DRAFT
WETLAND ASSESSMENT
WHITE-CEDAR-OSCEOLA PROJECT
EVART, MICHIGAN

Privileged and Confidential

February 6, 2004

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INTRODUCTION

The following wetland assessment has been prepared to ascertain the extent and magnitude of effects to wetlands in the vicinity of a groundwater pumping operation planned for an area near Evart, Michigan. In preparing this assessment Tilton & Associates, Inc. (TAI) relied on existing information on soils, hydrology and vegetation patterns as well as studies by Malcolm Pirnie, Inc. and S. S. Papadopulos & Associates, Inc. (SSPA) of the ground water of the area, as described in this report. Field investigations were conducted to study and describe the soil, hydrology, and vegetation of wetlands in the area of the proposed ground water pumping operation. Much of the field work was completed in association with botanist Glenn Vande Water (Vande Water Natural Resource Services), whose "Wetland Descriptions" are included with this report.

METHODS

The methodology used to identify and characterize wetlands is consistent with the Michigan Department of Environmental Quality (MDEQ) wetland determination criteria as described in the *MDEQ Wetland Identification Manual* (MDEQ 2001). An evaluation was conducted using three diagnostic parameters: vegetation, soils, and hydrology. Plant species associated with wetland versus upland conditions were identified and checked against either the *National List of Plant Species* (Reed 1988) or the *Michigan Plant Database* (Penskar *et al*. 2001). Soil profiles were examined by using either a tile spade or soil auger to examine profiles to a depth of at least 18 inches below the ground surface. Soil morphologies were examined for horizon thickness, color, texture, and presence of hydromorphic (wet soil) features and compared against the *Field Indicators of Hydric Soils in the United States* (USDA-NRCS 1998). Primary and secondary indicators of hydrology as described in the US Army Corps of Engineers *Wetland Delineation Manual* (Environmental Laboratory 1987) were used as criteria to confirm wetland hydrology. Particular attention was paid to soil and landscape features relevant to the hydrologic support of

individual wetlands. For example, wetlands with clayey soils were interpreted as having hydrologic regimes supported by direct precipitation, surface runoff and shallow subsurface lateral flow. Wetlands with coarse-textured soils and situated along a toe-slope, were interpreted as groundwater-fed.

Although the primary soil consideration for wetland ecology is the thickness that includes the plant rooting zone with its complex biogeochemistry, we also examined evidence of deeper soil horizon characteristics and glacial stratigraphy using published *Soil Survey* (Mennert 1969) data and geologic interpretations made by the Papadopulos investigation.

Wetland vegetation community structure was characterized using the classification system described in the *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin *et al*. 1979). Essentially all of the wetlands observed at the site were of the "Palustrine" class, which is a group including vegetated wetlands commonly known by such names as marsh, swamp, bog, fen, wet prairie, and pond. Palustrine wetlands form in depressions, seeps, and shoreward of lakes, rivers, streams. Abbreviations for community types referred to in this report follow in Table 1.

Table 1. Wetland classifications used in this report (Cowardin *et al*. 1979)

Community Class	Abbreviation	General Characteristics
Palustrine Emergent Wetland	PEM	Vegetation is characterized by erect, rooted, herbaceous (non-woody) hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. Perennial plants such as ferns, asters, sedges, cattails, bulrush, rushes, and grasses usually comprise the dominant species in these wetlands.
Palustrine Scrub-Shrub Wetland	PSS	Dominated by woody vegetation less than 6 m (20 feet) tall. The species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions.
Palustrine Forested Wetland	PFO	Characterized by woody vegetation that is 6 m (20 feet) tall or taller such as northern white cedar, tamarack, eastern hemlock, yellow birch, paper birch, red maple, sugar maple, red pine, and white pine.
Palustrine Open Water	POW	Ponds and streams with either an un-vegetated bottom or submerged aquatic plants.

Vande Water Natural Resource Services provided botanical surveys of all wetlands occurring within the White-Cedar-Osceola Project area and, in cooperation with Tilton & Associates, Inc., provided descriptions of the vegetation structure and composition of each wetland. Vegetation structure and composition data have been described on a wetland-by-wetland basis in the Results section, and a list of all plant species identified by Vande Water Natural Resource Services as occurring in the wetlands inspected for this report has been provided in Appendix 2.

RESULTS

Soils and Hydrology

Major Soil Map Units for the White-Cedar-Osceola Project Site

The *Soil Survey of Osceola County*, Michigan (Mettert 1969) shows soil types for the White-Cedar-Osceola Project site (Figure 1). Tilton & Associates, Inc. (TAI) compared field observations of soils to soil types mapped at each wetland location. In the northern portions of the study site, soils found in the smaller wetlands were too small to be mapped at the scale of the *Soil Survey*. The soil map units shown on the *Soil Survey* do provide information about general soil stratigraphy.

We also investigated soil stratigraphic evidence to determine soil properties and the nature of underlying soils within approximately 20 inches of the surface of the wetland. The *Hydric Soils of the State of Michigan* (1985) and NRCS criteria were used to determine which of the soil types listed as occurring in the study area were hydric. A summary of soil map units and water table data are shown in Table 2.

Table 2. Summary of hydric and non-hydric White-Cedar-Osceola Project soils and Figure 1.

Soil Survey Map Unit	Map Symbol	Hydric or Non-Hydric soil
Adrian muck	Ad	Hydric
Brevort loamy sand, overwash	Bv	Hydric
Carbondale muck	CbA	Hydric
Chelsea sand	ChB	Non-Hydric
Croswell sand	CrB	Non-Hydric
Houghton muck	Hm	Hydric
Iosco loamy sand 2-6% slopes	IcB	Non-Hydric
Isabella loam, 2-6% slopes	IeB	Non-Hydric
Isabella sandy loam, 2-6% slopes	IsB	Non-Hydric
Isabella sandy loam, 6-12% slopes, moderately eroded	IsC2	Non-Hydric
Kalkaska sand 6-12% slopes	KkC	Non-Hydric
Kent loam, 12-18%	KtD	Non-Hydric

Soil Survey Map Unit	Map Symbol	Hydric or Non-Hydric soil
Kent loam, 12-18% slopes	KtD2	Non-Hydric
Loxley muck	Lo	Hydric
Manistee loamy sand, 6-12% slopes	MdC	Non-Hydric
Marley muck	Me	Hydric
McBride sandy loam, 6-12% slopes	MlC	Non-Hydric
McBride sandy loam, 12-18% slopes	MmD	Non-Hydric
McBride sandy loam, 12-18% slopes, moderately eroded	MmD2	Non-Hydric
McBride sandy loam, 18-25% slopes	MmE	Non-Hydric
Menominee loamy sand, 6-12% slopes	MpC	Non-Hydric
Montcalm loamy sand, 0-6% slopes	MsB	Non-Hydric
Montcalm loamy sand, 6-12% slopes	MsC	Non-Hydric
Montcalm loamy sand, 12-18% slopes	MsD	Non-Hydric
Nester loam 2-6% slopes	NeB	Non-Hydric
Otisco loamy sand, 2-6% slopes	OsB	Non-Hydric
Shoals loam	Sh	Non-Hydric
Sims clay loam	Sm	Hydric
Tawas muck	Tc	Hydric
Tawas peat	Tp	Hydric
Ubly sandy loam	UbB	Non-Hydric

Field Investigation of Wetland Hydrology and Soils

A total of 57 wetlands were examined at the site (Figures 2, 3 and 4). For each wetland sampled using either a tile spade or soil auger, data were collected pertaining to soil morphology and depth to saturation. Soil horizon thickness, texture, matrix color, mottle color, depth to saturation (which differs from depth to free water as it includes soils saturated in the capillary fringe above the water table), and depth to fine-grained soil layer were recorded and are shown in Appendix 1.

Perched wetlands were identified using published and field evidence collected by TAI personnel, and findings reported by Malcolm Pirnie (2003) and SSPA (2003).

A breakdown of evidence relating to perched wetland hydrology is summarized in Table 3.

Table 3. Summary of evidence supporting perched wetland hydrology.

Source of Evidence	Wetland Identifier
Field evidence of low-permeability layer and perched wetland hydrology	B, N, P, V, X, Y, NC, ND, NG, NI, NL, NK
Soil Survey evidence of perched wetland conditions	H, I, P, T, U, V, Y, Z, DD, EE, GG, HH, II, JJ, OO, QQ, RR, SS, TT, UU, VV, WW, XX, NB, NJ
Ground water hydrology studies by Malcolm Pirnie and SSPA	All wetlands except A, G, H, R, CC, and PP

Although the *Soil Survey* data should not be considered "site specific", taken with additional soil field data and monitoring well data, the evidence supports the conclusion that most of the wetland areas at the White-Cedar-Osceola Project site are supported by surface water or shallow groundwater and are not likely to be affected by the proposed well. However, there is evidence that indicates wetlands A, G, H, R, CC, and PP are connected to the ground water source aquifer at the White-Cedar-Osceola Project site.

Plant Community Structure and Species Composition

Wetland Descriptions

Wetland A: A ravine drains south to the north side of Wetland A. The floor of the ravine near the staff gages (SG-203 and SG10) does not have a significant plant community. Groundwater emerges at the head of the ravine, near SG-203. This wetland supports a combination of PFO, POW, PEM, and PSS type wetlands. Chippewa Springs is the major inflow component of the water budget of this wetland. A canopy of lowland conifers dominates the PFO portion, with lowland hardwoods occurring to a lesser extent. Species observed include northern white cedar (*Thuja occidentalis*), eastern hemlock (*Tsuga canadensis*), red maple (*Acer rubrum*), yellow birch (*Betula alleghaniensis*), white pine (*Pinus strobus*), quaking aspen (*Populus tremuloides*), green ash (*Fraxinus pennsylvanica*), and tamarack (*Larix laricina*). The herbaceous layer supports high vascular plant diversity including wood nettle (*Laportea canadensis*), common horsetail and dwarf scouring-rush (*Equisetum arvense* and *E. scirpoides*, respectively), swamp and wrinkled goldenrod (*Solidago patula* and *S. rugosa*, respectively), dwarf raspberry (*Rubus*

pubescens), miterwort (*Mitella nuda*), water cress (*Nasturtium officinale*), oak fern, sensitive fern, cinnamon, lady, and bulblet ferns (*Gymnocarpium dryopteris, Onoclea sensibilis, Osmunda cinnamomea, Athyrium filix-femina,* and *Cystopteris bulbifera*, respectively), rough and ebony sedge (*Carex scabrata* and *C. eburnea*, respectively), American marsh penny-wort (*Hydrocotyle americana*), northern clearweed (*Pilea fontana*), goldthread (*Coptis trifolia*),and spotted touch-me-not (*Impatiens capensis*). The POW system, known as Decker Pond, consists of a shallow water pond that supports a dense layer of the macro-algae Chara (*Chara* spp.). The PEM system occurs primarily on the western periphery of Decker pond and along Chippewa Creek. It supports a predominance of herbaceous species that include broad-leaved cattail (*Typha latifolia*), swamp aster (*Aster puniceus*), water dock (*Rumex verticillatus*), fringed brome (*Bromus ciliatus*), sensitive fern, linear-leaf willow herb (*Epilobium leptophyllum*), marsh fern (*Thelypteris palustris*), green bulrush (*Scirpus atrovirens*), brome-like sedge (*Carex bromoides*), and purple loosestrife (*Lythrum salicaria*). The PSS system occurs along the northern and southern periphery of Decker Pond, the drainage way at the southwest corner of the pond, and scattered within the PEM system. These areas are dominated by various willows (*Salix* spp.) with red-berried elder (*Sambucus racemosa*), autumn olive (*Elaeagnus umbellata*), and glossy buckthorn (*Rhamnus frangula*) occurring to a lesser extent. Purple loosestrife, glossy buckthorn, and autumn olive do not currently cover large expanses of this wetland.

Wetland B: This small wetland supports a PEM wetland type that supports a diverse herbaceous layer. Runoff following precipitation events appears to be the major inflow component of the water budget of this depression wetland. Species observed at various densities and frequency of occurrence include Canada blue joint grass (*Calamagrostis canadensis*), swamp aster, sensitive fern, marsh fern, water parsnip (*Sium suave*), cinnamon fern, crested fern (*Dryopteris cristata*), lady fern, bladder, brownish, crowded, and rose-like sedge (*Carex intumescens, C. brunnescens, C. stipata,* and *C. rosea*, respectively), wool grass (*Scirpus cyperinus*), fowl manna grass (*Glyceria striata*), purple avens (*Geum rivale*), common boneset (*Eupatorium perfoliatum*), red top grass (*Agrostis gigantea*), spotted touch-me-not, American bellflower (*Campanula americana*), large fruited beggar-ticks (*Bidens coronata*), and golden saxifrage (*Chrysosplenium americanum*). Woody plants form only a minor component in this wetland, with northern white

cedar and eastern hemlock noted. A relict drainage way leads from the southeastern corner of Wetland B to Wetland A.

Wetland C: This small depression wetland supports a combination of PEM and PSS wetland types. The eastern portion of the wetland becomes inundated following significant precipitation events and supports a limited herbaceous component. Runoff from the surrounding moderately steep slopes following precipitation events appears to be a principal source of the water inflow to this wetland. The principal plants observed in the wetland's herbaceous layer include large fruit beggar-ticks, devil's beggar-ticks (*Bidens frondosa*), short-awn foxtail (*Alopecurus aequalis*), common duck weed (*Lemna minor*), water parsnip, sensitive, marsh and cinnamon fern, royal fern (*Osmunda regalis*), fowl manna grass, fringed and three seed sedge (*Carex crinita* and *C. trisperma*, respectively). The fringed sedge forms over 50% of the herbaceous vascular plant cover. A relatively dense layer of the thallose liverwort *Riccia fluitans* is present during both inundated and exposed soil conditions. A small PSS zone occurs in the approximate middle of the wetland and is dominated by Michigan holly (*Ilex verticillata*) with shining willow (*Salix lucida*) occurring to a lesser extent.

Wetland D: The physical features of this small wetland are similar to Wetland C, with both PEM and PSS wetland types present. Runoff appears to be a significant feature in the hydrology of this depression wetland. The principal species observed in this wetland include water parsnip, common duckweed, short-awn foxtail, fringed and crowded sedge, hop and retrorse sedge (*Carex lupulina* and *C. retrorsa*, respectively), marsh fern, wool grass, sensitive fern, soft rush (*Juncus effusus*), reed manna grass (*Glyceria grandis*), and meadow willow (*Salix petiolaris*). The fringed sedge comprises over 50% of the herbaceous cover with meadow willow the predominant woody plant. The leaf heterophylly observed on the water parsnip plants is an indication that portions of the wetland are inundated for a considerable length of time. (Leaf heterophylly refers to the occurrence of different shaped leaves on the same plant. Leaf heterophylly often is triggered in emergent wetland plants when standing surface water inundates the lower leaves during leaf development.)

Wetland E: This wetland supports a large PSS wetland dominated by leatherleaf (*Chameadaphne calyculata*), providing over 75% of the vegetative cover. A small PEM zone occurs at the eastern most end of the wetland. It is likely that precipitation is an important inflow component of the water budget of this depression wetland. Additional vascular plant species observed, primarily in the PEM type, include wool grass, Canada blue-joint grass, brownish and hop sedge, three-way sedge (*Dulichium arundinaceum*), lesser bladderwort (*Utricularia minor*), devil's beggar-ticks, water parsnip, bulblet bearing water hemlock (*Cicuta bulbifera*), beaded sedge (*Carex comosa*), marsh St. John's-wort (*Triadenum fraseri*), red top grass, soft rush, ribbon-leaf pondweed (*Potamogeton epihydrus*), cinnamon fern, small floating manna grass (*Glyceria borealis*), catberry (*Nemopanthus mucronatus*), with-rod (*Viburnum cassinoides*), Michigan holly, meadow willow, and shining willow.

Wetland F: Wetland F supports a combination of PSS and PFO wetland type. Runoff following precipitation events is likely a major inflow contributor to the water budget of this depression wetland. Black ash (*Fraxinus nigra*), and red maple are the principal tree cover in this wetland, with Michigan holly forming over 75% of the PSS cover. Additional associate species noted include large fruited beggar-ticks, bearded and bladder sedge, Canada blue-joint grass, spotted touch-me-not, cinnamon fern, water parsnip, hooded skullcap (*Scutellaria galericulata*), wild calla (*Calla palustris*), northern bugleweed (*Lycopus uniflorus*), and common duckweed. Common duckweed creates over 75% cover in inundated portions of the wetland. A historic drainage way toward Wetland Q occurs at the far eastern extension of the wetland.

Wetland G: This wetland supports a combination of PFO and PEM wetland types and appears to have historically been connected to Wetland R to the southeast and received seasonal overflow water from Wetland H to the northeast. Steep south facing slopes along the north side of the wetland probably contribute a significant amount of runoff to this wetland. Black ash forms over 75% of the tree cover in the western forested portion of the wetland while wool grass is the predominant species in the PEM portion. Other species observed, primarily in the PEM type, include fowl manna grass, golden saxifrage, marsh, crested, royal, lady, cinnamon, and sensitive fern, spotted touch-me-not, bulblet bearing water hemlock, bottle-shaped sedge (*Carex utriculata*), and Michigan holly.

Wetland H: This wetland supports a combination of PEM and PSS wetland types. Wool grass forms over 75% of the cover in the PEM portion while meadowsweet (*Spiraea alba*), common elderberry (*Sambucus canadensis*), red osier dogwood (*Cornus stolonifera*), and various willows are represented in the PSS zone. Other species noted to a lesser extent in the wetland include sensitive fern, swamp milkweed (*Asclepias incarnata*), soft rush, swamp aster, and red raspberry (*Rubus strigosus*). Precipitation events and possibly ground water are major inflow components of the water budget of this depression wetland.

Wetland I: This wetland supports approximately 70% PEM and 30% PSS wetland type. The PEM zone harbors species that include marsh and sensitive fern, green bulrush, swamp aster, wool grass, fowl manna grass, porcupine, yellow, graceful, and inland sedge (*Carex hystericina*, *C. flava*, *C. gracillima*, and *C. interior*, respectively), brownish, crowded, and fringed sedge, blue vervain (*Verbena hastata*), soft rush, and common horsetail. Sensitive fern comprises over 50% of the herbaceous cover in the PEM wetland. The PSS portion of the wetland supports black and Bebb's willow (*Salix nigra* and *S. bebbiana*, respectively), meadow willow, and stiff dogwood (*Cornus foemina*), with meadow willow and stiff dogwood the predominant species. A considerable amount of autumn olive occurs along the boundary of this wetland. Precipitation events and, to a lesser extent, ground water are inflow components of the water budget of this depression wetland.

Wetland J: This depression wetland supports a PEM wetland type, with wool grass comprising over 50% of the herbaceous cover. Other associated plant species include sensitive fern, swamp aster, green bulrush, wrinkled goldenrod, crowded sedge, and blunt broom sedge (*Carex tribuloides*). An ephemeral drainage way extends from the southern edge of the wetland to Wetland L. A fringe of quaking aspen occurs along the eastern edge of the wetland. Precipitation appears to be the principal input component of the water budget of this wetland.

Wetland K: This depression wetland consists largely of the PSS wetland type, with a minor component of PEM. Meadow willow provides over 75% of the cover in the PSS zone, with meadowsweet occurring to a lesser extent. The PEM areas that occur primarily within openings

in PSS type and at the periphery often support relatively thick growth of reed canary grass (*Phalaris arundinacea*). Other species comprising the herbaceous layer include water parsnip, climbing nightshade (*Solanum dulcamara*), devil's beggar's-ticks, marsh fern, water smartweed (*Polygonum amphibium*), broad-leaf water plantain (*Alisma plantago-aquatica*), tufted loosestrife (*Lysimachia thyrsiflora*), and the liverwort *Riccia fluitans*. Glossy buckthorn and autumn olive occur along the boundary of the wetland but are not currently a dominant plant. Portions of this wetland appear to become inundated to at least one-foot depth. Precipitation appears to be the principal input component of the water budget of this wetland.

Wetland L: This depression wetland supports a combination of PEM and PSS wetland types. The majority of the wetland undergoes seasonal water level fluctuation. A small open water zone occurs at the southwestern end of the wetland, with an outlet to a drainage way at its northwestern edge. Fringed and brownish sedge combine to provide over 50% of the herbaceous cover, with fowl manna grass, wool grass, and sensitive fern ranging between 5 and 25% of the cover. Other herbaceous species observed include reed canary grass, green bulrush, large-fruited beggar's-ticks, crested fern, porcupine sedge, swamp aster, swamp milkweed, necklace and fox sedge (*Carex projecta* and *C. vulpinoidea*, respectively), royal fern, giant goldenrod (*Solidago gigantea*), yellow avens (*Geum aleppicum*), stinging nettle (*Urtica dioica*), and spotted touch-me-not. Meadow willow and meadowsweet are the predominant shrubs in the PSS portion of the wetland. Quaking aspen and red maple occur along the periphery of the wetland.

Wetland M: This depression wetland supports a PEM wetland type. A constructed road divides it from Wetland W. Wool grass provides over 75% of the cover in the wetland with sensitive fern, crowded and fox sedge, reed canary grass, blue vervain, and meadowsweet occurring to a lesser extent. This wetland appears to be fed primarily by runoff from the surrounding upland.

Wetland N: This small drainage way supports a PEM wetland that is dominated by wool grass, with green bulrush and poison ivy (*Toxicodendron radicans*) occurring to limited extent. This wetland is fed primarily by precipitation and forms a shallow topographic drainage way.

Wetland O: This small perched depression wetland supports a PEM wetland type, with wool grass providing over 50% of the cover, and soft rush, sensitive fern and meadowsweet occurring to a lesser extent. This wetland is fed primarily by runoff.

Wetland P: This depression wetland supports a PEM wetland type, with a small excavated POW zone at its north end. The principal herbaceous material noted include broad-leaved cattail, green bulrush, soft rush, wool grass, common boneset, fringed and porcupine sedge, common duckweed, bulblet bearing water hemlock, curly dock (*Rumex crispus*), marsh fern, cinnamon fern, and lady fern, stinging nettle, jack-in-the-pulpit (*Arisaema triphyllum*), woodland horsetail (*Equisetum sylvaticum*), and giant goldenrod. This wetland appears to be fed primarily by runoff.

Wetland Q. The majority of this wetland supports a POW wetland type, the result of flooding from a beaver dam. The water surface has over a 90% cover of water shield (*Brasenia schreberi*). The ecotone between the open water and upland supports both PEM and PSS wetland types. Species observed in this zone include wool grass, fringed, bladder, crowded, fox, bearded, necklace, and crested sedge (*Carex cristatella*), sensitive and lady fern, red top grass, soft rush, meadowsweet, glossy buckthorn, and autumn olive. The latter two species occur at considerable density along the wetland boundary. A drainage way extends between Wetland Q and Decker's Pond to the north.

Wetland R: This expansive wetland supports PFO and PEM wetland types. Water is supplied to it from White Cedar, Northern Boomerang, Southern Boomerang, and Northern Ridge springs, which all feed small tributaries of Twin Creek. The PFO zone is dominated by either lowland hardwoods, conifers, or a combination of the two. The principal tree species occurring at various densities and frequency of occurrence include northern white cedar, black ash, green ash, yellow birch, eastern hemlock, red maple, and quaking aspen. The PEM zones are primarily the result of plant communities that developed after the forest canopy died following beaver damming activities. A diverse herbaceous layer occurs throughout the wetland. Species catalogued include New York, northern beech, and maidenhair ferns, (*Thelypteris noveboracensis*, *T. phegopteris*, and *Adiantum pedatum*, respectively), bulblet, oak, lady, cinnamon, crested, marsh and sensitive ferns, dwarf scouring rush, wood nettle, golden ragwort (*Senecio aureus*), jack-in-the-pulpit,

small and broad-leaf enchanter's nightshade (*Circaea alpina* and *C. lutetiana*, respectively), heart-leaved foamflower (*Tiarella cordifolia*), honewort (*Cryptotaenia canadensis*), water cress, swamp aster, rough-leaf goldenrod, swamp thistle (*Cirsium muticum*), curly dock, bitter dock (*Rumex obtusifolius*), round-leaved sundew (*Drosera rotundifolia*), fowl manna grass, spotted touch-me-not, common boneset, linear-leaf willow herb, creeping snowberry (*Gaultheria hispidula*), heal all (*Prunella vulgaris*), early coralroot (*Corallorhiza trifida*), white adder's mouth orchid (*Malaxis monophylla*), northern green orchid (*Platanthera hyperborean*), showy orchid (*Cypripedium reginae*), and fen orchid (*Liparis loeselii*), jointed and knotted rush (*Juncus articulatus* and *J. nodosus*, respectively), American marsh penny-wort, wool grass, wrinkled and rough-leaf goldenrod, bristle-leaf sedge, golden fruit, soft-leaf, and bristly stalk sedge (*Carex aurea*, *C. disperma*, and *C. leptalea*, respectively), and porcupine, fox, brownish, fringed, yellow, and crested sedges. Glossy buckthorn occurs sporadically throughout the wetland, but to date is not yet a dominant shrub.

Wetland S: This wetland consists of PSS, PFO, and PEM wetland types, ranging from seasonally saturated in the north portion to inundated in the south portion. Quaking aspen provides over 75% of the tree cover in the PFO portion, while meadow willow is the predominant shrub species with shining and black willow occurring to a lesser extent in the PSS portion. Reed canary grass and sensitive fern together provide approximately 50% of the herbaceous cover in the PEM wetland type, with wool grass, fringed sedge, red top grass, soft rush, nodding beggar's-tick (*Bidens cernua*), American bugleweed (*Lycopus americanus*), and reed manna grass comprising the remaining species. Glossy buckthorn and autumn olive are relatively common in the wetland/upland ecotone zone. Precipitation events appear to be the principal water budget input to this wetland.

Wetland T: This wetland supports a combination of PFO, PSS, and PEM wetland types, with a considerable amount of the wetland undergoing seasonal inundation. Quaking aspen and balsam poplar (*Populus balsamifera*) are the predominant trees along the periphery of the wetland while black willow and American elm (*Ulmus americana*) occur primarily within the wetland interior. Meadow willow is the principal shrub forming the PSS zones, with shining willow and interior willow (*Salix exigua*), meadowsweet, red raspberry, and glossy buckthorn occurring to a lesser

extent. The openings harboring PEM wetland type are dominated by reed canary grass. Other herbaceous species noted include fowl manna grass, spotted touch-me-not, enchanter's nightshade, fringed, hop, retrorse, graceful, bearded, crowded, and bottle-shaped sedges, wool grass, blue vervain, stinging nettle, water parsnip, broad-leaf water plantain, rough-leaved, giant, and wrinkled goldenrod, American bugleweed, hooked buttercup (*Ranunculus recurvatus*), soft rush, and swamp milkweed. Glossy buckthorn is present, though not currently dominant, in the ecotone zone.

Wetland U: This wetland supports a PEM wetland type that appears to receive significant runoff from a south-facing slope on agricultural land. Swamp aster provides over 75% of the herbaceous cover for this wetland with spotted touch-me-not, sensitive, cinnamon, and lady ferns, soft rush, bladder and crowded sedge, Bebb's sedge (*Carex bebbii*), hooked buttercup, stinging nettle, and sweet-scent bedstraw (*Galium triflorum*) occurring to a lesser extent. Meadow willow, stiff dogwood, and common elderberry are the principal shrubs occurring at the periphery of the wetland. Glossy buckthorn occurs as scattered plants, and autumn olive is prevalent to the east of the wetland.

Wetland V: This small sloping wetland supports a PEM wetland type and has undergone surface alteration in what appears to be an attempt to intercept and divert the subsurface water flow to a cattle water trough. Kentucky bluegrass (*Poa pratensis*) and fowl manna grass provide the greatest cover in this wetland. Other species observed in the wetland include soft rush, red top grass, common horsetail, and porcupine sedge.

Wetland W: This small depression wetland supports PSS and PEM wetland types and prior to road construction was connected to Wetland M. Meadow willow and sensitive fern are dominant species in the respective PSS and PEM types. Other species observed in the wetland include swamp aster, wool grass, and meadowsweet.

Wetland X: This wetland is divided into PFO and PEM wetland types that occur on a gentle west-facing slope. It appears to be fed by surface runoff and subsurface-perched water flow. Quaking aspen provides over 75% of the canopy in the PFO portion of the wetland with a

relatively dense sensitive fern ground cover. Swamp aster and green bulrush are the dominant herbaceous cover in the PEM. Other species noted include meadowsweet, swamp milkweed, porcupine and graceful sedge, curly dock, American bugleweed, common horsetail, and fowl manna grass. Glossy buckthorn occurs as scattered plants in this wetland.

Wetland Y: This wetland supports a PEM wetland type on a relatively steep west-facing slope. Marsh fern provides over 75% of the herbaceous cover in this wetland. Associate species include graceful and yellow sedge, sensitive fern, common horsetail, yellow avens, golden ragwort, royal fern, wrinkled goldenrod, showy orchid, tamarack, meadowsweet, red maple, and chestnut colored sedge (*Carex castanea*).

Wetland Z: Slough sedge (*Carex atherodes*), sensitive fern, and Kentucky bluegrass are the principal contributors to the herbaceous cover in this sloping PEM wetland type. Other species noted to a lesser extent include necklace sedge, soft rush, wool grass, and meadow willow. Autumn olive occurs at relatively high densities adjacent this wetland. This wetland appears to be fed by surface and subsurface lateral water movement.

Wetland AA: This shallow depression PEM wetland type appears to have been historically hayed during seasonal dry periods. Common horsetail provides over 75% of the herbaceous cover with crowded and porcupine sedge, soft rush, Canada goldenrod (*Solidago canadensis*), and red top grass occurring to a lesser extent. Precipitation appears to be the principal water budget input to this wetland.

Wetland BB: This wetland designation was not used.

Wetland CC: A spring-fed creek that bisects a stand of upland hardwoods flows south to a PEM zone along the north side of Decker Pond. Groundwater emerges from the bottom of the ravine near two weirs and two staff gages (SG-200 and SG-7), the wetland adjacent the ponds. The creek channel appears to support only a sparse growth of hydrophytes during the growing season. A few red-osier dogwoods were observed. The upland adjacent to the creek supports sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), big tooth aspen (*Populus*

grandidentata), northern red oak (*Quercus rubra*), evergreen wood fern (*Dryopteris intermedia*), bottlebrush grass (*Hystrix patula*), and heart-leaved foamflower. Thick organic soils are located at the mouth of the ravine (CC profiles 2 and 3) where the wetland is situated several feet above Decker Ponds. The water supporting this wetland appears to drain from the ravine and surrounding uplands, to the wetland, and eventually drop down into Decker Ponds.

The PEM zone fringing Decker Pond supports scattered trees and shrubs and a dense herbaceous layer. Species observed include American elm, trembling aspen, white birch (*Betula papyrifera*), green ash, northern white cedar, speckled alder (*Alnus rugosa*), glossy buckthorn, common elderberry, sensitive fern, green bulrush, giant goldenrod, soft rush, broad-leaved cattail, and purple loosestrife. Purple loosestrife occurs throughout the PEM zone, comprising over 50% of the cover.

Wetland DD: This small emergent wetland appears to collect water from the drainage of surrounding wetlands and is connected by a narrow drainage way to Decker Ponds. It may also receive water from Decker Ponds during periods of high water levels. The wetland is dominated by sedges (70%) and is fringed by a nearly continuous band of glossy buckthorn.

Wetland EE: This wetland appears to be essentially a closed basin, receiving drainage water from surrounding uplands. Sedges, wool-grass, red osier dogwood, and glossy buckthorn dominate it.

Wetland FF: Approximately 60% of this wetland is open water with 40% purple loosestrife fringe. The water level of this wetland appears to be controlled by that of Decker Ponds.

Wetland GG: This PEM depression basin occurs within the interior of a second growth upland forested area. Wool grass and various beggars–tick species comprise the predominant cover, with scattered meadowsweet. A dense cover of glossy buckthorn seedlings and saplings occur at the periphery of the wetland.

Wetland HH: This PEM depression basin supports a predominant cover of wool grass with sensitive fern and dense glossy buckthorn at the periphery. A shallow drainage way connects wetlands HH and GG.

Wetland II: This wetland supports distinct PEM and PSS conditions. Willows form the principal shrub cover. The PEM area supports a predominant cover of wool grass with retrorse sedge, fowl manna grass, climbing nightshade, sensitive fern, and several aster species occurring at varying density and frequency of occurrence. It appears surface water occasionally drains from this wetland to Wetland JJ.

Wetland JJ: This vernal depression wetland occurs within an upland hardwood forested area. No hydrophytes were observed during this late fall reconnaissance and it is doubtful that this wetland supports a significant herbaceous vegetative cover during the growing season.

Wetland KK: Apparently once connected to Wetland A, 100th Avenue now separates this wetland remnant from the larger Wetland A to the west. This wetland appears to receive drainage water from the road (as evidenced by silt plumes in the flooded zone), as well as from draining uplands. The wetland vegetation is dominated by red-osier dogwood, glossy buckthorn, meadowsweet, sensitive fern, and sedges comprise the dominant vegetation of this wetland.

Wetland LL: This scrub-shrub (PSS) wetland appears to receive runoff and shallow groundwater inputs from the surrounding uplands. It is likely that precipitation also is an important inflow component of the water budget of this depression wetland. The vegetation was similar to that found in Wetland E, which contained leather leaf as the dominant species, and included wool grass, Canada blue-joint grass, brownish and hop sedge, three-way sedge, lesser bladderwort, devil's beggar-ticks, water parsnip, bulblet bearing water hemlock, beaded sedge, marsh St. John's-wort, red top grass, soft rush, ribbon-leaf pondweed, cinnamon fern, small floating manna grass, catberry, with-rod, Michigan holly, meadow willow and shining willow.

Wetland MM: This wetland contained a mixture of PEM and PSS vegetation similar to that found in Wetland E, which contained leather leaf as the dominant species, and included wool

grass, Canada blue-joint grass, brownish and hop sedge, three-way sedge, lesser bladderwort, devil's beggar-ticks, water parsnip, bulblet bearing water hemlock, beaded sedge, marsh St. John's-wort, red top grass, soft rush, ribbon-leaf pondweed, cinnamon fern, small floating manna grass, catberry, with-rod, Michigan holly, meadow willow, and shining willow.

Wetland NN: This wetland contained a mixture of PEM and PSS vegetation similar to that found in Wetland E, which contained leather leaf as the dominant species, and included wool grass, Canada Blue-joint grass, brownish and hop sedge, three-way sedge, lesser bladderwort, devil's beggar-ticks, water parsnip, bulblet bearing water hemlock, beaded sedge, marsh St. John's-wort, red top grass, soft rush, ribbon-leaf pondweed, cinnamon fern, small floating manna grass, catberry, with-rod, Michigan holly, meadow willow, and shining willow.

Wetland OO: This wetland consists of a narrow vegetated PEM fringe adjacent to an open water pond. The pond is equipped with an outlet structure associated with the mill building on the south side. The pond apparently receives surface flow from the north. Emergent vegetation growing in the PEM was dominated by broad-leaved cattail, sedges, and purple loosestrife. Chara dominated the open water portion. At the time of our site visit, the pond appeared to have been drawn down approximately eight-feet below its normal high-water elevation, possibly for some reason related to maintenance or prevention of ice damage to the mill.

Wetland PP: This wetland is a PEM wetland that contained small patches of wetland shrubs. Emergent vegetation growing in the PEM was similar to that of Wetland CC, which included glossy buckthorn, common elderberry, sensitive fern, green bulrush, giant goldenrod, soft rush, broad-leaved cattail, and purple loosestrife.

Wetland QQ: This wetland was a PEM system with a small amount of POW in the center and a PSS fringe around the edges. Species observed within and along the periphery of the wetland included narrow leaf cattail, broad-leaf water plantain, various sedges and beggar's-ticks, water parsnip, fowl manna grass, reed canary grass, bulblet bearing water hemlock, with Michigan holly and various willows and dominant species of the PSS fringe. It appears that precipitation, surface runoff, and discharges from Wetland RR are the principal water sources for this wetland.

Wetland RR: This wetland is very similar to Wetland QQ in vegetation composition and hydrology. Species observed within and along the periphery of the wetland included narrow leaf cattail, broad-leaf water plantain, various sedges and beggar's-ticks, water parsnip, fowl manna grass, reed canary grass, bulblet bearing water hemlock, with Michigan holly and various willows the dominant species of the PSS fringe. It appears that precipitation, surface runoff, and discharges from Wetland UU are the principal water sources for this wetland.

Wetland SS: This wetland was a PEM system with POW in the center and a few wetland shrubs around the edges. Species observed in the wetland included narrow leaf cattail, broad-leaf water plantain, various sedges and beggar's-ticks, water parsnip, fowl manna grass, reed canary grass, bulblet bearing water hemlock, with Michigan holly and various willows the dominant species of the PSS fringe. It appears that precipitation and surface runoff are the principal water sources for this wetland.

Wetland TT: This wetland was a PEM wetland with a small PFO fringe. The vegetation composition was very similar to Wetland SS, except that there was very little broad-leaf water plantain present, and cottonwood and American elm growing around the edges. It appears that precipitation and surface runoff are the principal water sources for this wetland.

Wetland UU: We are unable to inspect this wetland. The National Wetland Inventory map for the area indicated that this wetland was a PEM wetland. Vegetation in a PEM wetland can be expected to be similar to that described for Wetlands RR and SS, which contained broad-leaf water plantain, various sedges and beggar's-ticks, water parsnip, fowl manna grass, reed canary grass, bulblet bearing water hemlock in the PEM areas, and Michigan holly and various willows the dominant species of the PSS fringe. It appears that precipitation, surface runoff, and discharges from Wetland VV are the principal water sources for this wetland.

Wetland VV: This wetland was very similar to Wetland TT, which was a PEM system with POW in the center and a small PFO fringe around the edges. Species observed in the wetland included broad-leaf water plantain, various sedges and beggar's-ticks, water parsnip, fowl manna

grass, reed canary grass, bulblet bearing water hemlock, and cottonwood and American elm the dominant species of the PFO fringe. It appears that precipitation and surface runoff are the principal water sources for this wetland. Occasional discharges from Wetlands YY and ZZ may supplement this wetland as well.

Wetland WW: This wetland is a PEM wetland that contained small patches of wetland shrubs. Emergent vegetation growing in the PEM was similar to that of Wetlands QQ and RR, which included broad-leaf water plantain, various sedges and beggar's-ticks, water parsnip, fowl manna grass, reed canary grass, bulblet bearing water hemlock in the PEM, and Michigan holly, catberry, and various willows the dominant species of the PSS fringe. It appears that precipitation and surface runoff are the principal water sources for this wetland.

Wetland XX: A shallow ditch connecting this wetland with a nearby roadside ditch had drained it and it had been placed into hay production. It appears that precipitation and surface runoff are the principal water sources for this wetland when it is not under active agricultural management.

Wetland YY: This wetland is a small PEM wetland with a small PFO fringe around the edges. Emergent vegetation growing in the PEM included broad-leaf water plantain, various sedges and beggar's-ticks, water parsnip, fowl manna grass, reed canary grass, bulblet bearing water hemlock, and cottonwood and American elm the dominant species of the PFO fringe. It appears that precipitation and surface runoff are the principal water sources for this wetland.

Wetland ZZ: This wetland is a small PEM wetland with a small PFO fringe around the edges. Emergent vegetation growing in the PEM included broad-leaf water plantain, various sedges and beggar's-ticks, water parsnip, fowl manna grass, reed canary grass, bulblet bearing water hemlock, and cottonwood and American elm the dominant species of the PFO fringe. It appears that precipitation and surface runoff are the principal water sources for this wetland.

Wetland AAA: This wetland is a small PEM wetland. Emergent vegetation growing in the PEM included broad-leaf water plantain, various sedges and beggar's-ticks, water parsnip, fowl manna grass, reed canary grass, bulblet bearing water hemlock, with small numbers of gray dogwood

and various willows occurring near the edge of the wetland fringe. It appears that precipitation and surface runoff are the principal water sources for this wetland.

Wetland BBB: This wetland is a small PEM wetland. Emergent vegetation growing in the PEM was similar to that of Wetland AAA. It appears that, as with Wetland AAA, precipitation and surface runoff are the principal water sources for this wetland.

Wetland CCC: This wetland is a PEM wetland that contains scattered inclusions of PSS wetland and a PFO fringe around the edges. The wetland contained glossy buckthorn, common elderberry, leather leaf, catberry, with-rod, Michigan holly, meadow willow, and shining willow, wool grass, Canada blue-joint grass, various sedges, various beggars-ticks, water parsnip, bulblet bearing water hemlock, marsh St. John's-wort, red top grass, soft rush, cinnamon fern, and small floating manna grass, with cottonwood, American elm, trembling aspen, green ash, northern white cedar, and speckled alder occurring in the PFO fringe. It appears that precipitation and surface runoff are the principal water sources for this wetland.

Wetland DDD: This wetland was a PEM system with a few wetland shrubs scattered around the edges. Species observed in the wetland included various sedges and beggar's-ticks, water parsnip, fowl manna grass, reed canary grass, water hemlock, with Michigan holly and various willows occurring occasionally throughout the wetland. It appears that precipitation and surface runoff are the principal water sources for this wetland.

Wetland EEE: This wetland was a PEM system with PSS vegetation interspersed in patches throughout and around the margins of the wetland. Species observed in the PEM included broad-leaf water plantain, various sedges and beggar's-ticks, water parsnip, fowl manna grass, reed canary grass, bulblet bearing water hemlock. Michigan holly, catberry, and various willows and dogwoods comprised the dominant species of the PSS part of the wetland. It appears that precipitation and surface runoff are the principal water sources for this wetland.

Wetland FFF: This wetland was a PEM system with a PSS fringe around the edges. Species observed in the wetland included various sedges and beggar's-ticks, water parsnip, fowl manna

grass, reed canary grass, bulblet bearing water hemlock in the PEM, and Michigan holly and various willows and dogwoods in the PSS fringe. It appears that precipitation and surface runoff are the principal water sources for this wetland.

Wetland NA: This large wetland supports PSS, and PEM wetland types. The majority of the PSS type has standing dead timber the result of flooding. The principal shrub cover within the PSS is Michigan holly. The PEM zone, which occurs primarily along the eastern side of the wetland, supports a relatively diverse flora including hop, fringed, bearded, bladder, and necklace sedge, wild calla, three-way sedge, wool grass, common duckweed, short-awn foxtail, fowl manna grass, reed canary grass, spotted touch-me-not, broad-leaf water plantain, broad-leaf cattail, soft rush, small floating manna grass, and glossy buckthorn. The latter species is currently not a dominant fixture in the flora of the wetland. Fringed sedge is the predominant herbaceous cover in the PEM type.

Wetland NB: This small isolated depression POW wetland is surrounded by a narrow fringe of PEM wetland and occurs within the interior of an upland hardwood forest. Fringed sedge comprises approximately 50% of the cover in the PEM zone. Other associates include Tuckerman's sedge (*Carex tuckermanii*), bladder and hop sedge, sensitive, lady, and cinnamon fern, reed manna grass, spotted touch-me-not, fowl manna grass, common duckweed, and a small number of Michigan holly. Red maple and American elm occur at the periphery of the wetland. Runoff appears to be the principal source of water to the wetland.

Wetland NC: This perched PFO wetland type lies within the interior of an upland hardwood forest. It supports only a few scattered lowland hardwoods and emergent vegetation along the periphery with limited vegetation in the inundated portion of the wetland. Lowland hardwood trees include red maple and black ash. The limited herbaceous layer includes wood nettle, jack-in-the-pulpit, fringed sedge, hooked buttercup, and brownish sedge. Runoff following precipitation events is the main water source to this wetland.

Wetland ND: This small isolated depression wetland supports a PEM wetland type. Historically it may have been connected to NA. Fringed sedge provides over 50% of the cover in this

wetland. Other herbaceous species observed include wool grass, broad-leaf water plantain, royal fern, necklace sedge, broad-leaf cattail, spotted touch-me-not, and water parsnip. A few Michigan holly occur in the interior of the wetland. Runoff appears to be the principal water source for this wetland.

Wetland NE: This wetland supports a PSS wetland type with Michigan holly providing over 75% of the cover and meadow willow occurring to a lesser extent. It appears to have historically been connected to Wetland NA by a drainage way. Other species observed in the wetland include fringed and hop sedge, wild calla, soft rush, sensitive, cinnamon, marsh, and royal ferns, devil's beggar's-tick, water parsnip, three-way sedge, short-awn foxtail, and reed canary grass.

Wetland NF: This depression wetland supports a PEM wetland that undergoes inundation. Water horsetail (*Equisetum fluviatile*) provides over 75% of the emergent cover in the inundated portion of the wetland. Common duckweed formed a dense layer on the surface water. Other species observed within and along the periphery of the wetland include broad-leaf water plantain, crowded, fringed, and retrorse sedges, nodding beggar's-tick, water parsnip, fowl manna grass, reed canary grass, small floating manna grass, bulblet bearing water hemlock, and shining and meadow willows. It appears this wetland undergoes water level fluctuations, with precipitation the principal water source.

Wetland NG: This depression wetland supports a PEM wetland that undergoes water level fluctuations. Reed canary grass provides over 50% of the herbaceous cover in the wetland. Additional species scattered throughout the wetland include broad-leaf water plantain, fringed sedge, water parsnip, water horsetail, and common duckweed. Runoff appears to be the principal source of water to this wetland.

Wetland NH: This depression wetland supports a PEM wetland that undergoes significant trampling and browsing by a resident cattle herd. Fringed sedge provides over 75% of the cover in this wetland, with broad-leaf water plantain, nodding beggar's-tick, and Tuckerman's sedge noted occasionally. Runoff appears to be the principal water source for this wetland.

Wetland NI: This depression wetland supports a predominance of PSS with PEM as a minor component. Michigan holly provides approximately 75% of the shrub cover in the PSS, with meadow willow occurring to a lesser extent. Species observed at varying densities in the PEM include fringed, hop, and retrorse sedges, small floating manna grass, broad-leaf water plantain, and water parsnip. Runoff to this wetland appears to be a principal source of water.

Wetland NJ: This wetland supports a PEM wetland type. Reed canary grass and wool grass provide over 75% of the cover in the wetland. Associate species observed include crowded, hop, bearded, retrorse, necklace, and fox sedge, common boneset, water parsnip, sensitive fern, nodding beggar's-tick, bulblet bearing water hemlock, small floating manna grass, broad-leaf cattail, reed manna grass, green fruit burreed (*Sparganium chlorocarpum*), autumn olive, meadow willow, and meadowsweet. The periphery of the wetland supports very dense autumn olive population. Runoff appears to provide significant input to this wetland.

Wetland NK: This small depression wetland supports a POW wetland type, with a very limited amount of PEM vegetation at the north end. It serves as a water source for foraging cattle, thus has undergone considerable trampling. Upland hardwoods surround this wetland. The limited herbaceous material included water parsnip, retrorse sedge, spotted touch-me-not, broad-leaf water plantain, and reed canary grass. Precipitation appears to be the principal source of water to the wetland.

Wetland NL: This small depression wetland supports a PFO wetland type that has undergone surface alteration from logging operations, thus affecting the normal hydrology. Black ash, green ash, and red maple are the principal trees present in hummock/hollow topography. The hummocks support considerable growth of sedges including hop, bladder, graceful, and necklace sedge. Runoff appears to be the major water source to this wetland.

Wetland NM: This small depression wetland has characteristics similar to Wetland K; supporting a small POW with limited PEM vegetation and trampled by resident cattle. It supports a small

number of false nettle (*Boehmeria cylindrica*), jack-in the pulpit, and one Michigan holly. Runoff appears to be the principal source of water to the wetland.

DISCUSSION AND CONCLUSIONS

Plant Ecology and Plant Species Dynamics

The hydrologic studies by Malcolm Pirnie (2003) and SSPA (2003) and soil investigations by TAI indicate that wetlands A, G, H, R, CC, and PP are likely connected to the ground water source aquifer. Therefore, the plant communities in these wetlands may be susceptible to changes associated with the supply of water from the ground water source aquifer. The type and magnitude of changes to plant species dynamics in any given wetland is dependent on many factors, but the primary driver would be a change in water level in the wetland.

The wetland delineation and assessment study described the wetland vegetation in wetlands A, G, H, R, CC, and PP. Wetland A is a combination of PFO, POW, PEM, and PSS wetland types. The forested wetlands are northern white cedar swamps with a diverse, species rich emergent wetland component. Wetland G is predominantly black ash, with wool grass comprising the emergent portion of the wetland cover. Wetland H is dominated by wool grass, with meadowsweet, common elderberry, and red osier dogwood comprising the shrubby portion of the wetland. Wetland R is a combination of northern white cedar wetland forest and pockets of sedge meadow vegetation. Wetland CC is a spring-fed creek that bisects a stand of upland hardwoods and flows south to a PEM zone along the north side of Decker Pond. The PEM zone supports scattered trees and shrubs and a dense herbaceous layer that included sensitive fern, green bulrush, giant goldenrod, soft rush, broad-leaved cattail, and purple loosestrife. Purple loosestrife occurs throughout the PEM zone, comprising over 50% of the cover. Emergent vegetation growing in the PEM was similar to that of Wetland CC. Wetland PP is a PEM wetland that contained small patches of wetland shrubs. Emergent vegetation growing in the PEM was similar to that of Wetland CC.

The following description of sedge meadows, northern white cedar swamps, and broad-leaf deciduous swamps provides descriptions of wetland ecology and plant species dynamics in these particular types of wetlands.

Sedge Meadows

Sedge meadows are herbaceous wetlands dominated by sedges of the genus *Carex* (Kost 2001). There are some areas in Wetland R that may be considered a sedge meadow. This vegetation type occurs in depressions, along the margin of lakes and streams, and in other areas where seasonal flooding is encountered (Curtis 1959, Kost 2001). Sedge meadows occur on organic soils and saturated mineral substrates typically exhibiting neutral to slightly alkaline pH values (Costello 1936, Curtis 1959, Stanley 2000, Kost 2001). However, sedge meadows occurring north of Michigan's Tension Zone (a line running between roughly Muskegon and Bay City that marks a significant change in vegetation, climatic, and soil conditions) often exhibit lower pH values and greater depth and duration of saturation than those occurring south of the Tension Zone (Kost 2001). Tussock sedge (*Carex stricta*) is a common dominant species in this vegetation type (Costello 1936, Curtis 1959, Stanley 2000, Kost 2001). The characteristic tussocks or hummocks formed by the species, and which can be two to three feet tall and a foot in diameter (Stanley 2000, Kost 2001), often can be used to identify a sedge meadow.

Seasonal water level fluctuation is a natural occurrence in sedge meadows (Costello 1936, Curtis 1959, Stanley 2000, Kost 2001). Water levels tend to be highest in spring, and decline throughout the summer months (Stanley 2000, Kost 2001). Water levels may remain near the ground surface (Costello 1936, Curtis 1959, Kost 2001), or they may drop to more than three feet below the ground surface during the growing season (Stanley 2000). In either case, occasional inundation, or surface saturation for a significant portion of the growing season, appear to be requirements for sedge meadow establishment and maintenance (Curtis 1959). Significant periods of saturation during the growing season suppress shrub and tree invasion of sedge meadows (Curtis 1959, Keddy and Reznicek 1986). By contrast, extended inundation drives the conversion of sedge meadows to marsh vegetation (*Ibid*. 1959, *Ibid*. 1986).

Fire is another important natural disturbance in sedge meadows (Frolik 1941, Curtis 1959, Kost and De Steven 2000). Fire, like substrate saturation, suppresses sedge meadow succession to shrub-carr or forested wetlands by killing woody seedlings before they can out-compete sedge meadow species for available light (Curtis 1959, Kost and De Steven 2000).

Purple loosestrife, common reed, (*Phragmites australis*), reed-canary grass, and glossy buckthorn are invasive plant species commonly occurring in Michigan sedge meadows (Kost 2001). All have the potential to significantly alter sedge meadow structure, species composition, and function (*Ibid*. 2001). TAI personnel observed purple loosestrife, common reed, glossy buckthorn and reed-canary grass in sedge meadows throughout the study area.

Northern White Cedar Swamps

Northern white cedar swamps, or rich conifer swamps (Kost 2002) are groundwater supported forested wetlands dominated by northern white cedar (*Thuja occidentalis*). Wetlands R and A contain areas that would be considered northern white cedar swamps. This vegetation assemblage occurs on organic soils in depressions in glaciated landscapes, along the edge of lakes or streams, or at the base of hills where a slow, but steady supply of oxygen- and mineral-rich water flows laterally through the substrate (Miller *et al*. 1990, Pregitzer 1990, Kost 2002). The steady supply of mineral-rich (minerotrophic) water results in a substrate with a circum-neutral pH (6.0-8.0) and a relatively rapid rate of organic matter decomposition (Pregitzer 1990, Miller *et al*. 1990). Variations in micro-topography caused by wind throw results in a range of inundation/saturation regimes, habitats, and plant species distributions within a cedar swamp (Pregitzer 1990, Kost 2002).

Seasonal water level fluctuation is a natural occurrence in cedar swamps (Curtis 1959, Miller *et al*. 1990, Pregitzer 1990, Kost 2002). Water levels tend to be highest in spring, and decline throughout the summer months (Kost 2002). However, the steady near-surface ground water flow characteristic of this vegetation type normally keeps the range of water level variation within a relatively narrow range (Miller *et al*. 1990, Pregitzer 1990).

Wind throw, fire, and herbivory are other natural disturbances to this vegetation type (Curtis 1959, Miller *et al*. 1990, Pregitzer 1990, Kost 2002). Each has its beneficial impacts on cedar swamp regeneration and maintenance when they occur within normal limits. However, increased whitetail deer (*Odocoileus virginianus borealis*) populations have placed excessive herbivory pressure on this vegetation type in recent years, thus greatly reducing the reproductive

success of northern white cedar. Cedar seedling and sapling survival declines rapidly once annual foliage removal exceeds approximately 20% (Aldous 1952). Excessive deer herbivory on cedar seedlings and saplings has reduced seed reproduction of the species to negligible levels (Pregitzer 1990).

Few exotic plants occur in cedar swamps (Kost 2002). Kost (2002) reported that only marsh thistle (*Cirsium palustre*), climbing nightshade, and glossy buckthorn occurred in cedar swamps, and of these, that only glossy buckthorn had the potential to alter the community structure and function of this vegetation type. TAI personnel observed no exotic invasive plants in cedar swamps in the study area.

Alteration of the hydrologic regime of cedar swamps can have different impacts, depending on the type of alteration involved. Excessive water level fluctuations are a major source of seedling mortality, drowning seedlings in the spring and desiccating them during the summer (Curtis 1959, Miller *et al*. 1990). Stagnation or permanent water level reductions quickly result in the development of acidic pH in cedar swamp substrates. When this occurs, succession to bog vegetation dominated by black spruce (*Picea mariana*) rapidly follows (Pregitzer 1990). Cedar swamp vegetation strongly relies on a constant flow of cold, mineral-rich groundwater through the underlying organic substrate for its establishment and maintenance on the landscape (Kost 2002). Significant alteration of the depth, duration, or frequency of cedar swamp saturation/inundation could adversely alter community stability, composition, and function.

Broad-leaf Deciduous Swamps

Broad-leaf deciduous swamps are forested wetlands dominated by black ash (*Fraxinus nigra*) and yellow birch (*Betula alleghaniensis*), with American elm (*Ulmus americana*), red maple (*Acer rubrum*), and balsam poplar (*Populus balsamifera*) occurring as common canopy associates of the dominant ash and birch (Curtis 1959, MNFI 1986). Eastern hemlock (*Tsuga canadensis*) and tamarack (*Larix laricina*) often grow interspersed among the dominant hardwoods in these wetlands. Wetland G contains areas that would be considered broad-leaf deciduous swamp. As with northern white cedar swamps, this vegetation assemblage typically occurs in depressions in glaciated landscapes and along the edge of lakes or streams in organic

soils that exhibit circum-neutral pH (6.0-8.0) values (*Ibid*. 1986). Broad-leaf deciduous swamps often occur in association with northern white cedar swamps, and are considered a successional sere of the cedar swamp (Curtis 1959). Northern white cedar swamps typically develop in the wetter, lower elevations of a wetland, with the broad-leaf deciduous swamps developing adjacent to, and directly up gradient from the cedar swamps in drier, better drained portions of the wetland (Curtis 1959, Kost 2002). In some cases, northern white cedar swamps develop a two-tier architecture, with the shade tolerant northern white cedars occupying the lower canopy layer and wetland hardwoods occupying the canopy (Pregitzer 1990). This two-tier architecture represents an intermediate stage of succession from cedar swamp to hardwood swamp, where northern white cedar are being replaced by black ash, yellow birch, and other associated hardwood species as water tables drop or accumulating soil raises the wetland surface (Curtis 1959).

Wind throws in broad-leaf deciduous swamps result in hummock and hollow topography. These higher hummocks and lower hollows provide micro-topographic habitat variation for the shrubs and herbaceous vegetation that occupy the understory of the hardwood swamp. However, unlike northern white cedars, the dominant hardwoods of the broad-leaf deciduous swamp typically do not propagate vegetatively, so wind throw provides canopy gaps that allow light to penetrate to the forest floor, making additional inputs of organic matter and coarse woody debris available at the wetland surface, and providing safe sites for seedling establishment and growth. The combination of rich organic soils, adequate soil moisture, good soil drainage, sufficient light penetration, and variable micro-topography yields a very species rich shrub and herbaceous layer in this vegetation assemblage (MNFI 1986).

Fire occasionally impacts broad-leaf deciduous swamps during drought periods (Curtis 1959). The mature trees and sometimes the upper organic soil layer will be destroyed when fire occurs in this vegetation type, resulting in the development of a sedge bog or sedge meadow in its place (*Ibid*. 1959).

Exotic and invasive species can be expected to occur in broad-leaf deciduous swamps with greater frequency compared to northern white cedar swamps because of the greater light

availability and drier, more mesic soil conditions found where this hardwood vegetation assemblage occurs. Glossy buckthorn can be expected to invade the understory of the broad-leaf deciduous swamp, and purple loosestrife, reed canary grass, and reed grass can be expected to invade canopy gaps and the less shaded swamp edges wherever the opportunity occurs. TAI personnel observed few exotic invasive plants in broad-leaf deciduous swamps in the study area.

Potential Wetland Impacts

Potential Soil-Water Effects

Based on the observations of wetland hydrology, plant community species composition, and wetland soil characteristics, wetlands that are hydrologically "perched" or separated by a low-permeability soil layer from the ground water source aquifer will not be impacted by the project.

The hydrologic model suggests that the groundwater source aquifer in the vicinity of wetlands A, G, H, R, CC, and PP may decline approximately 0.5 feet assuming a pumping rate of 150 gpm. For those wetlands that have evidence of connection to the ground water source aquifer, namely wetlands A, G, H, R CC, and PP, the water level decline is expected to be less than 0.5 feet and to have a seasonal pattern of fluctuation. The maximum decline in wetland water levels is expected to occur in August or September with a recovery of water levels to normal levels during the winter and spring.

The projected water level decline in wetlands is expected to have a limited effect on wetland ecology. The surface soil layers of wetlands A, G, H, R, CC, and PP consist of mostly hemic to sapric organic soil with some layers of woody peat. Portions of Wetland R have especially thick deposits of muck and peat. For organic wetland soils, drawdown of the water table will result in slight de-saturation and aeration of the organic material. Organic soil material in the newly aerated soil layer will decompose as a result of soil pores previously filled with water becoming filled with air. As decay progresses, mineralization of organically bound nutrients, particularly nitrogen and phosphorus, will become available to the surrounding plant community. Decomposition of the muck and peat soils may eventually cause slight subsidence of the soil surface. Subsidence may partially compensate for the potential groundwater drawdown by lowering the plant root zone closer to the new, and lower, zone of saturation. The precise amount

and rate of decomposition and subsidence is difficult to predict as it is subject to multiple environmental variables such as seasonality, weather and climate, microbial community dynamics, the composition of the organic matter, and the depth of drawdown.

Potential Impacts to Wetland Ecology

There are several minor impacts to Wetland R along Twin Creek that may result from a groundwater withdrawal. First, the groundwater withdrawal may lower the water table in the wetland. However, the magnitude of the water table draw down is not expected to alter the hydroperiod of the surface of the wetland. This is important because one potential impact to the wetland is a change in surface hydrology that may allow the establishment of invasive plant species. Since a mosaic of hydrologic conditions with little standing water characterizes the northern white cedar swamp, the opportunity for an increase in invasive species establishment in any wetlands that may be impacted by lower water levels is minimal. Another factor that will prevent invasion by exotic plants is that the native plant communities will not be disturbed and surface soils will not be exposed. Generally, when a wetland is colonized by invasive species it is a result of removing wetland vegetation and exposing the surface soil to colonization by invasive species seeds, roots, and other propagules. The proposed project will not alter or remove the existing vegetation or soil profiles in the wetlands in the study area.

A second potential impact that may result from the groundwater withdrawal is that the lower water table in the wetland may create a drier zone where decomposition of organic matter can increase. By increasing decomposition of organic matter, nutrient availability for existing wetland vegetation may increase, which may result in an increase in plant growth. This may be a positive impact, because increased nutrient availability often stimulates native plant growth and vigor. A healthy, vigorously growing native vegetation matrix typically is better able to resist invasive species establishment and growth.

The response of native wetland vegetation in Wetland R to hydrologic alteration caused by a beaver flooding suggests that local wetlands with altered hydrologic regimes are resistant to invasion by invasive wetland species, and that the native wetland plant species are resilient, and

will become reestablished, once the altered hydrologic conditions are discontinued, or when a new hydrologic equilibrium becomes established. A wetland area adjacent to Twin Creek was flooded, and then recently drained, when the beaver dam that caused the flooding failed. The re-colonization of the formerly flooded wetland area has been by native wetland plants with a variety of herbaceous and shrubby plant species. Purple loosestrife and glossy buckthorn, two of the more common invasive plants found in this type of wetland, were not observed in the recently drained wetland. The absence of these species in the drained wetland is further evidence that a minor water table reduction will not have a significant impact on the plant species composition of the existing wetlands.

Summary

This wetland assessment has been prepared to ascertain the extent and magnitude of effects to wetlands in the vicinity of a groundwater pumping operation planned for an area near Evart, Michigan. In preparing this assessment Tilton & Associates, Inc. (TAI) relied on existing information on soils, hydrology and vegetation patterns as well as studies by Malcolm Pirnie, Inc. and S. S. Papadopulos & Associates, Inc. (SSPA) of the ground water of the area, as described in this report. Field investigations were conducted to study and describe the soil, hydrology, and vegetation of wetlands in the area of the proposed ground water pumping operation.

The study of wetlands in the White-Cedar-Osceola Project site and the ground water hydrology supporting those wetlands indicates that there will be no significant effect on wetlands due to the proposed ground water pumping operation. Only seven of the fifty-seven wetlands identified in the study area are influenced by the source water aquifer. The remaining wetlands are perched wetlands that are isolated from the source water aquifer where the primary hydrologic inputs are precipitation or surface runoff. These wetlands will not be influenced by the planned ground water pumping operation.

The effect of the ground water pumping operation on water levels in wetlands is expected to be a lowering of the seasonal low water table in the wetland by less than 0.5 feet. Ground water models predict that the average pumping operation of 150 gpm will lower the source water

aquifer 0.5 feet in the vicinity of the ground water influenced wetlands. However, the water level drop in the wetlands themselves is expected to be less due to the physical properties of the histosols in the wetlands. In addition, the water level effect is expected to occur in August and September, but the normal water level in the wetlands is expected to return by winter or spring. The ecological effect of the lowering the seasonal low water table in the wetland less than 0.5 feet will be insignificant. Mineralization rates of organic soil in the affected wetlands and nutrient availability may increase slightly due to the lower water table. Over the long term increased decomposition rates may result in a slight subsidence of the wetland surface. Invasive species are not expected to colonize the wetlands at an increased rate because the wetlands in question are recognized as being resistant to colonization, the magnitude and seasonal pattern of water level decrease is not sufficient to allow establishment of invasive species, and the project will preserve existing vegetation and the soil profile, thus eliminating one mechanism for establishment of invasive species.

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Appendix 1. Field data for White-Cedar-Osceola Project wetland soils and shallow hydrology; Tilton & Associates, Inc.

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
A	Oe 0-12	Black (10YR 2/1)	None observed	Hemic to sapric muck	A2 Histic epipedon	Saturated from 0-12 and 18-24/ 22 and rising (free water level did not reach equilibrium with surrounding soil during the time of observation)	12
	A 12-18	Very dark gray (10YR 3/1)	None observed	Silty clay loam;			
	Bg 18-24	Very dark grayish brown (10YR 4/2	Common distinct 10YR 4/4 concentrations	sand			
	Surrounding Soil Survey Unit: Carbondale muck						
B	Oa 0-10	Black (10YR 2/1)	None observed	Sapric to hemic muck	A2 Histic epipedon	0/12	16
	A 10-16	Very dark gray (10YR 3/1)	None observed	Mucky clay;			
	Bg 16-24	Very dark grayish brown (10YR 4/1)	None observed	clay			
	Surrounding Soil Survey Unit: Kalkaska sand						

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
C	Oa 0-20	Black (10YR 2/1)	None observed	Sapric muck	A1 Histic epipedon	0/12	>20
	Soil Survey Unit: Kalkaska sand						
D	O 0-6	Black (10YR 2/1)	None observed	hemic to sapric muck;	A4 sulfidic odor	0/16 (and rising)	>20
	Bk 6-13	Dark grayish brown (10YR 4/2)	Common distinct dark yellowish brown (10YR 4/4) concentrations;	calcitic clayey sand			
	BC 13-18	Dark grayish brown (10YR 5/2)	Many distinct yellowish brown (10YR 5/4) concentrations	sand			
	Surrounding Soil Survey Unit: Otisco loamy sand						
E	Oe 0-14	Black (10YR 2/1)	None observed	hemic to sapric muck; sand	A2 histic epipedon	10/18 (and rising)	>20
	Bg 14-20	Dark grayish brown (10YR 4/2) to grayish brown (10YR 5/2)	Black (10YR 2/1) organic streaks				

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
	Surrounding Soil Survey Unit: Carbondale muck						
F	Oe1 0-11 Oe2 11-18	Black (10YR 2/1) Dark yellowish brown (10YR 3/4)	None observed Extensive iron-staining throughout the matrix	hemic muck; hemic muck with some wood peat	A2 histic epipedon	10/18 (and rising)	>20
	Soil Survey Unit: Menominee loamy sand						
G	O 0-6 Bg 6-10 BC 10-20	Black (10YR 2/1) Dark grayish brown (10YR 4/2) Dark grayish brown (10YR 4/2)	None observed None observed Many distinct yellowish brown (10YR 5/4) concentrations	hemic to sapric muck; clayey sand sand	A4 sulfidic odor	0/16 (and rising)	>20
	Surrounding Soil Survey Unit: Montcalm loamy sand						

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
H	O 0-14 Bg 14-20	Black (10YR 2/1) Dark grayish brown (10YR 4/2)	None observed; Many distinct dark yellowish brown (10YR 3/4) concentrations and black (10YR 2/1) organic streaks.	Sapric muck with some sedge leaves and hemic material; sand	A2 histic epipedon	Saturated to the surface	>20
	Surrounding Soil Survey Unit: McBride sandy loam						
I	Oa 0-10 Oe10-20	10YR 2/1 to 2/2 black to very dark brown; 10YR 2/1 to 2/2 black to very dark brown	None	Sapric to hemic muck; hemic to fibric OM	A1 Histosol	6/14 Water enters pit from root channels and macropores	>20
	Surrounding Soil Survey Unit: Kent Loam						
J	0-20	10YR 2/1 to 2/2 black to very dark brown;	None	Sapric to hemic muck;	A1 Histosol	>20 to saturation (not observed)	>20
	Surrounding Soil Survey Unit: Montcalm loamy sand						

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
K	0-20	10YR 2/1 to 2/2 black to very dark brown;	None	Sapric to hemic muck;	A1 Histosol	>20	>20
	Surrounding Soil Survey Unit: Montcalm loamy sand						
L	A 0-20	10YR 2/1 to 2/2 black to very dark brown	None	Sapric to hemic muck	A1 Histosol	10/15	>20
	Surrounding Soil Survey Unit: Houghton muck						
M	A 0-4 Bg 4-16 BC 16-24	10YR 3/2 very dark grayish brown; 10YR 4/2 dark grayish brown 10YR 4/2 dark grayish brown	Few fine 10YR 4/4 dark yellowish brown concentrations; Many prominent 7.5YR 5/6 strong brown concentrations; Very many prominent 7.5YR 5/6 strong brown concentrations	Loamy fine sand; loamy fine sand; loamy fine sand	S5 sandy redox	>24	>24
	Surrounding Soil Survey Unit: Montcalm loamy sand						

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
N	A 0-7 Bt1 7-14 Bt2 14-20	10YR 2/2 very dark brown; 10YR 4/2 dark grayish brown; 10YR 5/2	None Many prominent 7.5YR 4/6 concentrations; many prominent 7.5YR 4/6 concentrations	Loam Clay loam Clay loam	F3 Depleted matrix	>20	7
	Surrounding Soil Survey Unit: Montcalm loamy sand						
O	OA 0-3 A 3-15 Bg 15-20	10YR 2/2 to 3/2 10YR 3/2 to 4/2 very dark grayish brown to dark grayish brown; 10YR 4/2 dark grayish brown	None Many prominent 7.5YR 4/6 concentrations; Many prominent 7.5YR 4/6 and 10YR 5/2 grayish brown depletions	Mucky sand Sand Sand	S1 sandy mucky mineral	>20	>20
	Surrounding Soil Survey Unit: Montcalm loamy sand						

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
P	Oa 0-10	Black (10YR 2/1) with some very dark grayish brown (10YR 3/2) hemic and fibric material;	None	Sapric muck with some hemic and woody peat;	A1 histosol	9/14	20
	Oi 10-15	10YR 2/2 very dark brown;	None	woody peat with some sapric and hemic matrix;			
	Oa 15-20	Black (10YR 2/1)	None	sapric muck.			
	20-24 Bx	Light gray (5Y 7/2)	None	Silty sand (hard fragipan)			
	Surrounding Soil Survey Unit: Manistee loamy sand						
Q	OA 0-7	Black (10YR 2/1)	None observed	Mucky sand	S1 mucky sand	No saturation in profile, which is about 20-feet from the flooded center of the wetland	>18
	A 7-12	Very dark gray (10YR 3/1)	None observed	Sand;			
	Bg 12-18	Dark gray (10YR 4/1)	Common distinct dark yellowish brown (10YR 4/4) concentrations				

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
	Surrounding Soil Survey Unit: Adrian muck						
R Pit 1	Oa 0-24	Black 10YR 2/1	None	Sapric muck with some woody fibric material;	A1 Histosol	4/8 water entering pit from root channel macropores;	>24
R Pit 2	Oe 0-3	Black 10YR 2/1	none	Sapric to hemic muck	A4 hydrogen sulfide, A10 Muck (test indicator for this region)	8/18	3, >24
	Surrounding Soil Survey Unit: Houghton muck						

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
S Pit1	Oi 1-0 A 0-5 Bs 5-20 Bk 20-22	 10YR 3/2 dark brown; 10YR 4/2 to 4/3 dark grayish brown to dark brown; 10YR 7/2 light gray.	 many prominent 7.5YR 4/6 strong brown concentrations; many prominent 7.5YR 4/6 strong brown concentrations; none.	duff; fine sandy loam; fine sandy loam; loamy fine sand.	F6 redox dark surface	>22	>22
S Pit2	Oa 0-10 Cg 10-20	 10YR 2/1 black; 10YR 4/2 dark grayish brown	None. 10YR 2/1 organic streaks	Sapric to hemic muck with some fibric sedge leaves. Gravelly sand	A3 Black histic	2/6	>18
	Surrounding Soil Survey Unit: Montcalm loamy sand						

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
T	0-20 Oa	10YR 2/1 Black	None	Sapric muck with some hemic and fibric sedge leaves.	A1 Histosol	6/15	>20
	Surrounding Soil Survey Unit: Otisco loamy sand						
U	O 0-8 Bg 8-10 BC 10-20	Black (10YR 2/1) Very dark gray (10YR 4/1) Dark gray (10YR 5/3)	None observed None observed; Common distinct dark yellowish brown (10YR 4/4) concentrations	Sapric muck Sand; Sand	A2 histic epipedon	Saturated from 3-8 and 12-20	>20
	Soil Survey Unit: Otisco loamy sand						
V	A 0-9 Bg	Very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2) Dark grayish brown (10YR 4/2)	Common distinct dark yellowish brown (10YR 4/4) oxidized roots Common distinct dark yellowish brown (10YR 4/4) concentrations	Clay loam clay	F4 depleted below dark matrix	7/16	10
	Surrounding Soil Survey Unit: McBride sandy loam						

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
W	A 0-4 AB 4-10 B 10-20	10YR 2/2 to 3/2 black to very dark brown; 10YR 3/3 dark brown; 10YR 4/2 dark grayish brown;	None; Many prominent 7.5YR 4/6 strong brown; Many prominent 7.5YR 4/6 strong brown concentrations	Loamy fine sand; Fine sandy loam; Loamy fine sand.	TS5 Sandy redox (test indicator)	>20	>20
	Soil Survey Unit: Montcalm loamy sand						
X	A 0-11 BC 11-26	10YR 3/2 to 2/2 very dark grayish brown to very dark brown; 7.5YR 6/3 pinkish gray	Common prominent 7.5YR 4/6 concentrations; common prominent 10YR 6/6 concentrations	Loamy fine sand; Clayey sand (thin clay lamellae)	S5 Sandy redox	>26	11
	Soil Survey Unit: Menominee loamy sand						

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
Y	A 0-7	very dark brown (10YR 2/2);	None;	Mucky sand	S1 Sandy mucky mineral	>24	>18
	Bs 7-18	brown (10YR 5/3) to yellowish brown (10YR 5/4)	Many distinct (7.5YR 5/6) strong brown;	Fine sandy loam;			
	BC 18-24	yellowish brown (10YR 5/4)	None observed	Sandy clay			
	Surrounding Soil Survey Unit: Montcalm loamy sand						
Z	OA 0-14	Very dark brown (10YR 2/2);	Common distinct dark yellowish brown (10YR 4/4) oxidized roots	Mucky sand;	S1 sandy mucky mineral	15/>20	>20
	A 14-20	Very dark grayish brown (10YR 3/2)	Common distinct dark yellowish brown (10YR 4/4) oxidized roots and brown (10YR 4/3) depletions)	Sand			
	Surrounding Soil Survey Unit: McBride sandy loam						

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
AA	OA 0-9 A 9-18	Very dark brown (10YR 2/2); Very dark gray (10YR 3/1)	Common distinct dark yellowish brown (10YR 4/4) oxidized roots Common distinct dark yellowish brown (10YR 4/4) oxidized roots	Mucky sand; Sand	S1 sandy mucky mineral	>20	>20
	Soil Survey Unit: Shoals loam						
CC Profile 1	Oe 0-10 Bg 10-20	Black (10YR 2/1) Very dark gray (10YR 5/2)	None observed None observed	Hemic to sapric muck sand	A2 Histic epipedon, A3 hydrogen sulfide	Saturated to surface, free water rising to surface in pit. Seeping from east side of ravine wall.	>20 (not observed)
	Surrounding Soil Survey Unit: (MsC) Montcalm						

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
CC Profile 2	Oa 0-10	Black (10YR 2/1)	None observed	Sapric to hemic muck	A2 Histic epipedon	4/10	16
	Surrounding Soil Survey Unit: (CbA) Carbondale muck						
CC Profile 3	Oa 0-20	Black (10YR 2/1)	None observed	Sapric muck	A1 Histic epipedon	5/10	>20
	Soil Survey Unit: Carbondale muck						
DD	Oa1 0-12 Oa2 12-22	Very dark brown (10YR 2/2) Very dark grayish brown (10YR 3/2)	None observed None observed	Peaty muck Muck	A1 Histic epipedon	0/6 (and rising)	>20
	Soil Survey Unit: (MpD) Menominee loamy sand						

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
EE	AO BCg	Very dark gray (10YR 3/1) Gray (10YR 5/1)	None observed None	Mucky loam; Loamy fine sand	F1 loamy mucky materials	6-10/>24	>20
	Surrounding Soil Survey Unit:						
FF	Entirely inundated pond with partially submerged fringing vegetation						
	Surrounding Soil Survey Unit: Carbondale muck						
GG	Oa 0-20	Very dark grayish brown (10YR 3/2)	Common distinct 5YR 5/6 root channels	sapric muck; buried wood at 14 inches	A1 histosol	0-8 episaturation from recent rain	>20
	Soil Survey Unit: Iosco loamy sand						
HH	Oa 0-10 BC 10-20	Black (10YR 2/1) Gray (10YR 5/1)	None observed None observed	Sapric muck Loamy fine sand	A2 histic epipedon	0-10 episaturation from recent rain	>20
	Soil Survey Unit: Iosco loamy sand						
II	Oe1 0-14 Oa2 14-20	Dark grayish brown (10YR 4/2) Black (10YR 2/1)	None observed None observed	Hemic to sapric muck that appears derived from sedges Sapric muck	A1 histosol	16/18	>20
	Soil Survey Unit: Iosco loamy sand						

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
JJ	Oa 0-16 Bg 16-20	Very dark gray (10YR 3/1) Dark gray (10YR 4/1)	None observed None observed	Sapric to hemic muck Clay	A1 histosol	6-16/16 and rising; perching on top of clay	16
	Soil Survey Unit: Iosco loamy sand						
KK	A 0-10 Bg 10-20	Very dark brown (10YR 2/2) Dark grayish brown	None observed Common distinct	Mucky loam	F1 loamy mucky materials	0/4	>20
	Soil Survey Unit: Adrian muck						

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
OO	O 0-10 BCg 10-20	Black (10YR 2/1) Gray (10YR 5/1)	None observed None observed	Sapric muck sand	A2 Histic epipedon	14	>20
	Soil Survey Unit: Brevort loamy sand, overwash						
PP	OA 0-6 Bg	Black (10YR 2/1) Grayish brown (10YR 5/2)	None observed many prominent yellowish brown (10YR 5/4)	Mucky sand sand	S1 mucky sands	2	>20 Not observed

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
	Soil Survey unit: Montcalm loamy sand						
NA	O 0-8 BC 6-18	Black (10YR 2/1) Grayish brown to brown (10YR 4/2 to 4/3)	None	Sapric to hemic muck; sand	A2 histic epipedon, A4 sulfidic odor	2	>20 Not observed
	Soil Survey Unit: Tawas muck						
NB	OA 0-6 BC 6-18	Black (10YR 2/1) Grayish brown (10YR 5/2)	Many prominent dark yellowish brown (10YR 4/4) concentrations as oxidized roots; many faint yellowish brown (10YR 5/4) concentrations and black (10YR 2/1) organic streaks.	Mucky loam	F1 loamy mucky materials	>18 not saturation in profile; center of wetland inundated.	6
	Soil Survey Unit: Isabella sandy loam						

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
NC	OA 0-9	Black (10YR 2/1)	Many prominent dark yellowish brown (10YR 4/4) concentrations,	Mucky loam	F1 loamy mucky materials, A4 hydrogen sulfide	Saturated 2-9 inches, unsaturated below; probable episaturation	9
	9-20	Light brownish gray (10YR 6/2)	Many distinct yellowish brown (10YR 5/4) concentrations; Black (10YR 2/1) organic streaks	Sandy clay			
	Soil Survey Unit: Isabella sandy loam						
ND	OA 0-8	Black (10YR 2/1)	None	Mucky loam	F1 loamy mucky materials, A4 hydrogen sulfide	Saturated 2-8 inches, unsaturated below; probable episaturation	8
	BCg 8-20	Grayish brown (10YR 5/2)	Black (10YR 2/1) organic streaks	Sandy clay loam			
	Soil Survey Unit: Isabella sandy loam						
NE	O 0-9	Black (10YR 2/1)	None	Sapric to hemic muck; sand	A2 histic epipedon, A4 sulfidic odor	2	>20
	BC 9-18	Grayish brown (10YR 5/2)					

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
	Soil Survey Unit: Tawas muck						
NF	A 0-6	Very dark grayish brown 10YR 3/2	Common distinct yellowish brown 10Y 5/4 concentrations	Loam	F3 depleted matrix	Saturated 0-10 inches, unsaturated below. Probable episaturation.	14
	Bg 6-14	Dark grayish brown (10YR 4/2)	Common distinct yellowish brown 10Y 5/4 concentrations;	Loam			
	BCg 14-20	Dark gray (10YR 4/1)	Common distinct yellowish brown 10Y 5/4 concentrations	Loam			
	Soil Survey Unit: Montcalm loamy sand						
NG	0-5	Very dark grayish (10YR 3/2)	Many prominent 7.5YR 5/4 concentrations;	Silt loam	F6 Redox dark surface	Saturated 0-12 inches; central wetland flooded; probable episaturation	12
	5-12	Very dark grayish brown (10YR 3/2)	Many prominent 10YR 5/4 concentrations;	Silty clay loam			
	12-20	Olive gray (5Y 5/2)	Many prominent strong brown 7.5YR 5/6 concentrations	Clay loam			

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
	Soil Survey Unit: Montcalm loamy sand						
NH	A 0-9 A2 9-14 Bg 14-20	Very dark gray (10YR 3/1) Very dark gray (10YR 3/1) Dark gray (10YR 4/1 to 5/1)	Many prominent dark brown (7.5YR 4/4) concentrations as oxidized roots; Black (10YR 2/1) organic bodies and streaks;	Loam Sand Sand	F1 Loamy mucky materials	14/>20	>20
	Soil Survey Unit: Isabella sandy loam						
NI	A 0-6 Bg 6-12 BCg 12-20	Very dark brown (10YR 3/2); Dark grayish brown (10YR 4/2); Grayish brown (10YR 5/2)	Many distinct 10YR 4/4 concentrations; Many distinct 10YR 5/4 concentrations; Many distinct 10YR 5/4 concentrations.	Silt loam Silt loam Clay loam	F3 depleted matrix	>20	12
	Soil Survey Unit: Isabella sandy loam						
NJ	Oa 0-6 Cg 6-20	Black (10YR 2/1) Grayish brown (10YR 5/2)	None Black 10YR 2/1 organic streaks	Sapric to hemic muck; sand	A4 Hydrogen sulfide	0-6 inches saturated, draining into pit. Probable episaturation	>10

Wetland	Horizon Depth (inches)	Matrix Color (moist, Munsell)	Mottle Color (moist, Munsell)	Texture	Hydric Soil Indicator	Depth to Saturation/Free water (inches)	Depth to Confining Layer (inches)
	Soil Survey Unit: Otisco loamy sand						
NK	A 0-7 Bg 7-12	Very dark brown (10YR 3/2)	Many prominent brown 7.5YR 4/4 concentrations;	Silty clay loam	F6 Dark redox	>20 but center of wetland is flooded.	7
	Soil Survey Unit: Isabella sandy loam						
NL	A 0-7 2O 7-11 2Bg 11-18 2BC 18-20	Very dark brown (10YR 3/3); Black (10YR 2/1); Grayish brown (10YR 4/2) Dark grayish brown (10YR 4/2) Grayish brown (10YR 5/2)	Many prominent brown (7.5YR 5/4) concentrations; None; Many distinct brown (10YR 5/4) concentrations and (10YR 5/2) grayish brown depletions; Many distinct (7.5YR 5/4) concentrations; Many distinct (7.5YR 5/4) concentrations	Silt loam Hemic muck Clay loam Silt with stones and cobbles; silt	F1 mucky mineral material	>20	>20
	Soil Survey Unit: Shoals loam						

Appendix 2. List of the 161 plant species identified by Vande Water Natural Resource Services as occurring during 2004 in wetlands within the projected White-Cedar-Osceola Project draw down cone of depression.

Scientific name	Common name
Acer rubrum	Red maple
Acer saccharum	Sugar maple
Adiantum pedatum	Maidenhair fern
Agrostis gigantea	Red top grass
Alisma plantago-aquatica	Broad-leaf water plantain
Alnus rugosa	Speckled alder
Alopecurus aequalis	Short-awn foxtail
Arisaema triphyllum	Jack-in-the-pulpit
Asclepias incarnata	Swamp milkweed
Aster puniceus	Swamp aster
Athyrium filix-femina	Lady fern
Betula alleghaniensis	Yellow birch
Betula papyrifera	White birch
Bidens cernua	Nodding beggar's-tick
Bidens coronata	Large fruited beggar-tick
Bidens frondosa	Devil's beggar-tick
Boehmeria cylindrica	False nettle
Brasenia schreberi	Water shield
Bromus ciliatus	Fringed brome
Calamagrostis canadensis	Canada blue joint grass
Calla palustris	Wild calla
Campanula americana	American bellflower
Carex atherodes	Slough sedge
Carex aurea	Golden fruit sedge
Carex bebbii	Bebb's sedge
Carex bromoides	Brome-like sedge
Carex brunnescens	Brownish sedge
Carex castanea	Chestnut colored sedge
Carex comosa	Bearded sedge
Carex crinita	Fringed sedge
Carex cristatella	Crested sedge
Carex disperma	Soft-leaf sedge

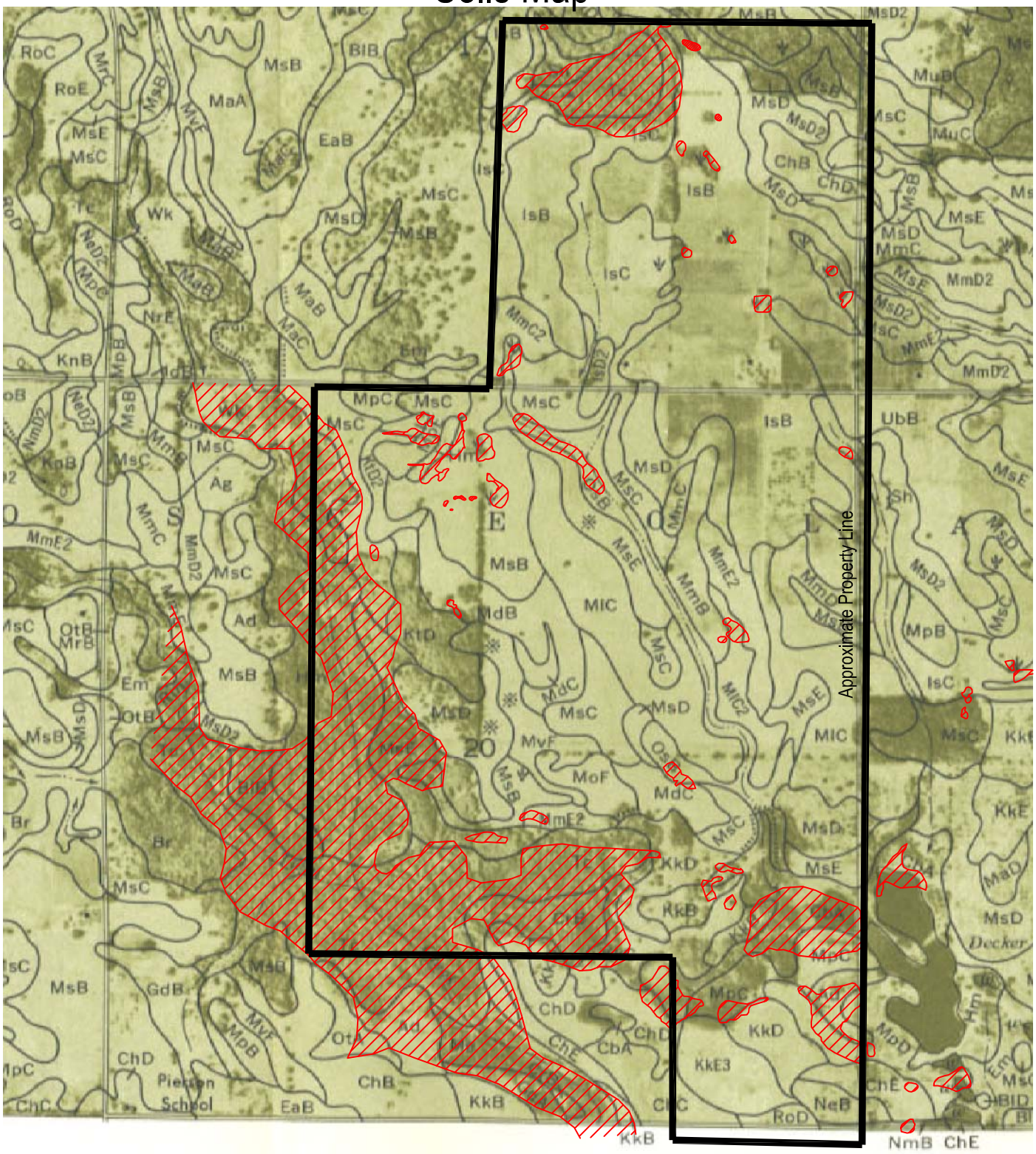
Scientific name	Common name
Carex eburnea	Ebony sedge
Carex flava	Yellow sedge
Carex gracillima	Graceful sedge
Carex hystericina	Porcupine sedge
Carex interior	Inland sedge
Carex intumescens	Bladder sedge
Carex leptalea	Bristly stalk sedge
Carex lupulina	Hop sedge
Carex projecta	Necklace sedge
Carex retrorsa	Retrorse sedge
Carex rosea	Rose-like sedge
Carex scabrata	Rough sedge
Carex stipata	Crowded sedge
Carex tribuloides	Blunt broom sedge
Carex trisperma	Three seed sedge
Carex tuckermanii	Tuckerman's sedge
Carex utriculata	Bottle-shaped sedge
Carex vulpinoidea	Fox sedge
Chameadaphne calyculata	Leather leaf
Chara spp.	Chara
Chrysosplenium americanum	Golden saxifrage
Cicuta bulbifera	Bulblet bearing water hemlock
Circaea alpina	Small enchanter's nightshade
Circaea lutetiana	Broad-leaf enchanter's nightshade
Cirsium muticum	Swamp thistle
Coptis trifolia	Goldthread
Corallorhiza trifida	Early coralroot
Cornus foemina	Stiff dogwood
Cornus stolonifera	Red osier dogwood
Cryptotaenia canadensis	Honewort
Cypripedium reginae	Showy orchid
Cystopteris bulbifera	Bulblet fern
Drosera rotundifolia	Round-leaved sundew
Dryopteris intermedia	Evergreen wood fern
Dryopteris cristata	Crested fern
Dulichium arundinaceum	Three-way sedge

Scientific name	Common name
Elaeagnus umbellata	Autumn olive
Epilobium leptophyllum	Linear-leaf willow-herb
Equisetum arvense	Common horsetail
Equisetum fluviatile	Water horsetail
Equisetum scirpoides	Dwarf scouring-rush
Equisetum sylvaticum	Woodland horsetail
Eupatorium perfoliatum	Common boneset
Fagus grandifolia	American beech
Fraxinus nigra	Black ash
Fraxinus pennsylvanica	Green ash
Galium triflorum	Sweet-scent bedstraw
Gaultheria hispidula	Creeping snowberry
Geum aleppicum	Yellow avens
Geum rivale	Purple avens
Glyceria borealis	Small floating manna grass
Glyceria grandis	Reed manna grass
Glyceria striata	Fowl manna grass
Gymnocarpium dryopteris	Oak fern
Hydrocotyle americana	American marsh penny-wort
Hystrix patula	Bottlebrush grass
Ilex verticillata	Michigan holly
Impatiens capensis	Spotted touch-me-not
Juncus articulatus	Jointed rush
Juncus effusus	Soft rush
Juncus nodosus	Knotted rush
Laportea canadensis	Wood nettle
Larix laricina	Tamarack
Lemna minor	Common duck weed
Liparis loeselii	Fen orchid
Lycopus americanus	American bugleweed
Lycopus uniflorus	Northern bugleweed
Lysimachia thyrsiflora	Tufted loosestrife
Lythrum salicaria	Purple loosestrife
Malaxis monophylla	White adder’s mouth orchid
Mitella nuda	Miterwort
Nasturtium officinale	Water cress

Scientific name	Common name
Nemopanthus mucronatus	Catberry
Onoclea sensibilis	Sensitive fern
Osmunda cinnamomea	Cinnamon fern
Osmunda regalis	Royal fern
Phalaris arundinacea	Reed canary grass
Pilea fontana	Northern clearweed
Pinus strobus	White pine
Platanthera hyperborean	Northern green orchid
Poa pratensis	Kentucky bluegrass
Polygonum amphibium	Water smartweed
Populus balsamifera	Balsam poplar
Populus grandidentata	Big-tooth aspen
Populus tremuloides	Trembling aspen
Potamogeton epihydrus	Ribbon-leaf pondweed
Prunella vulgaris	Heal all
Quercus rubra	Red oak
Ranunculus recurvatus	Hooked buttercup
Rhamnus frangula	Glossy buckthorn
Riccia fluitans	Liverwort
Rubus pubescens	Dwarf raspberry
Rubus strigosus	Red raspberry
Rumex crispus	Curly dock
Rumex obtusifolius	Bitter dock
Rumex verticillatus	Water dock
Salix bebbiana	Bebb's willow
Salix exigua	Interior willow
Salix lucida	Shining willow
Salix nigra	Black willow
Salix petiolaris	Meadow willow
Sambucus canadensis	Common elderberry
Sambucus racemosa	Red-berried elder
Scirpus atrovirens	Green bulrush
Scirpus cyperinus	Wool grass
Scutellaria galericulata	Hooded skullcap
Senecio aureus	Golden ragwort
Sium suave	Water parsnip

Scientific name	Common name
Solanum dulcamara	Climbing nightshade
Solidago canadensis	Canada goldenrod
Solidago gigantea	Giant goldenrod
Solidago patula	Swamp goldenrod
Solidago rugosa	Wrinkled goldenrod
Sparganium chlorocarpum	Green fruit burreed
Spiraea alba	Meadowsweet
Thelypteris noveboracensis	New York fern
Thelypteris palustris	Marsh fern
Thelypteris phegopteris	Northern beech fern
Thuja occidentalis	Northern white cedar
Tiarella cordifolia	Heart-leaved foamflower
Toxicodendron radicans	Poison ivy
Triadenum fraseri	Marsh St. John's-wort
Tsuga canadensis	Eastern hemlock
Typha latifolia	Broad-leaved cattail
Ulmus americana	American elm
Urtica dioica	Stinging nettle
Utricularia minor	Lesser bladderwort
Verbena hastata	Blue vervain
Viburnum cassinoides	With-rod

White - Cedar - Osceola Project - Evart, MI
Soils Map



Map Source:
Osceola County Soil Survey, Mettert 1969
Refer to report for soil description.
Refer to Figures 2, 3 & 4 for wetland location and name.
Wetland locations are approximate.

Map Date: November 10, 2003

Scale: 1":1000"

Figure 1 of 4

N

Legend

Approximate Wetland Location

Tilton & Associates, Inc.

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White - Cedar - Osceola Project - Evart, MI
North of 9 Mile

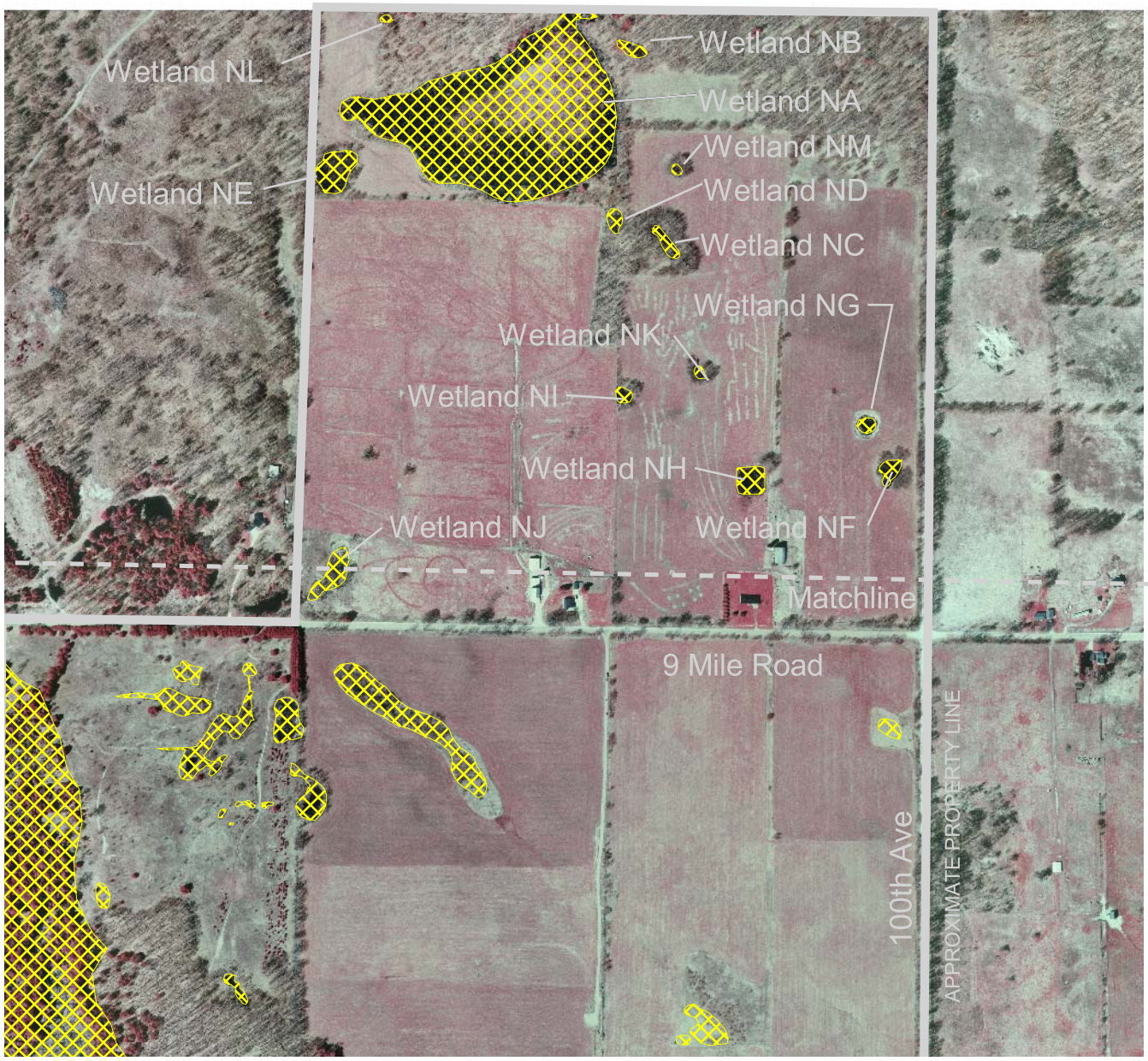

Figure 2 of 4

Map Source:
TAI Delineated Wetlands
June & November 2003

Map Date: November 10, 2003

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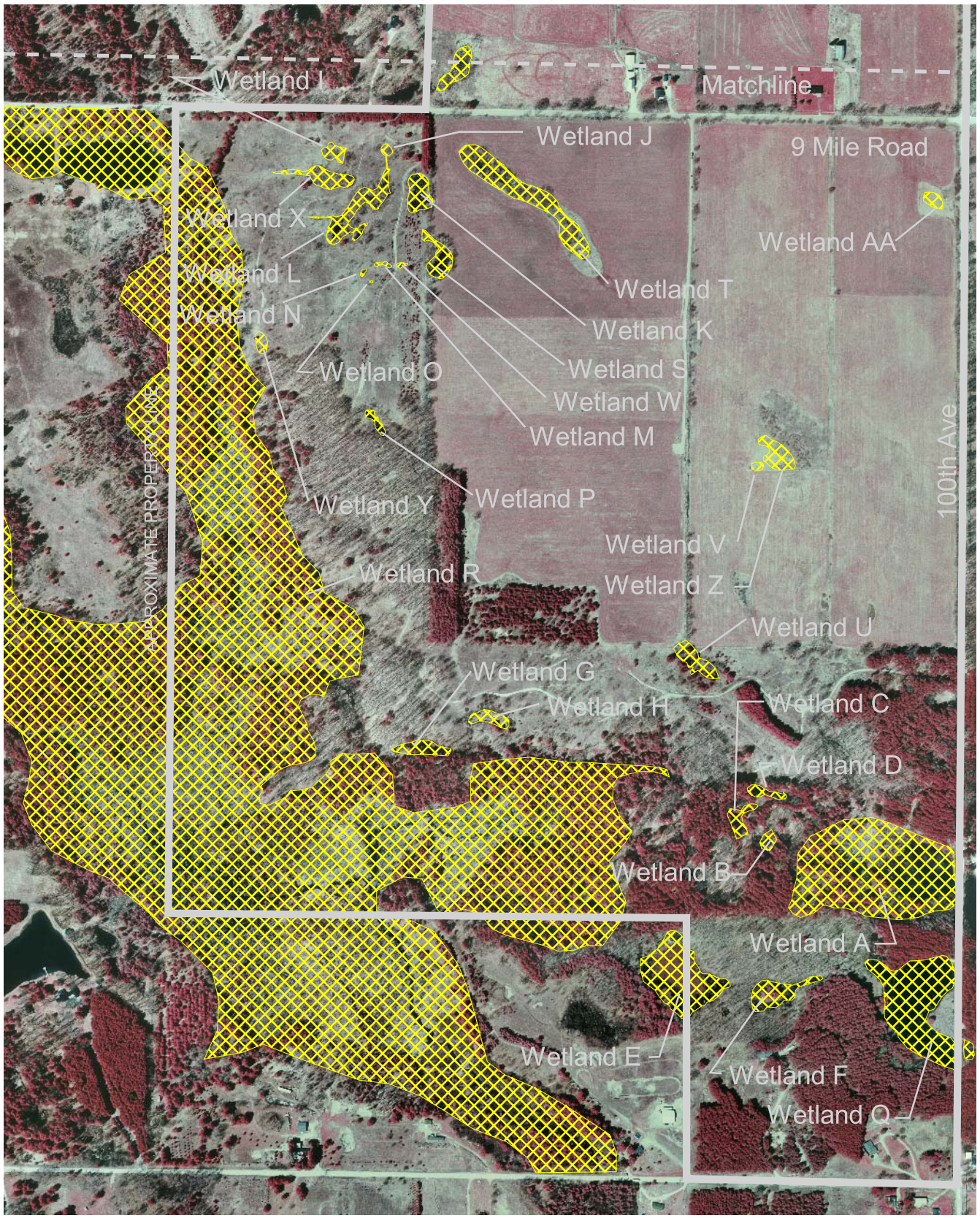
Tilton & Associates, Inc.

White - Cedar - Osceola Project - Evart, MI
South of 9 Mile



500 0 500 1000 1500 Feet

Figure 3 of 4

Map Source:
TAI Delineated Wetlands
June & November 2003

Map Date: November 10, 2003

Legend
Approximate Wetland Location Delineated June 2003

N W E S

Tilton & Associates, Inc.

...gis data\aerialir.apr

White - Cedar - Osceola Project - Evart, MI
South of 9 Mile East of 100th Avenue

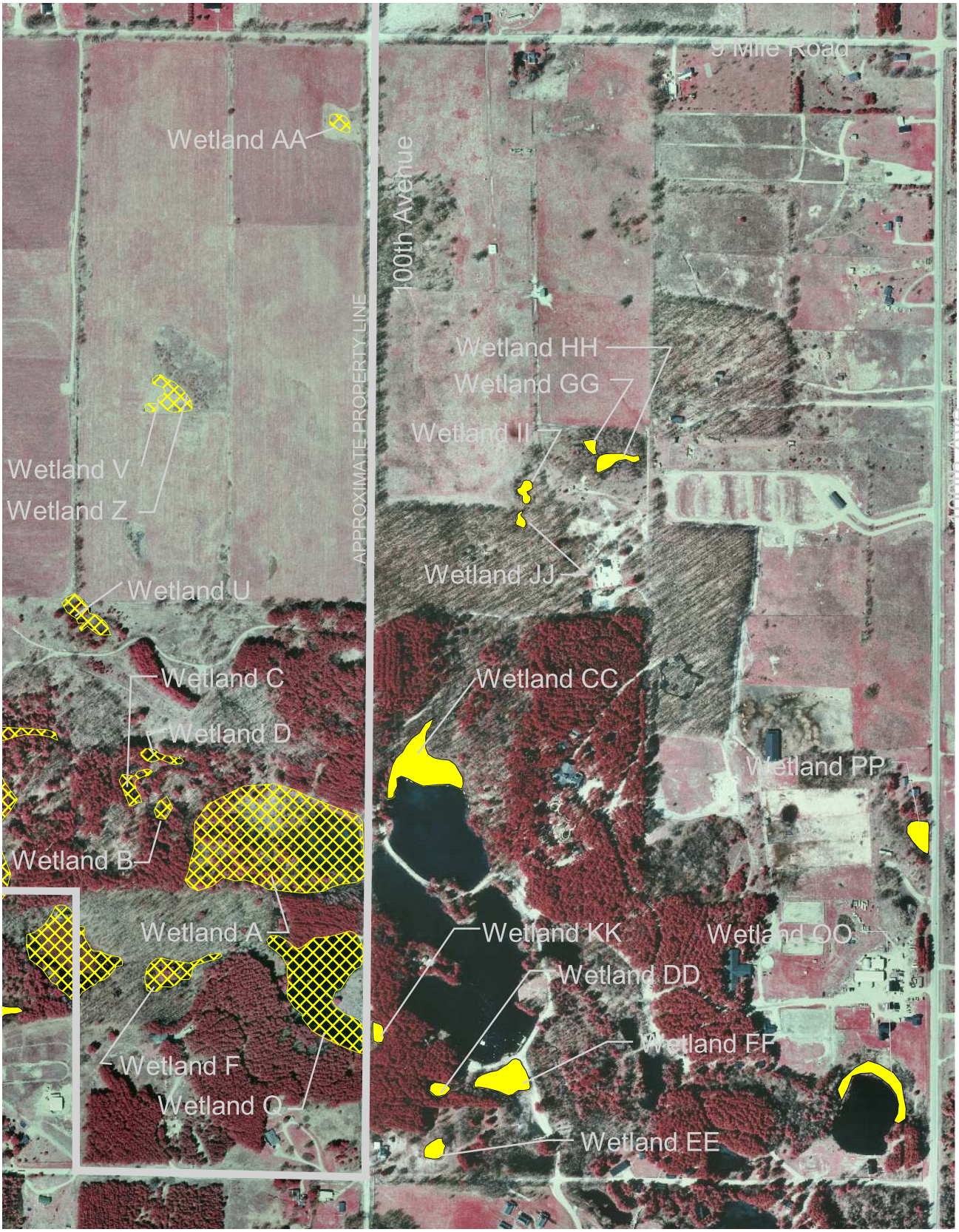


Figure 4 of 4

Map Source:
TAI Delineated Wetlands
June & November 2003

Map Date: November 10, 2003

Legend

- Approximate Wetland Location Delineated June 2003
- Approximate Wetland Location Delineated November 2003

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