Restoring Recreational Opportunities and Habitat and Ecological Integrity to the Onondaga Creek Corridor

A Restorative Analysis of the North Valley Area

Presented by:

Colin Bell
Hui Lin
Johanna Duffy
Zeno Levy

December 10, 2009

Table of Contents

<u>Figures</u>

Tables

Appendices

1.0 Introduction

The Onondaga Creek Conceptual Revitalization Plan (OCRP) was produced in order to initiate a revitalization process for the Onondaga Creek Watershed (Onondaga Environmental Institute, 2008) (Figure 1). This plan represents a unified vision of what the Onondaga Creek Watershed could, and should, be. This draft plan was approved for publication by the Onondaga Environmental Institute (OEI) on April 29, 2009. Implementation is the most critical obstacle facing the collective vision for restoration within the corridor (OEI, 2008).

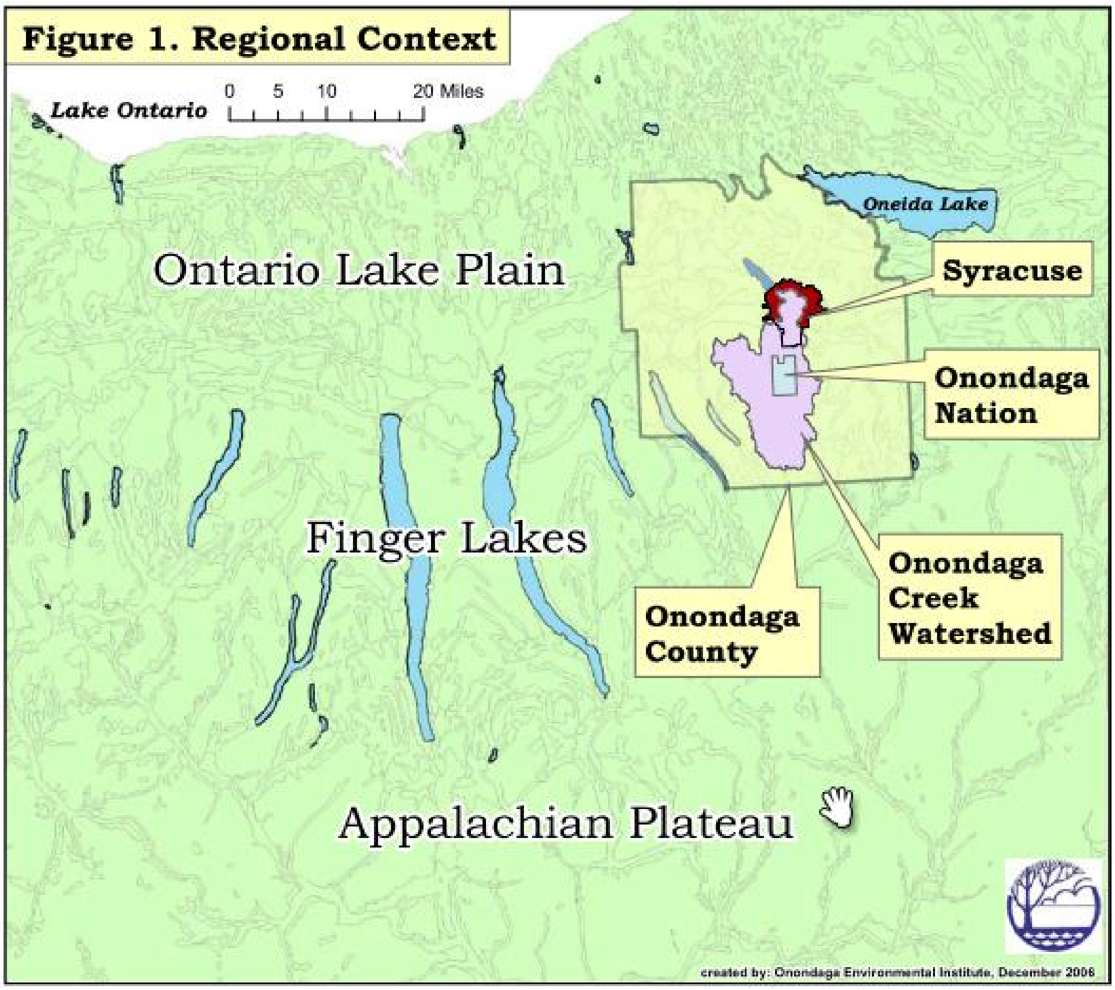


Figure 1 – Regional view of Onondaga Creek Watershed (OEI, 2008)

The objective of restoring recreational opportunities and habitat and ecological integrity to the Onondaga Creek corridor is proposed to assist the OEI in accomplishing the goals established in the OCRP. Our restorative analysis focuses on a section of the corridor referred to as the North Valley Area, located within the City of Syracuse, Onondaga County. Slightly different than the North Valley Area limits identified in the OCRP, our study comprised Onondaga Creek from the southern limits of Meacham Field to the location where Ballantyne Road crosses the creek (Figure 2). Within the OCRP, channel modifications were suggested for the North Valley Area. Stream meanders and floodplain restoration were proposed, along with instituting recreational opportunities such as boating, fishing, an interpretive trail creation. The North Valley Area is represented by a number of schools which would benefit from the restoration efforts proposed for this section of Onondaga Creek.

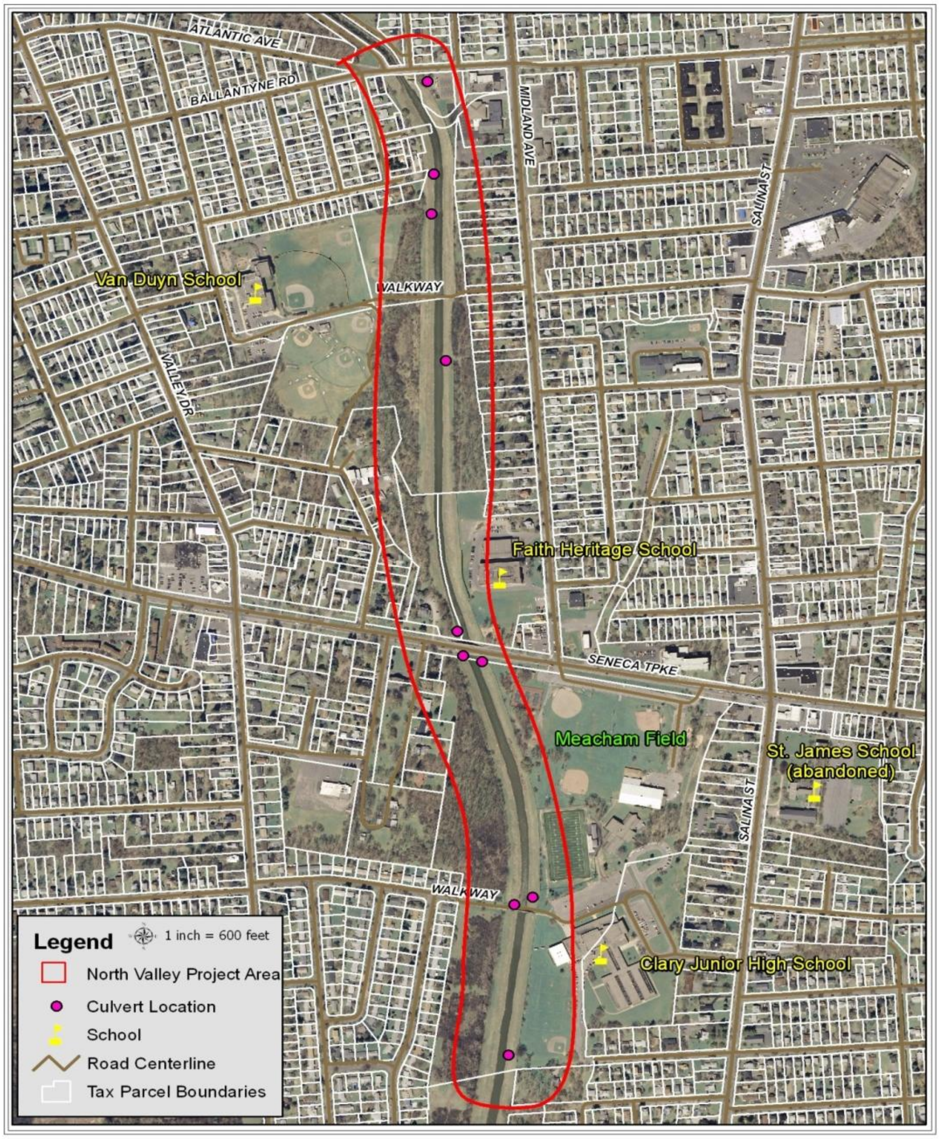


Figure 2 – Shows the limits of the North Valley Study Area

2.0 Site Location and History

Onondaga Creek is a major tributary of Onondaga Lake. It is part of the Seneca-Oneida-Oswego River Basin and contributes approximately 40 percent of the water that flows into Onondaga Lake. The headwaters of Onondaga Creek originate near Vesper, New York, south of the City of Syracuse. Onondaga Creek drains a 111 square mile area of mixed land use; general estimates are 80 percent forest, rural, and agricultural and 20 percent urban (OurLake.org, 2009). From Vesper, the Creek flows north through the Tully Valley to Onondaga Lake in the City of Syracuse. Onondaga Creek is documented to have over 66 tributaries, the major ones being Emerson Gulf, Furnace Brook, Hemlock Creek, Rainbow Creek, Kimber Brook, Rattlesnake Gulf, Pumpkin Hollow and Willow Creek (OEI, Onondaga Creek Fact Sheet). Figure 3 shows the approximate locations of some of the major tributaries of the Creek and the mapped limits of the Creek's sub-watersheds.

Table 1 – Watershed Dimensions for Onondaga Creek (Onondaga Environmental Institute, www.onondaganation.org/mediafiles/pdfs/onondaga_watershed.pdf)

Dimension	Units
Onondaga Lake Watershed Area	285 sq. miles
Onondaga Creek Watershed Area	111 sq. miles
Main Channel Length	33.05 miles
Highest Elevation in Watershed	Dutch Hill, 1879 feet
Headwater Elevation	Bailey Rd in Otisco, 1483 feet
Elevation at mouth of Onondaga Lake	363 – 365 feet

Historically, Onondaga Creek meandered 34 miles from Tully to Onondaga Lake. In the early 1800's, settlers began constructing mills that would utilize the water of the Creek. Mid-century, the Creek channel was straightened and deepened in response to sewage disposal and flooding concerns in the watershed. Major flood events that occurred in the early 1900's provoked the City of Syracuse, the U.S. Army Corps of Engineers (USACE), and New York State to implement further measures to channelize and dam portions of Onondaga Creek (OEI, 2008). The North Valley Area, that is considered the project site for this study, was channelized in 1962; the USACE straightened the Creek from Ballantyne Road to Dorwin Avenue, south of our project area. Prior to this channel manipulation, the Creek meandered through present-day Meacham Field.

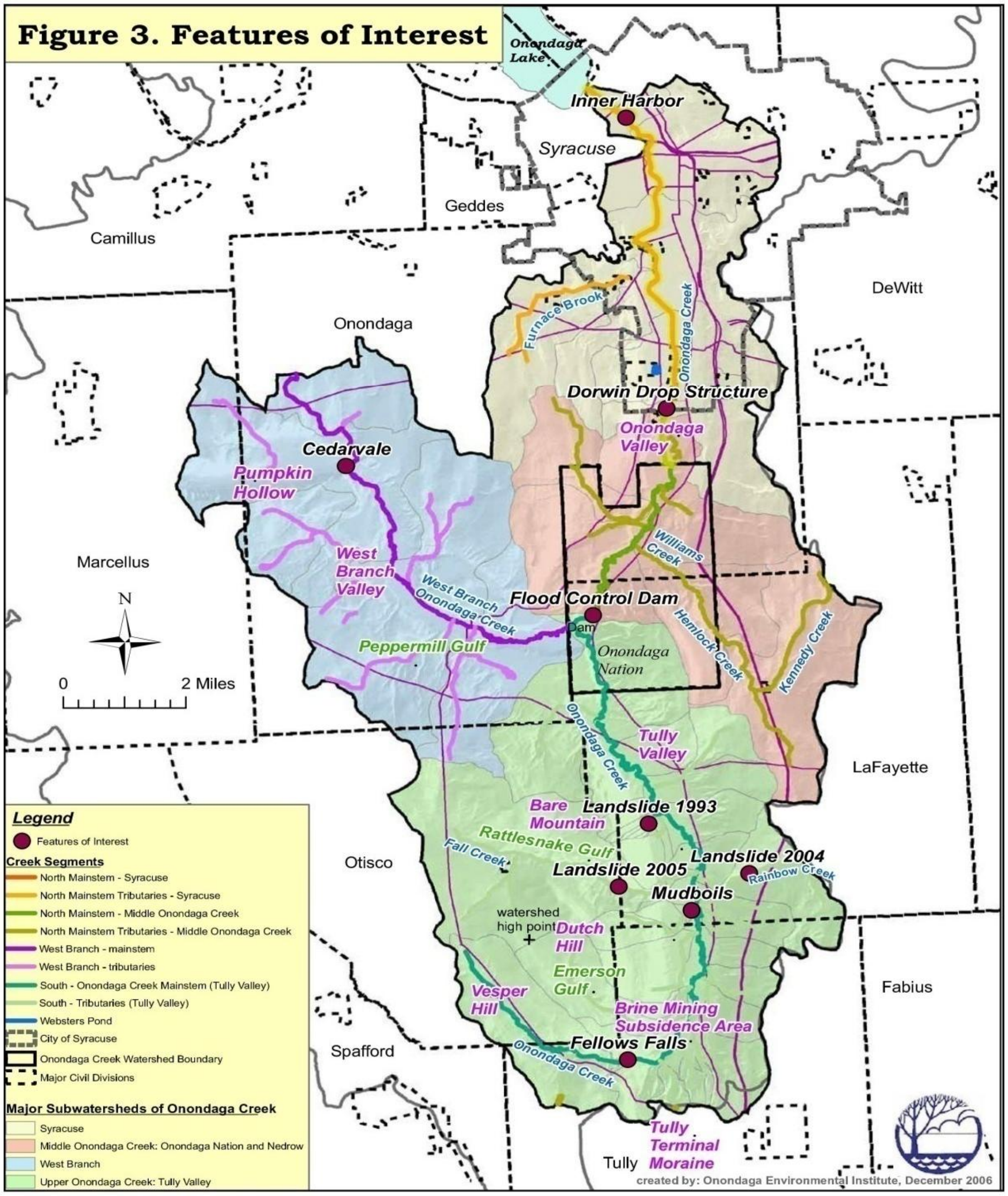


Figure 3 – This map shows the locations of main tributaries to Onondaga Creek and the limits of sub-watershed within the Onondaga Creek Watershed (OEI, 2008).

3.0 Site Conditions

3.1 Land Use

The majority of mapped soils within the North Valley Area are documented as Hamlin silt loam (Hc), Palmyra gravelly loam (3-8% slopes, PgB), and Palmyra gravelly loam (0-3% slopes, PgA) (USDA, SCS, 1977). Figure 4 shows the extent of mapped soils within the project area. Acres upon acres of forested and wetland area were transformed into miles of paved roads and other impervious surfaces as part of the urbanization around Syracuse that took place in the mid-1800's. Specifically within the project corridor, a swath of mowed vegetation, between approximately 60-90 feet in width, lines Onondaga Creek on both sides.

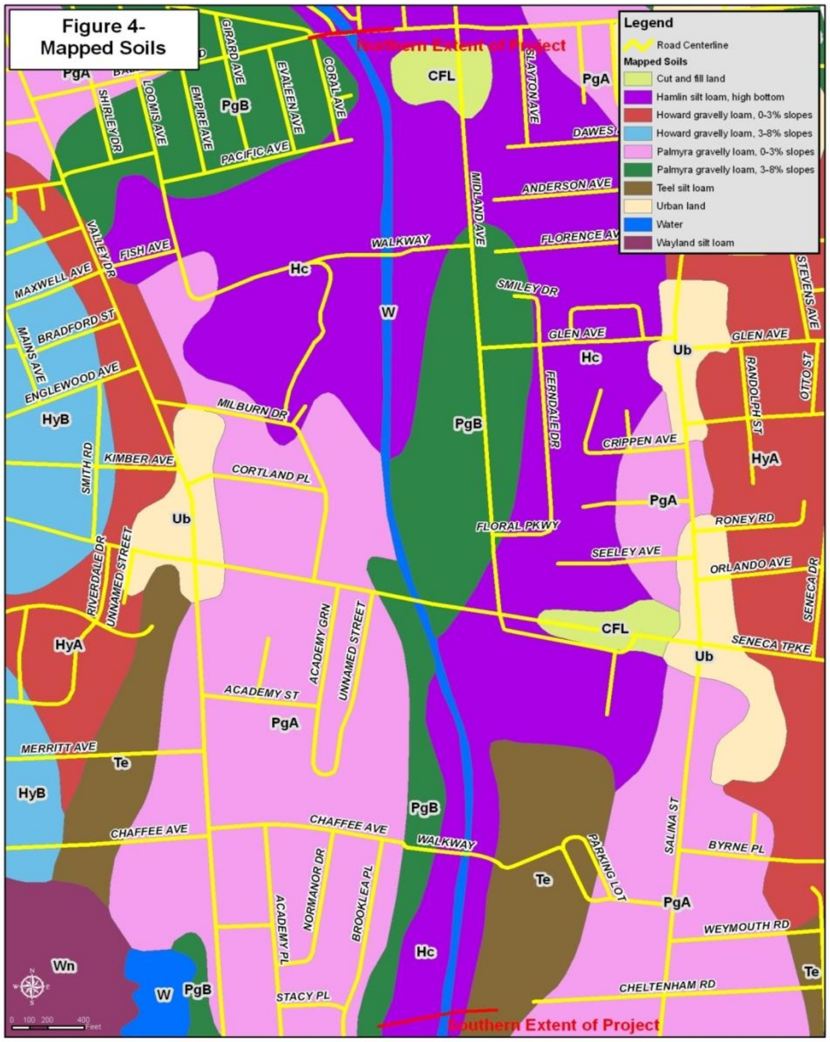


Figure 4 – Mapped soils within the project corridor (USDA, SCS, 1977)

Zoning within the North Valley study area is predominantly residential. Figure 5 shows the zoning classifications and zoning boundaries within and adjacent to the North Valley corridor. Table 2 lists the names and addresses (if available) of properties located within the project limits of this study. The ID numbers in this table reference the locations of specific tax parcels on Figure 6.

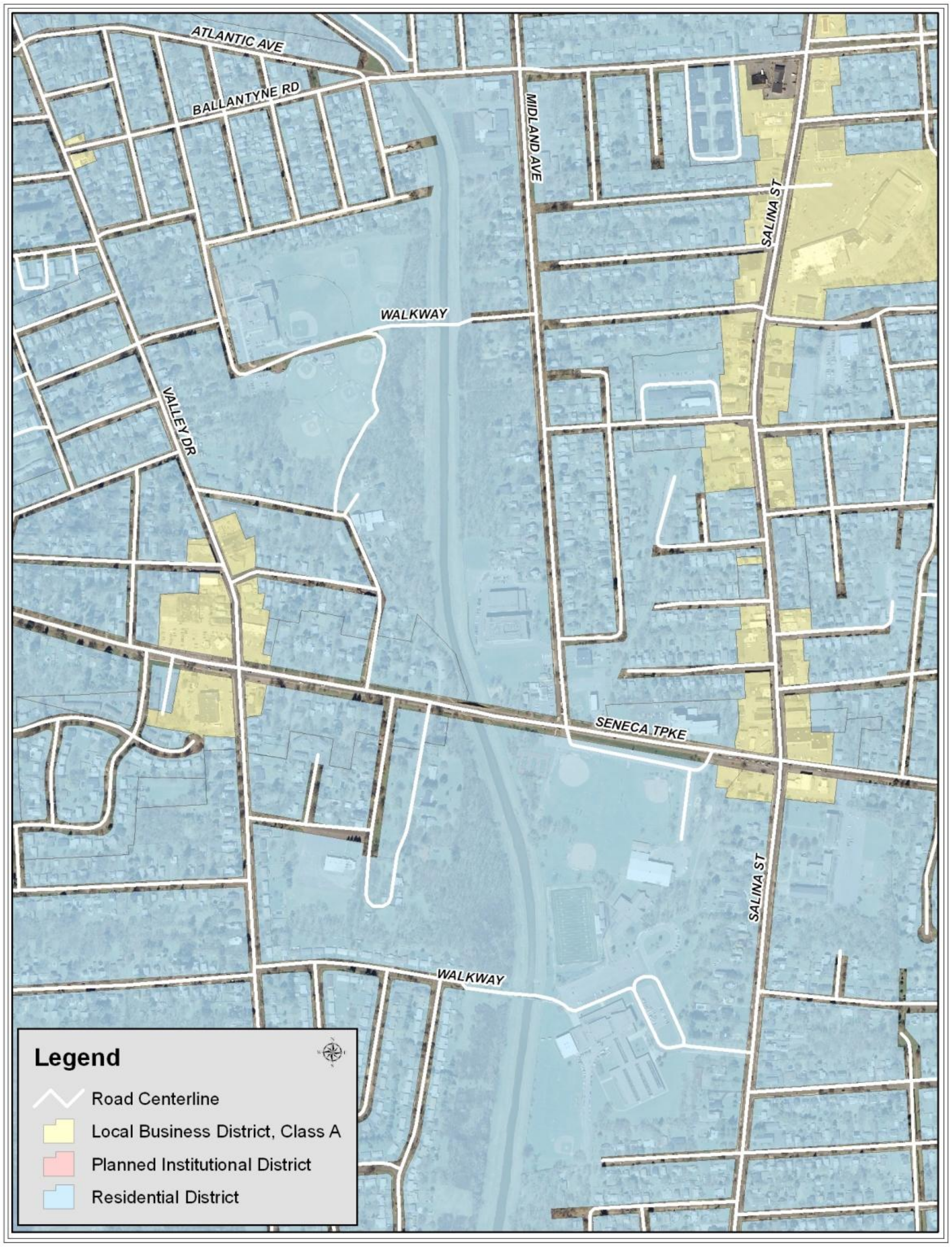


Figure 5 – Zoning classifications of properties within the study area

Table 2 – Property owners within the North Valley study area (Real Property Tax Service Agency)

Parcel Mapping ID	Property Owner Name	Parcel Location
1	Christian & Missionary Alliance (Church)	3112 Midland Avenue
2	City of Syracuse	--
3	Zen Center of Syracuse	266 West Seneca Trpk
4	City of Syracuse Parks (Meacham Field)	--
5	Faith Heritage School (school)	3740 Midland Avenue
6	William Leighton (private home)	214 West Seneca Trpk
7	210 West Seneca Trpk LLC. (storefront)	210 West Seneca Trpk
8	Faith Heritage School (residential)	3740 Midland Avenue

Figure 6 – Tax parcel mapping – City of Syracuse (Onondaga County GIS)

The areas listed above as being owned by the City of Syracuse (not Meacham Field) may actually be owned by the New York State Department of Environmental Conservation (NYSDEC). During a conversation with a NYSDEC official, he confirmed the DEC's ownership of the lands adjacent to Onondaga Creek, within the study area of this project. This shows conflicting data, since Onondaga County has these parcels listed in their tax parcel database as under the ownership of the City of Syracuse. This issue should be looked into further during subsequent phases of this project in order to confirm site ownership and jurisdiction.

3.2 Water Quality

The closest monitoring site to North Valley area is Dorwin Avenue. North valley is the upstream reach of Onondaga Creek's urban section. Since the goals of this restoration projects are habitat improvement and public access, the criteria used for evaluating water quality is NYSDEC standards for trout habitat and NYSDOH standards for recreational use.

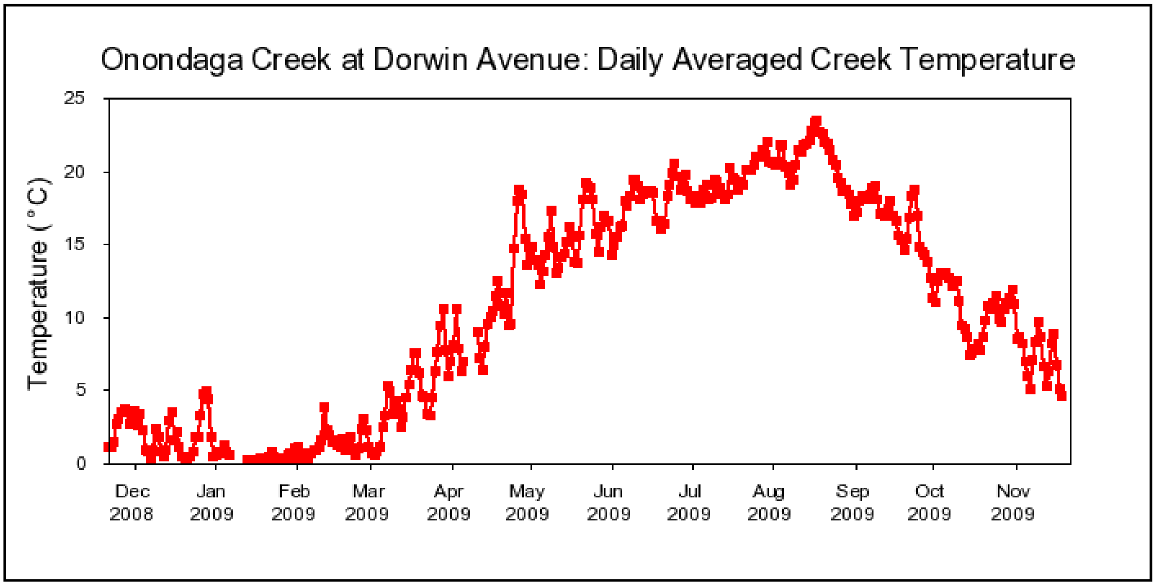
3.2.1 Temperature

Water temperature varies seasonally. Temperature can be locally influenced by:

- seepage of groundwater --a relatively constant year-round temperature ~50° F (10° C),
- domestic or industrial wastewater, and
- over-hanging and canopy vegetation which provides shade.

Most of Onondaga Creek tributaries are designated for trout habitat (Onondaga Environmental Institute, 2009). Trout require low temperatures year-round. Excessive heat in the summer can limit the available habitat for trout and/or threaten the sustainability of fish populations. Lethal temperatures for trout range from 73°F to 79°F (23°– 26°C). As water temperature approaches 70° F (21°C), trout are less able to compete with other fish species for food.

Dorwin Avenue is the only testing site that shows inhospitable temperatures for trout in summer. Temperature data for 2009, from ourlake.org (2009), is shown below (Figure 7):



3.2.2 Dissolved Oxygen

Dissolved oxygen (D.O.) is one of the most important water quality indicators because nearly all aquatic life, ranging from bacteria to fish, requires oxygen. Oxygen also regulates chemical reactions in aquatic systems.

Oxygen levels in Onondaga Creek are generally healthy throughout its length. D.O. is highest (13-15 mg/L) in cold weather, and lowest in the summer (8-9 mg/L). For waters designated for trout, which includes most of Onondaga Creek and its tributaries, the minimum daily average is 6 mg/L. For waters designated for trout spawning, which includes some tributaries of Onondaga Creek, the minimum is 7 mg/L (NYS DEC, 1999).

Our team sampled the water at North Valley on October 4th, and the DO is 8.5mg/L.

3.2.3 Turbidity and Solids Concentrations

Total solids content in water of our project area ranges from 30-100mg/l. For aquatic habitat, 25mg/l or less is optimal, 25-80mg/l is acceptable, 80 to 400 mg/l and 500mg/l will be fatal (Canadian Council of Ministers of the Environment, 1999).

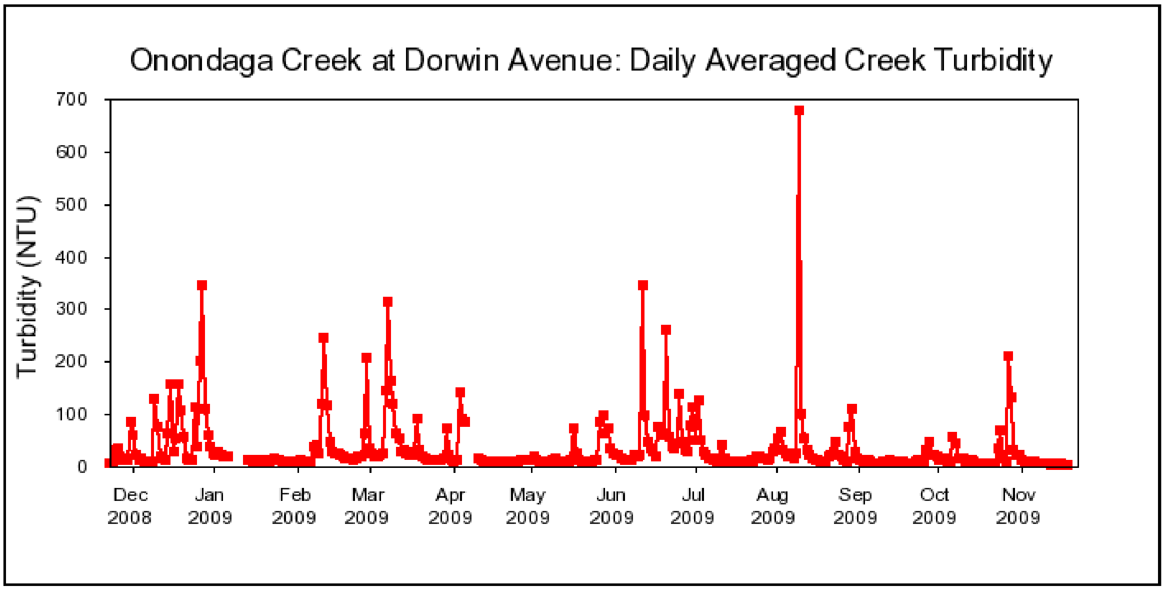


Figure 8 - Averaged Creek Turbidity at Dorwin Avenue (ourlake.org, 2009)

3.2.4 Nutrients

In the project area, high organic N levels during storm events was monitored, indicating that discharges and runoff containing N-rich are entering the creek.

Ammonia levels are below NYS toxicity standards, but occasionally reach close to the standards.

Nitrite level meets the standard for a warm water fishery. The standard for a cold water fishery is exceeded 12% of the time (As at Dorwin Ave).

3.2.5 Pathogens

Pathogens are microorganisms--bacteria, viruses, and protozoans which cause disease. Pathogens are commonly associated with decomposing carcasses and fecal material from animals of all kinds (human, other mammals, birds) (USEPA, 1997). For the case of Onondaga Creek, major source of contamination is sewage line seepage.

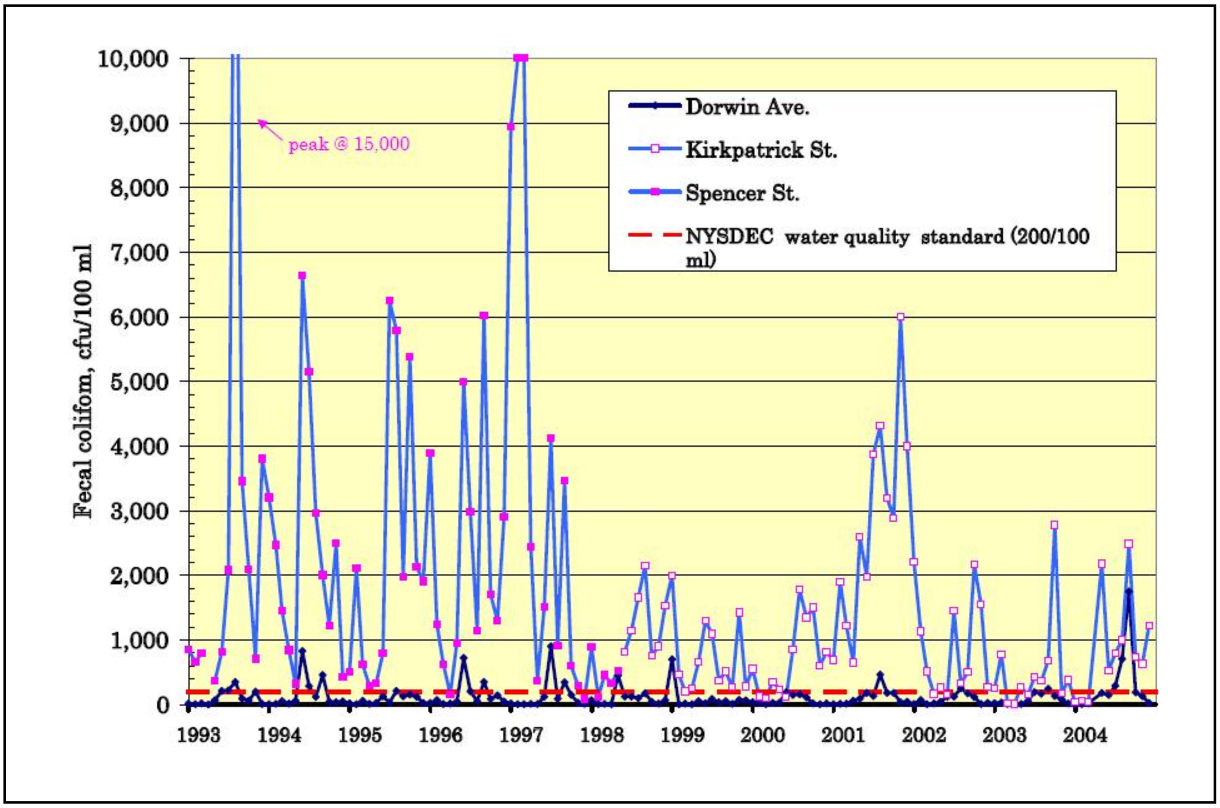


Figure 9 - Shows the fecal coliform concentration in creek at Dorwin Avenue. At most times the fecal coliform concentration is healthy, but from time to time the coliform level goes beyond standard

Average concentration of Enterococci at Dorwin Ave is 115 units/100ml water. This is 38% larger than the NYSDOH standard for bathing beaches, 61 units/100 ml in a single sample (Onondaga Environmental Institute, 2009). Without major improvement, water in our project range is not suitable for direct skin contact.

3.3 Ecological Resources

3.3.1 Fish Habitat

Surveys found a warm-water fish community exists in the city, downstream of Dorwin Avenue, including our project area. These fish include bluegill, large-mouth bass and other fish species that are also found in Onondaga Lake.

A coldwater assemblage occurs south of Dorwin Avenue, upstream in rural sections of the watershed; coincident with those stream stretches that remain natural and have not been channelized. This assemblage includes brown trout (a non-native trout), sculpins, creek chub, dace and white sucker. Wild brook trout were found in appreciable numbers only in small, upper watershed tributaries, including Furnace Brook.

A survey map of habitat along Onondaga creek is as follows, with the project area highlighted. Creek section in our project area was determined to have fair quality as aquatic habitat. Testing sites at Dorwin Avenue and Newell street, which are close to our project area, was mostly rated as “poor”, due to effects from channelization and poor riparian zone vegetation.

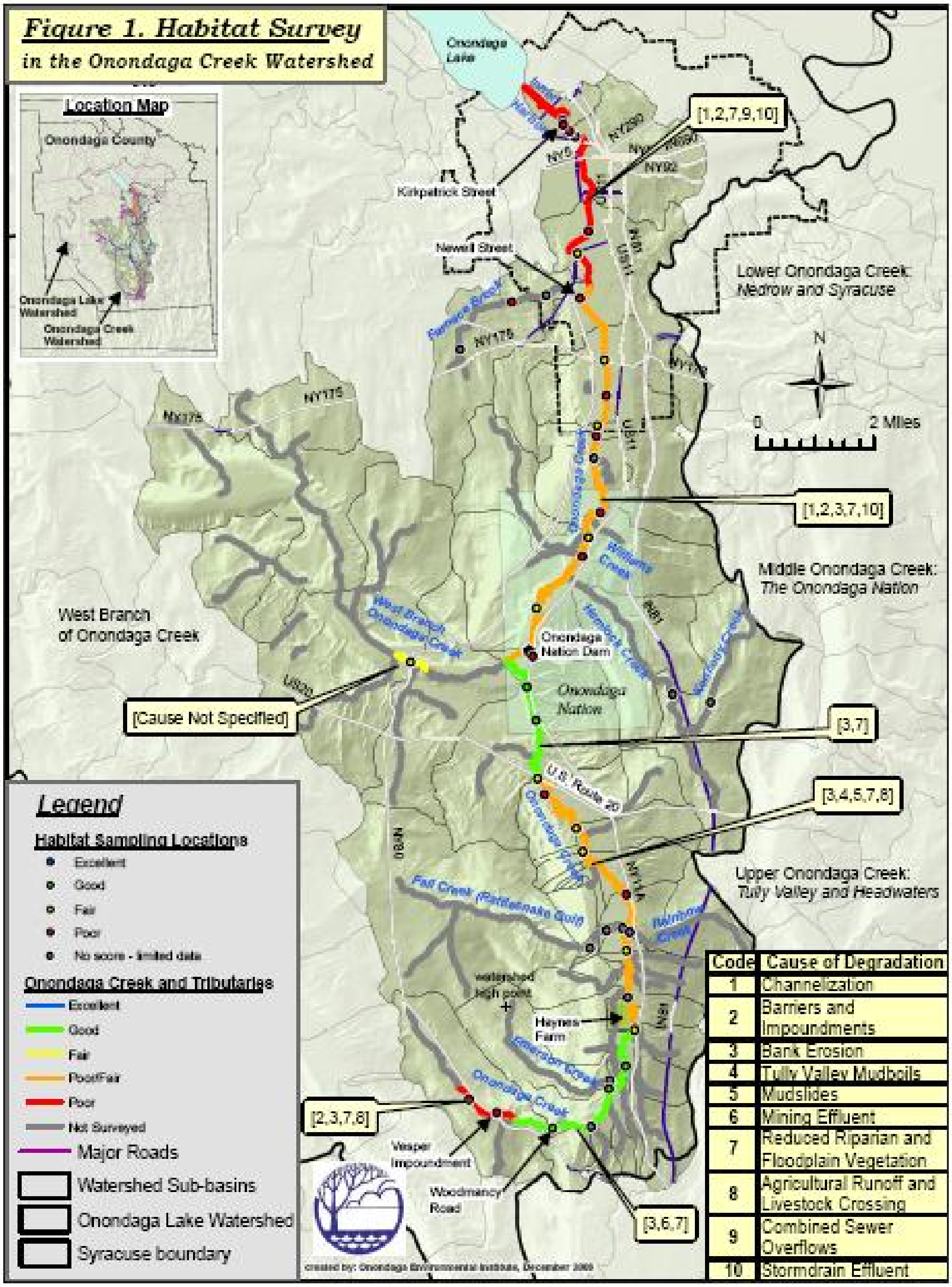


Figure 10 - Fish Habitat Survey of Onondaga Creek (Onondaga Environmental Institute, 2009)

4.0 Restoration Measures

4.1 In-stream Habitat Design

4.1.1 Goal

Though Onondaga Creek is designated for trout, high water temperature and nutrient level and other factors are keeping trout out of urban section of the creek[1]. Improving shading and sewer system along the stream corridor would be a straightforward method to improve the habitat for cold water fish, but is out of the scope of our project. Consequently, we decided to improve in stream habitat for: 1) warm water fish that already exist in the urban section of the creek; 2) amphibians that might inhabit the stream ponds along the banks; 3) small mammals that might use the riparian habitat.

Habitat requirement of the two major warm water fish currently found in the creek are (Onondaga Environmental Institute, 2009):

1) Bluegills inhabit lakes, slow-moving rivers, vegetated ponds and creek pools. Blue gills often feed in shallows near the surface during the spring and spawning season, and move into deeper waters when the water temperature rises in the summer.

2) Large-mouth bass thrive in a variety of waters from shallow muddy streams to deep clear water reserves. But the largemouth prefer swimming around distinct underwater structure ranging from changes in bottom composition to uncharacteristic underwater formations, and especially like structures that offer shade and security.

---

[1] For more trout habitat requirement, see http://www.ofah.org/Stream/Downloads/FactSheets/TroutHabitatEnhancement.pdf

4.1.2 Defining Problems

Suitable water quality, passage routes, and spawning grounds are some of the characteristics of fish habitat. Currently the capacity of fish habitat in this reach is evaluated as poor to fair (see current state chapter), and we determined the following problems needs to be addressed:

1) Water quality: high pathogen and solids level; high nitrite level

As already elaborated in previous chapters, water quality in the Onondaga creek is not optimal for aquatic life. Our project area ranks in the cleanest sections of the Syracuse urban watershed, but still the water is polluted with pathogen, solids and nutrient. Water pollution, although is not lethal to the warm water species, greatly reduces the quality of habitat.

2) Uniform flow rate, lack of riffles

Ideal places for fish are pools found at the end of a riffle. It allows for slower moving current, but also supplies the aquatic insects that fish need for food. However, almost no riffles exist in our project area. (http://www.blackfootchallenge.org/adoptatrout/trouthabitat.htm).

3) Lack of shade and shelter for fish or amphibians

Foliage cover at the edge of a stream is important to shade the stream so that the water temperature does not get too warm. The roots of the plants hold the soil together so that the stream bank does not wash away. The vegetation also allows cover for insects. These insects often fall into the stream and become food for the trout. From mid May to mid July cutthroat trout leave their normal habitat to find a spawning habitat which is usually on a gravel bar (http://www.blackfootchallenge.org/adoptatrout/trouthabitat.htm).

4) Poor functioning food chain

On the stream banks, vegetative growth is restricted and mowing is frequent in channelized sections south of Ballantyne Avenue. This reduces habitat for insects, birds, and wildlife. The lack of vegetation reduces shade;

channelization has produced a wide open, shallow stream profile, thus the high water temperatures noted above under water quality are prohibitive to cold-water fish, such as trout, in the summer.

4.1.3 Proposed Improvement Methods

Boulders: Hydrology Improvement and Shelter Creation

The strategic placement of large immobile boulders (>1 cubic yard) and boulder clusters within homogenous sections of streams increases diversity of water depth, substrate, and velocity, thereby increasing habitat value of an otherwise plane bed stream (Washington Department of Fish and Wildlife et al., 2004). Placing boulder also provides overhead cover and resting areas for aquatic life. Boulders can be used in most stream habitat types, while usage in streams with average flows exceeding 2 feet per second are realized to have the greatest benefits (USDA, 1993). Our project area has an average flow of about 200 cubic feet per second (Figure 11), and the cross section area is no larger than 100 square feet, which makes the flow rate larger than 2 feet per second. Group placements (Figure 12) of boulders are most desirable. This technique is also most effective in wide, shallow streams with gravel or rubble beds, as our project channel is.

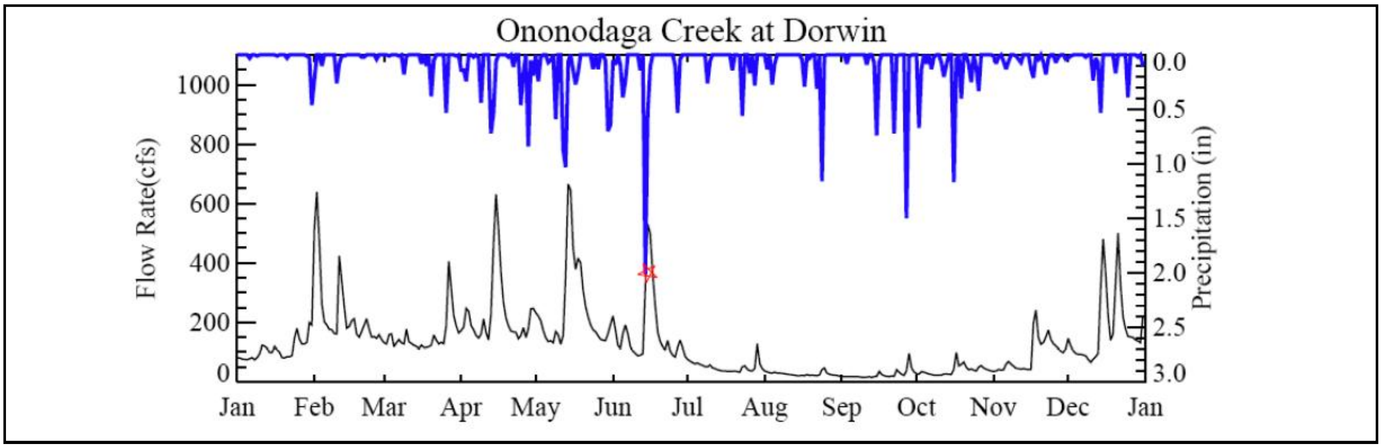


Figure 11 - Daily stream flow at Dorwin Ave. in 2002
(Upward scale, Onondaga Environmental Institute, 2009)

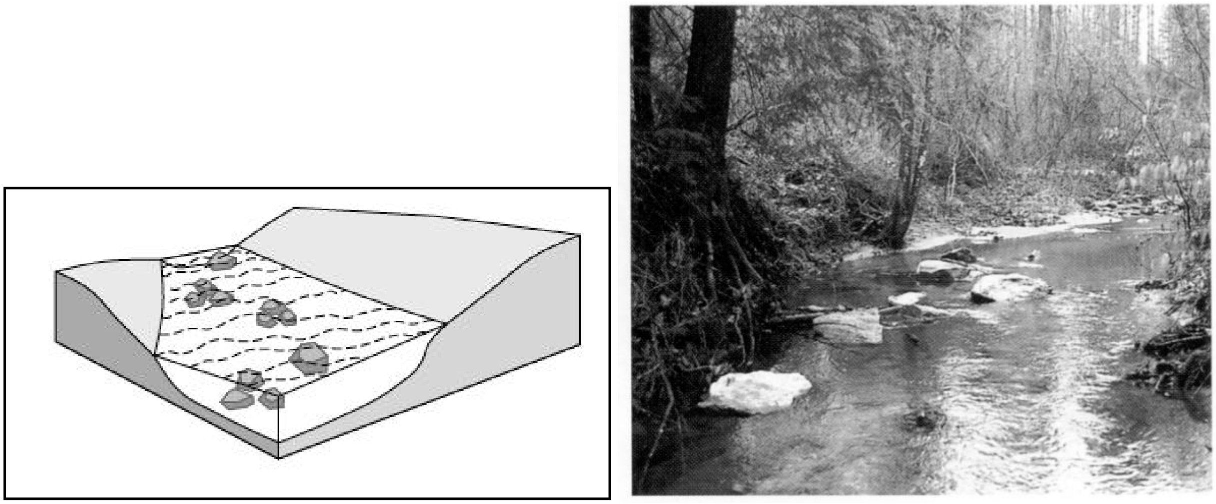


Figure 12 - Boulder Clusters (FISRWG 1998)

Shelter Structure: Create Fish Shelter and Improve Food Chain

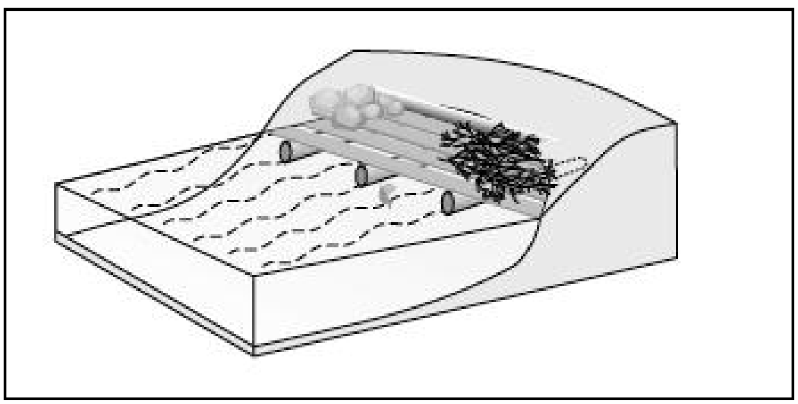


Figure 13 - Log, brush and rock shelter (FISRWG 1998)

In low gradient stream bends and meanders where open pools are already present, log, brush or rock shelters (Figure 13) can create an environment for insects and other organisms to provide an additional food source. These structures can be constructed from readily available materials found near the site, and are especially suitable for stable channels. These structures are important in streams where aquatic habitat deficiencies exist. And best results are found where they are used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerative source of stream bank vegetation.

Water Purification Wetlands

Although upgrade of sewer system and wastewater treatment facility would be required for purification of water in Onondaga Creek, establishment of in stream wetland would improve the water quality at our project scale.

Besides providing hydrologic flux and storage functions that reduce flooding, wetlands also provide biogeochemical cycling and storage that benefits water quality. Wetlands may be a sink for, or transform, nutrients, organic compounds, metals, and components of organic matter. Wetlands may also act as filters of sediments, pathogens, and organic matter (Whigham et al., 1988). And with solids removal, wetland actually serves as a filter of pathogens as well, since solids carry most pathogens.

In this case, in stream wetland can be well combined with the log shelter structures.

4.1.4 Habitat Creation: Integration of In-stream Structures and Plantings

To get optimal results, selection of plants and distribution of in-stream structures needs to be decided with consideration of upland vegetation and fauna structure. Figure 14 shows the proposed locations for the in-stream habitat measures that are proposed below.

Figure 14 - Locations of in-stream habitat enhancements are shown throughout the study corridor

<u>*Boulder Placement*</u>

To get distinct results, we decided that the boulders will be placed in the most uniform sections of our project area (Figure 15). These locations are 1) From Meacham Field to the Zen Center, 2) from the Zen Center to Ballantyne Road, and 3) upstream in proximity of in-bank shelter structures.

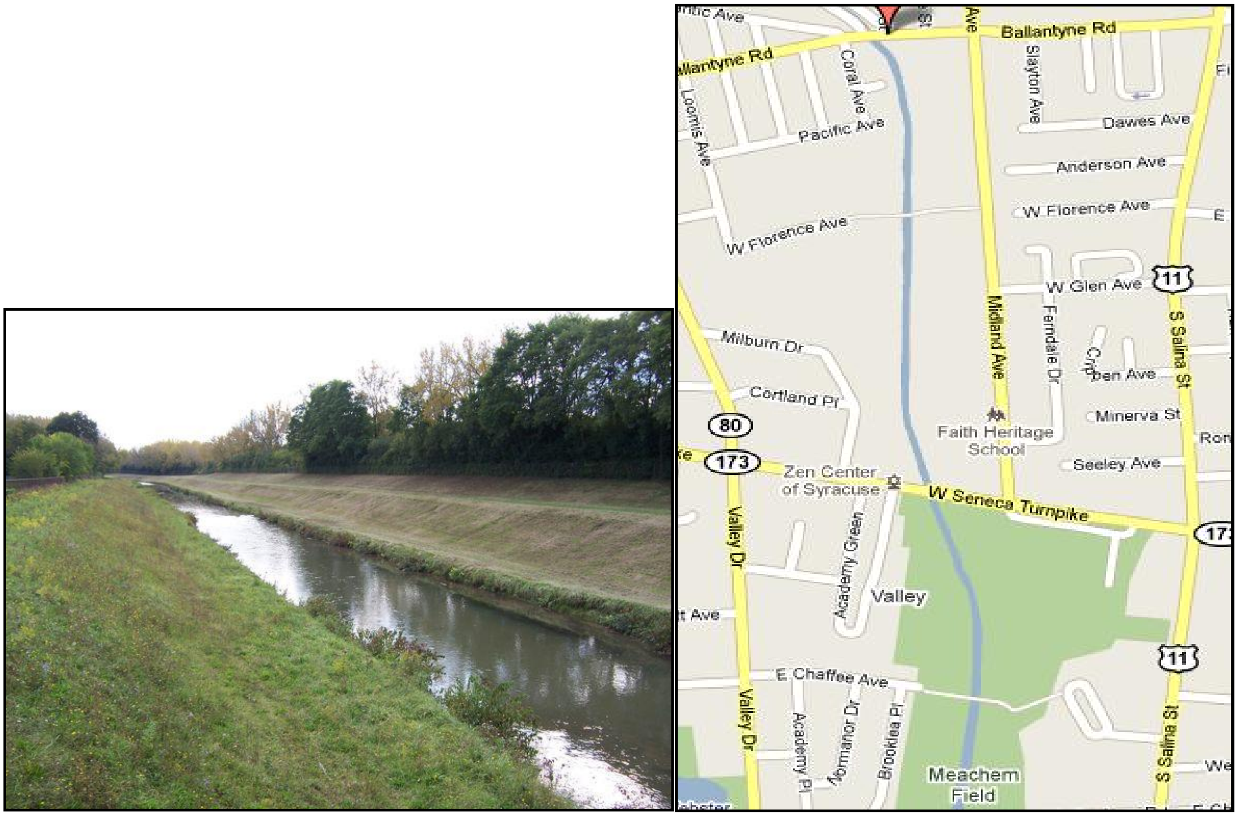


Figure 15 - Site Selection for In-stream Boulder Placement

In Bank Shelter Structure

These structures are best functioning where open pools already exist. In our project area, 3 open pools can be found. Two are out-bends of meanders, and the other one is created by human introduced cobble accumulation (Figure 16).

Figure 16 - Site Selection for In-bank Shelter

In-stream Wetland

We proposed establishment of wetland at the following locations (Figure 17) above the in-bank structure and at the section closed to drainage pipe (downstream). The first type of area has already the hydrology required by wetland creation. Actually, around the cobble accumulation spot we already saw wetland developing. The second area will serve the best function as a water purifier.

Figure 17 - Site Selection of In Stream Wetland Creation

4.1.5 Structure Design

Designs described below are conceptual phase. Once determined to implement these measures, more information from site assessment will be needed to carry out design specifications. *Stream Restoration Guidelines* by Washington Department of Fish and Wildlife in 2004 would be a good reference to help design these structures.

Boulder Placement

Large, irregular-surfaced boulders will be used because of their capacity of creating more hiding space for fish. Boulder clusters typically consist of three to seven boulders that are spaced 6 inches to 3 feet apart, the distance increasing with the size of the stream. Clusters should be located 10 to 12 feet apart to allow passage of bed material and floating wood and limit the reduction in stream flow capacity. Bearing this in mind, boulder clusters should be arranged to complement each other and work together to direct flow as desirable.

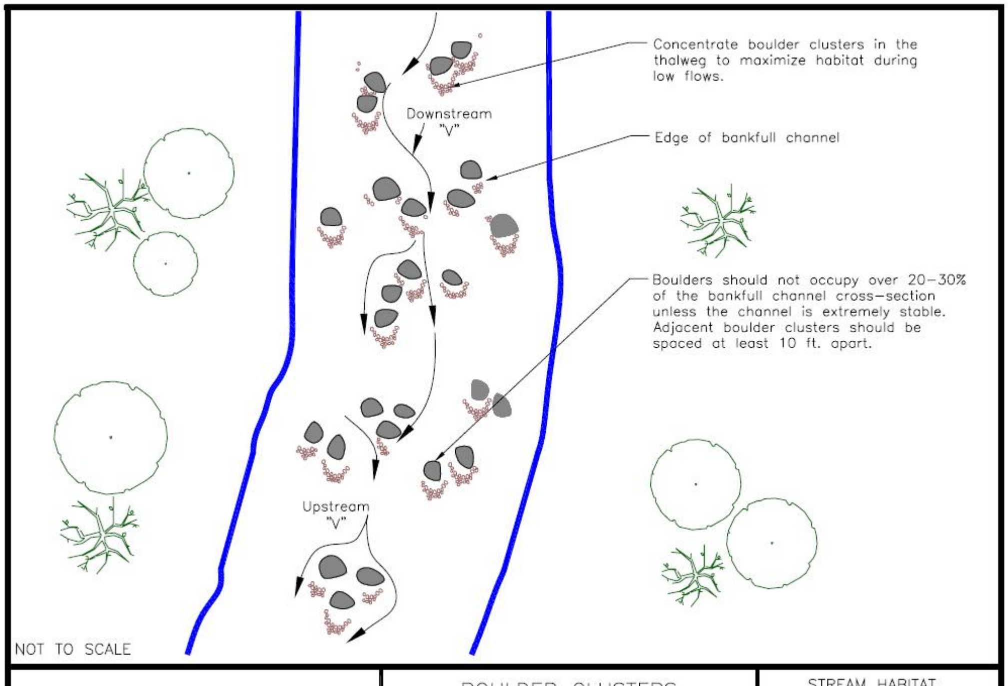


FIGURE 1 | BOULDER CLUSTERS CONCEPTUAL DESIGN | STREAM HABITAT RESTORATION GUIDELINES http://www.wa.gov/wdfw/hab/ahg/shrgdoc.htm

Figure 18 - Design of Boulder Placement (Washington Department of Fish and Wildlife, 2004)

<u>*In-bank Shelter*</u>

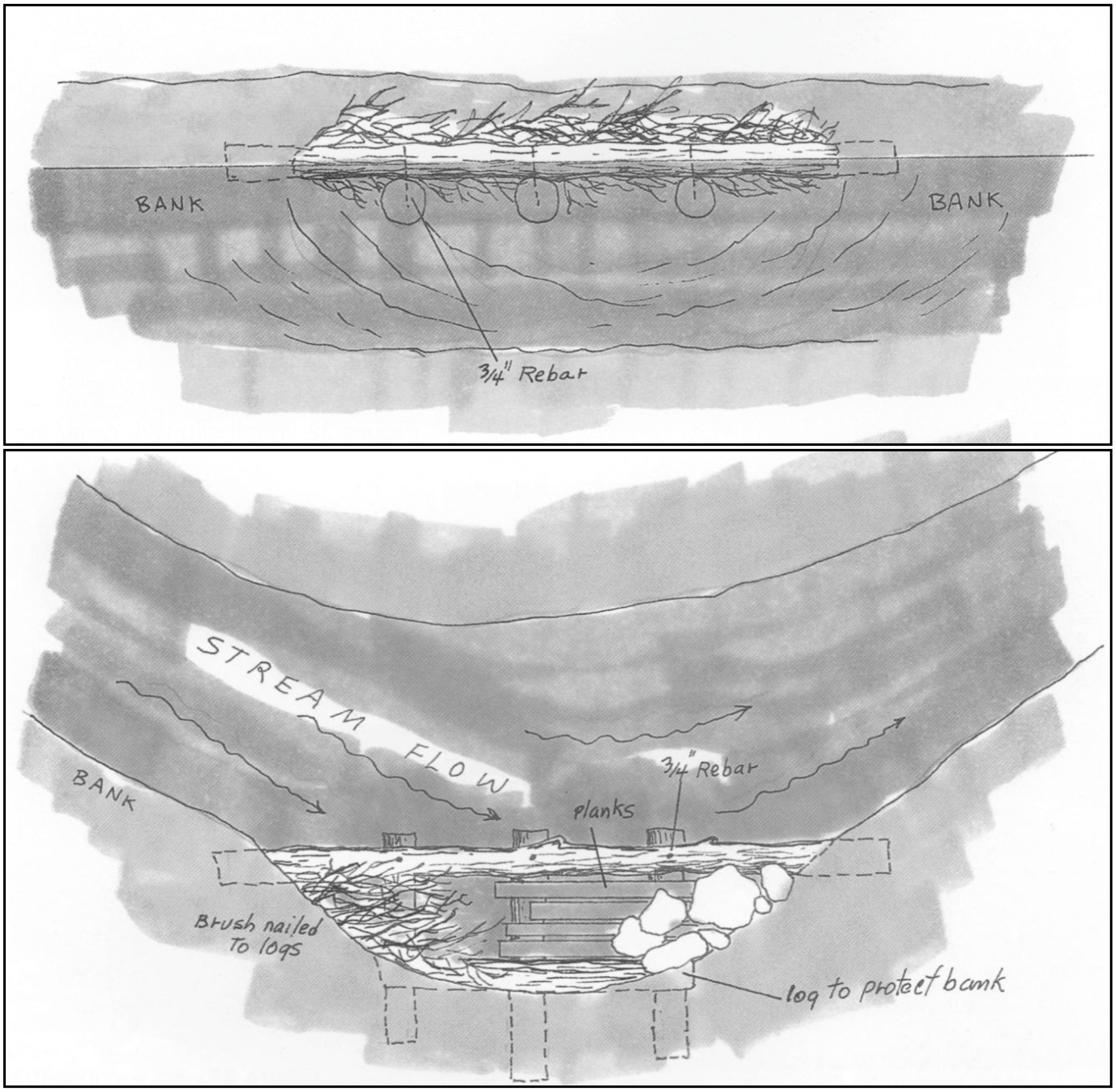


Figure 19 - Design of In-bank Shelter (USDA, 1993)

The most common log and brush shelter design is shown in Figure 19. Simple log structure is established to create a panel in the out bend of meander. Bush material and rock is placed above.

Figures 20 and 21 – In-bank Log Shelter (http://www.mostateparks.com/jshutins/pics_riverrest.htm, Washington Department of Fish and Wildlife 2004)

In-stream Wetland

Creating in-stream wetland above the shelter structure could be as simple as applying a layer of gravel and soil above the log structure and then introducing wetland plants (Figure 22). Roots of wetland plants may suspend in deeper water after development. Native wetland plants should be chosen.

Figure 22 – In-stream Wetland Example (Image Courtesy of University of Kenturcky, http://watersecretsblog.com/archives/2008/07/kentucky_commun.html)

4.2 Riparian Biodiversity

4.2.1 Riparian Corridor Overview

The Value of Healthy Riparian Corridors

The term riparian comes from the Latin word, *Riparius,* which means "of or belonging to the bank of a river." Today, we recognize riparian zones as biotic communities occurring on the shores of streams and lakes. Frequent flooding and disturbance regimes have caused these transitional ecosystems to be some of the most diverse and ecologically complex areas on the planet (Naiman and Decamps 1997).

Riparian zones provide an array of ecosystem services. Riparian vegetative buffers control sediment and nutrient runoff between upland areas and the river ecosystem. Trees and shrubs moderate the temperature of adjacent waters through evapotranspiration and the provision of shade. Riparian root systems help to stabilize stream banks (Richardson et al. 2007).

Riparian corridors can provide valuable ecological connectivity between fragmenting natural landscapes. An ecological corridor is a linear route through which biota can travel between habitat patches. Connectivity is the extent to which species and populations are exchanged between mosaic habitat structures. Core habitat patches within an ecological matrix can be joined either by continuous corridors or stepping stone corridors, where smaller habitat fragments provide oases of ecological connectivity between the larger core areas. Patch dynamics in riparian zones yield a diverse range of biotopes (environments that support a specific assemblage of plants and animals) that provide connectivity between multiple core habitats over large distances without being mutually exclusive to specific metacommunities (Hilty et al. 2006).

Importance of Fostering Vegetative Biodiversity in Riparian Corridors

Riparian zones provide exceptionally diverse habitats for a variety of terrestrial and aquatic organisms. The habitat heterogeneity characteristic of riparian corridors results in a densely populated, species rich landscape. In fact, up to 90% of plant species within a catchment can often be found in riparian areas (Naiman et al. 2005a). Diverse patch mosaic sub-communities located along riverine corridors serve a number of different species with contrasting life history strategies. 70% of vertebrate species in a region will utilize ecosystem services provided by riparian river corridors at some stage in their life cycle (Raedeke 1989 as cited by Naiman et al. 1993).

From a landscape ecology perspective, biodiversity can be thought of as encompassing both structural and functional diversity. The geomorphic variation and frequent disturbance regime characteristic of the riverine landscape create both an expansive resource gradient and the potential for niche overlap (Ward et al. 2002). The frequency of flooding and upland disturbance coupled with the small-scale variability in the topography of the riparian corridor result in a diverse mosaic of habitat structures and processes. Flooding destroys patches and redistributes sediment, varying altitudes and vegetative profiles create distinctive microclimates, pollinators from upland areas bring with them a variety of volunteer plant species. The natural stochastic disturbance of these dynamic ecosystems keeps them in a non-equilibrium state, inhibiting competitive exclusion and allowing for a variety of species to coexist (Naiman et al. 1993).

Habitat heterogeneity and vegetative species diversity enhance ecological connectivity in riparian river corridors. Patch mosaic structures encourage edge species usage due to high edge-to-interior ratios (Henry et al. 1999). Additionally, since riparian zones promote biotopes characteristic of both hill slope and hydric soils (Gregory et al. 1991), biota with different habitat requirements can move through intertwining stepping stone corridors in fragmented landscapes where both upland and aquatic habitats are disturbed.

Recent literature has pointed to riparian vegetative communities as ecosystem engineers. Early successional riparian species contribute large woody debris (LWD) to stream ecosystems (Naiman et al. 2005b). LWD creates a carbon rich habitat for biofilm algae to grow, attracting subsequent grazing snails and specialized macroinvertebrate species. LWD can also increase the retentive capacity of a channel and accrete sediment, creating islands and downstream scour pools (Gregory et al. 2003, Gurnell et al. 2005 as cited by Lake et al. 2007).

The capacity of riparian vegetation to engineer a heterogeneous riverine landscape can potentially be viewed as a form of biogeomorphic succession, where dominant riparian plants, such as willows and cottonwoods, alter the landscape in order to promote biodiversity in later seral stages. Analysis of these characteristics has led to a the novel conception of riparian floral species as niche constructers; perpetuating dynamic, heterogeneous stream habitat conditions through adaptive mechanisms such as brittle twig bases, buoyant propagules, adventitious roots, and seasonally synchronized seed release mechanisms, among others. The creation of in-stream habitat by LWD, stabilization of banks and islands by adventitious roots, and the control of nutrients between upland areas and the river system are just a few ways in which riparian vegetation can act as ecosystem engineers within riverine corridors. Therefore, it can be argued that vegetative biodiversity is a both a product and engineer of the habitat heterogeneity characteristic of riparian zones (Corenblit et al. 2009).

Due to flooding concerns, and a variety of other social factors, most modern urban stream corridors are highly engineered to promote bank stability. Static banks, vegetation control, and channelization have all severely impacted stream health and have served to fragment associated habitat. While bank alteration to a “pre-engineered” state and the reinstatement of flooding regimes may theoretically restore the riverine landscape to a more “natural,” dynamic state (Goodwin et al. 1997), the lack of conventional flood control and subsequent threats to human safety are not justifiable risks for this type of ecological restoration in modern, American society. However, it is the thesis of this restoration plan that increasing floral biodiversity along a stream corridor can, over the long run, serve to naturally engineer geomorphic variation throughout the riverine landscape, increasing habitat heterogeneity and the overall biodiversity of the region.

Naiman et al. (1993) points out that historic human impacts on river systems have been attempts to simplify their structure and function, whether through dams, diking, or channelization. Ecologically conscious stream restoration must therefore strive to restore ecological connection and complexity over space and time if it is to have a significant, sustained impact.

Propagule Dispersal and Impacts on Regional Biodiversity

It has been established that healthy riparian zones foster high levels of biodiversity. Restoration of these areas does not only benefit the riverine corridor; it can serve to help regenerate stocks of biodiversity in the greater watershed and beyond. Propagules can be moved from the riparian zone to other regions by wind, water, and pollinators. Often, seeds are picked up by wind blowing through the open river corridor and deposited into the water, where they are moved over large distances in a process called hydrochory. In this way, riverine landscapes serve as “conveyor belts,” rapidly moving propagules between different landscapes, often with loads of sediment which may also contain seed bank (Richardson et al. 2007).

Pollinator species such as birds, bees, and moths thrive in riparian zones, and can also help to disperse propagules between core habitat patches in fragmented, human-dominated landscapes. Williams and Kremen (2007) found that ecological connectivity between habitat patches in a mosaic landscape, particularly between agricultural and semi-natural, served to bolster bee populations. Increasing ecological connectivity both through the maintenance of healthy riparian river corridors expands pollinator resource bases and results in enhanced, far-reaching propagule dispersal.

Birds are extremely effective pollinators and often rely on riparian zones as a refuge in times of disturbance. In boreal forests, bird population densities have increased between 30% and 70% in riparian forest strips the year after clear cutting of surrounding forest areas. Populations in these protected strips drop subsequent to disturbance, as birds re-populate the disturbed areas (Darveau et al. 1995 as cited by Naiman and Decamps 1997). This suggests that riparian zones might both act as a refuge for bird populations in times of disturbance and as a stock of genetic biodiversity that can potentially be redistributed throughout fragmented landscapes by means of ornithochory.

As a final note, riparian zones can serve a valuable function as corridors for plant dispersal during periods of rapid climate change due to the modulated microclimates along river valleys. As climate change impacts plant range and diversity in the greater river basin, riverine corridors can function as sinks for biodiversity, preserving species that may not be able survive the temperature fluctuations and seasonal variability associated with climate change (Gregory et al. 1991).

Connectivity, Exotic Species and Ecosystem Function

Plant species best suited for survival in riparian zones typically display morphological adaptations such as the ability to withstand flooding, sediment deposition, and stem breakage (Naiman et al. 1998 as cited by Richardson et al. 2007). These required traits serve as "ecological filters," selecting species best suited for riparian zones from adjacent habitat within the river basin (Ellenberg 1988 as cited by Richardson 2007).

Propagule dispersal within the river corridor can be precipitated by wind, water, and pollinator activity. Successful colonization of the riparian zone depends highly on its disturbance regime and the plant's ability to adapt to the challenges posed by the dynamic environment. Exotic plant species are typically early seral organisms that thrive in low competition, high disturbance environments. Therefore, their presence is often correlated positively with the types of disturbances that occur in the riparian zone (Planty-Tabacchi et al. 1996 as cited by Richardson et al. 2007).

Recent literature suggests that ecosystem functions such as water filtration and bank stabilization decline when biodiversity drops to low levels. The loss of these services typically leads to an area being characterized as "degraded" (Hooper et al. 2005 as cited by Richardson et al. 2007). In order to determine the impact of invasive species on overall ecosystem function, one must first examine whether colonization by exotics has a substantial impact on biodiversity in the riparian zone. Studies of biodiversity in riparian corridors have shown similar levels of biodiversity in patches dominated by both native and exotic species alike (Bagstad et al. 2006 as cited by Richardson 2007). Additionally, positive correlations between native and exotic species richness have been observed (Stohlgren et al. 1999 as cited by Richardson et al. 2007).

In restorations concerned with restoring connectivity and encouraging volunteer species colonization, exotic species control will likely be a concern. However, though native species propagation is preferential (D'Antonio and Meyerson 2002), encroachment of exotics that do not compromise biodiversity and associated ecosystem functions should not curtail measures to promote ecological connectivity within the riparian corridor.

4.2.2 Plan for Restoration of Riparian Biodiversity: North Valley

The banks along the North Valley reach of Onondaga Creek in Syracuse display limited vegetative cover due to a mowing regime that occurs once in June and sometimes again in late September (Landis 2008). The banks have been highly engineered and seeded with turf grass to prevent flooding and erosion. Catherine Landis, a doctoral student in Environmental and Forest Biology at SUNY-ESF, intensively examined the riparian vegetation along the Onondaga Creek corridor, from a rural to urban gradient for her Master's Thesis. This restoration plan provides the steps and details needed to implement her recommendations for the North Valley reach of Onondaga Creek. Specifically, the following plan outlines a planting and maintenance scheme along Onondaga Creek that attempts to realize the goal of "passive restoration" or "watershed renaturalization," as suggested by Landis (2008).

No-mow areas and scarification of turf as proposed by Landis (2008) are incorporated here into a modular framework aimed at restoring keystone and pollinator attracting vegetative species, based on the habitat requirements of the three primary zones observed along the creek bank. This riparian restoration is divided into three zones, as recommended by the Federal Interagency Stream Corridor Restoration Working Group when designing an urban stream buffer (USDA 1998). In this plan, the three zones are broadly designated as hydric, xeric, and upland (Figure 23). Respectively, these correspond roughly to the narrow, silt based floodplains directly adjacent to the creek; the gravelly, engineered slopes continuing on upland from the creek; and the uppermost areas where the graded creek banks level off.

These landscape characteristics are hybridized with a representative assemblages of trees, shrubs, and herbaceous to create planting modules with which to plan vegetative transplantation and maintenance within the restoration corridor. The establishment and overlap of these specific planting modules are designed to function as vegetative nodes amidst mow, no-mow, and scarification zones—functionally creating the seral variation and habitat heterogeneity characteristic of dynamic riparian zones. The purpose of this restoration is to create an initially deconstructed array of micro-habitats with the goal of diversifying the upstream seed bank, promoting volunteer species from nearby core habitats, such as the nearby Rand Tract Forest, and ultimately allowing long-term, passive re-naturalization of both the restoration corridor and downstream reaches along Onondaga Creek.

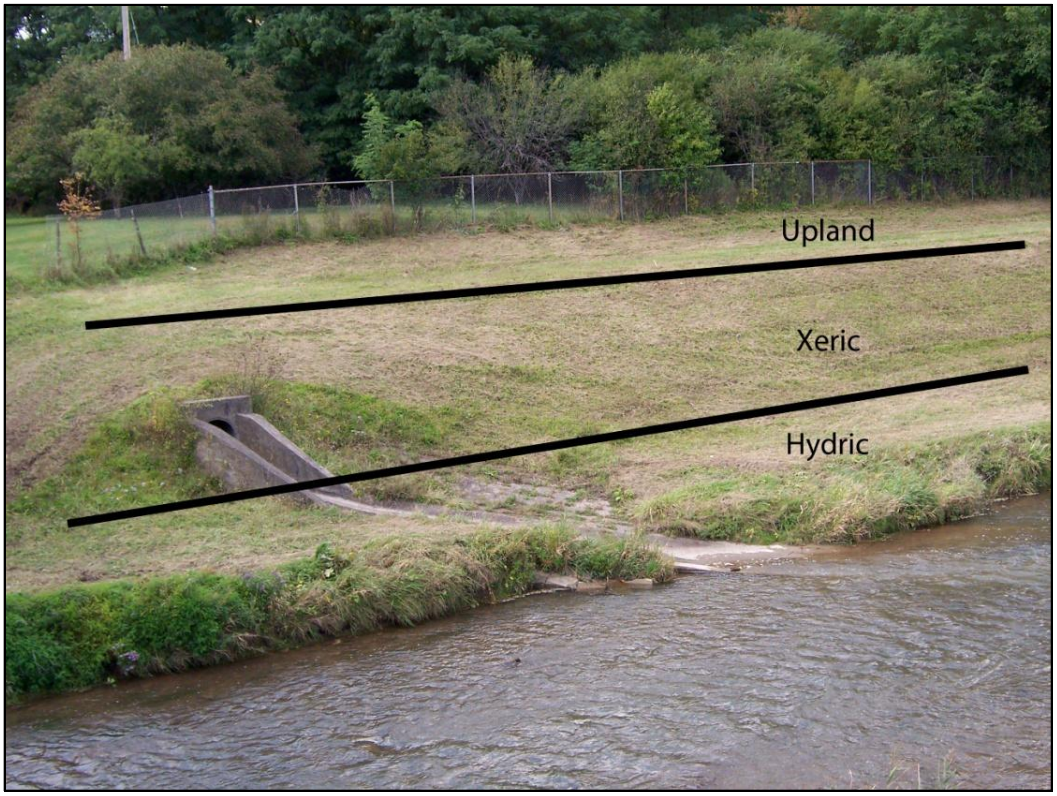


Figure 23 - The riparian zone is divided into three sub-zones for the purposes of this restoration. Hydric corresponds to the most commonly flooded region, xeric to the dry, gravelly slope, and upland to the outermost edge of the river corridor.

<u>*Vegetation Maintenance Zones*</u>

Mow (M): Areas designated as mow zones will retain current maintenance protocols. Preserving mowing regimes is a form of controlled, as opposed to unilateral, disturbance along the creek corridor. Mow zones will not only encourage pedestrian activity (another form of controlled disturbance), they will also serve as a baseline for restoration. The retention of mow zones will highlight the aesthetic and ecological impacts of the restoration, creating stark visual contrasts between natural successional changes throughout the no-mow and planted areas.

No-Mow (NM): Areas designated as now-mow zones will be allowed to develop without mechanical disturbance. A seed bank study completed by Landis in 2008 revealed that approximately 46% of the plant species that germinated in a controlled environment from soil samples taken adjacent to Seneca Turnpike were alien to the region. Of all the seed bank studies along the rural to urban gradient, purple-loosestrife (*Lythrum salicaria*) was the most prevalent propagule encountered along the banks of Onondaga Creek. Common old-field plants emerging from the seed bank study were Canada goldenrod (*Solidago canadensis*), hawkweed ox-tongue (*Picris hieracioides*), and wild carrot (*Daucus carota*). Non-native generalist species found in the study were hairy crabgrass (*Digitaria sanguinalis*), English plantain (*Plantago lanceolata*), and false baby's breath (*Galium mollugo*), though these particular invasive species were found more often in the urban study sites. Very few trees and shrubs appeared in the study. Out of 11 species identified, 6 were raspberry (*Rubus* spp.). Two beneficial, naturally occurring woody shrub species noted on the un-mowed banks of Onondaga Creek are red-stem dogwood (*Cornus sericea*) and silky dogwood (*Cornus amomum*). These species should be preserved, as they are naturally pervasive, native riparian shrubs that are contributing to creek shading and have other aesthetic benefits.

The mowing regimes for this project will be analyzed and concluded in a subsequent phase of this project. These areas need to be planned out in order to maximize their effectiveness both to humans and wildlife. Not every non-native species that emerges from the no-mow area should be removed. Careful monitoring will be undertaken by volunteers groups from local schools, supervised by biology teachers and/or qualified volunteers, such as graduate students from nearby universities. Species richness and Shannon Diversity Index, common metrics of biodiversity, should be calculated for non-mow areas. If, during monitoring, it becomes apparent that a particular species is adversely affecting biodiversity, student groups will target it for removal. Particularly aggressive species in Landis' noted the seed bank should be targeted for removal initially, such as purple-loosestrife and hairy crabgrass. She also points out that plants that reproduce by vegetative means are not accounted for in the seed bank study. Japanese knotweed (*Polygonum cuspidatum*), common reed (*Phragmites* *australis*), and reed canary grass (*Phalaris arundinacea*) are all aggressive riparian invasives and should be carefully monitored for removal in the no-mow zones. Removal should be done by hand, at first. Covering aggressive stands of invasive vegetation with black tarp is also an option. Herbicide should only be applied in extreme cases. As a final note, the scarcity of trees and woody shrubs in the seed bank study implies that areas in the no-mow zone will most likely initially develop a majority of early successional field species, unless specifically targeted for tree plantings (Landis 2008).

***Scarification (S)*: ** The removal of turf grass could potentially activate dormant propagules in the seed bank discussed above, as well as open a site up to the possibility of volunteer species (plants that establish themselves naturally in a given site) due to seed rain-- the production and deposition of seed from reproductive plants (Nathan and Muller-Landau 2000). Permanent scarified vegetation plots monitored by Landis (2008) in 2006 and 2007 recruited a significant number of native riparian tree species including green ash (*Fraxinus pennsylvanica*), eastern cottonwood (*Populus deltoides*), and box elder (*Acer negundo*). These three fast growing, early successional species are well suited for streamside establishment, and could be effective ecosystem engineers, creating habitat for later riparian seral stages. Eastern cottonwoods, in particular, were found to germinate along the entire corridor, independent of location on the rural to urban gradient. This is most likely due to intense seed rain.

Monitoring for biodiversity and invasive species should occur as in the now-mow areas. One particularly aggressive invasive species, common buckthorn (*Rhamnus cathartica*), appeared in smaller numbers than the native tree species throughout the experimental plot. Buckthorn is a pervasive invasive species noted throughout the creek corridor that greatly limits the biodiversity of the areas in where it becomes dominant. Buckthorn activity should be intensively monitored and it should be removed upon identification. Buckthorn stumps should be painted with herbicide to prevent re-establishment.

The down-slope edge and sides of scarified plots can be lined with stones. This not only can provide erosion control, but it provides a valuable service for bees, which are known to rest on stones in the early morning in order to warm their joints before taking off for the day (Toth pers. communication 2009).

Planting Modules

The following planting modules were developed in consultation with Catherine Landis (pers. communication 2009). Inspiration was also taken from a document produced by Don Leopold (2006), entitled *Native Plants for Difficult Sites*. These modules are meant to showcase representative species of the different conditions typical to the North Valley reach of Onondaga Creek. The plants chosen were either effective pollinator attracting species or keystone/nurse species. Keystone species act as integral components to the functionality of the entire riparian ecosystem. Nurse plants help buffer harsh environmental conditions and aid the establishment of more sensitive seedlings in a degraded restoration site (Padilla and Pugnaire 2006). The purpose of these planting modules is not to completely re-plant the reach, but to create vegetative nodes that are designed to encourage long-term, passive regeneration of biodiversity and habitat heterogeneity throughout the corridor. The proposed layout of the planting plan is included in three sections consisting of Figures 31-33.

Trees-Hydric (TH)

Figure 24 - Black Willow on river bank (http://www.naturehills.com)

American sycamore (*Platanus occidentalis*)
Black willow (*Salix nigra*)
Box elder (*Acer negundo*)
Eastern Cottonwood (*Populus deltoids*)
Green ash (*Fraxinus pennsylvanica*)

As mentioned previously, box elder, eastern cottonwood, and green ash are all extremely fecund species and will germinate in scarified patches by the creek bank. However, the proliferation of the emerald ash borer (*Agrilus planipennis*) threatens the sustainability of green ash plantings. Eastern cottonwood is an important tree for insectivorous birds in the region. Black willow is an important native species to the region but has largely been displaced by the crack willow (*Salix fragilis*). The black willow (Figure 24) was not observed in any of the experimental plots. Therefore, black willow seems a good candidate for concerted plantings by the stream bank (Landis 2008). Willows and cottonwoods in general are well adapted to flooding regimes typical in riparian corridors, exhibiting traits such as high bending stability, rapid root elongation after germination, seed release synchronized with spring flood recession, multi-stemmed regeneration from roots and damaged shoots, and brittle twig bases that serve as propagules for clonal regeneration (Corenblit et al. 2009).

Shrubs-hydric (SH)

Elderberry (*Sambucus spp.*)
Silky dogwood (*Cornus amomum*)
Red-stem dogwood (*Cornus sericea*)
Spicebush (*Lindera benzoin*)

Dogwoods (Figure 25) were chosen due to their natural proliferation on the creek bank and their ability to provide shading. Spicebush and elderberry both can be consumed by humans in a variety of ways, and will attract pollinators.

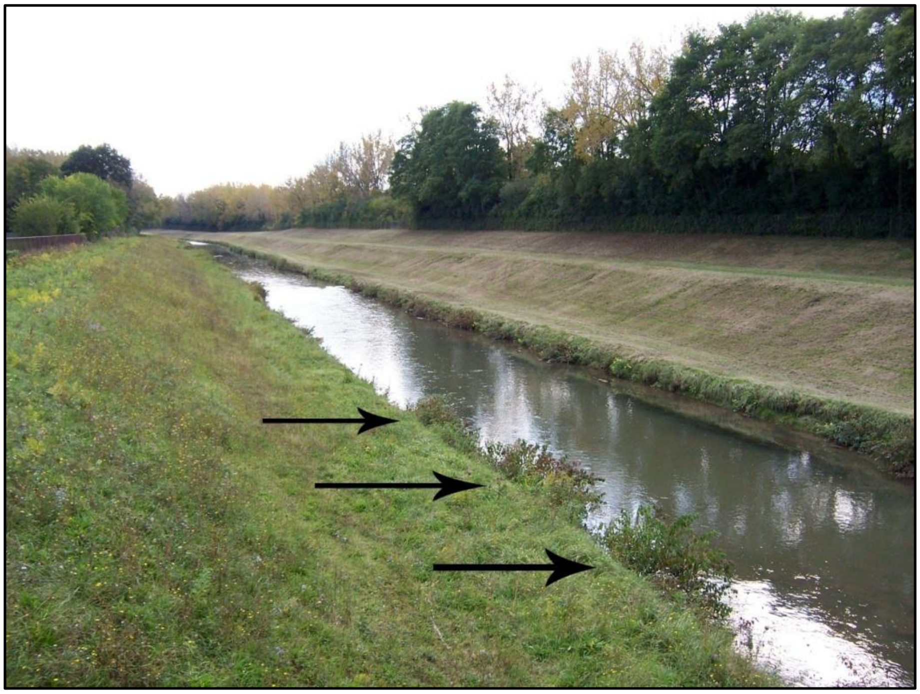


Figure 25 - Dogwoods volunteering along Onondaga Creek

Herbaceous-Hydric (HH)

Figure 26 - Wooly bear enjoying swamp milkweed.

Bee balm (*Monarda* spp.)

Boneset (*Eupatorium perfoliatum*)

Cardinal flower (*Lobelia cardinalis*)

Common bluebell (*Hyacinthoides non-scripta*)

Common goldenrod (*Solidago Canadensis*)

Great blue lobelia (*Lobelia siphilitica*)

Marsh marigold (*Caltha palustris*)

Northern blue flag (*Iris versicolor*)

Sedges (*Carex* spp.)

Spotted jewelweed (*Impatiens capensis*)

Spotted joe pye weed (*Eupatoriadelphus maculatus*)

Swamp milkweed (*Asclepias incarnata*)

Turtlehead (*Chelone glabra*)

The above plants were chosen primarily for their value in attracting pollinators. They also provide aesthetic benefits. Plants such as bee balm and jewelweed are known for their medicinal properties. This module can either be interspersed among the tree and shrub modules along the bank, or planted in a concentrated "floodplain pollinator gardens" along the banks of the creek. Sedges provide a good understory for willows and other riparian tree species.

Herbaceous-Xeric (HX)

Figure 27 - Butterfly weed in full bloom (http://www.rockwallgardens.com/)

Black-eyed susan (*Rudbeckia hirta*)
Butterfly weed (*Asclepias tuberosa*)
Common goldenrod (*Solidago Canadensis*)
Switchgrass (*Panicum virgatum)*
Little bluestem (*Schizachyrium scoparium*)
Blue lupine (*Lupinus perennis*)
Wild bergamont (*Monarda fistulosa*)
Eastern Coneflower (*Rudbeckia fulgida*)

This module is designed to withstand the harsh conditions of the gravelly, sloping section of the creek bank. The above plants were chosen for their functions as pollinators and bank stabilizers. Scarification and seeding with a native prairie meadow mix is recommended. Scarified plots should be carefully monitored for invasive species.

Trees-Upland (TU)

Figure 28 - Eastern cottonwood on the Mississippi (http://forestry.about.com/library/gallery/blg-nats_cottonwood.htm)

Burr oak (*Quercus macrocarpa*)
Eastern Cottonwood (*Populus deltoides*)
Hickory (*Carya* spp.*)*
White oak (*Quercus alba*)

The uppermost bank of the creek is bordered by narrow swathes of upland forest. Buckthorn remains as serious problem and should be removed. If possible, the application of herbicide to the stumps would be desirable. Black walnut (*Juglans nigra*) is common to this, as is box elder. Fence removal between forested stands and the creek corridor is desirable. Burr oak and white oak are well suited for the upland Palmyra gravelly loam soils series.

Shrubs-Upland (SU)

Figure 29 - Black beauty elderberry (http://www.naturehills.com/)

Black raspberry (*Rubus occidentalis*)

Blueberry (*Vaccinium* spp.)

Bush-honeysuckle (*Diervilla lonicera*)

Elderberry (*Sambucus spp.*)

Flowering Raspberry (*Rubus odoratus*)

Serviceberry (*Amelanchier spp.*)

Spicebush (*Lindera benzoin*)

These shade tolerant shrubs will be placed on the upland bank of the riparian zone and will attract both pollinating birds and pedestrian humans. They not only provide nutrition for birds and small mammals, they provide aesthetic benefits and bestow increased value upon riparian vegetation from the layperson's perspective.

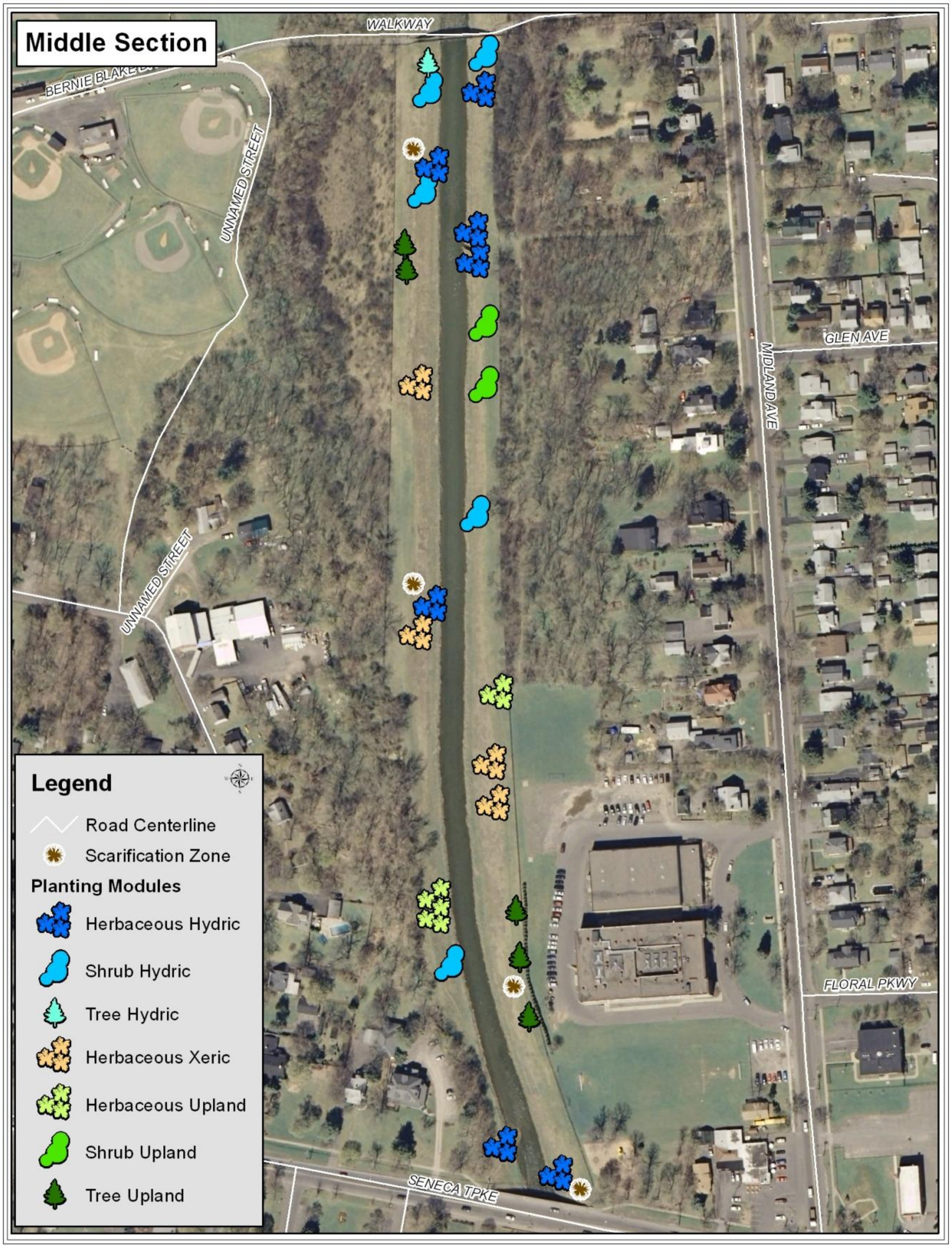
Herbaceous -Upland (HU)

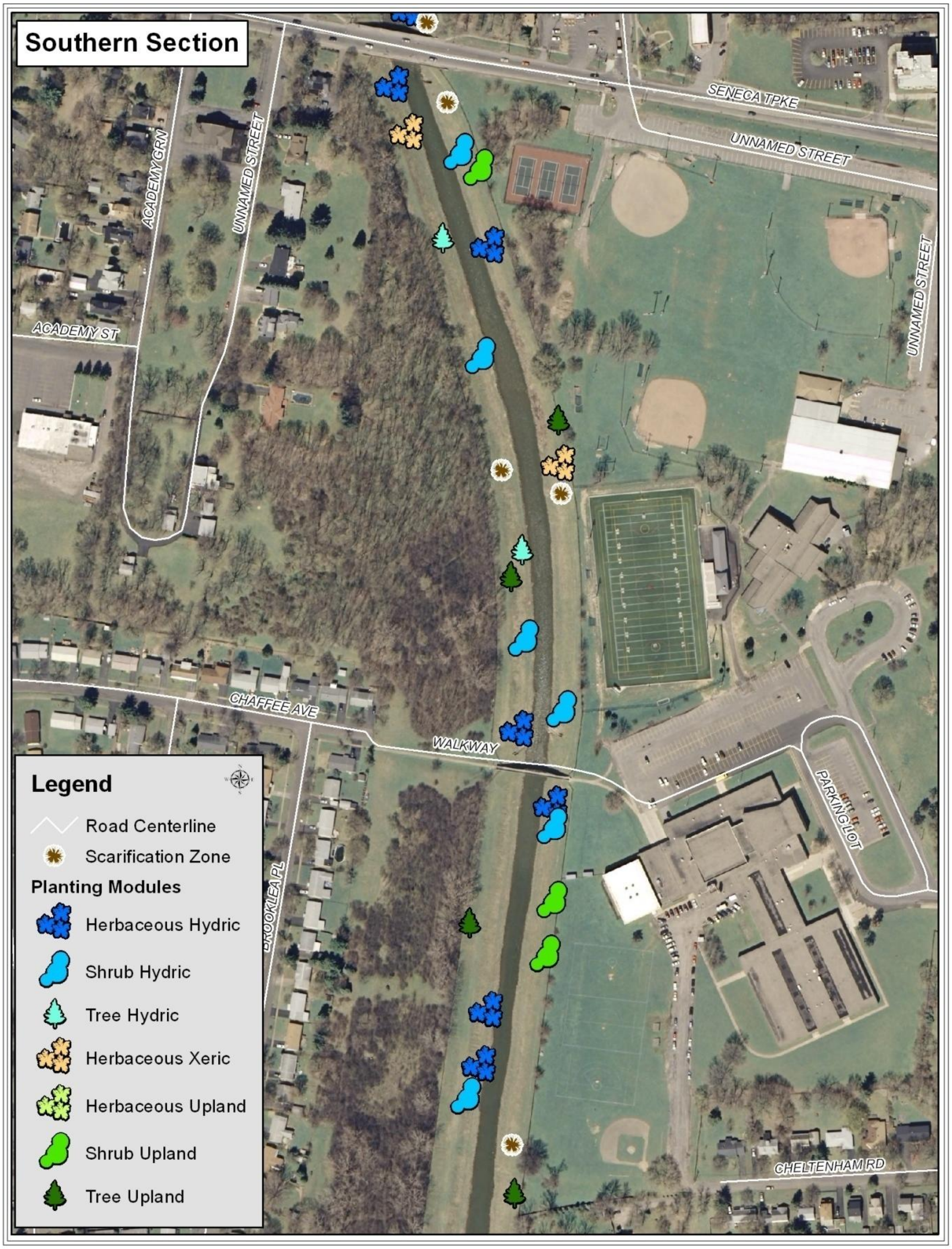
Figure 30 - Wild geranium (http://www.prairiemoon.com/)

Bloodroot (*Saguinaria Canadensis*)
Bluestem goldenrod (*Solidago caesia*)
Broad leaf sedge (*Carex platyphyllaI*)
Foamflower (*Tiarella cordifolia*)
Mayapple (*Podophyllum peltatum*)
Wild geranium (*Geranium maculatum*)
Zigzag aster (*Symphyotrichum prenanthoides*)

These herbaceous perennials are not only excellent pollinator attracting species, but they have wonderful aesthetic value and can be planted in patches along the pedestrian walkway and other points of access.

Figures 31-33 - Broken into three sections, these figures depict the proposed planting plan, described above


Middle Section
WALKWAY
BERNIE BLAKE DR
UNNAMED STREET
UNNAMED STREET
GLEN AVE
MIDLAND AVE
FLORAL PKWY
SENECA TPKE
Legend
Road Centerline
Scarification Zone
Planting Modules
Herbaceous Hydric
Shrub Hydric
Tree Hydric
Herbaceous Xeric
Herbaceous Upland
Shrub Upland
Tree Upland


Southern Section
SENECA TPKE
UNNAMED STREET
ACADEMY GRN
UNNAMED STREET
ACADEMY ST
UNNAMED STREET
CHAFFEE AVE
WALKWAY
PARKING LOT
BROOKLEA PL
CHELTENHAM RD
Legend
Road Centerline
Scarification Zone
Planting Modules
Herbaceous Hydric
Shrub Hydric
Tree Hydric
Herbaceous Xeric
Herbaceous Upland
Shrub Upland
Tree Upland

Creating Bee Nests

Bee nesting blocks (Figure 34) can easily be created by drilling holes into a block of wood. These boxes can be mounted on the sides of trees or posts. Another effective tact is to gather and cut hollow reeds, such as *Phragmites,* tie them together in a small bundle, and place them near a pollinator garden or other vegetated area. These serve as preferential nesting sites for mason bees (Figure 35). Pollinator education and workshops can be carried out with children from local schools (Toth pers. communication 2009). A simple set of instructions on how to build native bee nesting blocks is provided as Appendix A.

Figure 35 - Mason bee nest - this can be made easily by tying hollow reeds together
(http://z.about.com/d/gardening/1/0/M/7/OrconSmallBeeNest.jpg)

Figure 34 - Example of bee nesting block (http://ucanr.org)

Managed Succession

The restoration site maintenance strategy of managed succession is employed here. Managed succession aims at controlling the introduction of native plant species in order to encourage site conditions conducive to climax or later seral plant communities. The three main components of managed succession are included in this plan: designed disturbance, controlled colonization, and controlled species performance (WSDOT 2000).

However, it is questionable whether riparian zones can or should be managed to promote climax communities. Riparian zones function in non-equilibrium states that can be seen as antithetical to traditional conceptions of climax community structure. Therefore, this restoration design attempts to manage for biodiversity and natural recruitment of later successional plant species.

In this case, designed disturbance (scarification), encourages fast growing, hardy volunteer plant species. This serves to add nutrients to the site and re-stabilize soil while also promoting biodiversity and habitat heterogeneity.

Controlled colonization corresponds with the implementation of the designed planting modules. All of the plants referred to in this restoration were chosen for one of two reasons: they are known to either attract pollinators or to be nurse species (Padilla and Pugnaire 2006). These criteria were chosen in that they both promote secondary succession and associated biodiversity. Controlled species performance here can refer to the monitoring and maintenance of the site. Aggressive invasive species will be removed, using biodiversity maximization as the standard for management decisions. An adaptive management framework should be adopted based on this goal. Ultimately, members of the community should work closely with local academics in order to manage for the development of plant communities that both have ecological and aesthetic benefits. It should be recognized and accepted that humans will play a major role in directing the progression of plant succession in the North Valley Corridor.

4.3 Land Use and Community Involvement

4.3.1 Neighboring Land Use

The extent of Onondaga Creek relevant to this restoration plan begins at a pedestrian bridge in the south and ends at Ballantyne Road in the north. What is particularly interesting about this stretch of the creek is the high proportion publically owned land parcels that border it. The functions of these parcels are sport/recreation facilities, educational institutions, and community centers. In addition to these public spaces, many of the remaining adjacent parcels that are privately owned have community-oriented purposes. A list of these facilities and their function within the community is presented in Table 3. Because there is such a high density of community centers (locations of each presented in Figure 36), there is an excellent opportunity to foster public stewardship of the land.

The remaining land adjacent to the site is used mostly for residence. These residences play two roles in the restoration. The first is that it houses the "community" targeted for the community land stewardship, and the second is that some of residential area is covered by forest ecosystems. A description of these ecosystems and their contribution to the ecological restoration are elucidated later. Many narrow, informal walking paths cut through these forested areas. These paths connect the residential lots to one another, as well as to the Faith Heritage School. This existing community connection was one source of inspiration for the "greenway" incorporated in our restoration plan, which is also elucidated later in this report.

Table 3 - List of Community-Orientated Land Use

Map ID	Name	Purpose
Publicly Owned Parcels		
1	Bob Cecile Senior Center	Senior Recration Organization
2	Clary Middle School	Middle School Education
3	McCarthy Middle School	Special Needs Education – Middle School
4	Meacham Field	Sports Recreation – ice rink, turf fields, public pool
5	Van Duyn Elementary School	Elementaty School Education
Privately Owned Parcels		
6	Faith Heritage School	Faith-affiliated Education
7	Onondaga Valley Presbyterian	Religious/Spiritual Organization
8	Syracuse Alliance Church	Religious/Spiritual Organization
9	Syracuse Zen Center	Spirituality Center

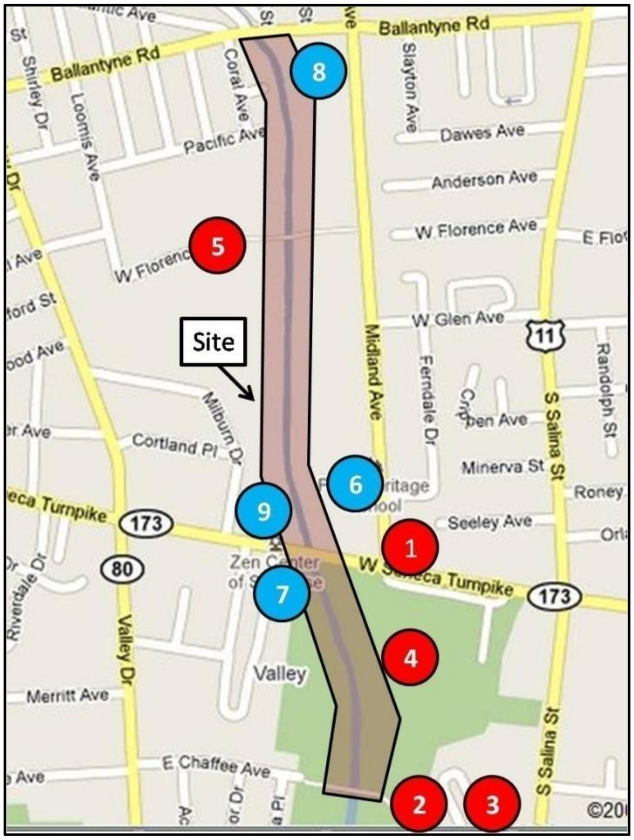


Figure 36 - Locations of important community centers along project corridor.

4.3.2 Current Land Use within Project Corridor

The land within the site boundaries is owned and maintained by the New York Department of Environmental Conservation (NYSDEC). Formerly a naturally meandering riparian zone, the stream was channelized as part of a flood control project executed by the U.S. Army Corps of Engineers. Once this federal project was completed, they handed the operation over to the NYSDEC to manage. The NYSDEC mows the grass biannually, in order to restrict the erosion-preventing vegetation from overgrowing (Delaney pers. communication 2009). While may this mowing may provide this function, it also prevents ecological succession from continuing out of the early stages. Also, the NYSDEC has expressed concerns over woody debris from the adjacent forest ecosystems falling into the creek and inhibiting the creek's function as a flood control section (Fisher and Larison pers. communication 2009). Similarly, many muskrats borrow into the stream banks, creating tunnels which the NYSDEC feels undermines that stability of the banks. Both of these concerns may be legitimate obstacles to flood control; however it is likely that the Onondaga Creek Flood Control Dam some 5-miles provides sufficient discharge control. When asked, Muria Larison, who's residency adjacent to the creek pre-dates channelization, has said she cannot remember a time since the dam was installed when the Creek was any more that 3-5 feet higher than its current level (Fisher and Larison pers. communication). These observations seem to imply that the NYSDEC's fears of woody debris and muskrat habitats be unfounded.

At the east and west borders of the site, fencing runs parallel to the creek on both sides of the bank. The fencing, which is maintained by the New York State Department of Transportation (NYSDOT), was designed to prevent public access to the waterway. Since its construction, the fence's purpose has been undermined as few access points do exist. These locations (Figure 37) are places where the fencing has been peeled away at from the pedestrian bridges, areas where the creek passes under automobile bridges, and there is another place where the fencing has been torn down.

Figure 37 - Site Access Points

4.3.3 Restoration Sustainability

To ensure that a restored ecosystem is sustained indefinitely, the restoration must include more than just an ecological component. No ecosystems, especially ones located in an urban environment, are isolated from the anthropogenic activities. The affect of these influences on the health of the system can be either positive or negative; therefore, the design must consider the interests of local stakeholders. This ensures that the use of the land is supported by the public, and if the public is happy with the state of the ecosystem, they will be more likely to preserve it with responsible management. This responsible land stewardship will then improve the relationship between the community and the creek, which will again encourage conscientious management. This positive feedback loop will ensure the restored ecosystem is preserved indefinitely. However, if the community goals for the ecosystem are ignored in the design, the converse is true: apathy will lead to poor stewardship, and poor stewardship to more apathy. Under this second scenario, the restored ecosystem will relapse to its degraded state (Figure 38).

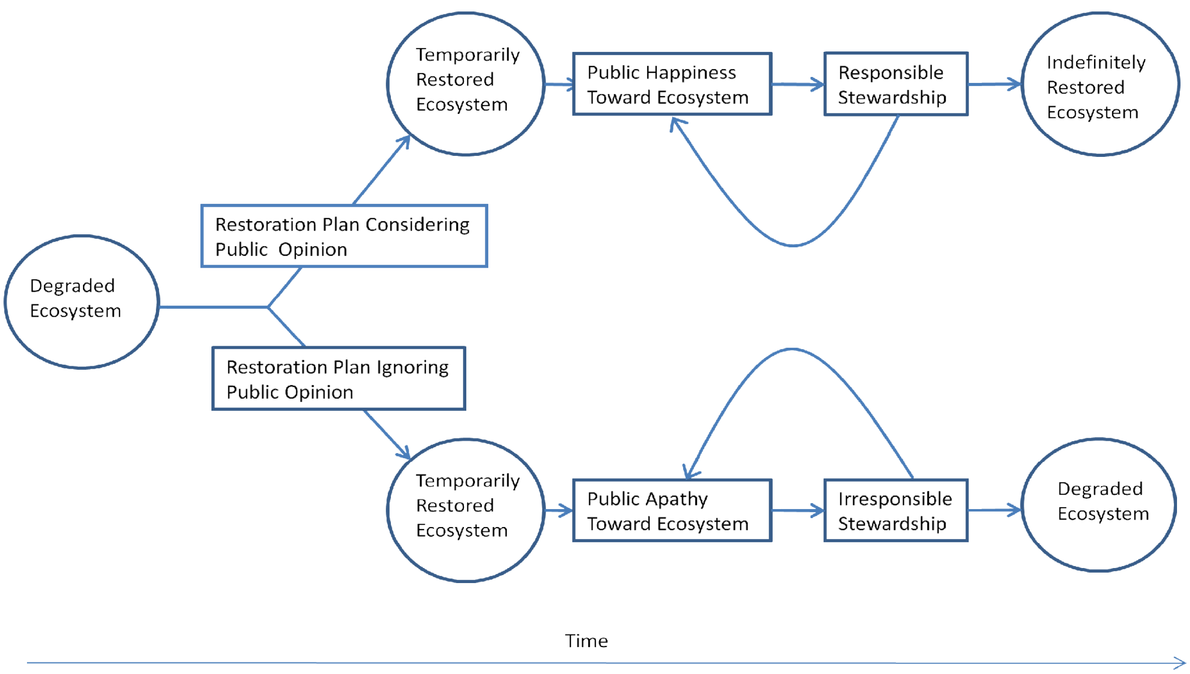


Figure 38 - Sustained Restoration: A Model of the Community-Ecosystem Relationship

4.3.4 Stake Holder Goals and Results of the Onondaga Creek Restoration Plan

Establishing exactly what the community wants from the restored ecosystem can be a difficult task. Fortunately, The Onondaga Environmental Institute's (OEI) Working Group has done much of the leg work needed to clearly establish these goals. The results of this work are published in the Onondaga Creek Conceptual Restoration Plan (OCCRP). The OEI Working Group hosted several community forums at many locations throughout the county. Of these forums, the one held at Clary Middle School produced results that best represent the interests of our target community. Two types of questions were asked of the meeting attendees: written responses to open-ended restoration questions, and which type of future land-use would be most desirable. The results of this survey showed that greatest portion of the people (33%) would like to use the land surrounding the creek for Open Spaces and Parks (OEI, 2008). When asked which qualities of the creek were most important, the categories "Recreational Opportunities," "Good Water Quality," "Wildlife Habitat," "Open Space, Parks, Greenways," and "Fishing Opportunities" all received 12% (the largest portion) of popular support (OEI, 2008).

We catered to the goals expressed by of this survey in our restoration design. Since we plan to open access to greenway / bike path that runs for the length of the site, there will be plenty of opportunity to enjoy the "Open Space." Also, since the primary purpose of the restoration is to improve ecological quality of the stream corridor, increasing fish and wildlife habitat and improving water quality were intrinsic to the design. A list of how each quality valued by the community is incorporated in our design can be found in Table 4.

Table 4 - Community Goals and the Design's Response

Quality Valued by North Valley Members	Incorporation into Restoration Design
Good water quality	Improving riparian communities will prevent sediment erosion and act as a nutrient buffer between the uplands and the water
Wildlife Habitat	Heterogeneous plant communities planted in patchwork matrix will provide a diversity of habitats for wildlife
Open Space, Parks, Greenways	Inclusion of a bike/footpath to provide residents with creek access and a connection to the local education, spiritual, and community centers.
Fishing Opportunities	Creation of fish habitat by installing micro-meanders in the creek bank and by lowering water temperature through the planting of shade trees and shrubs

4.4 Recreational Opportunities

4.4.1 Trail Design

It is critical that the people feel a connection to the restored creek stretch if they are to act as land stewards. The more time that any individual spends within an ecosystem, the stronger connection he will have to it. The challenge lies in establishing this initial connection. To encourage members of the North Valley community to frequent the site, we specify for easier access to the creek and the inclusion of a trail or path. An additional benefit of a path would be a safe traffic route connecting Ballantyne to Meacham Field and multiple school locations. By constructing a trail within the creek corridor, the community would be provided direct access to the creek and the restored ecosystem.

Our original design for the path was a wider greenway that could be used by both cyclists and pedestrians. However, as mentioned later in Section 5.3, we collected some information about the community's restoration goals. Responses indicated there may be a division of opinion between community members who support this formal, developed walking path and those who support a purely ecological restoration project. The latter would allow people to walk anywhere along the creek's bank, with no separation for the vegetation.

Since it is a critical to our plan to cater to all community member needs, we propose two design alternatives. The first, and primary alternative, includes the justifications as well as the specifications for a multi-use greenway. This alternative stipulates more informal methods in which the public can access the creek as well as providing the benefits that are associated with a recreational trail. The decision on which of these two "paths" is ultimately followed should be made by the community. Further details associated with a stakeholders meeting are provided in Section 5.3.

Alternative A: Shared-Used Path (primary alternative)

The American Association of State Highway and Transportation Officials (AASHTO) "Guide for The Development of Bicycle Facilities" provides recommendations and design specifications for bicycle transportation route development. According to their classification system, we would be incorporating a Shared-Used Path into our design. A shared-use path both has the function of a direct traffic route, but also the recreational potential of a walking path.

This shared use path would run the length of our stretch of Onondaga Creek: starting at Ballantyne Road in the North, proceeding southward across West Seneca Turnpike, and ending at the Meacham Field footpath, North of Dorwin Avenue (41). The length of this stretch is approximately 0.90 mi (1.5

km). Because the morphology of the stream bank is so steep at certain points, the proposed track is located on the flat, upland section of the riparian zone along the east side of the project corridor. The east side provided more width in order to construct a trail and would require less property acquisition or the obtainment of easements.

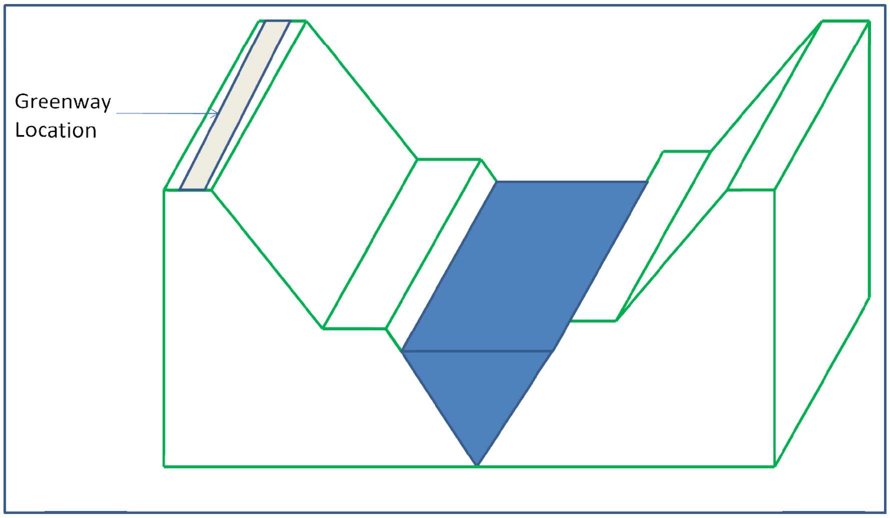


Figure 39 - Location of Greenway on Bank (not to scale)

Heading in a north to south direction, the path begins on the east side of Onondaga Creek, at the Ballantyne Road bridge crossing. Although the stream bank is level with Ballantyne Road and its sidewalk, a fence prohibits pedestrians from entering the creek area. Considering this obstruction, the fence would either be removed or a gate would be added. The path would continue south, hugging the bends in the creek until it reached the foot bridge that provides access to Van Duyn Elementary School. This pedestrian crossing connects Loomis Avenue on the west to Midland Avenue on the east.

The trail is proposed to continue south along the east bank of Onondaga Creek, making its way toward West Seneca Turnpike. At West Seneca Turnpike, the grade of the path would be increased slightly to meet the existing sidewalk along the roadway. The trail would follow the sidewalk for approximately 350-

feet in an easterly direction, until the first traffic light at the intersection of Midland Avenue and West Seneca Turnpike. This traffic intersection is already accessible to pedestrians with a crosswalk and walking signal system. The purpose of this minor on-road section, which deviates from the creek, is to provide trail users with safe travel across West Seneca Turnpike, without adding additional pedestrian crossing or traffic lights, which would undoubtedly impact existing traffic patterns. A detailed traffic analysis would need to be completed in order to change current traffic patterns and current pedestrian access. Once across West Seneca Turnpike, the trail would double-back down West Seneca Turnpike, heading west, where it would then reconnect with the creek bank and continue south to the Meacham Field walkway near the southern limits of the project corridor.

The fencing that prohibits access to the Onondaga Creek corridor will be removed, at a minimum, along all sections of the creek that are adjacent to a pedestrian walkway bridge. This includes the footbridges and Meacham Field and Van Duyn Elementary. Additional access points may be included based on the results of the proposed stakeholder meeting.

The dimensions of a shared-use path are clearly stipulated in AASHTO's guide. They recommend, and we agree, that a two-way shared used path should have a width of 10 ft (3 m). To ensure proper drainage, this path must be bordered by a 2 ft wide (0.6 m) land strip, graded with a maximum slope ratio of 1:6. A sample cross section of our path is demonstrated in Figure 39. To allow for these slopes, some minor filling may have to be done below the paths. However, the upper-bank is so flat that this work would be minimal.

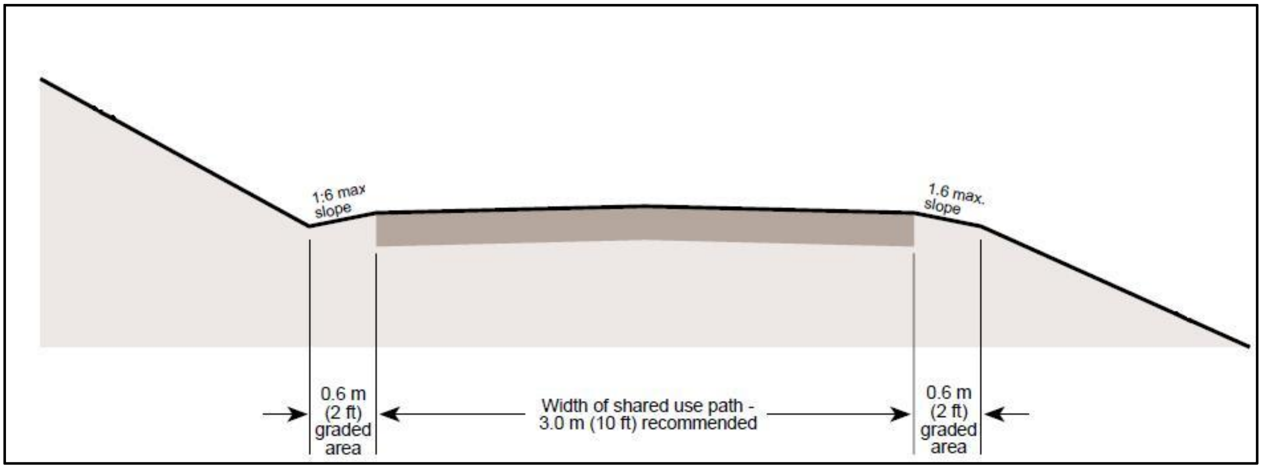


Figure 40 - Design Specifications for Shard Use Path

The path will run parallel to the fences that are currently in place on the upper bank. To allow for adequate clearance, the path must be separated from the fence and the stream bank by 5-feet (1.5 m). Although the available area on the upper bank varies with position along the stream, there is a minimum width of 19-feet (5.8 m) at all points. Because the bank exceeds this width at all points no costly cut and fill operations are needed to install this path. The trail would be made of stone dust. It is an inexpensive, easily maintained option. The total area of stone dust needed to cover the extent of the greenway is approximately 50,000 square feet (ft^2).

Also, to insure that this path is in compliance with the Americans with Disabilities Act (ADA), all portions of the trail must be minimally sloped at a ratio of 1:20 (ADA and ABA). To ensure that this standard is met, access ramps must be installed where the greenway crosses both of the pedestrian bridges. Apart from these two entry points, nowhere else on the path is so sloped so drastically that this problem must be addressed. However, the ADA also states that the cross slope of these paths must exceed a 1:48 ratio. This may be an issue throughout a <0.1mi stretch of land just north of West Seneca Turnpike, adjacent to the Faith Heritage School. In this particular section, the existing cross grade should be checked with proper surveying equipment to determine if it must be regarded. In the event that it should, soil must be added and compacted on top of the stream bank where the path is to run.

Apart from the trail itself, this design alternative can include other, smaller components which will improve the quality of the greenway and therefore connection of person to place. One of these smaller additions is the inclusion of park benches. If placed facing the creek, residents will take a seat and a have a moment to truly soak in the beauty of the ecosystem. Also, if baskets for the collection of wastes and recyclable items are dotted along the greenway, then the commuters will be discouraged from littering. This serves to both keep the ecosystem free from debris, and to instill a faint sense of stewardship in the travelers. Accompanying these waste receptacles, there can also be stations with plastic bags and additional barrels. These particular services could be used by any dog-walkers. It is very important to both for both the ecosystem and the public's perception of it to properly remove excess dog excrements from the area. To fulfill the greenway's educational goals, signs describing both the restoration process and the changes in ecology could be posted. Placing these signs near each one of the vegetative modules would help explain some of the ecosystem functions and which species are critical to those functions. These details may seem trivial, but the more the average citizen knows about a place, the better decisions they can make.

The following Figures 42-45 depict the proposed alignment of the trail system.

Figure 41 - The alignment of the proposed trail along Onondaga Creek

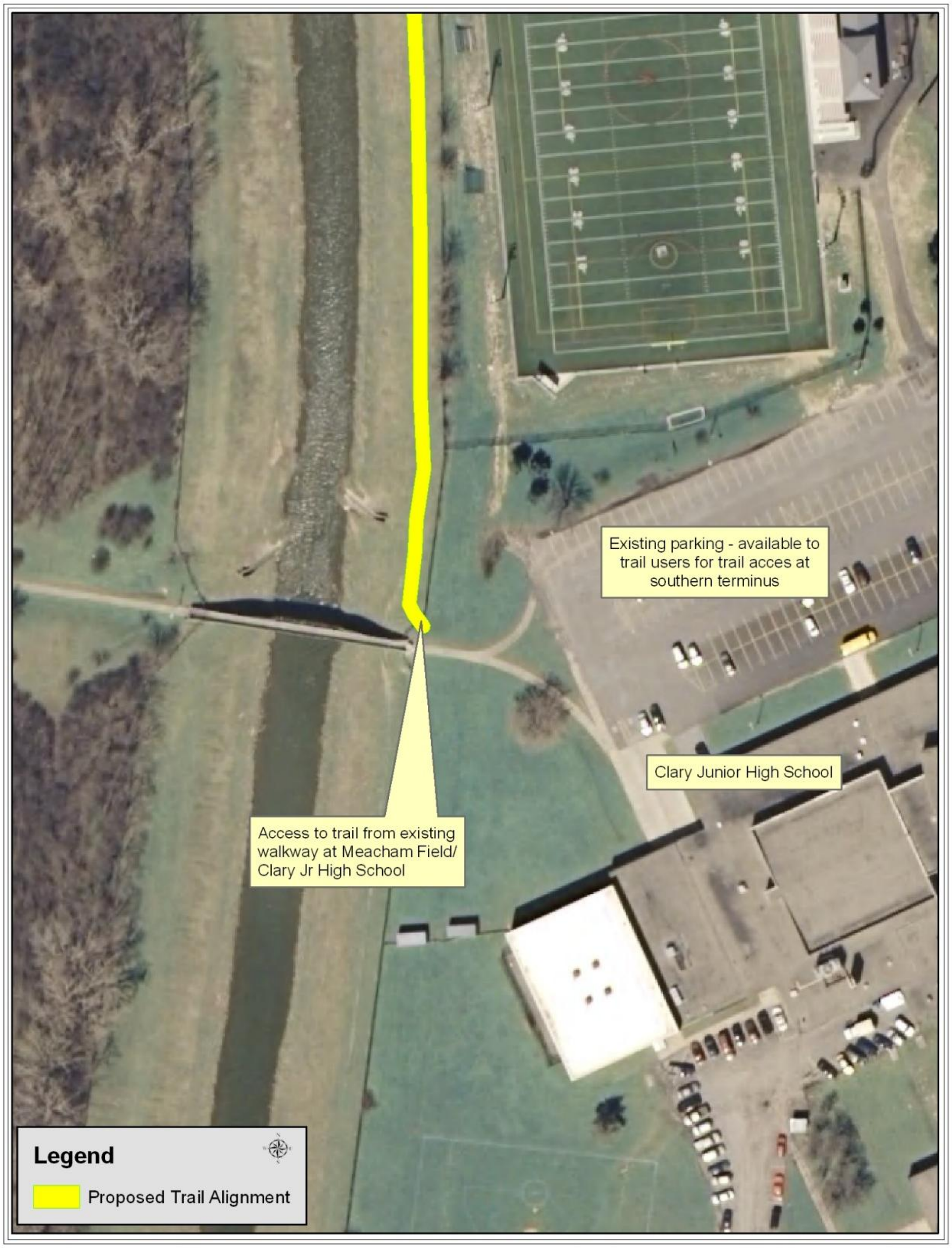


Figure 42 - Close-up of the southern-most extent of the proposed trail at the Meacham Field walkway

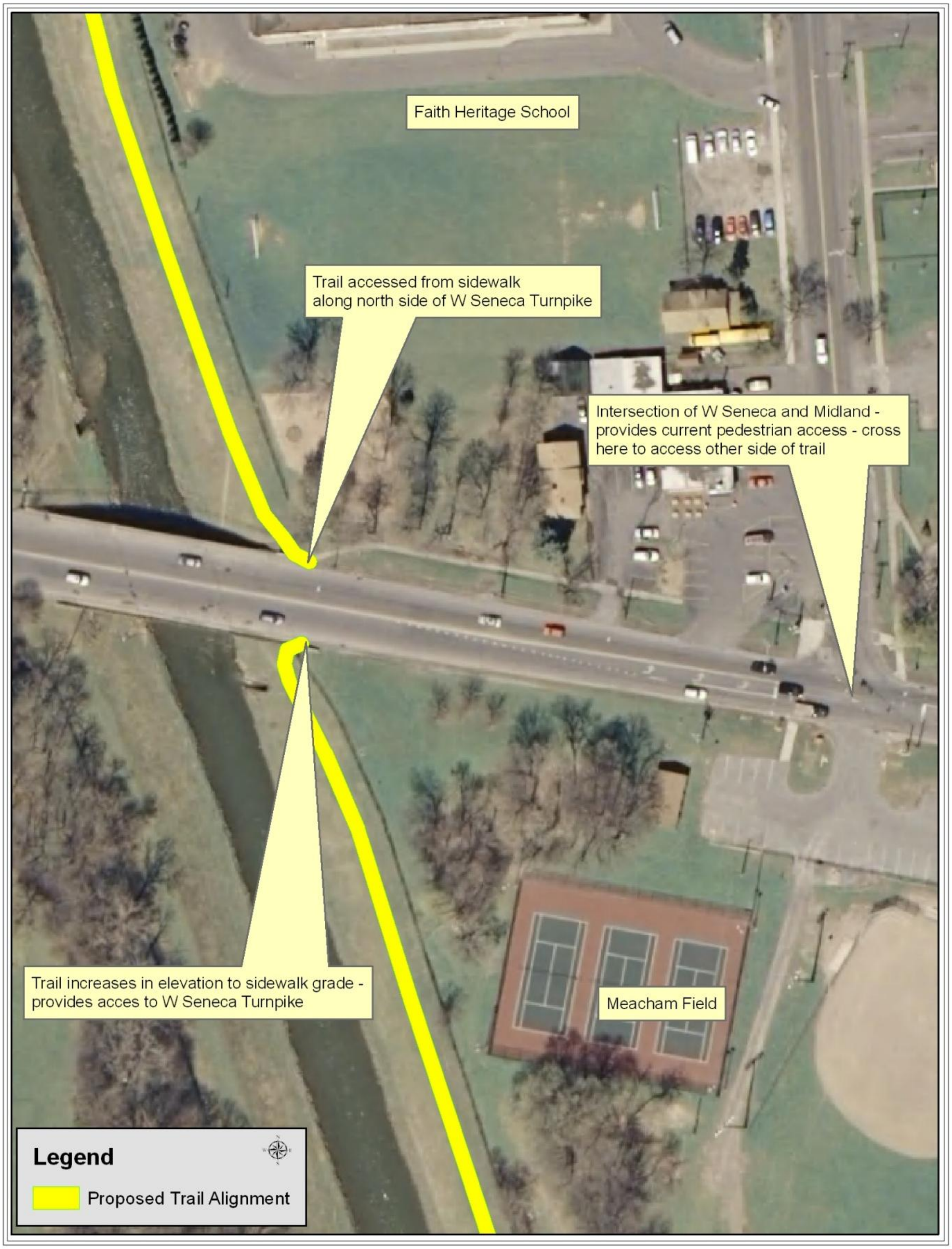


Figure 43 - Close-up of the middle section of the trail corridor, where an on-road section is proposed at West Seneca Turnpike

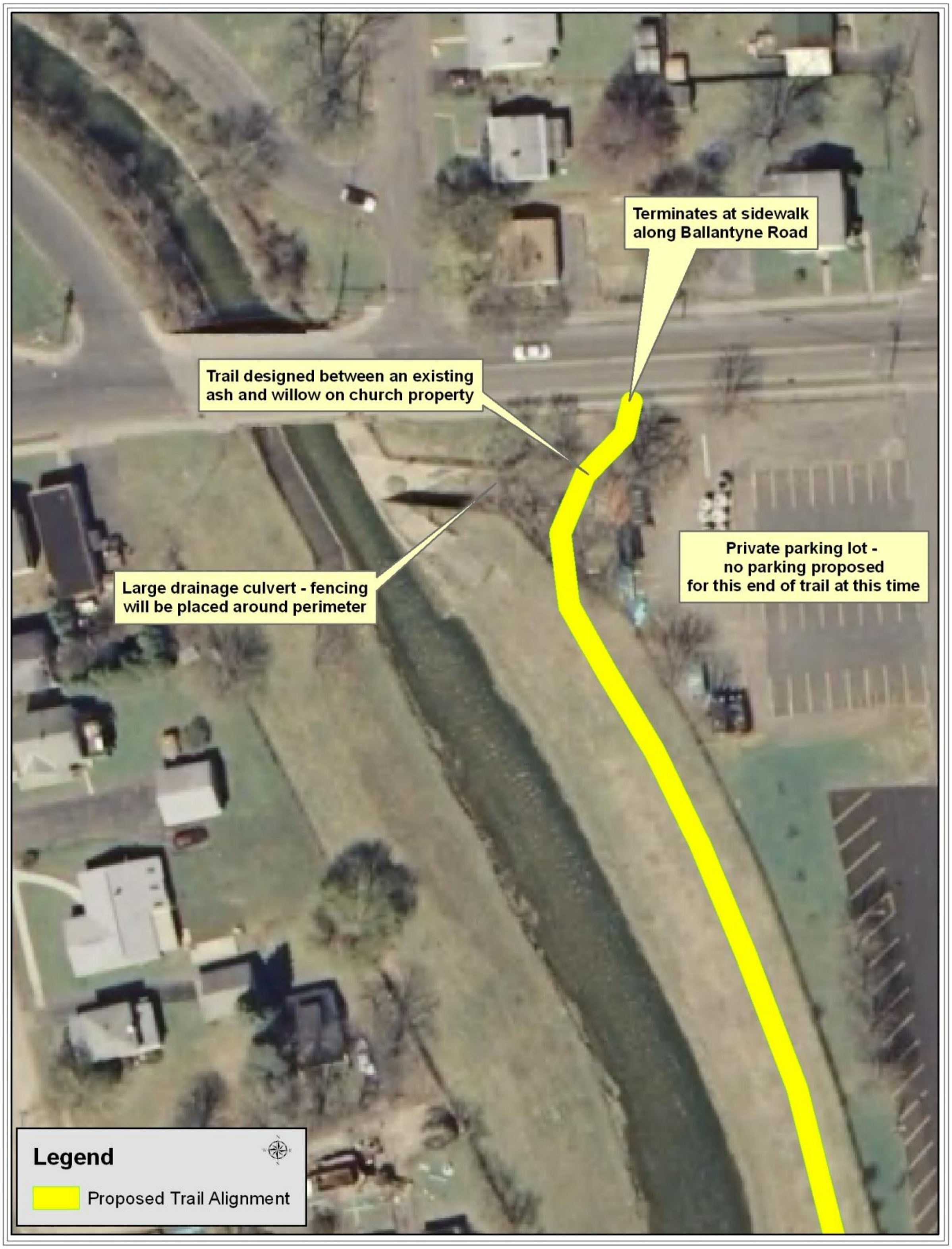


Figure 44 - Close-up of the northern extent of the proposed trail, at the Ballantyne Road terminus

Justification for Greenway

A shared-use path would provide more than just a quick way for bikers to travel from Ballantyne Road to Meacham Field. The first benefit of an AASHTO and ADA approved trail is that it can be enjoyed by people of all ages traveling on wheels and on foot. A paved corridor is much safer than one which is unpaved because the sure-footed surface reduces the chance of injury. This path would be an ideal route for children walking to school. Already, small trails are woven through the forest stands adjacent to the creek. The greenway would permit much longer site lines than these small trails do. The open spaces would limit the chance of any criminal activity, keeping the walkers safe from the dangers of the world that are worse than tripping over a log.

Since this path would directly connect schools in the area with one another, it may be an opportunity to streamline a trans-scholastic educational program. These programs could make use of the creek itself with a curriculum centered on biology and ecology, but not limited to those areas of study. This same feature is applicable for the programs at the spiritual centers. A clearly defined traffic lane would allow for more community interactions. The creek would be at the base of these relationships. All of these applications would bring individuals closer to the creek, and would facilitate the connection of culture to place that is critical for ensuring lasting success of a restoration process.

Alternative B: Informal Foot Trails with Improved Site Access

The second design alternative specifies the inclusion of a narrow, informal walking path on both upland creek banks. The construction of these two paths would be complete after one simple step: leaving a 5-foot wide strip of land parallel to length the creek unplanted. The location of this small path should be separated from the sloped portion of the corridor by 5-feet for safety. The bare-surface would be passively maintained by the footsteps of people visiting the creek and animals such as deer that use the creek as a transportation route of their own. Access points will be installed at the same locations as in design Alternative A.

Justification for Informal Footpath Design

This design option offers the community a different set of benefits. The first of which is that the ecosystem will be more pure and natural. The stone dust path will lead to a more fragmented drainage profile, as the rain falling directly onto the path would be unable to penetrate below the surface. This drainage disturbance is uncharacteristic of preserved ecosystems. Also, since a 5-foot buffer on either side of the stone dust path would have to be continually mowed, more surface area would be covered by the heartier native vegetative species. Also, because the path is self-maintaining and no true construction efforts are required, the cost of implementation will be almost nothing. The only identifiable cost is that the amount of plants purchased to cover the area would slightly higher. However, considering the extent of this project that value would be trivial.

The dirt path would no doubt keep the ecosystem pure, but some members of the community feel it would also keep the community pure (Fisher and Larison pers. Communication 2009). These community members feel that a “pedestrian highway” would bring people from across the county to their section of the creek. These visitors may not respect the community as their own, and would view it more as a tourist destination. An alienated interaction with the creek should be avoided for three reasons. The first is that these apathetic interlopers will only degrade the area through littering and destruction of the living organisms. The next reason for alarm is that an influx of tourists would separate of the North Valley residents from the land that is within their own community. This distance would interrupt the locals from their role as stewards of the land. The final reason to be weary is that infrastructure concentrates people, and concentrated people leads to the construction of more infrastructure. As Pat Fish stated, if there are lots of people coming in to visit the creek, a parking lot will have to be built to allow them a place to store their cars (Fisher and Larison pers. Communication 2009). The debate over infrastructure and safety versus ecological and communal purity is one for the community.

5.0 Future Phases and Monitoring Efforts

5.1 In-stream Habitat Monitoring and Maintenance Plan

Boulder Placement

Questions to ask after implementation include: Did the boulders stay in place? Is significant channel erosion happening because of the boulder placement? How has the habitat changed since the addition of the boulders? Monitoring surveys may include photos and detailed pre- and post-construction surveys of boulder locations and bed and bank topography to document changes over time, pre- and post-construction snorkeling of the site and a reference reach to document fish use.

Maintenance of a boulder placement project should not be required except in a few situations where the project is no longer meeting its objectives or unacceptable consequences have occurred. Regular monitoring of the site after high flow events will identify any maintenance requirements. Maintenance, when needed, may include re-positioning or removal of individual boulders, removal of wood that has racked up against the boulders, or armoring of eroding banks. However, repositioning of boulders is only recommended after careful evaluation to determine what went wrong to avoid repeating the mistake.

In-bank Shelter

Monitoring of log and rock shelter projects is important because design methods are still somewhat experimental. The performance of wood structures may be less predictable than non-wood structures.

Monitoring is expensive, and biological monitoring can be as expensive as the project itself. Monitoring of these projects should include comprehensive monitoring of both channel and bank features, with particular attention to habitat monitoring.

In-stream Wetland

In stream wetland lies above in bank shelter structure, so its structural stability should be monitored together with in bank shelter. Water quality survey is needed to determine whether water quality has been improved, at least around the close proximity of wetland. Biological survey should also be conducted to determine the effect of habitat improvement. Sediment removal might be necessary when too much sediment is trapped by plant roots and logs. Also, mosquito issues and plant survival conditions should be monitored; necessary hydrological alteration or plant replenishment might be needed.

5.2 Monitoring Riparian Diversity

Habitat degradation is often linked to the loss of ecosystem services (Richardson et al. 2007). However, local communities and stakeholders value ecosystem functions in different ways, biasing restoration efforts towards a variety of differing goals and associated assessment rubrics. The goal of this restoration effort is to promote biodiversity through engagement with local stakeholders, effectively creating opportunities for environmentally conscious stewardship for North Valley residents.

In order to assess biodiversity, volunteer groups and students from local schools should actively monitor the restoration site. Both plantings and volunteer species in scarified patches should be monitored at regular intervals. An invested graduate student or faculty from a local university should oversee the effort and tabulate data, using various diversity assessment metrics such as the Shannon-Weiner Index in order to monitoring results.

Ultimately, assessment of the success of riparian restoration efforts can be tricky, due to characteristic fluctuations of the system following disturbance events. In this case, we suggest that the presence of historically "dominant" or keystone species and the absence of aggressive invasives should be used as indicators of an effective habitat restoration (Richardson et al. 2007). Dominant species such as the eastern cottonwood, green ash, and black willow can be viewed as ecosystem engineers, promoting habitat heterogeneity and subsequent biodiversity within the riparian zone (Corenblit et al. 2009). Exotic species need not be intensively managed for fear of reducing the restoration into a "gardening exercise" (Tredici 2004 as cited by Richardson). However, invasive alien species that disrupt ecosystem functions and compromise biodiversity should be targeted for immediate removal. Such species include: purple loosestrife, *phragmites*, Japanese knotweed, and, especially, buckthorn.

Student and volunteer groups should be given the opportunity to develop their own metrics for biodiversity assessment in consultation with a coordinator from a local university. Species that are observed to attract pollinators or impinge upon other species should be dealt with accordingly. Finally, local stakeholders should assess the restoration from an aesthetic, cultural perspective. A biodiversity restoration the redefines land use for the North Valley reach of Onondaga Creek could potentially serve to redefine how local residents value a natural resource the runs, literally, through their own backyards.

5.3 Community Involvement: Now and in the Future

The results of the stakeholder meetings held by the OCCRP are a very helpful database. However, the opinions expressed were done so within the context of a larger, county-wide restoration plan. If we are to determine site-specific community goals, then we must add more to the existing knowledge bank. The first task would be to assemble a group of extremely active community members who would act as representative panel. There would be one person from each of the previously mentioned organizations (Table 1) serving on this panel. It would be the responsibility of the panel to elicit and publicize the opinions of its associated community members.

The recommended strategy for understanding popular opinion would be for the panel to circulate surveys to the people within their organization. These questions would start by asking for general restoration objectives, and the preferred future land use. Ensuing questions would ask to stipulate how these objectives could be met. Two sample surveys are included in this report, one designed for the spiritual centers and one for the educational centers. These surveys are provided as Appendix B. The questions would require free response answers which allow those surveyed to reply without the survey limiting their creativity or influencing their response.

After the each panel member has analyzed the survey results, they will be able to appropriately represent the opinions of their constituents. The next phase would be to organize and host a stakeholder meeting which would synthesize the survey results from all of the community centers. This meeting would be open to all the people living in the North Valley area. The panel would facilitate the discussion, as well as record all of the opinions relevant to the discussion topics. A list of meeting action items is included as Appendix C. Once all the important action items had been discussed at length, the panel would then vote on how is land is to be used. A summary of these findings would then be presented to the design team, who would select the design alternatives that best match the community desires. Finally, this panel is tasked with creating a committee devoted to managing the future of the project. This committee will be responsible for organizing the implementation and monitoring of the project. While the actual work of required to meet this task will not fall solely on this committee, it will be their job to motivate the necessary communities groups to help meet the goals set out at the stake holder meeting.

The scope of this project has restricted this design team's ability to execute the plan outlined in this section. However, efforts to contact the community have been made. The outcome of these conversations has allowed us to loosely achieve our goal of a community-led restoration.

5.3.1 Stewardship Plan

A portion of the implementation and maintenance will fall to the community members. In order to include them in this process, each of the major players in this effort must be defined. The first of these partners is the committee devoted to organizing the labor force. The committee could organize community work days between all of the spiritual centers and schools. These would be days where all interested members from the community are trained on the differences between invasive and local species. After being taught why it is important to keep the ecosystem pure, they would be asked to go out into the field and remove the invasive and plant the local species. This would be an immediate reinforcement of their education, and their contribution to beautifying of the landscape would develop an important sense of pride in the community. These same types of workdays could be organized for student groups, which elaborated on later in this section.

The State University of New College of Environmental Science and Forestry (SUNY ESF) is a higher-level educational institution devoted to the study and conservation of the natural environment, and therefore has a very significant role. It will be SUNY ESF’s responsibility to provide the community with any ecological or biological information pertinent to the restoration plan. In return, this project could be woven into the school’s education courses. The opportunities for ecological study at this site are numerous. If studies are conducted within this area, they should directly benefit the project. For example they could monitor the reestablishment of the planted species, measure the degree of erosion control, monitor nutrient and water fluxes, ecosystem response to flooding, etc.

Given SUNY ESF’s wealth of environmental knowledge, students and faculty members are excellent candidates to act as educational workshops leaders. These workshops would promote the life and physical science teachers at the local schools to start using Onondaga Creek in their programs. These school teachers could work together with university professors to develop curricula for students of all ages. Whether it is a high school laboratory class quantifying the physical characteristics of the ecosystem, or elementary school children learning the differences between producers and consumers, the creek is a deep educational resource which should not be ignored. Also, a focus of the workshops would be for teachers from different schools to develop educational programs together. They could combine outdoor lectures and share data for laboratory exercises. The ultimate goal of these inter-scholastic efforts would be to build a sense of communal ownership and responsibility of the creek. If the teachers agreed with the idea, part of the curriculum would be require students to participate work days. The days would follow the same blueprint as those mentioned before.

Developing this sense of land stewardship is much more than a source of free labor. If the community shares the responsibility of maintaining the land in their own neighborhood, a strong mutually beneficial relationship will exist between person and place.

5.3.2 Signage

An important component to this restoration is signage. Signage will provide North Valley Corridor patrons with information pertaining to restoration background, rationale, goals, and implementation strategies. It is essential that signs be developed through a collaborative process between local academics and North Valley community organizations. Signs are an effective way for the North Valley community to communicate land use values, justify restoration techniques, and educate the public on broader ecological issues. Potential topics for signage include: the value of riparian corridors, the importance of habitat heterogeneity, ecological connectivity, pollinators, managing succession, and redefining land use. Student groups from local schools can be recruited to help draft designs for signage. This will reinforce a sense of shared ownership and encourage stewardship of natural resources along the North Valley Corridor.

6.0 Cost Analysis

6.1 In-stream Habitat Modifications

The cost of design for habitat restoration projects generally ranges from 15 to 50 % of implementation costs. This may be higher than that for traditional civil engineering works. The reason for this is that 1) the same analysis is generally necessary whether the project is large or small so the percentage of implementation cost will be larger for smaller projects, and 2) habitat restoration projects are very site specific and it is generally not possible to apply designs used on previous projects to new ones.

Boulder Placement

The costs associated with boulder placement varies with the availability of boulders, proximity of the material source to the site, available access to the site, and the type of equipment used. For our project, access to the stream by heavy trucks is limited. Therefore, boulders need to be delivered to access points and stockpiled. The cost to deliver boulders to the stockpile locations is estimated to be between $35 and $300 per boulder (based on a 3-ft diameter rock).

A hydraulic excavator (with operator) will cost $100 to $150 per hour. With this type of equipment, a laborer ($35 per hour) and a construction supervisor / site engineer ($65 per hour) would be required. The total hourly cost would therefore be about $200 to $250 per hour. Assuming access conditions do not limit progress rates, an average of four boulders could be placed per hour. The average cost for placing each boulder is therefore estimated to be about $50 to $65.

The total cost for delivering a boulder to the stockpile and placing it in the river is therefore estimated to range from $85 to $365. Depending on our design, about 30 boulders will be needed, which makes the total cost ranging from $2550 to $10950, depending on boulder source proximity.

Shelter Structure

Output of one to two structures per crew day could be predicted with the scale of our project. Use of heavy equipment to drive and place logs will be required because no log is available on site. Buying and hauling wood can be expensive and is generally the biggest cost variable in a wood related habitat project. Prices vary widely depending on market conditions, so providing unit costs is not practical at this phase. But once delivered, the placement cost of individual log units is typically about $100 per log or tree. We expect to place three shelter structures, each with about ten logs, which makes the installation cost about $3000 without considering cost of logs.

In-stream Wetland

Costs will be associated with introducing wetland plants above shelter structure or to currently existing sediment island. Wetland plants will be moved from proximity and the cost would be minor.

6.2 Riparian Corridor Restoration

A cost estimate was compiled to provide a total cost for the planting aspect of this project that is proposed as an effort to restore the riparian area along Onondaga Creek. According to the restoration design, the proposed break-down of planting modules is as follows: 17 plots of herbaceous hydric, 12 plots of shrub hydric, 12 plots of tree upland, 8 plots of tree hydric, 8 plots of shrub upland, 8 plots of herbaceous xeric, and 4 plots of herbaceous upland. The basic costs provided in Table 5 are listed by vegetation type (i.e. shrub, tree, or herbaceous). Whether hydric, xeric, or upland the plant costs per vegetation type are similar. Trees and shrubs will be purchased as tubelings and herbaceous species will be purchased as 2-inch plugs. Tubelings have an approximate container size of 4-inches in depth and 2.25-inches in diameter. Tubelings are grown 32 cells per tray and range in size from 6-24 inches depending on the species and time of year.

Table 5 - Estimated costs for execution of proposed planting modules (Pinelands Nursery & Supply, 2007)

Vegetation Type	Approx. Amount Needed	Cost
Herbaceous Hydric	510	$0.83 each
Shrub Hydric	240	$1.50 each
Tree Hydric	160	$1.50 each
Herbaceous Xeric	240	$0.83 each
Herbaceous Upland	120	$0.83 each
Shrub Upland	160	$1.50 each
Tree Upland	240	$1.50 each
Total Cost:		$1922.10

Pinelands Nursery & Supply also offers a custom wetland seed mix which will be considered and potentially used to seed the North Valley project corridor. This seed mix can be purchased in 5-pound bags for $263.75 per bag. It should also be noted that the cost estimate provided above does not include any labor needed to plant the purchased tree, shrubs, and herbaceous vegetation. It is anticipated that the planting plan will be completed through the efforts of volunteers and school programs.

6.3 Trail Design and Construction

A cost estimate was put together for the primary alternative of the proposed trail alignment. The total estimated length of the trail is 5,100-feet. The actual trail width is designed to be 10-feet wide with 2-foot shoulders on either side to account for drainage. The trail alignment is planned 5-feet from the existing fence line, which denotes a change in parcel ownership throughout the corridor. Table 6 outlines the items and costs associated with this trail construction aspect of the restoration project.

Trail projects are expensive due to a lot of site preparation and the long linear length that most resemble. Sources of funding for recreational trail projects are available. It is suggested for this portion of the larger project to apply for federal funding under the Transportation Enhancement Act (TEA-21). A grant under this Act will cover 80% of the total project costs by the federal government (Federal Highway Administration – FHWA) and another 15% of the total project costs by the state government (NYSDOT), leaving the remaining 5% of the project to be covered by local funding sources (i.e., City of Syracuse, Onondaga County, NGO's, etc.). Information that can be used to determine whether a project is eligible for TEA funds is provided in Appendix D.

Table 6 - Cost estimate for trail construction

Item	Description	Estimated cost
Basic Costs:		
Site preparation	Clearing, excavation, earthwork	$50,000
Access point improvements	Bollards & fence modification	$50,000
Trail material	Stone & stone dust (3-inches packed stone dust)	$100,000
Drainage	Materials and installation	$16,000
Signage	Basic signage and rule posting	$10,000
Temporary ESC measures	Erosion and sediment control (assuming silt fence along length of stream)	$30,000
Subtotal 1:		$256,000
Other Costs:		
Survey		$5,000
ROW acquisition	Minimal right-of-way from 1 parcel	$10,000
M&PT	Maintenance & protection of traffic	$5,000
Mobilization	4% - standard	$10,000
Subtotal 2:		$286,000
Contingencies	15% - standard	$43,000
Total Cost Estimate:		**$329,000**

7.0 Permit Acquisition

Like any project that proposes to disturb the bed or banks of streams, state and federal permits will need to be obtained prior to any site construction. The total disturbance proposed as part of the North Valley restoration project will exceed 1.0-acre; therefore, a Stormwater Pollution Prevention Plan (SWPPP) will need to be completed. This plan will include all permanent and temporary erosion and sediment control measures that will be required throughout the length of the trail. A State Pollution Discharge Elimination System Permit (SPDES) will also be required for stormwater discharges from construction activities. The SPDES permit that will be needed is GP-0-08-001.

Onondaga Creek is recognized by the U.S. Army Corps of Engineers as a Water of the U.S.; therefore placing this waterbody under federal jurisdiction. Any disturbances to the creek bed, or other areas below the ordinary high water mark (OHWM) of the creek, are likely regulated by the USACE. A Section 404 Nationwide Permit will likely be required prior to project construction. The NYSDEC will require that an Article 15 Excavation and Fill in Navigable Waters and a Section 401 Water Quality Certification be obtained. Within the study area, the NYSDEC classifies Onondaga Creek as a Class B stream with B Standards. This classification indicates that the best usage of this stretch of Onondaga Creek is for contact and non-contact recreational activities (i.e. boating, fishing, swimming, etc.). As a result of this classification, an Article 15 Stream Disturbance permit will also be required from the NYSDEC. The costs associated with the obtainment of these permits are not included in this restoration report.

8.0 Works Cited

Canadian Council of Ministers of the Environment. 1999. Canadian Water Quality Guidelines for the Protection of Aquatic Life.

Central New York's Near-Real-Time Surface Water Quality Network. 2009. Water quality monitoring at Dorwin Avenue. http://ourlake.org/html/dorwin_avenue.html

Corenblit, D., Steiger, J., Gurnell, A.M., Naiman, R.J. (2009). Plants intertwine fluvial landform dynamics with ecological succession and natural selection: a niche construction perspective for riparian systems. *Global Ecology and Biogeography*. 18: 507-520.

D'Antonio, C. and Meyerson, L.A. (2002). Exotic Plant Species as Problems and Solutions in Ecological Restoration: A Synthesis. *Restoration Ecology*. 10(4): 703-713.

Delaney, Kevin. "Onondaga Creek Land Use." Telephone interview. 7 Dec. 2009.

Federal Interagency Stream Restoration Working Group (FISRWG).1998. Stream Corridor Restoration: Principles, Processes, and Practices.

Fisher, Pat and Muria Larison. "Defining Restoration Goals." Personal interview. 08 Dec. 2009.

Goodwin, C.N., Hawkins, C.P., Kershner, J.L. (1997). Riparian Restoration in the Western United States: Overview and Perspective. *Restoration Ecology*. 5(4S): 4-14.

Gregory, S.V., Swanson, F.J., McKee, W.A., Cummins, K.W. (1991). An Ecosystem Perspective of Riparian Zones. *Bioscience*. 41(8): 540-551.

Henry, A.C., Hosack, D.A., Johnson, C.W., Rol, D., Bentrup, G. (1999). Conservation corridors in the United States: Benefits and planning guidelines. *Journal of Soil and Water Conservation*. 54(4): 645-650.

Hilty, Jodi A., Lidicker, W.Z., Merenlender, A.M. (2006). Corridor Ecology: The Science and Practice of Linking Landscapes for Biodiversity Conservation. Washington DC: Island Press.

Lake, P.S., Bond, N., Reich, P. (2007). Linking ecological theory with stream restoration. *Freshwater Biology*. 52: 597–615.

Landis, C. (2008). Initial Riparian Restoration Along an Urban Stream Gradient, Onondaga Creek, New York. Master's Thesis. Syracuse: SUNY-ESF.

Leopold, D. (2006). *Native Plants for Difficult Sites*. SUNY-ESF.

Naiman, R.J., Bechtold, J.S., Drake, D.C., Latterell, J.J., O'Keefe, T.C., Balian E.V. (2005b) Origins, patterns, and importance of heterogeneity in riparian systems. In: Ecosystem

Function in Heterogeneous Landscapes (Eds G. Lovett, C.G. Jones, M.G. Turner & K.C. Weathers): 279–309. Springer-Verlag, New York.

Naiman, R.J. and Decamps, H. (1997). The Ecology of Interfaces: Riparian Zones. *Annual Review of Ecology and Systematics.* 28: 621–58.

Naiman, R.J., Decamps, H., and McClain, M.E. (2005a). Riparia: Ecology, Conservation and Management of Streamside Communities. San Diego: Elsevier Academic Press.

Naiman, R.J., Decamps H., Pollock, M. (1993). The role of riparian corridors in maintaining regional biodiversity. *Ecological Applications.* 3: 209–212.

Nathan, R. and Muller-Landau, H.C.. (2000). *Trends in Ecology and Evolution*. 15(7): 278-285. Onondaga Environmental Institute. 2009. Onondaga Creek Conceptual Revitalization Plan Draft.

Padilla, F.M., and Pugnaire, F.I. (2006). The role of nurse plants in the restoration of degraded environments. *Frontiers in Ecology and the Environment*. 4(4): 196–202.

Pinelands Nursery & Supply. 2007. Wholesale Catalog. Gloversville, New York.

Richardson, David M., Holmes, P.H., Ensler, K.J., Galatowitsch, S.M., Stromberg, J.C., Kirkman, S.P., Pysek, P., Hobbs, R.J. (2007). Riparian vegetation: degradation, alien plant invasions, and restoration prospects. *Diversity and Distributions*. 13: 126-139.

Syracuse Onondaga County GIS on the web. http://www.maphost.com/syracuse-onondaga/.

Toth, E. (2009). Director of New York City Native Plant Center: Personal Communication.

United States. American Association of State Highway and Transportation Officals. *Guide for the Development of Bicycle Facilities*. Vol. 1. 1999.

United States Access Boards. *Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines*. Vol. 1. 2004.

USDA. Federal Interagency Stream Restoration Working Group. (1998). Stream corridor restoration: principles, processes, and practices. Accessed Online: November 2009. www.usda.gov/stream_restoration/

USDA. 1993. Stream Habitat Improvement Handbook.

USDA. Soil Conservation Service. 1977. Onondaga County New York Soil Survey.

Ward, J.V., Tockner, K., Arscott, D.B., Claret, C. (2002). Riverine landscape diversity. *Freshwater Biology*. 47: 517-539.

Williams, N.M. and Kreman, C. (2007). Resource distributions among habitats determine solitary bee offspring production in a mosaic landscape. *Ecological Applications*. 17(3): 910–921.

Washington Department of Fish and Wildlife, US Fish and Wildlife Service, Washington Department of Ecology. 2004. Stream Habitat Restoration Guidelines

WSDOT. 2000. "Ch. 810: Vegetation Restoration." *Roadside Classification Plan*. Accessed Online: Dec 2009. www.ser.org/sernw/pdf/WADOT_Veg_Rest_810.pdf

Appendices

Appendix A

Instructions on How-to Build Native Bee Nesting Blocks

Home-Made Sweet Homes

Building Native Bee Nesting Blocks

Why build native bee nesting blocks? Read about why native bees are important for your garden, and how to attract them, in the PDF ***Better with Bees***.

Create homes for native bees!

Many of the wild bees you may encounter in your backyard garden make their burrow homes in the soil. Some bees create hives in snags (a dead or dying standing tree, often with its branches broken off), or in holes in trees. You can also encourage bee-residents by providing man-made nesting blocks or “Bee Condos.”

It’s easy to build a “Bee Condo” for your native bees.

MATERIALS YOU’LL NEED:

- a 4”x6” or 6”x6” dried pine or fir post (or you can try a weathered fence post or other scrap wood)
- Drill and drill bits, a variety of diameters, ranging from 1/4 in. to 3/8 in.
- Paper straws – not plastic (available at some hardware stores, or through a scientific supply store), or small hollow sticks, with one end sealed
- A warm location protected from rain and predators.

HOW TO DO IT:

1. Cut the wooden posts into blocks 8-12 in. long.
2. Drill holes into the wood blocks using a variety of hole diameters from 1/4 in. to 3/8 in. Drill holes 3-5 in. deep, and at least 3/4 in. apart. Smooth out ragged edges of holes.
3. Alternatively, a bundle of paper straws or hollow sticks, with one end sealed, will make an attractive bee home.
4. Bees prefer dark colored homes, so consider charring the front of your “Bee Condo” lightly with a torch.
5. Mount your “Bee Condo” on a post or attach to the side of a building. Place nesting blocks so that tunnels are horizontal. Make sure they are in a warm location with southern exposure and protected from rain. A good place could be under the eaves of a garage or shed.
6. If you don’t want to build your own “Bee Condo,” consider these commercial sources for bee nests: www.knoxcellars.com, www.raintreenursery.com, www.entomologic.com, www.pollinatorparadise.com, www.superseeds.com/birds_&_more.htm

Contact: **North American Pollinator Protection Campaign (NAPPC)** for more information on pollinators and pollinator gardening! www.nappc.org info@nappc.org
423 Washington St. 5th Fl, San Francisco, CA 94111 (415) 362-1137

Appendix B

Community Involvement – Initial Surveys

Appendix B: Community Involvement - Initial Surveys

1) Survey for Spiritual Center

Current Use:

1) How do you currently use Onondaga Creek?
2) In what ways do you see other members of your spiritual community using Onondaga Creek?
3) In what ways do you see all members of the North Valley using the Creek?
4) Does your spiritual community formally use the creek (ex: for guided meditations / services)?
5) Is the Creek and important part of your personal spirituality (ex: is it used for meditation / prayer)?
6) What relationship does your spiritual community have with the others also located on the Creek?

Improving Access:

7) How do you feel about the fences that currently prevent creek access?
8) If you support adding more access to the Creek, where exactly would you like these access points to be?
9) Do you think using natural hedgerows in place of the fences would be a good idea? (Improving aesthetics)
10) Do you feel there are any safety issues with allowing more access to the Creek?

Future Use of Creek:

11) What sort of Recreation opportunities do you feel the Creek should be used for (fishing, walk ways, park benches, and picnic areas)?
12) What sort of ecological improvements would you like to see made to the Creek (plants/animals you would like to see, removal of invasive)?
13) If it is not already, do you think there is potential to incorporate the creek into your spiritual program?
14) Do you think a walkway between the spiritual centers would be beneficial?
15) Do you think a connection between the all community centers would be beneficial?
16) Do you think that a walkway could be used to connect your spiritual program with that of the other schools?
17) If yes, would you support public stewardship of the Creek (including planting, weeding, and analysis of species diversity)?

2) Survey for Education Centers

Current Use:

1) How do students and their families currently use the creek?
2) How do the school's educational programs use the creek for biology classes?
3) What relationship do your school's students have with the other schools that are also located on the creek? (Van Duyn, Faith Heritage, Clary Junior High, Expeditionary Learning School) Athletics? Education?
4) How often do your student and families use Meacham Field?
5) If frequently, what do they use it for?

Improving Access:

6) How do you feel about the fences that currently prevent creek access?
7) Do you think using natural hedgerows in place of the fences would be a good idea? (Improving aesthetics)
8) If you support providing students more access to the Creek, where specifically would you like the access points to be?
9) Do you feel there would be any safety issues associated with allowing students more access to the creek?

Future Use of the Creek:

10) What sort of Recreation opportunities do you feel the Creek should be used for (fishing, walk ways, park benches, and picnic areas)?
11) What sort of ecological improvements would you like to see made to the Creek (plants/animals you would like to see, removal of invasive)?
12) Do you think there is potential to incorporate the creek into your education program (biology, ecology etc.)?
13) Do you think a walkway between the schools and Meacham field would be widely used?
14) Do you think it would connect the community in a beneficial way?
15) Do you think that a walkway could be used to connect your education program with that of the other schools?
16) If yes, would you support creek maintenance as an educational tool – including planting, weeding, and analysis of species diversity?
17) Would you envision the faculty getting involved?
18) What about student families?

Appendix C

Stakeholder Meeting Action Items

Appendix C: Stakeholder Meeting Action Items

Topic 1: Current Use

- Discuss each organization's use of Creek stretch
- Determine where land use interests overlap
- Express sense of communal ownership

Topic 2: General Goals

- Determine which organizations would like to use it for Recreation, and what sort of Recreation is preferred
    - "Traditional" park
        - Picnic areas
        - Benches
        - Paved sidewalk (safety, handicap accessible?)
        - Educational signs
    - Fishing areas
    - Boat access points?
    - Dog-walking park
    - Bicycle access
- Determine how it's ecological quality should be improve
    - Target species?
    - Target ecosystem function? i.e. improve water quality, wildlife habitat, ecological corridor, flood control
    - Should ecological improvements take precedence over recreational – i.e. no more infrastructure, no signage

Topic 3: Organization Use

- How do the above, specified uses add / subtract from spiritual and educational pursuits
- How should the restoration process be used in education?
    - Lessons on conservation, biology, ecology

Topic 4: Objective Summary

- Panel members should recap main arguments of each interest group
- Allow for any final comments
- If there is no obvious majority, decision making will go to vote

Topic 5: Selection of Restoration Committee

- Select members to organize public involvement in implementation and monitoring project

Appendix D

Transportation Enhancement Act

Funding Eligibility

Transportation Enhancement Activities

The list of qualifying TE activities provided in 23 U.S.C. 101(a)(35) is intended to be exclusive, not illustrative. Only those projects that are listed in one of the 12 categories are eligible for transportation enhancement funds. Examples of each activity are provided below.

Under 23 U.S.C. 504(e), TE funds may be used for direct educational expenses for surface transportation workforce development, training, and education, provided the activity specifically benefits eligible TE activities. Direct costs include training costs, conference and registration fees, and travel costs, but not salaries. See Transportation Enhancements Guidance Supplement - Surface Transportation Workforce Development, Training, and Education. [**Paragraph added 01/18/06**]

Each project activity must demonstrate a relationship to surface transportation.

For additional clarification we have developed a set of Guiding Principles and Questions for Transportation Enhancement Activities to help the decisionmaker assess how the proposed project meets the following 12 principles, and to assess some aspects of project viability.

	Activity	**Examples**
1.	Provision of facilities for pedestrians and bicycles.	New or reconstructed sidewalks, walkways, or curb ramps; wide paved shoulders for nonmotorized use, bike lane striping, bike parking, and bus racks; construction or major rehabilitation of off-road shared use paths (nonmotorized transportation trails); trailside and trailhead facilities for shared use paths; bridges and underpasses for pedestrians and bicyclists and for trails.
2.	Provision of safety and educational activities for pedestrians and bicyclists.	Educational activities to encourage safe walking and bicycling.
3.	Acquisition of scenic easements and scenic or historic sites (including historic battlefields).	Acquisition of scenic land easements, vistas, and landscapes; acquisition of buildings in historic districts or historic properties, including historic battlefields.
4.	Scenic or historic highway programs (including the provision of tourist and welcome center facilities).	For projects related to scenic or historic highway programs: Construction of turnouts, overlooks, and viewing areas; construction of visitor and welcome centers; designation signs and markers.
5.	Landscaping and other scenic beautification.	Landscaping, street furniture, lighting, public art, and gateways along highways, streets, historic highways, trails, and waterfronts. Landscaping recommendation: see FHWA's Roadside Vegetation Management website.
6.	Historic preservation.	Preservation of buildings in historic districts; restoration and reuse of historic buildings for transportation-related purposes.
7.	Rehabilitation and operation of historic transportation buildings, structures, or facilities (including historic railroad facilities and canals).	Restoration of historic railroad depots, bus stations, ferry terminals and piers, and lighthouses; rehabilitation of rail trestles, tunnels, and bridges; restoration of historic canals, canal towpaths, and historic canal bridges.
8.	Preservation of abandoned railway corridors (including the conversion and use	Acquiring railroad rights-of-way; planning, designing, and constructing multiuse trails; developing rail-with-trail projects.

	of the corridors for pedestrian or bicycle trails).	
9.	Inventory, control, and removal of outdoor advertising.	Billboard inventories and removal of illegal and nonconforming billboards. Inventory control may include, but not be limited to, data collection, acquisition and maintenance of digital aerial photography, video logging, scanning and imaging of data, developing and maintaining an inventory and control database, and hiring of outside legal counsel.
10.	Archaeological planning and research.	Research, preservation planning, and interpretation of archaeological artifacts; curation for artifacts related to surface transportation and artifacts recovered from locations within or along surface transportation corridors.
11.	Environmental mitigation-- (i) to address water pollution due to highway runoff; or (ii) reduce vehicle-caused wildlife mortality while maintaining habitat connectivity.	For existing highway runoff: soil erosion controls, detention and sediment basins, and river clean-ups. Wildlife underpasses or other measures to reduce vehicle caused wildlife mortality and/or to maintain wildlfe habitat connectivity.
12.	Establishment of transportation museums.	Construction of new transportation museums; additions to existing museums for a transportation section; conversion of railroad stations or historic properties to museums with transportation themes.

Each project activity must demonstrate a relationship to surface transportation.

To provide Feedback, Suggestions or Comments for this page contact Christopher Douwes at christopher.douwes@dot.gov.

This page last modified on September 22, 2008