ANL/EVS-14/9

Assessment of Threats to Wetland Integrity at New Boston Air Force Station, New Hampshire, with Recommendations for Mitigation

Prepared by

Environmental Science Division
Argonne National Laboratory

for

23 SOPS/CEA
U.S. Department of the Air Force
New Boston Air Force Station, New Hampshire

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NOTATION

The following is a list of the acronyms, initialisms, and abbreviations (including units of measure) used in this document.

ACRONYMS, INITIALISMS, AND ABBREVIATIONS

GIS	geographical information system
GPS	global positioning system
INRMP	Integrated Natural Resource Management Plan
NBAFS	New Boston Air Force Station
SOPS	Space Operations Squadron
UXO	unexploded ordnance
WPT	GPS waypoint

UNITS OF MEASURE

ac	acres(s)
cm	centimeter(s)
ft	foot (feet)
ha	hectare(s)
in.	inch(es)
km	kilometer(s)
m	meter(s)
mi	mile(s)

ASSESSMENT OF THREATS TO WETLAND INTEGRITY AT NEW BOSTON AIR FORCE STATION, NEW HAMPSHIRE, WITH RECOMMENDATIONS FOR MITIGATION

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ABSTRACT

Our study addressed two projects identified in the Integrated Natural Resources Management Plan (INRMP) for New Boston Air Force Station (NBAFS), New Hampshire that are related to sustaining high-quality wetland habitats on the station. These studies were intended to: (1) evaluate erosion and its impacts on NBAFS wetlands, (2) evaluate degraded wetlands for restoration potential and (3) develop designs for wetland restoration. This report includes brief descriptions of each wetland evaluated, existing and potential erosion problems at each wetland, and recommendations for restoration actions to mitigate impacting factors at high risk wetlands.

In October 2011, we surveyed 15 wetlands on NBAFS for evidence of impacts from erosion. These wetlands were chosen because they were adjacent to roads, developed areas, or disturbed areas, and therefore had a higher potential for impact from erosion. Parameters evaluated at these wetlands and adjacent areas included (1) evidence of existing sedimentation and erosion into wetland areas; (2) source of sediment; (3) slope; (4) soil type; (5) surrounding land cover; (6) presence and extent of intervening non-erosive land (e.g., vegetated surface, pavement); (7) water inputs (surface runoff, groundwater); and (8) frequency and nature of erosion events. The evaluation was watershed-based and utilized existing topographic information to determine the watershed of each wetland. Erosion problems at specific locations were ranked according to risk, including probability of occurrence, magnitude of effect, and severity of effects.

Our evaluations were used to determine opportunities for wetland restoration. Restoration activities were developed on a case-by-case basis with an emphasis on wetlands at highest risk of degradation. Our recommendations for restoration focused on eliminating or reducing risk using minimally intrusive procedures and engineering solutions that could be achieved at relatively low cost. We emphasize concepts such as permeable paving, stabilization of road surfaces, nonnative plant removals, and native plant buffers that eliminate the source of the disturbance or reduce the energy of runoff while increasing groundwater infiltration rates. Recommended restoration actions and solutions are intended to be sufficiently explicit to develop work plans for restoration activities.

1 INTRODUCTION

The U.S. Air Force manages natural resources on New Boston Air Force Station (NBAFS) through the implementation of an Integrated Natural Resource Management Plan (INRMP). The NBAFS INRMP (LaGory et al. 2006) describes the overall management goals and objectives at NBAFS, and projects that are planned to support those objectives. In the INRMP, goals, objectives, and projects were identified for seven specific natural resource management topical areas including (1) threatened, endangered, and rare species populations; (2) wetlands; (3) rare natural communities; (4) forest management; (5) control of invasive nonnative plant species; (6) outdoor recreation; and (7) unexploded ordnance (UXO) remediation.

Goals, objectives, and projects associated with wetland management on NBAFS focus on sustaining high-quality wetland habitats by monitoring trends, identifying threats, and restoring degraded wetlands. Wetlands at NBAFS perform important ecological functions such as maintenance of water quality, flood control, and groundwater recharge, and also provide habitat for plant and animal species including several state-listed and rare species.

On NBAFS, wetland degradation can be caused by invasive nonnative plants, natural succession, encroachment of human developments, and runoff from developed or disturbed areas. Monitoring wetland change and developing response actions before problems intensify are important components of the NBAFS INRMP. Four projects that address wetland management on NBAFS were identified in the INRMP:

- Project WE-1.1.1: Continue implementation of existing wetlands monitoring protocol.
- Project WE-1.2.1: Evaluate erosion and its impacts on NBAFS wetlands.
- Project WE-1.2.2: Evaluate degraded wetlands for restoration potential and develop designs for wetland restoration.
- Project WE-1.2.3: Implement wetland restoration activities after NEPA evaluations are complete.

This report presents the findings of a survey conducted in October 2011 to examine the current status of wetlands on NBAFS and supports Project WE-1.2.1.Those results are used to develop recommendations for remediating past or ongoing impacts on those wetlands and restoration of affected wetlands. Project WE-1.2.2 is addressed with the recommendations presented in Section 5. The objective of these projects is to look for opportunities to restore natural wetland conditions or prevent degradation of existing NBAFS wetlands. These two projects provide the information needed to complete project WE-1.2.3, which would build on the results of these projects.

2 DESCRIPTION OF THE STUDY AREA

NBAFS is in southcentral New Hampshire about 12 mi (19 km) west of Manchester. The 2,826-ac (1,144-ha) site is located within the towns of New Boston, Amherst, and Mont Vernon in Hillsborough County (Figure 1). The 23rd Space Operations Squadron (SOPS), a component

of the 50th Network Operations Group, 50th Space Wing, is housed on NBAFS, and is the sole military presence on the site. The 23 SOPS provides launch, operation, and on-orbit support for military satellites, communication satellites, and North Atlantic Treaty Organization and other allied nation satellites and for National Aeronautics and Space Administration missions.

The NBAFS site has also been used for military training exercises. Training activities that have occurred on NBAFS since 1974 include tactical maneuvers (force-on-force exercises), helicopter landing zone deployment, land navigation exercises, emergency response (e.g., simulated vehicle accidents and simulated natural disasters), reconnaissance and combat patrolling, establishment of field camps, and rock climbing and rappelling.

NBAFS is in an area of hilly and mountainous terrain (LaGory et al. 2006). The main physiographic features on NBAFS are Joe English Hill (in the northwest portion of the station), Chestnut Hill (east portion), P51 Hill (south-central portion), and Roby Hill (southwest portion). Joe English Pond is the largest open water feature and is located in the center of the site (Figure 1).[1] Elevations on NBAFS range from 340 ft (104 m) above mean sea level where Joe English Brook exits the southeastern corner of the site to about 1,275 ft (389 m) above mean sea level at the summit of Joe English Hill (Figure 1).

2.1 GENERAL HABITAT DESCRIPTIONS

More than 90% of NBAFS is forested (LaGory et al. 2006). Much of the area surrounding NBAFS is rural, with interspersed farms, forests, and residential areas. Land cover is consistent with the surrounding area, and much of the habitat on NBAFS is represented elsewhere in the county and region. However, residential development of surrounding lands increased within the past decade, and has resulted in an increase in the ecological importance of the undeveloped land on NBAFS. Nine land cover types have been delineated on NBAFS (Figure 2; LaGory et al. 1997) including mixed forest (45.5%), coniferous forest (24.9%), deciduous forest (18.9%), wetland (3.0%), old fields (1.7%), parkland (i.e., developed campgrounds and recreational areas; 1.6%), open water (1.5%), developed land (1.5%), and disturbed land (1.3%).

Coniferous forests on NBAFS are dominated by white pine (*Pinus strobus*) or eastern hemlock (*Tsuga canadensis*). Areas dominated by eastern hemlock usually have little if any understory vegetation, but areas dominated by white pine often have relatively diverse understories composed of young deciduous trees, including red oak (*Quercus rubra*), red maple (*Acer rubrum*), and black birch (*Betula lenta*); shrubs such as mountain laurel (*Kalmia latifolia*) and lowbush blueberry (*Vaccinium angustifolium*); and herbaceous species such as Solomon's seal (*Polygonatum pubescens*), bracken fern (*Pteridium aquilinum*), clubmoss (*Lycopodium* spp.), and pipsissewa (*Chimaphila umbellata*). The largest coniferous forest stands are in the southern portions of NBAFS (Figure 2).

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[1] In July 2010, the dam at the outflow of Joe English Pond was removed as part of UXO remediation efforts and resulted in the permanent lowering of the pond water level and reduction in the area occupied by the pond.

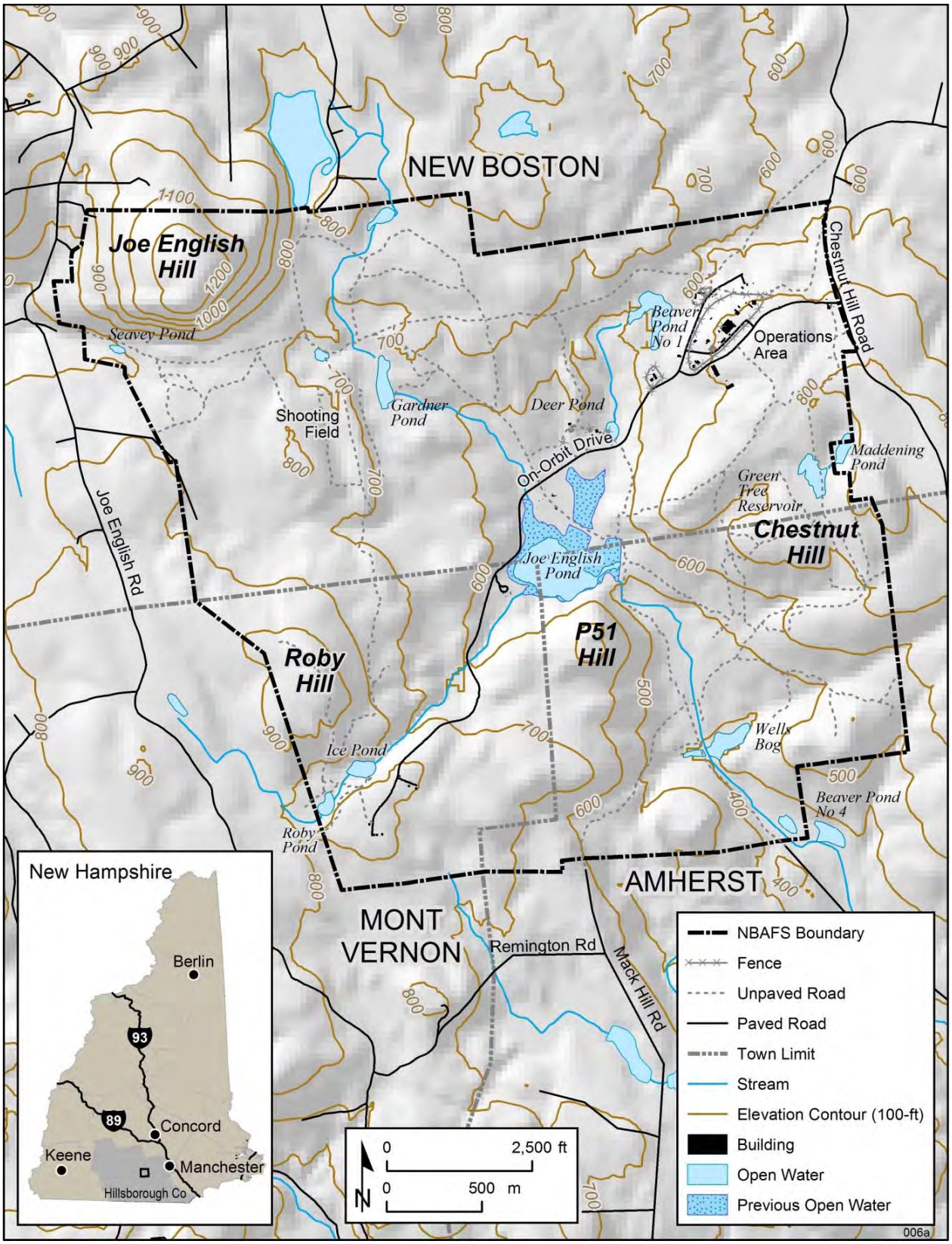

FIGURE 1. Shaded Relief Map of New Boston Air Force Station, New Hampshire (Source: LaGory et al. 2006, modified to show current Joe English Pond boundary)

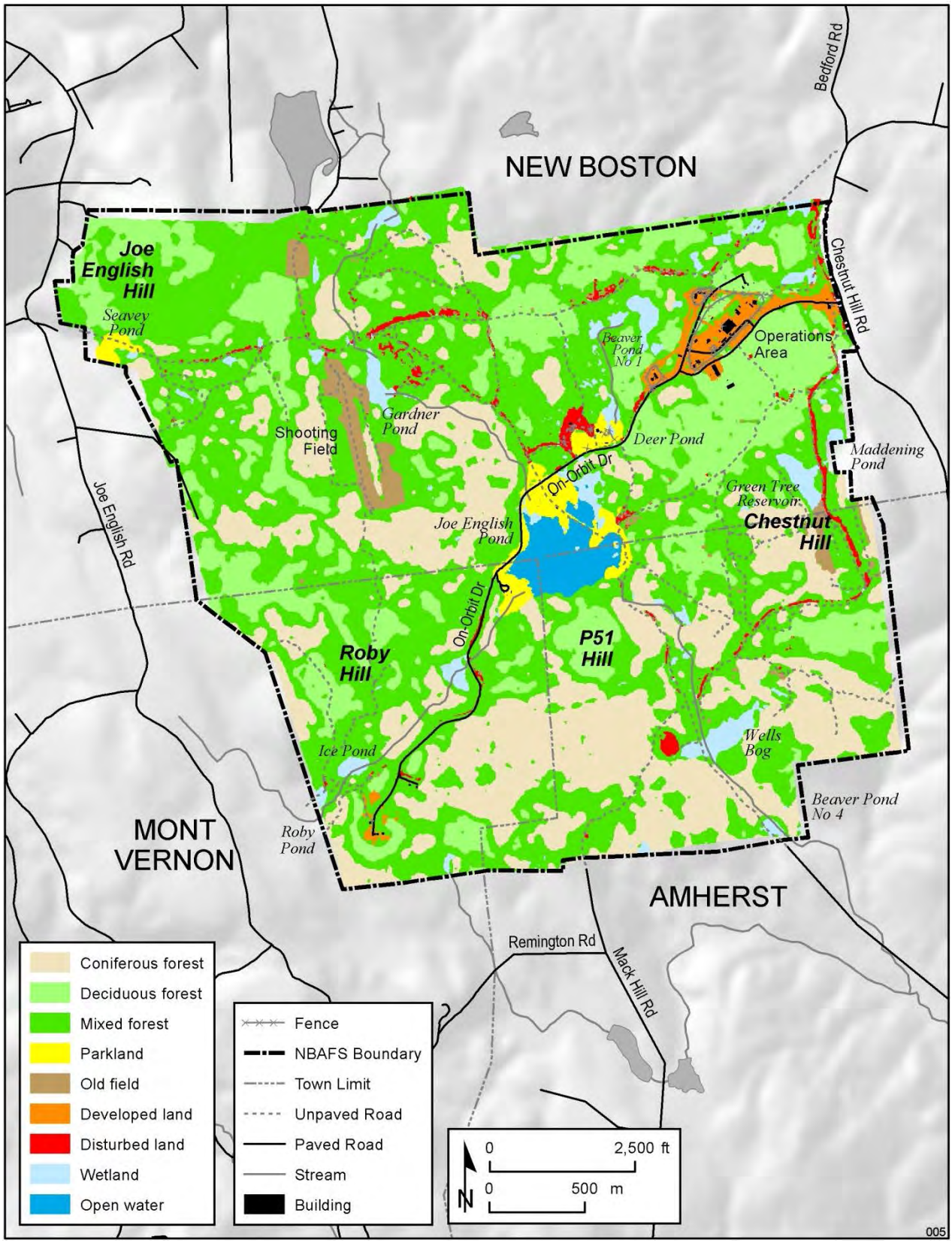

FIGURE 2. Land Cover Types of New Boston Air Force Station, New Hampshire as Delineated in LaGory et al. (1997)

Deciduous forests on NBAFS are dominated by red oak, black oak (*Quercus velutina*), American beech (*Fagus grandifolia*), white ash (*Fraxinus americana*), sugar maple (*Acer saccharum*), red maple, and gray birch (*Betula populifolia*). The understory is typically dominated by saplings of these and other deciduous trees as well as occasional white pine and eastern hemlock; shrubs such as witch hazel (*Hamamelis virginiana*), mountain laurel, and highbush blueberry (*Vaccinium corymbosum*); and herbaceous species such as wild sarsaparilla (*Aralia nudicaulis*), Canada mayflower (*Maianthemum canadense*), starflower (*Trientalis borealis*), clubmoss, wintergreen (*Gaultheria procumbens*), whorled wood aster (*Aster acuminatus*), Indian cucumber root (*Medeola virginiana*), and hay-scented fern (*Dennstaedtia punctilobula*). The largest stands of deciduous forest are in the northeastern portion of NBAFS (Figure 2).

Mixed forests on NBAFS have a tree canopy composed of a nearly even mix of coniferous and deciduous trees. Mixed forests vary widely in species composition and typically feature a mix of the species found in coniferous and deciduous forests. Mixed forest is the most extensive habitat type on NBAFS (Figure 2).

Old fields are early successional areas that are usually dominated by grasses and forbs. Most of the old field habitat on NBAFS is in three areas: the Shooting Field, the area south of Green Tree Reservoir, and the area east of Joe English Hill (Figure 2). These areas are periodically mowed or burned to maintain them as early successional habitat. Species found in old fields on NBAFS include broomgrass (*Andropogon scoparius*), timothy (*Phleum pratense*), meadow fescue (*Festuca pratensis*), New York aster (*Aster novi-belgii*), Queen Anne's lace (*Daucus carota*), goldenrod (*Solidago* spp.), and fireweed (*Erechtites hieracifolia*). Some shrubs and small trees are also scattered throughout old fields and include autumn olive (*Elaeagnus umbellata*), multiflora rose (*Rosa multiflora*), red maple, paper birch (*Betula papyrifera*), and white pine.

A total of 228 wetlands were identified during a wetland survey of NBAFS (PES 1996). A variety of wetland types occurs on NBAFS including forested, emergent, scrub-shrub, riverine, lacustrine, and mixed wetland types. Some wetland areas (Figure 2) were identified as open water in LaGory et al. (1997). Descriptions of wetland types are given in Section 2.3.

2.2 WATER RESOURCES

NBAFS contains a number of open water features and intermittent and perennial stream segments (Figure 1). The approximate area of the station's larger water bodies (including associated wetlands) are Seavey Pond, 0.5 ac (0.2 ha); Gardner Pond, 6.0 ac (2.4 ha); Green Tree Reservoir, 7.5 ac (3.0 ha); Joe English Pond, 20 ac (8 ha); Ice Pond, 2.8 ac (1.1 ha); and Roby Pond, 0.8 ac (0.3 ha) (Najjar 1998). Ponds range in depth between 1 and approximately 23 ft (0.3 and 7.0 m). The only known water quality problem in these impoundments is an increase in coliform bacteria during dry periods in the summer (Najjar 1998).

Joe English Pond, in the center of NBAFS, is the largest water body on the station (Figure 1). Removal of Joe English Pond Dam in 2010 lowered the water surface elevation to

approximately 498 ft (152 m) MSL and reduced the open water area to approximately 20 ac (8 ha). The dam had raised the water surface elevation of Joe English Pond by approximately 5 ft (1.5 m) above its natural elevation and increased the size of the pond to approximately 50 ac (20 ha). Figure 1 shows the areas of Joe English Pond that had been open water prior to the removal of the dam. Maximum depth of the pond is now about 23 ft (7.0 m). A gravel road causeway crosses the marsh north of Joe English Pond. Culverts convey streamflow from areas north of the causeway. Joe English Pond was designated by the State as a Class B water and considered suitable for swimming and other recreation, fish habitat, and, after adequate treatment, use as a water supply (PES 1995). UXO on the pond bottom currently precludes recreational use of the pond (ANL 2004a). After the pond level was lowered in 2010, exposed UXO was removed from substrate surfaces in previously inundated portions of the pond.

Streams on NBAFS include those that flow into Joe English Pond from the wetland areas of Murphy Swamp, Gardner Pond, Beaver Pond No. 1 (also referred to as "SATCOM Pond"), Deer Pond, and Ice Pond. Drainage from Joe English Pond flows southeast in Joe English Brook, which exits the station boundary about 1 mi (1.6 km) downstream of the pond. Joe English Brook is the largest onsite stream. It ranges from 10 to 20 ft (3 to 6 m) wide and between 2 and 5 ft (0.6 and 1.5 m) deep (PES 1995). Joe English Brook is designated as a Class B water by the state (PES 1995).

There are three watersheds on NBAFS (Figure 3). Most of NBAFS is located within the Joe English Brook watershed which flows towards the southeast. About half of the Operations Area is within the Bog Brook watershed which flows towards the northwest. Drainage from the northwestern portions of the station flows off site towards the west and north in the Meadow Brook watershed.

There are no permitted water pollution point sources on NBAFS. The station's wastewater treatment plant was replaced with a septic system in 2004 (ANL 2004b). Prior to developing the septic system, effluent from the wastewater treatment plant was discharged to Beaver Pond No. 1, which eventually drains into Joe English Pond (Najjar 1998). Industrial and sanitary wastewater from the Operations Area was collected by a sewer system and routed to the station's wastewater treatment plant. The plant provided primary treatment and extended aeration treatment and disinfection.

2.3 WETLANDS

A wetland delineation performed in 1995 and 1996 identified 228 wetland areas totaling 198 ac (80 ha) located within the boundaries of NBAFS (PES 1996). Wetland complexes were identified in the central portion of NBAFS associated with Joe English Pond; in the southeast associated with Joe English Brook and Wells Bog; along West Meadow Road south of Joe English Hill; along the Ice Pond drainage; and in the east central portion of the station associated with Green Tree Reservoir (Figure 4). Most of the wetlands identified were classified as

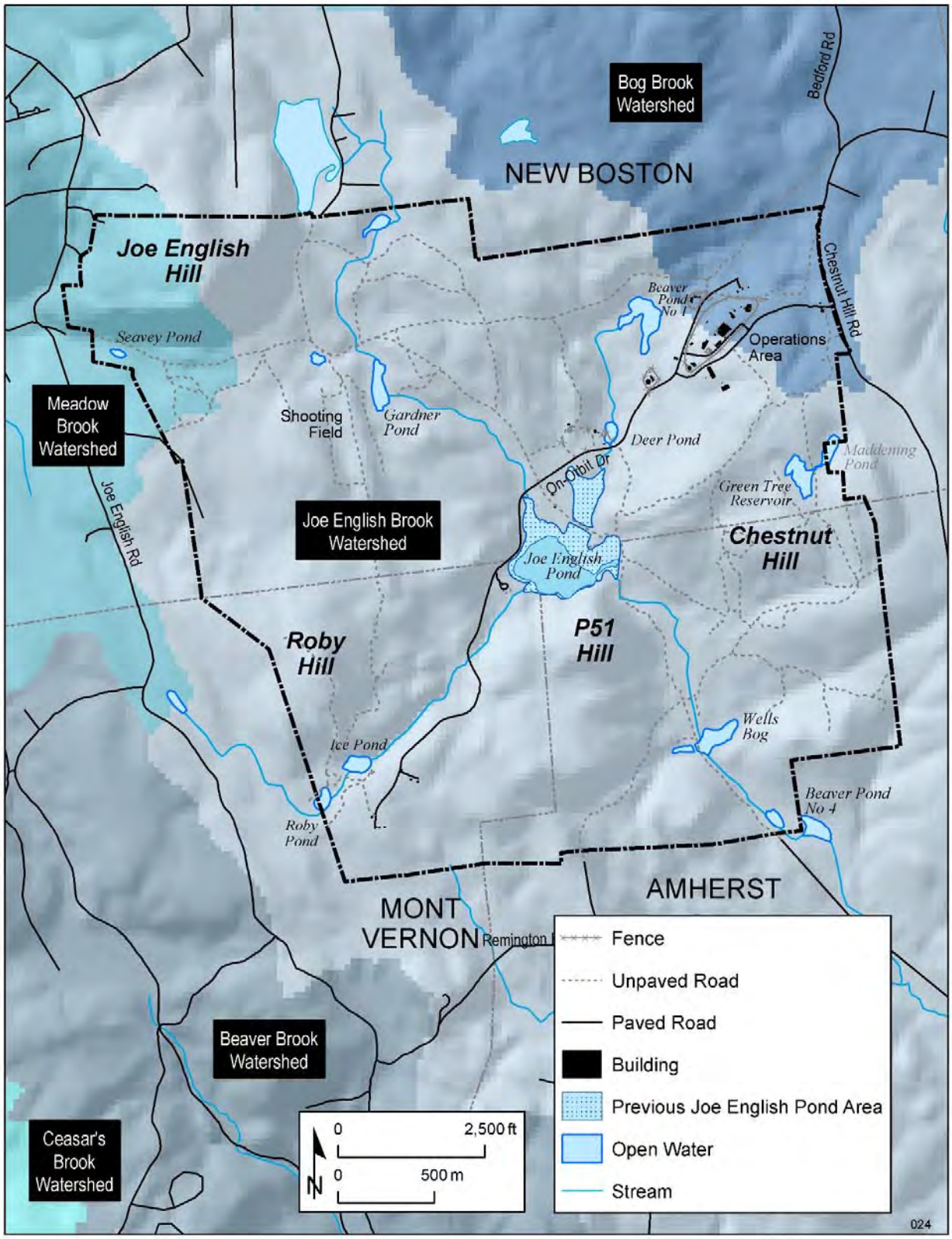

FIGURE 3. Watersheds of New Boston Air Force Station, New Hampshire. Watersheds are shown in shades of blue and gray (Source: LaGory et al. 2006, modified to show current Joe English Pond boundary).

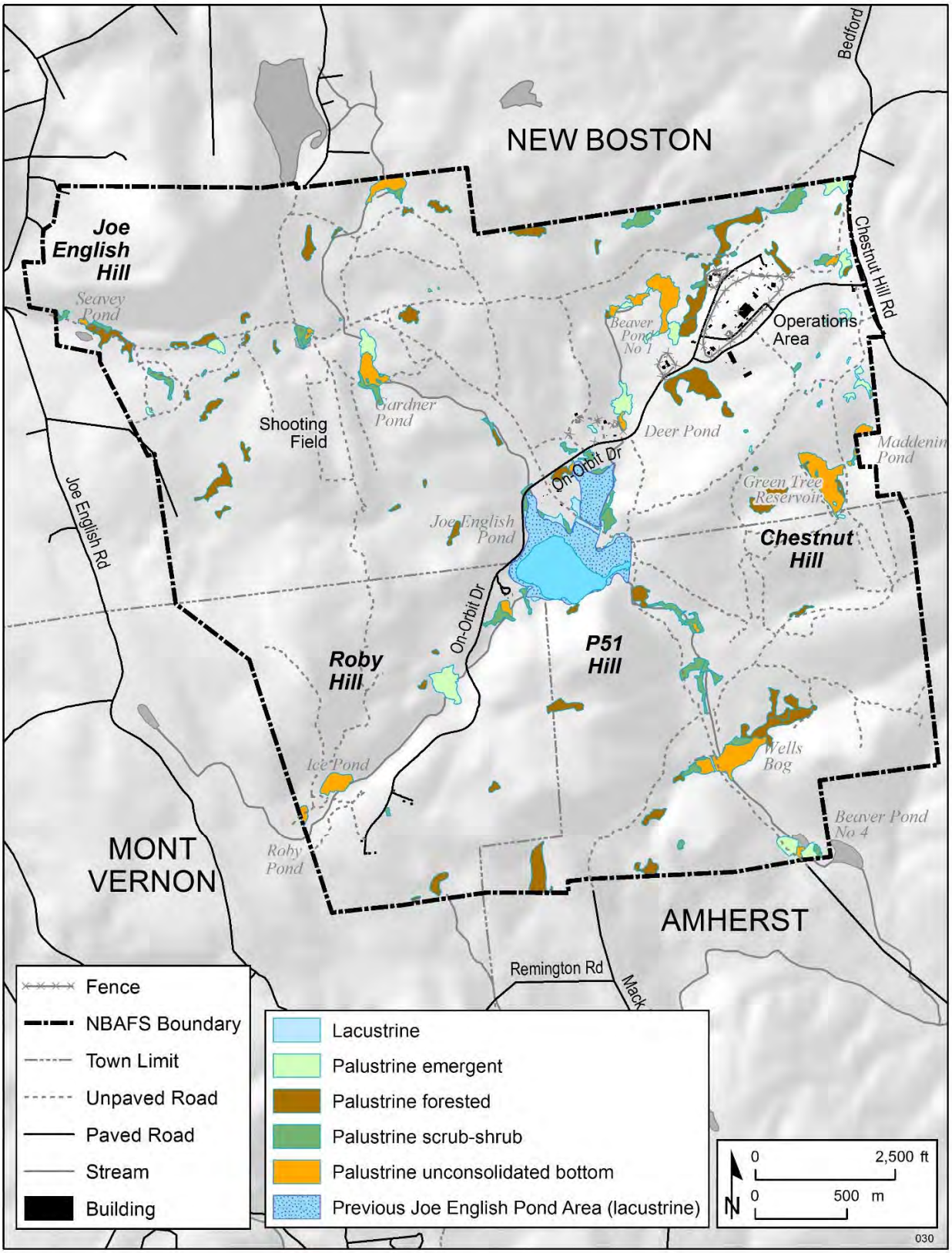

FIGURE 4. Wetlands of New Boston Air Force Station, New Hampshire (Source: PES 1996 modified to show current Joe English Pond boundary).

palustrine forested wetlands (60.4 ac [24.5 ha]) using the Cowardin et al. (1979) system of classification (PES 1996). Other wetland types on NBAFS include palustrine mixed (35.9 ac [14.5 ha]), palustrine open water (35.2 ac [14.3 ha]), palustrine scrub shrub (13.1 ac [5.3 ha]), and palustrine emergent wetlands (10.7 ac [4.3 ha]; PES 1996).

Wetland species on NBAFS include cattail (*Typha latifolia*), sedges (*Carex* spp.), rushes (*Juncus* spp.), Virginia chain fern (*Woodwardia virginica*), pitcher plant (*Sarracenia purpurea*), meadowsweet (*Spiraea alba*), boneset (*Eupatoreum perfoliatum*), button-bush (*Cephalanthus occidentalis*), leatherleaf (*Chamaedaphne calyculata*), yellow pondlily (*Nuphar lutea*), Oake's pondweed (*Potamogeton oakesianus*), sphagnum moss (*Sphagnum* spp.), sweet gale (*Myrica gale*), three-way sedge (*Dulichium arundinaceum*), red maple, and black gum (*Nyssa sylvatica*). Wetland monitoring has been conducted on NBAFS annually since 2003 to determine current conditions, existing disturbance, and potential threats.

Wetland complexes occur on NBAFS in the central portion of the station in and around Joe English Pond; in the southeast associated with Joe English Brook and Wells Bog; around Beaver Pond No. 1 (SATCOM Pond) in the northeast; and along West Meadow Road south of Joe English Hill (Figure 4; PES 1996). Other wetland complexes include those associated with the drainage between Ice Pond and Joe English Pond in the southwest and the Green Tree Reservoir system in the east central portions of NBAFS, respectively.

A total of 116 palustrine forested wetlands occupying about 60 ac (24 ha) were identified in the wetland survey (PES 1996). Forested wetlands typically contain an overstory of trees, an understory of saplings or shrubs, and an herbaceous layer (Cowardin et al. 1979); the canopy can be deciduous, coniferous, or mixed forest types. Irregular topography, the forested nature of the station and, in particular, the extensive evergreen forests found in large areas of NBAFS suggest that there may be numerous, isolated forested wetlands that were not identified with the photographic techniques used in the survey (PES 1996).

There are 21 palustrine emergent wetlands on NBAFS that occupy a total of 11 ac (4.3 ha); many of these have been influenced by beaver activities (PES 1996). Emergent wetlands are characterized by erect, rooted, herbaceous wetland plants that are present for most of the growing season. At NBAFS, the emergent wetlands are predominantly persistent, dominated by vegetation that normally remains standing through the winter months (PES 1996).

Thirty-one palustrine scrub-shrub wetlands totaling 13 ac (5.3 ha) occur on NBAFS (PES 1996). This type of wetland is dominated by short woody vegetation, and can include young trees or true shrubs. Often, the scrub-shrub community is a successional stage leading toward a forested wetland (Cowardin et al. 1979).

Thirty-three mixed wetlands totaling 36 ac (15 ha) occur on NBAFS. Mixed wetlands contain a variety of vegetation types that prevents a simple classification (e.g., combination of forested and scrub-shrub wetland types). The most common mixed wetlands were a combination of scrub-shrub and emergent marsh wetland types and scrub-shrub and forested wetlands (PES 1996).

NBAFS contains 24 open-water wetlands (palustrine unconsolidated bottom) totaling 35 ac (14 ha; PES 1996). These wetlands are characterized by open water with less than 30% vegetative cover (Cowardin et al. 1979). The open-water wetlands include ponds with relatively steep bottom slopes and little wetland vegetation, or naturally occurring and beaver-created ponds with an abundance of emergent vegetation. Wells Bog and Beaver Pond No. 1 are examples of open water habitats edged by emergent, scrub-shrub or mixed wetland environments (PES 1996). Vernal ponds and other depressions (potentially remnant bomb craters) provide other small open-water bodies (PES 1996).

One riverine wetland (stream segment between Deer Pond and On-Orbit Drive), totaling 0.1 ac (0.04 ha), occurs on NBAFS. Most other stream segments were classified as forested or scrub-shrub wetlands on the basis of the dominant shoreline vegetation. Only one lacustrine system (the deep water portion of Joe English Pond) totaling 43 ac (17 ha) was identified (PES 1996). With removal of Joe English Pond Dam, this system now totals 20 ac (8 ha).

3 METHODS

Between October 17 and 21, 2011, we surveyed 15 wetlands on NBAFS (Figure 5) for evidence of impacts from erosion of developed or disturbed lands, especially roads, and other potential threats (e.g., nonnative invasive plant species). Wetlands adjacent to roads, developed areas, and disturbed areas were evaluated for existing or potential erosion-related impacts. A number of parameters were examined at these wetlands and in adjacent areas including (1) evidence of existing sedimentation and erosion into wetland areas; (2) source of sediment; (3) slope; (4) soil type; (5) surrounding land cover; (6) presence and extent of intervening non-erosive land (e.g., vegetated surface, pavement); (7) water source (surface runoff, groundwater); and (8) frequency and nature of erosion events.

During the survey of each wetland, we walked the wetland perimeter and noted all locations of inflow from surrounding upland areas. Topographic maps of each wetland area were consulted for information regarding slopes and potential sources of flows. Although ephemeral flows were generally not present during the survey, we looked for and recorded evidence of previous flows. We recorded all locations of inflows, including areas of erosion and sedimentation, using a hand-held global positioning system (GPS) receiver (Garmin GPSMAP 60CSx) that had an accuracy of approximately +/- 3 m.

Existing NBAFS topographic information was used to determine the watershed of each wetland and develop a watershed-based evaluation. Erosion problems at specific locations were ranked according to risk (including probability of occurrence, magnitude of effect, and severity of effects). A geographical information system (GIS) layer showing risk from erosion was developed and used as the basis for developing restoration plans.

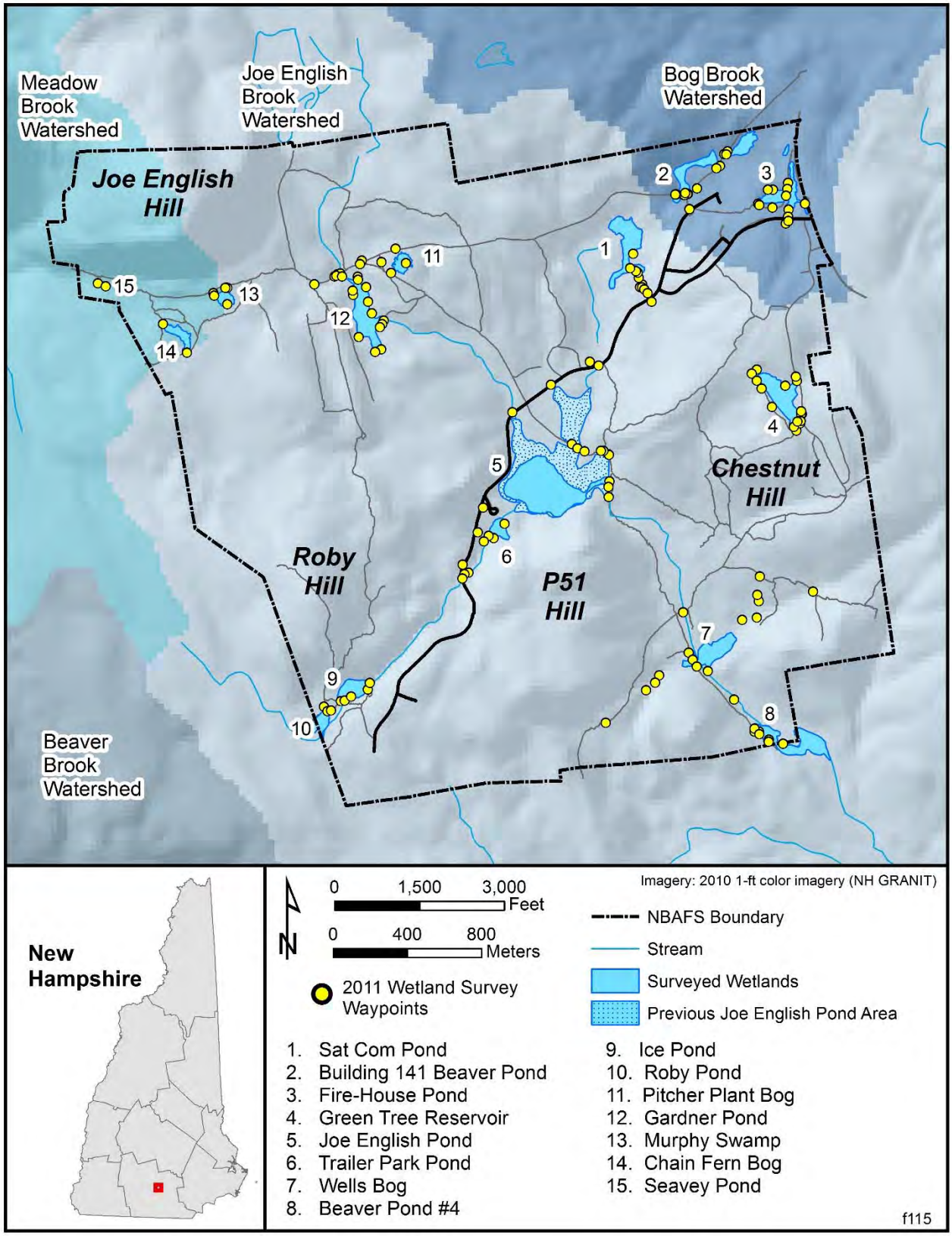

FIGURE 5. Wetlands Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

4 RESULTS

The wetlands we surveyed in 2011 are described in this section. Included are general wetland characteristics, including their hydrogeomorphic characteristics, inflows, surrounding soil characteristics, and any evident or potential sources of erosion or sedimentation. Where applicable, wetlands included in this survey that have also been identified as rare natural communities and described in LaGory et al (2011) are noted.

The results of the 2011 survey are summarized in Table 1, including a summary conclusion regarding the potential risk of erosion impacts. Impact potential is defined as follows:

- High: current threats that threaten the function and stability of the wetland;
- Moderate: Current threats that degrade the quality of the wetland but does not threaten function or stability of the wetland;
- Low: Minor or no current threats to the wetland;
- Very low: No current or potential threats observed.

Data sheets from the survey can be found in the Appendix and a catalogue of photos at different locations are provided separately. Specific locations described in the text are shown as waypoints (WPTs) on figures. Although some WPTs are not described in the text, they are the locations of photos and notes that are provided as supplemental materials.

4.1 SATCOM POND

This wetland, known locally as SATCOM Pond and Beaver Pond #1, is located in the northeastern part of NBAFS, northwest of On-Orbit Drive and directly north and east of the SATCOM facility (Figure 6). Two large beaver dams, located at the northwest and southwest areas of the pond, maintain water elevations in the pond.

Most of this wetland consists of open water, supporting a community of floating aquatic species such as fragrant water lily (*Nymphaea odorata*) and water-shield (*Brasenia schreberi*), and areas of emergent marsh with bur-reed (*Sparganium americanum*), manna-grass (*Glyceria* sp.), common cattail (*Typha latifolia*), wool-grass (*Scirpus cyperinus*), sedges (*Carex comosa*, and others), aster (*Aster* sp.), grass-leaf goldenrod (*Euthamia graminifolia*), bluejoint grass (*Calamagrostis canadensis*), spikerush (*Eleocharis acicularis*), pickerel weed (*Pontederia cordata*), and soft rush (*Juncus effusus*) (Figure 7). A large area of emergent marsh is also located in the southeast part of the wetland, with water levels maintained by a low beaver dam (WPT 294). The south portions nearest to the inlet stream are composed of a mosaic of tree and shrub swamp with relatively low canopy cover (WPT 291, 292, and 293). Tree and shrub species include red maple, gray birch, white pine, hemlock, red oak, meadowsweet, maleberry (*Lyonia ligustrina*), and highbush blueberry. Common herbaceous species include sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnamomea*), New York fern (*Thelypteris noveboracensis*), sedges, and short-husk (*Brachyelytrum* sp.). These tree, shrub, and herbaceous species also occur around the pond perimeter on wet soils. A small open area, possibly excavated, with shallow water at the time of the survey, impounded by a small beaver dam and dirt/rubble pile, is located on the southwest

TABLE 1. Summary Characteristics of Wetlands Surveyed in October 2011 on New Boston Air Force Station, New Hampshire

Wetland	Type	Watershed	Nearby Roads	Current and Potential Threats	Impact Potential
SATCOM Pond (Beaver Pond No. 1)	Beaver pond	Joe English Brook	On-Orbit Drive	Runoff from SATCOM parking lot and minor erosion of intervening mowed area. Small population of nonnative invasive purple loosestrife and potentially invasive native common cattail.	Low
Building 141 Beaver Pond	Beaver pond	Bog Brook	East Meadow Road, Building 141 service road	Severe erosion of steep service road. Poor condition and saturation of East Meadow Road especially at causeways. Blocked culverts along East Meadow Road. Small population of nonnative invasive purple loosestrife.	High
Fire-House Pond	Beaver pond	Bog Brook	Galaxy Way, Chestnut Hill Road, unnamed dirt roads	Minor erosion near culverts and swales along Galaxy Way and Chestnut Hill Road that carry flow to wetland. Large population of common cattail in marsh adjacent to causeway, and small population of nonnative invasive purple loosestrife.	Low
Green Tree Reservoir	Manmade impoundment	Joe English Brook	Unnamed gravel road, unnamed dirt road	Minor erosion near inlet culvert and deterioration of south berm resulting in water overflow. Potential for runoff from gravel road surface on eastern side of wetland. Small population of nonnative invasive purple loosestrife.	Low
Joe English Pond	Pond/marsh	Joe English Brook	On-Orbit Drive, Brook Road	Substantial erosion of Brook Road and causeway; minor erosion at inlet stream culverts along On-Orbit Drive; hydrology of the pond is altered by the causeway; substantial disturbance of exposed wetland soils resulting from UXO remediation activities. Small populations of nonnative invasive purple loosestrife and potentially invasive common cattail.	High
Trailer Park Pond	Beaver pond	Joe English Brook	On-Orbit Drive, unnamed paved road	Minor erosion at culverts along On-Orbit Drive that carry flow to wetland.	Very low

Table 1 (Cont.)

Wetland	Type	Watershed	Nearby Roads	Current and Potential Threats	Impact Potential
Wells Bog	Beaver pond	Joe English Brook	Brook Road, Mack Hill Road, unnamed gravel road	Poor condition and saturation of causeway; moderate erosion of Brook Road near wetland, and at dirt and gravel road crossing of stream flowing to northeastern arm of wetland; minor erosion at Mack Hill Road crossing of Joe English Brook and small inlet streams that pass through culverts under Mack Hill Road.	Moderate
Beaver Pond No. 4	Beaver pond	Joe English Brook	Brook Road	No erosion into wetland observed. Potential future concern at inlet of Joe English Brook where fast current flows along base of Brook Road.	Very low
Ice Pond	Manmade impoundment	Joe English Brook	Unnamed gravel roads	Substantial erosion of picnic area access road. Moderate erosion of adjacent campground road surfaces to pond at several locations.	High
Roby Pond	Manmade impoundment	Joe English Brook	Unnamed gravel road, unnamed dirt road	No erosion or potential for erosion into wetland observed.	Very low
Pitcher Plant Bog	Basin swamp	Joe English Brook	Campbell Road, unnamed gravel road	No erosion or potential for erosion into wetland observed.	Very low
Gardner Pond	Manmade impoundment	Joe English Brook	West Meadow Road, Campbell Road, East Meadow Road, unnamed gravel road	Moderate erosion at West Meadow Road bridge crossing of inlet stream; minor erosion at other inlet locations including East Meadow Road, Campbell Road, and Shooting Field Road.	Moderate
Murphy Swamp	Fen/bog	Joe English Brook	West Meadow Road, Gate 15 road	Minor erosion of West Meadow Road shoulder near wetland inlet stream, although no sedimentation of wetland observed.	Low to moderate
Chain Fern Bog	Fen	Joe English Brook	Gate 15 road, unnamed dirt road	No erosion into wetland observed; low potential for sediment input from road to Gate 15.	Very low
Seavey Pond	Manmade impoundment	Meadow Brook	West Meadow Road, unnamed gravel road	Substantial erosion of campground road surface especially at inlet stream crossing. Previous repairs are temporary and unlikely to prevent problems in future; minor erosion at other locations along the pond.	High

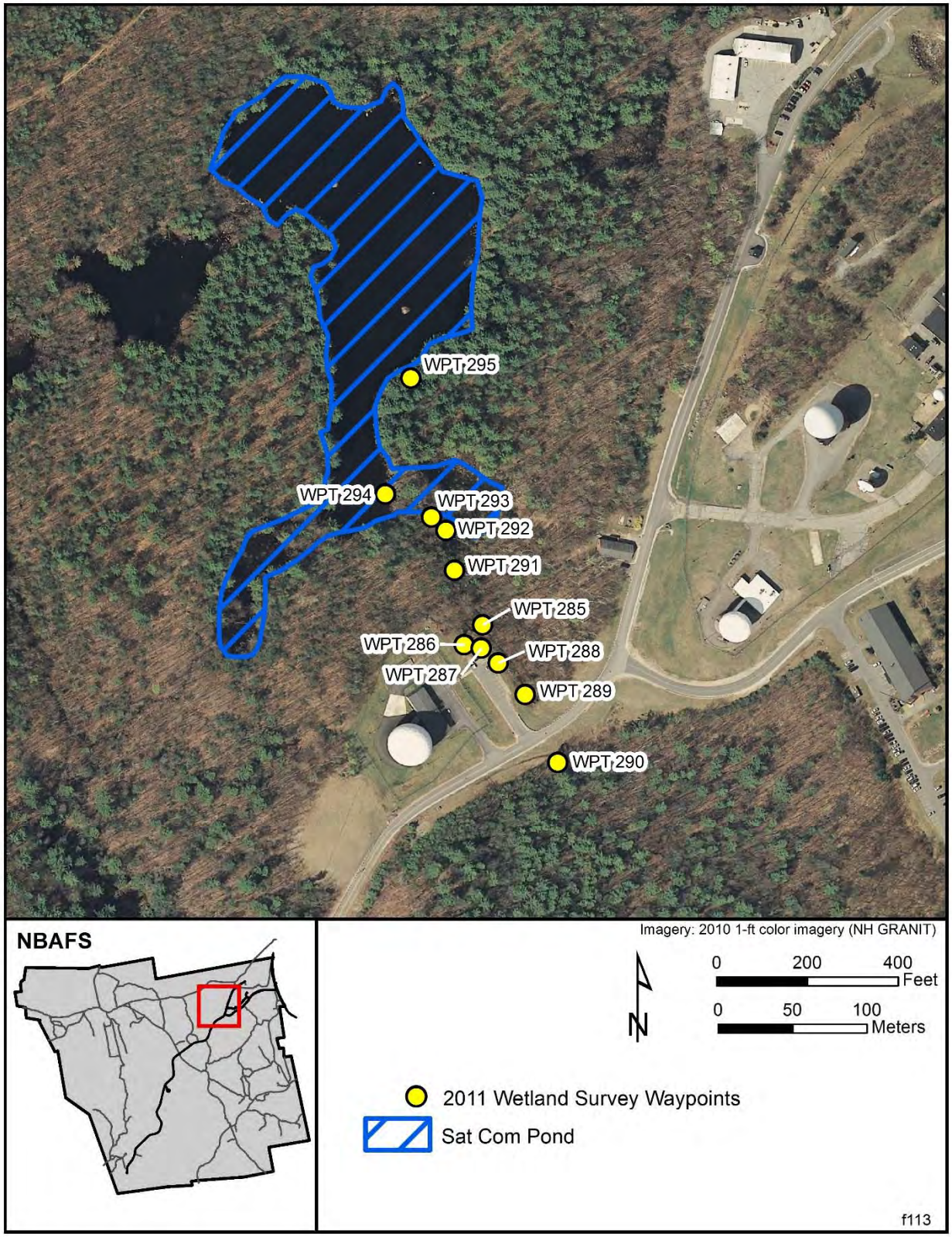

FIGURE 6. SATCOM Pond, Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

FIGURE 7. Wetland Communities in SATCOM Pond (WPT 294).

side of the wetland and supports a stand of common cattail (WPT 285). This pool receives inflows from a storm drain (WPT 286).

Purple loosestrife (*Lythrum salicaria*), a nonnative invasive plant species, was observed over a fairly wide area in the southern, wooded portion of the wetland. There appeared to be a low level of establishment of this species in the wetland and a relatively small population at the time of the survey. This species may pose a threat if population levels continue to grow and expand. Common cattail, a potentially invasive native species, was also observed, particularly in the small impoundment on the southeast.

SATCOM Pond is in the Joe English Brook watershed. The primary inflow to SATCOM Pond is an unnamed stream that flows from the south under On-Orbit Drive (WPT 289 and 290). A series of small beaver dams and gentle slope to the north has resulted in the development of multiple channels through the wooded area northeast of the SATCOM facility (WPT 291, 292, and 293). No other inflows were noted during the survey. Considerable surface runoff however, appears to come from the paved and mowed areas around the SATCOM facility. Slopes around

most of the wetland are moderate; however, steep slopes occur just below the shoulder of On-Orbit Drive, above and near the culvert, as well as areas adjacent to the SATCOM facility.

Soils in the area around the inlet are Woodbridge Stony Loam, 8-15% slope; along the west and northeast perimeter soils are Canton Stony Fine Sandy Loam, 3-8% slope; on a small part of the northwest perimeter soils are Canton Stony Fine Sandy Loam, 15-25% slope; and along the southeast perimeter soils are Paxton Stony Fine Sandy Loam, 8-15% slope.

The surrounding woodland is mixed evergreen/deciduous, with gray birch, hemlock, white pine, alder (*Alnus* sp.), yellow birch (*Betula alleghaniensis*), juniper (*Juniperus* sp.), witch hazel, mountain laurel, lowbush blueberry, and bracken fern. Mowed lawns of the SATCOM and main Operations Area are located beyond a narrow margin of woodland to the south and east.

The gravel shoulder of On-Orbit Drive was firm and in generally good condition, with some areas of loose gravel; however, no evidence of sedimentation into the wetland was observed. A wide vegetated margin separates the road shoulder and inlet stream. Some sediment input was observed originating from the margin of the SATCOM asphalt parking area, which receives runoff from On-Orbit Drive. The sloped margin of the parking lot is sparsely vegetated on the north and northwestern sides (WPT 287) and in areas adjacent to the pavement along the northeastern side (WPT 288). Soils in these adjacent areas consist of fine sand and gravel. Most of the northeastern slope is well-vegetated mowed turf grass. Erosion on the top and along the sides of the slopes was evident (Figures 8; WPT 287), with sediments transported primarily to the small excavated pool to the north (WPT 285), and small amounts to the woodland to the northeast. The well-established population of cattails, tolerant of degraded habitats, may be related to the sediment input to the impounded area. The inlet stream and wooded wetland areas could receive minor sediment inputs, but the potential for impacts from erosion or sedimentation in this wetland is currently considered to be low.

FIGURE 8. Erosion and Evidence of Sheet Flow on SATCOM Parking Lot Slope.

4.2 BUILDING 141 BEAVER POND

Building 141 Beaver Pond is a large wetland complex that consists of a series of ponds created by beavers. It is located in the northeast area of NBAFS, north of Building 141 and the Operations Area (Figure 9). Much of the wetland is situated to the north and northwest of East Meadow Road, with a large portion southeast of the road; within the station boundary, the road crosses the wetland in two locations, at an east (WPT 201, 203) and west (WPT 195, 197) causeway. The service road from the Building 141 storage lot runs east a short distance along the top of the slope and then turns north, proceeding down the slope towards East Meadow Road.

Shallow water areas of the wetland support an emergent marsh community of bur-reed, manna-grass, wool-grass, rush (*Juncus* sp.), three-way sedge, and bluejoint grass, with fragrant water lily and spatterdock (*Nuphar lutea*) over most of the pond (Figure 10). White pine saplings, red maple, and hemlock occur on saturated soils along the margin, along with mountain laurel and meadowsweet. These species also form a dense scrub-shrub wetland community east of the eastern causeway. A large number of standing dead trees were observed in the pond. A dense marsh community located at the eastern crossing of East Meadow Road is dominated by common cattail and includes wool-grass, sedges (*Carex* spp.), bur-reed, and meadowsweet. A few individuals of nonnative invasive purple loosestrife occur near the south margin of the wetland.

Water levels in the ponds are maintained in large part by beaver dams, although a culvert at the east crossing under East Meadow Road, observed during our survey to be blocked by beaver activity, also contributes to water levels. Adjacent slopes to the north are moderately steep. Nearby slopes to the south are extremely steep, with a narrow margin of level ground between the slope and East Meadow Road. This slope is located directly northwest of On-Orbit Drive. This portion of NBAFS is in the Bog Brook watershed, which drains to the northeast. Inflows to the wetland complex are located to the north and west. Flows through the wetland move eastward and pass under East Meadow Road at the eastern causeway (WPT 201, 203), then continue northeast and cross the station boundary near the northeastern corner. East Meadow Road slopes moderately down from the east and west toward the wetland, with low points at the two causeways. The west causeway isolates a small southwest portion of the pond. The northeast portion of East Meadow Road is elevated above the wetland area to the southeast.

Soils are primarily Greenwood Mucky Peat, to the northeast is Canton Stony Fine Sandy Loam, 8-15% slope, along the perimeter north and west is Canton Very Stony Fine Sandy Loam, 15-35% slope, to the southwest is Canton Stony Fine Sandy Loam, 3-8%, and to the southeast is Chatfield-Hollis-Canton Complex 8-15% slope. The surrounding woodland is mixed evergreen/deciduous, with white pine, red maple, yellow birch, gray birch, red oak, beech, and witch hazel.

The road surface of East Meadow Road is gravel and in generally poor condition, but receives little use. While there was evidence of sheet flow and minor erosion on the road slopes approaching the east causeway (Figure 11; WPT 201, 202), the road slope from the west approaching the west causeway (WPT 198) had evidence of greater erosion, including gullies. Some sediment deposition into the wetland from east and west of the east causeway was observed (WPT 201, 203). Little evidence of sediment washing into the wetland from the west of

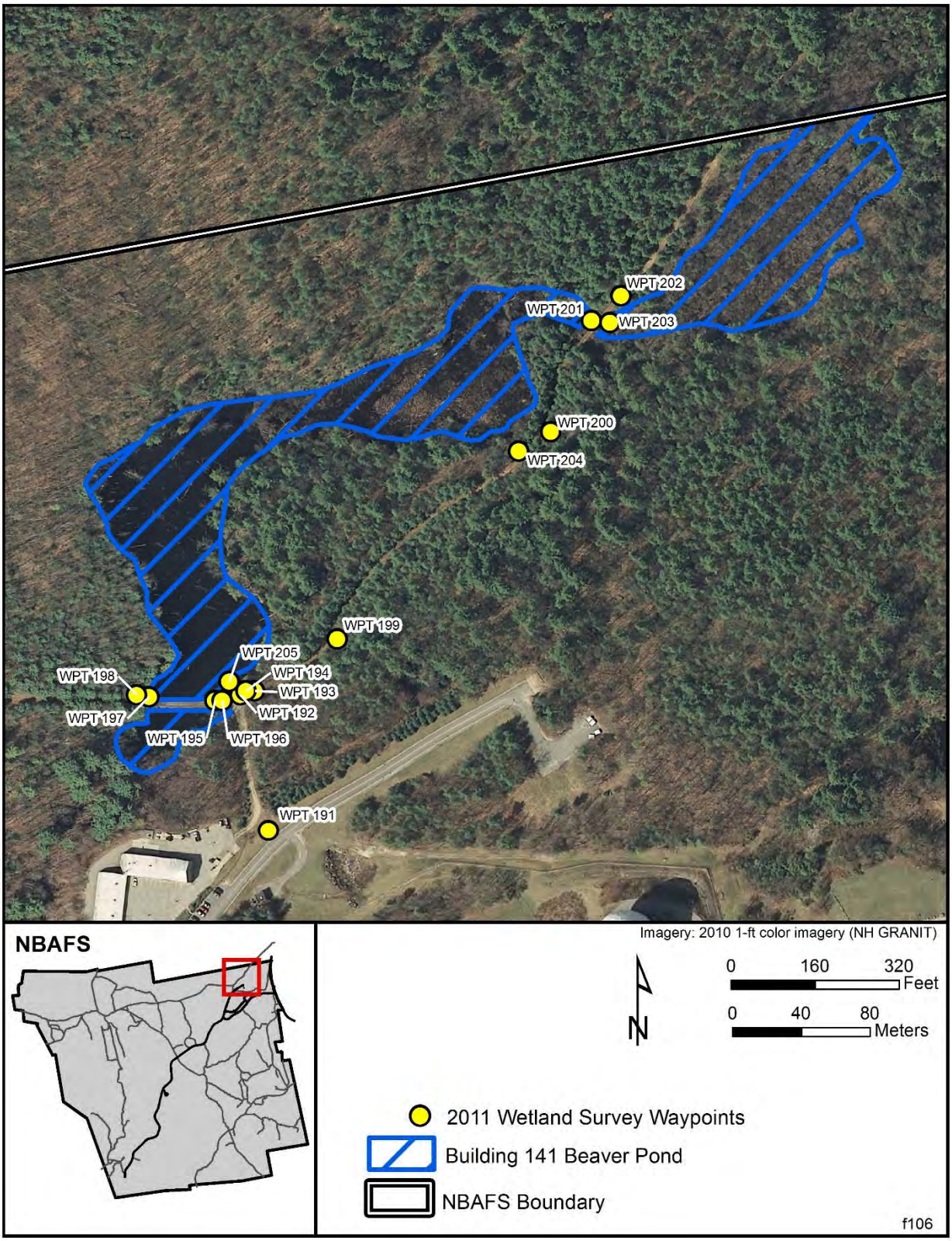

FIGURE 9. Building 141 Beaver Pond Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

FIGURE 10. Building 141 Beaver Pond, View from West Causeway.

the west causeway (WPT 198) was observed despite the erosion of the East Meadow Road surface, however, the potential for deposition appeared to exist. The road surface appeared relatively stable in most other areas. The east causeway had considerable vegetation cover with a stable surface.

Water was observed on East Meadow Road at three locations, with flows over the road surface at two of these (Figures 12 and 13; WPT 193 and 200) and shallow standing water on the west causeway (WPT 195). Flows across the surface of East Meadow Road were observed in two locations. The first location was just to the east of the intersection with the Building 141 service road (WPT 193) where a slight flow originated from a small ponded area just south of the road, flowed onto the road surface a short distance to the west (Figure 12), and drained north through a narrow strip of trees into the pond (a metal pipe seen at this location extending under the road and into the wetland conveyed a very small flow; WPT 194). The second location was farther east where a small stream originating from the slopes to the south was blocked by an obstructed culvert (WPT 204), and resulted in a large area of the road surface being flooded up to6-in. (15-cm) deep. This flooded portion of the road drained across a narrow wooded strip and into the pond (Figure 13; WPT 200). There was evidence of erosion at the two locations of active

FIGURE 11. Evidence of Sheet Flow on East Meadow Road, Sloping toward the East Causeway (WPT 202).

FIGURE 12. Water Flowing across East Meadow Road toward Building 141 Beaver Pond, Near the Building 141 Service Road Intersection (WPT 193).

FIGURE 13. Stream Crossing East Meadow Road, Draining into Building 141 Beaver Pond (WPT 200).

water flow across the road with sediment deposition into the wetland from the road as well as soil that had been placed by beavers at the west location. Minor instances of erosion at the causeway margins were also observed (WPT 203), with sediment entering the wetland. At the causeways, the road surface is about 1 ft (0.3 m) from the pond margin.

The service road from Building 141 is composed of rock and gravel and is severely eroded over nearly the entire road surface (Figure 14; WPT 191). Numerous gullies cut the road surface and a considerable amount of eroded gravel and sediment from the road has been deposited onto East Meadow Road (WPT 192) and into the wetland (WPT 196, 205) (Figure 15). There was evidence that rain events typically result in the transport of sediment down the slope, with larger events resulting in the deposition of sediment and gravel into the wetland (Figure 15). The potential for continued impacts from erosion or sedimentation in this wetland is considered to be high, and results primarily from erosion of sediment from the service road, and the poor condition of East Meadow Road.

FIGURE 14. Service Road Leading from the Building 141 Storage Yard (WPT 191).

FIGURE 15. East Meadow Road Western Causeway Showing Eroded Material from Service Road (WPT 192, left and WPT 196, right).

4.3 FIRE-HOUSE POND

This wetland, known locally as Fire-House Pond, is located in the northeastern part of NBAFS, directly north of Galaxy Way and the NBAFS Fire House (Building 103) (Figure 16). Chestnut Hill Road is located a short distance to the east. A causeway running north and south through the wetland is part of a buried utility right-of-way. This wetland is formed primarily by a series of beaver dams.

Fire-House Pond includes several distinct wetland communities. Wooded wetlands with a relatively open tree canopy occur at the south end (WPT 251) where the inlet stream enters under Galaxy Way and at the north end where the stream exits the wetland near the station boundary (WPT 248). Red maple and white pine are the dominant trees of the canopy and understory in these communities which appear to have been recently flooded as a result of beaver activity. Maleberry, meadowsweet, highbush blueberry, and sheep laurel (*Kalmia angustifolia*) form the shrub layer along with saplings of canopy tree species. Emergent marsh occurs on both sides of the causeway (WPT 250). A small population of nonnative invasive purple loosestrife occurs in the marsh; this species may pose a threat if population levels continue to grow and expand. A large population of common cattail occurs in the marsh west of the causeway (Figure 17). Additional species in both marsh communities include bur-reed, wool-grass, marsh fern, sensitive fern, and bluejoint grass. The eastern marsh supports scattered shrubs, including maleberry and highbush blueberry, in shallow-water areas. Small areas of open water, primarily west of the causeway, support floating aquatic species such as fragrant water lily.

The primary inlet stream flows into Fire House Pond from Chestnut Hill to the south, following a relatively steep gradient (WPT 258). This stream passes through a large culvert under Galaxy Way (WPT 257). A minor inflow in a roadside ditch was observed from a second smaller culvert under Galaxy Way to the east of the primary inlet stream, passing along a parking area and Chestnut Hill Road and downslope to the south end of the wetland (WPT 260). The

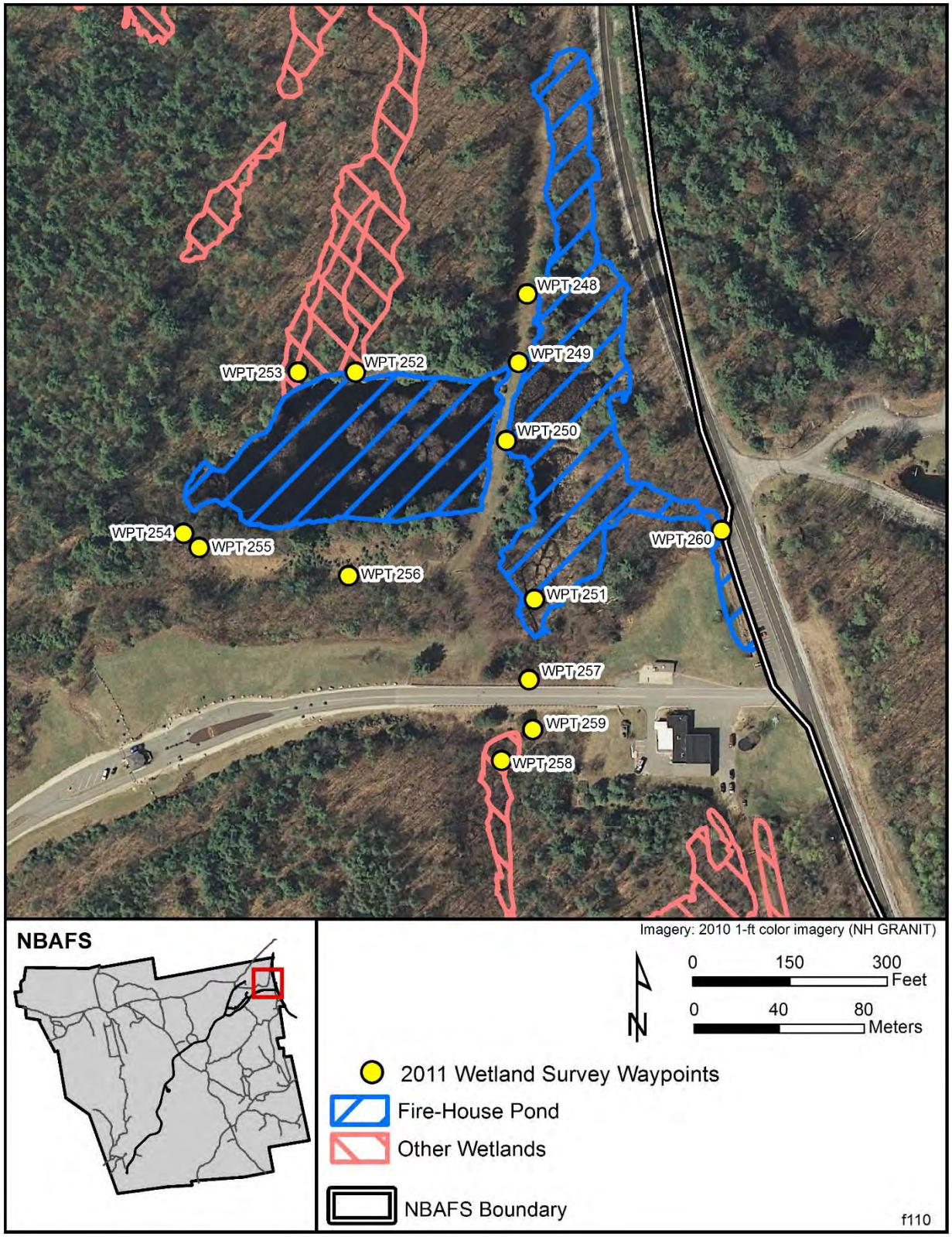

FIGURE 16. Fire-House Pond, Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

FIGURE 17. Fire-House Pond, View West from Causeway (WPT 250).

slopes immediately to the south (including the embankment along Galaxy Way) and west are very steep, as is the sloped bank along Chestnut Hill Road to the east, sloping toward the wetland. One of the two outflows runs to the north, east of the causeway (WPT 248), where the ground slopes gently away. At the time of the survey, there was some erosion where the outflow stream crosses the access road through a culvert. To the northwest, the land slopes steeply away, where a large beaver dam is located at the second outflow from the marsh to the west of the causeway (WPT 252 and 253). Fire-House Pond is in the Bog Brook watershed.

Soils to the west and northwest belong to the Chatfield-Hollis-Canton Complex, 8-15% slope, to the south Chatfield-Hollis-Rock Outcrop Complex, 15-35% slope, and to the east Paxton Fine Sandy Loam, 8-15% slope.

The woodland surrounding Fire-House Pond is mixed evergreen/deciduous, with white pine, red maple, hemlock, red oak, black birch, gray birch, and witch hazel. Most slopes are wooded, however, upper portions of the adjacent slope south of the cattail marsh (WPT 256) have an herbaceous community. The utility right of way (WPT 248, 249, and 250), including the causeway, has a well-established grass cover that is periodically mowed and in good condition.

The road shoulder along Galaxy Way is generally well vegetated and stable. A small amount of sediment was observed entering the primary inlet stream at the north and south sides of the culvert. A drainage swale east of the creek carrying runoff from south of Galaxy Way to the creek had areas of exposed soil, however there was no obvious evidence of sediment transport into the stream (Figure 18). The upper part of the swale is located in an area of mowed grass while the lower portion is wooded. This swale appeared to carry strong flows at times, indicating a potential for intermittent sediment inputs to the stream. Woody plants in the ditch running along the parking area adjacent to Chestnut Hill Road had recently been cut and some erosion in the ditch was evident, as well as the slope directly north of the parking lot (Figure 19; WPT 260). Some input of sediment into the drainage leading downslope to the stream below was observed.

FIGURE 18. Swale South of Galaxy Way (WPT 259).

FIGURE 19. Roadside Ditch near Chestnut Hill Road that Drains to Fire-House Pond (WPT 260).

A dirt road runs from the west along the west and south sides of the marsh to the west of the causeway (WPT 254, 255, and 256). Most of the road surface around the south side of the marsh is grass-covered (WPT 256). However, the western portion of the road surface is mostly exposed gravel and dirt. Here the road is 33 ft (10 m) from the wetland. A section of the road surface in this area was flooded at the time of our survey (WPT 254), apparently as a result of seepage from the slope to the southwest. A small flow through a narrow wooded margin carried some fine sediment into the marsh. The potential for impacts from erosion or sedimentation in this wetland is considered to be low.

4.4 GREEN TREE RESERVOIR

Green Tree Reservoir is a manmade impoundment constructed by the U.S. Air Force in 1974, located in the eastern area of NBAFS (Figure 20). It is located approximately 18 ft (5 m) west of an unnamed gravel road that separates Green Tree Reservoir from Maddening Pond.

Spatterdock occurred in scattered shallow water areas of this mostly open water reservoir (Figure 21). Emergent marsh, including soft rush, manna-grass, bur-reed, and wool-grass occurred around the margin with a wide band along the eastern side of the reservoir. Red maple and white pine occurred on wet soils on the margin, along with leatherleaf and mountain laurel. A large white pine, about 2 ft (0.6 m) in diameter, was located on the western berm. Red maple seedlings also occurred in shallow marsh areas. A dense thicket of mountain laurel bordered the north side of the reservoir. A small population of nonnative invasive purple loosestrife occurs in this wetland; this species may pose a threat if population levels continue to grow and expand.

Water levels in the reservoir are maintained by an 8-ft (2-m) high earthen berm that extends along nearly the entire western side of the reservoir (WPT 184) and continues around the south side as a 5-ft (2-m) high berm (Figure 22, WPT 177). Green Tree Reservoir was a relatively shallow emergent wetland prior to construction of the berms. Green Tree Reservoir and Maddening Pond are connected by a culvert under the intervening road (WPT 179), but there was no apparent flow between the two water bodies at the time of the survey. Green Tree Reservoir is in the Joe English Brook watershed. Flows out of the reservoir occur at the south (WPT 190); in addition, seepage occurs from the base of the berm along the southwestern side (WPT 185). These flows continue as small streams to the south and west, respectively, although the western flow is discontinuous, lacking a defined channel. A failed water outflow structure is located in the pond on the southeast. Flows from the reservoir had previously exited through a pipe from the structure, which passed through the berm and discharged to the outflow channel (WPT 189). No flow was observed in the pipe during the survey, however, water was observed flowing over the southeast berm near the water control structure, into the outlet stream (WPT 284). The adjacent slope north of the reservoir is steep, draining to the reservoir (WPT 182), while the slopes to the east and south are relatively gentle. To the west and southeast, the ground elevation drops away from the reservoir, more steeply on the west side.

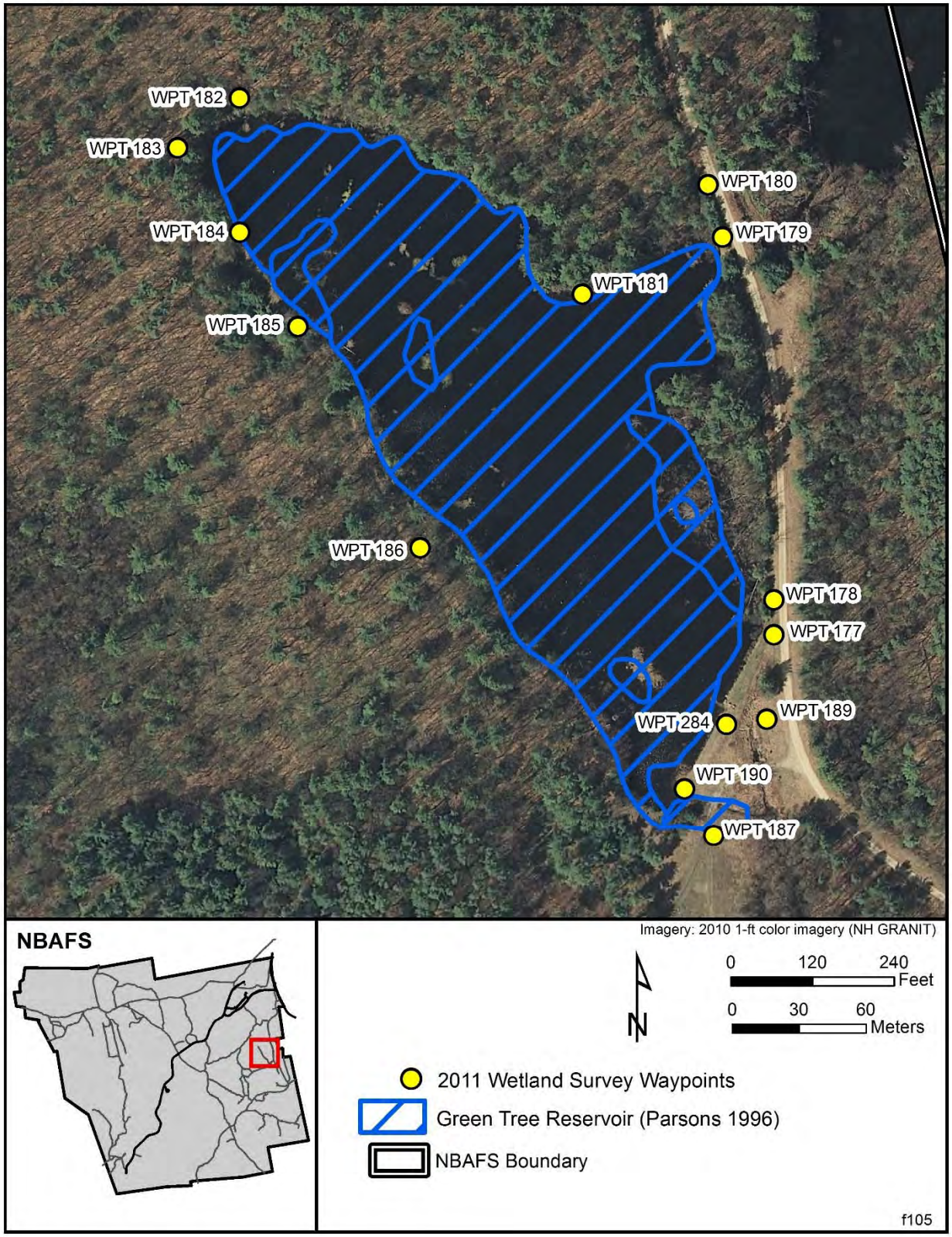

FIGURE 20. Green Tree Reservoir, Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

FIGURE 21. Green Tree Reservoir, View toward South Berm (WPT 181).

Soils to the northwest and along the north and east perimeters belong to the Chatfield-Hollis-Canton Complex, 8-15% slope; on the west is Paxton Fine Sandy Loam, 3-8% slope, with a small area of Canton Stony Fine Sandy Loam, 15-25% slope; a small area of Woodbridge Loam, 3-8% slope, occurs on the south, and Ridgebury Stony Loam, 3-8% slope, occurs at the location of the berm on the south. The surrounding woodland to the west and north is mixed evergreen/deciduous, with white pine, red maple, and red oak, especially to the north. The land cover to the south is predominantly old-field. A narrow strip of trees and periodically mowed grass lies between the reservoir and the road to the east (Figure 23, WPT 178).

The gravel surface of the road to the east is in good condition. The vegetation between the road and wetland generally acts as an effective barrier to sediment transport to the wetland (Figure 23, WPT 178). This road is heavily travelled; however, very little erosion from the road into the intervening grassy area was evident. Some evidence of sheet flow off the road and down the slope into the reservoir near the culvert from Maddening Pond was apparent (Figure 24, WPT 179). The water surface is about 12 ft (3.7 m) below the road at the culvert. The road gradually drops in elevation toward the south. A cleared pathway extends from the road to the reservoir just north of the culvert (Figure 25, WPT 180). Sheet flow runoff from the road can follow this path to the reservoir, although no erosion was evident.

FIGURE 22. South Berm of Green Tree Reservoir (WPT 177) and Failed Outflow Structure (arrow).

FIGURE 23. Road Margin Adjacent to Green Tree Reservoir (WPT 178).

FIGURE 24. Erosion on Slope above Green Tree Reservoir Near Inlet Culvert from Maddening Pond (WPT 179).

FIGURE 25. Cleared Pathway from Gravel Road to Green Tree Reservoir (WPT 180).

A dirt road leading from this road passes to the south of the reservoir (WPT 187). While the ground surface adjacent to the road slopes toward the reservoir, the berm prevents any runoff from entering the reservoir. Sediment from the road could enter the outflow stream and affect downgradient areas. The land elevation drops to the south a short distance from the road. A timber harvest downslope and south of the reservoir did not present a threat from sedimentation. Signs of beaver activity were apparent in several locations within the reservoir and around the south berm and outflowing stream (requiring periodic removal of mud and woody debris), however, impacts to the reservoir were not observed. The potential for impacts from erosion or sedimentation in this wetland is considered to be low.

4.5 JOE ENGLISH POND

Joe English Pond is a large pond and emergent marsh located in the central area of NBAFS (Figure 26). The open water portion of the pond was recently reduced as a result of the removal of the dam and lowering of the surface water elevation in 2010. On-Orbit Drive runs to the north and west of Joe English Pond, while Brook Road passes over a causeway through a formerly open water arm of the pond.

A wide variety of floating aquatic species have been recorded as occurring in the pond including spatterdock, fragrant water lily, water-shield, and floating-heart (*Nymphoides cordata*). The area of permanently or semipermanently flooded wetland south of the causeway is approximately 20 ac (8 ha) in size. A small area north of the causeway, near the bridge, also remains ponded. Common species in shallow water had included tussock sedge (*Carex stricta*), bur-reed, pickerel weed, three-way sedge, water-willow (*Decodon verticillatus*), buttonbush (*Cephalanthus occidentalis*), and meadowsweet (Figure 27). These species will likely remain in saturated soils and become established in new areas of shallow water. With lowered water levels throughout the former area of Joe English Pond, transitions to new wetland and upland plant communities will continue for a number of years. Scattered saplings of red maple, speckled alder (*Alnus incana* ssp. *rugosa*), and gray birch (*Betula populifolia*) occur north of the causeway. Shrubs that occur along the previous margin of the pond include maleberry, winterberry (*Ilex verticillata*), highbush blueberry, leatherleaf, dogwood (*Cornus* spp.), sweet gale, sheep laurel, and viburnum (*Viburnum* spp.), along with herbaceous species such as cinnamon fern, New York aster, and royal fern. Most of the shrubs and saplings within and along the pond have been cut for the UXO remediation project. White pine, hemlock, red maple, yellow birch and gray birch are common along the previous wetland margin.

Several small populations of potentially invasive native cattail, observed near the causeway to the north and south as well as in the northern area of the marsh, did not appear to be expanding prior to dam removal. Purple loosestrife, a nonnative invasive plant, occurs at the south margin near the trailer park and in the marsh north of the causeway.

Joe English Pond is in the Joe English Brook watershed. Numerous streams flow into Joe English Pond from the surrounding area, and water flows out of the pond into Joe English Brook on the east side of the pond (WPT 242). Most flow enters from the unnamed streams that drain Ice Pond, to the southwest, and Gardner Pond, to the northwest (WPT 298). A smaller stream

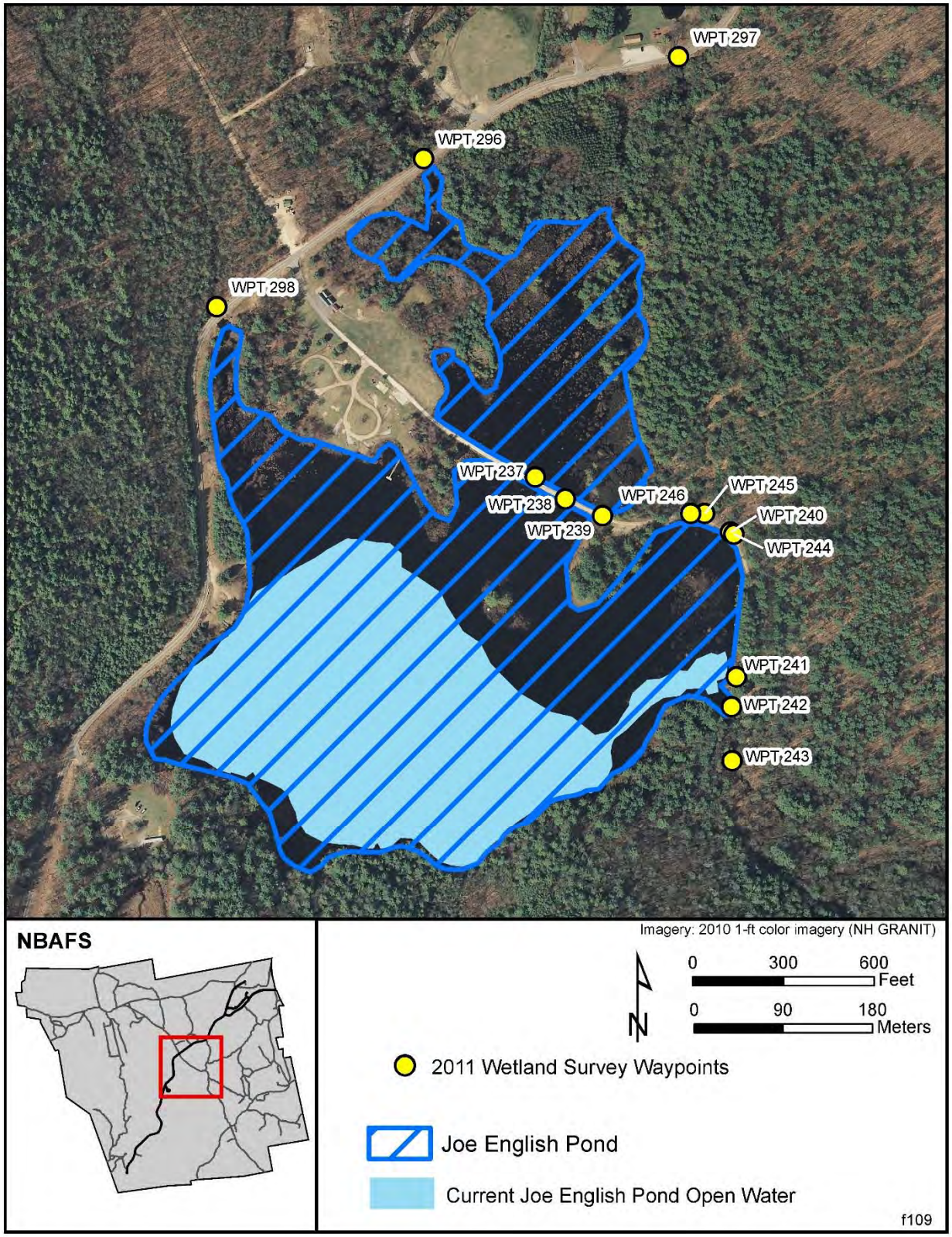

FIGURE 26. Joe English Pond, Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

FIGURE 27. Joe English Pond, View South from Causeway (WPT 238).

from Deer Pond (WPT 297) enters at the northeast. Additional minor inflows pass under On-Orbit Drive from the north (WPT 296) and west, from P51 Hill on the south, and from the area of Chestnut Hill on the northeast (WPT 244, 245 and 246). Adjacent slopes to the north and northwest draining toward the pond are relatively gentle. The remaining slopes are generally steep, including areas to the west of On-Orbit Drive.

A causeway cuts NW-SE across the northern portion of Joe English Pond (WPT 237 and 238). The causeway, constructed in the 19th century, has resulted in an alteration of the natural hydrology of the pond, restricting flows to the deepwater southern areas of the pond from the marsh north of the causeway. These flows pass through a single 11 foot-wide opening in the causeway (Hoyle, Tanner, and Associates, Inc. 2013) below a bridge (Figure 29, WPT 237). A blocked culvert is believed to be located northwest of the bridge. Historical records (USGS 1906) show a single stream flowing south through the marsh, intersecting the causeway near the southeastern end and continuing into the pond. It appears that, prior to the construction of the causeway, while some widespread surface water movement through the northern marsh may have occurred, particularly during periods of high water elevations, flows through the marsh had primarily been by way of the stream that now comes from Deer Pond. Currently, during periods of high water elevation, flows that would naturally flow south are constrained by the single opening. Some wetland areas north of the causeway likely have greater water depths at certain times than under natural flow conditions. Some wetland areas south of the causeway, particularly

areas farthest from the bridge, may potentially fail to receive adequate hydrology to maintain existing wetland communities.

Soils along the northern margin and extending west are Canton Stony Fine Sandy Loam 8-15% slope. Scituate Stony Fine Sandy Loam 0-3% slope also occurs to the west. Soils to the east are Paxton Stony Fine Sandy Loam 15-25% slope. A small area to the northeast is Chatfield-Hollis-Canton Complex 15-25% slope, and a small area to the northwest is Canton Stony Fine Sandy Loam 3-8% slope. Soils near the outflow of Joe English Brook are Canton Very Stony Fine Sandy Loam 15-35% slope. Along the west perimeter is Canton Stony Fine Sandy Loam 15-25% slope, and along the south perimeter is Chatfield-Hollis-Rock Outcrop Complex 15-35% slope. The surrounding woodland is mixed evergreen/deciduous, with white pine, hemlock, red maple, yellow birch, beech, and witch hazel. The former camping areas east and west of the causeway have a primarily herbaceous vegetation cover.

On-Orbit Drive crosses a large portion of the areas that drain to Joe English Pond. It is paved with a gravel shoulder that is in generally good condition and relatively stable with a well-established vegetation cover. The On-Orbit Drive shoulder drops off steeply away from the road in many areas. This slope is regularly mowed up to the forest margin which is often above the toe of the slope. The intervening vegetation between the road and wetland or inlet streams generally acts as an effective barrier to sediment transport to the wetland. At three of the On-Orbit Drive stream crossings, however, some erosion of the road shoulder was evident with some deposition of sediments into the adjacent stream: the streams from Gardner Pond (WPT 298), Deer Pond (WPT 297), and near the Recreation Center (WPT 296). Sediment inputs were minor at the stream crossing from Gardner Pond, although sediment entered from both sides of the road. Moderate erosion and sediment inputs were evident at the two culvert crossings farther north (WPT 296 and 297), with sediments entering the streams at the east side of the road.

Significant soil disturbance was observed in the Joe English Pond recreation area, on the causeway, along Brook Road, and within the wetland itself (the result of recent UXO remediation activities). Large areas of exposed and disturbed soils have resulted in erosion and transport of materials into and within the wetland and downstream. The surface of Brook Road and causeway is in poor condition with loose, disturbed gravel, and ponding water in numerous locations. The wetland margin is about 1-2 ft (0.3-0.6 m) from the causeway and road surface in some areas. At the time of survey, disturbance in the Joe English Pond recreation area (Figure 28) associated with UXO remediation activities was contributing to sedimentation from the road into the pond west of the causeway. Loose soil and gravel was observed eroding from the causeway, including areas adjacent to the bridge, and into the pond on the north and south sides of the causeway, along with fine sediments (Figures 29 and 30; WPT 237 and 238).

Erosion of fine sediments into the pond was observed at several locations along the south edge of Brook Road east of the causeway (WPT 244, 245 and 246). An old gravel road sloping down toward Brook Road from the north, east of the causeway, was observed to be eroding, with gravel and fine sediments being transported across Brook Road and into the pond (WPT 245). Much of the disturbance in and around Joe English Pond was associated with the UXO remediation project, however, dam removal in 2010 also resulted in disturbance. The potential for impacts from erosion or sedimentation in this wetland is considered to be high, and results

FIGURE 28. Disturbed Soil and Roadway in the Joe English Pond Recreation Area.

FIGURE 29. Erosion of the Causeway Adjacent to the Bridge (WPT 237).

FIGURE 30. Erosion of Gravel Road Surface along Causeway Margin (WPT 237, left and WPT 238, right).

primarily from the potential for eroded sediment to enter from the surface of the causeway and from UXO remediation activities within the wetland.

4.6 TRAILER PARK POND

Trailer Park Pond is a beaver pond located directly south of the trailer area and east of On-Orbit Drive in the center of the station (Figure 31). The trailer loop road is approximately 15 ft (5 m) from the northern margin of the wetland.

The southernmost areas of Trailer Park Pond support a dense marsh community that becomes relatively open in the northern portion (Figure 32). Near the beaver dam to the northeast clusters of emergent marsh plants are scattered, with open water being predominant. Species include wool-grass, bur-reed, bluejoint grass, sensitive fern, cinnamon fern, sedges, and cattail. Several shrub species are scattered throughout the pond, with higher densities along the margin, and include maleberry, highbush blueberry, and meadowsweet. Trees are scattered along the margin in saturated soils, including alder, white pine, hemlock, red maple, and yellow birch. Saplings of alder, red maple, and yellow birch are scattered in shallow water areas of the pond. No nonnative invasive plants in or adjacent to the wetland were observed during our survey, although a small population of potentially invasive native cattail was observed.

Trailer Park Pond is in the Joe English Brook watershed. Outflow from the pond passes through a forested area east of the trailer park and into the south side of Joe English Pond. Four streams flow into Trailer Park Pond from the west-southwest of On-Orbit Drive: the primary inlet stream flowing from Ice Pond (WPT 231 and 232) and entering the southwest end of the wetland, and three smaller streams flowing from the west (WPT 234, 235 and 236) and entering on the west side of the wetland. The primary inlet carried a strong flow at the time of our survey. The pond elevation is maintained by a beaver dam at the north end (WPT 227). The surrounding land generally slopes gently to moderately toward the wetland, with the ground northeast of the dam sloping gently away, becoming steep near Joe English Pond. Slopes below the shoulders of On-Orbit Drive are generally steep.

Soils in the wetland area generally belong to the Chatfield-Hollis-Rock Outcrop Complex, 15-35% slope, with Canton Very Stony Fine Sandy Loam, 15-35% slope, at the primary inlet and Canton Stony Fine Sandy Loam, 15-25% slope, to the west. The surrounding woodland is mixed evergreen/deciduous, with white pine, hemlock, red maple, yellow birch, chestnut, and witch hazel.

The main inlet stream passes through a double culvert under On-Orbit Drive with no evidence of erosion at the stream bed (Figure 33, WPT 232 and 233). On-Orbit Drive is paved with a gravel shoulder that is in generally good condition and relatively stable with a vegetation cover. The road shoulder drops off steeply near the road for much of its length near Trailer Park Pond. This slope is mowed up to the forest margin generally above the toe of the slope. The intervening vegetation between the road and wetland or inlet stream acts as an effective barrier to sediment transport and migration to the wetland.

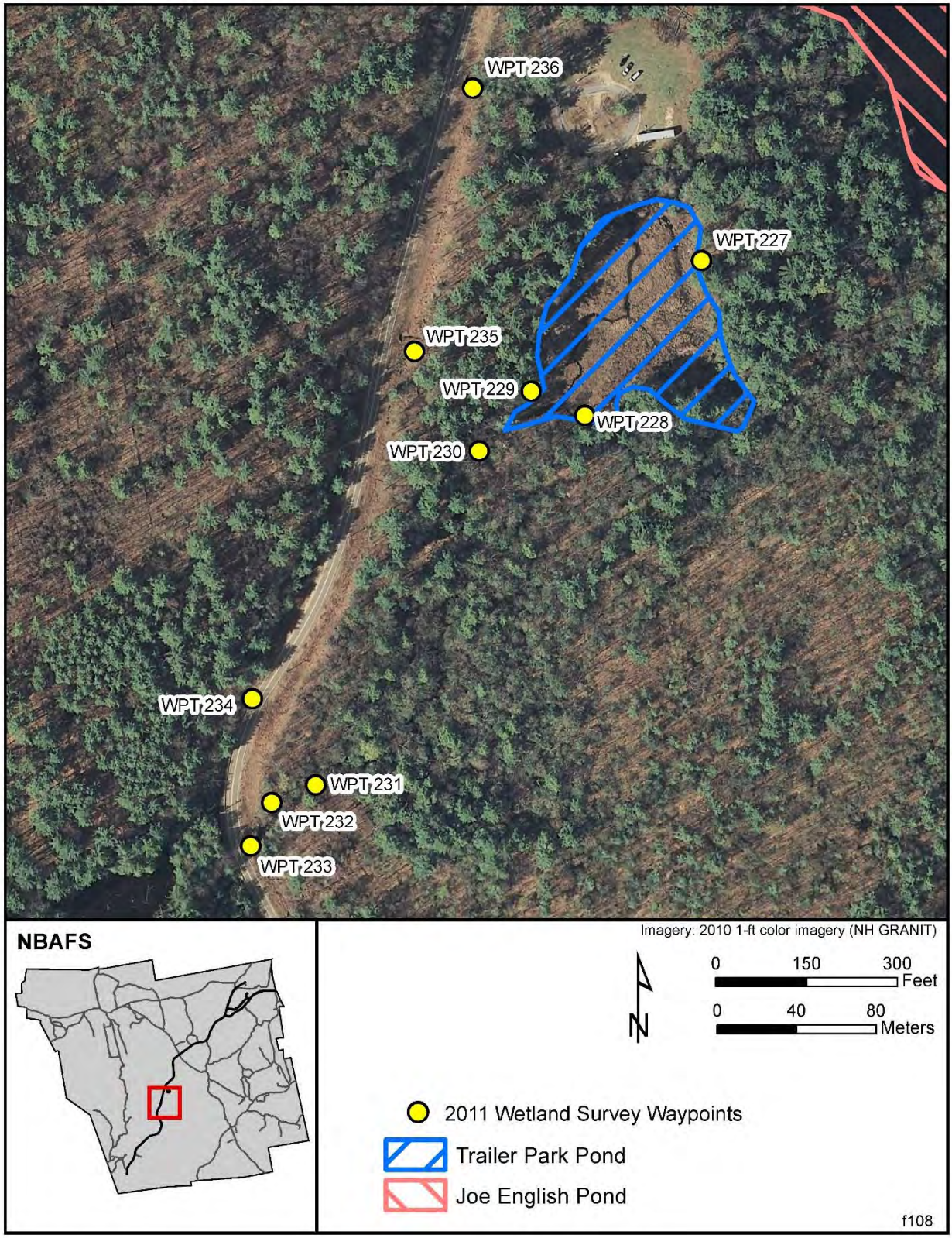

FIGURE 31. Trailer Park Pond, Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

FIGURE 32. Trailer Park Pond, with Beaver Lodge; View from near Dam (WPT 227).

In several locations near the stream crossings of On-Orbit Drive, some erosion of the road shoulder was evident with deposition of sediments into the adjacent stream (Figure 34; WPT 233, 234, 235 and 236). In some locations, the slope ends in a shallow swale sloping down to the stream, with some erosion along the swale (WPT 235 and 236). Sediment inputs were minor at the two southernmost crossings, with sediment entering on the east side of the road at the main inflow (WPT 233) and on both sides of the road at the other stream which passes through a pipe under the road (WPT 234). Moderate erosion and sediment inputs were evident at the two culvert crossings farther north (WPT 235 and 236), with sediments entering the streams at the west side of the road. There was a curb at the top of the three culverts that generally acted as a barrier to direct sediment inflows above the streams. A concrete cap used to stabilize the steep slope at one location (WPT 233) was broken and failing; however, current erosion was not evident. The potential for impacts from erosion or sedimentation in this wetland is considered to be very low.

FIGURE 33. Double Culvert under On-Orbit Drive for Primary Inlet Stream of Trailer Park Pond (WPT 232).

FIGURE 34. Minor Erosion Near Culverts Leading to Trailer Park Pond (WPT 233, left, and 235).

4.7 WELLS BOG

Wells Bog is a pond located in the southeastern part of NBAFS, southeast of Mack Hill Road (Figure 35). Brook Road cuts across the western arm of Wells Bog on a causeway running northwest to southeast. This wetland appears to be formed primarily by a beaver dam on the southeast side.

Most of Wells Bog is composed of an emergent marsh community with bur-reed, pickerel weed, bluejoint grass, sedges, three-way sedge, wool-grass, spikerush, and royal fern (Figure 36). Some open water areas occur near the causeway (WPT 261, 262, and 263) and dam (WPT 264) and include floating aquatic species such as fragrant water lily. A shrub community occurs along the margin with scattered shrubs in shallow areas of the wetland. Shrub species include meadowsweet, water-willow, buttonbush, maleberry, arrow-wood, winterberry, leatherleaf, and highbush blueberry. A dense patch of winterberry is located at the northeast end of the wetland in the area of an inflowing stream (WPT 271). Alder, red maple, and white pine also occur along the margin with occasional saplings in shallow water. No nonnative or invasive plants in or adjacent to the wetland were observed during our survey.

Wells Bog is in the Joe English Brook watershed. Several streams flow into Wells Bog. The primary inlet is Joe English Brook (WPT 261), flowing from Joe English Pond and entering at the northwest side near the causeway. Joe English Brook had a high flow at the time of the survey. A strong current was observed running parallel to the causeway toward the dam. Moderate inflows enter at the southwest (WPT 266) and northeast ends of Wells Bog (WPT 271), while two small streams were observed crossing under Mack Hill Road (WPT 265), flowing toward Wells Bog. A large beaver dam is located near the southeastern end of the causeway and is the only outflow from Wells Bog (WPT 264). A strong flow was observed going over the dam at the time of the survey. The adjacent slopes are steep to the northwest, leading up to P51 Hill, and to the southwest. Other surrounding slopes are moderate, with the valley of Joe English Brook falling away to the southeast.

Soils in the western half of the wetland are Leicester-Walpole Complex Stony, 0-3% slope; Canton Stony Fine Sandy Loam, 3-8% slope, occurs around most of the wetland perimeter and extends to the north and south; soils around the southeast perimeter and extending northeast are Canton Stony Fine Sandy Loam, 8-15% slope.

The surrounding woodland is mixed evergreen/deciduous, with white pine, hemlock, red maple, red oak, beech, hay scented fern (*Dennstaedtia punctilobula*), and bracken fern. There was a clear cut timber harvest (WPT 268) observed adjacent to the stream that flows into the west end of Wells Bog, with the potential for surface runoff from the area, including nearby Mack Hill Road, contributing sediments to the stream.

The surface of Brook Road and causeway is gravel and in generally good condition, with a vegetation cover outside the tire tracks. The causeway shoulder is relatively narrow, about 1-2 ft (0.3-0.6 m) wide. Much of the causeway was flooded at the time of the survey; however, the water was generally retained within the tire tracks by the slightly higher vegetated margin

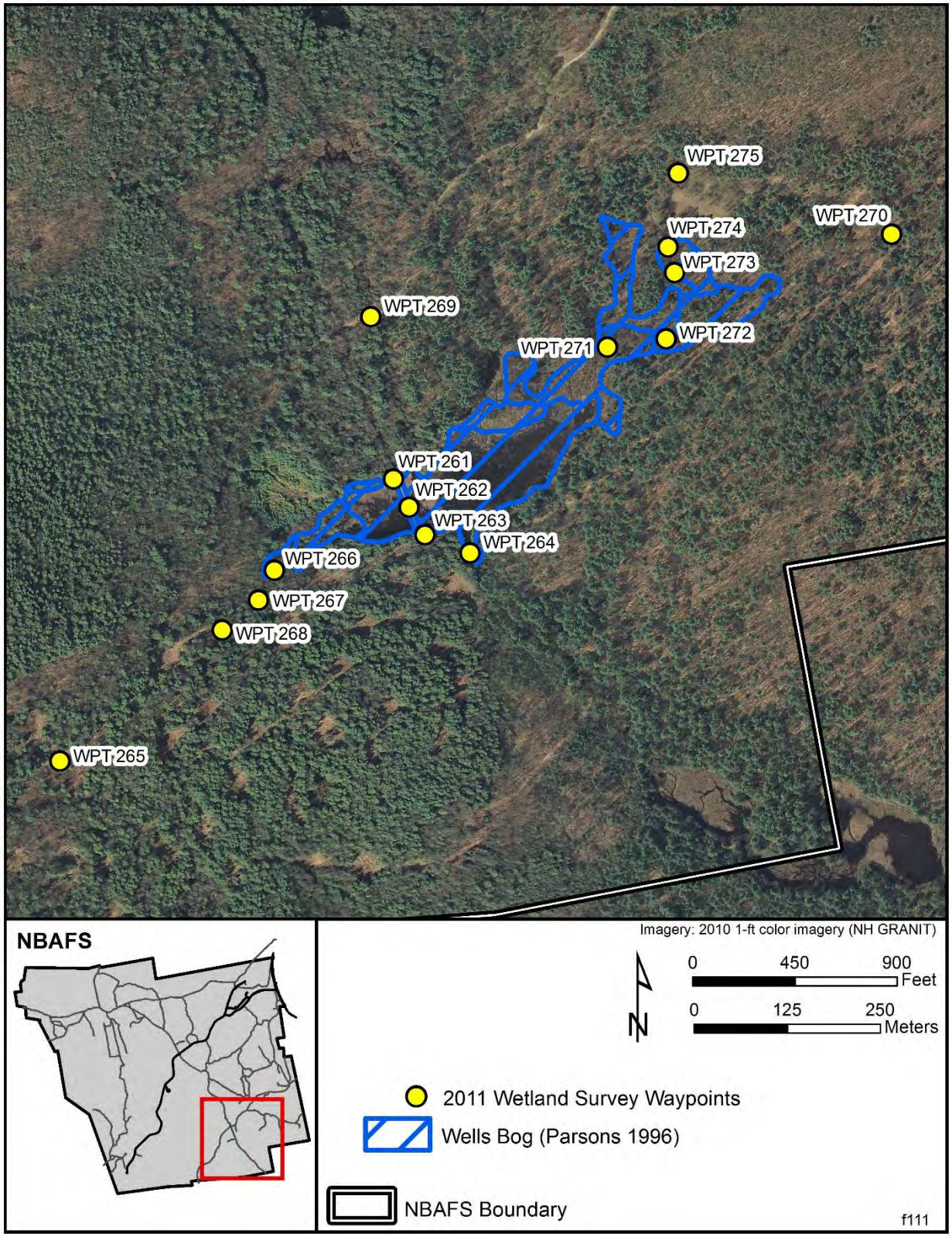

FIGURE 35. Wells Bog, Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

FIGURE 36. Wells Bog, View from Causeway (WPT 261).

and center (Figure 37). At one location, an approximately 1 ft- (0.3-m) wide section of the causeway margin had collapsed and was allowing water to flow off the causeway into the wetland, along with fine sediments and gravel (Figure 38; WPT 262). Brook Road slopes toward the causeway from the northwest and southeast, with sheet flow contributing to the causeway flooding. Deposits of gravel from tire tracks were observed on the causeway margin in some areas. Where the Mack Hill Road Bridge crosses Joe English Brook upstream of Wells Bog (WPT 269), a minor amount of sediment was observed entering the stream at an old ford on the north side of the bridge. Minor amounts of sediment were also observed entering two streams where they cross Mack Hill Road northwest and far upstream of Wells Bog (e.g., WPT 265). Considerable sedimentation was observed, however, at the ford crossing of an old gravel road across the stream flowing into the northeast end of Wells Bog (Figure 38; WPT 270). That road intersects with the road to Galaxy Way/Mack Hill Road. The road surface is badly eroded near the crossing, with loose gravel and soil. The potential for impacts from erosion or sedimentation in this wetland is considered to be moderate, and results primarily from the potential for eroded sediment to enter from the surface of the causeway.

FIGURE 37. Flooded Section of Wells Bog Causeway (left, WPT 261), with Area of Overflow and Erosion into Wetland (right, WPT 262).

FIGURE 38. Eroding Dirt and Gravel Road Crossing the Stream that Flows into the Northeastern Arm of Wells Bog (WPT 270).

4.8 BEAVER POND NUMBER 4

Beaver Pond No. 4 is located in the southeastern part of NBAFS, and is bisected by the south boundary (Figure 39). Brook Road runs along the southwestern side of the pond. This wetland is formed by a beaver dam on the southeast end.

Beaver Pond No. 4 primarily consists of a dense emergent marsh community composed predominantly of bluejoint grass (Figure 40). Other emergent species include wool-grass, royal fern, bur-reed, tussock sedge, and other sedges. Joe English Brook flows along the southwest margin. Open water areas, mostly near an old breached beaver dam and along the flow path of Joe English Brook, support a few floating aquatic plants. Shrubs, predominantly maleberry, arrow-wood, elderberry (*Sambucus canadensis*), and dogwood, form a dense thicket on the northeastern margin, with a narrow intermittent band along the southwest bank. Hemlock, alder, and red maple also occur along the margin. No nonnative or invasive plants were observed in or adjacent to the wetland during our survey.

Beaver Pond No. 4 is in the Joe English Brook watershed. The primary inflow is Joe English Brook (WPT 280), flowing from Wells Bog. The gradient of Joe English Brook is moderate, flowing into the northwest end of the pond and exiting at the southeast end. A very small unnamed stream runs down the slope to the southwest, flows through a culvert under Brook Road (WPT 279), and enters the pond near the inflow point of Joe English Brook. No other inflows were noted. At the time of our survey, an internal beaver dam that maintains water elevations in the northwest portion of this wetland was breached, and allowed a significant flow downstream. The slopes to the northeast are moderate, while those to the southwest are quite steep. A low rock wall extends along nearly the entire southwest perimeter of the pond between the road and the pond (WPT 277, 278, 281, and 282).

Soils on the northwest perimeter are Canton Stony Fine Sandy Loam, 8-15% slope; to the north and east soils belong to the Chatfield-Hollis-Rock outcrop complex 15-35% slope; the Chatfield-Hollis complex, 8-15% slope, occurs along most of the southwest perimeter and extends south; and Rippowam Fine Sandy Loam occurs at the outflow and downstream. The surrounding woodland is mixed evergreen/deciduous and mostly white pine to the north with hemlock and red maple less common; mostly hemlock to the south with red maple, red oak, beech, and white pine less common.

Brook Road runs roughly parallel to Joe English Brook and the southwest side of the pond, reaching to approximately 3.5 ft (1.1 m) from the wetland margin near the northwest end of the pond (WPT 278). A wooded slope separates the pond from most of the length of the adjacent road, with no evidence of erosion or sedimentation. A portion of the road near the small unnamed inlet stream showed signs of occasional flooding (WPT 279); the road slopes down to the area from both directions. The surface of the road is gravel and stable, with no evidence of erosion or sedimentation to the pond.

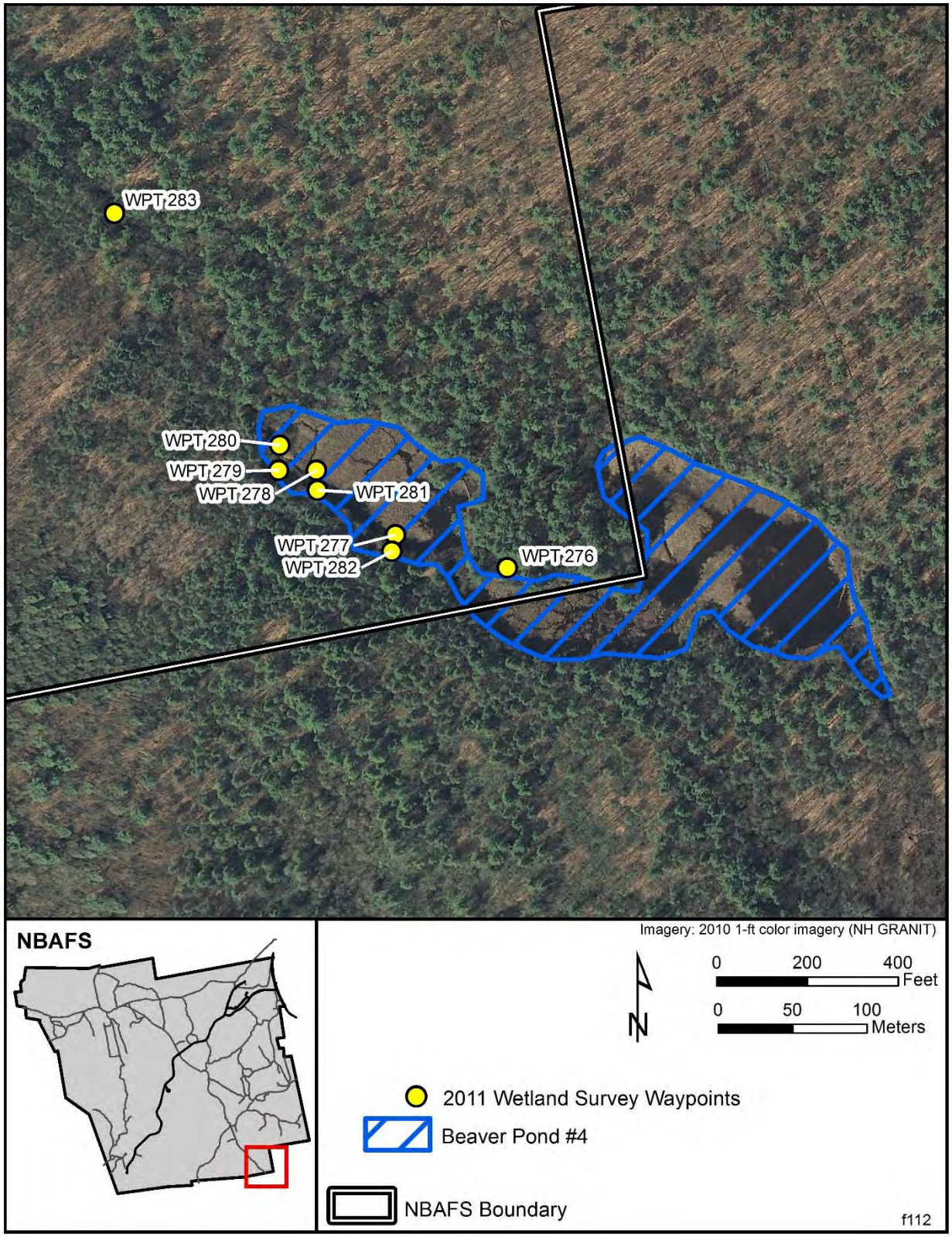

FIGURE 39. Beaver Pond No. 4, Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

FIGURE 40. Beaver Pond No. 4, View from Southwest Bank.

FIGURE 41. Closest Approach of Brook Road to Joe English Brook and the Inlet to Beaver Pond No. 4 (WPT 278).

A potential future concern is the proximity of the road to the edge of the pond just downstream of the Joe English Brook inflow point (Figure 41; WPT 278). During our survey, the current at this point was very strong and flowed into a steep bank before flowing away from the road and entering the pond. The rock wall is absent in this area and erosion of the bank may be occurring, possibly eventually reaching the road. The potential for impacts from erosion or sedimentation in this wetland is currently considered to be very low.

4.9 ICE POND

Ice Pond is an historic manmade impoundment located in the southwest area of NBAFS, northeast of Roby Pond (Figure 42). The unnamed loop road from On-Orbit Drive through the Roby Pond and Ice Pond primitive campground area passes to within 10 ft (3 m) of the southwest side of Ice Pond (WPT 171). An extension from this road runs east to a smaller loop 75 ft (23 m) from the southeast side of the pond. A small recreation area, including a boat dock, is located along the southern edge of the pond (WPT 173) and is accessed from the campground road; a picnic area is located near the southeast shoreline with an access road from the smaller loop (WPT 174). Several primitive campsites are located along the road south of the pond adjacent to the recreation area, on a natural bench about 6 ft (2 m) above the elevation of the pond shoreline.

Spatterdock and fragrant water lily were observed in shallow water areas of the mostly open water pond (Figure 43). A sparse narrow band of emergent marsh occurs around the pond margin, somewhat wider along the eastern and western sides, and includes sedges (*Carex crinita*), three-way sedge, larger blue flag (*Iris versicolor*) and bur-reed. White pine, red maple, and hemlock occur on saturated soils on the pond margin along with shrubs such as maleberry, huckleberry, and meadowsweet, as well as clearweed (*Pilea pumila*). No nonnative invasive plants in or adjacent to the pond were observed during our survey.

Ice Pond is in the Joe English Brook watershed. The pond elevation is maintained by a rock wall dam built in 1911 (WPT 175), apparently retrofitted with a concrete cap, along the eastern end of the pond. Outflow from Ice Pond runs over a narrow spillway weir, about 10 ft (3 m) wide and 2 ft (0.6 m) deep, and drops about 12 ft (3.7 m) to the stream below. The unnamed outflow stream flows northeast, eventually reaching Joe English Pond. The stream from Roby Pond flows into Ice Pond, entering on the southwest side (Figure 44; WPT 171), shortly after passing under the campground road through double culverts. The recreation area along the pond shore (WPT 173) is directly east of the inflow location (Figure 45). A smaller stream flows in from the area of Roby Hill, entering on the west side of the pond. The slopes to the north and south of the pond are steep, while the slope to the west is relatively gentle, all draining toward the pond. On the east side the ground slopes away from the pond. Most of the area bordering the pond to the south is mowed and is used for recreational access to the pond (Figure 45). A short steep slope borders this area, directly below the campground and continuing east.

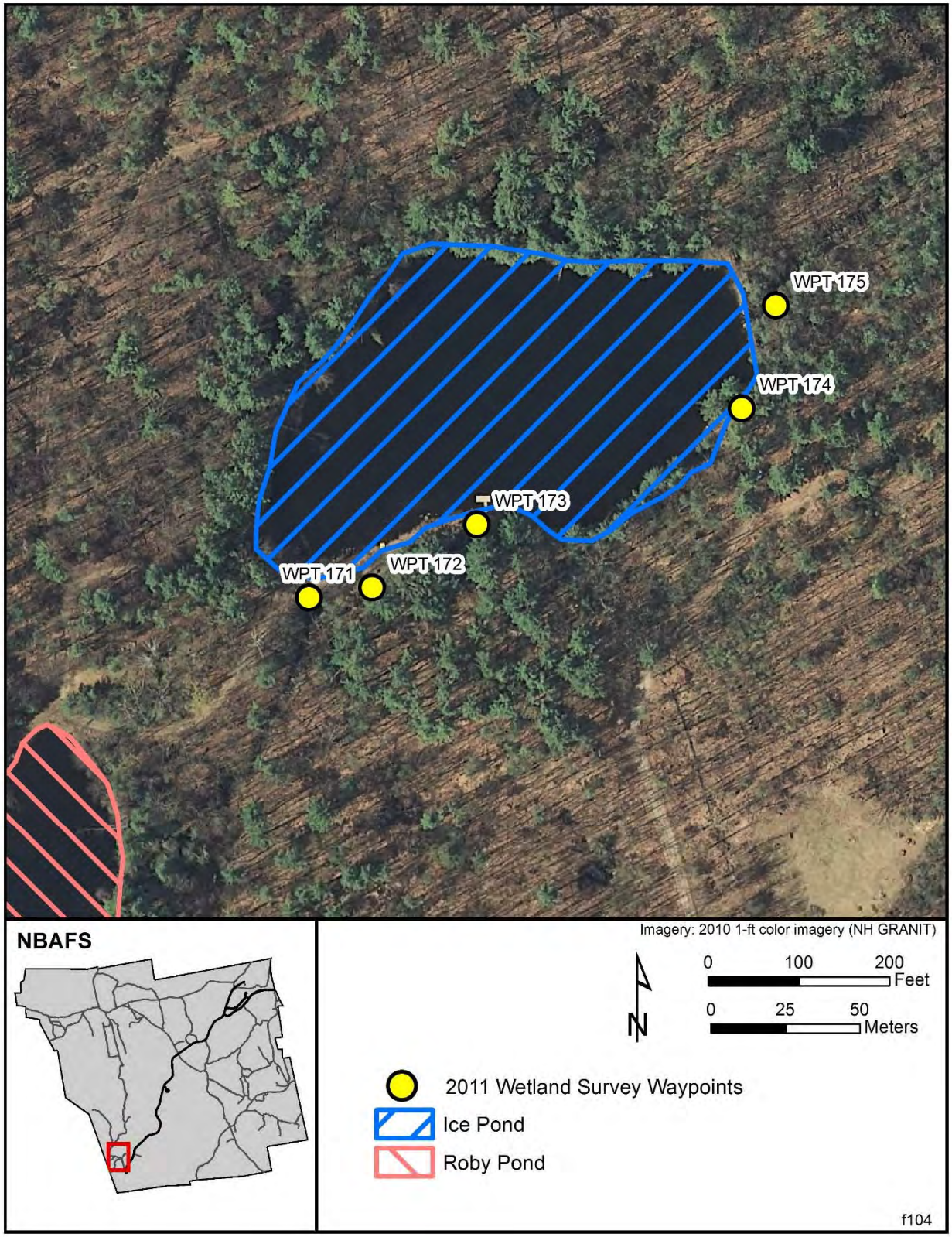

FIGURE 42. Ice Pond, Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

FIGURE 43. Ice Pond, View toward Dam.

Soils to the south and along the south perimeter of Ice Pond belong to the Chatfield-Hollis-Canton complex, 8-15% slopes; soils to the west are Ridgebury Stony Loam, 3-8% slope; Canton Stony Fine Sandy Loam, 15-25% slope, extends to the north and northeast; and a small area of Paxton Stony Fine Sandy Loam, 15-25% slope, is located on the northwest. The surrounding woodland is mixed evergreen/deciduous, with white pine, red maple, yellow birch, red oak, and beech. The nearby campground is also wooded.

The surfaces of the access and internal campground roads are gravel and are generally in good condition. However, portions of the roads to On-Orbit Drive and Roby Pond drop steeply down at their closest locations to Ice Pond, near the inlet stream. There is evidence of past surface flow and erosion along these road surfaces. A narrow margin of turf grass lies between

FIGURE 44. Campground Road Crossing at Ice Pond Inflow (WPT 171).

FIGURE 45. Ice Pond Recreation Area and Adjacent Road (WPT 173).

the roadway and pond margin (WPT 172). In 2007, high streamflows from the Roby Pond watershed destroyed the culvert and road crossing at this location (WPT 171), depositing a large amount of gravel into Ice Pond, The double culverts are of recent construction, and are intended to prevent further occurrences, however, future storm events may exceed the capacity of the culverts (see Appendix B). A footpath leading down toward Ice Pond from the campground shows evidence of erosion, with the possibility of some sedimentation into the pond. The surface of the loop road above the picnic area shows evidence of surface runoff toward the picnic area access road. The access road to the picnic area (WPT 174), proceeds down a steep slope, is highly eroded with gullies, and has resulted in considerable sedimentation into Ice Pond (Figure 46). There are no existing barriers to any of these sediment inputs. The potential for impacts from erosion or sedimentation in this wetland is considered to be high, and results primarily from the potential for eroded sediment to enter from the campground road near the picnic area.

FIGURE 46. Eroding Access Road to Ice Pond Picnic Area (WPT 174).

4.10 ROBY POND

Roby Pond is a manmade impoundment located in the southwest corner of NBAFS; the western portion of the pond occurs outside the station boundary (Figure 47). An unnamed gravel loop road leading from Ice Pond is located approximately 13 ft (4 m) from the northeast margin of the pond. A small primitive campground is located directly across the road from Roby Pond.

Spatterdock was observed in shallow water areas of the mostly open water pond (Figure 48). A narrow band of emergent marsh occurs around the pond margin, in many areas intermittent but continuous and somewhat wider along the western margin, and includes sedges (*Carex stricta* and *C. crinita*), marsh fern, three-way sedge, and bur-reed. Occasional short shrubs, including maleberry and meadowsweet, are found on near-shore saturated soils.

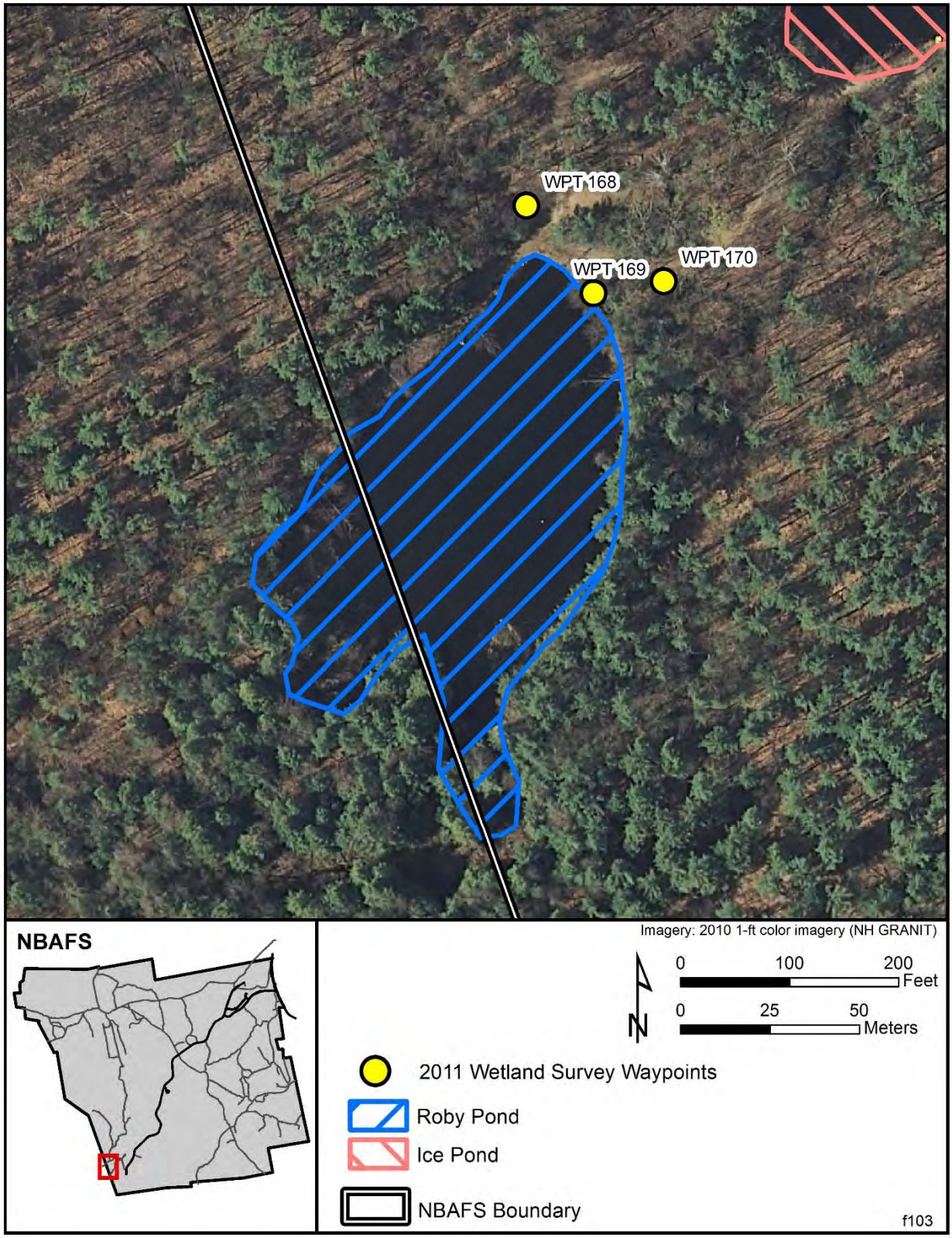

FIGURE 47. Roby Pond, Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

FIGURE 48. Roby Pond (WPT 168).

Roby Pond is in the Joe English Brook watershed. The pond elevation is maintained by a rock wall dam (WPT 169) along the eastern side of the pond (Figure 49). Outflow over the dam follows the loop road to the northeast (WPT 170). Inflow to Roby Pond is from a small stream entering on the southwest side off the station. Gentle slopes toward the pond occur on all sides of the pond, with the exception of the outflow area near the loop road. Soils to the west and much of the pond perimeter belong to the Chatfield-Hollis-Canton Complex, 8-15% slopes, with Chocorua Mucky Peat along the south and southeast perimeter. The surrounding woodland is mixed evergreen/deciduous, with white pine, hemlock, red oak, white oak, and bracken fern. The nearby campground is also wooded.

No nonnative invasive plants or other disturbances in or adjacent to the wetland were observed during our survey. The surface of the loop road is graded gravel, and is generally in good condition. The road margin is mowed; the mowed area extends to the northeast margin of the pond (Figure 50). This road is slightly downslope of Roby Pond and runoff from the road cannot enter the pond. An old dirt road, mostly overgrown, runs along the northwestern edge of the pond away from the loop road (Figure 50). The entire width of this road appears to be mowed periodically and is blocked by a NBAFS boundary fence and gate. Further to the southwest and past the station boundary, several piles of gravel and dirt block the road. No erosion or sediment input to Roby Pond from any of the nearby features was evident. The potential for impacts from erosion or sedimentation in this wetland is considered to be very low.

FIGURE 49. Roby Pond Dam (WPT 169).

FIGURE 50. Dirt Road Northwest of Roby Pond (left); Mowed Area Near Loop Road (right) (both WPT 168).

4.11 PITCHER PLANT BOG

This wetland was identified in LaGory et al (2011) as Black Gum-Red Maple Basin Swamp Number 5, and is locally referred to as Pitcher Plant Bog. It is located approximately 105 ft (32 m) east of Campbell Road, 117 ft (36 m) south of East Meadow Road, and 138 ft (42 m) from an unnamed diagonal road connecting these (Figure 51).

This 1.9-ac (0.8-ha) wetland is a mostly closed–canopy swamp with small scattered canopy openings (Figure 52). The dominant overstory species include red maple, black gum, white pine, eastern hemlock, and yellow birch (LaGory et al 2011). Occasional black spruce (*Picea mariana*) are also found near the wetland edge and in the interior. Midstory species include occasionally dense highbush blueberry, winterberry, yellow birch, and young white pine. Understory species include cinnamon fern, maleberry, mountain laurel, scattered leatherleaf, and seedlings of hemlock, red maple, white pine, and black spruce. Sphagnum is common in hummocks throughout, and pitcher plants are relatively common in the interior of the wetland.

Situated in a bowl-shaped basin, Pitcher Plant Bog is bordered by a ridge on the north, west, and south margins from which the elevation drops gradually away to the surrounding woodlands. A line of boulders runs along Campbell Road just inside the tree line and likely restricts runoff from the road. The land surface to the east is comparatively level, with no ridge being evident. The ridge to the north-northwest is relatively low, with seepage from the wetland moving northward and reaching East Meadow Road. Pitcher Plant Bog is in the Joe English Brook watershed. Soils throughout much of the wetland and surrounding area are Canton Stony Fine Sandy Loam, 15-25% slope, with 8-15% slope in the eastern part of the wetland and adjacent area. The north and south edges of the wetland extend into Scituate Stony Fine Sandy Loam, 3-8% slope. The surrounding woodland is mixed evergreen/deciduous, with white pine, hemlock, red oak, beech, red maple, white oak, sassafras (*Sassafras albidum*), witch hazel, mountain laurel, and starflower.

No nonnative invasive plants or other disturbances in or adjacent to the wetland were observed during our survey. The road surfaces of Campbell Road and the unnamed diagonal road were gravel and generally well maintained (Figure 53). The surface of East Meadow Road (WPT 160) was in generally poor condition, but downgradient of the wetland. Due to the landscape position, there was no opportunity for flows to enter this wetland from East Meadow Road or the diagonal road (WPT 159). A portion of Campbell Road (WPT 158) was elevated above the level of the wetland. However, because that location was a high point on the road and due to the presence of an intervening ridge and line of boulders, flows into the wetland from the road were highly unlikely (Figure 53). There was no observable sign of flows having occurred. There also was no observed erosion or sediment input to this wetland. The potential for impacts from erosion or sedimentation in this wetland is considered very low.

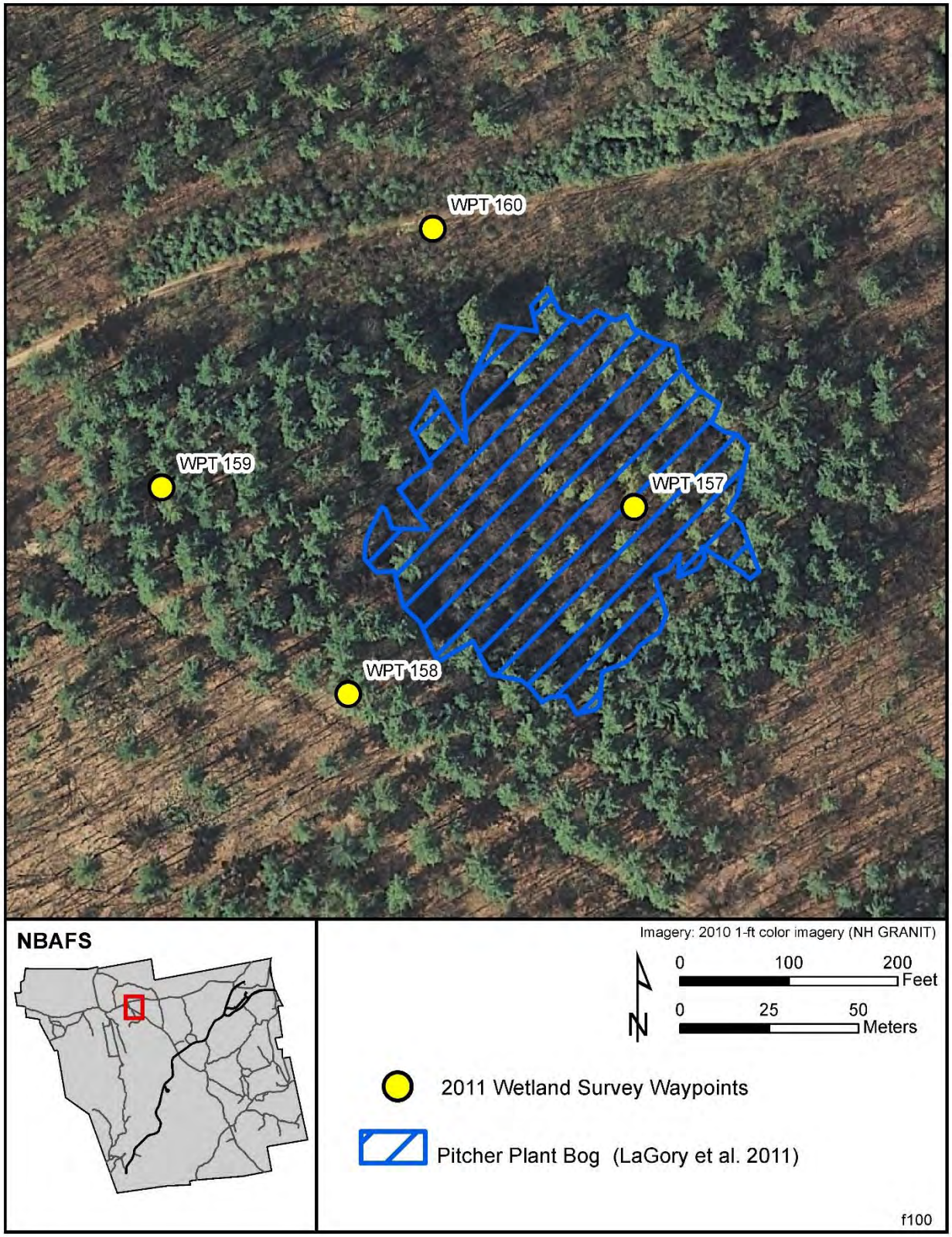

FIGURE 51. Pitcher Plant Bog, Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

FIGURE 52. Pitcher Plant Bog (Source: LaGory et al 2011).

FIGURE 53. View North on Campbell Road (WPT 158), Northeast on Diagonal Road, Showing Higher Ground that Serves as a Barrier to Runoff into Pitcher Plant Bog, which is Located to Right in Both Photos.

4.12 GARDNER POND

Gardner Pond is a manmade impoundment constructed by the U.S. Air Force after 1960, located south of West Meadow Road and west of Campbell Road (Figure 54). The pond elevation is maintained by an earthen dam along the eastern side of the pond (WPT 219). Based on a review of historic aerial photography, Gardner Pond was a relatively shallow wetland prior to construction of the earthen dam, and apparently the location of a beaver pond during the 1950s. The Gardner Pond dam (WPT 219) is accessed by a small dirt road off of Campbell Road. The pond lies directly east of the Shooting Field.

Scattered individuals of spatterdock and fragrant water lily occurred in shallow water areas of the mostly open water pond (Figure 55). A narrow band of emergent marsh occurs around the pond margin and includes bluejoint grass, sedges (*Carex* spp.), royal fern, cinnamon fern, rush (*Juncus marginatus*), pickerelweed, three-way sedge, bur-reed, common cattail, manna-grass (*Glyceria* sp.), and rice cut grass (*Leersia oryzoides*). A large area of dense emergent marsh, predominantly bluejoint grass and rice cut grass, is located where a relatively large stream flows into the northern end of the pond (Figure 54, near WPT 226). Another, although smaller, marshy area occurs at the southern end of the pond where two small streams enter (WPT 222 and 223). White pine occurs on saturated soils on the pond margin along with shrubs such as maleberry, sheep laurel, leatherleaf, and highbush blueberry, with arrow-wood (*Viburnum* sp.) also along the western shore, where shrub density is generally lower. Numerous dead white pines occur along the pond margins and in shallow water. Two small islands supporting marsh and shrub species are located in the south part of the pond. No nonnative invasive plants in or adjacent to the pond were observed during our survey, although a small population of potentially invasive native cattail was observed along the pond margin.

Gardner Pond is in the Joe English Brook watershed. Flows exit the pond through a water control structure in the dam, as well as a wide spillway on the south end of the dam (WPT 220). At the time of the survey, the spillway and water control structure were partially blocked by debris placed by beavers. The combined flows continue as a small stream draining to the east into Joe English Pond. Two small streams flow into the pond at the southern end (WPT 222 and 223), while the primary inflow enters at the north end (WPT 213). This stream drains a large watershed, east and southeast of Joe English Hill. A series of large beaver dams are located at the mouth of this stream (WPT 215), and many trees near the stream had been cut. The adjacent slopes around most of the pond are steep, draining toward the pond, while the slopes to the southwest and southeast are moderate. To the east, the ground elevation drops away gradually.

Soils along the west margin and extending to the northwest belong to the Chatfield-Hollis-Canton Complex, 15-25% slope; on the east is Canton Stony Fine Sandy Loam, 15-25% slope; Chatfield-Hollis-Canton Complex, 8-15% slope, extends to the north and south; and a small area of Paxton Fine Sandy Loam, 15-25% slope, occurs on the southwest.

The surrounding woodland is mixed evergreen/deciduous, with white pine, red maple, red oak, yellow birch, witch hazel. Canopy trees to the west are mostly white pine. Lowbush blueberry, wintergreen, and sheep laurel occur on the steep rocky slopes on the east side of the pond that in many areas is sparsely vegetated. That area had burned several years prior. The

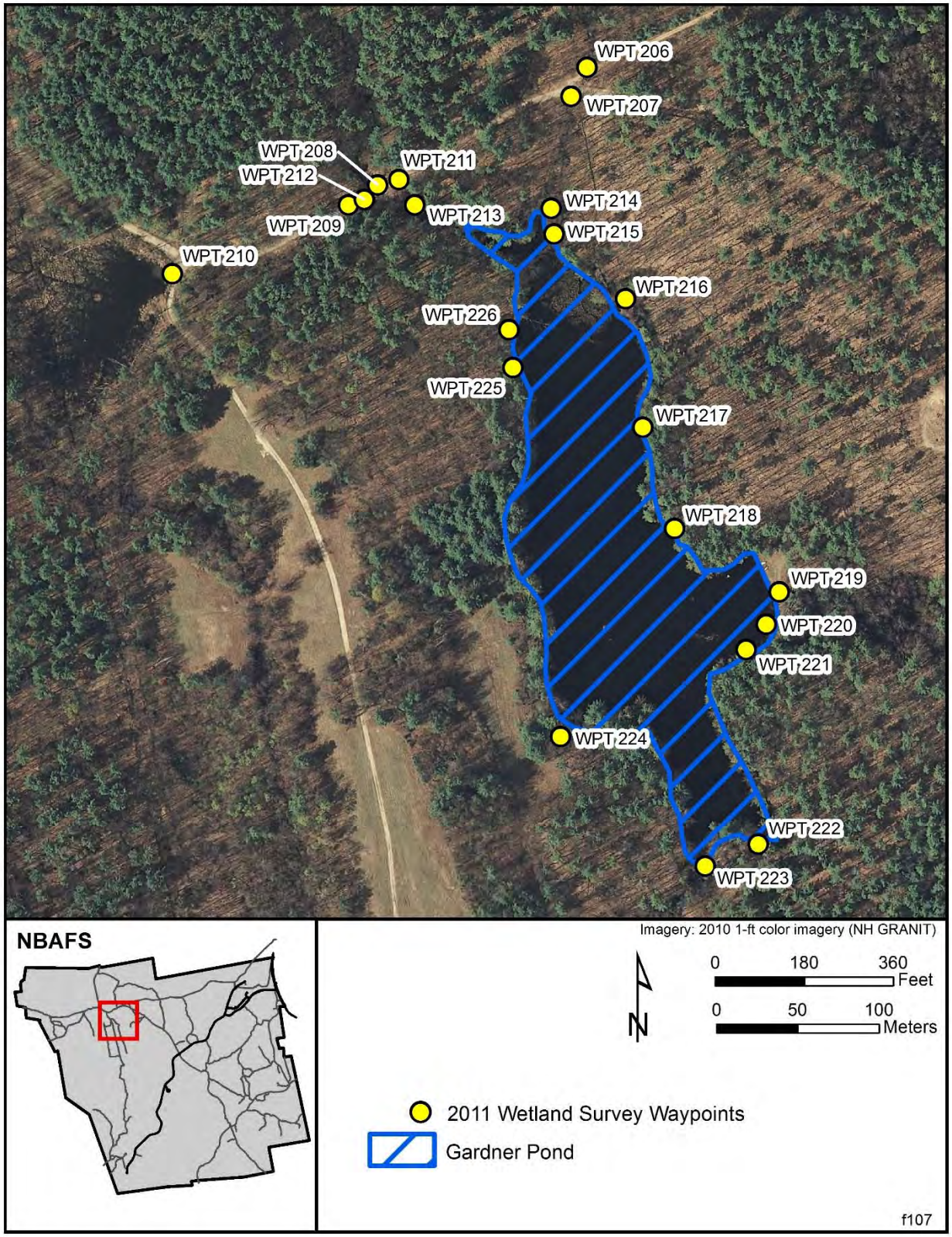

FIGURE 54. Gardner Pond, Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

FIGURE 55. Gardner Pond, View from Dam (near WPT 219).

Shooting Field, a large periodically mowed area, is located near and upgradient to the west of the pond. Some runoff from the Shooting Field mowed area enters Gardner Pond (WPT 224).

Across most of the Gardner Pond watershed area, the intervening vegetation between the roads and wetland or inlet stream acts as an effective barrier to sediment transport and migration to the wetland. The main inflow to Gardner Pond passes under a large relatively new concrete bridge on West Meadow Road (Figure 56; WPT 208). The road surface is generally well maintained and in good condition, with some loose gravel in places. A curb along the bridge is a barrier to sediment inflow to the stream. Ditches along West Meadow Road leading to the stream are well vegetated, however some sand entering the stream from the ditches was evident, as well as gravel from the ditch northeast of the bridge (WPT 211). That ditch appears to receive significant storm flows from a gravel road just to the east. A soil pile located just west of the stream and north of West Meadow Road (WPT 209) may contribute sediment during storm events. Deposits of gravel were observed in the streambed in several locations downstream of the bridge (Figure 56). The gravel had been placed under the bridge during its construction. A small unnamed tributary stream flowing from a small wetland west of the Shooting Field road receives some deposition of sand and gravel from that road (WPT 210) as well as the margin of West Meadow Road.

FIGURE 56. Primary Inflow to Gardner Pond at West Meadow Road Bridge (WPT 208). Tributary Stream from Shooting Field Road Enters at Left.

FIGURE 57. Gravel Deposits in Primary Inflow Stream to Gardner Pond (WPT 212).

A second small tributary stream passes under East Meadow Road (WPT 206) and Campbell Road (WPT 207) through culverts near their intersection. Long sections of East Meadow Road and Campbell Road slope toward the stream and show evidence of some sheet flow erosion and loose sand on the road edges near the stream; sand and small gravel were observed accumulating in the stream bed below the culverts. The surface of East Meadow Road in particular was observed to include considerable loose sand and gravel. In addition to these roads, a small dirt road leads to the dam from Campbell Road;, but the surface of this road is well-vegetated and stable. The potential for impacts from erosion or sedimentation into this wetland is considered to be moderate, and results primarily from the potential for eroded sediment to enter from the surface of West Meadow Road.

4.13 MURPHY SWAMP

This wetland, known locally as Murphy Swamp, is a 1.5-ac (0.6-ha) wetland with characteristics most similar to those of a kettle-hole bog system or a poor-level fen/bog system (LaGory et al 2011). Two natural communities were found in this wetland, a highbush blueberry-mountain holly wooded fen and a large cranberry-short sedge moss lawn. It is located approximately 75 ft (23 m) south of West Meadow Road and northwest of the road to Gate 15 (Figure 58).

Murphy Swamp is composed of three concentric vegetation zones that differ in species composition, structure, and water depth (LaGory et al 2011) (Figure 59). The outermost zone that borders upland forest consists of a dense tall shrub thicket dominated by highbush blueberry, but also contains mountain holly (*Nemopanthus mucronatus*), common winterberry, maleberry, chokeberry (*Photinia* sp.), and occasional white pine, red maple, and black gum. This tall-shrub zone (up to 60 ft [20 m] wide) transitions into a zone of tall herbaceous species and low shrubs dominated by tall sedges (*Carex rostrata*), large cranberry, scattered highbush blueberry (typically on hummocks), *Spiraea* sp., common buttonbush, seedling *Kalmia* sp., pod-grass (*Scheuchzeria palustris*), and sphagnum. The central portion of the wetland where the water is deepest has markedly shorter vegetation that includes needle spikerush, pod-grass, beaksedge (*Rhynchospora* sp.), three-way sedge, common arrowhead (*Sagittaria latifolia*), large cranberry (*Vaccinium macrocarpon*), sphagnum, and abundant sundews (*Drosera* sp.). White pine saplings occur in the central, short vegetation zone.

Murphy Swamp is in the Joe English Brook watershed. This wetland is located in a low area approximately 8-10 ft (2-3 m) below the elevation of West Meadow Road, which has a steep embankment (WPT 165). The slopes draining to the wetland on the north, east, and southeast are relatively steep, with a moderate slope to the northeast and low slopes to the west and southwest. A margin of relatively flat ground borders the wetland on the north, below the slope. A low ridge separates the wetland from the nearest portion of the road to Gate 15. A small ephemeral stream enters the wetland on the northwest corner, following a hummocky, discontinuous route. A slight flow was observed in the stream at the time of the survey. This inflow originated north of West Meadow Road, in the area of Joe English Hill, and passed through a culvert (WPT 161). An outflowing stream exits the wetland on the northwest side

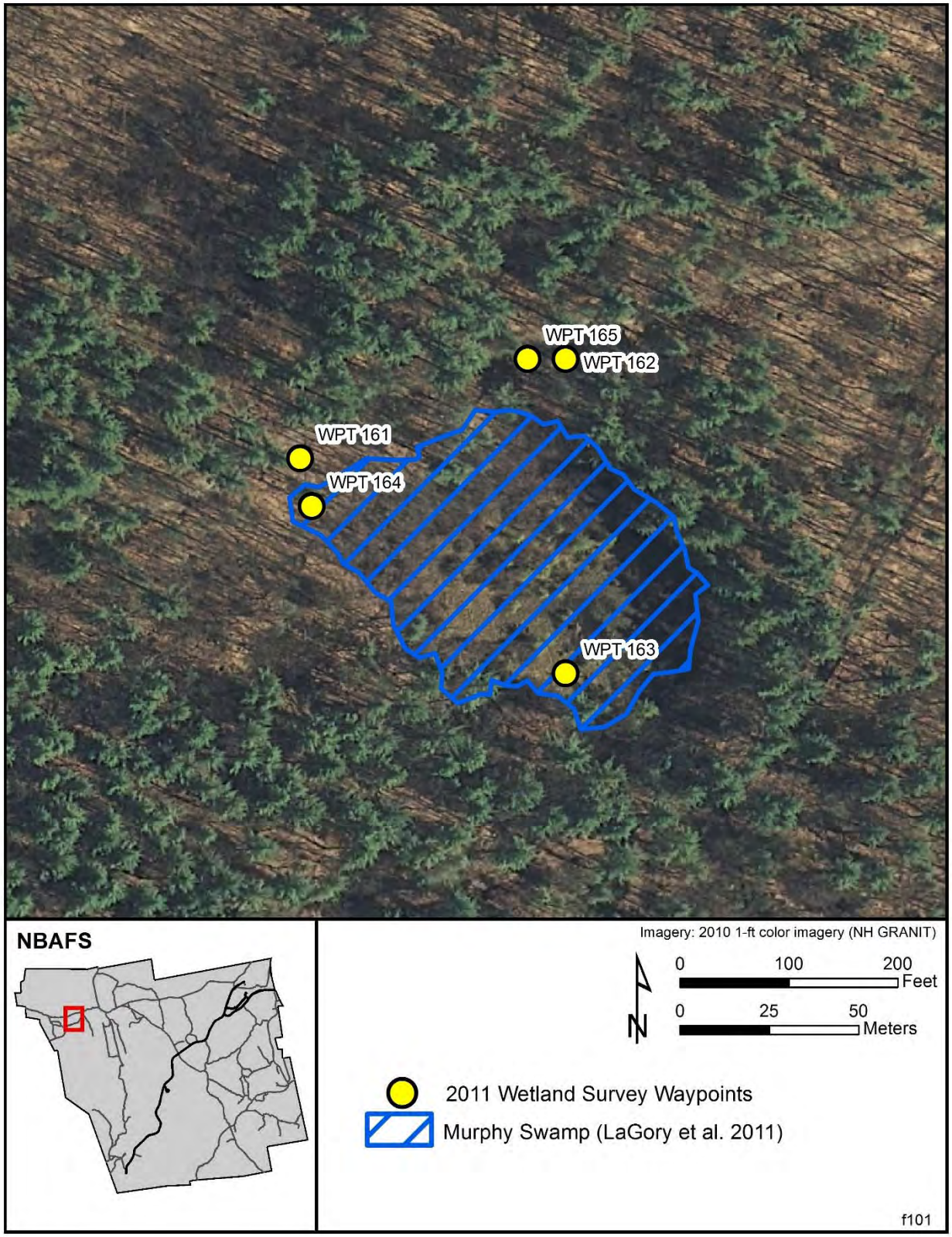

FIGURE 58. Murphy Swamp, Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

FIGURE 59. Murphy Swamp (WPT 163).

(WPT 164), near the inflow, and continues southwest. A moderate to strong flow was observed in this stream, with a portion of the flow appearing to come directly from the stream from Joe English Hill.

Soils throughout much of the wetland belong to the Chatfield-Hollis-Canton Complex, 8-15% slope, with Canton Stony Fine Sandy Loam, 3-8% slope, extending into the south edge, and Hinckley Loamy Sand, 8-15% slope, extending into the west edge. The surrounding woodland is primarily deciduous, with red maple, gray birch, red oak, white oak, sassafras, chestnut, yellow birch, witch hazel, and white pine.

No nonnative invasive plants or other disturbances in or adjacent to the wetland were observed during our survey. The road surface of West Meadow Road was graded gravel, and generally in good condition. The intervening vegetation between the road and wetland generally acted as an effective barrier to sediment transport and migration to the wetland. However, unstable, exposed soil occurred on a steep cut bank in some areas along the south edge of the roadway (Figure 60; WPT 165). Some disturbance of the road shoulder may be associated with roadside brush trimming. While the potential for sedimentation into the wetland or intervening

FIGURE 60. Eroding Shoulder of West Meadow Road above Murphy Swamp (WPT 162 and 165).

woodland area exists, no evidence was observed. The road to Gate 15, with a dirt/gravel surface, seems to receive low to moderate use and runoff from it is directed away from the wetland by an intervening ridge. The potential for impacts from erosion or sedimentation in this wetland is considered to be low to moderate.

4.14 CHAIN FERN BOG

This wetland, known locally as Chain Fern Bog and referred to as Wetland A in LaGory et al (2011), is a 2.1-ac (0.9-ha) wetland designated as a medium level fen system (Figure 61). Two natural communities were found in this wetland, a highbush blueberry-mountain holly wooded fen and a large cranberry-short sedge moss lawn. The road to Gate 15 abuts the south edge of the wetland (WPT 167). An unnamed dirt road lies approximately 48 ft (15 m) to the north of the wetland.

Chain Fern Bog includes three distinct vegetation zones (LaGory et al. 2011) (Figure 62). An outermost tall shrub zone borders the entire wetland and consists of a dense tall shrub thicket dominated by highbush blueberry, common winterberry, mountain holly, and maleberry with occasional red maple, white pine, yellow birch, eastern hemlock, and black gum. A zone of Virginia chain fern and sphagnum bisects the central portion of the wetland and extends from the inner eastern and western edges of the tall-shrub zone. This portion of the wetland is on a floating peat mat. To the north and south of the chain-fern zone is a medium-height sedge zone dominated by three-way sedge and sphagnum, with large cranberry and cottongrass (*Eriophorum spp.*). Bluejoint grass, sedge (*Carex crinita*), and cinnamon fern occur in scattered locations. No nonnative invasive plants in or adjacent to the wetland were observed during our survey, although a small population of common cattail, a potentially invasive native species was observed in the southern part of the wetland. Water depth in the open interior of the wetland was observed in 2009 to be 1 to 2 ft (0.3 to 0.6 m).

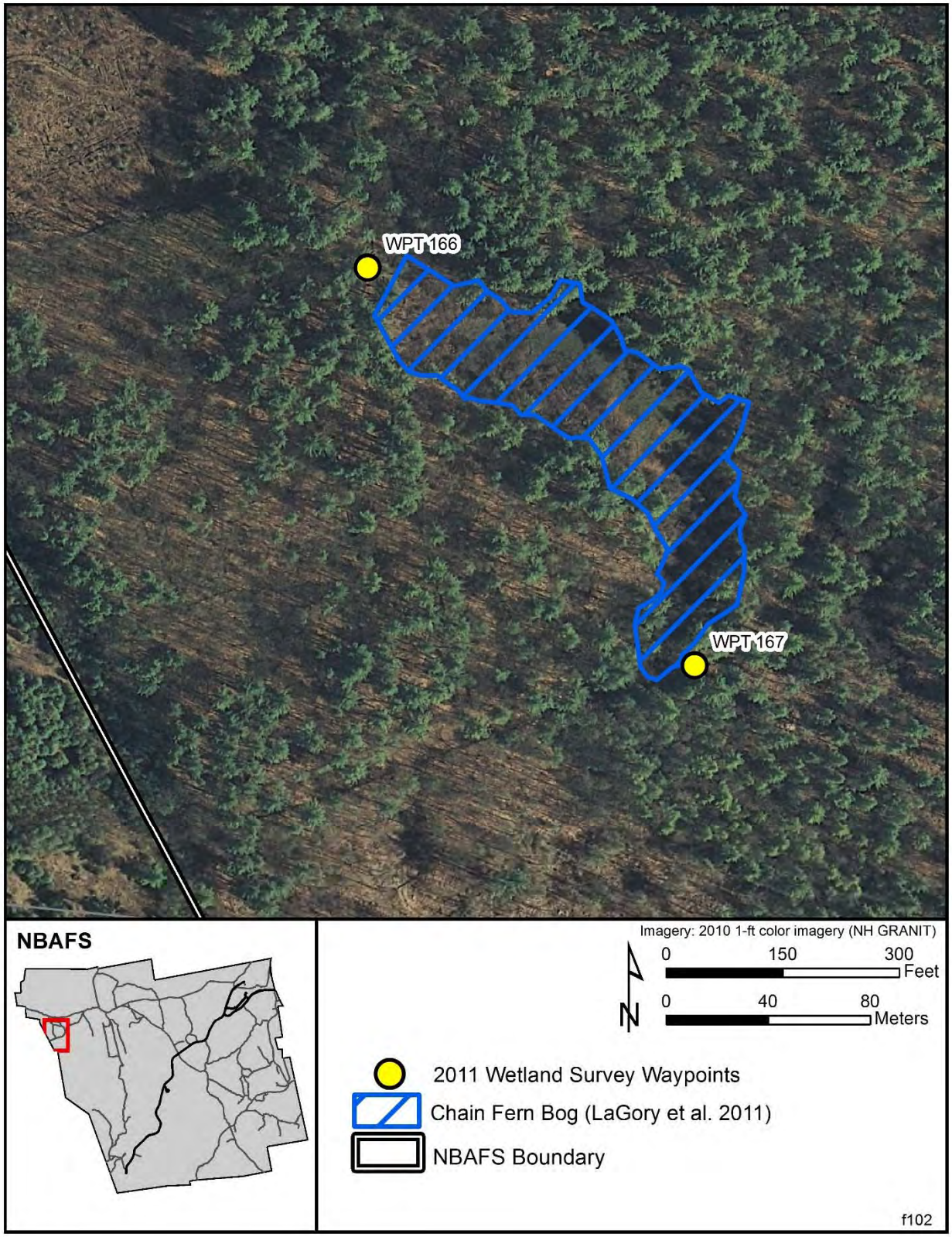

FIGURE 61. Chain Fern Bog, Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

FIGURE 62. Chain Fern Bog (Source: LaGory et al 2011).

Chain Fern Bog is in the Joe English Brook watershed. This wetland is located in a topographic depression with gentle slopes toward the wetland on all sides. Near the northern margin, the land begins to slope away to the northeast. Across from the road to Gate 15, the land slopes away to the south. Rock walls are present to the north (between the unnamed dirt road and the wetland), east, and southeast of the wetland (between the southeast margin of the wetland and the road to Gate 15) and likely restrict surface runoff into the wetland. Water drains from the wetland to the north through a small channel located in a low area at the northwest corner (WPT 166), but no point of inflow was observed. A very slight flow away from the wetland was observed south of the road to Gate 15.

Soils throughout much of the wetland are Canton Stony Fine Sandy Loam, 8-15% slopes, with Hinckley Loamy Sand, 8-15% slopes, extending into the north end of the wetland and Scituate Stony Fine Sandy Loam, 3-8% slopes, at the south edge. Chain Fern Bog was observed in 1995 to have a peat substrate. The surrounding woodland is mixed evergreen/deciduous, with white pine, hemlock, red oak, white oak, lowbush blueberry, witch hazel, and bracken fern.

The road to Gate 15 has a dirt and gravel road surface, elevated approximately one foot above the wetland (Figure 63). The intervening vegetation between the road and wetland

FIGURE 63. Road to Gate 15 with Chain Fern Bog on Right (WPT 167).

generally acts as an effective barrier to sediment transport to the wetland. A small amount of gravel was observed to have fallen into the wetland along the edge of the road, but no evidence of soil erosion or impacts were detected. The road to Gate 15 receives low to moderate use. This road prevents drainage to the south from the wetland.

No sign of sediment input from the dirt road north of the wetland was observed. This road appears to generally receive little use, however, a recent timber harvest had been conducted north of the road with some indications of associated road use. The potential for impacts from erosion or sedimentation in this wetland is considered to be very low.

4.15 SEAVEY POND

Seavey Pond is a mostly open-water, man-made impoundment located in the northwest corner of NBAFS, south of Joe English Hill and 78 ft (24 m) from West Meadow Road (Figure 64). The pond elevation is maintained by an earthen dam along the western side (WPT 299), however, failure of the outlet structure at the dam has resulted in a lowered pond elevation.

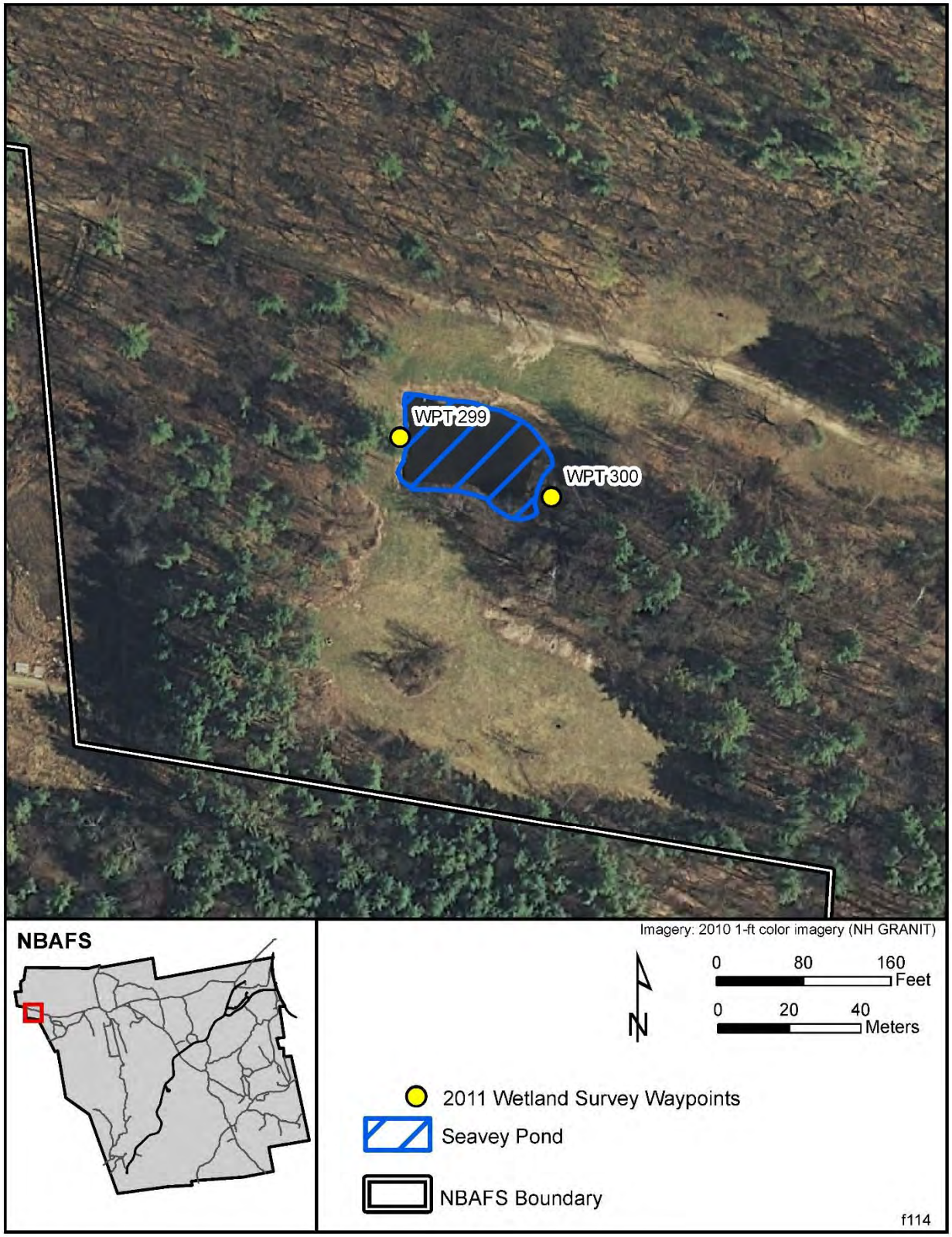

FIGURE 64. Seavey Pond Surveyed in October 2011, New Boston Air Force Station, New Hampshire.

Floating aquatic species in open-water portions of the pond included spatterdock and water-shield (Figure 65). A band of emergent marsh occurred around the pond margin, somewhat wider along the northern margin, and included sedges, bur-reed, manna-grass, wool-grass, common cattail, perfoliate boneset (*Eupatorium perfoliatum*), grass-leaved goldenrod, and bent grass (*Agrostis* sp.). Occasional alder saplings and meadowsweet were found on near-shore saturated soils. An expanse of saturated sand and gravel at the inlet supported a generally sparse community of grasses and sedges.

Seavey Pond is in the Meadow Brook watershed. Outflow occurs through an outlet structure at the dam, with the outlet stream flowing to the west. Inflow to Seavey Pond is from a small unnamed stream entering on the east side (WPT 300). An access road to a group camping area is located adjacent to the eastern margin of the pond and crosses the inlet stream. The stream makes two right-angle turns in the wooded area to the east, near the access road, before crossing under the road through a corrugated plastic culvert. Some bank erosion was noted at the turns. The area around the pond is relatively level, with gentle slopes toward the pond and sloping gently away to the west. The steep slopes of Joe English Hill are located to the north of the pond and West Meadow Road.

Soils in the eastern part of the Seavey Pond and eastern vicinity are Scarboro mucky loamy sand; soils in the western part and vicinity are Chatfield-Hollis-Rock outcrop complex, 15-35% slope. Soils of adjacent areas to the north are Chatfield-Hollis-Canton complex, 8-15% slopes.

Seavey Pond is surrounded by a steep embankment on all sides with a 4-10 ft- (1-3 m-) wide old-field plant community dominated by weedy species, particularly Canada goldenrod (*Solidago canadensis*), with common milkweed (*Asclepias syriaca*), pokeweed (*Phytolacca americana*), mullein (*Verbascum* sp.), and timothy grass (*Phleum pratense*) also present. The area surrounding the pond is primarily mowed turfgrass, extending from West Meadow Road and approximately 300 ft (90 m) south of the pond to the top of the pond embankment. Several red maple and a paper birch were located in the mowed area. Areas directly to the east and west were mixed deciduous/evergreen woods with white pine, red maple, and red oak. A small area of recent timber harvest was located to the southeast adjacent to the inlet stream and included resprouting autumn olive, an invasive shrub.

The surface of the adjacent campground access road was in poor condition, with loose gravel and sand. Considerable erosion of the road surface and shoulders had occurred with deposition on both sides of the culvert; rocks, sand, and gravel from the road surface and shoulder have fallen into the upstream portions of the pond (Figure 66). A significant input of sand and gravel has occurred at the inflow point, forming a delta in the eastern area of the pond along with mounds of sand and gravel (Figure 66). Minor erosion was observed in some other locations along the pond embankment, and some erosion has occurred on the dam. The potential for impacts from erosion or sedimentation in this wetland is considered to be high, primarily resulting from erosion of the campground access road surface and associated embankment near the pond inlet.

FIGURE 65. Seavey Pond, Looking toward the Outlet Structure and Dam (WPT 300).

FIGURE 66. Seavey Pond Inlet and Eroding Road Surface (left); Gravel Deposits from Road in Seavey Pond Inlet (right).

5 RECOMMENDATIONS

The results of the 2011 wetland surveys were used to develop recommendations for remediating past or ongoing impacts on those wetlands, and, where appropriate, restoration of affected wetlands. Project WE-1.2.2 (*Evaluate degraded wetlands for restoration potential and develop designs for wetland restoration*) is addressed with the recommendations presented in this section. The characteristics of each of the 15 wetlands we surveyed in 2011 and potential for impacts from erosion or sedimentation are presented in Section 4. While eight wetlands were rated low to very low for impact potential, four were rated as high to extremely high. For most wetlands, only minor mitigations for erosion and sedimentation concerns are recommended. Significant modifications of the nearby roadways, however, are recommended for several wetlands. Information and recommendations for each of the wetlands surveyed are presented below.

5.1 SATCOM POND

Impacts to SATCOM Pond (Beaver Pond No. 1) from erosion were considered to be low. Erosion was observed near the margin of the SATCOM parking area and resulted in sedimentation into the wetland. Erosion on the top and along the sides of the slopes was evident. We recommend a number of actions to address potential erosion and sedimentation issues:

- Areas of erosion along the margin of the parking lot should be repaired, and a dense cover of turf grass on the parking lot slopes should be established;
- Consideration should be given to replacing the asphalt surface with permeable paving; and
- Purple loosestrife should be removed from the wetland and future invasions monitored and controlled.

5.2 BUILDING 141 BEAVER POND

Impacts to the Building 141 Beaver Pond from erosion were considered to be high. We recommend a number of mitigations to address ongoing erosion and sedimentation concerns at several locations where East Meadow Road crosses or parallels this wetland.

- A primary recommendation is to eliminate the access road from Building 141 to East Meadow Road. While road gradients of 8% or less are generally recommended for low traffic volume/low speed access roads (USDOI and USDA 2007), the current access road has a gradient of approximately 17% (exceeding 20% on the upper portion) and is a significant source of eroded gravel and sand into the western portion of this wetland. The roadbed gravel and stone materials should be removed to the extent practicable, and topsoil placed on the remaining slope surface. The slope should be planted with native grasses, shrubs, and trees such as little bluestem, witch hazel, mountain laurel, lowbush blueberry, yellow birch, white pine, red oak, red maple, and beech. Erosion control

TABLE 2. Summary of Recommendations for Wetland Impact Mitigation at New Boston Air Force Station, New Hampshire

Wetland	Impact Potential	Recommendations
SATCOM Pond (Beaver Pond No. 1)	Low	Repair areas of erosion along margin of the SATCOM parking lot and establish turf grass; consider replacing asphalt surface with permeable paving.
Building 141 Beaver Pond	High	Eliminate (and, if needed, replace) the access road from Building 141 to East Meadow Road and plant the decommissioned roadway with native grasses, trees, and shrubs. Restore flow under East Meadow Road east of the west causeway to prevent surface flows across the road surface. Repair and elevate road surface to reduce saturation of surface gravels. Install a new culvert west of the east causeway where stream crosses road. Remove debris from culvert under east causeway to allow free flow; restore vegetation on the causeway margins and repair erosion.
Fire-House Pond	Low	Repair erosion along parking lot and Chestnut Hill Road ditch, and near culverts where inlet stream passes under Galaxy Way; establish vegetative cover on the road margins and on the dirt road to the west of the pond. Plant tall herbaceous plants in Chestnut Hill Road ditch to reduce flow velocities.
Green Tree Reservoir	Low	Stabilize the eroding slope near the culvert at the inlet; divert runoff from the road away from the inlet. Consider elimination of the mowed path north of the inlet culvert. As described in Section 4.4, Green Tree Reservoir was a relatively shallow emergent wetland prior to construction of the west and south berms by the USAF sometime after 1960. Depending on future management objectives for this wetland, the west and south berms could be eliminated or reduced in elevation to restore the natural hydrology of the wetland area. There could be a number of benefits to this restoration including the creation of more ecologically appropriate habitat for Blanding's turtles.
Joe English Pond	High	Repair and elevate causeway road surface to reduce saturation of surface gravels. Repair erosion along the causeway, and plant margins with native grasses to stabilize. Remove gravel deposits that have washed into adjacent areas. Repair erosion and establish vegetative cover near culverts where inlet streams pass under On-Orbit Drive. To improve hydrologic connection between the marsh area to the north of the causeway and the deepwater pond to the south, additional culverts could be placed to the west and east of the bridge or the causeway removed altogether.
Trailer Park Pond	Very low	Repair areas of erosion near culverts along On-Orbit Drive; establish native grasses on the road margins and in swales.

Table 2 (Cont.)

Wetland	Impact Potential	Recommendations
Wells Bog	Moderate	Repair and elevate causeway road surface to reduce saturation of surface gravels. Repair areas of erosion on the causeway margin and establish grasses along the margin. Repair erosion along the gravel and dirt road that crosses the inlet stream to the northeast of the wetland and establish grasses on the road surface.
Beaver Pond No. 4	Very low	Protect the bank of the pond along Brook Road from potential future erosion. Consider the placement of boulders or other reinforcement at the base of the Brook Road where Joe English Brook flows into the pond.
Ice Pond	High	Eliminate the picnic area access road and plant the decommissioned roadway with native grasses, trees, and shrubs; construct a runoff diversion at the top of the slope to divert flow away from the restored area. Stabilize the surfaces of the campground access roads; increase the area of the turf grass buffer. Discourage the use of the footpath from the camping area to the pond. Consider increasing culvert capacity at the primary inflow (see Appendix B).
Roby Pond	Very low	Avoid disturbance during mowing on adjacent dirt road northwest of the pond or area near dam.
Pitcher Plant Bog	Very low	Continue current maintenance of the road surfaces of Campbell Road, East Meadow Road, and the unnamed diagonal road adjacent to the wetland.
Gardner Pond	Moderate	Stabilize the margin of West Meadow Road where the concrete bridge spans the Gardner Pond inlet stream; stabilize the surface and margin of the Shooting Field entrance road; establish native grasses on the road margins. Repair East Meadow Road and Campbell Road where small inlet stream passes through culverts, and establish native grasses on the margins. As described in Section 4.12, Gardner Pond was a relatively shallow wetland prior to construction of the earthen dam by the USAF sometime after 1960. Depending on future management objectives for this wetland, the earthen dam could be eliminated or reduced in elevation to restore the natural hydrology of the wetland area. There could be a number of benefits to this restoration.
Murphy Swamp	Low to moderate	Repair and stabilize the shoulder of West Meadow Road north of the wetland near the inlet stream. Establish a cover of native grasses on the road margin.
Chain Fern Bog	Very low	Stabilize the margin of the road to Gate 15 by establishing a cover of native grasses.

Table 2 (Cont.)

Wetland	Impact Potential	Recommendations
Seavey Pond	High	Repair road surface and restore areas of erosion and loose gravel along the road; establish grasses on the road margin. Consider realigning the location of the inlet to the pond to reduce the potential for erosion and road damage at high flows. Consider installing a larger culvert to accommodate high flows. Consider eliminating the dam, and restoring natural hydrology of the stream course.

materials, such as excelsior erosion control blankets, should be placed over the topsoil following seeding and securely anchored. Loose eroded gravel and sand that has washed onto East Meadow Road and the wetland should be removed or stabilized.

- If access to East Meadow Road is required in this area, a new road located in a relatively low-slope area could be considered, extending from On-Orbit Drive. To minimize impacts, the road should follow the topographic contours to the extent possible, with a road gradient generally 8% or less, and preserve natural drainage patterns. Recommendations for road construction can be found in The Gold Book (USDOI and USDA 2007).

- The surface and shoulders of East Meadow Road through and adjacent to the wetland should be repaired where eroded and the road surface of causeways elevated to reduce saturation of surface gravels.

- If the use of East Meadow Road is not required in this area, consideration should be given to removing the two causeways to provide full restoration of the natural hydrology of the wetland. Sediment barriers should be installed at the causeways and the removals should be conducted during low-flow periods to minimize the downstream transport of sediment. This removal would involve excavation within the wetland and would therefore require permitting from the U.S. Army Corps of Engineers. Nationwide Permit 27, Aquatic Habitat Restoration, Establishment, and Enhancement Activities, authorizes activities in wetlands and open waters that restore or enhance aquatic habitat provided those activities result in net increases in aquatic resource functions and services. This permit requires a Pre-Construction Notification be submitted to the District Engineer prior to the commencement of project activities. The shoreline slope where causeway materials have been removed should be contoured to match the adjacent wetland areas. Following the removal of all causeway materials, emergent wetland species, such as *Calamagrostis canadensis*, *Dulichium arundinaceum*, *Scirpus cyperinus*, or *Sparganium americanum*, or *Spiraea alba* var. *latifolia* should be planted near the wetland margin. Erosion control materials, such as excelsior erosion control blankets, should be placed over the substrate surfaces following seeding and securely anchored.

- To restore connection between portions of the wetland and prevent flows across the road surface, a culvert or culverts should be placed under East Meadow Road immediately east of the existing access road.

- A new culvert should be placed under East Meadow Road where a small stream crosses the road east of the existing blocked culvert near the east causeway.

- Debris placed by beavers in a culvert under the east causeway should be removed.

- Bare or eroding areas along the causeway margins should be repaired and revegetated.

- Purple loosestrife should be removed and future invasions monitored and controlled.

5.3 FIRE-HOUSE POND

Impacts to Fire-House Pond from erosion were considered to be low. Areas of erosion along the ditch and shoulder adjacent to the Chestnut Hill Road parking lot and near the culvert on Galaxy Way contribute small amounts of sediments to inlet streams. Runoff from a dirt road contributes fine sediment to the pond. We recommend a number of actions to address potential erosion and sedimentation concerns.

- Areas of erosion in the drainage ditch and shoulder along Chestnut Hill Road should be repaired, and a cover of native grasses should be established in the eroded areas. A high density of tall obligate or facultative wetland herbaceous plants, such as bulrushes and sedges, should be planted in the ditch to help reduce flow velocities.

- Areas of erosion near culverts along Galaxy Way should be repaired and a cover of native grasses on the road margins should be established

- A dense vegetation cover of native grasses in the swale along Galaxy Way leading to the culvert should be established.

- A dense cover of native grasses on the dirt road to the west of the marsh should be established to reduce sedimentation.

5.4 GREEN TREE RESERVOIR

Impacts to Green Tree Reservoir from erosion were considered to be low. We recommend a number of actions to address potential erosion and sedimentation concerns.

- The eroding slope near the inlet culvert from Maddening Pond should be stabilized and vegetated. Runoff from the road should be diverted away from the steep slope at this location.

- The need for the mowed path from the road to the pond, north of the inlet culvert, should be assessed and elimination of the path should be considered as this path provides a route for road sediment to enter the wetland.

- As described in Section 4.4, Green Tree Reservoir was a relatively shallow emergent wetland prior to construction of the west and south berms by the USAF sometime after 1960. Depending on future management objectives for this wetland, the west and south berms could be eliminated or reduced in elevation to restore the natural hydrology of the wetland area. There could be a number of benefits to this restoration including the creation of more ecologically appropriate habitat for Blanding's turtles. While presently occurring native species populations along the pond margins would be expected to expand, supplemental planting of native wetland species would be recommended. Invasive species, such as purple loosestrife, should be monitored frequently and immediately eradicated.[2]

5.5 JOE ENGLISH POND

Impacts to Joe English Pond from erosion were considered to be high. Areas of erosion in the adjacent recreation area, on the causeway crossing the north arm of the wetland, Brook Road, and near the culverts through which inlet streams pass under On-Orbit Drive contribute sediments to the pond and several inlet streams. We recommend a number of actions to address ongoing erosion and sedimentation issues.

- Areas of erosion on the road surface and margins of the causeway and Brook Road east of the causeway should be repaired. Ponding on the road surface should be prevented.

- Runoff from the gravel road connecting to Brook Road east of the causeway should be diverted to avoid sediment flows into the pond.

- A dense cover of native grasses should be established along the causeway margin, on the margins of Brook Road east of the causeway where runoff and erosion has occurred, and in the Joe English Pond recreation area, to distribute flows and eliminate concentrated runoff.

- Gravel that has washed into the wetland from the causeway should be removed or stabilized.

- Areas of erosion near culverts along On-Orbit drive should be repaired and a cover of native grasses on the road margins should be established.

- Disturbed areas in the pond (e.g., rutted soils) should be restored (graded) and revegetated with appropriate native wetland species.

[2] In spring 2013, after this survey was conducted, the outfall culvert for Green Tree Reservoir failed, resulted in the draining of the reservoir, and a return to an emergent wetland condition.

- Purple loosestrife should be removed and future invasions monitored and controlled.

- The causeway likely disrupts surface and subsurface flows to the south. Although the opening under the causeway bridge is adequate for storm events (e.g., 100 year, 24 hour storm), additional culverts should be placed in the causeway to improve surface flow and reduce the hydrologic alteration of the wetland area. Some wetland areas north of the causeway likely have greater water depths at certain times than under natural flow conditions. Areas south of the causeway and farthest from the bridge may be the most susceptible to hydrologic changes resulting from the causeway, potentially unable to maintain present wetland communities.

- The bridge opening and any culverts should be monitored regularly for beaver activity and all debris removed.

- Full restoration of the natural hydrology and biotic communities of the wetland areas would require the removal of the causeway. Presently occurring native species populations along the margins and on hummocks would be expected to expand, but planting of native wetland species would be recommended to speed the process of vegetation establishment. Invasive species, such as purple loosestrife, would need to be monitored frequently and immediately eradicated.

5.6 TRAILER PARK POND

Impacts to Trailer Park Pond from erosion were considered to be very low. Areas of erosion near the culverts along On-Orbit Drive contribute small amounts of sediments to several inlet streams. We recommend a number of actions to address potential erosion and sedimentation concerns.

- Areas of erosion near culverts along On-Orbit drive should be repaired and a cover of native grasses on the road margins should be established.

- A dense vegetation cover of native grasses should be established in roadside swales that drain to culverts.

5.7 WELLS BOG

Impacts to Wells Bog from erosion were considered to be moderate. Water and sediment were observed flowing off the causeway into the wetland, and considerable erosion was occurring at the crossing of an old gravel road across the stream flowing into the east end of Wells Bog. We recommend a number of actions to address ongoing erosion and sedimentation issues.

- The road surface of the causeway should be elevated to reduce saturation of surface gravels.

- Areas of erosion on the causeway margin should be repaired, and a dense cover of native grasses along the causeway margin should be established to act as a buffer.

- Areas of erosion along the gravel road crossing the northeast inflow to Wells Bog should be repaired, and a cover of native grasses on the road surface should be established to prevent future erosion.

5.8 BEAVER POND NUMBER 4

Impacts to Beaver Pond No. 4 from erosion were considered to be very low. The proximity of the road to the edge of the pond just downstream of the Joe English Brook inflow point is a potential issue. A rock wall that parallels the edge of the pond is absent in this area and erosion of the bank may be occurring, possibly eventually reaching the road. We recommend that the edge of the road where Joe English Brook flows near the road and enters the wetland be protected from potential failure. Consideration should be given to the placement of boulders along the curve of the bank.

5.9 ICE POND

Impacts to Ice Pond from erosion were considered to be high. We recommend a number of actions to address ongoing erosion and sedimentation issues.

- The surfaces of the Ice Pond and Roby Pond campground access road should be repaired and stabilized. Runoff and sediment from these surfaces currently flows toward Ice Pond near the primary inlet stream. Increasing the width of the turf grass buffer in that location would reduce sediment input into the headwaters of the pond.

- The footpath from the camping area to the pond should be blocked because use of the path has resulted in some erosion of the slope and there is the potential for additional degradation and impacts to the pond.

- The most significant area of concern is the access road to the picnic area, which is located on a steep slope, is highly eroded, and is the source of ongoing sedimentation into Ice Pond. While road gradients of 8% or less are generally recommended for low traffic volume/low speed local roads (USDOI and USDA 2007), this access road has a gradient of approximately 15%. We recommend that this access road be eliminated and the decommissioned roadbed planted with native grasses, shrubs, and trees. Construction of a runoff diversion at the top of the slope to the picnic area and bordering the loop road would prevent high velocity flow down this slope.

- Consider increasing the capacity of the culverts at the primary inflow from Roby Pond or replacing them with a bridge. Present capacity may not be adequate to provide safe conveyance under high flow conditions, which may result in future erosion and deposition of gravel into Ice Pond. A 5-year, 24 hour storm may exceed the capacity of the existing culverts and overtop the road (see Appendix B). Assumptions used in this

estimation included a lack of storage capacity in Roby Pond and the upstream wetlands. A concrete box culvert sized to accommodate a 100 year-24 hour storm should be 13 feet wide, assuming a height of 2.5 feet. A narrower opening would require an increased height.

5.10 ROBY POND

Impacts to Roby Pond from erosion were considered to be very low. We recommend a number of actions to address potential erosion and sedimentation issues.

- Current maintenance of the gravel loop road through the camping area should be continued.
- Disturbance of soils on the pond margin during mowing of the adjacent northwestern dirt road or area near dam should be avoided.

5.11 PITCHER PLANT BOG

Impacts to the Pitcher Plant Bog from erosion were considered to be very low. We recommend a number of actions to address potential erosion and sedimentation issues.

- Current maintenance of the road surfaces and shoulders of Campbell Road, East Meadow Road, and the unnamed diagonal road adjacent to the wetland should be continued. Any actions should be avoided that would disturb these gravel road surfaces and shoulders.

5.12 GARDNER POND

Impacts to Garner Pond from erosion were considered to be moderate. Sediment inputs from the Shooting Field entrance road, West Meadow Road, East Meadow Road, and Campbell Road to inlet streams were identified. We recommend a number of actions to address potential erosion and sedimentation concerns.

- Erosion along the margin of West Meadow Road near the concrete bridge that spans the inlet stream to Gardner Pond should be repaired and the area stabilized.
- Erosion at culverts where inlet streams pass under the Shooting Field entrance road and Campbell Road should be repaired and the areas stabilized.
- Areas of loose gravel on the Shooting Field entrance road, East Meadow Road, and Campbell Road should be repaired.
- A cover of native grasses should be established on adjacent road margins as a buffer to catch sediments that would otherwise wash into inlet streams.

- As described in Section 4.12, Gardner Pond was a relatively shallow wetland prior to construction of the earthen dam by the USAF sometime after 1960. Depending on future management objectives for this wetland, the earthen dam could be eliminated or reduced to restore the natural hydrology to the wetland area. There could be a number of ecological benefits to this restoration. While presently occurring native plants along the margins would be expected to expand, supplemental planting of native wetland species would be recommended to speed the process of vegetation establishment. Although invasive species, such as purple loosestrife, were not identified during the survey, they would have to be monitored frequently and immediately eradicated.

5.13 MURPHY SWAMP

Impacts to Murphy Swamp from erosion were considered to be low to moderate. We recommend a number of actions to address potential and ongoing erosion and sedimentation issues.

- Current maintenance of the road surface of West Meadow Road should be continued. The shoulder of West Meadow Road near the northern end of the wetland especially where the inlet stream crosses under the road should be repaired, and unstable, exposed soil that occurs on a steep cut bank in some areas along the south edge of the roadway should be stabilized.

- A cover of native grasses should be established on the road margin to prevent erosion.

- Disturbance of the road shoulder during brush trimming operations should be avoided.

5.14 CHAIN FERN BOG

Impacts to the Chain Fern Bog from erosion were considered to be very low. We recommend a number of actions to address potential erosion and sedimentation issues.

- Current maintenance of the road to Gate 15 should be continued. A cover of native grasses should be established to stabilize the road margin.

- Actions that would result in any deposition of gravel or soil into the wetland should be avoided.

5.15 SEAVEY POND

Impacts to Seavey Pond from erosion were considered to be high. Large amounts of gravel and sand had eroded from the adjacent road into the pond. Some erosion was also noted along the banks of the inlet stream. We recommend a number of actions to address ongoing erosion and sedimentation issues.

- Areas of erosion and loose gravel along the road should be repaired.
- A cover of native grasses on the road margin should be established to serve as a buffer.
- Consideration should be given to realigning the stream section near the road to eliminate the right angle turn in the channel immediately upstream of the culvert. The stream channel should be restored to the original flow path, and the culvert alignment should follow the natural stream channel alignment.
- Consider increasing the capacity of the culvert at the inflow or replacing it with a box culvert. Present capacity may not be adequate to provide safe conveyance under high flow conditions, which may result in future erosion and deposition of gravel into Seavey Pond. A 5-year, 24 hour storm may exceed the capacity of the existing culverts and overtop the road (see Appendix B). A concrete box culvert sized to accommodate a 100 year-24 hour storm should be 4.6 ft wide, assuming a height of 2 ft. A narrower opening would require an increased height.
- Removal of the dam and water control structure should be given consideration, along with restoration of the natural hydrology of the original stream course. Material from the dam may be suitable for use in restoring gentler slopes in the old-field habitat along the former pond embankment. While presently occurring native plants along the margins would be expected to expand, supplemental planting of native wetland species would be recommended to speed the process of vegetation establishment. Species such as *Eupatorium perfoliatum*, *Euthamia graminifolia*, *Glyceria striata*, *Scirpus cyperinus*, *Spiraea alba* var *latifolia*, or *S. tomentosa*, could be planted along the channel. Although invasive wetland species, such as purple loosestrife, were not identified during the survey, they would have to be monitored frequently and immediately eradicated.

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APPENDIX A

FIELD DATA SHEETS FROM OCTOBER 2011

NBAFS Wetland Disturbance Survey

Date: 10/20/2011
Wetland Name: SATCOM Pond
Wetland Type: Pond, beaver impoundment
Coordinates: N: 42.94553 W: 71.63312
Observers: LaGory, Van Lonkhuyzen, Goulet, Drake
WP No.: 294 (main pond)

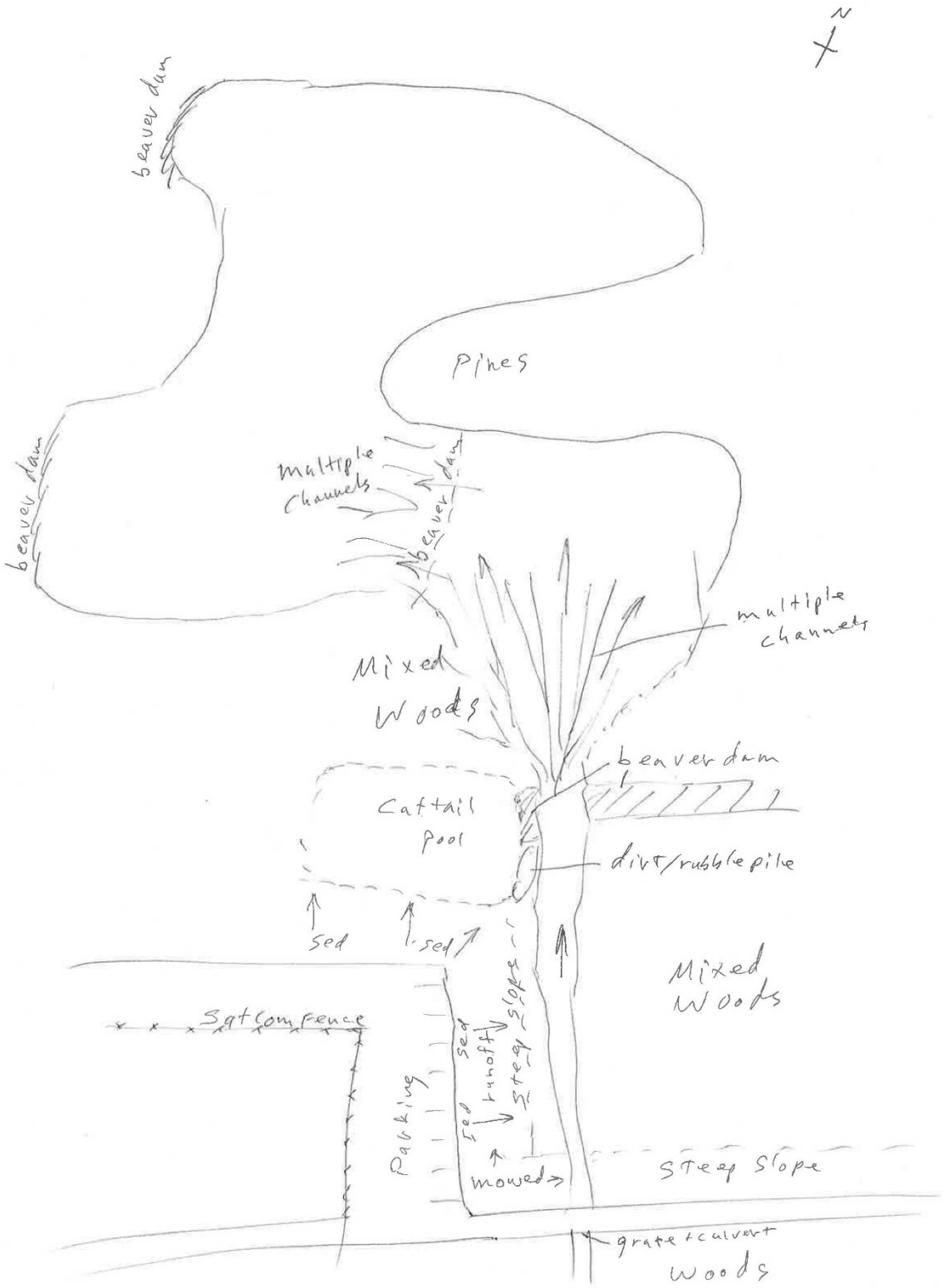
General Comments: Stream enters from south, remnant of old beaver dam, blocking drainage from lawn/parking lot to southwest, forming small pool with cattails. Upstream end is hemlock, red maple swamp/marsh (many small beaver dams); beaver dams to west and northwest, most od wetland is a pond; swampy and marshy areas to south.

Dominant Plant Species:
Tree: white pine, hemlock, red maple, red oak
Shrub/vines: *Spiraea alba*, maleberry, highbush blueberry
Herbaceous: *Onoclea sensibilis*, *Sparganium americanum*, *Glyceria* sp., *Typha latifolia*, *Scirpus cyperinus*, *Carex comosa*, other sedges, *Aster* sp., *Euthamia graminifolia*, cinnamon fern, New York fern , *Calamagrostis canadensis*, *Eleocharis acicularis*, *Brachyelytrum* sp., *Pontederia cordata*, *Brasenia schreberi*, *Nymphaea odorata*, *Juncus effusus*, purple loosestrife

Landscape context:
- **Features draining to**: On-Orbit Drive, SATCOM facility, surrounding woods.
- **Existing barriers to sediment input**: Remnant of old beaver dam blocks most flow from parking area; vegetation cover between road and stream-generally a wide buffer.
- **Surrounding land cover**: Mixed forest: gray birch, hemlock, alder, white pine, witch hazel, *Kalmia latifolia*, yellow birch, bracken, juniper, lowbush blueberry; some mowed areas at SATCOM.
- **Soil types**: Inlet: Woodbridge Stony Loam 8-15% slope; perimeter west and northeast: Canton Stony Fine Sandy Loam 3-8% slope; northwest perimeter: (minor) Canton Stony Fine Sandy Loam 15-25% slope; southeast perimeter: Paxton Stony Fine Sandy Loam 8-15% slope.
- **Distance from road**: About 20 feet from parking lot.
- **Road surface and condition**: Paved, gravel shoulder-mostly firm but loose in some areas

Erosion, sedimentation, and other signs of disturbance:
- **Erosion/sediment input including source magnitude**: Erosion along edge of parking lot-draining to small pool (small areas input to inlet stream-east side of parking lot).
- **Invasive nonnative species**: Purple loosestrife, in south section where inflowing stream opens up-widely distributed in this area but low density.
- **Other disturbance observed**: None

Overall assessment of erosion/sedimentation potential: Low
Potential mitigation strategy: Repair eroding sides of parking lot; permeable paving.


N
beaver dam
beaver dam
Pines
multiple channels
beaver dam
multiple channels
Mixed Woods
beaver dam
Cattail pool
dirt/rubble pile
sed
sed
Mixed Woods
Sat com fence
sed
runoff
steep slope
Parking
sed
mowed
steep slope
grate + culvert
Woods

NBAFS Wetland Disturbance Survey

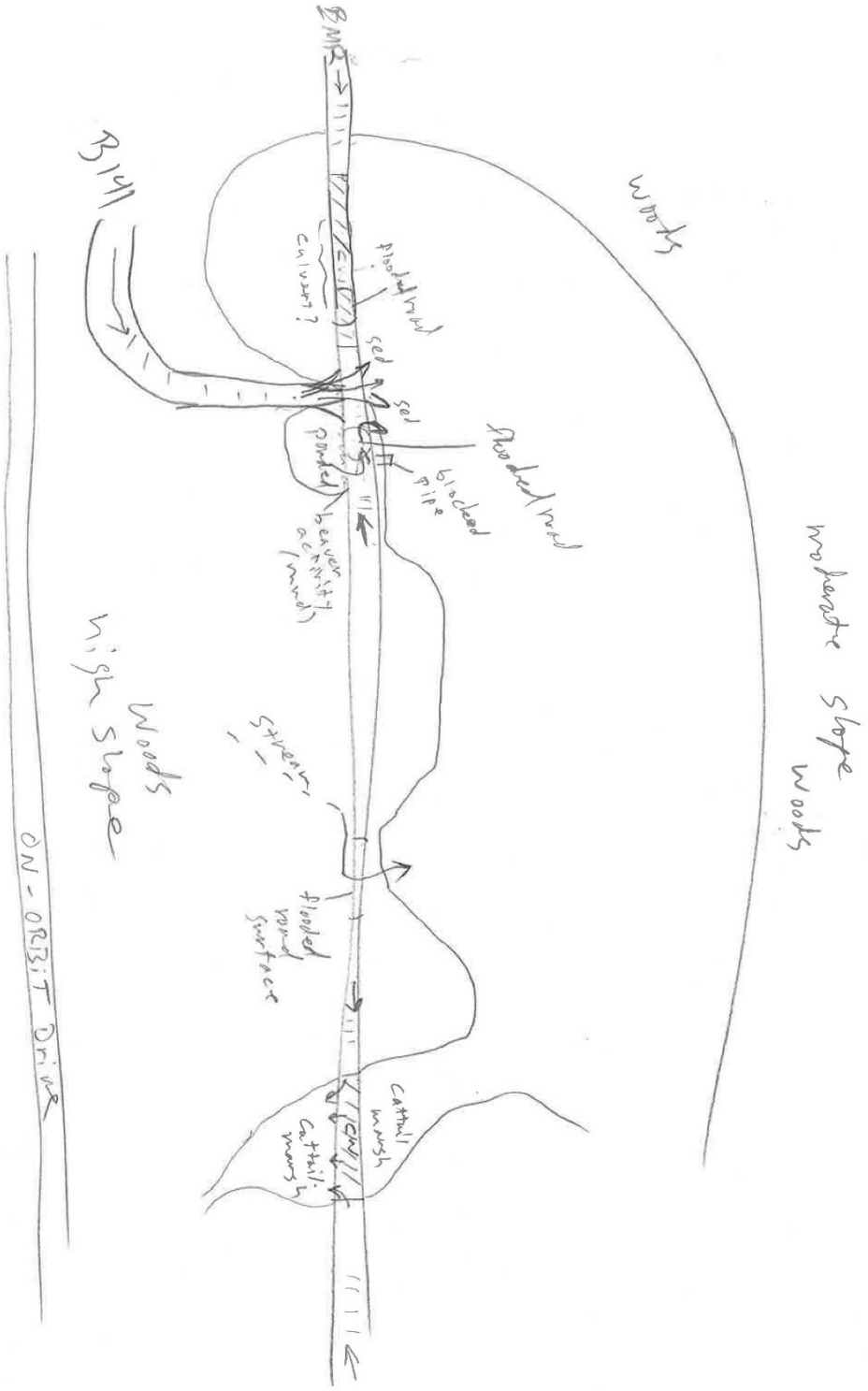
Date: 10/19/2011
Wetland Name: Building 141 Beaver Pond
Wetland Type: Beaver pond/swamp
Coordinates: N: 42.94918 W: 71.62949
Observers: LaGory, Van Lonkhuyzen, Goulet, Drake
WP No.: 205 (base of access road from building 141)
General Comments: Large wetland complex; series of beaver impoundments mostly north of East Meadow Road. Short causeway at west partially flooded; access road from building 141; and east causeway (blocked culvert) at exit.

Dominant Plant Species:
Tree: white pine saplings, red maple, hemlock
Shrub/vines: *Kalmia latifolia*, *Spiraea alba*
Herbaceous: *Sparganium americanum*, water lily, *Glyceria* sp., *Scirpus cyperinus*, *Juncus* sp., *Dulichium arundinaceum*, *Calamagrostis canadensis*, *Typha latifolia* (a few by access road); cattail marsh to east: *Typha latifolia*, *Scirpus cyperinus*, sedges, *Sparganium americanum*, *Spiraea* sp.

Landscape context:
- **Features draining to**: Recreation storage yard, slope from road to south, mixed woods surrounding, East Meadow Road, access Road from building 141, embankment below building 141.
- **Existing barriers to sediment input**: None at roads along and crossing wetland in portions.
- **Surrounding land cover**: Forest on all sides: white pine, red oak, red maple, gray birch, beech, yellow birch, witch hazel
- **Soil types**: Greenwood Mucky Peat; northeast: Canton Stony Fine Sandy Loam 8-15% slope; perimeter north and west: Canton Very Stony Fine Sandy Loam 15-35% slope; southwest: Canton Stony Fine Sandy Loam 3-8% slope, southeast: Chatfield-Hollis-Canton complex 8-15% slope.
- **Distance from road**: One foot at causeways.
- **Road surface and condition**: East Meadow Road: poor, gravel, some erosion on long slope, mostly stable ,sparsely vegetated, portions of road flooded; building 141 access road: rock, gravel, eroding severely; east causeway: good vegetation cover, stable.

Erosion, sedimentation, and other signs of disturbance:
- **Erosion/sediment input including source magnitude**: Large input of gravel, sediment from building 141 access road, some sediment from west causeway; flow across East Meadow Road, just east of building 141 road, from blocked pipe; East Meadow Road sloping from east and west; to east a stream crosses East Meadow Road with sediment (blocked culvert) and soil transported; gravel from causeway at east end of pond complex spills into cattail marsh; short slopes on East Meadow Road from east to west; some erosion on East Meadow Road; gravel at stream culvert.
- **Invasive nonnative species**: Small population of *Lythrum salicaria*.
- **Other disturbance observed**: None

Overall assessment of erosion/sedimentation potential: High
Potential mitigation strategy: Eliminate road from building 141?, Build up road in places where inundated and place culverts (e.g., west causeway and area on east side of East Meadow Road).


#2
Woods
Moderate Slope Woods
Flooded road
blocked pipe
Beaver activity (mud)
Culvert?
Flooded road
Stream
Flooded pond surface
Cattail marsh
Cattail marsh
Woods High Slope
ON-ORBIT Drive

NBAFS Wetland Disturbance Survey

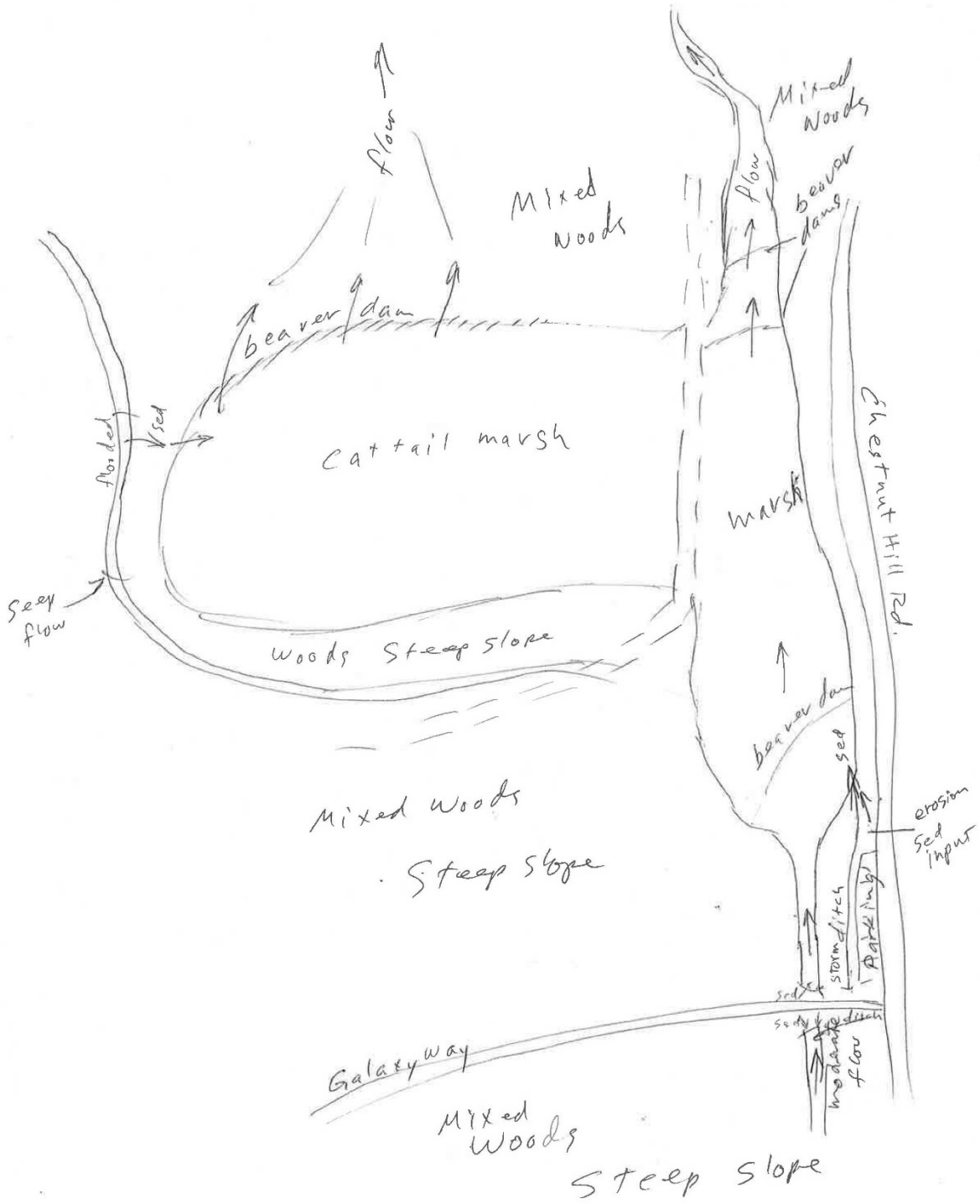
Date: 10/20/2011
Wetland Name: Fire-House Pond
Wetland Type: Marsh
Coordinates: N: 42.94937 W: 71.62275
Observers: LaGory, Van Lonkhuyzen, Goulet
WP No.: 249 (north end of marsh)
General Comments: Flow enters from south under Galaxy Way; moderate volume flow; south end of wetland with high, wooded slopes. Beaver dams at north end flooding trees. Buried transmission line/causeway cuts through north-south; beaver dam impounding west side (slopes down to north).

Dominant Plant Species:
Tree: red maple, white pine
Shrub/vines: maleberry, *Spiraea alba*, highbush blueberry, *Kalmia angustfolia*
Herbaceous: *Typha latifolia, Sparganium americanum, Nuphar lutea, Nymphaea odorata, Scirpus cyperinus,* marsh fern, sensitive fern, *Calamagrostis canadensis*

Landscape context:
- **Features draining to**: Chestnut Hill Road on east. Galaxy Way on south, mowed right-of-way for buried power line (good vegetation cover, no erosion)
- **Existing barriers to sediment input**: Vegetated buffers
- **Surrounding land cover**: Mixed forest: white pine, red maple, black birch, red oak, gray birch, hemlock, witch hazel, *Kalmia latifolia*; maintained herbaceous embankments of paved roads.
- **Soil types**: West and northwest: Chatfield-Hollis-Canton Complex 8-15% slope; south: Chatfield-Hollis-Rock Outcrop Complex 15-35% slope; east: Paxton Fine Sandy Loam 8-15% slope.
- **Distance from road**: 11 paces to dirt road on west; adjacent to Galaxy Way.
- **Road surface and condition**: Causeway: vegetated, good condition; dirt road: mostly good condition.

Erosion, sedimentation, and other signs of disturbance:
- **Erosion/sediment input including source magnitude**: Sediment inflow on west from dirt road, shallowly flooded at low spot by marsh (small steady flow to marsh)-road has rock and some gravel. Some erosion on slope above culvert (both sides) at Galaxy Way (minor), also into swale from building 103 area. Ditch on east boundary (by Chestnut Hill Road): erosion in ditch, two places on slope by north end of parking lot at Chestnut Hill Road.
- **Invasive nonnative species**: None observed.
- **Other disturbance observed**: Beaver dams.

Overall assessment of erosion/sedimentation potential: Low
Potential mitigation strategy: Retain and maintain vegetation along roadside ditch and inflow east of culvert to south side of Galaxy Way.


flow
Mixed Woods
Mixed Woods
flow
beaver dams
beaver dam
flooded
sed
Cattail marsh
marsh
Chestnut Hill Rd.
seep flow
Woods Steep slope
beaver dam
sed
erosion sed input
Mixed Woods
Steep Slope
storm ditch
Parking lot
sed
sed
sed
ditch
mod dam
flow
Galaxy way
Mixed Woods
Steep Slope

NBAFS Wetland Disturbance Survey

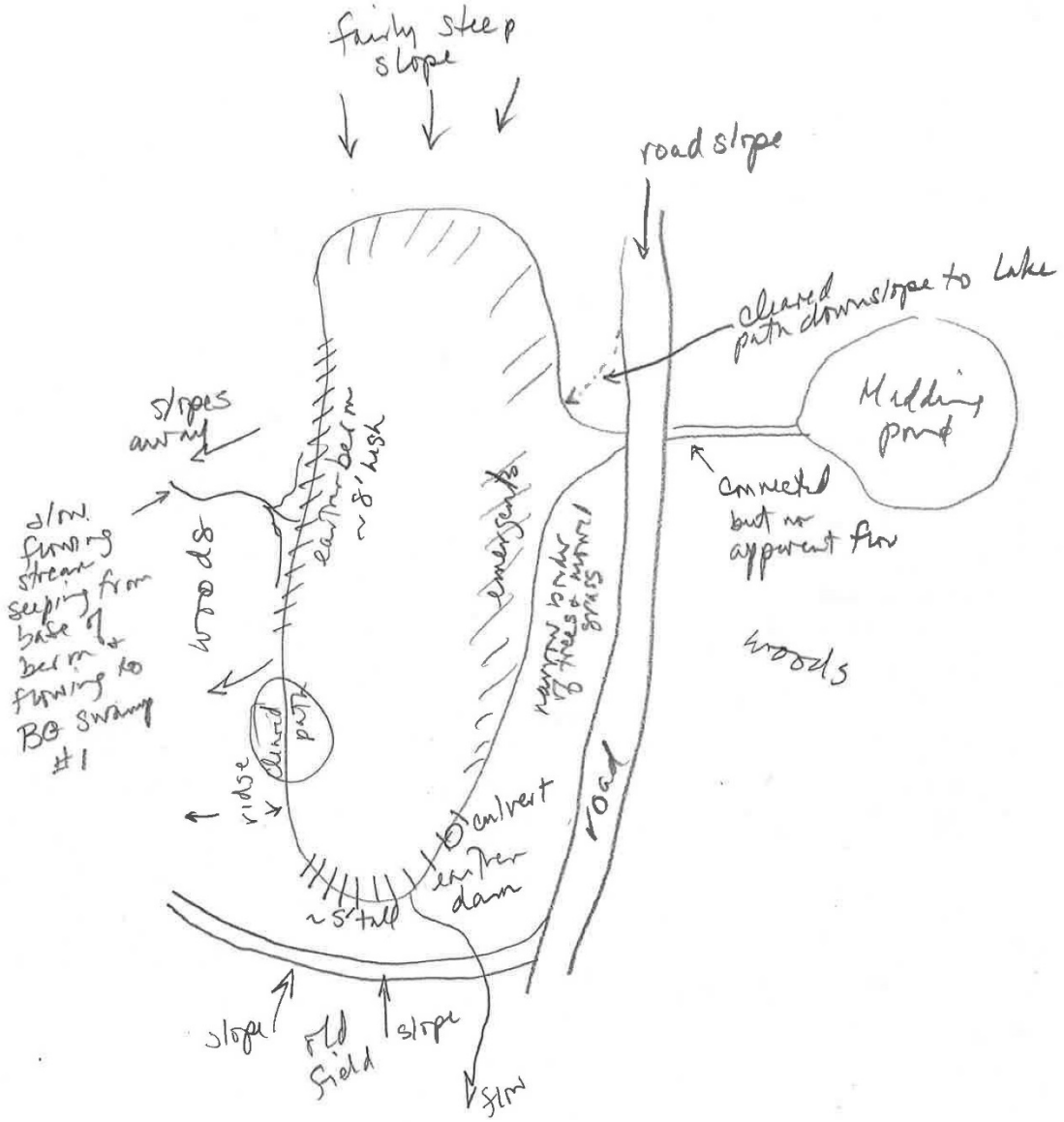
Date: 10/18/2011
Wetland Name: Green Tree Reservoir
Wetland Type: Impoundment
Coordinates: N: 42.93846 W: 71.62183
Observers: LaGory & Van Lonkhuyzen
WP No.: 177
General Comments: Earthen berm dam on south end; mostly open water; earth berm on west side.

Dominant Plant Species:
Tree: red maple, white pine
Shrub/vines: leather leaf, mountain laurel (dense band of laurel especially along north side).
Herbaceous: *Juncus effusus*, *Nuphar lutea*, *Glyceria* sp., mostly open with wide band of emergent vegetation on east side of pond with *Sparganium americanum*, *Scirpus cyperinus*

Landscape context:
- **Features draining to**: Main road on east and wooded slope to north.
- **Existing barriers to sediment input**: Narrow strip of trees and grass between pond and road.
- **Surrounding land cover**: mixed woods on west & north end (white pine and red maple, red oak especially on north), old field and road on south.
- **Soil types**: Northwest, also north and east perimeter: Chatfield-Hollis-Canton Complex 8-15% slope; west: Paxton Fine Sandy Loam 3-8% slope, also (minor) Canton Stony Fine Sandy Loam 15-25% slope; south (minor): Woodbridge Loam 3-8% slope; at south berm: Ridgebury Stony Loam 3-8% slope.
- **Distance from road**: 6 paces.
- **Road surface and condition**: Gravel, good condition, heavily travelled along east side of wetland

Erosion, sedimentation, and other signs of disturbance:
- **Erosion/sediment input including source magnitude**: Very little erosion from road.
- **Invasive nonnative species**: None
- **Other disturbance observed**: Tree harvest to south, but not affecting wetland.

Overall assessment of erosion/sedimentation potential: Low
Potential mitigation strategy: Consider berming to divert runoff away from cleared path from gravel road.


fairly steep slope
road slope
cleared path downslope to lake
Mudding pond
connected but no apparent flow
woods
slopes away
s/w. flowing stream seeping from base of berm flowing to BG swamp #1
earthen berm ~8' high
woods
emergent to
mature mixed grass
cleared path
ridge
culvert under dam
~5' tall
road
slope
old field
slope
flow

NBAFS Wetland Disturbance Survey

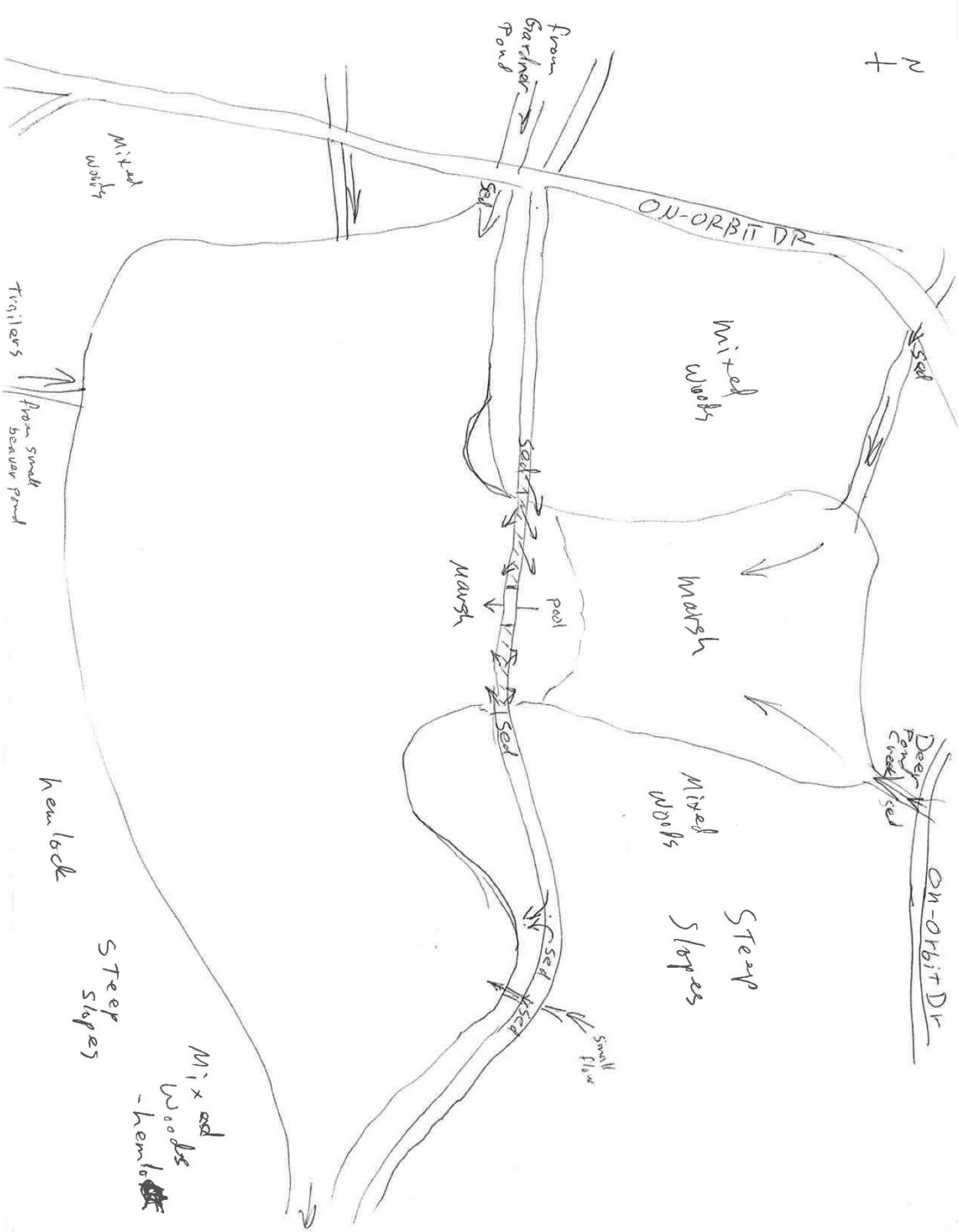
Date: 10/19/2011
Wetland Name: Joe English Pond
Wetland Type: Pond/ Emergent Marsh
Coordinates: N: 42.93701 W: 71.63697
Observers: LaGory, Van Lonkhuyzen, Goulet, Drake
WP No.: 237 (causeway bridge)
General Comments: Causeway through marsh. Drained by dam removal 2010; Causeway road passing near dam site. UXO removal project has created significant disturbance in pond and on causeway/road, open areas draining to pond

Dominant Plant Species:
Tree: red maple, alder, white pine, hemlock, gray birch
Shrub/vines: leatherleaf, *Decodon verticillatus*, buttonbush, highbush blueberry
Herbaceous: sedges, pickerel weed, water lily

Landscape context:
- **Features draining to**: Causeway, Brook Road, old recreation area, surrounding woods, old camping areas, On-Orbit Drive
- **Existing barriers to sediment input**: Vegetation in most areas - slightly above road surface; bridge concrete barriers.
- **Surrounding land cover**: Mostly mixed forest; herbaceous cover on road margin (low shrub density) and along peninsulas east and west of causeway.
- **Soil types**: West and perimeter north: Canton Stony Fine Sandy Loam 8-15% slope; also west: Scituate Stony Fine Sandy Loam 0-3% slope; east: Paxton Stony Fine Sandy Loam 15-25% slope; northeast (minor) Chatfield-Hollis-Canton- Complex 15-25% slope; northwest (minor) Canton Stony Fine Sandy Loam 3-8% slope; at dam: Canton Very Stony Fine Sandy Loam 15-35% slope; west perimeter of pond: Canton Stony Fine Sandy Loam 15-25% slope; south perimeter: Chatfield-Hollis-Rock Outcrop Complex 15-35% slope.
- **Distance from road**: 1-2 feet
- **Road surface and condition**: Poor - loose, disturbed gravel.

Erosion, sedimentation, and other signs of disturbance:
- **Erosion/sediment input including source magnitude**: Considerable sediment/gravel input at numerous locations on both sides of causeway; also two locations on south side of Brook Road; loose gravel at dam site; erosion on road joining Brook Road east of causeway (run off goes across Brook Road); moderate erosion at two north culverts of On-Orbit Drive.
- **Invasive nonnative species**: None observed, but purple loosestrife is known to be present.
- **Other disturbance observed**: UXO work in pond, bridge replacement, dam removal.

Overall assessment of erosion/sedimentation potential: High
Potential mitigation strategy: Add one or more culverts under causeway (especially west end). Remediate sediment inputs on Brook Road, On-Orbit Drive, and causeway.


N
ON-ORBIT DR
Mixed Woods
Mixed Woods
Marsh
Marsh
pool
Steep Slopes
Steep Slopes
Mixed Woods
Mixed Woods
Deer Pond Creek
ON-ORBIT DR
from Gardner Pond
Trailers
from small beaver pond
hemlock
Steep Slopes
Mix ed Woods -hemlo
Small flow
Sed

NBAFS Wetland Disturbance Survey

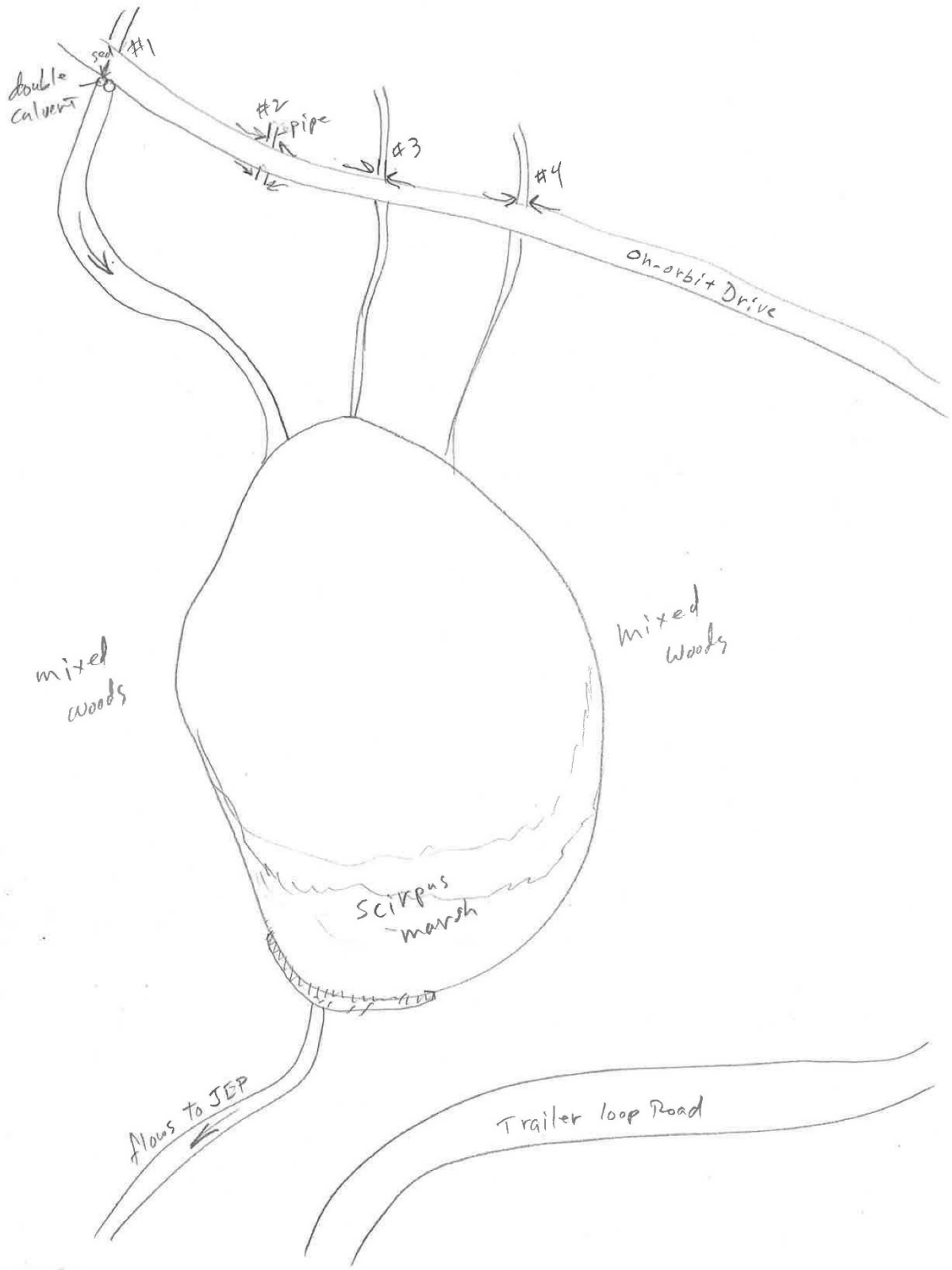
Date: 10/19/2011
Wetland Name: Trailer Park Pond
Wetland Type: Beaver Impoundment
Coordinates: N: 42.93315 W: 71.64141
Observers: LaGory, Van Lonkhuyzen, Goulet, Drake
WP No.: 227 (at beaver dam)
General Comments: Small marsh/pond with beaver dam, flows into south end of Joe English Pond. Four inlet streams crossing under On-Orbit Drive (1 primary, 3 minor); primary inflow from Ice Pond. Adjacent to old trailer park area.

Dominant Plant Species:
Tree: alder, white pine, hemlock, red maple, yellow birch
Shrub/vines: maleberry, highbush blueberry, *Spiraea alba*
Herbaceous: *Scirpus cyperinus*, *Sparganium americanum*, *Calamagrostis canadensis*, sensitive fern, cinnamon fern, sedges, *Typha latifolia*

Landscape context:
- **Features draining to**: Surrounding woods, On-Orbit Drive, woods northwest of On-Orbit Drive.
- **Existing barriers to sediment input**: Vegetation along road, curbs on most culverts.
- **Surrounding land cover**: Mixed forest: hemlock, white pine, red maple, yellow birch, chestnut, witch hazel; low-moderate slopes surrounding.
- **Soil types**: Chatfield-Hollis-Rock Outcrop Complex 15-35% slope; south inlet: Canton Very Stony Fine Sandy Loam 15-35% slope; to west: Canton Stony Fine Sandy Loam 15-25% slope.
- **Distance from road**: 5 paces from Trailer Park road.
- **Road surface and condition**: Paved, gravel shoulder-mostly well vegetated and stable. Some locations near culverts with shoulder erosion.

Erosion, sedimentation, and other signs of disturbance:
- **Erosion/sediment input including source magnitude**: Sediment inputs minor at most culverts; moderate erosion and input at culverts 3 & 4 (see map).
- **Invasive nonnative species**: None observed
- **Other disturbance observed**: None

Overall assessment of erosion/sedimentation potential: Very low
Potential mitigation strategy: Remediate sediment inputs along On-Orbit Drive.


#1
double culvert
#2
pipe
#3
#4
On-orbit Drive
mixed woods
mixed woods
Scirpus marsh
flows to JEP
Trailer loop Road

NBAFS Wetland Disturbance Survey

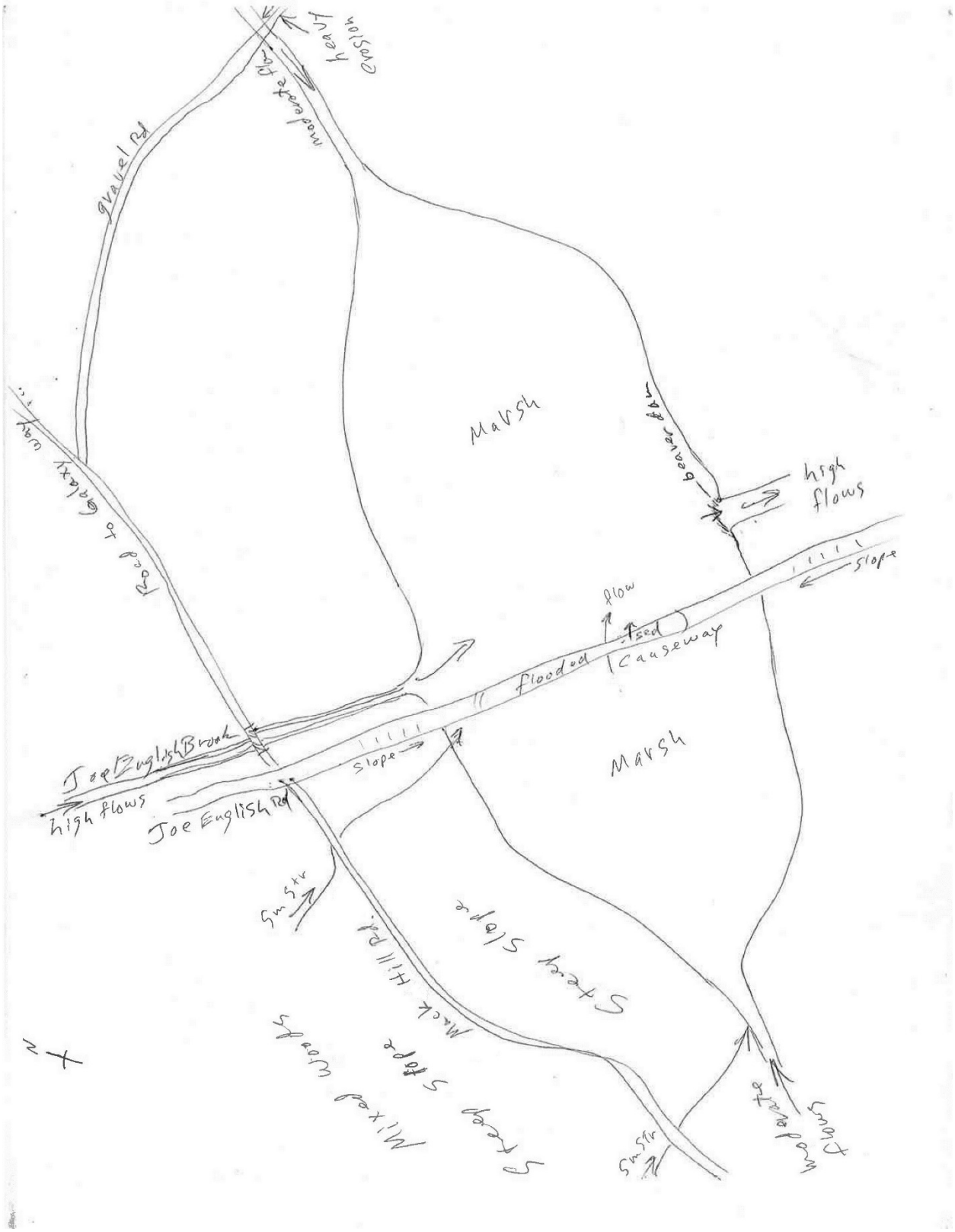
Date: 10/20/2011
Wetland Name: Wells Bog
Wetland Type: Marsh/impoundment
Coordinates: N: 42.92690 W: 71.62926
Observers: LaGory, Van Lonkhuyzen, Goulet
WP No.: 261 (causeway)
General Comments: Causeway runs through southeast-northwest, beaver dam at southeast side, Joe English creek enters northwest side; causeway partly flooded, mostly retaining water in tracks (one location collapsed shoulder, water flowing to marsh). Moderate streamflows into east and west ends. Shrub swamp (winterberry) at east end.

Dominant Plant Species:
Tree: alder, red maple, white pine
Shrub/vines: *Spiraea alba*, *Decodon verticillatus*, buttonbush, maleberry, arrow-wood, winterberry, leatherleaf, highbush blueberry
Herbaceous: *Sparganium americanum*, pickerel weed, *Calamagrostis canadensis*, sedges, *Dulichium arundinaceum*, *Scirpus cyperinus*, spike rush, royal fern, water lily

Landscape context:
- **Features draining to**: Causeway, Joe English Creek, Mack Hill Road, surrounding wooded slopes, service road to Galaxy Way.
- **Existing barriers to sediment input**: Causeway margin slightly higher than tire tracks; vegetation buffers; long distance from road erosion to wetland.
- **Surrounding land cover**: Woods, mixed: white pine, hemlock, red maple, red oak, black birch, hay-scented fern, bracken fern, beech.
- **Soil types**: Western part: Leicester-Walpole Complex Stony 0-3% slope; north, south, most of perimeter: Canton Stony Fine Sandy Loam 3-8% slope; southeast perimeter and northeast: Canton Stony Fine Sandy Loam 8-15% slope
- **Distance from road**: Causeway 1-2 feet
- **Road surface and condition**: Causeway: gravel, vegetation cover (except tracks), Brook Road sloping toward causeway; Mack Hill Road: loose gravel, eroded; gravel road to east: highly eroded; old road going north to Galaxy Way: stable.

Erosion, sedimentation, and other signs of disturbance:
- **Erosion/sediment input including source magnitude**: Area (about one foot wide) of collapsed margin of causeway allowing flow with sediment into marsh; some old gravel deposits on causeway edge; small inputs where small streams cross under Mack Hill Road; small input at west side of Joe English Brook bridge (old gravel road ford?); significant erosion of old road merging to road from Galaxy Way.
- **Invasive nonnative species**: None observed
- **Other disturbance observed**: Logging near stream coming from southwest.

Overall assessment of erosion/sedimentation potential: Moderate
Potential mitigation strategy: Repair and elevate causeway; repair eroding areas of old gravel road crossing northeast inflow.


Heavy erosion
Mudcreek Rd
gravel Rd
Road to Galaxy way
Marsh
beaver dam
high flows
slope
flow
sed
Causeway
flooded
Joe English Brook
slope
Marsh
high flows
Joe English Rd
Steep Slope
Mixed woods
Steep Slope
Mud creek
Mud creek
high flows

NBAFS Wetland Disturbance Survey

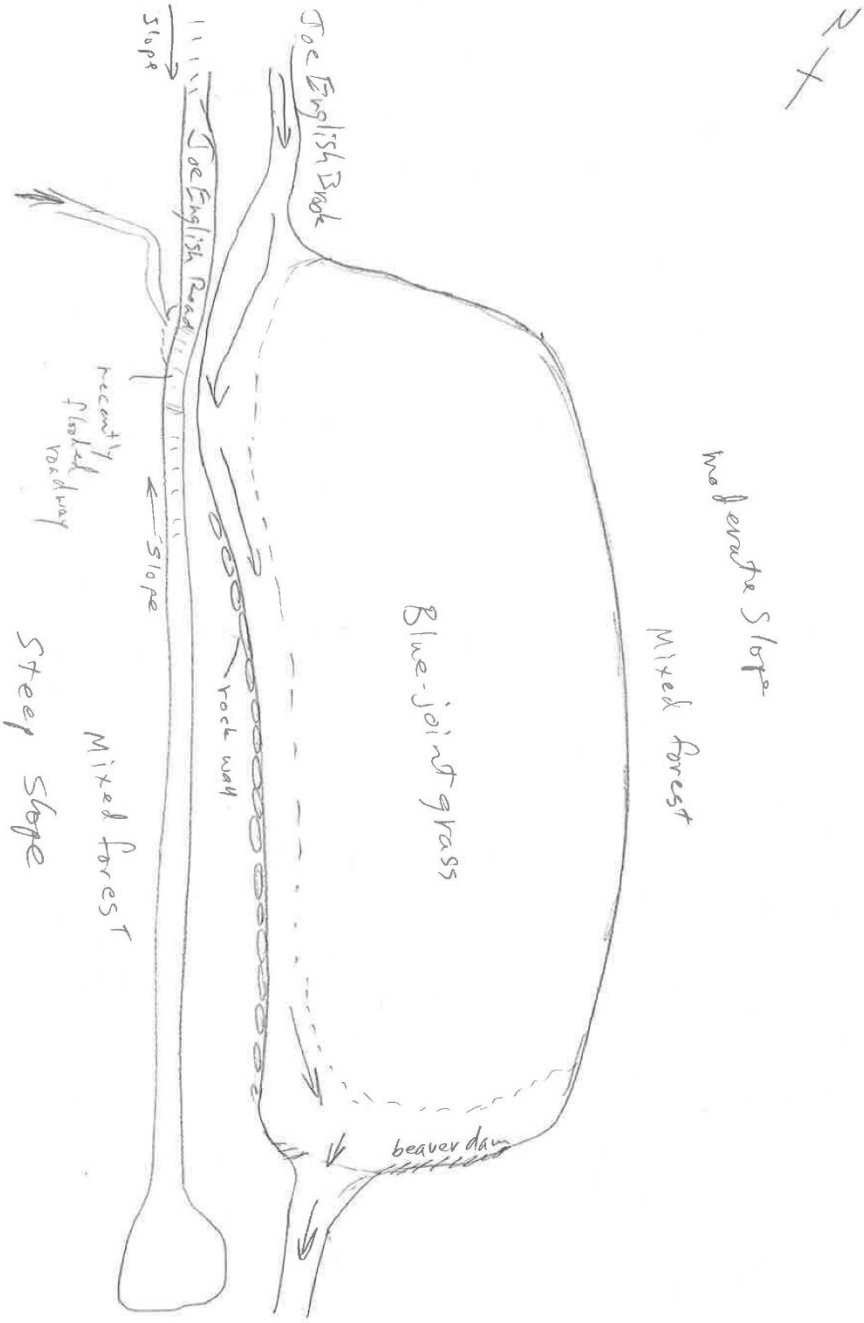
Date: 10/20/2011
Wetland Name: Beaver Pond #4
Wetland Type: Marsh
Coordinates: N: 42.92248 W: 71.62305
Observers: LaGory, Van Lonkhuyzen, Goulet
WP No.: 276 at beaver dam
General Comments: Beaver dam impounded marsh, dam breached; dense cover of bluejoint grass; Joe English Brook flows along south edge; Brook Road passes along to south, following Joe English Brook (close proximity at inlet point, outside bend of creek.); small inlet stream passing under road.

Dominant Plant Species:
Tree: hemlock, alder, red maple
Shrub/vines: maleberry, arrow-wood, *Sambucus canadensis*, dogwood
Herbaceous: *Calamagrostis canadensis*, *Scirpus cyperinus*, royal fern, tussock sedge *Sparganium americanum*, *Carex* sp.

Landscape context:
- **Features draining to**: Brook Road, surrounding woods, high slope to south, Joe English Brook.
- **Existing barriers to sediment input**: Flooding on road mostly confined to tire tracks (lower than margin); rock wall between stream and road, except at closest proximity and upstream.
- **Surrounding land cover**: Mostly white pine to north with red maple, hemlock; mostly hemlock to south with red maple, red oak, beech, white pine.
- **Soil types**: Northwest perimeter: Canton Stony Fine Sandy Loam 8-15% slope; north and east: Chatfield-Hollis-Rock Outcrop Complex 15-35% slope; southwest perimeter, south: Chatfield-Hollis-Complex 8-15% slope; outflow: Rippowam Fine Sandy Loam.
- **Distance from road**: About 3 ft (to 3.5 ft) at main inflow.
- **Road surface and condition**: Gravel, stable; portions flood occasionally.

Erosion, sedimentation, and other signs of disturbance:
- **Erosion/sediment input including source magnitude**: None observed, however, close proximity of road to creek at inflow point presents a possibility of eventual erosion of stream bank to road.
- **Invasive nonnative species**: None observed
- **Other disturbance observed**: None

Overall assessment of erosion/sedimentation potential: Very low
Potential mitigation strategy: Protect the bank at inflow point.


N
Moderate Slope
Mixed forest
Blue-joint grass
beaver dam
Joe English Brook
rock wall
Joe English Road
Slope
recently flooded roadway
Slope
Steep Slope
Mixed forest

NBAFS Wetland Disturbance Survey

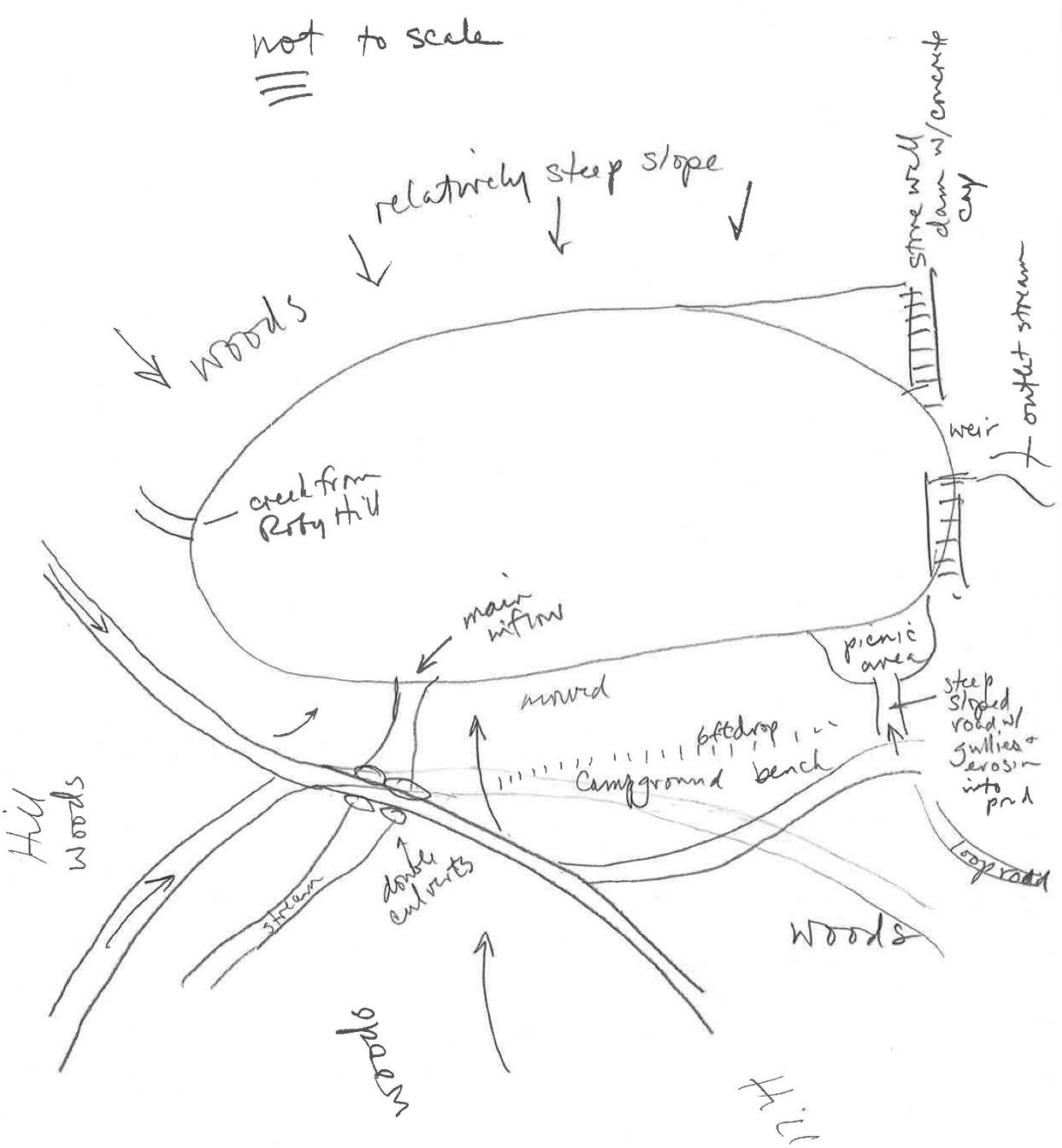
Date: 10/18/2011
Wetland Name: Ice Pond
Wetland Type: Impoundment
Coordinates: N: 42.92455 W: 71.65221
Observers: Van Lonkhuyzen & LaGory
WP No.: 171
General Comments: Stream from Roby Pond flows into Ice Pond. Campground and dock; rock wall dam retrofitted with concrete cap. Water flows over narrow weir.

Dominant Plant Species:
Tree: white pine and red maple along edge, hemlock
Shrub/vines: maleberry, huckleberry, *Spiraea alba*
Herbaceous: Few emergents except at upper and lower end, and whole margin: 3-way sedge, *Carex crinita*, spatterdock, *Sparganium americanum*, water lily, *Iris versicolor*, clearweed.

Landscape context:
- **Features draining to**: Loop road from Roby Campground drains into pond at stream inlet. Entrance road from On-Orbit Drive drains to pond. Fairly steep slopes all around.
- **Existing barriers to sediment input**: None at road, which can funnel runoff to pond.
- **Surrounding land cover**: Campground and dock on south side, woodland around remainder: white pine, red maple, yellow birch, red oak, beech.
- **Soil types**: South and perimeter to south: Chatfield-Hollis-Canton Complex 8-15% slope; perimeter west: Ridgebury Stony Loam 3-8%; north, northeast: Canton Stony Fine Sandy Loam, 15-25%, northwest: (minor) Paxton Stony Fine Sandy Loam 15-25% slope.
- **Distance from road**: At loop picnic area: 25 paces, at inlet stream: 1-3 m.
- **Road surface and condition**: Gravel, good condition, but some evidence of erosion

Erosion, sedimentation, and other signs of disturbance:
- **Erosion/sediment input including source magnitude**: Sheet flow from roads enters pond near inlet stream. Worn path and erosion from campground on bench. Runoff from higher road at picnic area with signs of recent runoff, erosion, and gullying.
- **Invasive nonnative species**: None
- **Other disturbance observed**: Campground activity, mowing

Overall assessment of erosion/sedimentation potential: High
Potential mitigation strategy: Close off entrance to picnic area, plant entrance roadway to stabilize substrate (e.g., trees, shrubs, grasses). Intercept runoff from Roby Camp Ground & main road.


not to scale
relatively steep slope
woods
stone wall dam w/cement cap
outlet stream
weir
creek from Rocky Hill
main inflow
picnic area
mowed
6ft drop
Campground bench
steep sloped road w/ gullies + erosion into pond
Hill woods
stream
double culverts
woods
meadow
Hill

NBAFS Wetland Disturbance Survey

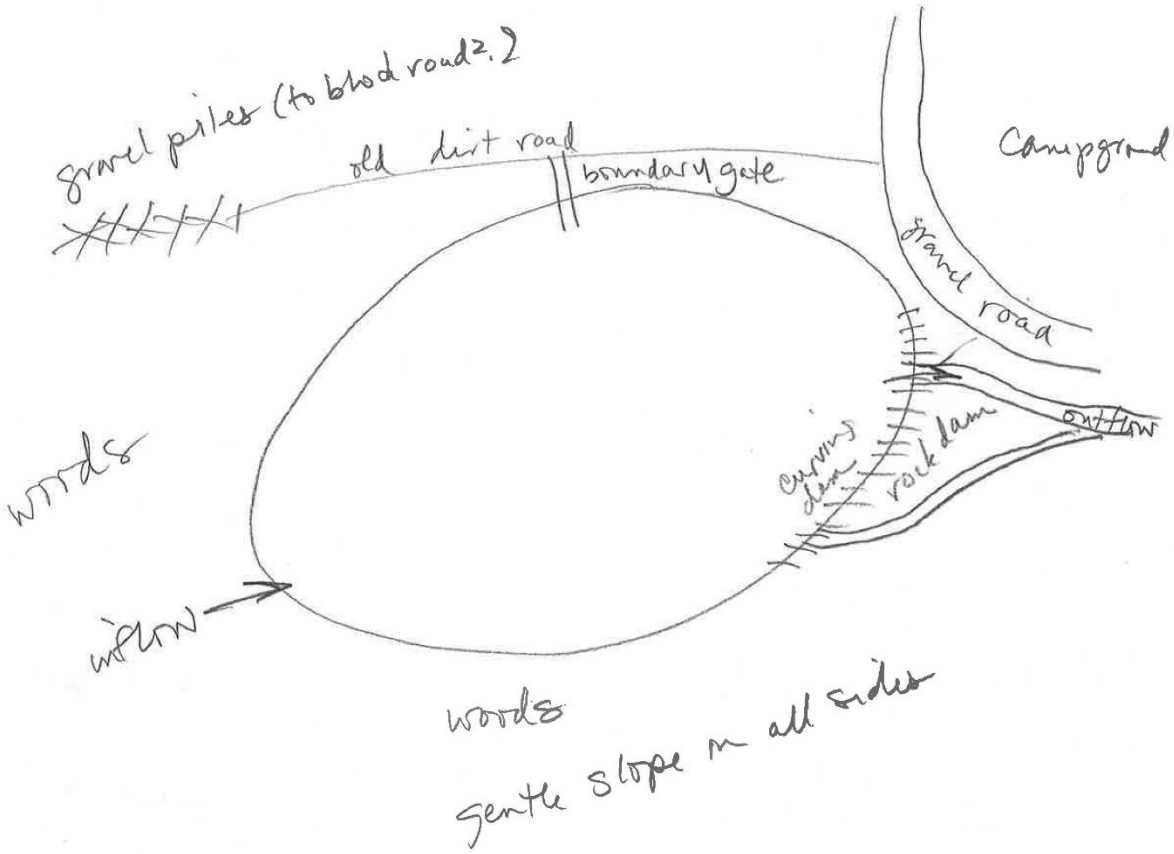
Date: 10/18/2011
Wetland Name: Roby Pond
Wetland Type: Impoundment
Coordinates: N: 42.92429 W: 71.65334
Observers: LaGory & Van Lonkhuyzen
WP No.: 168
General Comments: Small pond on west boundary with campground road near dam. Dam is rock wall. Flow over dam. Completely open center with minimal emergent vegetation, mostly at upstream end. Stream flows along road to Ice Pond.

Dominant Plant Species:
Tree: none
Shrub/vines: *Spiraea alba*, maleberry
Herbaceous: *Carex stricta*, *Carex crinita*, marsh fern, 3-way sedge, *Sparganium americanum*, water lily, *Nuphar lutea*

Landscape context:
- **Features draining to**: Gentle slopes on all sides.
- **Existing barriers to sediment input**: Woodland border to pond. Road is downslope of pond.
- **Surrounding land cover**: Woodland on all sides except primitive wooded campground at dam. Pond is bisected by NBAFS boundary.
- **Soil types**: West, perimeter (except south and southeast): Chatfield-Hollis-Canton Complex 8-15% slope; south and southeast perimeter: Chocorua Mucky Peat.
- **Distance from road**: 4 m, but road is downslope.
- **Road surface and condition**: Gravel, good condition.

Erosion, sedimentation, and other signs of disturbance:
- **Erosion/sediment input including source magnitude**: None
- **Invasive nonnative species**: None
- **Other disturbance observed**: Mowed edge (road width) on northwestern edge.

Overall assessment of erosion/sedimentation potential: Very low
Potential mitigation strategy: None needed


gravel piles (to block road?)
old dirt road
boundary gate
Campground
gravel road
outflow
rock dam
woods
inflow
woods
gentle slope on all sides

NBAFS Wetland Disturbance Survey

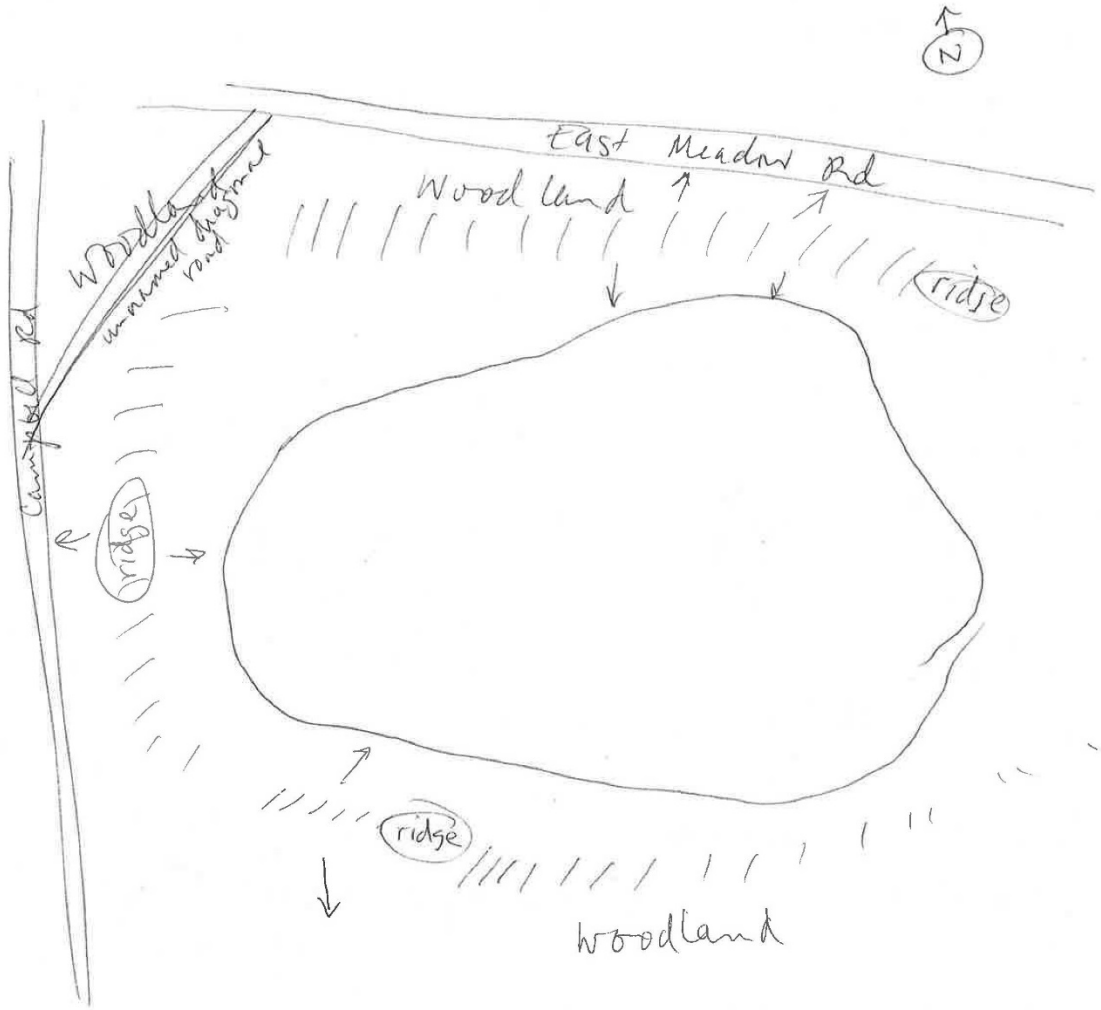
Date: 10/17/2011
Wetland Name: Pitcher Plant Bog (BGS 5)
Wetland Type: Black-gum-red maple basin swamp
Coordinates: N: 42.94578 W: 71.64971
Observers: LaGory & Van Lonkhuyzen
WP No.: 157
General Comments: "Pitcher plant-black spruce" bog. Mostly closed canopy wooded swamp.

Dominant Plant Species:
Tree: Red maple, white pine, black gum, yellow birch, black spruce
Shrub/vines: highbush blueberry, maleberry, mountain laurel, leatherleaf, winterberry, hemlock, red maple, white pine, black spruce
Herbaceous: cinnamon fern, *Sphagnum* sp.

Landscape context:
- **Features draining to**: In isolated bowl-shaped basin. High ridge to south then drops in elevation away from wetland into woods.
- **Surrounding land cover**: Mixed woodland: white pine, hemlock, witch hazel, starflower, red oak, beech, red maple, mountain laurel, sassafras, white oak.
- **Soil types**: Canton Stony Fine Sandy Loam 15-25% slope (8-15% slope on the east), north and south edge: Scituate Stony Fine Sandy Loam 3-8%
- **Distance from road**: 35 paces from Campbell Road, 46 paces from diagonal road, 39 paces from East Meadow Road
- **Road surface and condition**: Gravel, well maintained

Erosion, sedimentation, and other signs of disturbance:
- **Erosion/sediment input including source magnitude**: None observed. WPT 158 is a location where water could flow off road and down to wetland, but no sign of it, and near top of hill so watershed is small (35 paces to wetland). No other possible inflow to wetland from road.
- **Invasive nonnative species**: None
- **Other disturbance observed**: None

Overall assessment of erosion/sedimentation potential: Very low
Potential mitigation strategy: None needed


N
East Meadow Rd
Woodland
ridge
Woodland
unnamed dirt road
Campbell Rd
ridge
ridge
woodland

NBAFS Wetland Disturbance Survey

Date: 10/19/2011
Wetland Name: Gardner Pond
Wetland Type: Reservoir
Coordinates: N: 42.94300 W: 71.64938
Observers: LaGory, Van Lonkhuyzen, Goulet, Drake
WP No.: 219
General Comments: Streams entering from north under East Meadow Road & Campbell Road, woods surrounding, large stream under West Meadow Road; dense emergent marsh at north end (mostly grasses); low shrub density along west; earthen dam with beaver dam in outflow spillway; small water control structure with missing slat; 2 small inflow streams, dead pines along edges, 2 islands.

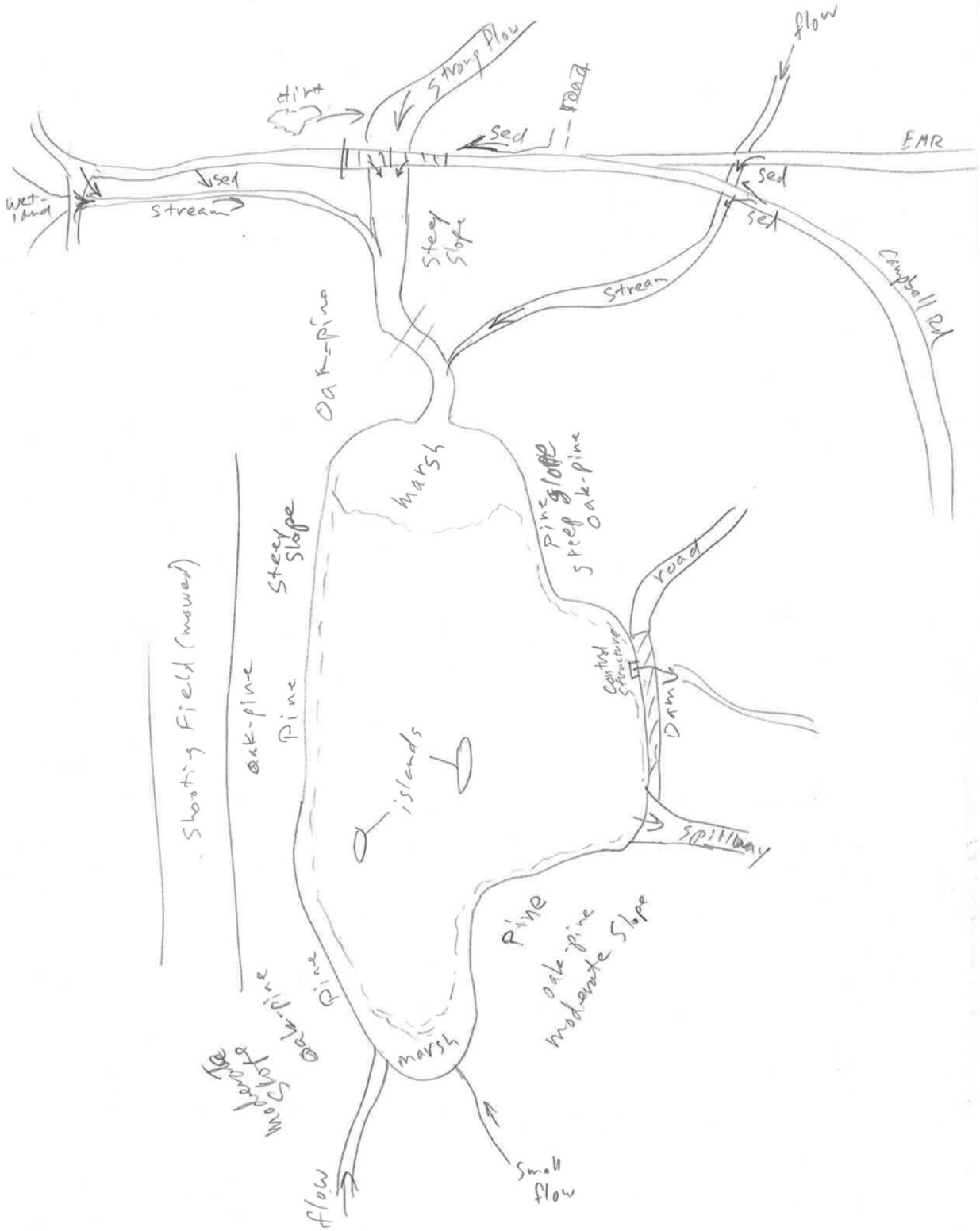
Dominant Plant Species:
Tree: white pine at edge
Shrub/vines: maleberry, *Kalmia angustifolia*, leatherleaf, highbush blueberry, *Viburnum* sp. (arrow-wood) on west side
Herbaceous: *Calamagrostis canadensis*, *Carex* spp., royal fern, *Sparganium americanum*, cinnamon fern, water lily, *Juncus marginatus*, pickerel weed, *Typha latifolia* (few), *Glyceria* sp., *Leersia oryzoides*

Landscape context:
- **Features draining to**: Woods north of East Meadow Road, west of Campbell Road, surrounding adjacent woods, shooting field (mowed) to west.
- **Existing barriers to sediment input**: Curb at bridge; vegetated road margins, vegetated ditches.
- **Surrounding land cover**: Mixed forest: white pine, red oak, yellow birch, red maple, witch hazel; mostly pine on west, near pond on east. Lowbush blueberry, wintergreen, *Kalmia angustifolia.*
- **Soil types**: West perimeter, northwest: Chatfield-Hollis-Canton complex 15-25%; to the east: Canton Stony Fine Sandy Loams 15-25%; north and south: Chatfield-Hollis-Canton complex 8-15%; southwest (minor): Paxton Fine Sandy Loam 15-25%
- **Distance from road**: Road crosses inflow and comes to dam.
- **Road surface and condition**: West Meadow Road: good (some loose gravel); Campbell Road: good mostly stable; East Meadow Road: loose sand and gravel, eroding.

Erosion, sedimentation, and other signs of disturbance:
- **Erosion/sediment input including source magnitude**: Sand input at East Meadow Road east culvert; sand and gravel at Campbell Road culvert (long slopes from east, East Meadow Road, Campbell Road)-filling stream bed; stream south of West Meadow Road: sediment/gravel input at culvert by shooting field Road, and along West Meadow Road. Culvert/bridge on West Meadow Road: eroding soil pile at west (north of road), gravel/sediment enters from ditch (north of road), along bridge on West Meadow Road; sand from northwest ditch.
- **Invasive nonnative species**: None seen

- **Other disturbance observed**: Gravel in main inflow stream from West Meadow Road bridge area, gravel bars in some places; beaver cut trees along stream (mostly black birch); beaver dam where stream enters, burn 2004 (?) on northeast slope; some steep burned slopes sparsely vegetated.

Overall assessment of erosion/sedimentation potential: Moderate
Potential mitigation strategy: Remediate sediment inputs at West Meadow Road, East Meadow Road, Campbell Road, Shooting Field road.


flow
strong flow
dirt
road
sed
EMR
sed
wet-land
stream
sed
sed
steep slope
stream
Campbell Rd
oak-pine
marsh
pine
steep slope
steep slope
oak-pine
road
Shooting Field (mowed)
oak-pine
pine
control structure
dam
islands
spillway
pine
oak-pine
moderate slope
pine
oak-pine
moderate slope
marsh
flow
small flow

NBAFS Wetland Disturbance Survey

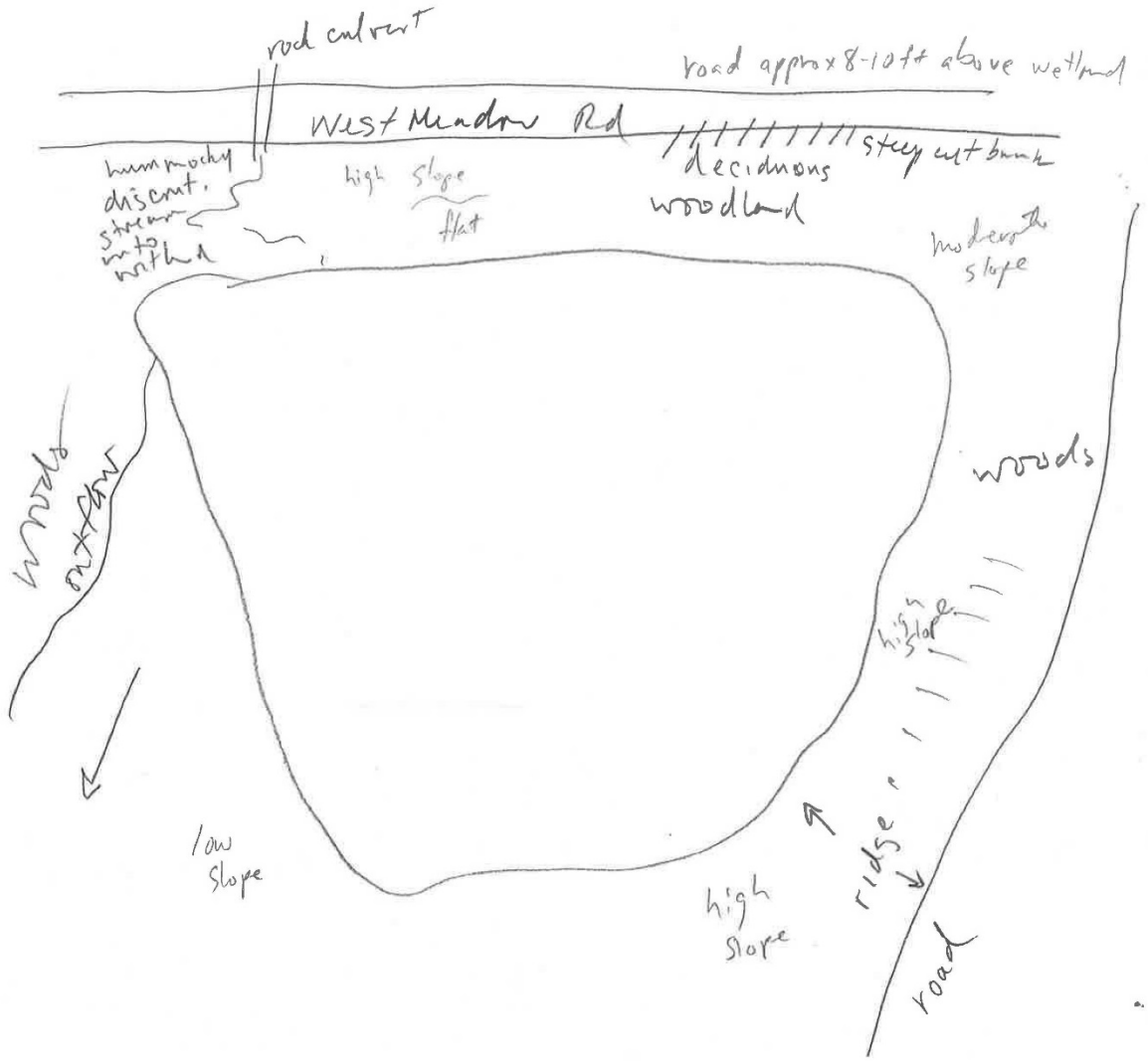
Date: 10/18/2011
Wetland Name: Murphy Swamp
Wetland Type: Wooded Fen/Cranberry-Sedge Moss Lawn
Coordinates: N: 42.94433 W: 71.66061
Observers: LaGory & Van Lonkhuyzen
WP No.: 161
General Comments: West Meadow Road borders wetland to North

Dominant Plant Species:
Tree: See rare communities report. Few trees except along margin (sapling white pine in marsh), red maple along edge
Shrub/vines: highbush blueberry, maleberry, winterberry, large cranberry, *Spiraea* sp., buttonbush, seedling *Kalmia* sp.
Herbaceous: sedges

Landscape context:
- **Features draining to**: Joe English Hill
- **Existing barriers to sediment input**: Wooded strip between wetland and road
- **Surrounding land cover**: Deciduous woodland: red maple, gray birch, red oak, sassafras, witch hazel, white oak, chestnut, yellow birch, white pine
- **Soil types**: Chatfield-Hollis-Canton Complex 8-15% slope; south edge: Canton Stony Fine Sandy Loam 3-8%; west edge: Hinckley Loamy Sand 8-15% slope
- **Distance from road**: 25 paces
- **Road surface and condition**: Graded gravel, generally good condition, 12" galvanized culvert with flow under road from Joe English Hill. Little-used road to east with intervening ridge

Erosion, sedimentation, and other signs of disturbance:
- **Erosion/sediment input including source magnitude**: West Meadow Road-steep cut in spots that could collapse; slopes directly into woods and wetlands. No sign of sedimentation into wetland or intervening area
- **Invasive nonnative species**: None
- **Other disturbance observed**: None

Overall assessment of erosion/sedimentation potential: Low to moderate
Potential mitigation strategy: Stabilization of cut bank of road


rock culvert
road approx 8-10ft above wetland
West Meadow Rd
steep cut bank
decidnous
woodland
hummocky
descent.
stream
into
wetland
high slope
flat
moderate
slope
woods
outflow
woods
high slope
ridge
low
slope
high
slope
road

NBAFS Wetland Disturbance Survey

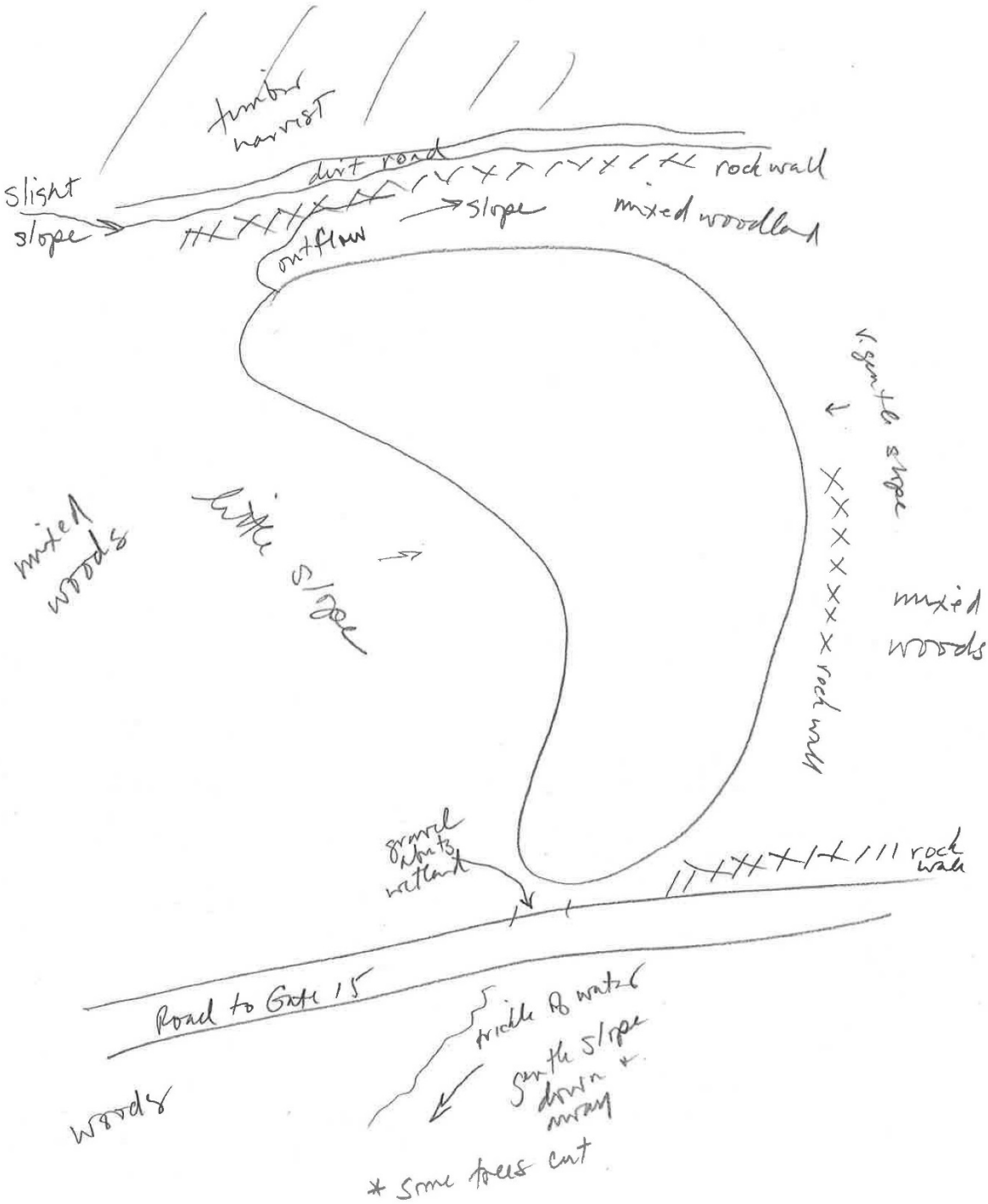
Date: 10/18/2011
Wetland Name: Chain Fern Bog
Wetland Type: Wooded Fen
Coordinates: N: 42.94284 W: 71.66394
Observers: LaGory & Van Lonkhuyzen
WP No.: 166
General Comments: Little-used road on north side, water flowing out to north, Gate 15 Road to south. Gentle slope all around.

Dominant Plant Species: See rare community report.
Tree: red maple on edge, hemlock, black gum
Shrub/vines: highbush blueberry, small white pine, large cranberry
Herbaceous: chain fern, 3-way sedge, *Calamagrostis canadensis*, *Carex crinita*, cinnamon fern

Landscape context:
- **Features draining to**: Gentle slope to west. Slopes down and away to north, down and away to south
- **Existing barriers to sediment input**: Rock wall separates wetland from road on north and portion of road to south. South road abuts wetland at one spot but no evidence of impact. Some gravel has fallen in.
- **Surrounding land cover**: Mixed woodland: white pine, white oak, red oak, witch hazel, bracken, lowbush blueberry, hemlock
- **Soil types**: Canton Stony Fine Sandy Loam 8-15% slope; north end: Hinckley Loamy Sand 8-15% slope. South tip at outlet: Scituate Stony Fine Sandy Loam 3-8% slope
- **Distance from road**: 16 paces to north road; 0 paces to Gate 15 Road
- **Road surface and condition**: Unmaintained dirt road with little sign of use except for recent timber harvest on north end. Road to Gate 15 has some gravel.

Erosion, sedimentation, and other signs of disturbance:
- **Erosion/sediment input including source magnitude**: No sign of sediment input from north road. South road adjacent to wetland and may block some flow to south. No evidence of erosion into wetland. South road about 1 foot higher than wetland.
- **Invasive nonnative species**: Very small patch of *Typha latifolia* in south end by chain fern. No sign of problem.
- **Other disturbance observed**: Recent timber harvest on north side of wetland on other side of rock wall and north of "road".

Overall assessment of erosion/sedimentation potential: Very low
Potential mitigation strategy: None needed


timber harvest
dirt road
rock wall
slight slope
slope
mixed woodland
outflow
v. gentle slope
mixed woods
little slope
mixed woods
rock wall
gravel into wetland
rock wall
Road to Gate 15
trickle to water
gentle slope down
woods
* some trees cut

NBAFS Wetland Disturbance Survey

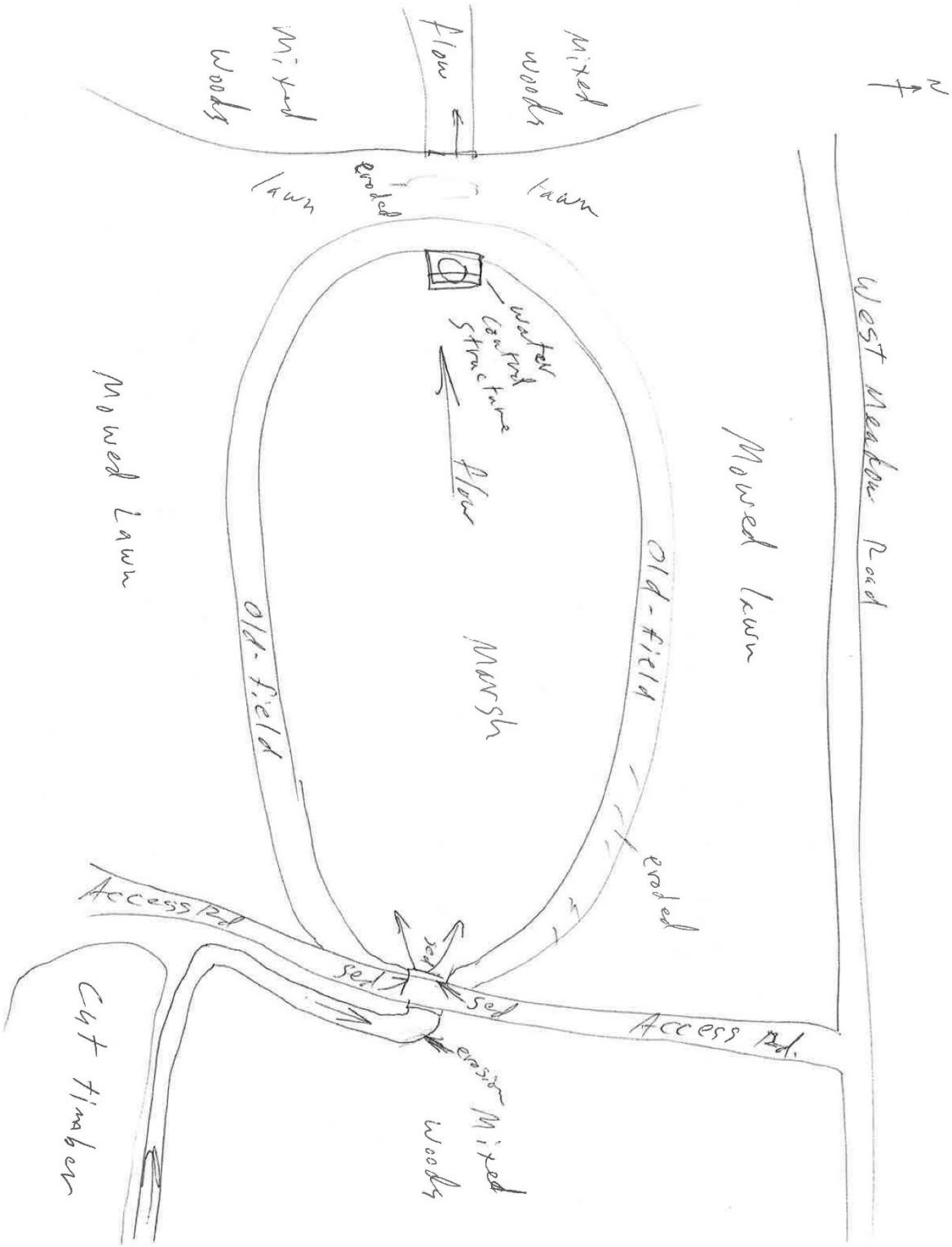
Date: 10/21/2011
Wetland Name: Seavey Pond
Wetland Type: Pond/impoundment
Coordinates: N: 42.94481 W: 71.66824
Observers: LaGory & Van Lonkhuyzen
WP No.: 299 at dam
General Comments: Small impoundment surrounded by mowed lawn; one inlet to east - culvert under small gravel roadway; one exit to west - culvert under earthen dam; grass (mowed) cover; water control structure at dam.

Dominant Plant Species:
Tree: alder
Shrub/vines: *Spiraea alba*
Herbaceous: *Glyceria* sp., sedges, *Scirpus cyperinus*, *Brasenia schreberi*, *Nuphar lutea*, *Sparganium americanum*, *Typha latifolia*, *Eupatorium perfoliatum*, *Euthamia graminifolia*, *Agrostis* sp.

Landscape context:
- **Features draining to**: Surrounding mowed turf, gravel access road, West Meadow Road, woods to east.
- **Existing barriers to sediment input**: Access road: none; West Meadow Road: intervening lawn.
- **Surrounding land cover**: 4-10 ft-wide old field margin (steeply sloped) surrounded by mowed turf grass continues to West Meadow Road north and about 100 yards south to woods. Inlet and outlet streams in woods (white pine, red maple, red oak).
- **Soil types**: Eastern half: Scarboro mucky loamy sand; western: Chatfield-Hollis-Rock outcrop complex 15-35% slope; adjacent north: Chatfield-Hollis-Canton complex 8-15% slope.
- **Distance from road**: Gravel access road: adjacent; West Meadow Road: 26 paces.
- **Road surface and condition**: Access road: gravel, poor condition, loose.

Erosion, sedimentation, and other signs of disturbance:
- **Erosion/sediment input including source magnitude**: Minor erosion on old-field slopes; significant gravel/sand input at upstream culvert from gravel road (both sides of culvert), has formed a delta in pond.
- **Invasive nonnative species**: Adjacent old-field: pokeweed, verbascum Thapsus; cut area: autumn olive.
- **Other disturbance observed**: Mowing; tree cutting by inlet stream.

Overall assessment of erosion/sedimentation potential: High
Potential mitigation strategy: Repair road surface; realign inlet; larger culvert; eliminate dam.


N
West Meadow Road
Mowed lawn
Mixed Woods
Flow
Mixed Woods
lawn
Eroded
lawn
water control structure
flow
Mowed Lawn
Old-field
Marsh
Old-field
eroded
Access Rd
sed
sed
sed
Access Rd.
erosion
Mixed Woods
Cut timber

APPENDIX B

HYDROLOGIC ANALYSIS OF ICE POND AND SEAVEY POND INFLOW

APPENDIX B

HYDROLOGIC ANALYSIS OF ICE POND AND SEAVEY POND INFLOW

Prepared by

Kelsey K. Wuthrich
Environmental Science Division
Argonne National Laboratory

In the spring of 2007, a rain storm of historic magnitude occurred in the southern region of New Hampshire and caused high levels of flooding throughout the New Boston Air Force Station (NBAFS). Stormwater structures at several locations on the NBAFS site were inefficient at managing the large amounts of water, and consequently loose debris was misplaced from nearby roads, trails, and general ground cover. Two ponds along the western side of the property, Ice Pond and Seavey Pond, were both heavily inundated with debris due to inadequate culverts. (see Figure 1 of the main report).

Excess sediment in aquatic ecosystems can create murky water which affects the visibility of aquatic food organisms, changes aquatic habitat conditions, and blocks sunlight necessary for aquatic vegetation growth. In an effort to prevent further disruption to the ponds' ecosystems, hydrologic models were created to assess prospective stormwater quantities reaching the culverts. Hydraulic models were then created to define the culvert capacity and determine what type of structure would be adequate to prevent flooding during future storm events.

B.1 ICE POND

This analysis focused on the stream that drains from Roby Pond to Ice Pond, and the culvert that conveys stream flow underneath the gravel road south of Ice Pond. The 2007 spring storm was so severe that the culvert underneath the road was insufficient for the flow. Located in the southwestern area of the NBAFS property much of the gravel road that runs along Ice Pond was consequently dislodged and deposited into the pond (Figure B-1). In an attempt to prevent further inundation of road material into the lake, the following assessment of the culvert at location WPT171 in Figure 1 (main report) was conducted to determine the capacity of the current culverts, and what type of structure would be adequate to prevent the road from flooding during future flooding events.

B.1.1 Hydrologic Analysis

To quantify the volume and flow rate of the water that will enter the culvert during storm events, a hydrologic analysis of the area which contributes rainwater to the structure was prepared. The area contributing surface water runoff to the culvert is referred to as the watershed, and is determined by evaluating the slope of the terrain. As precipitation falls over the watershed, the rainfall is infiltrated until the soil is saturated. Once the ground storage is full, precipitation

will accumulate on the ground as runoff and begin to flow towards the lower elevations of the center of the watershed. As the runoff begins to flow towards the same lower areas, dendritic flow paths form. With an estimation of the contributing area, its infiltration rates, and the time for the water to travel along the flow paths to the watershed outlet (location of the culvert), the expected water volume and rate can be found for a storm event.

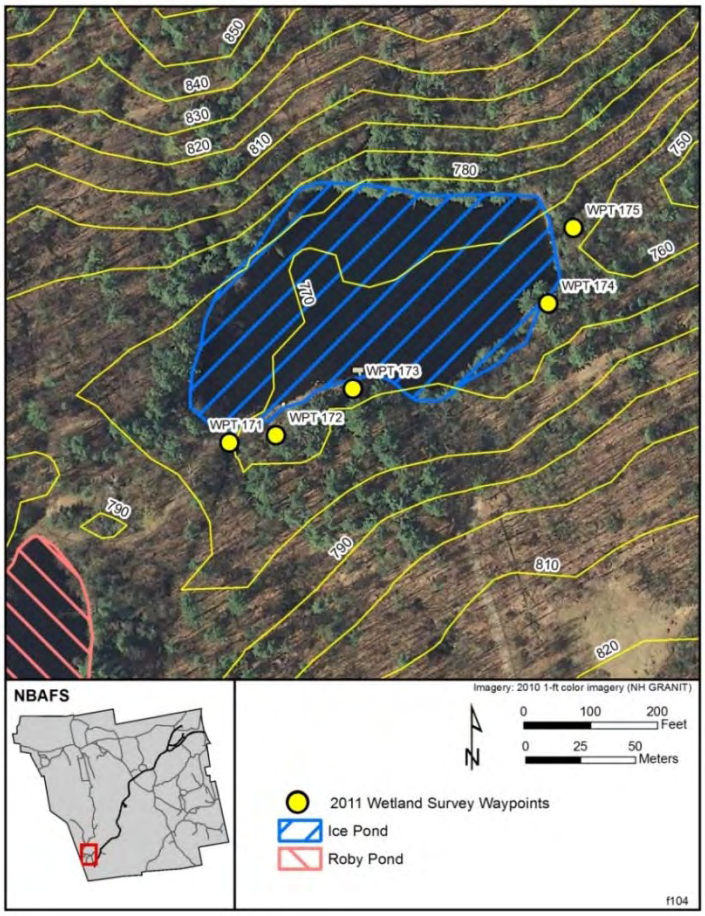


FIGURE B-1. Ice Pond and its Location on the NBAFS site.

B.1.1.1 Watershed Delineation

The Watershed Modeling System (WMS) is a program designed to aid in hydrologic and hydraulic assessments (Aquaveo 2012). For the Ice Pond culvert, the watershed delineation and hydrologic calculations were determined using the WMS package, TOPAZ. Using a 1/3 arc second (approximately 10 m by 10 m cells) gridded elevation layer downloaded from the U.S. Geological Survey (USGS) database, the inward sloping area of the watershed was defined with the WMS TOPAZ interface, which evaluated the relief between each cell of the elevation layer. The flow paths through the watershed were defined as those cells which have an area contributing runoff to them of at least 0.02 mi². The WMS delineated watershed and flow paths are shown in Figure B-2. The total area of the watershed is 0.34 mi².

Although elevation layers enable the accurate prediction of runoff flow, roads or other developmental structures which can divert or prevent natural flow may not be defined. In such cases, the watershed would be altered, and the amount of runoff collecting to the outlet point would decrease. For this watershed, a two-lane paved road runs through the southwest portion with a depression pond on the side furthest from Ice Pond. The roadway and depression pond are pictured in Figure B-2. Examining high resolution imagery in Google Earth, it is not clear whether this pond drains under the road via stormwater infrastructure or simply retains all the collected runoff from the drainage ditches along the roadway. However, a small channel flowing east from the road is visible, which suggests that there is a culvert and the area on the west side of the road eventually drains to the Ice Pond culvert. For this reason, the watershed is left as it was delineated by WMS with the inclusion of the area to the west of the road.

B.1.1.2 Storm Events (Precipitation Calculations)

The magnitude of a storm event is often defined by its recurrence interval based on the historical record of storm events that occur at a site. A 'one year storm' has a precipitation magnitude such that the probability of its reoccurrence is about once a year. A '100 year storm' has a precipitation magnitude that is very large relative to the historical record with a probability of occurring once every 100 years; however, this also means that it is has a 1% chance of occurring each year. Designing for this large of a storm event will prevent most cases of flooding while not overwhelming the design budget. This analysis quantified the amount of flow that would be generated during the 1, 2, 5, 10, 25 and 100 year storm events. The precipitation amounts for these storms for durations of 24 hours were determined using the charts in Technical Paper 40 (Hershfield 1961).

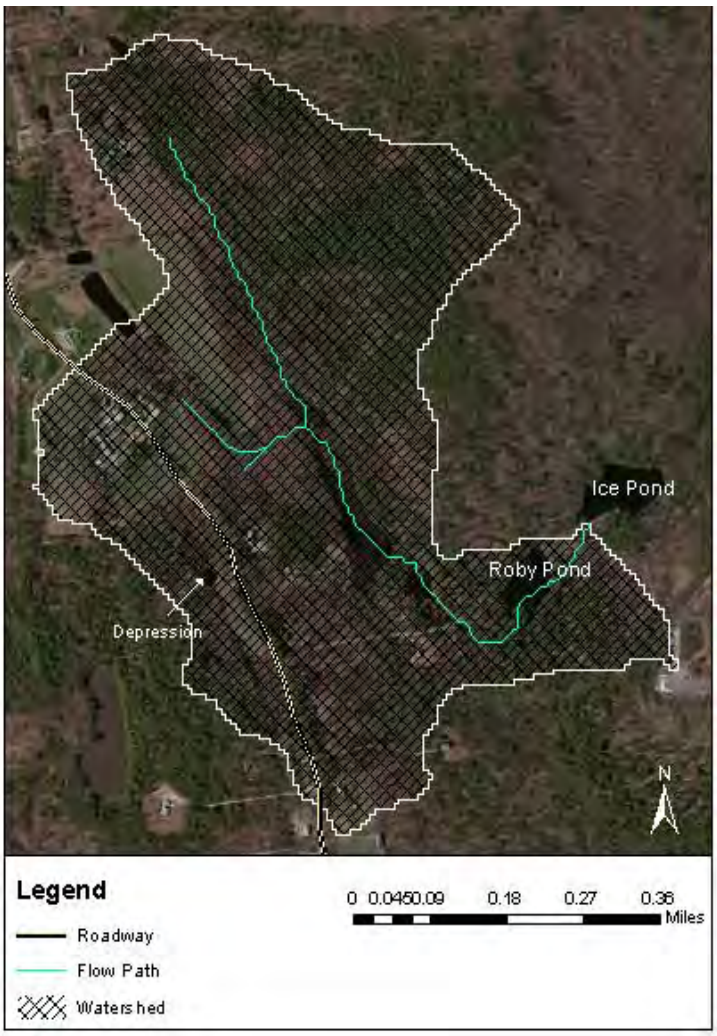


FIGURE B-2. The Watershed Boundary and Flow Paths to the Ice Pond Culvert.

A Presidential Disaster Declaration was issued for Hillsborough County, which includes NBAFS, and many of the surrounding counties as a result of the storm in April 2007 (Flynn 2008). Data downloaded from a National Oceanic and Atmospheric Administration's rainfall gage (NOAA 2013) at nearby Manchester showed that this storm recorded a total of 7.45 in. of rain over 30 hours from the start of the storm on April 16 to the end on April 17. This size of a storm is quite a bit larger than the estimated 100 year storm of 6.3 in. The discharge rates of nearby streams with gages were also higher than storms of higher precipitation due to snowfall which also occurred during the April 17 storm event (Flynn 2008). The presence of snow produces an increase in the volume of runoff due to snowmelt and through decreased infiltration caused by frozen ground conditions.

B.1.1.3 Hydrologic Calculations

If the precipitation intensity of a given storm is assumed to be constant, the maximum flow rate for the culvert will occur when the ground is fully saturated and the runoff from the furthest point of the watershed is contributing to the culvert. At that time, the volume of potential

runoff will be the greatest it can be, and the entire watershed will be contributing runoff to the culvert. The maximum flow rate, or peak discharge, that results from these conditions is the greatest that will flow through the culvert, and will therefore determine the effectiveness of the culvert for the given storm.

To calculate the peak discharge produced by the delineated watershed, the method in Technical Release 55, (TR-55) was used (USDA 1986). TR-55 was issued by the Natural Resources Conservation Service (NRCS, formerly Soil Conservation Service) for a simplified storm runoff calculation method. This approach quantifies the peak discharge by calculating the runoff volume of a precipitation amount and multiplying by a unit peak discharge based on the time to reach the peak conditions previously stated. The peak discharge, q_p (ft³/s) is calculated by the following equation.

$$q_p = Q * A * q_u \tag{1}$$

where Q is the runoff (in.), q_u is the unit peak discharge (csm/in.), and A is the area of the watershed (mi²). Note that "csm/in." refers to ft^3 of discharge per second per mi^2 of watershed per inch of runoff.

The runoff volume in equation 1 is calculated with an assigned integer number, called the curve number, for the watershed. The curve number defines an approximation of the infiltration capacities, and therefore allows an estimation of the amount of precipitation from a storm event that will become runoff. The curve number is determined by dividing the watershed into regions grouped by land cover and soil characteristics. Each group is assigned a curve number. As the land cover becomes more impervious (less ground cover for open spaces or more paved services for developed areas) and the soil allows for less infiltration (small granular sizes with less void space for water) the curve number will increase. A curve number of 100 will have the same amount of precipitation as runoff. The curve number (CN) for each land cover section is then weighted to determine the watershed's curve number according to

$$Weighted\ CN = \frac{CN_1A_1 + CN_2A_2 + \cdots + CN_nA_n}{\sum A_n} \tag{2}$$

The land cover type was determined from the USGS Water Resources NSDI Node application (DOI 2010) and the soil types were downloaded from the NRCS database and each was defined as one of the four soil classification types, A, B, C, or D. Table B-1 shows the land cover types for the watershed and their curve number values according to their soil classification type. For a more detailed explanation of the hydrologic soil groups, see TR-55, Chapter 2 (USDA, 1986). The weighted curve number for the watershed is determined to be 54.70.

The TR-55 method uses the following equation to determine the runoff of the watershed

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \tag{3}$$

where Q is the runoff (in.), P is the rainfall (in.), S is the potential maximum retention after runoff begins (in.) ($s = \frac{1000}{CN} - 10$), and I_a is the initial abstraction (in.) ($I_a = 0.2 * S$).

TABLE B-1. Curve Number Values for the Ice Pond Culvert Watershed

Land Cover	Percent of Land cover in Watershed	Curve Numbers for Hydrologic Soil Classification Group			
		A	B	C	D
Cropland and Pasture	17.7%	39	61	74	80
Evergreen Forest	13.74%	30	55	70	77
Mixed Forest	68.54%	30	55	70	77

The unit peak discharge is the peak discharge per square mile per inch of runoff and is calculated based on the relationship of $\frac{I_a}{P}$, the time of concentration, and a rainfall distribution type. The time of concentration is the time for runoff to travel from the furthest point of the watershed to the culvert, which corresponds to the time when the maximum amount of runoff is flowing through the outlet since the entire watershed is contributing. The TR-55 method quantifies overland flow, shallow concentrated flow, and flow in stream channel segments in order to calculate the travel path over the watershed. Chapter 3 in TR-55 contains the equations for the time of concentration segments. The time of concentration for the study watershed is 1.8 hours. Chapter 4, Exhibit 4 of TR-55 shows the graphical relations to determine the unit peak discharge (USDA, 1986). The unit discharge is based on a rainfall distribution from the start of the storm to the end. As different regions tend to experience different rainfall distributions, the TR-55 method created several distribution types. For the southern half of New Hampshire, a type III distribution is suggested. The unit peak discharge (q_u), and the runoff (Q) from equation 3 are used in equation 1 to determine the peak discharge. Results are shown in Table B-2.

B.1.1.4 Hydrologic Considerations

As runoff travels towards the Ice Pond culvert, it flows through a small natural depression pond just before flowing through Roby Pond. Since high resolution elevation data were unavailable for these ponds, there was no way to estimate their storage capacity. The ponds were therefore calculated as large channels with estimated depths. This assumption will overestimate the runoff volume and rate, which is a conservative approach in designing stormwater infrastructure.

It should also be noted that upon further review of the watershed imagery, a road crossing over the stream from the natural depression pond to Roby Pond was identified. Upstream stormwater structures can affect the flows reaching the downstream culvert. However, due to a lack of knowledge of this structure and unclear imagery, the crossing type (i.e. bridge, culvert) was not discernible and was therefore assumed to be a bridge that will not affect flow, even for the 100 year storm.

B.1.2 Hydraulic Analysis (Culvert Evaluation)

To test the inflow for the various magnitudes of storms calculated in the hydrologic analysis section, the culvert just upstream of Ice Pond is modeled using the HY-8 software (USDOT 2013). HY-8 is a culvert analysis program designed to route flow through culvert structures, using the appropriate equations for flow dependent on upstream water levels.

FIGURE B-3. View of Ice Pond Double Culvert.

The culvert at the inlet of Ice Pond contains two plastic 1.5 ft diameter cylindrical conduits with approximately 1.5 ft of rock and granular material (Figure 3 of main report) separating the top of the cylinders and the road. The width of the road was estimated to be approximately 17 ft across from high resolution imagery. From pictures taken on site (Figure B-3) it is inferred that the culverts are approximately 1.5 ft longer on each end than the road width, and that there is minimal (1 in.) soil deposition in the bottom of the culverts due to vegetation growth. The elevation drop from the entrance to the exit of the culverts is determined from the gridded elevation layer used for the hydrologic analysis and is approximately 1.2 ft. A diagram of the culvert is shown in Figure B-4. It is unknown if the two barrels are at a higher elevation of the stream bed, and are therefore assumed to be flush with the bed level.

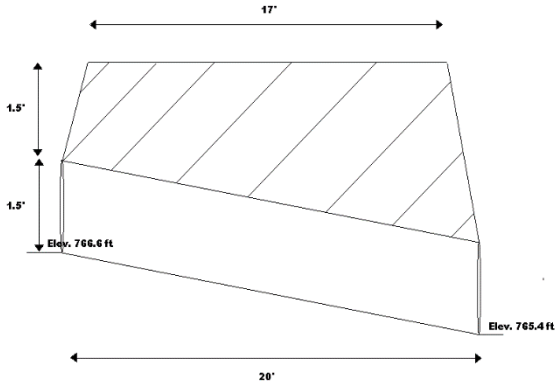


FIGURE B-4. Side Profile of the Ice Pond Culvert.

The short segment of channel downstream of the culvert was measured to be roughly 16 ft across using high resolution imagery. From this top width, a side slope and bottom width are estimated based on pictures and measurements common to this size stream. The cross sectional view of the downstream channel dimensions is diagramed in Figure B-5.

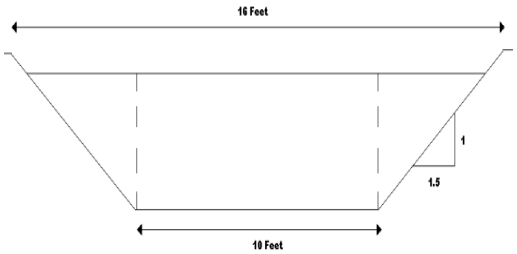


FIGURE B-5. Downstream Channel of the Ice Pond Culvert.

With the given parameters and assumptions, the HY-8 model estimates that the entire culvert will be submerged for all storm events modeled. For the 1 and 2 year storms, the water level will not reach the top of the road. However, for anything larger than a 5 year flood, the roadway will flood.

Results for each of the storm events are listed in Table B-2. Figure 6 profiles the culvert at the 100 year storm with the water surface represented by the blue lines. Recall from the hydrologic considerations that it is likely that these values are overestimates.

TABLE B-2. Hydrology and Hydraulic Model Outputs for each Storm Event at Ice Pond

Storm	Precipitation [in]	Peak Runoff Rate (Qp), Inflow at Ice Pond Culvert [cfs]	Ice Pond Double Culvert Water Level Percentage during Peak Flow (Current Conditions)	Ice Pond Concrete Box Culvert Water Level Percentage during Peak Flow (Design Conditions)
1 year, 24 hour	2.4	12.75	100%	19%
2 year, 24 hour	2.7	20.05	100%	23.6%
5 year, 24 hour	3.7	53.28	100%, Roadway Flooding	45%
10 year, 24 hour	4.3	76.96	100%, Roadway Flooding	61%
25 year, 24 hour	5	108.05	100%, Roadway Flooding	79%
100 year, 24 hour	6.3	173.35	100%, Roadway Flooding	100%

The existing double culvert was replaced with a simple concrete box structure in the HY-8 program. The height of the concrete box was set at 2.5 ft to keep the road height at its current level. If this type of structure were created, a width of 13 ft would be necessary to prevent flooding of the roadway for the 100 year storm. The water level percentages within the box for each storm event are listed in Table B-2. The profile of the concrete box structure at the Ice Pond culvert location for the 100 year storm is diagramed in Figure B-7.

B.1.3 Ice Pond Summary

The probability of a storm like the April 2007 event is very low, but this analysis suggests that flooding of the roadway over the culvert to Ice Pond can occur with a 5-year storm event (recall, this analysis was conservative by not accounting for potential flood storage in upstream shallow ponds). Preliminary analyses of concrete box culvert design suggest that one that is 2.5 ft in height and 13 ft in width will have the capacity to convey the 100-year storm event. Before any specific designs for a replacement culvert are considered, there should be further surveying analyses performed to better characterize the storage capacity upstream of Ice

Pond, as well as obtaining higher resolution topography data around the inlet and outlet regions of the culvert.

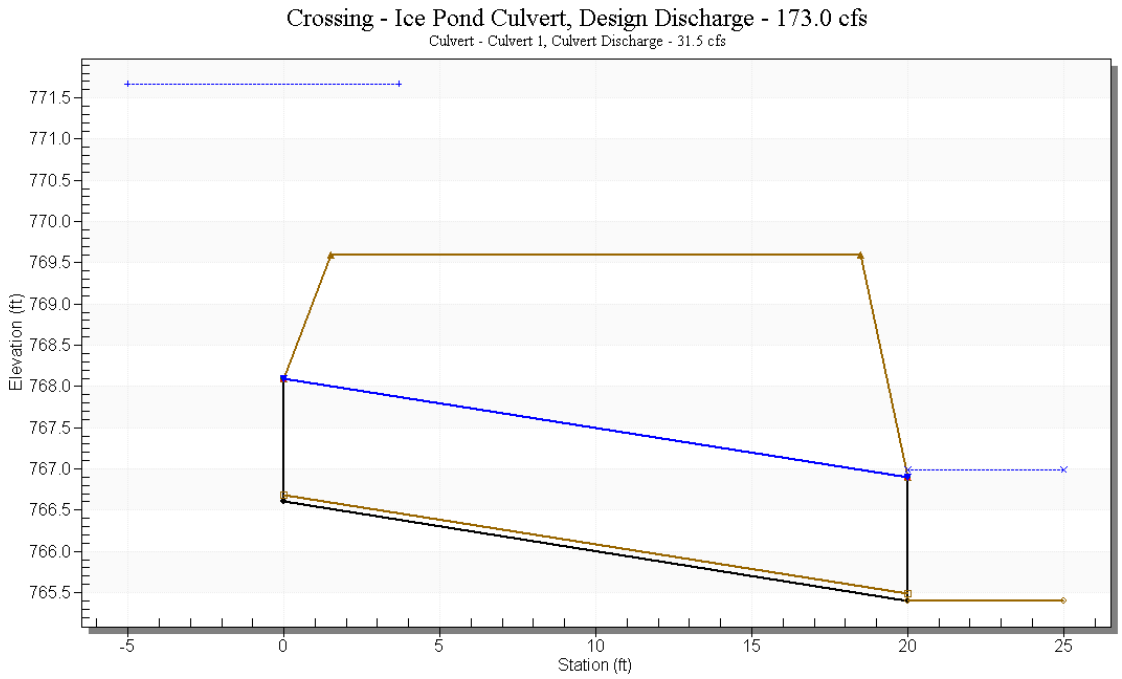


FIGURE B-6. HY-8 Model—Side Profile of the Existing Ice Pond Culvert for the 100 Year Storm.

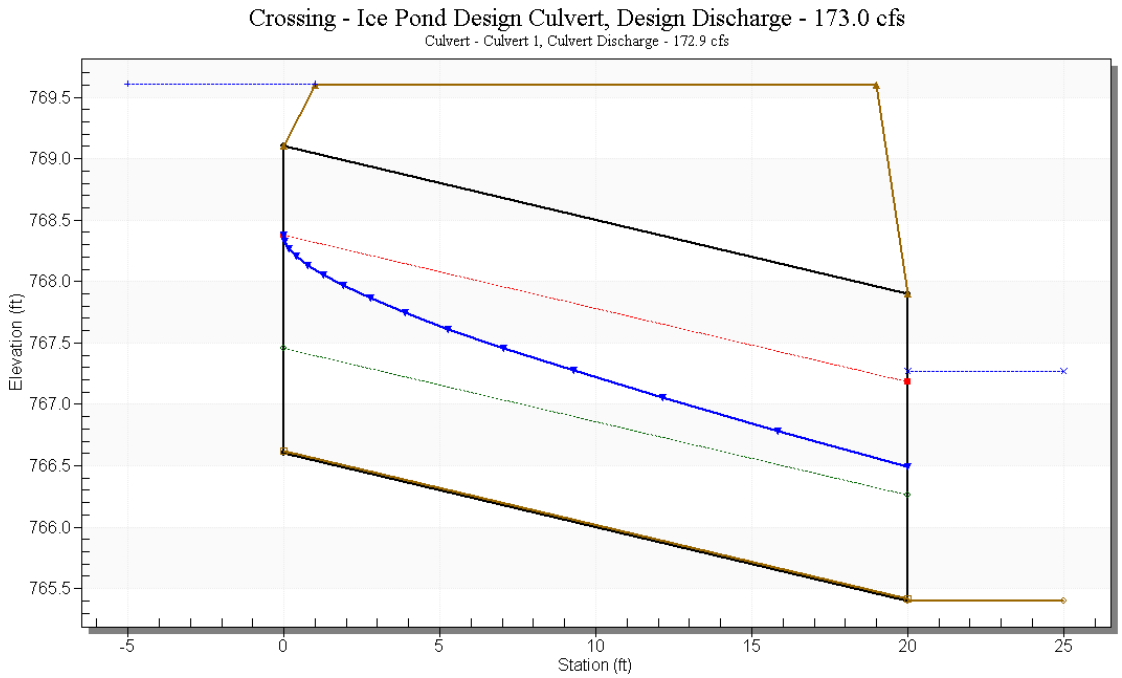


FIGURE B-7. HY-8 Model—Side Profile of a Concrete Box Design for the 100 Year Storm at Ice Pond

B.2 SEAVEY POND

B.2.1 Hydrologic Analysis

The assessment of Seavey Pond inflow was conducted using the same modeling approaches as those described above for Ice Pond. This section summarizes details relevant to the Seavey Pond assessment only. Generic descriptions of modeling steps used for the Ice Pond assessment apply to this section as well.

B.2.1.1 Watershed Delineation

The watershed that drains to Seavey Pond was determined using the Watershed Modeling System's TOPAZ tool which delineates watersheds based on elevation grids. A 10 m USGS elevation grid was used to create the watershed for this analysis, which is shown in Figure B-8. The estimated flow paths that occur from a storm event are defined as the cells with at least 0.005 mi² of watershed area contributing runoff to it.

Human development can alter the shape of a watershed. In contrast to the Ice Pond analysis, there is little human development within the watershed. In fact, there is only one road, West Meadow Road, and it has known culverts. Therefore, the Seavey Pond watershed is unchanged from its natural shape, and is approximately 0.13 mi².

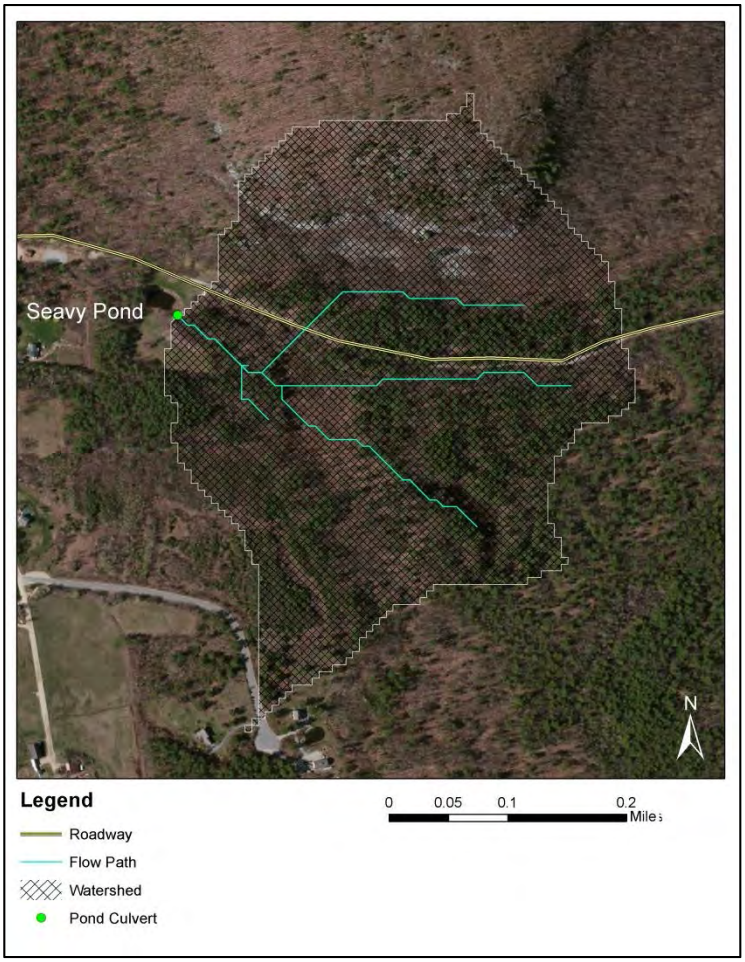


FIGURE B-8. The Watershed Boundary and Flow Paths to the Existing Seavey Pond Culvert

B.2.1.2 Storm Events and Hydrologic Calculations

The precipitation amounts for the 1, 2, 5, 10, 25, and 100-year, 24-hour storms for the Seavey Pond watershed were determined using Technical Paper 40 (Hershfield, 1961). These amounts are shown in Table 4. The Technical Release 55 (TR-55) method was used to calculate the amount of runoff the Seavey watershed would produce from these synthetic precipitation amounts (USDA, 1986). This technique requires an infiltration constant, called the curve

number, and a time parameter, called the time of concentration. NRCS soil maps and NLCD land cover maps were used to approximate an average curve number of 51.45 for the watershed. The land cover percentage values are shown in Table B-3. The other parameter needed is the time from the start of the storm for the longest flow path to reach the culvert, called the time of concentration. The time of concentration is approximately 0.6 hours. The Graphical Peak Discharge equation of TR-55 enables the calculation of the peak discharge from the curve number and the time of concentration using a type III distribution. The peak discharge values for the selected storm events are recorded in Table 4. (See the Hydrologic Calculations section of the Ice Pond analysis for a more detailed explanation of how the peak discharge was calculated.)

TABLE B-3. Curve Number Values for the Seavey Pond Watershed

Land Cover	Percent of Land cover in Watershed	Curve Numbers for Hydrologic Soil Classification Group			
		A	B	C	D
Mixed Forest	89.18%	30	55	70	77
Woody Wetland	2.31%	80	85	90	95
Cropland/Pasture	7.47%	39	61	74	80

B.2.1.3 Hydrologic Considerations

West Meadow Road is the central road through the watershed (Figure B-8). As previously mentioned, it was determined that altered flowpaths resulting from this road did not alter the shape of the watershed. However, flow could possibly be pooling if the culvert under the road were inefficient during higher intensity storms. As this could affect the amount of inflow to the Seavey Pond culvert, a separate watershed was created to assess the inflow to the West Meadow Road culvert. It was determined that a discharge of only 15 ft^3/s would occur at the flow path and road intersection point for a 100 year storm. Although information is limited on this culvert, the provided notes indicate a 12 in. diameter culvert that is partially clogged. Using conservative, assumed values of minimal slope, the runoff from the 100 year storm will likely be conveyed under the road without pooling; even with 1/3 of the culvert clogged.

The Chain Fern Bog drains to Seavey Pond from the southeast of the watershed. This type of permanent flooded area allows for very limited infiltration in most conditions due to its natural state of saturation. Information about the bog's water storage was inadequate to create detailed calculations of the discharge-storage relations. However, a curve number was assigned to the area to reflect the land feature in our calculations. We feel that this is an acceptable alternative, producing conservative discharge values. This is noted as 'Woody Wetland' in Table B-3.

Described in the Hydrologic Calculations section of the Ice Pond analysis (B.1.1.3), the time of concentration is the time it takes for runoff to flow from the furthest point of the watershed along the flow path to reach the outlet. The TR-55 method quantifies the flow path

into overland flow, shallow concentrated flow, and channel segments. Each segment type has an equation to calculate the time of travel for the flow through that section. The sum of the segment times is the total time of concentration for the watershed. For the Seavey Pond watershed, the high resolution imagery is not distinct enough to identify the small stream which flows to the Seavey Pond culvert. The equation which calculates the flow travel time of a channel segment requires the hydraulic radius of the channel and the length of the segment. With an indistinguishable start of channel flow and no method to approximate the width and depth of the channel, the different segment parameters were approximated based on the stream width at the culvert, and typical behavior of a creek that size. The time of concentration of 0.6 hours was computed using these approximations. To perceive the extent of the change in time due to the assumptions, a simulation was run where the entire length of the stream after overland flow was concentrated flow and another where the entire length of the stream after overland flow was channel flow. For the 100 year storm, the two extreme situations only change the calculated discharge at the Seavey culvert by 3 ft^3/s. With the maximum amount of change in the final discharge calculations being so low, we feel that our assumptions are acceptable for the purposes of this report.

B.2.2 Hydraulic Analysis

Rainfall which falls onto Joe English Hill forms a concentrated flow path as it travels to lower elevation, crossing Meadow Road. This flow joins with the concentrated flow from the Chain Fern Bog to form a small stream. The path reaches the road, and flows parallel to it for a short while before making a 90° turn into the culvert. The trapezoidal, stone inlet is roughly two feet tall and opens to a 2 ft diameter cylindrical conduit made of high density polyethylene (HDPE) (Figure B-9). Figure B-10 shows the sectioned view along the width of the road. Site personnel estimated a foot of road material above the top of the conduit. From elevation contours, we estimated a slope of 0.05 for the culvert, and a slope of about 0.02 for downstream of the outlet. The outfall from the culvert has become a delta due to flooding where road debris and possibly stream bed sediment was carried towards the pond in large storm events. The lighter colored triangular deposition of sediment where the water flows into the pond can be seen in Figure B11.

The created HY-8 culvert analysis model estimates that precipitation equaling a 10 year storm will maximize the capacity of the culvert, and the 25 and 100 year storms will flood the roadway (Table B-4). The 25 year storm has a calculated discharge of 26.23ft^3/s. The roadway flooding occurs at approximately 24 ft^3/s. Therefore, although the road will flood for the 25 year storm, the discharge at the road top for the storm is only about 1.1 ft^3/s. The 100 year storm, on the other hand, has approximately 25.1 ft^3/s road top discharge. The side profile of the 100 year storm is shown in the HY-8 model in Figure B-12. If a simple concrete box conduit were to replace the current culvert, it would need to be 4.6 ft wide assuming the height remains 2 ft tall. The side profile for the concrete box design in seen in Figure B-13.

FIGURE B-9. The Trapezoidal Inlet (Left) and the Outlet (Right) to the Culvert at Seavey Pond

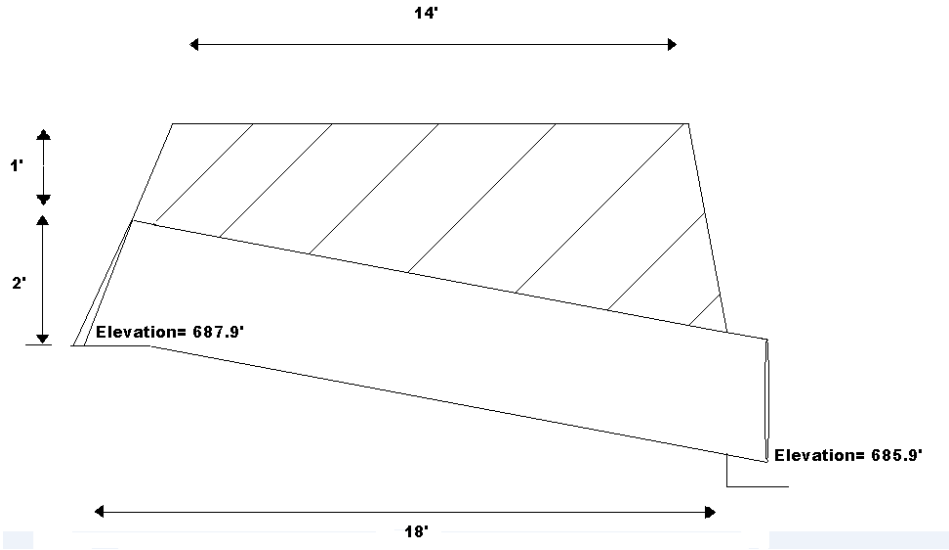


FIGURE B-10. The Side Profile of the Existing Seavey Pond Culvert (Not to Scale)

TABLE B-4. Hydrologic and Hydraulic Model Outputs for Each Storm Event at Seavey Pond

Storm	Precipitation [in]	Peak Runoff Rate (Qp), Inflow at Seavey Pond Culvert [ft^3/s]	Seavey Pond Culvert Level Percentage during Peak Flow (Current Conditions)	Seavey Pond Culvert Level Percentage during Peak Flow (Design Conditions)
1 year, 24 hour	2.4	0.2	9%	3%
2 year, 24 hour	2.7	0.7	19%	7%
5 year, 24 hour	3.7	6.4	63%	30%
10 year, 24 hour	4.3	13.9	100%	50%
25 year, 24 hour	5	26.23	100%, Roadway Flooding	80%
100 year, 24 hour	6.3	56.78	100%, Roadway Flooding	100%

FIGURE B-11. An Aerial View of Seavey Pond and the Nearby Access Road

B.2.3 Seavey Pond Summary

Our analysis showed that the 25 year storm and the 100 year storm would produce enough stormwater runoff to flood the road near Seavey Pond. However, the rate of water

movement across the road would be minimal, and only the 100 year flood would have enough discharge to displace sediment and then deposit it near the mouth of the pond. A simple 4.6 ft by 2 ft concrete box design would permit flow for the 100 year storm without flooding the road top. However, it is unclear whether the debris in the delta-shaped deposition at the entrance to the pond comes primarily from the road, or a combination of roadway material and stream sediment. As it is likely that the bend in the small stream just before entering the culvert slows the speed of the water current, any sediment in the water will settle out more quickly. Therefore, if the road material after flooding is not the only source of sediment, the delta deposition may continue to occur even if a larger conduit is installed to prevent roadway flooding. More detailed analysis and exact measurements of the site should be done to determine a new design for a stormwater structure at the site.

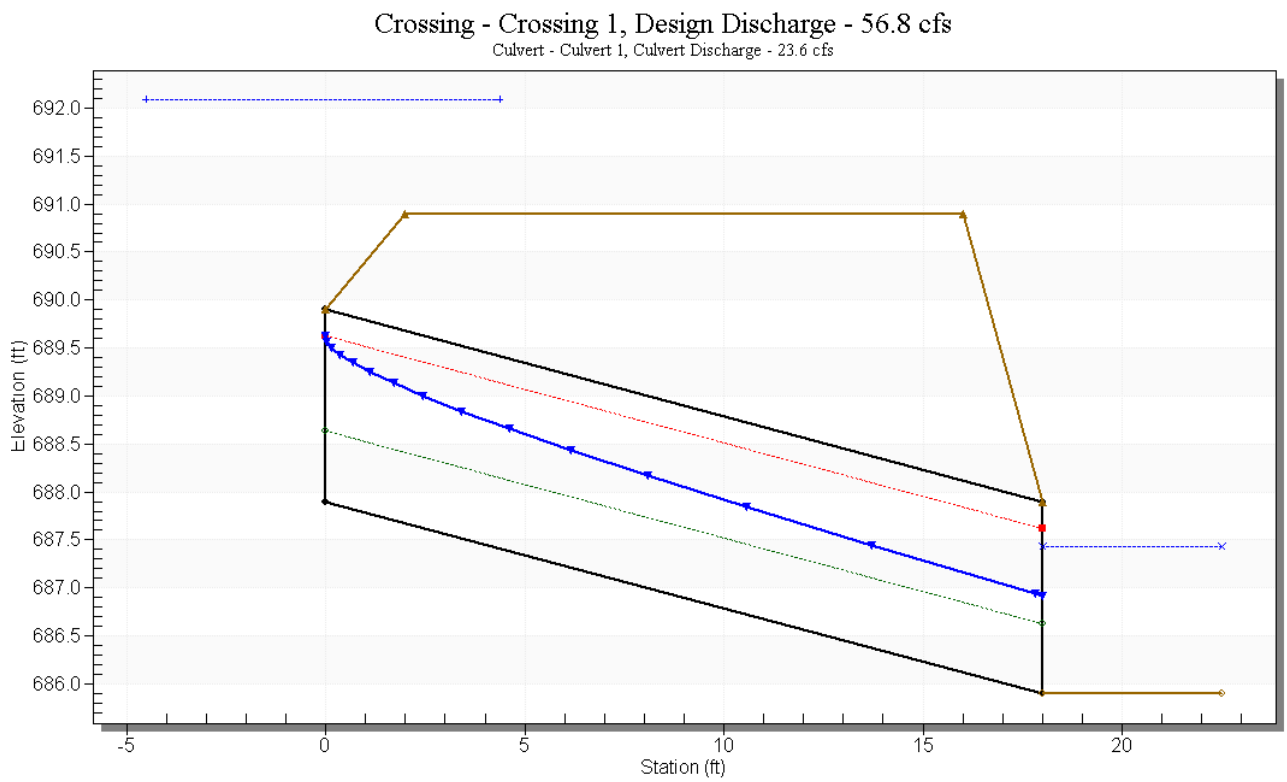


FIGURE B-12. HY-8 Model—Side Profile of Existing Seavey Pond Culvert for a 100 year Storm

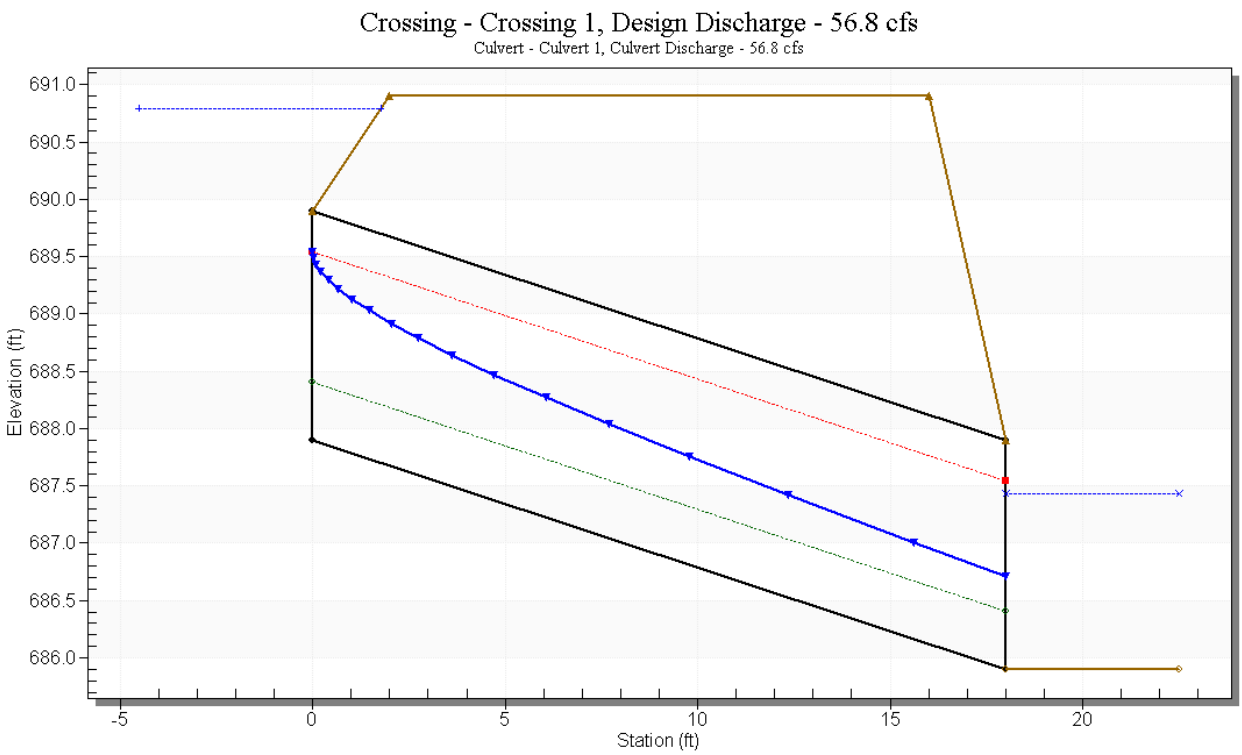


FIGURE B-13. HY-8 Model; Side Profile of a Concrete Box Design for the 100 Year Storm at Seavey Pond

B.3 REFERENCES

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