
Recommendations:	Add cb's to GPS, pave road and drives, see number 75 below.

75 Description:	12"x30" elliptical cmp for stream/brook with gravel bottoms and sides with cobbles, brook 3'wide x4'deep.
Location:	At Norcross Road.
Land Use:	Residential/woods.
Evidence of Pollution/erosion:	Sediment at inlet and outlet as well as in the lake at the outfall.
Potential Sources of Pollution:	Road runoff, Norcross Road and other gravel drives.
Recommendations:	Rip rap inlet and outlet, provide inlet pool and outlet plunge pool, increase maintenance, pave Norcross Rd., provide leak offs along Norcross Road, add curbs from high point located past Norcross road to new cb's as described for #74 above.

76 Description:	12" cmp outlet.
Location:	Near pole# 3361 between houses # 328 and 324.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment at outfall in lake, sediment and debris in cb's.
Potential Sources of Pollution:	Road runoff, some from gravel drives.
Recommendations:	Add GPS at basins low point, maintain system on regular basis.

Perch Rock Trail

77 Description:	18" rcp outlet submerged 4".
Location:	Perch Rock Trail between house # 244 and 240.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment and leaves in cb's to invert elevations, sediment at outfall in lake.
Potential Sources of Pollution:	Road runoff, minor erosion from lawns.
Recommendations:	Maintain system, add GPS at low point add cb's for 2nd half of Perch Rock Trail.

78 Description:	15" cmp outlet to lake.
Location:	Between house #214 and 212 Perch Rock Trail.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment at outfall sediment and debris in cb's on road.
Potential Sources of Pollution:	Road runoff, minimal maintenance, some swale erosion.
Recommendations:	Provide pool for swale opposite/near pump station at inlet opposite house #214, provide cb's to GPS along road.

Wakefield Boulevard

79 Description:	Cb's, swales and cross culvert on Wakefield Blvd. outlets to Perch Rock Trail drainage system.
Location:	Wakefield blvd. House #244 (pole#1455),242 (pole#1454) ,233E
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment in basins, erosion of swales.
Potential Sources of Pollution:	Road runoff, gravel driveways, runoff in swales eroding banks and bases
Recommendations:	Grass lined swales

80 Description:	Swale to inlet to outfall 24" ADS pipe.
Location:	Wakefield Blvd. between house # 150 and 148.
Land Use:	Residential/woods/roads.
Evidence of Pollution/erosion:	Sediment at outfall in lake, and at inlet.
Potential Sources of Pollution:	Minimal maintenance, road runoff, land development activities.
Recommendations:	Provide pool at swale inlet, riprap inlet, cb's to GPS, increase maintenance, riprap section of swale from upland areas.

81 Description:	18" rcp to 12"cmp at outlet.
Location:	See map, near pole #1428 between house #126 and 124.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment at outlet and in basins.
Potential Sources of Pollution:	Road runoff and lawn runoff, low maintenance.
Recommendations:	Provide splash pad for outlet, cb's to GPS.

82 Description:	24" rcp in basins to 24"cmp submerged outlet.
Location:	Near house #119, between house #120E and #114.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment delta at outfall, sediment in basins.
Potential Sources of Pollution:	Road runoff, new construction off of Carey Lane, gravel drives and roads.
Recommendations:	Add cb's to GPS, provide splash pad at outlet, pave roads and drives, increase maintenance.

<u>Shore Drive</u>

83 Description:	Paved leak off on lake side of road to grass swale.
Location:	Between house #176 and 174.
Land Use:	Residential/road.
Evidence of Pollution/erosion:	Sediment at paved leak off.
Potential Sources of Pollution:	Road runoff.
Recommendations:	Cb/GPS or maintain existing.

84 Description:	Yard drain with 6"pvc outlet to lake.
Location:	House # 148 near rear of house #146.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment at outlet and sediment and leaves in yard drain.
Potential Sources of Pollution:	Road runoff, lawn erosion.
Recommendations:	Install cb;s to GPS along Shore Drive.

85 Description:	12" cmp at outlet.
Location:	Between house # 134 and #136.
Land Use:	Residential.
Evidence of Pollution/erosion:	None at outfall submerged, sediment in basins to invert elevation.
Potential Sources of Pollution:	Road runoff.
Recommendations:	Cb's to GPS.

86 Description:	12"cmp with submerged outlet.
Location:	Between house # 118 and # 116.
Land Use:	Residential.
Evidence of Pollution/erosion:	Sediment in basins and at outfall.
Potential Sources of Pollution:	Road runoff.
Recommendations:	Curbs to cb's to GPS.

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Appendix II

Drainage Capacity Evaluation

+ HIGHLAND LAKE DRAINAGE STUDY
+ Prepared For The Town of Winchester, Connecticut.
+
+ W.M.C. Consulting Engineers
+
+ Date : May 1993
+

APPENDIX II
DRAINAGE CAPACITY EVALUATION

Tributary Areas for Outlets/Discharges To Highland Lake. Peak Discharge Estimate base on the Rational Method

Discharge No.	Coeff. of Runoff (a)	Drainage (Sq. Ft.)	Area (Acres)	Tc (minutes)	Rainfall Intensity (inches/hour) (b)	Peak Q-25yr. (c.f.s.)	Outlet Descr.	Est. Outlet's Capacity (c)	See Recommendations Adequate Capacity Insufficent Capacity
1	0.10	9882	0.23	5.0	7.1	0.2	plugged	0	Insufficent Capacity
2	0.30	339541	7.79	6.5	6.4	15.0	15" cmp	7	Insufficent Capacity
3	0.35	74702	1.71	5.0	7.1	4.3	12" rcp	5	Adequate Capacity
4	0.10	57318169	1315.84	-	2.0	263.2	2-60" cmp	240	(Note: controlled runoff)
5	0.20	195006	4.48	24.0	3.8	3.4	12" rcp	5	Adequate Capacity
6	0.30	65233	1.50	24.0	3.8	1.7	5'x4' box	136	Adequate Capacity
7	0.30	48341	1.11	5.0	7.1	2.4	12"	5	Adequate Capacity
8	0.20	178908	4.11	5.0	7.1	5.8	15" rcp	7	Adequate Capacity
9	0.20	97765	2.24	5.0	7.1	3.2	12" cmp	5	Adequate Capacity
10	0.20	202777	4.66	5.0	7.1	6.6	12" rcp	5	Insufficent Capacity
11	0.20	190233	4.37	5.0	7.1	6.2	none	0	Insufficent Capacity
12	0.20	418392	9.60	5.0	7.1	13.6	12" rcp	5	Insufficent Capacity
13	0.20	776309	17.82	5.0	7.1	25.3	12" cmp	5	Insufficent Capacity
14	0.20	286583	6.58	5.0	7.1	9.3	32"x16"	15	Adequate Capacity
15	0.20	319516	7.34	5.0	7.1	10.4	12" rcp	5	Insufficent Capacity
16	0.20	150522	3.46	5.0	7.1	4.9	8"pvc	1	Insufficent Capacity
17	0.30	9137	0.21	5.0	7.1	0.4	11"hx18"w cmp	3	Adequate Capacity
18	0.20	1401939	32.18	28.6	3.4	21.9	36" cmp	5	Insufficent Capacity
19	0.30	154844	3.55	21.0	4.0	4.3	12" rcp	5	Adequate Capacity
20	0.30	108813	2.50	21.0	4.0	3.0	12" rcp	5	Adequate Capacity
21	0.30	607443	13.94	21.0	4.0	16.7	15"hx18"w cmp	5	Insufficent Capacity
22	0.30	187595	4.31	22.0	4.0	5.2	12" rcp	5	Insufficent Capacity
23	0.30	240109	5.51	25.0	3.7	6.1	12" rcp	5	Insufficent Capacity
24	0.30	168932	3.88	25.0	3.7	4.3	12" rcp	5	Adequate Capacity
25	0.30	63214	1.45	21.0	4.0	1.7	12" rcp	5	Adequate Capacity
26	0.30	85711	1.97	21.0	4.0	2.4	12" rcp	5	Adequate Capacity
27	0.30	1467025	33.68	30.5	3.3	33.3	12" cmp	5	Insufficent Capacity
28	0.30	289952	6.66	21.0	4.0	8.0	12" rcp	5	Insufficent Capacity
29	0.30	800769	18.38	23.5	3.9	21.5	12" cmp	5	Insufficent Capacity

+	30	0.30	483055	11.09	23.5	3.9	13.0	12" rcp	5	Insufficent Capacity	+
+	31	0.30	69592	1.60	22.5	4.0	1.9	12" cmp	5	Adequate Capacity	+
+	32	0.30	91723	2.11	22.5	4.0	2.5	12" cmp	5	Adequate Capacity	+
+	33	0.30	128569	2.95	22.5	4.0	3.5	12" rcp	5	Adequate Capacity	+
+	34	0.30	417481	9.58	22.5	4.0	11.5	12" rcp	5	Insufficent Capacity	+
+	35	0.90	63532	1.46	5.0	7.1	9.3	12" rcp	5	Insufficent Capacity	+
+	36	0.20	32194	0.74	5.0	7.1	1.0	25' bridge	1000	Adequate Capacity	+
+	37	0.20	58517	1.34	5.0	7.1	1.9	swale	2	Adequate Capacity	+
+	38	0.20	6356106	145.92	44.5	2.5	73.0	12" rcp	5	Insufficent Capacity	+
+	39	0.20	883074	20.27	23.0	3.9	15.8	12" cmp	5	Insufficent Capacity	+
+	40	0.20	33910	0.78	23.0	3.9	0.6	none	0	Insufficent Capacity	+
+	41	0.20	0	0.00	-		0.0	none	0	Adequate Capacity	+
+	42	0.20	486163	11.16	23.0	3.9	8.7	12" cmp	5	Insufficent Capacity	+
+	43	0.20	1276026	29.29	29.5	3.4	19.9	12" cmp	5	Insufficent Capacity	+
+	44	0.20	70215	1.61	5.0	7.1	2.3	none	0	Insufficent Capacity	+
+	45	0.20	712287	16.35	29.5	3.4	11.1	12" rcp	5	Insufficent Capacity	+
+	46	0.30	194183	4.46	5.0	7.1	9.5	12" rcp	5	Insufficent Capacity	+
+	47	0.20	641554	14.73	25.0	3.7	10.9	24" rcp	13	Adequate Capacity	+
+	48	0.20	8273071	189.92	48.5	2.4	91.2	24" rcp	13	Insufficent Capacity	+
+	49	0.10	31716938	728.12	82.0	2.0	145.6	10'wx3'h	160	Adequate Capacity	+
+	50	0.20	2618341	60.11	40.5	2.8	33.7	24" rcp	13	Insufficent Capacity	+
+	51	0.30	451608	10.37	25.0	3.7	11.5	15" cmp	7	Insufficent Capacity	+
+	52	0.30	105999	2.43	5.0	7.1	5.2	15" rcp	7	Adequate Capacity	+
+	53	0.20	531516	12.20	31.0	3.2	7.8	none	0	Insufficent Capacity	+
+	54	0.20	206262	4.74	31.0	3.2	3.0	none	0	Insufficent Capacity	+
+	55	0.20	331373	7.61	31.0	3.2	4.9	15" rcp	7	Adequate Capacity	+
+	56	0.20	711547	16.33	32.5	3.2	10.5	15" cmp	7	Insufficent Capacity	+
+	57	0.20	1199209	27.53	37.5	2.9	16.0	18" cmp	9	Insufficent Capacity	+
+	58	0.30	1458363	33.48	5.0	7.1	71.3	8" pvc	1	Insufficent Capacity	+
+	59	0.20	120872	2.77	21.5	4.0	2.2	18" rcp	9	Adequate Capacity	+

	60	0.30	228663	5.25	5.0	7.1	11.2	15" cmp	7	Insufficent Capacity
	61	0.30	769004	17.65	29.5	3.4	18.0	15" rcp	7	Insufficent Capacity
	62	0.20	919290	21.10	29.5	3.4	14.4	12" cmp	5	Insufficent Capacity
	63	0.20	586121	13.46	29.5	3.4	9.1	15" rcp	7	Insufficent Capacity
	64	0.20	210075	4.82	29.5	3.4	3.3	18" rcp	9	Adequate Capacity
	65	0.20	169655	3.89	29.5	3.4	2.6	12" rcp	5	Adequate Capacity
	66	0.20	213710	4.91	29.5	3.4	3.3	20" rcp	16	Adequate Capacity
	67	0.20	287309	6.60	29.5	3.4	4.5	12" cmp	5	Adequate Capacity
	68	0.20	363234	8.34	29.5	3.4	5.7	24" rcp	13	Adequate Capacity
	69	0.20	249802	5.73	29.5	3.4	3.9	15" rcp	7	Adequate Capacity
	70	0.20	1417000	32.53	29.5	3.4	22.1	11"hx18"w cmp	3	Insufficent Capacity
	71	0.20	1260170	28.93	20.5	4.1	23.7	15" cmp	7	Insufficent Capacity
	72	0.30	212110	4.87	5.0	7.1	10.4	12" cmp	5	Insufficent Capacity
	73	0.30	578375	13.28	24.0	3.8	15.1	15" cmp	7	Insufficent Capacity
	74	0.20	1829648	42.00	29.5	3.4	28.6	15" cmp	7	Insufficent Capacity
	75	0.20	1587737	36.45	29.5	3.4	24.8	12"hx30"w cmp	11	Insufficent Capacity
	76	0.30	284209	6.52	26.0	3.6	7.0	12" cmp	5	Insufficent Capacity
	77	0.30	483189	11.09	26.0	3.6	12.0	18" cmp	9	Insufficent Capacity
	78 & 79	0.30	582978	13.38	26.0	3.6	14.5	15" cmp	7	Insufficent Capacity
	80	0.30	661907	15.20	26.0	3.6	16.4	24" ADS pipe	14	Insufficent Capacity
	81	0.30	359234	8.25	26.0	3.6	8.9	12" cmp	5	Insufficent Capacity
	82	0.20	1917619	44.02	29.5	3.4	29.9	24" cmp	13	Insufficent Capacity
	83	0.30	78340	1.80	5.0	7.1	3.8	leak off	4	Adequate Capacity
	84	0.30	24802	0.57	5.0	7.1	1.2	6" pvc	2	Adequate Capacity
	85	0.30	103260	2.37	5.0	7.1	5.0	12" cmp	5	Insufficent Capacity
	86	0.30	167442	3.84	5.0	7.1	8.2	12" cmp	5	Insufficent Capacity

NOTES :
a) C=0.3 for Residential Land Uses, C=0.2 For Woods and Residential Land Uses.
b) Tc = T1 +T2, T1 from Seelye Chart, T2 from Kirpich Chart.
c) Assumes inlet control with max. allowable headwater of 2 ft., unless not feasible.
d) Assumes pipe clear of sidiment and debris.
e) Adequacy of capacity based on a 25 yr. rainfall event.
as required by Town ofr Winchester regulations.
f) Drainage areas approximated from U.S.G.S. map at a scale of 1"=2000'.

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Appendix III

Miscellaneous Information
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