Comprehensive Plan for Invasive Species Control and Habitat Preservation

Onondaga Lake Watershed. Onondaga County, NY.

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ACRONYMS

ACRONYM	Definition
DOI	Department of the Interior
mg/L	milligrams per liter
NAVD	North American Vertical Datum
NRD	natural resource damage
NRDAR	natural resource damage assessment and restoration
NYNHP	New York Natural Heritage Program
NYSDEC	New York State Department of Environmental Conservation
OLCC	Onondaga Lake Conservation Corps
SCA	Sediment Consolidation Area
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

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EXECUTIVE SUMMARY

In March 2018, the United States Department of the Interior (DOI), acting through the United States Fish and Wildlife Service (USFWS) and the New York State Department of Environmental Conservation (NYSDEC), the Trustees settled a natural resource damage (NRD) claim with the Responsible Parties for the Onondaga Lake Superfund Site in Onondaga County, New York.

As part of the settlement of NRD for Onondaga Lake, the NRD Trustees (herein referred to as Trustees) will receive up to $3,000,000 over a 15-year period to implement invasive species controls in a manner consistent with the requirements and limitations in the Onondaga Lake NRD Consent Decree. The goal of the Trustees is to provide invasive species control and habitat restoration that includes reasonable and commensurate costs associated with planning and oversight. This Comprehensive Plan provides guidance and recommendations to the Trustees associated with the first five years of their invasive species control project and includes the recommended target species, priority areas where controls should be implemented, and methods for control.

Invasive species are common throughout the state, and the NYSDEC includes over 200 plant and animal species in their Prohibited and Regulated Invasive Plants and Animal List. Given invasive species are so common, it is necessary to focus efforts on the select areas, species and habitats that balance long-term ecological benefit and cost-effectiveness. For example, common carp (*Cyprinus carpio)*, Eurasian milfoil (*Myriophyllum spicatum*), and emerald ash borer (*Agrilus planipennis*), while significant in their environmental impacts, are beyond the scope of this Comprehensive Plan to control in any substantive way. For this reason, the Comprehensive Plan necessarily focuses on key habitats in and adjacent to Onondaga Lake and its tributaries and on the most problematic invasive species found in those areas.

Although centuries of human impacts have dramatically transformed the landscape around Onondaga Lake, remnants of significant natural communities still exist. Furthermore, extensive restoration efforts associated with the Onondaga Lake cleanup effort have resulted in broadscale improvements to ecological quality due to the creation of large intact wetland complexes. The academic literature strongly suggests that preventative measures aimed at keeping invasive species abundance low in areas of high quality and/or rare habitats will not only provide the greatest overall ecological benefit but will also be the most cost-effective effort. For this reason, the Trustees have determined that preventive measures in high quality habitats should be a priority. Although areas with a dominance of invasive species will be costly to successfully restore, if these areas are within or adjacent to a rare, high quality, or priority habitat, they were also considered. While the focus areas recommended in this report reflect these priorities, identifying new opportunities that emerge during and after the first 5 years that this report covers will also be an important component of the program.

A total of 17 areas are recommended for consideration in the first five-years. These areas encompass approximately 375-acres. Of these, 10 areas encompassing approximately 310-acres are best described as high quality habitats where preventative measures will be implemented, and seven areas encompassing approximately 65-acres are best described as invasive species dominated sites requiring restoration. The areas where preventative measures will be undertaken represent approximately 85% of the acreage being targeted by the program but represent only approximately 15% of the implementation costs. Likewise, the areas where restoration measures are needed represents approximately 15% of the acreage being targeted but incurs approximately 85% of the implementation costs.

This document thoroughly reviews the invasive species, potential methods of invasive species control, potential application for invasive species control, and possible locations where the invasive species should be addressed with nexus to the injury. The trustees agree that the chosen method of control and application for each area will need to be determined by the implementation team based on site conditions at the time control efforts are initiated, invasive species identity, extent of infestation, and expected effectiveness.

1.0 INTRODUCTION

In March 2018, the United States Department of the Interior (DOI), acting through the United States Fish and Wildlife Service and the New York State Department of Environmental Conservation (NYSDEC), together the Trustees, settled a natural resource damage assessment and restoration (NRDAR) claim with the Responsible Parties for the Onondaga Lake Superfund Site in Onondaga County, New York.

The Responsible Parties discharged a variety of hazardous wastes, including mercury, polychlorinated biphenyls, polycyclic aromatic hydrocarbons and chlorinated benzenes, into Onondaga Lake, its tributaries and other wetland and upland areas. These hazardous substances contributed to injuries to natural resources, including fish, birds, aquatic invertebrates, bats, frogs and turtles. The settlement of the natural resource damage claim provides a suite of ecological restoration projects designed to compensate for injuries to natural resources.

The March 2018 “Onondaga Lake Natural Resource Damage Assessment Consent Decree” and “Appendix C - Onondaga Lake Watershed Restoration Projects Scopes of Work” (Consent Decree)[1], describe the funding for an invasive species control and habitat preservation project. According to the March 2018 Scope of Work for Project 9, The “Invasive Species Control and Habitat Preservation Project” shall be implemented within Onondaga Lake and its watershed. The proposed project area includes approximately 2,000-acres of wetlands, lake/river littoral zone and riparian zone habitat and is further defined in Section II below.

An invasive species is one that is non-native to an ecosystem and causes or is likely to cause economic harm, environmental harm, or harm to human health. Invasive species can out-compete native species and reduce biodiversity (New York State Department of Environmental Conservation [NYSDEC] 2014). There are several theories on why some plant species have such characteristics where they are introduced and why natural communities become invaded by those species. One theory suggests that where a plant species’ natural herbivores are absent, the plant will evolve to shift resources away from herbivore defenses and toward growth (Blossey and Nötzold 1995). Ellstrand and Schierenbeck (2000) suggest that some species become invasive following a hybridization event between species or populations. A natural community may be more likely to become invaded by exotic plant species when there is an increase in the amount of unused resources present in that community (Davis et al. 2000). Lockwood et al. (2005) suggest that invasions are more likely where propagule pressure is greater (i.e., invasions are more likely at sites experiencing either a greater number of introductions of the invasive species or the introduction of a greater number of individuals of that species). Greater community diversity may reduce the probability that a site will be invaded (Eschtruth and Battles 2009). Disturbance, both natural and anthropogenic, may also increase the likelihood that a plant community will be invaded by exotic plant species (Burke and Grime 1996).

Invasive species have a considerable impact in their introduced ranges. Each year in the United States, invasive species cause damage worth about $122 billion (Ellstrand and Schierenbeck 2000). While the effect on native plant communities varies by the invading species, some may cause up to a 90% reduction in plant species richness (Hejda et al. 2009). Non-native plants most noticeably out-compete and reduce populations of native plants, but can impact other organisms indirectly through reduction of preferred food sources and altered physical community structure including loss of shelter. For example, the number of insects associated with an exotic plant is far less than the number associated with that plant in its native range (Tallamy 2004). Research suggests that a greater proportion of non-native plant species in the landscape causes a decrease in the amount of preferred food sources for some bird species, resulting in decreased reproduction and population declines (Narango et al. 2018). Additionally, it has been shown that nest predation in some bird species is greater when the birds nest in invasive woody plant species (Schmidt and Whelan 1999). Some exotic species have been

[1] https://www.fws.gov/northeast/nyfo/ec/onondaga.htm

shown to potentially influence ecosystem properties like geomorphology, hydrology, biogeochemistry, and disturbance (Gordon 1998).

There are demonstrated benefits of controlling and removing invasive plants from native ecosystems. Research by Prior et al. (2018) suggests that about 69% of invasive plant removal efforts result in an outcome that is at least partially positive, meaning an increase in individuals of a native species or increase in native species richness, or an ecosystem process attaining a beneficial state or one that reflected pre-invasion conditions. Some research suggests that the removal of invasive shrubs from eastern deciduous forest may result in increased plant diversity, greater native understory plant abundance, and regeneration of overstory tree species (Maynard-Bean and Kaye 2019). In some ecosystems, removal of an invasive plant and regrowth of native species may restore original arthropod communities (Gratton and Denno 2005).

Many methods are available for invasive plant management, each with advantages and disadvantages. They are classified as mechanical, chemical, biological, or other. Mechanical methods include mowing and cutting, sometimes accompanied by herbicide use. Chemical methods use herbicides, which differ greatly in their selectivity and mode of action. Biological methods of invasive plant control rely on an herbivore species to reduce the biomass of an invasive plant by feeding on it. These can be specific, such as biocontrol agents chosen for their host specificity, or a generalist herbivore such as goats that will eat most vegetation and are confined to an area where invasive plants are to be eliminated. Some other methods exist, such as using controlled burns to kill invasive plants and covering plants with plastic sheeting to kill them as the temperature under the tarp increases to lethal levels.

Many factors must be taken into consideration in invasive species management. Given that total elimination is sometimes difficult and costly, prioritization is important. It is generally easier to eliminate small patches of invasive plants before they become abundant at a site. Sensitive habitats or sites with sensitive or threatened species may also receive higher priority for invasive plant removal. There are risks and disadvantages to the removal of invasive plants, including incidental damage to native plants or wildlife. Removal of invasive plants may also result in invasion by, or increase in dominance of, other invasive plants. If elimination of invasive plants is not accompanied by the restoration of native plants, the result may be an immediate decrease in suitable habitat for native wildlife (Zavaleta et al. 2001).

In 2018, after entering into a consent order with Honeywell International Inc. and Onondaga County, the USFWS and the NYSDEC announced a series of new restoration projects that would improve and conserve habitat in and around Onondaga Lake. The focus of the invasive species control project described in this document is the Onondaga Lake watershed area. Onondaga Lake, its tributaries and shoreline, and adjacent wetlands are considered priority areas because they will provide the greatest potential for habitat improvements linked to the injuries described in the 2017 Onondaga Lake Natural Resource Damage Assessment Restoration Plan and Environmental Assessment.

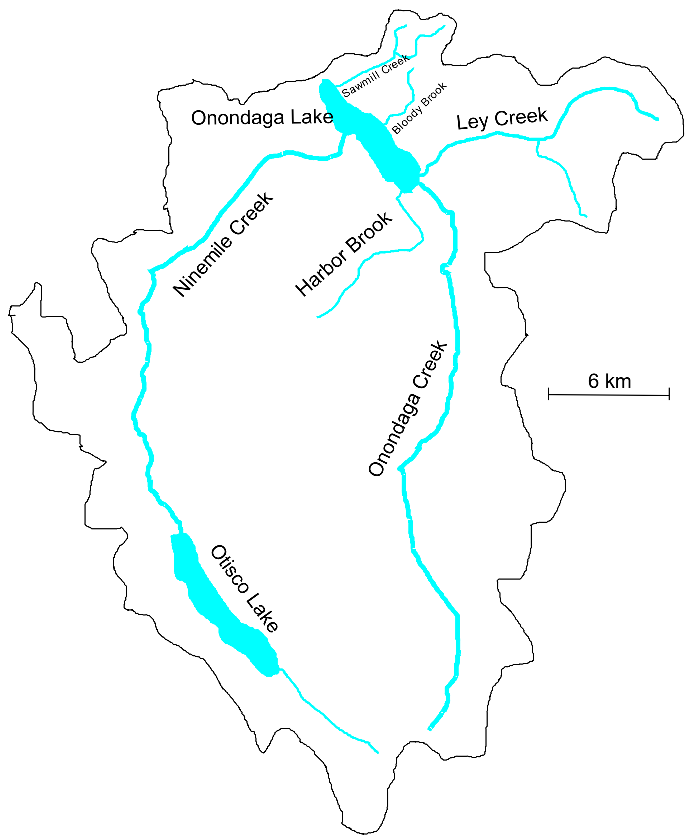
2.0 INVASIVE SPECIES IN THE ONONDAGA LAKE WATERSHED

2.1 Existing Conditions of the Onondaga Lake Watershed

2.1.1 Overall Condition

The Onondaga Lake watershed encompasses approximately 285 square miles including two substantial lakes (Onondaga and Otisco), cultivated cropland and pasture, extensive deciduous forests and forested wetlands, and a major metropolitan city (Onondaga County 2018). The Onondaga Limestone Escarpment divides the county in half, with Ontario lake plain in the north (<180 meters above mean sea level) and the Allegheny Plateau in the south (180 to 620 meters above mean sea level) (Hill 1985).

Historically, the Onondaga Lake watershed was extremely biodiverse. The lake was once a source of salmon and American eel. It was surrounded by floodplain forests, emergent marshes, rich mesotrophic hardwood forests, rare inland salt marshes and expansive cedar swamps supporting hundreds of plant species including calypso orchids *(Calypso bulbosa)*, dragon's mouth orchids (*Arethusa bulbosa*) and yellow lady slippers (*Cypripedium parviflorum*). The influence of dolomite and limestone bedrock also supported rich fens throughout the watershed (Landis 2016). Not only invasive plants but development and the deposition of industrial wastes along extensive stretches of the Onondaga Lake shoreline have greatly reduced the presence of these communities. Although centuries of anthropogenic disturbance have dramatically transformed the landscape, remnants of some of these unique communities still exist in the watershed. Furthermore, extensive restoration efforts associated with the Onondaga Lake Cleanup effort have resulted in large, intact wetland complexes surrounding the lake and broad-scale improvements in the ecological quality of the watershed.



Onondaga Lake Watershed Tributaries

There are six natural tributaries to Onondaga Lake, all of which have undergone significant modification, such as channelization, in their lower reaches. Onondaga Creek, Ninemile and parks before reaching Onondaga Lake. A small inland salt marsh community fed by salt springs exists in a backchannel wetland along the lower reaches of the creek near Onondaga Lake. This community was created as part of the habitat restoration efforts associated with the Onondaga Lake Cleanup. Flowing into Ninemile Creek approximately one mile from Onondaga Lake, Geddes Brook has undergone a dramatic restoration that created 13-acres of high-quality wetland habitat. Ley Creek originates in wetlands near Minoa, New York, and is a slow-moving stream along most of its length. Remedial activities have occurred, or are scheduled to occur, along the several miles of stream closest to the lake. A recent remedial effort resulted in the restoration of several acres of quality wetlands approximately one mile from Onondaga Lake.

2.1.2 Native Species and Plant Communities

Deciduous forest accounts for 29% of land cover in the watershed, which is by far the largest natural community, followed by woody wetlands at 5% land cover (Figure 2.1). In the Ontario lake plain, the major forest type is elm/ash/red maple. Northern hardwood forests are prevalent in the southern Allegheny Plateau and are composed of American beech *(Fagus grandifolia*)*,* yellow birch *(Betula alleghaniensis*)*,* black cherry *(Prunus serotina*)*,* sugar maple *(Acer saccharum*)*,* and tulip trees (*Liriodendron tulipifera*; Hill 1985). The major wetland type in the watershed is freshwater forested/shrub wetlands in valleys of the Allegheny plateau and a mix of forested and freshwater emergent wetlands in the north. Many of these habitats are affected by invasive species. Emergent wetlands in the watershed are heavily impacted by phragmites (*Phragmites australis*), an invasive plant. Another invasive plant, European buckthorn (*Rhamnus cathartica*), has impacted many wetlands in the area. Forested communities in the area have experienced species composition changes as a result of Dutch elm disease, beech bark disease, and emerald ash borer impacts. Much of the forested areas in the watershed are also highly fragmented, and regeneration may be inhibited by intensive deer browse.

2.1.3 Rare and/or Critical Habitats

Several remaining rare or critical habitat types or unique areas in the Onondaga Lake watershed are described below with the labels of rare or critical habitats and unique areas bolded.

Rich fens are groundwater-fed, peat-forming wetlands which are mineral-rich and nutrient-poor, often formed where calcium rich bedrock interacts with source water. Their unusual soil and water chemistry supports extremely diverse assemblages of calciphytic plants (Raney and Leopold 2017). Several types of rich fens exist, including rich sloping fens, rich graminoid fens and rich shrub fens. In Syracuse, limestone dolomite bedrock once supported a patchwork of rich fens, remnants of which still exist. In Pumpkin Hollow, near Marcellus New York, the New York Natural Heritage Program (NYNHP) has identified a rich sloping fen, a critically imperiled habitat at the state level, which can be viewed on the NYSDEC Environmental Resource Mapper (NYNHP 2020; NYSDEC 2020).

Inland salt marsh is a globally endangered wetland type associated with salt springs which supports a unique community of salt-tolerant species typically found only in coastal salt marshes. In our region, inland salt marsh aquifers interact with a thick salt layer more than 1,000 feet below the earth's surface, which was deposited more than 400 million years ago when the region was covered by a shallow hypersaline sea (Faust and Roberts 1983). This unique feature of the region's geomorphological history was responsible for the salt industry in Syracuse that lasted for more than a century and produced more than 11.5 million tons of finished salt (U.S. Geological Survey [USGS] 2000). Prior to industrialization, there were expansive inland salt marshes around the south side of the lake and in the area around Montezuma, New York. However, development and habitat destruction have reduced these unique communities to a few small patches, most of which are now heavily invaded by phragmites. A small, restored inland salt marsh lies along Ninemile Creek west of the state fairgrounds. There are other small pockets of salt affected soil near the I-690 overpasses. These may be a result of road salt, but they support salt-tolerant communities including the state-threatened annual saltmarsh aster (*Symphyotrichum subulatum* var. *subulatum*). The largest natural remnant is the Danforth Ponds area on the southeastern lakeshore. Although heavily invaded by phragmites, it would be a highly significant community if restored.

Mildred Faust, a professor of botany at Syracuse University, with her students at an expansive inland salt marsh in the 1930s. The location is likely around the NBT Bank Stadium today (provided by Dr. Donald Leopold).

Located less than 0.25 miles from Onondaga Creek, **Rand Tract** is a 90-acre natural area in the heart of the City of Syracuse. It contains a 30-acre state regulated class 1 wetland (class 1 refers to the highest level of ecological importance given to a state regulated wetland). The remaining 50-acres consist of mature high-quality forests dominated by sugar maple, shagbark hickory (*Carya ovata)* and ash *(Fraxinus americana*). In the spring, the understory contains wild leek (*Allium tricoccum*), trout lily (*Erythronium americanum*), and white trillium (*Trillium grandiflorum*). Many hiking trails, bathing pools, and small waterfalls make this park extremely culturally valuable and of high quality ecologically.

Wizard of Oz Memorial Oak Grove is a 7-acre **old-growth oak grove** behind North Syracuse Junior High School. It is among the last remaining old-growth forest in the state and likely the only old-growth in the watershed.

Camillus Forest Unique Area is mostly a mixture of old field habitat and young forest. However, a 38-acre section of this 350-acre preserve is high-quality mature forest. Up to 200-year-old stands of sugar maple and American beech occupy this rare resource adjacent to Ninemile Creek in the town of Camillus.

2.1.4 Significant Restoration Sites Present in the Watershed

More than 70-acres of wetlands have been restored or created during the Onondaga Lake cleanup. These properties have been planted with over 600,000 native herbs, trees and shrubs and have become home to hundreds of wildlife species as they return to the lake and its associated wetlands. The restored lower reach of Ninemile Creek consists of high-quality restored wetlands, riparian zones, and more than two miles of restored streambed. Geddes Brook enters Ninemile Creek west of the state fairgrounds and is the most complex wetland restoration in the watershed. The 21-acre habitat complex consists of ponds, perched wetlands, channel grade wetlands, and riparian floodplains arranged around the meandering Geddes Brook. This complex supports over 170 species of plants and 178 species of wildlife including the New York State threatened Bald Eagle and Pied-billed Grebe. These and other Onondaga Lake restoration areas are summarized in the table below.

SITE	APPROXIMATE TOTAL AREA RESTORED (ACRES)	APPROXIMATE WETLAND/RIPARIAN AREA RESTORED (ACRES)
The LCP Wetlands	15	15
Geddes Brook Wetlands	21	20
Ninemile Creek	24	24
Onondaga Lake Wetlands Mouth of Ninemile Creek	19	18
Onondaga Lake Western Shoreline	30	30
Onondaga Lake Southwest Shoreline and Harbor Brook	17	17
Upper Harbor Brook	2.5	2.5
Crouse-Hinds Wetlands	14	14

Summary Acreages of Previously Restored Areas and Wetlands in Proximity to Onondaga Lake.

2.2 Invasive Species of the Onondaga Lake Watershed

New York State is a hub of global commerce and the Port of New York/New Jersey remains the largest U.S. port on the Atlantic coast (Bureau of Transportation Statistics 2010). The state has been an invasion point for non-native species to the U.S. for more than two centuries, and is an area of high importance for national invasive species control.

Invasive species impact a variety of habitats in the watershed. However, this management plan focuses primarily on wetland invasive plant species. Detailed fact sheets provided in Appendix A outline identification, ecology, impacts and control strategies for five of the most common and threatening invasive wetland species. The species selected are phragmites, purple loosestrife (*Lythrum salicaria*), European buckthorn), Japanese knotweed (*Reynoutria japonica*) and water chestnut (*Trapa natans*). Phragmites and purple loosestrife establish monocultures in generally wet soil, choking out native species by forming dense stands that block light from reaching the soil. Phragmites layers dead stems, slowly raising the ground level and permanently altering wetland soils. Phragmites is also salt-tolerant, making it a threat to the survival of inland salt marshes in the region. European buckthorn is typically thought of as an upland invader, but it can also tolerate wet soils and intermittent flooding. Not only does buckthorn shade out native species and alter wildlife usage in wetland and upland forests, its tissues contain allelopathic chemicals which inhibit the growth of many native species. Japanese knotweed is a significant threat to riparian areas in the watershed, forming monocultures along streams and distributing seed along waterways, potentially dispersing long distances. Water chestnut is a rooted floating aquatic which can form dense mats on a lake's surface, blocking light from reaching submerged aquatic plants and aquatic animals. As an annual, its floating rosettes decompose yearly and can cause oxygen depletion, killing fish and invertebrates in lakes and ponds. In addition to ecological harm, all five species reduce recreational and cultural value in natural areas, causing tremendous economic harm.

3.0 GUIDELINES FOR INVASIVE SPECIES MANAGEMENT WITHIN PROJECT AREAS

3.1 Target Invasive Species

The species of greatest concern in this invasive species management project include phragmites, purple loosestrife, European buckthorn, Japanese knotweed, and water chestnut. Each species can grow in dense stands, creating shade and reducing native species richness and growth, and all five are prevalent in or around Onondaga Lake. Information regarding each targeted species can be found in Appendix A. For most of these species, few control methods will be fully effective when used alone. Larger, well established stands may require multiple treatments and rapid establishment of beneficial species is an essential component of any invasive species control plan.

3.1.1 Management Control Methods

MECHANICAL METHODS

Mechanical methods of invasive plant control range from pulling plants by hand to mulching entire trees with a forestry mulcher. When entire plants can be pulled from the ground with stems and root systems intact, this method is highly selective and effective (but may require repeated application if the invasive species is present in the seed bank). Hand-cutting (with cutters or chainsaw) is also selective but may not kill the plant on first cutting and may require years of re-cutting unless an herbicide is applied to kill the below-ground part of the plant. Note that hand-pulling and cutting are only selective if workers can reliably distinguish target plant(s) from all other plants.

Mowing can be used to control larger areas of herbaceous or small-diameter woody invasive plants. Methods using heavy equipment like a forestry mulcher are much more efficient than hand-pulling or hand-cutting. However, the spatial arrangement of plants may make it unrealistic to target individual species for removal. Heavy equipment may also cause rutting and soil compaction. Another consideration for mechanical removal is disposal of biomass. A forestry mulcher mulches woody plants, leaving the biomass on site. This may be undesirable if the biomass contains propagules that may re-invade that site or another. If plants are hand-pulled or cut, the biomass will occupy more space. It may be necessary to remove it from the site, increasing time and cost.

Mechanical control of phragmites may slow the growth or spread of stands but is unlikely to be successful when used alone and not repeated multiple times. Hand pulling is generally not a feasible method of phragmites control because of the expansive network of rhizomes that will remain after pulling (http://nyis.info/invasive_species/common-reed/).

Cutting of phragmites, followed by flooding may achieve a greater level of long-term control than cutting alone (Saltonstall 2005; Howell 2017). Good control of phragmites was achieved at Collingwood area of Ontario, Canada when a large number of volunteers manually cut phragmites, below the water line and removed all cut materials from the site (Deakin et al. 2016). This method requires the ability to regulate water levels in a phragmites patch or stand.

Mowing or cutting of phragmites may reduce the mass of material, making herbicide treatment easier. If cutting or mowing is performed after herbicide use, it should not be done for at least two weeks to allow mobilization of herbicide to the phragmites rhizomes (Avers et al. 2014).

CHEMICAL METHODS

Chemical methods of invasive plant control apply herbicides to kill plants. There are many herbicides with different properties available for use. The selectivity of an herbicide depends on its active ingredient as well as the application method. Broad-spectrum herbicides such as glyphosate may be effective against a wide range of species. Grass-specific herbicides like sethoxydim can reduce impact to non-target plants. Herbicides can be applied to individual stems (e.g., by painting or injection), using a backpack sprayer, or sprayed from a vehicle or aircraft. Application to individual stems is highly selective but unrealistic for large stands. Backpack spraying is applicable to larger stands; it is more likely to affect non-target species, but the risk can be reduced by the choice of herbicide and considering such factors as wind speed and direction. Similar risks apply to herbicide application by a vehicle, but this method is most appropriate for very large stands where the boundary with native vegetation is minimal.

The herbicide most likely to be used in the Onondaga Lake wetland or aquatic areas is glyphosate, although there may be consideration of using herbicides such as imazapyr or fluridone. These herbicides are best applied in late summer/early fall after the plant has flowered either as a cut stump treatment or as a foliar spray (Avers at al. 2014). Glyphosate was found to result in 90% reduction in either biomass or stand density of phragmites (Cheshier et al. 2012; Derr 2008). However, repeated applications are generally required to maintain phragmites control and little information exists on the long term effectiveness of glyphosate for controlling phragmites once the treatment stops (Hazleton et al. 2014). As with all forms of phragmites control, prompt establishment of desired vegetation is important to reduce phragmites reinvasion (Hazleton et al. 2014).

It is important to apply glyphosate according to label and state regulations in order to maximize effectiveness while minimizing adverse impacts to the environment. None of the formulations that mix glyphosate with surfactants (e.g. Roundup) is allowed for use in aquatic environments in New York State.

In a USGS study of U.S. streams, glyphosate was detected in 74% of 3,200 samples at a mean concentration of 0.05 milligrams per liter (mg/L) and a maximum concentration of 8.1 mg/L (Medalie et al 2020). Due to the widespread nature of glyphosate in the environment demonstrated by this study, it is important to consider an integrated approach to invasive species management to minimize the amount of glyphosate that enters the environment.

The impacts of glyphosate on biological organisms can be minimized through proper application rates and methods. Technical glyphosate (also knowns as Rodeo) has minimal impacts on amphibians when used according to state regulations and applied in the summer or fall to reduce exposure to early life stages. For example, the 96-hour LC50 [2] for technical grade glyphosate to green frog larvae (*Rana clamitans*) was > 38.9 mg/L (Howe et al. 2004). This concentration is unlikely to be reached in the environment after glyphosate application, considering that 38.9 mg/L exceeds the maximum field concentration of 8.1 mg/L reported by Medalie et al. (2020). Roundup and other glyphosate formulations that have added surfactants are much more toxic to amphibians than technical glyphosate. The Roundup Original 96 hour LC50 for green frog larvae was 6.5 mg/L, illustrating that it is more toxic to green frog larvae than glyphosate (Howe et al. 2004).

Bringolf et al. (2007) evaluated the effects of various glyphosate formulations on the freshwater mussel, *Lampsilis siliquiodea*. The 96 EC50 [3] was greater than 200 mg/L for technical grade glyphosate to juvenile mussels, much greater than the 8.1 mg/L maximum field concentration reported by Medalie et al. (2020). By contrast, the 96 hour EC50 for Roundup to juvenile mussels was 5.9 mg/L, demonstrating the much greater toxicity of Roundup to this species than technical grade glyphosate. The 4 day LC50 concentration of glyphosate

[2] LC50: Concentration of a substance in an environmental medium expected to cause 50% mortality of test organisms in a given population under a defined set of conditions.
[3] EC50: Concentration of a substance in an environmental medium expected to produce a certain effect in 50% of test organisms in a given population under a defined set of conditions.

to fathead minnows (*Pimephales promelas*) was 97 mg/L compared to a Roundup LC50 to this species of 2.3 mg/L (Folmar et al. 1979).

Although toxicity to amphibians, mussels and fish can be minimized by using glyphosate without added surfactants and following label and state guidelines, it is important to consider other methods of invasive species control as alternatives to herbicide use. The aquatic half-life of glyphosate is predicted to be 2-14 days (Geisy et al. 2000), yet 74% of the USGS stream samples found this chemical, indicating some level of environmental persistence of this chemical. There are also concerns about the impact of glyphosate on algal blooms exacerbated by glyphosate (Hebert et al. 2018), so landscape context should be considered as part of a plan to use glyphosate. This would include evaluating the watershed-wide use of glyphosate and evaluating glyphosate concentrations in downstream water bodies. Glyphosate may pose a risk to human health of applicators and others exposed to the herbicide (Myers et al. 2016); conformance with state guidelines and protective measures may reduce these risks.

BIOLOGICAL CONTROL METHODS

Biological control is implemented by classical biocontrol, in which an insect known to feed specifically on an invasive plant species and reduce its vigor is introduced to an invaded area, or by livestock herbivory, in which livestock known to feed on an invasive plant species are released into an area and allowed to reduce the biomass of the plants.

Livestock

Control by livestock can be an effective management strategy for controlling invasive plants (Kleppel et al. 2011). In studies of intensive rotational grazing by sheep in a New York wet meadow invaded by purple loosestrife and reed canary grass (*Phalaris arundinacea*), the canopy height of the invasive species was reduced, and species richness increased relative to a control ungrazed area (Kleppel and LaBarge 2011). A similar strategy produced positive results in a riparian zone in New York invaded by phragmites (Silliman et al. 2014) 2-4 week periods decreased phragmites stem density by 50% and stem height by 60%, with an increased number of native plant taxa in the treatment plots vs. the control plots. Grazing can aid plant growth by increasing sun exposure, aerating the soil, and increasing nutrient availability (Frank 2008). Invasive plant control by livestock grazing is not selective and can reduce biomass of non-target plants, a concern if sensitive native species are present. Sometimes supplemental feeding is required. For example, livestock can persist for only a short period of time (i.e., weeks to months) on a phragmites-centered diet without negatively impacting their health (Kleppel et al. 2011; Silliman et al. 2014). The animals must be tended by providing adequate water and protection from predators (Kleppel and LaBarge 2011). The targeted area must be fenced in to contain the livestock. For some grazing regimes, the animals must be moved on a regular basis (Kleppel et al. 2011).

Goats may avoid areas with standing water, which may present an obstacle to their use in some phragmites-dominated wetlands in the project area[4]. While grazing by goats and cattle may decrease phragmites density, it does not impact the root system (Great Lakes Phragmites Collaborative), and may therefore be only a short term solution.

Insects

Classical biological control of an invasive plant species is the intentional introduction of a host-specific natural enemy from that species' native range in order to reduce its populations to levels that are no longer harmful (Thomas and Reid 2007). For many invasive plant species there are no classical biocontrol agents available, but those that are available can be effective. One meta-analysis indicates that biocontrol agents can reduce the size, mass, and density of target invasive plants, as well as flower and seed production. Diversity of non-target plants

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[4] https://www.theguardian.com/environment/2014/oct/22/are-goats-the-answer-to-the-reed-choking-us-east-coast-marshes

can increase following biocontrol release, although the new species are not necessarily native. Beetle species (Coleoptera) tend to be most effective (Clewley et al. 2012). Two beetle species released for purple loosestrife control were shown to effectively spread beyond their release site to additional purple loosestrife populations. Of all monitored populations, 88% showed signs of herbivory, but the amount of damage was less at non-release sites (Boag and Eckert 2013).

Although there have been insect controls tested for phragmites, none is approved for use by the U.S. Department of Agriculture. Blossey et al. (2018) found that the two European noctuid moths in the genus *Arcanara* laid eggs on shoots of the *phragmites*, but also laid eggs on the native North American *Phragmites australis americanus*, albeit to a lesser extent. The lack of species specificity of these moths to the non-native phragmites may present challenges for their environmental use. For many invasive plant species there are no classical biocontrol agents.

OTHER METHODS

There are methods of invasive species control beyond those mentioned above, including prescribed burning and solarization. Prescribed burning is most effective against late-season perennial forbs (i.e., herbaceous, non-grass species). However, burning may promote some perennial forbs, and so must be used as part of an integrated management plan. It is difficult to control woody invasive plants with prescribed fire because plants may produce new growth from their trunk or roots if the fire has not killed them (DiTomaso et al. 2006). For prescribed burning to be successful, sufficient fuel load and appropriate weather conditions (ex: appropriate relative humidity) must be present to reach the desired outcome. Burning can be difficult to use in wetlands because the fire will not spread through sufficiently wet areas, which could leave untreated invasive species. Prior to burning, fire breaks must be created to help contain the fire to the area being treated and wind conditions must be considered so that fire or smoke does not affect non-target areas.

For phragmites, burns need to be hot enough to kill underground rhizomes. This rarely occurs if phragmites is growing in wet sites[5]. Burning has been used in conjunction with herbicides to remove leaf litter, allowing germination of desirable species (Beall, 1984).

Solarization is the application of plastic sheeting to the ground to elevate the temperature under the sheeting to lethal levels. This may kill underground propagules including perennating structures and seeds (Elmore, Roncoroni, and Giraud 1993). While generally regarded as effective only in warmer climates, there is some evidence that it can be effective in cooler climates (Lambrecht and D'Amore 2010). Solarization may be considered where herbicides are not able to be used. Initial setup can be time-consuming and require more manpower to implement than herbicides or mowing, which can be performed by a single person. Existing vegetation must be cut very short to minimize the risk of stems penetrating the plastic. The plastic must then be applied to the ground and the edges weighted to prevent it from moving. The plastic must be removed once the solarization process is complete, which can take several years. Solarization may be undesirable near public areas where the appearance of a site is valued, since the plastic must remain on the ground for an extended period.

3.1.2 Preferred Control Strategies by Attribute

The optimal control method for invasive plants will depend heavily on the size of the infestation, habitat and other conditions at the site, and the growth form and identity of the invasive species. Other considerations are cost and availability of personnel or equipment. Often a single method will not control an invasive plant population; multiple methods must be used as part of an integrated management plan.

[5] http://www.fs.fed.us/database/feis/plants/graminoid/phraus/all.html#FIRE%20EFFECTS

SMALL INFESTATIONS

Small infestations are easiest to control and may require the least extreme methods. For small, shallow-rooted plants, it may be possible to hand-pull or hand-dig plants. Depending on the size of the infestation, this method may be relatively inexpensive and not too time-consuming. If it is easy to remove the entire plant, complete eradication may be possible with minimal effort. Hand-pulling is typically easier in moist soils. One drawback is that the soil around the plants will be disturbed, increasing the risk of reinvasion and encouraging germination of invasive plants in the seed bank. This can be mitigated by immediately seeding or planting with appropriate native plants. In areas where soil disturbance is not desirable, herbicides or solarization may be used. Typically, herbicide is the best management practice for treatment of invasive species over solarization. For woody species it may be desirable to hand-cut individuals prior to applying herbicides. Many woody species will regrow from their stump or roots, so it will be necessary to apply multiple herbicide applications. Although solarization may be effective for small infestations of some invasive species, it will require the purchase of extra materials, plants still need to be cut low to the ground prior to treatment, and the plastic sheeting will need to be monitored for breaks as woody species regrow. For a small infestation that can easily be eliminated by hand or herbicide application, any other control method is unlikely to be cost-efficient.

LARGE INFESTATIONS

The largest infestations require control methods be applied in a reasonable amount of time, whether biological, mechanical (forestry mulcher, mowing) or chemical (herbicide application from a vehicle). If target invasive plants dominate the area to be treated, incidental damage to non-target plants will be minimal. If target plants are interspersed with non-target plants, more care will be needed. Habitat is also an important consideration for control methods involving vehicles. Use of a wheeled vehicle may be prohibited by wetlands, rough terrain, or steep slopes. The impact of vehicular movement within a site must also be considered – rutting or soil compaction may result and could be difficult to reverse. A prescribed burn could be an option if the site meets the conditions required, but fire is unpredictable and may not affect the entire site uniformly. Patches of target invasive species may survive that must be addressed later. Methods involving solarization or herbivores may be unrealistic for large infestations due to logistical constraints related to the size of the area, water levels or the ability to fence the area.

WETLANDS

Control methods in wetlands must be carefully planned to comply with state and federal regulations and avoid damaging the wetlands unnecessarily. Vehicle use in wetlands may not be possible if soils are saturated or if there is standing water. In this case, hand-pulling, hand-cutting, or application of herbicide by hand or backpack sprayer is recommended. Herbicides applied in wetlands must not contain surfactants to avoid harming aquatic wildlife. The general condition of a site should be considered when planning invasive plant control. If the invasive plants at a site are sparse and there is valuable native habitat remaining, then an effort should be made to preserve that habitat to reduce the risk of reinvasion and the amount of work that will be necessary to restore it. This may require the non-vehicular application methods outlined above.

GROWTH FORMS

Invasive plants exhibit multiple growth forms, and these can help determine appropriate control methods for them. Annual plants with shallow root systems are more easily hand-pulled, whereas those with a taproot may be more difficult to remove without digging. Some perennial plants have rhizomes, horizontal underground stems that make hand-pulling nearly impossible (e.g. phragmites). These plants can regrow even from small pieces of rhizome, necessitating either complete removal from the soil (which may not be realistic without heavy equipment) or cutting followed by herbicide application to kill parts of the plant that were not removed. Woody plants are often capable of regrowth from stumps or roots after being cut, and often cannot be pulled from the ground because of their large root systems. Typical treatments of woody invasive plants include either cutting to near ground level then applying herbicide to the cut stump or cutting a notch in the tree and applying herbicide to it.

3.2 Target Locations and Project Areas

In order to effectively plan the treatment of invasive species and habitat preservation within the watershed, a series of target locations and project areas were determined based on a series of logistical and ecological considerations (see Table 3.1 for a list of these areas). The recommended project areas for invasive species management for the first five years are within or near Onondaga Lake and focus on wetlands, lake/river littoral zone, and riparian zone habitats (Figures 3.1a and 3.1b). The magnitude of the presence of invasive species and the level of effort and cost to both eliminate invasive species from and then restore areas dominated by these species is so high that the entire available funding could easily be spent on a relatively small area. Therefore, the Trustees have previously identified that efforts focused on preventative measures in areas of high quality and/or rare habitats will not only provide the greatest overall ecological benefit but will also be the most cost effective. Based on the review of potential areas where invasive species control could occur in and around Onondaga Lake, it is recommended that the focus for the initial five years be split between preventive measures in areas of high-quality wetland and riparian habitat that were restored as part of remedial efforts in and around the lake and on targeted areas that have not been previously restored. These recommended areas are discussed in greater detail below. Figures 3.2a and 3.2b include additional priority areas that were identified during the selection process that the Trustees may consider either in the future or within the five-year timeframe covered by this report should funds be available.

These project areas have been broken down into two priority categories for potential implementation in the first five years (Tier 1 and Tier 2), and other areas of interest for future program implementation (Section 3.2.1). Tier 1 areas are recommended for implementation within the first five years covered by this report (2021 through 2025) and are the focus areas included in the cost estimations provided in Section 5.2 of this report. These areas are recommended for both ecological and logistical reasons, including the following:

- They are high quality habitat near the lake that will benefit from preventative measures.
- They are adjacent to these high-quality habitats and contain a prevalence of target invasive species that could serve as a colonization source to adjacent areas if left untreated.
- The existing information available regarding the area is sufficient to allow for limited preliminary site investigations. Access for implementation is likely to be granted by the landowner.
- The cost/benefit of control efforts align with overall program goals and budget.
- Additional benefits may be gained from control efforts, such as improved recreational access (please note that recreational benefits alone would not qualify an area for selection).

Tier 2 priority areas are recommended for consideration within the first five years if the costs for Tier 1 efforts are less than expected and once preliminary logistics are resolved (such as access agreements and pre-implementation site reconnaissance and planning). Also, if a Tier 1 priority site is put on hold for logistical reasons, it may be replaced by a Tier 2 priority site.

The different priority tiers for the project areas are reflected in Figures 3.1a and 3.1b.

For all areas where controls are initiated, some invasive species other than the primary target species will likely be encountered. Those species should be also be controlled to the extent possible while control teams are on site to avoid having to replicate efforts. If unexpectedly large areas of invasive species are found that, if controlled upon initial discovery would potentially prevent the intended scope from being completed on budget, then the Trustees should be consulted prior to expending any additional effort.

As discussed in Section 3.1.2, there are multiple methods that can be used for invasive species control, each of which has benefits or limitations in certain situations. The sections below discuss each priority area and suggest control methods that may be most effective given what is known about each area. The suggested methods below are listed in order by most preferred to least preferred, assuming ideal conditions. The chosen method of control and application for each area will need to be determined by the implementation team based on site conditions at the time control efforts are initiated, invasive species identity, extent of infestation, and expected effectiveness.

PRIORITY TIER 1 PROJECT AREAS

Area #1A: Onondaga Lake Shoreline (Figure 3.1a)

This project area encompasses an approximately 100-foot buffer inland from the lake shoreline, considered to be at the average lake water elevation of 362.8 feet (North American Vertical Datum [NAVD] 88). Most of the shoreline is owned by Onondaga County or Honeywell, both of whom will be coordinated with prior to any control efforts. Phragmites is the primary, but not the only species of concern along the shoreline, and appears to be scattered along most of the shoreline with intermittent dense patches also present. Representatives of Onondaga Lake Park have provided the Trustees a map showing known locations of the more significant patches along the eastern shore. This map should be used as the basis to guide initial control efforts. The northwestern shoreline should also be prioritized early in the program because the natural, forested shoreline is used by a variety of fish and wildlife and is near other NRD habitat restoration projects. Following control efforts in larger patches of phragmites, it is recommended that any areas devoid of vegetation be seeded with a native seed mix. The County has indicated that areas along the northwest shoreline also contain a prevalence of noxious species, such as poison ivy, that have impacted recreational use and will likely create logistical safety issues for treatment in this area. The general locations of these noxious species should be identified prior to implementation and control efforts initiated as needed to allow the teams to safely access the area.

Other sections of the lake shoreline should also be visited to identify and control areas of invasive species as time/budget allows. These efforts will need to be closely coordinated with other ongoing invasive species efforts along the shoreline to avoid overlap. For example, Honeywell has obligations under the NRD Consent Order to initiate phragmites control efforts along the Maple Bay shoreline. Honeywell also has ongoing obligations related to wetland restoration near the mouth of Ninemile Creek and along the southwest shoreline.

Due to the widespread value of managing invasive species surrounding Onondaga Lake, it is recommended that management efforts be conducted annually between 2021 and 2025. For dense stands of phragmites, one method that could be considered is cutting, followed by prolonged flooding. This method may be effective if there is a way to flood the phragmites without flooding adjacent lands (e.g., by erecting a temporary dike). Another method for controlling large stands of phragmites may be cutting followed by broadcast herbicide use (likely multiple applications, preferably in the late summer and fall to reduce risks to amphibians. For sparse stands of phragmites, a one-time application of herbicide using the hand-wicking method may be effective and has the additional benefit of limiting impacts to adjacent vegetation. Solarization may be used on very small stands of phragmites. Livestock such as goats may be an option to reduce phragmites if the site does not have standing water, can be fenced and the livestock can be provided with water and supplemental nutrition. For other species, isolated individuals of non-rhizomatous species can be hand-pulled or dug out if possible.

Area #1B: Onondaga Lake Littoral Zone (Figure 3.1a)

The Onondaga Lake Littoral Zone restoration area will generally be considered the in-lake area approximately from the edge of shore (elevation 362.8 feet NAVD88) to 100 feet into the lake, and includes the Onondaga Lake outlet up to where it meets the Seneca River near the John Glenn Boulevard Bridge. The lake water where control will occur are under New York State jurisdiction.

The only species recommended for control efforts is water chestnut, an extremely problematic floating aquatic species. Given that the current extent and abundance of water chestnut in the lake appears limited, the control efforts recommended here are considered a preventative measure designed to limit the ability of this species to expand in the lake. There have been several recent volunteer water chestnut pulling events in the lake and outlet by members of the Onondaga Lake Conservation Corps (OLCC). Since these efforts appear to have been effective at limiting the spread of this species, it is recommended that the Trustees coordinate with the OLCC and/or other similar groups and fund annual pulling efforts to ensure that they continue. Prior to the event(s), the sponsored group(s) should be required to conduct a survey of the nearshore areas to broadly document the extent of water chestnut so that control efforts can be focused on areas of greatest concern. This information should be provided to the Trustees, or their representative, prior to the event so that they can provide input on target areas. Events should be a minimum of four hours in duration, and more than one event may be needed each year. The timing of the pulling events should be in early summer prior to the maturation of water chestnut fruit that generally occurs in August. The approximate quantity of water chestnuts pulled from the lake annually should be tracked using a standardized measure agreed upon with other organizations involved in water chestnut removal to help gauge if control efforts are being effective. The sponsored group should be responsible for all coordination, implementation, and proper disposal of collected water chestnut plants.

Area #1C: Pottery Road (Figure 3.3)

The Pottery Road site is a privately-owned area located West of Onondaga Lake and is adjacent to the NRD Hudson Farms property. Permission from the property owners will be needed before any on-site work can begin. An unnamed creek connects the Pottery Road site to the area of the Hudson Farms site that is currently undergoing extensive wetland restoration. The Pottery Road site has not previously been restored but has been chosen as a priority area due to connectivity to a Hudson Farms restoration site and potential for spread of invasive species via the stream.

Aerial photographs of the site suggest that the site is dominated by a dense monotypic stand of phragmites. Significant portions of the site are likely to require extensive invasive treatment followed by restoration with native seeding and plantings. If restoration efforts are not conducted, then it is highly likely that invasive species will immediately recolonize the site. Given that the phragmites stand appears very dense, it is recommended that the same methods being used on the Hudson Farms site be used here. These methods include mowing in mid-summer (after flowers, but before seeds are produced) followed by herbicide application several weeks later after the stand has been allowed to grow to a height of approximately three to five feet. This allows for a more efficient application of herbicide by applying it over the top of plants compared to applying it through a dense wall of plants. This has the benefit of using less herbicide and the cutting and subsequent regrowth may also weaken the phragmites somewhat prior to treatment. Subsequent herbicide treatments will likely be required the following spring and fall to eliminate plants that may have survived or that sprout from the existing seedbank or rhizomes. Since this is a large, dense stand of phragmites, an alternative method to explore is cutting followed by flooding, if it is determined that water levels can be maintained to flood cut stems for an extended period of time. This would entail some blockage of the unnamed creek that drains into Ninemile Creek.

Following successful control efforts, seeding and planting with robust native species is also recommended to improve habitat resilience to reinvasion. Following restoration, a monitoring and maintenance program will be needed for a minimum of three years to five years. The program should include periodic site visits during the growing season to check on native plant growth and document any recolonization by invasive species. It should be expected that portions of the site will require re-seeding/planting and some areas will contain interspersed invasive species that should be spot--treated on an annual basis where they occur.

Area #1D: Geddes Brook and Ninemile Creek Maintenance Area (Figure 3.4)

The Geddes Brook and Ninemile Creek project area consists of a network of previously restored wetland and riparian areas (totaling approximately 50-acres) that create a high quality habitat corridor along an approximately two mile stretch from where Ninemile Creek enters Onondaga Lake to the Geddes Brook site west of the New York State Fair. The upstream area of Geddes Brook and Ninemile Creek to the I-695 offramp is owned by Honeywell. The remainder of the area is either part of New York State Department of Transportation rights of way or owned by Onondaga County. Prior to remedial action and subsequent habitat restoration by Honeywell, the habitat was dominated by phragmites. However, since remediation and restoration, this area is now represented by high quality and diverse habitats that are used by a wide variety of wildlife. Several plant and animal species listed as threatened, endangered, or rare have been documented in these areas. In addition, a small inland salt marsh occurs here. The remediation and restoration efforts of Geddes Brook were completed in 2014, and the monitoring period following restoration was completed in 2019. Restoration efforts in Ninemile Creek were completed in sections between 2012 and 2014. As of 2019, the five years of mandated monitoring and invasive species control associated with the site remedy have been completed in all sections of this area. Verification from NYSDEC that habitat related obligations by Honeywell have been met will be needed before maintenance control of invasive species can be considered by the Trustees.

According to the most recent annual progress reports approved by NYSDEC (Parsons 2017), invasive species control appears to have been successful at both the Geddes Brook and Ninemile Creek sites, with invasive species cover below 2% in most areas and below the maximum target value of 5% cover in all areas. The high-quality habitat that now exists here, including a rare inland salt marsh area, combined with the diverse assemblage of plants and animals that have been documented using these habitats, makes this area a priority for preventative invasive species control efforts. With invasive species cover having already been maintained at low levels as part of the mandated five-year site maintenance program that is now complete, the level of effort required to continue controls is likely low for such a large area. It is recommended that this entire area be a primary focus in year one of the invasive species control project. Given that invasive species are now uncommon here, it is expected that additional control will require low effort and will likely only be needed every other year in the form of spot treatment, hand-wicking with herbicide, and hand pulling of individual new growth plants. These methods should be sufficient to maintain habitat quality and thereby minimize peripheral impacts. For this reason, we recommend revisiting this area in years three and five. Should conditions at the site change, then the frequency of invasive controls should be adjusted.

Area #1E: Geddes Brook and Ninemile Creek State Fair Wetland (Figure 3.4)

The Geddes Brook and Ninemile Creek State Fair Wetland project area is located on State Fair Property, adjacent to the Ninemile Creek wetland Reach CD and the Geddes Brook site (see Figure 3.4). This site has not been managed in a previous restoration effort and will require additional reconnaissance to assess current invasive species conditions. However, because this location is adjacent to the previously managed Geddes Brook and Ninemile Creek sites which contain few invasive species, this site has been considered a primary focus of the invasive species control project during the first five years. Restoration of the site would not only create additional high quality habitat in this area but would also limit the potential for reintroduction of invasive species into previously restored sites nearby.

A large portion of the site appears to contain phragmites with interspersed trees. The extent and density of phragmites at the site suggest that multiple herbicide applications may be the best approach. The site should be evaluated to determine if any portion would benefit from mowing prior to the first treatment. Ideally, the first treatment would be late summer of year one, followed by a second treatment in late spring/summer of the following year, and a final spot treatment of any remaining invasive plants in late summer. Significant restoration of native species through planting and seeding will be necessary following elimination of invasive plants. The density and types of plantings will need to be determined based on information gained from site visits during the invasive control period. The addition of trees and shrubs in select areas may be beneficial to both further diversify habitat and also minimize the chances of recolonization because phragmites does not tolerate shade. Following restoration, a monitoring and maintenance program will be needed for a minimum of three to five years. The program should include periodic site visits during the growing season to check on native plant growth and document any recolonization by invasive species. It should be expected that portions of the site will require re-seeding/planting, and some areas will contain interspersed invasive species that will need to be spot-treated annually where they occur.

Area #1F: Onondaga Lake Wetlands – Mouth of Ninemile Creek (Figure 3.5)

This project area includes approximately 20-acres of wetland and in-lake emergent and floating aquatic habitat on the western side of Onondaga Lake at the mouth of Ninemile Creek. The area was previously restored as part of the Onondaga Lake remediation. The restoration took place in 2016 and improvements in native vegetation cover and a decrease in invasive species cover is clearly visible. It also provides habitat for over 75 documented wildlife species according to the latest annual progress report (Parsons 2018b). The third year of the five-year mandated monitoring period for the site was completed in 2019. Invasive species cover is very low overall according to the latest annual report, with sparsely distributed purple loosestrife and some limited phragmites. Assuming habitat criteria are achieved at the end of the mandated five-year monitoring and maintenance period in 2021, it is recommended this area be added to the Trustees control program beginning in 2022. The criteria at this site is for invasive species cover to be no greater than 5%. Therefore, invasive species should be under control and preventive controls will be the priority. Purple loosestrife should be hand pulled before it goes to seed in late summer to the extent possible; however, spot spraying or hand-wicking with herbicide may also be necessary in some areas. The hand-pulled purple loosestrife should be examined closely for signs of insect herbivory. If none, or little, is observed, then obtaining a permit for appropriate biological controls should be considered. The frequency of controls to maintain habitat quality should begin at every other year and adjusted if needed.

Area #1G: Western Shoreline Wetlands and Adjacent Area (Figure 3.6)

This project area consists of approximately 12-acres of restored wetlands along the western shoreline of Onondaga Lake, including three inland (perched) wetlands and one wetland that is connected to Onondaga Lake. The project area encompasses approximately 35-acres which include a wetland buffer around the wetlands and along the shoreline. The property is owned by Onondaga County, and the area was restored by Honeywell as part of the lake cleanup effort. The Trustees will verify that Honeywell's obligations for invasive species control are complete and will coordinate with Onondaga County prior to initiating further preventative controls.

Prior to remedial action and subsequent habitat restoration, most of the area was generally devoid of vegetation except for scattered stands of invasive phragmites that provided little habitat value. The area now consists of a high quality, diverse wetland/riparian zone complex. The wetlands proximity to the shoreline makes it an important area for shorebirds, amphibians, and turtles. In fact, the shoreward banks of wetlands in some areas were specifically designed with coarser materials for turtle nesting. Some of the native vegetation from the inland wetlands has spread into the adjacent shallow areas along the lake shore resulting in an unexpected benefit to the habitat there. With invasive species cover having been controlled as part of a mandated five year site maintenance program associated with the remedy, the level of effort required to continue controls is likely low for such a large area. It is recommended that the wetland and shoreline areas be a primary focus in year one of the invasive species control project and then revisited in years three and five. The adjacent buffer areas should be inspected prior to the initial control efforts to determine if there is evidence of invasive species encroachment so that any needed targeted controls in those peripheral areas can be undertaken.

Visual observations of the shoreline suggests that purple loosestrife is sparsely scattered along the shoreline and isolated small patches of phragmites are also occasionally present. Attempts to hand-pull individual purple loosestrife plants should be made first; however, spot treatment or hand-wicking with herbicide may be necessary for mature plants with deep root systems or in patches where plants are more numerous. Phragmites will likely need herbicide spot treatment (for patches), hand wicking (for sparse growth), or stem injection (for individual plants) with herbicide because the likelihood of leaving behind rhizomes that will sprout new growth is too great if attempts are made to hand-pull plants.

Area #1H: Danforth Ponds and Southeast Shoreline (Figure 3.7)

The Danforth Ponds area is adjacent to Onondaga Lake's southeast shoreline that includes areas on both sides of Onondaga Lake Parkway from the railroad bridge at the north end to the on-ramp to I-81 at the south end.

This area includes approximately 13-acres of shallow ponds, phragmites dominated wetlands, and parkland. The wetland area furthest to the south, near the on ramp to I-81 is part of the NYSDEC wetland SYW-12, and two other ponds are federal wetlands. This area is influenced by saline groundwater and contains the largest known remnant of the expansive inland salt marshes that once existed on the southeastern side of the lake. There are three areas of known saltwater surface discharge, including adjacent to the northeast side of the railroad bridge, the Gale Salt Spring at the approximate mid-point of the site, and a wetland area adjacent to the Danforth Pond near the southern end of the site. The area is mostly on County-owned property, with CSX Transportation appearing to own a section adjacent to the railroad tracks that parallel the property.

The wetland complex along the southern portion of the site occupies approximately 11-acres and is dominated by phragmites that is limiting biodiversity and wildlife usage. Control efforts alone would likely only result in temporary improvements because the saline conditions favor phragmites re-invasion. Therefore, a focused restoration effort would also be needed to establish a robust native inland salt marsh plant community. Although costly, restoration of this area would not only represent the re-establishment of a globally endangered ecosystem type, it would also significantly increase biodiversity and habitat value in one of the few remaining wetlands along the shores of Onondaga Lake. In addition, there are plans underway for the final section of the Loop-the-Lake trail to be constructed adjacent to this area and offers a unique opportunity for the public to interface and learn about this incredibly rare habitat. For these reasons, it is recommended that the Trustees consider an aggressive invasive species control effort in this area followed by restoration using native salt marsh plants. This may be an area where goats could be used to reduce phragmites stand density. This could be followed by using mechanical/herbicide methods. The recommended approach would include mowing in mid-summer (after flowering, but before seed set) followed by herbicide application several weeks later after the stand has been allowed to grow to a height of approximately three to five feet. This method allows for a more efficient application of herbicide by applying over the top of plants compared to applying through a dense wall of plants. This has the benefit of using less herbicide and effectively applying herbicide to smaller phragmites plants that would otherwise be overtopped by larger plants. Plant cutting and subsequent regrowth may also weaken the phragmites somewhat prior to treatment. Subsequent herbicide treatments would be conducted the following spring and fall to eliminate phragmites that may have survived or that sprout from the existing seedbank or rhizomes. During the fall following the final treatment, a native seed mix composed primarily of salt-tolerant species would be installed. The next spring, herbaceous salt marsh plants would be installed at an average density of at least 3,000 plants per acre. While the native vegetation becomes established over at least the first five-years, invasive species control should occur twice a year (late spring and late summer/early fall) to prevent recolonization by phragmites. It should also be expected that some level of replanting/seeding will be needed for at least the first two years.

The exact boundaries of this work would be determined following consultation with Onondaga County regarding plans for the future trail. Dr. Donald Leopold, of the State University of New York College of Environmental Science and Forestry, is an expert on inland salt marshes and should be consulted as part of the planning and restoration efforts. Permission may also be needed from CSX prior the start of work. The costs of this effort will likely be greater than can be accomplished under the invasive species control project without sacrificing controls in other areas, so alternatives should be considered. For example, since most costs are likely associated with restoration and maintenance following initial controls, those components could be funded as part of a separate project. Some costs for planting could potentially be mitigated by using volunteer groups such as the OLCC.

In addition to the primary area under consideration at the southern end of the site, there are opportunities to control phragmites in other areas along this shoreline. Controls instituted in these areas would both enhance habitat value, reduce potential colonization sources for the restored areas, and restore additional inland salt marsh areas in some cases. For example, the saltwater discharge near the railroad bridge feeds a small wetland/ditch area that is less than half an acre in size and could be restored as a small salt marsh. In addition, most of the east edge of the area is at the base of a steep hill and phragmites is abundant in some areas, especially along the southern end across the road from the primary restoration area.

Area #1I: Crouse Hinds Restoration Area (Figure 3.8)

The Crouse-Hinds location is the site of two inactive landfills, referred to as North and South Landfills, along Ley Creek near the southeast end of Onondaga Lake. The area is owned by Cooper Crouse-Hinds. The approximately 14-acre site has previously undergone remediation followed by habitat restoration that included three wetland areas. Connectivity to the lake, its location along the bank of Ley Creek, the proximity to Project Area #1H, and status as part of the NYSDEC wetland SYW-12 all contribute this area being recommended for inclusion. The site has at least one year of habitat maintenance requirements remaining before it could be considered for additional preventative controls by the trustees, assuming obligations by Cooper Crouse-Hinds have been met. The site is somewhat visible from 7th North Street which bisects the property, and it appears that there is a limited amount of phragmites along the edges of the visible wetlands. As a previously restored site, the level of effort for prevention is presumed to be low. Once NYSDEC indicates that habitat obligations at the site have been met (assumed to be in 2021) and permission is granted by the owner, it is recommended that preventative invasive species control measures be considered in 2022 and 2024. The need for preventative measures beyond this should be discussed in the 2024 report.

Area #1J: Ninemile Creek Upstream (Figure 3.9)

The Ninemile Creek Upstream project area will encompass approximately 3.5 miles of Ninemile Creek (7.5 miles of streambank total) extending from the southwestern edge of Geddes Brook [Project area #1D]) to the intersection with the Erie Canal (near Thompson Road, southwest of Amboy, New York. The primary owners include the State of New York and Honeywell; however, an approximately 3,700- foot stretch of east bank at the southern end of the site is owned by private landowners. The project area contains patches of invasive species along the banks interspersed with native species. Although phragmites appears to be the primary species of concern, purple loosestrife is also sporadically present, as are Japanese knotweed and European buckthorn. The largest patches of phragmites appear to be along the north bank just upstream of Geddes Brook. The connectivity to other project areas and Onondaga Lake make Ninemile Creek Upstream a priority site for prevention of the spread of invasive species. Direct benefits to habitat will be gained from the control of invasive species along the riparian zone of the creek.

Control efforts in the lower reaches of this site are a priority because these areas are the closest to the lake and downstream restoration areas. Because this site encompasses such a large area, it is anticipated that implementation will occur each year for at least the first five years of the program. Starting at the downstream end near Geddes Brook. Control efforts will then gradually move upstream in subsequent years. It is anticipated that most invasive species are sporadically distributed along the banks and those plants will be hand pulled, spot treated or hand-wicked for efficiency. Only minimal follow-up restoration using a native seed mix is expected in these areas. Areas with an abundance of invasive species may need to be visited over consecutive years and will likely require both seeding and some plantings of native vegetation following completion of controls. The extent of restoration efforts required will need to be determined on a case by case basis and will be discussed in the annual report. It appears that areas with an abundance of phragmites are mostly located along the northern bank at the downstream end of the project area. Some sections of this area are scheduled to enhanced in the near future as part of Honeywell efforts related to Settling Basins 9 through 11, so coordination with NYSDEC and Honeywell will be necessary to avoid these areas until the restoration and associated maintenance period are successfully completed.

Area #1K: Native Grassland – SCA (Figure 3.10)

The Native Grasslands Sediment Consolidation Area (SCA) project area consists of an approximately 50-acre native grassland created by Honeywell, on Honeywell owned land, as a requirement of Project #6 of the NRD Consent Decree. Native grasslands are uncommon and provide important habitat for many bird species, some of which are uncommon. The Trustees view this area as a critical habitat component for the area and wish to continue invasive species management at the site once Honeywell's obligations are fully met. The native grassland at the SCA was completed in 2017, and Honeywell's obligations for invasive species control continue through at least the five-year period of 2018 through 2022. If the goals for invasive species control are met at the end of that timeframe, then Honeywell's obligations related to invasive species will end, and the Trustees can begin preventive control efforts. As noted in the most recent annual progress report submitted by Honeywell to the Trustees, the site has demonstrated significant native vegetation growth, an increase in grassland species diversity, and low invasive species cover. Because this site is mostly composed of upland habitats, the species that may be considered for control differs from many of the other project areas that are mostly wetlands. The primary species of concern appears to be mugwort (*Artemisia vulgaris*), which is present in low numbers on the site. Mugwort is a common upland invasive species that is difficult to eradicate. Limited amounts of phragmites have also been documented on moist areas of the site. Another species that is mentioned in the CD scope of work as being potentially problematic is reed canary grass. Although this species should be targeted if present, it currently appears to be practically absent. With an abundant cover of native species, conditions seem unfavorable for it to be become problematic in the future.

Due to the apparent success of current management of invasive species at the site, it is suggested that preventative controls occur every other year beginning in 2023.

Area #1L: LCP Wetlands and Adjacent Area (Figure 3.11)

This project area includes approximately 20-acres of restored wetlands located on Honeywell owned property south of the New York State Fairgrounds. This area is upstream of the Geddes Brook, Ninemile Creek and Onondaga Lake habitat restoration sites, making it an important component of this habitat restoration complex. Prior to Honeywell's remediation efforts, the site was dominated by a monoculture of invasive phragmites that offered little habitat value. The restored wetland complex is composed of three diverse wetlands (A, B, and C) and a small wetland ditch called the West Flume. Restoration in Wetlands A and B was completed in 2007 with the removal of impacted soils and the planting of native wetland plant species. Restoration in Wetland C and a small portion of Wetland A that needed rework was completed in 2012 that restarted the five-year monitoring and maintenance period in Wetland A. After the five-year monitoring period was completed for Wetland B in 2012, the restoration was considered successful, and NYSDEC approved the recommendation that monitoring and maintenance activities could end there (Parsons 2018a). The five-year monitoring and maintenance period for Wetlands A and C was completed in 2017. The last publicly available annual report from 2016 indicates that invasive species cover was well below goals, suggesting that obligations there will also end soon. Honeywell's obligations for all habitat maintenance will likely be complete by the time the Trustees invasive species control program begins. However, this should be verified with NYSDEC prior to the start of any work associated with this site. The low percent cover of invasive species documented in the most recent annual reports for the site suggest that the Trustees efforts should focus on preventative measures every other year starting in 2021. These measures should be focused on maintaining habitat value while preventing the site from becoming a potential colonization source for the other downstream restoration areas.

Based on available annual reports for the site, it appears phragmites will be the primary species of concern. By the time Trustees' efforts begin, some areas such as Wetland B will have presumably not received invasive controls for at least several years. Although robust wetland restoration areas are typically capable of deterring invasive species, it is recommended that the Trustees and/or their representatives conduct a site inspection prior to the start of work to delineate control boundaries and ascertain the level of effort that will be required. Following that inspection, adjusted to the schedule and/or level of effort may be needed.

The project area shown on Figure 3.11 also includes a large buffer area of approximately 18-acres that includes both wetland and upland habitats. These areas have not previously been managed, and phragmites appears to be abundant. Most of the areas with phragmites are adjacent to railroad tracks and/or a scrap yard, making them less than ideal candidates for full control and restoration. They have therefore not been included as areas recommended for control/restoration efforts in the first five years. The focus in these areas should be aimed at deterring the phragmites from migrating into previously restored areas. This can be done with herbicide spraying targeted at the edge of dense phragmites growth. This will effectively "push back" the phragmites edge from the restoration areas and provide a buffer zone.

Area #1M: Native Grassland – C&D (Figure 3.12)

The C&D Native Grassland is located on approximately 32-acres of landfill operated by the Town of Camillus. Honeywell installed the 32-acre grassland in 2019 as part of their obligations under the NRD Consent Decree (Project #6). Ultimately, the size of the grassland will grow to approximately 50-acres, with the additional acreage being added as portions of the landfill are closed in the future.

Maintenance and monitoring obligations by Honeywell for the 32-acre section will begin in 2020 and conclude in 2024 if performance criteria are met. Therefore, the earliest the Trustees will consider invasive species control will be in 2025. Invasive species abundance following the initial five-years of control by Honeywell is expected to be low, so the Trustees may wish to consider delaying the start of preventative measures until the entire ~50-acre area is available. The monitoring results of the Honeywell program should be reviewed following submittal of the 2024 report and a decision made then regarding timing and methods of control.

Area #1N: Southwest Shoreline Wetland Restoration Area (Figure 3.13)

This area includes an approximately 18-acre restored wetland complex along the southwestern shore of Onondaga Lake. Prior to restoration, this area was almost entirely composed of dense stands of phragmites. The site now contains a diverse assemblage of habitats that includes emergent, floating aquatic, and forested wetlands, as well as approximately 4,500 linear feet of shoreline riparian zone. The shoreline areas were restored in 2017 as part of the Onondaga Lake remedy and represent approximately 17 of the 18-acres at the site. These will be monitored and maintained as part of that program until at least 2022. An additional approximately 1-acre inland wetland was restored in 2019 near the mouth of Harbor Brook as part of the Settling Basin B remedy and will be maintained under that program until at least 2024. The most currently available monitoring results documented over 100 plant species within these restored areas, and invasive species percent cover is less than one percent. Extensive use by over 70 fish and wildlife species including several that are threatened or of special concern was also documented

Most of the site (approximately 17 of 18 acres) completed its second year of the five-year mandated monitoring period in 2019. Invasive species cover is very low overall according to the latest available annual report. Purple loosestrife and some limited phragmites are sparsely distributed. Assuming habitat criteria are achieved at the end of the mandated five-year monitoring and maintenance period in 2022, it is recommended this area be added to the Trustee control program beginning in 2023. The remaining 1-acre inland wetland will not be eligible for consideration until at least 2025, at which time it should also be added to the program. To the extent possible, purple loosestrife should be hand-pulled before it goes to seed in late summer; however, spot spraying or hand-wicking with herbicide may also be necessary in some areas. The hand-pulled purple loosestrife should be examined closely for signs of insect herbivory and if none, or little, is observed, then obtaining and permit for appropriate biological controls should be considered. Phragmites will likely require herbicide to be effectively controlled; hand wicking should be prioritized when possible to minimize damage to surrounding native vegetation. The frequency of controls to maintain habitat quality should begin at every other year and be adjusted if needed.

Area #1O: Upper Harbor Brook Area Maintenance Area (Figure 3.14)

The project area extends from the mouth of Harbor Brook upstream approximately 1,000 feet and includes approximately 3 acres of wetlands and riparian zone restored as part of remedial activities. Prior to restoration these wetlands were dominated by a combination of phragmites and to a lesser extent purple loosestrife. The restoration included installation of approximately 60 different native species. Initial observation documented in the Performance Verification and Monitoring Plan indicate successful establishment of the native vegetation (OBG 2015). Annual reports that document post-restoration invasive species cover are not yet available.

However, the criterion for percent cover of invasive species after five years is a maximum of 5% (OBG 2015), so it is expected that efforts conducted as part of the Trustees invasive species program will focus on preventative measures. These measures will protect both the 2.5-acres of on-site wetlands and also the 17-acre wetland complex along the southwest shore of Onondaga Lake that is immediately downstream. The five-year monitoring and maintenance period associated with the restoration will end, at the earliest, in 2021. It is anticipated that preventative control efforts performed every other year should be sufficient if the invasive species cover is less than 5% at the end of the required five-year period associated with the initial restoration. The species present and their distribution will dictate the types of controls used; however, it is expected that they will be similar to those recommended at other previously restored sites.

Area #1P: Upper Harbor Brook Area Upstream Areas (Figure 3.14)

The Upper Harbor Brook Area Upstream Areas consist of approximately 1.5-acres of streambank and riparian zones along approximately 3,500 linear feet of stream that starts directly upstream of Project Area #1O and ends at a section of Harbor Brook that starts an approximately 5,500-linear-foot section that is completely underground. The project area has not been previously restored and appears to be periodically mowed along much of the west bank. The east bank appears to have a tree canopy along the downstream half and is mowed along much of the upstream half. Invasive species are likely interspersed within the project area. Invasive propagule pressure is likely low because the upstream source areas are underground and the project area is small. The level of effort is therefore expected to be low. A site assessment should be carried out in 2021, and the results of that assessment used to recommend appropriate control measures to be implemented in 2022 and 2024.

Area #1Q: Inner Harbor Restoration Area (Figure 3.15)

This last Tier 1 project area is located on the north riparian edge of the Inner Harbor canal, from the Hiawatha Boulevard overpass to the mouth of Inner Harbor at the south end of Onondaga Lake near where the CSX rail tracks cross over Onondaga Creek. This area was chosen because of its proximity to downstream restoration areas along the lake's shore and the prevalence of invasive species, including phragmites and European buckthorn along the shoreline. A secondary benefit of this effort may occur from the elimination of phragmites that is restricting use of an adjacent recreational trail. Although there appears to be one large area of phragmites present that will likely require a multi-year effort to control, most areas appear to contain small to moderate size stands that may be controlled with a single targeted application of herbicide. Japanese knotweed may also be present and should be controlled in a similar fashion. European buckthorn and other invasive trees and shrubs are present along the shoreline slope. A site assessment should be undertaken in the first few years of the program to determine the extent of these species and recommend specific actions. Areas with dense stands of phragmites should be reseeded with a native seed mix following successful elimination of phragmites. Areas where invasive trees and shrubs are removed should be re-planted with native species selected based on site conditions. Given this area has not been previously restored, an annual effort for at least the first five years will likely be needed.

PRIORITY TIER 2 PROJECT AREAS

Area #2A: NRD Wetland Conservation Hayes Road Area (Figure 3.16)

The NRD Wetland Conservation Hayes Road Area is an approximately 130-acre site located adjacent to Seneca River at the North end of Onondaga Lake. Restoration has not previously occurred on the site, but site visits conducted as part of the initial NRD process suggest that the site offers excellent habitat that has an abundance of cattail and native wetland trees/shrubs. Some invasive yellow iris (*Iris pseudacorus*) is present, but does not seem dominant. There does appear to be one small area of phragmites (< 1-acre) that could be considered for control in the future. The site has been identified as a Tier 2 priority area because it currently offers overall excellent habitat value that should be protected if possible, and it is near the lake. However, it is not directly connected to the lake or associated with other restoration sites. If time/budget allow, a site assessment should be conducted to determine if this area should have an increased focus in future years.

Area #2B: Long Branch Road (Figure 3.17)

The Long Branch Road project area is located on the northern end of Onondaga Lake east of the Seneca River outlet and is bisected by Long Branch Road. The approximately 42-acre site is almost entirely composed of dense phragmites. This area is considered a Tier 2 priority even though restoration of such a large area would have significant ecological benefits. However, it is not directly connected with the lake or other project areas, restoration would require permissions from multiple landowners, and the costs would be very high which would cause many of the previously identified Tier 1 areas to be removed from the program. As the Trustees invasive species program progresses, this area should be considered if the budget allows for additional full-scale restoration.

Area #2C: Thompson Road (Figure 3.18)

Located between Ninemile Creek Upstream areas and Thompson Road, this project area consists of approximately three acres of unrestored riparian wetland approximately 100-feet from Ninemile Creek that appears to be largely dominated by phragmites. While the project area is relatively small, the apparent high density of phragmites would likely require multiple years of control and restoration efforts to achieve success and would be costly. However, the proximity to Ninemile Creek and the connectivity to downstream sites makes this one of the best sites to potentially move into Tier 1 in the future.

Area #2D: Erie Canal Trail (Figure 3.19)

A new section of the Erie Canal Trail will run west from Bridge Street in Solvay to Reed Webster Park in Camillus and is scheduled for completion in 2020. This section of trail will provide access to a variety of habitats that previously were not easily accessible. In addition, the current trail runs adjacent to the canal from Reed Webster Park west to the Ninemile Creek Aqueduct where the Tier 1 Ninemile Creek Upstream Invasive Species Control project ends. Combined, the two sections of trail are over four miles long. The ease of access the trail offers to a diversity of habitats would make invasive control efforts highly cost efficient over such a wide area. However, the level of invasive species abundance along these sections of trail is not well documented, so the project should be considered as secondary effort until additional informational be obtained.

Area #2E: Town of Camillus Highway Garage (Figure 3.20)

The Town of Camillus Highway Garage area is an approximately 10-acre wetland site located along Ninemile Creek to the west of the Camillus Highway Garage in the Town of Camillus. Aerial photographs suggest the periphery of the wetland is mostly phragmites; however, the extent of invasive species cover has not yet been assessed. The proximity to Ninemile Creek and its location in a largely isolated wooded area would make it an excellent candidate for restoration. This area is designated as Tier 2 until additional information can be obtained that will allow for a better estimation of potential cost and benefits. Following an invasive species assessment, this focus area may be re-evaluated.

Area #2F: Camillus Valley Natural Area (Figure 3.21)

Camillus Valley Natural Area is a 248-acre nature preserve owned by the Central New York Land Trust. Just south of the village of Camillus, it contains almost 2.5 miles of Ninemile Creek and appears to contain several large to moderately sized stands of phragmites. The size of the preserve makes it impractical to conduct invasive species controls throughout, but targeted controls could also potentially yield significant benefits. If the landowners are willing to consider control efforts, then this area should be considered for additional evaluation.

3.2.1 Other Target Areas and Considerations

Other areas of potential interest for future program implementation, beyond the initial five-year timeframe, are shown in Figures 3.2a to 3.2b. These focus areas were deemed significant enough for consideration but were not included as Tier 1 or 2 areas for a various reasons that are discussed briefly below.

NRD Tully North and NRD Tully South

The NRD Tully locations consist of two wetland areas within the area designated in the NRD Consent Decree as the Tully Recreational Area and Nature Preserve Project. Both locations fall between Tully Farms Road and Route 11A in Tully, New York. Onondaga Creek flows through both sites, making them impactful on the Onondaga Lake Watershed. The current extent of invasive species cover is unknown, but appears to be moderate. Although these areas would benefit from invasive controls, their distance from Onondaga Lake suggests they should be considered after areas closer to the lake are addressed.

Murphy’s Island

Located at the South end of Onondaga Lake between Ley Creek and Onondaga Creek, Murphy’s Island is recommended as a potential future invasive species control location. Connectivity to Onondaga Lake, proximity to other high priority sites, and ecological value as shoreline wetland habitat would make this a Tier 1 area. However, the site has been identified as potentially requiring remediation so cannot be considered for this project. Should remedial activities not be required or if remediation/restoration and associated monitoring obligations are completed within the timeframe of the trustees Control Plan, then this area should be given serious consideration.

Ley Creek

Ley Creek is located in the Southeast corner of Onondaga Lake between the lake and Project Area #1I and contains a prevalence of phragmites along the creek banks. Because of its proximity to the lake and the upstream restoration site, it would be a high priority for consideration. However, this area is part of an ongoing remediation project and so cannot be considered at this time.

Seneca River

The Seneca River project area is located immediately upstream of Onondaga Lake and contains areas of dense water chestnut. Water chestnut preventative efforts within the lake is currently recommended as a Tier 1 project. Control efforts funded by the Trustees to control established areas in the Seneca River would require continued maintenance as water chestnut will continually re-invade areas following its removal and would have minimal positive impacts to the lake as long as preventive measures remain in place there.

3.3 Post-Control Management Strategies

Complete eradication of target invasive plants at a site may not be realistic; reduction of the population to non-harmful levels may be an attainable goal but may require multiple years of treatment. It must be assumed that any remaining individual or patch of an invasive plant may expand in the future, even reaching pretreatment levels if not managed correctly. Even if invasive plants are eradicated at a site, there is always a risk of reinvasion. For this reason, post-control (that is, after success criteria have been met) management and monitoring should be implemented at all treated sites for a minimum of five years. Post-control monitoring will identify site areas that should be targeted for follow-up treatments. Follow-up should happen annually if the target invasive species are present at the site.

The goal of monitoring is to identify areas within sites where follow-up treatment of target invasive plants is needed and where native restoration plantings and/or seeding should be added, expanded, or replanted.

Monitoring is also conducted to identify any other measures that may be used to reduce the chance of reinvasion or spread of remaining invasive plants. The extent and details of monitoring activities each year will be based on the site assessment and recommendations discussed in the annual report for the previous year. Areas known to have had invasive plants the previous year should be monitored for the efficacy of treatment, treated again if needed, and tracked until the patch size reaches a level that can be routinely addressed each year. Monitoring frequency may be reduced when an area has been free of invasive plants for multiple years and restoration plantings have been successful. If it is decided the invasive plants at a site have been reduced to desired levels and follow-up treatment appears to prevent their expansion, monitoring may be replaced by a routine annual site-wide treatment by an applicator.

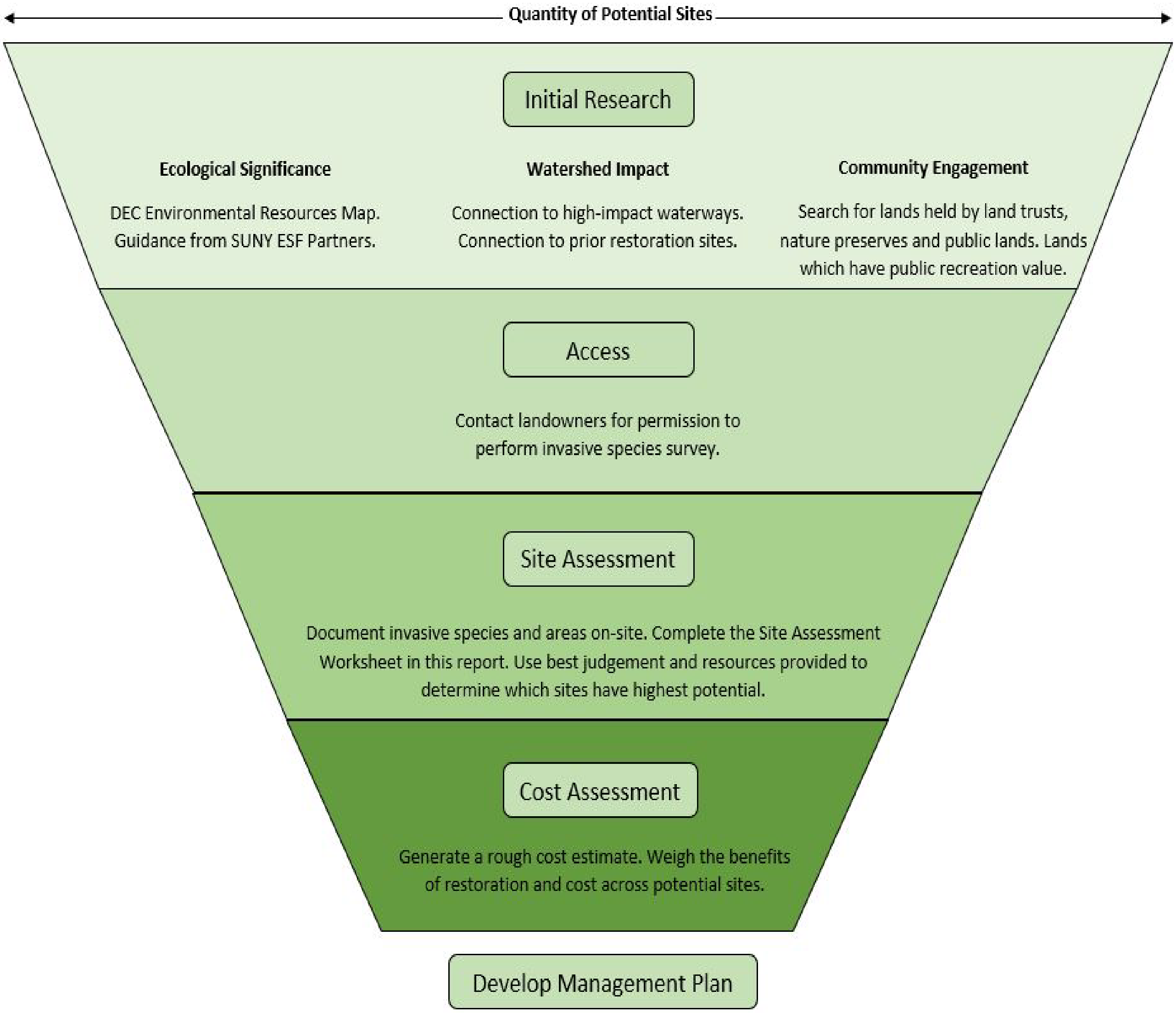
As important as eliminating invasive plant populations from sites is taking measures to reduce the chance of reestablishment. There is evidence that while the resident species in a community may not prevent the spread of exotic plants, they do reduce the success of invasions (Levine et al. 2004). Work by Naeem et al. (2000) suggests that invasive plant performance may decrease with increasing native diversity. It follows that plantings of native species may be beneficial to the long-term maintenance of a site in which invasive plants have been eradicated or reduced to non-harmful levels. Plantings should be located to increase competition with any invasive plants that may regrow following treatment and to minimize the amount of area at a site that is disturbed or prone to becoming disturbed (e.g., slopes prone to erosion). The species chosen for a site should be appropriate based on their specific identity and environmental tolerances and should include as many functional types as possible to maximize resource use, since unused resources may increase the probability of invasion (Davis et al. 2000).

3.4 Decision-Making Matrix

This section describes decision-making factors used to identify target areas for invasive species management that maximize positive ecological outcomes and cost-to-benefit ratios in the context of the region. Four priorities of invasive species management are presented as a framework for decision making (Sheley and Smith 2012; NYSDEC 2018):

1. Prevention of invasive species establishment on high-value sites
2. Early detection and rapid response
3. Ecologically significant habitats
4. Community engagement/public service

The focus areas recommended in this report reflect these priorities. However, identifying new opportunities that emerge during and after the first 5 years that this report covers will also be an important component of management. For this task, we present resources for identifying new potential sites, performing a site assessment, and developing an integrated management plan as visualized on the next page.



Decision-Making Process

3.4.1 Decision-Making Factors

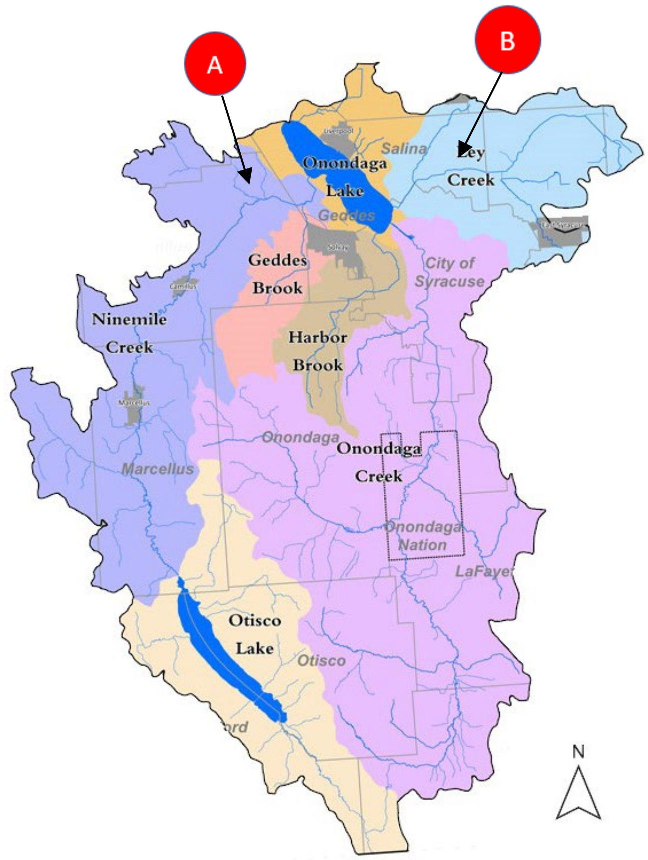
1. PREVENTION

Propagule pressure is defined as the number of colonizing individuals following an introduction event (Carr 2019). Sometimes also called invader supply, propagule pressure represents the pressure that invaders are putting on adjacent habitats and habitats along spread vectors. With high propagule pressure, environments that experience natural or human disturbance are at risk of invasion. Habitats that are frequently disturbed, such as riparian zones, are particularly at risk. Reducing propagule pressure requires a two-pronged approach. The first prong is reducing human-mediated transport of invasive propagules, and the second is controlling high-impact populations of invasive species.

Humans are the largest disperser of non-native species. Human transportation of aquatic invasive species is particularly impactful. A 2016 study in Illinois found that only 63% of boaters perform recommended actions to reduce the spread of aquatic invasive species on the exterior of their boats. However, recognition of prevention slogans in the region had a significant positive impact on always performing recommended prevention behaviors (Cole et al. 2016). This suggests that boater education on the transport of aquatic invasive species is impactful. With two high-use lakes in the watershed, targeted public outreach initiatives on the spread of aquatic invasive species could be resources well spent. On sites with public trails, educational signage should outline the danger of invasive species and recommend strategies to reduce their spread such as boot washing.

The second prong of reducing propagule pressure is actively controlling populations of invasive species on high-impact sites. High impact is defined here as sites that likely contribute a high volume of propagules to influential waterways. In the Onondaga Lake watershed, invasive species management in wetlands or riparian areas with surface flow connection to Ninemile Creek or Onondaga Creek will have the highest downstream benefits as they are likely the major distributors of waterborne propagules as depicted in the figure on the preceding page. Secondarily, management of lands connected to Ley Creek or Harbor Brook will have smaller but still significant effects. Reducing invasive propagules in these waterways will lessen the likelihood of invasions and reduce the ongoing management burden of high-quality and previously restored sites downstream.

To illustrate this point, consider the locations A and B on the figure to the right. Location B is contributing invasive propagules to Ley Creek, which drains into Onondaga Lake. It is certainly important to reduce propagule pressure on the lake, but Location B has few other high-quality sites downstream. Location A is a wetland complex on Pottery Road in Warners, New York which contributes propagules to Ninemile Creek upstream of Hudson farms, a large wetland complex in the process of being restored, and highly restored areas on Ninemile Creek near Onondaga Lake. While controlling Location B would reduce pressure on the lake, controlling Location A will reduce pressure on Hudson farms, multiple highly restored reaches of Ninemile Creek and Onondaga Lake. Therefore, we conclude that Location A has a higher watershed impact than Location B.



Onondaga Lake Watershed drainage patterns and example site locations (Onondaga Environmental Institute 2011).

2. EARLY DETECTION AND RAPID RESPONSE

Traditionally overlooked, early detection and rapid response on relatively invasive-free sites is the first priority in invasive species management (Sheley and Smith 2012; NYSDEC 2018). Early detection and rapid response also pays dividends in avoiding future costs. One dollar spent on such efforts can save 17 dollars spent on control or removal if invasive species establish (US Congress 1993).

Early detection of invasions is critical to maintain high-value sites. Once high-quality sites are identified for invasive species prevention, an invasive species assessment or walk-through must be conducted annually and new invaders must be treated. Compared to treating established populations of invasive species, this requires a low level of effort. Community involvement using citizen science apps such as iMapInvasives and SAS Pro and open communication with local nature and conservation groups and Partnerships for Regional Invasive Species

Management (PRISMs) can enhance early detection of invasive species on sites with public access or where permission from landowners has been granted. If detected in the earliest stages of invasion, control can sometime be achieved by mechanical means for certain species, thereby avoiding the use of chemical herbicides. Included in this category of high-value sites are the previously restored wetlands and waterways surrounding Onondaga Lake.

3. ECOLOGICAL SIGNIFICANCE

Ecologically significant habitats in the watershed may deserve restoration for their rarity and uniqueness in the landscape. These ecosystems often contain rare plants and animals, unusual soil and water chemistry, and historical and cultural significance. These often small and isolated habitats may not have high watershed impact but may be in immediate need of restoration as habitat loss and invasive species threaten to remove them from the landscape. An example of an ecologically significant habitat in need of restoration is the inland salt marshes of Onondaga lake. These globally endangered wetlands are fed by hypersaline water, making them toxic to most plant species and supporting a unique community of coastal halophytes hundreds of miles inland. Inland salt marshes were once expansive on the south end on Onondaga Lake, but centuries of anthropogenic disturbance have relegated them to a few small patches, most of which are invaded by the salt-tolerant phragmites.

4. COMMUNITY ENGAGEMENT/PUBLIC SERVICE

A 2015 study from Cornell found that about 87% of people in the Finger Lakes Region (for their study encompassing the Onondaga Lake watershed) were aware of invasive species, and 47% of people “know at least something” about invasive species (Connelly et al. 2015). Additionally, only 13% of respondents reporting know “a lot” about invasive species. Statewide, 41% of residents had never heard of water chestnut, 58% had never heard of zebra mussels, and 75% had never heard of hydrilla. They also analyzed awareness by stakeholder group: among other groups, only 54% of boaters in New York State reported to “know at least something” about invasive species (Connelly et al. 2015). Studies also suggest that education about the prevention of aquatic invasive species improves boater behavior (Cole et al. 2016; Gunderson 1994), presumably reducing aquatic invasive introduction. The savings in invasive response and removal from improved boater behavior have also been suggested to far outweigh the cost of public education (Oh et al. 2018).

Enhancing sites with public access provides additional value to invasive species removal. Ecological enhancement aside, improving areas of high public use creates a positive narrative and engenders support from the community. For this reason, assigning additional value to areas of public recreation is appropriate. Additionally, partnering with nature preserves, land trusts and public land stewards builds a valuable network that improves community engagement, early detection and response, and ongoing sustainability of initiatives.

3.4.2 Site Assessment

A site assessment worksheet (Table 3.2) has been developed to inform new site assessments. It reflects the priorities of invasive species management and can be used to evaluate the strengths or weaknesses of potential candidate sites for restoration. It is to give perspective to practitioners as they evaluate candidates. The worksheet questions assume that site access has already been arranged and landowners are receptive to an invasive species site assessment. Seeking partnerships with private lands held by land trusts, private or public conservation organizations and even private landowners with ecologically valuable properties is recommended.

The following paragraphs summarize the factors considered for site assessment:

- Status of invasive species on site: The first priority of invasive species control is early detection and rapid response. Sites that have high invasive species cover will be costly to restore and less likely to return to intact habitats. Sites with invasive species interspersed with native species will be less costly to control and will already have a native seedbank and native species on site. Sites with few or no invasive species will be very inexpensive to control and monitor, likely to remain intact, and prioritizing them saves on future management costs.

- Watershed Impact: Sites with a significant surface water connection to Ninemile Creek and Onondaga Creek will have the highest impact on the watershed. Invasive propagules traveling along these spread vectors will have long-distance dispersal across the watershed, potentially causing invasions across large areas. Sites with less potential impact receive lower scores.

- Ecological Significance: Ecologically significant habitats in the watershed may deserve restoration for their rarity and uniqueness in the landscape. These ecosystems often contain rare plants and animals, unusual soil and water chemistry, and historical and cultural significance. NYSDEC's Environmental Resource Mapper (https://gisservices.dec.ny.gov/gis/erm/) displays rare, threatened or endangered species habitat use and significant natural communities on an interactive map.

- Community: Community engagement is paramount in successful invasive species management plans. Local support can change the narrative and the public perception of restoration initiatives. Engagement and education can also reduce avoidable human-mediated spread of invasive species. Projects that improve the recreational or community value of public-access sites are encouraged.

- Effort: Assessing effort is a necessary element of any project with limited funds. Sites that score high in other categories and low in effort are preferred and reflect a high benefit-to-cost ratio. Perhaps a range of costs could be used to quantify effort in this section.

4.0 EDUCATION AND OUTREACH

Education and Outreach initiatives are key to keep the public informed and engaged in the management of invasive species in their communities. By increasing public knowledge and awareness about the impacts that invasive species have on the local biodiversity and public health, greater involvement can be achieved in applying preventative measures and in public participation activities.

Part of the approach proposed to increase public awareness lies in improving access to information on the presence and impacts of invasive species in communities. Information about invasive species can be conveyed to the public using various media and outlets, such as a webpage and social media platforms (i.e. Facebook, Twitter, and Instagram). These outlets should carry a common message consistent with that of local invasive-species management groups (e.g. PRISMs) and state-wide initiatives (such as Invasive Species Awareness Week). They could provide a means to increase awareness of major and accurate sources of information about invasive species, while promoting reasonable and effective actions people can take to reduce the spread of invasive species.

Another approach which could provide an opportunity for effective public education and outreach, is to carry out awareness campaigns targeting specific groups of people. These campaigns would help educate the public on what they can do to manage invasive species on their own land and how to prevent the spread of invasive species. These sources of information can also encourage landowners to participate in conservation incentive programs such as the USDA's Wildlife Habitat Incentive Program, the Wetland Reserve Program, and New York's Forest Tax Law. Other opportunities for education and outreach include making use of existing educational curriculum about invasive species as part of a science curriculum at all educational levels, in local schools, science museums, and so on https://www.dec.ny.gov/education/116542.html.

A key component to performing education and outreach efforts cost-effectively, is to work closely with the education and outreach staff in PRISMs and create partnerships with municipalities to encourage them to integrate invasive species management into their current management efforts. This can help extend the impacts of the invasive species management program beyond its original scope, while generating long term partners who can continue with legacy treatment programs beyond the duration of this plan.

Another form of partnerships can be through local stakeholder and interest groups, who can help coordinate volunteer opportunities for the public to engage in the actual invasive plant removal activities (a good opportunity for this is the water chestnut removal efforts proposed in Section 3.2). These opportunities strengthen relationships in the community and improve local engagement and buy-in to the program goals. Relationships with local non-for-profit organizations with missions related to environmental stewardship and vegetation management can also be good partners to help support public engagement, and to partner on the invasive species treatment work (a further opportunity to bring down costs while also enhancing the education and outreach program).

Potential stakeholder groups who might be interested in possible partnerships are identified (but not limited to) the following list:

- Bicycling Community
- Camillus Canal Society
- Izaak Walton League
- IWL-Alternate
- Nine Mile Creek Conservation Council
- Onondaga Audubon
- Onondaga County Fisheries Advisory Board
- Onondaga County Sportsmen's Federation
- Onondaga Lake Conservation Corps
- Onondaga Earth Corps
- Onondaga Lake Remediation CPWG
- Onondaga Yacht Club
- Sierra Club
- Syracuse United Neighbors

5.0 RESOURCES NEEDED AND ANTICIPATED COSTS

5.1 Resources Needed

The resources necessary to implement a comprehensive invasive species control program are discussed below and can be broken down into several categories, including:

- Program & Project Management
- Implementation (invasive species management and restoration activities)
- Safety and Quality Assurance and Quality Control Field Oversight
- Monitoring

PROGRAM MANAGEMENT

A strong program management structure will be necessary for the invasive species control program to be implemented in as safe and cost-efficient way as possible that maximizes effective implementation and associated habitat benefits. Ideally, the program will be managed by a small team that have experience managing large and complex habitat enhancement projects in New York State. As the Invasive Species Control Project proceeds in the coming years, the team will inevitably need to deal with a wide variety of challenges associated with implementation. Program management tasks would include coordination with the trustees and interested parties in the program, oversight of project specific management items such as attaining owner access agreements, contract management, obtaining the necessary permitting paperwork, managing financials and procurement costs, subcontractor oversight, and so on. The program should be led by a qualified biologist with experience successfully managing complex environmental projects including invasive species management and habitat restoration. An understanding of the target areas and their history will be essential to managing the program as efficiently as possible.

IMPLEMENTATION

The implementation stage of the program will require that a New York State certified herbicide applicator be used. If herbicide can enter an area of standing water greater than one acre then the applicator will need to be certified for Category 5A – Aquatic Vegetation Control, and have experience applying selective herbicide targeting invasive species with the objective of improving habitat quality. The ability of field staff to differentiate invasive from native species will be critical. Equipment may include hand held or mechanical application tools depending on the extent of the treatment that needs to be carried out. Any mechanized equipment that is needed in large wetland environments will need to be low-impact amphibious vehicles (such as a MarshMaster with a herbicide applicator or mowing attachment), to minimize any compaction and adverse impacts to existing wetlands, wildlife, water quality, and natural resources. All permit requirements will need to be met in order to minimize these impacts, which include the use as needed of erosion controls and/or wetland matting, applying cleaning protocols to mechanized vehicles to minimize any spread of invasive species, following fueling operations and leak prevention plans, and so on.

Part of the implementation efforts will also include restoration activities such as planting and seeding. Personnel dedicated to these efforts will at a minimum hold qualifications and experience in working on the restoration and habitat enhancement of large and complex impacted sites in the State of New York. All planting materials and seed used in the restoration efforts will consist of native species present in the Onondaga Lake watershed and will be approved by the Trustees prior to installation.

To complete implementation tasks in a cost-efficient manner the primary contractor responsible for implementation of invasive controls should likely be within a half day's driving distance from the Onondaga Lake area.

SAFETY AND FIELD OVERSIGHT

Safety is an important component to any restoration project to protect the wellbeing and health of all personnel working on a project. Therefore safety will be a paramount consideration for implementation and the safety records of potential contractors will be carefully considered. This is especially important given some work will occur within or in close proximity to public use areas. During field activities, staff shall require the use of personal protective equipment suitable for each task being performed, and safety coordination meetings and logistics will take place throughout the duration of the program to minimize any exposure to hazards throughout all field activities. Any use of herbicides will strictly follow permit requirements and manufactures protocols. Part of the surveillance efforts includes the oversight of any subcontractors acting on site, to track work performed and coordinate activities with the focus of performing the scope at hand at each project area efficiently and safely. Tracking and documentation of the work performed also serves as quality control and quality assurance checks and will provide the team and Trustees assurance that what was designed to be implemented was carried out as intended.

MONITORING

Post-implementation monitoring efforts will be needed in order to document completed activities and the effectiveness of both the treatment of invasive species and restoration efforts, and identify any other measures that may be used to reduce the chance of spread of invasive plants. It is expected that most monitoring efforts will be qualitative site visits by qualified biologists to help guide decision making. Quantitative surveys may be needed at complex or problematic sites, but it is suggested that these efforts be minimized so that the focus of the program remains on implementation, not collection of data. The extent and details of monitoring activities each year will be based on the site assessment and recommendations discussed in the annual report for the previous year. To facilitate efficient decision making, the same team dedicated to program management and field oversight should lead post-implementation monitoring.

5.2 Anticipated Costs

Costs for invasive species control vary broadly based on circumstance, but are generally proportional to the amount of invasive species present and site complexity. Although the available literature does include some discussions of costs, they generally focus on the physical implementation of controls with ancillary costs, such as planning, permitting, etc., often not included or clearly defined. For example, in a 7-year (2002-2008) control study of phragmites on interdunal swales in Cape Cod, the yearly cost per acre of phragmites herbicide treatment was as high as $1,200, but this did not include indirect costs (Lombard et al. 2012). If we assume a 2% yearly increase based on inflation from 2002-2020, that cost would increase to $1,714 per acre.

Given the inherent variability of invasive species control efforts and the level of uncertainty regarding site conditions, the costs that are actually incurred for each individual project during implementation are likely to be different from what is presented here. However, general preliminary cost estimates associated with each project area have been developed using unit rates per acre based on a combination of relevant information from the literature and actual experience managing and implementing similar projects (Table 5.1).

It is anticipated that, initially, approximately 15-20% of the overall budget will be associated with preparatory work. This includes tasks such as procurement, preliminary site reconnaissance, preparation logistics, owner access agreements, project management efforts specific to each project area (financial tracking, subcontracting, team coordination, etc.), safety, permitting, and so on. As the program matures, this percentage is expected to decrease as tasks become more routine.

The greatest costs are, as expected, associated with the implementation of invasive species management, which has two components: invasive species control, and subsequent restoration efforts (where needed). The estimated costs for implementation are expected to account for approximately 70% of the overall budget, and will vary depending on the site specific nature of the planned field activities in any given year. It is important to note that restoration costs are proportionally much higher than invasive species management and maintenance alone. This is because the restoration components incur both material costs (plants/seed) as well as substantial labor costs due to sheer quantity of plants that are physically installed per acre (costs assume an installation rate of 3,000 herbaceous plants per acre and 50 small trees or shrubs per acre).

In addition, approximately 2-5% of the overall budget has been allocated to stakeholder involvement and education/outreach programming (see Section 4.0 for more details on what these efforts might include). We estimate an annual cost of $30,000 for the production of an annual work plan and report providing a basic summary of work performed that year, results of monitoring efforts, and recommendations for the following year. Finally, an overall program management allocation of ~5% of the budget was also included to cover overall program oversight, contract management, and coordination with Trustees.

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FIGURES

PARSONS

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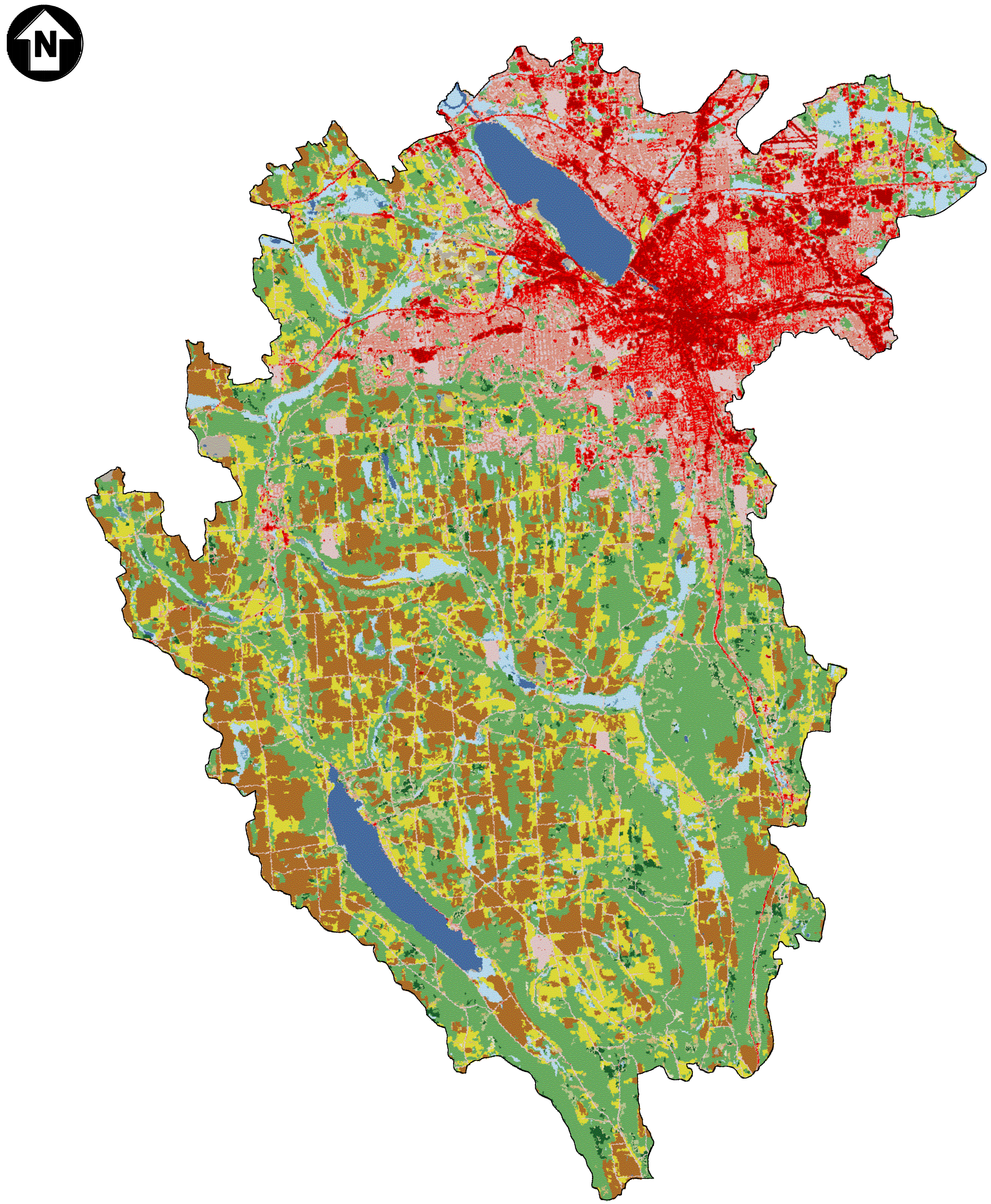
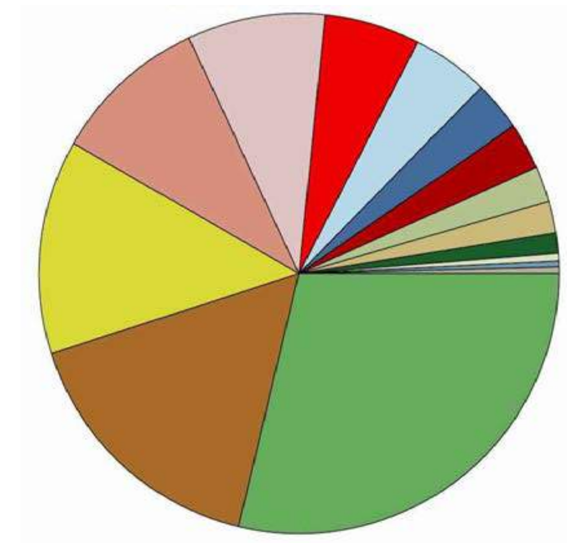


ONONDAGA LAKE WATERSHED LAND COVER



LEGEND:

- DECIDUOUS FOREST (28.76%)
- CULTIVATED CROPS (16.22%)
- HAY/PASTURE (13.34%)
- DEVELOPED, LOW INTENSITY (9.70%)
- DEVELOPED, OPEN SPACE (8.61%)
- DEVELOPED, MEDIUM INTENSITY (5.92%)
- WOODY WETLANDS (4.76%)
- OPEN WATER (3.08)
- DEVELOPED, HIGH INTENSITY (2.91%)
- MIXED FOREST (2.19%)
- SHRUB/SCRUB (2.00%)
- EVERGREEN FOREST (1.22%)
- HERBACEOUS (0.49%)
- EMERGENT HERBACEOUS WETLANDS (0.40%)
- BARREN LAND (0.39%)

NOTES:

1. LAND COVER DATA PROVIDED BY THE MULTI-RESOLUTION LAND CHARACTERISTICS CONSORTIUM (2016 LAND COVER).

FIGURE 2.1

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

2016 ONONDAGA LAKE WATERSHED LAND COVER

PARSONS

301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

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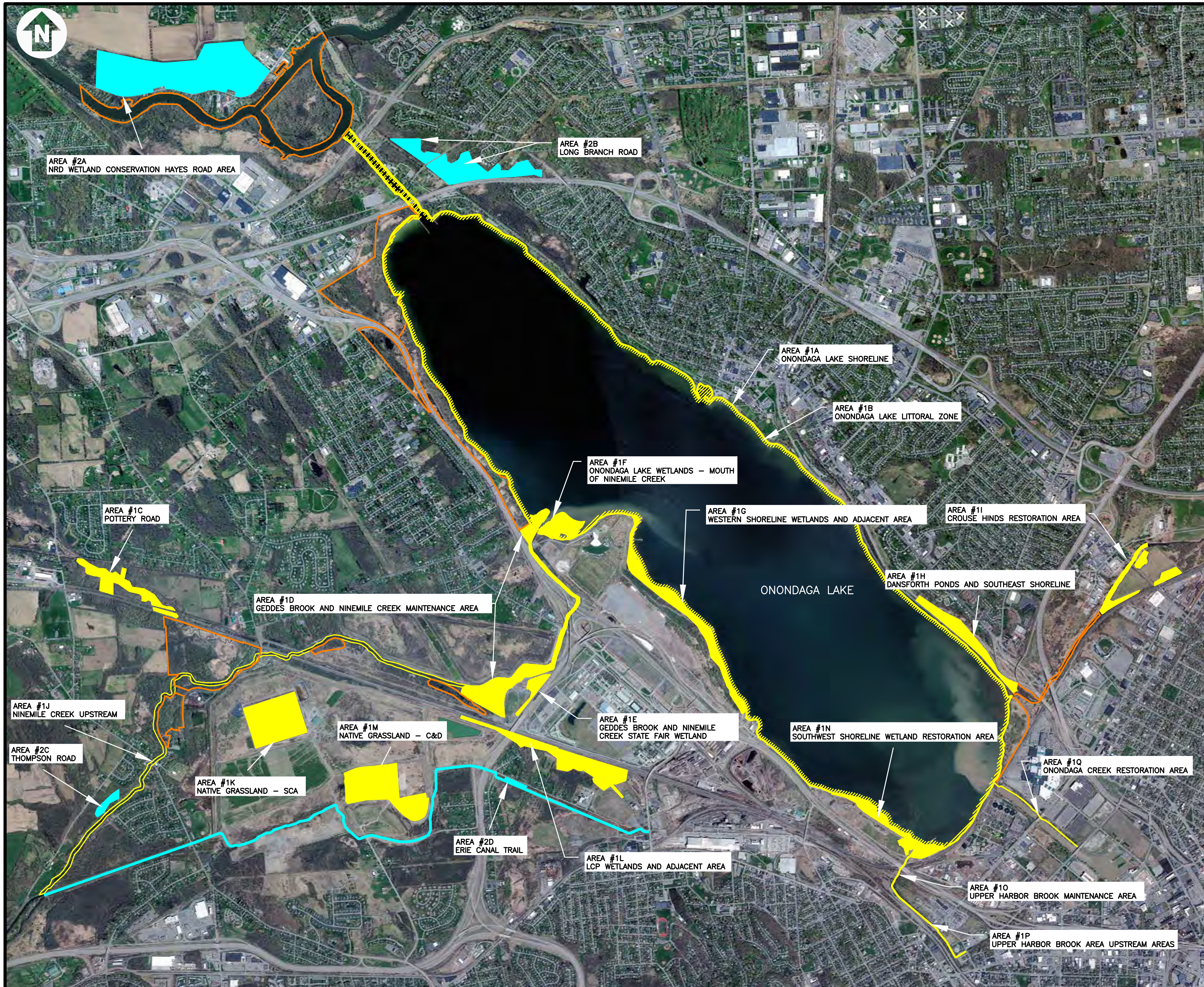

LEGEND:

TIER 1 PROJECT AREA

PROJECT AREAS RECOMMENDED FOR IMPLEMENTATION IN YEARS 1–5.

TIER 2 PROJECT AREA

PROJECT AREAS RECOMMENDED FOR IMPLEMENTATION ONCE MINOR LOGISTICS ARE ADDRESSED.

OTHER TARGET AREA

OTHER AREAS OF INTEREST FOR FUTURE PROGRAM IMPLEMENTATION AFTER YEAR 5.

3000 1500 0 3000 6000

SCALE: 1"=3000'

FIGURE 3.1a

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

TARGET LOCATION PROJECT AREAS
(ONONDAGA LAKE)

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 • 315–451–9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\PRIORITYAREAS.DWG
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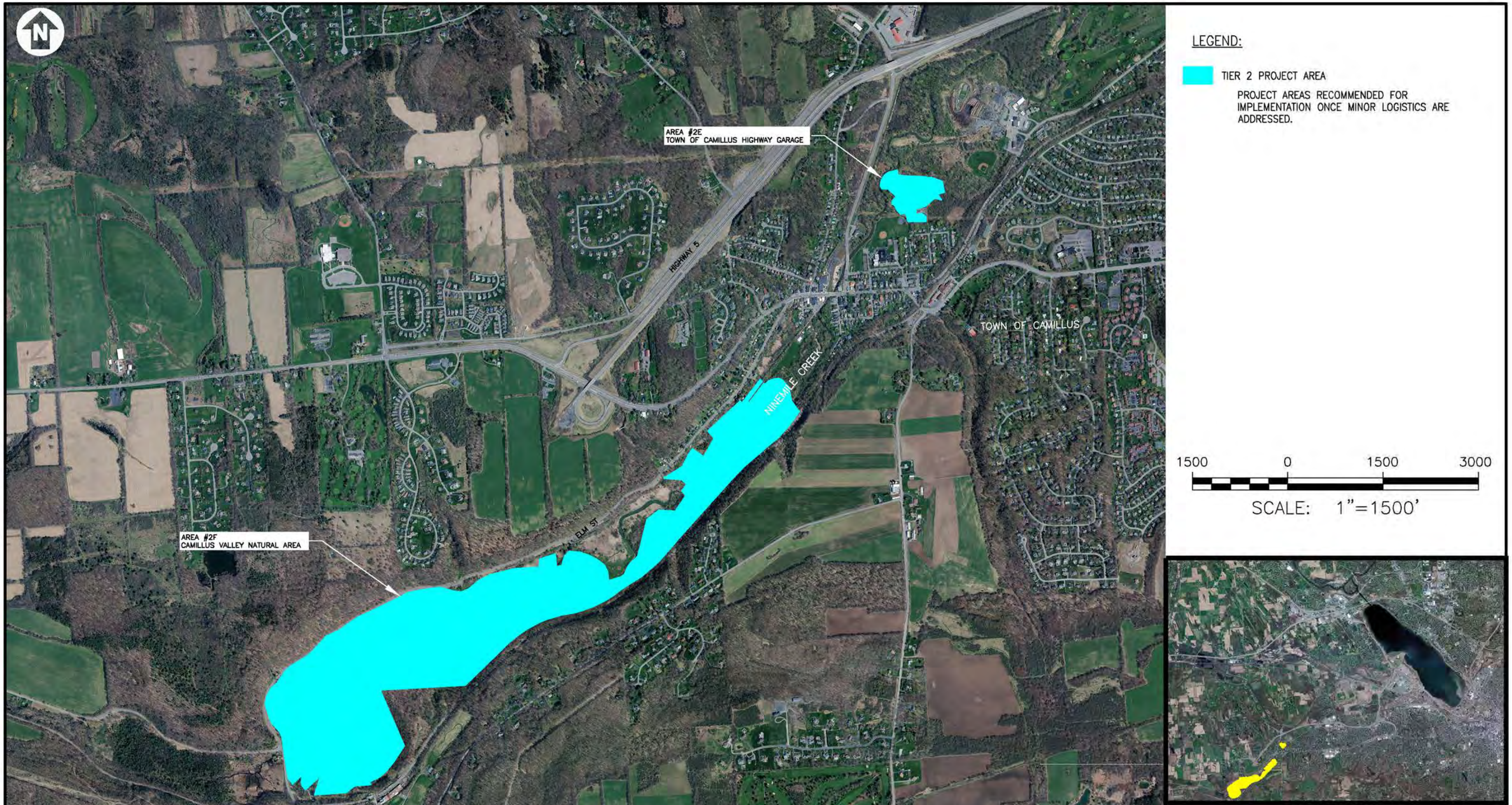

FIGURE 3.1b

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

TARGET LOCATION PROJECT AREAS (CAMILLUS)

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\PRIORITYAREAS.DWG
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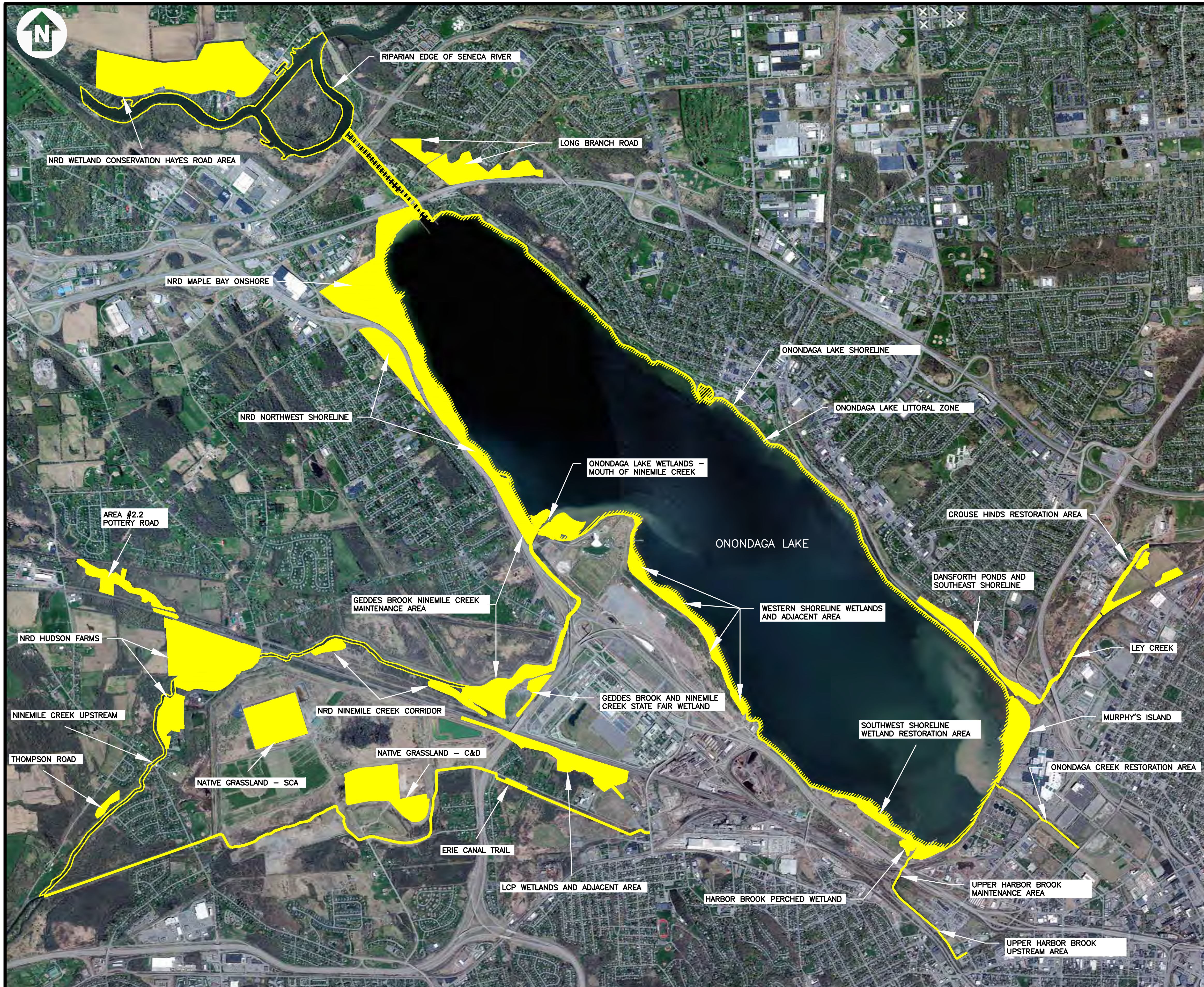

LEGEND:

INVASIVE SPECIES MANAGEMENT AREAS

3000 1500 0 3000 6000

SCALE: 1"=3000'

FIGURE 3.2a

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROGRAM PROJECT AREA RECOMMENDATIONS

(ONONDAGA LAKE)

PARSONS

301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 • 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\PRIORITYAREAS.DWG
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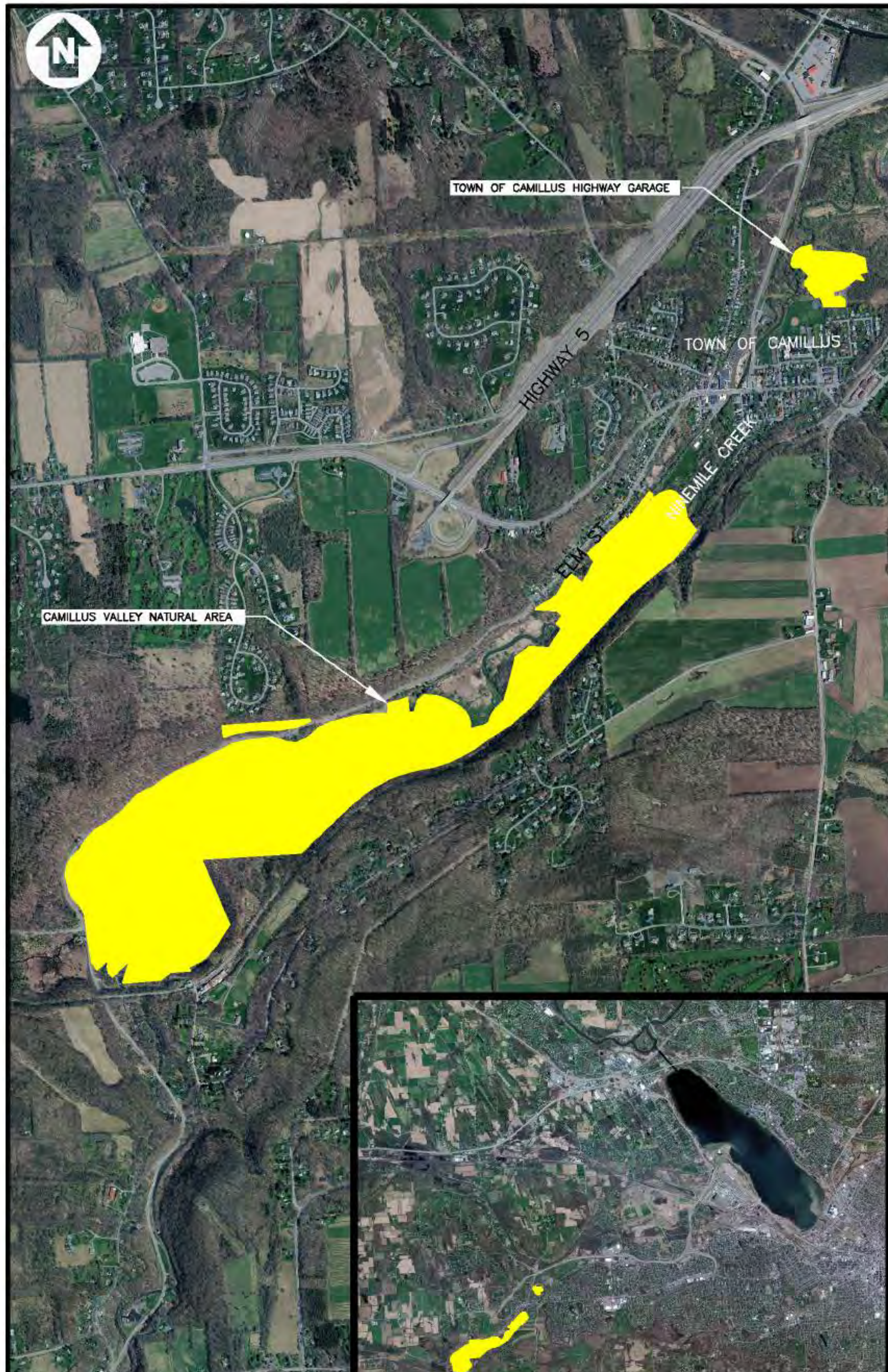

2000 1000 0 2000 4000

SCALE: 1"=2000'

2000 1000 0 2000 4000

SCALE: 1"=2000'

LEGEND:

INVASIVE SPECIES MANAGEMENT AREAS

FIGURE 3.2b

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROGRAM PROJECT AREA RECOMMENDATIONS (CAMILLUS/TULLY)

PARSONS

301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 - INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\PRIORITYAREAS.DWG
PLOT DATE: 2/7/2020 9:55 AM PLOTTED BY: MORANZ, KAITLYN

LEGEND:

PROJECT AREA (SEE NOTE 2)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. GIVEN THAT THIS PROJECT AREA HAS NOT UNDERGONE PREVIOUS RESTORATION ACTIVITIES, MORE EXTENSIVE EFFORTS TO CONTROL INVASIVE SPECIES MAY BE EXPECTED.

500 250 0 500 1000

SCALE: 1"=500'

FIGURE 3.3

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #1C
POTTERY ROAD

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
PLOT DATE: 2/13/2020 11:07 AM PLOTTED BY: MORANZ, KAITLYN

LEGEND:

PREVIOUSLY RESTORED AREAS (SEE NOTE 2)

AREAS NOT PREVIOUSLY RESTORED (SEE NOTE 3)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. AREAS RESTORED BY OTHERS AS PART OF REMEDIAL EFFORTS. ONCE RESTORATION GOALS HAVE BEEN MET BY THE RESPONSIBLE PARTY, THESE AREAS WILL BE ELIGIBLE FOR FURTHER INVASIVE SPECIES MAINTENANCE BY THE TRUSTEES.
3. GIVEN THAT THIS PROJECT AREA HAS NOT UNDERGONE PREVIOUS RESTORATION ACTIVITIES, MORE EXTENSIVE EFFORTS TO CONTROL INVASIVE SPECIES MAY BE EXPECTED.

600 300 0 600 1200

SCALE: 1"=600'

FIGURE 3.4

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREAS #1D AND #1E
GEDDES BROOK AND NINEMILE CREEK AREA

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 - INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
PLOT DATE: 2/13/2020 11:18 AM PLOTTED BY: MORANZ, KAITLYN

LEGEND:

PREVIOUSLY RESTORED AREAS (SEE NOTE 2)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. AREAS RESTORED BY OTHERS AS PART OF REMEDIAL EFFORTS. ONCE RESTORATION GOALS HAVE BEEN MET BY THE RESPONSIBLE PARTY, THESE AREAS WILL BE ELIGIBLE FOR FURTHER INVASIVE SPECIES MAINTENANCE BY THE TRUSTEES.

500 250 0 500 1000

SCALE: 1"=500'

FIGURE 3.5

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #1F
ONONDAGA LAKE WETLANDS – MOUTH OF NINEMILE CREEK

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS_1_23254_EE98D727.SV$.DWG
PLOT DATE: 2/10/2020 2:43 PM PLOTTED BY: MORANZ, KAITLYN

LEGEND:

PREVIOUSLY RESTORED AREAS (SEE NOTE 2)

PREVIOUSLY RESTORED WETLAND BUFFER (SEE NOTE 3)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. AREAS RESTORED BY OTHERS AS PART OF REMEDIAL EFFORTS. ONCE RESTORATION GOALS HAVE BEEN MET BY THE RESPONSIBLE PARTY, THESE AREAS WILL BE ELIGIBLE FOR FURTHER INVASIVE SPECIES MAINTENANCE BY THE TRUSTEES.
3. ADJACENT BUFFER AREAS WILL BE MAINTAINED TO PROVIDE ADDITIONAL PROTECTION AGAINST INVASIVE SPECIES AROUND THE RESTORED WETLANDS.

600 300 0 600 1200

SCALE: 1"=600'

FIGURE 3.6

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #1G
WESTERN SHORELINE WETLANDS AND ADJACENT AREA

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
PLOT DATE: 2/13/2020 1:52 PM PLOTTED BY: MORANZ, KAITLYN

LEGEND:

PROJECT AREA (SEE NOTE 2)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. GIVEN THAT THIS PROJECT AREA HAS NOT UNDERGONE PREVIOUS RESTORATION ACTIVITIES, MORE EXTENSIVE EFFORTS TO CONTROL INVASIVE SPECIES MAY BE EXPECTED.

500 250 0 500 1000

SCALE: 1"=500'

FIGURE 3.7

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #1H
DANFORTH PONDS AREA

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 • 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
PLOT DATE: 2/14/2020 9:40 AM PLOTTED BY: MORANZ, KAITLYN

LEGEND:

PROJECT AREA (SEE NOTE 2)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. GIVEN THAT THIS PROJECT AREA HAS NOT UNDERGONE PREVIOUS RESTORATION ACTIVITIES, MORE EXTENSIVE EFFORTS TO CONTROL INVASIVE SPECIES MAY BE EXPECTED.

300 150 0 300 600

SCALE: 1"=300'

FIGURE 3.8

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #1I
CROUSE HINDS RESTORATION AREA

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 • 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
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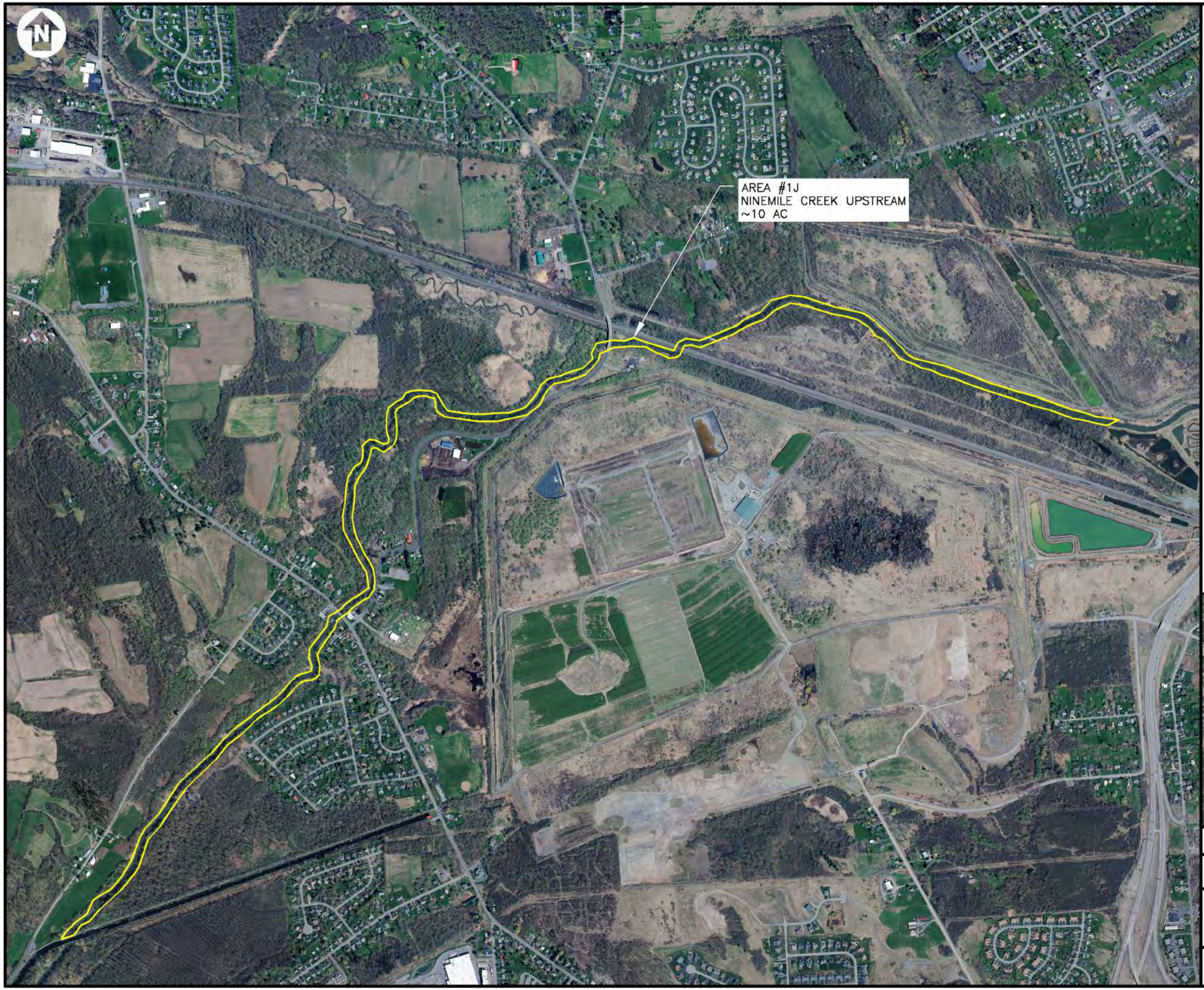

LEGEND:

PROJECT AREA (SEE NOTE 2)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. GIVEN THAT THIS PROJECT AREA HAS NOT UNDERGONE PREVIOUS RESTORATION ACTIVITIES, MORE EXTENSIVE EFFORTS TO CONTROL INVASIVE SPECIES MAY BE EXPECTED.

1200 600 0 120 2400

SCALE: 1"=1200'

FIGURE 3.9

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #1J
NINEMILE CREEK UPSTREAM

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
PLOT DATE: 2/13/2020 11:22 AM PLOTTED BY: MORANZ, KAITLYN

LEGEND:

PREVIOUSLY RESTORED AREAS (SEE NOTE 2)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. AREAS RESTORED BY OTHERS. ONCE RESTORATION GOALS HAVE BEEN MET BY THE RESPONSIBLE PARTY, THESE AREAS WILL BE ELIGIBLE FOR FURTHER INVASIVE SPECIES MAINTENANCE BY THE TRUSTEES.

300 150 0 300 600

SCALE: 1"=300'

FIGURE 3.10

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #1K
NATIVE GRASSLANDS – SCA

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
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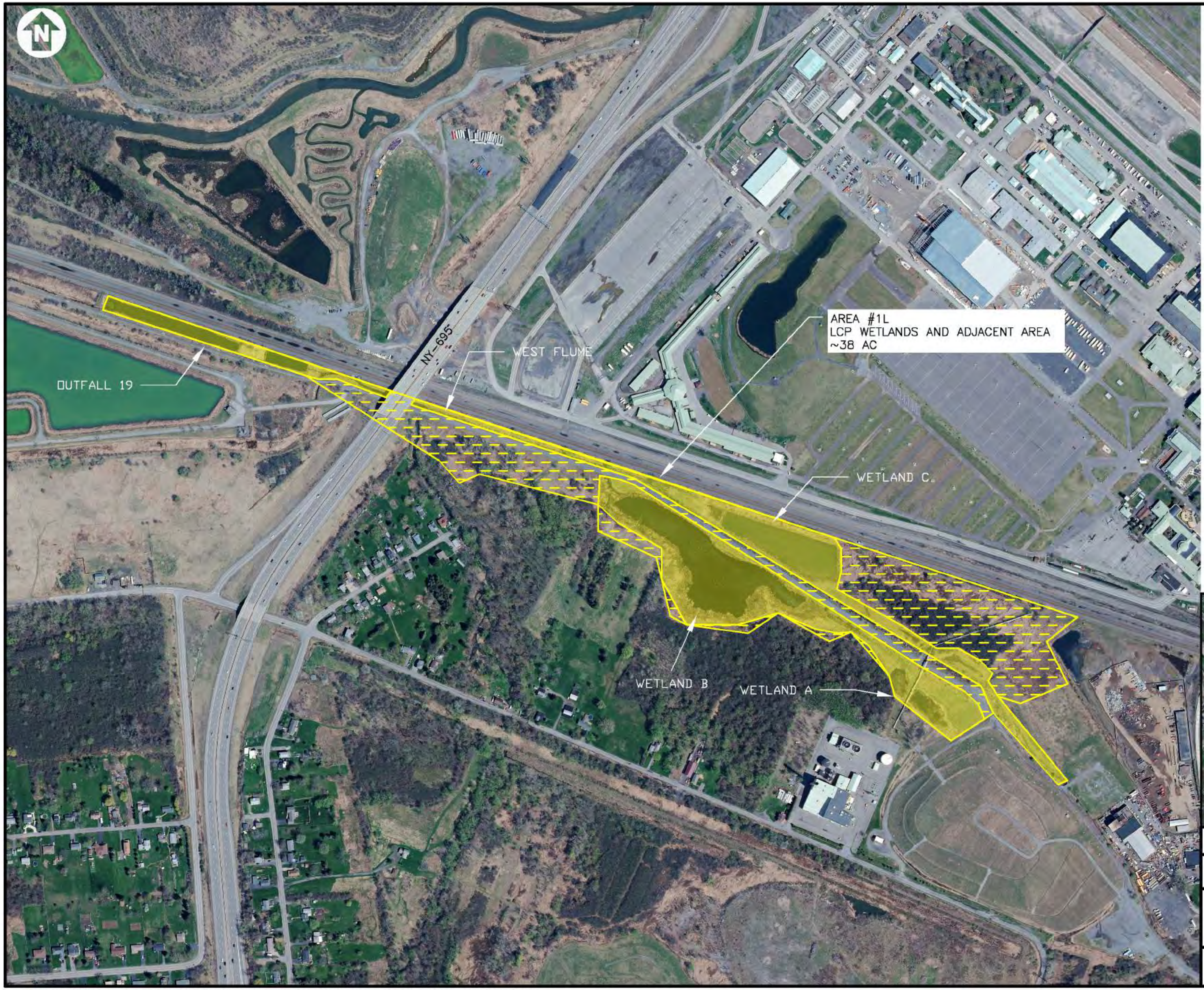

LEGEND:

- PREVIOUSLY RESTORED AREAS (SEE NOTE 2)
- ADJACENT AREAS (SEE NOTE 3)
- AREA # — PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. AREAS RESTORED BY OTHERS AS PART OF REMEDIAL EFFORTS. ONCE RESTORATION GOALS HAVE BEEN MET BY THE RESPONSIBLE PARTY, THESE AREAS WILL BE ELIGIBLE FOR FURTHER INVASIVE SPECIES MAINTENANCE BY THE TRUSTEES.
3. ADJACENT AREAS HAVE NOT BEEN PREVIOUSLY RESTORED AND WILL REQUIRE MORE EXTENSIVE EFFORTS TO CONTROL INVASIVE SPECIES THAN PREVIOUSLY RESTORED AREAS.

500 250 0 500 1000

SCALE: 1"=500'

FIGURE 3.11

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #1L
LCP WETLANDS AND ADJACENT AREA

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS_1_23254_EE9BD727.SV$.DWG
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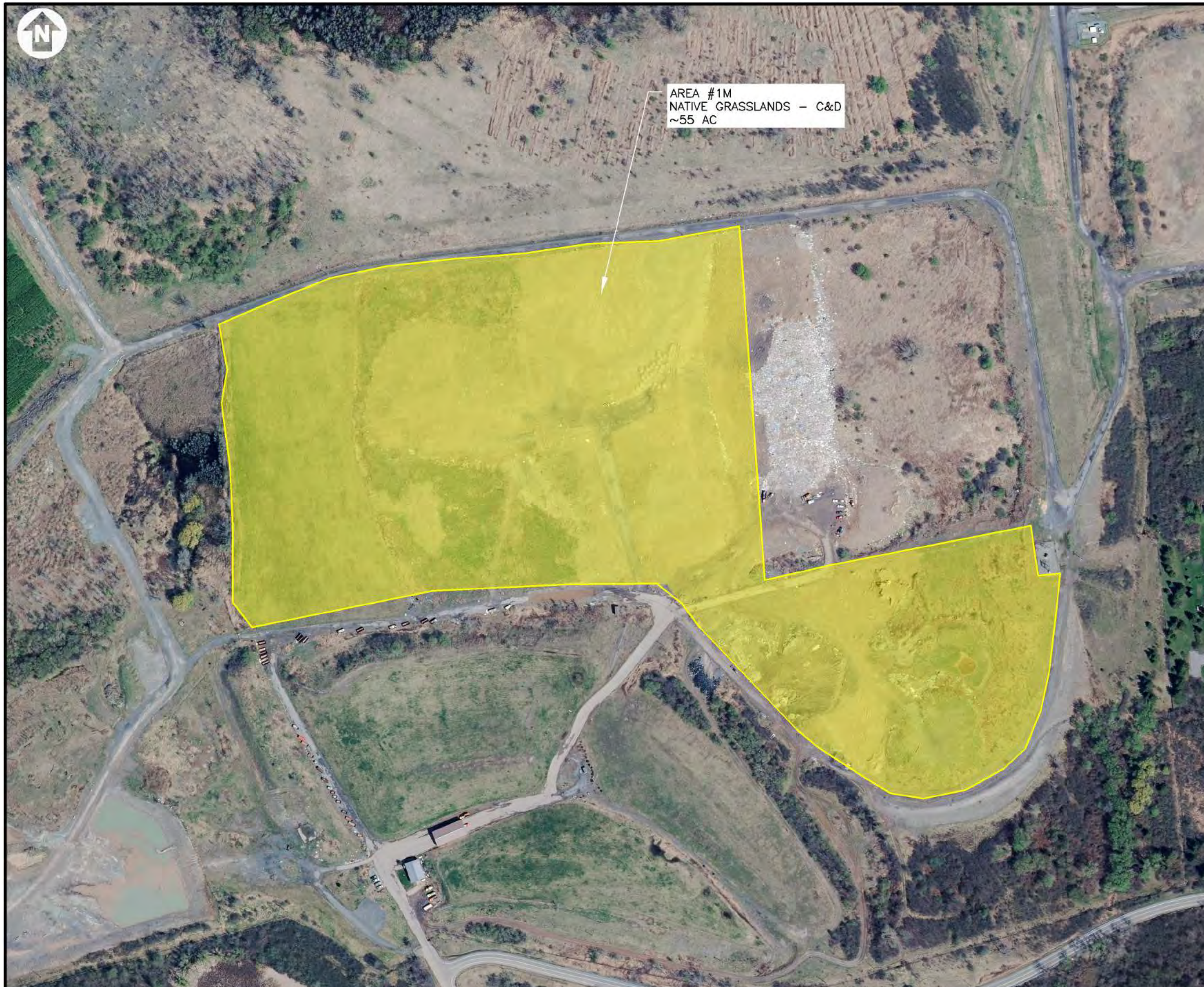

LEGEND:

PREVIOUSLY RESTORED AREAS (SEE NOTE 2)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. AREAS RESTORED BY OTHERS. ONCE RESTORATION GOALS HAVE BEEN MET BY THE RESPONSIBLE PARTY, THESE AREAS WILL BE ELIGIBLE FOR FURTHER INVASIVE SPECIES MAINTENANCE BY THE TRUSTEES.

300 150 0 300 600

SCALE: 1"=300'

FIGURE 3.12

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #1M
NATIVE GRASSLANDS – C&D

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
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LEGEND:

PREVIOUSLY RESTORED AREAS (SEE NOTE 2)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. AREAS RESTORED BY OTHERS AS PART OF REMEDIAL EFFORTS. ONCE RESTORATION GOALS HAVE BEEN MET BY THE RESPONSIBLE PARTY, THESE AREAS WILL BE ELIGIBLE FOR FURTHER INVASIVE SPECIES MAINTENANCE BY THE TRUSTEES.

300 150 0 300 600

SCALE: 1"=300'

FIGURE 3.13

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #1N
SOUTHWEST SHORELINE WETLAND RESTORATION AREA

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
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LEGEND:

- PREVIOUSLY RESTORED AREAS (SEE NOTE 2)
- AREAS NOT PREVIOUSLY RESTORED (SEE NOTE 3)
- AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. AREAS RESTORED BY OTHERS AS PART OF REMEDIAL EFFORTS. ONCE RESTORATION GOALS HAVE BEEN MET BY THE RESPONSIBLE PARTY, THESE AREAS WILL BE ELIGIBLE FOR FURTHER INVASIVE SPECIES MAINTENANCE BY THE TRUSTEES.
3. GIVEN THAT THIS PROJECT AREA HAS NOT UNDERGONE PREVIOUS RESTORATION ACTIVITIES, MORE EXTENSIVE EFFORTS TO CONTROL INVASIVE SPECIES MAY BE EXPECTED.

350 175 0 350 700

SCALE: 1"=350'

FIGURE 3.14

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREAS #10 AND #1P
UPPER HARBOR BROOK AREA

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
PLOT DATE: 2/13/2020 1:16 PM PLOTTED BY: MORANZ, KAITLYN

LEGEND:

PROJECT AREA (SEE NOTE 2)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. GIVEN THAT THIS PROJECT AREA HAS NOT UNDERGONE PREVIOUS RESTORATION ACTIVITIES, MORE EXTENSIVE EFFORTS TO CONTROL INVASIVE SPECIES MAY BE EXPECTED.

500 250 0 500 1000

SCALE: 1"=500'

FIGURE 3.15

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #2A
NRD WETLAND CONSERVATION HAYES ROAD AREA

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
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LEGEND:

PROJECT AREA (SEE NOTE 2)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. GIVEN THAT THIS PROJECT AREA HAS NOT UNDERGONE PREVIOUS RESTORATION ACTIVITIES, MORE EXTENSIVE EFFORTS TO CONTROL INVASIVE SPECIES MAY BE EXPECTED.

400 200 0 400 800

SCALE: 1"=400'

FIGURE 3.16

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #2B
LONG BRANCH ROAD

PARSONS

301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
PLOT DATE: 2/13/2020 11:35 AM PLOTTED BY: MORANZ, KAITLYN

LEGEND:

PROJECT AREA (SEE NOTE 2)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. GIVEN THAT THIS PROJECT AREA HAS NOT UNDERGONE PREVIOUS RESTORATION ACTIVITIES, MORE EXTENSIVE EFFORTS TO CONTROL INVASIVE SPECIES MAY BE EXPECTED.

200 100 0 200 400

SCALE: 1"=200'

FIGURE 3.17

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #2C
THOMPSON ROAD

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
PLOT DATE: 2/13/2020 11:40 AM PLOTTED BY: MORANZ, KAITLYN

LEGEND:

PROJECT AREA (SEE NOTE 2)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. GIVEN THAT THIS PROJECT AREA HAS NOT UNDERGONE PREVIOUS RESTORATION ACTIVITIES, MORE EXTENSIVE EFFORTS TO CONTROL INVASIVE SPECIES MAY BE EXPECTED.

750 375 0 750 1500

SCALE: 1"=750'

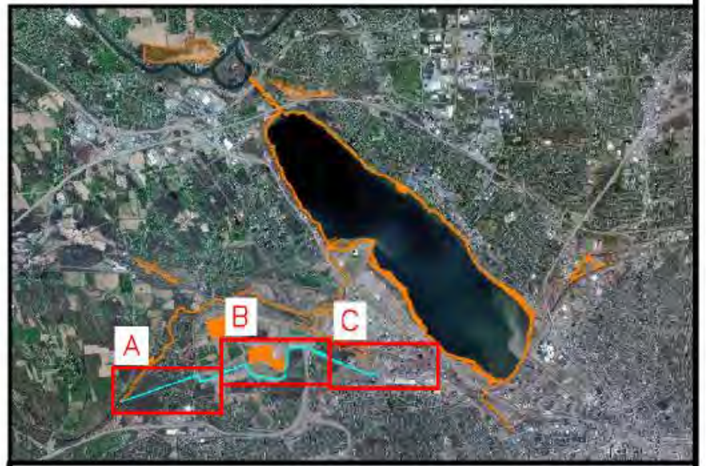

FIGURE 3.18

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #2D
ERIE CANAL TRAIL

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 - INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
PLOT DATE: 2/13/2020 11:43 AM PLOTTED BY: MORANZ, KAITLYN

LEGEND:

PROJECT AREA (SEE NOTE 2)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. GIVEN THAT THIS PROJECT AREA HAS NOT UNDERGONE PREVIOUS RESTORATION ACTIVITIES, MORE EXTENSIVE EFFORTS TO CONTROL INVASIVE SPECIES MAY BE EXPECTED.

200 100 0 200 400

SCALE: 1"=200'

FIGURE 3.19

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #2E
TOWN OF CAMILLUS HIGHWAY GARAGE

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
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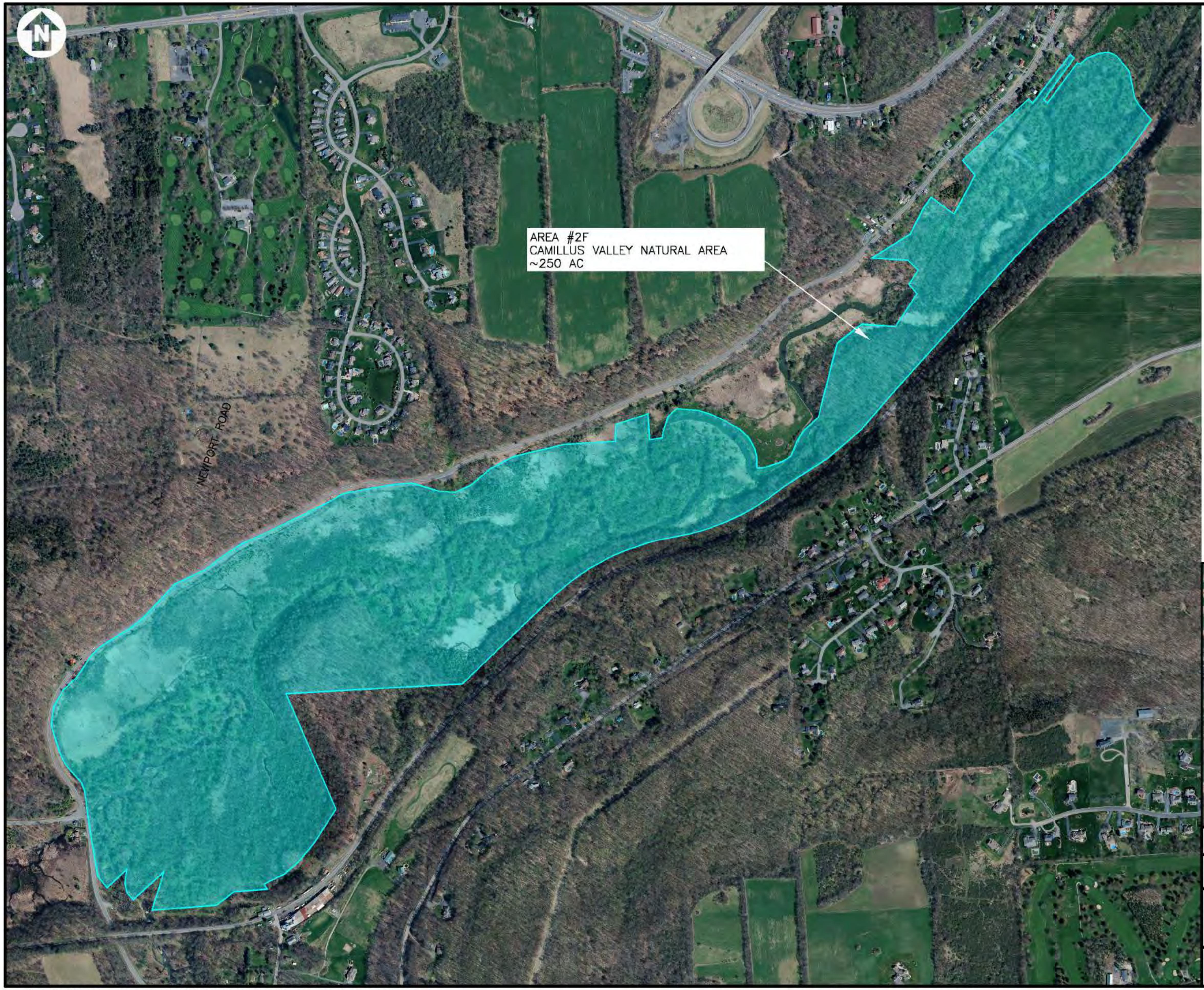

LEGEND:

PROJECT AREA (SEE NOTE 2)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. GIVEN THAT THIS PROJECT AREA HAS NOT UNDERGONE PREVIOUS RESTORATION ACTIVITIES, MORE EXTENSIVE EFFORTS TO CONTROL INVASIVE SPECIES MAY BE EXPECTED.

750 375 0 750 1500

SCALE: 1"=750'

FIGURE 3.20

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #2F
CAMILLUS VALLEY NATURAL AREA

PARSONS

301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 * 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
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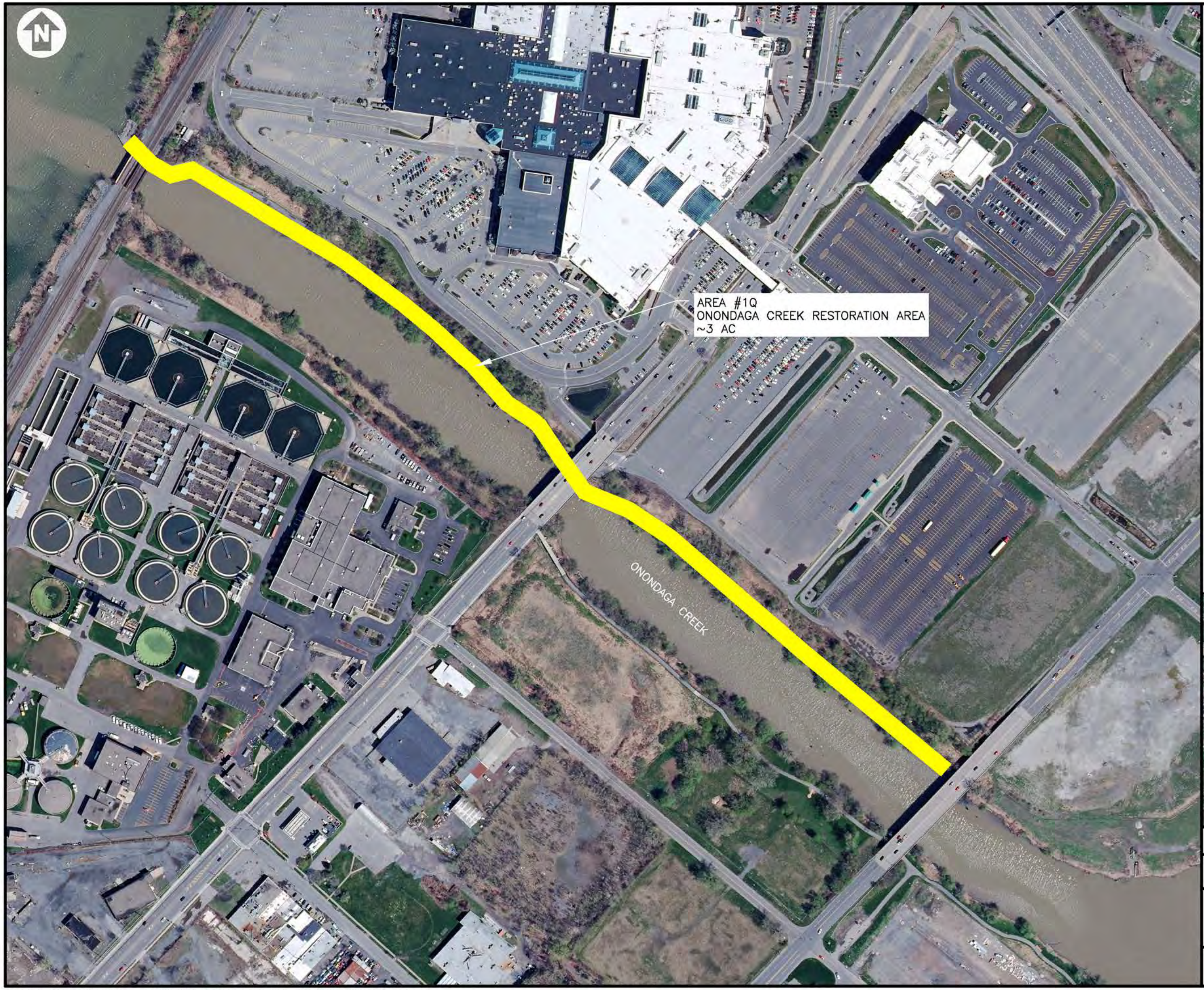

LEGEND:

PROJECT AREA (SEE NOTE 2)

AREA # PROJECT AREA PRIORITY DESIGNATION (SEE TABLE 3.1)

NOTES:

1. AREA OUTLINES ARE APPROXIMATE.
2. GIVEN THAT THIS PROJECT AREA HAS NOT UNDERGONE PREVIOUS RESTORATION ACTIVITIES, MORE EXTENSIVE EFFORTS TO CONTROL INVASIVE SPECIES MAY BE EXPECTED.

300 150 0 300 600

SCALE: 1"=300'

FIGURE 3.21

COMPREHENSIVE PLAN FOR INVASIVE SPECIES CONTROL AND HABITAT PRESERVATION (SYRACUSE, NEW YORK)

PROJECT AREA #1Q
ONONDAGA CREEK RESTORATION AREA

PARSONS
301 PLAINFIELD ROAD, SUITE 350, SYRACUSE, NY 13212 • 315-451-9560

FILE NAME: P:\USF&W\110210 – INV SP COMP PLAN\10.0 TECHNICAL CATEGORIES\INDIVIDUALAREAS.DWG
PLOT DATE: 2/13/2020 3:53 PM PLOTTED BY: MORANZ, KAITLYN

TABLES

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TABLE 3.1

INVASIVE SPECIES MANAGEMENT PROJECT AREAS

Priority Category[1]	Project #	Project Area	Approximate Area
Tier 1	1A	Onondaga Lake Shoreline	TBD
Tier 1	1B	Onondaga Lake Littoral Zone	TBD
Tier 1	1C	Pottery Road	20 acres
Tier 1	1D & 1E	Geddes Brook and Ninemile Creek Area	50 acres
Tier 1	1F	Onondaga Lake Wetlands - Mouth of Ninemile Creek	20 acres
Tier 1	1G	Western Shoreline Wetlands and Adjacent Area	30 acres
Tier 1	1H	Dansforth Ponds and Southeast Shoreline	13 acres
Tier 1	1I	Crouse Hinds Restoration Area	14 acres
Tier 1	1J	Ninemile Creek Upstream	10 acres
Tier 1	1K	Native Grassland - SCA	50 acres
Tier 1	1L	LCP Wetlands and Adjacent Area	38 acres
Tier 1	1M	Native Grassland - C&D	55 acres
Tier 1	1N	Southwest Shoreline Wetland Restoration Area	13 acres
Tier 1	1O & 1P	Upper Harbor Brook Area	8 acres
Tier 1	1Q	Onondaga Creek Restoration Area	3 acres
Tier 2	2A	NRD Wetland Conservation Hayes Road Area	130 acres
Tier 2	2B	Long Branch Road	42 acres
Tier 2	2C	Thompson Road	3 acres
Tier 2	2D	Erie Canal Trail	15 acres
Tier 2	2E	Town of Camillus Highway Garage	10 acres
Tier 2	2F	Camillus Valley Natural Area	250 acres
Other	-	NRD Tully North and NRD Tully South	-
Other	-	Murphy's Island	-
Other	-	Ley Creek	-
Other	-	Seneca River	-

[1] The project areas have been broken down into two priority categories for potential implementation in the first five years (Tier 1 and Tier 2), and "other areas of interest" for consideration for future program implementation (Section 3.2)

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TABLE 3.2

SITE ASSESSMENT WORKSHEET

For each section, score potential site based on the point value corresponding to the criteria that apply to it.

Point Value	Status of Invasive species on site (Select one)	Scored Value
0	Invasive species dominance. Few or no native species present.	________
1	Invasive species interspersed with native species. Native seedbank present.	________
2	Few or no invasive species present. "High Quality" habitat.	________
	Watershed impact (Select one)	
0	Little or no surface water connection to waterways.	________
1	Adjacent or connected to Onondaga Lake.	________
2	Surface water connection to Ley Creek, Harbor Brook or Geddes Brook.	________
3	Surface water connection to Ninemile Creek or Onondaga Creek.	________
	Ecological significance (Select all that apply)	
0	No ecological significance.	________
2	Supports rare, threatened or endangered species	________
4	Significant Natural Community (NYNHP)	________
	Community (Select all that apply)	
0	No potential for community engagement	________
2	Public access	________
2	High-visibility/high-use site for community engagement	________
	Effort (Select one)	
0	Invasive species dominance. Treatment area >5 acres	________
1	Invasive species dominance. Treatment area < 5 acres	________
2	Invasive species interspersed with native species. Treatment area > 5 acres	________
3	Invasive species interspersed with native species. Treatment area < 5 acres	________
4	Few or no invasive species present. Site area > 5 acres	________
5	Few or no invasive species present. Site area < 5 acres	________
	Total Score	/20

PARSONS

TABLE 5.1
ESTIMATED COSTS

Type	Projct Area #	Project Area	Acres	2021	2022	2023	2024	2025	Total
Restoration	1A	Onondaga Lake Shoreline	10	$28,000	$28,000	$29,000	$29,000	$30,000	$144,000
Prevention	1B	Onondaga Lake Littoral Zone	95	$14,000	$14,000	$14,000	$14,000	$14,000	$70,000
Restoration	1C	Pottery Road Area - Upstream of Hudson Farms	20	$48,000	$56,000	$98,000	$451,000	$122,000	$775,000
Maintenance	1D	Geddes Brook/Ninemile Creek Maintenance Area	27	$19,000	-	$19,000	-	$20,000	$58,000
Restoration	1E	Geddes Brook/Ninemile Creek State Fair Wetland	6	$14,000	$19,000	$29,000	$135,000	$49,000	$246,000
Maintenance	1F	Onondaga Lake Wetlands - Mouth of Ninemile Creek	8	-	$6,000	-	$6,000	-	$12,000
Maintenance	1G	Western Shoreline Wetlands and Adjacent Area	38	$23,000	-	$24,000	-	$25,000	$72,000
Restoration	1H	Dansforth Ponds Area	13	$31,000	$41,000	$64,000	$293,000	$106,000	$535,000
Maintenance	1I	Crouse Hinds Restoration Area	14	-	$11,000	-	$11,000	-	$22,000
Restoration	1J	Ninemile Creek Upstream Area	10	$17,000	$18,000	$18,000	$18,000	$19,000	$90,000
Maintenance	1K	Native Grasslands - SCA	50	-	-	$6,000	-	$6,000	$12,000
Maintenance	1L	LCP Wetlands and Adjacent Area	16	$11,000	-	$11,000	-	$12,000	$34,000
Maintenance	1M	Native Grasslands - C&D	33	-	-	-	-	$5,000	$5,000
Maintenance	1N	Southwest Shoreline Wetland Restoration Area	25	-	-	$10,000	-	$11,000	$21,000
Maintenance	1O	Upper Harbor Brook Area Maintenance Area.	3	-	$2,000	-	$2,000	-	$4,000
Restoration	1P	Upper Harbor Brook Area Upstream Areas	1.5	-	$6,000	-	$7,000	-	$13,000
Restoration	1Q	Onondaga Creek Restoration Area	5	$8,000	$8,000	$21,000	$12,000	$10,000	$59,000
		Stakeholder Education and Outreach Communications		$10,000	$10,200	$10,400	$10,600	$10,800	$52,000
		Reporting allowance		$30,000	$30,600	$31,200	$31,800	$32,400	$156,000
		Overall Program Management (5%)		$12,650	$12,490	$19,230	$51,020	$23,610	$119,000
		Total	**374.5**	**$266,000**	**$262,000**	**$404,000**	**$1,071,000**	**$496,000**	**$2,499,000**

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5.1 Estimated Costs.xlsxTable 5.1

Appendix A

Invasive Species Fact Sheets

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APPENDIX A INVASIVE SPECIES FACT SHEETS

Appendix A.1 *Lythrum salicaria* Fact Sheet

Appendix A.2 *Phragmites australis* Fact Sheet

Appendix A.3 *Reynoutria japonica* Fact Sheet

Appendix A.4 *Rhamnus cathartica* Fact Sheet

Appendix A.5 *Trapa natans* Fact Sheet

Appendix A.1 *Lythrum Salicaria* Fact Sheet

Lythrum salicaria
(Purple loosestrife)

Figure 1 *Lythrum salicaria.* Photographs by Gary A. Monroe (USDA Plant Database)

General

Lythrum salicaria is an herbaceous perennial species in the Lythraceae family. It is native to Eurasia and forms dense monospecific stands across North America. Due to its showy purple inflorescences (Figure 1) and long flowering time, purple loosestrife has been a popular commercial plant in the United States for more than 150 years and was sold in New York as early as 1829 (Mack 1991). Its stems are roughly square in cross-section, and the simple leaves are elongated with smooth margins. The leaves are whorled or oppositely arranged and are sessile to clasped around the stem. The bright purple flowers in dense inflorescences are 6-petaled and in bloom from July through September (Gleason and Cronquist 1991).

Below ground, a vigorous system of roots store nutrients and allow the plant to survive and regrow when stems are cut (New York State Department of Environmental Conservation [NYSDEC] 2019). In addition to vigorous vegetative growth, a single plant can produce approximately 2.7 million seeds in one growing season (Thompson et al. 1987). These buoyant seeds are primarily spread by water, though dispersal by mud adherence to animals, humans and machinery is also likely common (Thompson et al. 1987). Intentional spread by horticulturists was once common, and beekeepers commonly dumped *L. salicaria* seeds at stream heads in order to spread the species and provide forage for their hives (Thompson et al. 1987).

Range and Habitat

Except for Florida, *L. salicaria* is present in all lower 48 states except Florida (Blossey et al. 2001) and has been reported in 53 of 62 counties in New York State (Figure 2). However, the New York Flora Atlas relies exclusively on catalogued herbarium specimens, so this is certainly an underestimate of species distribution.

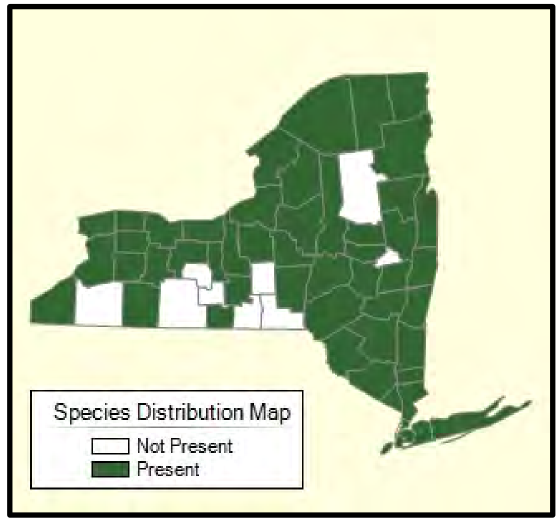

Figure 1 Distribution of *Lythrum salicaria* in New York State by county (New York Flora Association 2019)

L. salicaria is typically found in disturbed wet places, on the edges of lakes and ponds, and in open marshes. Because wetlands are sinks for propagules, the water-dispersed seeds of *L salicaria* can spread rapidly within watersheds, and alternate means of dispersal transport seeds across watershed lines.

Although *L. salicaria* thrives in wetlands, it can germinate in any environment from crushed stone on railroad tracks to deep alluvial soils along rivers. It has been observed to germinate in soils as acidic as pH 4.0 and as alkaline as pH 9.1 (Shamsi and Whitehead 1974; Thompson et al. 1987). However, light-availability is critical to the survival of *L. salicaria*. It can survive in small gaps along streams and in forested wetlands, but it declines in vigor and reproductive ability in areas that are less than 50% full sun (Thompson et al. 1987).

Impacts

L. salicaria forms dense monotypic stands which can competitively exclude native species (Thompson et al. 1987). Its incredible seed production has been shown to dominate seed banks and reduce native seed diversity (Welling and Becker 1990; Yakimowski et al. 2005). It has also been shown to display higher phenotypic plasticity, the ability of individuals to adapt to local conditions, than native cohabitators (Chun et al. 2007; Chun 2011). The presence of *L. salicaria* has also been shown to reduce pollination and seed production in its rare native congener, *L. alatum* (Brown et al. 2002). Ecosystem effects from increased *L. salicaria* cover also include alteration of decomposition rates and soil/water chemistry in wetlands (Grout et al. 1997; Templer et al. 1998) and changes in bird assemblages often including a reduction in species diversity (Tavernia and Reed 2012; Whitt et al. 1999).

Management

As with most effective invasive management plans, the successful removal of *L. salicaria* can be achieved with a combination of the strategies described below, long-term monitoring, and adaptive management.

I Mechanical – Cutting and Pulling

Since there are large stores of nutrients in the hardy root systems of *L. salicaria*, cutting at the base has not been found to be an effective control strategy in large stands. However, managers can cut the plants if only to prevent additions to the seedbank, especially where only few plants are found. Pulling may be effective for very small populations of *L. salicaria*, but the disturbance of soil in pulling may result in a resurgence of *L. salicaria* from the seedbank (NYSDEC 2019). Cutting or pulling initial colonizers or few remaining plants after a more intensive control effort can prevent additions of *L. salicaria* to the seedbank. McCaughey and Stephenson (1999) found that seeds were viable at three weeks after flowering, so managers should make sure to cut either before flowering or soon after to prevent additions to the seedbank.

II Chemical

The application of glyphosate-based herbicide is recommended for control (NYSDEC). Knezevic et al. (2018) provides one of the few long-term studies on *L. salicaria* control with successive herbicide applications. They found the number of successive years of herbicide application to achieve complete control of *L. salicaria* was related to the age of the stand. In three-year-old stands, complete control using glyphosate was achieved in 2 years of successive applications. In five-year-old stands, complete control was achieved in 2 to 5 years of successive application. In older stands (>10 years old), the number of successive years of application was as high as 9 to achieve complete control.

Chemical control is likely the fastest and most efficient means of eradicating populations of *L. salicaria*. However, successive years of monitoring is necessary after complete control is achieved due to the persistence of *L. salicaria* in the seedbank.

III Biological

Grazing: Kleppel and LaBarge (2011) found a positive effect of intensive rotational grazing (IRG) of Romney sheep on wet meadows heavily invaded by *L. salicaria*. After a period of IRG throughout four treatment paddocks, they recorded a 40% reduction in *L. salicaria* cover and a 20% increase in species richness compared to adjacent control paddocks. However, in diverse stands with interspersed *L. salicaria*, grazing will likely result in significant non-target herbivory, potentially reducing native diversity and cover. As with mechanical methods of removal, this strategy will not result in complete eradication but may be a reasonable treatment in small monotypic stands where livestock are available.

Insect biological control: Two species of beetle, *Neogalerucella calmariensis* and *N. pusilla*, have been widely released and distributed as a biological control agent for *L. salicaria* for almost 20 years in North America. Several studies have been released on the efficacy of the beetles, with findings differing from study to study. The most recent study from St. Louis et al. (2020) found that *L. salicaria* in wetlands with the beetles had notable levels of herbivore damage and differences in inflorescence structure. However, they did not detect a significant difference in *L. salicaria* biomass, fruit production or recovery of native species richness. Other studies have found high levels of success with the biocontrol agents, and some find differing success across sites within a study (Landis 2003; McAvoy et al. 2016). In any event, the release of these beetles has not been found to have negative ecosystem effects and is recommended in combination with other control measures.

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Appendix A.2 *Phragmites Australis* Fact Sheet

Phragmites australis
(Old world phragmites)

Figure 1 *Phragmites australis.* Photographs by Andrew Nelson (New York Flora Association 2020)

General

Phragmites australis (P. australis) (Figure 1) may be the most threatening invasive species to wetlands in the region and has been impacting freshwater and brackish wetlands in North America since the turn of the 20th century (Chambers et al. 1999). Standing up to 18 feet tall, it is a perennial grass species capable of forming dense monotypic stands (Clayton 2006; United States Fish and Wildlife Services [USFWS] 2019).

Though some believe that *Phragmites australis* seeds are non-viable, the literature suggests otherwise. In a 2009 study of seed viability in the Chesapeake Bay, the viability of P. australis ranged from <1% to 21% (Kettenring and Whigham 2009). With each stem producing over 1,000 seeds, this is a significant means of reproduction. In addition to producing large amounts of wind-dispersed seed, *P. australis* spreads by rhizomes and reproduces clonally by fallen stems which root from nodes and facilitate rapid expansion. These reproductive strategies, along with high density growth (shading out other species), tolerance to salinity, and the ability to survive in a range of soil moisture conditions, make *P. australis* a highly aggressive invasive species (USFWS; National Oceanic and Atmospheric Administration [NOAA] 2019).

Range and Habitat

P. australis has been reported in all US states except Alaska, and in New York State it has been reported in 50 of 62 counties (Figure 2). However, the New York Flora Atlas relies exclusively on catalogued herbarium specimens, so this is certainly an underestimate of species distribution.

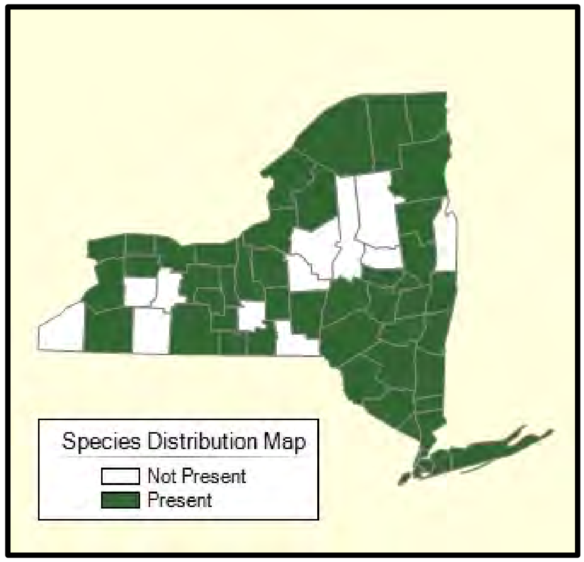

Figure 2 *Phragmites australis* distribution in NY State (New York Flora Association 2020)

Disturbed places will be more vulnerable to invasion, while dense, intact areas which limit light penetration will be more resilient. *P. australis* seeds require light and daily soil temperature fluctuations, characteristics of gaps created by natural or human disturbance, to break dormancy (Ekstam and Foresby 1999; Ekstam et al. 1999).

Because it is tolerant of saline conditions, *P australis* spreads easily along salt-treated highway ditches and other salt-affected areas (Lelong et al. 2007; Brisson et al. 2010). It is also commonly found in shallow wetlands and colonizes wetland edges where it expands by rhizomes and stolons into deeper areas.

Impacts

Unlike its native congener, *Phragmites australis* is densely packed, allowing very little light to reach the ground. It occurs in dense monospecific stands, allowing very little other plant life to survive (Keller 2000). The establishment of *P. australis* stands has also been shown to dramatically alter hydrologic regimes and damage insect and fish communities (Able and Hagan 2003; Gratton and Denno 2005). Due to its salinity tolerance, *P. australis* is also a significant threat to New York's remaining inland salt marshes, a globally endangered ecosystem type (Eallonardo and Leopold 2014).

Look-alikes

As it is currently understood, there are multiple *Phragmites* taxa in North America, some of which are considered native (Meyerson et al. 2012). In New York State, the native *Phragmites americanus* can be found in a few isolated populations in inland salt marshes. The European *P. australis* is the most common and invasive taxa and is the species described here. Due to its similarity to the native, it is thought that the introduced *P. australis* almost entirely replaced the natives in a large-scale expansion long before it was noticed. Such unnoticed replacements are referred to as a cryptic invasions (Saltonstall 2002).

Identification of the native *Phragmites* species can be difficult, and there is evidence of hybridization between non-native and native lineages (Meyerson et al. 2012). However, no native communities of *Phragmites* have been described around Onondaga Lake in recent times.

Management

I Mechanical

Mowing:

Due to its extensive network of rhizomes, mechanical removal of *P. australis* stems by mowing or cutting is not by itself an effective long-term strategy for the control of the species and may even stimulate growth (Güsewell et al. 1998; Warren et al. 2001). However, mowing can be an effective component of an integrated control program if coupled with one or more of the following:

- Herbicide application is used when the target area is too large for plastic sheeting (Hazleton et al. 2014).
- Black plastic sheeting can increase soil temperature to lethal levels and can be highly effective for small stands with adequate light (Burdick 2010; Wilcox 2013).
- Mulching or removal of stems after cutting may improve outcomes in combination with shading or herbicide (Kiviat 2006).
- Although fire is often considered to control invasive species, it may stimulate bud formation and vigorous growth in phragmites unless it is coupled with herbicide or other controls (Cross and Fleming 1989).
- Cutting before flooding season has been shown to improve outcomes in some cases (Kiviat 2006) because stems are inundated and cannot provide carbon dioxide to the rhizomes. However, this benefit may only be evident in poorly-drained soils. Post-cut flooding has been found to have little effect in sandy or well-aerated soils (Weisner and Granéli 1989).

Timing of mowing is also important. Asaeda et al. (2006) found that cutting in June produced significant decreases in aboveground and rhizome biomass the following season, but cutting in July produced no significant difference to controls.

Excavation:

Excavation has been shown to be highly effective when it is deep enough to remove all rhizomes, and all materials are removed from the treatment site. Excavation of *Phragmites* has been highly successful around Onondaga Lake at Geddes Brook, Ninemile Creek and the Ninemile Creek spits, and at Harbor Brook. The obvious trade-off with excavation is cost.

II Chemical

Martin and Blossey (2013) report that 94% of land managers employ herbicide to control phragmites. Although shading and other non-chemical methods have been proven effective in some cases on small stands, herbicide is often the only option for large stands of phragmites. The two most commonly used herbicides used for phragmites control are glyphosate and imazapyr.

- Glyphosate is the most common systematic herbicide in use. It can be highly effective with multiple treatments over several years. The half-life of glyphosate in the environment, given adequate light and microbial activity, is typically several days to a few weeks. The longest half-life recorded for glyphosate in a controlled environment and in complete darkness was 315 days (Mercurio et al. 2014).
- Imazapyr has been found to be more effective than glyphosate in the control of P. australis (Kay 1995; Derr 2008a; Mozder et al. 2008). However, there may be serious ecosystem effects due to its persistence in soils. With a half-life of up to four years (Tu et al. 2001), imazapyr may have serious seedbank and recolonization hampering effects (Mozder et al. 2008).

Timing is also an important consideration for herbicide application. Traditional methods recommend late season application because stems are translocating nutrients back to the rhizomes. However, recent studies suggest that an early season application (June vs. September) is more effective (Derr 2008b; Mozder et al. 2008). While late-season application reduces the impact on native vegetation in a mixed stand, in monospecific stands, early season application is recommended.

The truth is that there are very few long-term studies on the efficacy of herbicides in the control of *P. australis*. However, the existing literature stresses the importance of multiple-year applications and monitoring to ensure successful control (Kay 1995; Warren et al. 2001; Cheshier et al. 2012; Lombard et al. 2012).

III Biological

Herbivory:

Although some studies have found that herbivory by goats can reduce *P. australis* density (Brundage 2010; Tesauro and Ehrenfeld 2007), *P. australis* is not a preferred food species for goats. In a study of coastal wetlands with mixed stands of *P. australis* and native species, goats ate all other species before resorting to *P. australis* (Teal and Peterson 2005). Grazing also may result in soil compaction, trampling and nutrient enrichment from excrement (Hazleton et al. 2014). Goat grazing will also not be sufficient to kill the underground rhizomes, which will produce new stems once goats have left. Given this evidence, grazing may only be effective in small, isolated, monospecific stands of *P. australis*.

Muskrats have also been suggested as a control species for *P. australis*. Unfortunately, muskrat activity is often out of the control of land managers, and damage to *P. australis* is incidental in large monotypic stands (Cross and Fleming 1989). In combination with other control measures, land managers can choose to encourage the establishment of muskrat populations by constructing muskrat stands and other structures to improve habitat for native herbivores (Kiviat 2006), but there is no evidence that muskrats act as an effective control on *P. australis* independently.

Insect Biocontrol:

Researchers at Cornell University have been working on isolating an insect biocontrol for *P. australis* since 1998. Two moth species, *Archanara neurica* and *A. geminipuncta*, have been selected as ideal candidates for release after 14 years of host-specificity screenings of more than 150 herbivores (Blossey at al. 2018). In 2019, Canada issued field release permits for these species. Although field release permits have not been granted in the US, the permit for release is in the final stages of review (Blossey 2019). Due to the enormous potential of this biocontrol, close attention should be paid to this program over the next few years.

Post-Control Resistance:

Rapid reestablishment of a diverse native plant community can dramatically alter restoration trajectories. Areas where *P. australis* has been controlled but not replanted with native species are often reinvaded by *P. australis* immediately (Hazleton et al. 2014).

As a grass, the *P. australis* seed lifespan is short. Effective control and reestablishment of native species can remove *P. australis* s from the seedbank in a relatively short time, and intact wetlands will allow less opportunity for *P. australis* to recolonize (Kennedy et al. 2002).

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Appendix A.3 *Reynoutria Japonica* Fact Sheet

Reynoutria japonica var. japonica
(Japanese knotweed)

Figure 1 Japanese knotweed in flower. Photograph by Elaine Haug (USDA Plant Database)

General

Japanese knotweed (*Reynoutria japonica var. japonica*) is a shrub-like herbaceous perennial in the family Polygonaceae. It is highly invasive in North America and Europe and it has been listed as one of the world's 100 most invasive species by the World Conservation Union (IUCN) (Lowe et al. 2000). It is native to Asia, primarily Japan, Taiwan and Northern China (Weston et al. 2005) and was introduced as an ornamental in the 1860s to North America (Del Tredici 2017).

Japanese knotweed stands up to 10 feet tall, with green hollow stems and reddish speckles, often compared to the stems of bamboo. Its leaves are heart shaped and up to 6 inches long. Its small flowers are green to white and in slender inflorescences that emerge from the leaf axils (Figure 1) (Gleason and Cronquist 1991).

Range and Habitat

Japanese knotweed is widely distributed across North America, occurring in 40 of the lower 48 states (United States Department of Agriculture [USDA] Plant Database), and is reported in 45 of the 62 counties in New York State (Figure 2). However, New York Flora Atlas relies exclusively on catalogued herbarium specimens, so this is certainly an underestimate of species distribution.

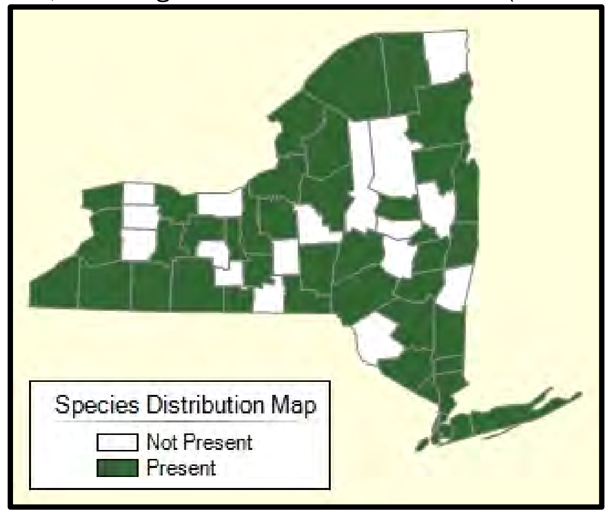

Figure 2 *Reynoutria japonica* distribution in NY State (New York Flora Association 2020)

Japanese knotweed thrives in riparian habitats, abandoned agricultural fields, disturbed places, and roadway ditches (Barney et al. 2006). In the Northeast, it spreads clonally by underground rhizomes as well as by seed which requires bare soil to germinate (Del Tredici 2017).

Knotweeds can survive in a variety of soil conditions, can tolerate drought and moderate soil salinity, but have low shade tolerance (Jackson 2020; Dommanget et al. 2013).

Look-Alikes

In New York State, there are three knotweed species which are all considered highly invasive: Japanese knotweed (Reynoutria japonica var. japonica), giant knotweed (R. sachalinensis), and their hybrid, bohemian knotweed (R. ×bohemica). A simple way to distinguish Japanese and giant knotweed is the size of their leaves. Japanese knotweed's leaves typically grow no larger than 6 inches long, whereas the leaves of giant knotweed routinely reach lengths of 12 inches (Jackson 2020). Bohemian knotweed, their hybrid, displays intermediate leaf size (Jackson 2020). For management purposes, it is not critical to be able to distinguish between the three species.

Impacts

Japanese knotweed grows in extremely dense clonal stands which often reach 10 feet tall and shade out other species, reducing native plant species richness (Gerber et al. 2008; Aguilera et al. 2010; Wilson et al. 2017). It also prevents colonization by riparian tree species, which over time may transform riparian forests into knotweed dominated shrubland (Wilson et al. 2017). Where it forms dense stands in riparian areas, the species has been shown to dramatically reduce stream baseflow and litter decomposition rates (Vanderklein et al. 2014; Mincheva et al. 2014) and reduce function and species richness in bird populations (Serniak et al. 2017). The species has also been found to have allelopathic qualities, which may aid in invasion (Murrell et al. 2011; Vrchotová and Šerá 2008). Hybridization of giant and Japanese knotweed producing Bohemian knotweed may also rapidly increase genetic variation and fitness (Gaskin et al. 2014; Parepa et al. 2013).

Management

Japanese knotweed can be effectively controlled with an integrated management plan that incorporates elements of the classic control strategies described below. An early summer cutting depletes stored energy in the rhizomes. Cutting should be followed by herbicide application in late summer when stems return to about four feet tall. This, in combination with planting and seeding native vegetation can effectively control Japanese knotweed long-term (Gover et al. 2007). A biocontrol agent may soon become available in the US and could serve as a valuable component of the integrated management plan (USDA 2019).

I Mechanical

Mowing Japanese knotweed is not by itself an effective control measure, but it can be effective in combination with herbicide application. Cutting in early June reduces the nutrient stores in the rhizomes and makes the plants more vulnerable when herbicide is applied in late summer (Gover et al. 2007).

II Chemical

At least two successive years of stem injection or spraying using glyphosate-based herbicide has been shown to be the most effective method of knotweed control (Hagen and Dunwiddie 2008; Delbart et al. 2012). However, these methods have not been shown to completely eradicate Japanese knotweed. To control the species long term, it is necessary to develop an integrated control plan that includes early season mowing and planting native trees (Gover et al. 2007; Delbart et al. 2012; Dommanget et al. 2013). It is also possible to achieve control with biannual glyphosate applications (spring and late summer) instead of early-season mowing in combination with late-season herbicide (Jones et al. 2018). Due to the labor intensity of stem injection, this control method is only reasonable for small stands.

III Biological

Because knotweed inhibits recruitment of native trees, and shade creation will exclude knotweed in the long run, proactive buffer plantings in combination with glyphosate injection is recommended (Delbart et al. 2012; Dommanget et al. 2013). Planting fast-growing riparian species is recommended to establish canopy quickly—willows have been found to successfully compete with Japanese knotweed and significantly reduce its growth (Dommanget et al. 2019). Monitoring treated stands until effective shade has been created is necessary to ensure successful control.

Over the past 20 years, an insect biocontrol program has been developing in North America and the United Kingdom (USDA Forest Service). Since 2010, there have been multiple releases of the psyllid *Aphalara itadori* in the United Kingdom, and it has recently been approved and released in parts of Canada. However, the psyllid is having limited success establishing in the Canadian field. This may be related to an inability to withstand environmental variability after many generations of stable laboratory conditions (Skuse 2018). In May 2019, the USDA released a preliminary assessment approving the psyllid for release in the US, but no field release permit has been approved (USDA 2019). It is possible that in the next few years, the release of *A. itadori* will become a valuable part of an integrated control plan.

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Appendix A.4 *Rhamnus Cathartica* Fact Sheet

Rhamnus cathartica
(European buckthorn

Figure 1 *Rhamnus cathartica.* Photographs by Andrew Nelson (New York Flora Association 2020)

General

European buckthorn is a woody shrub or small tree in the family Rhamnaceae. Native to Europe and western Asia, it has become a highly aggressive invasive in regions of North America (Kurylo and Endress 2012). It was likely introduced to North America multiple times, first for medicinal qualities in the late 18th century and then as a hedgerow species during the early 19th century. Its berries have been used as a purgative in Europe for centuries and are referred to in medical writing as early as the 16th century.

European buckthorn can reach 20 feet in height and live for approximately 40 years (Kurylo and Endress 2012). Its leaves are broadly elliptic with a finely serrate margin and veins that upturn toward the tip. The leaf arrangement is variable, but most often sub-opposite, or nearly opposite (Gleason and Cronquist 1991). The bark of European buckthorn is dark gray, smooth with horizontal lenticels on young trees and then peeling or flaky at maturity (Figure 1). Distributed by birds who consume its black drupes, it can spread rapidly across watersheds and other barriers.

Range and Habitat

European buckthorn is present in 34 of the lower 48 states (United States Department of Agriculture [USDA] Plant Database) and reported in 42 of 62 counties in New York State (Figure 2). However, the New York Flora Atlas relies exclusively on catalogued herbarium specimens, so this is certainly an underestimate of species distribution.

European buckthorn thrives in successional or disturbed forests in moderate shade, thickets and open pastures or successional fields in full sun, on calcareous soils and bedrock, and in fens (New York Flora Atlas; Kurylo et al. 2007). It is typically thought of as an upland invader; however, it can also tolerate prolonged flooding (Kurylo et al. 2015). Due to its broad tolerance of environmental factors, it presents a threat to both upland and wetland habitats.

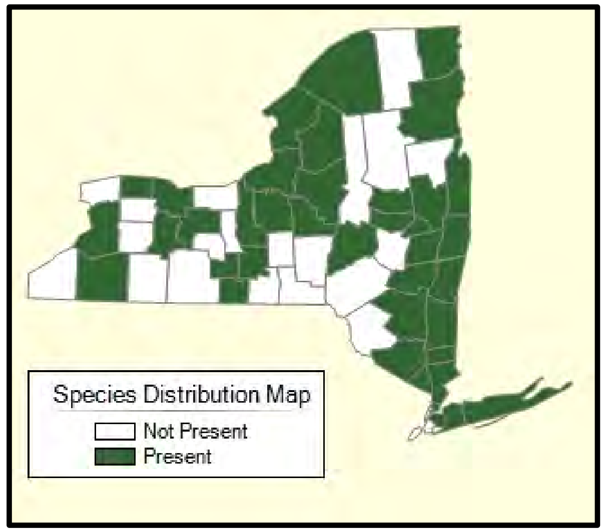

Figure 3 *Rhamnus cathartica* distribution in NY State (New York Flora Association 2020)

Impacts

European buckthorn stands dramatically reduce understory diversity in forests and increase litter decomposition rates, reducing carbon storage in soil organic matter and changing soil nitrogen concentrations (Knight et al. 2007; Freund et al. 2013; Larkin et al. 2014). There are also multiple studies indicating that the leaf litter and soils impacted by European buckthorn reduce germination, growth and flowering rates in many understory species, supporting the idea that the species is allelopathic (Klinosky et al. 2011; Warren et al. 2017). European buckthorn stands also alter mammal use of landscapes (Vernon et al. 2014) and reduce diversity and abundance of insect communities (Shuh and Larsen 2015; Grunzweig et al. 2015). Due to its flood tolerance, European buckthorn may pose a threat to disturbed forested wetlands, an extremely high value ecosystem which has been declining in area across the country in recent years (Dahl 2011).

Look-Alikes

Frangula alnus, or glossy buckthorn, is a non-native shrub or small tree with a similar appearance and habitat to European buckthorn. Glossy and European buckthorns can be distinguished by leaf characteristics, branching pattern and bud characteristics. Glossy buckthorn has leaves with five to nine pairs of veins and a smooth margin, alternate branching, and twigs with a large naked terminal bud. European buckthorn has leaves with three to five pairs of veins and a finely serrated margin, sub-opposite branching, and twigs often ending in a sharp spine subtended by two opposite buds covered in scales (Haines 2011). Glossy buckthorn is also considered invasive and should be controlled if found in invasive species treatment areas.

Rhamnus alnifolia, or alder-leaved buckthorn is a small native shrub that primarily occupies wetlands and is present in the Onondaga Lake watershed (New York Flora Association). It may be confused with young non-native buckthorns. *R. alnifolia* has leaves with a finely serrated margin, alternate branching and buds with scales. The tips of twigs are not armed with a sharp spine as in *R. cathartica* (Haines 2011).

Management

Although much has been published on the ecology and impacts of European buckthorn, there are few peer-reviewed studies on its management. There are, however, agency fact sheets and recommendations as well as observations from land managers. For large stands, a combination of cutting and stump herbicide application may be the only viable option. Controlled European buckthorn stands must be monitored in the years following treatment because there will still be a significant seedbank in soils. On new invasions or first-year germinants, mechanical removal may be possible, and a novel method using black plastic bags may be useful on small stands with mature individuals where herbicide is not an option. All control methods discussed should be coupled with native plantings and continued monitoring.

I Mechanical

Since European buckthorn is dispersed by fruit and grows from seed, very early invasions can be controlled by pulling. However, if plants are too large to pull completely out of the ground, mechanical removal is not viable. Cutting or mowing without of the use of herbicide promotes vigorous new growth and should only be done to prevent fruiting and expansion as a short-term strategy. Cutting combined with stump herbicide application can be an effective way to control mature stems (Michigan Department of Natural Resources [DNR]). There is also a novel treatment for mature stumps that was recently developed at the University of Wisconsin as part of a thesis project (Thornton 2016). This method uses 5-mil black plastic bags to cover cut stumps of European buckthorn. Results suggest that a 100% mortality rate on stems up to 4 inches in diameter can be achieved if the bags are left in place undisturbed for one year This method does not seem to address seedbank germination that is likely to occur following removal of the mature trees, and there are no separate studies demonstrating the effectiveness of this method. The bag methodology should be considered experimental, but may be an option worth considering on smaller stands if management of seedlings is also considered.

II Chemical

Published in the University of Wisconsin's student journal, Samuel Gale (2000) compiled interviews of land managers using a range of approaches to European buckthorn removal. Several managers claimed that the application of glyphosate to cut stumps in late fall was a highly effective means of control, while others claimed that a more powerful herbicide such as Garlon 3A or Tordon RTU was necessary. While this may be true, these stronger herbicides may result in significant groundwater contamination and should be avoided if possible (Gale 2000). Applying glyphosate to cut stumps with a wicking applicator is also recommended by other trusted sources and state conservation agencies (Cornell University Cooperative Extension; Michigan DNR; Minnesota DNR). In the year following application, many new individuals may germinate from the seedbank, and stumps may still sprout new stems. These new stems should either be cut and treated again or treated with foliar spray (Heidorn 1991; Michigan DNR). First-year germinants may also be removed manually in the years after chemical treatment.

III Biological

Plantings are an important part of an integrated management plan and are often overlooked, resulting in reinvasion (Schuster et al. 2018). Controlling European buckthorn also means preventing future invasions and making an ecosystem more resilient to invasions. In woodlands, planting native shade-tolerant trees is recommended. Intact forests are generally thought of as resistant to invasion (Martin et al. 2009). Fisichelli et al. (2014) found that the presence of temperate tree leaf litter reduced rates of germination for European buckthorn. However, there are legacy effects of buckthorn stands. The soil and leaf litter will contain allelopathic chemicals which may inhibit the growth of planted trees and understory herbs (Klionsky et al. 2011; Warren et al. 2017). Some species, such as Eastern white pine (*Pinus strobus*), appear to be immune to the allelopathy of European buckthorn (Warren et al. 2017). In time, and with continued management of new stems, the legacy effects of European buckthorn should subside. There are currently no insect or pathogen biocontrols available for European buckthorn (Gassman and Tosevski 2014).

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Appendix A.5 *Trapa Natans* Fact Sheet

Trapa natans
(Water chestnut

Figure 1 *Trapa natans.* Photographs by Andrew Nelson (New York Flora Association 2020)

General

Native to Africa and Eurasia, water chestnut is a floating-leaved macrophyte in the family Lythraceae. (Gleason and Cronquist 1991; Crow and Hellquist 2000). Introduced to the Northeastern United States sometime in the 1870s, it is now highly invasive in New York waterways (New York State Department of Environmental Conservation [NYSDEC]). Water chestnut is an annual species that overwinters as a large 4-horned nut in aquatic sediments (Figure 1). After germination, rosettes of leaves extend to the water surface via cord-like stems. These stems, which can grow up to 16 feet long also have feather-like submerged leaves and adventitious roots. Each floating rosette consists of several whorls of triangular leaves with coarsely toothed margins. The leaves are glabrous above and hairy below, and spongy tissues in swollen leaf petioles act as a float for the leaf (Figure 1). The flowers of water chestnut arise from the center of the rosette, with four white petals that bloom from late June to September. After cross or self-pollination, the fruit swells and tips below the water, eventually detaching and sinking to the sediments where it will overwinter. Most seeds will germinate the following year, but some may remain dormant and can remain viable for up to 12 years (Sea Grant and Cornell Cooperative Extension 2019). Since each seed can produce 10 to 15 rosettes, and each of those rosettes produce 15 to 20 more seeds, water chestnut spreads rapidly in areas where it is not actively controlled (Central New York Water Chestnut Task Force 2006).

Range and Habitat

Water chestnut is reported in seven eastern states from Virginia to Vermont (United States Department of Agriculture [USDA] Plant Database). In New York, herbarium specimens account for its presence in 18 of 62 counties (Figure 2). However, the New York Flora Atlas relies exclusively on catalogued herbarium specimens, so this is certainly an underestimate of species distribution (New York Flora Association 2020). The NYSDEC reports that it is found in 43 of 62 counties.

Water chestnut forms dense mats on the surfaces of ponds, lakes, bays, canals, and slow-moving rivers where it anchors to muddy substrates in shallow water (New York Flora Association 2020). The species spreads primarily by floating rosettes detached from their root systems and human-mediated translocation (NYSDEC).

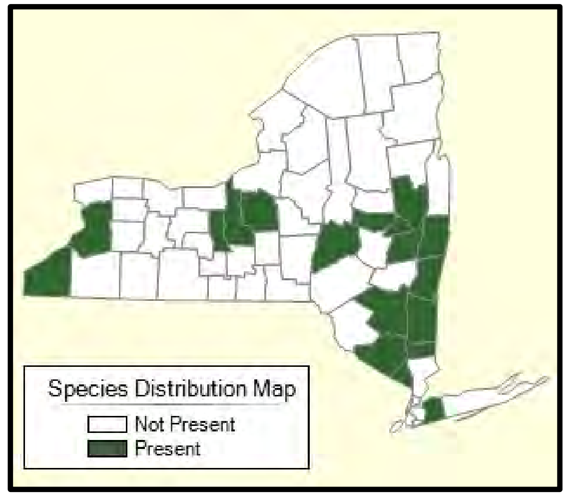

Figure 4 Distribution of *Trapa natans* in New York State by county (New York Flora Association).

Look-Alikes

In 2014, a water chestnut species with a two-horned seed was discovered in Virginia. Since then, DNA analysis has revealed this second species to be the Taiwanese *Trapa bispinosa* var. *iinumai* (Chorak et al. 2019). The most reliable way to differentiate this new species from *Trapa natans* is that it has only two horns on its seed instead of four. *T. bispinosa* also has a pink flower instead of a white flower (Rybicki 2019). Although the range of *T. bispinosa* is limited, it is possible that many populations assumed to be *T. natans* are misidentified *T. bispinosa*.

Impacts

Water chestnut impacts are substantial in lake and river ecosystems. Heavy infestations can form mats of rosettes on the water's surface and shade out native submerged macrophytes which provide habitat for aquatic organisms. As an annual, these mats decompose every fall and can substantially reduce dissolved oxygen in the water, potentially impacting fish and invertebrate populations (Hummel et al. 2006). The economic impacts of infestation are also substantial. As a shallow water species, infestations of water chestnut can make waters un-navigable by kayak and boat, reduce the value of waterfront property, and exclude sport fishing and waterfowl hunting. Additionally, the sharp horns embedded in shallow sediments can cause painful wounds and discourage swimming. (NYSDEC).

Control

The size of a water chestnut infestation is the major determinant of appropriate control methods. Early invasions can often be controlled with hand pulling. However, large infestations must be mechanically removed by a commercial harvester and/or treated with aquatic herbicide. A potential biocontrol agent is also discussed, though not yet approved for release in the U.S. Due to the long seed lifespan (up to 12 years) and the ability of this species to disperse long distances within and across watersheds, continuous monitoring is necessary to keep populations low. Populations of water chestnut in the Onondaga Lake Watershed are currently low and preventing the establishment of large colonies may be enough to control the species (Figure 2). Specifically, control efforts are recommended in Otisco Lake and Onondaga Lake.

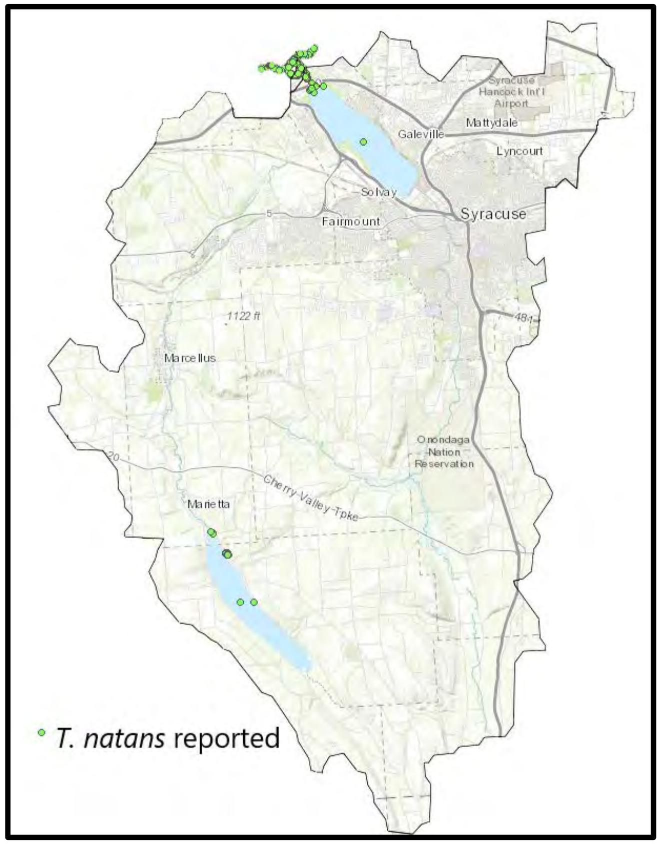

Figure 5 Reported populations of water chestnut (*Trapa natans*) in the Onondaga Lake Watershed (IMapInvasives 2020).

I Mechanical

In addition to NYSDEC recommendations, yearly hand-pulling efforts on the south side of Onondaga Lake have anecdotally demonstrated that early invasions can be effectively controlled with hand-pulling from canoes or kayaks. Community pulling events may be an effective way to organize yearly control efforts. Pulling events should be executed in early June before flowering to prevent additions to the seedbank. Proper disposal of the pulled water chestnuts is also extremely important. For small amounts, allowing plants to dry out in the sun on land should be enough to kill them and any fruits they may have produced (Phartyal et al. 2018). Large quantities of aquatic invasive plant material may also be used as biofuel or to make fertilizer (Lee and Fagan 2015; Güereña et al. 2015).

When infestations are too large for hand-pulling, it may be necessary to resort to a mechanical harvester. These large aquatic machines use a conveyor belt to scoop up floating invasive species with an effect similar to a lawn mower or farm combine. The trade-offs of this method are high cost and non-target kills of native vegetation and aquatic organisms. Because this method requires long-term monitoring and repeated execution, mechanical harvesting is often used in combination with herbicide application to remove treated biomass before it begins to decompose and impact dissolved oxygen levels. Though not regularly practiced, cutting with an air boat has been shown to result in no net gain of seeds in the seedbank (Methé et al. 1993). Following initial removal, yearly early summer assessments will inform whether hand pulling or mechanical harvesting is necessary. Unfortunately, monitoring in perpetuity is necessary to keep the species under control. Presumably, only hand-pulling will be required after the second year (Sea Grant and Cornell Cooperative Extension 2019).

II Chemical

Due to public concerns over the use of herbicides on recreational waters, herbicide application is generally considered a last resort. However, the selective herbicide 2,4-D has been shown to be non-adverse on non-target species. The broad-spectrum systemic herbicide glyphosate is also effective on water chestnut and approved for over water use. If applying herbicide to a large population of water chestnut, it may be necessary to mechanically remove the treated rosettes after the herbicide has taken effect to avoid dissolved oxygen depletion (Sea Grant and Cornell Cooperative Extension 2019).

III Biological

Because biological and chemical control methods are both costly and require monitoring in perpetuity, much attention has been given to the development of an insect biological control agent. Since 2002, researchers at Cornell and partners in China have been developing an insect biological control for water chestnut. Since 2015, the promising beetle species *Galerucella birmanica,* a predator species of water chestnut in its native China, has been undergoing host specificity tests. A proposal for field release should be submitted to the Technical Advisory Group (TAG, within USDA/APHIS) shortly (Blossey et al. 2019). The progress of this program should be monitored closely by managers in the watershed.

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