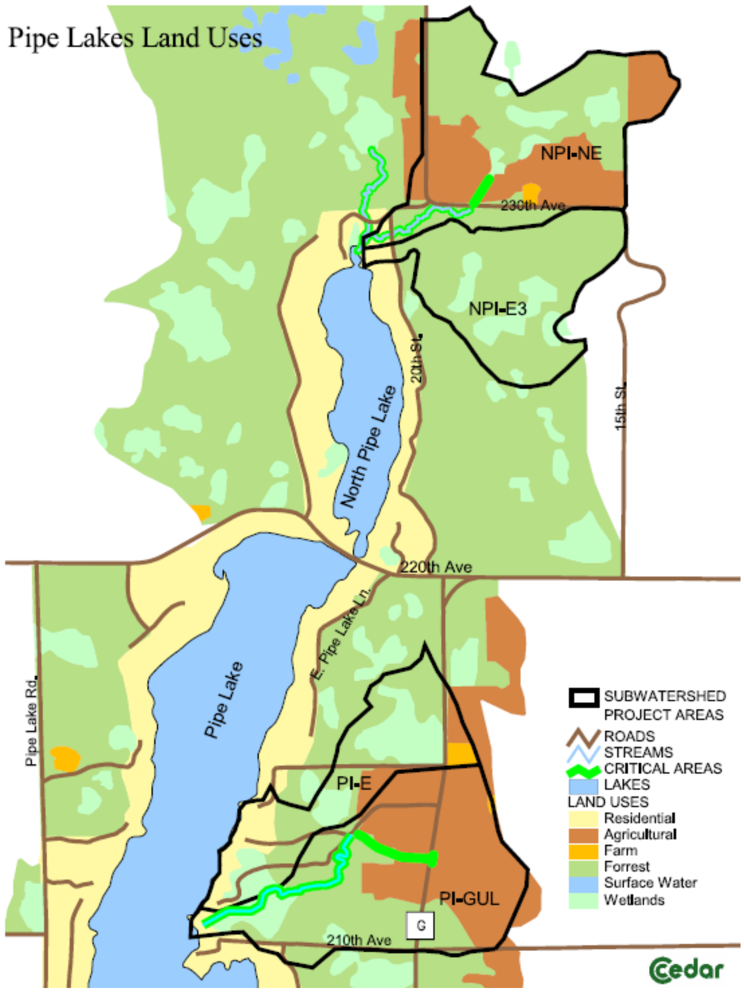
Subwatershed Recommendations Report
Pipe Lakes Protection and Rehabilitation District
Polk County



Prepared for:
Pipe Lakes Protection and Rehabilitation District

Assistance by:
Cedar Corporation
Polk County Land and Water Conservation Department
Wisconsin Department of Natural Resources

Pipe and North Pipe Lakes
Subwatershed Recommendations Report

Introduction

Cedar Corporation has prepared the following report with assistance provided by the Pipe Lakes Protection and Rehabilitation District, DNR, and Polk County Land and Water Conservation Department for North Pipe Lake and Pipe Lake. The principal goal of this project is to reassess four critical sub-watersheds that were previously identified as having greater potential to contribute to lake water quality degradation than the other sub-watersheds of this basin and assess the current condition of both lakes' shoreline. To accomplish this goal, Cedar Corporation has analyzed existing information, completed site inspections, and completed computer modeling of water quantity runoff and water quality models, and compiled the project recommendations presented in this report.

The project goal is to improve runoff water quality in these four critical sub-watersheds. This goal requires a multifaceted approach including; ongoing observation and project implementation to properly mitigate the water quality degradation that comes with poorly planned development on and around the lakes. Water quality in North Pipe Lake and Pipe Lake is currently average and better than average, respectively. The project recommendations are directed at protecting those natural features of the lakes' watersheds that provide a water quality benefit.

The project goals as stated in the DNR Lake Management Planning Grant are:

1. Visit and identify areas of significant erosion along the intermittent tributaries for both North Pipe and Pipe Lakes.
2. Determine runoff water quantity and quality coming off the various land uses in the subwatershed project area.
3. Identify the locations of shoreland that are likely contributing the highest nutrient load per unit of shoreline.
4. Complete an aquatic plant survey following the current techniques recommended by the Wisconsin DNR.
5. Recommend appropriate BMPs to address erosion, water quantity and quality issues and inadequate buffering, identified in goals 1, 2, and 3.

In order to achieve these goals, multiple tasks were presented in the grant narrative. A summary of the tasks completed during this planning grant project is:

- Completion of field reconnaissance in the subwatershed planning area to identify, locate, and confirm areas of erosion, improper land use, and infrastructure concerns previously noted by the District.
- Acquired computer modeling preprocessing information from the County and previous planning grant projects. Information included contour data, soil and land use information, and location of culverts.

- A survey and analysis of the entire shoreline was completed. Areas of erosion and concern were identified, photographed, mapped, and assessed. Recommendations on how to address those concerns were determined and summarized.
- An aquatic plant survey was completed using the DNR approved point-intercept method.
- WiLMs and HydroCAD modeling was completed on the entire watershed area for both Pipe and North Pipe Lakes including separate models for each of the subwatershed areas.
- Best Management Practices (BMPs) were identified and evaluated for their feasibility of implementation, effectiveness, and cost.

Based on the information from these completed tasks, a number of BMPs that should be implemented to protect and improve the existing conditions of both lakes have been recommended. The water quality and clarity of the Pipe Lakes are considered above average when compared to other lakes around Wisconsin. Understanding that and wishing to be proactive to establish human practices that will encourage and enhance long term water quality improvement; the District has set an aggressive and admirable goal of achieving a 15% water clarity improvement by 2015. Although the work completed as part of this project is unable to predict quantitatively, the anticipated water quality improvement, the recommendations for water quality and habitat improvement presented herein should be considered a good start towards reaching the District's goal.

The following summary prioritizes the recommendations described in greater detail later in this report:

Phase 1 (1-5 years):
1. Implement shoreline recommendations in the most needed areas.
2. Repair and stabilize erosion areas along the streambanks in the subwatershed planning area.
3. Replace existing culverts.
4. Repair and improve outlet protection.

Phase 2 (1-10 years):
1. Acquire easements over critical areas.
2. Ensure Polk County and Wisconsin DNR Program Compliance.

Phase 3:
1. Reassess the effectiveness of the completed Phase 1 and Phase 2 projects.
2. Monitor identified areas as potential grade control structure.
3. Monitor identified area as potential wet detention basin area.

The recommendations presented are intended to address the lakes' water quality by adhering to the following procedure:

First, repair the areas within critical watersheds and shoreline buffers that are currently contributing some level of water quality degradation. The areas designated for improvement projects show signs of unmitigated development harming the runoff water quality which ultimately carries sediment and nutrients into the lakes. These types of projects will include stream bank, and shoreline restorations. Repairing these areas should be the first focus of the District as their stabilization will create a foundation for future projects.

Second, complete the nonstructural projects to ensure smart development and protection of existing environmental corridors providing a water quality benefit. These recommendations include acquire management rights or easements over critical areas, and ensuring that other agencies programs and regulations designed to protect water quality are being adhered to in the critical watersheds.

Third, reassess the overall effect of the completed projects. The first two steps have corrected ongoing, and observed, pollution and ensured that property within the critical watersheds is being managed and developed in an environmentally responsible manner. With the completion of these projects, the District should evaluate the progress these projects have made moved towards achieving its water quality improvement goals.

Finally, if more work is required to reach overall water quality goals, investigate the opportunities for large scale construction projects. The benefit of these structures will not be efficiently utilized until the previous project concerns have been addressed. These projects should be considered after it has been determined that repairing the watersheds and shorelines, protecting critical environmental corridors, and ensuring responsible land management, have not together produced the desired water quality results. At that time, the District should investigate altering the hydrology of the watersheds to provide for simulated environmental corridors that provide greater treatment of watershed runoff. These projects will work to reduce stream velocities, provide more opportunities for sediment deposition, increase vegetative up take of runoff nutrients. These projects will require greater financial capital output, and routine maintenance throughout the effective project life. One must be continually aware that when implementing structural recommendations to alter the hydrology of a given area, there is always the potential of having a negative impact on the ecology of the lake system. Hence, the reasoning to lower the priority on these types of recommendations.

Critical Watershed Project Recommendations

Previous planning efforts have identified projects and critical areas in the North Pipe Lake and Pipe Lake Watersheds. This report has analyzed the identified "Critical Watersheds" (Map 1) and recommends specific projects to address the negative impacts that future development in these watersheds will have on North Pipe Lake and Pipe Lake. Some of the recommendations will maintain existing conditions that are considered positive for water quality, while other recommendations are made to improve existing conditions.

The goals of the recommendations can be grouped into three categories:

1. Repair existing, and ongoing, surface runoff degradation.
2. Protect the critical land features currently protecting surface runoff water quality.
3. Modify the current hydrology to better treat surface runoff.

Each category should be considered as one phase in improving the surface runoff water quality for each watershed. Projects that repair and protect water quality, Phase 1 and 2 Projects should be implemented first and may be completed in concert. Following their completion, the benefits to the lake should be assessed. Projects that modify the current hydrology, Phase 3, would be completed subsequently if the completed Phase 1 and 2 projects do not show the desired benefits and greater levels of treatment are still necessary. The hydrology modifying projects are generally larger scale projects with high construction and maintenance costs and are usually not recommended until the watersheds have been stabilized by repairing and protecting the existing water quality features.

The following areas have been identified as watersheds critical to the water quality of Pipe Lake and North Pipe Lake by previous Lake Management Planning and local District projects.

NPI-NE
Watershed NPI-NE is located in the northeast corner of the Pipe Lakes Watershed. It contains approximately 177 acres of mixed land uses predominantly agricultural (elk farm) and forestland, with a small mix of wetlands, rural residential, and residential.

NPI-E3
Watershed NPI-E3 is also located in the northeast corner of the Pipe Lakes Watershed and is adjacent to NPI-NE. This watershed eventually drains into the wetland area north of North Pipe Lake. Approximately 113 acres in size, it consists of land uses predominantly forestland and wetland, with a small area of residential development.

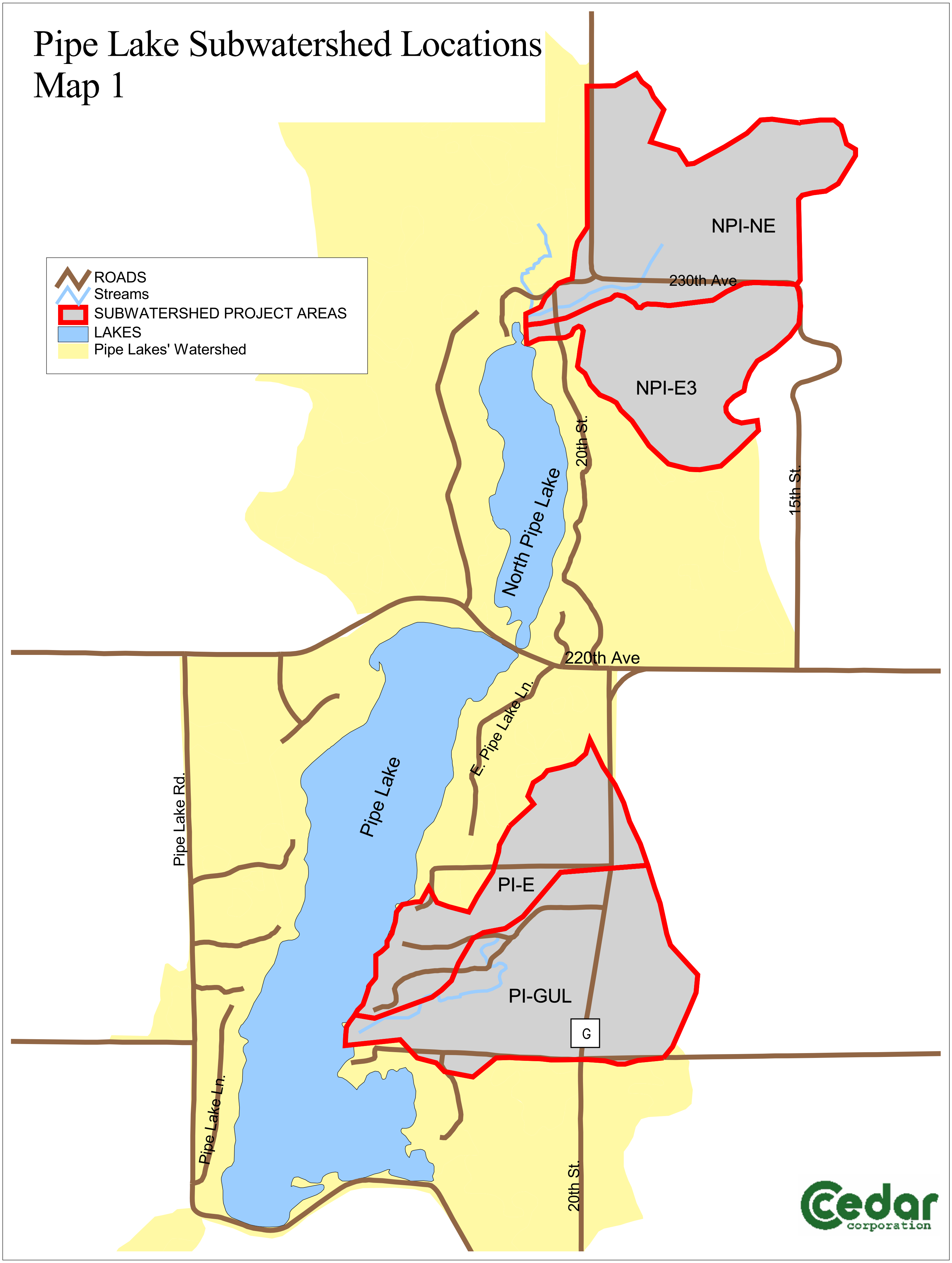
PI-E
Watershed PI-E is located on the east side of the Pipe Lakes Watershed. This watershed eventually drains to the eastern shore of Pipe Lake. It contains approximately 98 acres and is a mix of predominantly forestland and wetland, with some residential, agricultural, and rural residential development. Our evaluation of Watershed PI-E indicates it does not have identifiable issues that we felt are the source of some of the water quality concerns expressed by the District.

PI-GUL
Watershed PI-GUL is located on the east side of the Pipe Lakes Watershed and is adjacent to PI-E. This watershed eventually drains to the eastern shore of Pipe Lake. It contains approximately 174 acres consisting of predominantly agricultural land and forestland. There are substantial areas of wetlands and some residential and rural residential development.

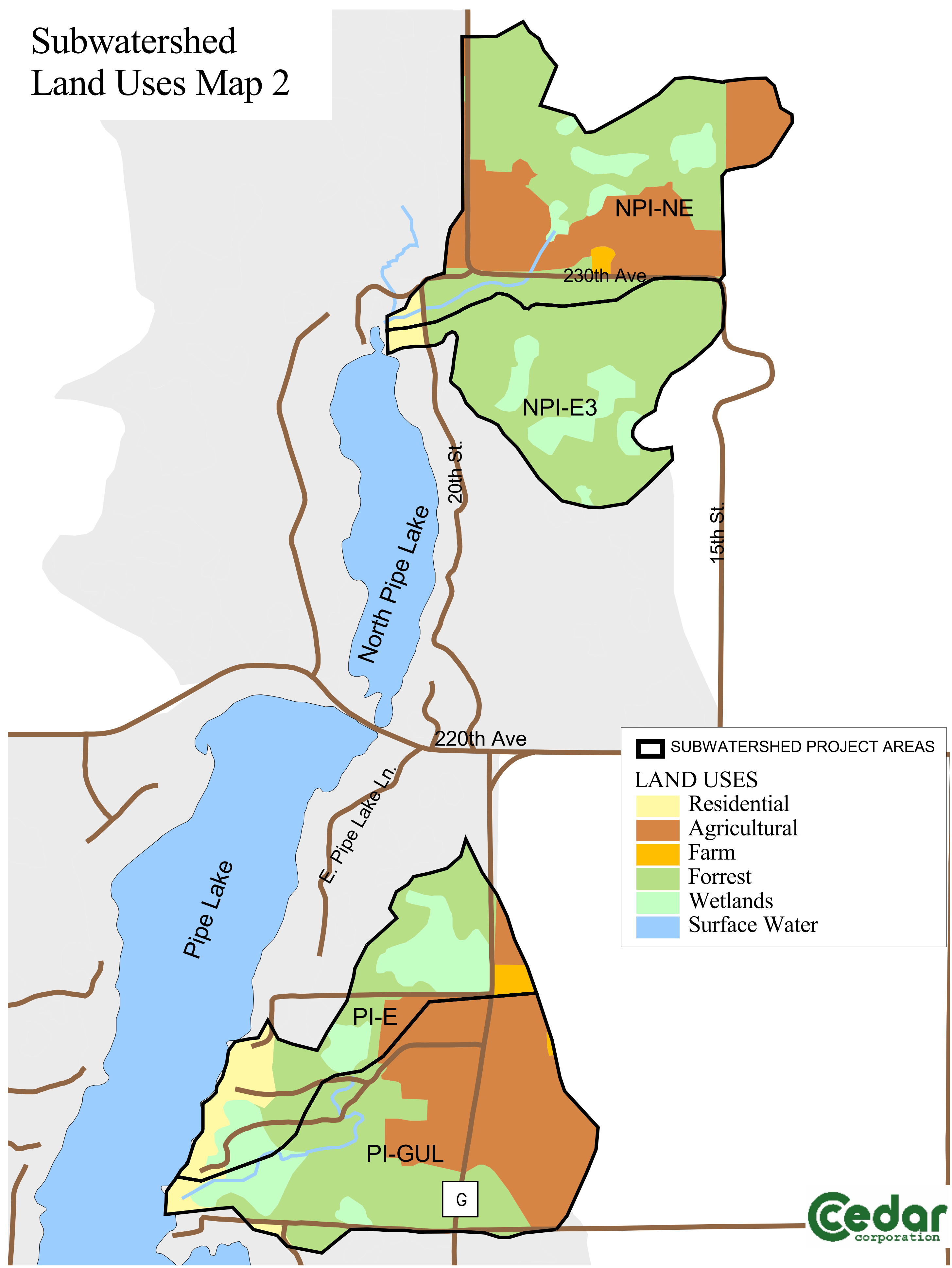
The watershed reconnaissance completed in the spring of 2007 was a critical first step in the development of project recommendations is Several items of note that are considered detrimental to water quality were recorded and presented here as areas for Water Quality Improvements.

Critical watershed recommendations for water quality improvements are identified on a series of maps. Each map represents a particular recommendation. Maps A through H locate the site and identify the corresponding recommendation which may be presented in more than one location in the critical watersheds.

Map Key	Recommendation
A	Acquire easements over critical areas
B	Ensure Polk County and WI DNR program compliance
C	Improve/Repair outlet protection
D	Replace existing culverts
E	Stabilize stream bank slopes
F	Install hydraulic drop structure
G	Monitor as a potential grade control area
H	Monitor as a potential wet detention basin area


Pipe Lake Subwatershed Locations
Map 1
ROADS
Streams
SUBWATERSHED PROJECT AREAS
LAKES
Pipe Lakes' Watershed
NPI-NE
230th Ave
NPI-E3
20th St.
15th St.
North Pipe Lake
220th Ave
E. Pipe Lake Ln.
Pipe Lake
Pipe Lake Rd.
PI-E
PI-GUL
G
Pipe Lake Ln.
20th St.
Cedar corporation

Subwatershed Land Uses Map 2



Recommendation A: Acquire easements over critical areas

Throughout the identified critical watersheds, several existing natural geographical and human practice features protect the lake from runoff pollutants. Conservation of these wetlands, swales, and streams that are currently protecting the lakes should be a consistent goal of the District. As water quality monitoring continues, the District should look for opportunities to acquire permanent conservation and access easements over the identified sites. Each recommendation is identified on the map by map key and number reference in this report.

A1. The District should work with the elk farmer located north of 230th Avenue and the property owners to the south to acquire easements along the existing intermittent streams.

The easement areas should be where water collects and either remains as standing water or is eventually conveyed downstream to the Lakes. The width of the easement will vary with the size of the stream or wetland. The easement should cover the entire banks of the streams as well as the areas classified as wetlands.

A2. Acquire easements to protect wetlands in NPI-E3.

NPI-E3 consists of mostly undeveloped forestland and wetlands. These types of land uses are ideal for areas surrounding lakeshores. Our modeling did not indicate a significant loading coming off this subwatershed however some of the past samples and observations have indicated that there are some loading concerns. Protecting the wetlands in this subwatershed is one of two recommendations for this area.

A3. Acquire easement in vegetated area between farmed areas in PI-GUL.

A4. Acquire easement for stream that flows to the wetlands surrounding Pipe Lake in PI-GUL.

A5. Look to acquire easements over wetland areas just east of Pipe Lake in PI-E.

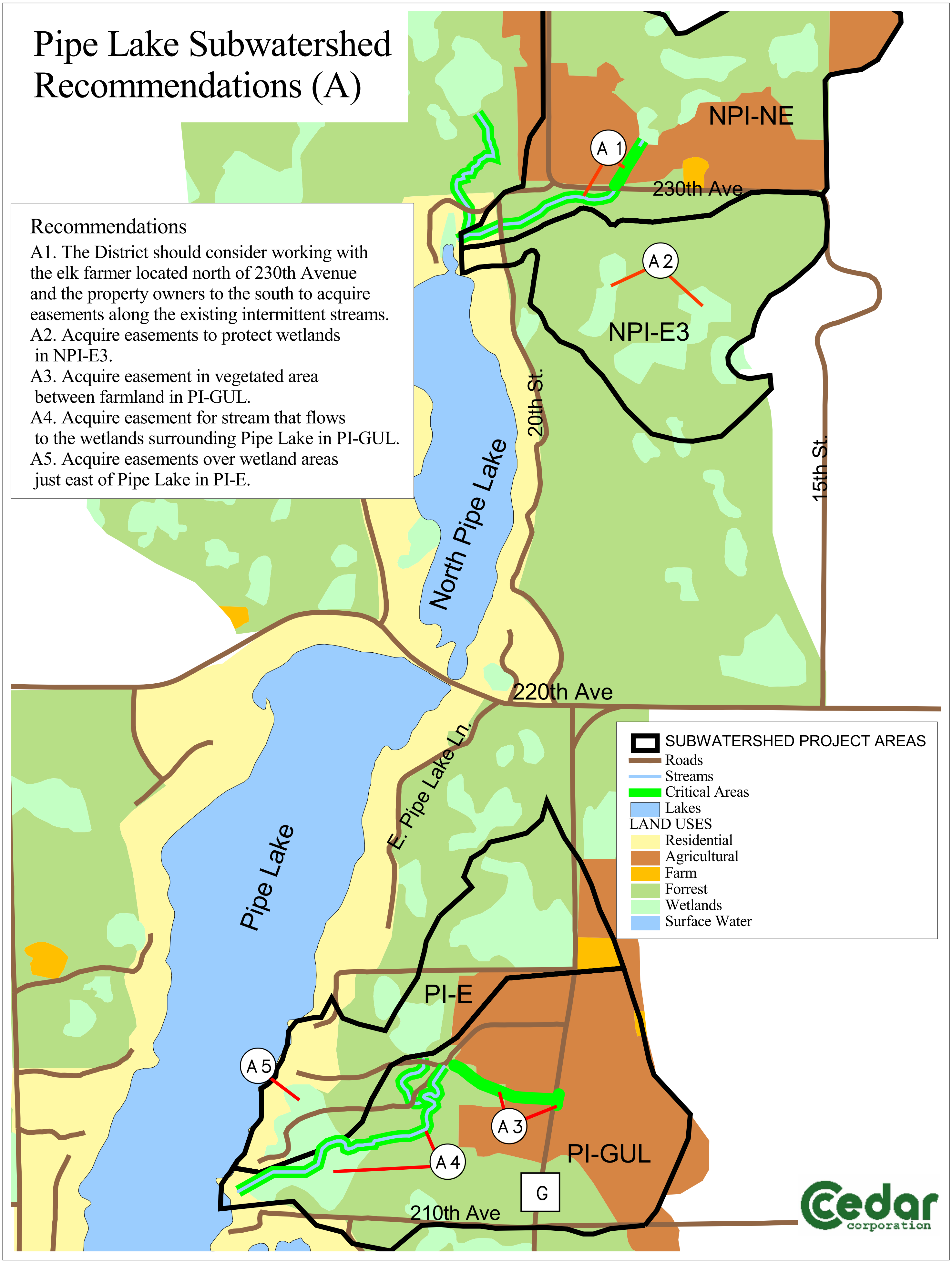
Acquiring easements over critical areas such as wetlands, swales, and streams is important to protect the existing conditions of the water quality as well as preserve these areas from possible future development. Development pressure in the future could have significant impact on the land uses surrounding the Pipe Lakes. If easements are not acquired and development takes place in the proposed easement areas and surrounding watershed, it will be much more difficult and more expensive to remove sediments and nutrients that will degrade water quality. The focus of this recommendation is to limit the impact of future development on existing water quality.

Property owners have yet to be contacted about acquiring easements. Once the District decides to pursue easements, it will be important to begin preliminary talks with the property owners of the easement areas to introduce the issues to them and explain the importance of protecting those areas to improve water quality of the Lakes, wetlands, streams, and critical habitat areas.

Pipe Lake Subwatershed Recommendations (A)

Recommendations

A1. The District should consider working with the elk farmer located north of 230th Avenue and the property owners to the south to acquire easements along the existing intermittent streams.
A2. Acquire easements to protect wetlands in NPI-E3.
A3. Acquire easement in vegetated area between farmland in PI-GUL.
A4. Acquire easement for stream that flows to the wetlands surrounding Pipe Lake in PI-GUL.
A5. Acquire easements over wetland areas just east of Pipe Lake in PI-E.



Recommendation B: Ensure Polk County and WI DNR program compliance

Farming practices are typically a source of nutrients. Subwatersheds NPI-NE, PI-E, and PI-GUL have farmland that is upstream of critical areas identified for protection. The District should discuss utilizing a nutrient management plan with the farmers.

While there are very few sources of monies available for cost sharing; two programs that should be investigated are EQIP and MALWEG, federal programs to assist in nutrient management plans. Another approach might be for the District to assist with the cost sharing of the nutrient management plans for the farm fields. DATCP (the Department of Agriculture and Consumer Protection) has published estimated that the cost for a nutrient management plan is $7-$8 per acre for the first four years ($28-$32 per acre total). The District should also consider the potential to increase the width of the setbacks of agricultural practices from drainage swales and ditches.

B1. Work with farmer to encourage up to date farm plan in NPI-NE.
B3. Work with farmer to encourage up to date farm plan in PI-E.
B4. Work with farmer to encourage up to date farm plan in PI-GUL.

There are approximately 55 acres of farmland in NPI-NE, 8 acres of farmland in PI-E, and 94 acres in PI-GUL. Most of the farmland in NPI-NE is not cropped, and is primarily used for elk farming. At one point there was a Conservation Reserve Plan (CRP) in place which established a buffer to protect the stream down slope. The County Land and Water Conservation Department does not feel that this particular farm is contributing much in the way of nutrients because of the CRP. However, the land may not always be managed properly if new owners take over, or the cost of proper land management becomes too expensive, it will be important for the District to have good relationship with the farmer. The farmer may want to consider updating his CRP.

The District also may want to consider to continue to take stream samples in areas downstream of agriculture land uses to ensure upstream buffers are filtering nutrient runoff properly. If over the course of two to three years there seems to be consistently high phosphorus or sediment concentration in the stream sampling, then the existing practices are not working properly and it would be time to work with the farmer to upgrade his CRP.

The farmland in PI-E and PI-GUL is mostly mixed agriculture and row crops. This is the area that is important to incorporate a nutrient management plan. It doesn't appear as though the farmer has a nutrient management plan in place at this time. A nutrient management and plan could reduce the amount of fertilizer needed for the farmer to have productive farmland. The District should contact the farmer to see if he has a nutrient management plan in place. If not, the District should encourage and possibly assist the farmer with the development of a nutrient management plan. One positive activity from the farmer is his willingness to leave the ravine between the two fields left unplowed. This ravine is a excellent natural buffer that limits the amount of nutrient and sediment runoff from the farmland.

B2. Talk to property owner about road building in NPI-E3 and see if the necessary permits were obtained. Explain that the DNR and Polk County should be contacted when conducting earth moving activities that disturb more than one acre. If violations persist after the property is notified, then the warden or local water regulation and zoning specialists should be contacted to address the violations.

Roads that have been built in the past 3-4 years are not up to Town standards, nor have there been erosion control implementations in place while road building and grading took place.

B5. The existing logging road should be improved or removed in PI-GUL.

The existing logging road should be improved or removed. In its current state, a heavy storm could produce significant erosion and washout from the road that would add sediment to the stream below. The USDA Natural Resources and Conservation Service, or the Polk County Land and Water Department may be able to assist with designing of fords or culverts.

All private property owners must meet the standards set forth in NR 151. The following information identifies the regulations that need to be met when land disturbing activity takes place. If the District is aware of activities that are not following the criteria, then the District should inform the property owner of the regulations pertaining to the land disturbing activities described below:
NR 151.11 sets forth the construction site erosion control performance standards for construction projects that disturb more than 1 acre of land. The following items need to be met:

- A written erosion control plan must be prepared by the design engineer.
- Reduce sediment load by 80%.
- Prevent tracking from the construction site (install tracking pads).
- Prevent discharge of sediment during de-watering operations (install filters in discharge lines).
- Protect storm sewer inlets from sediment (install inlet protection).

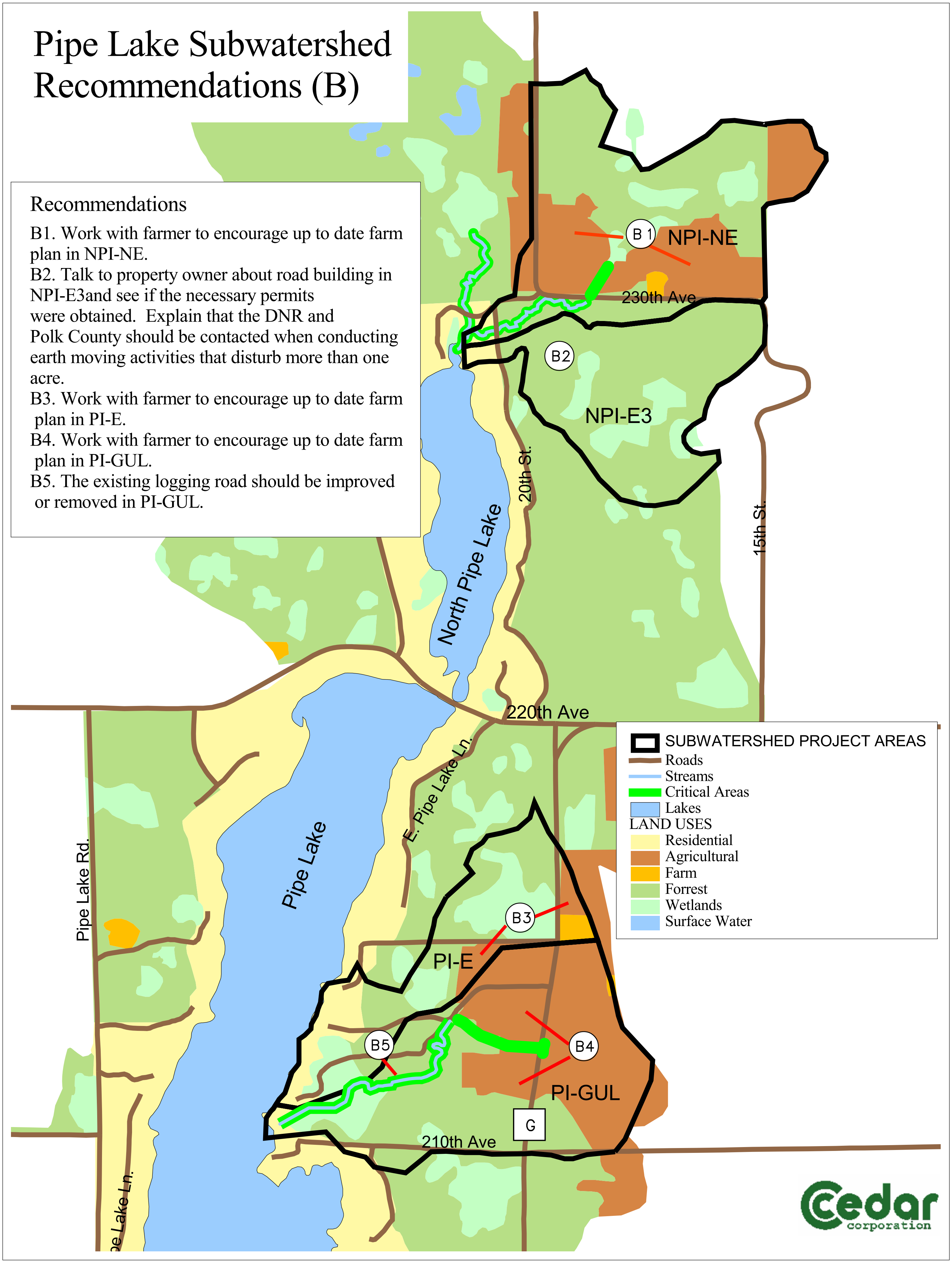
NR 151.12 sets forth the post-construction performance standards for construction projects that disturb more than 1 acre of land. Primarily, the following items need to be met:

- A written storm water management plan must be prepared by the design engineer.
- Water Quality: Suspended solids removal of 80% (new development) or 40% (redevelopment).
- Peak Discharge: Match post-construction peak discharge rate to the pre-development peak discharge rate for the 2-year storm event.
- Infiltration: Infiltrate 25% of the 2-year storm event (residential) or 10% of the 2-year storm event (non-residential).

Pipe Lake Subwatershed Recommendations (B)

Recommendations

B1. Work with farmer to encourage up to date farm plan in NPI-NE.
B2. Talk to property owner about road building in NPI-E3and see if the necessary permits were obtained. Explain that the DNR and Polk County should be contacted when conducting earth moving activities that disturb more than one acre.
B3. Work with farmer to encourage up to date farm plan in PI-E.
B4. Work with farmer to encourage up to date farm plan in PI-GUL.
B5. The existing logging road should be improved or removed in PI-GUL.



Recommendation C: Improve/Repair outlet protection

Storm water, which can reach velocities of 10 feet per second when flowing through culverts, can cause erosion when discharged onto unprotected ground. For this reason it is recommended to provide outlet protection at each culvert outlet. Outlet protection dissipates the energy by slowing and spreading the flow before it is released onto native ground or into existing creeks or drainage ways. Outlet protection is typically constructed of rock riprap. A typical outlet protection installation detail is shown in Figure A. We recommend that the District verify that all major culverts have outlet protection installed. In instances where outlet protection is missing or ineffective, we recommend that the District work with the Township to request the installation of additional outlet protection.

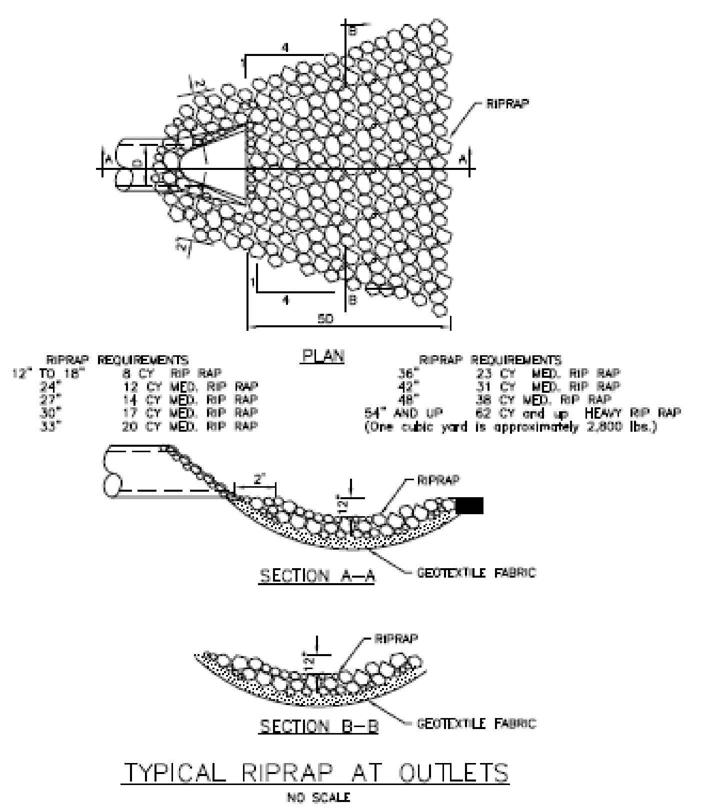
C1. The District should work with the Town to have adequately sized riprap installed and replace the existing geotextile fabric directly downstream of the east Town Road culvert in NPI-NE.

Culvert pipes at road crossings generally increase the hydraulic energy within the stream directly impacting the erosive potential of the running water. Armoring the immediate downstream areas help to prevent score adjacent to the culvert and dissipate the energy gained at the crossing. The District should continue to monitor all major culverts to ensure that proper outlet protection practices are installed and maintained.

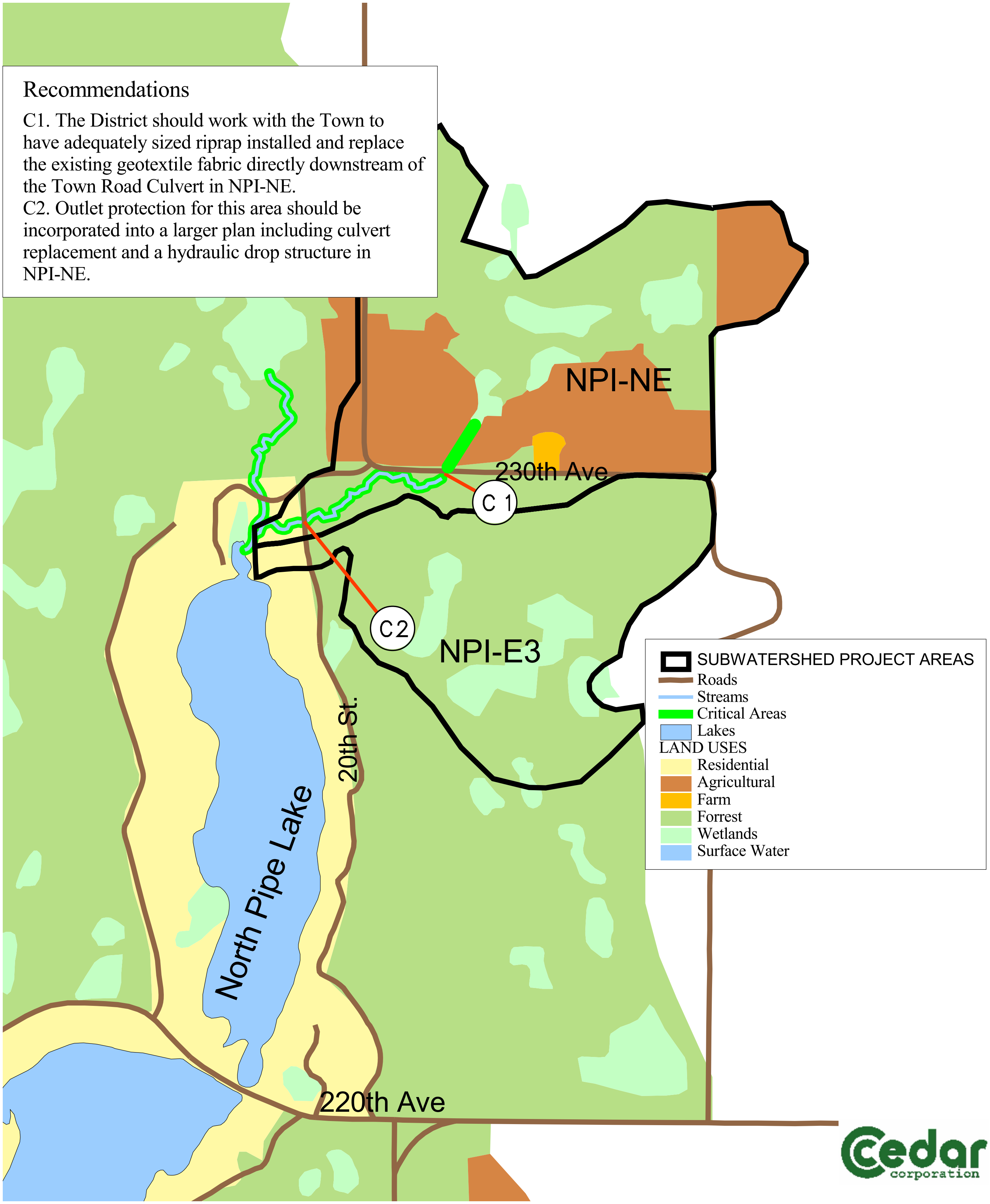
C2. Outlet protection for this area should be incorporated into a larger plan including culvert replacement and a hydraulic drop structure on the private road (20th Street) in NPI-NE.

Polk County has previously discussed this area as a potential stream restoration pilot project. The District should work with the County to ensure that all concerns are addressed in future plans for the area.

Figure A - Outlet Protection



Pipe Lake Subwatershed Recommendations (C)



Recommendation D: Replace existing culverts

Culvert pipes at road crossings generally increase the hydraulic energy within the stream directly impacting the erosive potential of the running water. Properly sized and installed culverts can reduce the hydraulic energy increase at the crossing.

D1. The District should consider replacing the existing two culverts in NPI-NE with one culvert designed to safely pass runoff large storm events.

The stream bed upstream of these two 24 inch diameter culverts is stable and sustainable. The area downstream of the crossing has undergone substantial erosion and the road over the culverts has been overtopped during large storm events. The District should consider replacing the existing two culverts with one culvert designed to allow runoff from large storm events without erosion or overtopping. This will minimize the increase of hydraulic energy downstream and reduce the likelihood of the road washing out. Polk County has previously discussed this area as a potential stream restoration pilot project. The District should work with the County to ensure that all concerns are addressed in future plans for the area.

D2. Re-grade and widen private road ditch in PI-GUL.

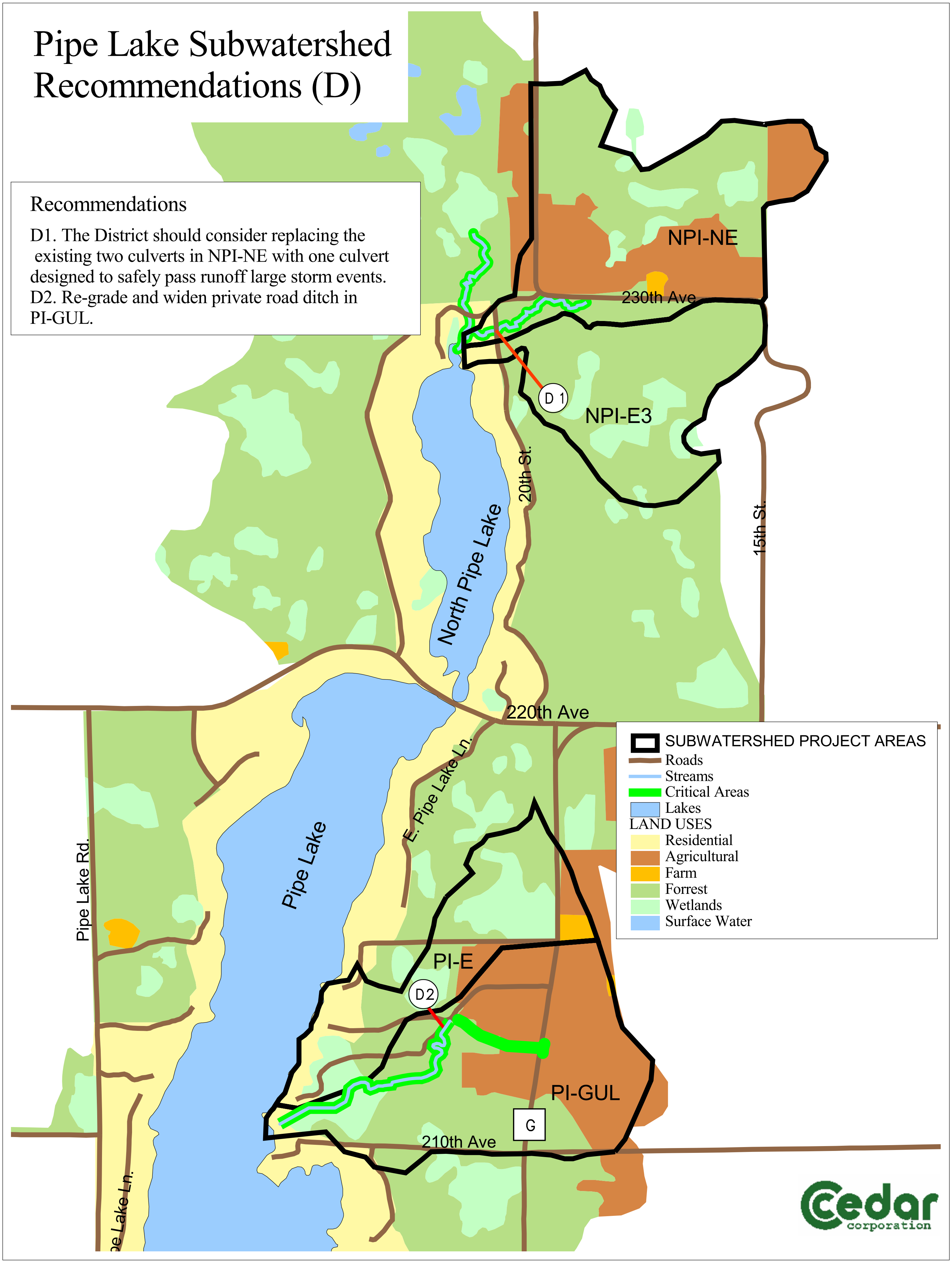
The private road in this area has a narrow, unstable, ditch that receives runoff from a large portion of Eastern PI-GUL. A stable swale intersects the private road directing all runoff through the road ditch. The intersection has a sharp meander and is currently eroding toward the road bed.

The District should approach the road owners to address both the water quality concerns caused by the resulting erosion and increased runoff velocity and the potential threat of washing out the gravel road. The sharp meander at the road ditch should be armored and the ditch should be widened to reduce the hydraulic energy increase as runoff is forced through the narrow ditch.

Pipe Lake Subwatershed Recommendations (D)

Recommendations

D1. The District should consider replacing the existing two culverts in NPI-NE with one culvert designed to safely pass runoff large storm events.
D2. Re-grade and widen private road ditch in PI-GUL.



Recommendation E: Stabilize stream bank slopes

Stream bank erosion can be a significant source of sediment within the watershed. Erosion is a natural byproduct of a flowing stream. However, it is advisable to stabilize stream banks in situations where continued erosion may threaten improvements such as roadways and/or structures. There are biological methods of stream bank stabilization, such as root wads, bush layering, live fascines and willow poles, but stream bank stabilization is typically constructed with rock riprap. A typical stream bank stabilization installation detail is shown in Figure B. We recommend that the District monitor major drainage ways periodically to detect encroachment toward roadways and/or structures. When encroachment is noted, we recommend that the District approach the property owner and/or Township to determine if access and funding are available to allow the construction of stream bank stabilization.

As stream banks erode, the toe of the defined channel is undercut causing a much more rapid rate of erosion and destabilizing the adjacent land. The stream then carries eroded sediment downstream causing further scour as it travels. Stream bank restoration aims to reduce the erosive capacity of the stream using a collaboration of the following techniques: soil bioengineering or riprap on slopes, installing riprap or root wads at the toe, and installing J hook weirs or Newbury riffles in the stream bed.

E1. The District should consider a streambank restoration in NPI-NE just downstream of the 20th Street culvert.

The area immediately downstream of the culvert crossing has undergone substantial erosion. The area bank slopes are currently unstable and continually contributing sediment and nutrients to the stream. The predominant meander in the area should have work done to armor the slope toe and re-vegetate and stabilize the eroding bank. Polk County has previously discussed this area as a potential stream restoration pilot project. The District should work with the County to ensure that all concerns are addressed in future plans for the area.

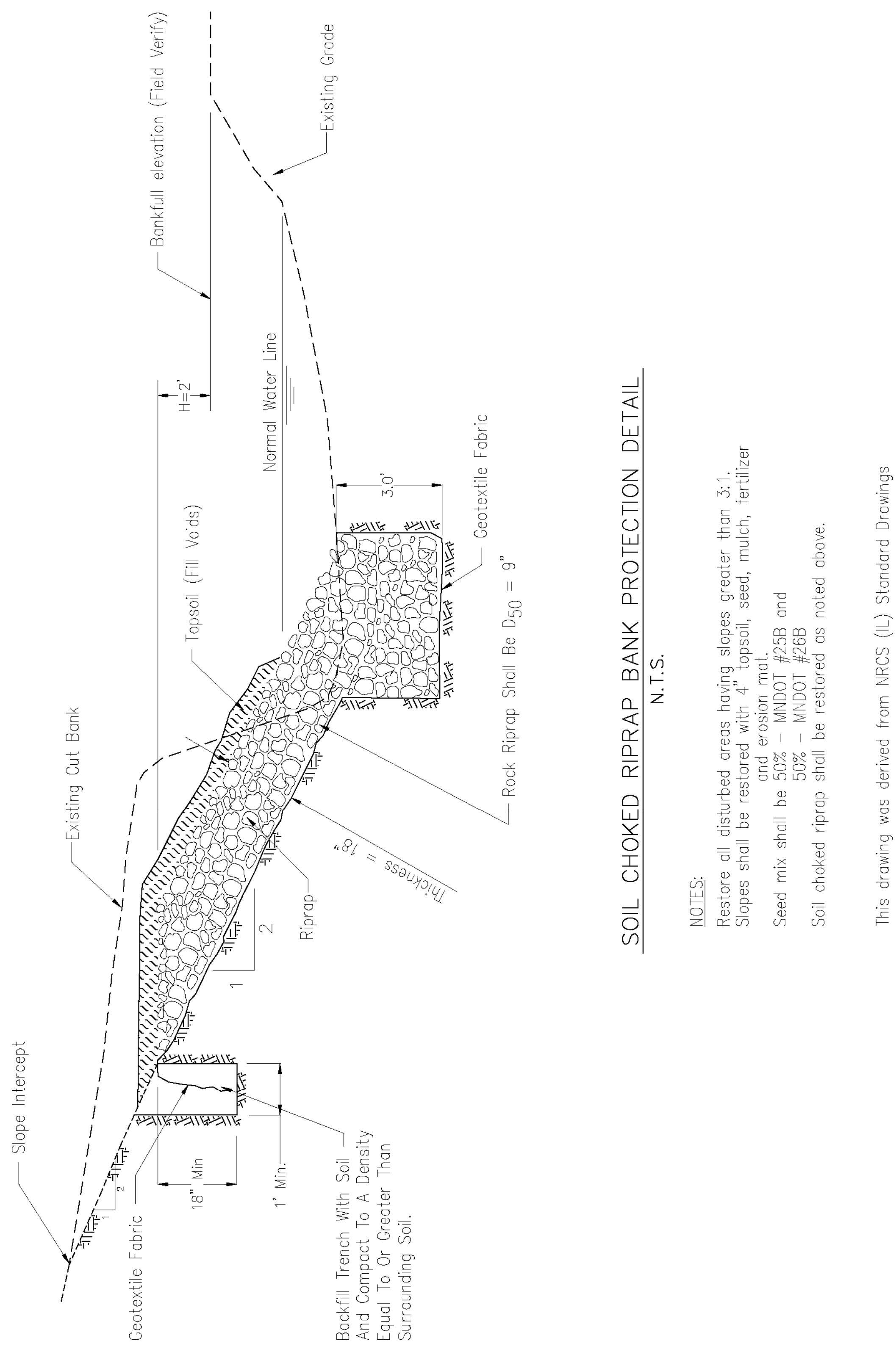
E2. The District should consider a streambank restoration in NPI-NE just upstream of the 20th Street culvert.

E3. Streambank restoration in PI-GUL along the private road should be considered.

E4. Downstream of the private road, but upstream of wetlands are streambanks that the District should consider for restoration projects in PI-GUL.

Streambank protection will provide some sediment load reduction however it won’t provide a significant reduction of phosphorus. In order to get some reduction it is important to convert portions of the intermittent stream that has significant erosion and bare earth problems into grassy swales. Grassy swales will provide some reduction in the amount of phosphorus as the vegetation will slow down the streams and uptake some of the phosphorous load.

Figure B – Bank Protection



Pipe Lake Subwatershed Recommendations (E)

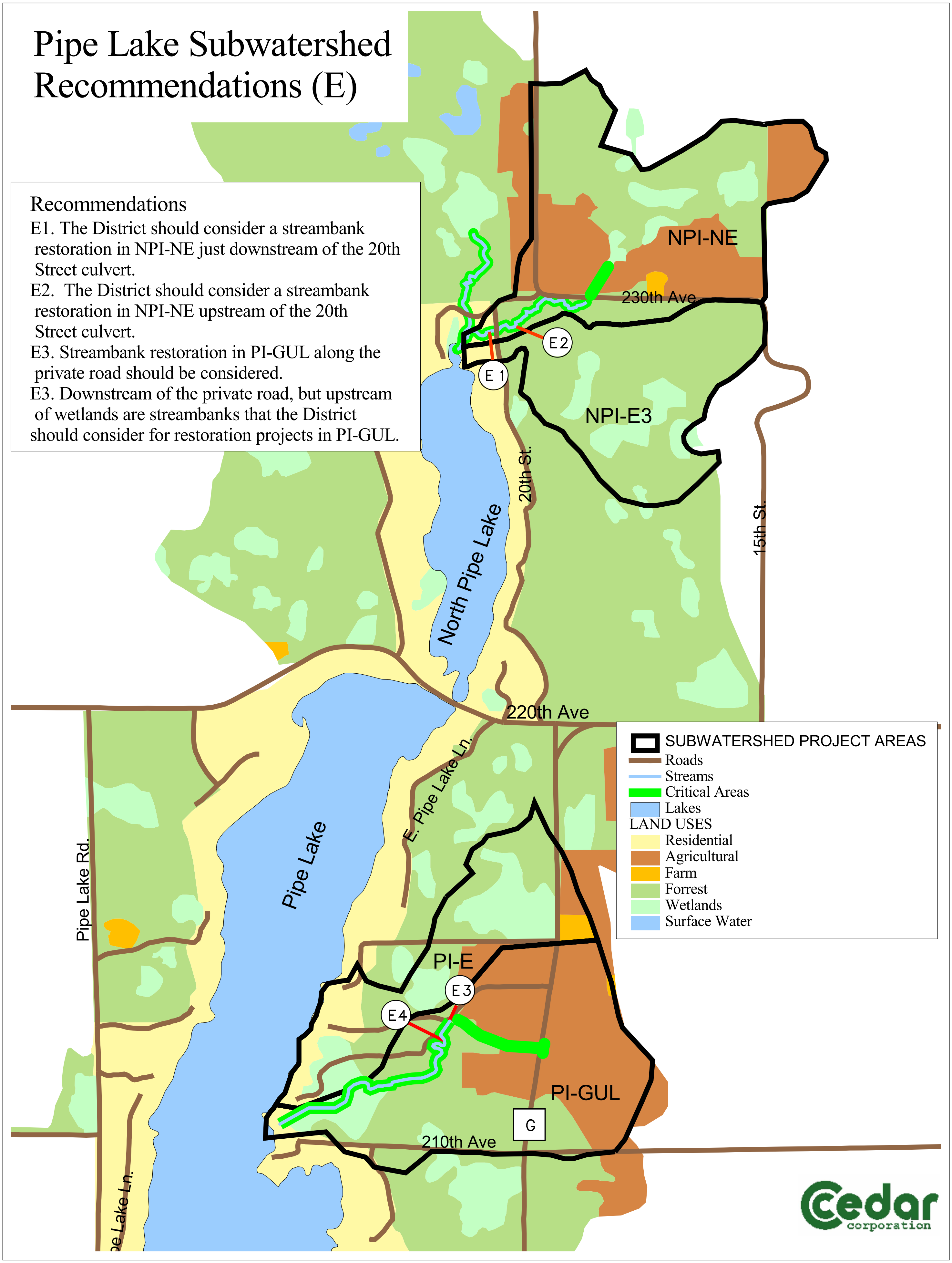
Recommendations

E1. The District should consider a streambank restoration in NPI-NE just downstream of the 20th Street culvert.

E2. The District should consider a streambank restoration in NPI-NE upstream of the 20th Street culvert.

E3. Streambank restoration in PI-GUL along the private road should be considered.

E3. Downstream of the private road, but upstream of wetlands are streambanks that the District should consider for restoration projects in PI-GUL.



Recommendation F: Install hydraulic drop structure

Culvert pipes at road crossings generally increase the hydraulic energy within the stream directly impacting the erosive potential of the running water. A hydraulic drop structure is an armored device which lowers the energy by reducing the average slope and thus, the stream velocity downstream.

F1. A drop structure should be considered in conjunction with replacing the culverts and protecting the outlet in NPI-NE.

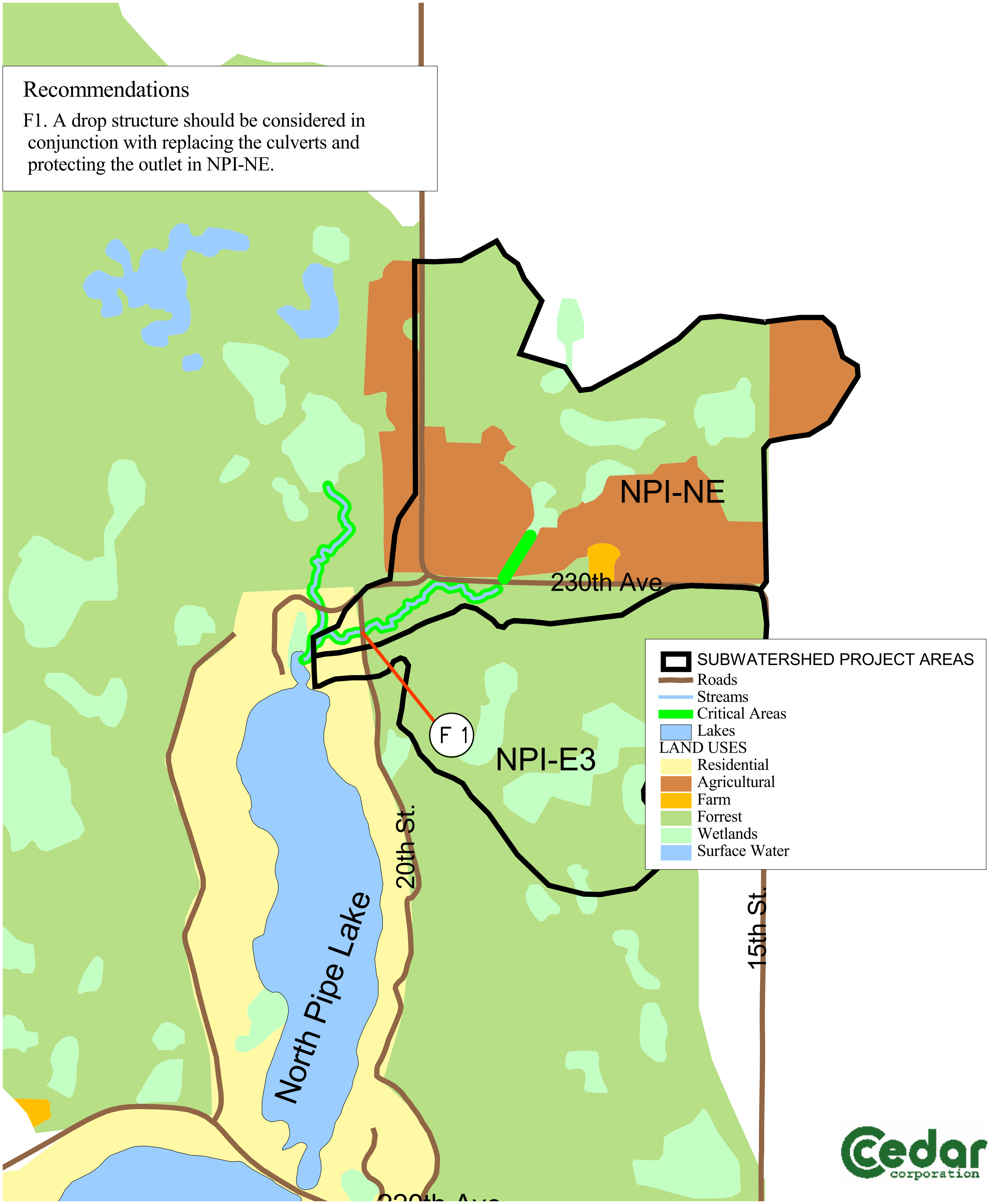
This area currently has a large vertical drop from the culvert inverts to the stream bed. This has been caused by years of erosion at the outlet due to the small culvert diameters and insufficient outlet protection. Polk County has previously discussed this area as a potential stream restoration pilot project. The District should work with the County to ensure that all concerns are addressed in future plans for the area.

Figure C – Drop Structure

Pipe Lake Subwatershed Recommendations (F)

Recommendations

F1. A drop structure should be considered in conjunction with replacing the culverts and protecting the outlet in NPI-NE.



Recommendation G: Monitor as a potential grade control area

The stability of a stream is generally inversely proportional to the velocity of the flow and therefore the slope of the stream bed. At higher slopes (i.e. higher velocity) flowing water has more ability to erode material from the stream bed and banks. At lower slopes (i.e. lower velocity) flowing water is less likely to dislodge particles and in fact will deposit material previously eroded upstream. This process is called degradation and aggradation.

Grade control structures are used to control the slope of the stream and therefore the velocity of the flowing water, by providing, in essence, steps in the stream bed. The grade control structures provide a protected location for the stored energy to be dissipated in a protected location, instead of occurring naturally and uncontrollably. Grade control structures can be used in series to protect long stretches or alone to protect critical locations. A typical grade control structure installation detail is shown in Figure D-1 and D-2.

Figure D-1 – Grade Control Structure

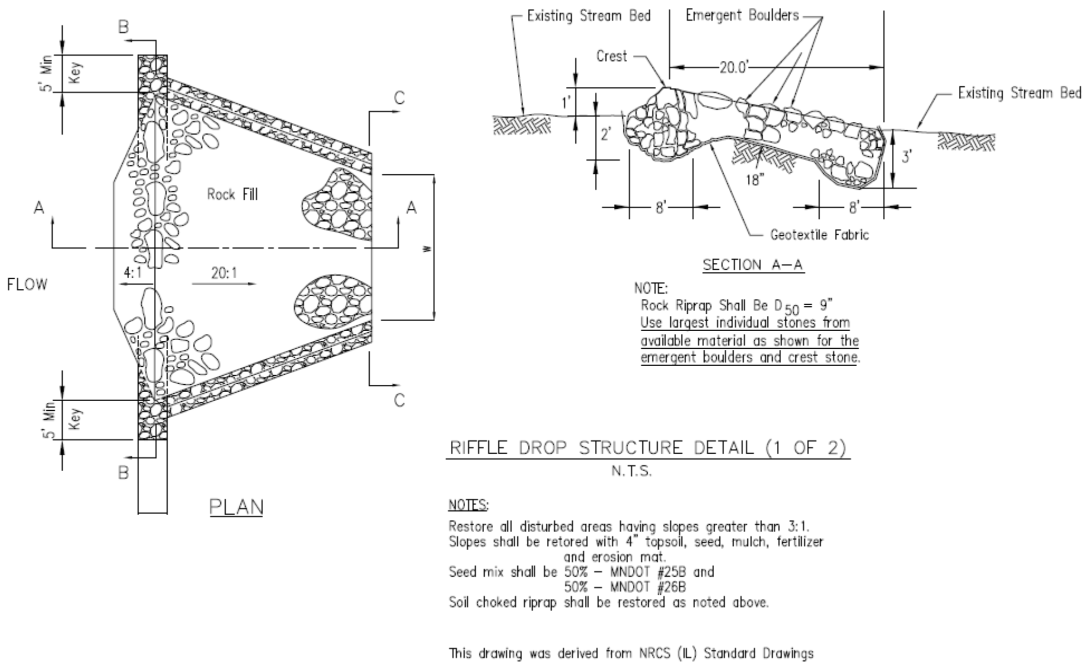
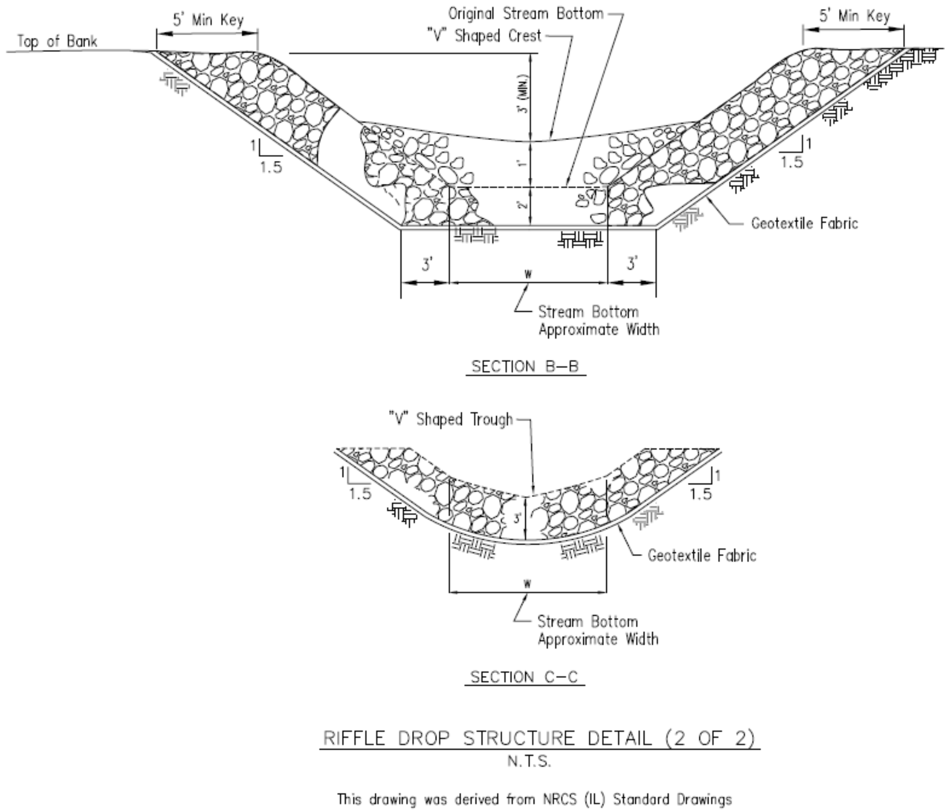


Figure D-2 – Grade Control Structure



We recommend that the District monitor major drainage ways downstream of critical areas (road crossings, forks in streams, etc) periodically to detect head cutting. Head cutting occurs when the stream takes an abrupt change in elevation without bedrock or some other form of protection to protect the streambed from erosion. When head cutting is noted, we recommend that the District approach the property owner and/or Township to determine if access and funding are available to allow the construction of grade control structure(s).

G1. Potential grade control area for PI-GUL just downstream of the farmer's field.
G2. Potential grade control area for PI-GUL downstream of erosion near private road.

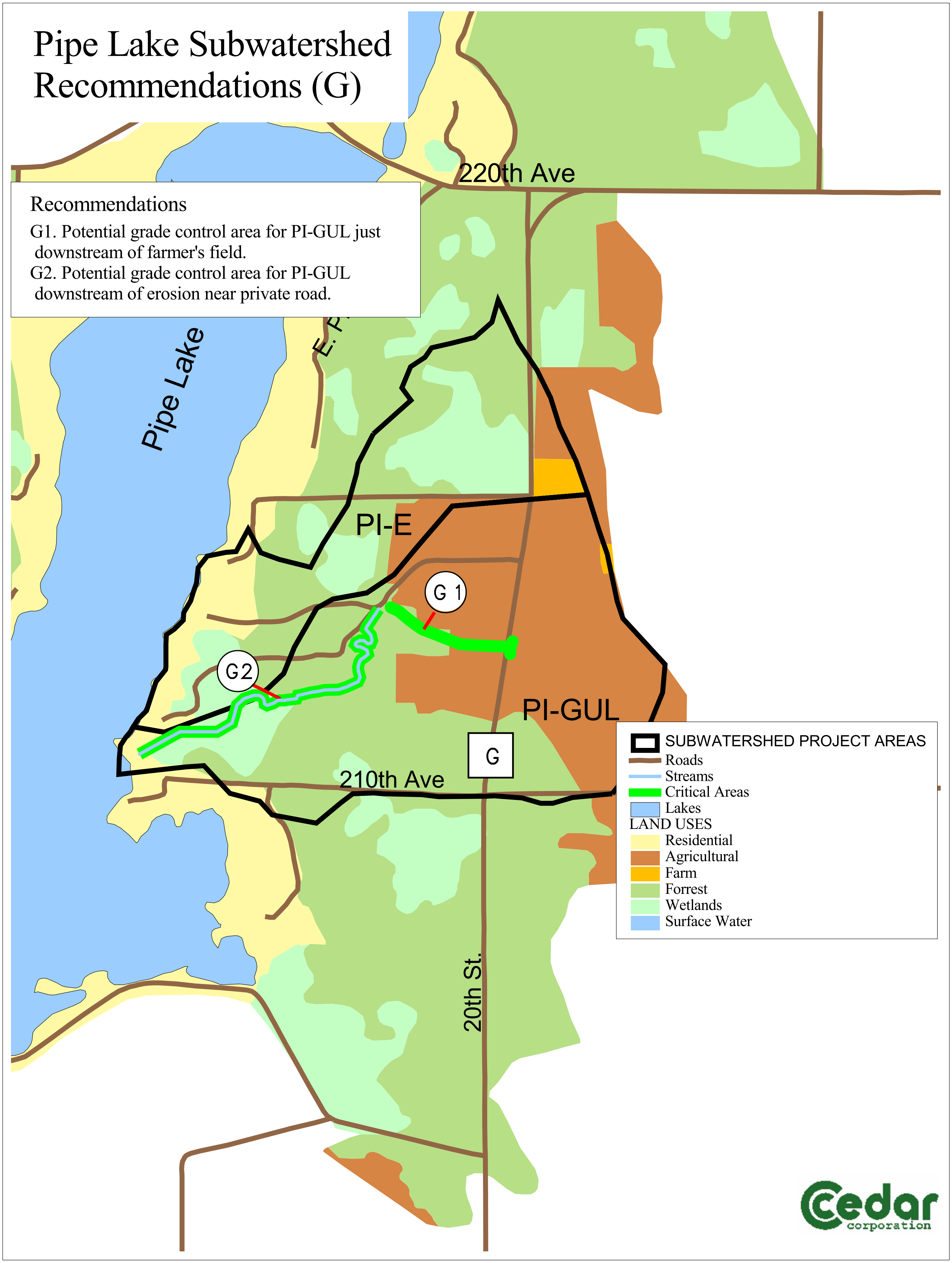
This area represents an opportunity to reduce the potential energy of the swale due to the relatively large change in elevation over a short distance. A drop structure placed near the end of this swale would allow that hydraulic energy to be dissipated within an armored structure and not pass on downstream.

The District should monitor the effectiveness of prior implemented practices downstream. If the desired water quality goals are not being met or downstream erosion persists, a drop structure and settling pool may be able to provide ample treatment in this location.

Pipe Lake Subwatershed Recommendations (G)

Recommendations

G1. Potential grade control area for PI-GUL just downstream of farmer's field.
G2. Potential grade control area for PI-GUL downstream of erosion near private road.



Recommendation H: Monitor as a potential wet detention basin area

If after monitoring and sampling of the Lakes and intermittent streams over the course of the next 10 years does not yield the desired results upon the implementation of the more immediate recommendations, this area would suit a large scale Wet Detention Basin to treat both the runoff quality and runoff rate within watershed NPI-NE. This step would require land acquisition and high construction and maintenance costs, but could also provide a high level of treatment in a critical watershed.

H1. Construct a large scale Wet Detention Basin to treat both the runoff quality and runoff rate within watershed NPI-NE.

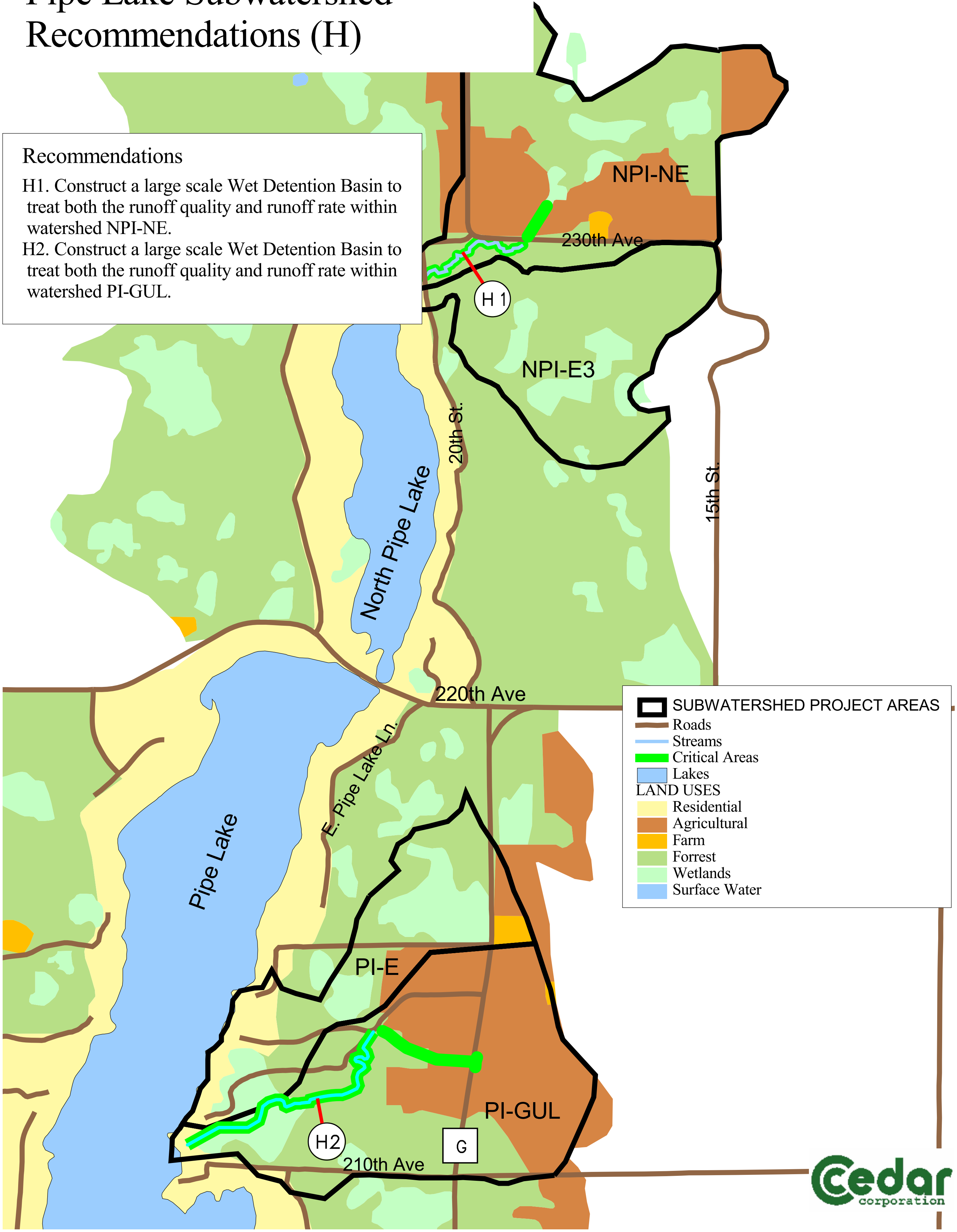
A wet detention basin sited in this location would provide some level treatment from approximately 165 acres of the 177 acre NPI-NE watershed during large storm events. The Wisconsin DNR technical standards recommend a minimum wet pool surface of approximately 0.6% of the upstream watershed for the current land uses. This would result in an approximate pool surface of 1.0 acres and an approximate depth of four to six feet.

H2. Construct a large scale Wet Detention Basin to treat both the runoff quality and runoff rate within watershed PI-GUL.

A wet detention basin sited in this location would provide some level treatment from approximately 140 acres of the 174 acre PI-GUL watershed during large storm events. The Wisconsin DNR technical standards recommend a minimum wet pool surface of approximately 0.6% of the upstream watershed for the current land uses. This would result in an approximate pool surface of 0.8 acres and an approximate depth of four to six feet.

Appendix A is a summary table listing all the above described recommendations. The table provides information including general rank for priority, type of benefit, location and estimated cost.

Pipe Lake Subwatershed Recommendations (H)



Shoreline Recommendations

As the shoreline is the last opportunity to capture nutrients and sediments before they enter the lake, it is critical that steps are taken to ensure proper land uses and behaviors are implemented in shore land areas. To enjoy the water quality that lakes provide, most lake shores are surrounded by residential land uses. However, residential land uses in shore lands often don't provide the protection or buffering that the lakes receive in the natural environment. Developed lands host impervious surfaces and lawns that are sources of sediment and nutrients. There are a number of steps lakeshore property owners can initiate to minimize the negative impact their developed properties may have on lake water quality. The following steps are outlined in "Protecting Your Waterfront Investment", a brochure published in conjunction with the WDNR:

- Use phosphorus free fertilizer
- Household phosphorous management
- Properly dispose of hazardous wastes
- Minimize erosion
- Inspect and maintain your septic system regularly
- Reduce the hard surfaces like rooftops and driveways on your property
- Plant trees and shrubs to protect your wooded areas
- Direct downspouts onto your lawn or landscaping, not onto hard surfaces
- Install a rain barrel
- Build a rain garden
- Protect or restore your shoreland buffer

The shoreline vegetation not only provides a mechanism for capturing some of the nutrients before it enters the lake, it also provides necessary habitat for fish, aquatic organisms, and animals. All of which are important for sustaining a healthy ecosystem. Beaches and lawns sterilize the shoreland areas, robbing the ecosystem of its needed natural habitat.

A shoreline survey was completed of the Lakes by boating along the shore and documenting existing conditions. Appendix B is a complete shoreline inventory of both Pipe and North Pipe Lakes. The attached CD-ROM contains the spreadsheet with all the GPS points and linked photos of the shoreline. The inventory takes into account the canopy, understory, ground cover, shoreline substrate, slope, human influence, and mitigation factors. The entire shoreline was marked with GPS, photographed, and assessed for features having a potentially negative impact on the lake's water quality. Each of those factors contributes to the quantity of stormwater runoff that reaches the lake and has the potential to degrade the lake water quality.

Appendix C presents a hard copy of the spreadsheet (without photos) showing the ratings for each GPS point. The ratings were based on a scale ranging from 0 to 4. GPS points that had categories that were observed to be nonexistent were given a 0. Areas that were observed to have a significant amount of a given category were given a 4. For example, some of the shoreline areas were flat without any slope. Those points were given a 0 under the slope column. The numbers are arbitrary and used only to provide a degree to how much each category exists at a given GPS point.

This inventory is a snapshot of the shoreline conditions in the summer of 2007. Land uses and shoreline conditions may change and, therefore, some of the shoreline areas where recommendations were made may not be relevant if land use practices have changed since the inventory was completed. It is also conceivable that some land owners alter their shoreline in a negative way. In those situations those shorelines that are considered to have an adequate buffer during this inventory survey, will have a degraded or inadequate buffer in the future.

Below is a list of the various recommendations for some of the problem areas along the lakeshore that were identified while conducting the shoreline inventory. Some areas have more than one concern. Many of these recommendations will help to reduce the adverse affects lake shore development has on lake water quality including providing needed habitat for fish and wildlife populations.

Map Key	Recommendation
A	Stop mowing to shoreline/riprap - leave minimum of 35' wide buffer strip.
B	Plant trees in open areas.
C	Enforce Setbacks for future development.
D	Encourage property owners to use rain barrels/rain gardens to capture roof and driveway runoff.
E	Stabilize bank and vegetate sloped areas.
F	Plant native grasses and shrub species.
G	Incorporate vegetated terrace strips/BioSox.
H	Plant native grasses in areas of bare soils.
I	Add vegetation density to existing buffer.
J	Remove beach area.
K	Stop fertilizing or use only phosphate-free fertilizer.
L	Make path to shoreline perpendicular to slope.
M	Study to determine the affects of septic systems on the lakes.

Maps A through L locate the problem areas and identify the corresponding recommendation. Most of these recommendations such as using phosphate-free fertilizer, enforcing setbacks, and installing rain gardens/barrels are not limited to just the locations identified on the map. They should be considered on all properties as these are generally good practices to incorporate into residential land use. The areas that have been identified on the maps for specific recommendations are those that would benefit the most by implementing the designated recommendations.

The starting point for implementing these recommendations is to educate the property owners. Everyone can do their part and it is important for property owners to understand how their activities on the land affect the quality of the water. The District has already started setting money aside to assist property owners with implementing the recommendations below. The money could be used to provide assistance to the property owners or it could be used as part of a cost share for a DNR Lake Protection Grant. A Lake Protection Grant would provide financial assistance with shoreline buffer and habitat improvements. Shoreline property owners could be petitioned to see who would be willing to participate in the grant effort. If the District can get at least half of the property owners to participate, they likely will have a strong application for a Lake Protection Grant. It will be important to work closely with the DNR and the Polk County Land and Water Conservation Department as the District moves forward with these recommendations.

Recommendation A: Stop mowing to shoreline/riprap - leave minimum of 35' wide buffer strip.
One of the best ways to allow for the natural shoreline to come back is to stop mowing it. Seeds in the soil will germinate and will allow native plants to reappear.

Recommendation B: Plant trees in open areas.
Lawns typically create more runoff and absorb less rainfall than an area left in its natural state. Planting trees or shrubs in open areas will allow for some canopy to disperse the energy of the rainfall from hitting the ground directly and dislodging sediment from bare soil areas. Trees and shrubs also have deeper root systems than grasses and allow for more stability on steep slopes and more space to permit rainfall to infiltrate rather than runoff.

Recommendation C: Enforce Setbacks for future development.
Some of the properties along Pipe Lake are right on the lakeshore. Development that occurred prior to the passing of the Polk County Shoreland Protection Ordinance and NR 115 is grandfathered in. Any new development should adhere to the setbacks within the ordinance. If the District is aware of development taking place that is in violation of the ordinance, they should notify the County.

Recommendation D: Encourage property owners to use rain barrels/rain gardens to capture roof and driveway runoff.
Stormwater runoff from roofs and driveways can contain high levels of sediments and other pollutants. Capturing the stormwater runoff from these sources can greatly protect the water quality of the lakes. Rain barrels can be placed at the end of downspouts and used for watering the landscape. Rain gardens can capture rain water from downspouts, driveways, and other impervious surfaces, allowing the stormwater to infiltrate.

Recommendation E: Stabilize bank and vegetate sloped areas.
Some areas along the shoreline have bare soils along slopes. Some of those slopes are rather severe. It is important to try to stabilize those banks prior to planting native vegetation to prevent further erosion. It is also important to divert any channelized water from above. This will improve the chances of the restoration efforts taking hold and stabilizing the bank. Any bare soil should be planted with seeds and/or seedlings and mulched. In some instances it is necessary to use netting or matting along with planting native vegetation. Detailed instructions can be found in the Wisconsin Construction Best Management Practice Handbook.

Recommendation F: Plant native grasses and shrub species.
Lawns by themselves without any vegetative buffer do little to slow down stormwater runoff and protect the lake. Most of these areas, if not mowed, will recover naturally. Areas that may need some intervention regarding re-establishing the native vegetation include lawns where turf grass is dominant and sites that have exotic species (so far Pipe and North Pipe Lakes have been fortunate to avoid exotic species). In these areas it is important to assist the

natural recovery process by planting native vegetation consisting of a combination tall grasses, shrubs, and trees.

Recommendation G: Incorporate vegetated terrace strips/BioSox.
Areas where the entire lakeshore is sloped may prove difficult to slow down the stormwater runoff especially in areas where bare soil is dominate, it may be necessary to implement vegetative terrace strips and/or a commercial product called BioSox. Both methods can slow down runoff and capture erosion and nutrients at each strip or terrace. This technique is most effective on slopes that are generally longer.

Recommendation H: Plant native grasses in areas of bare soils.
A number of areas along the lakeshore, particularly on Pipe Lake, have significant amounts of bare soil. It is important to protect these areas from further degradation. Because the area is bare, it is unlikely native vegetation will re-establish naturally. So vegetation must be seeded or planted. Specific recommendations for planting seeds can be found in the "Shoreline Buffer Restoration, A Guide for Landowners." This guidebook was developed by Burnett County Land and Water Conservation Department.

Recommendation I: Add vegetation density to existing buffer.
Some areas along the shoreline had established buffer areas, but the buffers had little effectiveness due to the vegetation being so sparse. Those areas will likely need assistance by planting additional seeds or seedlings to make the buffer denser.

Recommendation J: Remove beach area.
Most beach areas are not natural and don't provide good natural habitat for fish or wildlife. While this may prove to be very difficult, the only way to re-establish the shoreline to its natural conditions would be to remove the beach area, stabilize the banks, and replant native vegetation. Prior to doing this it is important to talk with the DNR, Polk County Land and Water Conservation Department, or the zoning office as removing or filling soils from the shoreland is regulated by the Polk County Shoreland Protection Zoning Ordinance.

Recommendation K: Stop fertilizing or use only phosphate-free fertilizer.
Phosphorous is often the limiting factor for algal growth in most lake systems. Therefore the more phosphorous added to a lake, the more algal blooms there will likely be, reducing water quality. Using fertilizers with phosphorous can contribute significant amounts of phosphorus to the lake. Some areas have banned the use of fertilizers containing phosphorous. Current County Shoreline Zoning regulations prohibit the use of fertilizers containing phosphorous within 1,000 feet of a lake. So if you must fertilize do not use fertilizers that contain phosphorous (The middle number on the front of the fertilizer bag indicates the amount of phosphorous. For example if a bag of fertilizer shows 10-0-10 on the bag it indicates fertilizer contains no phosphorous).

Recommendation L: Make path to shoreline perpendicular to slope.
Some areas have adequate buffers along the shoreline, but the path leading to the lakeshore is turf lawn and the land is sloped so that most of the runoff is directed to the path rather than to the buffers. This scenario limits the effectiveness of the buffers and allows most of the runoff to reach the lake without having to traverse the buffers. Making a path that is perpendicular to the slope with buffers on both sides of the path will capture the runoff much

more effectively. Another alternative on these sites could be constructing an elevated staircase.

Recommendation M: Study to determine the actual affects of septic systems on the lakes.
The water table for Pipe and North Pipe Lakes is considered perched. If this is the case, previous researchers have indicated that existing septic systems should have little to no adverse affects on the Lakes' water quality. The Pipe's Lake District conducted a lake water conductivity test in the last planning grant to evaluate conductivity variations that may be indicative of septic system effluent entering the lake system. The conductivity test provides a measure of water conductivity at various points along the lake shore or continuously from a sensor towed behind a boat as it is piloted around the lake shore. In theory, locations where the conductivity would go up would be locations suspected of having an influx of septic system effluent, however, the anticipated conductivity variations were not found. The water quality researchers concluded that the method is suspect in Pipe Lakes due to lake water conductivity background values.

Previous researches have concluded that the Pipe Lakes are not dependant on the regional water table for water contribution as the regional water table is "deeper" than the surface of the lake. Using the "Generalized Water Table Map of Polk County" prepared by WGNHS (the Wisconsin Geologic and Natural History Survey) in 2000, the water table elevation at Pipe Lake is mapped at 1,220 feet above sea level. From the USGS topographic map, the lake elevation is 1,241 feet above sea level. The deepest part in North Pipe Lake is mapped at 30 feet below the surface (approximate elevation is 1,211 feet above sea level) and Pipe Lake is over 60 feet below surface or 1,181 feet above sea level. Using available USGS topographic maps, the majority of the lake shore homes are established within 1,250 and 1,270 feet above sea level or about 30 to 50 feet above the water table.

The conclusions that are drawn from this information suggest:

1. The fine grained tills present in this region are forming a layer that maintains the lake water elevations 20 feet above the regional water table.
2. The deeper parts of the lakes are well below the elevation of the "regional" water table and are likely connected to the regional water table.
3. Septic tanks and drain fields are installed in the fine grained tills some 20 to 40 feet above the water table. Established drain fields have a "zone of saturation" that extends vertically downward from the septic effluent distribution pipe. This zone typically intersects the water table (perched or regional) under the drain field location.
4. The connection between the drain field zone of saturation and the regional aquifer intersecting the deeper portion of the Lakes provides a plausible mechanism that septic system drain field effluent is entering the lake system.

Concerns that we present given the geography of the lake and groundwater system:

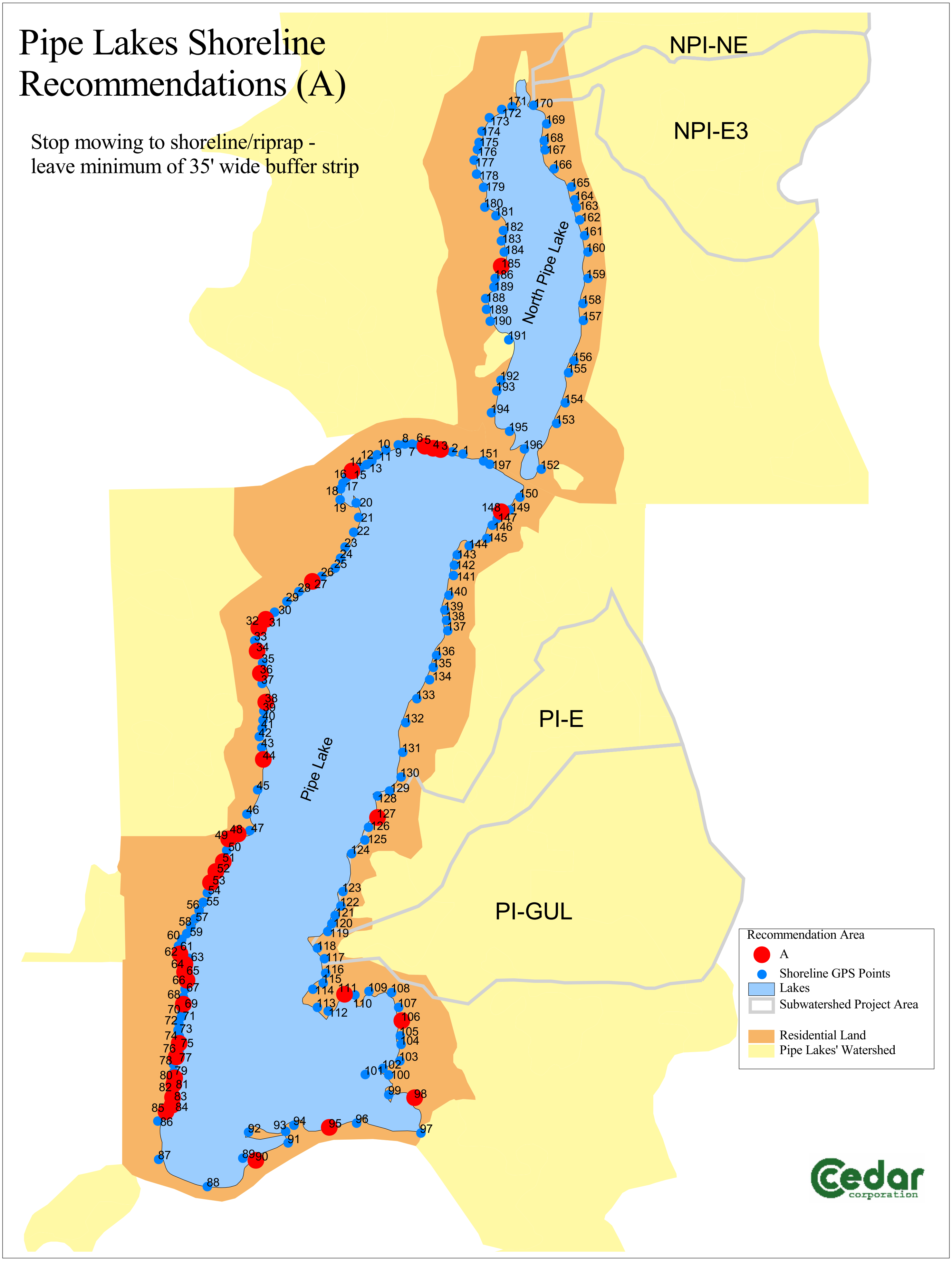
1. It is unclear, based on the given information, that there is no connection between the "regional" water table and the lakes. Clearly the vertical depth of the lakes is well below the water table surface, as the two surfaces have only a 20 foot elevation difference and the lakes are over 20 feet deep. It would appear that the fine grained tills surrounding the lake are preventing the lake water from seeping into the surrounding soils at a greater rate than the water is being replenished. It also suggests that the Lakes are an expression of the confined regional aquifer that is present to the

east in western Barron County and as it extends into eastern Polk County. That perched aquifer and the confining layer do not extend southward of Pipe Lake on the WGNHS maps.

2. The "regional" water table in this area is characterized as sand and gravel, a media that has relatively no ability to attenuate (retard the movement) of septic system effluent.
3. Groundwater movement is considered to be from northeast to the southwest in the local area, thus septic systems on the east side of the lake can be considered a potential contributor to lake water quality degradation. Given this information the septic systems on the west side of the lakes are not considered contributors based on the anticipated groundwater movements but could be considered potential contributors until the complex hydrogeology of the lake-ground water system is better understood.
4. The movement of groundwater into/out of the lake system appears to occur over 20 feet below the lake surface and could be a potential source for phosphorus influence to the lake system.

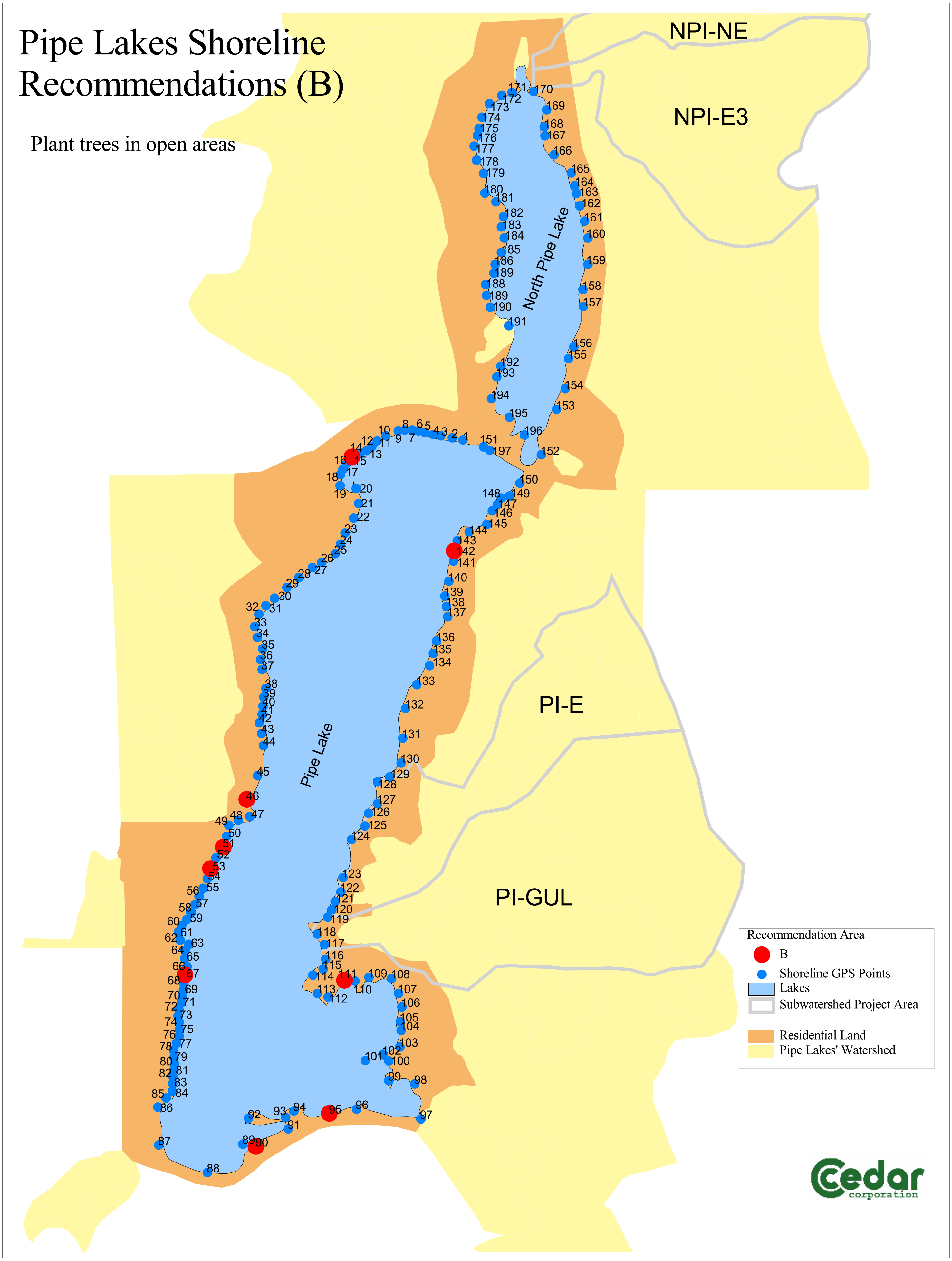
Future work may include:

1. Installation and monitoring of groundwater monitoring wells to understand the lake's hydrogeological interactions with the groundwater.
2. Water quality monitoring of the wells could identify phosphorus contribution in groundwater and provide insight on lake water quality degradation.
3. Deep water samples could be taken during winter months (when the lakes are not stratified) at multiple different elevations to test for phosphorous concentration. The foci of this investigation is to determine the phosphorous concentrations above and below the 1220 foot elevation (the estimated ground water elevation as determined by WGNHS)
4. Dye testing of certain septic systems selected as "Effluent Test Systems" coupled with one or more groundwater monitoring points between the drain field and the lake to define time of travel and pathway of travel.


Pipe Lakes Shoreline Recommendations (A)
Stop mowing to shoreline/riprap - leave minimum of 35' wide buffer strip
NPI-NE
NPI-E3
North Pipe Lake
Pipe Lake
PI-E
PI-GUL
Recommendation Area
A
Shoreline GPS Points
Lakes
Subwatershed Project Area
Residential Land
Pipe Lakes' Watershed

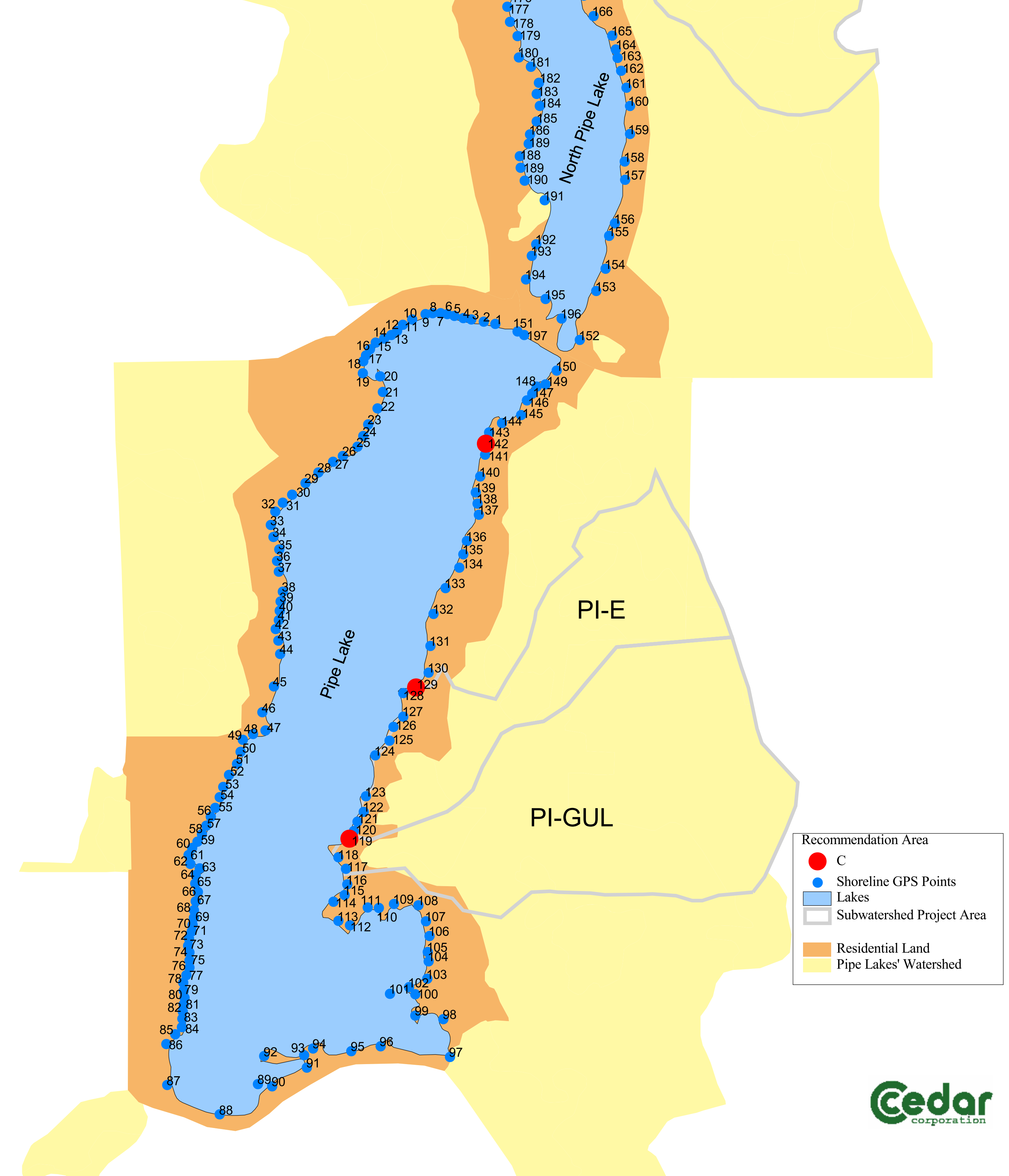
Pipe Lakes Shoreline Recommendations (B)

Plant trees in open areas



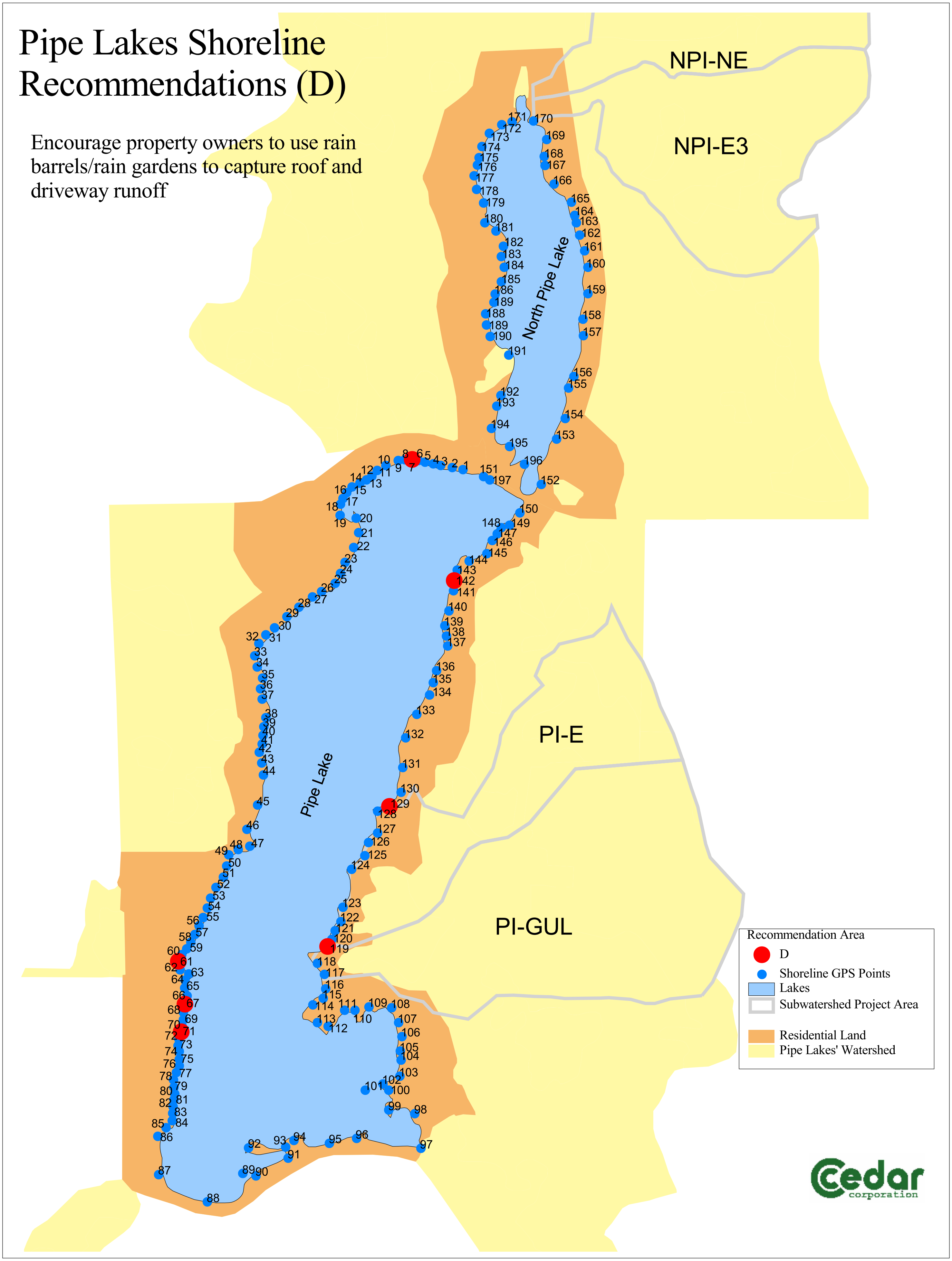
Pipe Lakes Shoreline Recommendations (C)

Enforce setbacks for future development



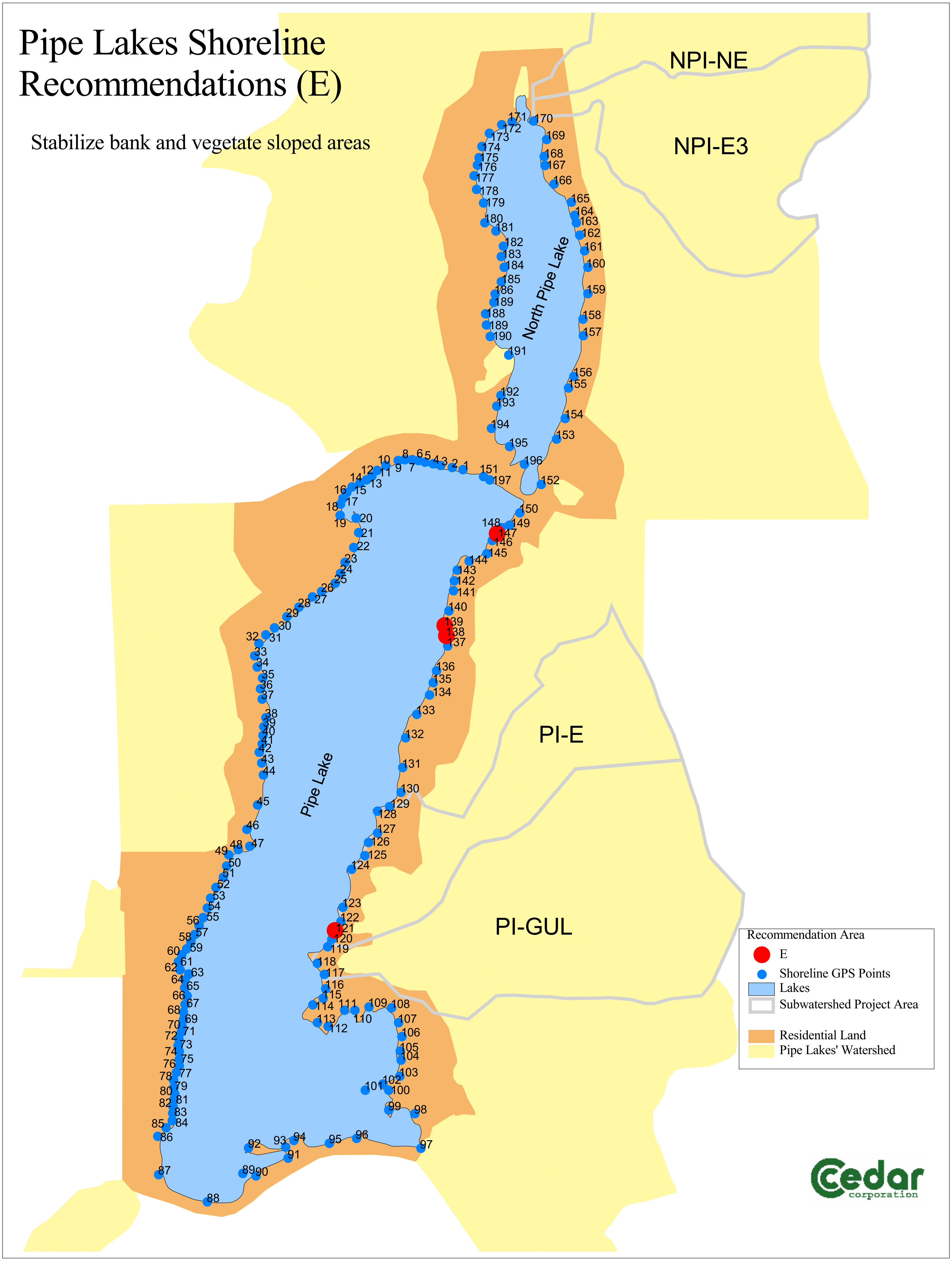
Pipe Lakes Shoreline Recommendations (D)

Encourage property owners to use rain barrels/rain gardens to capture roof and driveway runoff



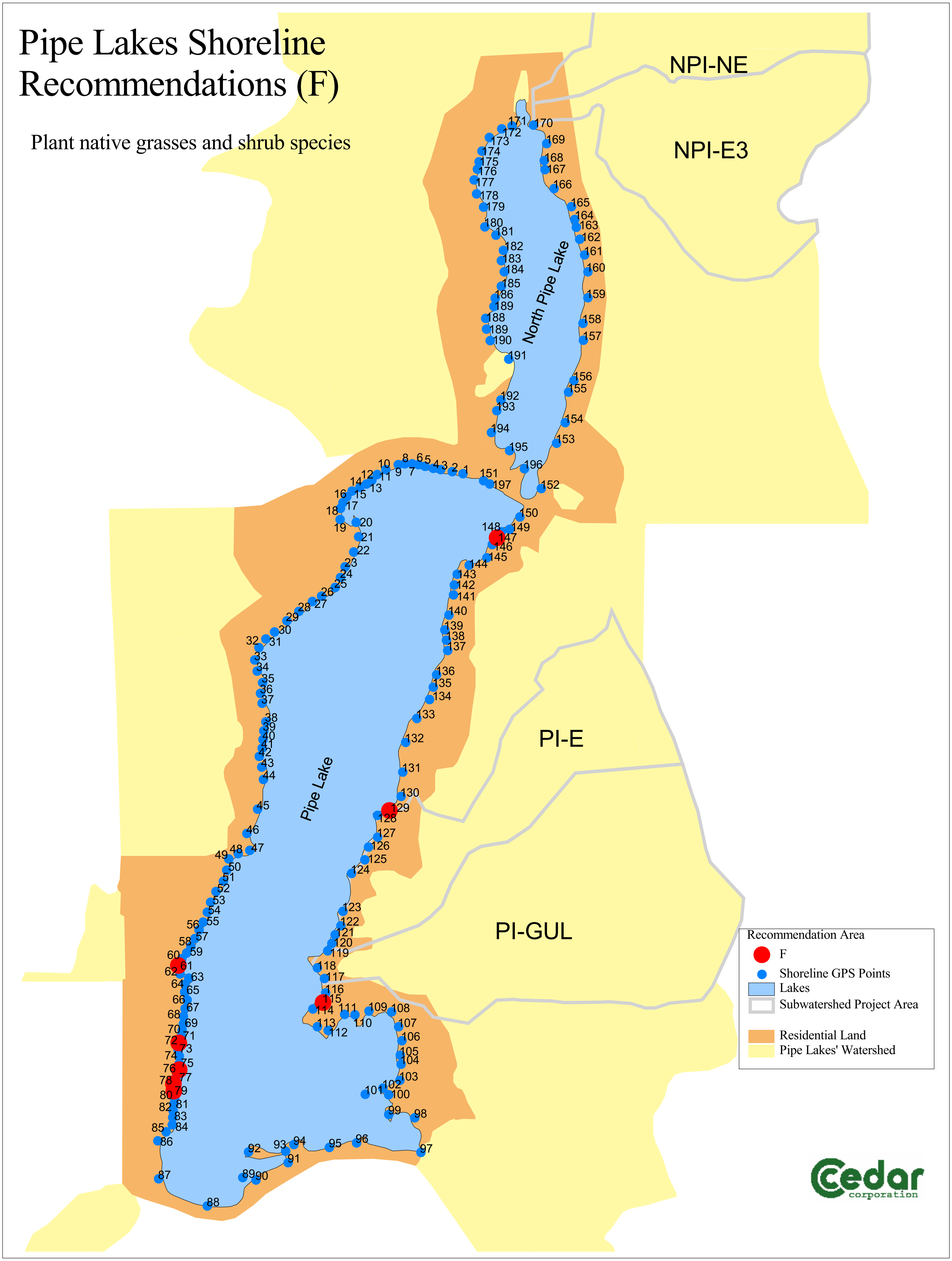
Pipe Lakes Shoreline Recommendations (E)

Stabilize bank and vegetate sloped areas



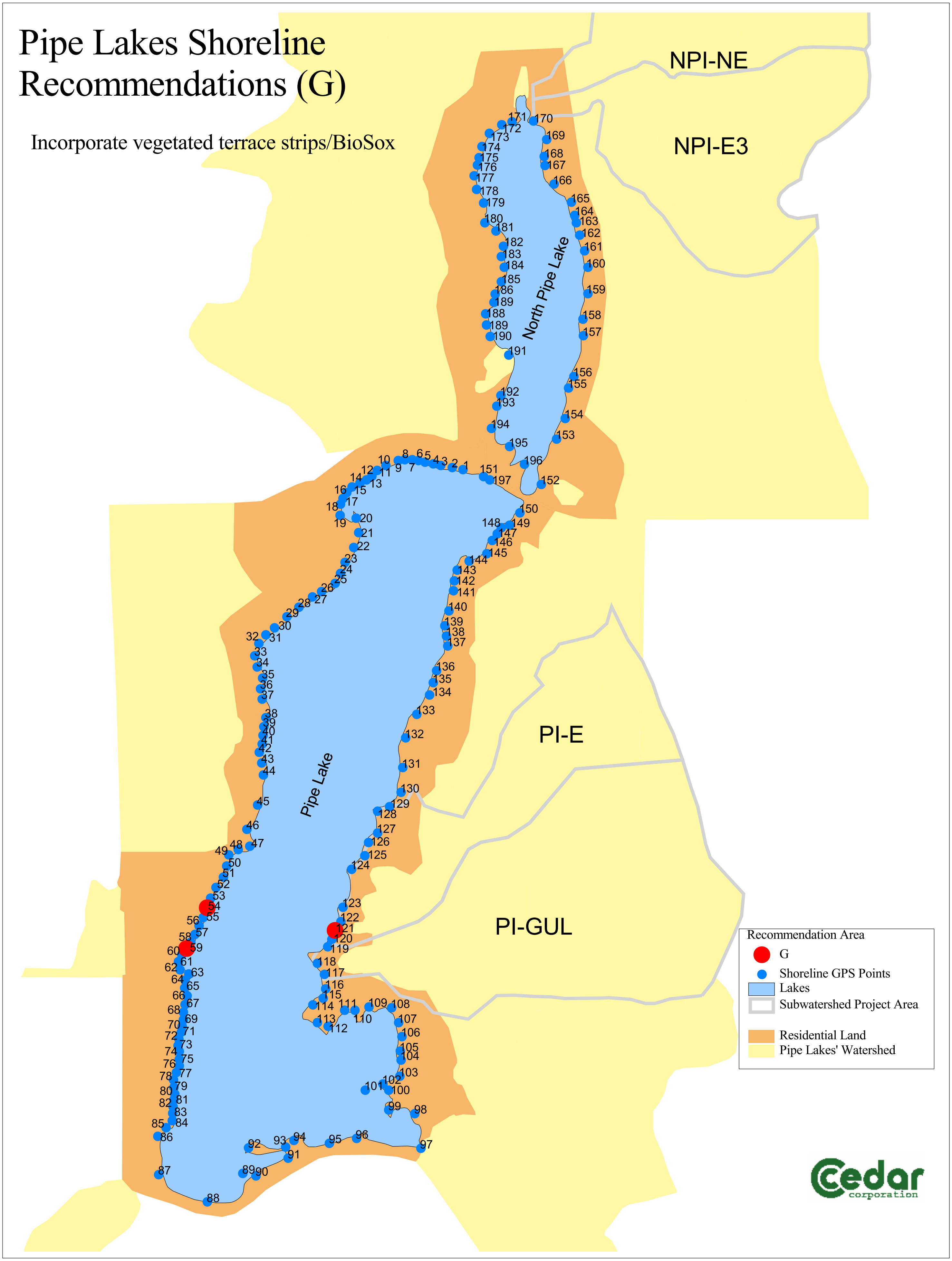
Pipe Lakes Shoreline Recommendations (F)

Plant native grasses and shrub species



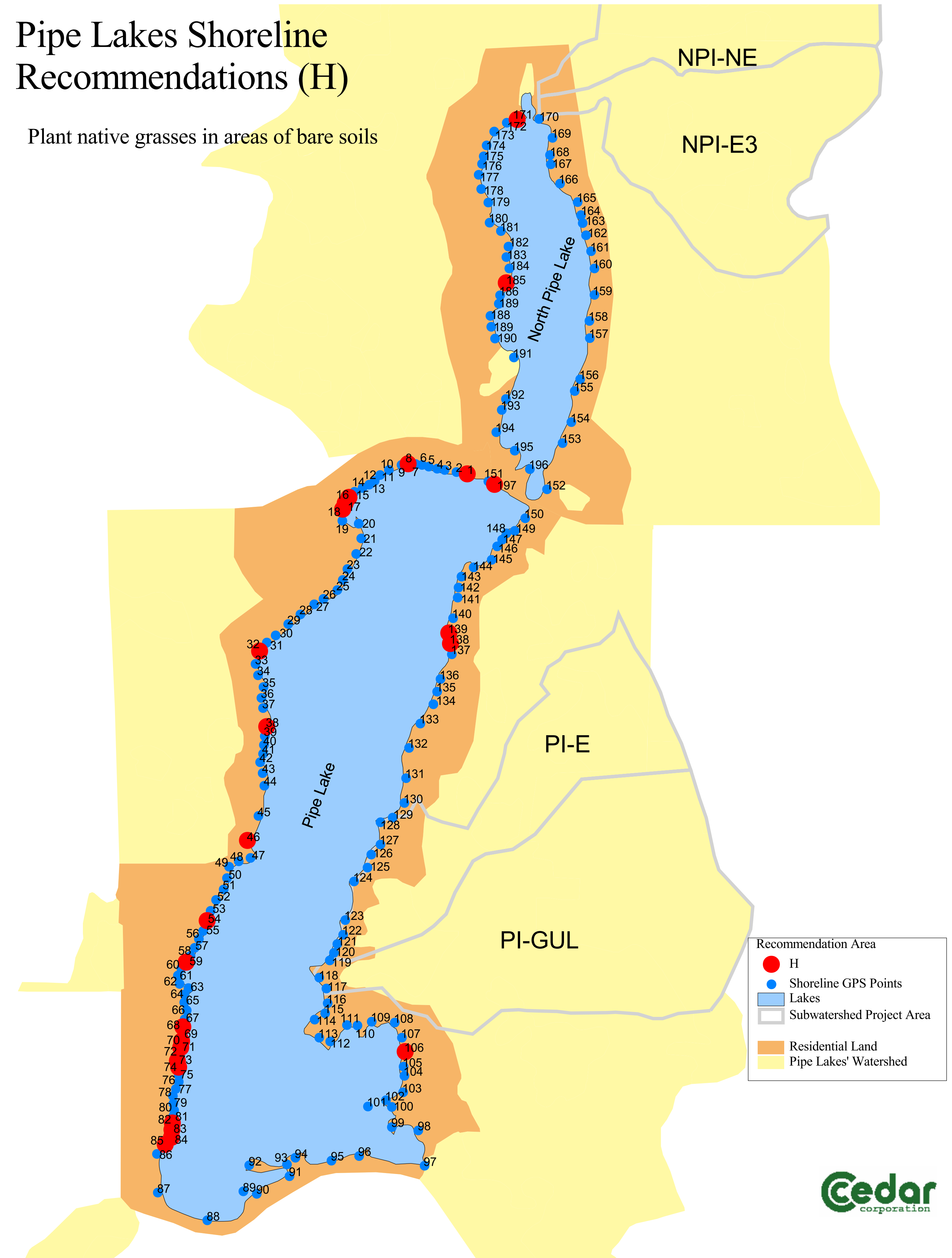
Pipe Lakes Shoreline Recommendations (G)

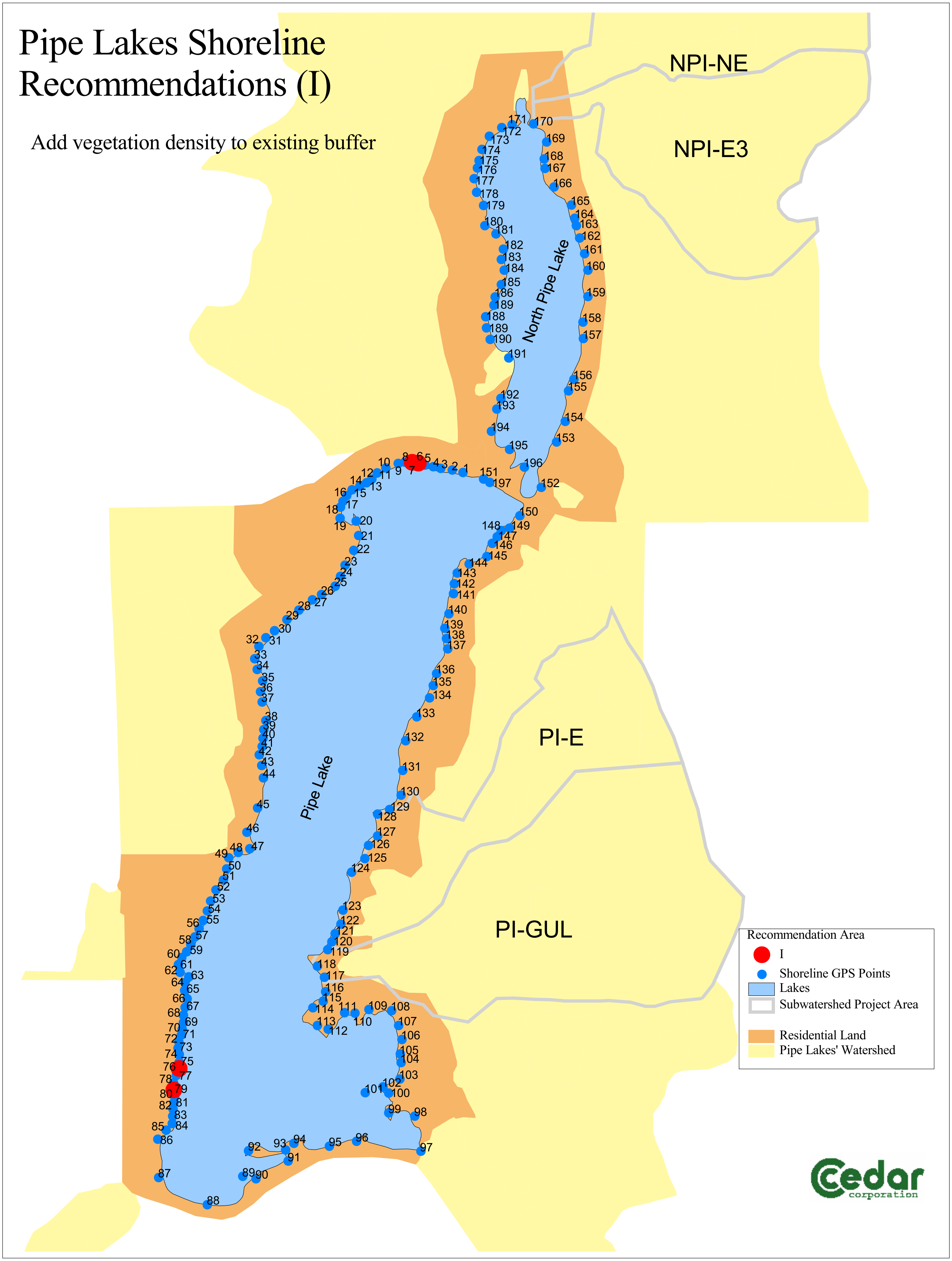
Incorporate vegetated terrace strips/BioSox



Pipe Lakes Shoreline Recommendations (H)

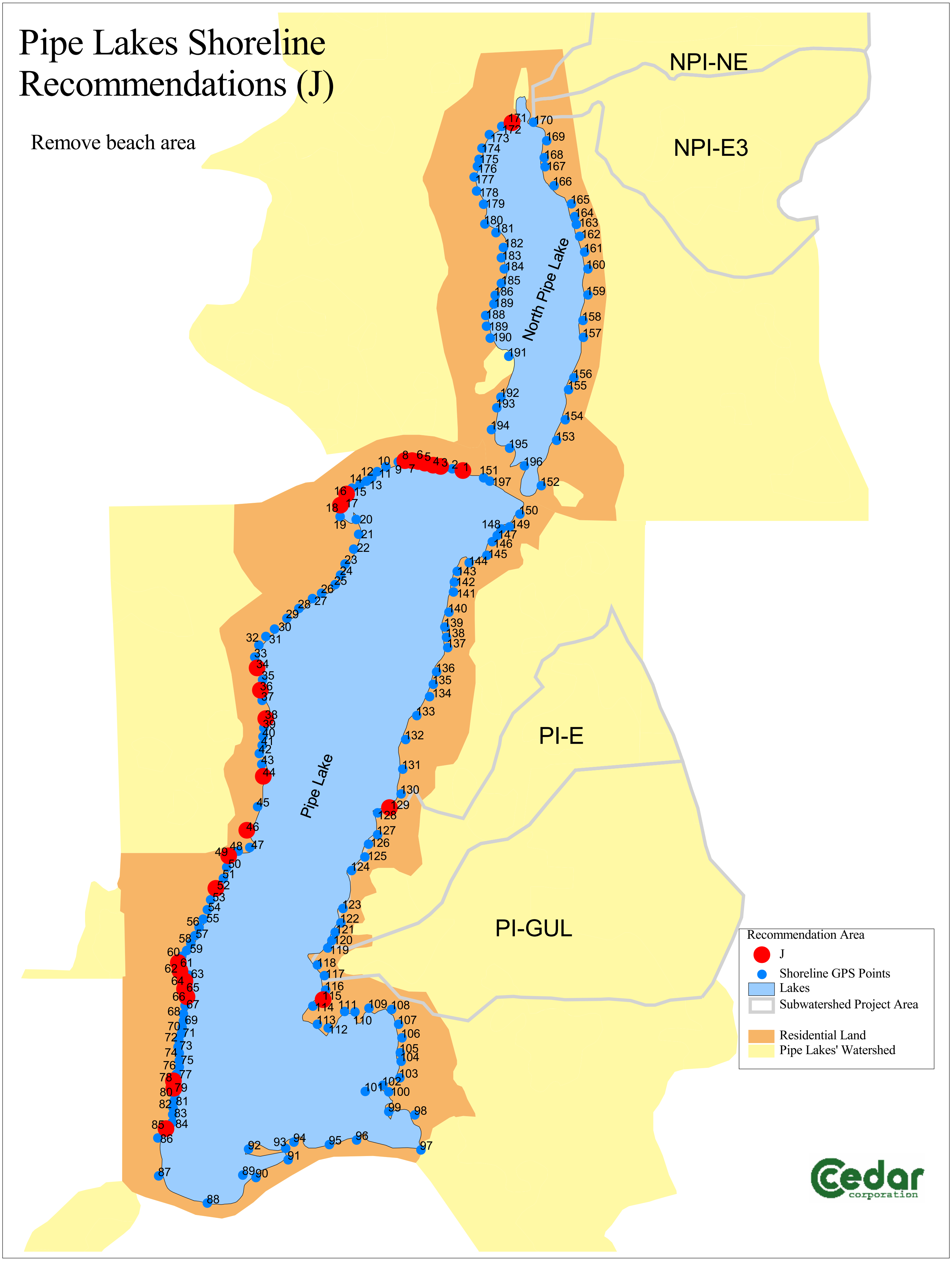
Plant native grasses in areas of bare soils




Pipe Lakes Shoreline
Recommendations (I)
Add vegetation density to existing buffer
NPI-NE
NPI-E3
North Pipe Lake
Pipe Lake
PI-E
PI-GUL
Recommendation Area
I
Shoreline GPS Points
Lakes
Subwatershed Project Area
Residential Land
Pipe Lakes' Watershed

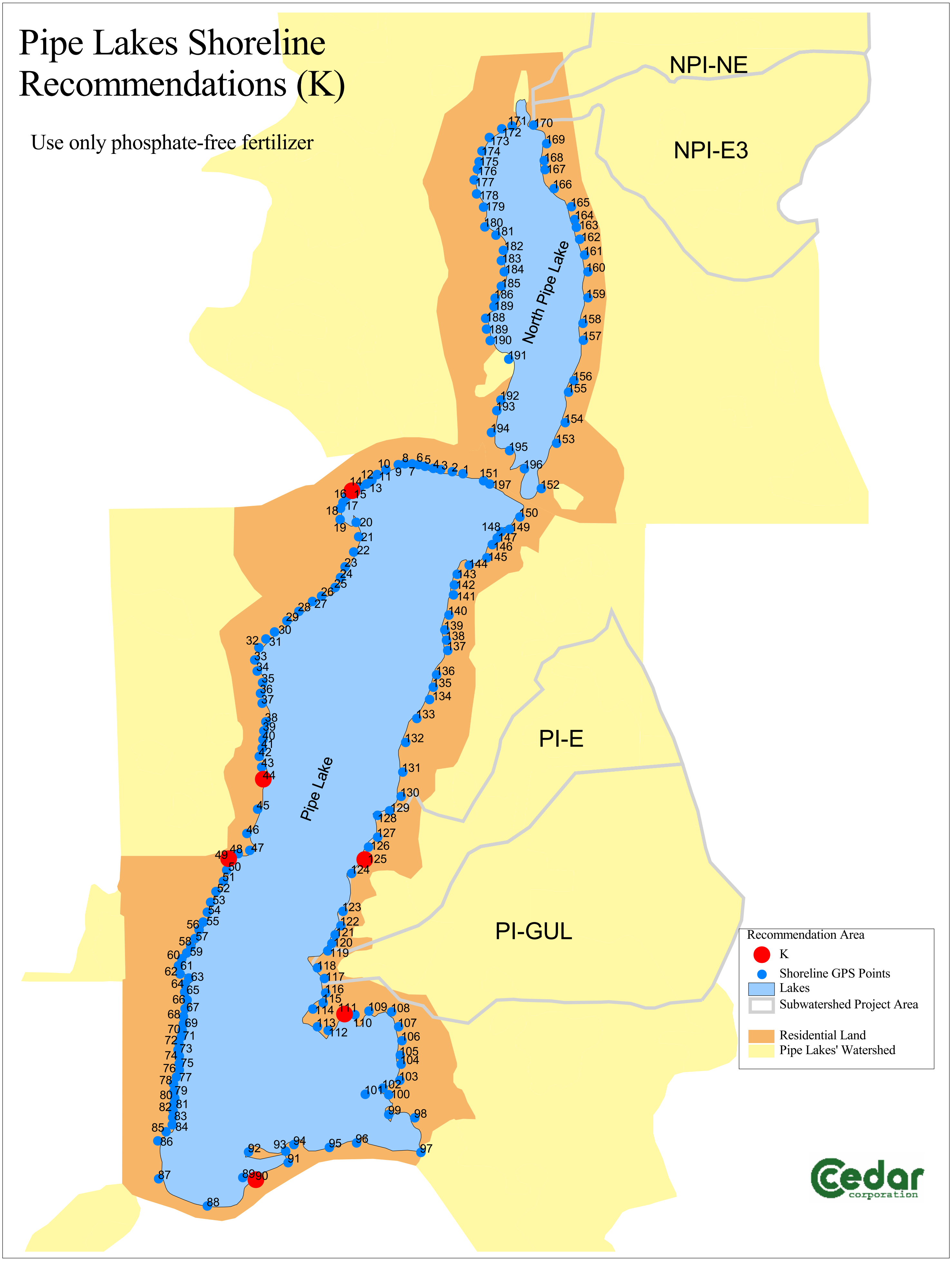
Pipe Lakes Shoreline Recommendations (J)

Remove beach area



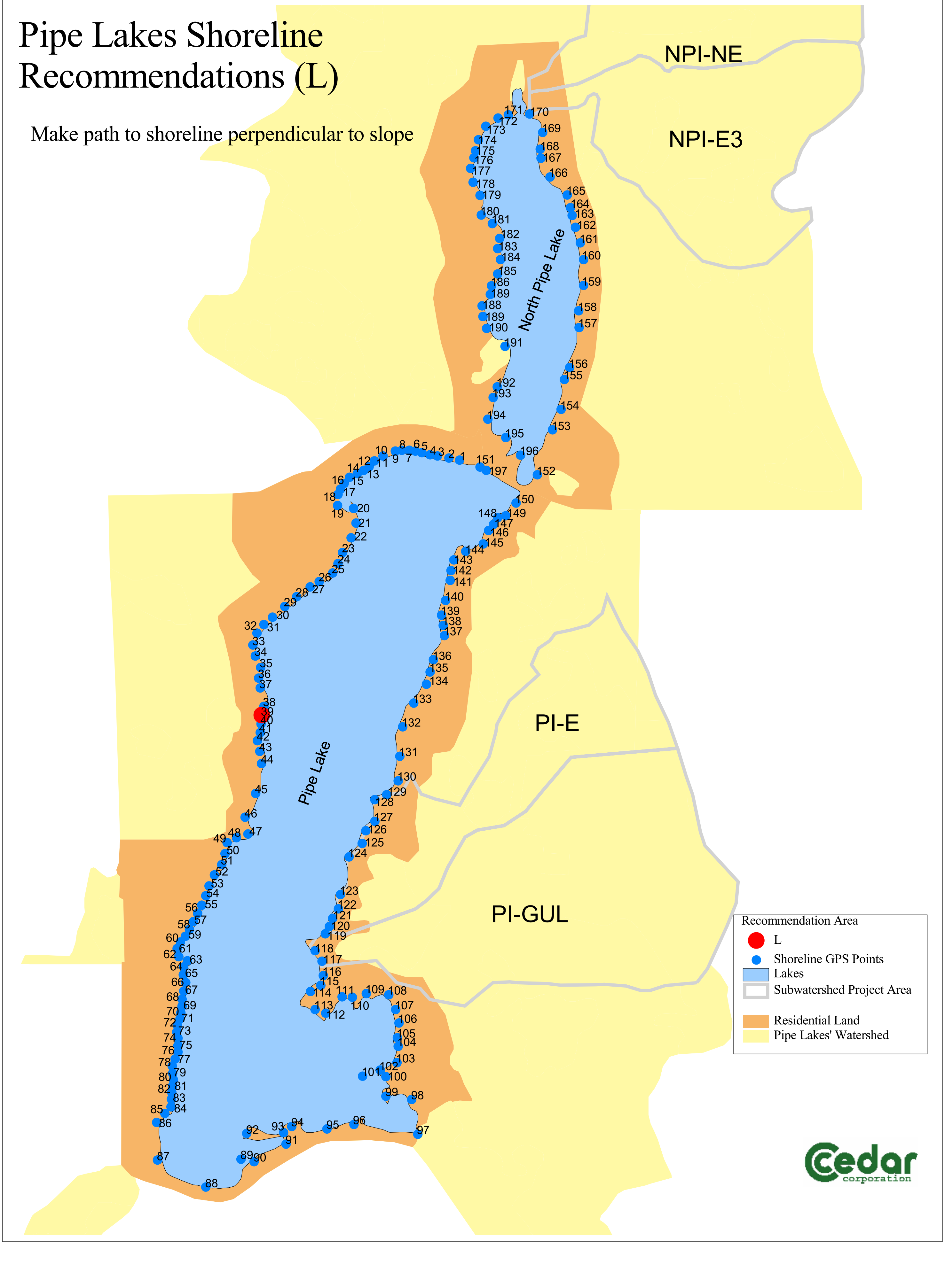
Pipe Lakes Shoreline Recommendations (K)

Use only phosphate-free fertilizer



Pipe Lakes Shoreline Recommendations (L)

Make path to shoreline perpendicular to slope



Modeling

The modeling effort consists of water quality modeling (focusing on phosphorous) and water quantity modeling. Modeling efforts included modeling of the existing system and also with proposed recommendations.

WiLMs Modeling (Water Quality)

Introduction

The overall basin and contributing watersheds for both Pipe and North Pipe Lake have been the subject of computer modeling efforts on three different previous occasions and yielded three different outcomes. This is not necessarily unexpected, modeling is subjective and the variables are usually adjusted for the unique circumstances for each watershed as the modeling effort progresses. The goal of this project was to prepare and run a computer model for the project area watersheds using the established coefficients and methodologies derived from previous modeling efforts. As the sub-watershed boundaries were redefined, the computer model simulations of the surrounding watersheds of both lakes were also rerun.

Model Preparations

Previous models limited the phosphorous contributions from septic systems. For this project, two modeling scenarios were conducted. One does not include any septic system contribution and the other estimates the septic system capita years (62.5 for North Pipe and 145.7 for Pipe). Septic system per capita years are calculated estimates reflecting the effluent produced by one person using a septic system for an entire year. Because many of the homes on lakeshores are seasonal, the septic system per capita year values are estimated to reflect how the number of persons that may live in each house and the percentage of home occupancy. Clearly the number is an estimate. For example, a house on the lake could have two people that live there for six months out of the year. This would be considered one capita year.

To accomplish the modeling, data was extracted for the subwatershed project areas of interest. Existing input data (existing and future land uses, existing soil conditions, wetlands, and surface waters) from previous WiLMs modeling was extracted for the delineated sub-watersheds project areas. The four subwatershed areas include NPI-E3, NPI-NE, PI-E, and PI-GUL (Map 1). The subwatersheds are based on previous watershed delineations and were slightly modified after a reassessment of the topography in the area.

Land uses incorporated in the modeling are based on the current land use map as noted in the Pipe Lakes Comprehensive Planning Report, 2002, completed by Polk County. Land uses for the entire watershed for Pipe and North Pipe Lakes were mapped. In order to determine the loading from each subwatershed in the project area the land uses (Map 2) were extracted and utilized so modeling could be completed on each subwatershed individually.

The export coefficients used in the WiLMs modeling are based Craig Roesler's previous models. The modeling export coefficients were derived from an email from Craig Roesler and a memo based on notes to use in conjunction with the "Pipe Lakes Understanding Updates" memo dated 5/8/2006. The table below summarizes the export coefficients used in the modeling and records the acreage assigned for each land use in each subwatershed.

Land Use	Loading (kg/ha-year)	NPI-NE (ac)	NPI-E3 (ac)	PI-E (ac)	PI-GUL (ac)
NRow Crop AG	0.96	-	-	-	-
Mixed AG (North)	0.76	23.98	-	-	-
Mixed AG (Pipe)	0.38	-	-	8.4	88.76
Pature/Grass	0.26	44.81	-	-	-
HD Urban	1.50	-	-	-	-
MD Urban	0.50	-	-	-	-
Rural Residential	0.36	3.74	2.17	17.5	4.56
Wetlands	0.06	12.08	16.47	32.1	12.17
Forest	0.06	91.86	93.69	39.3	68.18
Surface Water	0.30	-	-	-	-
Total	-	176.47	112.33	97.35	173.67

Results

The model results for the WiLMS model are presented for both with and without septic system influence and also as a percentage of contribution by critical sub-watershed. The WiLMs model calculates the average septic system per capita year contribution in the Pipe Lakes system is approximately 0.1 kg phosphorous per year.

The table below presents a comparison of the total external phosphorus load estimates from all of the WiLMs modeling efforts (3 previous ones and the 2007 Update - current grant).

Lake	Planning Grant 1 (Data to 2001)	Planning Grant 2 (Data to 2003)	2006 Update (Data to 2005)	2007 Update (no septic)	2007 Update (septic)
North	94 kg/yr	58 kg/yr	60 kg/yr	66.1 kg/yr	68.3 kg/yr
Pipe	156 kg/yr	59 kg/yr	124 kg/yr	115.4 kg/yr	119.7 kg/yr

The table below compares the total external phosphorus load estimates from all four sub-watersheds.

Subwatershed	External Loading Estimates	Area (acres)	kg/yr/ac	Percent of Lake Loading
NPI-NE	15.2 kg/yr	176.47	0.0861	22.25%
NPI-E3	3.0 kg/yr	112.33	0.0267	4.39%
PI-E	5.6 kg/yr	97.35	0.0575	4.68%
PI-GUL	16.3 kg/yr	173.67	0.0939	13.62%

Based on the modeling it is evident that sub-watersheds NPI-NE and PI-GUL contribute the most external loading overall and concentration (kg/ac). These sub-watersheds are the primary target for the many of the recommendations identified in this report.

Post Implementation of Recommended BMPs

Because water quality improvement projects such as water quality ponds and streambank restorations are typically completed in urban areas it follows most of the modeling and related studies conducted on the estimates of sediment and nutrient removal are based on urban settings. The Pipe Lakes sub-watershed project areas are in a rural, forested setting. This makes it challenging to describe the effect some of the recommendations will have on improving water clarity. Although these recommendations are based on sound engineering practices to improve water quality, it is difficult to gauge the quantitative improvement they may have on the Lakes as well as the possible ecological impacts changing the hydrology of the area may have on the Lakes.

The three recommendations that can be modeled with a degree of confidence in the output data are grassed swales, water quality ponds, and easements. For the first two, grassed swales and water quality ponds, engineers are able to provide an estimated level of phosphorus reduction as can be achieved in an urban setting. Therefore some of the recommendations may not reach the estimates of 80% phosphorus reduction for a water quality pond and 15% phosphorus reduction for a vegetated grassed swale.

To evaluate conservation easements we “reverse modeled” the scenarios, meaning we removed the land uses that are currently acting as an effective grass swale or buffer in areas surrounded by agricultural practices (approximately 3.5 acres between the two farm fields in PI-GUL) and modeled them as if they were being farmed. Modeling it this manner shows the estimated loading that could be expected if an easement isn’t acquired.

Subwatershed (Recommendation)	Loading utilization Recommendation	Existing Loading	% Reduction
Swale*			
NPI-NE Total (E1)	12.9 kg/yr	15.2 kg/yr	15.1%
PI-GUL Total (E3)	14.1 kg/yr	16.3 kg/yr	13.5%
Pond**			
NPI-NE Total (H1)	3.6 kg/yr	15.2 kg/yr	76.3%
PI-GUL Total (H2)	4.3 kg/yr	16.3 kg/yr	73.6%
Easement			
NPI-NE Total (A1)	14.7 kg/yr	15.2 kg/yr	3.3%
PI-GUL Total (A3)	16.3 kg/yr	*17.0 kg/yr	4.1%

*Assumes 15% reduction if stream is converted to grassy swale
** Assumes 80% reduction if pond can be sized and built in proper location
***Modeling assumes existing grassed swale area would be farmed
Clearly the model results indicate that protection of these existing natural defenses for polluted runoff are valuable tools in the water quality protection of Pipe Lakes.

HydroCAD Modeling (Peak Flow)

In addition to the water quality modeling it is important to understand the peak flow (cubic feet per second) that can be expected for certain storm events. This information is needed to size some of the recommendations made in this report such as a stormwater pond as well as estimate phosphorous mass contributions form different storm events. The 1, 2, 10, 25, and 100 year storm event were all modeled through HydroCAD. The required information to run the modeling includes runoff area, land uses, soil types, and slope. Each subwatershed area was modeled independently. The table below presents the peak flow in cubic feet per second (cfs) for each subwatershed area during the aforementioned storm events as well as the amount of rainfall for that corresponding storm event.

Subwatershed	1-Year (2.3")*	2-Year (2.7")	10-Year (4.1")	25-Year (4.7")	100-Year (5.8")
NPI-E3	2.4**	5.6	26.3	38.6	64.8
NPI-NE	7.4	13.6	45.8	63.2	98.7
PI-E	5.0	9.3	32.3	44.8	70.1
PI-GUL	10.8	18.5	56.0	75.6	114.6

* Anticipated rainfall in inches
**Peak Flow in cubic feet per second

This information can be utilized in designing the required size for culverts. There would need to be some refinement in the numbers as the sizes of the subwatersheds upstream of a replaced culvert would have to be modified for the specific location of the culvert.

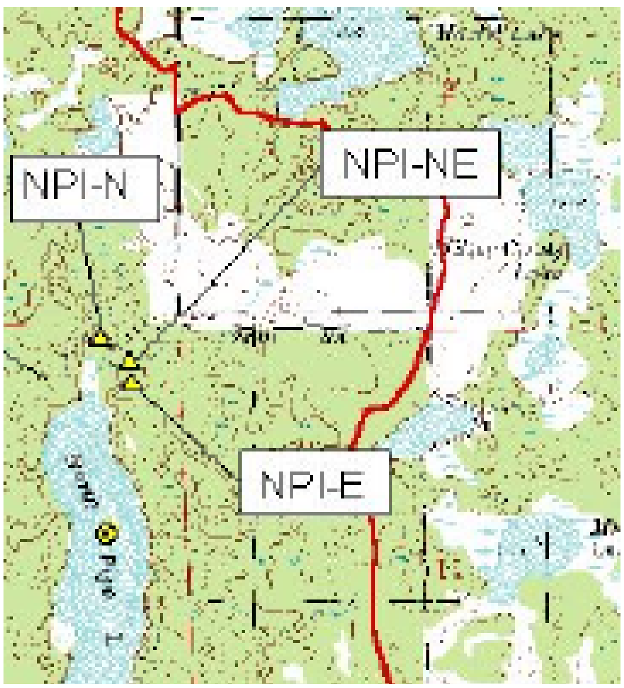
The modeling suggests Subwatershed PI-GUL has the highest peak flow even though it does not have the largest area of the subwatersheds in the project area. One thing to point out in the modeling is that the modeled peak flow is not the same as velocity. Some of the observations and sample test runs indicate that the velocity (and therefore emotional component) of PI-E is barely detectable. The reason it shows up as high as it does in the HydroCAD modeling is that the residential land use along the shoreline is included in the model. The land use is at the end of the watershed and will likely flow directly into Pipe Lake and won't be contributing directly to the peak flow of a stream flowing through the subwatershed project area.

Stream Sampling

The WiLMs and HydroCAD modeling in the previous section indicate that PI-GUL has the highest loading potential in the subwatershed project area. Some of the sampling results indicate that NPI-NE and NPI-E3 also have some high concentrations of phosphorus loading. Stream sampling was not part of the grant project but is an ongoing consideration and activity of the District. It is an important consideration because it shows evidence of significant loading coming from some of the subwatershed project areas. Both the modeling and stream sampling should be considered when looking at priorities as both provide a useful indication of the conditions of the subwatersheds.

Sampling of the intermittent streams in these watersheds is conducted by volunteer efforts and has taken place over the past few years. Sample locations are presented on the map below.

Figure E – Grab Sample Locations



Total Phosphorus ug/l	NPI-E3	NPI-NE
08/04/04	267	151
09/06/04	191	382
04/15/05	49	76
06/12/05	103	170
10/05/05	181	477
04/05/06	88	122
04/27/07	119	233
10/05/07	**346**	**976**
10/08/07	-	**3540**
10/18/07	249	585

Samples taken from intermittent streams in the subwatersheds NPI-E3 and NPI-NE for the past three years are listed on the table above. The sample taken October 8, 2007 shows a rather significant spike in total phosphorus concentrations in the stream flow in NPI-NE. That dramatic a spike might be due to laboratory or sampling procedure error, but the sample taken on October 5, 2007 is still extremely high. These results are likely due to the accumulation of phosphorus in the surface areas over the previous few months because of a dry spell in the summer of 2007. The dramatic jump can be considered a “first flush” which usually contains high concentrations of phosphorus. Recommendations such as restoring eroded streambanks, incorporating grassed swales, and constructing water quality ponds, will provide some reduction in the phosphorous concentrations in these “first flush” events.

One of the difficulties with sampling intermittent streams is the lack of a consistent flow. Intermittent streams may have occasionally high concentrations of phosphorus however those concentrations may be misleading in that the mass loading of phosphorus to the Lakes is actually quite low as compared to the long term contribution of a flowing stream at a lower phosphorous concentration. So while the concentration may be higher during sampling events, the overall amount of phosphorus reaching the lakes is less than the same concentrations on a steady stream.

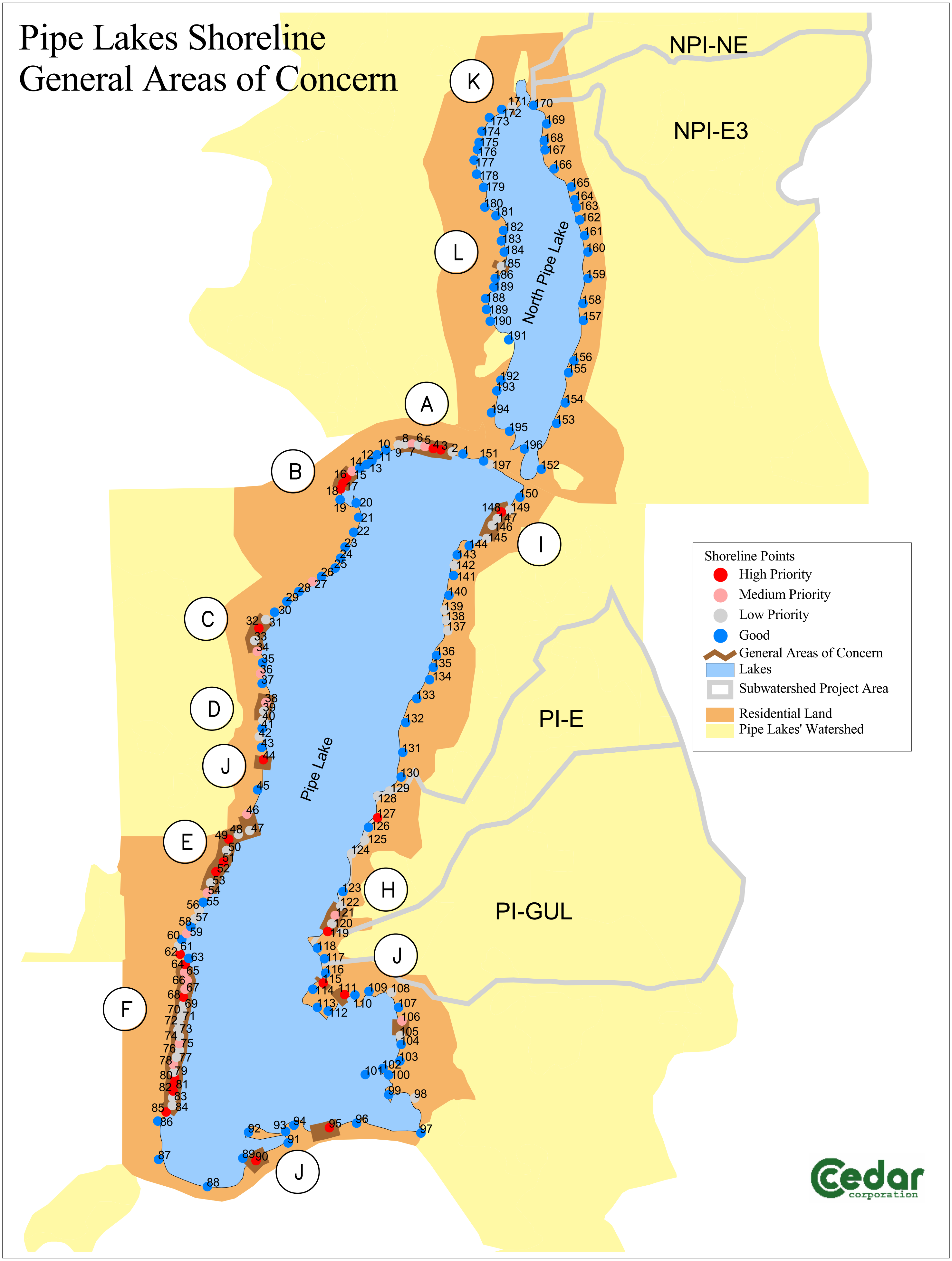
Appendix A
Recommendations

Appendix A Project	Specific Area Waypoint	Critical Watershed	Primary Treatment Capacity			Primary Benefit		Project Priority	Estimated Project Cost
			Sediment Reduction	Hydraulic Energy Reduction	Nutrient Reduction	Improve Existing Condition	Protect Future Degradation		
Acquire Easements over Critical Areas	A1	NPI-NE	●		●		●	Medium	Variable
Outlet Protection	C1	NPI-NE	●	●		●		High	$1,200
Review County Farm Plan Compliance	B1	NPI-NE	●		●		●	Medium	Volunteer Time
Monitor as potential Wet Detention Basin	H1	NPI-NE	●	●	●		●	Low	Volunteer Time (Implementation $100,000 - $120,000)
Stream Bank Slope Stabilization	E1	NPI-NE	●		●	●		High	$6,000
Hydraulic Drop Structure	F1	NPI-NE		●		●		Low	$5,000
Replace Culverts	D1	NPI-NE		●		●		High	$3,000
Outlet Protection	C2	NPI-NE	●	●		●		High	$1,200
Stream Bank Slope Stabilization	E2	NPI-NE	●		●	●		High	$6,500
Acquire Easements over Critical Areas	A2	NPI-E3	●		●		●	Medium	Variable
Review WiDNR NOI Requirements	B2	NPI-E3	●		●	●	●	Medium	Volunteer Time
Acquire Easements over Critical Areas	A3	PI-GUL	●		●		●	Medium	Variable
Review County Farm Plan Compliance	B4	PI-GUL	●		●		●	Medium	Volunteer Time
Monitor as potential Grade Control Area	G1	PI-GUL	●	●	●		●	Low	Volunteer Time
Acquire Easements over Critical Areas	A4	PI-GUL	●		●		●	Medium	Variable
Stream Bank Slope Stabilization	E3	PI-GUL	●		●	●		High	$2,500
Regrade and Widen Private Road Ditch	D2	PI-GUL		●				High	$3,000
Stream Bank Slope Stabilization	E4	PI-GUL	●		●	●		High	$8,500
Review WiDNR Forrest Management Guidelines	B5	PI-GUL	●			●		Medium	Volunteer Time
Monitor as potential Grade Control Area	G2	PI-GUL	●	●	●		●	Low	Volunteer Time
Monitor as potential Wet Detention Basin	H2	PI-GUL	●	●	●		●	Low	Volunteer Time (Implementation $80,000 - $90,000)
Promote Shore land Restoration/Monitoring	NA	PI-E	●		●	●	●	High	Volunteer Time
Acquire Easements over Critical Areas	A5	PI-E	●		●		●	Medium	Variable
Review County Farm Plan Compliance	B3	PI-E	●		●		●	Medium	Volunteer Time

Appendix B
Shoreline Inventory (CD)

Appendix C
Shoreline Inventory Spreadsheet

Pipe Lakes Shoreline General Areas of Concern



1-1%-25% 3-51%-75%
2-26%-50% 4-76%-100%

Location	GPS POINT	PHOTO NUMBER									CANOPY (D, C, M) (1-4)	CANOPY Yard (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50%	CANOPY Buffer (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50	UNDERSTORY (0.5m TO 5m) (D, C, M)	Woody Shrubs (0-4)	Tall Herbs, Grasses, Forbs (0-4)	GROUND COVER (<0.5m)	Woody Shrubs (0-4)	Herbs, Grasses, Forbs (0-4)	Bare Dirt/Barren (0-4)	SHORELINE SUBSTRATE	Gravel (0-4)	Sand (0-4)	Muck (0-4)	Organic (0-4)	SLOPE (1-4) Yard	Slope (0-4) Buffer	HUMAN INFLUENCE	Buildings	Docks	Walls/Riprap	Lawn to Shoreline	Beach Area	MITIGATION EFFORTS/NATURAL	Shoreline Restoration	Buffer Width (0=none, 1 = 1'-5', 2 = 5'-15', 3 = 15'-35', 4 = 35'<	Rating
1	1	1									m	3	3	m	2	2		1	2	1		2	2	0	0	1	0		1	1	0	0	1		0	3	4.0
2	2	2									m	2	2	m	1	1		2	2	0		2	2	0	0	2	2		1	1	0	0	0		0	3	3.0
3	3	3	55								m	2	1	0	0	0		0	1	3		2	2	0	0	2	1		1	1	1	0	1		0	1	-15.5
4	4	4	56								m	1	3	0	0	0		0	1	3		2	2	0	0	1	1		1	1	1	0	1		0	1	-14.0
5	5	5	57								m	2	1	0	0	0		0	1	0		1	2	0	0	0	1		1	1	1	0	1		0	1	-6.5
6	6	6	58								m	1	3	0	0	0		1	2	0		2	2	0	0	0	1		1	1	1	0	1		0	2	1.0
7	7	7									m	2	2	0	0	0		1	1	2		2	2	0	0	0	1		1	1	1	0	1		0	1	-8.0
8	8	8									m	4	2	0	0	0		1	2	1		2	2	0	0	0	1		1	1	0	1	1		0	3	-1.0
9	9	9									m	3	2	m	1	1		1	2	1		2	2	0	0	0	1		1	1	1	0	1		0	2	2.0
10	10	10									m	3	3	m	1	1		2	2	0		2	2	0	0	0	1		1	1	0	0	0		0	2	7.0
11	11	11									m	1	2	d	1	0		2	2	0		2	2	0	0	0	1		1	1	0	0	0		0	2	4.5
12	12	12									m	1	2	0	0	0		2	2	0		2	2	0	0	0	1		1	1	0	0	0		0	2	3.5
13	13	13	59								m	1	1	0	0	0		2	2	0		2	2	0	0	0	1		1	1	0	0	0		0	2	3.0
14	14	14									m	1	1	0	0	0		2	2	0		2	2	0	0	0	1		1	1	0	0	0		0	2	3.0
15	15	15	17								m	0	1	0	0	0		0	1	3		1	2	1	0	0	1		1	1	1	0	1		0	1	-9.0
16	16	16									m	3	2	0	0	0		0	1	3		1	2	1	0	0	1		1	1	1	0	1		0	0	-13.0
17	17	18									m	3	2	0	0	0		0	1	3		1	2	1	0	0	2		1	1	0	1	0		0	1	-11.0
18	18	19									m	4	3	0	0	0		0	1	3		1	2	1	0	0	2		1	1	0	0	1		0	1	-11.0
19	19	20	21	22	23						m	4	4	m	2	2		2	2	0		1	1	1	1	1	1		0	0	0	0	1		0	4	13.0
20	20	24	25								m	4	4	m	2	2		2	1	1		1	1	1	1	1	1		1	1	0	0	1		0	4	9.0
21	21	26	27	28							m	4	4	m	2	2		2	2	0		1	1	1	1	1	1		0	0	0	0	1		0	4	13.0

0-non existant, 1-4 density rating with 4 being the most dense

D-deciduous, C-coniferous, M-Mixed

Location	GPS POINT	PHOTO NUMBER									CANOPY (D, C, M) (1-4)	CANOPY Yard (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50%	CANOPY Buffer (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50	UNDERSTORY (0.5m TO 5m) (D, C, M)	Woody Shrubs (0-4)	Tall Herbs, Grasses, Forbs (0-4)	GROUND COVER (<0.5m)	Woody Shrubs (0-4)	Herbs, Grasses, Forbs (0-4)	Bare Dirt/Barren (0-4)	SHORELINE SUBSTRATE	Gravel (0-4)	Sand (0-4)	Muck (0-4)	Organic (0-4)	SLOPE (1-4) Yard	Slope (0-4) Buffer	HUMAN INFLUENCE	Buildings	Docks	Walls/Riprap	Lawn to Shoreline	Beach Area	MITIGATION EFFORTS/NATURAL	Shoreline Restoration	Buffer Width (0=none, 1 = 1'-5', 2 = 5'-15', 3 = 15'-35', 4 = 35'<	Rating
22	22	29	30	31							m	4	4	m	2	2		2	2	0		1	1	1	1	2	1		0	1	0	0	1		0	4	11.0
23	23	32	33								m	4	4	m	2	2		2	2	0		1	1	1	1	3	2		0	1	0	0	1		0	4	9.0
24	24	34	35								m	4	4	m	2	2		2	2	0		1	1	1	1	3	3		0	1	0	0	1		0	4	8.0
25	25	36	37								m	4	4	m	2	2		2	2	0		3	0	1	0	3	4		1	1	0	0	1		0	4	6.0
26	26	38	39								m	4	4	m	2	2		2	2	0		3	0	1	0	2	2		1	1	0	0	1		0	4	9.0
27	27	40	41	42	1						d	3	4	m	1	0		1	1	0		2	2	0	0	1	1		1	1	0	1	0		0	0	-7.5
28	28	43	44								d	4	4	m	1	1		1	1	0		1	2	1	0	1	1		1	1	0	1	0		0	3	5.5
29	29	45									d	4	4	m	1	1		1	3	0		1	2	1	0	1	1		1	1	0	1	0		0	3	7.5
30	30	46	47	48							m	4	4	m	1	1		1	2	0		1	2	1	0	0	2		1	1	0	0	0		0	3	7.5
31	31	49	50	2							m	4	4	0	0	0		0	1	1		1	1	1	1	0	1		1	1	0	1	0		0	3	-2.0
32	32	51	3								m	4	3	m	1	0		0	0	3		1	1	1	1	1	2		1	1	0	1	0		0	1	-12.0
33	33	52	53	4							d	1	3	m	1	2		1	2	1		1	1	1	1	2	2		1	1	0	0	1		0	2	0.5
34	34	54	55	5							d	3	3	d	0	1		0	1	2		1	2	1	0	1	0		1	1	1	0	1		0	2	-5.0
35	35	56	57	58							m	4	4	m	1	1		2	1	1		1	2	1	0	0	1		1	1	0	0	0		0	3	7.5
36	36	59	6								m	2	1	0	0	0		1	1	1		2	2	0	0	1	0		1	1	1	0	1		0	1	-6.5
37	37	60	61								d	1	1	d	1	0		1	2	1		2	2	0	0	1	1		1	0	0	0	0		0	2	2.0
38	38	62	7								m	3	1	0	0	0		1	1	1		2	2	0	0	1	1		1	1	1	0	1		0	3	-6.0
39	39	63	8								m	3	1	0	0	0		1	1	1		3	1	0	0	1	1		1	1	1	0	0		0	3	-0.5
40	40	64	9								d	4	4	m	1	0		1	1	1		3	1	0	0	1	2		1	1	1	1	0		0	2	0.0
41	41	65									m	4	4	m	1	1		1	1	2		3	1	0	0	1	1		1	1	1	0	0		0	2	2.5
42	42	66	67	10							m	4	4	c	1	0		1	1	2		2	2	0	0	1	2		1	1	0	0	1		0	2	0.0

0-non existant, 1-4 density rating with 4 being the most dense

D-deciduous, C-coniferous, M-Mixed

Location	GPS POINT	PHOTO NUMBER									CANOPY (D, C, M) (1-4)	CANOPY Yard (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50%	CANOPY Buffer (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50	UNDERSTORY (0.5m TO 5m) (D, C, M)	Woody Shrubs (0-4)	Tall Herbs, Grasses, Forbs (0-4)	GROUND COVER (<0.5m)	Woody Shrubs (0-4)	Herbs, Grasses, Forbs (0-4)	Bare Dirt/Barren (0-4)	SHORELINE SUBSTRATE	Gravel (0-4)	Sand (0-4)	Muck (0-4)	Organic (0-4)	SLOPE (1-4) Yard	Slope (0-4) Buffer	HUMAN INFLUENCE	Buildings	Docks	Walls/Riprap	Lawn to Shoreline	Beach Area	MITIGATION EFFORTS/NATURAL	Shoreline Restoration	Buffer Width (0=none, 1 = 1'-5', 2 = 5'-15', 3 = 15'-35', 4 = 35'<	Rating
43	43	68									m	2	2	m	2	0		2	1	1		1	2	1	0	0	2		1	1	1	0	0		0	3	3.5
44	44	69	70	11							m	3	1	0	0	0		0	0	0		0	4	0	0	1	0		1	1	1	0	1		0	0	-13.0
45	45	71	72	73							m	3	4	m	2	2		2	1	1		1	2	1	0	1	2		1	1	1	0	0		0	4	6.5
46	46	74	75	12							d	1	1	0	0	0		0	1	1		2	2	0	0	2	2		1	1	0	0	1		0	1	-10.0
47	47	76	77	13							m	2	2	m	2	1		0	1	1		2	2	0	0	1	2		1	1	1	0	0		0	3	0.0
48	48	78	14								c	3	1	c	1	0		1	1	0		2	2	0	0	1	1		1	1	1	0	0		0	2	-0.5
49	49	79	15								m	2	2	c	1	0		1	1	1		2	1	1	0	2	1		1	1	1	1	1		0	2	-10.5
50	50	80	16								m	2	1	0	0	0		2	2	0		1	1	1	1	1	1		1	1	1	0	0		0	2	0.5
51	51	81	17								d	1	1	0	0	0		1	1	0		2	1	1	0	3	2		1	1	1	0	0		0	1	-13.0
52	52	82	18								d	4	1	0	0	0		1	0	0		2	1	1	0	3	3		1	1	1	0	1		0	2	-12.0
53	53	83									m	1	1	c	1	0		1	1	0		2	1	1	0	3	2		1	1	1	0	0		0	2	-2.5
54	54	84	85	19							d	3	3	0	0	0		1	2	1		2	2	0	0	2	2		1	1	1	0	0		0	1	-6.0
55	55	86	87								d	3	3	d	1	1		3	1	0		2	2	0	0	3	2		1	1	1	0	0		1	4	4.5
56	56	88									m	2	2	m	1	1		2	1	1		2	2	0	0	3	2		1	1	1	0	0		0	4	1.5
57	57	89									m	2	2	m	1	1		2	1	1		2	2	0	0	3	2		1	1	1	0	0		0	4	1.5
58	58	90									m	4	3	m	1	1		2	1	1		2	2	0	0	3	2		1	1	1	0	0		0	4	3.0
59	59	91	20								m	4	2	0	0	0		1	1	2		2	2	0	0	3	2		1	1	1	0	0		0	2	-5.5
60	60	92									d	4	4	m	1	1		3	1	0		2	2	0	0	3	2		1	1	1	0	0		0	4	3.5
61	61	93	21								d	4	4	0	0	0		0	1	0		2	2	0	0	1	1		1	1	1	0	1		0	2	-2.5
62	62	94	21								m	4	2	0	0	0		0	1	0		2	2	0	0	1	1		1	1	1	1	1		0	0	-13.0
63	63	95	96								m	4	4	m	2	2		2	2	0		4	0	0	0	1	1		1	0	0	0	0		0	3	10.5

0-non existant, 1-4 density rating with 4 being the most dense

D-deciduous, C-coniferous, M-Mixed

Location	GPS POINT	PHOTO NUMBER									CANOPY (D, C, M) (1-4)	CANOPY Yard (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50%	CANOPY Buffer (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50	UNDERSTORY (0.5m TO 5m) (D, C, M)	Woody Shrubs (0-4)	Tall Herbs, Grasses, Forbs (0-4)	GROUND COVER (<0.5m)	Woody Shrubs (0-4)	Herbs, Grasses, Forbs (0-4)	Bare Dirt/Barren (0-4)	SHORELINE SUBSTRATE	Gravel (0-4)	Sand (0-4)	Muck (0-4)	Organic (0-4)	SLOPE (1-4) Yard	Slope (0-4) Buffer	HUMAN INFLUENCE	Buildings	Docks	Walls/Riprap	Lawn to Shoreline	Beach Area	MITIGATION EFFORTS/NATURAL	Shoreline Restoration	Buffer Width (0=none, 1 = 1'-5', 2 = 5'-15', 3 = 15'-35', 4 = 35'<	Rating
64	64	97	98	22							d	3	2	d	0	0		0	0	2		0	4	0	0	1	0		1	1	0	0	1		0	0	-13.5
65	65	99	100	23							m	2	3	m	0	0		1	0	1		0	4	0	0	1	2		1	1	0	0	1		0	0	-7.0
66	66	101	24								m	3	3	m	0	0		1	0	1		0	4	0	0	1	2		1	1	0	0	1		0	0	-8.0
67	67	102	25								m	1	1	0	0	0		1	1	0		1	1	1	1	0	1		1	1	1	0	0		0	0	-8.0
68	68	103	26								m	2	3	m	0	0		1	0	2		2	1	1	0	0	2		1	1	1	0	0		0	0	-10.5
69	69	104	105								m	4	3	d	1	0		1	1	0		2	1	1	0	1	1		1	1	1	0	0		0	1	-2.5
70	70	106	27								m	4	3	d	1	0		1	1	0		2	1	1	0	1	1		1	1	1	0	0		0	1	-2.5
71	71	107									m	4	3	d	1	0		1	1	2		2	2	0	0	1	2		1	0	1	0	0		0	2	-0.5
72	72	108	28								m	4	3	d	1	0		1	1	2		2	2	0	0	1	2		1	1	1	0	0		0	2	-1.5
73	73	109	29								m	4	3	m	1	0		1	1	2		2	2	0	0	1	2		1	1	1	0	0		0	2	-1.5
74	74	110	30	31	32	33					m	4	3	c	1	0		1	1	2		1	2	1	0	1	2		1	1	1	0	0		0	1	-2.5
75	75	111									m	4	3	d	1	0		1	1	1		1	2	1	0	0	2		1	1	1	0	0		0	1	-6.0
76	76	112									m	4	3	d	1	0		1	1	0		1	2	1	0	0	2		1	1	1	0	0		0	1	-2.5
77	77	113	34								m	4	4	d	1	0		1	1	0		1	2	1	0	1	1		1	1	1	0	0		0	1	-3.0
78	78	114	35								d	3	3	m	1	0		1	1	1		1	1	1	1	2	1		1	1	1	0	1		0	2	-5.0
79	79	115	36								m	3	3	m	1	0		1	1	1		1	1	1	1	2	1		1	1	1	0	1		0	2	-3.5
80	80	116	37								m	2	1	0	0	0		1	1	1		1	1	1	1	1	2		1	1	1	0	0		0	0	-13.0
81	81	117	38								m	2	1	0	0	0		1	1	1		1	1	1	1	1	2		1	1	1	0	0		0	1	-10.5
82	82	118	39								m	2	1	0	0	0		1	1	1		1	1	1	1	2	2		1	1	1	0	0		0	1	-11.5
83	83	119	40								d	3	2	0	0	0		2	1	0		4	0	0	0	1	2		1	1	1	0	0		0	2	-0.5
84	84	120	41								d	4	3	0	0	0		1	1	2		4	0	0	0	1	2		1	1	1	0	0		0	2	-2.5

0-non existant, 1-4 density rating with 4 being the most dense

D-deciduous, C-coniferous, M-Mixed

Location	GPS POINT	PHOTO NUMBER									CANOPY (D, C, M) (1-4)	CANOPY Yard (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50%	CANOPY Buffer (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50	UNDERSTORY (0.5m TO 5m) (D, C, M)	Woody Shrubs (0-4)	Tall Herbs, Grasses, Forbs (0-4)	GROUND COVER (<0.5m)	Woody Shrubs (0-4)	Herbs, Grasses, Forbs (0-4)	Bare Dirt/Barren (0-4)	SHORELINE SUBSTRATE	Gravel (0-4)	Sand (0-4)	Muck (0-4)	Organic (0-4)	SLOPE (1-4) Yard	Slope (0-4) Buffer	HUMAN INFLUENCE	Buildings	Docks	Walls/Riprap	Lawn to Shoreline	Beach Area	MITIGATION EFFORTS/NATURAL	Shoreline Restoration	Buffer Width (0=none, 1 = 1'-5', 2 = 5'-15', 3 = 15'-35', 4 = 35'<	Rating
85	85	121	122	123	42	43	44				d	4	3	0	0	0		1	1	2		1	2	1	0	2	2		1	1	1	0	1		0	1	-12.5
86	86	124	125	126							m	4	4	m	2	2		2	2	0		1	1	1	1	0	2		0	0	0	0	0		0	4	14.0
87	87	127									m	3	4	m	2	2		2	2	0		1	1	1	1	2	2		1	1	1	0	0		0	3	5.5
88	88	128	129	130	131	132					0	0	0	m	2	0		1	2	1		1	1	1	1	0	1		0	0	0	0	1		0	3	3.5
89	89	134									m	4	4	m	2	2		1	2	1		1	1	1	1	0	0		0	0	0	0	0		0	4	14.0
90	90	133	135								d	1	0	0	0	0		0	3	0		0	1	2	1	0	1		1	1	1	1	1		0	0	-12.5
91	91	136	137	138	139	140	141	142	143		m	4	4	m	2	2		2	2	0		0	1	2	1	0	1		0	0	0	0	0		0	4	15.0
92	92	144	145								m	4	2	m	2	1		2	2	0		2	1	1	0	0	0		0	0	0	0	0		0	4	14.0
93	93	146	147								m	4	3	m	2	1		1	3	0		1	0	2	1	0	0		1	0	0	0	0		0	4	13.5
94	94	148	149								m	3	4	m	2	2		1	3	0		2	2	0	0	1	1		1	1	0	0	0		0	3	10.0
95	95	150	45	69							d	0	1	d	1	0		0	1	0		1	1	1	1	1	1		0	0	0	1	0		0	0	-10.5
96	96	151	152	153							d	3	2	d	1	0		1	3	0		1	2	1	0	0	1		1	1	0	0	0		0	3	5.5
97	97	154	155								d	2	2	d	1	0		1	3	0		1	2	1	0	0	1		1	1	0	0	0		0	3	5.0
98	98	156	157	158	159						m	2	4	0	0	0		1	1	0		0	0	2	2	2	1		1	1	0	1	0		0	4	-0.5
99	99	160									m	4	4	m	2	2		1	3	0		1	1	1	1	0	1		1	1	0	0	0		0	4	12.5
100	100	161	162	163							m	4	4	m	2	2		1	2	1		1	2	1	0	0	1		0	1	0	0	1		0	4	9.5
101	101	164									m	4	4	m	2	2		1	2	1		2	1	1	0	0	0		0	0	0	0	0		0	4	14.0
102	102	165	166								m	4	2	m	0	2		0	2	2		1	2	1	0	1	1		0	0	0	0	1		0	4	4.0
103	103	167	168								m	4	4	m	2	2		2	2	0		0	0	2	2	0	0		1	1	0	0	0		0	4	14.0
104	104	169									m	3	4	m	1	1		2	2	0		0	0	2	2	0	0		1	1	0	0	0		0	3	10.5
105	105	170	171	172	173						m	2	2	m	2	2		1	1	2		1	2	1	0	1	1		1	1	0	0	1		0	4	0.0

0-non existant, 1-4 density rating with 4 being the most dense

D-deciduous, C-coniferous, M-Mixed

Location	GPS POINT	PHOTO NUMBER								CANOPY (D, C, M) (1-4)	CANOPY Yard (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50%	CANOPY Buffer (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50	UNDERSTORY (0.5m TO 5m) (D, C, M)	Woody Shrubs (0-4)	Tall Herbs, Grasses, Forbs (0-4)	GROUND COVER (<0.5m)	Woody Shrubs (0-4)	Herbs, Grasses, Forbs (0-4)	Bare Dirt/Barren (0-4)	SHORELINE SUBSTRATE	Gravel (0-4)	Sand (0-4)	Muck (0-4)	Organic (0-4)	SLOPE (1-4) Yard	Slope (0-4) Buffer	HUMAN INFLUENCE	Buildings	Docks	Walls/Riprap	Lawn to Shoreline	Beach Area	MITIGATION EFFORTS/NATURAL	Shoreline Restoration	Buffer Width (0=none, 1 = 1'-5', 2 = 5'-15', 3 = 15'-35', 4 = 35'<	Rating
106	106	174								m	2	2	d	1	0		0	1	2		0	2	1	1	2	1		1	1	1	0	1		0	1	-6.5
107	107	175	176	177						m	2	1	d	2	1		1	2	1		1	1	1	1	2	1		1	1	0	0	1		0	4	2.5
108	108	178								m	3	4	0	0	0		1	2	1		1	2	1	0	1	0		1	1	0	0	1		0	3	2.0
109	109	179	180	181	182	183	184	185		m	4	1	d	2	2		1	2	0		0	0	2	2	0	0		0	0	0	0	0		0	4	13.5
110	110	186								m	4	4	m	2	2		2	2	0		0	1	1	2	2	1		1	1	0	0	1		0	4	8.0
111	111	187								m	1	0	0	0	0		1	0	0		0	1	2	1	2	1		1	1	1	1	1		0	0	-16.5
112	112	188	189	190						m	4	4	m	2	2		1	2	1		2	1	1	0	1	0		1	1	0	0	0		0	4	10.0
113	113	191	192	193	194					m	4	4	m	2	0		1	2	1		1	2	1	0	0	1		1	0	0	0	1		0	4	7.0
114	114	195	196	197						m	3	3	m	2	0		2	1	1		3	1	0	0	1	1		1	1	0	0	0		0	4	6.0
115	115	198	46							m	2	1	0	0	0		1	1	2		2	2	0	0	1	0		1	1	1	0	1		0	0	-13.5
116	116	199	200							m	4	4	m	1	0		1	2	1		2	1	1	0	1	0		1	1	1	0	1		0	3	3.0
117	117	201								m	3	4	m	2	0		1	2	1		1	1	1	1	1	1		1	1	0	0	0		0	3	5.5
118	118	202	203	204						m	4	4	m	2	1		2	2	0		1	1	1	1	1	1		1	1	0	0	1		0	4	9.0
119	119	205	206	47						m	2	2	0	0	0		0	1	2		1	2	1	0	1	1		1	1	1	0	1		0	1	-11.5
120	120	207								m	2	3	m	2	0		1	1	1		2	2	0	0	0	2		1	1	0	0	0		0	3	0.5
121	121	208	209	210	48					m	1	3	m	1	0		1	1	2		2	1	1	0	0	3		1	1	1	0	1		0	2	-6.5
122	122	211	212							m	3	2	m	2	0		1	2	1		1	2	1	0	0	1		1	1	0	0	1		0	2	1.5
123	123	213	214							m	4	4	m	2	0		2	2	0		4	0	0	0	1	0		0	0	0	0	0		0	4	13.0
124	124	215	216	217	218	219				m	4	4	m	1	1		1	1	1		1	1	1	1	2	1		1	1	0	0	1		0	3	1.0
125	125	220	221	222	63	64	65	66		m	2	2	c	1	0		2	2	0		2	2	0	0	1	1		1	1	1	0	1		0	2	0.5
126	126	223	224							m	4	3	d	2	0		1	1	0		3	1	0	0	1	2		1	1	1	0	0		0	3	3.0

0-non existant, 1-4 density rating with 4 being the most dense

D-deciduous, C-coniferous, M-Mixed

1-1%-25% 3-51%-75%
2-26%-50% 4-76%-100%

Location	GPS POINT	PHOTO NUMBER									CANOPY (D, C, M) (1-4)	CANOPY Yard (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50%	CANOPY Buffer (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50	UNDERSTORY (0.5m TO 5m) (D, C, M)	Woody Shrubs (0-4)	Tall Herbs, Grasses, Forbs (0-4)	GROUND COVER (<0.5m)	Woody Shrubs (0-4)	Herbs, Grasses, Forbs (0-4)	Bare Dirt/Barren (0-4)	SHORELINE SUBSTRATE	Gravel (0-4)	Sand (0-4)	Muck (0-4)	Organic (0-4)	SLOPE (1-4) Yard	Slope (0-4) Buffer	HUMAN INFLUENCE	Buildings	Docks	Walls/Riprap	Lawn to Shoreline	Beach Area	MITIGATION EFFORTS/NATURAL	Shoreline Restoration	Buffer Width (0=none, 1 = 1'-5', 2 = 5'-15', 3 = 15'-35', 4 = 35'<	Rating
127	127	225	226	227	49						m	2	0	0	0	0		0	0	0		3	1	0	0	0	1		1	1	1	0	0		0	0	-13.0
128	128	228	229	230							m	2	2	d	1	0		1	1	0		3	1	0	0	0	2		1	1	1	0	0		0	2	1.5
129	129	231	232	233	50						m	3	3	m	1	0		1	0	0		2	2	0	0	3	1		1	1	1	0	1		0	4	-4.0
130	130	234	235								m	4	4	m	2	1		1	1	0		3	1	0	0	2	1		1	1	1	0	0		0	4	5.5
131	131	236	237	238	239						m	4	4	m	2	1		1	1	0		3	1	0	0	2	1		1	1	1	0	0		0	4	6.0
132	132	240	241	242	243	244					m	4	4	m	2	1		1	1	0		3	1	0	0	2	1		1	1	1	0	0		0	4	6.0
133	133	245	246	247							m	4	4	m	2	1		1	1	0		3	1	0	0	2	1		1	1	0	0	0		0	4	8.0
134	134	248	249								m	4	4	m	2	1		1	1	0		3	1	0	0	2	1		1	1	0	0	0		0	4	8.0
135	135	250	251								m	4	4	m	2	1		1	1	0		3	1	0	0	2	1		1	1	1	0	0		0	4	6.5
136	136	252	253	254	255	256	257				m	4	4	m	2	1		1	1	0		3	1	0	0	3	1		1	1	1	0	0		0	4	5.5
137	137	258	259	260	261	51					m	4	4	m	2	1		1	1	1		3	1	0	0	3	2		1	1	1	0	0		0	4	2.0
138	138	262	263								m	3	3	m	1	0		1	1	2		3	1	0	0	3	2		1	1	1	0	0		0	4	-2.0
139	139	264	265	266							m	3	3	m	1	0		1	1	2		3	1	0	0	4	2		1	1	1	0	0		0	4	-4.0
140	140	267	268								m	3	3	m	1	0		2	2	0		3	1	0	0	1	2		1	1	1	0	0		0	3	3.0
141	141	269	270								m	3	3	m	1	0		2	2	0		3	1	0	0	1	3		1	1	1	0	0		0	4	4.0
142	142	271	272	52							m	1	0	d	1	0		2	2	0		3	1	0	0	2	3		1	1	1	0	0		1	3	-2.0
143	143	273	274								m	4	4	m	2	1		1	1	0		3	1	0	0	3	1		1	1	1	0	0		0	4	5.5
144	144	275	276	277							m	4	2	m	3	1		2	1	1		1	3	0	0	2	1		1	1	1	0	1		0	4	4.0
145	145	278	279								m	4	3	m	2	1		1	1	1		3	1	0	0	2	1		1	1	1	0	1		0	4	2.0
146	146	280	281	282							m	3	3	m	1	0		2	1	0		2	2	0	0	3	3		1	1	1	0	0		0	4	1.0
147	147	283	284								m	3	3	m	1	0		1	1	2		3	1	0	0	4	2		1	1	1	0	0		0	4	-4.0

0-non existant, 1-4 density rating with 4 being the most dense

D-deciduous, C-coniferous, M-Mixed

Location	GPS POINT	PHOTO NUMBER									CANOPY (D, C, M) (1-4)	CANOPY Yard (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50%	CANOPY Buffer (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50	UNDERSTORY (0.5m TO 5m) (D, C, M)	Woody Shrubs (0-4)	Tall Herbs, Grasses, Forbs (0-4)	GROUND COVER (<0.5m)	Woody Shrubs (0-4)	Herbs, Grasses, Forbs (0-4)	Bare Dirt/Barren (0-4)	SHORELINE SUBSTRATE	Gravel (0-4)	Sand (0-4)	Muck (0-4)	Organic (0-4)	SLOPE (1-4) Yard	Slope (0-4) Buffer	HUMAN INFLUENCE	Buildings	Docks	Walls/Riprap	Lawn to Shoreline	Beach Area	MITIGATION EFFORTS/NATURAL	Shoreline Restoration	Buffer Width (0=none, 1 = 1'-5', 2 = 5'-15', 3 = 15'-35', 4 = 35'<	Rating
148	148	285	53								m	2	1	c	1	0		0	1	0		3	1	0	0	2	1		1	0	1	0	0		0	0	-11.5
149	149	286	287	288	54						m	3	1	0	0	0		1	1	2		1	2	1	0	2	2		1	1	1	0	0		1	4	-4.0
150	150	289	290								m	4	3	m	2	1		1	2	1		3	1	0	0	3	1		0	1	0	0	0		0	4	7.5
151	151	291	292	293	294	295					d	1	1	d	1	1		2	2	0		0	1	2	1	2	2		0	0	0	0	0		0	3	6.0
152	152	297	298	299	300	301	302	303			m	4	4	m	2	2		2	2	0		0	0	2	2	3	2		0	1	0	0	0		0	4	10.0
153	153	304	305	306							m	4	4	m	2	2		2	2	0		3	0	1	0	3	2		0	1	0	0	0		0	4	9.5
154	154	307	308	309	310	311					m	4	4	m	2	2		2	2	0		3	0	1	0	3	3		0	0	0	0	0		0	4	10.0
155	155	312	313	314							m	4	4	m	2	2		2	2	0		3	0	1	0	1	3		0	0	0	0	0		0	4	11.5
156	156	315	316	317	318	319					m	4	4	m	2	2		2	2	0		1	1	1	1	2	1		1	1	1	0	1		0	4	8.5
157	157	320	321	322							m	4	4	m	2	2		2	2	0		2	1	1	0	1	2		0	1	0	0	0		0	4	11.5
158	158	323	324	325							m	4	4	m	2	2		2	2	0		2	1	1	0	2	2		0	1	0	0	0		0	4	11.0
159	159	326	327	328							m	4	4	m	2	2		2	2	0		2	1	1	0	3	2		0	1	0	0	0		0	4	10.0
160	160	329	330	331	332	333	334				m	4	4	m	2	2		2	2	0		2	1	1	0	3	3		0	1	0	0	0		0	4	8.5
161	161	335	336								m	4	4	m	2	2		2	2	0		2	1	1	0	3	3		0	1	0	0	0		0	4	8.5
162	162	337	338								m	4	4	m	2	2		2	2	0		2	1	1	0	3	3		0	1	0	0	0		0	4	8.5
163	163	339	340								m	4	4	m	2	2		2	2	0		2	1	1	0	3	3		0	1	0	0	0		0	4	8.5
164	164	341	342								m	4	4	m	2	2		2	2	0		2	1	1	0	3	3		0	1	0	0	0		0	4	8.5
165	165	343	344	345	346						m	4	4	m	2	2		2	2	0		2	1	1	0	3	3		0	1	0	0	0		0	4	8.5
166	166	347	348	349	350	351					m	4	4	m	1	0		2	2	0		3	1	0	0	3	2		1	1	1	0	0		0	4	4.5
167	167	352	353	354							m	4	4	m	1	0		2	2	0		2	2	0	0	3	2		1	1	0	0	0		0	4	5.5
168	168	355	356	357							m	4	4	m	1	0		1	3	0		2	2	0	0	2	1		1	1	0	0	1		0	4	6.5

0-non existant, 1-4 density rating with 4 being the most dense

D-deciduous, C-coniferous, M-Mixed

Location	GPS POINT	PHOTO NUMBER									CANOPY (D, C, M) (1-4)	CANOPY Yard (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50%	CANOPY Buffer (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50'	UNDERSTORY (0.5m TO 5m) (D, C, M)	Woody Shrubs (0-4)	Tall Herbs, Grasses, Forbs (0-4)	GROUND COVER (<0.5m)	Woody Shrubs (0-4)	Herbs, Grasses, Forbs (0-4)	Bare Dirt/Barren (0-4)	SHORELINE SUBSTRATE	Gravel (0-4)	Sand (0-4)	Muck (0-4)	Organic (0-4)	SLOPE (1-4) Yard	Slope (0-4) Buffer	HUMAN INFLUENCE	Buildings	Docks	Walls/Riprap	Lawn to Shoreline	Beach Area	MITIGATION EFFORTS/NATURAL	Shoreline Restoration	Buffer Width (0=none, 1 = 1'-5', 2 = 5'-15', 3 = 15'-35', 4 = 35'<	Rating
169	169	358	359	360							m	4	4	m	1	0		1	3	0		2	2	0	0	2	1		1	1	0	0	1		0	4	6.5
170	170	361	362	363	364	70	71				m	4	4	m	1	0		1	3	0		2	2	0	0	3	1		1	1	0	0	1		0	4	5.5
171	171	365	366	367							m	4	2	m	2	0		1	2	1		1	2	1	0	1	1		1	1	0	1	1		0	3	-2.5
172	172	368	369	370	371						d	4	4	m	2	0		1	2	1		1	1	1	1	0	1		1	1	1	0	0		0	4	4.5
173	173	372	373	374	375	376					d	4	4	d	2	0		2	2	0		1	1	1	1	0	1		1	1	0	0	0		0	4	10.5
174	174	377	378	379							d	4	4	d	2	0		2	2	0		1	1	1	1	0	2		1	1	0	0	0		0	4	9.5
175	175	380	381								d	4	4	d	2	0		2	2	0		1	1	1	1	0	2		1	1	0	0	0		0	4	9.5
176	176	382	383	384							d	4	4	d	2	0		2	2	0		2	1	1	0	0	2		1	1	0	0	0		0	4	9.5
177	177	385	386	387	388						d	4	4	m	2	0		2	2	0		2	1	1	0	0	2		1	1	0	0	0		0	4	9.5
178	178	389	390	391	392	393					m	4	4	m	2	0		2	2	0		1	1	1	1	0	0		1	1	0	0	0		0	4	11.5
179	179	394	395	396	397						m	4	4	m	2	0		2	2	0		2	1	1	0	0	2		1	1	0	0	0		0	4	9.5
180	180	398	399	400	401						m	4	4	m	2	0		2	2	0		0	0	2	2	0	0		1	1	1	0	0		0	4	9.0
181	181	402	403	404	405	406					m	4	4	m	2	0		2	2	0		2	1	1	0	2	2		1	1	0	0	0		0	4	7.5
182	182	407	408	409							m	4	4	m	2	0		2	2	0		2	1	1	0	2	2		1	0	0	0	0		0	4	8.5
183	183	410	411	412							m	4	4	m	2	0		2	2	0		0	0	2	2	0	0		1	1	1	0	0		0	4	10.0
184	184	413	414	415	68						m	4	4	m	1	0		2	2	0		2	2	0	0	0	0		1	1	0	1	0		0	4	5.0
185	185	416	417	418							m	4	4	m	1	0		1	1	1		2	2	0	0	0	2		1	1	0	0	0		0	4	-0.5
186	186	419	420								m	4	4	m	1	0		2	2	0		2	2	0	0	0	0		1	1	0	1	0		0	3	4.0
187	187	421	422	423							m	4	4	m	2	0		1	3	0		1	1	1	1	1	0		1	1	0	0	0		0	4	10.5
188	188	424	425								m	4	4	m	2	0		1	1	0		0	0	2	2	1	0		1	1	0	0	0		0	4	8.5
189	189	426	427								m	4	4	m	1	0		1	1	2		1	1	1	1	2	1		1	1	0	0	1		0	4	2.5

0-non existant, 1-4 density rating with 4 being the most dense

D-deciduous, C-coniferous, M-Mixed

Location	GPS POINT	PHOTO NUMBER									CANOPY (D, C, M) (1-4)	CANOPY Yard (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50%	CANOPY Buffer (0=none, 1 = 1%-10%, 2 = 11%-25%, 3 = 26%-50%, 4 = 50	UNDERSTORY (0.5m TO 5m) (D, C, M)	Woody Shrubs (0-4)	Tall Herbs, Grasses, Forbs (0-4)	GROUND COVER (<0.5m)	Woody Shrubs (0-4)	Herbs, Grasses, Forbs (0-4)	Bare Dirt/Barren (0-4)	SHORELINE SUBSTRATE	Gravel (0-4)	Sand (0-4)	Muck (0-4)	Organic (0-4)	SLOPE (1-4) Yard	Slope (0-4) Buffer	HUMAN INFLUENCE	Buildings	Docks	Walls/Riprap	Lawn to Shoreline	Beach Area	MITIGATION EFFORTS/NATURAL	Shoreline Restoration	Buffer Width (0=none, 1 = 1'-5', 2 = 5'-15', 3 = 15'-35', 4 = 35'<	Rating
190	190	428	429	430	431	432	433				m	4	3	m	2	0		2	2	0		0	0	2	2	1	1		1	1	1	0	1		0	3	4.0
191	191	434	435	436	437	438	439				m	4	4	m	2	0		2	2	0		1	1	1	1	0	0		0	0	0	0	0		0	4	14.0
192	192	440	441	442							m	4	4	m	2	0		2	2	0		1	1	1	1	3	1		1	1	0	0	0		0	4	7.5
193	193	443	444	445	446						m	4	4	m	2	0		2	1	1		1	1	1	1	2	1		1	1	0	0	0		0	4	5.5
194	194	447	448	449	450						m	4	4	m	2	0		2	2	0		1	1	1	1	2	1		1	1	0	0	0		0	4	8.5
195	195	451	452	453							m	4	4	m	2	0		2	1	1		0	0	2	2	1	0		1	1	0	0	0		0	4	7.5
196	196	454	455	456	457	458	459				m	4	4	m	2	0		2	2	0		1	1	1	1	0	0		0	0	0	0	0		0	4	14.0
197	197	296									d	0	0	d	1	1		1	1	2		0	3	1	0	2	2		0	0	0	0	1		0	2	-10.5

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