Vermillion River Linear Park
Natural Resource Management Plan

Prepared by:

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This Natural Area Management Plan and Work Plan has been reviewed and approved by:

City of Hastings, MN

_____ Date: _____
Cory Likes, Parks Maintenance Supervisor

Dakota County

_____ Date: _____
Al Singer, Land Conservation Manager

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EXECUTIVE SUMMARY

Vermillion Linear Park (Linear Park) is a 60-acre city park located in Hastings, MN. It is owned and managed by the City of Hastings, MN. The park is located between the Vermillion River's intersection with Highway 61 and it's intersection with Highway 46-47 (approximately 3800 feet long and 500 feet wide), and is a long, linear area that roughly follows the channel of the river. The site was designated as prairie in pre-settlement, which agrees with the soil data and also with the historic aerial photos. Today, about 150 years after settlement, the site has experienced many changes and has been altered quite significantly. A dump that was located at the northern and western end of the park site was operated by the City for several years during the twentieth century. More significant, though, were alterations made to the channel. In response to a record flood in 1965, an entire meander was removed from the river (just north of the park, upstream of the river's intersection with Highway 46-47) and a levee was constructed to hold floodwaters from spilling into a nearby residential neighborhood (the natural floodplain) to the north of the channel. Another component of the flood abatement project was begun in 1979 when a large area south of the channel was excavated to receive floodwaters in lieu of loss of the natural floodplain to the north. This spillway, or "Bypass Channel" is under the jurisdiction of the US Army Corps of Engineers, but is managed by the City of Hastings.

No rare plants or animals have been recorded on the site. In spite of this fact, this plan recommends to restore native plant communities to improve habitat for wildlife, especially prairie and savanna communities, which are targeted by the MN DNR as being the most in need of restoration in this ecological subsection (Oak Savanna subsection). Breeding bird surveys are recommended by this plan, to monitor the site for bird diversity, the measure of which would show trends, over time, which would indicate whether the site's habitat is improving for wildlife.

Existing conditions today show evidence of much disturbance to the site, in the past, especially a proliferation and dominance of non-native vegetation. This plan calls for the restoration of native plant communities to the entire site, with a particular focus on prairie restoration, since that was the predominant vegetation type pre-settlement. Much of the park north of the channel is currently managed for turf and picnic areas. A small, narrow stretch of buffer along the north banks of the channel was restored by native shrub and graminoid plantings by Dakota County SWCD, which is performing well. This plan calls for expansion of such practices into existing turfed areas, to improve water quality and stabilize banks on the north side of the channel.

The river channel shows signs of many impacts resulting from increased water volumes in the channel, increased flow rates during floods, and point source damage to riverbanks where stormwater inlet pipes dump directly into the channel. This

plan calls for the stabilization and restoration of degraded riverbanks within the park. A combination of hard and soft armoring of the banks, incorporating bio-engineering techniques such as wattles, fascines, live stakes, and boulder toe construction, is recommended for four of the most degraded sections of riverbank.

The restoration of the site is broken into four phases, with the first phases targeting the higher priorities, and the later phases targeting the lesser priorities. The restoration is spread out over about six years and is estimated to cost as much as $310,000. Activities recommended are removal of undesirable woody brush, conducting controlled burns throughout the site, prudently treating with systemic herbicides to control exotic vegetation, and planting and seeding with appropriate native shrubs, grasses, sedges, and forbs. Long-term, a monitoring program is part of the schedule. FMR can help with obtaining grants for funding of the restoration, as well as with the management and coordination of restoration activities on the site.

INTRODUCTION

This Natural Resource Management Plan presents the site analysis and recommended management and land use activities for the 60.6-acre Vermillion Linear Park (Linear Park) Property in Hastings, Minnesota (**Figure 1**). This document can be changed only by written agreement by both the City of Hastings, MN and Dakota County.

The Linear Park property is owned by the City of Hastings, Minnesota. Like its name indicates, it is a long, linear piece of property, approximately 3800 feet long and 500 to 700 feet wide, and parallels the Vermillion River. Being located just upstream of it's intersection with Highway 61, Linear Park encapsulates that part of the river between the Hastings Levee and the Falls of the Vermillion River. The river channel, in this reach of the river, is very restricted, especially at both ends. It is prevented from meandering or overflowing into the historic floodplain to the north of highway 47, and it is restrained to a narrow, straight channel in the last couple hundred feet upstream of Highway 61. A "Bypass Channel" or "spillway" or "high-flow channel", encompassing approximately 20 acres, was constructed south of the channel to help relieve pressure from floodwaters upstream (just north of the intersection of the Vermillion and Highway 47, at the levee).

The Linear Park site can be roughly split into two pieces, the first being the northern half, consisting of the river channel and riparian zone adjacent to the channel (approximately 28 acres), and the second being the southern half that is dominated the grasslands (including the Bypass Channel). The site, in it's entirety, is bounded by Highway 46-47 to the north, Highway 61 to the east, private residential property that abuts Bohlken Drive, to the south, and two large private lots that abut 31st Street W, to the west.

Overall, the topography of the site is rather flat, with only a slight grade downhill towards the east and north (towards the Mississippi River, where the watershed drains towards). Bedrock is very close to the surface, and actually exposed at the eastern end of the channel and spillway. Soils change in character across an east-west gradient. Soils at the western end of the site are deep, floodplain soils formed in loamy to sandy alluvium that are rarely flooded. Soils in the middle part of the site consist of sandy alluvial sediments, and sandy glacial outwash. At the eastern end of the park, the soils are well-drained and shallow on a terrace and form a thin mantle of loamy glacial drift underlain by limestone bedrock.

No rare plants or animals have been recorded on the Linear Park property, but within one mile to the northeast, at Old Mill Park, were found two remnants of native plant communities, Dry Sand Gravel Savanna (UPs14b), a state-threatened plant community, and Oak Forest (SE) Mesic Subtype. *Besseya bullii*, "kitten-tails", a

threatened oak savanna/prairie native plant species occurred in Old Mill Park. In addition, *Trillium nivale*, "snow trillium", occurred in the nearby Hastings SNA.

Linear Park is located in the northern part of the eastern lobe of the *Oak Savanna* ecological subsection, as designated by the Minnesota DNR (Figure 14). Although there may not be many Species of Greatest Conservation Need (SGCN) that could potentially be harbored at the Linear Park property, due to its urban nature and disturbed history, restoring wildlife habitat is still a priority for this plan. Habitat loss and degradation have been the primary causes of problems for SGCN species in the subsection, with prairie, oak savanna, and grassland currently containing the most species affected.

The DNR recommends to stabilize and increase SGCN populations in oak savanna and prairie areas by managing invasive species, using prescribed fire and other practices to maintain savanna and prairie, to encourage restoration efforts, to manage grasslands adjacent to native prairie to enhance habitat, and to provide technical assistance and protection opportunities to interested individuals and organizations. The pre-settlement vegetation for this site was "prairie" over about 95% of the site, and "oak openings & barrens", or "oak savanna" over about 5% of the site. Today, although the site has been greatly altered and has a history of neglect, there are still a few small prairie remnants that occur on the property. Restoring prairie and other native plant communities will be one of the top priorities of this management plan. Also improving and expanding the buffer of the Vermillion River, as well as stabilizing certain badly degraded riverbanks, are priorities, and will be explored in depth herein.

The purpose of this management plan is to:

- Identify the existing ecological conditions on the property
- Identify best management practices to maximize wildlife values, and retain and improve water quality and increase community diversity
- Document allowable uses and activities of the property

Specific ecological and cultural goals for this property are to:

- Increase coverage and diversity of native plant species and reduce non-native species
- Provide connectivity with other natural areas in the landscape and along the river corridor
- Maintain and manage the property for water quality by recommending erosion control and stabilization of riverbanks, and controlling runoff and nutrient loading
- Create a model for responsible public land stewardship
- Utilize this property to guide surface water management activities on adjacent land in a manner that protects and fosters natural community establishment

- Utilize this property to enhance and expand the ecological functions of the property

SITE INFORMATION

Owner name, address, city/township, county and phone:
City of Hastings, Minnesota
920 10th Street West
Hastings, MN 55033
Contact Person: Cory Likes, Parks Maintenance Supervisor,
651-480-6178

Township, range, section:
T115N, R17W, Sections 33 and 34.

Watershed:
Vermillion River

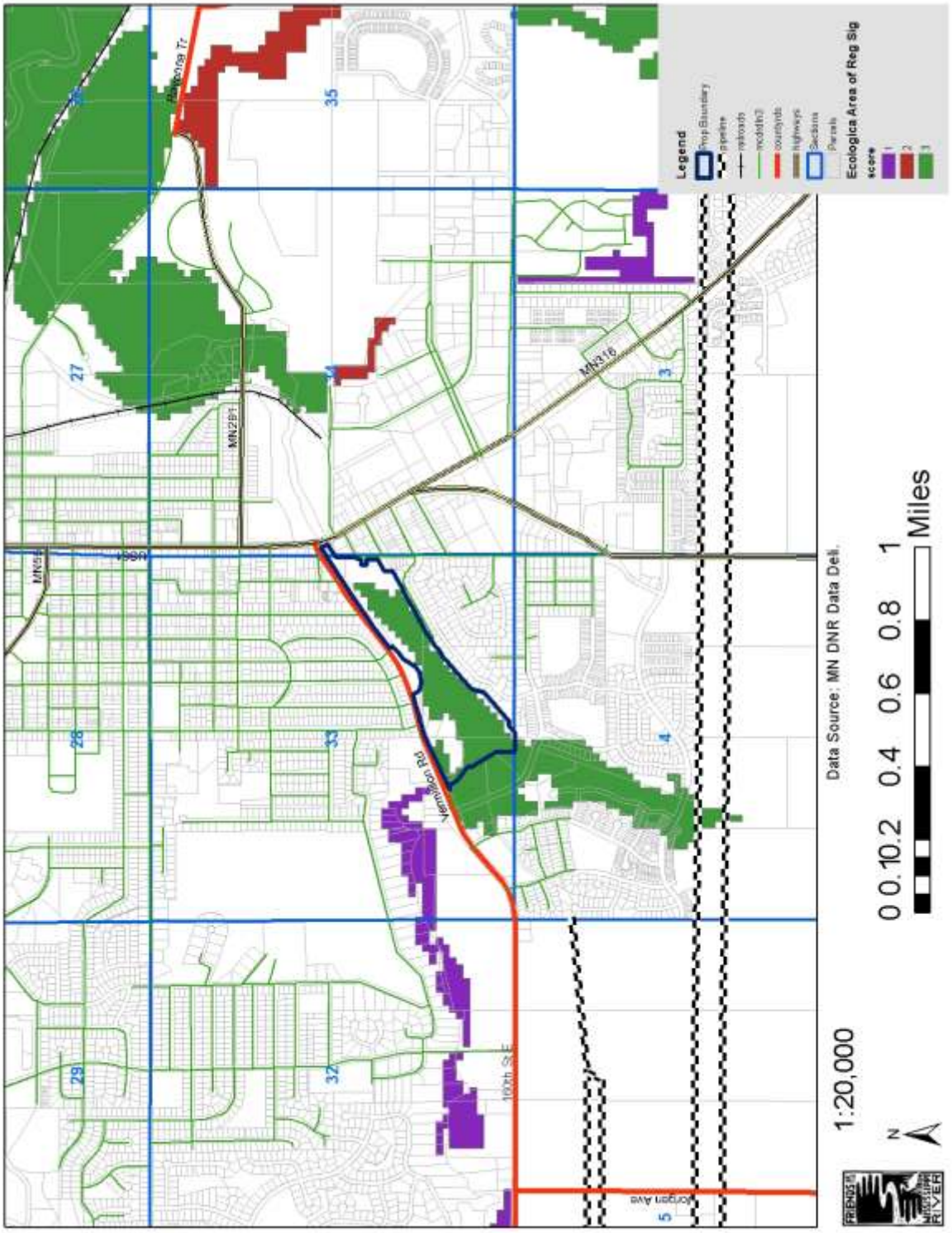
Watershed District:
Vermillion River Joint Powers Organization

Parcel Identification Numbers:
190330065012
190330065014
190330081010
190330084011
190370007012
190370007013
190370012012
190370010012
190370012020
190370013010
190370014010
190370016011
190400002022
198170002052
LAKE
RIGHT OF WAY

Natural Area Conservation Easement:
Property is not in Conservation Easement.

Rare Features:
No occurrences on the property.

Figure 1. Property Parcels



LANDSCAPE CONTEXT

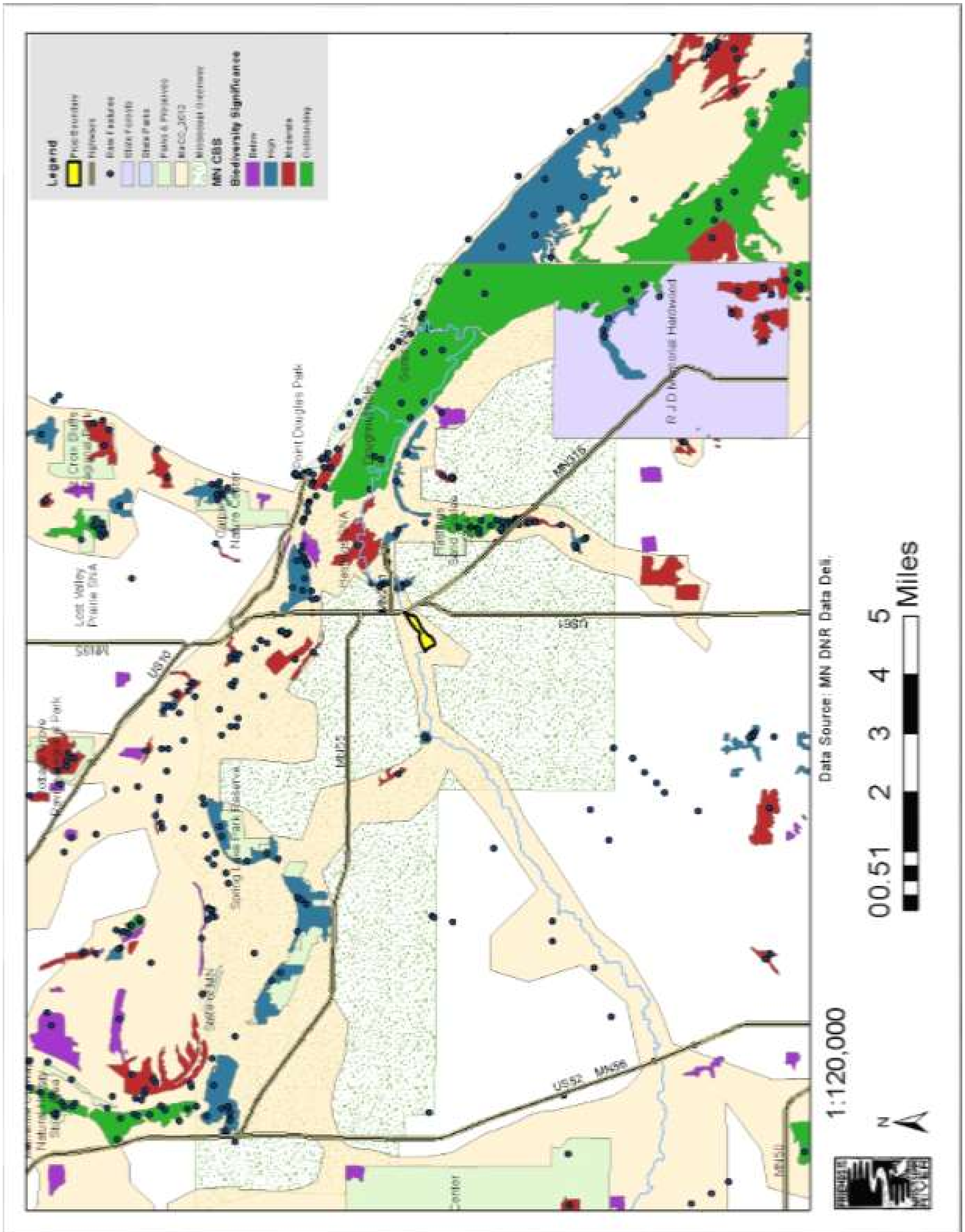
Proximity to established greenways

This property is assigned within the Metro Conservation Corridors (**Figure 2**), a regional land protection plan of the DNR. This property is also mapped within the Mississippi Greenway Corridor, a regional land protection plan of the DNR. Linear Park is also part of a chain of city parks that traverse the Vermillion River through Hastings. It is near Old Mill Park and Hastings SNA, each of which contains rare species and important native plant communities. In addition, the property is included in the Dakota County Farmland and Natural Areas Program (FNAP) natural areas eligibility zone.

Ecological significance and wildlife value

This park, although not ranked by Minnesota County Biological Survey as biologically significant, is within an ecological area of regional significance, ranked 3 on a scale of 1 to 3 (where 1 is highest), by Metro Conservation Corridors. As part of the Vermillion River, this property has inherent wildlife significance. All forms of wildlife depend on the river for sustenance, especially invertebrates, amphibians, reptiles, and fish. Mammals and birds also benefit greatly from the water, shelter and nutrients provided by the river.

FIGURE 2. LANDSCAPE CONTEXT



SITE GEOLOGY AND GROUNDWATER

The surficial geology consists primarily of fluvial deposits, or floodplain alluvium, and also, with a small portion at the easternmost portion of the property, bedrock (**Figure 3**). The floodplain alluvium is described as being poorly bedded, moderately well sorted sediments deposited by modern streams during flood stage. It is chiefly sand in the valleys of the Vermillion, and typically interbedded with organic-rich layers and buried soil (Hobbs, et al., 1990).

Surficial bedrock of the site is composed of two types: Jordan Sandstone in the western 2/3 of the property, and Prairie du Chien in the eastern 1/3. These formations originated some 510 to 478 million years ago, during the late Paleozoic era, but Jordan Sandstone is older (underlies) the younger Prairie du Chien formation. Prairie du Chien is a harder formation, composed of limestone and dolostone. The Prairie du Chien bedrock crops out in the vicinity of Hastings, and can be seen in the far eastern part of the river channel and the "spillway" on this property. Dolostone of the Prairie du Chien is commonly *karsted*, which means that it is scattered with underground caverns formed from a weakly acidic groundwater solution that dissolved the basic limestone.

Regional groundwater flows towards the largest regional surface water body. In Dakota County, regional groundwater flows from the southwest to the northeast, toward the Mississippi. Erroneous attempts have been made to delineate the "Vermillion River groundwatershed" that have similar boundaries to the surface watershed, but the Vermillion's "groundwatershed" is much, much smaller -- relatively narrow bands along the Vermillion and its tributaries (Travis Thiel, personal communication, December, 2012). Most of the water that goes into the groundwater within the surface watershed flows roughly parallel to the Vermillion toward the Mississippi, not into the Vermillion itself.

A Buried Bedrock Valley (BBV) underlies the area near the city of Hastings, MN. This valley would have formed prior to the last glaciation event, and helped form the route of today's Vermillion River. The BBV ranges from as much as 500 feet deep, at its deepest, to as shallow as only about 50 feet deep at its periphery. The BBV affects the water table of the region. Upstream of the BBV, at the city of Vermillion, the water table is very high—actually it is higher than the river level. At the location of the BBV, the water table drops about 70 feet, but the river level remains high, near the surface. At the Falls of the Vermillion, just east of Hwy 61, both the water table and river elevations drop (Travis Thiel, personal communication, December, 2012).

The interaction of water table levels and river elevations has a profound effect on the hydrology and the ecology of the area (see **Appendix G** for more information). Where the water table is higher than the river elevation, near the City of Vermillion and westward, the river floods frequently, since it gets abundant inputs from the groundwater (a "gaining reach"). Where the water table is lower than the river

elevation, east of Vermillion, the river floods rarely, since it gets no inputs from groundwater (a "losing reach"). This affects the plants that grow in these reaches, and it affects fish habitat also. Prairie communities would most likely be best suited to the well-drained soils with low water tables, which would create very dry conditions at the surface. Regarding fish, in the upstream "gaining reaches", the river water is much colder, due to the inputs of the groundwater, whereas in the downstream "losing reaches", the river water is warmer since no groundwater enters there. Thus adequate trout habitat would exist upstream, near City of Vermillion, but not downstream near Hastings.

Figure 3. Surficial Geology.

Since the Prairie du Chien also contains the primary aquifer for drinking water for the region, every effort should be made to protect it, and not contaminate it. Sensitivity of this aquifer to pollution is ranked "high" throughout most of the site, and at the very eastern end, where the bedrock crops out, it is ranked "very high" (Hobbs, 1990). Activities such as herbicide application should be performed under the strictest control, so as not to contaminate the aquifer.

SOILS AND TOPOGRAPHY

Topography

The topography is quite flat throughout Linear Park (**Figure 4**). It varies only by approximately 10 or 15 feet. It is a little higher at the western end of the park (790 to 800 feet above sea level) than at the eastern end (780 feet above sea level). North of the river, the topography is generally a little lower than it is south of the river, and thus the natural floodplain would have been to the north of the river, had not the "spillway" been created just to the south of the river. The spillway was made to drain high flow flood events away from the residential district to the north and to prevent floodwaters from backing upstream (Blomstrand, personal communication, 2012). Today, the spillway is a few feet lower than the area north of the river, so it is probably around 780 to 790 feet above sea level.

Soil

As stated in the Introduction, soils vary in character across sort of an east-west gradient (**Figure 4**). Soils at the western end of the site are deep, floodplain soils formed in loamy to sandy alluvia that are rarely flooded (Zumbro). Soils in the middle part of the site consist of sandy alluvial sediments, and sandy glacial outwash (Dickinson and Hubbard). At the eastern end of the park, the soils are well-drained and shallow on a terrace and form a thin mantle of loamy glacial drift underlain by limestone bedrock (Copaston). A summary of soil and their associated characteristics is listed in **Table 1**.

TABLE 1. SOILS

Soil Code	Soil Name	Percent Slope	Acres	Soil Family	Hydric (yes or no)	Drainage	Erodibility (Combined water & wind)
27A	Dickinson	0 to 1	30.18	Coarse-loamy, mixed, mesic, Typic Hapludolls	N	Well drained to Somewhat Excessively Well Drained	Medium
7B	Hubbard	1 to 6	7.23	Sandy, mixed Udorthentic Haploborolls	N	Excessively well drained	High
100B	Copaston	1 to 6	6.45	Loamy, mixed, mesic, Lithic Hapludolls	N	Well drained	High
495	Zumbro	0 to 1	5.00	Sandy, mixed, mesic Entic Hapludolls	N	Well to Moderately Well Drained	Low
1029	Pits	0 to 1	1.52				

39C	Wadena	6 to 12	0.07	Fine-loamy over sandy or sandy-skeletal, mixed mesic Typic Hapludolls	N	Well drained	High
857A	Urban Land	0 to 1	3.45				Low
W	Water		6.09				
	TOTAL		59.99				

The letters in the code indicate the percent slope, with A = 0 to 1%, B = 1 to 6%, C = 6 to 12%, D = 12 to 18%, and F = 25 to 65% slopes. As can be seen, all of the soils are quite flat; some are "A" and none are more than a "B".

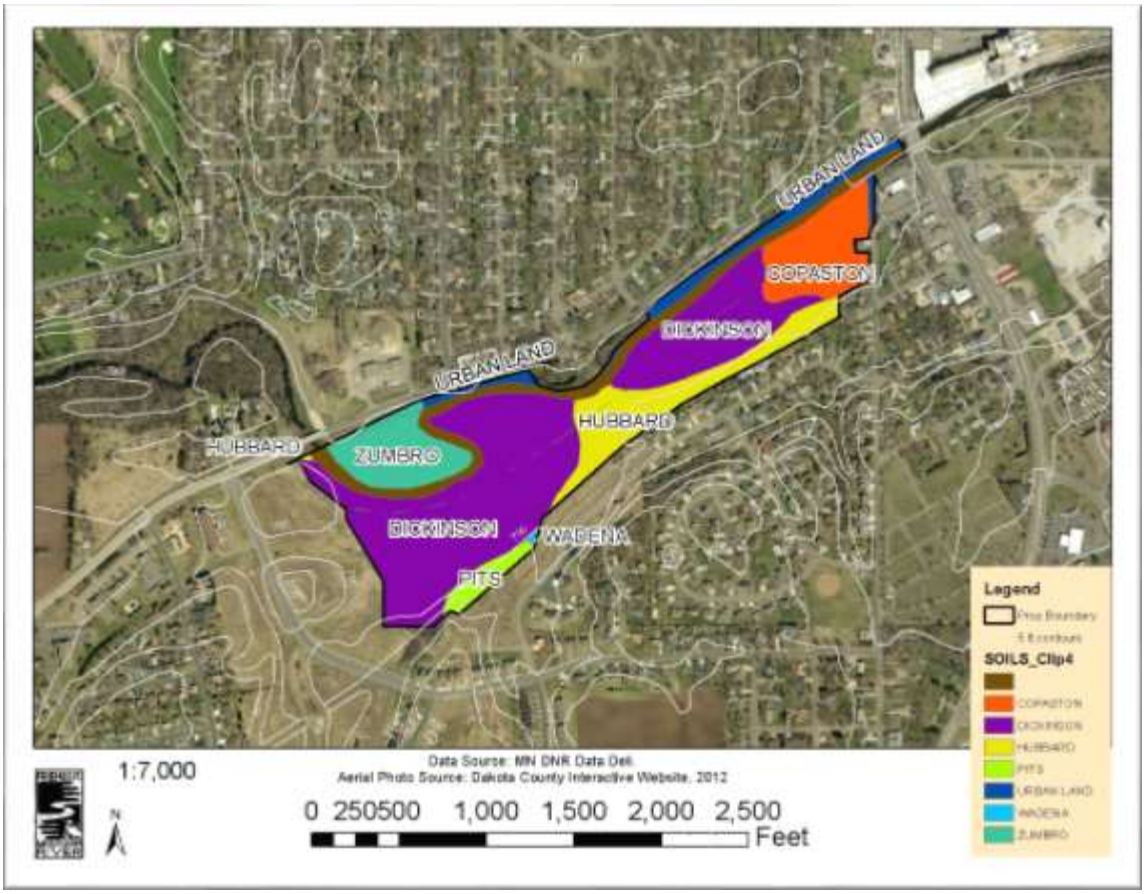


Figure 4. Soils and Topography.

Soil formation is the result of the interaction of five soil-forming factors: parent material, climate, organisms, topographic position or slope, and time (Foth, 1990). Taken collectively, these factors can help determine the dominant floral and faunal communities that helped form the soils. Dickinson, Hubbard, Copaston, Zumbro, and Wadena (all of the soils on the site) are all *mollisolls*, which are prairie soils, generally deep, dark in color, and rich in cations, and thus would have been dominated by graminoid vegetation (prairie or savanna) pre-settlement. Zumbro and Hubbard soils are *entic* soils, which means they are young in origin, since they

were recently deposited fluvial sediments. Zumbro soils also rarely flood. All of the soils of the project area are well drained or excessively well drained. Zumbro soils have low available water capacity and moderate amounts of organic matter. None of them are considered hydric soils, which indicates that they must not be wet enough for long enough to have developed enough organic matter accumulations to be considered hydric—an interesting phenomenon, being so near to the river channel.

RARE SPECIES

There are no rare species recorded on the property of Linear Park according to the DNR natural heritage database. The closest elements of occurrence exist to the northeast about one mile, in Old Mill Park and Hastings SNA (**Figure 2**). At Old Mill Park were found two remnants of native plant communities, Dry Sand Gravel Savanna (UPs14b), a state-threatened plant community, and Oak Forest (SE) Mesic Subtype. The Dry Sand-Gravel Savanna was last observed in 1997 and had a "fair" estimated viability. Field notes read as follows: "Small savanna remnants above path at Vermillion River Gorge. Scattered open-grown *Quercus macrocarpa* (bur oak), occasional groves of shrubs, large open areas dominated by prairie species, but with *Bromus inermis* (smooth brome) and *Poa pratensis* (Kentucky bluegrass) common." This description could similar to the general situation at Linear Park, had it not been disturbed by agriculture, pasturing, and dredging. Linear Park, however, would most likely not been as dry as a sand-gravel prairie, but a little more mesic, like a Southern Dry Prairie or Southern Dry Savanna.

Besseya bullii, "kitten-tails", a threatened oak savanna/prairie native plant species occurred in Old Mill Park (a few scattered plants by a roadside ditch, last observed in 1987). At Hastings SNA, a patch of *Trillium nivale*, "snow trillium", was recorded (over 200 plants located at base of steep slope with limestone outcrops under mature maple-basswood forest, last observed in 2008).

HISTORIC VEGETATION

The boundaries of Linear Park lie within what would have been prairie in pre-settlement times (**Figure 5**). The dominant landcover type in this region was prairie, as was shown on Marschner's map, which is a compilation of the notes taken from the first Public Land Survey (PLS) in the 1850's. Prairie was an area dominated by tall and short to medium sized grasses and forbs (wild flowers), with patches of shrubs and very few to no trees. The next most populous landcover type of the region was "oak openings and barrens", which we today would call savanna. Savanna is an area of scattered trees, primarily bur oak, with large areas of open prairie between them. The difference between prairie and savanna is created by frequency and intensity of fire. Generally, frequent fire (every 2 to 5 years) will result in prairie, while slightly less frequent fire (3 to 8 years) will result in savanna. Abutting to the north of where Linear Park is located today lays an area that was

designated as “oak openings and barrens”—perhaps the Vermillion River curtailed fire just enough to create this distinction.

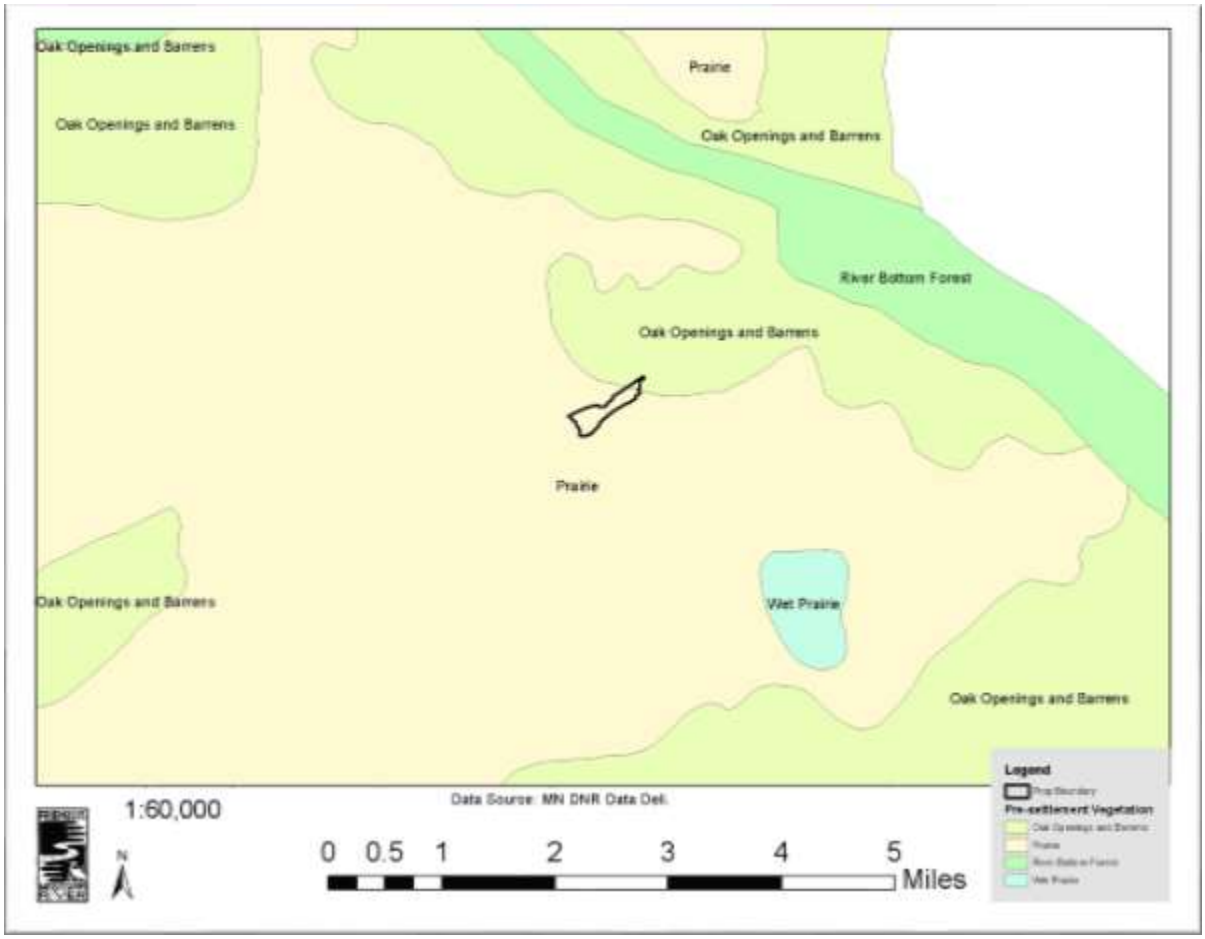


Figure 5. Pre-settlement Vegetation

Bearing trees were noted by the PLS surveyors to help identify each section of land. If no trees were in the section, that was also noted. Two bearing trees were located within this parcel: one at the very southwest end and the other at the very northeast end. The one at the southwest end was called “prairie” and the one at the northeast end was “bur oak”. Note that the soils data and the pre-settlement vegetation data concur: soils are prairie soils and pre-settlement vegetation shows prairie and savanna landcover.

Whether trees lined the river channel is another matter. It is possible that trees and shrubs could have existed along certain stretches of the Vermillion, pre-settlement. Much of the river was probably a prairie river, though, with prairie grasses coming right up to the channel, perhaps forming lips over the banks, and stabilizing the bank slopes.

Historical Aerial Photos

Historical aerial photos can help us reconstruct what the vegetation was like during the last ¾ of a century. The oldest aerial photo that we have for this site is from 1937 (**Figure 6 and 9**), and sheds light on past conditions of the area. At the time of this photo, the area was much more open than it is today. The Vermillion River channel was lined and dotted with trees, but very few trees occurred outside of that corridor. Off to the north and northeast of the property, trees were much more abundant, but note that they did not form closed canopied forests, but had space around each tree, and they are in a random configuration, not planted in rows, which indicates these were oak woodlands that were once oak savannas 75 years earlier. Also note how trees grew right up to the road in the northeast portion of today's park boundaries, shading the road in that area—today there is a strip of

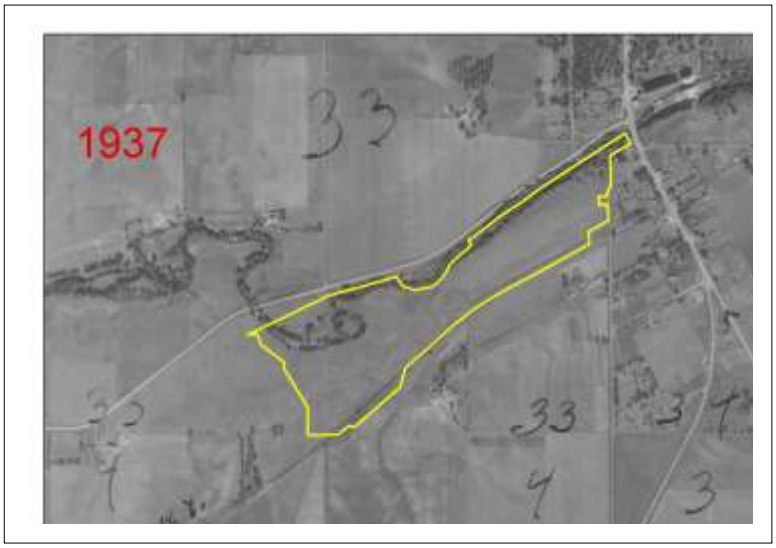
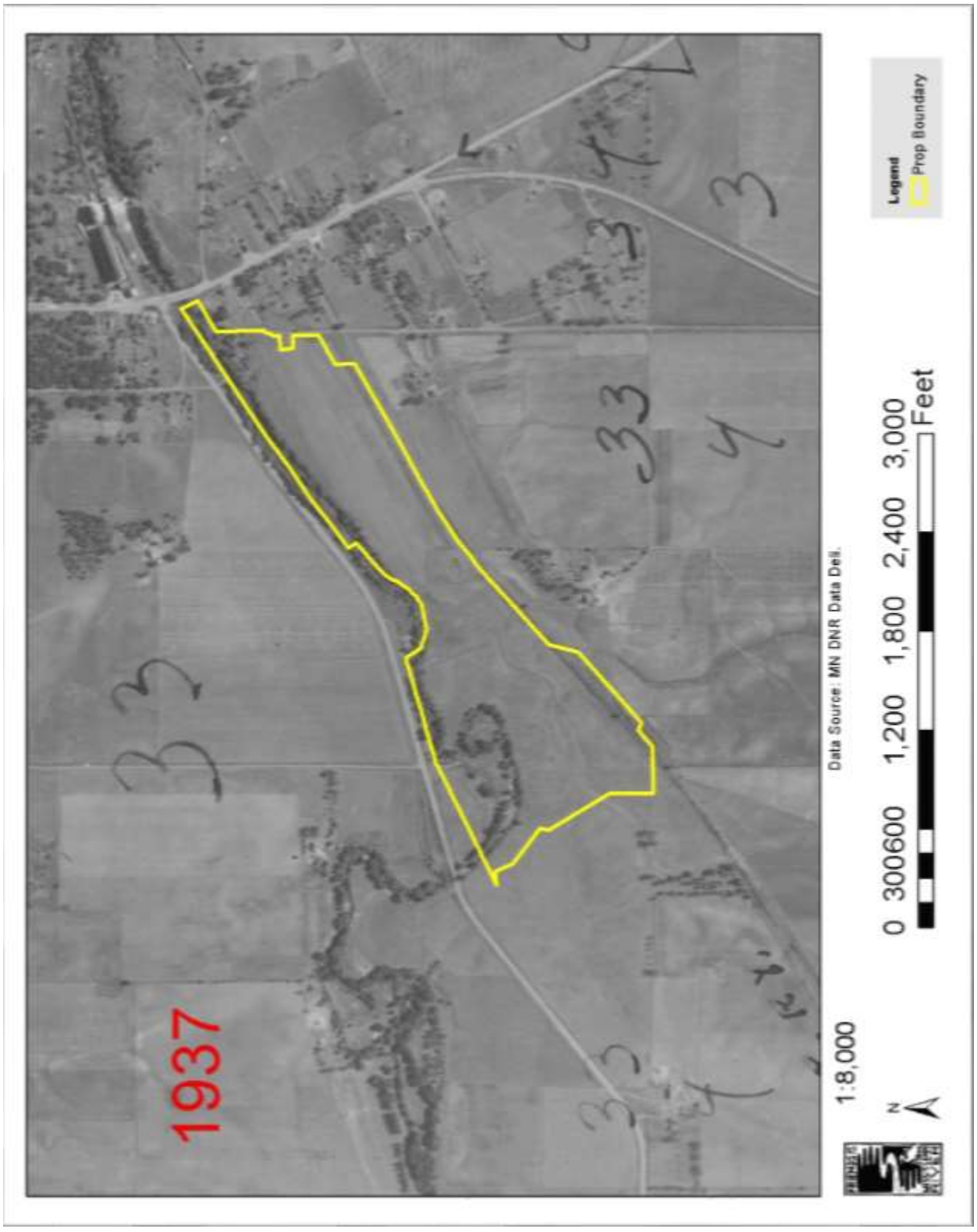


Figure 6. 1937 Historical Aerial Photo.
Figure 7. 1970 Historical Aerial Photo.
Figure 8. 2012 Aerial Photo.

Figure 9. Close up of 1937 Aerial Photograph



mowed turf here. Trees were also very dense along the river corridor right up to Highway 61, whereas today the channel is devoid of trees for about 760 feet upstream of the highway.

Agricultural fields dominated the landscape, and many occurred where they do not occur today. North of Highway 47, agricultural fields abounded, and so did they south of the river. The next most prominent man-made features were probably Highway 61, Highway 47, and the Old Mill. The Bypass Channel has not been excavated yet, either. A few homes existed along Hwy 61, but not many occurred elsewhere—this was a decidedly rural landscape.

Many changes happened in the intervening period from 1937 to 1970. The aerial photo from 1970 (**Figures 7**) shows a dramatic increase in residential housing, having replaced the agricultural fields. Housing was built right up to Highway 47.

The river channel was altered quite a bit, too. On the stretch of river just upstream of Highway 61, all of the trees were removed and the channel banks were hard-armored with riprap. On the other end, just upstream of where the river crosses Highway 47, the river channel was truncated and a shortcut channel was made. A levee was built on the cut-bank side and heavily armored. This was done, presumably, because the river flooded at this point, and the new residential development needed to be protected from flooding.

The "bypass channel" was not evident, in the 1970 photo. Actually, this large spillway area was excavated starting in 1979 and into the early 1980's. This bypass channel, or "high flow channel", was installed to increase flow rates so the water does not back up farther upstream (Blomstrand, personal communication, 2012). It also supports the levee from damage. Also, the bridge at Highway 61 is a pinch point, and this area can easily be backed up and overflow.

Photo 1. Steep slope with exposed bare soil (just to the right of, and behind, the trees in this photo). This is a cutbank slope, and is located in one of the bends of the river on the western side of the park.

The cumulative effect of all of these changes to the watershed and the river channel is hard to pinpoint. It can be safely stated, however, that one of the resulting affects to the channel has been to more effectively "lock it in place": to not allow it to meander where it once did, nor to overflow its banks where it once did. Coupled with increased flow volumes from increased amounts of surface runoff (due to increased impervious surfaces) and increased amounts of loading from tributary streams (due to increased

amounts of drain tiling in agricultural fields), the banks of the Vermillion River are having a hard time maintaining their structure. In several spots, the riverbanks have eroded, and are currently eroding, quite seriously (**Photo 1**). In places, the channel is becoming quite entrenched, with several stretches of riverbank, primarily the cut-bank parts, having much active erosion, very steep banks, and scoured slope toes. Solving watershed issues and upstream issues goes beyond the scope of this report, but some stabilization recommendations are made in the section "Existing Landcover and Ecological Recommendations".

In terms of native plant communities, the alterations done to the area over the past century have caused much disturbance. Wholesale destruction was caused by plowing for agricultural fields and then by creating the Bypass Channel. Restoration of these areas will be technically impossible. Reconstruction of former communities can occur, but would have to start virtually from scratch. Change from forested to open areas along the channel at the eastern end of the river, by Highway 61, will probably be permanent. Change from prairie vegetation to closed canopy forest, along some stretches of the river, can potentially be restored.

HISTORIC AND EXISTING LAND USE

Historic land use was partially discussed in the previous section. Other interesting information is as follows.

Vermillion Linen Mill

In 1871 Joseph Ennis and brother constructed a dam of wood and stone to obtain power for a mill. This was located about 1 mile upstream from the Gardner Mill. The dam was 100 feet long and 4' wide at the top (45" wide at the bottom) to provide an 11' head. In 1873 the Ennis brothers built a mill of wood, 30'x40' with a stone basement and three stories above. This was a flour mill. During the 1890s the mill was partially dismantled and moved down river to the foot of Eddy Street—near an already existing dam—and became part of the Cadwell Grist Mill, later operated as the *Vermillion Linen Mill (***Figure 10**). In 1911 the building was moved down river again and became part of the Gardner Mill. (Dick Darsow's Hastings Archives).

During its heyday (1880's and 90's), the Linen Mill "regularly employed 400 hands". It had three floors with 16 looms, three bleaching vats, one washing machine and one finishing machine.

Figure 10. Vermillion Linen Mill, February 21, 1899. This is a view looking west from the Vermillion River Bridge at what would today be Hwy 61 Bridge, capturing what would be most of today's Linear Park property. This is definitely a prairie landscape—note the lack of trees in the photo, except around the mill itself and a few in the distance, perhaps lining the stream. Photo courtesy of Cindy Thury Smith, Curator of the Hastings Pioneer Room, City of Hastings, MN.

City Dump

Research into more recent history revealed that in the 1940's-50's, the City of Hastings operated a city dump on West 18th Street that dead-ended at Pine Street, near where the current parking pull-off lot for the park is today. There was a gravel access road to the dump with was about ½ block from Pine Street (Smith, personal communication, 2012). The city dump was flooded in 1965.

Flood

In 1965, the Vermillion River had the greatest flood event in recent history (**Figures 11a and 11b**). Floodwaters inundated a 42-block area of Westwood, flooding out 250 homes, and families had to temporarily evacuate.

Figure 11a. Floodwaters from Vermillion River north of Linear Park. Hastings Gazette reported this on Dec 20, 1965: "Looking south, this airview of Westwood Addition shows the area hardest hit by flooding from the Vermillion River. The river itself, normally a quiet stream only a few feet wide, runs along the top of the picture, with trees outlining its natural course. Photo was taken on Wednesday, April 7, when the floodwaters were still holding after the crest. West 19th Street curves across the center of the picture. The outline of the hockey rink in the West 19th Street Park can be seen at left center. A total of 42 blocks in the city were under water from Monday through Thursday of that week, and more than 250 families were forced from their homes." Photo from Pioneer Room.

Figure 11b. Photo from April 6, 1965 showing the flooding in the Westwood addition of Hastings. Photo from Pioneer Room, City of Hastings (Cindy Thury Smith, Curator).

Response to the 1965 Flood

In 1976, the Hastings City Council passed "Resolution Directing Condemnation of Lands Needed for Public Purposes of Flood control and Recreational Uses." After the flooding of the Vermillion River in 1965 the NRCS, the Army Corps of Engineers and citizens came together and proposed a bypass channel to prevent further flooding. Consequently work was done on developing both the Vermillion Falls Park and the Vermillion River Linear Park. In 1984 Vermillion Falls Park was designated an SNA. (Smith, personal communication, 2012; source: records box 17 in Basement, History of the Hastings Parks).

Recent History

Recent history of the site has been one of City of Hastings ownership. Since that time, the north side of the channel has been used as parkland, with picnic tables and mowed turf and one parking lot. On the western half of the site, the flatter areas (Zumbro soils and Dickinson soils—near the former City Dump) have been used by City Public Works as storage areas for wood chips and storm damage trees from the surrounding neighborhood. All of this landuse history has resulted in a very disturbed set of plant communities and probably significant soil issues such as soil compaction.

The City currently mows the Bypass Channel area approximately one to three times annually. They also mow the north side of the channel, in the narrow green space between the channel and Highway 47, consistently enough throughout the summer to keep the grass short.

The upland areas of the south side of the site are used as stormwater holding and treatment areas for stormwater runoff from the newly established residential neighborhood to the south. A stormwater holding pond ("wet pond") has been recently installed in the southwest corner of the site. A paved trail system has also been recently installed in the south side and west side of the property that is parallel to the river channel. This trail connects with local trail system.

WATER RESOURCES

Surface Waters

Rivers

The Vermillion River is the obvious surface water resource of this area. Although it meanders, the Vermillion does not often flood in this reach of the river. Each year it floods the sidewalk under the Highway 61 Bridge, but the Bypass Channel does not get flooded very frequently (maybe once every 3 years or so—personal communication with Garret Blomstrand, 2012). Water flow rates are generally low, except following large rain events, especially in the spring, when flows can be quite high (**Photo 2**). Since the river does not flood very much, the floodplain tends to be quite narrow, and it tightly follows the course of the river. Flood resistant vegetation would reflect this narrow band, with floodplain species not ranging out very far from the river channel. Therefore, prairie vegetation would broadly occupy the uplands, and come very near the river valley.

Photo 2. Swift flow in river channel; June 21, 2012 during a flooding event. Located at the northeast end of the park just before the Highway 61 Bridge. Note the white caps on the water.

Floodplain

The 100-year floodplain is almost entirely contained within the park boundaries (**Figure 11c**). It spills out of park boundaries on the north side of the river, at the private residence parcel, in the middle of the map. Also note that a two spurs of the

100-yr floodplain extend from the main channel, one on the west side of the property which connects to the south, and one near the middle of property which connects to the south—the former is a historic creek and the latter is an artifact of stormwater runoff (**Figure 9**).

The buffer area on the south side of the river should provide very good water quality protection here. However, the buffer width on the north side of the river is much narrower. Some planting on the north banks has already been done by Dakota County SWCD, and this management plan recommends continuing that effort. Converting currently mowed turf areas and some picnic areas to native vegetation should also improve buffer effectiveness. Also, several culverts dump untreated stormwater directly into the river, from the residential neighborhood to the north, at 3 points along the north side of the river. These points are causing degradation of the banks near the inlet structures (see discussion below on Restoration and Management Recommendations). Capturing runoff in the nearby neighborhood to the north is recommended, so that runoff is reduced and treated. Perhaps creating many raingardens and bio-infiltration swales would work. Restoring and stabilizing the degraded banks near the inlet structures is also recommended.

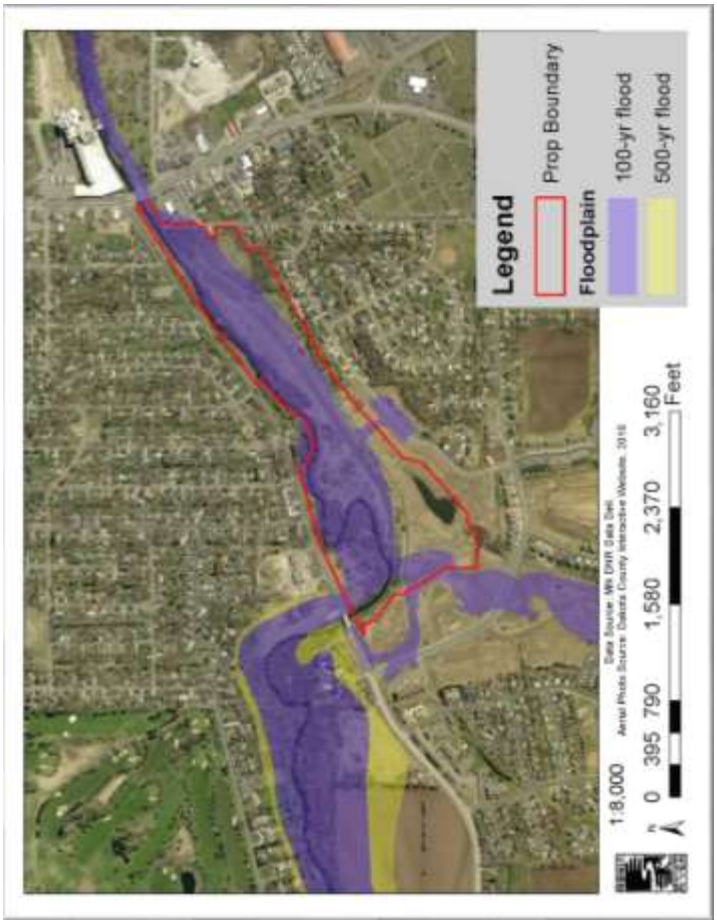


Figure 11c. 100-yr and 500-yr Floodplains

The Vermillion is a river of riffles and pools, throughout most of its length, and this is the case in Linear Park (Photo 3). Even though this reach of the river is not a trout stream, the riffles and pools are important for other wildlife habitat, since riffles oxygenate water and pools allow for slow water flow areas.

Photo 3. Riffle in stream (turbulent water). Note the pool (quiet water) downstream of the riffle.

Sediment loading to the Vermillion is rather high. During a December 2012 site visit, the FMR Ecologist startled a group of ducks that were on the water, and when the ducks flew away, a large plume of sediment was left in their wake (**Photo 4**). There is no vegetation growing on the river bottom, which may be normal for this stream (Jim Davidson, personal communication, 2012). A well-functioning *hyporheic zone*, the zone of saturated sediments lying below the streambed and extending laterally beneath the streambanks, is critical to river health, and can be threatened by siltation (Brooks et. al., 2003). Both local and more distant sediment origins contribute to this load. To control sediment loading to the river, both local BMPs (bank stabilization) and regional/watershed BMPs (upstream/up-watershed) would need to be employed. Refer to the Dakota County SWCD and the Vermillion River Joint Powers Organization website for more information regarding this. FMR can also assist landowners with information and contacts to help improve land conservation practices.

Photo 4. View of river bottom. Note the muddy plume near the shore. Also note the complete lack of vegetation on the riverbed. Reed canary grass dominates the vegetation on the steep slope in the foreground.

One way to determine the ecological "health" of a river or stream is to monitor the biota in the stream. Biota, unlike water sampling, integrates all of the factors that impact water quality and habitat quality for a species or a community. Joe Beattie, a Hastings High School biology teacher, and Veda Kanitz, Rosemount High School teacher, bring their students to the river to sample macroinvertebrates to determine trends in the river's health (**Photo 5**). Students determine the number of different macroinvertebrate families found at monitoring sites, because a healthy river is diverse in its macroinvertebrate families. Three specific macroinvertebrate families are sensitive to environmental degradation. These families, Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are particularly important in assessing river health, since they require higher water clarity conditions than many of the other families. At the annual River Summit, students present and discuss their data and learn what other students around the Metro are finding in their streams. Data from the reach of the Vermillion River at Linear Park appear to reveal that the health of the stream is at least holding steady over the last 10 years, and perhaps slightly improving (**Table 2).** For more information see **Appendix F**.

Photo 5. Students from Joe Beattie's Hastings High school class sampling macroinvertebrates in the Vermillion River in 2011. Photo courtesy of Dakota County SWCD.

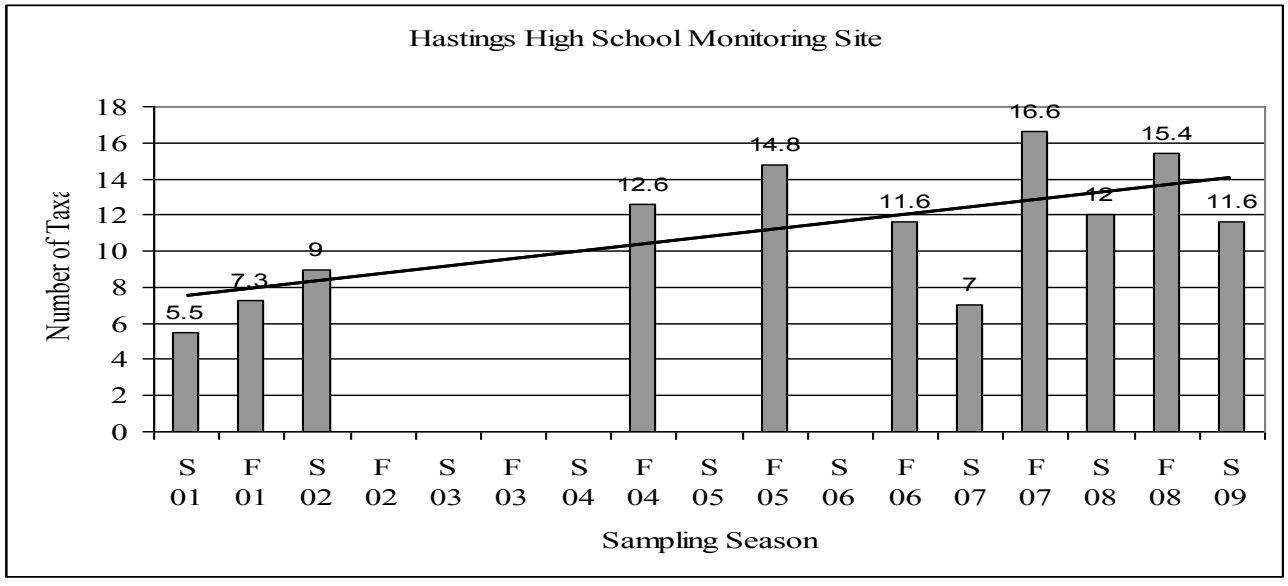


Table 2. Graph showing macroinvertebrate sampling data from the Vermillion River at Linear Park by Hastings High School students. Sampling site was near the parking lot on the north side of the river. Data courtesy of Joe Beattie and Dakota County SWCD.

Wetlands

There are three official wetlands on the Linear Park property, according to the National Wetland Inventory (NWI) (**Figure 12**). They are all classified as PFO1A wetlands, which stands for:

- *Palustrine* (all nontidal wetlands dominated by trees, shrubs, emergents, mosses or lichens)
- *Forested* (woody vegetation that is 6 m tall or taller),
- *Broad-leaved deciduous* (woody angiosperms [trees or shrubs] with relatively wide, flat leaves that are shed during the cold or dry season),
- *Temporary flooded* (surface water is present for brief periods during growing season, but the water table usually lies well below the soil surface for most of the growing season—plants that grow both in uplands and wetlands may be characteristic of this water regime).

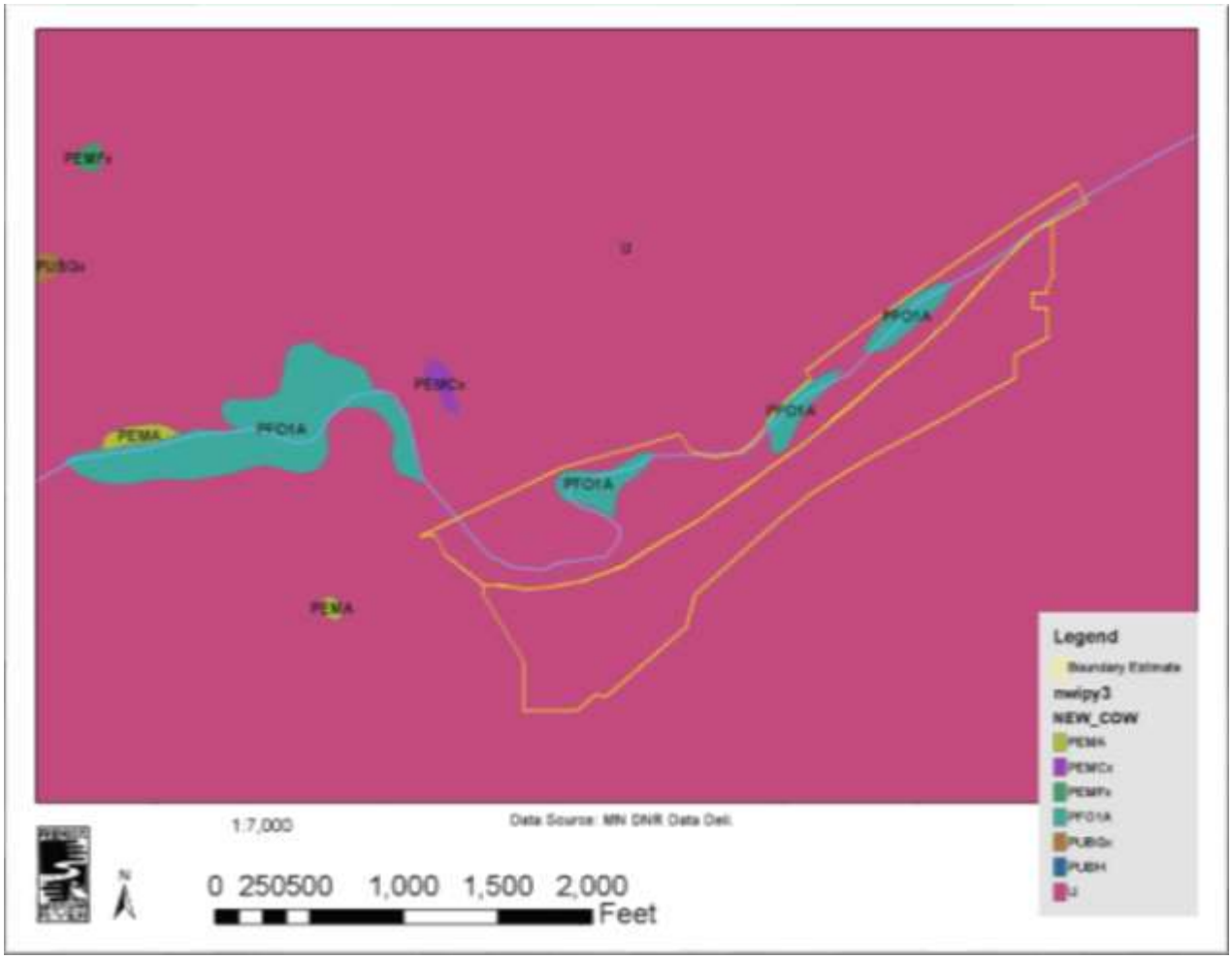


Figure 12. National Wetland Inventory Map for Linear Park.

These wetlands are all connected to and closely associated with the river channel, and, since classified as forested, temporarily flooded wetlands, they would be associated with flooding events—flooding which primarily occurs in June, but also can occur following snow melt in spring.

Groundwater Recharge or Infiltration Areas

Since the area in the vicinity of Linear Park is ranked high and very high for sensitivity of the Prairie du Chien aquifer to pollution, it follows that this would be a zone of recharge to groundwater. Therefore, all activities carried out on the property that pose a risk of groundwater contamination should be strictly controlled and the highest safety measures should be used. Activities such as applying herbicide to control non-native plant species would be an example of such a tightly controlled activity.

Since this is primarily an area of groundwater recharge, surface water will infiltrate into the ground. This situation is the reverse in areas that are located further upstream on the Vermillion. Further upstream (past Goodwin Ave), groundwater actually discharges into the surface waters, which produces cold, clean water to the streams and lakes of this zone. Brown trout require cold, clear water to survive and reproduce. When water temperatures reach even 72 degrees F, trout become lethargic and can die. In the "losing reach" at this part of the river (vicinity of Linear Park), inputs from surface runoff are critical. Since no groundwater is entering the river here, surface water runoff makes up all of the inputs to the river. Surface water runoff can be warm, especially in summer months. Inputs from shallow holding ponds and from direct runoff from roads and other impervious surfaces can easily elevate river water temperatures above critical levels for trout. This makes the upstream reaches of the Vermillion good trout habitat, and conversely, makes the downstream reaches poor trout habitat (Jim Davidson, personal communication, 2012). Thus, one would not likely find trout in Linear Park, regardless of other factors like abundance of pools and riffles, etc.

Photo 6. Stormwater inlet to river. The concrete structure is visible on the left.

Stormwater Management Issues

Vermillion River Stormwater Inlet Pipes

Stormwater management is a huge issue in Linear Park. The residential neighborhood to the north of the park

(north of Hwy 47) produces copious amounts of stormwater that gets discharged directly into the Vermillion River at Linear Park. Two large inlet pipes were found, on the north side of the river channel that dump directly into the river (**Photo 6**). The opposite riverbanks, at the points of entry of the stormwater discharge pipes, have been blown out, as evidenced by large gouges present in the banks at these points, and by active erosion of the banks also (**Photo 7**). These blown out banks require stabilization and restoration. It would seem logical to pre-treat the stormwater, somehow, before it enters directly into the river. Direct discharge into rivers not only releases water at high volumes and flow rates during large rain events, but also transfers nutrients, pollutants, and warm water into the river (loading). Due to the lack of green space/buffer on the north side of the river, the area to infiltrate or pre-treat stormwater is insufficient to prevent loading and high discharge rates. A potential solution, perhaps, would be to install multiple raingardens throughout the residential neighborhood. The raingarden strategy has successfully reduced stormwater discharge in other communities around the country (10,000 Raingardens Initiative, Kansas City, Missouri; Metro Blooms, Minneapolis, MN, etc.).

Photo 7. Gouge in riverbank opposite stormwater inlet pipe from Photo 6. Note the bare soil and band of erosion on the mid and low bank. Exotic shrubs dominate the vegetation on top of the bank.

Stormwater Runoff Pond

The stormwater runoff pond at the southwest corner of the property collects stormwater from the residential neighborhood to the south of the park. The pond has fairly gradual slopes surrounding it, with vegetation established (**Photo 8**). The vegetation, however, is a dominated by non-native plant species, and could be improved for habitat value by restoring with native plant species of the appropriate plant community (see Management Recommendations section, below).

Photo 8. Stormwater holding pond at southwest side of property.

There are some issues with gully erosion and a blowout of the edge of the pond, on the south side of the pond at an inlet structure (**Photo 9**). Here, the liner was breached and requires repair.

Either increasing the hard armoring of this area and/or reducing the amounts and rates of flows from the pipe would be solutions to this problem. Reducing flow would require stormwater BMPs up the watershed, for example raingardens, rain barrels, infiltration areas, pervious pavement, etc.

This stormwater pond appears to have its natural outlet at the northwest end, overflowing into the Bypass Channel, crossing under the bituminous trail via a culvert. There is probably very little chance of any of this runoff ever reaching the river, which is a good thing, since this type of surface runoff would likely elevate river water temperatures.

Photo 9. Blowout caused by rushing water from inlet pipe on south side of stormwater pond.

ADJACENT LAND USE

Adjacent land use to Linear Park is dominated by urban land use (**Figure 13**). To the north, the east, the south, and to the west are residential neighborhoods with some commercial mixed in. There is a golf course the northwest and Con Agra to the northeast. About one mile to the northeast are two high quality natural areas, Old Mill Park and Hastings SNA, but these are not connected directly with Linear Park. The Vermillion River runs through rural land for most of its length, to the west (upstream from Linear Park), until it reaches the City of Hastings, where it passes through an urban landscape. East of Hastings, the Vermillion emerges from the urban land and passes through Bull Frog Lake and splits into two parts, each which flow through natural areas until they reach the Mississippi River.

Urban runoff, loading of nutrients, pollutants, and warm water from streets, roads, parking lots, buildings, etc., all occur as the Vermillion passes through this urban zone in Hastings. The river downstream of the Falls, right next to the Con Agra facility, is considered an impaired water, due to turbidity. This is probably due in large part to the affects of the urban watershed on the river here, among other things.

In the middle of the park, on the north side of the river, is located a privately owned, residential home/lot—address is 709 County Rd 47, Hastings, MN 55033. The lot of this parcel is 2.2 acres. The City of Hastings has had a longtime interest in

purchasing this property with the intent of adding it to the park. At such a time when that happens, this natural resource management plan will need to be amended to include the parcel, with plans to restore the parcel to an appropriate natural condition.

Figure 13. Adjacent Landuse to Vermillion Linear Park.

Tree Disease

Dutch Elm Disease and Emerald Ash Borer

There are many large elms and green ash trees growing along the Vermillion River in Linear Park. Elms are susceptible to Dutch Elm Disease and Ash are susceptible to Emerald Ash Borer, and have a high likelihood of dying in the near future. When such large trees die, it will have a big affect on the vegetation and the water in the river. They act to shade the water, which is a good thing for fish. When large trees die, they open up the canopy, creating gaps, which in turn releases the understory that was formerly suppressed by the shade from such trees. If desirable species like native forbs, grasses, sedges, and shrubs exist in the understory, then this can be a good thing, since the result will probably be a net increase in bank stability and diversity. In the case of Linear Park, these canopy gaps will likely be filled by buckthorn and Tartarian honeysuckle, which are poised to take advantage of such a

situation. In order to avoid this undesirable scenario, active management is recommended. Removal of undesirable shrub species and replacing them with desirable native shrubs and herbaceous plant species is a recommended management strategy.

Oak Wilt and Bur Oak Blight

There are very few oaks currently growing in Linear Park, so oak wilt or bur oak blight is not a concern. If the area were to be restored to oak savanna, however, this would become a concern. Monitoring for oak wilt and bur oak blight is recommended if oaks are planted in the future.

EXISTING LAND COVER & ECOLOGICAL MANAGEMENT RECOMMENDATIONS

The Department of Natural Resources (DNR) developed a system called the Minnesota Land Cover Classification System (MLCCS), which defines and classifies all types of landcover. This information was used as a basis for the site evaluation, which was conducted by FMR's ecologist in the summer and fall of 2012.

For determining target plant communities for restoration (**Table 3**), we considered the following: 1) historic conditions, 2) existing conditions, and 3) relative effort vs. benefits. Relative effort vs. benefit simply means that if the amount of energy and work that needs to go into restoring a particular community is too great, in terms of the benefits received, then restoration would not be recommended.

Table 3. Restoration Target Plant Communities for Existing Landcover.

MLCCS Unit	Acres	Dominant Soil Types	Target Community
Grassland (Gr-1)	8	*Dickinson* sandy loam, 0-2% slopes (27A), *Hubbard* loamy sand, 1 - 6% slopes (7B).	Southern Dry Prairie (UPs13).
Grassland (Gr-2)	5.5	*Dickinson* sandy loam, 0-2% slopes (27A); *Hubbard* loamy sand, 1 - 6% slopes (7B); *Copaston* loam, 2 - 6% slopes (100B).	Prairie, mixed dry and mesic (possibly some wet also) (UPs13, UPs23, WPs54).
Grassland (Gr-3)	10	*Hubbard* loamy sand, 1 - 6% slopes (7B)	Southern Dry Prairie (UPs13).
Grassland (Gr-4)	11	*Dickinson* sandy loam, 0-2% slopes (27A)	Primarily Dry Prairie (UPs13), with some Mesic Prairie (UPs23), some Wet Prairie (WPs54), and some Bulrush-Spikerush Emergent Marsh (MRn93) around pond.
Deciduous Woodland, Altered (DWA-1)	5.3	*Dickinson* sandy loam, 0-2% slopes (27A); *Zumbro* fine sandy loam (495).	Southern Mesic Savanna (UPs24), and Southern Terrace Forest (FFs59).
Deciduous Woodland, Altered (DWA-2)	6	*Copaston* loam, 2 - 6% slopes (100B).	Southern Dry Prairie (UPs13).
Short grasses w sparse tree cover	6	*Urban Land*, 0 - 1% slopes (857A)	Southern Dry Prairie (UPs13), Southern Mesic Prairie (UPs23).

Lowland Hardwood Forest	2.2	*Dickinson* sandy loam, 0-2% slopes (27A)	Southern Terrace Forest (FFs59).
Grassland w sparse deciduous trees	2.1	*Zumbro* fine sandy loam (495).	Southern Mesic Prairie (UPs23).
Open linear water	4.2	*Water*	River Shore (sand/gravel/cobble) (RVx32), River Shore (rocky) (RVx43).
TOTAL	**60.3**		

As a guideline for the target plant community goals, we used the *Field Guide to the Native Plant Communities of Minnesota: the Eastern Broadleaf Forest Province* (DNR, 2005). This book describes the system developed by the Minnesota Department of Natural Resources for identifying ecological systems and native plant community types in the state, based on multiple ecological features such as major climate zones, origin of glacial deposit, plant composition, and so on.

There are four ecological provinces in Minnesota (prairie parkland, eastern broadleaf forest, Laurentian mixed forest, and tallgrass aspen parkland), ten sections within the provinces, and 26 subsections **(Figure 14)**. The Linear Park property is classified as follows:

Ecological Province: *Eastern Broadleaf Forest*
Section: *Minnesota and Northeast Iowa Morainal*
Subsection: *Oak Savanna*

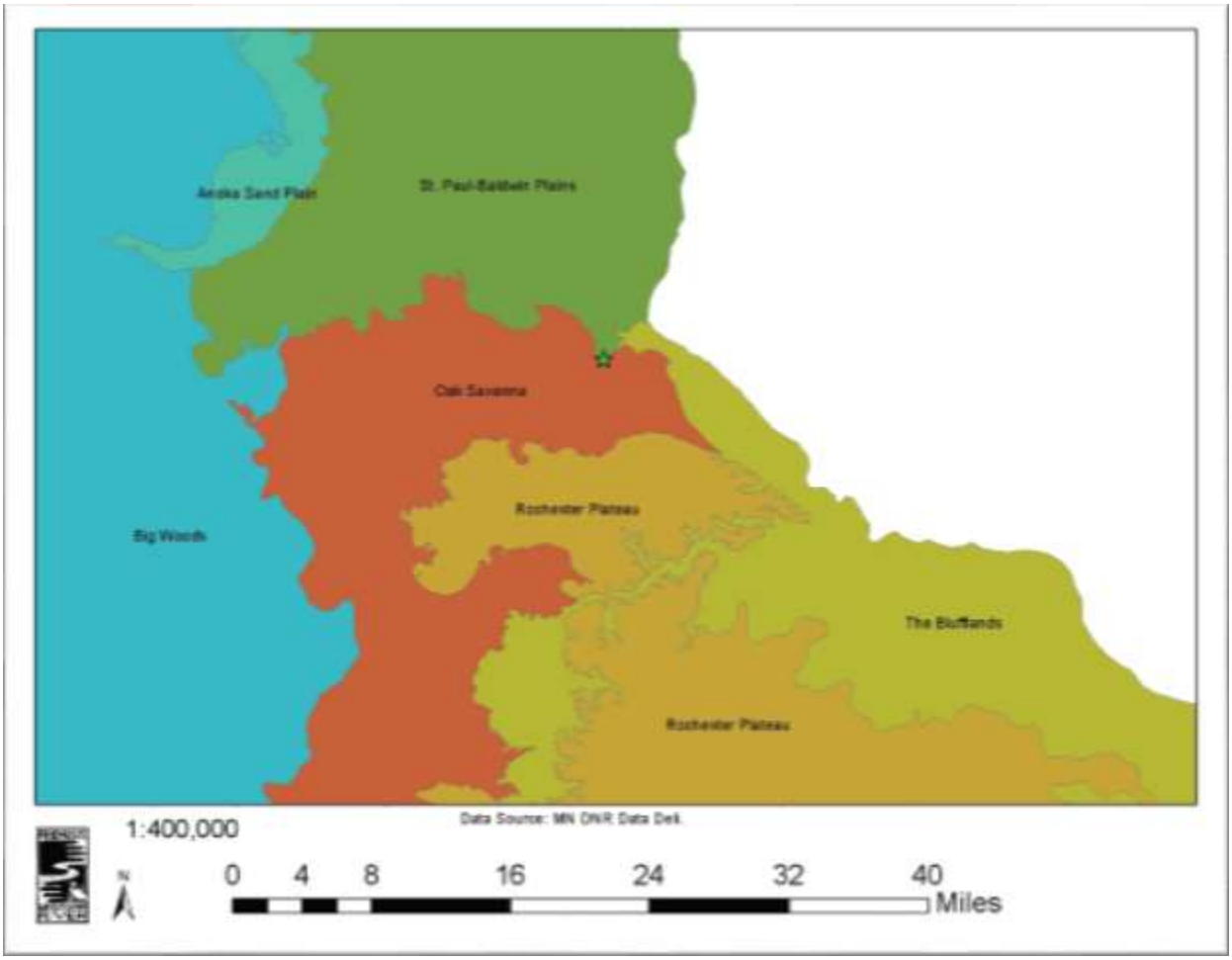


Figure 14. Ecological Subsections in southeastern MN.

As was stated earlier in the Historic Vegetation section, the vegetation of Linear Park, in pre-settlement times, was most likely prairie. This is still appropriate for most of the site, although there has been some succession of communities. Some areas that had formerly been prairie have succeeded to overgrown woodland/savanna. Also, the strip of vegetation that parallels the river channel may have been dominated by trees and shrubs or perhaps was punctuated by groves of trees and shrubs. Thus, today it may be more appropriate to manage some areas as savanna or as floodplain forest. Also, some areas of the Bypass Channel have to be maintained in riprap rock (by order of the Army Corps of Engineers), which makes restoration of native plant communities in these areas untenable. In addition, small amounts of mowed turf would be recommended for the areas near and surrounding the parking lot and the picnic areas between Hwy 47 (Vermillion Road) and the river. For the majority of the site, however, prairie is most appropriate.

Figure 15. Existing Landcover

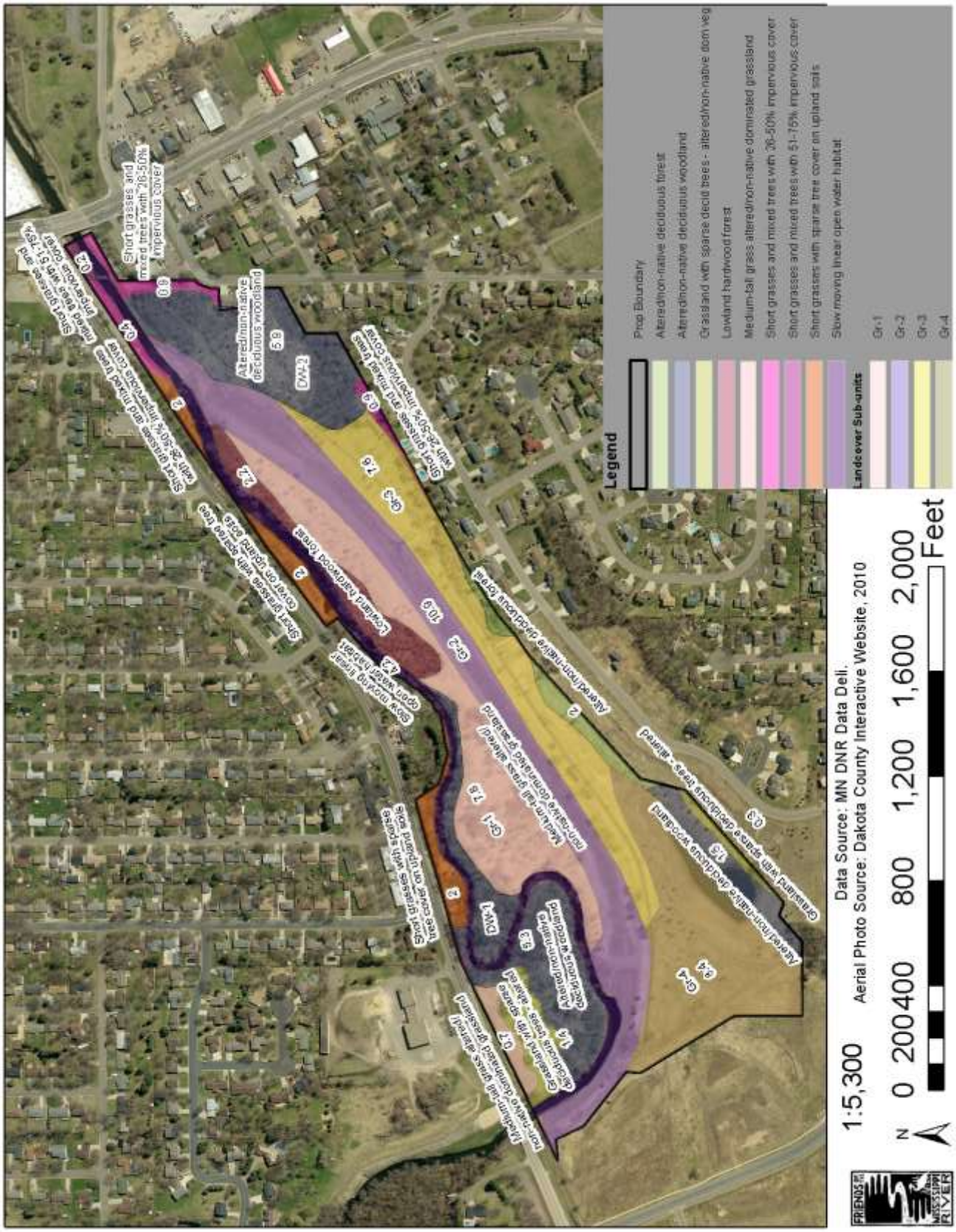


Figure 16. Existing Landcover with Waypoints

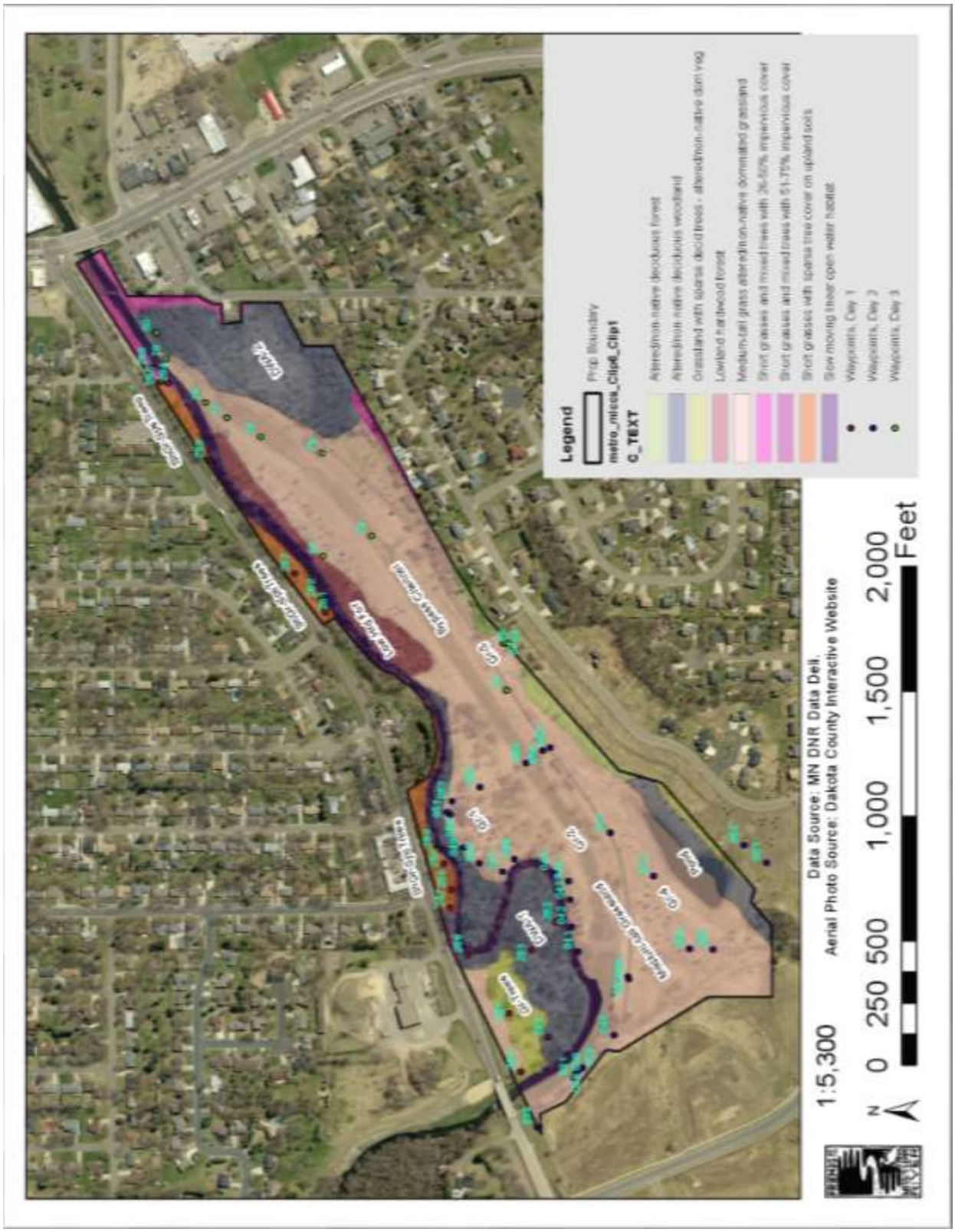


Table 4. List and description of waypoints associated with Figure 16.

Wypt	Comment
1	Starting point. Near Marie Ct.
2	Stormwater inlet structure--hyb catts. Lots of rip-rap. Bank eroding--blowout--in one spot--photo.
3	Whorled milkweed. Photo.
4	Lots of shrubs and seedlings. photo
5	Paved trail and bench.
6	Paved trail
28	Paved trail
29	100 yds straight west: young red tail hawk in cott tree. Very lg bird. Crying almost constantly.
30	Cow vetch by trail.
31	Paved trail
39	Paved trail
40	Trailed crossed by a mowed "road". Access for city vehicles?
41	Cleared zone to river. Cott stumps, rip-rap. Brush cut veg. 5'-tall ragweed-like plant. Lots of motherwort.
42	Chip pile.
43	Another access--bare soil area to river. Tire tracks.
44	Patch of bouncing bet
45	Hack on bank: 14" dia. Lots of grp vine.
46	HS & burdock on bank. "Bend" of river area: open, flat: sm brome, small box, cherry, elm.
47	Small patch of natives: ground cherry, cup plant, yarrow; pocket gophers--encroached upon on all sides.
48	More heavily wooded here. GM too
49	Thick patch of tall prickly ash. Virgins bower too! (Com. toadflax too). Leafy bracts, alt, tall (7')--(looks like Culvers root, sort of).
50	Sm brome "road"--looks like they are still occassionally driving on it.
51	Red-berried elder patch.
52	Can thistle patch. Lots of bees, wasps, beetles. (scattered Berteroa, too)
53	Old pasture field. Dom by sm brome; also present Linarea, cow vetch, bull thistle, com milkweed, curly dock, scattered box (3-10")
54	Mid-"spill-way". Huge length of mowed area! RCG, sm brome, sp. knap, nettle.
55	A patch of cup plant, too! (Jap beetles on flowers)
56	Paved trail (by cup plants)
71	Paved trail by bench.
72	White spruce, between pond and paved trail.
73	Small sink hole.
74	Sunflower patch.
75	Culvert and rocked runoff channel, 20' long
76	Exposed bedrock in swale.
77	Rip rap starts here -- more weeds: RCG, Can thistle, dominant
78	Pocket gopher mounds; lots violets
79	Scour in overflow channel; alyssum, pickerel weed (?), RCG, sting nettle
80	Jewel weed in amongst rip rap
81	33-50 was edge if mow line. 52 is cup plant: many flowers, nipped off by deer-by bank
82	Patch of natives--other side of trail: flower spurge, bush clover, pr rose, ? grass
251	Clearing in floodplain. Someone is mowing the burdock. Lots of burdock here.
252	At river bank.
253	West end. Boxelders dominant here. 1 cott. A few ash and willow.
254	3 river birch--they have no wind damage!
255	Middle of open, mowed field: sm brome, scattered box & cott; gopher mounds! History of this area? Restore to mesic prairie.
256	River bend
257	Big cott near pk lot. Erosion on cut bank here.
258	By pk lot--swirl pool at bank--eroding--steep.
259	Concrete "box". Culvert?
260	Alluvial terrace--or "rill-bank". Could control exotic grasses & burdock. Replant w natives and would be nice.
261	Concrete "gate".
262	Disturbed. Can thistle, bindweed
263	Shrubs planted by Dakota SWCD. Nice diversity of natives.
264	Floodplain near where channel narrows before going under bridge. Very fast current! Dom by non-native grasses--reconnect w broader floodplain
265	Cheat grass in rip-rap.
266	Cup plant & water smartweed by concrete "gate" (gi. ragwd, RCG, cur dock too)
267	Flooded this year! All floodplain--but currently mowed--restore to native veg.

The following are descriptions of the various cover types, found on the property. The cover types were described and designated by Minnesota Land Cover Classification System (MLCCS). Some of the cover types were re-designated to a more appropriate type than was designated by MLCCS. They were then arranged in order of size of area, with the largest cover types listed first and the smallest listed last. Cover types may be represented by multiple units of the same cover type (e.g. Grassland represented by Gr-1, Gr-2, and Gr-3). Also, if one unit was very small, it was lumped with a larger one. Please refer to **Figures 15 and 16** (Landcover) and **Figure 17** (Target Plant Communities) throughout this section.

Grassland, Medium Tall, Altered (34.5 ac)

This landcover unit is divided into four sub-units, Gr-1, Gr-2, Gr-3, and Gr4 (**Figure 15**). These sub-units are approximate, and aid the discussion, and are roughly delineated on the map.

Gr-1 (approximately 8 ac)

Gr-1 subunit was the northernmost grassland subunit, located adjacent to the wooded areas south of the river, between that and the mowed swale of the Bypass Channel. It was a long, linear sub-unit, traversing most of the length of the property. This sub-unit although it is a "natural area" and does not appear that it has ever been plowed, has nonetheless undergone a great deal of disturbance. The two western bends in the river had the following issues:

- The first bend at the western end, had evidence of a trail access that was mowed where heavy equipment had traversed (waypoint 40).
- There was a cleared zone to the river with cut stumps and riprap (waypoint 41). There was a chip pile right on the river (waypoint 42).

Photo 10. Chip pile on top of riverbank at southwest part of park. Note the proliferation of exotic forbs indicating disturbance.

- There was an access area with bare soil and tire tracks right by the river (waypoint 43).

- Numerous invasive plant species here, including a large patch of a very tall, ragweed-like plant, and abundant Tartarian honeysuckle, common buckthorn, and burdock.
- A large area where grape vine was completely covering all of the other vegetation—a sign of a disturbed tree canopy.
- The second bend at the western end was more wooded (riparian forest) on the south side of the river. Much of the woody vegetation consisted of Tartarian honeysuckle and common buckthorn. On the southern edge of the riparian forest was a mix of native and non-native species. Non-native species included garlic mustard, Canada thistle, and smooth brome.

The upland side of this sub-unit was a former pasture, as evidenced by the dominance of smooth brome grass (**Photo 11**). Scattered throughout this area were many small to medium-sized (3" to 10" diameter) boxelder trees that had invaded within the last 20 to 30 years. Also present here were non-native invasive species such as bull thistle (non-native), and curly dock as well as desirable, though moderately invasive species such as common milkweed,.

Photo 11. View of Gr-1. Note the Scattered trees and matrix of grassland dominated by smooth brome. The tall forbs are common milkweed.

The entire western end of this sub-unit was not disturbed, however. A small spot on the edge of the unit, between bends in the river on the west side of the property (waypoint 47) had a small remnant of native plants, including ground cherry, cup plant, yarrow, and with many pocket gopher mounds (**Photo 12**). Unfortunately, this little remnant was being encroached on all sides by disturbed areas with many invasive, exotic plants. This little remnant should be preserved and expanded into the rest of the surrounding area, if possible.

Photo 12. Small remnant of native vegetation in Gr-1. Cup plant is the taller forb in the middle. Smaller forbs also include ground cherry, yarrow, and whorled milkweed. Exotic, invasive weeds were invading: curly dock is the reddish forb on the right.

The northeast end of Gr-1 was mowed right up to the water's edge (**Photo 13**). At the turn of the first bend, riprap had been installed not only on the banks,

but also right up to the river in some spots.

The northeast side of Gr-1 was similar in topography to Gr-2, but it was narrower, being bordered by the mowed swale to the south and the riparian forest to the north. There were also signs of disturbance, but it was difficult to tell whether this part had ever been plowed. Non-native grasses dominated this area, primarily smooth brome and quack grass. There were also many non-native forbs. A couple patches of natives occurred, in spite of the disturbance, which included species such as cup plant and native sunflowers.

Photo 13. West end of property, west of river bend. Note the mowed vegetation near the river and the riprapped bank.

Pocket gopher mounds were found in abundance at a spot in the northeast end of Gr1 (waypoint 78), very near where the riprap started on the side slopes of the swale. This is a good sign, since pocket gophers prefer loose, native soils to compacted, altered soils. They also are a "keystone" species, meaning that they influence and effect many other species that depend on their activities (bull snakes inhabit burrows, annual plants germinate in soil mounds, tunnels aerate the soil, etc.).

Gr-2 (approximately 5.5 ac)

Photo 14. Bypass Channel looking eastward. River is on the left, with Lowland Hardwood Forest unit (trees on left). Note the broad, shallow swale dominated by short grasses with some forbs. Con Agra tower can be seen in the background.

Gr-2 subunit was the mowed swale of the Bypass Channel (**Photo 14**). This includes the sides of the swale and the bottom of the swale. It was also a long, linear area that traverses most of the property. Both the sides and the bottom of the swale were dominated by grasses. Both native and non-native grasses were present, mixed together. Purple love grass (native) was abundant, and porcupine grass (native) was rare. Also present were the non-native grasses green foxtail, Kentucky bluegrass, quack grass (in abundance). Forbs were both scattered and found in large patches. The native forb whorled milkweed (*Asclepias verticillata)* formed large patches. Other natives found in scattered patches were cup plant, stiff goldenrod, heath aster, yarrow, purple prairie

clover, common ragweed, hoary vervain, ground cherry, a sunflower species, and a cinquefoil species. Non-native forbs were abundant, including spotted knapweed (abundant), sweet clover, sow thistle, cow vetch, common St. John's wort, bird's-foot trefoil, and field bindweed. Also present was a species of *Lycopodium* and also wild grape vine.

The westernmost end of Gr-2 consisted of a very heavily rip-rapped east-facing slope (**Photos 13 and 15**) and the western end of the paved trail. To the east of this, the Bypass Channel opened up into a long (4,300 feet), broad (100-150 feet), shallow swale (6-8 feet deep) covered by non-native grassland dominated vegetation (**Photo 14**).

Photo 15. Extensive field of riprap on swale side-slopes at western end of park.

Rip rap

Not only the western end, but also the north-easternmost end of this sub-unit was altered by the addition of riprap on the sides of the swale, presumably to armor the slopes from erosion (**Photo 2**). The riprap started at waypoint 77 and continued to the bridge at Highway 61 (**Photo 16**). The MLCCS cover types were listed as *Short grasses and mixed trees with 26-75% impervious cover*, but will be included in this discussion. The north side was more infested with herbaceous weeds than the other part of the unit. Weeds were dominated by reed canary grass, but also present were patches of Canada thistle, hoary alyssum, and stinging nettle. The south side had a dense growth of jewelweed, a native wetland forb.

Photo 16. View looking east towards Hwy 61 bridge. Note the riprap on both sides of the channel. Vegetation is a mix of native and non-native (cup plant in middle foreground and reed canary grass in background).

The northeastern end also had episodes of exposed limestone bedrock (Prairie du Chien formation), located in the bottom of the swale. The bedrock would not have been exposed had not this swale (Bypass Channel) been excavated. Consider that there is no protection to the aquifer here.

The bottom of the swale/Bypass Channel was scoured in the farthest northeastern stretch. The scour was caused from high flows during flooding events. These

scour/erosion spots were sort of gouged out of the substrate, and had exposed, bare soil. Surrounding these scour areas, the plant community consisted of reed canary grass, hoary alyssum, pickerelweed (a native emergent plant), and stinging nettle.

The Bypass Channel was also used by snowmobilers, since numerous snowmobile tracks were seen in a December field visit by the FMR Ecologist. Such a large open tract of land is probably irresistible them.

Animals

Animals observed in Gr-2 were the following: white tail deer, monarch butterflies, cat birds, goldfinches, grass hoppers, toads, damselflies, crows, house wrens, rusty skipper butterfly, red dragonflies.

Photo 17. View of Gr-3 showing the grassland in the foreground, a grove of medium sized trees in the background and the paved trail on the right.

Gr-3 (approximately 11 ac)

Gr-3 was that part of the grassland cover type that borders the swale of the Bypass Channel to the south, and is along the southern edge of the property (**Photo 17**). Again, this was a long, linear sub-unit that traverses the entire length of the southern part of the property. This portion of the unit located on the south side of the paved trail appeared to have escaped much of the disturbance caused by construction of the Bypass Channel. Included in this discussion are two small, narrow MLCCS cover type units at the south boundary: "Altered/non-native deciduous trees" and "Short grasses and mixed trees with 26-50% impervious cover".

Scattered small remnants of the native dry prairie were found, but the dominant vegetation of the unit was non-native. Native species contained within the prairie remnants included flowering spurge, round headed bush clover, hoary vervain, prairie rose, porcupine grass, sand dropseed, false boneset, prairie sage, a Cyperus-sedge species, and a prairie sunflower species. Lots of spotted knapweed was invading these remnants. A small sink hole was found in the middle part

Photo 18. View of vegetation around pond. Dry, non-native grassland in the background, and some native emergents in the foreground: bulrush, sandbar willow, and cottonwood seedlings.

of Gr-3 (waypoint 73). A paved trail, which has recently been built, winds its way through this sub-unit. Also, a culvert and rocked runoff channel are located at the northeast end of this sub-unit (waypoint 75).

Gr-4 (approximately 11 ac)

Gr-4 was the grassland subunit surrounding the stormwater holding pond, located in the southwest corner of the property. This subunit was roughly triangular in shape, unlike the other three grassland subunits. The northern edge of this subunit is bounded by the paved trail. The eastern half of this subunit contained, and was altered by, the stormwater pond and thus was much more disturbed than the western half of the subunit. The topography was shaped like a bowl around the pond. The area around the pond was dominated by non-native vegetation, with the grasses smooth brome, Kentucky bluegrass being dominant, and with other forb species present such as bird's foot trefoil, spotted knapweed, red clover, sweet clover, Siberian elm seedlings, common mullein, etc. There were only a few native species including switch grass, hoary vervain, evening primrose, and giant ragweed.

The area directly surrounding the pond was dominated primarily by very young cottonwood seedlings. There was a patch of sandbar willow on the south side of the pond. There were a few patches of softstem bulrush, pathrush, and river bulrush on the margin of the pond—undoubtedly the remnants of a native planting that had been done around the pond. There was evidence of much sediment entering the pond. At one of the inlet channels, there was a "blowout", with much active erosion and the bank of the pond gouged out (**Photo 9**). At the inlet channel was also a patch of hybrid cattail.

The same non-native dominated grassland community occupied the western half of Gr-4, except that a few more native species were present, and native abundance was a bit higher than the eastern half that surrounds the pond. For example, whorled milkweed (**Photo 19**) and a few native shrub species were present here. Also found here were soapwort, an exotic forb species that is invasive in dry prairies, and abundant Canada goldenrod. There was also still an abundance of spotted knapweed and Siberian elm seedlings. Scattered throughout both halves of Gr-4 were small trees, primarily planted white spruce trees, but also a few redcedar—a native species, and small Siberian elm trees—an exotic species.

Photo 19. Close up of whorled milkweed, *Asclepias verticillata* from Gr-4.

In terms of animals, many dragonflies (several different species) were observed around the pond. Birds observed were: clay-colored sparrow, red-tailed hawk (fledgling and parents), red-winged black bird, and goldfinch.

Deciduous Woodland, Altered (11.2 ac)

This unit was divided into two sub-units, DWA-1, and DWA-2.

DWA-1 (5.3 ac)

This woodland sub-unit was located at the far western end of the property, on the north side of the first bend of the river (Zumbro soil unit) and the south side of the second bend of the river (Dickinson soil unit), and then it follows the river in a narrow band to approximately the middle of the property, opposite the private residence on 709 Co. Rd. 47, at which point Lowland Hardwood Forest takes over (**Figure 15**).

Riparian Forest

Basically, a narrow strip of floodplain or "riparian" forest (**Photo 20**) hugged the entire length of the river channel, all the way until the very northeastern end of the property, at which point the trees gave way to open, rip-rapped banks, before the river flowed under the bridge for Hwy 61. The trees of this riparian forest were typical floodplain species consisting of silver maple, boxelder, American elm, green ash, cottonwood, black willow, hackberry, and walnut. These trees were primarily medium to large in size (8" to 36" diameter), with not much regeneration of younger trees. Some snags were scattered throughout the riparian forest strip. The understory of this riparian forest was not diverse, and there were many exotics. The shrub layer was fairly dense, and dominated by non-native species (buckthorn and Tartarian honeysuckle). The ground layer was sparse to absent, in many spots, with large areas of riverbank slope exposed to bare soil (**Photo 21**). There were

Photo 20. View of Riparian Forest at Linear Park in June, 2012. Canopy coverage is mixed: sometimes it completely covers the channel and sometimes it does not. In this photo a mix of sun and shade fall on the water.

Photo 20. Note the banks of the river that are canopied with trees, but much bare soil is exposed on the right bank. Water was high at the time of this photo, in June, 2012—note how "muddy" it is.

numerous, large grape vines throughout the riparian forest, that had grown up into the canopy.

Photo 21. View of river bend at western part of property. Note the very steep slopes along the entire bank. Also not the meager amount of vegetation covering the banks—much is actually bare soil. This is the "cutbank" side of the bend.

Disturbance was evident in the Riparian Forest. Numerous trails had been worn into the slopes, presumably as access to the river. Several areas on the banks showed signs of active erosion, with scoured lower and mid-banks, very steep slope angles, and bare, exposed soil. This was particularly evident in banks opposite stormwater sewer inlet pipes (**Photo 7**). Cut banks were much more degraded, in general, than fill banks. At the westernmost (first) bend of the river, there were two areas of very serious erosion on the cut banks of the bends (**Photos 1 and 21**). For recommendations to stabilize these banks see the section on Management Recommendations, below.

Photo 22. Damage to trees in Linear Park. This large boxelder lost several large limbs.

Photo 23. Beginnings of a brush pile, in cleared areas of the Riparian Forest and Deciduous Woodland, which was stacked by city crews after a storm.

At the time of this survey, many larger trees had sustained significant damage due to a recent straight-line wind storm event (**Photo 22**). Several trees were blown over, having been uprooted. Many large limbs were down. This makes sense, since most of the tree species are fast growing, weak wooded-type trees like boxelder and silver maple. City crews were using parts of this unit as a work area for stacking hauled down tree material (**Photo 23**). Many of the trees in this unit sustained damage. It would make sense to continue the removal of damaged trees, and either replant with new ones or convert to prairie/savanna vegetation, while large

equipment is being utilized. Limbs can be saved and used to help stabilize slopes of riverbanks (installed as root wads or to armor banks—see **Appendix E**).

Other Woodland Areas in DWA-1

Not counting the Riparian Forest, this sub-unit consists of an overgrown savanna/prairie, called "woodland" by the MLCCS, which the riparian forest has gradually encroached upon over the last 75 to 100 years. This area was located between the western bends of the river (**Figure 15**), and underlain by Zumbro soils (mixed mesic, entic) (**Figure 4**).

Photo 24. View of DWA-1. Not large cottonwood in middle ground.

This sub-unit can be described as a mix of open and closed canopy, with scattered, tall trees (cottonwood, boxelder, silver maple) that punctuated a matrix of herbaceous ground cover (**Photo 24**). There were scattered shrubs too. Snags (dead standing tall stumps) were present also. The ground layer was dominated by forbs, primarily non-native ones. There were extensive areas that had been cleared of trees (**Photo 25**). In these cleared areas, burdock was dominant. Wood nettle was abundant in patches. Areas that had been cleared showed evidence of use by heavy equipment. These areas were being used as temporary storage for storm-damaged trees that had been removed from nearby (**Photo 23**). Where the soil was not compacted, in its unaltered state, it was quite loose, underscoring its recent deposition. Much of the soil, however, was compacted from heavy equipment.

Photo 25. DWA-1. Note the flat topography and the cleared zone in the foreground. Vegetation had been brush cut or mowed.

The grassland unit probably has the greatest potential for bird habitat of any area in the park. It was fairly wide and it borders the river . Breeding bird surveys are recommended for this area so as to monitor conditions before and after restoration.

A second area designated as Deciduous Woodland by MLCCS was located just across the bend in the river, and underlain by Dickinson soils (coarse loamy). This "woodland" was actually more like a floodplain/riparian forest than a woodland. It

was designated as a PFO1A wetland by the National Wetland Inventory. A PF01A wetland is a palustrine (inland), forested, broad-leaved deciduous, temporary flooded wetland. Temporary flooded is defined as having surface water present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the growing season; plants that grow both in uplands and wetlands may be characteristic of this water regime (NWI Wetlands Code Interpreter website).

DWA-2 (5.9 ac)

This woodland sub-unit was located at the eastern end of the property, south of the Bypass Channel (**Figure 15**). This sub-unit was underlain by Copaston and Hubbard soil units (**Figure 4**). This woodland sub-unit is in the early to middle stages of succession, being composed of very recent woody invaders—trees range in diameter from 3 to 12", with the average of 8". The trees are very tightly assembled, with a spacing from 1 to 8 feet. The great majority are Siberian elms (*Ulmus pumila)*—an invasive exotic species—about 70% of all trees. Most of these Siberian elms were quite tall, being about 45' tall. The next most populous tree species was cottonwood (10%), which had several 45' tall specimens also. The remaining tree species, which rounded out the total, were redcedar, green ash, boxelder, black cherry, black walnut, Amur maple, and pin oak. The understory was dominated by buckthorn and honeysuckle, with an interrupted ground layer of Virginia stick seed (aggressive native), common yarrow (native of disturbed areas), motherwort (exotic weed), smooth brome, Canada goldenrod (aggressive native), and a few asters (desirable native).

Photo 26. View of DWA-2 looking east. Note the abrupt boundary of the woodland.

Photo 27. East end of DWA-2. Note the open space in the foreground. Also note the abundant shrubs and scattered trees in the background.

The woodland had a rather abrupt boundary with the grassland unit on the west side of the unit (**Photo 26**). On the east and south side it borders a residential street. The north side is bounded by the trail. The east half of the unit (**Photo 27**) is more open than the west half, which has a fairly closed canopy (**Photo 28**).

The eastern part of Gr-3 has numerous small patches of trees; many of similar composition to DWA-2, but some have river birch. The river birches were probably planted. Other planted trees were some young white pines and white spruce, planted in loose groves. Otherwise, the rest of the trees most likely volunteers.

Photo 28. DWA-2 showing the fairly closed canopy. Note the upright stature of the trees, indicating that they grew up crowded and competing for light.

Photo 29. Little boxelder woodland in December, 2012. Note the prolific growth of exotic shrubs and the young age of the

On the farthest eastern end, across the north side of the trail (near the Appleby's), a little woodland occurred that was distinct from the larger Siberian elm woodland that was adjacent to the south of the trail (**Photo 28**). This little woodland was comprised primarily of boxelder, with an understory of Tartarian honeysuckle and buckthorn. Although it is still not a desirable type of woodland, it was not dominated by Siberian elm, which is an exotic.

Lowland Hardwood Forest (2.2 ac)

This unit is really an extension of the Floodplain/riparian forest that was described in the Deciduous Woodland-Altered (DWA-1) cover unit section, above. The only difference is that the "lowland hardwood forest" is a little bit wider than the rest of the Riparian Forest. Vegetation layers were the same as in the Riparian forest, and so are species composition, structure, and age class distribution (**Photo 30**). Shrub and ground layers were primarily the same, also.

Photo 30. The "lowland hardwood forest" is on the left and the "riparian forest" is on the right. Note the similarity of the two.

Regarding age, some of the cottonwoods were quite large, but they grow fast. Most of the trees were actually not terribly old, indicating that perhaps

they have not occupied this space for too long—relatively recent invaders of a former "prairie river".

Grassland with Sparse Deciduous Trees, Altered (2.1 ac)

This unit was located just north of the DWA-1 unit, on Zumbro soil. It was combined with the MLCCS unit to the north, called "Medium tall grass altered", since it was really all the same landcover type. This unit was primarily open, with scattered large boxelders and cottonwoods (**Photo 31**). This unit has been disturbed, probably formerly pastured or hayed, since smooth brome was dominant here. Many pocket gopher mounds abounded in this unit, which was a good sign. This field was currently being mowed, but could potentially be restored to mesic prairie or mesic oak savanna. On the west end of the unit were three large river birches. Notably, they sustained little damage from a storm that produced lots of damage to other tree species on the site (especially boxelders and silver maples).

Photo 31. Grassland with Sparse Deciduous Trees, Altered. Note the large expanse of mowed turf. Trees in the background are medium-aged boxelders and cottonwoods.

Short Grasses with Sparse Tree Cover on Upland Soils (6 ac)

This cover type unit was located on three small strips of land on the north side of the river, bordering the river channel. It was being utilized as parkland, with mowed turf and scattered shade trees. There were three picnic table groupings in the unit, one at either end of the park, and one in the middle (**Photo 32**). The picnic table at the southwest end of the park also had a small parking lot adjacent to it. The parking lot was not sloped towards the river, which is good, since stormwater will not runoff directly into the river.

Photo 32. View of the middle of the unit. Note the large area of mowed turf, and the very scant trace of non-mowed buffer along the stream. Picnic table is in background, behind tree.

The soils in this unit were very soft and spongy, with numerous tunnels throughout. At the time of the survey in the summer of 2012, the river had just overflowed its banks, since a large storm had just occurred the previous weekend.

At the time of the June field survey, many areas of mowed turf were wet and stained brown with floodwater sediments (**Photo 33**). In June 2012, a large silver maple tree, towards the middle of the unit, was blown down. Restoring most of this unit to

Photo 33. Flooding onto the mowed turf buffer. The area of flooding actually extended farther upland: note the brown stains on the grass from river sediment.

Photo 34. Large silky dogwood shrub that was planted on the river buffer on the north side of the river. The profusion of blossoms and fruit attracts a variety of birds.

a riparian buffer would be an improvement for the ecosystem and would alleviate a great amount of maintenance that the City of Hastings has to perform each year. Access to the river would still be an issue, though, since park visitors will undoubtedly always try to get down to the water. Official access points could be constructed to control foot traffic, which would limit wear and tear on the land. In a spot just northeast of the private property, on the north side of the river, there

Photo 35. View of reed canary grass buffer as stream approaches Hwy 61 bridge.

Photo 36. Cup plant in bloom. This is actually in Gr-3, but the image shows the species.

was much disturbance (waypoint 261-262). This was near a concrete gate connected to the stormwater sewer system. There were unstable soils and abundant herbaceous weeds, including Canada thistle and field bindweed. Nearby this are was a section of riverbank that was planted to native shrubs and native sedges by the Dakota County SWCD, which was working well to stabilize the bank (**Cover photo** and **photo 34**). The shrub

zone also had the most bird activity of any area in this unit. Continuing this practice is recommended for more of this unit.

Near the northeastern end of the property, the floodplain narrowed before going under Highway 61 Bridge (**Photo 35**). This area was riprapped and open, dominated by non-native grasses, primarily reed canary grass, but also with large patches of cheat grass growing amongst the riprap. There were scattered patches of cup plant, (a tall, desirable native wetland forb species that produces copious amounts of attractive yellow flowers—**Photo 36**) also. Other species found here were water smartweed (native), giant ragweed (aggressive native), curly dock (exotic), and Siberian garlic (exotic).

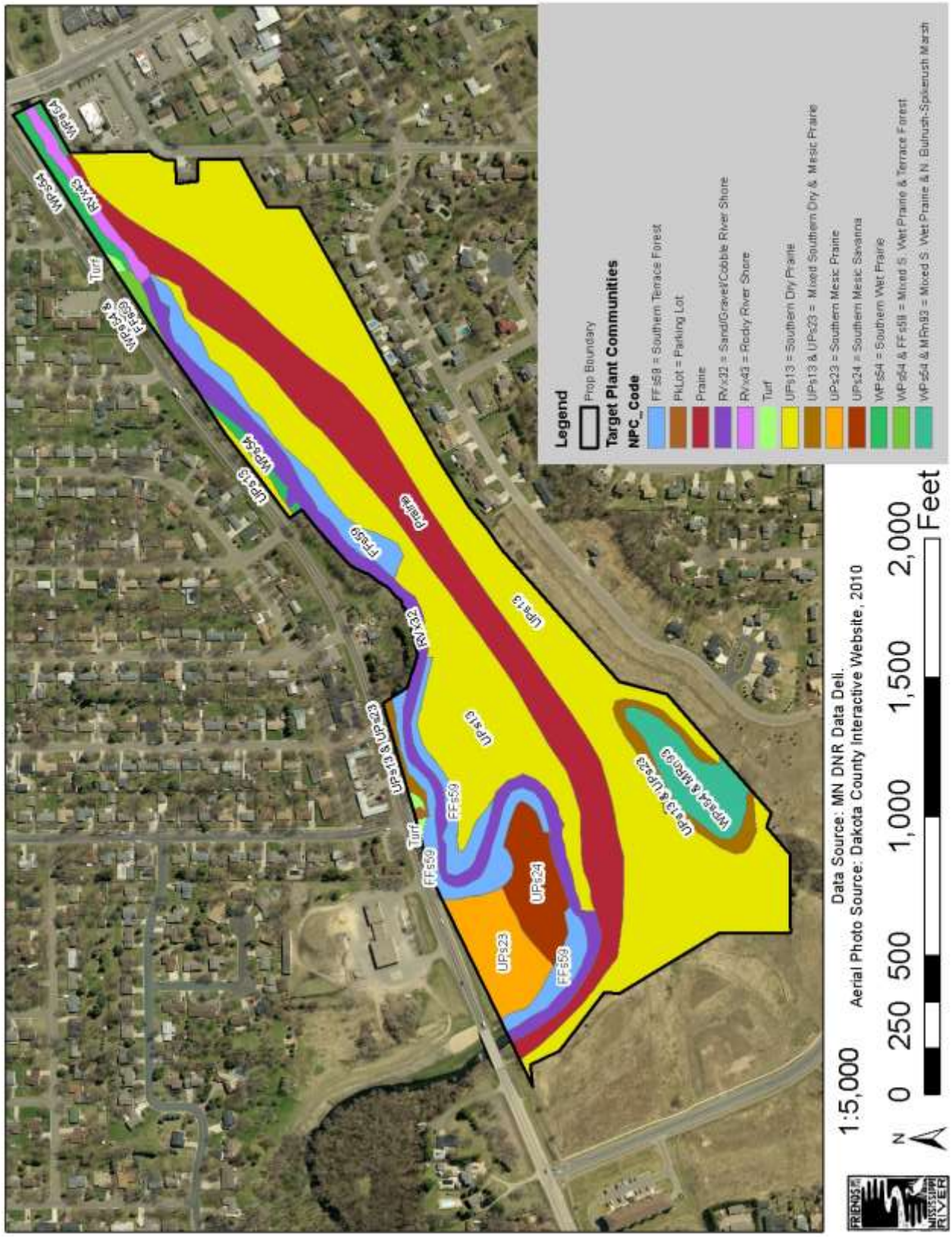
Water, Open, Slow-Moving (4.2 ac)

This cover unit designates the river channel proper. Normally a slow-moving, rather shallow stream, however when filled in the spring after a large rain event, it can be very fast-moving. At the time of the survey in mid-June, the current was very swift, especially at the northeast end of the park where the channel constricts to get under the bridge for Highway 61 (**Photos 2** for fast stream and **Photo 37** for slow stream).

Photo 37. Stream flow is slower in wider channel. Compare with Photo 2, for a fast moving flow in a narrow channel. Both photos were taken on the same date, June 21, 2012.

According to local accounts, the river floods at the northeast end by the bridge nearly every year in the spring (Blomstrand, personal communication, 2012). The rest of the reach probably does not flood that often, although when it does, it may be quite catastrophic. The Bypass Channel was built to accommodate overflow to the system, so as to avoid flooding on developed land.

Figure 17. Target Plant Communities at Linear Park



NPC Code Key

FFs59 = Southern Terrace Forest

Wet mesic deciduous forest on silty or sandy alluvium on level, occasionally flooded sites along small streams to large rivers in the southern half of Minnesota.

PkLot = Parking Lot

Maintained by the City of Hastings

Pr = Prairie = Mixed Southern Wet, Mesic, Dry Prairie

Mix of all three of these types of prairie. This Community occupies the Bypass Channel. Dry prairie would prevail on the side slopes of the swale, whereas mesic to wet prairie would likely prevail at the bottom of the swale.

RVx32 = Sand/Gravel/Cobble River Shore

Sparsely to densely vegetated plant community on sand, gravel, or small cobbles on river shores. Characterized by annual herbaceous species, firmly rooted perennial species tolerant of inundation, and species dispersed by tubers and other floating propagules. Scoured annually during spring breakup and flooding by ice and currents, and following heavy rains.

RVx43 = Rocky River Shore

Sparsely vegetated plant community on bedrock or boulder substrates along river shores. Scoured annually during spring breakup by ice and strong currents and during other periods of flooding.

Turf = Mowed Turfgrass

Maintained by the City of Hastings around structures, parking lots, and picnic tables.

UPs13 = Southern Dry Prairie

Grass-dominated herbaceous community of level to steeply sloping sites with droughty soils. Moderate growing-season moisture deficits occur most years, and severe moisture deficits are frequent, especially during periodic regional droughts. Historically, fires probably occurred every few years.

UPs23 = Southern Mesic Prairie

Grass-dominated but forb-rich herbaceous community on somewhat poorly drained to well-drained loam soils mainly formed in unsorted glacial till, sometimes in a thin loess layer over till, and locally in lacustrine sediments and outwash deposits. Communities in this class occur primarily on level to gently rolling sites. Drought stress is irregular in occurrence and usually not severe.

UPs24 = Southern Mesic Savanna

Sparsely treed community with tallgrass-dominated ground layers on somewhat poorly drained to well-drained loam soils mainly formed in unsorted glacial till, sometimes in a thin loess layer over till, and locally in lacustrine sediments and outwash deposits. Present primarily on level to gently rolling sites. Drought stress is irregular in occurrence and usually not severe.

UPs13 & UPs23 = Mixed Southern Dry and Mesic Prairie

Mix of dry and mesic prairie types. In areas either near fluctuating water levels or of uncertain soil moisture conditions due to unpredictable hydrologic conditions.

WPs54 = Southern Wet Prairie

This is a grass dominated but forb-rich herbaceous community on poorly drained loam soils, typically in slight depressions. Flooded for brief periods at most; upper part of rooting zone is not saturated for most of the growing season, but saturation usually persists in the lower zone for much of the season.

WPs54 & FFs59 = Mixed Southern Wet Prairie and Terrace Forest

Mix of Wet Prairie and Terrace Forest, depending on the amount of flooding, fire frequency and weather conditions.

WPs54 & MRn93 = Mixed Southern Wet Prairie and Northern Bulrush-Spikerush Marsh

Mix of Wet Prairie and Northern Bulrush-Spikerush Marsh, which is an emergent marsh community, typically dominated by bulrushes or spikerushes, present along lakeshores and stream borders. The emergent marsh would be at the lower elevations of the pond margin, and the wet prairie would be at slightly higher elevations surrounding the pond. Due to water level fluctuations ("bounce") and weather conditions, these two communities can mix together.

RESTORATION PROCESS

Undertaking a restoration project of this size is a significant task and assistance is available to help landowners with the process. Friends of the Mississippi River and Dakota County will continue to work closely with the landowners, if desired, by helping to secure funding and providing project management and oversight. Professional firms that can conduct management tasks are listed in **Appendix D**.

Management recommendations were developed for each land cover area, with the overall goals for the easement area focused on 1) stabilizing degraded riverbank slopes, 2) restoring the riparian buffer, 3) restoring native prairie and savanna, and 3) providing wildlife habitat. Overall management practices to achieve those goals are:

- remove non-native, invasive, woody species;
- control non-native invasive herbaceous species, including, reed canary grass, hybrid cattail, Canada thistle, common burdock, and smooth brome grass;
- reshape riverbank slopes, where necessary;
- restore ground layer and shrub layer on steep riparian slopes;
- remove middle and eastern picnic tables and concrete slabs and convert to appropriate native riparian communities;
- restore native prairie throughout undisturbed upland grassland areas of site by planting and seeding appropriate native species;
- reconstruct native prairie in Bypass Channel
- conduct periodic prescribed burning to maintain prairie, savanna, and woodland vegetation and reduce invasive shrubs and overabundant tree seedlings;

- monitor annually for potential erosion and sedimentation, as well as for non-native invasive woody species;
- institute a monitoring plan to track effectiveness of management and restoration activities.

Restoration Goals

The primary objective for this site is to improve the composition of the plant communities throughout the property to better reflect the diversity, composition and structure that would have been present at the time of European settlement and to improve the ecological functions that the historic native plant communities would have provided, including:

- habitat for a diversity of wildlife species,
- nutrient and water cycling,
- carbon storage,
- moderation of water-table levels,
- erosion control,
- filtration of nutrients, sediments and pollutants,
- development and enrichment of soils,
- local temperature moderation.

Though degraded by past uses, the existing plant cover retains a good variety of native species and could be readily improved. A healthy and diverse plant community can provide much greater wildlife value than a degraded one, and tends to be much more stable, and less susceptible to disease, invasive species, and other concerns.

Consider that many once stable rivers are now deeply incised with eroded banks, the result of agricultural development, urbanization, and the many stream channel alterations carried out for navigation and flood control purposes (Brooks et. al, 2003), as is the case with this reach of the Vermillion River. The net effect that human development has had can be viewed in terms of *lost storage* and *increased conveyance*. Storage was lost through a combination of destruction of natural features like beaver dams and drainage of wetlands. Channelization (straightening, widening, and/or deepening of a channel) and levee construction removed floodplain storage and increased conveyance of stream channels, which flow at greater velocities. The frequency and severity of flooding and flood damages have increased (Hey and Wickencamp, 1998). Restoration of floodplain and wetland storage should become important objectives of stream restoration that can lead to reductions in flood damage.

Within a watershed, riparian systems exert varying influences on flooding, depending on their type (Brooks et. al, 2003). Forest vegetation can provide large woody debris to channels, which helps reduce velocity, provides shade and detritus to streams, provides cover for fish and other stream dwellers. Prairie vegetation,

although it does not provide the same amount of shade as do trees, stabilizes soils and banks and minimizes sediment delivery into the channel, which helps maintain stream channel capacity to transmit floodwaters. Where transitional (phreatophytic) vegetation occurs extensively along floodplains, there are trade offs that must be considered in evaluating the role of riparian vegetation (Brooks et. al, 2003). Such vegetation increases channel roughness, slowing the velocity of floodwaters and causing higher stages and, where development occurs in the floodplain, more frequent flood damages. However, the benefits of increased storage and reduced flow velocities in upstream areas will reduce flood frequency and damaging flows downstream and can improve downstream water quality as well (Brooks et. al, 2003). We are not advocating a dramatic increase in the roughness coefficient of the Bypass Channel. In fact, if any significant decrease in flow rate occurs in the Bypass Channel, this would go against the tenets of the Maintenance Agreement between the Army Corps of Engineers and the City of Hastings. Thus we recommend only using short grass prairie species in the Bypass Channel and not using any woody vegetation. The point of this conversation is to raise this important issue to consider it in future management decisions.

For the scope of restoration on this property, streambank stabilization will occur only on the most degraded areas of riverbank, since a wholesale restoration of the entire reach would be far too large of a project. For those areas that are the most degraded, streambank stabilization will require a combination of both hard and soft armoring of slopes. *Hard armoring* consists of installing riprap, boulders, or cedar revetment along the toe bottom zone of the riverbank slope. Riprap is a methodology that should be avoided, and only used in extreme cases, since it transfers energy downstream, transferring the problem elsewhere. It is also quite unattractive and does little to create wildlife habitat, generate large woody debris, etc., and there is so much of it already on the site in the Bypass Channel. *Soft armoring* consists of using bioengineering techniques such as installing willow fascines or brush mattresses along mid-slopes, from the top of the hard armoring upward to the slope crest. Rock vanes may also be installed to direct the main current of the river (thalweg) away from the banks and toward the middle of the channel. See **Appendix E** for more information. Also, the Dakota County Soil and Water Conservation District (SWCD) is available as a resource to help with technical assistance for bank stabilization projects.

Target Plant Communities

The restoration sites on the property will consist primarily of a mix of Riparian forest and native upland prairie plant communities. The restoration of target communities for this property are listed in **Table 3** and mapped in **Figure 15**.

As can be seen from **Figure 15** and **Table 3**, the majority of target landcover in Linear Park is upland prairie (mainly *Dry* but also *Mesic Prairie*). The other target landcovers are *Mesic Savanna, Terrace Forest, Wet Prairie*, and *Emergent Marsh*. Prairie will undoubtedly dominate the site. This agrees with all of the information

compiled for the site: historical accounts of pre-settlement vegetation, historical aerial photos of the site, soil data, topography data, and hydrological data. The natural feature that punctuates the matrix of prairie is, of course, the Vermillion River, which winds its way through the site, and results in the riparian buffer that flanks the channel. This riparian buffer will be the site of *Terrace Forest* and *Wet Prairie*.

One area on the southern side of the river, in the middle of the property (across from the private residence) has been designated as *Dry Prairie* coming almost right up to the riverbanks. Tall grass species (big blue, Indiangrass) would grow right along the river, for their deep roots. Here it seemed probable that prairie would have a better chance of dominating than terrace forest, given the high banks and the lack of woody vegetation in this vicinity (which actually may be the case for more of the site, but given the current presence of many trees elsewhere, the scenario of riparian prairie was reduced). Of course, the determining factor will be fire intensity and frequency. With more fire, prairie will prevail, and with less frequent fires forest will win out. Prairie banks may actually increase in area, as compared with what is shown on the map in **Figure 17**, with increased fire frequency. In fact, it is recommended to encourage the treed areas be converted to prairie if opportunities (blowdown) arise.

The two man-made features that strongly influence the site are the Bypass Channel and the Stormwater Pond. The result of the Bypass Channel on target plant communities is moderation towards moister soil conditions, especially at the bottom of the swale—thus *Mesic Prairie* was targeted there. This would not be the natural community of the site, which would be Dry Prairie, but given the altered nature of the topography and hydrology, the moister option was favored. Perhaps a mix of dry and mesic species would be ideal, so that things can be sorted out naturally over time. The riprap of the channel walls will also make it difficult for prairie vegetation to thrive—they may always be weed-prone areas. The eastern end of the Bypass channel is particularly tricky due to the narrowness of the land and active channel, the profusion of riprap, the bedrock at the surface, and the history of significant disturbance.

The stormwater pond also resulted in wetter conditions than would have prevailed naturally. Targeted communities are sort of terraced, with a ring of *Emergent Marsh* at the waters edge of the pond, followed by a ring of *Wet Prairie* just up from that, followed by a ring of mesic prairie. These target plant communities around the prairie are subject to change depending on water level fluctuations and weather conditions, and thus can grade into each other or mix with each other over time.

The target community over the *Zumbro* soils, at the west end of the river, is a combination of *Terrace Forest* and *Mesic Savanna*. The delineation between these two communities may vary based on several factors; hence the boundaries will likely be wavy or intergraded. The fact that the soils are fine sandy loam, and that

they do flood occasionally to rarely, will dictate the community outcome: they may be in flux or they may have indistinct boundaries.

The slim slices of land between the road (Hwy 46-47) and the river, on the north side of the river, are targeted to a variety of native and non-native plant communities. The native ones vary primarily with hydrology, and the non-native ones with designated use of the site (picnic area vs. stormwater inlet structures, for instance). Communities that vary with hydrology are targeted as *Wet Prairie* and *Terrace Forest* for the wetter end of the spectrum, and *Dry* to *Mesic Prairie* on the drier end of the spectrum. The non-native communities are designated as *Mowed Turf* or *Parking Lot*, for around picnic tables, parking lots, and inlet structures.

The river channel itself has been designated as *River Shore.* There are two types of river shore, depending on the substrate/bottom: *sand/gravel/cobble* and *rocky*. The sand/gravel/cobble type occurs throughout the western 3/4 of the site, and the rocky type occurs in the eastern 1/4 of the site, which corresponds to surficial geologic and field data.
Recommended species lists for restoration for each of the targeted plant communities (except for Mowed Turf and Parking Lot) can be found in **Appendix B.**

As alluded to herein, although the plant communities on **Figure 17** are shown as having distinct borders, in actuality they would for the most part have rather fuzzy borders. One community generally grades into another, with community structure being interwoven, with wavy margins separating them—nature tends to have few straight lines. Management of, for example a terrace forest unit and an adjacent oak savanna unit, may sometimes mix together, and that is fine. Also, if a unit does not respond to being restored to a specific plant community, then it is reasonable and acceptable to adapt the plan to the situation at hand, sort of going with what the site dictates. This also underscores the importance of annual evaluations performed by ecologists or other natural resource professionals.

Restoration Process

Restoration is a process. It takes time to restore ecosystems to their former functioning; sometimes this can only be approximated. It took many years to degrade the ecosystem and biological communities of the Linear Park site, so it will not be restored overnight. Many steps are typically involved in a successful restoration. Even deciding when a restoration is complete/successful can be very difficult. A good guide on how to accomplish restoration is using the concept of *adaptive management.* Adaptive management is a strategy commonly used by land managers and restorationists, and integrates thought and action in the process. It can be described as a strategy that uses evaluation, reflection, communication, and also incorporates learning into planning and management. It is set up like a feedback loop and looks like this: Assess Problem -→ Design -→ Implement -→ Monitor -→ Evaluate -→ Adjust -→ Assess Problem -→ and so forth. Thus, moving forward with restoration, each round of adaptive management refines and hones

the process to better fit the conditions of the site and time. This strategy should be used at the Linear Park site.

The restoration of the biological communities at Linear Park should be broken into phases. Each phase will address the restoration of each given target plant community. Phases will be spread out over a number of years. Restoration will also be prioritized, with the most important resources or vital areas taking precedence. On this site two general areas share in the highest priority: 1) restoring the Riparian buffer area and 2) restoring the prairie south of the river. Water quality is a priority in the county (Jim Davidson, personal communication, 2012) and prairie is a priority in the county and the state (personal communication with staff at Washington Conservation District, January, 2012; Minnesota Department of Natural Resources, 2006 and 2012).

Restoring riparian buffer and prairie are large projects, since there is so much of each and since they vary between wet and dry communities throughout the site. Therefore restoration will be broken into phases. Each phase can be restored independently, sequentially, or concurrently. Certain tasks lend themselves to being more successfully completed by doing them concurrently, such as removal of woody brush. Other tasks can be divided, such as controlled burns and planting/seeding.

Probably the best strategy is to complete riverbank stabilization and restoration in the interior of the property first, then follow with by restoring prairie to the peripheral parts of the property. Given the linear arrangement of this property, it may be best to divide it up into chunks oriented along an east-west axis, which would reduce the amount of travel and mobilization during restoration activities.

Table 4 is a schedule of proposed management activities and cost estimates, and lists each step in the process.

Site-Wide Invasive Woody Plant Removal/Control

The initial restoration goal will be the eradication of non-native woody species. This can be done in phases, according to priority, with riparian buffer areas coming first, followed by Oak Savanna, and Prairie. Restoration of each of the proposed plant community types, following in subsequent phases, as listed, can proceed depending on funding and scheduling. It would be nice to attain this goal all at once for the entire property, a process that typically takes three to five years. However, more closely integrating seeding, following removal, may be necessary, especially on the steep riverbank slopes. Part of the exotic woody control would be prescribed burns, which will reduce seedlings of exotic species and will help to foster native species.

Restoration Priorities

PRIORITY 1: <u>Restore/Stabilize Eroding Riverbanks</u>

It would seem to make the most sense to do this first, given the high priority of water quality to the county and state, and given the fact that the river is the central feature of the park. Working from the inside to the outside also seems to be a good strategy, since trampling and destruction of restoration work already completed would be minimized.

Figure 18. Degraded areas of the Vermillion River at Linear Park.

Four areas stand out as the most degraded (**Figure 18**). The first degraded area of riverbank (#1) is associated with the first tight bend in the river (**Figure 19**), and the cutbank is very steep, profuse with exposed bare soil, and actively eroding. Note the native prairie remnant very close by degraded bank #1—care must be taken to protect this remnant during restoration activities.

Figure 19. Degraded riverbank areas numbers 1 and 2 on the western end of the river.

Two other degraded bank areas (#2

and #3) are associated with stormwater inlet structures, taking the brunt of runoff water that directly issues into the river from the surrounding watershed. The final one (#4) has already been stabilized, to some extent, by Dakota county SWCD, but an extended buffer width and length is recommended (**Figure 20**). Other areas along the river system also could use attention, but these four are the highest priorities and will take considerable effort to stabilize/restore. Once these have been completed, focus can be turned to other spots.

Figure 20. Degraded riverbanks numbers 3 and 4, in the middle of the river.

Restoration and stabilization of these four areas can be done by using a combination of Best Management Practices (BMPs). See **Appendix E** for more information. An example might be the following:

1. Remove exotic brush. Cut and treat stumps. Use an aquatic approved systemic herbicide due to the proximity to surface water. Haul and stack the cut brush into piles to be burned or chipped. As these sites are fairly accessible, it might be easiest and cheapest to chip and haul. Burning can either happen at the time of removal, or can be done later. Brush removal is typically done in the fall or winter, when it is cooler, however working on steep riverbank slopes may best be done before they become icy and slippery in the winter. Use best judgment given site and weather conditions.
2. Reshape riverbanks to allow for better plant establishment and more stable slope conditions. Reshaping the bank with a backhoe to a steepness of 1:3 or 1:4 (vertical feet to horizontal feet, or "rise over run") is recommended. Right now they are the reverse, about 2:1 or 3:1, which makes for very unstable conditions.
3. Install hard armoring at slope toe and at mid-slope. Slope toe prevents scouring and undercutting, and mid-slope prevents scouring due to high water levels during the "June Rise". Hard armoring consists of installing

riprap and redcedar revetment. Avoid using riprap, unless boulders do not work (such as very steep slopes). Boulders should be round stones with no sharp or flat surfaces (Class V Mn/DOT uncut, undressed field stone boulders with no blast or shear marks are recommended). Areas directly across from inlet structures would be good candidates for boulder revetment, and cedar revetment can be used in other areas that are not too high in energy flow. Boulders should be installed so that it emerges above the "bankfull" height—that height at which the water levels are highest in heavy flooding events. Consider underlying the stone with a durable fabric. If riprap must be used, it can be covered with topsoil or compost to fill in the spaces and then hydroseeded, so that the final result is more aesthetically pleasing.

4. Install soft armoring on banks. Soft armoring refers to bio-engineering solutions for erosion control, meaning the use of plants. Plants form an interwoven matrix of roots that bind and stabilize soil particles. Fibrous roots, such as prairie plants, are most effective at binding fine soil particles, so are recommended. On mid-slopes and on north-facing slopes, where sunlight is limited, can be difficult to establish prairie vegetation, so shrubs are recommended for these spots. Shrubs can most effectively be utilized via structures such as fascines or brush mattresses. Fascines use rows of interwoven shrub live cuttings, buried on one end into the riverbank soil. Brush mattresses are similar, but are laid down and can be made of either liver or dead material to stabilize slopes. The preferred species for fascines are sandbar willow, but others such as red or silky dogwood are acceptable. Larger tree species are not recommended, since they will cast too much shade at maturity and they will blow out the bank if their anchor roots become too exposed, which is typical. Shrubs may also be planted from transplants or bare root.

5. Install prairie plugs and/or seed at the tops of the riverbanks and in spaces on the side slopes and between boulders. If seed is used, an erosion control blanket may be necessary on steeper slopes.

Other practices may be used also, such as wattling or water bars and planting pockets. Wattles are made of either live thicket plant material (both material that will readily root {willow, dogwood, etc.}, or not can be used). Wattles should be about 6-10" in diameter. Water bars should be cut from downed tree limbs that are at least 10" in diameter. Both wattles and water bars should be trenched into place on the slope, either in trenches that are dug in rows or randomly placed on the slope. Install the wattles or water bars so that they are buried about 1/2 –way down. Stake wattles and or water bars in with sturdy stakes, at least 4 feet long. Drive stakes in perpendicular to the slope. Plant plugs or seed around the installed wattles and/or water bars.

When planting larger prairie plants on the slope, it is recommended to dig a planting pocket into the slope to facilitate irrigation. The plant is set well forward in the pocket, establishing a basin to the inside that will retain water and protect the plant

from a certain amount of eroding or sloughing soil. An overflow spillway will prevent the pocket from being washed out by all but the heaviest rains. Create an overflow spillway by cutting into the undisturbed slope at one side of the pocket so that water will flow out of and away from the basin before the berm is breached.

Planting transplants (plugs, container-grown plants) is probably the best way to assure success in a planting. It is expensive, though. For steep slopes, however, it is the recommended method. Seed may be used to fill in the bare areas around the plugs or on less steep slopes. Planting a few prairie shrubs, scattered across the slope, from larger containers would also be recommended.

Hydroseeding can also be used on steep slopes. This method will be successful only if good seed to soil contact is established. If the substrate (soil) does not have enough moisture and nutrient capacity, then seed will not germinate and grow. Irrigation is vital during the germination period. If the seed mix is stacked with a high percentage of quick germinating species like wild rye, bottlebrush grass, and annual oats or winter wheat for cover crop, germination success will be greater. Whenever a seeding method is used, good site prep is vital. Doing adequate weed control prior to seeding is highly recommended. Perhaps apply two or multiple rounds of herbicide treatments, to flush out the weed seed bank, just before seeding with natives.

Broadcast seeding should work, too, and is less expensive, but it does not have a tackifier so it will not stick to slopes like hyrdroseed will. Consider broadcast seeding by hand into microsites that are suitable, i.e., ones that have exposed bare soil, are on a slight flat spot, and have decent soil (not too much debris or rock), or are not too steep. This may be a good way to increase diversity on the site, after plug planting and shrub planting occur. The best times for seeding and planting are in spring and fall, due to moisture availability.

PRIORITY 2: Restore a Wider and Longer Riparian Buffer (of Native Plant Communities) along the Vermillion River

Restoring and establishing native plant communities in the buffer zone on both sides of the river would improve water quality of the river and improve wildlife habitat. Four different native plant communities have been targeted in the buffer zone: Terrace Forest, Wet Prairie, Dry Prairie, and Mesic Oak Savanna. Pre-settlement, the Terrace Forest would have been much reduced compared to its extent today. So one of the goals should be to chip away at the current extent of Terrace Forest and increase Prairie.

Woody Plant Removal (optional)

There are many woody plants in the current Vermillion River buffer area that need to be removed in preparation for restoration of the buffer area. All exotic woody species should be removed, including buckthorn, Tartarian honeysuckle, Siberian elm, Amur maple, etc. Also, most of the boxelder trees should be removed, since

they are a fast growing, opportunistic species that flourish under disturbance conditions. Removal of woody brush should ideally be done for the entire park all at one time. If this is not possible (due to budget, labor, or time constraints) then phasing is an acceptable option. Brush should be cut, stumps treated, and brush hauled and stacked into piles. Piles are typically burned (easiest and most economical), but can also be chipped if so desired. Some of the larger branches should be saved for making waterbars for slope stabilization on the riverbanks.

Grass Control, Burning and Seeding (optional)
For prairie and savanna units, a key part of the site preparation involves controlling competing exotic herbaceous vegetation, especially smooth brome. Eliminating smooth brome involves properly timed activities. First attempts should be late season burns. Late season burns are beneficial because they more completely deplete plants of energy reserves by destroying the biomass of the top-growth. Early season burns can only destroy what little top-growth that has formed at that early part of the growing season. Late season burns also are more damaging to native forbs, so don't continue with them for too many years. Two consecutive years of late-season burns should be adequate. Then switch to a regular (early) burning cycle of 2 to 5 years. If late-season burning alone proves to be unsuccessful, then spot treatments of herbicide can be performed. A grass-specific herbicide can be used to curtail the smooth brome. Care should be taken to reduce collateral damage to the native plants, although there are not an abundance of them in this area (**Appendix C**).

Dry prairies do not require as frequent burning as do mesic ones, since tree and shrub invasion is somewhat inhibited by dry and nutrient poor conditions of the soil (MN DNR, 2005). However, as can be seen from the dense vegetation of this site, they still do require frequent enough fire to keep woody plants from invading. Two years of back-to-back Rx burns are recommended for the bluff prairie, followed by burns every 3 to 5 years from then on. Also, the prairie areas could be divided into two or three burn units so that burning could be rotated between units. The site should be evaluated after each burn to see how well plants (and animals) recover.

Usually before deciding whether or not to seed, a site will be monitored and evaluated after a couple of burns to see if any native come into open gaps. For Linear Park, however, this method is recommended only for the area where the little remnant is located (**Figure 16, waypoint 47**). Sometimes a latent seedbed can be released following smooth brome control. If it turns out, for this remnant area, that after 2 years or so, no natives are filling in the gaps, then seeding will probably be required. For the rest of the site seeding will be required, since the site is so degraded. Adequate amounts of seed will not be obtained from this site via collection of the remnant alone; therefore seed will have to be purchased. Purchase seed of local genetic origin (local ecotype origin) that is appropriate to the community. Origin within 100 miles is desirable.

For the Mesic Oak Savanna community, it is common to first establish prairie and then plant trees. Bur oaks can be planted in pods or groups, after prairie has been established (5 to 7 years). Once trees are planted, they should be protected from fire for the first 15 to 20 years or so. Following that, they should be able to withstand light surface fires, since they have thick, corky, fire-resistant bark.

Terrace Forests do not need to be burned. Historically, they only experienced light surface fires once about every 80 years (DNR, 2005). Removal of exotic brush and replanting with native shrubs is all that is required. As was stated before, one of the goals of this plan is to gradually reduce the amount of Terrace Forest, and replace it with prairie (both Wet Prairie and Dry Prairie). Thus, small, incremental cuttings along the forest margins each year for perhaps 20 years would be a recommended strategy. As the forest gets pushed back, native prairie can be seeded in its place. Starting out with a diverse seed mix is recommended. Also recommended is to get enough grass component established early on so that a running fire can carry through the area.

Implementation Phases

Since the riparian area is quite long, it is recommended to break it into two pieces, for the sake of easier implementation. The first part (Phase 1) to be started would be the middle or south piece, from the east side of the rip-rap (on the south side of the river) to the east end of where the prairie comes right down to the riverbank (**Figure 20A**). Included in this initial part would be the corresponding areas on the north side of the river, including the Southern Mesic Prairie, the Southern Mesic Savanna and the areas between Hwy 47 and the river channel (FFs59, UPs13 & UPs23, and Turf areas). Removal of picnic tables and restoration of turf areas on the north side of the river could occur at the same time. The degraded areas of the bank (numbers 1 and 2, **Figure 20**) would require bank re-shaping, and therefore adequately sufficient zones around these degraded banks should be left un-restored until after the banks are re-shaped and root wads or rock vanes have been installed.

The next piece (Phase 2) would be on the east end of the river. Access may be an issue, since there are no outlots owned by the city on Bohlken Drive, but there is a small trail access on Bohlken Dr (five houses west of Hackberry Drive), where small equipment can traverse. Large equipment will have to access the site via the west end, where Public Works goes in when they need to access the site. There is also trail access on the eastern end of the park, at the bend of the road where 22nd St W turns into Cannon Street.

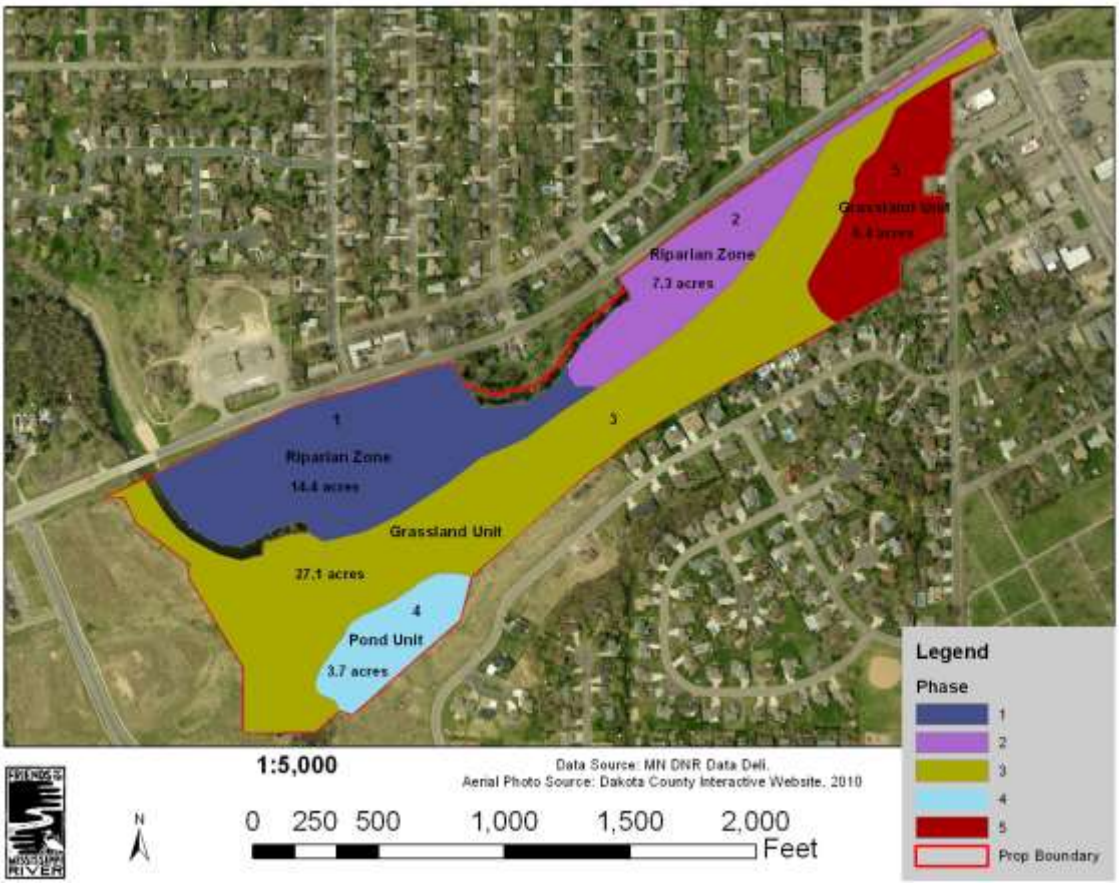


Figure 20A. Suggested restoration phases at Linear Park.

Phase 3 would be the majority of the grassland, including the Bypass Channel. The remaining portion of the grassland might be saved for last (Phase 5), since it requires the removal of many trees, and would need special preparation in terms of community outreach and education. The pond unit since it is a lower priority, would be done at or near the end (Phase 4).

PRIORITY 3: Restore Prairie to Mowed Turf Areas and to the Entire Area South of the Riparian Buffer, including the Bypass Channel.

Restoration of prairie to the area south of the Riparian Buffer zone (the majority of the park), will help attain many of the goals of this plan, including improve water quality, improve wildlife habitat, etc. It also will reduce the area currently being mowed, including the turfed areas and the Bypass Channel. The middle turf and picnic table area should be eliminated altogether, and restored to wet and dry prairie. This will allow the river to flood naturally and to give what little bit of land now available on the north side of the river to be utilized as buffer—something that is desperately needed there.

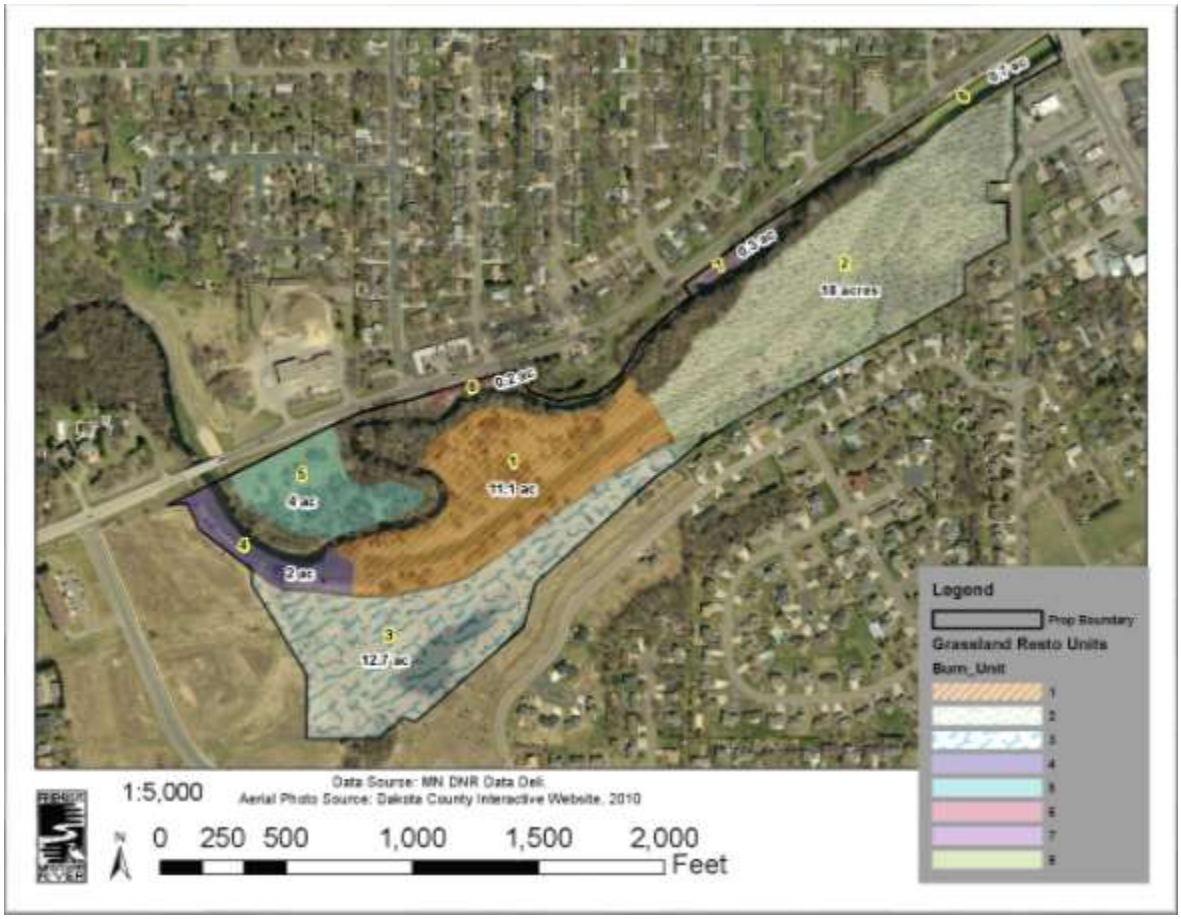


Figure 21. Potential burn units at Linear Park.

The Bypass Channel is currently being mowed one to three times a year by the City of Hastings. This could be eliminated by restoring the area to prairie, and then managing the vegetation by burning every couple of years. The Army Corps of Engineers administers this area, and requires that no woody vegetation be allowed to grow in the Bypass Channel (Blomstrand, personal communication, 2012). Therefore, a fire rotation of one to three years would have to be maintained in order for woody volunteers to be controlled in the Bypass Channel. This should not be a

hardship, and would be much preferable to mowing, from the standpoint of the health of the ecosystem.

Phasing

Phasing of the prairie restoration may be necessary, since it is such a long, linear area. The site could be potentially divided into sections, with each section being restored on its own. Using existing trails and the river as burn breaks would be logical, and thus inform the process. A potential scenario for division of the site can be seen in **Figure 21**.

The general process for restoring prairie would be:

1. woody brush removal
2. exotic grass and forb control
3. burn the site
4. seed the site

Since much of this area is currently quite open, the woody brush removal portion will not be as great as along the riparian buffer, except in the DWA-2 unit at the northeast end of the site. In DWA-2 there is a very dense growth of trees, primarily Siberian elm, that need to be removed. This area will require more work than the rest of this part.

The exotic grass and forb control step would involve treatment with a systemic herbicide to areas that were dominated by exotic species. Prior to treatment, the higher quality remnant areas should be surveyed and marked by a trained professional (ecologist or equivalent). Once remnants are marked, then herbicide application can proceed, but in a very careful manner, such that plants within remnants are not damaged.

Since spotted knapweed is very plentiful throughout the grasslands of this site, it is recommended to release spotted knapweed weevils as soon as possible, as a bio-control. Three species of beetles are used for spotted knapweed control: Knapweed Root Weevil (*Cyphocleonus achates),* Blunt Knapweed Flower Weevil (*Larinus obtusus),* and Lesser Flowerhead Weevil (*Larinus minutus).* Weevils can be purchased readily from on-line vendors and root weevils are the most important species to get. This bio-control does not reap positive results right away; it usually takes about five years before you notice any depletion in knapweed populations. Nevertheless, the weevils are an effective long-term control. Once the weevil populations get established, they will remain as long as they have a host to target. They do not cross over to other species, either, so they will not become an ecological liability.

Seeding could be done by broadcasting seed by hand or by using a seeding machine. The key to successful seed germination is to get good seed to soil contact. Prior to

seeding, the site should be clean and free of thatch and large soils clods. Burning clears the site of thatch, and disking and harrowing breaks up soil clods. Ecological contractors can help guide one through the process of seeding (**Appendix D**).

PRIORITY 4: Reconstruct native vegetation buffer around the Stormwater Pond

Once all other areas are restored, then the zone around the Stormwater Pond can be reconstructed to native vegetation. This is because the Stormwater Pond is a man-made feature and it is a highly disturbed part of the park. Follow the Target Plant Communities map as a guide to restore the pond (**Figure 17**). It is recommended to use transplants (plugs and potted plants) around the pond, since seed is notoriously difficult to establish in these types of landscapes.

Prescribed Burns—More Information

It is recommended to split the entire site up into burn units, for ease of operation and for ecological reasons (impacts on insects and animals, for instance). It is important to leave some areas unburned (refugia) to allow insect and animal populations to recover and repopulate burned areas. Rotate the burning of units from year to year, and try not to burn adjacent units in consecutive years. Prior to a prescribed burn, a burn plan must be devised. The burn contractor can help with the burn plan. Permits must be obtained from the DNR and local fire officials. Initially, burning would be rotated every one or two years, so that each year a different burn unit would be burned. Long-term, burns should occur every 5-9 years in woodlands and 2-4 years in prairies and 3-5 years in savannas.

Prior to burning, burn breaks must be created to contain the fire. Burn breaks consist of a mowed swath in grassland areas, typically at least 8 feet wide. In woodland areas, the break line is created by clearing the leaf litter and any other debris to reach mineral soils. Locating breaks on the periphery of the easement is a logical place for them. Also utilizing the trail system and edges of forests would be useful and easier than making them from scratch. The burn contractor can also help with the placement and installation of burn breaks. Allowing fire to run into adjacent different land covers is a good strategy. For example, breaklines in a prairie unit that is adjacent to woodland should be placed a short distance into the woodland, where feasible. This makes for a more natural looking and functioning landscape and helps to prevent the woodland from encroaching into the prairie.

Smoke management is the main concern for burning on this property, since there are a number of nearby residences, buildings, and roads.

Long-Term Monitoring and Maintenance

Monitoring is very important to restoration success. Monitoring, evaluation and assessment should be done at least annually by an ecologist or a restoration professional. More frequent monitoring will be needed in the initial phases of restoration to evaluate the success of the methodology and to inform future

strategies. Adapting to issues or factors observed during monitoring and assessment is vital to the restoration process.

Once the primary restoration tasks are completed, the restoration process will convert to a monitoring and adaptive management phase. Long-term maintenance for the savanna areas will consist of burning every 3 to 6 years and monitoring every year and managing for exotic species. Lowland Hardwood Forests will require burning once every 20 years. For Prairies, burning should occur every 2 to 5 years.

Restored areas must be regularly monitored to identify ecological issues, such as erosion and sedimentation, invasive species, and disease. Monitoring is also important for detecting human-related issues such as illegal activities (hunting, ATV use, tree harvesting, etc.) Early detection of concerns enables quick responses to address them before they become significant problems.

Monitoring animal as well as plant communities is also helpful for evaluating results of the restoration. A comparison of bird populations before and after restoration, for example, would be a valuable tool for quantifying positive impacts on the land.

RESTORATION SCHEDULE AND COST ESTIMATES

An approximation of restoration/management tasks, priorities, and costs are provided in **Table 5**, below. Project cost estimates are not based on actual contractor bids, but on typical costs for similar projects. Actual project costs could be significantly higher or lower, depending on multiple factors. Costs could potentially be decreased by, for example, reducing the diversity of prairie seed costs, contracting for the entire project with one contractor, using volunteers or STS (Sentence to Serve) crew for portions of the labor such as hauling brush. Some activities may be carried out by the landowner if they wish, and have the time and equipment to do so. Project tasks and costs may also change over time, as more information is learned about the property and as the site conditions change.

The most important short-term issue to address is exotic woody species control at all the units. Ideally, this should be addressed site-wide prior to any other restoration activities to eliminate seed sources of these exotic species. However, if budget concerns preclude this, woody brush removal may be phased and accomplished over several years time.

Table 5. Linear Park Restoration Schedule and Cost Estimates
These tables are rough schedules and approximate costs for restoration and management tasks for the Linear Park property. Both the project tasks and costs are likely to change as the project progresses - these tables should be used only as rough guides. Tasks were phased, with 1 being the highest priority. Work units correspond with those shown in **Figure 15**.

Yr	Season	Units	Activity	Acres	Cost/Ac	Cost Est.
PREREQUISITE: RESTORE and STABILIZE ERODING RIVERBANKS						
1	Fall, winter	Degraded River Channel	Control large exotic woody brush plants and other undesirable native woody brush throughout both units. Cut and treat stumps. Haul brush to piles and burn in fall or winter.	1.0	1500	$2,000.00
1	Spring, Summer	Degraded River Channel	Reshape/recontour the degraded banks to a slope of 1:3 or 1:4.	1.0		$10,000.00
1	Summer, fall	Degraded River Channel	OPTONAL: Install rock vanes or root wads.	1.0		TBD
1	Summer, fall	Degraded River Channel	Hard armor the riverbank slopes. Boulder toe and mid-slope as necessary. Cover with compost or topsoil and hydroseed, if desired.	0.3		$20,000.00
1	Spring, fall	Degraded River Channel	Hard armor riverbank slopes. Install cedar revetment and waterbars.	0.3		$20,000.00
1	Summer, fall	Degraded River Channel	Soft armor the riverbank slopes. Install wattles, fascines, brush mattresses.	0.3		$20,000.00
1 & 2	Spring, fall	Degraded River Channel	Plant prairie plugs and shrubs on slopes.	0.3		$15,000.00
1 & 2	Spring, Fall	Degraded River Channel	Seed between gaps of plantings and armoring of slopes.	1.0		$4,000.00
1 & 2	Any	Degraded River Channel	Annual Ecological evaluation and assessment.	1.0		$1,050.00
	Subtotal Range			1.0		$92,050.00
PHASE 1: RESTORE SOUTHWESTERN PORTION OF RIPARIAN BUFFER ZONE ALONG VERMILLION RIVER IN THE PARK						
1, 2	Any	DWA-1, LHF	Remove a strip of trees from Terrace Forest.	0.5	1500	$750.00
1, 2	Fall, winter, early spring	DWA-1, Gr-1, LHF, Gr-Tr	Control woody brush plants and other undesirable native woody brush throughout the riparian units. Brush cut whips in June-July. Allow to resprout. Foliar treat with Glyphosate in Sept/Oct.	14.4	1200	$17,280.00
2	Fall, summer	DWA-1, Gr-1, LHF, Gr-Tr	Spot-apply systemic herbicide to control herbaceous weedy species. Protect remnant from herbicide damage. Mark remnants prior.	14.4	300	$4,320.00
2	Spring or fall	Gr-1, Gr-Tr	Burn open buffer areas (in conjunction with Gr-1 unit, if possible) to prepare the site for seeding.	8.0	250	$2,000.00
2	Spring, summer	DWA-1, Gr-1, LHF, Gr-Tr	Treat exotic resprouts	14.4	200	$2,880.00
2	Fall, spring	DWA-1, Gr-1, LHF, Gr-Tr	Broadcast prairie seed (purchased) onto prairie target areas.	9.0	1100	$10,400.00

Yr	Season	Units	Activity	Acres	Cost/Ac	Cost Est.
2	Spring, Summer	Gr-1	Mow Gr-1 unit three times during first growing season.	4.5	300	$1,850.00
3	Fall, spring	DWA-1, LHF	Plant native shrubs in Terrace Forest.	3.0		$4,400.00
8	Fall, spring	DWA-1, Gr-Tr	Plant bur oaks in pods in Oak Savanna unit.	2.0		$7,000.00
Subtotal				14.4		$50,880.00
PHASE 2: RESTORE NORTHEASTERN PORTION OF RIPARIAN BUFFER						
3,4	Any	LHF	Remove a strip of trees from Terrace Forest.	0.2	1500	$300.00
3,4	Fall, winter, early spring	LHF, Short grasses w sparse tree cover	Control woody brush plants and other undesirable native woody brush throughout the riparian units. Brush cut whips in June-July. Allow to resprout. Foliar treat with Glyphosate in Sept/Oct.	7.3	1200	$8,760.00
4	Summer, fall	Short grasses w Sparse tree cover units	Remove picnic tables and concrete slabs.	2.0		TBD
4	Fall, summer	LHF, Short grasses w sparse tree cover	Spot-apply systemic herbicide to control herbaceous weedy species. Protect remnant from herbicide damage.	7.3	300	$2,190.00
4	Spring or fall	LHF, Short grasses w sparse tree cover	Burn open buffer areas (in conjunction with Gr-1 unit, if possible) to prepare the site for seeding.	3.0	250	$750.00
4	Spring, summer	LHF, Short grasses w sparse tree cover	Treat exotic resprouts	7.3	200	$1,460.00
4	Fall, spring	LHF, Short grasses w sparse tree cover	Broadcast prairie seed (purchased) onto prairie target areas.	7.3	1100	$8,030.00
5	Fall, spring	LHF	Plant native shrubs in Terrace Forest.	2.0		$3,000.00
Subtotal				7.3		$24,490.00
PHASE 3: RESTORE PRAIRIE TO MOWED AREAS IN THE BYPASS CHANNEL AND GRASSLAND UNITS SOUTH OF THE BYPASS CHANNEL						
0, 1, 7, 8	June	All	Breeding bird survey in all units, one year before, one year during, and two years after restoration.			3600
4, 5	Fall, winter, early spring	*GR-2, Gr-3, and Gr-4* units	Control large exotic woody brush plants and other undesirable native woody brush throughout both units. Cut and treat stumps. Haul brush to piles and burn in fall or winter.	27.1	800	$21,680.00

Yr	Season	Units	Activity	Acres	Cost/Ac	Cost Est.
5	Spring or fall	*GR-2, Gr-3, and Gr-4* units	Conduct prescribed burn on grassland units. Allow burn to climb into adjacent units, if possible.	27.1	250	$6,775.00
5	Summer, fall	*GR-2, Gr-3, and Gr-4* units	Treat exotic resprouts	27.1	200	$5,420.00
5	Summer	All	Ecologist identify and mark remnants to be protected.	27.1		$2,000.00
5	Late summer, early fall	*GR-2, Gr-3, and Gr-4* units	Broadcast apply herbicide to control herbaceous weeds. Protect remnants from herbicide damage.	27.1	200	$5,525.00
5	spring, summer, fall	*GR-2, Gr-3, and Gr-4* units	Spot treat with herbicide to control herbaceous weeds.	27.1	200	$5,420.00
5	spring or fall	*GR-2, Gr-3, and Gr-4* units	Seed native prairie mix.	27.1	1000	$27,100.00
5	June, July, Aug	*GR-2, Gr-3, and Gr-4* units	Mow 3 times during growing season	27.1	300	$8,130.00
6	June, summer	*GR-2, Gr-3, and Gr-4* units	Mow once in spring. Spot treat during growing season	27.1	100	$2,710.00
6 or 7	Fall, or spring	Burn unit 1	Start control burn rotation; do one burn unit.	11.0	250	$2,750.00
5, 6	Summer	*GR-2, Gr-3, and Gr-4* units	Annual Ecological evaluation and assessment.	5.0		$1,050.00
	Subtotal			27.1		$92,160.00
RECONSTRUCT NATIVE VEGETATION BUFFER AROUND STORMWATER POND						
6	Fall, winter, early spring	Pond unit	Control woody brush plants and other undesirable native woody brush throughout the unit.	3.7	1000	$3,700.00
6	Fall, summer	Pond unit	Spot-apply systemic herbicide to control herbaceous weedy species.	3.7	200	$740.00
6	Spring or fall	Pond unit	Burn unit, with grassland units if possible, to prepare the site for seeding.	3.0	250	$750.00
6	Fall, spring	Pond unit	Plant shrubs on slopes.	3.0		$2,000.00
6	Fall, spring	Pond unit	Plant transitional prairie plugs on pond slopes.	1.0		$20,000.00
6	Fall, spring	Pond unit	Plant emergent transplants at OHW and below.	1.0		$7,000.00
6	Fall, spring	Pond unit	Hand broadcast prairie seed (purchased) onto slopes.	2.0	1000	$2,000.00
	Subtotal			3.7		$36,190.00

Yr	Season	Units	Activity	Acres	Cost/Ac	Cost Est.
PHASE 5: RESTORE NATIVE PRAIRIE ALTERED DECIDUOUS WOODLAND, DW-2						
7	Fall, Winter	DW-2	Control large exotic woody brush plants and other undesirable native woody brush. Cut and treat stumps. Haul brush to piles and burn in fall or winter.	6.4	1500	$9,600.00
7	Spring, Summer	DW-2	Spray or forestry mow resprouts and seedlings	6.4	750	$4,800.00
7	Fall	DW-2	Seed with native prairie seed mix.	6.4	1000	$6,400.00
7	Spring, Summer	DW-2	Mow three times during first growing season	6.4	300	$1,920.00
7	Spring	DW-2	Mow once in spring of second season	6.4	100	$640.00
7	Any	DW-2	Spot treat as necessary.	6.4	200	$1,280.00
7	Spring or Fall	DW-2	Include into burning rotation with other grassland units.	6.4	300	$1,920.00
	Subtotal			6.4		$26,560.00
	Total			**60.0**		**$322,330.00**

Long-Term Management

Once initial restoration tasks are completed, then long-term management ensues. Long-term management includes tasks that are required to be done periodically to maintain the plant community. **Table 6** lists these tasks with associated cost estimates for 20 years following establishment.

Table 6. Long-Term Management Schedule and Cost Estimates

Season	Units	Activity	Acres	Cost/Ac	Cost Est.
Spring or fall	Grassland units	Burn the Prairie and Savanna every 2-5 years for 20 years.	50.0	150	$52,500.00
	All	Spot treat invasives as necessary.	10.0	150	$10,500.00
Spring or fall	DWA-1, DWA-2, LHF	Burn the Terrace Forest unit every 15-20 years.	4.0	200	$800.00
Spring or fall	All	Check on the survival of plantings for 20 years. Replant if necessary.	7.0	200	$2,800.00
Summer, fall	Degraded riverbanks	Check on the success of BMPs on shoreline. Adaptive management strategy as needed.	1.0		TBD
Fall, summer, spring	All	Evaluation and assessment by ecologist, every 3 years for 20 years.	60.0		$2,100.00
Total (Long-Term Mgmt)					$68,700.00

WORKPLAN

The following tasks and budget (**Table 7**) are based on known costs and project needs at the time of the restoration agreement. All parties, prior to implementation, will agree upon additional future tasks.

Table 7. Workplan

Yr	Season	Activity	Acres	Cost Est.	FNAP	City of Hastings	Other
RESTORE and STABILIZE ERODING RIVERBANKS							
1	Fall, winter	Control large woody exotic brush and treat resprouts on Bluff Prairie and surrounding units.	1	$3,000.00			
1 & 2	Spring, summer	Reshape and contour the degraded bank slopes.	1	$10,000.00			
1	Summer, fall	OPTIONAL: Install rock vanes or root wads.	1	TBD			
2	Summer, fall	Hard-armor the banks	0.3	$40,000.00			
2	Summer, fall	Soft armor the banks	0.5	$20,000.00			
1 & 2	Spring, fall	Plant prairie plugs and shrubs and seed between gaps.	0.3	$19,000.00			
RESTORE RIPARIAN BUFFER of VERMILLION RIVER in the PARK							
1 & 2	Fall, winter, summer	Remove a strip of trees from Terrace Forest and Control large woody exotic brush, and other undesirable woody brush, and treat resprouts on Woodland and Forest units	10.5	$27,000.00			
4	Summer, fall	Remove picnic tables and concrete pads.					
3	June-July and Sept-Oct	Control herbaceous exotic species and undesirable native species.	10	$12,000.00			
4	May-June; Spring, Fall	Burn the open buffer areas (in conjunction with Gr-1 unit).	18	$10,000.00			
4	Spring, fall	Seed the prairie target areas within the former wooded riparian units	18	$18,800.00			
4	Spring, fall	Plant native shrubs in the Terrace Forest and bur oaks in Savanna unit	3	$10,400.00			
RESTORE PRAIRIE TO MOWED AREAS IN THE BYPASS CHANNEL AND GRASSLAND UNITS SOUTH OF THE BYPASS CHANNEL							
1, 2, 3	Fall, winter, summer	Control exotic brush and other undesirable native brush throughout grasslands. Treat exotic resprouts.	27	$22,000.00			
4	Late summer, early fall	Apply herbicide to control herbaceous and woody exotic and weedy species as seed site prep and as spot treat afterwards.	27	$17,000.00			
4	Spring, fall	Burn grassland units as site prep for seeding	27	$7,000.00			
4 & 5	Spring, fall	Seed grassland units.	27	$25,000.00			
5,6	June, July, Aug	Mow grassland units three times during the first year, and once during the second year.	27	$11,00.00			
0, 1 3, 4	June	Breeding bird survey in all units, both two years before and two years after restoration.	27	$4,000.00			

Yr	Season	Activity	Acres	Cost Est.	FNAP	City of Hastings	Other
2, 4	Spring, summer, fall	Ecologists evaluation and assessments	27	$6,000.00			
RECONTSTRUCT NATIVE VEGETATION BUFFER AROUND STORMWATER POND							
5	Fall, winter	Control woody brush plants and other undesirable vegetation	4	$4,000.00			
5	Spring, fall	Burn the unit (with the grassland units, if possible)	4	$1,000.00			
5	Spring	Plant shrubs, transitional plugs, and emergent transplants and seed around pond	4	$31,000.00			
RESTORE NATIVE PRAIRIE ALTERED DECIDUOUS WOODLAND, DW-2							
		Control exotic brush and weeds on unit.	7	10,000.00			
		Prepare seed bed by controlling seedlings and resprouts.	7	5,000.00			
		Seed with native prairie seed.	7	6,400.00			
		Follow up maintenance to establish prairie.	7	4,000.00			
		Include in burn rotation.	7	2,000.00			
TOTAL			**60.0**	**$322,400.00**			

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APPENDICES

APPENDIX A. Plant Species Recorded at the Vermillion Linear Park Property

The following plant species were identified at the site by Friends of the Mississippi River in June, August, and December of 2012.

Grassland, Medium-tall, Altered (Gr-1, Gr-2, Gr-3, Gr-4)

GRASSLAND, MEDIUM-TALL, ALTERED					
Non-Native	Scientific Name	Common Name	Cover	Diameter (inches)	Comments
CANOPY/SUBCANOPY		**12 to 70 ft height**	**+ to 3**		**Sparse to Interrupted**
	Acer negundo	Boxelder	+ to 3	2 to 12	Abundant nearer to river
	Betula nigra	River birch	+	4 to 10	Planted in Gr-3
	Celtis occidentalis	Hackberry	+	2 to 10	
	Fraxinus pennsylvanica	Green ash	+	2 to 10	
	Juglans nigra	Black walnut	+	1 to 10	
	Juniperus virginiana	Eastern redcedar	+ to 1	3 to 8	
	Picea glauca	White spruce	+ to 1	3 to 6	Planted in Gr-4
	Pinus resinosa	Red pine	+	3 to 6	Planted in Gr-3
	Pinus strobus	White pine	+	3 to 6	Planted in Gr-3
	Populus deltoides	Eastern cottonwood	+	2 to 12	
	Ulmus americana	American elm	+	2 to 12	
x	*Ulmus pumila*	Siberian elm	+ to 5	1 to 12	
UNDERSTORY/SHRUB LAYER		**4 to 12 ft height**	**Total Cover: + to 1**		
	Cornus sericea	Red-osier dogwood	+		Patchy
x	*Lonicera tatarica*	Tartarian honeysuckle	1 to 2		Scattered throughout
	Populus tremuloides	Quaking aspen	+		Seedlings
x	*Rhamnus cathartica*	Common buckthorn	1 to 2		Scattered throughout
	Rhus glabra	Smooth sumac	+		West of pond
	Salix exidua	Sandbar willow	+		Around pond
	Sambucus racemosa subs. *Pubens*	Red berried elder	+		
	Zanthoxylum americanum	Prickly ash	+ to 2		
GROUND LAYER		**to 4 ft height**	**Total Cover: 5**		
Graminoids					
x	*Bromus inermis*	Smooth brome	1 to 3		Fairly dominant
x	*Bromus tectorum*	Cheat grass	+ to 1		Dominant in some riprap areas
	Carex spp.	Ovales sedge	+		In Gr-3 remnant
	Cyperus spp.	Cyperus sedge	+		In Gr-3 remnant
	Dichanthelium depauperatum	Poverty panic grass	+		
x	*Elymus repens*	Quack grass	3		Co-dominant in places
	Eragrostis spectabilis	Purple love grass	1		Abundnat in places; patchy
x	*Festuca cf. rubra*	Creeping fescue	1		
	Panicum virgatum	Switch grass	2		Abundant
	Paspalum setaceum	Bead grass	+		In Gr-3 remnant
x	*Phalaris arundinacea*	Reed canary grass	1		
x	*Poa pratensis*	Kentucky bluegrass	2		Abundant in places
x	*Setaria viridis*	Green foxtail	2		Abundant
	Sporobolus cryptandrus	Sand dropseed	+		In Gr-3 remnant
	Stipa spartea	Porcupine grass	+		In Gr-3 remnant

Forbs					
	Acer negundo	Boxelder	+ to 1		Seedlings
	Achillea millefolium	Yarrow	1		
x	*Allium schoenoprasum*	Chives	+		
	Ambrosia atremisiifolia	Common ragweed	1		
	Antennaria spp	Pussy toes	+		
	Apocynum sibiricum	Clasping dogbane	+		In Gr-3 remnant
	Arctium minus	Common burdock	+ to 1		
	Asclepias ovalifolia	Oval-leaved milkweed			In Gr-1 remnant
	Asclepias syriaca	Common milkweed	1		
	Asclepias verticillata	Whorled milkweed	1 to 2		Abundant in places; patchy; in Gr-1 remnant
	Aster ericoides	Heath aster	+		
x	*Berteroa incana*	Hoary alyssum	+		
X	*Centaurea stoeba* subsp. *Micranthos*	Spotted knapweed	1 to 2		
x	*Cirsium arvense*	Canada thistle	1 to 2		Patchy
x	*Cirsium vulgare*	Bull thistle	1		
X	*Convulvulus arvensis*	Field bindweed	1		
	Dalea purpurea	Purple prairie clover	+		
	Eregiron spp.	Daisy fleabane	1		
	Euphorbia corollata	Flowering spurge	+		In Gr-3 remnant
	Fraxinus pennsylvanica	Green ash	+		seedlings
	Gleditsia triacanthos	Thornless honeylocust	+		Re-sprouts
	Helianthus spp	Sunflower species	+		
	Hypericum spp	St. John's wort	+		In Gr-1 remnant
	Juniperus virginiana	Eastern redcedar	+ to 1		Seedlings
	Lespedeza capitata	Round headed bush clover	+		In Gr-3 remnant
x	*Linaria vulgaris*	Butter and Eggs	+		
x	*Lonicera tatarica*	Tartarian honeysuckle	1		Seedlings
x	*Lotus corniculatus*	Bird's foot trefoil	1		
	Lycopodium spp	Scouring rushes	+		
	Malus spp.	Crabapple	+		Seedlings
x	*Medicago sativa*	Alfalfa	1		
x	*Melilotus albus*	White sweet clover	1		
x	*Melilotus officinalis*	Yellow sweet clover	1		
	Mirabilis nyctaginea	Four-o'clock	+		
x	*Oxalis corniculata*	Creeping wood-sorrel	1		
	Parthenicissus quinquifolia	Virginia creeper	+		
x	*Pastinaca sativa*	Wild parsnip	+		
	Physalis virginiana	Ground cherry	+ to 1		Abundant in places; patchy; in Gr-1 remnant
	Polygonum cf. achoreum	Knotweed	+		
	Potentilla arguta	Prairie cinquefoil	+		In Gr-1 remnant
	Prunus pensylvanica	Pin cherry	+		
x	*Rhamnus cathartica*	Buckthorn	1		Seedlings
	Rosa arkansana	Prairie rose	+		In Gr-3 remnant
	Rumex crispus	Curly dock	1		
x	*Saponaria officinalis*	Bouncing Bet	+ to 1		
x	*Silene vulgaris*	Bladder campion	+		
	Silphium perfoliatum	Cup plant	+		Scattered patches
	Solidago canadensis	Canada goldenrod	1		
	Solidago giganteus	Giant goldenrod	+		
	Solidago rigida	Stiff goldenrod	+		
x	*Sonchus spp.*	Sow thistle	+		
	Toxicodendron rydbergii	Poison ivy	+		
x	*Tragopogon dubius*	Goat's beard	+		
x	*Trifolium pratense*	Red clover	1		
x	*Ulmus pumila*	Siberian elm	1		Seedlings
	Urtica dioica	Stinging nettle	+ to 1		
x	*Verbascum thapsis*	Mullein	1		
	Verbena stricta	Hoary vervain	+		
x	*Vicia cracca*	Cow vetch	1		
	Viola spp	Violet species	+		
	Vitis riparia	Grape vine	+		
Vines					
	Parthenicissus quinquifolia	Virginia creeper	+		
	Vitis riparia	Grape vine	2		

Deciduous Woodland, Altered
DWA-1:

DECIDUOUS WOODLAND, ALTERED					
DWA-1					
Non-Native	Scientific Name	Common Name	Cover	Diameter (inches)	Comments
CANOPY		**20-40 ft height**	**Total Cover: 3 to 4**		
	Acer saccharinum	Silver maple	1	6 to 20	
	Acer negundo	Boxelder	2	4 to 20	
	Celtis occidentalis	Hackberry	+	4 to 20	
	Fraxinus pennsylvanica	Green ash	1 to 2	10 to 23	
	Juglans nigra	Black walnut	+	3 to 18	
	Populus deltoides	Eastern cotonwood	2	15 to 60	
	Salix nigra	Black Willow	+	6 to 40	
	Ulmus americana	American elm	1	4 to 20	
x	*Ulmus pumila*	Siberian elm	+	4 to 15	
UNDERSTORY/SHRUB LAYER		**4 to 12 ft height**	**Total Cover: 2 to 3**		**Patchy to dense**
	Cornus sericea	Red osier dogwood	+		
	Fraxinus pennsylvanica	Green ash	1		Whips
x	*Lonicera tatarica*	Tartarian honeysuckle	2		Co-dominant
x	*Rhamnus cathartica*	Buckthorn	2		Co-dominant
	Sambucus canadensis	American elderberry	+		
	Sambucus racemosa	Red elderberry	+		
	Vitis riparia	Grape vine	1		
GROUND LAYER		**to 4 ft height**	**Total Cover: 3**		**Sparse to patchy**
Graminoids					
x	*Bromus inermis*	Smooth brome	+		
	Carex blanda	Light green wood sedge	1		
	Carex communis	Dark green wood sedge	1		
x	*Phalaris arundinacea*	Reed canary grass	1		
x	*Poa pratensis*	Kentucky bluegrass	1		
Forbs					
	Ambrosia artemisifolia	Common ragweed	1		
	Ambrosia trifida	Giant ragweed	1		
x	*Arctium minus*	Common burdock	1		
	Armbrosia trifida	Giant ragweed	1		
x	*Cannabis sativa*	Hemp	1		
x	*Circium arvense*	Cannada thistle	+		
	Laportia canadensis	Wood nettle	1		
x	*Leonurus cardiaca*	Motherwort	2		
x	*Lonicera tatarica*	Tartarian honeysuckle	1		
	Maianthemum racemosum	Falso Solomon's seal	+		
x	*Melilotus albus*	White sweetclover	+		
	Parthenecisus quinquefolia	Virginia creeper	1		
	Polygonum amphibium	Water smartweed	+		
x	*Rhamnus cathartica*	Common buckthorn	1		
x	*Rumex crispus*	Curly dock	+		
	Solidago gigantea	Giant goldenrod	1		
	Thalictrum dasycarpum	Tall meadow rue	+		
x	*Ulmus pumila*	Siberian elm	+		
	Urtica dioica	Stinging nettle	1		
	Viola spp	Violets	+		
LIANA LAYER			**Total Cover: 4 to 5**		
	Vitis riparia	Wild grape	2		Sometimes forms thickets.

Deciduous Woodland, Altered
DWA-2:

DWA-2					
Non-Native	Scientific Name	Common Name	Cover	Diameter (inches)	Comments
CANOPY		**20-40 ft height**	**Total Cover: 3 to 4**		
x	*Acer ginnala*	Amur maple	+ to 1	2 to 5	
	Acer negundo	Boxelder	2	4 to 20	
	Betula nigra	River birch	+	4 to 10	
	Fraxinus pensylvanica	Green ash	+ to 1	2 to 10	
	Juglans nigra	Black walnut	+ to 1	2 to 5	
	Juniperus virginiana	Eastern redcedar	1	2 to 8	
	Malus spp	Crabapple	+	5	
	Picea glauca	White spruce	+	4	
	Pinus strobus	White pine	+	8	
	Populus deltoides	Eastern cottonwood	1	5 to 18	
	Prunus serotina	Black cherry	1	3 to 8	
	Quercus macrocarpa	Bur oak	+	3 to 8	
	Salix nigra	Black Willow	+	6 to 40	
	Tilia americana	Basswood	+	4	
	Ulmus americana	American elm	1	4 to 20	
x	*Ulmus pumila*	Siberian elm	4	3 to 20	Dominant
UNDERSTORY/SHRUB LAYER		**4 to 12 ft height**	**Total Cover: 2 to 3**		**Patchy to dense**
x	*Acer ginnala*	Amur maple			
	Cornus sericea	Red osier dogwood	+		
x	*Lonicera tatarica*	Tartarian honeysuckle	2		Co-dominant
x	*Rhamnus cathartica*	Buckthorn	2		Co-dominant
	Sambucus racemosa	Green ash	+		Whips
	Sambucus racemosa	Red elderberry			
	Viburnum trilobum	Highbush cranberry			
GROUND LAYER		**to 4 ft height**	**Total Cover: 3**		**Sparse to patchy**
Graminoids					
x	*Bromus inermis*	Smooth brome	+		
x	*Elymus repens*	Quack grass	1		
x	*Poa pratensis*	Kentucky bluegrass	1		
x	*Phalaris arundinacea*	Reed canary grass	1		
Forbs					
	Achilea millefolium	Yarrow	+		
x	*Arctium minus*	Common burdock	1		
	Aster lanceolatus	Panicled aster	+		
x	*Circium arvense*	Cannada thistle	+		
	Hackelia virginiana	Virginia stick seed	1		
x	*Linurus cardiaca*	Motherwort	2		
x	*Lonicera tatarica*	Tartarian honeysuckle	1		
x	*Melilotus albus*	White sweet clover	+		
x	*Rhamnus cathartica*	Common buckthorn	1		
	Solidago canadensis	Canada goldenrod	2		
x	*Ulmus pumila*	Siberian elm	+		

Lowland Hardwood Forest (LHF)

LOWLAND HARDWOOD FOREST					
Non-Native	Scientific Name	Common Name	Cover	Diameter (inches)	Comments
CANOPY		**20-40 ft height**	**Total Cover: 3 to 4**		
	Acer saccharinum	Silver maple	+	6 to 20	
	Acer negundo	Boxelder	2	4 to 20	
	Celtis occidentalis	Hackberry	+	4 to 20	
	Fraxinus pennsylvanica	Green ash	1 to 2	10 to 23	
	Juglans nigra	Black walnut	+	3 to 18	
	Populus deltoides	Eastern cotonwood	2	15 to 60	
	Salix nigra	Black Willow	+	6 to 40	
	Ulmus americanum	American elm	1	4 to 20	
	Ulmus pumila	Siberian elm	+	4 to 15	
UNDERSTORY/SHRUB LAYER		**4 to 12 ft height**	**Total Cover: 2 to 3**		**Patchy to dense**
	Cornus sericea	Red osier dogwood	+		
	Fraxinus pennsylvanica	Green ash	1		Whips
	Lonicera tatarica	Tartarian honeysuckle	2		Co-dominant
	Rhamnus cathartica	Buckthorn	2		Co-dominant
	Sambucus canadensis	American elderberry	+		
	Sambucus racemosa	Red elderberry	+		
	Vitis riparia	Grape vine	1		
GROUND LAYER		**to 4 ft height**	**Total Cover: 3**		**Sparse to patchy**
Graminoids					
	Bromus inermis	Smooth brome	+		
	Phalaris arundinacea	Reed canary grass	1		
	Poa pratensis	Kentucky bluegrass	1		
Forbs					
	Ambrosia artemisifolia	Common ragweed	+		
	Ambrosia trifida	Giant ragweed	1		
x	*Arctium minus*	Common burdock	+		
	Armbrosia trifida	Giant ragweed	1		
x	*Circium arvense*	Cannada thistle	+		
x	*Leonurus cardiaca*	Motherwort	1		
	Lonicer tatarica	Tartarian honeysuckle	1		
	Maianthemum racemosum	Falso Solomon's seal	+		
	Parthenecisus quinquefolia	Virginia creeper	1		
x	*Rhamnus cathartica*	Common buckthorn	1		
	Rumex crispus	Curly dock	+		
	Solidago gigantea	Giant goldenrod	1		
x	*Ulmus pumila*	Siberian elm	+		
	Urtica dioica	Stinging nettle	1		
	Viola spp	Violets	+		
LIANA LAYER			**Total Cover: 4 to 5**		
	Clematis virginiana	Virgin's bower	+		
	Vitis riparia	Wild grape	2		Sometimes forms thickets.

Grassland with Sparse Deciduous Trees (on Zumbro soil unit)

GRASSLAND WITH SPARSE DECIDUOUS TREES					
Non-Native	Scientific Name	Common Name	Cover	Diameter (inches)	Comments
The Flat					
CANOPY		**20-80 ft height**	**Total Cover: 2**		**Scattered**
	Acer negundo	Boxelder	2	10 to 18	Most abundant
	Populus deltoides	Eastern cottonwood	+	10 to 15	
	Fraxinus pennsylvanica	Green ash	1	10 to 15	
	Betula nigra	River birch	+	10 to 25	Planted by river
UNDERSTORY/SHRUB LAYER		**4 to 12 ft height**	**Total Cover: 2**		**Scattered**
x	*Lonicera tatarica*	Tartarian honeysuckle	1		
x	*Rhamnus cathartica*	Common buckthorn	2		
GROUND LAYER		**to 4 ft height**	**Total Cover: 5**		**Continuous**
Graminoids					
x	*Bromus inermis*	Smooth brome	5		
	Phalaris arundinacea	Reed canary grass	+		
x	*Festuca spp.*	Fescue species	1		
x	*Poa pratensis*	Kentucky bluegrass	3		
Forbs and others					
x	*Centauria*	Spotted knapweed	3		
x	*Cirsium arvense*	Canada thistle	1		
x	*Lonicera tatarica*	Tartarian honeysuckle	1		seedlings
x	*Rhamnus cathartica*	Common buckthorn	2		Seedlings
	Solidago canadensis	Canada goldenrod			
x	*Verbascum thapsis*	Common mullein	2		

Short Grasses with Sparse Tree Cover on Upland Soils

SHORT GRASSES WITH SPARSE TREE COVER ON UPLAND SOILS					
CANOPY		**20-80 ft height**	**Total Cover: 2**		
	Populus deltoides	Eastern cottonwood	1	20 to 60	
	Acer saccharinum	Silver maple	1	35	
	Celtis occidentalis	Hackberry	+	4 to 16	
	Fraxinus pensylvanica	Green ash	1	4 to 10	
	Juglans nigra	Black walnut	+	2 to 8	
	Ulmus americana	American elm	+	3 to 12	
UNDERSTORY/SHRUB LAYER		**4 to 12 ft height**	**Total Cover: 2**		
	Amorpha fruticosa	Wild indigo bush			Planted
	Aronia melanocarpa	Chokeberry			Planted
	Cornus racemosa	Gray dogwood			Planted
	Cornus sericea	Red-osier dogwood			
x	*Lonicera tatarica*	Tartarian honeysuckle			
x	*Rhamnus cathartica*	Common buckthorn			
	Sambucus canadensis	American elderberry			
	Sambucus racemosa	Red elderberry			
	Viburnim triloba	Highbush cranberry			Planted
GROUND LAYER		**to 4 ft height**	**Total Cover: 3**		
Graminoids					
x	*Bromus inermis*	Smooth brome	1		
	Bromus tectorum	Cheat grass			
x	*Elymus repens*	Quack grass	1		
	Elymus riparia	Riverbank rye	+		
	Elymus virginiana	Wild rye	+		
x	*Phalaris arundinacea*	Reed canary grass	1		
x	*Poa pratensis*	Kentucky bluegrass	2		
Forbs					
x	*Arctium minus*	Burdock			
	Artemesia trifida	Giant ragweed			
	Asclepias syriaca	Common milkweed	2		
x	*Berteroa incana*	Hoary alyssum	2		
	Parthenocissus quinquefolia	virginia creeper	+		
	Polygonum amphibium	Water smartweed			
x	*Rhamnus cathartica*	Common buckthorn	2 to 4		
x	*Rumex crispa*	Curly dock			
	Silphium perfoliatum	Cup plant			
	Solidago canadensis	Old-field goldenrod	2		
	Thalictrum dasycarpum	Tall Meadow rue			
	Vitis riparia	wild grape	1		

APPENDIX B. Plant Species for Restoration at Vermillion Linear Park Property

Dry Savanna, Southern (UPs14)
Sparsely treed communities with grass-dominated herbaceous ground layers on nearly level to steeply sloping sites with droughty soils. Moderate growing season moisture deficits occur during most years, and severe moisture deficits are frequent, especially during periodic regional droughts. Trees are open grown, typically small and gnarled. Graminoid cover is patchy to continuous. Mid-height grasses are most important, although tallgrass species are often important as well, especially in more mesic spots. Species composition varies with variation in soils and topography. Little bluestem and porcupine grass are usually dominant, and big bluestem and Indian grass are usually present and often more common than in dry prairie. Pennsylvania sedge, a woodland species, is often present. Forb cover is sparse to patchy. Forb diversity is similar to that of dry prairie. The fern ally rock spikemoss (*Saliginella rupestris*) is usually common on sand substrates. Vines are a minor component. Shrubs layer is typically patchy and composed of low semi-shrubs, taller shrubs, and oak seedlings and stunted oak "grubs". Trees are scattered individuals or scattered small clumps, with total cover typically betweer 24% and 50%. Bur oak is most common, but northern pin oak is also usually present.

Genus	Species	Common Name	Freq*	Genus	Species	Common Name	Freq*
Trees							
Quercus	*macrocarpa*	Bur oak	43				
Quercus	*ellipsoidalis*	Pin oak	27				
Semi-Shrubs							
Amorpha	*canescens*	Leadplant	53				
Rosa	*arkansana*	Prairie rose	43				
Shrubs							
Ceanothus	*americanus*	New Jersey tea	9				
Prunus	*virginiana*	Chokecherry					
Corylus	*americana*	Amer. Hazelnut					
Rhus	*glabra*	Smooth sumac					
Amelanchier	*humilis or alnifolia*	Low juneberry					
Forbs				*Potentilla*	*arguta*	Tall cinquefoil	36
Allium	*stellatum*	Prairie wild onion	18	*Ratibida*	*pinnata*	Gray-headed coneflower	9
Anemone	*cylindrica*	Long-headed thimbleweed	36	*Rudbeckia*	*hirta*	Black-eyed Susan	9
Anemone	*patens*	Pasque-flower	27	*Senecio*	*plattensis*	Prairie ragwort	27
Antennaria	*spp.*	Pussytoes	27	*Silene*	*antirrhina*	Sleepy catchfly	36
Artemisia	*campestris*	Tall wormwood	45	*Solidago*	*nemoralis*	Gray goldenrod	73
Artemisia	*frigida*	Prairie sagewort	18				
Artemisia	*ludoviciana*	Western mugwort	18	*Solidago*	*missouriensis*	Missouri goldenrod	18
Asclepias	*verticillata*	Whorled milkweed	18	*Solidago*	*rigida*	Stiff goldenrod	18
Asclepias	*viridiflora*	Green milkweed	45	*Solidago*	*ptarmicoides*	Upland white aster	9

Asclepias	*syriaca*	Common milkweed	18	*Solidago*	*speciosa*	Showy goldenrod	9
Asclepias	*tuberosa*	Butterfly-weed	27	*Thalictrum*	*dasycarpum*	Tall meadow-rue	9
Aster	*ericoides*	Heath aster	18	*Tradescantia*	*occidentalis*	Western spiderwort	36
Aster	*sericeus*	Silky aster	45	*Verbena*	*stricta*	Hoary vervain	27
Aster	*oblongifolius*	Aromatic aster	18	*Veronicastrum*	*virginicum*	Culver's root	9
Aster	*oolentangiensis*	Sky-blue aster	27	*Viola*	*pedatifida*	Prairie bird-foot violet	27
Aster	*prenanthoides*	Crooked-stemmed aster	9	*Zizia*	*aptera*	Heart-leaved alexanders	9
Aster	*laevis*	Smooth aster	9				
Astragalus	*crassicarpus*	Buffalo-bean	27	**Grasses, Rushes and Sedges**			
Calylophus	*serrulata*	Toothed evening primrose	27	*Andropogon*	*gerardii*	Big bluestem	67
Campanula	*rotundifolia*	Harebell	27	*Aristida*	*basiramea*	Base-branched three-awn	18
Chrysopsis	*villosa*	Prairie golden aster	18	*Bouteloua*	*curtipendula*	Side-oats grama	23
Comandra	*umbellata*	Bastard toad-flax	36	*Bouteloua*	*hirsuta*	Hairy grama	30
Coreopsis	*palmata*	Stiff tickseed	18	*Bromus*	*kalmii*	Kalm's brome	9
Cycloloma	*atriplicifolium*	Winged pigweed	9	*Calamovilfa*	*longifolia*	Sand reed-grass	37
				Carex	*foenea*	Hay sedge	53
Dalea	*purpurea*	Purple prairie-clover	55	*Carex*	*pensylvanica*	Pennsylvania sedge	37
Dalea	*villosa*	Silky prairie-clover	9	*Carex*	*tenera*	Marsh-straw sedge	9
Dalea	*candida*	White prairie-clover	9	*Carex*	*muhlenbergii*	Muhlenberg's sedge	37
Delphinium	*carolinianum*	Prairie larkspur	18	*Carex*	*siccata*	Hay sedge	9
Desmodium	*illinoense*	Illinois tick-trefoil	9	*Cyperus*	*schweinitzii*	Schweinitz' cyperus	27
Euphorbia	*corollata*	Flowering spurge	18	*Cyperus*	*lupulinus*	Hop-like cyperus	27
				Digitarria	*cognatum*	Fall witch grass	23
Helianthemum	*bicknellii*	Hoary frostweed	9	*Elymus*	*wiegandii*	Canada wild rye	9
Helianthus	*pauciflorus*	Stiff sunflower	36	*Elymus*	*trachycaulus*	Slender wheatgrass	18
Kuhnia	*eupatorioides*	False boneset	18	*Eragrostis*	*spectabilis*	Purple lovegrass	53
Lathyrus	*venosus*	Veiny pea	9	*Koeleria*	*pyramidata*	June-grass	80
Lespedeza	*capitata*	Round-headed bush-clover	36	*Muhlenbergia*	*cuspidata*	Plains muhly	27
Liatris	*punctata*	Dotted blazing star	45	*Panicum*	*perlongum*	Long-leaved panic grass	37
Liatris	*aspera*	Rough blazing star	18	*Panicum*	*oligosanthes*	Scribner's panic grass	30
Linum	*sulcatum*	Grooved yellow flax	18	*Panicum*	*wilcoxianum*	Wilcox's panic grass	27
Lithospermum	*caroliniense*	Hairy	27	*Panicum*	*virgatum*	Switchgrass	37

		puccoon					
Lithospermum	*incisum*	Narrow-leaved puccoon	27	*Panicum*	*leibergii*	Leiberg's panic grass	9
Mirabilis	*hirsuta*	Hairy four-o'clock	45	*Schizachyrium*	*scoparium*	Little bluestem	70
Monarda	*fistulosa*	Wild bergamot	27	*Sorghastrum*	*nutans*	Indian grass	40
Oenothera	*biennis*	Common evening-primrose	9	*Sporobolus*	*cryptandrus*	Sand dropseed	45
Oenothera	*clelandii*	Cleland's evening-primrose	18	*Sporobolus*	*heterolepis*	Prairie dropseed	37
Onosmodium	*molle*	False gromwell	9	*Stipa*	*spartea*	Porcupine-grass	55
Oxalis	cmx.	Wood-sorrel	9	*Stipa*	*comata*	Needle-and-thread grass	9
Pediomelum	*argophyllum*	Silvery scurf-pea	9				
Pediomelum	*esculentum*	Prairie-turnip	9				
Penstemon	*grandiflorus*	Large-flowered beard-tongue	45				
Penstemon	*gracilis*	Slender beard-tongue	9				
Physalis	*virginiana*	Ground-cherry	36				
Physalis	*heterophylla*	Clammy ground-cherry	36				

Mesic Prairie, Southern (UPs23) and Mesic Oak Savanna, Southern (UPs24)

Genus	Species	Common Name	Likelihood of Establishment	Conservation Coefficient (Milburn, 2007)	Commonly Commercially Available
Trees					
Quercus	*macrocarpa*	Bur oak	M	5	x
Shrubs					
Amorpha	*canescens*	Lead-plant	L	7	x
Prunus	*virginiana*	Chokecherry	M	3	x
Rosa	*arkansana*	Prairie rose	M	5	x
Salix	*humilis*	Prairie willow	M	6	x
Symphoricarpos	*abla*	Snowberry	M	6	
Grasses, Rushes and Sedges					
Andropogon	*gerardii*	Big bluestem	M	4	x
Bromus	*kalmii*	Kalm's brome	M	8	x
Carex	*bicknellii*	Bicknell's sedge	M	6	x
Carex	*meadii*	Mead's sedge	M	6	
Carex	*muhlenbergii*	Muhlenberg's sedge	M	4	x
Elymus	*canadensis*	Canada wild rye	H	4	x
Dicanthelium	*perlongum*	Long-leaved panic grass	M	7	
Panicum	*virgatum*	Switchgrass	H	2	x
Schizachyrium	*scoparium*	Little bluestem	M	4	x
Sorghastrum	*nutans*	Indian grass	M	5	x
Sporobolus	*heterolepis*	Prairie dropseed	L	10	x
Stipa	*spartea*	Porcupine-grass	M	9	x
Forbs					
Allium	*canadense*	Wild garlic	M	4	
Allium	*stellatum*	Prairie wild onion	M	9	x
Anemone	*canadensis*	Canada anemone	M	4	x
Anemone	*cylindrica*	Long-headed thimbleweed	M	6	x
Anemone	*virginiana*	Virginia thimbleweed	M	5	
Antennaria	*species*	Pussytoes	L	3	
Apocynum	*androsaemifolium*	Spreading dogbane	M	3	
Artemisia	*campestris*	Tall wormwood	M	4	x
Artemisia	*frigida*	Prairie sagewort	L	9	
Asclepias	*syriaca*	Common milkweed	H	1	
Asclepias	*tuberosa*	Butterfly-weed	M	6	x
Aster	*ericoides*	Heath aster	M	4	x
Aster	*laevis*	Smooth aster	M	6	x
Aster	*lanceolatus*	Panicled aster	M	4	x
Aster	*novae-angliae*	New England aster	H	3	x
Aster	*oolentangiensis*	Sky-blue aster	M	5	x
Astragalus	*canadensis*	Canada milk-vetch	L	8	x
Campanula	*rotundifolia*	Harebell	M	5	x
Comandra	*umbellata*	Bastard toad-flax	L	6	
Coreopsis	*palmata*	Stiff tickseed	M	8	x
Dalea	*candida*	White prairie-clover	M	8	x
Dalea	*purpurea*	Purple prairie-clover	M	7	x
Desmodium	*canadense*	Canadian tick-trefoil	M	4	x
Euphorbia	*corollata*	Flowering spurge	M	4	
Euthamia	*graminifolia*	Grass-leaved goldenrod	M	4	x
Fragaria	*virginiana*	Common strawberry	M	2	x
Galium	*boreale*	Northern bedstraw	M	5	x
Gentiana x	*billingtonii*	Closed gentian	L		

Geum	*triflorum*	Prairie smoke	M	7	x
Helianthus	*maximiliani*	Maximilian's sunflower	M		x
Helianthus	*pauciflorus*	Stiff sunflower	M		x
Heliopsis	*helianthoides*	Ox-eye	H	5	x
Heterotheca	*villosa*	Prairie golden aster	M	5	
Heuchera	*richardsonii*	Alum-root	M	7	x
Lathyrus	*venosus*	Veiny pea	M	6	
Lespedeza	*capitata*	Round-headed bush-clover	M	5	x
Liatris	*aspera*	Rough blazing star	M	5	x
Liatris	*ligulistylis*	Northern plains blazing star	M	7	x
Liatris	*pycnostachya*	Gayfeather	M	7	x
Lilium	*philadelphicum*	Wood lily	L	9	x
Lobelia	*spicata*	Rough-spiked Lobelia	M	7	x
Maianthemum	*racemosum*	False Solomon's-seal	M	5	x
Maianthemum	*stellatum*	Starry false Solomon's-seal	M	5	x
Mirabilis	*hirsuta*	Hairy four-o'clock	M	3	
Monarda	*fistulosa*	Wild bergamot	H	3	x
Oenothera	*biennis*	Common evening-primrose	H	1	x
Pedicularis	*canadensis*	Wood-betony	L	8	
Phlox	*pilosa*	Prairie phlox	L	7	x
Physalis	*heterophylla*	Clammy ground-cherry	M	3	
Potentilla	*arguta*	Tall cinquefoil	M	7	
Pycnanthemum	*virginianum*	Virginia mountain-mint	M	6	x
Ratibida	*pinnata*	Gray-headed coneflower	H	4	x
Rudbeckia	*hirta*	Black-eyed Susan	H	4	x
Sisyrinchium	*campestre*	Field blue-eyed grass	L	7	x
Solidago	*missouriensis*	Missouri goldenrod	M	7	x
Solidago	*nemoralis*	Gray goldenrod	M	4	x
Solidago	*ptarmicoides*	Upland white goldenrod	M	8	
Solidago	*speciosa*	Showy goldenrod	M	5	x
Thalictrum	*dasycarpum*	Tall meadow-rue	M	4	x
Tradescantia	*bracteata*	Bracted spiderwort	M	7	x
Veronicastrum	*virginicum*	Culver's root	M	6	x
Viola	*pedatifida*	Prairie bird-foot violet	L	9	x
Zizia	*aurea*	Golden alexanders	H	6	x
Ferns and Fern Allies					
Equisetum	*arvense*	Field horsetail	L	7	
Equisetum	*hyemale*	Tall scouring-rush	L	3	
Equisetum	*laevigatum*	Smooth scouring-rush	L	2	

Wet Prairie, Southern (WPs54)

Genus	Common Name	Likelihood of Establishment	Conservation Coefficient	Commonly Commercially Available
Quercus	Bur oak*			x
Shrubs				
Cornus racemosa	Gray dogwood*	H	2	x
Cornus sericea	Red-osier dogwood*	M	3	x
Salix bebbiana	Bebb's willow*	M	6	x
Salix discolor	Pussy willow*	M	3	x
Salix petiolaris	Slender willow*	M	5	x
Spiraea alba	Meadowsweet*	M	5	x
Forbs				
Achillea millefolium	Yarrow	H	1	x

Agastache foeniculum	Blue giant-hyssop	M	4	x
Anemone canadensis	Canada anemone	M	4	x
Apios americana	Groundnut	M	4	
Apocynum sibiricum	Clasping dogbane	M	3	
Asclepias incarnata	Swamp milkweed	H	4	x
Aster lanceolatus	Panicled aster	M	4	x
Aster novae-angliae	New England aster	H	3	x
Aster firmus	Red-stemmed aster	M	6	x
Aster umbellatus	Flat-topped aster	M	6	x
Calystegia sepium	Hedge bindweed			
Campanula aparinoides	Marsh bellflower	M	5	
Castilleja coccinea	Indian paintbrush	M	6	x
Chelone glabra	White turtlehead	M	7	x
Chenopodium desiccatum	Narrow-leaved lamb's quarters			
Cicuta maculata	Spotted water-hemlock	L	5	
Cirsium muticum	Swamp thistle	L	6	
Comandra umbellata	Bastard toad-flax	L	6	
Desmodium canadense	Canadian tick-trefoil	M	4	x
Epilobium species	Willow-herb (multiple species)	M	3 to 8	
Eupatorium maculatum	Spotted Joe-pye weed	M	4	x
Eupatorium perfoliatum	Common boneset	M	4	x
Euphorbia corollata	Flowering spurge	M	4	x
Euthamia graminifolia	Grass-leaved goldenrod	M	4	x
Fragaria virginiana	Common strawberry	H	2	x
Galium triflorum	Three-flowered bedstraw	M	6	
Gentiana x billingtonii	Closed gentian	L		
Gentianopsis procera	Smaller fringed gentian**	L	8	
Geum aleppicum	Yellow avens	H	3	
Geum canadense	White avens	H	2	
Helenium autumnale	Autumn sneezeweed	M	4	x
Helianthus giganteus	Giant sunflower*	M	4	x
Helianthus grosseserratus	Sawtooth sunflower*	M	3	x
Hypoxis hirsuta	Yellow star-grass	L	8	
Iris versicolor	Northern blue Flag	M	4	x
Krigia biflora	Two-flowered Cynthia	M	5	
Lathyrus palustris	Marsh vetchling	M	6	
Lathyrus venosus	Veiny pea	M	6	
Liatris ligulistylis	Northern plains blazing star	M	7	x
Liatris pycnostachya	Gayfeather	M	7	x
Lilium michiganense	Michigan lily	L	7	x
Liparis loeselii	Loesel's twayblade	L	6	
Lobelia siphilitica	Great lobelia	H	5	x
Lobelia spicata	Rough-spiked lobelia	M	7	
Lycopus americanus	Cut-leaved bugleweed	M	4	
Lycopus uniflorus	Northern bugleweed	M	5	
Lysimachia ciliata	Fringed loosestrife	M	5	x
Lysimachia quadriflora	Prairie loosestrife	L	8	
Lythrum alatum	Wing-angled	M	6	

	loosestrife			
Maianthemum stellatum	Starry false Solomon's-seal	M	5	x
Mentha arvensis	Common mint*			
Mimulus ringens	Purple monkey-flower	M	5	x
Oenothera perennis	Perennial evening-primrose*	M	6	
Oxalis species	Wood-sorrel			
Oxypolis rigidior	Cowbane			
Parnassia glauca	American grass-of-Parnassus	L	9	
Pedicularis canadensis	Wood-betony	L	8	
Pedicularis lanceolata	Swamp lousewort	L	8	
Phlox pilosa	Prairie phlox	L	7	x
Plantathera lacera	Ragged fringed-orchid	L	7	
Plantathera psycodes	Small purple fringed-orchid**	L	7	
Polygala sanguinea	Purple milkwort	L	5	
Polygala senega	Seneca snakeroot	L	7	x
Polygonum amphibium	Water smartweed	M	4	
Polygonum punctatum	Dotted smartweed	M	5	
Potentilla simplex	Old-field cinquefoil	H	2	
Prenanthes racemosa	Smooth rattlesnake-root	L	9	x
Pycnanthemum virginianum	Virginia mountain-mint	M	6	x
Ratibida pinnata	Gray-headed coneflower	H	4	x
Rubus pubescens	Dwarf raspberry	M	6	
Rudbeckia laciniata	Goldenglow	M	4	x
Saxifraga pensylvanica	Swamp saxifrage	L	7	
Scutellaria parvula	Prairie skullcap	M	6	
Senecio aurea	Golden ragwort	M	6	
Silphium perfoliatum	Cup-plant*	H	4	x
Sisyrinchium mucronatum	Pointed-petal blue-eyed grass	L	7	
Solidago canadensis	Canada goldenrod			
Solidago gigantea	Giant goldenrod			
Solidago riddellii	Riddell's goldenrod	M	7	x
Stachys palustris	Woundwort	M	4	
Teucrium canadense	Germander	M	4	x
Thalictrum dasycarpum	Tall meadow-rue	M	4	x
Triglochin maritima	Seaside arrow-grass	L	10	
Verbena hastata	Blue vervain	H	6	x
Vernonia fasciculata	Bunched ironweed	M	5	x
Veronicastrum virginicum	Culver's root	M	6	x
Vicia americana	American vetch			
Viola species	Violet (multiple species)	M	5	x
Zizia aurea	Golden alexanders	H	6	x
Grasses, Rushes and Sedges				
Agrostis hyemalis	Rough bent-grass	L	8	
Andropogon gerardii	Big bluestem	M	4	x
Bromus ciliatus	Fringed brome	M	6	x

Calamagrostis canadensis	Bluejoint	M	4	x
Calamagrostis stricta	Bog reed-grass	L	7	
Carex bebbii	Bebb's sedge	M	4	x
Carex buxbaumii	Buxbaum's sedge	L	8	
Carex conoidea	Field sedge	L	8	
Carex granularis	Granular sedge	M	3	
Carex haydenii	Hayden's sedge	L	8	
Carex interior	Inland sedge	L	7	
Carex lacustris	Lake-sedge	L	6	
Carex sartwellii	Sartwell's sedge	L	7	
Carex scoparia	Pointed-broom sedge	M	4	
Carex stipata	Awl-fruited sedge	H	2	x
Carex stricta	Tusssock-sedge	M	7	x
Carex tenera	Marsh-straw sedge	M	4	
Carex tetanica	Wood-sedge	L	7	x
Carex pellita	Woolly sedge	M	4	
Dicanthelium boreale	Northern panic grass	M	5	
Eleocharis compressa	Flattened spike-rush	L	8	
Eriophorum angustifolium	Narrow-leaved cotton-grass	L	9	
Glyceria striata	Fowl manna-grass	M	4	x
Hierochloe odorata	Sweet grass	M	7	x
Juncus nodosus	Knotty rush	M	5	
Juncus tenuis	Path rush	M	1	x
Juncus vaseyi	Vasey's rush	L	7	
Juncus dudleyi	Dudley's rush	M	3	
Leersia oryzoides	Rice cut grass	H	3	
Muhlenbergia frondosa	Swamp satin-grass	M	3	
Muhlenbergia glomerata	Clustered muhly grass	L	8	
Panicum virgatum	Switchgrass	H	2	x
Poa palustris	Fowl meadow-grass	M	5	
Scirpus atrovirens	Dark green bulrush	M	4	x
Scirpus cyperinus	Wool-grass	M	3	x
Sorghastrum nutans	Indian grass	M	5	x
Spartina pectinata	Prairie cord-grass	M	5	x
Sphenopholis obtusata	Prairie wedge-grass	L	8	
Ferns and Fern Allies				
Equisetum arvense	Field horsetail	L	7	
Equisetum pratense	Meadow horsetail	L	9	
Onoclea sensibilis	Sensitive fern	L	4	x
Ophioglossum pusillum	Adder's-tongue**	L	8	
Thelypteris palustris	Northern marsh-fern	L	7	x

*Plant small quantities of these species.

Terrace Forest, Southern (FFs59)

Genus	Species	Common Name	Likelihood of Establishment	Conservation Coefficient	Commonly Commercially Available
Canopy Trees (>10 m)					
Acer	*saccharinum*	Silver maple	H	5	x
Celtis	*occidentalis*	Hackberry	H	3	x
Fraxinus	*pennsylvanica*	Green ash	H	2	x
Populus	*deltoids*	Cottonwood	M	2	x
Salix	*Ingra*	Black willow	H	4	x
Tilia	*americana*	Basswood	M	5	x
Ulmus	*rubra*	Slippery elm	M	4	
*Ulmus**	*americana**	American elm*	H	3	x
Understory Trees					
Acer	*saccharinum*	Silver maple	H	2	x
Carya	*cordiformis*	Bitternut hickory	M	6	x
Celtis	*occidentalis*	Hackberry	H	3	x
Fraxinus	*pennsylvanica*	Green ash	H	2	x
Ostrya	*virginiana*	Ironwood	M	5	x
Tilia	*americana*	Basswood	M	5	x
*Ulmus**	*americana**	American elm*	H	3	x
*Ulmus**	*rubra**	Slippery elm*	M	4	
Shrubs					
Cornus	*amour*	Silky dogwood	M	4	x
Euonymus	*atropurpureus*	Wahoo	M	7	
Prunus	*virginiana*	Chokecherry	M	3	x
Ribes	*americanum*	Wild black currant	M	4	x
Ribes	*cynosbati*	Prickly gooseberry	H	3	x
Ribes	*missouriense*	Missouri gooseberry	H	4	x
Sambucus	*canadensis*	Common elder	H	3	x
Sambucus	*racemosa*	Red-berried elder	H	5	x
Viburnum	*lentago*	Nannyberry	M	4	x
Vines					
Menispermum	*canadense*	Canada moonseed	M	5	
Parthenocissus	spp.	Virginia creeper	H	5	x
Forbs					
Allium	*tricoccum*	Wild leek	L	6	x
Anemone	*quinquefolia*	Wood-anemone	M	6	x
Arisaema	*triphyllum*	Jack-in-the-pulpit	M	4	x
Aster	*cordifolius*	Heart-leaved aster	M	6	x
Aster	*ontarionis*	Ontario aster	M	6	
Aster	*pubentior*	Flat-topped aster	M	6	x
Campanula	*americana*	Tall bellflower	M	4	x
Caulophyllum	*thalictroides*	Blue cohosh	L	8	x
Circaea	*alpina*	Small enchanter's nightshade	L	7	
Circaea	*lutetiana*	Canada enchanter's nightshade	H	2	
Cryptotaenia	*canadensis*	Honewort	H	3	
Dicentra	*cucullaria*	Dutchman's-breeches	L	7	x
Enemion	*biternatum*	False rue-anemone	L	7	x

Erythronium	*albidum*	White trout-lily	L	7	x
Galium	*aparine*	Cleavers	H	1	
Galium	*triflorum*	Three-flowered bedstraw	M	4	
Geranium	*maculatum*	Wild geranium	M	4	x
Geum	*canadense*	White avens	H	2	
Hydrophyllum	*virginianum*	Virginia waterleaf	H	3	x
Impatiens	*capensis*	Touch-me-not	H	2	
Lilium	*michiganense*	Michigan lily	L	6	x
Maianthemum	*canadense*	Canada mayflower	M	5	x
Osmorhiza	*claytonii*	Clayton's sweet cicely	H	3	x
Phlox	*divaricata*	Blue phlox	L	7	x
Polygonatum	*biflorum*	Giant Solomon's-seal	M	4	
Ranunculus	*abortivus*	Kidney-leaf buttercup	H	1	
Rudbeckia	*laciniata*	Goldenglow	H	6	x
Sanguinaria	*canadensis*	Bloodroot	L	6	x
Sanicula	*gregaria*	Gregarious black snakeroot	H	3	
Smilacina	*racemosa*	Racemose false Solomon's-seal	M	5	x
Smilacina	*stellata*	Starry false Solomon's-seal	M	5	
Smilax	*lasioneura*	Carrion-flower	M	4	
Stachys	*palustris*	Woundwort	M	5	
Thalictrum	*dasycarpum*	Tall meadow-rue	M	4	x
Thalictrum	*dioicum*	Early meadow-rue	M	5	x
Trillium	*cernuum*	Nodding trillium	L	8	
Trillium	*flexipes*	Drooping trillium	L	7	
Uvularia	*grandiflora*	Yellow bellwort	L	7	x
Viola	spp.	Violet	M	5	x
Grasses, Rushes and Sedges					
Calamagrostis	*canadensis*	Bluejoint	H	5	x
Carex	*amphibola*	Ambiguous sedge	M	4	
Carex	*pedunculata*	Long-stalked sedge	L	7	
Carex	*sprengelii*	Sprengel's sedge	M	6	x
Carex	*radiata*	Stellate sedge	M	4	x
Cinna	*arundinacea*	Stout woodreed	M	5	
Elymus	*hystrix*	Bottlebrush grass	M	6	x
Elymus	*virginicus*	Virginia wild rye	H	6	x
Elymus	*wiegandii*	Canada wild rye	H	4	x
Glyceria	*striata*	Fowl manna-grass	M	4	x
Ferns and Fern Allies					
Matteuccia	*struthiopteris*	Ostrich-fern	M	5	x

*Plant disease resistant varieties.

River Shore, sand/gravel/cobble bottom (RVx32) and River Shore, rocky bottom (RVx43)

Genus	Species	Common Name	Likelihood of Establishment	Conservation Coefficient	Commonly Commercially Available
Upper Zone					
Shrubs					
Amorpha	*fruticosa*	False indigo	M	6	x
Salix	*exigua*	Sandbar willow	H		x
Forbs					
Asclepias	*incarnata*	Swamp milkweed	L	4	x
Iris	*versicolor*	Northern iris	H	4	x
Mimulus	*ringens*	Monkey flower	H	5	x
Physostegia	*virginiana*	Obedient plant	H	6	x
Polanisia	*dodecandra*	Clammy weed	M		
Scirpus	*cyperinus*	Woolgrass	M	3	x
Stachys	*palustris*	Woundwort	H	4	
Verbena	*hastata*	Blue vervain	L	4	
Vernonia	*fasciculata*	Ironweed	M	5	x
Grasses, sedges, and rushes					
Bulboschoenus	*fluviatilis*	River bulrush	H	4	x
Calamagrostis	*canadensis*	Canada bluejoint	H	4	x
Carex	*emoryi*	Emory's sedge	M	7	
Schoenoplectus	*acutus*	Hardstem bulrush	H	6	x
Schoenoplectus	*tabernaemontani*	Softstem bulrush	H	4	x
Lower Zone					
Graminoids					
Bulboschoenus	*fluviatilis*	River bulrush	H	4	x
Carex	*bebbii*	Bebb's sedge	H	5	x
Carex	*lacustris*	lake sedge	H	5	x
Carex	*stricta*	Tussock sedge	H	5	x
Carex	*utriculata*	Beaked sedge	H	7	
Cyperus	*oderatus*	Fragrant cyperus	M	4	
Cyperus	*squarrosus*	Awned umbrella sedge	M	2	
Echinochloa		Barnyard grass	H	1	x
Eleocharis	*erythropoda*	Spikerush	M	3	
Eleocharis	*intermedia*	Spikerush	M	6	
Eleocharis	*ovata*	Spikerush	M	6	
Eragrostis	*hypnoides*	Creeping lovegrass	H	4	
Eragrostis	*spp*	Lovegrass species	H		
Juncus	*nodosus*	Knotty rush	M	5	
Panicum	*philadelphicum*	Philadelphia panic grass	M	4	
Potentilla	*palustris*	Marsh cinquefoil	H		x
Schoenoplectus	*tabernaemontani*	Softstem bulrush	H	4	x
Sparganium	*eurycarpum*	Giant bur reed	H	5	x
Forbs					

Bidens	*cernua*	Nodding beggars ticks	H	3	x
Equisetum	*fluviatile*	Water horsetail	M	7	
Gnaphalium	*uliginosum*	Low cudweed	M		
Lindernia	*dubia*	False pimpernel	M	6	
Mimulus	*ringens*	Monkey flower	H	5	x
Mollugo	*verticilatta*	Carpetweed	H		
Penthorum	*sedoides*	Ditch stonecrop	M	3	
Sagittaria	*cuneata*	Arum-leaved arrowhead	M	6	
Sagittaria	*rigida*	Sessile-fruited arrowhead	M	7	
Veronica	*americana*	Speedwell	H	6	
Veronica	*catenata*	Speedwell	H		
Zosterella	*dubia*	Water stargrass	M		

Bulrush-Spikerush Marsh, northern (MRn93)

Genus	Species	Common Name	Likelihood of Establishment	Conservation Coefficient	Commonly Commerciall y Available
Shrubs					
Amorpha	*fruticosa*	False indigo	M	6	x
Forbs					
Acorus	*calamus*	Sweet flag	M		x
Alisma	*subcordatum*	Heart-leaved water-plantain	L	4	
Alisma	*triviale*	Ordinary water-plantain	L	4	x
Aster	*lanceolatus*	Panicled aster	M	4	x
Bidens	*species*	Beggar-ticks (multiple species)	M	5	
Boehmeria	*cylindrica*	False nettle	M	5	
Campanula	*aparinoides*	Marsh bellflower	M	5	
Cicuta	*bulbifera*	Bulb-bearing water-hemlock	L	7	
Cicuta	*maculata*	Spotted water-hemlock	L	5	
Epilobium	species	Willow-herb	L	3 to 8	
Eriocaulon	*aquaticum*	Pipewort	L	9	
Eupatorium	*maculatum*	Spotted Joe-pye weed	M	4	x
Eupatorium	*perfoliatum*	Common boneset	M	4	x
Eupatorium	*purpureum*	Sweet Joe-pye weed	M	4	x
Euthamia	*graminifolia*	Grass-leaved goldenrod	M	4	x
Galium	*labradoricum*	Marsh bedstraw	M	9	
Galium	*tinctorium*	Small bedstraw	M	5	
Galium	*trifidum*	Three-cleft bedstraw	M	6	
Hypericum	*majus*	Large St. John's-wort	M	5	
Impatiens	species	Spotted touch-me-not (two species)	H	2 to 5	
Iris	*versicolor*	Northern blue Flag	M	4	x
Ludwigia	*palustris*	Common water primrose	L	5	
Lycopus	*americanus*	Cut-leaved bugleweed	M	4	
Lycopus	*asper*	Rough bugleweed	M	4	
Lycopus	*uniflorus*	Northern bugleweed	M	5	
Lysimachia	*ciliata*	Fringed loosestrife	M	5	x
Lysimachia	*terrestris*	Yellow loosestrife	M	7	
Lysimachia	*thyrsiflora*	Tufted loosestrife	M	6	
Mentha	*arvensis*	Common mint	H	3	

Mimulus	*ringens*	Purple monkey-flower	M	5	x
Nuphar	*luteum*	Yellow pond-lily	L	9	
Nymphaea	*odorata*	Waterlily	L	6	
Physostegia	*virginiana*	Obedient plant	M	6	x
Polygonum	*amphibium*	Water smartweed	M	6	
Polygonum	*lapathifolium*	Nodding smartweed	M	2	
Polygonum	*pensylvanicum*	Pennsylvania smartweed	M	1	
Polygonum	*punctatum*	Dotted smartweed	M	5	
Potentilla	*norvegica*	Rough cinquefoil	M	1	
Ranunculus	*hispidus*	Hispid buttercup	M	6	
Ranunculus	*pensylvanicus*	Bristly buttercup	M	5	
Rumex	*maritimus*	Golden dock	L	1	
Sagittaria	*latifolia*	Broad-leaved arrowhead	M	3	x
Sagittaria	*rigida*	Sessile-fruited arrowhead	M	7	
Scutellaria	*galericulata*	Marsh skullcap	M	5	
Scutellaria	*lateriflora*	Mad-dog skullcap	M	5	
Sium	*suave*	Water-parsnip	L	5	
Sparganium	*androcladum*	Branching bur reed	L	8	
Sparganium	*eurycarpum*	Giant bur-reed	M	5	x
Sparganium	*erectum*	Unbranched bur reed	L	7	
Triadenum	*fraseri*	Marsh St. John's-wort	M	6	
Verbena	*hastata*	Blue vervain	H	6	x
Grasses, Rushes and Sedges					
Calamagrostis	*canadensis*	Bluejoint	M	4	x
Carex	*comosa*	Bristly sedge	M	5	x
Carex	*diandra*	Lesser-panicled sedge	L	9	
Carex	*scoparia*	Pointed-broom sedge	M	4	
Cyperus	*odoratus*	Fragrant cyperus	M	4	
Dulichium	*arundinaceum*	Three-way sedge	M	8	
Eleocharis	*acicularis*	Least spikerush	M	4	
Eleocharis	*elliptica*	Elliptic spikerush	M	7	
Eleocharis	*ovata*	Ovoid spikerush	M	6	
Glyceria	*borealis*	Northern manna grass	M	8	
Glyceria	*grandis*	Tall manna-grass	M	6	x
Juncus	*brevicaudatus*	Narrow-panicled rush	M	7	
Juncus	*effusus*	Soft rush	M	4	x
Juncus	*nodosus*	Knotty rush	M	5	
Juncus	*canadensis*	Canada rush	M	7	
Leersia	*oryzoides*	Rice cut grass	M	3	
Schoenoplectus	*acutus*	Hard-stemmed bulrush	M	6	x
Schoenoplectus	*fluviatilis*	River bulrush	M	4	x
Schoenoplectus	*smithii*	blunt-scale bulrush	M	8	
Schoenoplectus	*validus*	Softstem bulrush	M	4	x
Scirpus	*atrovirens*	Dark green bulrush	M	4	x
Scirpus	*cyperinus*	Wool-grass	M	3	x
Spartina	*pectinata*	Prairie cord-grass	M	5	x

Likelihood of establishment: H = high, M = moderate, L = low
Coefficient of Conservatism is a number from 0 to 10. This spectrum ranks how *conservative* or how much *fidelity* a species has for its native environment. For exotic species, they get a score of 0. A score of 1 is for species with very low fidelity and 10 for the most conservative ones. 4 or 5 would be in the middle. Anything 3 and less would be sort of a generalist. A score of 5 and over is considered a conservative species.

APPENDIX C. Methods for Controlling Exotic, Invasive Plant Species

TREES AND SHRUBS

Common Buckthorn, Tartarian Honeysuckle, Siberian Elm, and Black Locust are some of the most common woody species likely to invade native woodlands or prairies in Minnesota. Buckthorn and honeysuckle are European species that escaped urban landscapes and invaded woodlands in many parts of the country. They are exceedingly aggressive and, lacking natural disease and predators, can out-compete native species. Invasions result in a dense, impenetrable brush thicket that reduces native species diversity.

Siberian elm, native to eastern Asia, readily grows, especially in disturbed and low-nutrient soils with low moisture. Seed germination is high and seedlings establish quickly in sparse vegetation. It can invade and dominate disturbed areas in just a few years. Black locust is native to the southeastern United States and the very southeastern corner of Minnesota. It has been planted outside its natural range, and readily invades disturbed areas. It reproduces vigorously by root suckering and can form monotypic stands.

Chemical Control

The most efficient way to remove woody plants that are 1/2 inch or more in diameter is to cut the stems close to the ground and treat the cut stumps with herbicide immediately after they are cut, when the stumps are fresh and the chemicals are most readily absorbed. Failure to treat the stumps will result in resprouting, creating much greater removal difficulty.

In non-freezing temperatures, a glyphosate herbicide such as Roundup can be used for most woody species. It is important to obtain the concentrated formula and dilute it with water to achieve 10% glyphosate concentration. Adding a marker dye can help to make treated stumps more visible. In winter months, an herbicide with the active ingredient triclopyr must be used. Garlon 4 is a common brand name and it must be mixed with a penetrating oil, such as diluent blue. Do not use diesel fuel, as it is much more toxic in the environment and for humans.

Brush removal work can be done at any time of year except during spring sap flow, but late fall is often ideal because buckthorn retains its leaves longer than other species and is more readily identified. Cutting can be accomplished with loppers or handsaws in many cases. Larger shrubs may require brush cutters and chainsaws, used only by properly trained professionals.

For plants in the pea family, such as black locust, an herbicide with the active ingredient clopyralid can be more effective than glyphosate. Common brand names for clopyralid herbicides are Transline, Stinger, and Reclaim.

In the year following initial cutting and stump treatment, there will be a flush of new seedlings as well as resprouting from some of the cut plants. Herbicide can be applied to the foliage of these plants. Fall is the best time to do this, when desirable native plants are dormant and when the plant is pulling resources from the leaves down into the roots. Glyphosate and Krenite (active ingredient – fosamine ammonium) are the most commonly used herbicides for foliar application. Krenite prevents bud formation so the plants do not grow in the spring. Krenite can be effective, but results are highly variable. Glyphosate or a triclopyr herbicide such as Garlon can also be used. Glyphosate is non-specific and will kill anything green, while triclopyr targets broadleaf plants and does not harm graminoids. All herbicides should be applied by licensed applicators and should not be applied on windy days. Care should be taken to avoid application to other plants. "Weed Wands" or other devices that allow dabbing of the product can be used rather than spraying, especially for stump treatment.

Undesirable trees and shrubs can also be destroyed without cutting them down. Girdling is a method suitable for small numbers of large trees. Bark is removed in a band around the tree, just to the outside of the wood. If girdled too deeply, the tree will respond by resprouting from the roots. Girdled trees die slowly over the course of one to two years. Girdling should be done in late spring to mid-summer when sap is flowing and the bark easily peels away from the sapwood. Herbicide can also be used in combination with girdling for a more effective treatment.

Basal bark herbicide treatment is another effective control method. A triclopyr herbicide such as 10% Garlon 4, mixed with a penetrating oil, is applied all around the base of the tree or shrub, taking care so that it does not run off. If the herbicide runs off it can kill other plants nearby. More herbicide is needed for effective treatment of plants that are four inches or more in diameter.

Mechanical Control

Three mechanical methods for woody plant removal are hand-pulling (only useful on seedlings and only if few in number), weed wrenching (using a weed wrench tool to pull stems of one to two inches diameter), and repeated cutting. Pulling and weed wrenching can be done any time when the soil is moist and not frozen. The disadvantage to both methods is that they are somewhat time-consuming, as the soil from each stem should be shaken off. Weed wrenching also creates a great deal of soil disturbance and should not be used on steep slopes or anywhere that desirable native forbs are growing. The soil disturbance also creates opportunities for weed germination. This method is probably best used in areas that have very little desirable native plant cover.

Repeated cutting consists of cutting the plants (by hand or with a brush cutter) at critical stages in its growth cycle. Cutting in mid spring (late May) intercepts the flow of nutrients from the roots to the leaves. Cutting in fall (about mid-October)

intercepts the flow of nutrients from the leaves to the roots. Depending on the size of the stem, the plants typically die within three years, with two cuttings per year.

Stems, Seedlings and Resprouts

Prescribed burning is the most efficient, cost effective, and least harmful way to control very small stems, seedlings, and resprouts of all woody plants. It also restores an important natural process to fire-dependant natural communities (oak forests and prairies, for example). Burning can only be accomplished if adequate fuel (leaf litter) is present and can be done in late fall or early spring, depending site conditions.

If burning is not feasible, critical cutting in the spring is also effective, though it can impact desirable herbaceous plants as well. Foliar (leaf) application of a bud-inhibitor herbicide (Krenite) during fall is also effective. This method can also affect non-target species, though most natives will be dormant by that time.

Prickly ash

A native shrub, prickly ash can become excessively abundant, especially in areas that have been disturbed or grazed. Complete eradication may not be necessary, but management may target reducing the extent of a population. Removal is most easily accomplished in the same manner as for buckthorn – cutting shrubs and treating cut stumps with glyphosate herbicide. Cutting can be completed at any time of the year.

Disposal

The easiest and most cost-effective method to handle large amounts of brush is usually to stack it and burn it in winter. In areas where brush is not dense, it can be cut up into smaller pieces and left on the ground where it will decompose in one to three years. This method is especially useful on slopes to reduce erosion potential. Small brush piles can also be left in the woods as wildlife cover. Where there is an abundance of larger trees, cut trees may be hauled and chipped and used for mulch or as a biofuel. Alternatively, the wood can be cut and used for firewood, if a recipient can be found.

FORBS

Canada thistle

While native thistles are not generally problematic, exotics such as Canada thistle are clone-forming perennials that can greatly reduce species diversity in old fields and restoration areas (Hoffman and Kearns 1997). A combination of chemical and mechanical control methods may be needed at the property. Chemical control is most effective when the plants are in the rosette stage and least effective when the plants are flowering. A broadleaf herbicide such as 2,4-D would be appropriate for

the south grassland (G1), to minimize damage to native grasses. It is most effective when applied 10-14 days before the flowering stems bolt. It is applied at rate of 2-4 lb/acre using a backpack or tractor-mounted sprayer or in granular form. Dicamba could also be used, with the advantages that it can be applied earlier in the spring at a rate of 1 lb/acre. Plants that do not respond to treatment or that are more widely dispersed could be controlled mechanically. Another herbicide that is effective on Canada thistle is aminopyralid (brand name "Milestone"), which can be applied up to bud stage and still work. Although only very small amounts of aminopyralid are required, the herbicide is quite expensive.

Mechanical control, involving several cuttings per year for three or four years, can reduce an infestation, if timed correctly. The best time to cut is when the plants are just beginning to bud because food reserves are at their lowest. If plants are cut after flowers have opened, the cut plants should be removed because the seed may be viable. Plants should be cut at least three times throughout the season. Late spring burns can also discourage this species, but early spring burns can encourage it. Burning may be more effective in an established prairie, where competition from other species is good, than in an old field, where vegetation may not be as dense.

Sweet clover

White and yellow sweet clover are very aggressive annual exotic forb species that *increase* with fire. Sweet clover was found in the prairie and would be eliminated by treatment that eliminates the smooth brome, if prairie restoration occurs. However, it is a common plant in agricultural areas, so if restoration is implemented, the area should be surveyed for this species on an annual basis. Individual plants or small populations can be removed by hand-pulling. If seed production occurs, prodigious amounts of seed could be spread at the site.

Spotted Knapweed

Knapweed is a perennial species, and a pernicious one at that. It cannot be controlled with burning—like sweet clover it actually increases with fire. Also like sweet clover, hand-pulling individuals or a small groups of individuals is effective if populations are small. Volunteers do well for hand-pulling of knapweed. If knapweed populations are large, a bio-control (knapweed beetles) is recommended. Release of knapweed beetles (weevils) during summer is effective to achieve long-term control. Beetles can be purchased online and they are sent via the mail. Knapweed populations should be monitored each year to keep a record of the effectiveness of the bio-control. Spot treatment with a systemic herbicide can also be effective. Treatment should be done before plants can form seed, so late spring and early summer are best. Professional pesticide applicators are required for treatment.

Common Burdock and Common Mullein

Usually not as big of a concern as the other species listed here, Burdock and Mullein can sometimes become problematic: for Mullein especially on dry, low-nutrient soils, and for Burdock especially on disturbed sites. Sometimes burdock can actually trap small birds (by sticking to their feet), leaving them to die. Hand pulling or "spiking" with a shovel (cutting or "popping" with a spade shovel below the soil surface to remove most of the tap root) are effective, if populations are small. If populations are large, consider spot treating with systemic herbicide. Spot spraying should be done before the plants become too large, which takes copious amounts of herbicide and increases damage to nearby plants. Since both Burdock and Mullein are biennials, adequate control should be achieved eventually (3 to 5 years or so) if seeds are prevented from dispersing—but this takes persistence and diligence.

GRASSES

Smooth Brome

Conducting late-season (late June) burns in two consecutive years can be effective against smooth brome grass. Typically the burns are followed by seeding, but not always, depending on the quality of the site and the potential of the seed bank. This method will usually be sufficient to control smooth brome. (The usual practice is to collect seed from on-site first, and if there is not enough, then purchase local ecotype seed from off-site). Evaluate after the two years. If this is not working, perhaps try a cool-season overspray of a *grass-specific* herbicide—Fluazifop-P-butyl ("Fusilade") or sethoxydim ("Poast" or "Vantage") either in the spring (April) or in the fall (October). Using glyphosate as a cool-season overspray herbicide application is a last resort, since it kills everything. Take care when using herbicides near water bodies, though, since many of them are not aquatic-approved.

Reed canary grass

This species is extremely difficult to eradicate and requires repeated treatment over a period of one to three years. A combination of burning, chemical treatment and mowing can be used, in accessible areas, or chemical treatment alone in inaccessible areas. The combination method starts by burning in late spring to remove dead vegetation and to stimulate new growth. When new sprouts have reached a height of 4 to 6 inches, the site can be sprayed with a 5% solution of a glyphosate herbicide appropriate for wetland habitat (e.g. Rodeo). The site is then mowed in late summer, followed by chemical application after re-growth. This treatment will stimulate new growth and germination to deplete the seed bank. The sequence of chemical treatment and mowing are repeated for at least a second season, and possibly a third until the grass is completely eradicated. Then native grass and forb seed can be broadcast or drilled.

If reed canary is eradicated from an area, future management of the grassland, namely burning, will likely keep the reed canary in check. Monitoring and mapping new individuals or clumps should continue, however, and treated if burning is not

adequate. If the plants are small they can be removed by digging out the entire root. Generally though, chemical treatment is more feasible. If plants are clumped, they can be treated by tying them together, cutting the blades, and treat the cut surface with herbicide. Otherwise herbicide should only be applied in native planted areas on very calm days to avoid drift to non-target plants.

Appendix D. Ecological Contractors

Following is a list of contractors to consider for implementing the management plans. While this is not an exhaustive list, it does include firms with ecologists who are very knowledgeable with natural resource management. Unless otherwise noted, all firms do prescribed burning. Many other brush removal companies are listed in the yellow pages (under tree care), but most do not have knowledge or understanding of native plant communities. We recommend hiring firms that can provide ecological expertise. Additional firm listings can be found on the DNR website:
http://www.dnr.state.mn.us/gardens/nativeplants/index.html

Friends of the Mississippi River (FMR) has extensive experience working with landowners to implement natural resource management plans. FMR can assist landowners with obtaining funding for restoration and management projects and providing project management, including contractor negotiations, coordinating restoration and management work, and site monitoring and evaluation.

Applied Ecological Services, Inc.
21938 Mushtown Rd
Prior Lake, MN 55372
952-447-1919
www.appliedeco.com

Conservation Corps Minnesota
2715 Upper Afton Road, Suite 100
Maplewood, MN 55119
(651) 209-9900

Great River Greening
35 West Water St, Suite 201
St. Paul, MN 55107
651-665-9500
www.greatrivergreening.org

Minnesota Native Landscapes, L.L.C. 14088 Highway 95 N.E.
Foley, MN 56329
(320) 968-4222 Phone www.mnnativelandscapes.com

Prairie Restorations, Inc.
PO Box 305
Cannon Falls, MN 55009
507-663-1091
www.prairieresto.co

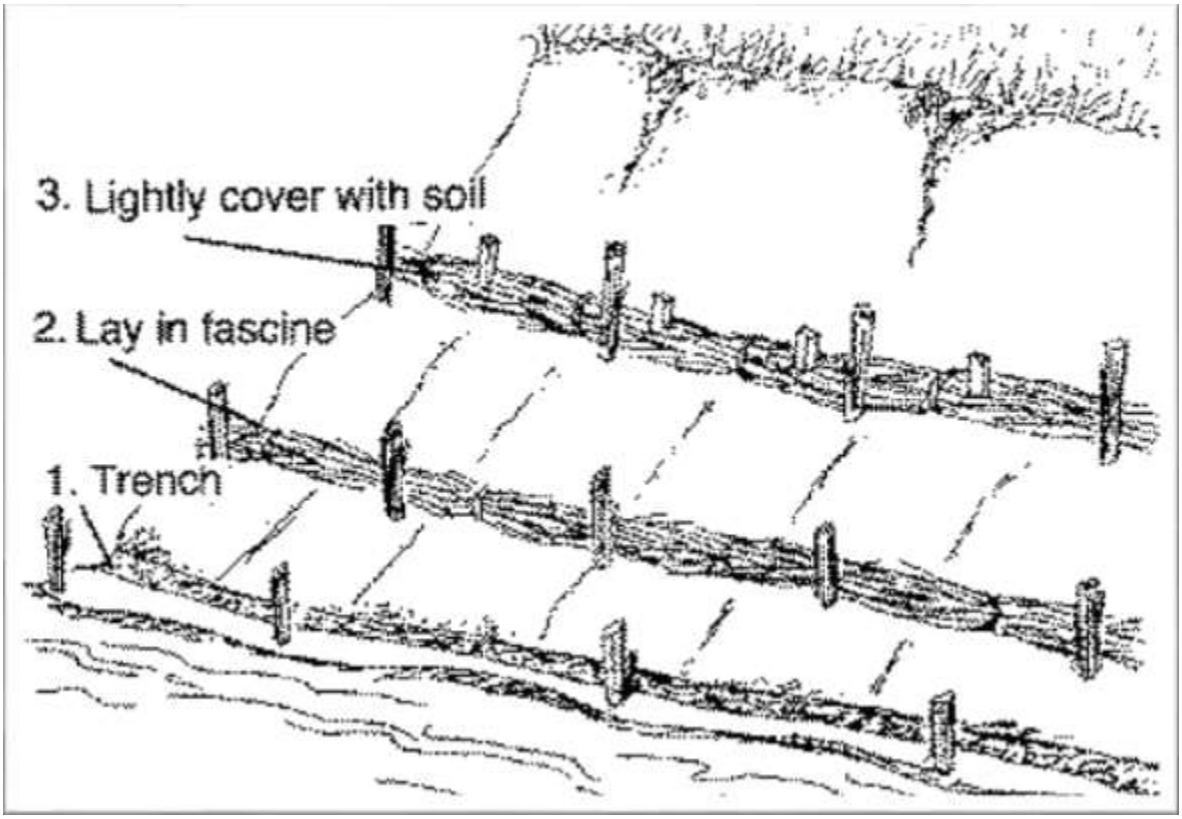
Stantec
2335 West Highway 36
St. Paul, MN 55113
651-604-4812
www.stantec.com

Wetland Habitats Restoration, LLC.
1397 Chelmsford St.
St. Paul, MN 55108
Cell: 612-385-9105
Fax: 636-333-8834
www.whr.mn
Email: wetlandhabitat@gmail.com

Appendix E. Shoreline Stabilization

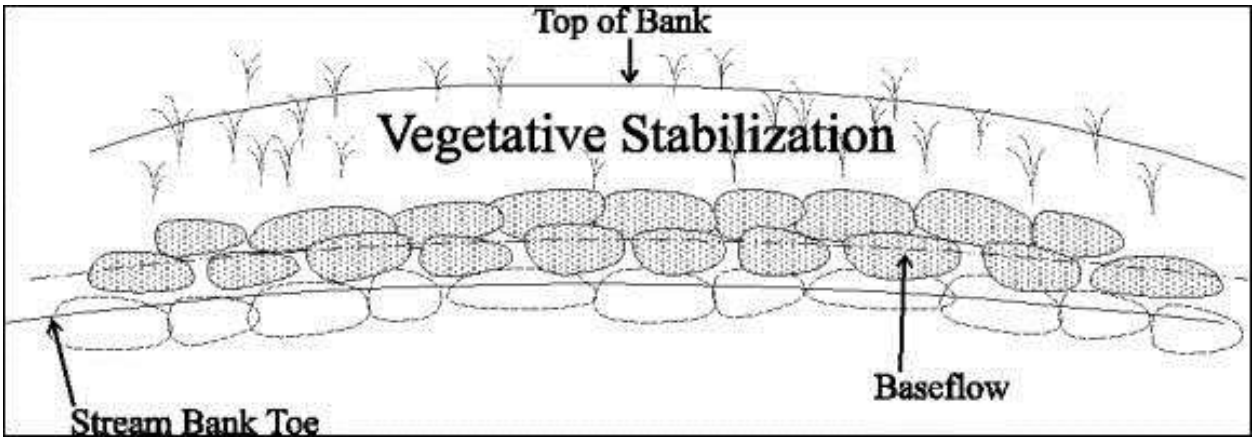
Fascines

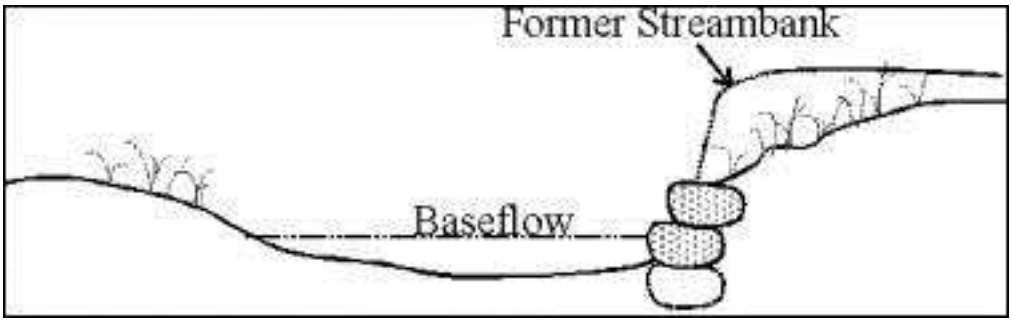
Fascines are long bundles of live branch cuttings placed in shallow trenches parallel or diagonal to streambanks, and secured with dead stout stakes into the soil, at or just above base flow elevation. They are used in combination with erosion control fabric. Fascines offer immediate reduction in surface erosion, are effective for streambanks, enhance colonization of native plant species by creating a microclimate for germination, and provide cooling shade for coldwater streams.
For installation, see *Minnesota Soil Bioengineering Handbook,* page 25.



Boulder Toe

Boulder toe is the practice of placing boulders at the bottom of a slope or bank to increase stability, effective in combination with live stakes, fascines, or brush mattresses. Boulder toe is immediately and highly effective stabilization on streambanks, it extends to the bank full elevation in the stream channel, and provides immediate protection for plantings while they establish in streams that have highly erosive velocities or frequent, severe stormwater events. Boulder toe does not provide wildlife habitat enhancement.
For installation, see *Minnesota Soil Bioengineering Handbook,* page 19.

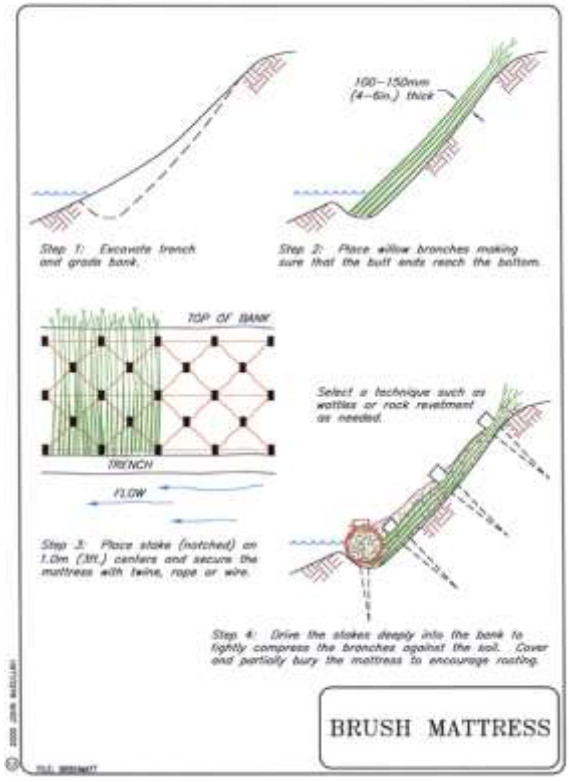




Brush Mattresses

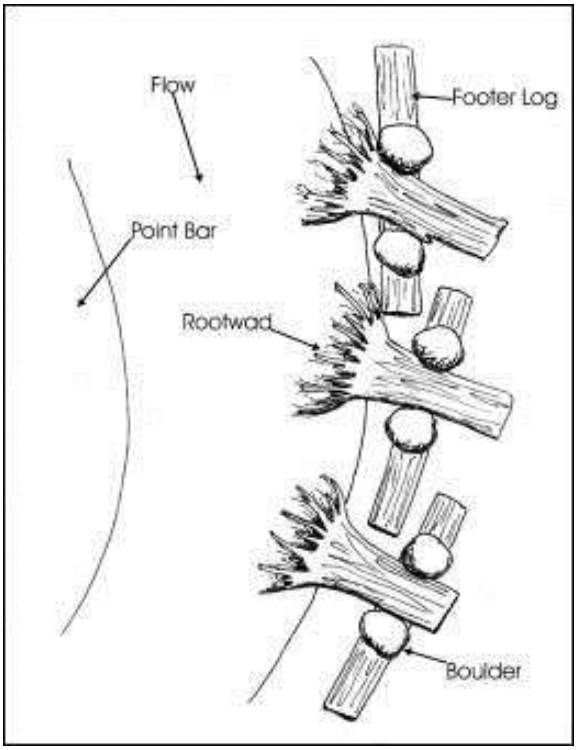
Brush mattresses are mats or mattresses created from woven wire, single strands of wire, or coir twine and live cut branches secured to a bank with stakes, wire, and twine.

For installation, see *Minnesota Soil Bioengineering Handbook,* page 23.

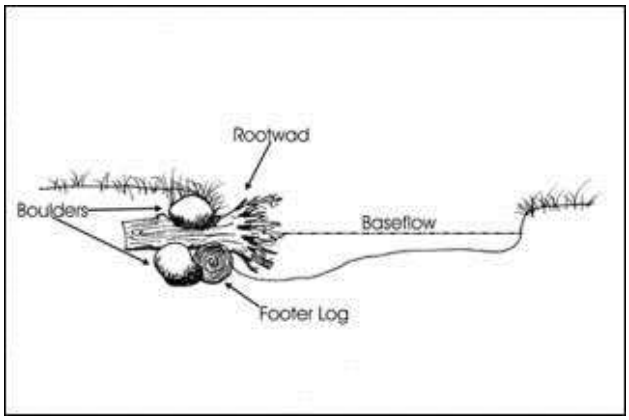


Brush Bundles
Brush bundles are live cut branches placed in a trench excavated along bank contours above bank full elevation. Alternating layers of live cut branches and compacted backfill repair small holes in banks and create a filter that keeps sediment from washing into streams. Also known as "brush layering" or "branch packing".
For installation, see *Minnesota Soil Bioengineering Handbook*, page 21.

Root Wads
Root wads are a form of soil bioengineering technique, which uses large tree trunks and boulders to stabilize the shoreline of very high-energy situations, like large rivers shorelines that receive the highest erosive flow velocities. The trunk and root flare is buried into a streambank to provide armored protection against erosion and create habitat for aquatic organisms, especially juvenile fish. Root wads can be harvested and reused from trees on site. Trees should be 14 to 20 feet long, with a minimum of 12" diameter trunk. Footer boulders are used to help anchor the root wads into the shoreline. Footer boulders should be 350 to 450 lbs, 24" to 30" in diameter uncut, undressed.
For installation, see *Minnesota Soil Bioengineering Handbook,* page 33.

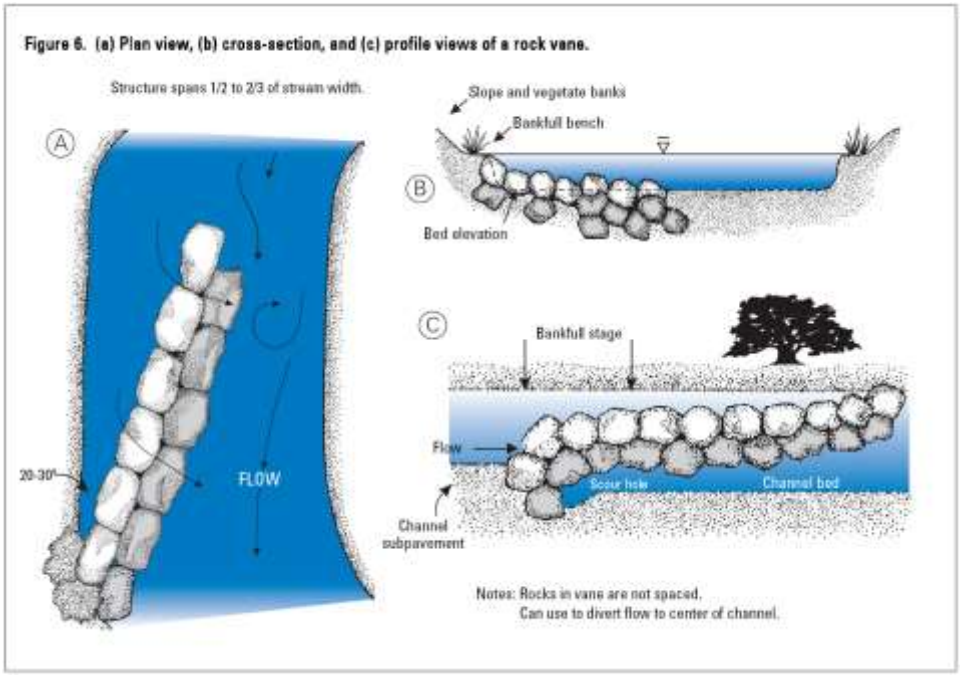


- Root wads alone do not provide enough stability. Placing boulders behind and over them and planting transplants behind boulders gets better results.



Rock Vanes
Rock vanes are structures made of boulders, placed in the stream channel to direct the current of the stream towards the center of the channel, away from the shore, to reduce bank erosion. This is an alternative to other hard armor techniques such as weir structures or gabions. Riffles and pools can be constructed to increase stream oxygenation and habitat. Boulders should be round, granitic stones, uncut, free from blast marks, with no

square surfaces. Limestone does not make a good material for this practice, since it is not durable enough.
For installation, see *Minnesota Soil Bioengineering Handbook,* page 31



Appendix F. Macroinvertebrate Monitoring Data

Metrics Used by Joe Beattie's Hastings High School Students

Family biotic index

This measure, also called the modified Hilsenhoff index, uses tolerance values to provide an indication of levels of pollution at the site. The lower the family biotic index, the greater the health of the stream.

$$\text{family biotic index} = \sum (X_i t)/n$$

where $\sum$ = the summation of $X_i t$

X_i = no. of individuals in each family
t = tolerance value for each family
n = number of individuals in sample

index	evaluation	organic pollution
0.00 – 3.75	excellent	pollution unlikely
3.76 – 4.25	very good	possible slight pollution
4.26 – 5.00	good	some pollution probable
5.01 – 5.75	fair	fairly substantial pollution likely
5.76 – 6.50	fairly poor	substantial pollution likely
6.51 – 7.25	poor	very substantial pollution likely
7.26 – 10.00	very poor	severe pollution likely

Grade the river

metric	A	B	C	D
number of families	12-15	9.1-11.9	6-9	<6
number of EPT families	9-12	6-8.9	3-5.9	<3
family biotic index	0-4	4.01-5.75	5.76-6.5	>6.5

Joe Beattie's Hastings' High School Students River Sampling Data since 1998.

	temp	F	EPT	PD	FBI
F 1998					3.1
	temp	**F**	**EPT**	**PD**	**FBI**
S 1999					4.4
	temp	**F**	**EPT**	**PD**	**FBI**
F 2000					3.6
S 2001	**temp**	**F**	**EPT**	**PD**	**FBI**
Team 1		7	4	85% Hydropsychidae	3.65
Team 2		3	3	89% Hydropsychidae	3.57
Team 3		6	5	74% Hydropsychidae	3.14
Team 4		6	3	82% Hydropsychidae	3.14
average		5.5	3.75	82.5%	3.38
F 2001	**temp**	**F**	**EPT**	**PD**	**FBI**
Team 1		8	4	85% Hydropsychidae	3.98
Team 2		8	2	73% Hydropsychidae	3.82

Team 3		6	3	87% Hydropsychidae	4
average		7.3	3	81.7%	3.93
S 2002	**temp**	**F**	**EPT**	**PD**	**FBI**
Team 1		4	4	84% Hydropsychidae	3.75
Team 2		14	7	27% Hydropsychidae	2.51
average		9	5.5	55.5%	3.12
F 2004	**temp**	**F**	**EPT**	**PD**	**FBI**
Team 1		16	6	49% Hydropsychidae	3.97
Team 2		16	7	21% Dytiscidae	2.40
Team 3		11	3	23% Hydropsychidae	3.92
Team 4		13	6	23% Gammaridae	3.09
Team 5		7	3	47% Hydropsychidae	3.59
average		12.6	5	32.6%	3.39
F 2005	**temp**	**F**	**EPT**	**PD**	**FBI**
Team 1		16	4	30% Gammaridae	5.1
Team 2		11	5	74% Hydropsychidae	4.1
Team 3		16	6	32% Pelecypoda	4.57
Team 4		17	7	26% Hydropsychidae	4.38
Team 5		14	5	36% Hydropsychidae	4.35
average		14.8	5.4	39.6%	4.48

F 2006	**temp**	**F**	**EPT**	**PD**	**FBI**
Team 1	49	15	5	24% Hydropsychidae	3.59
Team 2	47	7	5	71% Hydropsychidae	4.21
Team 3	50	11	3	82% Hydropsychidae	4.02
Team 4	48	15	5	51% Hydropsychidae	4.12
Team 5	48	10	4	78% Hydropsychidae	3.92
average	48.4	11.6	4.4	61%	3.97
S 2007	**temp**	**F**	**EPT**	**PD**	**FBI**
	67	7	3	40%	4.63
F 2007	**temp**	**F**	**EPT**	**PD**	**FBI**
Team 1	50	18	7	25% Hydropsychidae	5.34
Team 2	50	13	4	67% Hydropsychidae	4.13
Team 3	50	17	7	22% Hydropsychidae	4.36
Team 4	51	17	4	33% Hydropsychidae	5.23
Team 5	50	18	3	38% Hydropsychidae	4.96
average	50	16.6	5	37%	4.80
S 2008	**temp**	**F**	**EPT**	**PD**	**FBI**
	57	12	4	31%	5.14
F 2008	**temp**	**F**	**EPT**	**PD**	**FBI**
Team 1	57	10	3	40% Hydropsychidae	4.17
Team 2	54	14	3	21% Tipulidae	4.08
Team 3	43	16	5	40% Hydropsychidae	4.16

Team 4	50	15	4	48% Hydropsychidae	4.07
Team 5	59	22	5	20% Gastropoda	5.79
average	50.6	15.4	4	34%	4.45

S 2009	**temp**	**F**	**EPT**	**PD**	**FBI**
Team 1	48	11	5	30% Heptageniidae	4.01
Team 2	46	10	6	77% Hydropsychidae	3.95
Team 3	50	13	6	41% Hydropsychidae	4.02
Team 4	41	14	6	54% Hydropsychidae	3.14
Team 5	48	10	6	77% Hydropsychidae	3.95
average	46.6	11.6	5.8	56%	3.81
F 2009	**temp**	**F**	**EPT**	**PD**	**FBI**
Team 1	39	13	4	25% Tipulidae	3.8
Team 2	43	16	5	25% Tipulidae and 25% Hydropsychidae	3.9
Team 3	43	17	7	23% Hydropsychidae	4.2
Team 4	33	11	4	71% Tipulidae	3.4
Team 5	41	17	5	39% Gammaridae	4.0
average	39.8	14.8	5.0	37%	3.86
	temp	**F**	**EPT**	**PD**	**FBI**
S 2010	59	14	5	67% Baetidae	4.1
F 2010	**temp**	**F**	**EPT**	**PD**	**FBI**
Team 1 and 2	41	15	5	21% Gammaridae	4.2
Team 3 and 5	39	15	4	20% Elmidae	4.4
Team 4	40	13	4	53% Elmidae	4.6
average	40	14.3	4.3	31%	4.4
S 2011	**temp**	**F**	**EPT**	**PD**	**FBI**
Team 1	44	12	5	61% Chironomidae	5.3
Team 2	46	11	3	61% Chironomidae	5.5
Team 3	42	11	1	66% Chironomidae	5.6
average	44	11.3	3	63%	5.4
F 2011	**temp**	**F**	**EPT**	**PD**	**FBI**
Team 1 and 5	44 41	11	4	26% Hydropsychidae	3.6
Team 2	42	9	4	77% Hydropsychidae	3.6
Team 3	42	9	4	30% Hydropsychidae	2.9
Team 4	43	11	4	54% Hydropsychidae	3.9
average	42	10	4	47%	3.5
S 2012	**temp**	**F**	**EPT**	**PD**	**FBI**
Team 1	42	9	4	72% Baetidae	3.8
Team 2	46	9	4	55% Baetidae	3.6
Team 3	44	9	5	58% Baetidae	3.9
average	44	9	4.3	62%	3.8

Appendix G. Geology of the Hastings, MN Area

The following slide was provided courtesy of Travis Thiel, Dakota County SWCD: