Appendix A.3:
Zavoral Property Forest Management Plan

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Zavoral Property

Forest Management Plan
Scandia, Washington County, Minnesota
May 3, 2011

Client:

Tiller Corporation
PO Box 1480
Maple Grove, Minnesota 55311-6480

Consultant:

Critical Connections Ecological Services, Inc.
PO Box 184
Scandia, Minnesota 55073

Critical Connections
Ecological Services, Inc.

Introduction

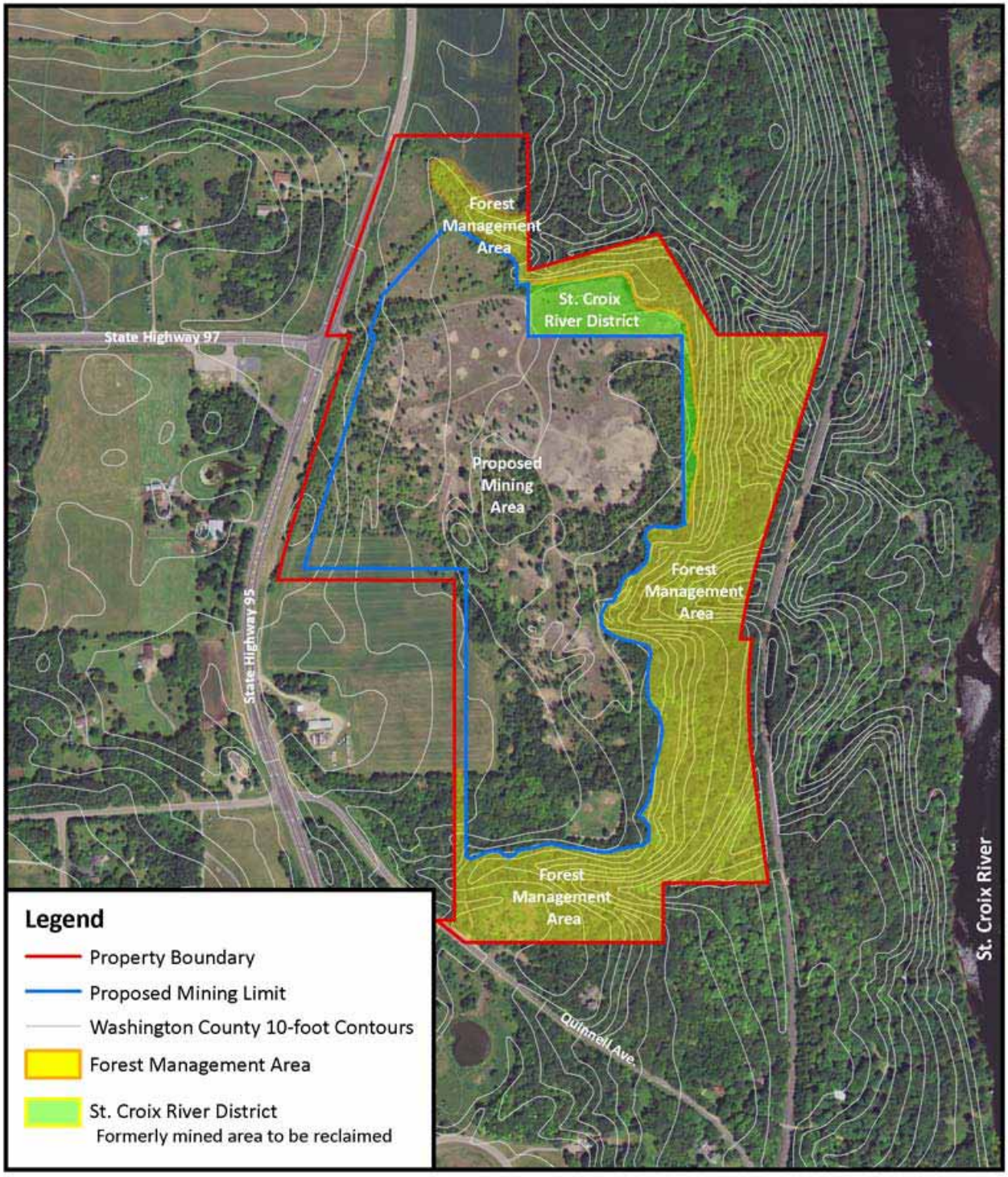
Critical Connections Ecological Services, Inc. (CCES) was retained by Tiller Corporation (Tiller) to create a forest management plan for forested areas located within the Zavoral property that will remain undisturbed during and after the proposed Zavoral Mining and Reclamation Project. The Zavoral site is located in the City of Scandia east of State Highways 95 and north of Quinnell Avenue. The proposed forest management area within the Zavoral property covers approximately thirty-eight acres of forested bluff and ravine systems that drain east toward the St. Croix River (**Figure 1**).

At the request of Tiller, CCES developed this forest management plan to assist Tiller and the Zavoral family with strategies to maintain and/or improve the health of the forested areas that surround the proposed mining and reclamation areas. The management plan is intended to compliment the reclamation plan for the proposed mining project and to provide recommendations to achieve a natural transition between the plant communities to be created during reclamation and the existing plant communities that will not be disturbed during the project. This forest management plan describes the overall health, capability, and current condition of the forested areas located on the Zavoral property outside of the project limits.

For preparation of the management plan, CCES reviewed historic air photos of the Zavoral site to access land use changes and how these changes have influenced forest and tree cover over the years. Eleven different years of historic air photos for the site were reviewed, ranging from 1938 through 2010. Over the past seventy years land use at the Zavoral property has transitioned from predominantly agricultural use in the late 1930's until the late 1960's when sand and gravel mining started to expand throughout the property. By the mid to late 1970's mining had displaced much of the former agricultural fields. **Appendix A** of this report includes figures of the eleven years of historic air photos overlayed by the project boundary, proposed mining limits, and the forested areas to be managed.

Over the past seventy years the forests within the Zavoral property have transitioned from mostly closed canopy forests with areas of open woodlands to an all closed-canopy forest that continues off-site to the north, south, and east. Today the forests within the Zavoral property are part of a larger contiguous forest unit within the St. Croix River Valley. The forested plant communities found within the Zavoral property currently consist mainly of mixed White Pine Hardwood Forest, Black Ash Seepage Swamp, and Maple Basswood Forest. These types of forested plant communities are unique to the St. Croix River Valley and provide a natural corridor for plants and wildlife in the region.

Tiller recognizes the value in protecting these natural forest communities located within the Zavoral property and is providing this forest management plan that outlines specific recommendations to achieve forest management goals. The management plan will be a useful guide to assist the forest management activities for the Zavoral property.



Zavoral Property
Site Location Map

0 187.5 375 750 1,125 1,500 Feet

NORTH

Critical Connections Ecological Services, Inc.

Figure 1

Existing Conditions

Forest Management Area

The forested area to be managed within the Zavoral property is located primarily on land that extends from the top of the bluff where mining previously took place and continues down slope towards the railroad tracks to the east. These steep forested slopes are made up of mature stands of mixed White Pine Hardwood Forest, Black Ash Seepage Swamp, and Maple Basswood Forest community types. This forest management area runs contiguously from the north to south property lines. The forest within the Zavoral property is a component of a larger forest ecosystem that extends beyond the property boundaries within the St. Croix River Valley. Within the ravine systems of the forest management area on the Zavoral property several forested upland, wetland plant communities and maderate cliff areas are located. **Figure 2** depicts the forest management area within the subject property and outlines the locations of the north, central, and south ravine areas.

The composition of plant communities in the forested areas within the Zavoral property is strongly influenced by the soils, landscape position, and available water and nutrients that occur on-site. Much of the forested areas occur on steep slopes on predominantly well-drained sandy soils that are generally east facing. Micro-habitats can be found within the three separate ravine systems and include areas of poorly drained soils with seeps as well as north facing and south facing slopes. These different soil types and positions in landscape further influence available water and nutrients for the trees growing within these areas and can provide distinct changes in plant community composition.

In general the forested areas within the management area are located below the bluff line and are included within the Minnesota Department of Natural Resources (MNDNR) designated Regionally Significant Ecological Area (RSEA) of the Twin Cities. The classification of RSEA denotes the presence of a high quality plant community with the potential to have suitable habitat for rare species located within it. On the Zavoral property the RSEA is composed primarily of the White Pine Hardwood forest along the steep east-facing bluff, Maple Basswood Forest within the southernmost ravine system, and Black Ash Seepage Swamp located along the eastern boundary of the site within ravine systems adjacent to the railroad tracks.

Using the MNDNR's plant community assessment protocols CCES determined that most of the upland forest that makes up the management area were found to have good to moderate ecological quality (B or C rank) with a diversity of tree species present. However, parts of the management area adjacent to the former agricultural lands and mining area are now becoming established by invasive plants like Common Buckthorn (*Rhamnus cathartica*). The areas where Buckthorn has become established only rank as having moderate ecological quality at best. Natural plant communities that rank as good quality (B rank) have their natural processes intact, but can show signs of past human impacts along with having low levels of exotic species. Moderate quality ranked (C rank) plant communities have obvious past disturbance but are still recognizable as a native community and are not dominated by weedy species in any layer. Overall the stand composition of the upland forested areas within the management area

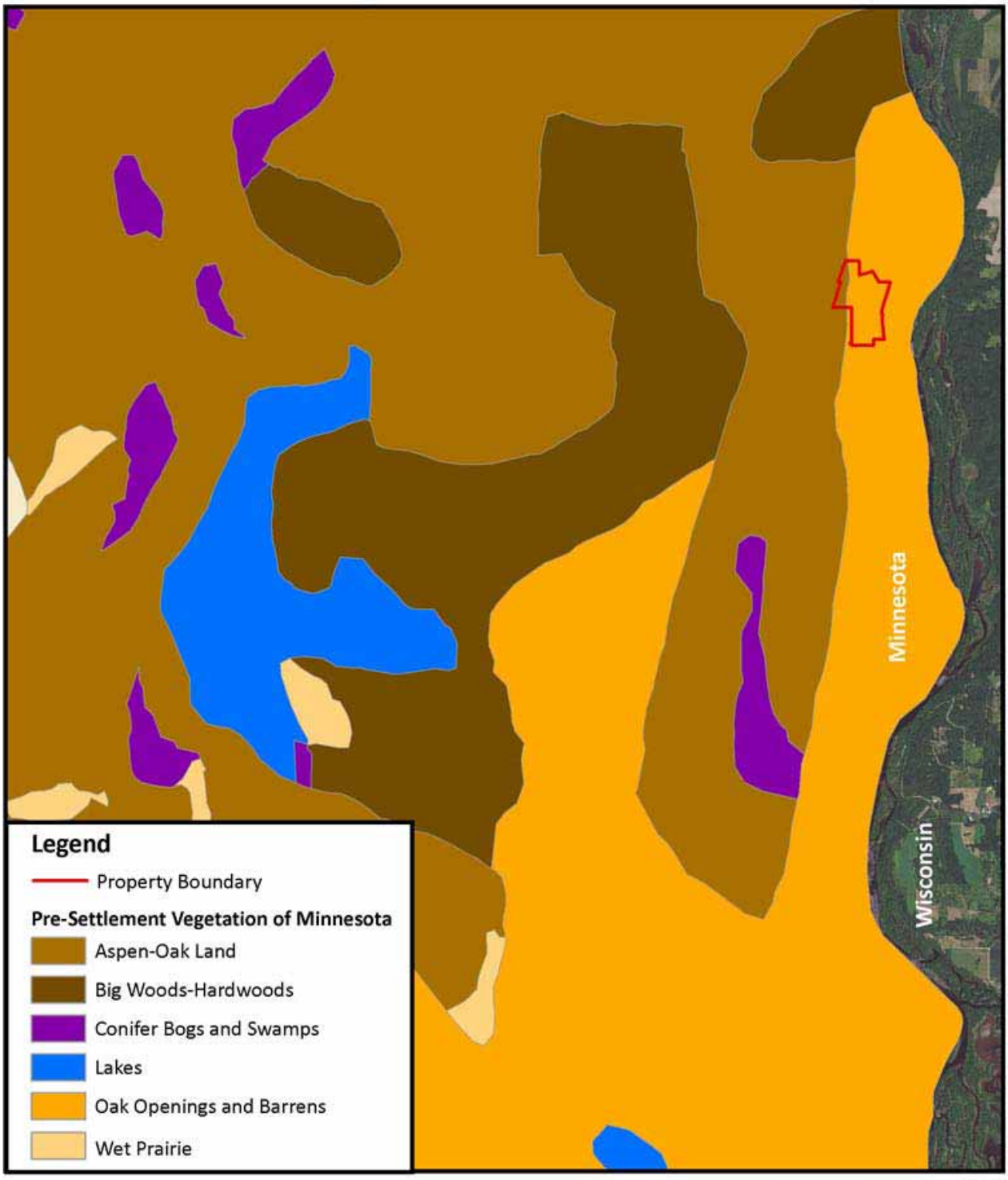
consist of a diverse mix of trees and herbaceous plants that include: White Pine (*Pinus strobus*), Red Oak (*Quercus rubra*), White Oak (*Quercus alba*), Basswood (*Tilia americana*), Bitternut Hickory (*Carya cordiformis*), Ironwood (*Ostrya virginiana*), Sugar Maple (*Acer saccharum*), Paper Birch (*Betula papyrifera*), Penn's Sedge (*Carex penslyvanica*), Round-Lobed Hepatica (*Hepatica americana*), False Solomon's Seal (*Smilacina racemosa*), Maidenhair-Fern (*Adiantum pedatum*), Bloodroot (*Sanguinaria canadensis*), Virginia waterleaf (*Hydrophyllum virginianum*), Wild Geranium (*Geranium maculatum*), Blue Cohosh (*Caulophyllum thalictroides*), Zig-Zag Goldenrod (*Solidago flexicaulis*), American Spikenard (*Aralia racemosa*), and Groundpines (*Lycopodium dendroideum* or *L. hickeyi*).

Areas of forested wetland found within the ravine systems are dominated by tree species that include primarily Black Ash (*Fraxinus nigra*) and Yellow Birch (*Betula alleghaniensis*) with the occasional Blue Beech (*Carpinus caroliniana*) and Sugar Maple (*Acer saccharum*). The Black Ash Seepage Swamp areas were assessed to be of good to moderate ecological quality (B and C Rank). Steep ravine systems with seepage discharge areas support the streams and wetlands located toward the eastern boundary along the railroad tracks. Seepage wetlands and streams on the property support a diversity of native plant species. Along the eastern edge of the property in two ravine systems are Black Ash Swamp Seepage Subtype wetlands that are dominated by Black Ash (*Fraxinus nigra*), Yellow Birch (*Betula alleghaniensis*), Common elder (*Sambucus canadensis*), Skunk Cabbage (*Symplocarpus foetidus*), Jewel-weed (*Impatiens capensis*), True Forget-Me-Not (*Myosotis scorpioides*) and Clearweed (*Pilea pumila*).

Maderate Cliff areas are found within the northern ravine area along Zavoral Creek where they form several outcrops and gorge-like features. Due to the inaccessibility (i.e. steepness) of these cliff areas, many of the bedrock outcrops had not been directly disturbed by past land use practices. Herbaceous and woody plant species typical of these moist cliff habitats include: Basswood (*Tilia americana*), Paper Birch (Betula papyrifera), Columbine (*Aquilegia canadensis*), Bulblet Fern (*Cryptopteris bulbifera*), Smooth Cliff-Brake (*Pellaea glabella*), as well as several moss, lichen, and liverwort species.

Pre-Settlement Vegetation (Circa 1850)

According to vegetation data compiled from the Original Land Survey Notes of Minnesota (circa 1850), and mapped by F.J. Marschner (1974), the natural vegetation of what is the Zavoral property at the time of European settlement was comprised of oak openings and barrens as well as aspen-oak land **(Figure 2)**. Historically, oak openings and barrens were comprised of scattered trees and groves of oaks of scrubby form with some brush and thickets and today this community would be classified as Dry Oak Savanna which includes many areas that have succeeded to oak woodland-brushland or oak forest. Historically aspen-oak land were comprised of aspen, generally dense, and small in most places, with scattered oaks and a few elms, ash and basswood and today this community would be classified as Oak Forest in an early successional stage.



Zavoral Property
Pre-Settlement Vegetation Map

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Figure 2

Geology

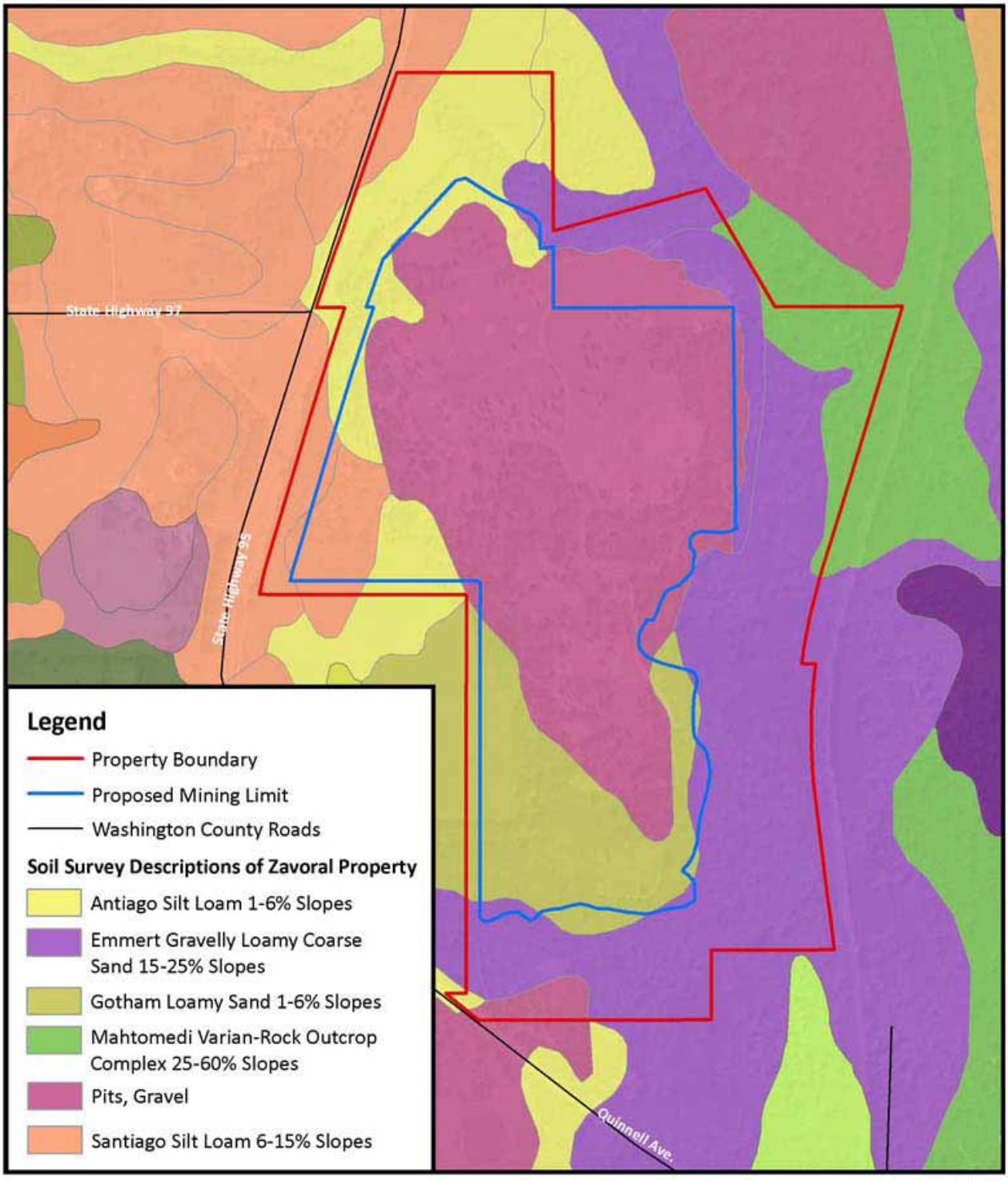
The Zavoral property is located within the St. Paul-Baldwin Plains and Moraines ecological subsection of Minnesota. This subsection is dominated by a Superior lobe end moraine complex. South of this moraine is a series of outwash plains associated with the Superior lobe. There are some areas of loess plain over bedrock or till in the southeastern portion of the subsection. Topography is generally rolling to hummocky on the moraine (steep, short complex slopes) and level to rolling on the outwash.

This subsection of the Minnesota and NE Iowa Morainal section covers much of the eastern half of the Twin Cities including St. Paul and its suburbs. The Mississippi River flows through the middle of this subsection with the St. Croix River at its eastern boundary. Before European settlement into the area oak and aspen savanna were the predominant plant communities along with prairie and maple-basswood forests also being common. Urban lands dominate this subsection with pockets of forest remaining typically in the northern region of Washington County.

Soil Types

The soils of the Zavoral property and surrounding landscape are comprised of predominantly sandy and silt loam soil types typical of the St. Paul Baldwin Plains. The soils mapped within the Forest Management Area of the Zavoral property include: Antiago silt loam with 2-6% slopes, Emmert gravelly loamy coarse sand with 15-25% slopes, Gotham loamy sand with 1-6% slopes, Mahtomedi variant rock outcrop complex with 25-60% slopes, Pits-gravel, and Santiago silt loam with 6-15% slopes **(Figure 3)**. Of these soil types the vast majority of the forest management area occurs within Emmert and Mahtomedi soil types with only small portions being included in Antiago, Gotham, and Santiago. In general the soil types located within the forest management area are typically sandy in composition and very well drained.

The complete official soils series descriptions (OSD's) for all of the soil types mapped within the forest management area of the Zavoral property are provided in **Appendix B** of this report. No soils description is available for areas mapped as pits, gravel on the soil survey map.



Zavoral Property
Washington County Soil Survey Map

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Figure 3

Forest Management Sub-Areas

The following section on existing conditions describes in further detail the forest management area as three general forest community areas: Sub-Area 1, Sub-Area 2, and Sub-Area 3. These forest community areas that make up the whole management area were delineated based on the general topography of three separate ravines within the site and to some degree the changes in forest community type.

Within each sub-area section the general location, topography, plant composition and ecological rank is described in detail. Location of each area is given in reference to the property boundary and is depicted in **Figure 4** on the following page. The dominant woody and herbaceous plant species that are commonly found growing within each sub-area are listed for each natural and semi-natural plant community. Ecological ranking for the different plant communities was assessed by CCES and is based on the MNDNR Element Occurrence Ranking (EOR) Guidelines. These guidelines are used to assess plant communities for their relative ecological quality. Specifically the EOR Guidelines are a detailed, community-specific methodology developed by the Minnesota Department of Natural Resources Natural Heritage Program. These DNR assessment protocols have been applied and refined for most natural community types found within the Minneapolis/Saint Paul metropolitan area, and have been used as the assessment methodology for the biological surveys of all the metropolitan counties.

During surveys of the forest management area at the Zavoral property, CCES ecologists assessed the overall ecological quality of the natural and semi-natural vegetation remnants as depicted in **Figure 5** on the second following page. Natural land cover types are assigned a rank of A, B, C, or D while semi-natural land cover types are assigned a rank of either NA or NN. The following are the definitions of the different levels of ecological quality ranking which is taken from the Minnesota Land Cover Classification System (MLCCS) manual:

A = Highest quality natural community, no disturbances and natural processes intake.

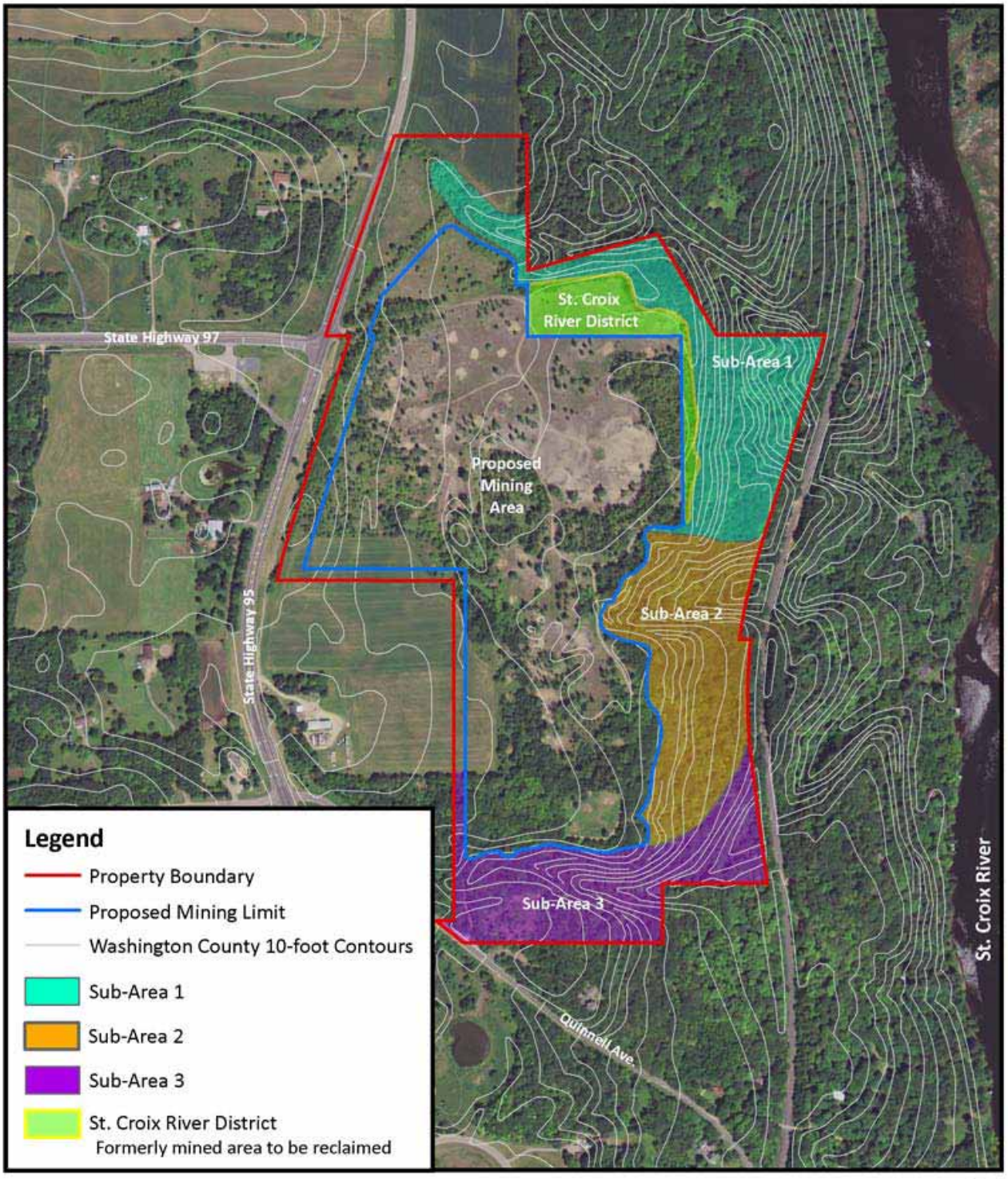
B = Good quality natural community. Has its natural processes intact, but shows signs of past human impacts. Low levels of exotics.

C = Moderate condition natural community with obvious past disturbance but is still clearly recognizable as a native community. Not dominated by weedy species in any layer.

D = Poor condition of a natural community. Includes some natives, but is dominated by non-natives and/or is widely disturbed and altered.

NA = Native species present in an altered/non-native plant community.

NN = Altered/non-native plant community with little to no native vegetation present.



Zavoral Property
Forest Management Units Map

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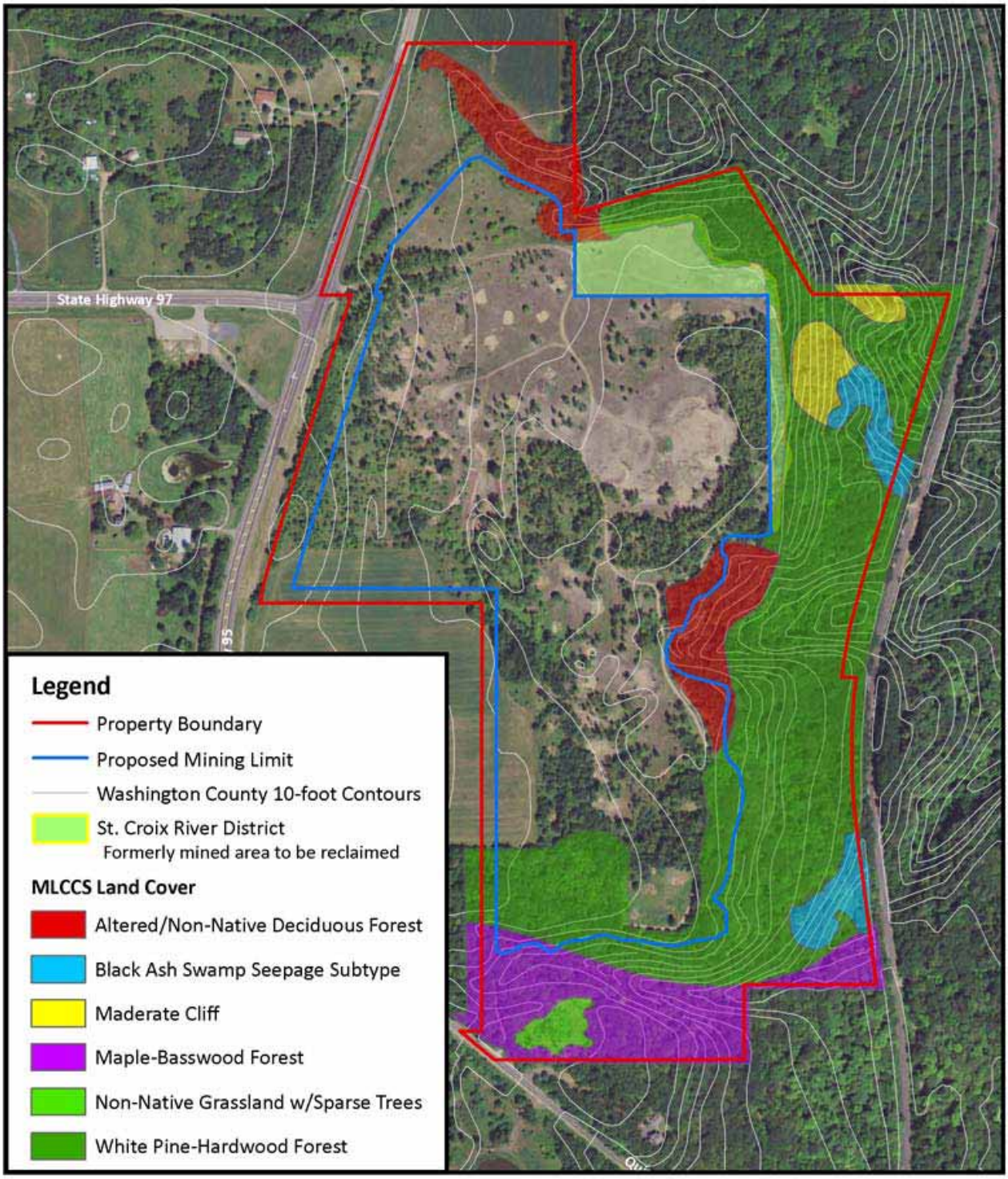
Figure 4



Zavoral Property
Washington County MLCCS Land Cover Map

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Figure 5

Plant communities present within the Forest Management Area include four native and two altered/non-native plant communities: White Pine Hardwood Forest, Black Ash Swamp Seepage Subtype, Maple-Basswood Forest, Maderate Cliff, Altered/Non-Native Deciduous Forest, and Non-Native Grassland with Sparse Trees.

The White Pine Hardwood Forest found throughout the Forest Management Area is dominated by mature White Pine and other mixed hardwood trees and is considered to be of good to moderate ecological quality (EOR rank of B to C) that supports a diversity of tree and herbaceous plant species. Typical tree and herbaceous species found within the White Pine Hardwood Forest include: White Pine (*Pinus strobus*), Red Oak (*Quercus rubra*), White Oak (*Quercus alba*), Basswood (*Tilia americana*), Paper Birch (Betula papyrifera), Ironwood (*Ostrya virginiana*), Yellow Birch (*Betula alleghaniensis*), Penn's Sedge (*Carex penslyvanica*), Round-Lobed Hepatica (*Hepatica americana*), False Solomon's Seal (*Smilacina racemosa*), American Spikenard (*Aralia racemosa*), and Groundpines (*Lycopodium dendroideum* or *L. hickeyi*).

The Black Ash Swamp Seepage Subtype areas found within the Forest Management Area are characterized by large seepage areas that support wetland vegetation. These two Black Ash Seepage Swamps are ranked as having good and moderate ecological quality (EOR rank of B and C) and support a diversity of native tree and herbaceous plant species. Typical tree and herbaceous species found within the Black Ash Swamps include: Black ash (*Fraxinus nigra*), Yellow Birch (*Betula alleghaniensis*), Sugar Maple (*Acer saccharum*), Common elder (*Sambucus canadensis*), Jewel-weed (*Impatiens capensis*), True Forget-Me-Not (*Myosotis scorpioides*) and Clearweed (*Pilea pumila*).

The Maple Basswood Forest which is located only in Sub-Area 3 of the Forest Management Area is dominated by Sugar Maple and Red Oak and is considered to be of good ecological quality (EOR rank of B) that supports a diversity of tree and herbaceous plant species. Typical tree and herbaceous species found within the Maple-Basswood Forest include: Sugar Maple (*Acer saccharum*), Basswood (*Tilia americana*), Paper Birch (Betula papyrifera), Ironwood (*Ostrya virginiana*), Red Oak (*Quercus rubra*), White Oak (*Quercus alba*), Maidenhair-Fern (*Adiantum pedatum*), Bloodroot (*Sanguinaria canadensis*), Virginia waterleaf (*Hydrophyllum virginianum*), Wild Geranium (*Geranium maculatum*), Blue Cohosh (*Caulophyllum thalictroides*), Penn's Sedge (*Carex penslyvanica*), and Zig-Zag Goldenrod (*Solidago flexicaulis*).

The Maderate Cliffs which are located in only Sub-Area 1 of the Forest Management Area are characterized by rock outcrops with near vertical bedrock exposures and sparse vegetative cover. Based on the DNR MLCCS User Manual sparse vegetation communities like the Maderate Cliffs located in Sub-Area 1 do not receive an ecological rank. Typical tree and herbaceous species found growing on the Maderate Cliffs include: Basswood (*Tilia americana*), Paper Birch (Betula papyrifera), Columbine (*Aquilegia canadensis*), Bulblet Fern (*Cryptopteris bulbifera*) as well as several moss, lichen, and liverwort species.

Altered Non-Native Deciduous Forest areas located within the Forest Management Area occur where original tree cover was altered from past land uses and have since grown back as woodland/forest that is dominated by faster growing tree species like Box Elder, Cottonwood and Quaking Aspen. Typically areas of Altered Non-Native Deciduous Forest are characterized by the presence of faster growing tree species and often times a ground layer dominated by non-native herbaceous plants like Motherwort and Common Dandelion. Based on DNR MLCCS protocol this type of semi-natural plant community does not receive an ecological ranking of A-D but rather is described as either having natives present (rank of NA) or being dominated by Non-Natives (rank of NN). In particular this community does have some level of natives present and would be described as having a NA rank. Typical tree and herbaceous species found within the Altered Non-Native Deciduous Forest include: Box Elder (*Acer negundo*), Eastern Cottonwood (*Populus deltoides*), Green Ash (*Fraxinus pennsylvanica*), Quaking Aspen (*Populus tremuloides*), Basswood (*Tilia americana*), Common Buckthorn (*Rhamnus cathartica*), Prickly Ash (*Zanthoxylum americanum*), Tartarian Honeysuckle (*Lonicera Tatarica*), Common Dandelion (*Taraxacum officinale*), Motherwort (*Leonurus cardiaca*), White Avens (*Geum canadense*), Penn's Sedge (*Carex penslyvanica*), and a Bedstraw species (*Galium* spp.).

The other semi-natural community located within the Forest Management Area is Non-Native Grassland with Sparse Trees and is found in Sub-Areas 1 and 3 where mining activity had occurred. These areas have very little organic soil development and an herbaceous ground layer that is dominated by non-native plants like Spotted Knapweed and Smooth Brome Grass with a few scattered Red Cedar and Quaking Aspen trees throughout. Like the other semi-natural areas no ecological ranking is given to this community but is rather described as having native plants present (rank of NA). Typical tree and herbaceous species found within the Non-Native Grassland with Sparse Trees areas include: Eastern Red Cedar (*Juniperus virginiana*), Quaking Aspen (*Populus tremuloides*), Spotted Knapweed (*Centaurea maculosa*), Common Mullien (*Verbascum thapsus*), Smooth Brome (*Bromus inermis*), and a Bluegrass species (*Poa* spp.).

Sub-Area 1

Photo of typical forested slopes (background) and wetland seep area (foreground) of the Sub-Area 1

Sub-Area 1 is located at the northern limits of the Zavoral property where it begins as a drainage ditch for multiple sources of stormwater runoff, including agricultural and roadway drainage, near State Highway 95 and continues east, where it develops into a ravine system containing rocky outcrops and a perennial creek (**Figure 6**). Sub-Area 1 begins on the Zavoral property, and then continues off-site for several hundred feet before it occurs again within the subject property where it then extends to the south and east to the railroad tracks. This ravine area contains seeps that function as the source of the creek approximately 1,000 feet west of the railroad tracks. The seeps occur in locations throughout the ravine and contribute to the perennial flow in the creek. The topography in Sub-Area 1 is rather dramatic with a change in elevation of approximately 190 feet from the top of the ravine near State Highway 95 to the intersection of the creek with the railroad tracks. The elevation at the head of the ravine occurs at approximately 890 feet and decreases to an elevation of 702 feet where the creek intersects the railroad tracks.

Plant communities present within Sub-Area 1 include three native and two altered/non-native plant communities: White Pine Hardwood Forest, Black Ash Swamp Seepage Subtype, Maderate Cliff, Altered/Non-Native Deciduous Forest, and Non-Native Grassland with Sparse Trees.

The White Pine Hardwood Forest which covers over half of Sub-Area 1 is dominated by mature White Pine and other mixed hardwood trees. This plant community is considered to be of good to moderate ecological quality (EOR rank of B to C) that supports a diversity of tree and herbaceous plant species. Typical tree and herbaceous species found within the White Pine Hardwood Forest of Sub-Area 1 include: White Pine (*Pinus strobus*), Red Oak (*Quercus rubra*), White Oak (*Quercus alba*), Basswood (*Tilia americana*), Paper Birch (Betula papyrifera), Ironwood (*Ostrya virginiana*), Sugar Maple (*Acer saccharum*), Yellow Birch (*Betula alleghaniensis*), Maidenhair-Fern (*Adiantum pedatum*), Wild Ginger (*Asarum canadense*), Penn's Sedge (*Carex penslyvanica*), Round-Lobed Hepatica (*Hepatica americana*), and Zig-Zag Goldenrod (*Solidago flexicaulis*).

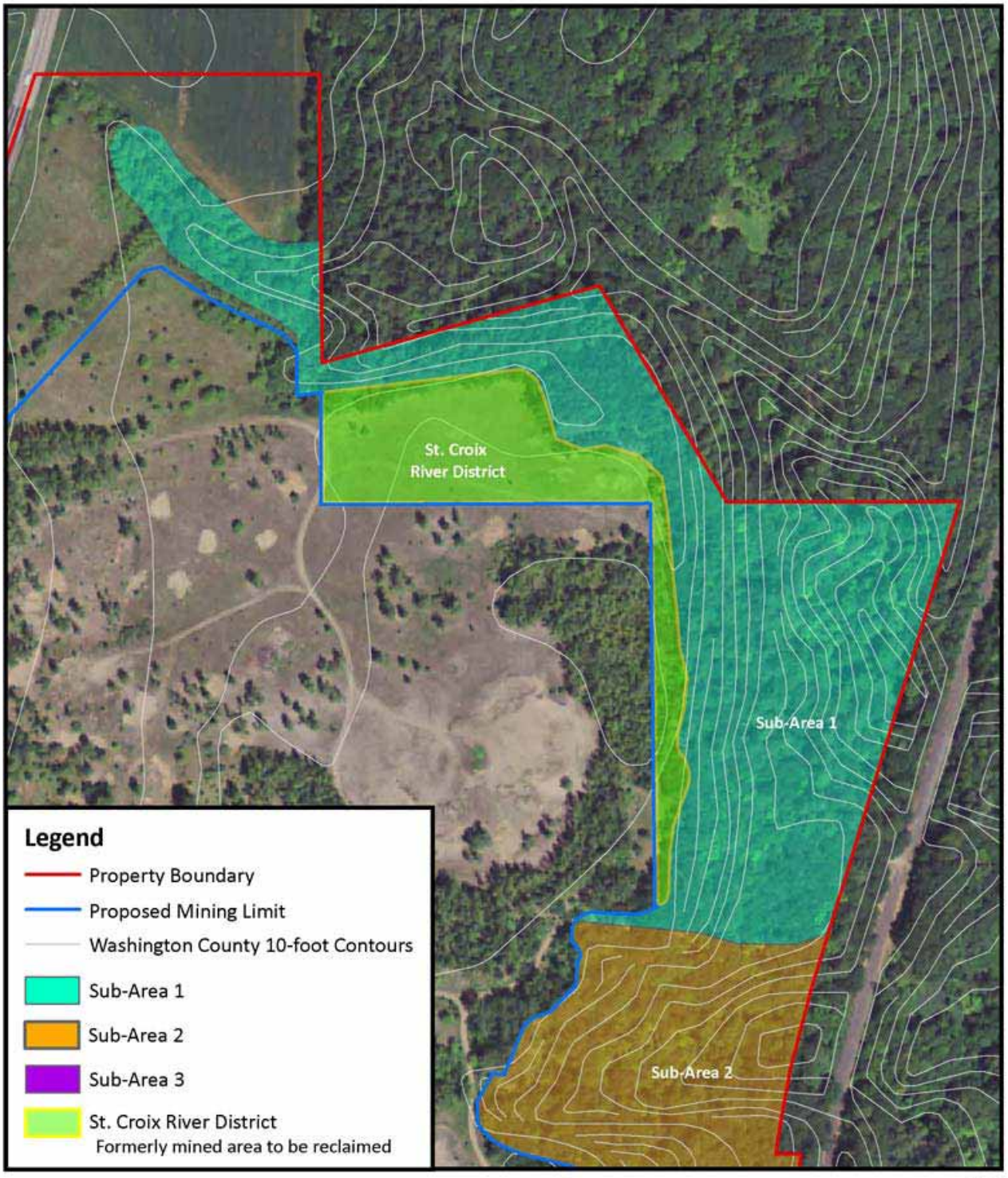
Within the lower reaches of the ravine in Sub-Area 1 a Black Ash Swamp Seepage Subtype is located that is characterized by several seepage areas along the side slopes of the ravine. This plant community is dominated by Black Ash (*Fraxinus nigra*), Common Elder (*Sambucus canadensis*), Jewel-Weed (*Impatiens capensis*), and Clearweed (*Pilea pumila*) and is considered to have good ecological quality (EOR rank B). The seeps are positioned on both sides of the creek channel with flowing water present and saturated mucky soils. The seeps are typically located near the base of the slopes and contribute to the flowing water in the creek. Areas within the creek bed upstream from where seeps daylight into the ravine are dry with upland forest plants occurring. Typical tree and herbaceous species found growing within the Black Ash Swamp Seepage Subtype of Sub-Area 1 include: Black ash (*Fraxinus nigra*), Yellow Birch (*Betula alleghaniensis*), Sugar Maple (*Acer saccharum*), Common elder (*Sambucus canadensis*), Jewel-weed (*Impatiens capensis*), True Forget-Me-Not (*Myosotis scorpioides*) and Clearweed (*Pilea pumila*).

Two areas of Maderate Cliffs are located in Sub-Area 1 and are characterized by rock outcrops with near vertical bedrock exposures and sparse vegetative cover. No ecological ranking is given for sparse vegetation communities like Maderate Cliffs. Typical tree and herbaceous species found growing on the Maderate Cliffs include: Basswood (*Tilia americana*), Paper Birch (Betula papyrifera), Columbine (*Aquilegia canadensis*), Bulblet Fern (*Cryptopteris bulbifera*), Smooth Cliff-Brake (*Pellaea glabella*), as well as several moss, lichen, and liverwort species.

The Altered Non-Native Deciduous Forest located within Sub-Area 1 occurs where the original tree cover was altered from past land uses and have since grown back as woodland/forest that is dominated by faster growing species like Box Elder, Cottonwood, and Quaking Aspen. This plant community is located in the upper reaches of the ravine within Sub-Area 1 and is ranked as having some native present in an altered plant community (NA rank). Typical tree and herbaceous species found growing within this Altered Non-Native Deciduous Forest include: Box Elder (*Acer negundo*), Eastern Cottonwood (*Populus deltoides*), Green Ash (*Fraxinus pennsylvanica*), Quaking Aspen (*Populus tremuloides*), Basswood (*Tilia americana*), Common Buckthorn (*Rhamnus cathartica*), Tartarian Honeysuckle (*Lonicera Tatarica*), Common Dandelion (*Taraxacum officinale*), Motherwort (*Leonurus cardiaca*), White Avens (*Geum canadense*), Penn's Sedge (*Carex penslyvanica*), and a Bedstraw species (*Galium* spp.).

The Altered Non-Native Grassland with Sparse Trees located within Sub-Area 1 is an area where mining activity had taken place. This area now has very little organic soil development and an herbaceous

ground layer that is dominated by non-native plants like Spotted Knapweed and Smooth Brome Grass with a few scattered Red Cedar trees throughout. Like the other semi-natural area no ecological ranking is given to this community but is rather described as having native plants present (rank of NA). Typical tree and herbaceous species found within the Non-Native Grassland with Sparse Trees area include: Eastern Red Cedar (*Juniperus virginiana*), Spotted Knapweed (*Centaurea maculosa*), Common Mullien (*Verbascum thapsus*), Smooth Brome (*Bromus inermis*), and a Bluegrass species (*Poa* spp.).



Zavoral Property
Sub-Area 1 Map

0 100 200 400 600 800 Feet

NORTH

Critical Connections
Ecological Services, Inc.

Figure 6

Sub-Area 2

Photo of forested slopes and creek channel within the central ravine area looking to the west

Sub-Area 2 is located in the middle of the property, from the bluff area at the eastern limits of the proposed project down slope toward the railroad tracks and consists of steep forested slopes and a perennial creek with several seeps located along the hillsides (**Figure 7**). Topography in this area is more gradual than the ravine to the north. The elevation change from the top of the bluff to the intersection of the creek with the railroad tracks is approximately 125 feet, with the bluff top occurring at approximately 860 feet and the base of the creek near the intersection of the railroad tracks occurring at approximately 735 feet.

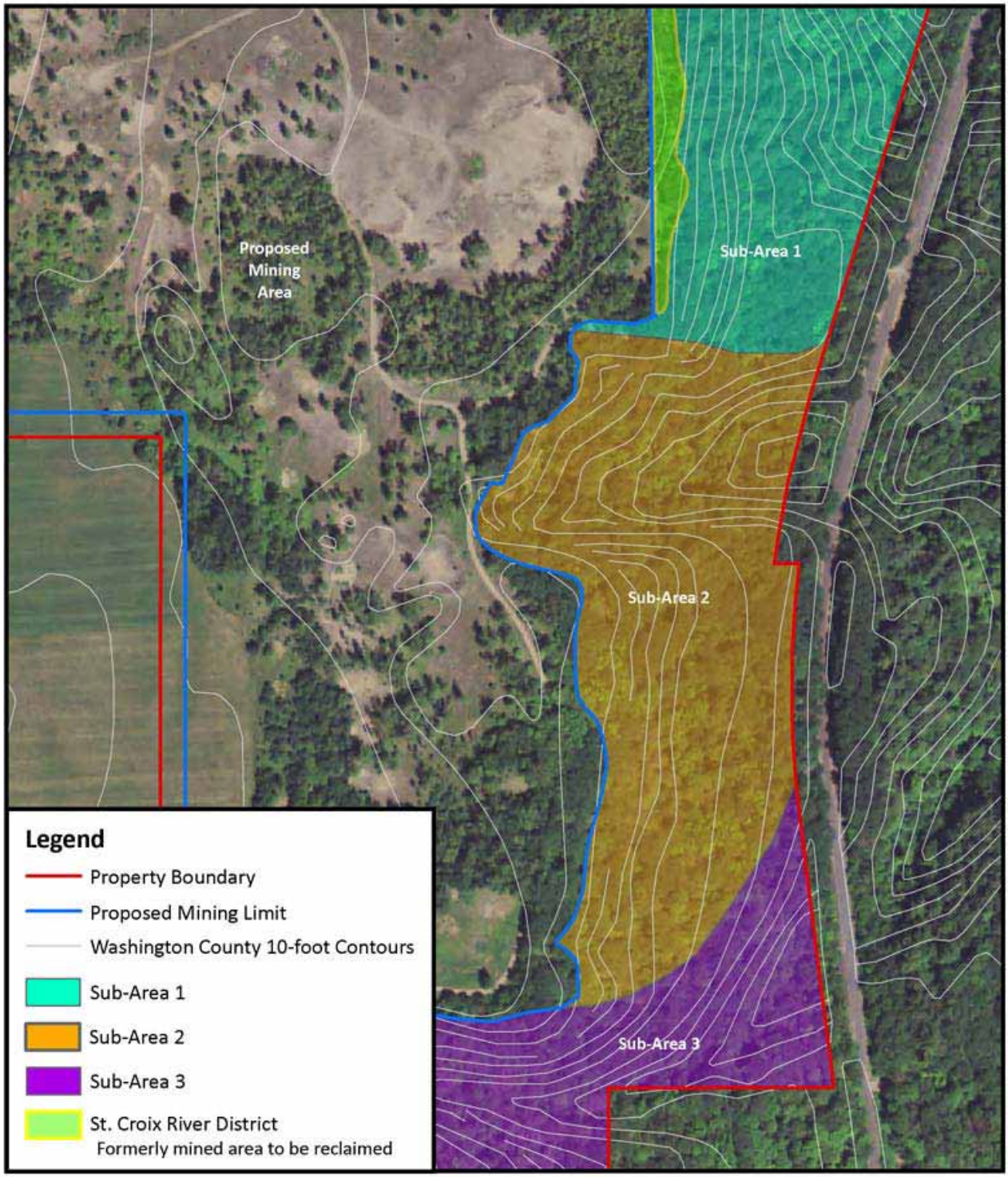
White Pine Hardwood Forest is the only native forest community present within Sub-Area 2 along with a portion of the area being classified as Altered/Non-Native Deciduous Forest. The northwestern portion of Sub-Area 2 is where the Altered/Non-Native Deciduous Forest is located which is part of the ravine that was cleared of trees in the past and is now dominated by fast growing tree species like Cottonwood and Quaking Aspen. The part of Sub-Area 2 found along the steeper slopes of the bluff is where the White Pine Hardwood Forest occurs which is dominated by a mix of mature White Pine and other mixed hardwood deciduous tree species. Fewer mature White Pine trees are present within the southern part of Sub-Area 2 where the forest community transitions to a Maple Basswood Forest in Sub-Area 3. The White Pine Hardwood forest of Sub-Area 2 is considered to be of good to moderate ecological quality (EOR rank of B to C), which still supports a diversity of tree and herbaceous plant species but does have

some level of non-native plant species present. The ecological ranking of the White Pine Hardwood Forest is based on the current condition of the forest, the composition of native plant species, and the relatively low level of Common Buckthorn being present.

Some of the typical upland plant species found within Sub-Area 2 include: White Pine (*Pinus strobus*), Red Oak (*Quercus rubra*), White Oak (*Quercus alba*), Basswood (*Tilia americana*), Paper Birch (Betula papyrifera), Ironwood (*Ostrya virginiana*), Sugar Maple (*Acer saccharum*), Prickly Ash (*Zanthoxylum americanum*), Large-Leaved Aster (*Eurybia macrophylla*), Penn's Sedge (*Carex penslyvanica*), White Snakeroot (*Eupatorium rugosum*), and Zig-Zag Goldenrod (*Solidago flexicaulis*).

Within the lower reaches of Sub-Area 2 several seepage areas are located which are dominated by Black Ash (*Fraxinus nigra*), Common Elder (*Sambucus canadensis*), Jewel-Weed (*Impatiens capensis*), and Clearweed (*Pilea pumila*). These seeps are found on both sides of the creek channel with flowing water present and saturated mucky soils. The seeps are typically located near the base of the slopes and contribute to the flowing water in the creek. Areas within the creek bed upstream from where seeps daylight into the ravine are dry with upland forest plants occurring.

The Altered/Non-Native Deciduous Forest within Sub-Area 2 occurs in areas of past agricultural and mining activity (Rank NA). Although part of the upper reaches of the ravine had been cleared of trees in the past it is now dominated primarily by Cottonwood (*Populus deltoides*) and Quaking Aspen (*Populus tremuloides*) trees with a few other types of deciduous trees also present. Common Buckthorn (*Rhamnus cathartica*) can be found in low to moderate levels within the shrub layer of this Altered/Non-Native Deciduous Forest area. Currently the population of Buckthorn found within this ravine area would be considered manageable but left to spread on its own will contribute to a decline in ecological quality.



Zavoral Property
Sub-Area 2 Map

Critical Connections Ecological Services, Inc.

Figure 7

Sub-Area 3

Photo of creek bed near the railroad tracks within Sub-Area 3

Sub-Area 3 is located in the southern part of the property, south of the proposed project limits and continues down slope in an easterly direction toward the railroad tracks (**Figure 8**). Topography in Sub-Area 3 experiences an elevation change of approximately 114 feet from the top of the bluff to the intersection of the creek with the railroad tracks. The top of the bluff occurs at approximately 860 feet and the base of the creek near the intersection of the railroad tracks occurs at approximately 746 feet. Part of Sub-Area 3 includes a portion of previously disturbed land adjacent to Quinnell Avenue where past mining had occurred as indicated on the 1938 historic aerial photo. The mined area which has become established with native and non-native vegetation occurs above the bluff line where mining faces and stockpiles are still present.

Plant communities present within Sub-Area 3 include three native plant communities: White Pine Hardwood Forest, Black Ash Swamp Seepage Subtype, and Maple Basswood Forest. White Pine Hardwood Forest is found within this sub-area from the bluff top down to the railroad tracks. Based on the current plant community composition within this stand and the low to moderate levels of Common Buckthorn present, this mixed coniferous and deciduous forest would be ranked as having good to moderate ecological quality (EOR ranking of B to C). The Maple Basswood Forest present within the ravine area found in the south end of Sub-Area 3 would be ranked as having good ecological quality (EOR ranking of B) due primarily to the lack of Common Buckthorn in the understory and a moderately

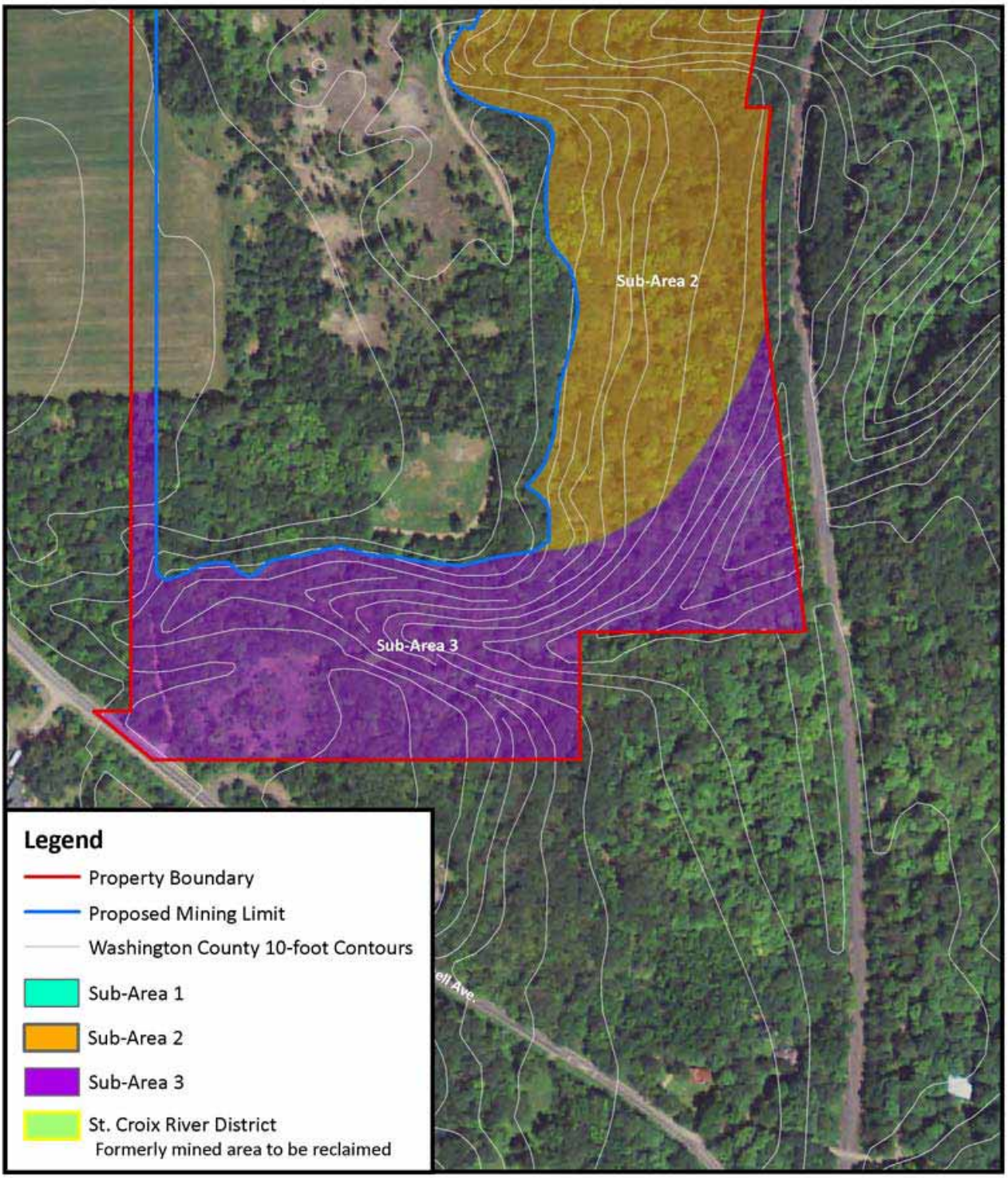
diverse ground layer plant community that is dominated by native plant species. The Black Ash Swamp Seepage Subtype is found below several seepage discharge areas within the ravine toward the railroad tracks. This natural plant community would be ranked as having moderate ecological quality (EOR ranking of C) due to the presence of the non-native, invasive plant Reed Canary Grass (*Phalaris arundinacea*) which is found throughout several parts of this swamp but does not dominate the herbaceous layer.

Within Sub-Area 3 the forest transitions from White Pine Hardwood Forest in the northern part to Maple Basswood Forest which is located in the southern part of the area in a steep ravine. Common herbaceous plants that occur within this ravine area include: Peduncled Sedge (*Carex pedunculata*), Wild Ginger (*Asarum canadense*), Zig-Zag Goldenrod (*Solidago flexicaulis*), and Maidenhair-Fern (*Adiantum pedatum*). However the Maple Basswood Forests within Sub-Area 3 do show some evidence of impacts from invasive earthworms, such as reduced leaf litter and reduced leaf mold (likely due to earthworm herbivory), reduced herbaceous species cover in the ground layer, and some minor soil erosion.

Some of the typical upland plant species found within the White Pine Hardwood Forest of Sub-Area 3 include: White Pine (*Pinus strobus*), Red Oak (*Quercus rubra*), White Oak (*Quercus alba*), Basswood (*Tilia americana*), Paper Birch (Betula papyrifera), Ironwood (*Ostrya virginiana*), Prickly Ash (*Zanthoxylum americanum*), Large-Leaved Aster (*Eurybia macrophylla*), Penn's Sedge (*Carex penslyvanica*), White Snakeroot (*Eupatorium rugosum*), and Zig-Zag Goldenrod (*Solidago flexicaulis*).

The Black Ash Swamp Seepage Subtype located within Sub-Area 3 are dominated by Black Ash (*Fraxinus nigra*) and Cottonwood (*Populus deltoides*) trees along with a moderate diversity of herbaceous plants like Common Scouring-Rush (*Equisetum hyemale*), Jewel-Weed (*Impatiens capensis*), Linear-Leaf Willow-Herb (*Epilobium leptophyllum*), and Smooth Goldenrod (*Solidago gigantea*). The seeps contribute flowing water to the small creek that forms approximately 500 feet west of the railroad tracks. Areas within the creek bed that are upstream from where seeps daylight into the ravine are dry with upland trees and herbaceous plants.

Located within the southwest corner of Sub-Area 3 is a mined area that has become established as relatively open grassland with trees on remaining stockpiles. Trees that have become established in this area are mainly Quaking Aspen (*Populus tremuloides*) and Eastern Red Cedar (*Juniperus virginiana*). Common Buckthorn is present in the understory where open areas transition into woodland toward the top of the bluff line. Buckthorn can also be found to a lesser degree within the ravine. Currently the population of Buckthorn found within this ravine area would be considered manageable but left to spread on its own in time will contribute to a decline in ecological quality.



Zavoral Property
Sub-Area 3 Map

Critical Connections Ecological Services, Inc.

Figure 8

Management Objectives and Recommendations

Management of forested areas like the one located within the Zavoral property can complement other ecological management practices that are being implemented to similar forested lands in the general vicinity of the St. Croix River Valley. The forested area to be managed within the Zavoral property is part of a larger contiguous White Pine Hardwood Forest area within the St. Croix River Valley that is a significant landscape feature of the region. Very few unbroken stands of forest remain within the metropolitan area which makes this region of the St. Croix River so important from an ecological perspective. Maintaining the current health of this part of the forest will be beneficial to all of the species that utilize to some degree the different communities found within the Zavoral property.

Currently the forested areas within the Zavoral property supports a moderately diverse plant community from the herbaceous ground layer to the overstory canopy of trees, but also has areas that support to some degree low to moderate levels of non-native, invasive species. Maintaining this current diversity of plants will continue to provide suitable habitat for the birds, insects, amphibians, mammals, and fishes that already utilize the areas within the proposed forest management area.

The primary objective of the forest management plan is to maintain the current ecological quality of the forest which in turn protects the forest community for wildlife habitat. To achieve these goals there are a number of tasks that should take place in order to address current levels of invasive species and tree disease already present on-site. A secondary objective of the forest management plan is to create a natural transition between the existing forest area and the proposed areas of reclamation that occur within the proposed mining and reclamation project limits.

The forested areas located within the Zavoral property play an important role as a natural corridor for plants and wildlife in the region. Much of these forested areas to be managed are located within the St. Croix National Scenic Riverway and are included within federal scenic easements. Scenic easements are created with the purpose of protecting the natural qualities of a designated wild, scenic or recreational river area and are acquired by the National Parks Service (NPS). This type of scenic easement permits all existing, legal single family residential and family farming uses to continue and generally permit new or additional development of that type with permission of the NPS.

In general the scenic easement over the St. Croix River is land located within approximately ¼ mile from the ordinary high water mark on both sides of the river. This type of easement still allows the landowner to utilize their property but does impose certain restrictions. Since parts of the forest management areas within the Zavoral property are within this scenic easement a written request to the NPS Superintendent should be submitted for approval before any forest management activities take place.

The following are three lists taken from the Policy Statement on the Management and Interpretation of the Terms of St. Croix National Scenic Riverway Scenic Easements dated December 2006. The three lists include activities that can continue under the scenic easement, activities allowed with permission of the NPS, and activities that are prohibited.

Activities that are permitted within the scenic easement include:

- All legal activities, uses and stages of development existing on the property at the time of purchase of the easement.
- All regular and normal maintenance and upkeep of the property including painting and replacement of roofing, siding, windows and doors on structures and the maintenance of lawns, gardens and existing open green space adjacent to structures.
- Repairs and rehabilitation of structures required to comply with safety or sanitation standards.
- Shoring up of structures affected by subsidence of soil.
- Repair, replacement or installation of service utility lines necessary for the reasonable use and enjoyment of the property.

Additional activities that may be allowed within the scenic easement with permission from the NPS include:

- New or additional farming or grazing activities on land suitable for such activities if they are performed using good husbandry practices, if they do no harm or damage to cultural and natural resources and values, and if the activity is approved under local zoning ordinances.
- In-home or cottage-type business or activities which take place completely within an approved structure, do not involve significant or continuous on-site public participation or attendance, occur out of sight from the river, and are approved activities under local zoning ordinances.
- The installation of wind electric generators, solar collector panels, large satellite dishes, ham radio towers or other towers or structures used for the sole benefit and enjoyment of the property owner. Permission will generally be granted as long as the installation does not adversely affect the scenic values and natural and cultural resources of the Riverway and meets local zoning requirements.

Activities that are prohibited within the scenic easement include:

- Any new or additional industrial, mining, quarrying, oil, gas, sand, gravel or other minerals development projects, including the removal of topsoil.
- Any other change in general character or topography of the land including the draining of wetlands or the creation of lakes, ponds or bogs.
- The creation of or continued use and expansion of a public health hazard or nuisance including trash dumps, dumps for spoiled soils and hazardous waste dumps.
- The accumulation and storage of junk and other unsightly materials including (but not limited to) vehicles, machinery, tires, lumber, wood, scrap metal, wire, household and plumbing fixtures and appliances.
- Any new or additional business or commercial activities that involve significant or continuous on-site public participation or attendance.
- The granting of any new access rights, public utility easements or rights of way across the property.

- The placement of certain types of signs, billboards or advertisements except: A) a single permanent sign or marker identifying the property address and/or owner; B) no more than two additional temporary signs offering the sale of products raised or produced on the land, political expression signs during elections, and signs offering the property for sale or lease. No sign, whether permanent or temporary, may be larger than 720 square inches (roughly 24 x 30 inches).
- Any new use or activity not in compliance with local zoning ordinances.

Within the scenic easement brush and small trees may be cut, trimmed and removed without prior NPS approval as long as the intent is to remove material from existing roadways, driveways or access routes, to maintain existing lawns and open spaces around structures and to maintain existing vistas of the river. However any cutting, trimming or removal of any vegetation to create a new or expanded view of the river is prohibited. Trees and brush may also be cut, trimmed and removed with prior written permission of the NPS to remove diseased or damaged hazard trees. Trees may also be removed to develop wildland fire defensible space areas in accordance with accepted structure fire proofing standards. Trees can also be cut, trimmed or removed to accommodate a building site and project approved by the NPS. Any dead and down wood may be gathered and cut for personal use like firewood. As forest management practices are being implemented for the managed forested areas within the Zavoral property these scenic easement rules should be taken into account.

Invasive Species Management

The first task in order to maintain and or improve the current ecological quality of the forest management area should involve the management of invasive species currently found on-site. Management of invasive species within the forest management area of the Zavoral property should focus on two problematic non-native, invasive species: Common Buckthorn (*Rhamnus cathartica*) and Reed Canary Grass (*Phalaris arundinacea*). These two species currently are found in upland forested areas in the case of Common Buckthorn and in low-lying wet or damp areas in the case of Reed Canary Grass. Although these two invasive plants are currently at lower levels of establishment, leaving them unmanaged will likely increase their opportunity to spread further throughout the forest management area as well as increase the cost of future management. By taking an approach of controlling non-native species now, ecological quality within the managed area should only improve. This approach may in turn provide an example to other local residents who may be interested in managing their forested lands in a similar way.

Common Buckthorn

Photos: Common Buckthorn leaves (left) and Common Buckthorn seeds (right)

Monitoring and managing Common Buckthorn (*Rhamnus cathartica*) is one of the most important tasks to accomplish within the forest management area. If this non-native shrub/tree goes unchecked, in time the forest can change dramatically which in turn will affect the ecology of the forested area. Buckthorn can influence the way forests succeed to climax communities by outcompeting native trees and shrubs for space and available light and water. Although Common Buckthorn has established on the site, there is still ample time to manage the relatively small populations of this species before it is able to spread further and to higher densities. However, if Common Buckthorn is left unchecked and untreated, it will continue to spread and further degrade the remaining good to moderate quality forested communities of the Zavoral property. Once this plant becomes very well established, natural community restoration and management will be significantly more difficult and expensive to implement.

Common Buckthorn (*Rhamnus cathartica*) is a European shrub that invades and establishes within native forest and woodland understories in Minnesota. Once Buckthorn establishes within natural communities, it can outcompete most native species and influence the natural forest succession. Common Buckthorn was observed in various densities throughout the forest and woodlands at the Zavoral property with the majority found within the forested area that is being proposed for mining. The steeper slopes and ravine areas have only a minimal amount of Buckthorn present.

Removal and management of Buckthorn can be a labor intensive and costly undertaking. The first phase of managing Buckthorn includes locating and removing all mature, fruit-producing individuals, as to minimize seed dispersal and invasion. An effective method to control Buckthorn involves cutting the tree down and treating the stump with a non-selective herbicide like Round-Up. This method can sometimes involve applying a second application of herbicide to stumps that may re-sprout. Another method to control Buckthorn is to physically remove the tree and root system from the ground with the

use of tools like a weed wrench and/or vise grips for Buckthorn with smaller stems. Removal of Buckthorn on steep slopes found within the management area should be cut and treated with the root system being left in place to minimize soil disturbance. CCES recommends coordination with landowners adjacent to the Zavoral Property, to secure permission to remove and treat buckthorn along adjacent property boundaries, where feasible.

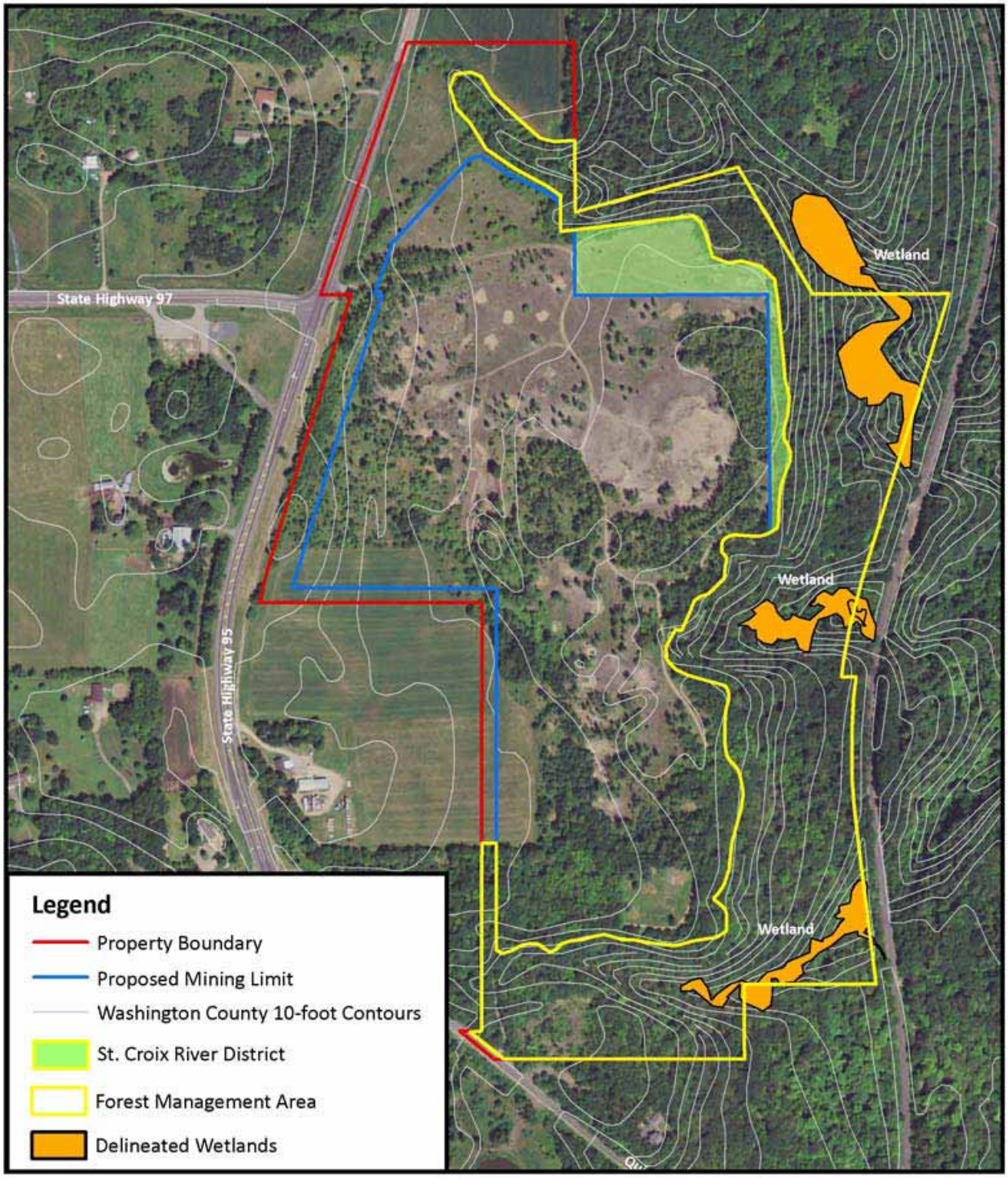
Reed Canary Grass

Reed Canary Grass (*Phalaris arundinacea*) is an invasive wetland grass that is very common to degraded wetlands within the Minneapolis/Saint Paul metropolitan area and throughout Minnesota. Reed Canary Grass is considered native to North America, but this species has been hybridized and cultivated as an aggressive and naturalizing forage grass that is also used for erosion control in agricultural landscapes.

Photo: Reed Canary Grass in a wetland situation (Anoka County, 2008)

Reed Canary Grass occurs in low levels within the three sub-areas of the forest management area. CCES recommends some level of management and treatment of Reed Canary Grass within the wetland areas to contain the further spread into the remaining wetland areas not already affected by this problematic plant. **Figure 9** on the following page depicts the locations of the three wetlands that were located within the Zavoral property.

Reed Canary Grass can be effectively managed with a grass-specific herbicide (Vantage/Sethoxydim) or non-specific herbicides (Aqua Neat and/or Round-Up) and manual removal (where feasible). After the initial and follow-up herbicide treatments to areas of Reed Canary Grass periodic monitoring (every two to three years) within the wetland areas should be part of regular management objectives. In the future additional herbicide or mechanical treatments may be needed to control any new populations or re-sprouting from areas that were originally treated.



Zavoral Property
Delineated Wetlands Map

Critical Connections
Ecological Services, Inc.

Figure 9

Tree Disease and Pest Management

The other management objective for maintaining the current ecological quality of the forested areas should involve monitoring for tree diseases and other problematic pests. Tree disease and pest management within the proposed forest management area of the Zavoral property should involve some level of tree inspection for several common tree diseases and insect pests that may have a direct affect on the current composition of the forest. There are several commonly occurring tree diseases found within the central part of the state, but due to the tree species present, there are three diseases that have the potential to adversely affect trees on the Zavoral property. Oak Wilt, Dutch Elm Disease, and Butternut Canker are three diseases that should be regularly monitored for on either an annual or at a minimum every other year basis within the proposed forest management area. Monitoring for these diseases will help slow the spread, if detected, to other healthy trees on the property as well as off-site forested areas that are contiguous with the Zavoral property. If left undetected these diseases can easily establish and change the overall composition of trees over time.

Since oak and elm trees are commonly found growing within the Zavoral property monitoring for these two diseases should be implemented to prevent any outbreaks from becoming too serious. Early detection of both of these diseases is important for minimizing the spread of the disease and for recommending and facilitating proper treatment and sanitation of infected trees. The third disease that should be monitored for within the forest management area is Butternut Canker. This disease has already been found within the property and should be managed to minimize spread to any remaining healthy Butternut trees on the property as well as nearby trees located off-site.

In addition to the three diseases to be monitored for, observing the forest for the presence of Emerald Ash Borer (*Agrilus planipennis* Fairmaire) is yet one more potential biotic problem that should be considered when performing tree inspections. Emerald Ash Borer has recently been introduced to the state of Minnesota and can have a significant effect on forested and urban areas where ash trees are typically found. Although ash trees are not a dominant tree within most of the forest area within the Zavoral property, there are small pockets of Black Ash that do occur within wetland areas within the forest management area. Monitoring for this pest should only focus on early detection in order for proper sanitation to take place if detected. Treatment of ash trees found growing in the wild is not a feasible option for control of this pest due to accessibility and costs. Emphasis should rather be placed on monitoring and early detection of the insect which will help limit its spread if detected.

Butternut Canker

Butternut (*Juglans cinerea*) is a native deciduous tree that is a minor component of the overall deciduous forest found on the Zavoral property but is one tree species that has been greatly affected by a fungal disease that is present on the property. Within the Zavoral property, Butternut is typically found growing along woodland and forested edges with a few occurrences within the completely forested parts of the property. Initial management for this tree species should include sanitation (removal) of all infected trees to minimize further spread to remaining healthy butternut trees on-site and any other nearby trees. Currently, removal of infected trees is the only method to control the

spread of Butternut canker since there are no chemical treatments available for use to control the destructive fungus.

Based on prior tree surveys throughout the Zavoral property it appears that all but one of the located Butternut trees are currently infected with an introduced (i.e. non-native) fungal disease know as Butternut Canker (*Sirococcus clavigignenti-juglandacearum*). When Butternut trees get infected by this fungal disease, the trees form cankers along the main stem of the tree. The cankers appear as sunken bark that is dark in color that eventually girdles and kills the tree. Butternut canker is a fatal tree disease.

Since its discovery in the late 1960's it is estimated that this fungal disease has killed over 80-90% of the Butternut trees in some regions of the United States and has caused a steep decline in Butternut populations of larger diameter at breast height trees (DBH of greater than 12") throughout the state of Minnesota. Butternut is currently listed as Special Concern by the Minnesota DNR and therefore *does not require* avoidance, protection, or mitigation for taking of the plant species under Minnesota Statute 84.0895.

Butternut is typically a minor component of mesic hardwood forests that often occur along or near rivers in Minnesota. All but one of the individuals on the Zavoral property show clear signs of infection by the Butternut Canker with typical dieback and visible cankers on branches and trunks of each tree. The single tree that appears disease free is also the largest Butternut surveyed on the property. This tree has a DBH of 17.5" and appears to have a full canopy with no visible signs of active cankers along the main trunk and lower branches. This individual Butternut tree is located at the base of the bluff above the railroad tracks in the central part of the property and is relatively isolated from the other individuals found elsewhere on the property.

Oak Wilt

Since Red and White Oaks are a key component to the overstory within the forested areas to be managed, monitoring for the presence of the tree disease Oak Wilt should be implemented as part of the management plan. This type of inspection can be done concurrently with all other tree disease monitoring that takes place within the management area. Based on prior surveys done throughout the proposed forest management area and over much of the Zavoral property the past two years, it appears that no Oak Wilt infection centers are present within the property. Though CCES has completed extensive field surveys for several different natural resource based reports for the Zavoral property Oak Wilt inspection was not a primary focus for any of the completed tasks, but was noted if observed. No observations were detected for this tree disease during field work within the Zavoral property.

Oak Wilt, *Ceratocystis fagacearum*, is a fungal disease that affects all types of Red and White Oaks and can be fatal if left undetected and/or untreated. Left unchecked, Oak Wilt can progressively spread from one tree to another by two methods. Oak Wilt fungal spores can be spread overland by insect or wind transmission. The fungus can also spread from tree to tree underground by root grafts between nearby oak trees of the same species. In general Red Oaks are more susceptible to the disease than

White Oaks. Once a Red Oak becomes infected, the tree can die within a single growing season, whereas White Oaks can be infected for several years before finally succumbing to the disease.

The Oak Wilt fungus enters an oak either through a root graft or a fresh wound. Once inside the tree, the fungus grows in the water carrying vessels of the tree and spreads throughout the roots, trunk, and branches. As a mode of defense, the tree attempts to stop the spreading fungus by using gummy substances, called tyloses. These tyloses clog the water vessels within the tree, but do not stop the fungus. The lack of water flow causes leaves to wilt rapidly and fall to the ground. The oak essentially shuts off the water supply and dies from drought.

Symptoms of Oak Wilt can be difficult to recognize. Red and White Oaks have many insect and disease symptoms that will mimic the symptoms of Oak Wilt. Also, Red Oaks and White Oaks show different symptoms of Oak Wilt. The most visual symptom of Oak Wilt in Red Oaks is the rapid progression of wilting leaves from the top of the tree downward. Olive-tan, curled leaves are typical of an infected oak. White Oaks display a much different progression of wilting symptoms. In most cases, minor wilting begins to occur in isolated branches. The leaves are slightly curled and sections of the leaves will be discolored. After successive years of infection, a diseased White Oak will slowly wilt and die. Severe infections can cause a White Oak to completely wilt and die within a year.

If detection of the disease is confirmed prompt control of all dead and dying oaks should take place to minimize the further spread of the disease to healthy oaks. Oak wilt control can involve either the installation of mechanical barriers around diseased trees or chemical fungicide treatments. Root graft barriers are a common type of mechanical barrier used to control Oak Wilt and is installed by a vibratory plow around known infection centers where roots between diseased and healthy trees are severed underground in order to stop further underground spread of the disease. If root graft barriers are utilized to control Oak Wilt they should be first installed before the removal of any diseased oak tree takes place. Typically two root graft barriers are installed around any know infection centers, a primary and secondary line.

Chemical control of Oak Wilt involves injection of fungicide into either infected oak trees (White Oak trees only) or into healthy oak trees (both Red and White Oak) that are immediately next to a known infected oak tree. When the disease is detected early enough chemical treatment with fungicide can be utilized to prevent further spread of the disease within an infected tree as well as any nearby trees that are grafted underground by root systems. Typically chemical treatment for oak wilt is only recommended for White Oak species and in certain cases with Red Oak if detected within a month of visible symptoms. Once an oak tree is infected with Oak Wilt, treatment involves injecting a systemic fungicide at the base of the tree to control the spread of the fungus. Following chemical treatment the infected parts of the tree are then removed.

Dutch Elm Disease

Elm trees are found to a lesser degree within the wooded areas of the Zavoral property due to the occurrence of Dutch Elm Disease (DED). For several decades this disease has had a profound effect on

populations of elm trees throughout the state. At one time elm played a more significant role in the ecology of the forests found within the Zavoral property but now only exists as smaller populations. Several standing dead elm trees that were found throughout the property indicate that DED is still present on-site. Regular monitoring for this disease should focus on detection so proper sanitation can be implemented to slow the further spread of the disease to trees both on and off-site. Sanitation of diseased elm trees involves prompt removal and disposal of dead and dying elms which reduces potential elm bark beetle breeding sites. Elm bark beetles spread the fungus that causes DED from tree to tree so proper sanitation is important to minimize local spread of the disease to healthy elm trees.

Dutch Elm Disease is a fungal disease of elm trees which is spread by the elm bark beetle. Although believed to be originally native to Asia, the disease was accidentally introduced into America and Europe, where it has devastated native populations of elms which had not had the opportunity to evolve resistance to the disease. DED is caused by the fungus *Ophiostoma ulmi (syn. Ceratocystis ulmi)* which is transmitted by two species of bark beetles or by root grafting. The American Elm (*Ulmus americana*) is the most seriously affected of all elms in Minnesota. The Siberian Elm, *Ulmus pumila*, which does occur within the Zavoral property, is tolerant but not immune to the disease.

Similar to an oak trees' defense against Oak Wilt, elm trees try to halt the internal spread of the fungus by plugging up part of their cambium layer (layer under the bark where water and nutrients flow within the tree) which in effect cuts off the ability of the tree to transport and receive water and nutrients. Once part of the tree is infected by the disease the leaves in the upper parts of the tree begin to turn yellow and dry up leaving areas of dieback in the branches. This disease can continue to spread quickly throughout a tree leaving it dead within a single season.

Emerald Ash Borer

Due to the very recent introduction of this non-native, highly destructive insect pest to the state of Minnesota, it is recommended that any tree inspection of the forest management area also include monitoring for Emerald Ash Borer – *Agrilus planipennis* (EAB). Within the Zavoral property ash trees are not a dominant overstory tree but do occur occasionally to frequently within specific plant communities such as the seepage areas located within the ravines of the forest management area. Early detection of this pest will allow for prompt sanitation if detection does occur. If EAB detection is confirmed within the Zavoral property removal of all infected trees should take place immediately to minimize further spread of the insect. Once an ash tree is infected by EAB it will kill the tree. Often times it takes two to four years for an ash tree to die once infested. Symptoms of EAB are apparent by the second year with thinning of the leaves and dieback beginning to show in the canopy. By the third year major dieback occurs throughout the tree with little foliage present. Ash trees can tolerate lower levels of EAB but are girdled and killed when insect populations become higher.

Currently EAB has been found in three counties within Minnesota: Hennepin, Houston, and Ramsey. If this insect is ever detected on the property it will need to be confirmed by the Minnesota Department of Agriculture and the affected trees will need to be properly sanitized to help minimize the continued spread to other healthy ash trees located within the property or any nearby populations.

During the life cycle of this insect the adults lay eggs in crevasses in the bark of all species of ash trees. When the eggs develop into larvae, these larvae burrow into the bark after hatching and consume the cambium and phloem, effectively girdling the tree and causing death within two years. EAB has caused nearly complete loss of all species of ash where infestation has occurred in the eastern United States. Preventative treatment to healthy ash trees is an option for managing this insect but typically is only attempted in an urban setting where ash trees are a valuable shade tree asset and not in a wild setting like the ash trees found within the Zavoral property where accessibility and cost limit the current method of preventative treatment.

Summary

A forest management plan for approximately thirty-eight acres of forested bluff and ravine systems located within the Zavoral property was created to assist Tiller and the Zavoral family with strategies to maintain and/or improve the health of the forested areas that surround the proposed mining and reclamation areas. The forest management area within the Zavoral site is located primarily in the eastern part of the property from the top of the bluffs down to the railroad tracks. This management plan compliments the reclamation plan for the proposed mining project and other detailed natural resource plans generated for this project. The forest management plan describes in detail the overall health, capability, and current condition of the forested areas to be managed.

Natural plant communities that make up the vast majority of the management area include White Pine Hardwood Forest, Black Ash Seepage Swamp, and Maple Basswood Forest community types. This forest management area runs contiguously from the north to south property lines and is a component of a larger forest ecosystem that extends beyond the property boundaries within the St. Croix River Valley. Areas located within the proposed forest management area are included within the Minnesota Department of Natural Resources designated Regionally Significant Ecological Area (RSEA) of the Twin Cities. Ecological quality for the natural plant communities that occur within the forest management area were assessed to be of good to moderate ranking and were based on MNDNR Element Occurrence Ranking Guidelines.

The primary objective of the forest management plan is to maintain the rank of good to moderate ecological quality of the forest in order to protect the different natural plant communities for wildlife habitat. To achieve the management goals set forth in this plan the focus of management should be on the monitoring and managing of problematic invasive species as well as monitoring and facilitating the proper sanitation of trees affected by disease and/or problematic pests. Two invasive plants that should be considered for management are Common Buckthorn and Reed Canary Grass. Left unchecked these two plants can significantly influence natural plant succession by out competing native plants for space, light and available water and nutrients. Management for Common Buckthorn and Reed Canary Grass should involve to some degree the removal and treatment of these two species throughout the forest management area. In addition, the forest management plan should include annual or every other year inspections throughout the forest management area for detection of any ongoing or new occurrences of tree disease and/or problematic pests. The three tree diseases that should be inspected for include:

Butternut Canker, Oak Wilt and Dutch Elm Disease. The only insect pest that needs to be inspected for within the forest management area is Emerald Ash Borer. Currently Butternut Canker and Dutch Elm Disease can be found on the property and have affected a large percentage of the Butternut and American Elm trees within the property.

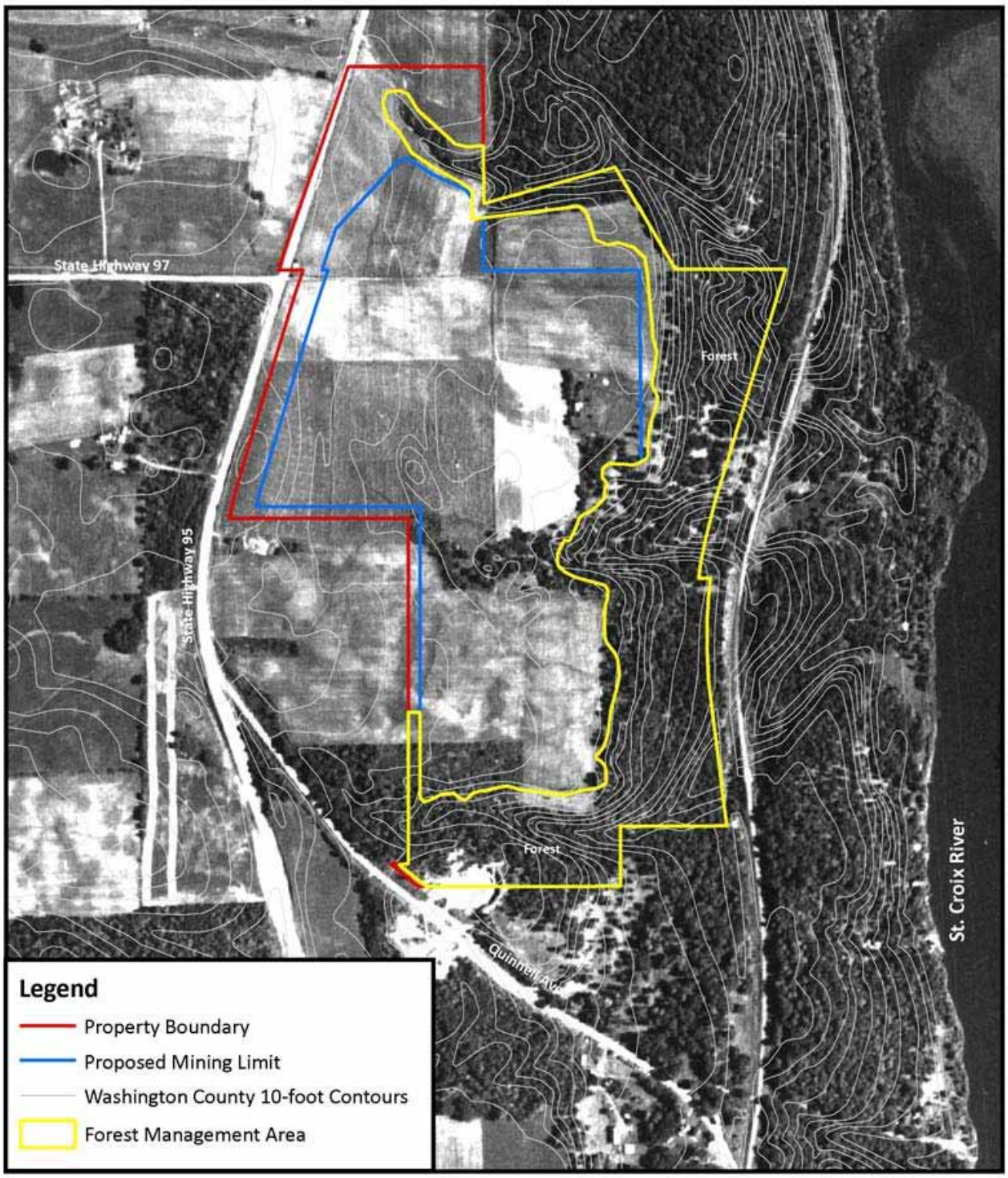
A secondary objective of the forest management plan is to create a natural transition between the existing managed forest area and the proposed reclamation areas of the proposed mining and reclamation project. A component of this objective can be achieved by implementing invasive species management and monitoring the edge areas for any occurrences of fatal disease or insect outbreaks. In the future when reclamation of the mined areas is complete a seamless transition between the existing natural plant communities and the planted plant communities should be achieved if management practices are implemented and followed.

The management plan provides specific recommendations to achieve forest management goals and will be a useful guide to assist the forest management activities for the Zavoral property. Finally, since parts of the forest management areas within the Zavoral property occur within the scenic easement a written request to the NPS Superintendent should be submitted for approval before any forest management activities take place.

Appendix A

Historical Air Photos

1938



Zavoral Property

Historic Aerial Photo Forest Cover Map-1938

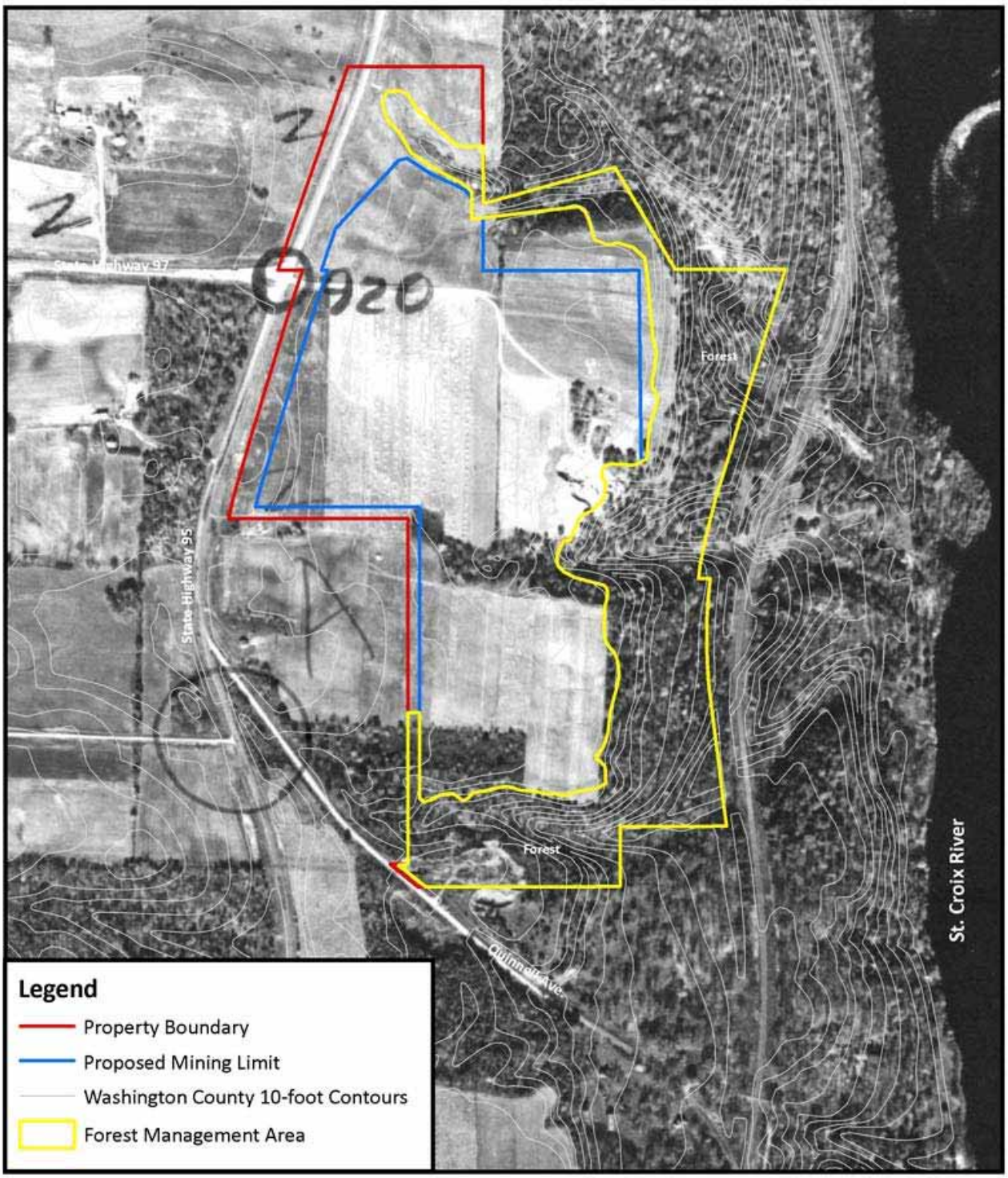
0 125250 500 750 1,000 Feet

NORTH

Critical Connections Ecological Services, Inc.

Appendix A

1949



Zavoral Property
Historic Aerial Photo Forest Cover Map-1949

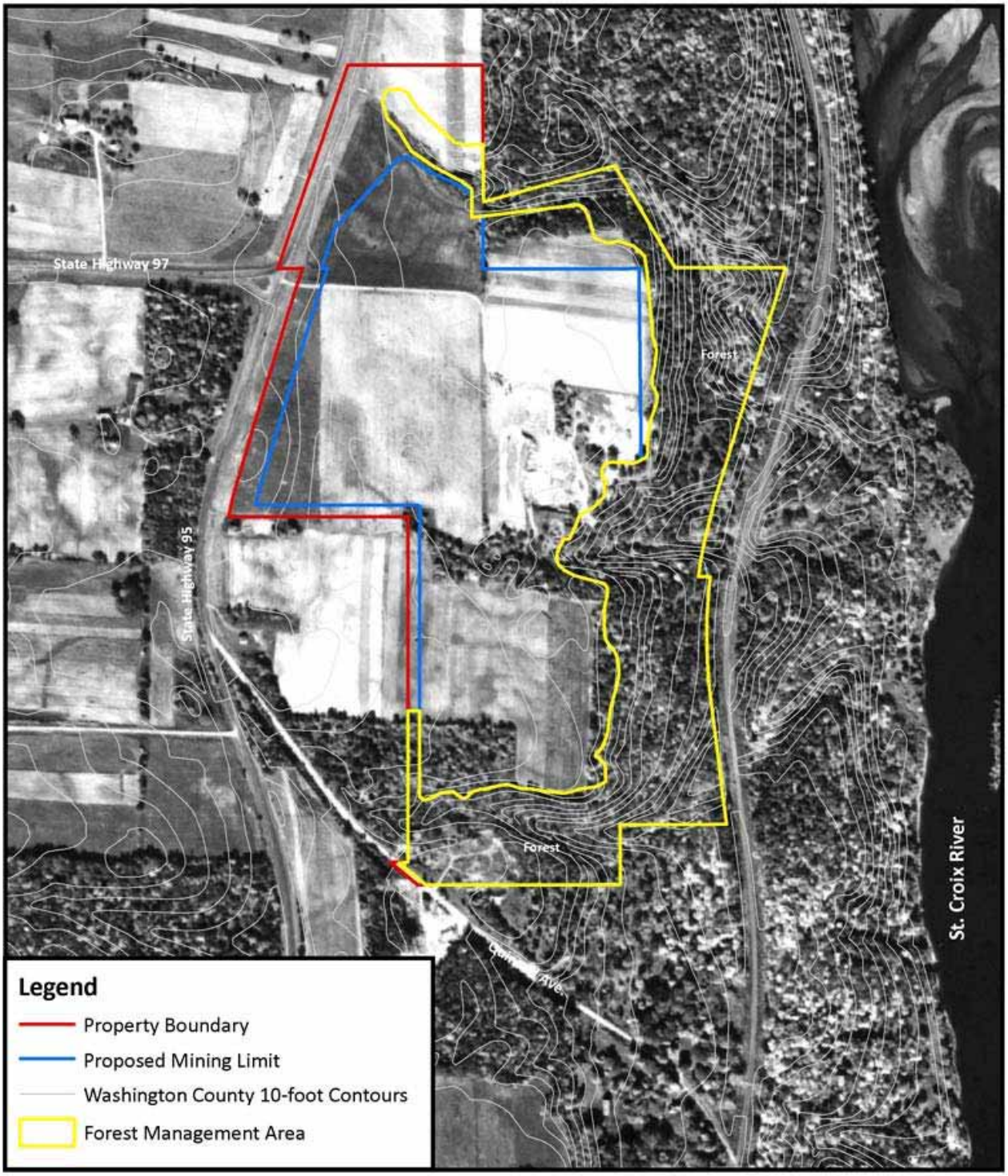
Feet
0 125250 500 750 1,000

NORTH

Critical Connections
Ecological Services, Inc.

Appendix A

1953



Zavoral Property
Historic Aerial Photo Forest Cover Map-1953

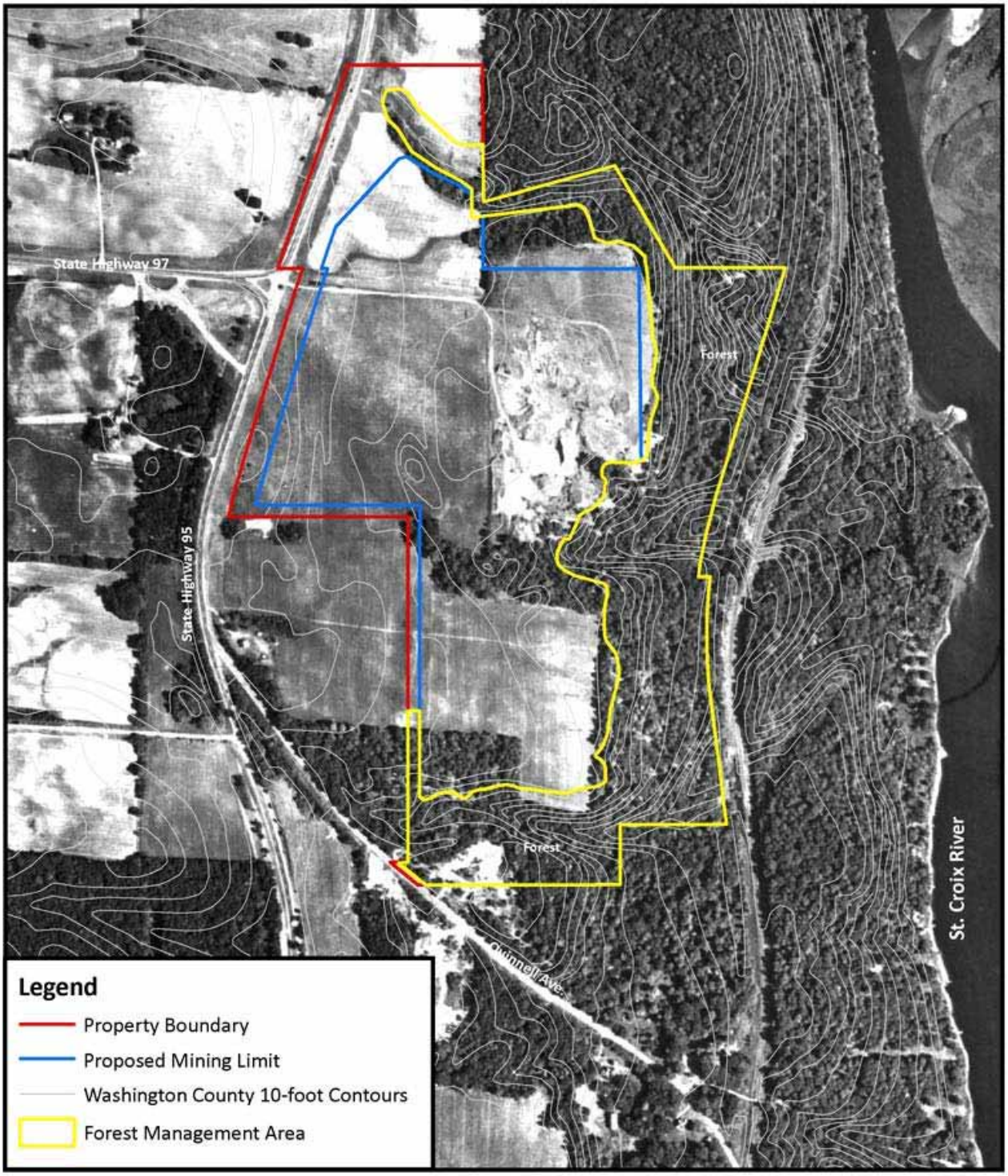
0 125250 500 750 1,000 Feet

NORTH

Critical Connections Ecological Services, Inc.

Appendix A

1964



Zavoral Property
Historic Aerial Photo Forest Cover Map-1964

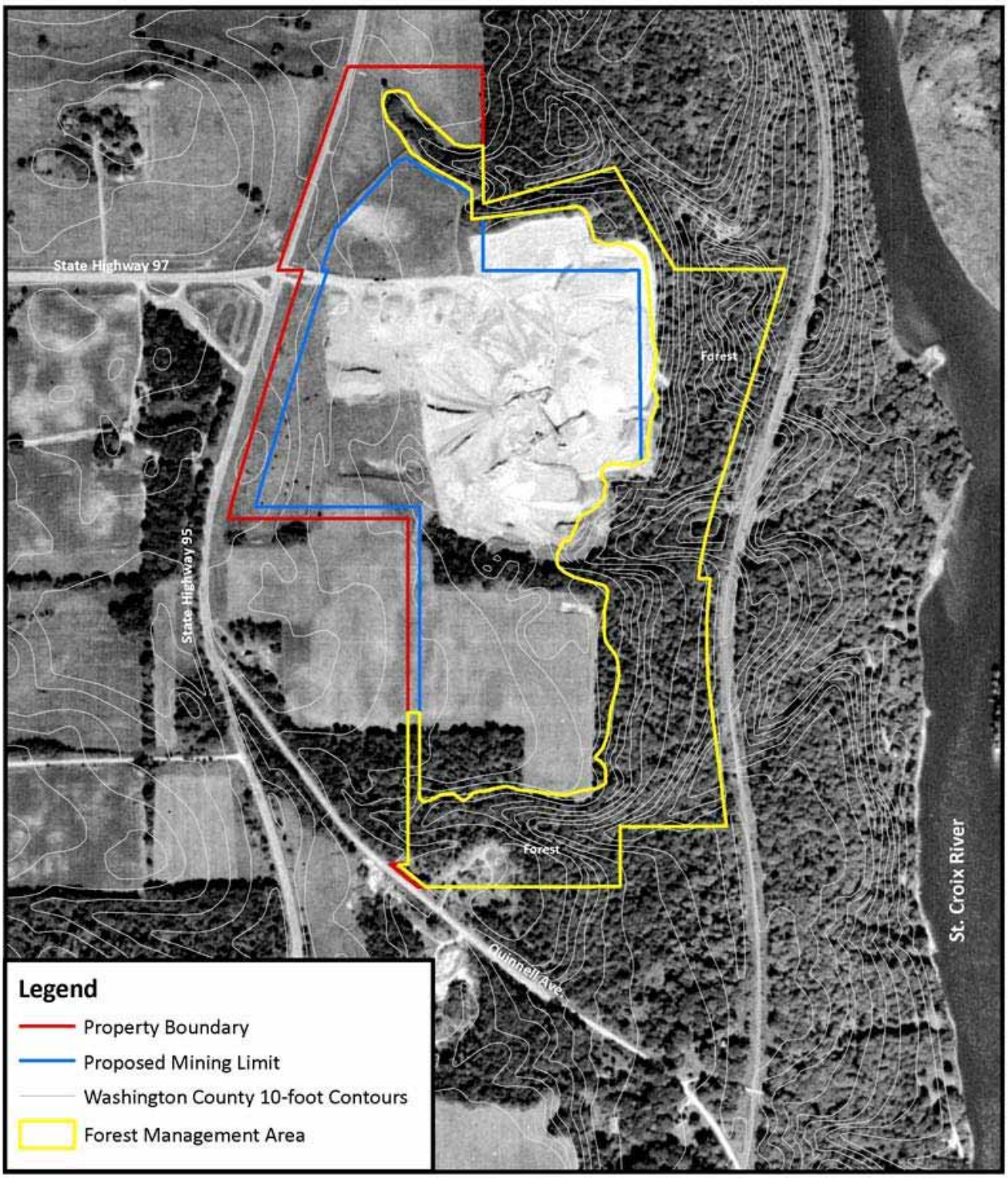
0 125250 500 750 1,000 Feet

NORTH

Critical Connections Ecological Services, Inc.

Appendix A

1970



Zavoral Property
Historic Aerial Photo Forest Cover Map-1970

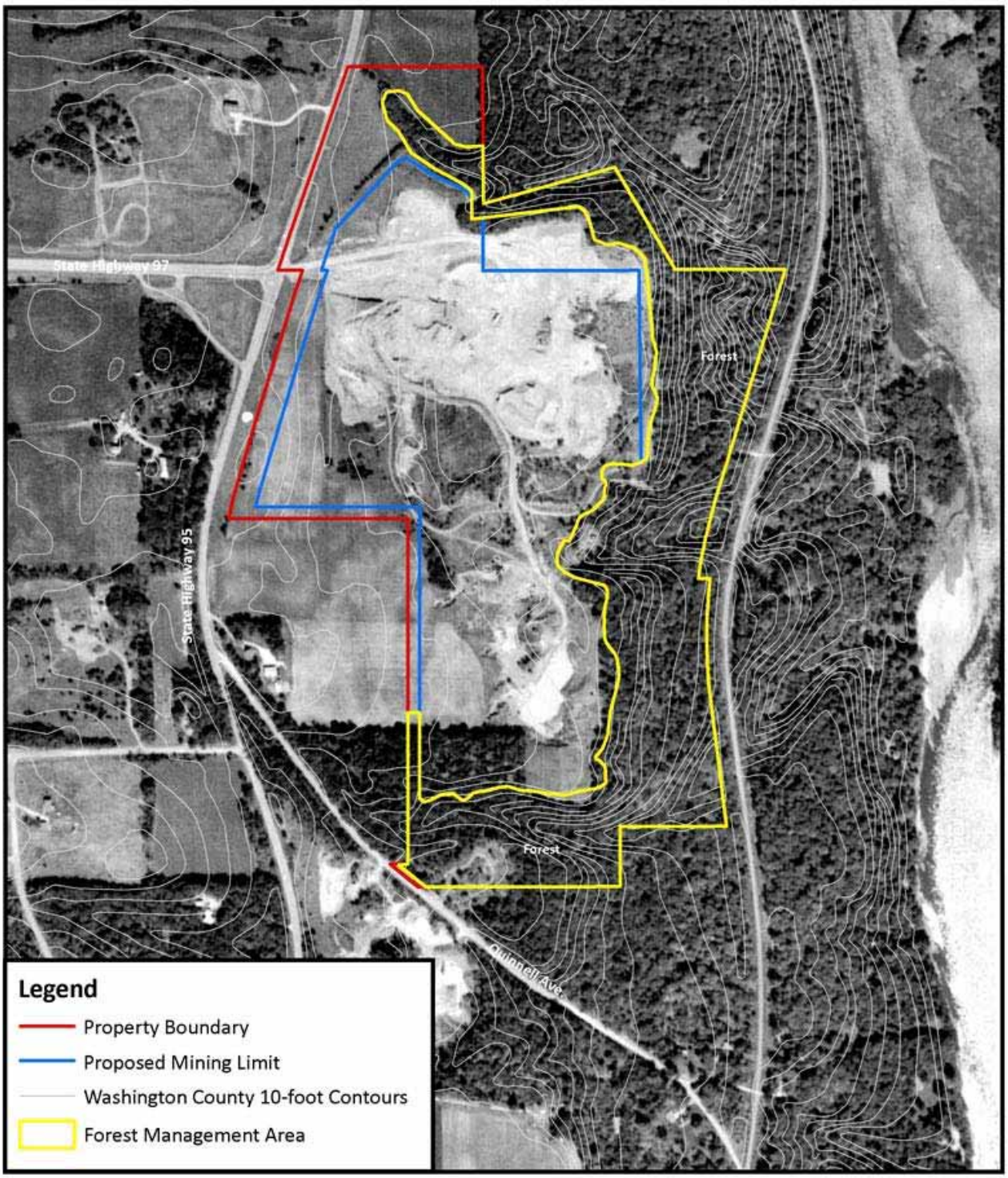
0 125250 500 750 1,000 Feet

NORTH

Critical Connections Ecological Services, Inc.

Appendix A

1980



Zavoral Property
Historic Aerial Photo Forest Cover Map-1980

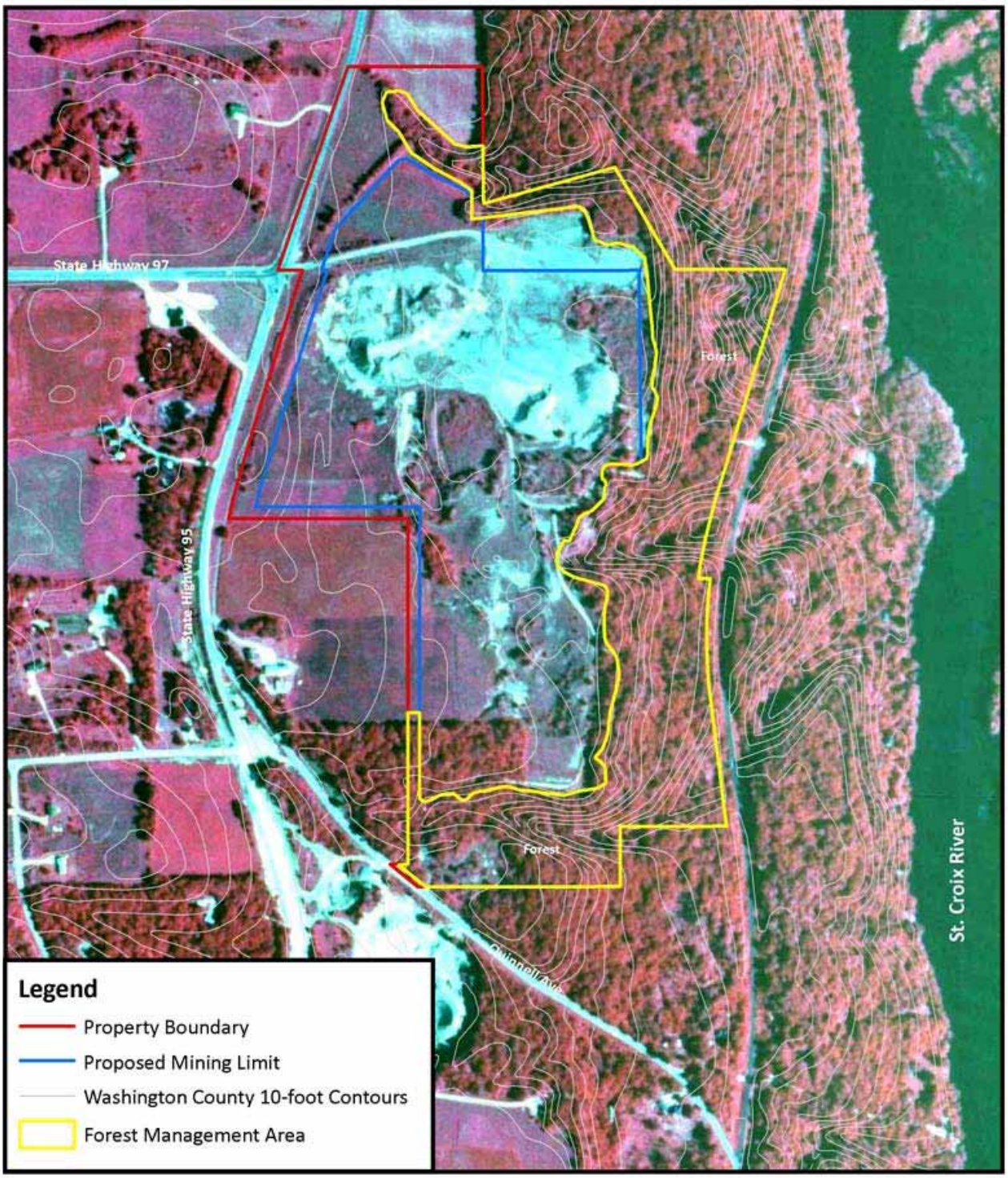
0 125250 500 750 1,000 Feet

NORTH

Critical Connections Ecological Services, Inc.

Appendix A

1986



Zavoral Property
Historic Aerial Photo Forest Cover Map-1986

Feet
0 125250 500 750 1,000

NORTH

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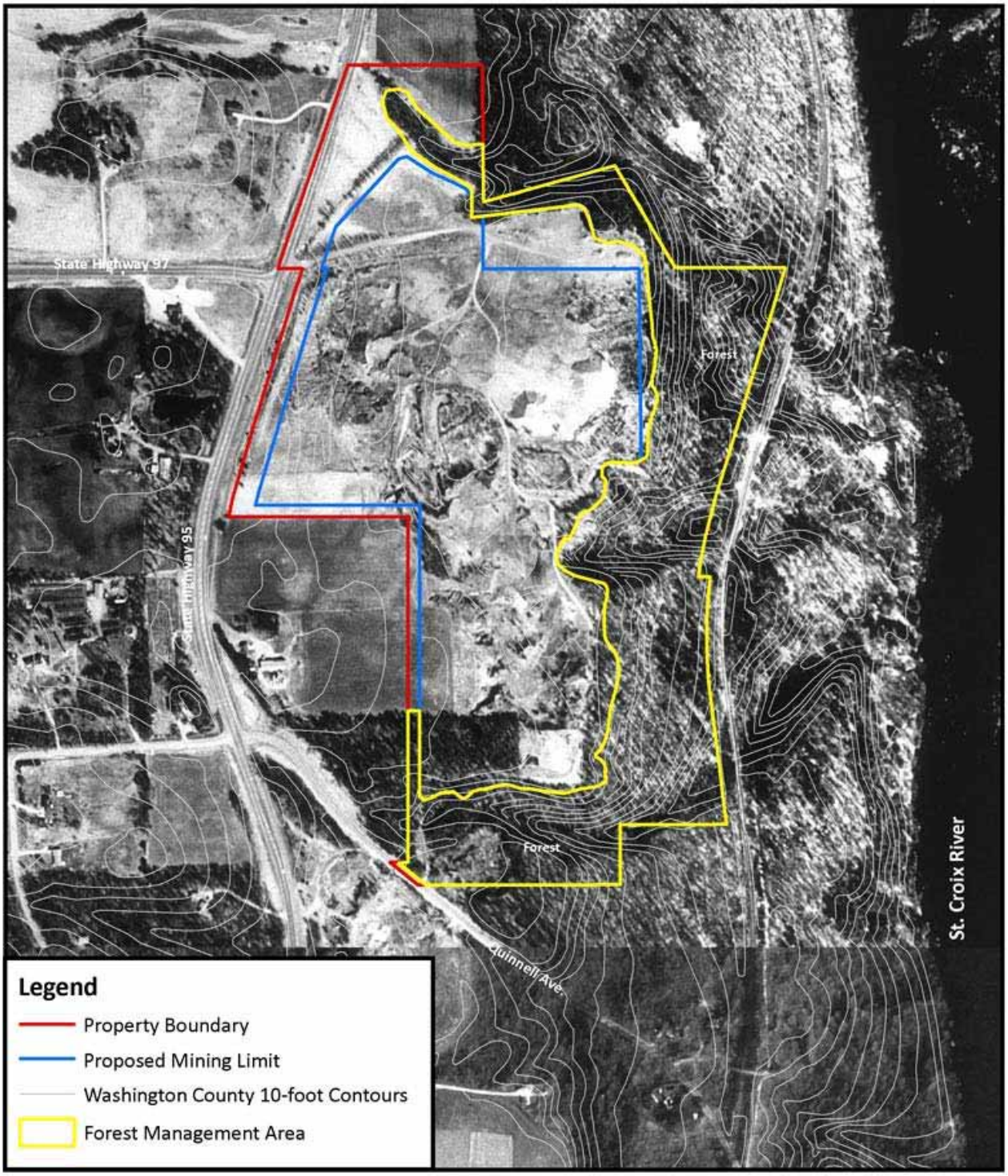
Appendix A

1991



Zavoral Property
Historic Aerial Photo Forest Cover Map-1991

0 125250 500 750 1,000 Feet

NORTH

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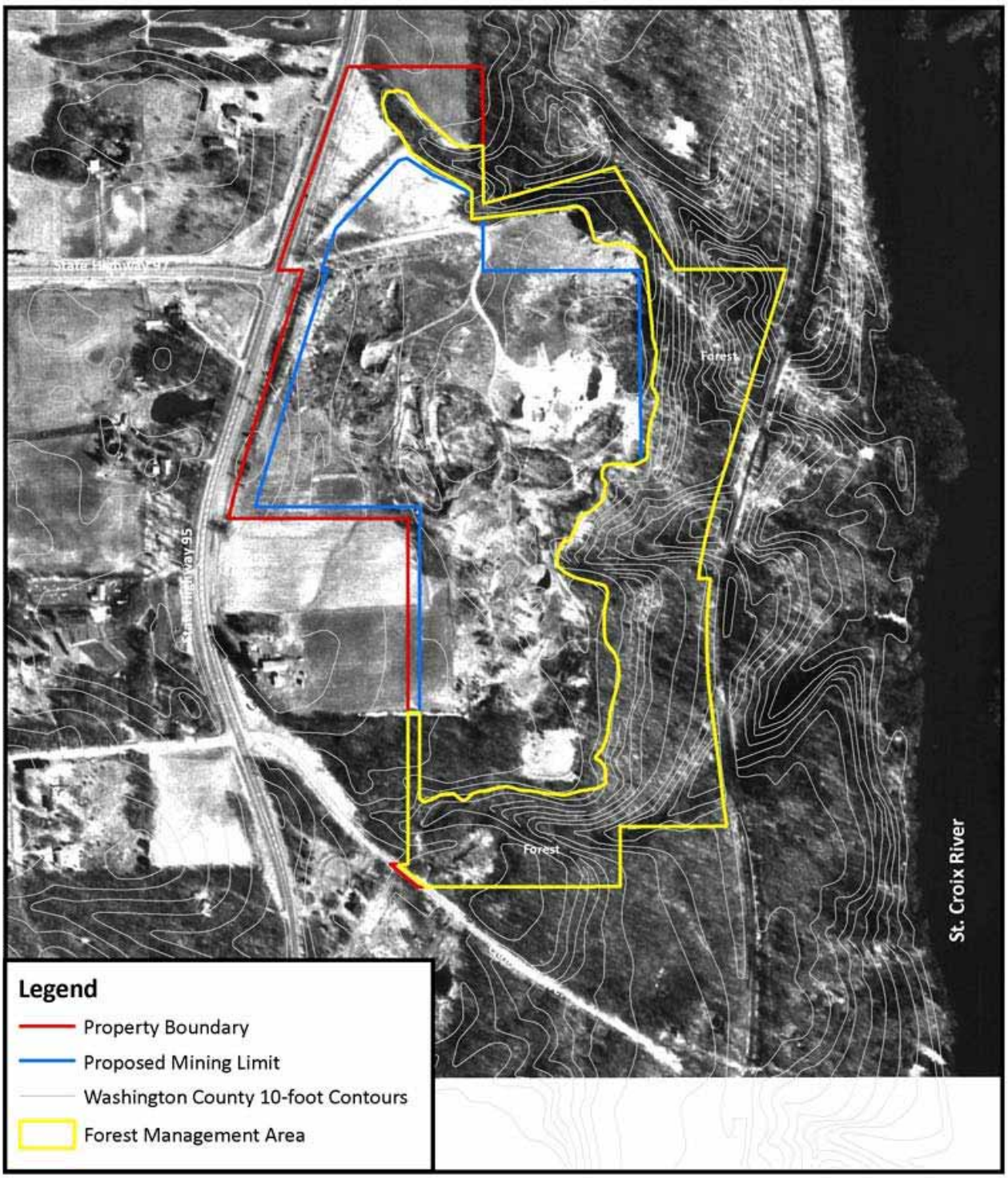
Appendix A

1997



Zavoral Property
Historic Aerial Photo Forest Cover Map-1997

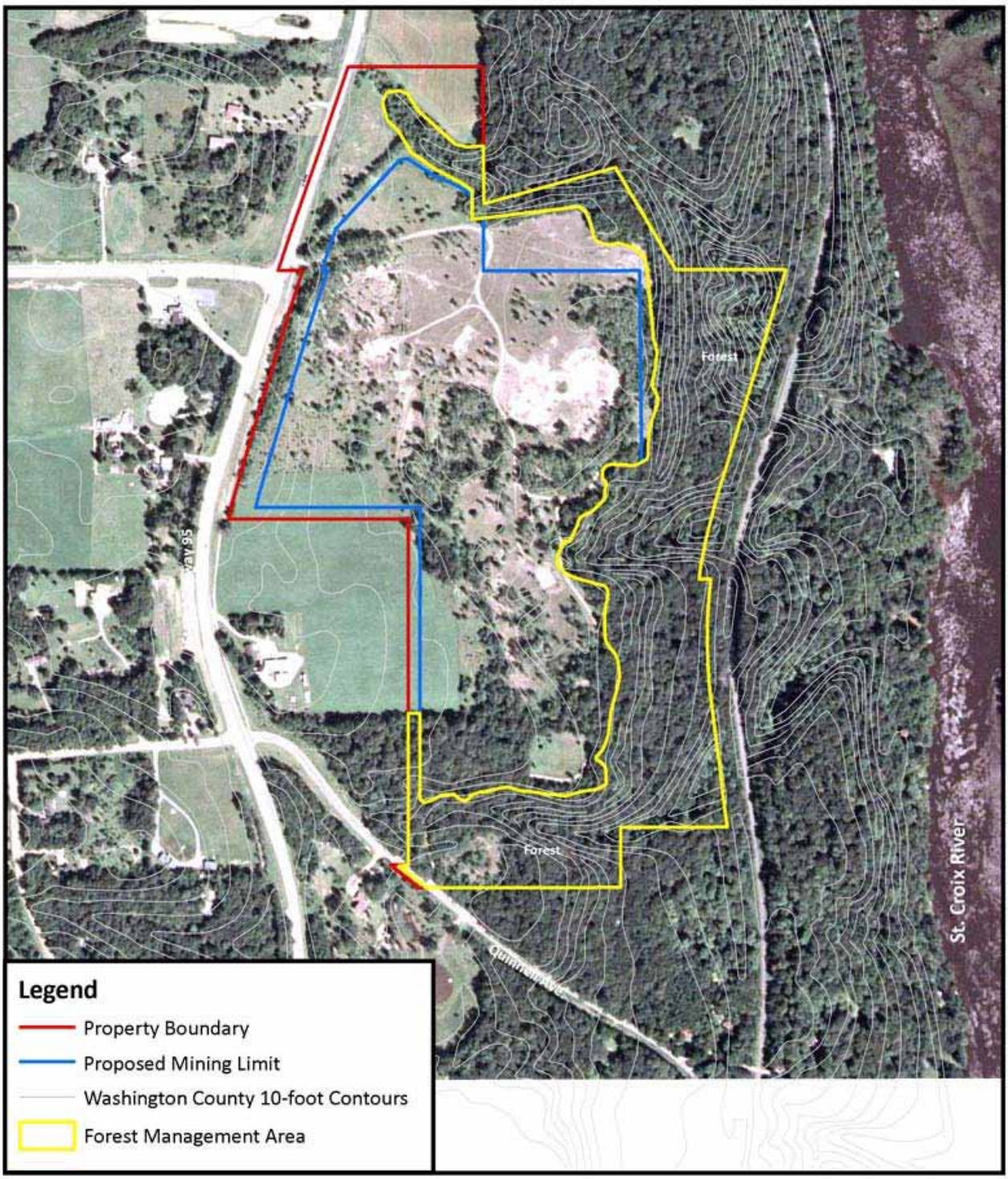
Feet
0 125250 500 750 1,000

NORTH

Critical Connections
Ecological Services, Inc.

Appendix A

2003



Zavoral Property
Historic Aerial Photo Forest Cover Map-2003

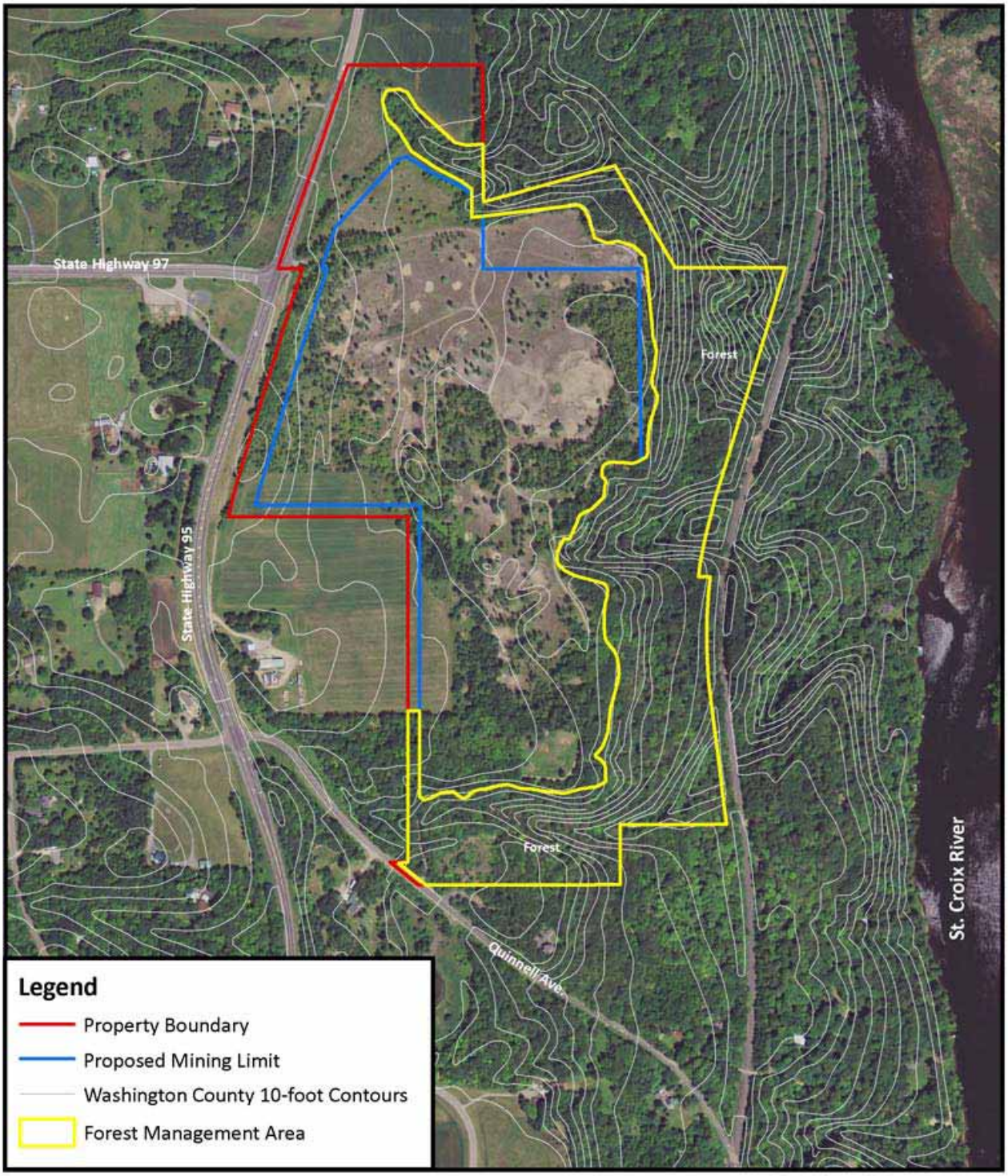
Feet
0 125250 500 750 1,000

NORTH

Critical Connections Ecological Services, Inc.

Appendix A

2010



Zavoral Property

Historic Aerial Photo Forest Cover Map-2010

Feet
0 125250 500 750 1,000

NORTH

Critical Connections
Ecological Services, Inc.

Appendix A

Appendix B

Official Soils Series Descriptions

(USDA & NRCS)

Antiago

LOCATION ANTIGO WI+MN

Established Series
MJM-HFG-JJJ-DJH
12/2005
ANTIGO SERIES

The Antigo series consists of very deep, well drained soils which are moderately deep to sandy outwash. These soils formed mostly in loess or silty alluvium and in loamy alluvium underlain by stratified sandy outwash. Typically these soils are on outwash plains, stream terraces, outwash terraces, kames, eskers, glacial lake plains, glacial drainageways, and outwash areas of moraines. Permeability is moderate in the silty and loamy layers and rapid or very rapid in the sandy outwash. Slopes range from 0 to 30 percent. Mean annual precipitation is about 30 inches. Mean annual air temperature is about 42 degrees F.

TAXONOMIC CLASS: Coarse-loamy over sandy or sandy-skeletal, mixed, superactive, frigid Haplic Glossudalfs

TYPICAL PEDON: Antigo silt loam - on a plane slope of less than 1 percent in a cultivated field at an elevation of about 1520 feet. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 9 inches; dark grayish brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; weak fine subangular blocky structure; very friable; many fine roots; about 6 percent gravel and 2 percent cobbles; neutral; abrupt smooth boundary. (5 to 12 inches thick)

E--9 to 12 inches; brown (10YR 5/3) silt loam, very pale brown (10YR 7/3) dry; weak thin platy structure; very friable; common fine roots; about 1 percent gravel and 1 percent cobbles; slightly acid; clear wavy boundary. (0 to 10 inches thick)

B/E--12 to 19 inches; 70 percent dark yellowish brown (10YR 4/4) silt loam (Bt); moderate very fine angular blocky structure; friable; few distinct brown (7.5YR 4/4) clay films on faces of peds; penetrated by brown (10YR 5/3) silt loam (E), very pale brown (10YR 7/3) dry; weak thin platy structure; very friable; common fine roots; very strongly acid; clear irregular boundary. (0 to 19 inches thick)

Bt1--19 to 28 inches; dark yellowish brown (10YR 4/4) silt loam; moderate fine angular blocky structure; friable; common fine roots; common distinct brown (7.5YR 4/4) clay films on faces of peds; common coatings of pale brown (10YR 6/3) clean silt and very fine sand grains on vertical faces of peds; about 1 percent gravel and cobbles; very strongly acid; abrupt wavy boundary. (0 to 20 inches thick)

2Bt2--28 to 31 inches; brown (7.5YR 4/4) loam; moderate medium subangular blocky structure; friable; common fine roots; common prominent dark reddish brown (5YR 3/4) clay films on faces of peds and in pores; common coatings of pale brown (10YR 6/3) clean silt and sand grains primarily on vertical faces of peds; about 11 percent gravel and 2 percent cobbles; very strongly acid; abrupt wavy boundary.

2Bt3--31 to 33 inches; brown (7.5YR 4/4) very gravelly sandy loam; weak coarse subangular blocky structure; friable; few fine roots; few distinct dark reddish brown (5YR 3/4) clay bridges between mineral grains; about 34 percent gravel and 2 percent cobbles; very strongly acid; abrupt wavy boundary. (Combined thickness of the 2Bt horizon ranges from 0 to 10 inches)

3C--33 to 60 inches; brown (7.5YR 5/4) stratified sand and gravelly sand; single grain; loose; about 16 percent gravel and 2 percent cobbles; few fine roots; strongly acid.

TYPE LOCATION: Langlade County, Wisconsin; about 2 miles northeast of Antigo; 1270 feet west and 345 feet north of the southeast corner of sec. 16, T. 31 N., R. 11 E. USGS Bryant Wis., Quad. Latitude 45 degrees, 09 minutes 48 seconds N., Longitude 89 degrees 07 minutes 08 seconds W. NAD 27.

RANGE IN CHARACTERISTICS: Depth to stratified sandy outwash ranges from 20 to 40 inches. Thickness of the silty mantle ranges from 20 to 40 inches. The coarse-loamy part of the particle-size control section averages 8 to 17 percent clay and 15 to 50 percent fine sand or coarser. Volume of gravel ranges from 0 to 10 percent in the silty mantle and from 0 to 40 percent in the loamy subsoil. Volume of gravel in the sandy outwash ranges from 3 to 45 percent as a weighted average but ranges from 0 to 65 percent in individual strata. Volume of cobbles ranges from 0 to 5 percent throughout. A few stones are on the surface or in the solum in some areas. Reaction typically ranges from very strongly acid to slightly acid in the solum but it ranges to neutral in the upper part, where the soil is limed. It ranges from strongly acid to slightly acid in the substratum. Carbonates are absent to depths of more than 5 feet.

The Ap horizon has hue of 7.5YR or 10YR, value of 3 to 5, and chroma of 2 or 3. Where the value moist is 3, the value dry is 6 or more. Uncultivated areas have an A horizon 1 to 5 inches thick with hue of 7.5YR or 10YR, value of 2 or 3, and chroma of 1 or 2. Texture of the Ap or A horizon is silt loam.

The E horizon has hue of 5YR, 7.5YR, or 10YR; value of 4 to 6; and chroma of 2 or 3. Colors of 4/3 or 5/3 have value, dry of 7 or more. Texture is silt loam.

Some pedons have a Bw horizon below the A or E horizon with hue of 10YR, value of 3 to 6, and chroma of 4 to 6. Texture is silt loam.

Antigo soils have a glossic horizon (E/B or B/E horizons, or both). Horizonation has a wide range depending on the thickness of the silty mantle and the degree to which eluviation has occurred. Therefore, there can be E/B, B/E, 2E/B, or 2B/E horizons, singly or in combination, with or without Bt or 2Bt horizons.

The E part of the E/B or B/E horizons has color and texture like the E horizon described above. The Bt part has hue of 7.5YR or 10YR and value of 3 to 5. texture is silt loam.

The Bt horizon has color and texture like the Bt part described above.

The 2E part of the 2E/B or 2B/E horizons has hue of 5YR, 7.5YR, or 10YR; value of 4 to 6; and chroma of 2 or 3. Texture is loam, sandy loam, fine sandy loam, or the gravelly or very gravelly analogs. These horizons have less than 50 percent fine sand or coarser or are less than 5 inches thick.

The 2Bt part of the 2E/B or 2B/E horizons has hue of 5YR, 7.5YR, or 10YR; value of 3 to 6; and chroma of 4 to 6. It has textures like the 2E part described above.

The 2Bt horizon has color and texture like the 2Bt part described above. 2Bt horizons with 50 percent or more of fine sand or coarser are less than 5 inches thick.

Some pedons have a 3Bt horizon with color like the 2Bt part described above. Texture is sand, coarse sand, loamy sand, loamy coarse sand, or the gravelly or very gravelly analogs.

The 3C horizon has hue of 5YR, 7.5YR, or 10YR; value of 4 to 6; and chroma of 3 to 6. Texture is typically stratified sand, coarse sand, or the gravelly or very gravelly analogs, but some individual strata may be extremely gravelly.

COMPETING SERIES: There are no competing series. Similar soils are the Anigon and Sconsin series. Anigon soils average 18 to 27 percent clay and less than 15 percent fine sand or coarser in the argillic horizon. Sconsin soils have a densic contact and zone of saturation with redoximorhpic concentrations above the sandy outwash within the series control section.

GEOGRAPHIC SETTING: These soils are typically on glacial outwash plains and stream terraces, but in some places they are on eskers and kames or on glacial lake plains and moraines. Slope gradients range from 0 to 30 percent. The soils formed mostly in 20 to 40 inches of loess or water laid silty deposits and in loamy alluvium or sandy outwash or both, underlain by stratified sandy outwash. Mean annual precipitation ranges from 28 to 33 inches. Mean annual temperature ranges from 39 to 45 degrees F. The frost free period is estimated to range from 120 to 135 days. Elevation ranges from 800 to 1,950 feet.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Billyboy(T), Langlade, Minocqua, Ossmer, and Sconsin soils. The moderately well drained Billyboy(T) and Sconsin soils, the somewhat poorly drained Ossmer soils, and the poorly drained Minocqua soils form a drainage sequence with Antigo soils. Sconsin soils are on more level landscape positions. Billyboy(T) and Ossmer soils are on lower landscape positions associated with apparent water tables, or are adjacent to moraines. Minocqua soils are in depressions and drainageways. The well drained Langlade soils are on similar landscape positions as Antigo soils where the loamy mantle is more than 40 inches thick.

DRAINAGE AND PERMEABILITY: Well drained. The potential for surface runoff ranges from negligible to very high. Permeability is moderate in the silty and loamy layers and rapid or very rapid in the sandy outwash.

USE AND VEGETATION: Most areas of this soil are used for cropland. Common crops are corn, small grains, and hay. In some places, potatoes and snap beans are important crops and some areas are used

for pastureland. Some areas remain in woodland. Timber stands are mostly American basswood, sugar maple, yellow birch, white ash, big tooth aspen, quaking aspen, and black cherry.

DISTRIBUTION AND EXTENT: Northern Wisconsin. LRR K, MLRA 90A, and MLRA 90B. This soil is of large extent.

MLRA OFFICE RESPONSIBLE: St. Paul, Minnesota

SERIES ESTABLISHED: Langlade County, Wisconsin, l947.

REMARKS: Diagnostic horizons and features recognized in this pedon:

ochric epipedon - 0 to 12 inches (Ap,E);

albic horizon - 9 to 19 inches (E, E part of B/E);

glossic horizon - 12 to 19 inches (B/E);

argillic horizon - 12 to 33 inches (B/E, Bt1, 2Bt2, 2Bt3).

Lithologic discontinuity - at the upper boundary of the 2Bt2 horizon at 28 inches and at the upper boundary of the 3C horizon at 33 inches.

ADDITIONAL DATA: Refer to soil survey sample number S79WI-067-088 for data on typical pedon. Refer to soil survey sample number S81WI-069-001 for data on another pedon.

National Cooperative Soil Survey

U.S.A.

Emmert

LOCATION EMMERT MN+WI

Established Series
Rev. KAC-AGG
01/2004
EMMERT SERIES

The Emmert series consists of very deep, excessively drained soils that formed in sandy and sandy-skeletal glacial outwash on eskers, kames, terraces, and moraines. These soils have rapid or very rapid permeability. Their slopes range from 1 to 70 percent. Mean annual precipitation is about 28 inches. Mean annual air temperature is about 40 degrees F.

TAXONOMIC CLASS: Sandy-skeletal, mixed, frigid Typic Udorthents

TYPICAL PEDON: Emmert loamy sand with a convex slope of about 40 percent on an esker under deciduous forest. (Colors are for moist soil unless otherwise stated.)

A--0 to 2 inches; very dark gray (10YR 3/1) loamy sand, dark gray (10YR4/1) dry; weak fine granular structure; very friable; about 10 percent gravel; slightly acid; abrupt smooth boundary. (1 to 4 inches thick)

E--2 to 12 inches, brown (7.5YR 5/3) gravelly loamy sand, light brown (7.5YR 6/3) dry; weak fine granular structure; very friable; about 15 percent gravel; slightly acid; gradual smooth boundary. (0 to 15 inches thick)

Bt1--12 to 19 inches, brown (7.5YR 4/4) gravelly loamy coarse sand; weak fine granular structure; about 20 percent gravel; common clay bridging between sand grains; neutral; gradual smooth boundary.

Bt2--19 to 37 inches, brown (7.5YR 4/4) gravelly coarse sand; weak fine granular structure; about 30 percent gravel, common clay bridging between sand grains, neutral; gradual smooth boundary. (combined thickness is 4 to 40 inches)

C--37 to 80 inches, dark brown (7.5YR 3/3) very gravelly coarse sand; single grain; loose; about 50 percent gravel; neutral.

TYPE LOCATION: Mille Lacs County, Minnesota; about 10 miles northeast of Milaca, 800 feet east and 1000 feet south of the northwest corner of Sec. 14, T. 40 N., R. 25 W..

RANGE IN CHARACTERISTICS: Depth to free carbonates is greater than 80 inches. The particle size control section has 35 to 90 percent by volume, of rock fragments commonly dispersed throughout the matrix, but in some pedons the fragments are in distinct strata. They are mostly of igneous origin and commonly 0.5 to 10 cm in diameter.

The A horizon has hue of 10YR to 5YR, value of 2 or 3, and chroma of 1 or 2. It is coarse sandy loam, sandy loam, fine sandy loam, loamy coarse sand, loamy sand, sand or coarse sand or their gravelly analogues. It is slightly acid to strongly acid.

The E horizon has hue of 10YR or 7.5YR hue; value of 4 to 6; and chroma of 1 to 3. It is coarse sandy loam, sandy loam, fine sandy loam, loamy coarse sand, sand or coarse sand or their gravelly analogues. It is slightly acid to strongly acid.

The Bt horizons have hue of 5YR to 10YR; value of 3 to 5; and chroma of 2 to 6. They are coarse sand, sand, loamy coarse sand, or loamy sand or their gravelly or very gravelly analogues. They are neutral to strongly acid.

Some pedons have a Bw horizon with colors and textures similar to the Bt horizon.

The C horizon has a hue of 5YR to 10YR, value of 3 to 5, and chroma of 3 to 6. It is sand or coarse sand in the fine-earth fraction and stratification is common. It is neutral to strongly acid.

COMPETING SERIES: These are the Boscawen, Hopkinton, Stonelake and Yellowdog series. The Boscawen soils do not have clay bridging in the upper part of the profile. Hopkinton soils are not currently in the OSD database. Stonelake soils have free carbonates at a depth above 60 inches. Yellowdog soils have a lithic contact at depths of 20 to 40 inches.

GEOGRAPHIC SETTING: These soils have convex and linear slopes on kames, eskers, moraines, and terraces. Slope gradients commonly are 9 to 18 percent but range from 1 to 70 percent. These soils formed in noncalcareous, sandy and sandy-skeletal outwash of Late Wisconsinan Age. The mean annual air temperature is approximately 35 to 45 degrees F. Mean annual precipitation is about 24 to 34 inches. Frost-free days range from 90 to 140 days. Elevation above sea level ranges from 700 to 1600 feet.

GEOGRAPHICALLY ASSOCIATED SOILS: The Emmert soils primarily are in association with the well drained Antigo, Rosholt, Sanburn, Cloquet, and Onamia soils and somewhat excessively drained Chetek soils all of which have a thicker loamy mantle. They also are associated in some places with the upland till soils.

DRAINAGE AND PERMEABILITY: Excessively drained. Surface runoff is low to medium. Permeability is rapid or very rapid.

USE AND VEGETATION: Mostly in forest and some is pastured. Native vegetation is mixed hardwoods and conifers.

DISTRIBUTION AND EXTENT: MLRA-90 and 93. Central and northern Minnesota and northern Wisconsin. The series is moderately extensive.

MLRA OFFICE RESPONSIBLE: St. Paul, Minnesota

SERIES ESTABLISHED: Mille Lacs County, Minnesota, 1927.

REMARKS: Diagnostic horizons and features recognized in this pedon are: ochric epipedon - the zone from o to 12 inches (A and E horizons); udic moisture regime.

The Bt horizons do not qualify for an argillic because the clay increase is less than 3 percent.

ADDITIONAL DATA: Refer to MAES Central File Code No. 742 for some results of laboratory analysis of the typical pedon.

National Cooperative Soil Survey

U.S.A.

Gotham

LOCATION GOTHAM WI+MN

Established Series
Rev. AJK-GWH-HFG
06/2001
GOTHAM SERIES

The Gotham series consists of deep, well drained and somewhat excessively drained soils formed in sandy glaciofluvial deposits on moraines, outwash plains, stream terraces, and glacial lake basins. These soils have rapid permeability. Slopes range from 0 to 35 percent. Mean annual precipitation is about 32 inches, and mean annual temperature is about 49 degrees F.

TAXONOMIC CLASS: Mixed, mesic Psammentic Hapludalfs

TYPICAL PEDON: Gotham loamy fine sand - on a 2 percent slope in a cultivated field. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 9 inches; very dark grayish brown (10YR 3/2) loamy fine sand, light brownish gray (10YR 6/2) dry; weak very fine granular structure; very friable; many fine roots; slightly acid; abrupt smooth boundary. (6 to 9 inches thick)

Bw1--9 to 15 inches; yellowish brown (10YR 5/4) loamy fine sand; weak medium subangular blocky structure; very friable; many fine roots; slightly acid, gradual smooth boundary.

Bw2--15 to 20 inches; dark yellowish brown (10YR 4/4) loamy fine sand; weak medium subangular blocky structure; very friable; few fine roots; slightly acid; gradual smooth boundary. (Combined thickness of Bw horizon ranges from 0 to 11 inches.)

Bt--20 to 32 inches; dark brown (7.5YR 4/4) and strong brown (7.5YR 5/6) loamy fine sand; weak coarse subangular blocky structure; friable; clay fraction bridges sand grains and occupies some of the pores; slightly acid; clear smooth boundary. (6 to 21 inches thick)

BC--32 to 38 inches; strong brown (7.5YR 5/6) loamy fine sand; weak medium subangular blocky structure; very friable; loose; moderately acid; clear smooth boundary. (5 to 8 inches thick)

C--38 to 60 inches; strong brown (7.5YR 5/6) fine sand; single grain; loose; medium acid.

TYPE LOCATION: Richland County, Wisconsin; about 1/4 mile south of Gotham; 300 feet north and 1,100 feet east of the center, sec. 31, T. 9 N., R. 2 E.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 24 to 40 inches. The A horizon is medium acid to neutral. The B and C horizons are strongly acid to neutral. Volume of pebbles range from 0 to 2 percent in the A horizon and from 0 to 15 percent in B and C horizons, but typically most pedons contain

less than 5 percent. Loamy substratum and sandstone substratum phases are recognized in some places.

The A or Ap horizon has 10YR or 7.5YR hue, value of 2 or 3, and chroma of 1 to 3. It typically is loamy fine sand or loamy sand, but in some pedons it is fine sandy loam. A thin loamy fine sand or loamy sand E horizon is present in some pedons.

The Bw horizon has 10YR or 7.5YR hue, value of 4 or 5, and chroma of 3 to 6. It is loamy fine sand, or loamy sand. In some pedons, indistinct illuviation is evidenced in the lower part of the Bw horizon by some coated sand grains and by some clay bridging of the sand grains.

The Bt horizon has 10YR, 7.5YR, or 5YR hue; value of 4 or 5; and chroma of 4 to 6. It is loamy fine sand or loamy sand with at least 3 percent more clay than the overlying eluvial horizon. Clay bridging is distinct.

The BC horizon has 10YR, 7.5YR, or 5YR hue; value of 4 or 5; and chroma of 4 to 6. It is loamy fine sand, loamy sand, fine sand, or sand. Clay bridging is indistinct or not present.

The C horizon has 10YR, 7.5YR, or 5YR hue; value of 4 to 6; and chroma of 3 to 6. It is loamy fine sand, loamy sand, fine sand, or sand. Some pedons contain lamellae 1/8 to 1 inch thick in the lower part of the C horizon.

COMPETING SERIES: These are the Bloomfield, Lilah, Montieth, Moundville, Pearl, Richford, Spinks, and Watertown series in the same family and the Arkport, Chelsea, Coloma, Dickinson, Galen, Hubbard, and Lamont series. Bloomfield soils have Bt horizons of lamellae with aggregate thickness of more than 6 inches thick. Lilah soils typically are fine sandy loam in the A horizon and upper part of the B horizon and, in addition, contain a higher percentage of gravel above a depth of 40 inches. Montieth soils have Bt horizons consisting of lamellae and a paralithic contact between a depth of 20 and 40 inches. Moundville soils have distinct mottles in the solum and in the C horizon above a depth of 40 inches. Pearl and Richford soils have sandy loam Bt horizons. In addition, Richford soils typically contain more gravel. Spinks soils have light-colored surface horizons and B horizons consisting of lamellae with an average thickness of less than 6 inches within 60 inches of the soil surface. Watertown soils have sand dominantly in the medium and coarse sand range and allow more coarse fragments in the solum and C horizon. Arkport soils have Bt horizons of lamellae but are coarse-loamy. Chelsea and Coloma soils have Bt horizons consisting of lamellae with an aggregate thickness of less than 6 inches thick within 60 inches of the soil surface. Dickinson and Hubbard soils have thicker, darker color A horizons and do not have argillic horizons. Galen soils have high chroma mottles in the upper part of the subsoil and are coarse-loamy. Lamont soils have thicker, fine sandy loam argillic horizons with 10 to 15 percent clay and higher value in the surface horizons.

GEOGRAPHIC SETTING: Gotham soils are on nearly level to moderately steep undulating stream terraces, moraines, outwash plains, and glacial lake basins. Slope gradients typically are 0 to 12 percent

but range to 35 percent. The soil formed in glaciofluvial deposits of loamy sand or sand. Mean annual temperature ranges from 45 to 52 degrees F, mean annual precipitation ranges from 28 to 35 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: Gotham soils are associated on similar landscape positions with Dakota, Meridian, Moundville, Plainfield, and Sparta soils. Dakota and Sparta soils have mollic epipedons. Meridian soils have finer-textured sola. Moundville soils have mottled lower subsoils. Plainfield soils do not have the argillic horizon.

DRAINAGE AND PERMEABILITY: Well and somewhat excessively drained. Runoff is negligible to low. Permeability is rapid.

USE AND VEGETATION: Most areas have been cleared and are being cropped to small grains, corn, and soybeans. Native vegetation was mixed prairie grasses with deciduous and a few coniferous trees.

DISTRIBUTION AND EXTENT: Southwestern Wisconsin and other sandy areas in the Lake States. This soil is of moderate extent.

MLRA OFFICE RESPONSIBLE: St. Paul, Minnesota

SERIES ESTABLISHED: Richland County, Wisconsin, 1956.

National Cooperative Soil Survey

U.S.A.

Mahtomedi

LOCATION MAHTOMEDI MN+MI WI

Established Series
KRV-ELB-ROP
11/2002
MAHTOMEDI SERIES

The Mahtomedi series consists of very deep, excessively drained, rapidly permeable soils formed in sandy outwash of Late Wisconsinan Age on glacial moraines and outwash plains. These upland soils have slopes ranging from 0 to 45 percent. Mean annual temperature is about 41 degrees F. Mean annual precipitation is about 28 inches.

TAXONOMIC CLASS: Mixed, frigid Typic Udipsamments

TYPICAL PEDON: Mahtomedi loamy sand with a 13 percent convex southwest-facing slope on a glacial outwash plain under oak forest. (Colors are for moist soil unless otherwise stated.)

A--0 to 5 inches; very dark gray (10YR 3/1) loamy sand, grayish brown (10YR 5/2) dry; weak fine and medium granular structure; very friable; about 5 percent gravel; moderately acid; abrupt smooth boundary. (0 to 7 inches thick)

E--5 to 8 inches; brown (7.5YR 5/2) sand; single grain; loose; about 10 percent gravel; strongly acid; clear smooth boundary. (0 to 13 inches thick)

Bw1--8 to 15 inches; brown (7.5YR 4/4) gravelly coarse sand; single grained; loose; about 25 percent gravel and 10 percent cobbles; strongly acid; clear smooth boundary.

Bw2--15 to 30 inches; reddish brown (5YR 4/4) gravelly sand; single grain; loose; about 18 percent gravel and 2 percent cobbles; strongly acid; gradual smooth boundary. (Combined thickness of the Bw horizons is 4 to 30 inches.)

C1--30 to 44 inches; reddish brown (5YR 5/4) gravelly sand; single grain; loose; about 25 percent gravel and 1 percent cobbles; strongly acid; gradual smooth boundary.

C2--44 to 60 inches; light reddish brown (5YR 6/3) gravelly sand; single grain; loose; about 15 percent gravel and 1 percent cobbles; moderately acid.

TYPE LOCATION: Washington County, Minnesota; about 1 1/2 miles northwest of Mahtomedi; 2240 feet south and 100 feet east of the northwest corner, sec. 16, T. 30 N., R. 21 W.

RANGE IN CHARACTERISTICS: Free carbonates typically are absent to depths of 10 feet or more, but a small amount are in the C horizon of some pedons. Content of rock fragments in the control section averages between 10 and 35 percent by volume but subhorizons in some pedons have less than 10

percent or more than 35 percent. They are mostly of igneous origin and commonly 0.2 to 5 cm in diameter but ranges to 2 percent cobbles in the A horizon and 10 percent in the B and C horizons. The texture of the fine-earth fraction in the control section is sand or coarse sand. Mottles are below a depth of 30 inches in some pedons.

The A horizon has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 1 or 2. The E horizon has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 1 to 3. The A and E horizons are coarse sand, sand, loamy coarse sand, loamy sand, fine sand, loamy fine sand, coarse sandy loam, sandy loam or fine sandy loam, or their gravelly analogues. It is strongly acid to slightly acid. Cultivated pedons have an Ap horizon with hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 1 to 3. Some pedons have a thin O horizon.

The Bw horizon has hue of 10YR to 5YR, value of 3 to 5, and chroma of 3 to 6. It is coarse sand, sand, or their gravelly analogues, but has finer textured subhorizons in some pedons. It is strongly acid to slightly acid. Some pedons have a thin BE or BC horizon.

The C horizon commonly has hue of 10YR to 5YR, value of 4 to 6 and chroma of 3 to 6. It is coarse sand, sand, or their gravelly, very gravelly, or cobbly analogues, but has finer or coarser textured subhorizons in some pedons. It is strongly acid to slightly alkaline.

COMPETING SERIES: These are Champlain (T), Claire, Corliss (T), Friendship, Grayling, Menahga, Nymore, Omega, Pelkie, Plainbo, Sartell, Serden, Shawano, and Sunday series. Champlain, Claire, Friendship, Grayling, Menahga, Nymore, Omega, Pelkie, Plainbo, Sartell, Serden, Shawano, and Sunday soils have 10 percent or less rock fragments in the series control section. Corliss soils have a free calcium carbonate within 40 inches. All of these soils have less than 10 percent rock fragments.

GEOGRAPHIC SETTING: These soils have plane or convex slopes on glacial moraines and outwash plains. Slope gradients range from 0 to 45 percent. These soils formed in sandy glacial outwash of Late Wisconsinan Age. Mean annual temperature ranges from 36 to 45 degrees F. Mean annual precipitation ranges from about 22 to 33 inches. Frost-free days range from 88 to 142. Elevation above sea level ranges from 670 to 1600 feet.

GEOGRAPHICALLY ASSOCIATED SOILS: Mahtomedi soils are in association with well drained Antigo, Chetek, Onamia, and Rosholt soils. All of those soils formed in a mantle of loamy or silty sediments and underlying sandy or sandy-skeletal glacial outwash. Also, they are associated with Emmert soils which contain more than 35 percent rock fragments in the control section. They are associated in some places with Kingsley and Milaca soils which formed in glacial till.

DRAINAGE AND PERMEABILITY: Excessively drained drained. Surface runoff is slow or medium. Permeability is rapid. The apparent water table is at 2.5 to 6 feet for the moderately well drained phase.

USE AND VEGETATION: Mostly in forest and some is pastured. Native vegetation was mixed hardwood-coniferous forest.

DISTRIBUTION AND EXTENT: Central and northern Minnesota and possibly northern Wisconsin. This series is inextensive.

MLRA OFFICE RESPONSIBLE: St. Paul, Minnesota

SERIES ESTABLISHED: Washington and Ramsey Counties, Minnesota, 1978.

REMARKS: Diagnostic horizon and feature identified in this soil is: ochric epipedon - the zone from the surface to 8 inches (A and E horizons); udic moisture regime. The moderately wet Mohtomedi is now the Lenroot series.

ADDITIONAL DATA: Refer to MN Agr. Exp. Sta. Central File Code No.'s 2006, the typical pedon and 2008, an additional pedon, for results of some laboratory analyses.

National Cooperative Soil Survey

U.S.A.

Santiago

LOCATION SANTIAGO WI+MN

Established Series
Rev. DJH-DEJ-HFG
02/2006
SANTIAGO SERIES

The Santiago series consists of well drained soils which are deep to a densic contact. They formed in loess or silty lacustrine deposits and in the underlying dense sandy loam till on ground moraines, disintegration moraines, and end moraines. Permeability is moderate in the silty mantle, slow or moderately slow in the lower part of the solum, and very slow in the substratum. Slope ranges from 1 to 45 percent. Mean annual precipitation is about 30 inches. Mean annual air temperature is about 42 degrees F.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, frigid Haplic Glossudalfs

TYPICAL PEDON: Santiago silt loam, on a convex, northeast-facing slope of 8 percent, in a cultivated field, at an elevation of about 1,180 feet. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 10 inches; dark brown (10YR 3/3) silt loam, light brownish gray (10YR 6/2) dry; moderate medium granular structure; friable; many fine and few medium roots; 4 percent gravel; slightly acid; abrupt smooth boundary. (6 to 12 inches thick)

E/B--10 to 15 inches; about 60 percent brown (10YR 5/3) silt loam (E), very pale brown (10YR 7/3) dry; weak medium platy structure parting to moderate very fine subangular blocky; friable; extends as tongues into or surrounds remnants of dark yellowish brown (10YR 4/4) silt loam (Bt); moderate very fine subangular blocky structure; friable; common faint dark yellowish brown (10YR 3/4) clay films on faces of peds; common fine and medium roots; 1 percent gravel; moderately acid; clear smooth boundary.

B/E--15 to 23 inches; about 70 percent dark yellowish brown (10YR 4/4) silt loam (Bt); moderate very fine subangular blocky structure; friable; common faint dark yellowish brown (10YR 3/4) clay films on faces of peds; penetrated by tongues of brown (10YR 5/3) silt loam (E), very pale brown (10YR 7/3) dry; weak medium platy structure parting moderate very fine subangular blocky; friable; common fine and few medium roots; 1 percent gravel; very strongly acid; abrupt wavy boundary. (Glossic horizon ranges from 5 to 20 inches thick.)

2Bt1--23 to 36 inches; dark brown (7.5YR 3/4) gravelly sandy loam; moderate fine prismatic structure tending to part along horizontal cleavage planes to weak medium plates inherited from the parent material; firm; common fine roots; common faint dark brown (7.5YR 3/3) and few distinct reddish brown (5YR 4/4) clay films on all faces of peds; few prominent brown (10YR 5/3) silt coats on vertical faces of

peds; 14 percent gravel and about 1 percent cobbles; slightly brittle; strongly acid; abrupt wavy boundary.

2Bt2--36 to 49 inches; dark brown (7.5YR 3/4) fine sandy loam; moderate fine prismatic structure tending to part along horizontal cleavage planes to weak medium plates inherited from the parent material; firm; few fine roots; many faint dark brown (7.5YR 3/3) clay films on all faces of peds; very few prominent brown (10YR 5/3) silt coats on vertical faces of peds; 11 percent gravel and about 1 percent cobbles; slightly brittle; strongly acid; gradual wavy boundary. (Combined thickness of the 2Bt horizon ranges from 8 to 30 inches.)

2BCd1--49 to 69 inches; dark reddish brown (5YR 3/4) sandy loam; weak very coarse prismatic structure tending to part along horizontal cleavage planes to weak medium plates inherited from the parent material; firm; few fine roots; few faint dark reddish brown (5YR 3/3) clay films on top faces of peds; 9 percent gravel and about 1 percent cobbles; moderately acid; gradual wavy boundary.

2BCd2--69 to 87 inches; dark reddish brown (5YR 3/4) sandy loam; weak extremely coarse prismatic structure tending to part along horizontal cleavage planes to weak medium plates inherited from the parent material; firm; few fine roots; few distinct dark reddish brown (5YR 3/3) clay films on top faces of peds; 7 percent gravel and about 1 percent cobbles; few sandstone channers; moderately acid; gradual wavy boundary. (Combined thickness of the 2BCd horizon ranges from 0 to 70 inches.)

2Cd--87 to 102 inches; reddish brown (5YR 4/4) sandy loam; tending to part along horizontal cleavage planes to weak medium plates; firm; dense and compact; 9 percent gravel and about 1 percent cobbles; slightly acid.

TYPE LOCATION: Barron County, Wisconsin; about 2 miles east and 1.5 miles south of Reeve; located about 1,840 feet south and 2,040 feet east of the northwest corner of section 34, T. 32 N., R. 14 W.; USGS Connorsville topographic quadrangle; lat. 45 degrees 13 minutes 09 seconds N. and long. 92 degrees 05 minutes 12 seconds W., NAD 83.

RANGE IN CHARACTERISTICS: Thickness of the silty mantle ranges from 12 to 36 inches. Depth to the base of the argillic horizon and to densic contact ranges from 40 to 60 inches. Content of clay averages from 7 to 17 percent in the particle-size control section and the content of fine sand or coarser averages 15 to 70 percent. The base saturation (by sum of cations) is less than 60 percent in some part of the argillic horizon. Volume of gravel ranges from 0 to 10 percent in the silty mantle and from 5 to 35 percent in the till. Volume of cobbles ranges from 0 to 3 percent in the silty mantle and from 0 to 5 percent in the till. Volume of stones ranges from 0 to 1 percent in the silty mantle and from 0 to 3 percent in the till. Surface stones have coverage ranging from 0 to 3 percent. Reaction ranges from extremely acid to slightly acid in the solum, except it ranges to neutral in the Ap horizon where the soil is limed. Reaction ranges from strongly acid to neutral in the substratum.

The Ap horizon has hue of 7.5YR or 10YR, value of 3 or 4, and chroma of 1 to 3. Dry value is greater than 5.5. Uncultivated pedons have an A horizon, 1 to 4 inches thick, with hue of 7.5YR or 10YR, value of 2 or 3, and chroma of 1 or 2. Texture is silt loam.

Some pedons have an E horizon with hue of 7.5YR or 10YR, value of 4 to 6, and chroma of 2 or 3. Colors of 4/3 or 5/3 have value dry of 7 or more. The E horizon is silt loam or silt.

Some pedons have a Bw horizon with hue of 7.5YR or 10YR, value of 3 to 5, and chroma of 4. It is silt loam. Bw horizons with spodic color have less than 0.6 percent organic carbon.

Santiago soils have a glossic horizon. Horizonation has a wide range depending on the thickness of the silty mantle and the degree to which eluviation has occurred. Therefore, there can be E/B, B/E, 2E/B, or 2B/E horizons singly or in combination.

The E part of the E/B or B/E horizon has color and texture like the E horizon described above. The Bt part has hue of 7.5YR or 10YR, value of 3 to 5, and chroma of 4 to 6.

Some pedons have a Bt horizon with color and texture like the Bt part described above.

The 2E part of the 2E/B or 2B/E horizon has hue of 5YR, 7.5YR, or 10YR, value of 4 to 6 and chroma of 2 or 3. Colors of 4/3 or 5/3 have value dry of 7 or more. The 2E part is typically sandy loam, fine sandy loam, loam, or their gravelly analogs, but in some pedons it is loamy sand or gravelly loamy sand. The 2Bt part has color and texture like the 2Bt horizon described below.

The 2Bt horizon has hue of 2.5YR, 5YR, or 7.5YR, value of 3 to 5 and chroma of 4 to 6. It is typically sandy loam, fine sandy loam, loam, or their gravelly analogs. The bulk density ranges from 1.65 to 1.90 gm/cc. Some pedons have pockets or strata of loamy sand or gravelly loamy sand.

The 2BCd horizon has hue of 2.5YR, 5YR, or 7.5YR, value of 3 to 5 and chroma of 4 to 6. It is typically sandy loam, fine sandy loam, or their gravelly analogs. Bulk density ranges from 1.8 to 2.0 gm/cc. Some pedons have pockets or strata of loamy sand or gravelly loamy sand.

The 2Cd horizon has hue of 2.5YR, 5YR, or 7.5YR, value of 3 to 5 and chroma of 4 to 6. It is typically sandy loam, fine sandy loam, or their gravelly analogs. Bulk density ranges from 1.8 to 2.0 gm/cc. Some pedons have pockets or strata of loamy sand or gravelly loamy sand.

COMPETING SERIES: These are the Amery, Arland, Automba, Goodland, Itasca, Kennan, Langlade, Marathon, Pemene, Rosholt, Scoba, and Steamboat series.

Amery and Automba soils do not have a 12 to 36 inch thick mantle that is more than 50 percent silt. In addition, Automba soils have base saturation of more than 60 percent in all parts of the argillic horizon.

Arland soils have a paralithic contact of sandstone at a depth of 20 to 40 inches.

Goodland, Itasca, Kennan, Langlade, Marathon, Pemene, Rosholt, Scoba, and Steamboat soils do not have a densic contact within the series control section.

GEOGRAPHIC SETTING:

Parent material--loess or silty lacustrine and in the underlying dense sandy loam till of Late Wisconsinan Age

Landform--ground moraines, disintegration moraines, and end moraines

Slope--1 to 45 percent

Elevation--800 to 1950 feet

Mean annual air temperature--39 to 45 degrees F

Mean annual precipitation--28 to 33 inches

Frost-free period--120 to 135 days

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Amery, Freeon, Haugen, Magnor, Newood, Newot, Otterholt, and Spencer soils.

The moderately well drained Freeon and somewhat poorly drained Magnor soils are in a drainage sequence with Santiago soils. They are on slightly lower or less sloping landscape positions.

The well drained Amery and Newot soils are on similar landscape positions and the moderately well drained Haugen and Newood soils are on less sloping landscape positions to those of Santiago soils where the silty mantle is less than 12 inches thick, or is absent.

The well drained Otterholt soils and moderately well drained Spencer soils are on landscape positions similar to those of Santiago soils where the silty mantle is more than 36 inches thick.

DRAINAGE AND PERMEABILITY: Well drained. Surface runoff is medium to very high. Permeability is moderate in the silty mantle, slow or moderately slow in the lower solum, and very slow in the substratum.

USE AND VEGETATION: Many areas of this soil are used for cropland. Corn, small grains, and hay are common crops. Some areas remain in woodland. Native vegetation is mixed hardwood forest with a few conifers. Common trees are sugar maple, American basswood, northern red oak, white ash, American elm, and quaking aspen with some white pine and red pine.

DISTRIBUTION AND EXTENT: Northwestern Wisconsin and east-central Minnesota. LRR K, MLRA 90A and MLRA 90B. This soil is extensive.

MLRA OFFICE RESPONSIBLE: St. Paul, Minnesota

SERIES ESTABLISHED: Mille Lacs County, Minnesota, 1927. Type location moved to Barron County, Wisconsin with the correlation of the soil survey in 1992.

REMARKS:

Particle size control section - the zone from 15 to 35 inches

Diagnostic horizons and features recognized in this pedon are:
Ochric epipedon - the zone from 0 to 15 inches (Ap, E/B);
Albic horizon - the zone from 10 to 15 inches (E part of the E/B);
Glossic horizon - the zone from 10 to 23 inches (E/B, B/E);
Argillic horizon - the zone from 15 to 49 inches (B/E, 2Bt1, 2Bt2);
Densic contact - the contact with dense till (2BCd1, 2BCd2, 2Cd) at 49 inches;
Lithologic discontinuity - at the upper boundary of the 2Bt1 horizon at 23 inches.

The bulk density and platyness of the argillic horizon is considered to be relict of the till, but studies are needed to determine whether or not these horizons meet criteria for fragipans or fragic soil properties.

The 2BCd1 and 2BCd2 horizons were originally described as 2Bt horizons, but were redesignated because they are transitional to the substratum and exhibit densic characteristics.

ADDITIONAL DATA: Former Soil Interpretation Records - WI0137 and WI0346. Refer to soil survey sample number S90WI-005-008 for NSSL data on the typical pedon.

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