DESAIR LAKE RESTORATION, INC.
LAKE MANAGEMENT REPORT OF ACTIVITIES
AUGUST 2003 – MAY 2006

Prepared for:

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FOREWARD

It's in the Water

Rod Olson
President, Desair Lake Restoration, Inc.

Haugen Hills near Rice Lake, Wisconsin was created when the last great ice sheet stopped pushing glacial till into massive windrows. At the base of a six square mile watershed within these hills, a depression filled with melt water. Later it would be called Desair Lake. The melt water ran swiftly until the glacier receded and left its watershed baron. The gravel lake bottom was washed clean of its silt and crystal clear ice water took the next thousand years to warm.

First there were tundra plants, then boreal forests and by the time Christ was born, the hills were densely covered with 100-foot white pines. Wind created hushed music in the canopy and wildlife flourished along the lakeshore. The lake became home to fish, beaver, otter and migrating ducks. Life found a balance, one generation replaced another, death for one creature meant life for another.

Native American hunting parties, following well-worn trails, must have stopped along the north shore's gravel point. They likely speared fish in the spring or maybe camped to roast a rabbit as the evening sunset colored the still waters.

French fur trappers appeared in the 1700's to take the beaver in trade for European goods. For the first time in all these ages, some small thing was taken from this land and not returned.

By 1870, taking from the land began in a big way. The Knapp Stout Lumber Co. obtained the land from the US Government. The sound of the crosscut saws echoed through the woods as hearty immigrants were hired to feed the hungry sawmill in Rice Lake. The largest flow of sediment followed the clearcutting of the forest. The thick layer of humus on the forest floor was exposed to the rain and washed to the lake. In the years to follow, as the stumps were cleared and the soil turned by the plow, prescious soil moved off the fields and into the waterways.

Nelson Desair and his family, from whom the lake received its name, was the first settler in 1880. He bought 160 acres of cutover land east of the lake and built a farm.

By 1930, all the logs from the watershed were "taken away" and replaced by several small dairy farms. Hard working farm families raised crops on the fertile soil. Cattle drank from the streams and lakeshore, cooling themselves on hot summer days. Desair Lake, called French Lake or Little Bear Lake by locals, was a source of entertainment for the farm kids. It was a secluded swimming hole for some, great ice fishing in winter for others and for many, a quiet retreat in a wooden boat on a Sunday afternoon in July. Everyone remarked how clear the water was, "you could see down 20 feet!" Old timers are convinced there was no better place to catch sunfish.

The whole watershed for Desair is sloping hills, once water gets going it moves fast. By the time it reaches the lake, spring runoff and summer storms carry soils from the fields and manure from the feedlots. One farmer dumped his winter manure in piles on the lake, "to feed the fish". Without the deep humus of a forest, nothing slowed the water as it cut into stream banks and roared into the lake. Desair was the catchment basin and, "**the muck stops here**!"

In the 1960's the soil had played out, fertilizer becomes commonly used. No one knew the soil was naturally rich in phosphorous so more was added and it moved with erosion to the lake with every storm. A cheese factory operated from the 1920's to the 1970's dumped its whey in a ravine. Fishermen often noted foam floating on the lake. We, as consumers, came to fish, to play, to use. In return, our lifestyle left the lake choked with silt and sewage.

The clear water absorbed all it could, but eventually it became so fertile with phosphorous and nitrogen that algae began to grow. By the late 1980's, as lake homes started to appear along the shores, algae blooms became common. When the lake wasn't pea green in the summer, it was brown with slit after a storm. Seeing deep into the water has since been, "out of the question".

Deep winter ice and snow cover combined with decaying algae to consume oxygen dissolved in the water. In 1996 and again in 1997 this lack of oxygen caused "winter kill", destroying thousands of fish. When the ice came off in the spring rotting fish washed up to shore in floating masses.

Lake owners became concerned and in 1992 an association was formed to address the issues. A tiny group of neighbors looked for ways to stem the destruction. We all agreed that, in spite of our behavior, the lake remained beautiful. Nestled among high rolling hills, now regrown into woods, the little 80-acre lake remains quiet and wilderness-like in comparison to our noisy hectic lives. We yearn for moments when we can take time to lay in the sun along its banks or fish on its glass-like surface. Seasons come and go dressing the lake and its banks in changing vivid colors and reflections. It is our healing salve in a harsh world. For the first time someone asked, "What can we give the lake so it can heal?" It was time to give back after a century of just taking.

A hundred years of abuse will take many years of effort to reverse. Desair Lake Restoration, Inc. (DLR) is the small band of local individuals who have set this effort into motion. The group first needed to learn about the biology and ecology of our watershed. We began with little changes:

- A Slow-No Wake rule was brought to and passed by the Town Board. Boats traveling less than 15mph will lessen wildlife disturbance and keep the lake quiet. Slower boats do not stir up the muck as much as jet skis and powerboats.
- Appealed to the County Board to expand future lot sizes from 100ft to 250ft just for our lake. Open corridors to the lake are now restricted to 30ft keeping the remainder of the shore in a wild state.
- Encouraging all lakeshore residents to let the shoreline grow natural to improve the filtering of runoff.
- Cleaning up waste dumps in ravines leading to the lake.
- Sealing off three open wells in the watershed.
- Removing cattle from a feedlot next to the lake.
- Joining the State's Self-help Lake Monitoring Program to track our lake's clarity, phosphorous, chlorophyll and oxygen levels.
- After the fish kill, we obtained permission to build and run an aerator that we pay for. It has been in operation since 1998.
- Reforesting three fields along the lakeshore.
- Monitoring home building to minimize site erosion.
- Raising funds by selling Christmas trees and putting on a Kinship Fishing Derby.

Social trends have helped the lake in some ways as the family farms started to disappear from the watershed. All three of the lakeside farms are now gone. Only five dairy operations or cattle feedlots remain where there were thirteen in 1980. Acres of highly erodable land have been placed in crop reserve. Nearly every waterway is now free of cattle access where there was a time when they all were used for pasture. The present owners and the type of people buying lots on this small lake tend to want to promote a more natural environment.

With tremendous help from the Barron County Land Conservation Department and the Department of Natural Resources, (DNR), money and expertise were put to work to begin addressing the problem of erosion.

A $150,000 grant awarded from the Wisconsin Department of Natural Resources was used for targeted runoff management. Through cost sharing with landowners, two large sediment basins were constructed on the watershed. A series of rock gabion dams were designed and installed in a steep ravine. A rock waterway was placed in a wooded washout gully. Feedlot and grass waterway management programs for local farmers were designed and funded. A major push to encourage no-till farming (in the watershed) has been ongoing with future funding support on the way.

What is there to do now? The Lake Management Planning Grant, also a cost share with DLR, has completed a study you are about to read. We look to this report for recommendations.

Desair Lake Restoration has plenty to do: We have constant monitoring of water quality, destructive construction on the watershed, and the watch for exotic invasive species. Farmers will work to keep the nutrients on the fields where they want them. Poorer fields for farming will continue to grow back to forest. And in this process we gather for picnics and fundraisers, to talk and plan, to walk the trails and meet on the lake in our boats. It is this joining together that adds meaning and joy to our work.

When the sediment slows to near presettlement levels, we may then dream of clear water again.

Thank you to the hard working people from the Barron County Conservation Department, Wisconsin DNR, US Geological Service, and Cedar Corporation for completing this study of Desair Lake.

Rod Olson, MD
President, Desair Lake Restoration, Inc.
March 20, 2006

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CHAPTER 1: INTRODUCTION

Desair Lake is an 81 acre stratified seepage lake with a 4100 acre sub watershed located in the Bear Creek sub watershed, in the southwest corner of the Brill River watershed (labeled LC10) of the Red Cedar River Basin. Located in the Town of Rice Lake in Barron County, Desair Lake is less than 5 miles from the City of Rice Lake. The landscape is characterized by steep slopes and drainage swales that rapidly convey storm water runoff to Desair Lake after a rain event. In 1964, the land use within this sub-watershed was reported to be 75% agricultural. The lake has experienced significant changes in water quality in the past century. The changes representative of water quality degradation include: diminishing water clarity, fish kills, sediment accumulation, and increased algae bloom. In 1997, the degradation of water quality in Desair Lake (designated as WI2104500_106) was so great that it was the only Lake in Northwest Wisconsin to be categorized by EPA as a 303d Impaired Water. The presence of low dissolved oxygen, phosphorus, and other nutrients defines the 303d category. Desair Lake is now one of three lakes in Barron County with this designation.

Residents of the lake continued to express their concerns of the water quality in the Lake and organized Desair Lake Restoration, Inc to further their concerns and develop ways and means to implement lake water quality restoration. To evaluate the problem, the lake and surrounding watershed has been the subject of several studies and restorative efforts.

The four main components of this planning grant completed during this phase of the project include:

- delineating the watershed and sub watersheds;
- a sediment core recovery and analysis performed by the WDNR;
- tributary, groundwater, and water quality analysis by the USGS; and
- the distribution and completion of a sociological survey to residents throughout the watershed.

This report documents these efforts and brings together documentation of ongoing restoration efforts as well as past studies.

This planning grant project has reviewed existing documents such as land use maps, zoning maps, aerial imagery, topographic maps, and soil surveys. These documents were used to delineate the watersheds and categorize land use as well as make other evaluations and recommendations regarding the entire watershed. Field reconnaissance was also conducted as a way to verify the accuracy of some of the collected data as well as truth the delineation of the watersheds.

<u>Grant Activities</u>

The Desair Lake In-Lake Study grant application defined the following tasks for various responsible parties:

Cedar Corporation:

- Watershed and Sub-watershed Delineations
- Land Use Mapping
- Community Survey (with Association assistance)
- Water Quantity and Water Quality Modeling (not completed – see below)
- Report Compilation and Presentation

USGS:

- Install and Monitor Tributary Garages
- Install and Monitor Groundwater Monitoring Points
- Install and Monitor a Lake Stage Gage
- Conduct In-lake Water Quality Data Collection
- Publish and Distribute Results

Wisconsin DNR:

- In lieu of Water Quantity and Water Quality Modeling, conduct a Lake Sediment Core Sample Collection and Analysis

Desair Lake Restoration, Inc.

- Communicate, Distribute, and Educate Watershed Residents and Visitors of the Project and its Results
- Continue to monitor lake quality as they have been since 1992
- Raise funds for 30% of the cost sharing of restorative projects from Lake Protection Grants

Barron County considers Desair Lake to be a Class 3 lake having reasonably restrictive development standards that will minimize future water quality impacts. Development restrictions on Class 3 lakes in Barron County are (Table 1):

Minimum Lot Size:	80,000 square feet
Minimum Lake Frontage:	250 feet
Building Setback from Lake:	at least 100 feet
Shoreland Buffer Zone:	75 feet from ordinary high water mark
Allowed viewing corridor width:	30 feet

Results have been communicated throughout this project through presentations, reports and press releases. A final presentation of this project was made at the Desair Lake Restoration, Inc. meeting in May, 2006.

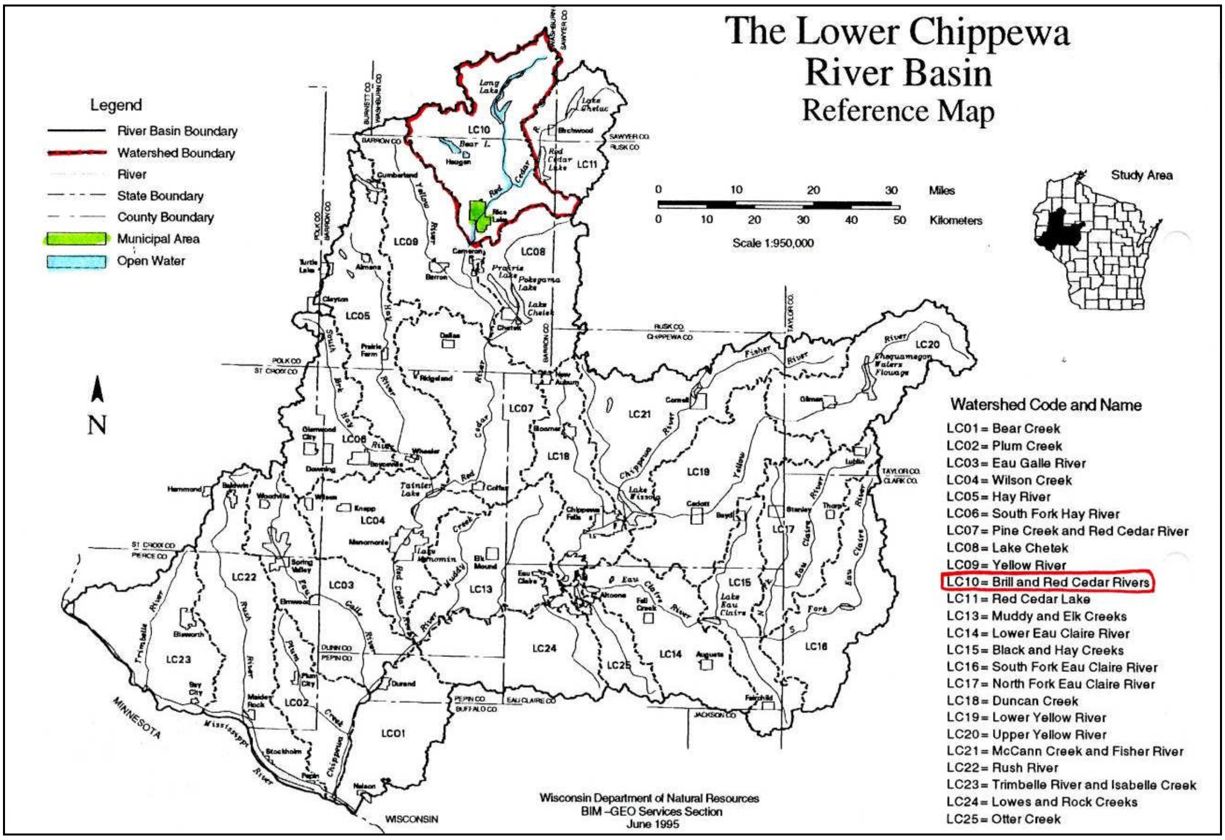
This report presents the cumulative efforts of the Desair Lake Restoration, Inc., Barron County Land and Conservation Department, Cedar Corporation, Wisconsin DNR, and the US Geologic

Survey all completed with the financial assistance of the Association and Wisconsin DNR grant LPL-913-04.

CHAPTER 2: DELINEATION OF WATERSHED AREAS

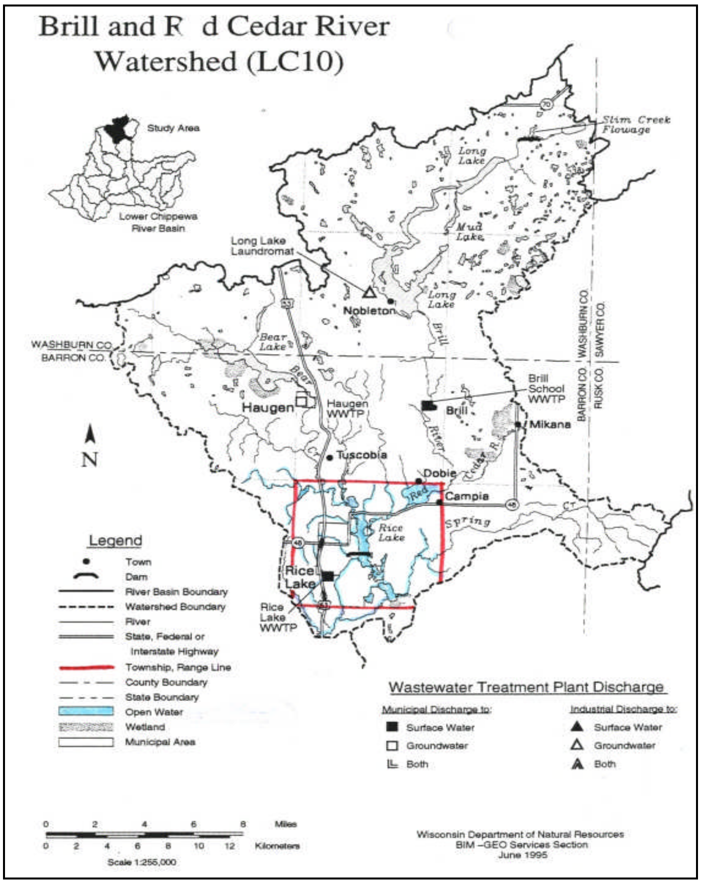
Desair Lake is located in Section 6, Township 35 North, Range 11 West of the Town of Rice Lake. Topographically, the Desair Lake 4,100 acre sub watershed is located in the the Bear Creek watershed which in turn is in the southwest corner of the Brill River watershed of the Red Cedar River Basin, designated LC10 of the Lower Chippewa River Basin (Figures 2-1, 2-2).

Figure 2-1.



Sub watershed delineation is important to define natural runoff water travel direction. This knowledge provides the basis for determining runoff water quantity; runoff water quality; sources and flow direction, sediment, nutrients and other pollutants; identifying problem areas; and, potential runoff water quality improvement restoration sites. With the watershed defined into its tributary sub-watersheds, soil types, soil permeability, and current and future land use activities can be incorporated into an overall model to determine water quantity and water quality.

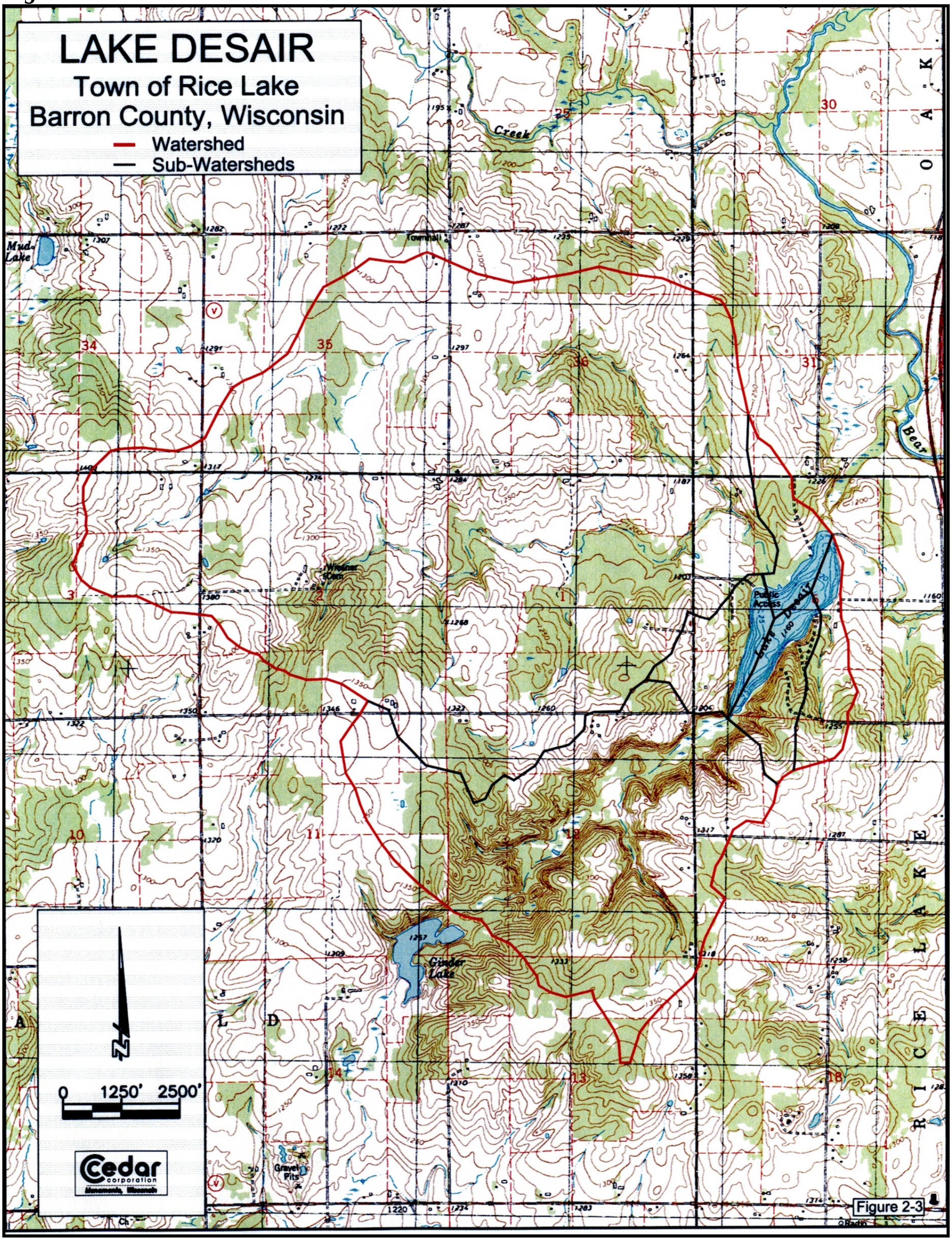
Figure 2-2



<u>Watersheds</u>

The 4,100 acre watershed delineated in Figure 2-3 is based on a USGS topographic map with 10 foot contours. The 10 foot contours were interpolated to a 2 foot contour interval. This means that features smaller that this in the landscape are not defined, and the modeling is based on assumed contours, providing generalized results. These results are intended to provide an overall view of the watershed and not necessarily site specifications. Recent efforts by the Barron County Land and Conservation Department include digital topographic mapping to define one foot contours which can be used to improve the accuracy of this mapping, when the data is available.

Figure 2-3.


LAKE DESAIR
Town of Rice Lake
Barron County, Wisconsin
Watershed
Sub-Watersheds
0 1250' 2500'
Cedar corporation
Figure 2-3

Sub Watersheds

The sub watersheds (Figure 2-4) were for the most part delineated by using ridge tops, valley bottoms, and roads as boundaries. On site visual observations of storm water culverts, location of ridges, valleys, etc., was conducted to further identify the boundaries of the six sub watersheds labeled A, B, C, D, E, and F. Sub watershed A is the largest contributor and covers approximately 60% of the watershed that drains into Desair Lake. Sub watershed B is the second largest and covers approximately 25% while sub watersheds C, D, E, and F combined, make up the balance of the watershed and are adjacent to the lake.

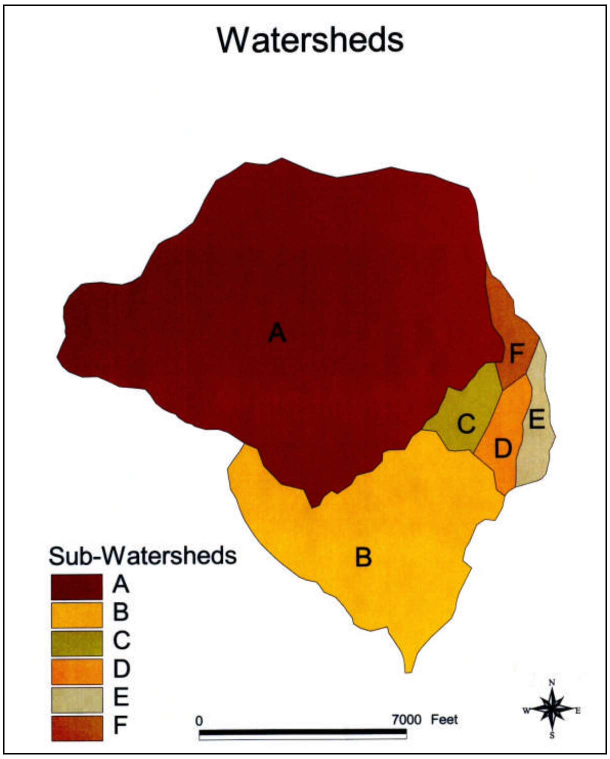


Figure 2-4

Land Use

Existing land use (Figure 2-5) is based on WiscLand 1992 which is the analysis of 1992 satellite imagery analyzed to determine land cover in the State of Wisconsin. This base reference was compared with a survey of existing conditions and aerial photography. Overall the land use in the watershed is mostly forest cover or agricultural land. Wetlands, grasslands, rural residential, and fallow ground make up a small percentage within the watershed. Land use is identified to determine water runoff potential as opposed to actual land use. Thus, rural residential acreage may be identified as forested, if in fact the larger percentage of this parcel is forested and not hardened surface.

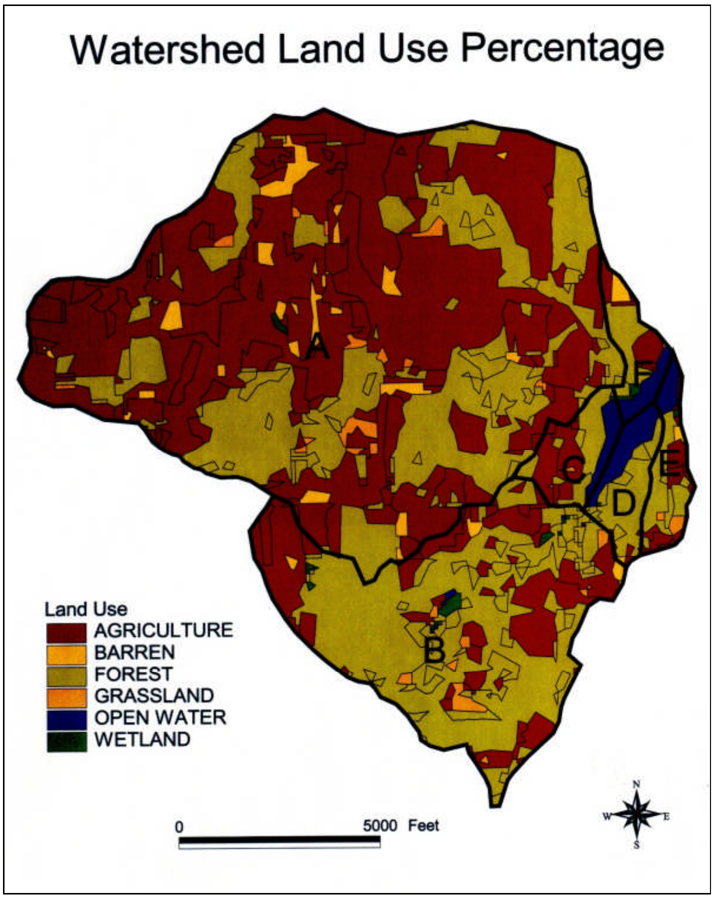


Figure 2-5.

The Desair Lake Watershed is delineated into six sub-watersheds. Land Use within these sub-watersheds is determined to be:

Acres	A	B	C	D	E	F
Forest	823.3	581.8	41.4	59.6	39.6	31.1
Grassland	28.5	17.3	0.6	0.06	4.0	0
Barren	73.5	7.0	0	0.8	2.3	5.6
Wetland	2.2	9.0	0.3	0.2	1.1	2.7
Open Water	0	2.2	17.9	29.25	12.0	18.8
Agriculture	1605.8	263.0	42.0	3.5	24.5	21.8
Urban – low	0	0	0	0	0	0
Urban – high	0	0	0	0	0	0
TOTALS	2533.8	880.3	102.2	93.4	83.5	80.0

Percentage	A	B	C	D	E	F
Forest	32	66	41	64	47	39
Grassland	1	2	1	0	5	0
Barren	3	1	0	1	3	7
Wetland	0	1	0	0	1	3
Open Water	0	0	18	31	14	24

Agriculture	63	30	41	4	20	27
Urban – low	0	0	0	0	0	0
Urban – high	0	0	0	0	0	0

Storm Water Runoff

The purpose of defining watershed topography and land use is to identify surface water runoff and infiltration characteristics in the various watersheds. Land use has a strong affect on surface water drainage. Increasing development correlates to increasing runoff. This coupled with a variety of soil types that vary from more permeable sandy soils to high runoff clay soils requires an understanding of both land use and soil type to predict runoff water quantity and runoff water quality.

The next step in watershed water quality and water quantity evaluation is to develop computer models that will determine runoff water quantity and quality. These models can incorporate water quality improvements (or BMPs – Best Management Practices) to evaluate the impact of BMP implementation runoff water quality.

CHAPTER 3: LAKE SEDIMENT CORING

Sediment core sampling was completed by Paul Garrison of the Wisconsin Department of Natural Resources (WDNR) in July 2004. The full WDNR sediment core report is included as Appendix F. Evaluation of Sediment cores can determine numerous lake characteristics:

- pre-sedimentation water quality
- age of sedimentation
- chemical characteristics of sediment and the watershed
- nutrient concentrations
- feasibility of chemical treatment to stabilize phosphorous

Sediment cores taken near the surface of the lake bottom are referred to as top cores, and are approximately 10 cm long. Longer core samples are taken to evaluate lake history.

Top sediment cores (10 cm) were taken at three locations on the lake and an historical core (60 cm) from the deep hole (28 feet). The top 10 cm of each core was analyzed in 2 cm increments for sediment density. The purpose of this study was to determine if an alum treatment, which binds the phosphorus to the aluminum sulfate, thus sealing it in the sediment, would be an effective method to interrupt the phosphorus cycle in the lake.

Results of the coring indicate a low density of water (<90%) in the top 10 cm of sediment. Based on these results, it appears that the alum treatment would be effective remaining on top of the sediments thus sealing in the phosphorus. This action would disrupt the phosphorus cycle, reducing sediment contribution as a result of lake bottom sediment biological activity.

Recommendations from the WDNR include additional corings and sediment incubation studies with alum treatments. This will help to estimate the amount of alum necessary and associated costs for an effective treatment.

CHAPTER 4: US GEOLOGICAL SURVEY DATA

The USGS played a key role in this study, offering valuable insight and data collection in the completion of a diagnostic study to assess the significance of external versus internal phosphorous loading in Desair Lake. The USGS was responsible for installing and operating monitoring equipment necessary for measuring external loading contributors and water levels. For the full USGS report please see Appendix G. The following is a list of devices installed by the USGS along with an explanation of their operations:

1. Tributary Gauges – A tributary gauge was installed near the mouth of each inlet of three influent tributaries. The tributaries were sampled by the USGS during four runoff events including: spring snowmelt, spring rainfall, a summer rainfall, and a late summer or fall rainfall. Samples were collected both manually and by siphon samplers. The siphon samplers automatically collected samples during the earlier stages of runoff events as is necessary due to the flashiness of these streams. (The streams tend to have short durations of high water during storms.)

2. Lake Stage Gauge - In addition to tributary gauges, a lake stage (or water elevation) gauge was installed by the USGS at the public access of Desair Lake to evaluate changes in water storage within the lake. Lake stage data is useful to provide a semi-quantitative assessment of the significance of watershed runoff during and following a runoff event. By determining the stage increase associated with a runoff event, the increase was used to provide an indication of the volume and the speed of runoff. A crest-stage gauge recorded the peak lake stage during runoff events.

3. Groundwater monitoring points (piezometers) - In the effort to evaluate the concentration of phosphorus in the groundwater entering the lake, piezometers (small diameter monitoring wells) were installed in groundwater at five sites near the lake. Three of the wells were installed on the west side of the lake and two wells were installed on the east side of the lake. During the first sampling round it was determined by the groundwater elevations that the natural flow of groundwater is to the east-southeast. The upgradient piezometers were sampled two times and analyzed for phosphorus concentration, while the downgradient piezometers were not sampled. During the first round of sampling, a multi-parameter meter was used to measure temperature, dissolved oxygen, pH, and specific conductance of the groundwater in the upgradient wells.

With the tributary and lake stage gauges installed (including the automatic siphon samplers), the USGS obtained valuable external loading information for Desair Lake. The USGS data suggests heavy external loading from the three influent tributary streams. For example after the October 4, 2005 rain storm in which 10.12 inches of rain fell (only 0.48 inches less than the state record for 24 hour rainfall), these tributaries increased the water level from 6.50 feet to a crest of 9.95 feet on October 5th, raising the water level 3.45 feet from runoff. It is estimated that during this rain event 90 – 91 million gallons of water was flowing through Desair Lake. Phosphorus loading was sampled at this time in each of the three tributaries, with an average phosphorus concentration of 0.903 mg/L being contributed per tributary. This is equivalent to an estimated 700 pounds of additional phosphorus from external loading. The amount of water and phosphorus flowing out of Desair Lake at that same time is not known.

Tributary concentrations of phosphorus and total suspended solids were determined in the spring, summer, and fall of 2005. For all three tributaries, the data indicate a 2 to 5 times increased concentration of phosphorus during the spring runoff event as compared to mid-June. Fall concentrations are also higher than summer. The Northwest tributary, draining watershed A, experiences the highest phosphorous concentrations while, the Southwest tributary draining B, C, and D and the East tributary draining sub-watersheds E and F have similar concentrations. Phosphorous concentrations ranged from a low of 0.103 mg/L to a high of 2.13 mg/L. The highest value occurred during the near record October 4, 2005 rain event.

Five piezometers were installed around Desair Lake in May 2004. Water elevations were collected May 5 and August 17, 2004 and correlated with lake stage (elevation) data collected on the same date. Piezometers 1, 2, and 4 were installed on the western shore of the lake, while piezometers 3 and 5 were located on the east shore. Groundwater elevation data (see Figure 3, Appendix G) indicate higher groundwater elevations to the west and lower to the east with respect to the lake elevation. This indicates an eastward flow of ground water through the lake. This is likely in response to the discharge of groundwater into the Red Cedar River some 8 miles east of the lake, and the movement of groundwater toward that discharge point.

Groundwater from the three upgradient piezometers are noted to contribute an average of 0.103 mg/L of phosphorus per well. The well with the highest contribution is Piezometer #2 with 0.254 mg/L when sampled on May 5, 2004. Only two wells were sampled on August 17, 2005 with an average of 0.05 mg/L of phosphorus per well. Piezometer #4 was not sampled due to the lack of water in the well. Piezometers #3 and #5 were not sampled as they were considered downgradient of Desair Lake, and not contributing to phosphorus loading.

Internal loading is also contributing to the degradation of Desair Lake, according to the USGS water quality data which was collected on August 17, 2005 from the lake's deep hole. Continuous sampling from the top to the bottom of the lake was completed at increments ranging from ½ foot to 1 foot. Results showed temperature and dissolved oxygen concentrations were highest at the top of the water column and lowest at the bottom of the column. An increase in phosphorus concentration is observed towards the bottom of the lake. With the low levels of dissolved oxygen at the bottom, these higher phosphorus concentrations indicate phosphorous is being released from the sediment and suspended in the water column. For a complete listing of internal water quality parameters including depth, temperature (ºC), pH, specific conductance (US/cm), dissolved oxygen (mg/L) and total phosphorus (mg/L); see Appendix G, Table 1.

CHAPTER 5: DESAIR LAKE COMMUNITY SURVEY

The survey was designed as part of the grant project to assess the characteristics, practices, and perceptions of the Desair Lake Community concerning Desair Lake and the surrounding watershed. This survey provides an assessment of the present (2005) and future recreational use of the lake and the concerns and attitudes of current lake residents and users. The Desair Lake Planning Committee sent out 50 surveys to residents in the Desair Lake Watershed Community. A total of 28 surveys (56%) were returned and tabulated in May 2005. The tabulated results of the community survey is included as Appendix H.

Based on survey results, 52% of the people have lived and/or visited Desair Lake in the last 10 years or less and 48% of the people have been present for 11 years or more. The top ten comments suggest:

1. Most of the respondents (81%) are members of Desair Lake Restoration, Inc. Of those that aren't members, concerns about their available time are keeping the majority of them from joining.

2. Eighty-eight percent of those surveyed either agree or strongly agree that there is a problem with the amount of algae in Desair Lake.

3. Lake water quality affects 50% of the lake users, while it greatly affects 35% of the respondents. The remaining 15% felt the water quality had little or no affect on their decision to use the lake.

4. For those respondents that live on or visit Desair Lake, fishing/ice fishing is the most participated in activity. Boating and observing wildlife is considered the second-most popular, and canoeing/rowing/kayaking is the third favorite activity on the lake.

5. The three things people like most about the Desair Lake area is that it provides peace and quiet, the beauty and abundance of wildlife, and the large amount of undeveloped shoreline surrounding the lake.

6. The three most disliked things about the Desair Lake area include the abundance of algae, amount of runoff entering the lake, and decline in the quality of fishing over the years.

7. Many are concerned with surface water problems surrounding Desair Lake. They believe the top contributing factors are: farm fertilizers, erosion from crop fields, fertilizers/pesticides from lakeshore homes, and storm water runoff from house roofs, driveways, and roads.

8. Eighty-one percent of the respondents felt that the Lake Association could help improve water quality in Desair Lake by monitoring lake quality and keeping everyone in the watershed informed about the lake condition and what is being done. Seventy-eight percent would also encourage and support farming practices that minimize erosion and barnyard runoff. The same number of people would also like to find funding to clean the algae from the lake.

9. Eighty-one percent felt that the newsletter was the best way for Desair Lake Restoration, Inc. to communicate with them.

10. Almost half (48%) of the respondents would be willing to volunteer for a role in the Desair Lake Restoration, Inc. organization and over one-third of these volunteers have special skills that could be used by the organization.

CHAPTER 6: BARRON COUNTY LAND AND CONSERVATION

In 2001, Barron County applied for a TRM (Targeted Runoff Management) Grant through the Wisconsin DNR. The grant application (presented in Appendix I) identified the need for water quality improvement projects within the Desair Lake watershed. The proposed projects were to be completed within three areas of the watershed:

1. farm yard and cropland runoff (Gabion Construction)
2. forested and residential runoff (Sediment Basin Construction)
3. uplands runoff (Agricultural Land Conversion to Wetland)

The three projects that were completed utilized different designs to address the specific problem area.

<u>Rock Gabion Dam</u>

A swale drains agricultural fields and a farm yard on the east edge of Desair Lake. Now a hobby farm, this former beef and dairy operation generated runoff from agricultural practices and livestock that was quickly washed into the swale and directly into the lake. Now the farm is free of livestock and water management practices are in place.

A series of rock gabion dams were installed along the swale creating check dams that would reduce runoff water velocity during runoff events and create sedimentation/ infiltration ponds to reduce sediment loading of runoff water.

The active gully was eroding into the south side of the lake. The waterway drains 80 acres of woodland and pastures. Three rock gabion structures (Appendix J) were installed in the waterway to allow some of the energy to be dissipated at each structure. Installation was done in late June 2005. Unfortunately a storm October 4, 2005 dumped approximately 12 inches of rain on the watershed. The volume of water “cleaned out” the woods and plugged the 5’x3’ outlets of one of the structures and it was breached. Repairs were completed in the fall of 2005

Upon stabilization of the project additional water may be diverted from the residential area west of the waterway to protect an active gully that also drains into the lake.

Rock Gabion in restored Swale

Olson Pond

Installed on Rod Olson’s property to minimize runoff water from former agricultural fields and upstream forested areas, the pond is a simple retention pond with overflow to allow sediment stilling and a controlled discharge of the runoff water (Appendix J). The construction included stream bank restoration and erosion reduction projects at road and bridge crossings upstream of the pond. The pond controls erosion runoff from a cropland and wooded area of approximately 40 acres.

Olson Pond at Beginning of Restoration

This project involved diverting a waterway that drained 37 acres directly into the lake into a constructed basin. It has a pond area of about .5 acres. It is able to fill during a runoff event to a depth of 3 feet before the spillway flows. The floodwaters are then drained through a 4” outlet pipe.

<u>Phil Henkel – Wetland Restoration / Sediment Basin</u>

The Henkel property is in the southwest corner of the watershed, at the headwaters of the southwest tributary. A saucer shaped former wetland converted to agricultural cropland was reclaimed and improved to form a shallow, controlled discharge retention fore bay (Appendix J). This area consists of a low berm and overflow discharge that minimizes water velocity and sediment leaching before runoff water enters a tributary swale to the lake. The erosion controlled area is upwards of 80 acres of agricultural croplands.

Before

The site was reed canary grass meadow surrounding an existing pond at the edge of a farm field. A drainage ditch had been constructed draining water to the East and eventually the south end of Lake Desair. Approximately 80 acres of cropland drains into and out of the wetland.

After

In the fall of 2003 the Reed Canary grass was scraped and removed. In the spring of 2004 a 4' high 200' long embankment was constructed using material from borrow sites adjacent to the dam. This created 2 additional 8' ponds on the site.

The normal water level creates a pond of about 2 acres. During a runoff event, it will fill to cover an area of 5 acres. This water is released through a 6inch outlet pipe over the course of several days.

The landowner has entered into a CREP agreement and planted a native grass buffer surrounding the pond.

CHAPTER 7: CONCLUSIONS

Surface water quality samples were collected from Desair Lake through the summer months of 2005 by self-help lake monitor Rod Olson. Results show phosphorus concentrations ranging from 57 – 180 micrograms per liter. Any concentration above 50 micrograms per liter is considered high. Near bottom phosphorus samples were collected by the USGS on August 17, 2005. The analytical results reported phosphorus levels at 922 micrograms per liter. This combined with a low dissolved oxygen reading of 0.1 milligrams per liter, is indicates that phosphorus is being released from lake bottom sediments resulting in increased internal phosphorous loading in Desair Lake.

USGS data from the tributary sampling indicates that there is a high concentration of phosphorus and sediments entering the stream following runoff events. As expected during a runoff event with greater flows come higher phosphorus and sediment concentrations. Between the three tributaries, the southwest and east tributaries are the highest overall contributors. This is a result as the land use for both sub watersheds is predominantly agricultural. The northwest tributary, which funnels in from the largest sub watershed, is also a major quantity contributor during heavy runoff events. However, as land use is predominantly forest, some phosphorus and sediments are filtered from the runoff before reaching Desair Lake. From a loading perspective however, the northwest tributary contributes the most pounds of nutrient load to the lake.

Internal and external phosphorus loading are both very high in Desair Lake. Though BMP's have been implemented, there may be a need to expand and/or add additional BMP's to control the external loading. External loading needs to be controlled and reduced before an alum treatment is considered. Without controlling the external loading, any lake phosphorous management alternatives will be quickly rendered ineffective by the influx of phosphorous and sediments from the tributaries into the lake.

Management of the watershed to protect lake and river quality is necessary. Recommendations to improve water quality include:

1. Conduct additional sediment core studies to determine the feasibility of alum treatment to stabilize phosphorous in the lake bottom sediments. Requires external

experts for core sampling, analysis, laboratory feasibility study using alum or other stabilizing agents. Project is lake management planning grant eligible.

2. Reforestation of barren cropland. Focus on upland watershed areas. Requires cooperation of land owners and County.

3. Maintain the Slow, No Wake Policy on Desair Lake. Use of watercraft with powerful motors creates water turbulence which disturbs bottom sediments. With these sediments disturbed, water clarity decreases and phosphorous rich water bottom sediments are mixed in the water column. This increases the availability of nutrients to existing algae.

4. Promote no till farming practices to limit the quantity of sediment that is eroded from croplands.

5. Promote more restrictive erosion control practices in the watershed and in particular along the tributaries and the shores of Desair Lake. Such practices might include increased vegetative buffers in agricultural areas, erosion control for small construction (less than one acre) projects, fencing cattle from streambeds and floodplains, etc. The northwest tributary carries 60% of the sediment to Desair Lake. We recommend a feasibility study for the construction of a large overflow sediment basin in a field adjacent to the public landing. This would vastly decrease the sediment and phosphorous load on Desair.

6. Improve roads and storm water conveyance systems for roads within the watershed. Focus on roads that have a high probability of washing out. In particular, 23rd Street just southeast of the lake, is a gravel road that slopes towards the lake. This sediment and nutrient source could be mitigated with proper drainage and hard surfacing. The private extension of 23rd Avenue is a steep grade, high volume unimproved road that extends downhill nearly to the lake. Water flowing in that watershed comes down the road washing out deep gullies and flushing road gravel into the Lake. Continued repairs of dumping loads of gravel each year on the road are not improving the road stability or minimizing sediment erosion into the lake. An engineered design for water diversion and roadbed stabilization are highly recommended.

7. Improve drainage and erosion control at the public boat landing. An extensive watershed diverts the water to the public landing and washes down the road making gullies and carrying sediment to the Lake. Water diversion and waterway control are necessary to stabilize sediment loading to the lake from the public landing.

8. Promote the use of low phosphorous fertilizers in the watershed.

9. Promote phosphorous based as opposed to nitrogen based nutrient management for agricultural practices in the watershed.

10. Use conservation easements to protect sensitive ecosystems.

11. Continue working with Barron County on the implementation of water quality improvement devices.

12. Promote the development of a high water, sediment treatment area approximately ¼ mile upstream of the mouth of the northwest tributary into the Lake. The intent is to direct high flow volume runoff water into a detention basin to allow sediments and nutrients to settle out of the water. Treated water would be discharged to the lake by infiltration to ground water or overflow of an emergency overflow weir at an engineered discharge point in the weir bank.

RESULTS OF SEDIMENT CORES TAKEN FROM LAKE DESAIR, BARRON COUNTY, WISCONSIN

Paul Garrison, Wisconsin Department of Natural Resources
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Aquatic organisms are good indicators of a lake's water quality because they are in direct contact with the water and are strongly affected by the chemical composition of their surroundings. Most indicator groups grow rapidly and are short lived so the community composition responds rapidly to changing environmental conditions. One of the most useful organisms for paleolimnological analysis are diatoms. These are a type of algae which possess siliceous cell walls, which enables them to be highly resistant to degradation and are usually abundant, diverse, and well-preserved in sediments. They are especially useful, as they are ecologically diverse. Diatom species have unique features as shown in Figure 1, which enable them to be readily identified. Certain taxa are usually found under nutrient poor conditions while others are more common under elevated nutrient levels. Some species float in the open water areas while others grow attached to objects such as aquatic plants or the lake bottom.

By determining changes in the diatom community it is possible to determine water quality changes that have occurred in the lake. The diatom community provides information about changes in nutrient, water color, and pH conditions as well as alterations in the aquatic plant (macrophyte) community.

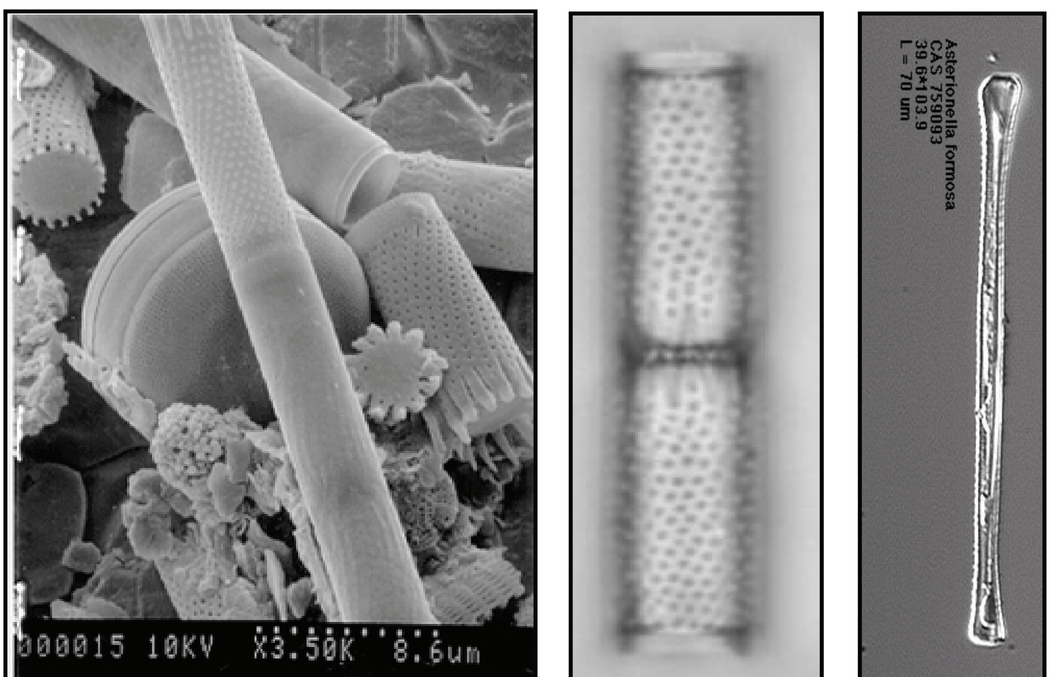

Figure 1. Photomicrographs of diatoms *Aulacoseira subarctica* (left), *Aulacoseira granulata* (middle), and *Asterionella formosa* (right). *A. subarctica* is found in low nutrient lakes while *A. granulata* occurs in higher nutrient environments. *A. formosa* typically is found in lakes with moderate nutrient levels.

On 8 July 2004 cores were taken from three locations in Magnor Lake (Figure 2). Near Site DS-1 a core was extracted to determine water quality changes in the lake during the last 150 years. This core was 60 cm long. The top 2 cm and bottom 2 cm were kept for analysis. It is assumed that the upper sample represents present conditions while the deeper sample is indicative of historical water quality conditions. At this and 2 other sites cores (Table 1) were extracted and the top 10 cm kept. These samples were used to determine the density of the upper sediment in order to estimate the depth to which alum would settle if it were applied to the lake.

Table 1. Location of coring sites.

Coring Site	**Latitude**	**Longitude**	**Water Depth** (ft)
DS-1	N 45° 32.775'	W 091° 46.645'	28
DS-2	N 45° 32.682'	W 091° 46.766'	25
DS-3	N 45° 32.410'	W 091° 46.936'	15

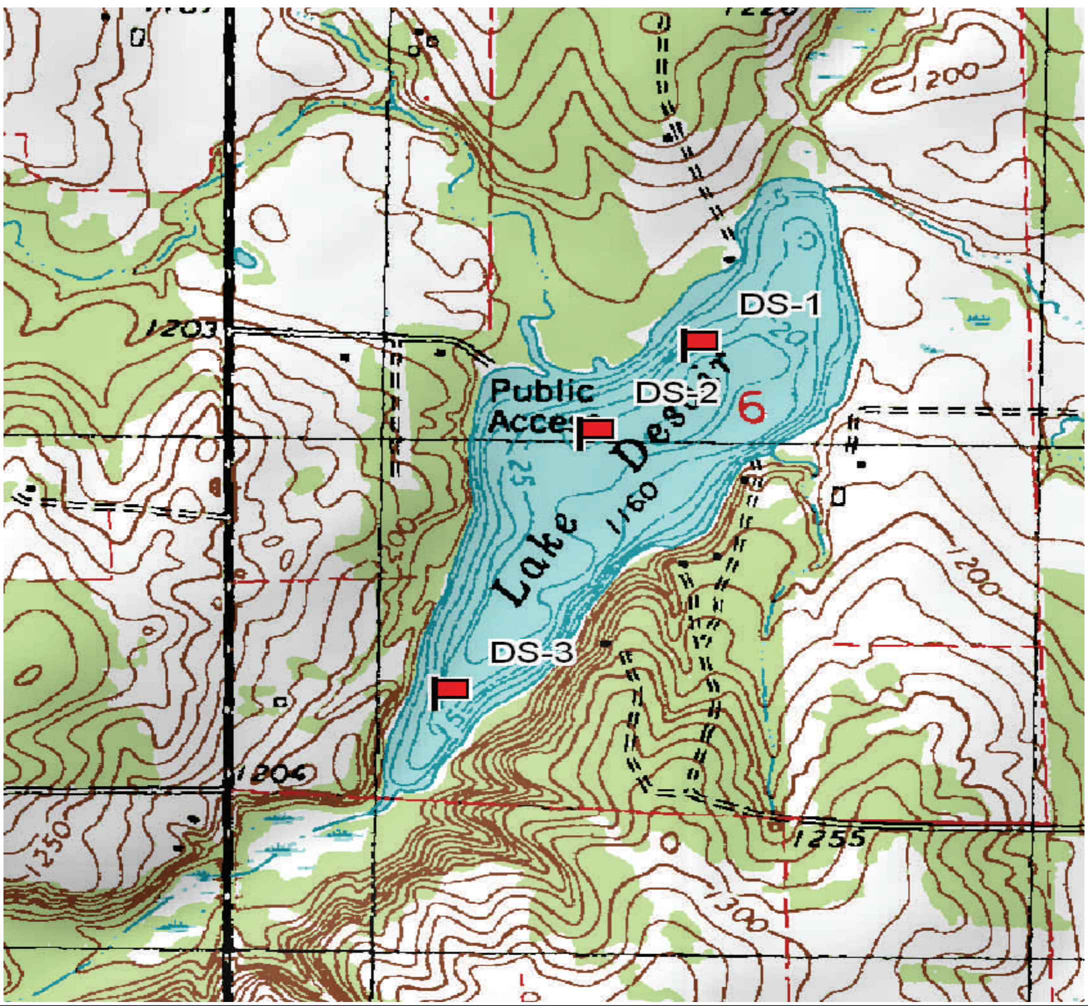

Figure 2. Location of sampling sites of cores collected on 8 July 2004. The top/bottom core was collected near Site DS-1 in about 30 feet of water.

Water Quality Changes

The diatom community at the bottom of the core is much different than the one at the top. In fact the difference is greater than I have observed in any other lake. The difference is so great than none of the common species at the bottom are common at the top of the core. Although the percentage of planktonic diatoms (those that typically are found floating in the open water) at the top of the core is less than at the bottom by about 10% (Figure 3), the biggest difference is in species composition. Historically, the dominant diatom was *Aulacoseira subarctica*. This species is found in low nutrient conditions and often very softwater. This species was absent from the top of the core and was replaced by other *Aulacoseira*, e.g. *A. granulata* and *A. ambigua* (Figure 3). These species are typically found at higher nutrient levels, especially *A. granulata*. Other species which were common at the top of the core were *Fragilaria vaucheriae* and *F. capucina* var. *mesolepta* which also are found under elevated nutrient levels. The abundance of *Asterionella formosa* is more common at the bottom of the core. Its decline is also an indication of higher nutrient levels since it prefers moderate nutrient levels.

The diatom community indicates that changes other than increased nutrients have occurred in the lake. The community indicates that historically, there was more color (brown color) in the water and the alkalinity (pH) was lower than it is at the present time. These changes, along with higher nutrients, are likely the result of large changes in landuse in the lake's watershed. These changes are likely associated with agricultural activities.

Diatom assemblages historically have been used as indicators of nutrient changes in a qualitative way. In recent years, ecologically relevant statistical methods have been developed to infer environmental conditions from diatom assemblages. These methods are based on multivariate ordination and weighted averaging regression and calibration. Ecological preferences of diatom species are determined by relating modern limnological variables to surface sediment diatom assemblages. The species-environment relationships are then used to infer environmental conditions from fossil diatom assemblages found in the sediment core.

Such models were applied to the diatom community in the core from Lake Desair. The models indicated that historical phosphorus levels were around 10 µg L^{-1} while current phosphorus levels are about 35-40 µg L^{-1} (Table 2). The estimated present day concentrations are lower than values measured in 2003 (50-70 µg L^{-1}) but the model does indicate a significant increase in phosphorus during the last 100 years. The models also indicate a decline in water color from 29 to 13 units and an increase in alkalinity from 11 to 84 mg L^{-1} (Table 2).

In summary, the diatom community indicates that Lake Desair has undergone a large change in water quality during the last 100 years. There has been a large increase in nutrients, especially phosphorus, a decline in water color, and an increase in alkalinity. These changes are likely the result of agricultural activities in the watershed. These changes resulted in the increased delivery of phosphorus and sediment from the watershed which caused higher nutrient levels and more solids (alkalinity) in the lake.

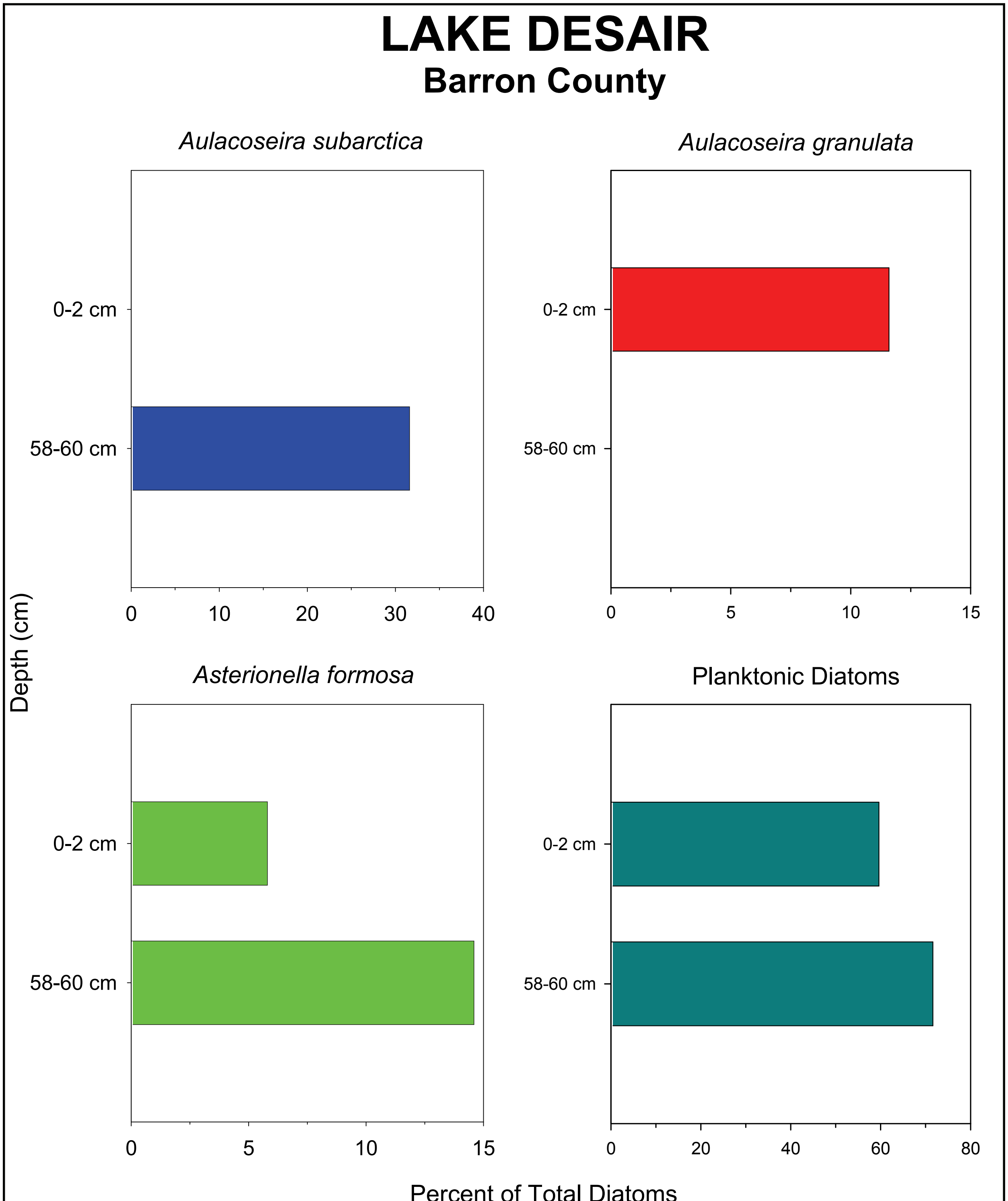

Figure 3. Changes in abundance of common diatoms found at present and presettlement times. *A. subarctica* is a planktonic diatom that is found under low nutrient levels. *A. granulata* indicates eutrophic phosphorus levels while *A. formosa* if found under moderate nutrient conditions.

Table 2. Estimated values of water quality variables. Values were inferred from the diatom community using multivariate statistical models.

Core Depth	Summer Phosphorus ($\mu g\ L^{-1}$)	Color	Alkalinity ($mg\ L^{-1}$)
Top	35	13	84
Bottom	10	29	11

Sediment density

The density of the top 10 cm of sediment was measured at 3 locations in the lake. The purpose of this measurement was to estimate how deep alum (aluminum sulfate) might penetrate the sediments. Alum treatments have been used successfully to significantly reduce internal phosphorus loading from bottom sediments. Phosphorus is released when water overlying these sediments is devoid of oxygen. The lack of oxygen results in the form of iron changing from ferric (+3) to ferrous (+2). When this happens phosphorus that was bound to the iron is solubilized and moves from the sediments to the overlying water. Aluminum bound phosphorus does not become soluble in the absence of oxygen and thus stays in the sediment. Alum often is denser than lake sediments and when this is the case, alum will settle into the sediments until is reaches a depth where its density is equal to, or less than the sediments.

In all of the samples from Lake Desair the percentage of water was less than 90% (Table 3). Other studies have found that this can be a reasonable estimate of the depth alum will settle. This analysis indicates that an alum treatment would likely remain on top of the sediment and therefore alum may be appropriate for this lake. A more accurate test of the effectiveness of alum would be to extract cores from the lake and treat them with sequential amounts of alum. This analysis will better estimate the amount of alum necessary to bind the sediment phosphorus. This analysis will also give a better estimate of the cost of an effective alum treatment.

Table 3. Percent water in the top 10 cm of sediments at 3 locations in Lake Desair. Refer to Figure 1 for locations.

DS-1

Depth (cm)	**Water** (%)
0-2	84.3
2-4	81.9
4-6	82.7
6-8	83.5
8-10	76.2

DS-2

Depth (cm)	**Water** (%)
0-2	69.8
2-4	67.7
4-6	53.9
6-8	47.9
6-8 rep	49.0

DS-3

Depth (cm)	**Water** (%)
0-2	89.1
2-4	84.7
4-6	81.5
6-8	80.9
8-10	83.3

LAKE DESAIR
Barron County

Core Top (0-2 cm)

TAXA	COUNT TOTAL Number	Prop.
Achnanthidium linearis	5	0.016
Achnanthidium minutissima	6	0.019
Asterionella formosa	18	0.058
Aulacoseira ambigua	14	0.045
Aulacoseira granulata	35	0.113
Aulacoseira italica	8	0.026
Aulacoseira (VV)	1	0.003
Cocconeis placentula var. linearis	4	0.013
Cyclostephanos sp.	2	0.006
Cyclotella atomus	11	0.036
Cyclotella distinguenda	15	0.049
Cyclotella pseudostelligera	6	0.019
Cyclotella sp.	6	0.019
Cymbella sp.	2	0.006
Eucocconeis flexella	1	0.003
Eunotia bilunaris	0.5	0.002
Eunotia incisa	0.5	0.002
Eunotia sp.	1	0.003
Fragilaria crotonensis	22	0.071
Fragilaria crotonensis var. oregona	2	0.006
Fragilaria vaucheriae	27	0.088
Fragilaria (GV) (14-15/10u) (central area)	38	0.123
Gomphonema truncatum	1	0.003
Hantzschia amphioxys	0.5	0.002
Luticola goeppertiana	1	0.003
Navicula cincta	1	0.003
Navicula lanceolata	6	0.019
Navicula minima	20	0.065
Navicula (GV) (short)	2	0.006
Nitzschia acicularis	0.5	0.002
Nitzschia amphibia	1	0.003
Nitzschia gracilis	1	0.003
Nitzschia palea	3.5	0.011
Nitzschia pusilla	3	0.010
Nitzschia sp.	1	0.003
Pseudostaurosira brevistrata	2	0.006
Sellaphora pupula	3	0.010
Staurosira construens var. venter	4	0.013
Staurosirella pinnata	1	0.003
Stephanodiscus sp.	6	0.019
Synedra acus	3	0.010
Synedra minuscula	3	0.010
Synedra rumpens var. familaris	15	0.049
Synedra sp.	6	0.019
Surirella angusta	1	0.003
Unknown	2	0.006
Unknown (raphid)	1	0.003
TOTAL	308.5	1.000
Chrysophyte scales	1	
Chrysophyte cysts	25	
Planktonic taxa		0.596
Nonplanktonic taxa		0.394

LAKE DESAIR
Barron County

Core Bottom (58-60 cm)

TAXA	COUNT TOTAL Number	Prop.
Achnanthes lacus-vulcani	6	0.018
Achnanthidium exiguum	1	0.003
Achnanthidium minutissima	4	0.012
Achnanthidium sp.	3	0.009
Asterionella formosa	49	0.146
Aulacoseira distans var. tenella	15	0.045
Aulacoseira perglabra var. floriniae	1	0.003
Aulacoseira ambigua	29	0.087
Aulacoseira subarctica	71	0.212
Aulacoseira VV	35	0.104
Cyclotella atomus	2	0.006
Cyclotella glomerata	4	0.012
Cyclotella pseudostelligera	2	0.006
Cyclotella stelligera	8	0.024
Diatoma vulgare	2	0.006
Encyonema silesiacum	2	0.006
Eunotia bilunaris	1	0.003
Eunotia incisa	0.5	0.001
Eunotia praerupta	1	0.003
Eunotia sp.	2.5	0.007
Fistulifera pelliculosa	2	0.006
Fragilaria crotonensis	5	0.015
Fragilaria vaucheriae	3	0.009
Fragilaria (GV) (14-15/10u) (central area)	2	0.006
Gomphonema minutum	2	0.006
Gomphonema sp.	2	0.006
Meridion circulare	2	0.006
Navicula agretis	2	0.006
Navicula difficillima	2	0.006
Navicula lanceolata	1	0.003
Navicula minima	4	0.012
Navicula (GV) (short)	5	0.015
Navicula sp.	2	0.006
Nitzschia acicularis	1.5	0.004
Nitzschia palea	2	0.006
Nitzschia pusilla	1	0.003
Nitzschia sp.	2.5	0.007
Pseudostaurosira brevistrata	4	0.012
Sellaphora pupula	1	0.003
Staurosirella pinnata	4	0.012
Synedra minuscula	1	0.003
Synedra radians	2	0.006
Synedra rumpens	11	0.033
Synedra rumpens var. familaris	6	0.018
Synedra tenera	4	0.012
Synedra sp.	3	0.009
Tabellaria flocculosa str. III	8	0.024
Tabellaria flocculosa str. IIIp	15	0.045
Tabellaria flocculosa str. IV	1	0.003
Unknown	1	0.003
Unknown (raphid)	0	0.000
TOTAL	335	1.000
Chrysophyte scales	10	
Chrysophyte cysts	35	
Planktonic taxa		0.716
Nonplanktonic taxa		0.281