Total Maximum Daily Load
For Siltation and Nutrients
Lake Darling
Washington County, Iowa

December 2002

Iowa Department of Natural Resources
TMDL & Water Quality Assessment Section

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TMDL for Siltation and Nutrients
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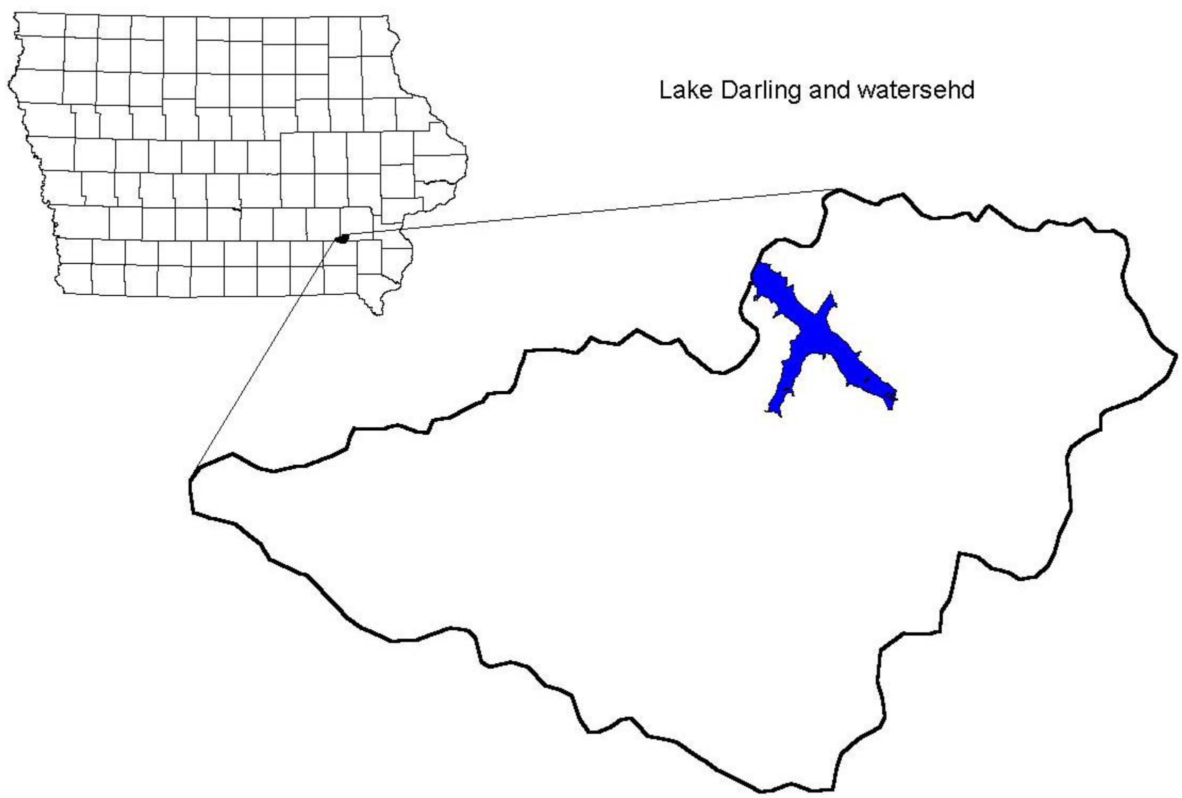
Waterbody Name:	Lake Darling
IDNR Waterbody ID:	IA 03-SKU-01450-L
Hydrologic Unit Code:	070801070605
Location:	Section 21 T74N R9W
Latitude:	41 Deg. 12 Min. N
Longitude:	91Deg. 54 Min. W
Use Designation Class:	A (primary contact recreation) B(LW) (aquatic life) C (potable water source)
Watershed:	12,179 acres
Lake Area:	240 acres
Major River Basin:	Skunk River Basin
Tributaries	Honey Creek and several unnamed tributaries
Receiving Water Body:	Honey Creek
Pollutant:	Siltation and Nutrients
Pollutant Sources:	Agricultural nonpoint source
Impaired Use	Aquatic Life and Primary Contact
1998 303d Priority:	High



1. Introduction

The Federal Clean Water Act requires the Iowa Department of Natural Resources (IDNR) to develop a total maximum daily load (TMDL) for waters that have been identified on the state's 303(d) list as impaired by a pollutant. Lake Darling was been identified as partially supporting its primary contact recreation and aquatic life uses due to excessive siltation and nutrients. The purpose of these TMDLs for Lake Darling is to calculate the maximum amount of siltation and nutrients that the lake can receive and still meet water quality standards, and then develop an allocation of that amount of siltation and nutrients to the sources in the watershed.

Specifically these siltation and nutrient TMDLs for Lake Darling will:

- Identify the adverse impact that excess siltation and nutrients are having on the designated uses of the lake.
- Describe how siltation and nutrient loads in the lake violate the water quality standards.
- Identify target conditions and loads that assure the designated uses will be achieved.
- Calculate acceptable siltation and nutrient limits, including a margin of safety, and allocate the loads to the sources.
- Provide implementation guidance for IDNR staff and watershed stakeholders to achieve designated use goals.

The IDNR believes that sufficient evidence and information is available to begin the process of restoring Lake Darling. The Department acknowledges that to fully restore the primary contact recreation and aquatic life uses at Lake Darling, additional information will likely be necessary. In order to accomplish the goals of these TMDLs, a phased approach will be used. By approaching the restoration process in phases, feedback from future assessment can be incorporated into the plan.

Phase I of these TMDLs for Lake Darling will develop target siltation and nutrient limits based on a reduction of the current levels that will be protective of the primary contact recreation and aquatic life uses. Phase II will evaluate the effect those targets have on the intended results. Included in Phase II will be monitoring for results, reevaluating the extent of the siltation and nutrient impairments, and evaluating if the specific primary contact recreation and aquatic life impairments originally identified in the TMDL have been remedied.

2. Description of Waterbody and Watershed

Lake Darling State Park was dedicated on September 1, 1950, when J.N. "Ding" Darling "set the gate", completing the impoundment process. It is a 240-acre lake, located in Washington County 3 miles west of Brighton, Iowa. Lake Darling has a mean depth of 9 feet, a maximum depth of 24 feet, and a storage volume of 2,626 acre-feet. Lake Darling is entirely within the 1,417acre Lake Darling State Park. The lake and park provide facilities for boating, swimming, fishing, camping, picnicking, and hiking. Park usage is estimated at approximately 50,000 visits per year.

The Lake Darling watershed has an area of approximately 12,179 acres and has a watershed-to-lake ratio of 41:1. The landuses and associated areas for the watershed are shown in the table below.

Table 1. Landuse in the Lake Darling watershed

Landuse	Area in Acres	Percent of Total Area
Cropland	8,500	70
Pasture & Hayland	563	4.5
CRP	1,100	9
Timber	1,462	12
Other (roads, etc)	554	4.5
Total	12,179	100

Average rainfall in the area is 34 inches/year, with the greatest monthly amount (5.5 inches) occurring in June.

3. Applicable Water Quality Standards

The *Iowa Water Quality Standards* (IAC, 2000) list the designated uses for Lake Darling as Primary Contact Recreation (Class A), Aquatic Life (Class B(LW)), and Potable Water Source (Class C). The State of Iowa does not have numeric water quality standards for siltation or nutrients. The swimmable and fishable uses (Class A & B) for Lake Darling have been assessed as partially supported due to excessive siltation and nutrients since 1992. These assessments of partially supporting of Class A and Class B(LW) have continued to be used in subsequent biennial reports. Excess siltation and nutrients impact the Class B(LW) designated use by altering the physical and chemical characteristics of the lake so that a balanced community normally associated with lake-like conditions is not maintained (IAC 567-61.3(1)b(7)).

The altering of the physical and chemical characteristics caused by excess siltation and nutrients include the following impacts to the beneficial uses: 1) interference with reproduction and growth of fish and other aquatic life; 2) creating a light-limiting environment that interferes with establishment of aquatic vegetation; and, 3) excessive suspension of siltation and nutrient rich water create poor water quality that inhibits proper functioning of aquatic life.

The primary impact of sediment at Lake Darling is identified as interference with reproduction and growth of fish and other aquatic life. IDNR Fisheries biologists cited that siltation impacts aquatic life primarily in the upper portions of the lake. Although the entire lake was listed, it is the excessive sediment deposition in the upper arms of the lake that has lead to the lake being assessed as not meeting water quality standards. The upper arms of the lake are shallow and were ideal as an aquatic habitat. Those areas are now covered with fine silt that make successful spawning almost impossible. The deposition of sediment in these arms has severely limited the fishery in the entire lake.

Secondarily, the colloidal nature of the sediment delivered to Lake Darling creates a less than ideal feeding area for sight feeders. Bass and Bluegill primarily feed along the shoreline, and the fry use the vegetative cover along the shoreline for protection from predators. The water clarity inhibits aquatic vegetation from growing, leaving the smaller fish exposed and unable to feed successfully.

The Class A designated use is also impaired due to the high turbidity levels in the lake. The high turbidity makes the lake aesthetically objectionable to recreate in, which is a violation of the narrative water quality criteria. Decreased sediment and nutrient loads will improve the clarity, as well as management of rough fish in the lake.

While nutrient levels in Lake Darling are higher than the average for Iowa Lakes, water quality problems associated with high nutrient levels are not prominent at the lake. This is due in large part to the light limiting conditions caused by high levels of suspended sediments. If the transparency increases, the probability of heavy algal blooms is very high. Through this TMDL, efforts to decrease sediment will also result in decreased loads of phosphorous. Therefore, a TMDL for phosphorous will also be established.

4. Water Quality Conditions

4.1 Water Quality Studies

Water Quality studies have been conducted at Lake Darling in 1979, 1990, and 2000-present (Bachmann et al., 1980, Bachmann et al., 1994, Downing and Ramstack, 2002). Additional monitoring was completed by University Hygienic Laboratory under contract with the IDNR in 2002 in support of TMDL development.

Samples were collected three times each summer for the lake studies conducted in 1979 and 1990 (Bachmann et al., 1980, Bachmann et al., 1994). This data is shown in Tables 2 and 4 in the Appendix.

Lake Darling was sampled again in 2000-01 as part of the Iowa Lakes Survey (Downing and Ramstack, 2002). This survey will sample the lake three times each summer for five years. The data collected in 2000-01 is shown in Tables 5 and 6 (Appendix).

Lake Darling was monitored from March 2002 to August 2002 by UHL under contract with the IDNR. The data collected during this study are presented in Tables 6-8 (Appendix).

4.2 Angling (excerpt from a letter of support to the Lake Darling Watershed Project from Don Kline, IDNR Fisheries Biologist)

The silt load drops out in the upper ends of the bays as the flowing water meets the lake water. I have seen the upper ends of all the drainage ways filled in during the last 30 years. The original camping area and boat ramp had to be moved because the silt filled in the lake out in front of where it was located. Lake Darling originally had 305 surface acres of water, but now is listed as 187 acres. However, most of the lake remains at about the same depth as when the lake was built in 1950. We still have lots of 18 feet deep water out in front of the dam and 10 to 12 feet deep at the middle of the lake and into the major bays. Although the upper ends have become shallow, Lake Darling still has a great deal of recreational potential.

The suspended solids in the form of fine silt and clay particles have been the cause of the degraded water quality over the years. Silt particles may settle out in a few days while clay may take a year to settle out. The effect of silt and clay turbidity at Lake Darling is seen as a brown color to the water. The high turbidity levels mean the sight feeding fish have a hard time locating their prey, fish gill membranes are abraded, and algae blooms are limited by shading.

5. Desired Target

The listing of Lake Darling is based on narrative criteria. Lake Darling was included on the list of Iowa impaired waters based on the best professional judgment of IDNR field staff regarding the water quality. Lake Darling has been assessed as "partially supported" since 1992. The IDNR Fisheries Bureau indicates that siltation and nutrients are impairing the Class A and Class B(LW) designated uses. There are no numeric criteria for siltation or nutrients applicable to Lake Darling or its sources in Chapter 61 of the *Iowa Water Quality Standards* (Iowa, 2000). The targets for Lake Darling need to include siltation and nutrient loads as well as a measurement of the aquatic life. This is a phased TMDL and each phase will incorporate a separate target. Phase I will include a target for siltation and nutrient delivery to the lake. Monitoring the water quality and the fishery of the lake will be included in both Phase I and Phase II.

5.1 Nutrients

As discussed in section 3, the State of Iowa does not have numeric water quality criteria for nutrients applicable to Lake Darling. Excess nutrients are also not being fully expressed due to the light limiting conditions caused by the high levels of suspended sediment. Therefore, an acceptable nutrient target needs to be identified.

Trophic State Indices (TSI) are an attempt to provide a single quantitative index for the purpose of classifying and ranking lakes, most often from the standpoint of assessing water quality. The Carlson Index is a measure of the trophic status of a body of water using several measures of water quality including: transparency or turbidity (Secchi disk depth), chlorophyll-a concentrations (algal biomass), and total phosphorous levels (usually the limiting nutrient in algal growth).

The Carlson TSI ranges along a scale from 0-100 that is based upon relationships between secchi depth and surface water concentrations of algal chlorophyll, and total phosphorous for a set of North American lakes. A TSI value above 70 indicates a very productive waterbody with hypereutrophic characteristics; low clarity, high chlorophyll and phosphorous concentrations, and noxious surface scums of algae.

Without numeric water quality standards to base a target on, the Carlson TSI will be used to determine the Phase I target for nutrients. The Phase I target is to reduce the trophic state of Lake Darling to below hypereutrophic. This would be reflected in a TSI of 70. The current TSI based on chlorophyll-a is 46, for total phosphorous is 85, and based on transparency (secchi) is 80. The nutrient target for Lake Darling will be measured by a Carlson TSI for chlorophyll-a, total phosphorous, and secchi of 70 or below. While the chlorophyll-a TSI is already below 70, as transparency is improved, algae blooms may become more prominent and begin to express the excess nutrients in the water column. Therefore, the desired phase I target is to reduce the secchi and total phosphorous TSI to 70 or below, and maintain the chlorophyll-a below 70.

The CNET and EUTROMOD modeling completed on Lake Darling indicate the current phosphorous load to the lake is 35,257 lbs/year. To achieve a total phosphorous TSI of 70, the in-lake total phosphorous concentration needs to be at approximately 100 µg/L. To achieve this in-lake concentration, the phosphorous loading to the lake needs to be reduced to 8,110 pounds/year (77% reduction). This loading represents the allowable amount of phosphorous delivered from internal and external sources.

5.2 Siltation
The Phase I sediment delivery target will address the amount of sediment delivered to the lake from the watershed. A direct measure of the sediment load is difficult to make given seasonal variability and actual measurement tools. Acceptable estimates using established soil loss equations can be made to predict the erosion rates in the watershed, and subsequent delivery to the lake.

The EUTROMOD modeling completed for Lake Darling and its watershed predicted a current sediment delivery of 20,758 t/y based on landuse in the watershed. Since there are no numeric standards for sediment or siltation, an appropriate target for sediment needs to be identified. This is a phased TMDL, which allows for the targets to be revisited and adjusted as new data and information are available. Phosphorous is typically bound with soil and sediment delivery, and therefore the initial or Phase I target for sediment is to reduce sediment loading by the same percent reduction for phosphorous, a 77% reduction. This sets the Phase I siltation target at 4,774 tons/year delivered to the lake.

Achieving the phase I nutrient and siltation targets will reduce the turbidity of the water, making the water less aesthetically objectionable and moving towards restoring the Class A designated use. The Class A uses will be reassessed to ensure that the sediment and nutrient targets are appropriate for restoring the designated use.

5.3 Aquatic Life
The Phase II aquatic life target for this TMDL will be achieved when the fishery of Lake Darling is determined to be fully supporting the Class B aquatic life uses. This determination will be accomplished through an assessment conducted by the IDNR Fisheries Bureau. This assessment will be in accordance with the Statewide Biological Sampling Plan protocol (Larscheid, 2001). This protocol is currently being used to develop benchmarks for the fishery of Iowa's lakes. The results from the Lake Darling assessment will be compared with the benchmarks being developed. These assessments will include age, growth, size structure, body condition, relative abundance, and species.

Lake Darling will not be considered restored until the Phase II target is achieved. If the aquatic life target is achieved prior to the sediment and nutrient delivery targets, then the level of land practices may be maintained at a level at or above those in place at the time of the assessment. If however, after a reasonable time following the completion of the sediment and nutrient delivery practices the aquatic life has not been restored, then further study and practices may be necessary.

6. Loading Capacity
The State of Iowa does not have numeric water quality criteria for siltation or nutrients that apply to Lake Darling. Excess siltation and nutrients are causing impairment of the Class A and Class B(LW) designated uses.

The Phase I nutrient target for Lake Darling is to achieve a Carlson TSI for total phosphorous, and transparency of 70, and to maintain a Carlson TSI for chlorophyll-a below 70. This initial target will bring the lake below hypereutrophy and result in an initial step towards restoring the impaired designated uses. The Phase I target of a TSI value of 70 results in a loading capacity of 8,110 pounds/year of phosphorous.

The Phase I sediment target for Lake Darling is based on a reduction of the current modeled sediment delivery. This target results in a loading capacity of 4,774 tons/year of sediment delivered to the lake. This is an initial step towards improving water quality for the aquatic life by reducing the amount of suspended sediment and improving transparency for sight feeding fish.

7. Pollutant Sources

Water quality in Lake Darling is influenced only by nonpoint sources. There are three zero discharge lagoons in the watershed. All three of these lagoons being upgraded to reduce potential impact to the water quality of Lake Darling. The Youth Center Camp located on the east side of Lake Darling, is planning renovations to the lagoon at the camp, and will involve a wetland to provide second stage treatment before discharging to a pond above the lake. A wasteload allocation has been prepared for this facility and requires discharge from the wetland to be at or below background concentrations for CBOD, ammonia, and TSS. It is expected that these upgrades will be completed in 2003. Zero discharge lagoons also exist at the DNR district office and at the state park campgound and beach. An engineering study has been completed on both of these facilities, and construction is tentatively planned for 2003. The plans for the beach/campground lagoon involves converting it to a controlled discharge system, with the discharge located below the dam of Lake Darling. The lagoon at the DNR district office will be converted to a subsurface sand filtration system. Concerns of these lagoons as potential sources will be removed with the upgrade of these systems.

Nonpoint source pollution is caused by material transported to the lake by runoff from the watershed. Gully, streambank/streambed, sheet and rill, and shoreline erosion can contribute significantly to poor water quality and deterioration of the lake. Streambank and streambed erosion do not appear to be primary sources of sediment delivery to Lake Darling. Shoreline stabilization had been conducted around the lake in the past, but most of it has degraded over time, and therefore is again a source of sediment. Internal resuspension of sediment and nutrients is a significant source nutrients to the water column, and also contributes to the poor water clarity by maintaining sediments in suspension. Gully erosion in the wooded portions of the park are also contributing to the sediment load delivered to the lake.

8. Pollutant Allocation

8.1 Point Sources

Although there are three wastewater lagoons in the Lake Darling watershed, these are all zero discharge lagoons. Information regarding these lagoons is included in Part 7. Because these are zero discharge lagoons, the Wasteload Allocation for siltation and nutrients established under this TMDL is zero.

8.2 Non-Point Sources

Production agriculture dominates the watershed of Lake Darling. Sheet and rill erosion from the large watershed contributes both sediment and nutrients to the lake. There are numerous gullies present along the shoreline adjacent to the camping areas on the south end of the Park, and under the footbridges across the south and east portions of the lake. Streambank/streambed erosion is not a major factor, but shoreline erosion also contributes to sediment delivery around a major portion of the lake. These small gullies and shoreline problems have high sediment delivery rates due to the close proximity to the lake and the nature of the soils. In addition, resuspension of sediment and nutrients from the lake bottom is a significant contributor to the poor water quality at Lake Darling.

Lake Darling was modeled using EUTROMOD to determine the reduction of nutrient inputs necessary to achieve the desired targets. The model predicted an in-lake phosphorus concentration of 145 µg/L. This is about half of the actual observed values in Lake Darling. EUTROMOD takes into account tributary loading, but does not consider internal nutrient loading or recycling of phosphorus, which can help to explain the discrepancy between the monitored and calculated values. Lake Darling has a large population of rough fish, and the colloidal nature of the sediments make it difficult for them to settle out. This constant mixing of the water column in Lake Darling by the rough fish allows resuspension of sediment and nutrients from the lake bottom to considerably influence the water quality of the lake. The difference between the monitored and calculated in-lake phosphorous values can be explained in part by this large internal component. Based on these differences and the lake's susceptibility to internal nutrient loading, it is assumed that approximately half of the nutrient load originates from within the lake, while the other half is delivered to the lake from the watershed. In order to achieve a total phosphorous concentration of 100 µg/L, a 77% reduction in phosphorous loading is needed from a combination of internal and external sources. The current phosphorous load as determined by EUTROMOD is 35,257 lbs/year. Therefore, a 77% reduction from internal and external sources results in a Load Allocation for total phosphorous of 8,110 tons/year. Reductions of total phosphorous from internal sources will be achieved by in-lake improvements, including rough fish removal and shoreline stabilization. The Load Allocation for sediment established under this TMDL is 4,774 tons/year.

8.3 Margin of Safety

The margin of safety for this TMDL is implicit. The multiple targets for this TMDL assures that the designated uses will be restored regardless of the accuracy of the Phase I siltation and nutrient delivery targets. Failure to achieve water quality standards will result in review of the TMDL, allocations, and/or sediment management approaches and probable revision. In addition, calculations were made using conservative estimates.

9. Seasonal Variation

This TMDL accounts for seasonal variation by recognizing that (1) loading varies substantially by season and between years, and (2) impacts are felt over multi-year timeframes. Sediment and nutrient loading and transport are predictable only over long timeframes. Moreover, in contrast to pollutants that cause short-term beneficial use impacts and are thus sensitive to seasonal variation and critical conditions, the sediment and nutrient impacts in this watershed occur over much longer time scales. For these reasons, the longer timeframe (tons per year and pounds per year) used in this TMDL is appropriate.

10. Monitoring

Monitoring will be completed at Lake Darling as part of the Iowa Lakes Survey. In-lake water monitoring will be completed three times per year for each of the field seasons 2000 – 2004. In addition, the IDNR Fisheries Bureau will conduct an assessment of the fishery of Lake Darling in accordance with the Statewide Biological Sampling Plan protocol (Larscheid, 2001). This assessment will be completed after the lake restoration project is complete. At the completion of this assessment, the data will be evaluated to determine the listing status of Lake Darling.

A lake mapping and sediment core study was undertaken by the IDNR and USGS in the fall of 2002. This data will provide a bathymetric map of Lake Darling, estimates of sediment volume and location, and sediment core samples from the lake basin. This information will be used to determine more precisely the current amount and location of sediment in the lake, and also serve as a baseline for measuring TMDL implementation success. While this information is not available for the development of the TMDL, it will be very useful in Phase II of the TMDL.

11. Implementation

The Iowa Department of Natural Resources recognizes that an implementation plan is not a required component of a Total Maximum Daily Load. However, the IDNR offers the following implementation strategy to DNR staff, partners, and watershed stakeholders as a guide to improving water quality at Lake Darling.

The primary impact of sediment at Lake Darling is interference with reproduction and growth of fish and other aquatic life. Habitat degradation as a result of excess sediment contributes to the lake being assessed as not meeting water quality standards. Phase I of this TMDL reduces the sediment delivery to the lake. This will stop the continuing negative impact to the lake. The Lake Darling Watershed Project was first funded in 2001 to begin addressing sediment and nutrient delivery to Lake Darling. This project is funded by CWA Section 319 grant funds administered through the IDNR and Watershed Protection funds from the Iowa Department of Agriculture and Land Stewardship, Division of Soil Conservation. This project works cooperatively with landowners to install and implement best management practices in the watershed to reduce sediment and nutrient delivery to Lake Darling.

In addition, gully erosion within the timbered portions of the state park will be addressed by constructing sediment and water retention structures within the park. These structures will also be funded through CWA Section 319 funds. In-lake work needs include rip-rap along areas of eroding shoreline, rough fish removal, and establishment of emergent vegetation.

The three lagoons located in the watershed are currently in the planning stages of construction upgrades. Information regarding these lagoons and the planned upgrades is included in Part 7 of this document. Construction of the upgrades is tentatively planned in 2003 for all three of these sites.

The IDNR Fisheries Bureau will conduct an assessment of Lake Darling in accordance with the Statewide Biological Sampling Plan protocol (Larscheid, 2001) to characterize the condition of aquatic life. Sampling techniques for these surveys are outlined in "Standard Gear and Techniques for Fisheries Surveys in Iowa", 1995. This assessment will include growth, size structure, body condition, relative abundance, and species.

12. Public Participation

Public meetings regarding the procedure and timetable for developing the Lake Darling TMDL were held on January 14, 2002, in Des Moines, Iowa; and on January 22, 2002 in

Brighton, Iowa. A draft version of the TMDL was available for public notice from November 14 through December 6, 2002. Appropriate comments will be incorporated into the Lake Icaria Sediment TMDL prior to submittal to EPA for final approval.

13. References

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USDA/Natural Resources Conservation Service. 2000. Iowa Field Office Technical Guide- January 2000. “Predicting Rainfall Erosion Losses, The Revised Universal Soil Loss Equation (RUSLE)”, Section I, Erosion Prediction.

USDA/Natural Resources Conservation Service. 1998. Iowa Field Office Technical Guide Notice No. IA-198. “Erosion and Sediment Delivery Procedure”, Section I, Erosion Protection.

14. Appendix

Table 2. Data collected in 1979 by Iowa State University (Bachmann, et al, 1980).

Date Collected	7/6/1979	8/9/1979	9/5/1979
Secchi (meters)	0.5	0.5	0.4
Suspended Solids (mg/L)	24	24	18
Dissolved Oxygen (mg/L)	8.9	11.4	12.5
Ammonia Nitrogen (mg/L)			0.06
Total Phosphorus (mg/L) po4	0.241	0.381	0.298
Chlorophyll a (ug/L) Corrected	70.7	12.6	87.9

Samples collected near the surface

Table 3. Data collected in 1990 by Iowa State University (Bachmann, et al, 1994).

Date Collected	5/18/1990			6/23/1990			7/21/1990		
Sample Number	1	2	3	1	2	3	1	2	3
Secchi (meters)	0.6			0.5			0.05		
Suspended Solids (mg	25.4	22.6	33.5	321.4	307.1	253.8	128.8	114	115.4
Total Nitrogen (mg/L)	5.7	4.8	5	4.5	5	5.8	4.3	4.2	4.4
Total Phosphorus (mg	103.3	131.2	108.3	879.9	746.6	716.3	377.3	416.9	300
Chlorophyll a (ug/L) Corrected	87.1	68.3	51.2	1.5	7.3	1.2	10.5	5.3	7

Each sample was a composite water sample from all depths of the lake.

Table 4. Data collected in 2000 by Iowa State University (Downing and Ramstack, 2001)

Parameter	**6/28/2000**	**7/25/2000**	**8/15/2000**
Secchi Depth m	0.4	0.4	0.4
Chlorophyll (ug/L)	8	4	3
NH_3+NH_4^+ -N (ug/L)	1216	756	1277
NH_3 –N (un-ionized) (ug/L)	5	199	32
NO_3+NO_2-N (mg/L)	2.34	--	0.07
Total Nitrogen (mg/L as N)	3.44	2.02	1.95
Total Phosphorus (ug/l as P)	335	262	296
Silica (mg/L as SiO_2)	59	9	34
pH	6.9	8.8	7.6
Alkalinity (mg/L)	182	104	110
Total Suspended Solids (mg/L)	23.9	29.5	24.1
Inorganic Suspended Solids (mg/L)	18.1	17.1	14.4
Volatile Suspended Solids (mg/L)	5.8	12.4	9.6

Table 5. Data collected in 2001 by Iowa State University (Downing and Ramstack, 2002)

Parameter	5/30/2001	6/26/2001	7/30/2001
Secchi Depth m	0.1	0.4	1.0
Chlorophyll (ug/L)	--	14	28
NH_3+NH_4^+ -N (ug/L)	4488	1270	719
NH_3 –N (un-ionized) (ug/L)	12	57	108
NO_3+NO_2-N (mg/L)	3.96	5.33	2.93
Total Nitrogen (mg/L as N)	4.76	7.00	3.77
Total Phosphorus (ug/l as P)	432	215	110
Silica (mg/L as SiO_2)	95	28	11
pH	6.9	7.9	8.4
Alkalinity (mg/L)	65	88	100
Total Suspended Solids (mg/L)	112.4	38.1	21.0
Inorganic Suspended Solids (mg/L)	89.2	31.2	15.1
Volatile Suspended Solids (mg/L)	23.2	6.9	5.9

Table 6. Surface sample results from Lake Darling, collected by UHL 3/2002 – 8/2002.

Parameter	Min	Max	Median	St Dev
Secchi (m)	0.1	1.1	0.5	0.37
Ammonia Nitrogen as N (mg/L)	0.05	0.3	0.05	0.11
Chlorophyll a – corrected (ug/L)	2	160	23.5	60.14
Dissolved Oxygen (mg/L)	5.8	18.2	8.85	4.39
pH	7.4	9.6	8.6	0.85
Nitrate + Nitrite Nitrogen as N (mg/L)	0.1	5.8	3.55	2.1
Total Kjeldahl Nitrogen (mg/L)	1	2.4	1.1	0.55
Total Phosphate as P (mg/L)	0.05	0.3	0.125	0.11
Total Suspended Solids (mg/L)	2	38	14	12.34

Table 7. Mid-water column sample results from Lake Darling, collected by UHL 3/2002 – 8/2002.

Parameter	Min	Max	Median	St Dev
Ammonia Nitrogen as N (mg/L)	0.05	0.31	0.12	0.12
Chlorophyll a – corrected (ug/L)	1	55	16.5	19.9
Dissolved Oxygen (mg/L)	5.3	11.5	6	2.4
pH	7.1	8.4	7.85	0.57
Nitrate + Nitrite Nitrogen as N (mg/L)	0.1	5.7	3.7	2.07
Total Kjeldahl Nitrogen (mg/L)	0.8	2.8	1.2	0.74
Total Phosphate as P (mg/L)	0.06	0.37	0.16	0.13
Total Suspended Solids (mg/L)	8	37	18	9.87

Table 8. Bottom sample results from Lake Darling, collected by UHL 3/2002 – 8/2002.

Parameter	Min	Max	Median	St Dev
Ammonia Nitrogen as N (mg/L)	0.05	0.66	0.07	0.256
Chlorophyll a – corrected (ug/L)	1	40	18.5	16.74
Dissolved Oxygen (mg/L)	0.1	11.4	4.45	4.51
pH	7.3	8.4	7.6	0.48
Nitrate + Nitrite Nitrogen as N (mg/L)	0.1	4.9	3.8	1.9
Total Kjeldahl Nitrogen (mg/L)	0.79	2.8	1.25	0.75
Total Phosphate as P (mg/L)	0.07	0.72	0.26	0.24
Total Suspended Solids (mg/L)	8	56	42	18.7