WILLAND POND ENGINEERING REVIEW: SUMMARY OF WATERSHED ASSESSMENT AND ALTERNATIVES ANALYSIS

FINAL REPORT

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1.0 INTRODUCTION

1.1 Project Background

1.1.1 Watershed Description

Willand Pond is a natural, spring-fed kettle pond located in southwestern Somersworth, NH, and northeastern Dover, NH (Bradley, 1964). Tucked between High Street (NH Route 9) in Somersworth and NH Route 108 (New Rochester Road) in Dover, the Pond is located in the (Middle) Salmon Falls watershed, has a drainage area of approximately 330 acres, and a surface area of approximately 80 acres.

The watershed was used as a public drinking water source by the City of Dover dating back from at least 1876 until 1966. It has served as a public recreational area since the 1890s when it was the site of a Victorian-style park. The pond's historical use as a water supply and recreational destination protected it from significant commercial development pressure until the 1980s when the area of Dover immediately to its south was aggressively developed and locally referred to as the "Miracle Mile." Development pressure increased steadily since the early 1990s when the Weeks' Traffic Circle (the intersection of Central Avenue, Dover and High Street, Somersworth) was reconfigured, permitting easy access onto the Spaulding Turnpike (NH Route 16) and promoting increased commercial development, especially along High Street in Somersworth. (The area of the watershed within Dover city limits was at or near build-out in the late 1980s and therefore ahs not seen as much recent development as watershed areas within the city limits of Somersworth.)

Geologically, the watershed is located within a kame plain – an area of moderate-to-thick (50-75 ft) glacial ice-contact deposits of sand and gravel. The kame plain underlies much of Somersworth and extends into Dover and Rollinsford (Bradley, 1964). Because of the high permeability of these deposits, ice-contact terrain such as the Willand Pond watershed are generally capable of yielding large amounts of water and transmitting it rapidly. It is not surprising then that high yielding water supply wells within this deposit, and springs along its periphery historically supplied much of the drinking water to the cities of Somersworth and Dover. The Willand Pond watershed was tapped for as much as 700,000 gpd to 1Mgd from surface and groundwater sources until 1966 (Bradley, 1964). Surface water in the Pond is recharged through groundwater inflow (springs), precipitation and stormwater discharges; the Pond "discharges water" via subsurface (groundwater) discharge to the adjacent wetlands and evapotranspiration. Use of the Pond as a primary water supply well was halted in the mid-1960s due to naturally-occurring elevated iron and manganese concentrations; however, anecdotal reports indicate that concerns of summertime algal blooms prevented surface water from the Pond being used as a water supply during July and August (Bisson, 1979). A review of Willand Pond surface water elevation data over tune shows the Pond level increased significantly from 1967 to 1976, the trend plateaued until circa 2002, when, in addition to the cessation of pumping for water supply purposes, during the period 2006-2008 southern New Hampshire witnessed record-breaking precipitation amounts. This led to elevated surface water elevations and flooding, especially following the so-called Mother's Day Storm of 2006. The elevated surface water elevations have been sustained for a period of over three years. In mid-May 2009, the elevation of the Pond was 192.6 ft NGVD, only 0.5 ft lower than the highest elevation observed in May 2007 (193.1 ft NGVD). A graph comparing Willand Pond elevation data with precipitation values over time is included as **Appendix B-4**.

Because the watershed is relatively small, it is particularly sensitive to natural and anthropogenic water quality impacts and recharge/discharge fluctuations. Typical of kettle ponds, the east, south and western shorelines of Willand Pond are steep. Fluctuations in surface water elevations over the past 75 years are documented in shoreline changes depicted on aerial photographs, historical topographic maps, and anecdotal reports. Because the Pond is constrained by the steep slopes on the other shorelines, during periods of high water the Pond expands along its northern reach, discharging into a wetland area which stretches approximately 0.3 miles northward along a relatively broad, shallow valley. Various references document the Pond acreage as varying between 66 and 86 acres – this storage variation is a reflection of the Pond adjusting to changes in recharge and discharges. In addition to the commercial and residential development pressures along High Street and Route 108, the discharge area north of the site has also been subjected to development pressures: land-clearing, gravel extraction, road-building, and drainage diversion were conducted in the area since the 1960s by the private landowner; aerial photographs suggest that drainage alteration in this area may have reversed natural surface water flows during periods of low water, allowing the wetlands to discharge *back into Willand Pond* **(Appendix B-2G)**. Additionally, a water main utility was installed in 1971 by the City of Somersworth which intersects the southern portion of this discharge area and a sewer utility was constructed by the property owner Mr. Stackpole in the mid-1990s. This sewer main intersects the northern portion of the discharge area. Currently, the completion of Commercial Drive, a roadway connecting Willand Drive (near Stackpole Pond) in Somersworth with High Street near Home Depot in Somersworth, is underway by the private landowner. A gravel road has existed as in the area of Commercial Drive roadway since the installation of a water service from Willand Drive to Home Depot circa 2003 by Mr. Stackpole.

Despite its location between two busy travel corridors and on-going development pressure, the Pond continues to provide the Dover and Somersworth communities with a local, recreational sanctuary and a valued natural resource. The cumulative effect of 100 years of encroachment, land clearing, and filling in the discharge outlet, compounded with cessation of water withdrawals and three consecutive years of record-breaking precipitation (2006-2008) have contributed to sustained elevated surface water levels, flooding, property damage, and water quality degradation resulting in restricted recreational use of Willand Pond and surrounding trails. Various references document the Pond acreage as varying between 66 and 86 acres – this storage variation is a reflection of the Pond adjusting to changes in recharge and discharges.

1.1.2 Problem Description

Willand Pond is listed as a Class A water body – suitable for use as a public drinking water supply. It has carried this designation since its historic use as a public water supply circa 1870s to 1966, and its status as a "backup water supply" until the late 1970s. The Pond was listed as impaired on the DES 2006 305(b)/303(d) Surface Water Quality Assessment for the following: The Pond does not meet the DES Surface Water Quality Standard, Env-Ws 1703.01 Water Use Classification, (c) "All surface waters shall provide, whenever attainable, for the protection and propagation of fish, shellfish and wildlife, and for recreation in and on the surface waters" and (d) "Unless the flows are caused by naturally occurring conditions, surface water quantity shall be maintained at levels adequate to protect existing and designated uses." The designated Aquatic Life and Primary Contact Recreation Uses are not being met. The record-breaking precipitation in 2006 caused flooding of the shoreline which compounded water quality degradation from urban stormwater. The water quality impairments are likely caused by a combination of conditions that include: (1) stormwater from developed areas of the watershed discharging nutrients to the Pond, and (2) water levels in Willand Pond becoming chronically too high, resulting in flooding of the surrounding lands, supplying additional nutrients into the water body and feeding naturally occurring flora. Water quality degradation of the Pond culminated with a large cyanobacteria bloom that in the summer of 2007. The pond was posted and closed for recreational purposes from mid-July until the fall of 2007. Historically, the adjacent wetland area has been a crucial factor in the Pond's ability to balance its water budget (through floodflow alteration and storage). However, the man-made alterations to the discharge area described above, and the increased recharge from precipitation and stormwater inputs (watershed development) has overwhelmed the system's ability to equilibrate itself. The sustained surface water elevations in the Pond since 2006 suggest that this condition will not correct itself in the short term on its own. To improve water quality, actions are necessary to reduce both nutrient sources and surface water elevation.

1.1.3 Project Description

The goals of this project have been to review and assess the natural and anthropogenic factors causing flooding and water quality issues at Willand Pond. The Project Team has consisted of S. W. Cole Engineering, Inc. (SW Cole) and Horsley Witten Group, Inc. (HW) working with information from and the support of the cities of Dover and Somersworth. The Team assessed historical and current hydrologic and land use conditions in order to understand the hydrology of the Willand Pond watershed and identified viable solutions to mitigate impacts, which serve as the basis for a watershed management plan currently being developed. Additionally, the project team was asked to assess whether the causes of basement flooding reported in neighborhoods west of Willand Pond were related to the issues at Willand Pond.

2.0 HISTORICAL ANALYSIS OF WILLAND POND WATERSHED

2.1 General Overview of Watershed from 1875 to 1940

2.1.1 Water Supply

The Willand Pond watershed has served as a public recreational destination and public water supply since the late 1800s. In the mid-1800s, Hussey Springs, located just south/southeast of the Pond, was used as a water supply serving the northern portion of Dover. Hussey Springs is a geological phenomena sometimes referred to as a contact spring, created by the interception of the highly productive kame deposit with impermeable silty clay from the marine incursion. These silty clays formed a broad wetland which stretched southward to Garrison Hill. The springs reportedly flowed at a rate of 500 gallons per minute (Bradley, 1964). To increase water volume, an aqueduct was constructed from Willand Pond to the area of the springs in 1876 by the Cochecho Aqueduct Association (later part of the Dover Water Department). Use of the springs as a water supply was halted due to high iron concentrations. The dates of use of the spring are vague, however, the 1928 Annual Report of Dover Water Commissioners indicates that maintenance work at the springs during that year had increased discharge volumes there, suggesting the springs were in use from the mid to late 1800s until at least around 1930. A City of Dover pump house was constructed at the southern end of the Pond (behind the current day Indian Brook Commons) at about the turn of the 20th Century. Surface water from the Pond is believed to have been used until about 1954 when a groundwater supply well was installed on the northwest shore of the Pond, near the current boat launch area.

2.1.2 Recreational Destination

In the 1890s the eastern shore was occupied by a Victorian-style park; shortly after the turn of the Century, a horse track ("Granite State Trotting Park") was developed near the northwestern shoreline and a subdivision of seasonal camps known as Lake View Park (now year-round homes) was developed along the western shoreline of the Pond.

The park was first known as Burgett Park, named after the agent for the electrical trolley car company which was the primary mode of transport to and from the park. The park, which attracted visitors from throughout the region, featured a grand Victorian-style pavilion with a dance hall, a broad veranda overlooking the Pond, and a restaurant/banquet hall. Later renamed Central Park, its amenities included walking trails, row boats and a "steamer" touring boat, tennis courts, a bandstand for public concerts, a popular baseball field where Babe Ruth is rumored to have played, and an amphitheater for plays and performances (Bisson, 1979). The burgeoning automobile was blamed for the Park's demise in the mid-1920s. The trolley depot building, located on High Street in Somersworth adjacent to the entrance to walking trails along the Pond, is all that remains of the former park.

In the late 1970s, the Willand Pond District Commission was created as a Commission representing both cities to "provide for the long term conservation of the area as a natural area, to protect the existing rights and interests of both communities in the use of Willand Pond, and to provide for the passive recreation use of the Willand Pond area by the citizens of Dover and Somersworth." Various ideas generated as a result of the interest in the Pond included creating a community-based, multi-generational recreational center and a State park (Bisson, 1979).

Despite the fact that a formal municipal or State park never came to fruition, Willand Pond has continued to provide the communities with a local, recreational sanctuary in the midst of the two busy travel corridors. A State boat launch was constructed in Dover in 1996 providing access to non-motorized boats. The pond has been stocked yearly with rainbow trout by the New Hampshire Fish and Department since 2001. A walking trail from the boat launch around the north shore of the Pond was constructed by the Somersworth DPW in 2001. Footbridges which crossed the wetland on the north side of the Pond were washed out when the Pond flooded in 2007.

2.2 General Overview of Watershed from 1940 to 1995

Aerial photographs dating to 1940 were the primary source of information used to evaluate the evolution of development in the watershed and land use changes in the drainage outlet area, and to assess the resulting effects on Willand Pond. **Appendix B-6** presents a photographic continuum from 1940 to 2007, which was the basis of our assessment.

1940 – Land use in the area was primarily agricultural. Central Park on the eastern shore was closed, and Lake View Park on the western shore was sparsely developed. Land south of the Pond and northeast of the Pond was cleared, and large tracts east of High Street were cleared; however, the outlet area was densely wooded. The 1941 USGS topographic map illustrates the Pond at elevation 184 ft msl (comparable to NGVD) and depicts wetlands in the outlet area; Peters Marsh Brook is identified further to the north. The 1940 aerial photograph depicts the Pond at a lower elevation than seen in recent years, as indicated by the non-vegetated shoreline visible on the photo. The Dover Water Department pump house is visible on the southern shoreline. The 1941 topographic map depicts a gravel roadway or trail in the area north of the Pond, near the current-day Commercial Drive; however, this is not visible on the aerial photo, see **Appendix B-2**.

1951 – Little change in land use is apparent in this photo. The gravel road at the north end of the watershed depicted in the 1940 topographic map is visible. Land clearing and road building is apparent south of the Pond, in the area of Hussey Springs. Track activities to the northwest of the Pond have increased, with the addition of roadways, and some land clearing is visible west of High Street opposite the track. Land clearing northwest of the track is also apparent. The Pond level appears to be higher than in 1940, as the shoreline is mostly vegetated.

1953 –A northwest/southeast trending transect is apparent at the northern extreme of the watershed. The land clearing northwest of the track is clearly a lot of automobiles (reported to be a former auto salvage yard which since been vacated).. A small man-made pond is depicted in the northeast portion of the track. Reforestation to the west of Route 108 is apparent. An orchard is visible in a formerly cleared field (current Target property) on the eastern side of the watershed, and the roadway for the Midway Park residential neighborhood has been constructed.

1956 – The USGS topographic map depicts the surface water elevation in Willand Pond at 182 ft msl. The channel of Peters Marsh Brook is shown to connect to the northern shore of Willand Pond. Homes have been constructed along Midway Park. Kelwyn Park has been developed opposite High Street, south of the Pond, and the Weeks' Traffic Circle has been constructed.

Although not indicated on the topographic map, records indicate that a public drinking water supply well has been drilled into sand and gravel on the northwest shore of the Pond and a pump house constructed. The well is reported to be capable of yielding 350-400 gpm (approximately 0.5Mgd).

Surface water from the Pond is believed to have been used as a drinking water supply until about 1954 when a groundwater supply well was installed on the northwest shore of the Pond, near the current boat launch area. The combined groundwater and surface water use from the watershed ranged from 700,000 to 1Mgd during winter months. Reportedly, surface water from the Pond was not used during summer months due to the presence of algae. (Bisson, 1976; Bradley 1964).

1962 – Surface water levels in Willand Pond are markedly lower than in 1953, and appear lower than 1940 (when the Pond was mapped at 182 ft msl). The westernmost cove of the Pond is nearly isolated from the rest of the water body by the promontory which projects from the southern shoreline. The Dover Water Department pump house is visible on the northwestern shore of the Willand Pond. The forested wetland north of the Pond appears to have been thinned, and significant land clearing/gravel mining has been conducted in the area of Stackpole Pond, which is a dry bed in the photo. A gravel roadway is apparent from High Street to Stackpole Pond. The land south of this roadway (current Home Depot) has been cleared and apparently mined for gravel. A small kettle pond is apparent to the northwest of Midway Park. Three other small, interconnected surface water bodies are visible east of Stackpole Pond, near High Street. The southernmost of the ponds appears man-made. Commercial development south of the Pond (current Indian Brook Commons) is apparent.

1970 – This is a large-format aerial photograph dated April 1970 obtained from the City of Somersworth. It focuses on the northern shoreline of Willand Pond and the northern portion of the watershed. In the photo, Stackpole Pond is water-bearing. A gravel roadway has been constructed along the esker deposit, which is visible for the first time. The gravel roadway segments the northern part of the wetland. Gravel from the esker has been moved southeastward to extend the roadway from the toe of the esker into the wetland. Narrow channels are apparent along the eastern edge of the wetland and near the 'toe' of the esker/center of the wetland. The eastern channel reaches to the Pond. The western channel is clearly man-made; the western channel may have been man-made or may have been enhanced. The configuration of the channels indicates that the purpose of the channels was to direct water from the wetland to Willand Pond. The early to mid 1960s were marked by drought conditions; however, precipitation normalized at the end of the decade and the surface water elevation in Willand Pond was observed to rebound in the photo compared with the 1962 photo.

1973 – A channel connects Stackpole Pond to Peters Marsh Brook. The area between Stackpole Pond and High Street has been essentially cleared. An inlet channel on the southwest shore of Stackpole Pond is visible; the area north and west of this channel has been deforested. An east-west trending transect indicates the location of a City of Somersworth water main intersecting the outlet area. With the exception of the construction of Tri-City Plaza on the east side of High street, the eastern shoreline is not significantly altered. However, increased development of residential properties on the western shore (Lake View Park and Old Rochester Road areas) is significant. The track appears disused; an apartment complex has been constructed on Route

108, between Willand Pond and the track. The surface water elevation of Willand Pond appears to have rebounded, as the shoreline is completely vegetated.

1976 – A 2-ft contour topographic map prepared by J.W. Sewall based on 1976 ground-controlled aerial photography depicts the man-made channels visible in the 1970 aerial photo. The Willand Pond elevation is mapped between 188 and 190 ft msl. This plan was used as the base map for a 1979 Master Plan Study for a recreational area at Willand Pond, and as the base map for a 1990 proposed golf course. According to J.W. Sewall, the methods used to map topography are accurate to +/- 1 ft.

1981 – Reforestation of much of the wetland complex is apparent. A gravel road leads from the southern shore of Stackpole Pond southwestward to the water utility near the former track. Another gravel roadway is visible from the north shore of Stackpole Pond trending due west; this roadway approximates the current-day Willand Drive. Additional land clearing and development is visible east of the apartment complex and north of the Dover Water Department pump house. Pond level appears lower than in 1973 as a narrow, unvegetated strip is visible along the north/northwestern shoreline.

1987 – Little change is apparent on this photograph, which does not depict the northern part of the wetlands or the Stackpole Pond area. Surface water elevations appear to have risen as encroachment of the surface water northward into the wetlands is indicated. A small area of land clearing northwest of the Pond, between the race track and the water main is apparent.

1993 – The USGS photo-enhanced topographic map depicts a network of gravel roads north and northwest of Willand Pond. These gravel roads or trails correspond with the water main and gravel roads observed on aerial photographs. The Willand Pond outlet stream has been modified to re-route it through Stackpole Pond before discharging to Peters Marsh Brook. The kettle ponds identified in the 1962 aerial photo have been added.

Land clearing, road building, land-filling and drainage alteration in the Willand Pond outlet area was conducted primarily in the 1960s through the early 1980s. The historic fluctuation of Pond level and anecdotal reports of algae which pre-date significant commercial development or alteration in the discharge area suggest that the Pond is intrinsically sensitive to changes in precipitation and anthropogenic influences. Because of its use by the City of Dover as a water supply, much of the immediate shoreline of the Pond was conserved as a water supply protection zone, and therefore, was protected from development.

2.3 Historical Timeline from 1995 to 2008

Aerial photography coverage of the watershed area during the period 1981 through 1998 was not found.

1998 – The State boat launch has been constructed off Route 108, at the western-most point of the Willand Pond shoreline. The unused track is slowly being reclaimed by natural processes. Willand Drive has been constructed at the northern end of the watershed, stretching from Route 108 to Stackpole Pond. A gravel roadway (and presumed subsurface sewer utility) stretches from Stackpole Pond east toward High Street. The (former Mobil) gasoline station has been constructed on the eastern shore of Willand Pond, opposite Tri-City Plaza, adding a direct stormwater discharge to the Pond. Weeks' Traffic Circle has been reconfigured, widening High Street and Central Avenue in this area. The Willand Pond surface water elevation appears to be consistent with the vegetated shoreline. Wal-Mart has been constructed on the east side of High Street. Stormwater at Wal-Mart drains to a detention pond which discharges to wetlands further east, not in the Willand Pond watershed.

2001 – Development of Indian Brook Commons plaza at the southern extent of the watershed, adding significant impervious surface and stormwater discharge on the southern shore of Willand Pond. A water utility line extending from the northeast corner of Stackpole Pond under the (soon-to-be completed 2009) Commercial Drive was also constructed. The water utility segmented the wetland north of the existing Home Depot detention Pond.

2004 – The construction of Home Depot and its stormwater detention pond was completed. The Home Depot detention pond drains to a wetland to the north and is not located within the Willand Pond watershed. The drainage outlet from the detention pond is constrained; the detention pond does not drain as designed.

2007 – The Target Department store and stormwater constructed wetland are constructed in 2006. A watershed assessment in 2006 by NH DES designates Willand Pond as "impaired." Record-breaking precipitation result in flooding in May 2006 and sustained water levels through 2007. The highest recorded Pond elevation (193.1 ft msl) measured in May 2007. In July 2007, a cyanobacteria bloom forces the closure of Willand Pond for recreational uses until Autumn 2007.

2008 – A UNH study of nutrient loading at Willand Pond finds high phosphorus and nitrate concentrations at stormwater outfalls in Dover and Somersworth. Dover receives a DES grant to assess the watershed and develop alternatives to mitigate the flooding and nutrient loading issues of the Pond. Mr. Stackpole initiates construction of Commercial Drive along the northern portion of the watershed. Dover reconstructs stormwater system in the area of State boat launch on Route 108. Appendix B-5 is a hard comparing documented Willand Pond surface water elevations and the percentage of the watershed covered by impervious surfaces, over time. The chart illustrates a direct relationship between increased surface water elevations and increased impervious areas within the watershed.

Basement Flooding
Residents who live in the Strafford Road/Wellington Avenue, Cranbrook/Maplewood Avenue and so-called "Indian Village" (Apache Street area) neighborhoods of Dover, west of Willand Pond, were impacted by flooded basements in Spring of 2007. According to residents, basement flooding corresponded with high water levels in Willand Pond, and they are distressed and concerned that the elevated water levels in the Pond are contributing to their problems. According to the City of Somersworth, the Indian Village neighborhood is constructed on filled wetlands.

As noted previously, Willand Pond is a kettle pond formed in the wide kame plain which underlies much of Somersworth and extends into Dover and Rollinsford. The kame plain is a highly permeable ice-contact deposit of sand, gravel and boulders. The Willand Pond watershed lies at the southern end of the kame terrace; Willand Pond itself lies in the southern end of the (Middle) Salmon Falls watershed. Watershed divides roughly coincide with Route 108 and Route 9, see Appendix B-2. As its name suggests, a watershed divide marks the location where groundwater moves in opposite directions. Groundwater within the Willand Pond watershed moves toward the Pond and then northward toward Peters Marsh Brook; groundwater west of the divide moves south and westward toward the Cocheco River, and groundwater east of the divide moves south and eastward toward Rollins Brook (USGS, 1992).

The water level at Willand Pond was surveyed in July 2007 by the City of Somersworth. To assess conditions in residents' homes, the water level in the basement sump of a Strafford Road residence was also surveyed at that time and found to be 2 feet *higher* than the surface water in the Pond. All of these neighborhoods are located within the Cochecho River watershed. Water in the basement of an Indian Village residence was found to be 6 feet *higher* than the surface water in Willand Pond. The presence of the groundwater divide along Route 108, confirmed by the 2007 survey data indicates that the groundwater discharging to Willand Pond is not the cause of water in basements on the other side of the divide.

Nevertheless, homeowners are concerned about the potential for future flooding, and the value of their property. We plotted historic annual precipitation values for southern New Hampshire and documented surface water elevations at Willand Pond, see **Appendix B-4**[1]. In addition, the Team also plotted Willand Pond water surface elevations over time against historical impervious surface data (determined using the method described in **Section 3-2**) in **Appendix B-5.** A review of these plots reveals that surface water levels at Willand Pond are near record highs. As Willand Pond is a kettle pond, the surface water level is reflective of groundwater levels. The watersheds are in the same aquifer, therefore, the natural geology of the two watersheds is similar. However, groundwater flows in opposite directions. It can be expected that groundwater levels in the adjacent watersheds will behave similarly to those reflected in Willand Pond.

2.4 Evaluation of the Peters Marsh Brook Wetland Complex

Adjacent land development (increased stormwater discharges due to changes in impervious surface, decreased evapotranspiration due to land clearing, road construction or repair, addition or changes to drainage culverts, etc.) as well as wetland alterations (filling or creation for mitigation) directly and indirectly alter the hydrologic balance of a watershed, manifesting in gradual or abrupt changes to the shape, connectivity, plant community, and hydrologic capacity of a wetland. Historic maps and aerial photographs, as well as historic development timeline, guided our evaluation of the wetland complex to highlight areas of change in the wetland complex which serves as the drainage outlet of Willand Pond.

[1] We relied on engineered plans, reports and topographic maps for the data compiled, see data table included in Appendix B-4.

The Team reviewed current and historic topographic maps, aerial photographs, NWI wetlands mapping, and NRCS soil mapping data to evaluate and analyze the evolution of land use changes in the wetland complex on the north shore of Willand Pond. Historic topographic maps indicated a channelized outlet connecting Willand Pond to Peters Marsh Brook, located north of Commercial Drive. However, field reconnaissance and detailed review of historical aerial photographs did not confirm the presence of a natural outlet. Rather, groundwater discharge from the Pond to this wetland area appears to have been the primary outlet for the Pond. Regardless, due to historical references, and the ultimate discharge at Peters Marsh Brook to the north, the wetland complex in the outlet area is referred to in this report as the "Peters Marsh Brook wetland complex."

2.5 Watershed and Wetlands Map

The Team constructed a working watershed base map using available topographic and NWI wetlands mapping, aerial photographs, and stormwater infrastructure mapping from the cities of Dover and Somersworth. A field reconnaissance was performed on October 10, 2008 during which the Team (civil engineers, wetland/soil scientists, and hydrogeologist) toured the watershed to observe the topographic, hydrologic, geologic, and wetlands features of the area. Field-derived data was used to revise the working base map.

The Team's NH-certified wetland scientists assessed and delineated the wetlands in the Willand Pond watershed during the October field reconnaissance. The civil engineering component of the Team verified the watershed boundary inspecting the areas depicted on the working base map boundary and by identifying and verifying stormwater management structures in the field. The Watershed and Wetlands Map for the Willand Pond watershed is included in **Appendix B-1**.

The Peters Marsh Brook wetland complex is dominated by a forested wetland complex, with smaller areas of scrub-shrub wetland adjacent to Willand Pond. The wetland is classified, under the Cowardin, et al. (1979) classification system, as a palustrine, forested, broad-leaved deciduous wetland with portions of palustrine, scrub-shrub, broad-leaved deciduous wetland. The deciduous forested wetland is dominated by red maple (*Acer rubrum*) with occasional eastern white pine (*Pinus strobus*) and highbush blueberry (*Vaccinium corymbosum*), alder (*Alnus* spp.), glossy buckthorn (*Rhamnus frangula*), and some winterberry (*Ilex verticillata*) in the shrub stratum, and tussock sedge (*Carex stricta*), sphagnum moss (*Sphagnum* spp.), and cinnamon fern (*Osmunda cinnamomea*) in the herbaceous stratum. The soils in the forested portion of the wetland are generally deep, organic soils, with lesser amounts of loamy sand-textured mineral soils that have a thick organic surface. Both soil types observed were saturated to the surface. The scrub-shrub wetland is dominated by red maple and winterberry, with lesser amounts of highbush blueberry, chokeberry (*Aronia* spp.) and glossy buckthorn. Species observed in the herbaceous stratum included royal fern (*Osmunda regalis*), St. John's wort (*Triadenum virginicum*), and beggar's ticks (*Bidens frondosa*) as well as clumps of sphagnum moss. The soils in the scrub-shrub portion of the wetland are deep, organic soils with 6 to 12 inches of ponded water on the surface.

Based on information obtained from the historical topographic maps, the Team attempted to find evidence of a historical/residual outlet channel during our field reconnaissance. Historical USGS topographic maps (dated 1893, 1956, and 1993) indicate that a stream, flowing north, drained Willand Pond. Earlier USGS topographic maps dated 1916, 1918, and 1941 depicted the outlet as wetlands; Peters Marsh Brook was depicted further north, see **Appendix B-2**. Aerial photographs dated 1940, 1951, 1953, 1962, 1973, 1974, 1981, 1998, and 2004 did not confirm the presence of a channel draining the Pond (perhaps due to the scale and foliage cover or perhaps because there was no channel to observe). However, a large-format aerial photograph dated 1970 shows man-made or -enhanced drainage channels from the wetlands in the north *back to Willand Pond.* This was at a time when pond elevations were approximately 182 ft above mean sea level (msl) and the wetlands would have been at a higher elevation. The presence of these channels is also visible in low elevation photographs taken of the Willand Pond shoreline in the winter of 1978-1979. Aerial photographs are included in **Appendix B-3**. See **Appendix B-6** for a photographic presentation of the evolution of the shoreline over time.

We found a deep channel within the scrub-shrub wetland south of the esker, which may be a residual stream channel. There were no indications of flowing water (scoured mineral bottom) in this area.

In this same area, several older, dead white pines were observed; these trees serve as an indicator of changing hydrology and drier conditions in this location in the past. These observations are consistent with a stream that may have drained Willand Pond, prior to the rising water levels seen in recent years.

The Team observed the hydrologic connection between Willand Pond and the Peters Marsh Brook wetland complex. A walking trail and the City of Somersworth water line intercept the outlet area and may have interrupted flow between the Pond and the wetland. The scrub-shrub portions of the wetland complex, which are adjacent to the Pond, provide subsurface hydrologic connectivity.

In addition to the wetland assessment, the Team identified and located stormwater management structures in the Willand Pond watershed. The Team first reviewed existing stormwater infrastructure mapping available from the Cities of Dover and Somersworth and then verified the structures in the field. Five existing stormwater management practices were identified: the Target constructed wetland, two infiltration basins behind the DollarTree/Seacoast Bingo, the dry extended detention basin/underground storage for Indian Brook Commons, and the water quality unit installed at the outfall from NH Route 108 (State boat launch area) at the western edge of the Pond. These structures are identified on the Watershed and Wetlands Map for the Willand Pond watershed included in **Appendix B-1**.

3.0 WATERSHED ANALYSES

3.1 Hydrologic Regime Evaluation

A field reconnaissance was performed on October 10, 2008 during which the Team toured the watershed to observe the topographic, hydrologic, geologic, and wetlands features of the area. In general, the wetlands complex which serves as the discharge outlet for Willand Pond has been hydrologically segmented and isolated through a variety of private and public projects. The segmentation inhibits the natural flow from Willand Pond to Peters Marsh Brook and ultimately the Salmon Falls River. Our findings are summarized below and illustrated on the Watershed Map included as **Appendix B-1**.

Stackpole Pond: The inlet and outlet to Stackpole Pond were observed. The inlet is a narrow, man-made drainage which extends from a gravel road to the western shore of Stackpole Pond. The outlet is also man-made, connecting the eastern shore of Stackpole with Peters Marsh Brook. The outlet flows through two 24-inch culverts beneath Commercial Drive. A beaver dam was observed at the pond outlet, keeping the pond elevation (surveyed at 191 ft by the Team in October 2008) approximately 3.5 feet higher than the outlet invert (187.5 ft, Tritech Engineering). Additional beaver dams have since been identified by the City of Somersworth downstream of this area.

Commercial Drive Water Line: A water line was installed in 2001 by the private landowner. According to the City of Somersworth, the landowner was granted a wetlands permit for the work, which bisected the wetland area east of Stackpole Pond; a culvert was required for the road crossing, however, was not constructed. We observed evidence of ponding water and minor erosion of the gravel road crossing, indicating that the non-culverted road created a minor dam of water flow from the wetland. The completion of Commercial Drive to municipal standards is currently underway. The culvert in this area will have inverts lower than the existing gravel, which is expected to mitigate this issue.

Commercial Drive Sewer Line: A gravel roadway extending from High Street to Stackpole Pond was constructed circa 1960. In the mid-1990s, a sewer utility was constructed (by the private landowner, Mr. Stackpole) along the roadway from High Street, along the southern property of the current Home Depot to the eastern shore of Stackpole Pond, connecting to Willand Drive. The roadway is elevated between the rear of Home Depot and Stackpole Pond. The invert of the sewer line is approximately 192 ft msl. The elevation of surface water in the adjacent (upgradient) wetland surveyed by the Team was 193.5 ft msl. The sewer line and elevated roadway segregate the wetland to the south from the wetland to the north, cutting off the flow of water and effectively creating a watershed divide, see **Appendix B-1**.

Home Depot Detention Pond: The stormwater management system at Home Depot flows to a detention pond adjacent to the sewer line. The detention pond is designed to drain to the north away from Willand Pond. However, the outlet of the detention pond was improperly constructed, resulting in standing water in the pond. The conditions at the detention pond may present a constant head boundary in the area, exacerbating the segmented drainage condition between the Willand Pond watershed and Peters Marsh Brook. According to the City of Somersworth, an assessment of the failed detention pond has been completed, and Home Depot is in the process of obtaining permits to correct the problem. Resolution of the issue is expected to be completed during the 2009 construction season.

Esker Roadway: An elongated sand and gravel deposit known as an esker is present along the western wetlands boundary, see **Appendix B-1**. A gravel roadway was constructed in the late 1970s which courses along the ridge of the esker, varying from about 195 ft to 212 ft in elevation. The gravel roadway extends northeasterly and southeasterly into the wetlands. The northern portion of the roadway is shallow, but nonetheless, was observed to intersect the wetland in this area of the site.

Stackpole Pond Gravel Roadway: A gravel roadway, constructed by the mid-1970s, skirts the south side of Stackpole Pond from Commercial Drive southwesterly to the former race track. The inlet to Stackpole Pond is intercepted by the roadway. During our site reconnaissance, the Team identified the area and concluded that the road creates a drainage divide for the wetland area located in the Willand Pond watershed west of the esker and the Stackpole Pond watershed.

Wetland channels: Field work was conducted during high water conditions in October 2008. No continuous stream channels within the wetland were observed during our field work, as described in **Sections 2.4 and 2.5**. Wetlands scientists reported what appeared to be a segment of a stream channel to the south of the esker; however, there were no indications of flowing water (scoured mineral bottom) in this area, and the “channel” was discontinuous, disappearing into the standing water of the wetland. Remnants what appeared to have been former channels were observed adjacent to wetlands south and west of the Home Depot detention pond. Man-made (or enhanced) channels apparently intended to direct flow from the wetland to the north shore of Willand Pond were observed in aerial photographs dated 1970 and 1979. These channels were not observed during our field reconnaissance.

1971 Water Main: A 16 inch ductile iron water pipe was constructed across the southern end of the wetland complex in 1971. City of Somersworth officials could not provide the invert of the water pipe. During our field reconnaissance, the area of the water main was visible. A review of a National Wetlands Inventory Map depicts mapped wetlands oriented on either side of the water main transect.

3.2 Impervious Surface Assessment

Impervious area was delineated in GIS based on aerial photography (New Hampshire Geographical Information System – GRANIT, 2005) and engineering plans from projects in the watershed constructed after 2005. The total impervious cover within the Willand Pond watershed has been computed to be approximately 48.3 acres within a total watershed area of approximately 326.1 acres (or approximately 15%). Included in the 326.1 acres is nearly 80 acres of the Willand Pond surface itself, and 28.1 acres of wetlands. Thus, if one calculates the impervious cover percentage of the land area contributing to the Pond and wetlands, the percentage rises to over 22%.

It is well established that the cumulative amount of impervious cover can be a robust indicator or measure of adverse impacts to aquatic and terrestrial ecosystems through various mechanisms, including the direct impact of converting natural habitat to pavement and buildings, and indirect impacts such as altering groundwater and surface water hydrology and chemistry. These hydrologic and chemical alterations facilitate the accumulation and transport of pollutants, and decrease aquatic community diversity, among other measurable effects (Calhoun and Klemens, 2002; Carter, 1996; CWP, 2003; Coles, et al., 2004; National Research Council, 2008; Schiff and Benoit, 2007; Schueler, 1987; and Skidds, et al., 2007).

A number of studies have also demonstrated adverse effects on biodiversity when impervious cover exceeds 10% of a watershed (CWP, 2003; Coles, et al., 2004). The number of different species within the watershed (species diversity) has been shown by many studies to be inversely related to the percentage of impervious cover in the watershed. The greater the percentage of impervious area, the fewer the number of species present.

Recent work by the United States Geological Survey (USGS) describes how "…studies have used the amount of impervious surface in a basin as a surrogate for urban intensity. Several studies have shown impervious surface to decrease ground-water recharge, change discharge patterns, increase stream-water temperature, and increase the delivery of contaminants to streams" (Coles, et al., 2004). The USGS study developed an "Urban Index" based on 24 variables related to infrastructure, land cover, socioeconomic factors, and population density. The Urban Index has a high degree of correlation (R2 = 0.962) with the percent of impervious surface in the watershed for 206 sites evaluated in the Boston region. Adverse effects to biological communities were significant at Urban Index threshold values of ~ 30 to 40, corresponding to watershed impervious areas ranging from ~ 10 to 25%.

In general, these results indicate that increasing urban intensity, as measured by the Urban Index, is associated with a decline in biological, physical, and chemical parameters.

The Center for Watershed Protection's (CWP) Impervious Cover Model utilizes the results of these and other research to help establish a planning framework for watershed assessment and management. Water bodies are classified into planning categories based on the amount of current and predicted future impervious cover (see **Figure 3-1**). The prospects and strategies for protection and/or restoration of a water body are usually markedly different depending on what category the resource falls within.

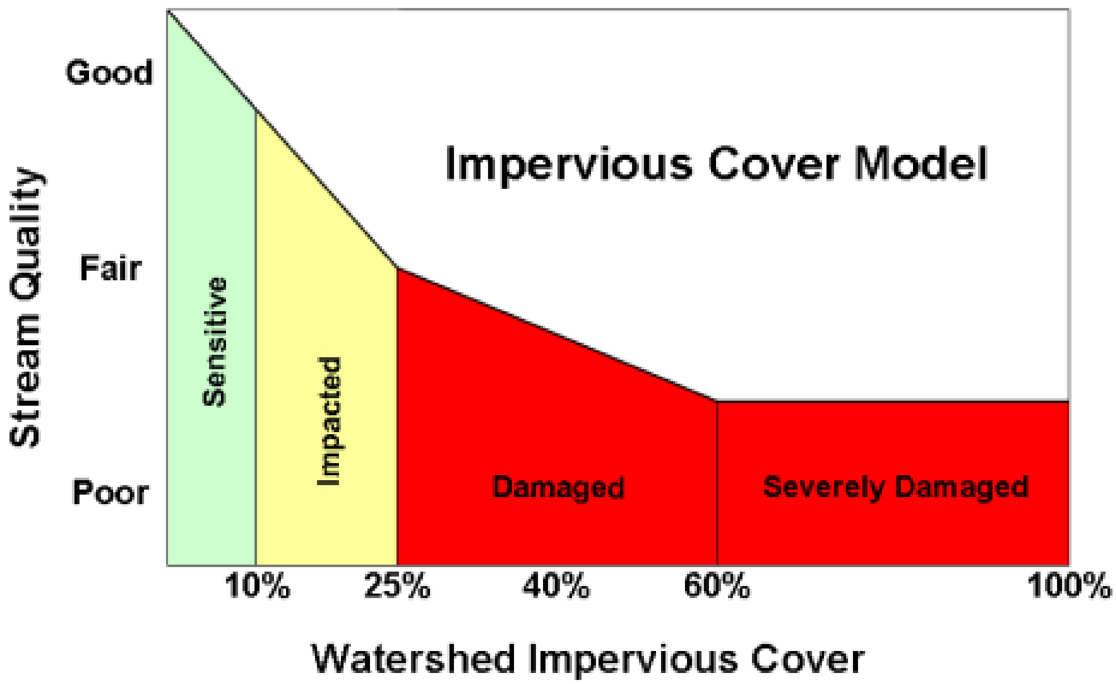


Figure 3-1: Watershed Impervious Cover Model (CWP)

In the context of Willand Pond, where the watershed itself is relatively small in comparison to the water body surface, these prior studies are useful but do not necessarily pre-determine the management level. Depending on how the impervious cover percentage is calculated, the Willand Pond watershed contains either 15 or 22% imperviousness, which puts it in the "Impacted" category. Given the recent large cyanobacteria blooms that occurred in the Summer of 2007, the classification of "Impacted" seems appropriate. As discussed in **Section 1.1.2**, the water quality impairments are likely caused by a combination of conditions that include: (1) stormwater from developed areas of the watershed discharging nutrients to the Pond, and (2) inadequate drainage from Willand Pond, primarily due to the lack of a well-defined outlet.

While the "Impacted" classification might be viewed as a negative in terms of current water resource quality, it is not so completely degraded to limit the application of management strategies and allows for a range of opportunities for restoration that, if implemented, can lead to improved conditions. Incoming pollutants from stormwater sources can be treated, in part through the implementation of stormwater retrofits (see **Section 4.0**) and the nonstructural pollution prevention strategies discussed in **Section 6.0**, and the outlet of Willand Pond could be better defined to increase the flushing potential of the Pond system (see **Section 5.0**).

3.3 Hydrologic Analysis

The Team conducted a watershed-based hydrologic analysis to quantify the amount of stormwater runoff and recharge loss as a result of the impervious surfaces in the watershed. This evaluation was performed using HydroCAD software, based on NRCS Technical Release 20. We evaluated runoff flows and volumes from various storm events, including the 2-year, 10-year, and the 100-year, 24-hour storm, as well as a storm that approximates the Patriot's Day

Storm of 2007 that contributed to the flooding conditions that year. We also compared existing conditions with estimated conditions of the natural "undeveloped" watershed, and the watershed conditions in 1995 in order to present a basic evolution of the watershed runoff characteristics.

Rainfall data for each 24-hour design storm was determined based on information from Appendix A in the New Hampshire Stormwater Management Manual, Volume II (2008), which was originally interpolated from Technical Paper No. 40. These values are as follows: 2-year, 3.0 inches; 10-year, 4.3 inches; and 100-year, 6.4 inches. Rainfall data for the April 2007 storm was determined from a USGS report (Flynn, 2008), which listed approximately 5.5 inches of rain over a 24-hour period.

3.3.1 Model Inputs

The main inputs to the HydroCAD model include the curve numbers for various areas in the watershed, as well as the time of concentration. The curve number is an empirical parameter used to estimate the runoff from different areas and is based on an area's hydrologic soil group, land cover (e.g., lawn, forest, impervious area, wetland, etc.), and hydrologic condition. The time of concentration is the longest time required for water to travel from the outer edge of a watershed to the outlet, which in this case is Willand Pond itself. The area and curve numbers in the watershed varied for the three time periods assessed. However, the time of concentration remained the same for each, given that the longest flow path in the watershed (forested area north of the Pond) has remained relatively untouched through the years. The detailed HydroCAD inputs and results are included in **Appendix C-3**.

Current Conditions (2008) **-** The total watershed draining to Willand Pond is 326.1 acres. Input values of 91.6 acres of forest, 40.1 acres of scrub land, 38.3 acres of grass cover, 28.1 acres of wetland, and 79.7 acres of pond were used. The combined curve number for this time period was calculated to be 65.

Pre-development Conditions **-** The Willand Pond watershed was assumed to be the same size as under the current conditions, but completely forested in pre-development conditions, with no impervious coverage. Input values of 217.4 acres of forest, 28.1 acres of wetland, and 79.7 acres of pond were used. The combined curve number for this time period was calculated to be 52.

1995 Conditions - The Willand Pond watershed in 1995 mainly varied from current conditions in the following ways: the Target development had not been built, nor had the Indian Brook Commons Shopping Center. In addition, the total watershed area draining to Willand Pond was only 316.2 acres. Input values of 100.6 acres of forest, 40.1 acres of scrub land, 38.3 acres of grass cover, 28.1 acres of wetland, and 79.7 acres of pond were used. The combined curve number for this time period was calculated to be 62.

3.3.2 Model Results

The HydroCAD Model was used to estimate peak flow and total runoff volume for the various storm events analyzed, as well as the percent increase over pre-development conditions. The results are summarized in **Tables 3.1** and **3.2** below. As expected, the increase in impervious area for the 1995 and current conditions results in great increases in both peak flow and runoff volume when compared to pre-development conditions. In particular, the percent increases are highest for the 2-year storm event, with existing conditions showing over 500% increase in peak flow and almost 300% increase in total runoff volume. These increases reflect the significant increase in the amount of runoff associated with the increase in impervious area and conversely the decrease in the amount of pervious area above the highly permeable soils in the watershed formerly contributed to groundwater recharge. These results correspond with the high water levels recorded in Willand Pond in recent years as the impervious area has increased.

Table 3.1 Summary of Peak Flow for Various Storm Events

	2-year Storm Event		10-year Storm Event		100-year Storm Event		April 2007 Storm	
	peak flow (cfs)	*% Increase*	*peak flow (cfs)*	*% Increase*	*peak flow (cfs)*	*% Increase*	*peak flow (cfs)*	*% Increase*
Pre-development Conditions	5.4		31.3		115		72.4	
1995 Conditions	24.4	352%	76.4	144%	195	70%	138	91%
Existing Conditions (2008)	34.8	544%	96.6	209%	228.5	99%	166.2	130%

Table 3.2 Summary of Total Runoff Volumes for Various Storm Events

	2-year Storm Event		10-year Storm Event		100-year Storm Event		April 2007 Storm	
	runoff volume (af)	*% Increase*	*runoff volume (af)*	*% Increase*	*runoff volume (af)*	*% Increase*	*runoff volume (af)*	*% Increase*
Pre-development Conditions	3.5		14.0		40.9		27.6	
1995 Conditions	10.5	200%	27.1	94%	62.4	53%	45.6	65%
Existing Conditions (2008)	13.8	294%	32.8	134%	71.9	76%	53.5	94%

3.4 Nutrient Loading Budget

The Team used the Watershed Treatment Model (Caraco, 2001, as updated), which utilizes the Simple Method (Schueler, 1987), for pollutant loading calculations to estimate the annual load from the Willand Pond watershed for three time periods - existing conditions (2008), the natural "undeveloped" watershed, and the watershed conditions in 1995. Annual loads were estimated for the primary pollutant of concern, total phosphorus (TP). The method uses loading coefficients and impervious cover estimates to calculate annual pollutant loads, and does not account for spatial distribution throughout the watershed. The Team used the New Hampshire Stormwater Manual (2008) as a reference for phosphorus loading coefficient values for various land uses. See **Appendix C-2** for the detailed spreadsheets for the nutrient loading model.

3.4.1 Model Inputs

Current Conditions (2008)

The total watershed draining to Willand Pond (but not including the Pond itself but including tributary wetlands) is 245.5 acres, with 20% impervious cover. Land use in the watershed was determined to be the following: forest (including scrub land), 131.7 acres; wetlands, 28.1 acres; highway, 4.5 acres; residential, 41.6 acres; and commercial, 39.6 acres. The total estimated phosphorus loading from these land uses is 107.5 lbs per year.

However, there are currently a few existing stormwater best management practices (BMPs) in the watershed that will remove phosphorus. Load reductions from the existing structural BMPs for each site were computed based on the rated BMP pollutant removal efficiency from the New Hampshire Stormwater Manual - Volume I, Appendix E (2008). The total load reduction for each drainage area was calculated by subtracting the reduction potential for the structural BMPs. Detailed results are presented in **Appendix C-2**.

The constructed wetland treating runoff from Target will remove approximately 45% of the phosphorus from that site. The infiltration basins behind the Dollartree and Seacoast Bingo will remove approximately 65% of the phosphorus in the runoff. The dry extended detention basin/underground storage for Indian Brook Commons and the water quality unit installed at the outfall from NH Route 108 are expected to remove little to no phosphorus from the runoff in those drainage areas and were not considered as a part of this nutrient model.

Pre-development Conditions

Given the difficulty in accurately determining the pre-development watershed boundary due to the many human alterations through the years (described in **Section 2.0**), the Willand Pond watershed was assumed to be the same overall size as under the current conditions. This is expected to be a conservative assumption for this nutrient model given that the watershed was likely smaller in the pre-development condition; thus, contributing even less phosphorus to the Pond. The watershed was assumed to be completely forested, with no impervious coverage. Phosphorus loading concentrations were assumed for 217.4 acres of forest and 28.1 acres of wetland.

1995 Conditions

The Willand Pond watershed in 1995 mainly varied from current conditions in the following ways: the Target development had not been built, nor had the Indian Brook Shopping Center. In addition, the total watershed area draining to Willand Pond (but not including the Pond) was only 236.5 acres, with 13% impervious cover. Land use in the watershed was determined to be the following: forest, 141.6 acres; wetlands, 28.1 acres; highway, 4.5 acres; residential, 41.6 acres; and commercial, 20.7 acres.

3.4.2 Model Results

The results from the nutrient loading model are summarized in **Table 3-3** below, as well as the percent increase over the pre-development conditions. The current phosphorus loading in the watershed has increased over 700% compared to pre-development conditions, leading to the decline in water quality currently observed. While this increase seems overwhelming to manage, the watershed is relatively small and the areas contributing the majority of the phosphorus are concentrated, providing localized opportunities to reduce loading. Implementation of stormwater retrofits as discussed in **Section 4.0** and nonstructural pollution prevention strategies discussed in **Section 6.0** can help to greatly reduce this phosphorus input to Willand Pond.

Table 3-3 Summary of Phosphorus Loading for Three Different Time Periods in the Willand Pond Watershed

	Total Phosphorus Loading (lbs/yr)	**% Increase**
Pre-development Conditions	12.7	
1995 Conditions	68.6	440.2%
Current Conditions (2008)	102.9*	710.2%

* This value represents the phosphorus loading AFTER estimated treatment removals from existing stormwater BMPs.

4.0 STORMWATER MANAGEMENT ASSESSMENT

This stormwater management assessment addresses stormwater runoff as a source of pollutant loading in the Willand Pond watershed and helps to identify potential areas for the installation of stormwater best management practices (BMPs) to reduce this load. The results of this assessment are then used to recommend site-specific stormwater management implementation projects in key locations within the watershed. By identifying and prioritizing the most effective retrofit opportunities, the Cities will have a reasonable set of specific management options with which to move forward. Successful implementation of the identified opportunities is expected to help reduce stormwater runoff pollution and improve overall water quality conditions in Willand Pond.

4.1 Assessment Methodology

The Team identified potential BMP locations using information from the New Hampshire Geographical Information System (GRANIT), as well as data layers provided by the City of Somersworth, including data such as soils, rivers, wetlands, parcels, and land use. Impervious area was delineated in GIS based on aerial photography (2005) and engineering plans from more recent projects in the watershed. The potential BMP locations were further investigated during a site reconnaissance on October 10, 2008. Three sites were selected from the potential locations based on field assessments of the observed site conditions, physical constraints, and retrofit feasibility. These sites and the proposed retrofits are described below. Preliminary drainage areas for these locations were initially delineated based on topography mapping. However, construction of impervious surfaces, the use of storm drain systems, and grading of land surfaces to accommodate different site designs can alter the overall size and shape of the watershed. The site visit, as well as the review of drainage plans for the area, allowed for more accurate drainage delineation and a better sense for site issues and constraints. The goal for each proposed retrofit was to size BMPs for a water quality volume based on treating 1-inch of runoff from each drainage area.

4.2 Investigated Sites and Selected BMP Descriptions

The following are descriptions of the three selected retrofit sites identified in the watershed. **Figure 4-1** illustrates the locations of these sites. BMPs were chosen to match site characteristics with recommended design criteria; general descriptions and schematics of the proposed BMPs are provided in **Appendix D-1**. Preliminary sizing and cost information for each site is provided in **Appendix D-3**.

4.2.1 WP-1 – Willand Pond Boat Launch

Site WP-1 is located on a portion of the Willand Pond State boat launch property. The boat launch is a State-owned area located on the western side of Willand Pond, with an entrance off NH Route 108. The site itself is relatively small, comprised of the entrance drive, a parking lot, and vegetated areas. However, runoff from a larger drainage area is directed to Willand Pond at this site, with the outfall discharging into the portion of the Pond separated by the park road. The entire drainage area is approximately 7.3 acres with 55% impervious cover. The drainage area

includes the commercial properties to the west of the site, a small portion of the residential area to the southwest, and portions of NH Route 108. NH Route 108 was recently improved in this area, and the drainage network was modified. The proposed retrofits described below take into account the recent modifications to the Route 108 drainage network. The retrofits proposed for the boat launch site will serve two goals: to improve the water quality of the stormwater before it reaches Willand Pond and to raise community awareness about Pond management efforts by implementing the project in a highly visible, public location.

The space available at the boat launch site is too small to treat the entire drainage area. Thus, two separate retrofits were proposed for this site to treat portions of the total drainage area: WP-1A and WP-1B.

WP-1A

Retrofit WP-1A treats runoff from the northwestern subdrainage area along NH Route 108, which is approximately 1.7 acres and 44% impervious. Stormwater pollutants from the road and surrounding area include sediment and car fluids, as well as any fertilizers used on the landscaped areas, which are mostly lawn. The Team proposes to construct a terraced bioretention swale along the north side of the entrance, which is currently a vegetated area. The existing drainage pipe from NH Route 108 is located in this area. Stormwater runoff from the 1-inch storm event will be diverted from the existing pipe into the bioretention swale, while stormwater from larger events will continue to discharge into Willand Pond via the existing pipe and outfall.

The proposed retrofit for WP-1A will treat 100% of the WQv. The total planning level cost of constructing the facility is estimated at $43,000, including the bioretention area, diversion manhole, and a 30% estimate for contingencies. The design and permitting cost is estimated at $8,000, and the 20-year design-life maintenance cost is estimated at $32,000. The conceptual layout can be found in **Appendix D-4**.

WP-1B

Retrofit WP-1B targets the southeastern subdrainage area along NH Route 108, which is 0.3 acres and 100% impervious. Stormwater pollutants from the road include mainly sediment and car fluids. The Team proposes to construct a bioretention facility in the existing vegetated depression between the entrance road and the first parking lot. Road runoff from the 1-inch storm event will be diverted from the existing pipe into the bioretention area. Stormwater from larger events will continue to discharge into Willand Pond via the existing pipe and outfall.

The proposed retrofit will treat 100% of the WQv. The total planning level cost of constructing the facilities is estimated at $42,000, including the bioretention areas, diversion manhole, paved flume, and a 30% estimate for contingencies. The design and permitting cost is estimated at $6,000, and the 20-year design-life maintenance cost is estimated at $24,000. The conceptual layout can be found in **Appendix D-4**.

4.2.2 WP-2 – Gas Station Property Near Willand Pond Recreation Area

The second potential retrofit site is located near the entrance to the Willand Pond Recreation Area on the eastern side of Willand Pond. The site consists of an open grassy area behind a former gas station. The drainage area to this site is comprised of the gas station parking lot, the recreation area entrance road, and the parking lot/storage area for an adjacent landscaping company. The drainage area is approximately 1.8 acres with 84% impervious cover. Stormwater runoff from this area currently flows without treatment into catch basins along the entrance road, which outfall to Willand Pond.

The Team proposes to construct a bioretention facility within the existing grassy area. Stormwater will be directed into the BMP via two paved flumes. Stormwater from large storm events will be directed back into the existing drainage system in the road via an outlet structure. The proposed BMP will not only treat 100% of the target WQv, but it will also help to raise community awareness about the Willand Pond management efforts by implementing the project in a highly visible location.

The proposed retrofit for WP-2 will treat 100% of the WQv. The total planning level cost of constructing the facilities is estimated at $69,000, including the bioretention area, paved flumes, and a 30% estimate for contingencies. The design and permitting cost is estimated at $15,600, and the 20-year design-life maintenance cost is estimated at $63,000. The conceptual layout can be found in **Appendix D-4**.

4.2.3 WP-3 – Indian Brook Commons Shopping Center

The Indian Brook Commons Shopping Center is located at the intersection of NH Routes 9 and 108 on the southern side of Willand Pond. The shopping center consists of several large buildings and a large parking lot, for a total drainage area of approximately 12.4 acres with 98% impervious cover. This site has an existing stormwater management system that ultimately discharges to Willand Pond and consists of a deep, dry extended detention pond with a sediment forebay and an underground detention system (box culvert, leaching chambers, perforated pipe, and crushed stone) for additional storage. The stormwater management system was designed for full buildout at the site; currently, two acres remain undeveloped.

The proposed retrofit for this site includes replacing the large sediment forebay in the Pond with a gravel wetland for enhanced treatment. While dry extended detention ponds do remove some sediment from stormwater, their phosphorus removal ability is limited. This proposed retrofit would be constructed such that the surface of the gravel wetland is the same as the current forebay elevation; thus, not reducing total storage volume. Runoff will flow from the existing inlets into sediment chambers for pretreatment. These chambers are sized to convey one inch of runoff/impervious acre into the bottom of the gravel wetland. The stormwater will filter up through the gravel and then discharge via the existing structure. Runoff from larger storm events will overflow the sediment chamber directly into the basin as in current conditions. Even though this site has not been completely developed yet, this retrofit was sized for buildout conditions.

The proposed retrofit for WP-3 will treat 100% of the WQv. The total planning level cost of constructing the facilities is estimated at $124,000, including the gravel wetland and a 30% estimate for contingencies. The design and permitting cost is estimated at $28,500, and the 20-year design-life maintenance cost is estimated at $114,000. The conceptual layout can be found in **Appendix D-4**.

Table 4-1 Summary of Performance and Cost Data for Proposed Retrofit Sites

Retrofit Site	Ownership (public/ private)	% WQv Treated	Estimated Construction Cost*	Estimated Design/ Permitting Cost**	Estimated Maintenance Cost Over Design-Life
WP-1A	public	100%	$43,000	$8,000	$32,000
WP-1B	public	100%	$42,000	$6,000	$24,000
WP-2	private	100%	$69,000	$15,600	$63,000
WP-3	private	100%	$124,000	$28,500	$114,000

* The estimated construction costs are planning-level estimates only, and include the cost for constructing the practices as well as a 30% estimate for contingencies.
** These costs are estimated assuming all BMPs would be designed and permitted at the same time.

4.3 Stormwater Pollutant Loading Assessment

Similar to the method described in **Section 3.2**, the Team used the Watershed Treatment Model (Caraco, 2001, as updated), which utilizes the Simple Method (Schueler, 1987), for pollutant loading calculations to estimate the annual load from each site's drainage area. Annual loads were estimated for the primary pollutant of concern, TP. The method uses loading coefficients and impervious cover estimates to calculate annual pollutant loads but does not account for spatial distribution throughout the watershed. The Team used the New Hampshire Stormwater Manual (2008) for determining phosphorus loading values for various land uses and load reduction efficiencies from stormwater management practices.

Load reductions from the proposed structural BMPs for each site, described in **Section 4.2**, were computed based on the percent of the impervious area captured by the BMPs and the rated BMP pollutant removal efficiency (based on the size and type of each BMP chosen). The total load reduction for each drainage area was calculated by subtracting the reduction potential for the structural BMPs and is included in **Table 4.2**. Detailed results are presented in **Appendix D-2**.

Table 4-2 Summary of Phosphorus Loading Reductions for Proposed Retrofit Sites

Retrofit Site	Estimated TP Removal (lbs/year)
WP-1A	4.4
WP-1B	0.77
WP-2	3.0
WP-3	23.5
Total	31.7

As described in **Section 3.4**, the total estimated watershed phosphorus loading under current conditions is 102.9 lbs/yr. If all of the proposed retrofits are implemented, this loading would be reduced to 71.2 lbs/yr for a decrease of almost 31%. This represents a significant reduction in phosphorus entering Willand Pond to levels near the loading estimated for 1995 conditions (69.2 lbs/yr).

4.4 Stormwater Retrofit Ranking System

Since the Cities may not be able to implement all of the recommended projects at once, it is important to go through a ranking process to identify priority sites. Not all recommendations are equal when it comes to implementation. Some proposed projects may require land acquisition or need detailed planning and permitting, which takes time, while others may require a large amount of upfront infrastructure costs.

Ranking candidate projects allows restoration sites to be compared to find the most cost-effective and feasible projects in the study area. Each selected site was ranked based on a retrofit ranking system. The proposed retrofit ranking system included the following major factors:

1. Pollutant Removal Potential based on impervious area treated, percent of water quality target volume treated, and pollutant load reduction;
2. Project cost; and
3. Implementation feasibility based on wetland impact/permitting, public education, ownership, and maintenance.

The ranking system used a 100-point scoring system, where the relative merit of each proposed retrofit BMP was evaluated by assigning points based on its ability to meet various criteria under each of the three major factors cited above. Summing the assigned points for each of the factors gave an overall site score. Sites with the highest score represented the best overall candidates for implementation.

The ranking system places an emphasis on the pollutant reduction potential by weighting it more heavily. Specifically, 40% of the total points were allocated to this category (impervious area treated, water quality volume treated, and pollutant reduction). Another 30% of the points were allocated to project cost, as well as implementation feasibility. The cost estimates are based on a combination of compiled data and best professional judgment based on experience. The exact costs will vary from these estimates based on final engineering design, permitting and contingencies. Contingency costs can be generally estimated at approximately 30% of the base construction costs (CWP, 2007).

The rationale for the emphasis on the area and volume of water treated, as well as the cost and feasibility of a project, is two-fold. First, one goal of the retrofit approach is to manage a large percentage of the untreated impervious area runoff, in order to maximize water quality benefits to receiving waters. Therefore, these retrofit sites that are able to capture and effectively treat a larger drainage area or treat the greatest direct pollutant sources are deemed to be more important and valuable and thus assigned higher point values. Second, the feasibility of a proposed retrofit, in terms of both cost and implementation is important. Simply put, there are frequently “fatal flaws” for proposed retrofits in the form of capital costs, maintenance, and property ownership (private vs. public). There is little point in proceeding with a retrofit design concept if there is a high probability that an existing constraint cannot be overcome. Therefore, proposed retrofits where these types of constraints are minimal or non-existent will be awarded higher point values. In addition, sites that include opportunities to increase public awareness of water quality issues will receive higher scores. Specifics of the ranking, including BMP sizing and cost estimates, are included in **Appendix D-3** and results are summarized in **Table 4.3** below.

Table 4-3 Summary of Ranking for Proposed Retrofit Sites

Stormwater Retrofit Technical Feasibility	Site WP-3	Site WP-1A	Site WP-2	Site WP-1B
1a. Impervious Area Treated =Max IA treated (10), Min IA treated (1)	10.00	1.35	1.90	1.00
1b. % of Water Quality Volume Treated = $WQV_{design}/WQV_{req'd}$ *10	10.00	10.00	10.00	10.00
1c. Pollutant Load Reduction Percent of TP Load Reduction for BMP (eff. *20)	12.80	13.00	13.00	13.00
1. Pollutant Removal Potential (Total Possible Points 40)	**33**	**24**	**25**	**24**
2. Project Cost (Total Possible Points 30)	**30**	**12**	**15**	**1**
3a. Wetland Impact / Permitting No permitting issues = 5	5	3	5	3
3b. Public Education Low = 1, High = 5	3	5	5	5
3c. Ownership (public/private) Poor = 1, Good = 10	1	10	1	10
3d. Maintenance High = 1, Low = 10	3	7	7	7
3. Implementation (Total Possible Points 30)	**12**	**25**	**18**	**25**
Total Score (Maximum Score = 100)	**75**	**61**	**58**	**50**

5.0 HYDROLOGIC CONNECTION ASSESSMENT

5.1 Existing Hydrologic Barriers

As described in detail in **Section 3.1**, the wetlands complex which serves as the discharge outlet for Willand Pond has been hydrologically segmented through a variety of activities. This segmentation inhibits the natural flow from Willand Pond to Peters Marsh Brook and ultimately the Salmon Falls River. The major impediments include the Stackpole Pond Gravel Roadway, the Esker Roadway, the Sewer Line/Roadway, and the Home Depot detention pond. In order to provide an outlet for Willand Pond and restore the hydrologic connection between the Pond and the Peters Marsh Brook, one or more of these impediments must be overcome.

5.2 Alternatives Analysis

Four alternatives for restoring the hydrologic connection between Willand Pond and the Peters Marsh Brook were analyzed and compared as a part of this project. These alternatives were identified based on historic research of the watershed, analysis of available mapping and engineering plans, and site visits which included taking survey measurements of ground and water surface elevations. At the outset, the Project Team envisioned conducting a comparative analysis of these remedial alternatives in a manner similar to that presented for the stormwater retrofits in **Section 4.4**. While the alternatives in this section were compared, the scope of the proposed alternatives did not lend themselves to a detailed comparison similar to the stormwater retrofits. The final recommendation from this section is based primarily on engineering/ permitting feasibility and effectiveness for reducing the water level in Willand Pond.

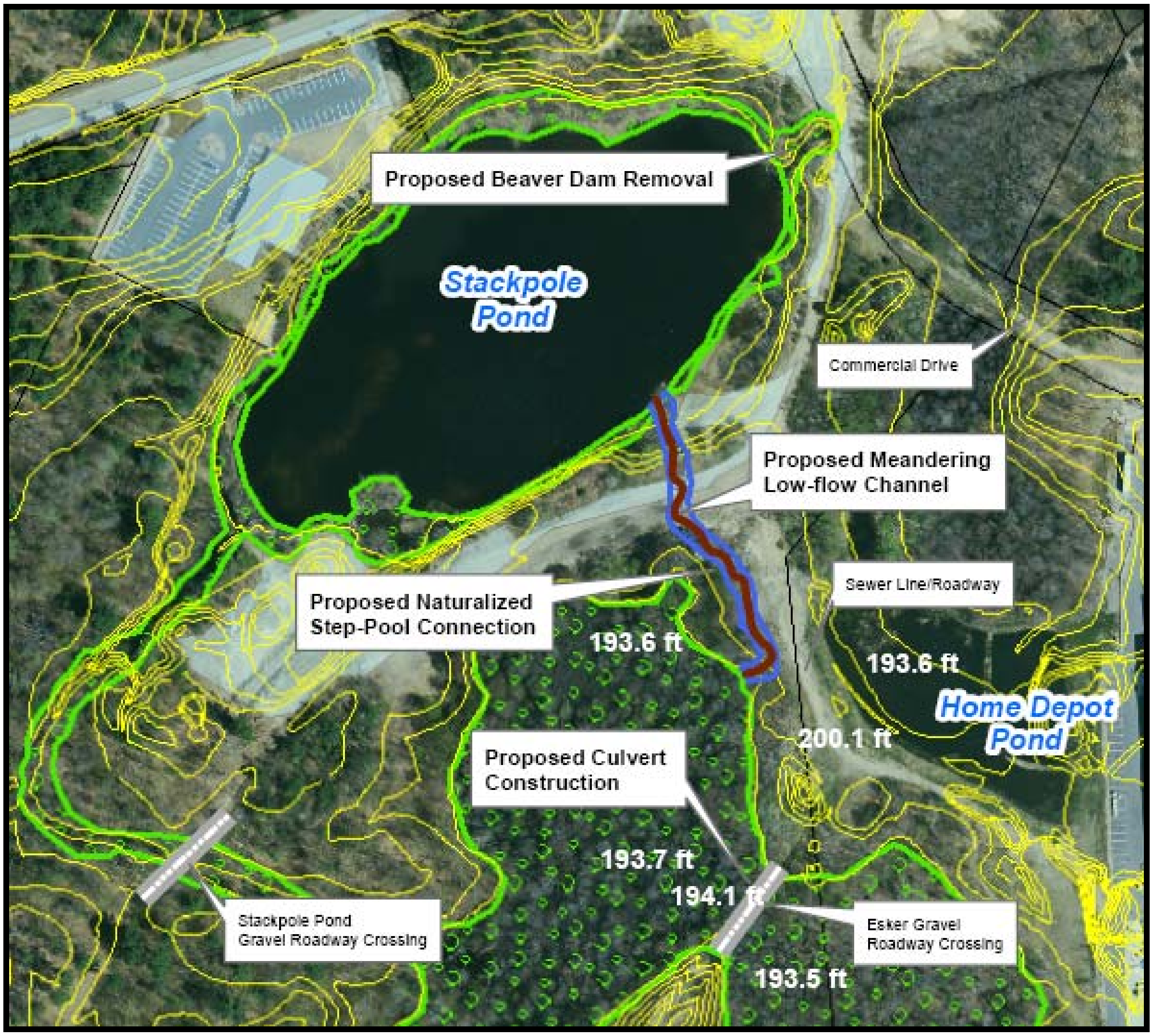
5.2.1 Redesign of Sewer Line, Home Depot Pond, and Commercial Drive Culverts

Historically, it is believed that a hydrologic connection between the Pond and Peters Marsh Brook existed via continuous wetlands and drainage channels through the area that is currently bisected by the Sewer Line/Roadway, the Home Depot detention pond, and Commercial Drive. In order to restore this historical connection, the sewer line would have to be lowered and the Home Depot Pond would need to be redesigned to eliminate or reduce the impediment to groundwater flow, and several additional culverts and/or a bridge would need to be designed for the area where Commercial Drive crosses the wetland. While there are currently plans for Home Depot to re-design the detention pond outlet to reduce the permanent pool, it is difficult to determine at this time if the detention pond will remain dry. Even if the Home Depot Pond were completely modified such that it did not create a constant head, the sewer line would still create a flow blockage. The sewer would need to be lowered, and the access/maintenance road would need to either be removed altogether or modified such that a bridge spanned the area to be restored as wetland. The high cost and low feasibility of these modifications make this a non-viable alternative. Due to these unknowns and difficulties, the concept for this alternative was not fully developed.

5.2.2 Hydrologic Connection to Stackpole Pond - *Conceptual*

Stackpole Pond is currently connected to Peters Marsh Brook via two 24-inch culverts underneath Commercial Drive. To take advantage of this existing outlet, this alternative considers creating a hydrologic connection to Stackpole Pond from the wetland area along the northern boundary of the Willand Pond watershed. In order to create an effective connection, this alternative requires three components: construction of culverts underneath the Esker Roadway to re-connect the wetlands on either side, the removal of beaver dams downstream of Stackpole Pond, and construction of a step-pool system between Stackpole Pond and the closest wetlands (**Figure 5.1**).

Figure 5.1 Components of Alternative 2 – *Conceptual* Hydrologic Connection to Stackpole Pond



Culvert Construction at the Esker Roadway

During the field visit in October 2008, the Team surveyed the low point in the Esker Roadway, and the water surface elevation in the wetlands on either side. The low point was 194.1 ft while the water surface elevations in the wetlands on the west and east sides were 193.7 ft and 193.5 ft, respectively. To mitigate for this blockage of flow, the Team proposes a series of five 12-inch culverts along an approximately 50-ft stretch of roadway. These culverts would provide a path for groundwater movement from the east to the west of the Esker Roadway. Alternatively, if there is no public need to maintain the Esker Roadway as a trail for passive recreation, a portion of the road fill could be removed altogether, allowing for continuous wetland throughout that area.

Beaver Dam Removal in Stackpole Pond

The water surface elevation in Stackpole Pond in October 2008 was measured at 191 ft. However, a beaver dam near the outlet was observed that was holding back approximately 2-2.5 feet of water. According to the City of Somersworth, additional beaver dams located downstream of the Stackpole Pond outlet culvert along Peters Marsh Brook in Spring 2009. The Team proposes that the beaver dams be removed and the situation be regularly monitored into the future to prevent re-establishment of the dams. This will result in lowering the normal water surface elevation in Stackpole Pond to approximately 189 ft, providing additional storage in Stackpole Pond for flows from a hydrologic connection with the Willand Pond watershed. The estimated cost of this component is negligible. Watershed volunteers could team up with municipal staff for a work day. Minimal costs could be associated with proper disposal of the removed debris. Maintenance over the long run would likely require a beaver management plan, which would be more costly than the initial dam removal.

Naturalized Step-Pool Design

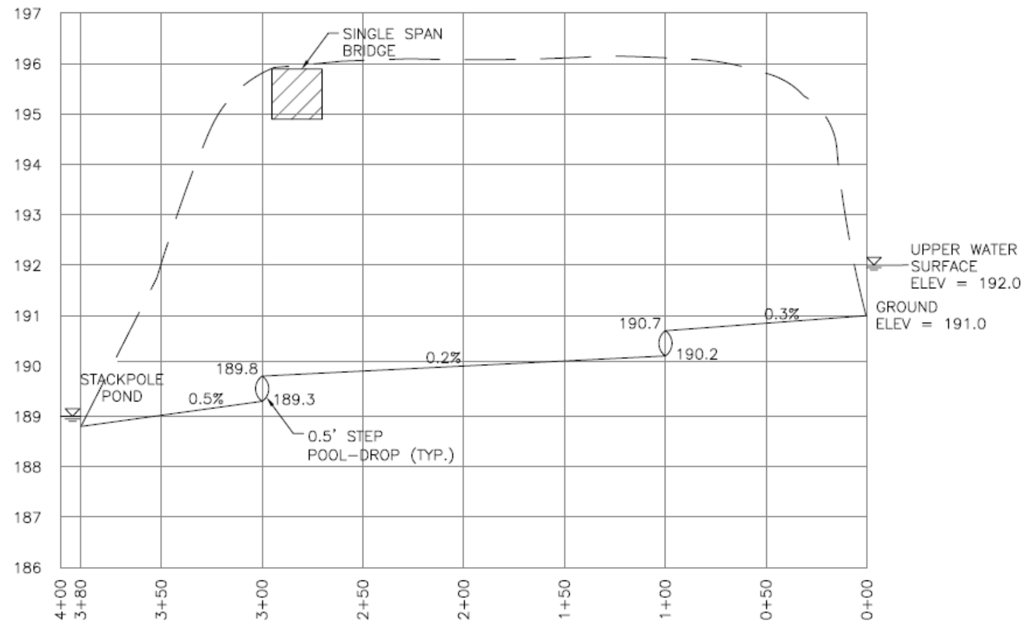
A step-pool system would be constructed from the wetland to Stackpole Pond, see **Figure 5.1**. This area already has the lowest ground elevation and thus provides the best opportunity for creating an outlet. The step-pool system would be constructed with two 0.5 ft drops along a length of 380 feet and an alternating pool/riffle design for maximum in-stream habitat. Baseflow from the wetland would be conveyed in a small, low-flow channel that would meander in the larger channel in a naturalized design. This low-flow channel would be lined with 3 to 4 inches of organic soil and underlain with 18 inches of gravel to promote groundwater movement through the connection. Larger flows during 1- to 2-year storm events would be contained in the bankfull channel, and flow from extreme events would flow out into the “floodplain” portion of the design (see **Figure 5.2**). A single span bridge or a right-of-way easement on an abutting parcel would be needed to maintain access to this private parcel from Willand Drive.

This hydrologic connection was modeled using HydroCAD as described in **Section 3.3** with the inputs for the existing Willand Pond watershed (2008), as well as inputs for the Stackpole Pond watershed. The total watershed draining to Stackpole Pond is 326.1 acres. Input values of 33.4 acres of forest, 10.4 acres of impervious cover, 5.3 acres of gravel roadway, and 6.0 acres of pond were used. The combined curve number for this watershed was calculated to be 54. The proposed hydrologic connection was modeled using a “Reach” in HydroCAD, connecting the Willand Pond watershed to the Stackpole Pond watershed. Storage estimates for both Willand Pond and Stackpole Pond were estimated based on topographic data. The existing wetland water surface elevation was modeled at 192 ft, and Stackpole Pond was modeled at an elevation of 189 ft, which assumes the beaver dam removal discussed above. The dimensions of the twin, 24-inch culverts under Commercial Drive were entered as the outlet for the entire system. Even at large storm events (25-year and 100-year events), the storage and outlet culverts appear to be sufficient for the additional flow from the Willand Pond watershed. The detailed HydroCAD model inputs and results are included in **Appendix E**.

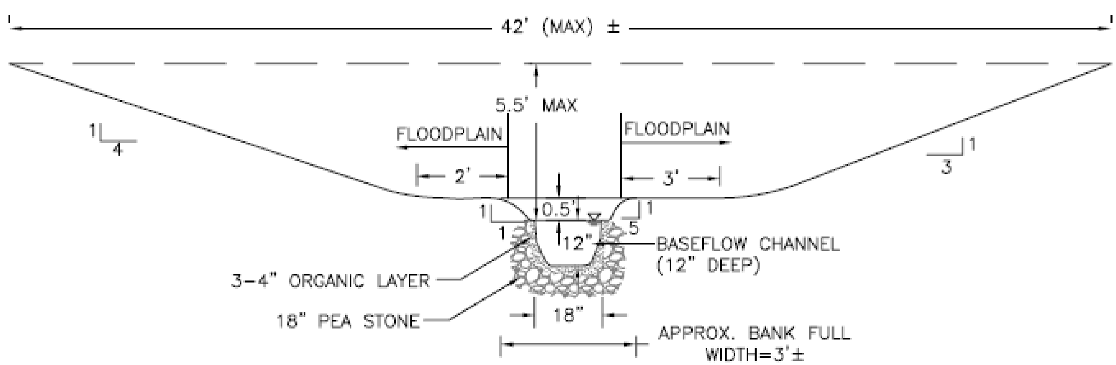
The estimated construction cost of the entire alternative is $244,000, which includes a 30% contingency but does not include the cost of land procurement, if any. The estimated design and permitting cost is approximately $56,000. See the detailed cost worksheet in **Appendix E** for a breakdown of each item.

Figure 5.2 a) *Conceptual* Profile and b) *Conceptual* Cross-section of Proposed Hydrologic Connection

a)



b)



5.2.3 Reactivate Water Supply Wells and/or Install New Wells

As described in detail in **Section 2.0**, the Willand Pond watershed was used as a source for drinking water for nearly a century, initially as a surface water withdrawal (until circa 1954) and then as a groundwater withdrawal until approximately 1966. This use was discontinued due to naturally-occurring elevated iron and manganese concentrations. During these periods of pumping, the surface of Willand Pond, with one observed exception, was markedly lower than current water levels. Thus, it is believed that if the existing well was reactivated and/or new groundwater wells were installed within the highly permeable kame deposits surrounding the Pond and groundwater withdrawals were resumed, it is logical to expect that the Pond water surface elevation would be lowered. This alternative would require an in-depth and detailed environmental and engineering assessment of a range of technical and administrative issues which is beyond the scope of this watershed assessment. Such an analysis would need to answer at least the following questions:

- What rate and volume would be necessary to lower the water level?
- Where would the pumped groundwater be discharged?
- How much would it cost to design, construct, and maintain the required infrastructure?
- What permits would be required and would this alternative be justified?
- How much energy consumption would be required to operate the pumps indefinitely? and
- Would this be a sustainable alternative, meaning could it be implemented indefinitely and contribute to a positive, long-term solution to water level issues in Willand Pond?

One approach would be to pipe the water to the 'No Bottom Pond' recharge area south of the Pond in order to augment drinking water supplies from that source. This would involve a number of assessments, including how much water this aquifer system is capable of infiltrating, an evaluation of the condition and capacity of existing infrastructure, and/or the requirements for new infrastructure related to pumping, conveyance, discharge, and treatment.

Another option would be to discharge this pumped water to the wastewater system; although this would involve a range of issues including additional treatment costs, increased energy consumption to treat the additional flow, out-of-basin transfer of water from one resource to another, and potentially decreased treatment efficiencies at the wastewater treatment plan due to increased flow volume. The U.S. Environmental Protection Agency, which permits and evaluates wastewater water plant operations, typically would not approve a discharge of out-of-basin groundwater resources into a wastewater plant with a surface water discharge.

Permitting for resumption of the well pumping may require a Major Groundwater Withdrawal permit, including an alternatives analysis from the NHDES, hydrogeological testing and modeling, and assessment of the effects of the withdrawal, among other requirements, this evaluation and permitting process may take up to two years to complete.

Lastly, the energy consumption to restore the pumping would need to be evaluated in terms of the cost and impact to lowered water levels. The source, costs, and who would pay for the pumping would all need to be evaluated as part of the detailed assessment.

5.2.4 No Action

The "No-Action" alternative assumes that no topographic change will be implemented in the northern portion of the Willand Pond watershed to provide an outlet to the Peters Marsh Brook. While this alternative requires no capital investment, there are potential associated costs. If an outlet is not provided for the Pond, water elevations may continue to rise, particularly if annual precipitation continues to increase as seems to be the recent trend. Rising water elevations will continue to affect private property owners. The continued lack of flushing in the Pond combined with the nutrients from urban runoff may lead to more frequent and sustained cyanobacteria blooms, which will affect all residents and visitors who use the Pond for recreation. While this alternative is the easiest to implement, continuing with the current conditions in the Pond does not seem to be a viable option.

6.0 NONSTRUCTURAL POLLUTION PREVENTION STRATEGIES

6.1 Recommendations for Potential Revisions to Subdivision and Site Plan Review Regulations

The Team conducted an initial review of the Subdivision Regulations and Site Plan Review Regulations for both Cities. In general, these recommendations should be viewed as potential modifications to help reduce non-point source loading from future development or redevelopment projects in the watershed. Since much of watershed is already developed, the implementation of these recommendations would have little effect on current loadings. Nonetheless, since there are still several undeveloped parcels in the watershed (almost all of these are in the City of Somersworth), the potential to manage future development loads is an important consideration. The results of this initial assessment can be found in **Appendix F**.

6.2 Public Education and Outreach

6.2.1 Recommended Focus Areas

An education and outreach campaign can be used to target specific audiences to try to positively influence human behaviors in the watershed to help reduce pollutant loading to the Pond. At the same time, the program can reach a broader audience to raise general awareness that land use and human activity within the watershed have a direct effect on the health and quality of the Pond. The theory is that if people understand the connection between their individual activities and the water resource, they will be more apt to alter their behavior. Many behaviors can be positively influenced by public education. The key public education issues in the Willand Pond watershed that will help address the water quality impairment are as follows:

- waterfowl management;
- lawn management;
- pet waste management;
- stormwater management; and
- septic system maintenance.

These focus areas are described below, followed by a description of recommended education and outreach programming techniques. These techniques are intended to be a menu of possible strategies that can be employed in various combinations depending on time, budget, and target audience.

Waterfowl/Gull Management

There are a handful of methods that are used in various situations to reduce the populations of waterbirds in and around a water body, thereby reducing nutrient and bacteria loads to that area. These include habitat modification, frightening, exclusion, discontinuation of feeding, live capture, hunting, and egg addling. Some of these methods require changes in practices by the landowners in the area, and some require professional or third-party assistance, and in some cases, permitting through the NHDES and/or U.S. Fish and Wildlife. For example, habitat modification refers to the modification of open grassed areas that are often mowed directly to the water's edge. These areas are attractive to waterfowl such as geese, swans, and ducks that like to have a clear sight line and open access to the water. Modifying these open spaces to allow for a vegetated buffer along the water edge makes the area much less attractive to these waterfowl. A 50-foot vegetated buffer, with vegetation growth up to 3-4 feet high, makes a large impact in deterring geese and swans by breaking up the open lawn space from the open water. Creation of this buffer, however, often depends on the will of the land owner to convert mowed area to vegetated area. This is where public education comes into play. Public education implementation tools include the following: mailers, television and radio advertisements, newspaper articles and signage.

An added bonus from allowing mowed and manicured lawn areas to revegetate is that maintenance is significantly lower and less fertilizer or other lawn chemicals would be used. This leads into the next area of focus for public education in the Willand Pond watershed, which is lawn management.

Other methods of waterbird management include live capture of the birds, egg addling, and hunting. Egg addling is a method used to control the hatching of eggs. The eggs in a nest are shaken, making them nonviable, and then replaced in the nest. These methods require permits from the U.S. Fish and Wildlife Service and may require NHDES and/or local permits as well. In some cases, these methods may face local opposition; but in severe situations of uncontrolled waterbird populations, a local municipality may opt for these more direct methods.

Lawn Management

Many lawns are maintained over the majority of the available lot area, irrigated with potable water, and treated with fertilizers and herbicides. Some lawns consist of non-native grasses. Public education can be used to help change these practices and teach homeowners about alternative lawn care practices. Smaller lawns are easier to maintain and allow room for larger more diverse and colorful vegetation. The use of native grasses and compost amended into the soil can reduce the need for additional pesticides and herbicides and will provide a more drought-resistant groundcover, which will in turn require less irrigation. In cases where irrigation is still required or preferred, the homeowner can use a variety of methods to reduce irrigation demand, including rain barrels or cisterns to catch rooftop runoff for irrigation, or programmed irrigation systems to water their lawns only during early morning or late evening hours.

Providing this guidance to homeowners and other landowners within the watershed requires an effective public outreach plan. This can be done through a media campaign, which could be a combined effort with the other focus areas. It could also benefit from a demonstration project site that would show other homeowners what a smaller, more natural lawn and yard with more diverse landscaping can look like. A demonstration site could be a mechanism to provide information about cost savings and time savings due to lower maintenance requirements, and to collect information about any increase in song birds, decrease in nuisance species, etc.

There are several example programs in the northeast that promote healthy and sustainable lawn management. The University of New Hampshire Cooperative Extension Program (http://extension.unh.edu/resources/category/Home_and_Garden) provides guidance on sustainable gardening and lawn maintenance to promote the use of native vegetation that is suitable for the soil and site conditions and to reduce impact on water quality in local resources.

In Westchester County, New York, the Grassroots Healthy Lawn Program was an initiative of the county government and a non-profit organization called Grassroots Environmental Education, based in Port Washington on Long Island. The goal of this initiative was to promote healthy lawn management by reducing the use of pesticides and other toxins on lawns throughout the county. The program provided training to landscapers, provided public outreach services, served as a liaison between manufacturers and retailers, and developed a list of natural lawn care product suppliers for public distribution (http://www.ghlp.org/).

Pet Waste Management
Pet waste can be a nuisance to the public in addition to contributing bacteria and nutrients to the Pond when it is washed off the ground surface by rainfall and stormwater runoff. For those people that have pets, picking up after your dog can also be a nuisance. However, more and more people are realizing the aesthetic and environmental health benefits of cleaning up pet waste from public areas and their own back yards, and in many communities throughout the country now, there are "pooper-scooper" laws requiring people to clean up. While the idea of convincing the public to pick up after their dogs may seem difficult at first, a few pooper-scooper signs and bags, and the risk of being seen not picking up after their dogs can go a long way. A media campaign can easily be created with a sense of humor to get the message across, and signage at public open spaces and along walking trails can bolster the message.

Stormwater Management
A stormwater awareness program can be a very useful tool in promoting effective and sustainable stormwater management. Mailings and inserts with local billings and other municipal communications to residents can raise awareness and inspire vigilance among local residents. Residents can help to monitor catch basins, stormwater treatment practices, and discharge locations to see that they are functioning properly. They can act as a first defense against failures and can report problems to the public works department. In the fall, residents can help by clearing leaves and debris from the catch basin grates and by not throwing leaves and debris into drainage swales, onto roadways, or into other stormwater pathways. In the winter, the same is true for snow that is shoveled and plowed off driveways and sidewalks. They can also help by not washing vehicles excessively, which can use large volumes of potable water, and by not washing them in their driveways, which can contribute phosphorus from the soap into the storm drain system and into the Pond. Instead, residents should use modern commercial car washing facilities that are outfitted with a wash water collection and treatment system, or at least opt for low/no phosphorus soaps if possible.

Residents can also install on-site retrofits to improve the stormwater management on an individual house lot. These can include installation of rain barrels to collect water from rooftops through roof leaders. Rain barrels that are properly fitted with tightly closed solid tops or a mesh screen at the top should alleviate mosquito concerns as these precautions will prevent mosquito larvae from hatching out and leaving the barrel. A rain barrel program could be established through the cities or a local non-profit organization, in conjunction with a rain barrel distributor, to sell rain barrels at a discounted price to community members. In addition, other on-site retrofits may include installation of a dry well to collect and infiltrate roof runoff and overflow from the rain barrels, if they have been installed. Bioretention areas (a.k.a. rain gardens) can easily be implemented in a yard to collect roof and driveway runoff and can be planted with aesthetically pleasing flowering vegetation.

In addition to educating the general public on stormwater management issues, city staff and private companies should also be educated on the need for regular inspections and maintenance of stormwater infrastructure. Without a long-term inspection/maintenance program in place, any new or existing stormwater BMPs implemented in the watershed will eventually lose effectiveness over time. Even the best BMPs are only as effective as their maintenance plan.

Septic System Maintenance

Septic systems require regular maintenance and inspection, and require that homeowners are actively aware of the location and operational characteristics of the system. The residential area to the south of Willand Pond, as well as Midway Park, depends on septic systems for waste management. NHDES recommends that these systems are inspected yearly and that the septic tank be pumped out approximately every 3 years to remove the solids that have accumulated over that time period.

There are many septic system maintenance additives marketed to reduce the accumulation of solids and the frequency of pumping of the septic tank. However, these additives can frequently be harmful to the system, particularly when used inappropriately, by impairing the microbial community responsible for much of a system's treatment ability, by reducing the effectiveness of the leach field, and by contributing chemical contaminants to the underlying groundwater. This is particularly important in areas characterized by sandy soils where groundwater movement to receiving waters can be very rapid. A properly designed, installed, and maintained septic system should not need chemical additives to function properly. It is important for homeowners to be aware of what they put into their septic system and what the potential effects may be. Without proper maintenance, the system can lose significant treatment capacity and can clog up. This can cause a failure where the system's leach field fails to leach and the leachate breaks out at the ground surface. Alternatively, it could back up into the household. Both of these scenarios cause a public health concern as well as a threat to the water quality of Willand Pond.

The Piscataqua Region Estuaries Partnership (PREP) offers a variety of septic system outreach materials that could be used in the Willand Pond watershed, including a maintenance folder and an informational video (http://www.nhep.unh.edu/resources/septic.htm). These materials could be updated to include references to Willand Pond and connect the need for septic system maintenance to the water quality and cyanobacteria blooms. In addition, the Rhode Island Cooperative Extension has developed a number of helpful fact sheets aimed at homeowners with information about septic system maintenance, ways to prolong the life of the system, ways to upgrade the system to provide better treatment, the effects of additives, and other useful information.

6.2.2 Public Education and Outreach – Recommended Programs

The following provides a menu of activities that could be undertaken as part of a watershed-wide or city-wide outreach and education program to address the environmental health of Willand Pond. These activities are designed so that they could focus on one or a combination of the five areas discussed above. These activities could be implemented by each city, in conjunction with NHDES and the citizen group.

Watershed Awareness Day

Hold a watershed awareness day, perhaps associated with an Earth Day program. The cities could organize a watershed awareness day to take place along the shore or some place within the watershed. This could include educational booths, games related to water quality, demonstrations of innovative technologies, sales of rain barrels and native grass seed, a swim or kayak race, a road race through the watershed, and/or an afternoon or evening picnic. This is a great way to get people outside, making the visual and experiential connection between the Pond they love and the watershed in which they live and play.

Media Campaigns

A host of media campaigns could be developed with specific messages regarding applicable management strategies such as residential septic system maintenance, repair or replacement; residential fertilizer management; shoreline vegetation management; car washing; or pet waste management. These campaigns can include fliers and brochures to be distributed at community events or mailed out with utility bills, as well as posters to be distributed and posted in municipal offices, public libraries, schools, and other highly visible areas. Articles, or a series of articles, can be developed for the local newspaper to focus people on watershed management. Television advertisements or stories on local television stations or the local cable access stations can be devoted to homeowner activities that impact the watershed. Brochures related to pet waste clean up could be handed out with dog licenses and distributed by local veterinarians. These efforts could be tied to the public outreach and education requirements of the National Pollutant Discharge Elimination System (NPDES) permits required for Dover and Somersworth as regulated separate storm sewer system communities.

Demonstration Projects

Projects that can be used to illustrate a vegetated buffer, retrofit stormwater management practices such as recommended in **Section 4**, or a low-maintenance lawn can be invaluable in an education campaign. Demonstration projects are helpful because they allow people to see a work in progress and a finished product, so they can know what to expect and they can evaluate the outcome realistically. They can also involve members of the general public in the planning and implementation of the demonstration project, which serves as a great educational experience. Once a project has been undertaken, the development and implementation phases can be documented in photographs that can be used in mailers, brochures, posters, and a media campaign. They can serve as a centerpiece for a local news story as well. Signage about the project can be placed at the edge of the site to catch the attention of passersby and provide educational information and a place to go for more information to anyone who is interested.

One example of a successful demonstration project took place at Long Lake in Littleton, MA. Long Lake was in a deteriorated state due to nutrient loading from nonpoint source pollution.

The town used a grant to work with a consultant to retrofit a portion of the Long Lake watershed by installing rain gardens, grassed swales, rain barrels and a constructed wetland park with walkways for the public to enjoy the area and learn about the stormwater management practices. A description of the project, with project design information and photographs, is posted on the state Executive Office of Environmental Affairs website and serves to inform other interested people about the project.

School Watershed Science Programs

Science and humanities programs in local schools can help to educate young people on the various themes of watershed management, and the connection between human land uses and the water quality in the Pond. Hands-on school programs related to the environment may include water quality monitoring, gardening, recycling, and composting. These programs can serve as a vehicle to teach students about watershed management and stewardship.

7.0 RECOMMENDATIONS

7.1 Stormwater Recommendations

The Project Team recommends that the concepts for the proposed stormwater retrofits described in **Section 4.2** are advanced to final design. Permission will first be required for the two sites on private property (WP-2 and WP-3). Detailed field survey and soil test pitting or borings will then be necessary at each location, and final construction documents should be prepared. Finally, we recommend that the retrofits be implemented in order of their ranked priority: WP-3, WP-1A, WP-2, and WP-1B.

7.2 Hydrologic Connection Recommendations

The Team recommends that the proposed concept for Alterative 2 - Hydrologic Connection to Stackpole Pond described in **Section 5.2.2** is advanced to final design. Permission will first be required for this project, which is located on private property (the Stackpole Parcel). Additional hydrogeologic analysis should be performed, including borings to identify any locations of bedrock and the composition of the soils in the proposed area, and possible hydrologic/hydraulic impacts that the proposed concept may have downstream from the outlet of Stackpole Pond. Detailed field survey will then be necessary. Full hydro-geological modeling should be performed based on the detailed survey. The final design and construction documents should be prepared, with implementation of those plans to follow. In addition, the Team recommends that both Cities retain a consultant to fully evaluate the well drawdown option discussed in **Section 5.2.3.**

7.3 Nonstructural Pollution Prevention Recommendations

The Team recommends that the Cities review the initial assessment of their regulations and convene local committees to consider adoption of the recommended modifications as outlined in **Section 6.1** and **Appendix F** to better protect the water quality of Willand Pond. We also recommend that the Public Education Consultant review the suggestions for recommended focus areas and programs for public education and outreach in the watershed. These nonstructural pollution prevention strategies can be quite effective in reducing pollutant loading, particularly in such a small watershed with concentrated focus areas.

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