Total Maximum Daily Load
For Siltation and Nutrients
Arbor Lake
Poweshiek County, Iowa

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Iowa Department of Natural Resources
TMDL & Water Quality Assessment Section

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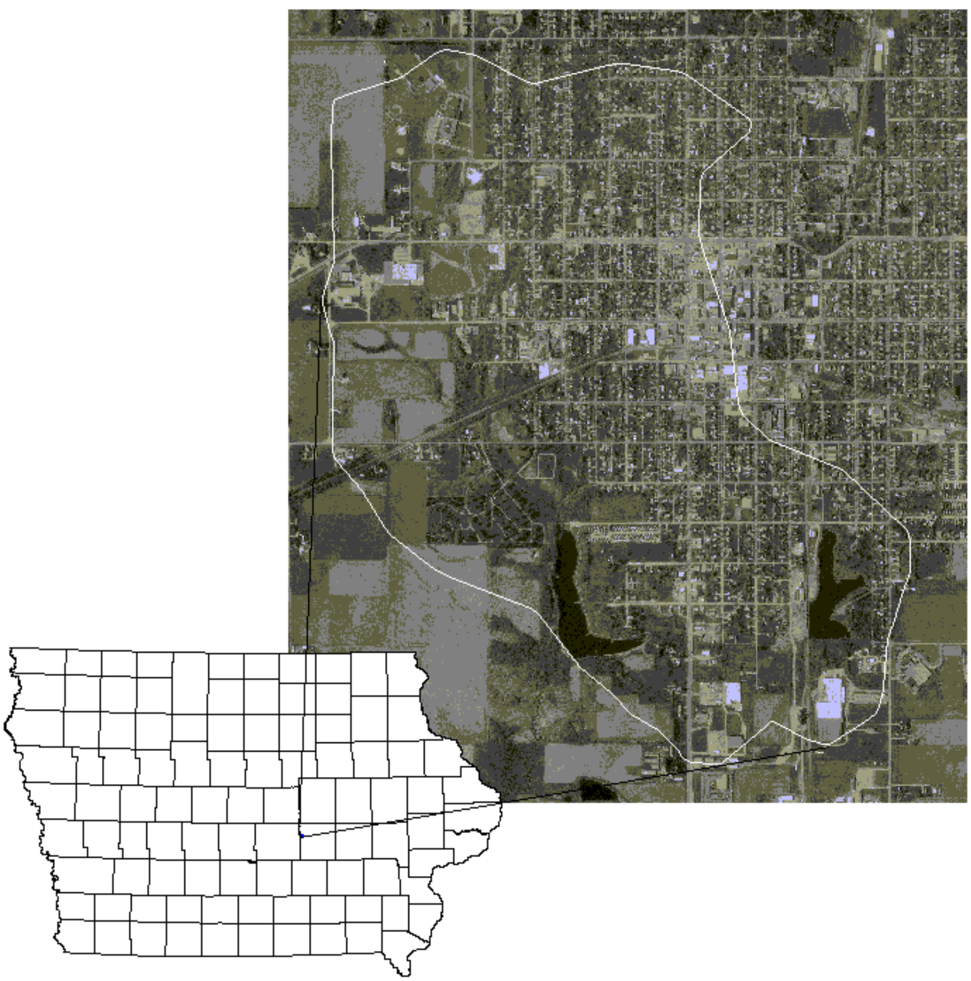
TMDL for Siltation and Nutrients
Arbor Lake
Poweshiek County, Iowa

Waterbody Name:	Arbor Lake
IDNR Waterbody ID:	IA 03-NSK-00330-L_0
Hydrologic Unit Code:	070801060204
Location:	Section 17 T80N R16W
Latitude:	41 Deg. 43 Min 56 Sec N
Longitude:	92 Deg. 43 Min 57 Sec W
Use Designation Class:	A (primary contact recreation) B(LW) (aquatic life)
Watershed:	1,069 acres
Lake Area:	14 acres
Major River Basin:	Skunk River Basin
Receiving Water Body:	tributary to Sugar Creek
Pollutant:	Siltation and Nutrients
Pollutant Sources:	Agricultural and Urban NPS
Impaired Use	Aquatic Life and Primary Contact
1998 303d Priority:	Low



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. Arbor Lake has been identified as impaired by siltation and nutrients. The purpose of these TMDLs for Arbor Lake 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 TMDLs for Arbor Lake will:

- Identify the adverse impact that siltation and nutrients are having on the designated uses of the lake and how the excess sediment and nutrient loads are impairing the water quality standards,
- Identify a target by which the waterbody can be assured to maintain its designated uses, and
- Calculate acceptable sediment and nutrient loads, including a margin of safety, and allocate to the sources.

The IDNR believes that sufficient evidence and information is available to protect Arbor Lake from further degradation by siltation and nutrients. The Department acknowledges, however, that additional information will likely be necessary. Therefore, in order to accomplish the goals of these TMDLs, a phased approach will be used. This will allow feedback from future assessments to be incorporated into the plan.

Phase I of this TMDL for Arbor Lake will be to reduce the sediment and nutrient loads that are impairing the primary contact and aquatic life uses. Phase II will evaluate the effect that the sediment and nutrient load targets have on the intended results. In Phase II, monitoring of Arbor Lake will continue and the allocation of sediment and nutrients will be reassessed. Phase II will include monitoring to evaluate the target sediment and nutrient loads, reevaluating the extent of the sediment 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

2.1 General Information

In 1903, the Grinnell Soft Water Company in cooperation with the Ladies Cemetery Association dammed a small tributary on the southwest edge of Grinnell and created Arbor Lake. The lake was built to provide soft water for the boiler system that provided heat to downtown Grinnell. Recreational opportunities were also provided by Arbor Lake, with a beach and pavilion on the east side of the lake, which were heavily used for many years. The beach and pavilion no longer remain at the lake.

Arbor Lake is located on the southwest edge of Grinnell, Iowa, and has a surface area of 14 acres, a mean depth of 7 feet, a maximum depth of 20 feet, and a storage volume of 103 acre-feet.

Arbor Lake is owned and managed by the City of Grinnell. Arbor Lake has designated uses of Class A (primary contact recreation) and Class B(LW) (aquatic life). The lake provides facilities for fishing, boating and picnicking. The lake was historically used for swimming, with a beach and clubhouse on the shore of the lake. However, the lake is no longer used for swimming and there are no facilities provided for doing so. In addition to the listed lake uses, a park on the east side of the lake and a walking trail around the lake are frequently used by area residents.

The Arbor Lake watershed has an area of approximately 1,069 acres and has a watershed to lake ratio of 76:1. The landuses and associated areas for the watershed are shown in the table below.

Table 1. Landuse in the Arbor Lake watershed (2000)

Landuse	Area in Acres	Percent of Total Area
Urban	759	71
Cropland	278	26
Other (timber, roads, etc)	32	3
Total	1,069	100

The Arbor Lake watershed is dominated by the urban landscape of the City of Grinnell. The city accounts for 71% of the watershed (759 acres). Cropland comprised 26 percent of the watershed (278 acres). The remaining area includes timber, county roads, and other uses.

While the majority of the watershed is established urban area, there has been some development in recent years adjacent to the lake and in the northwest portion of the Arbor Lake watershed. The majority of the development has been the construction of apartment complexes, which typically disturb larger areas and can be a considerable source of sediment if proper erosion controls are not in place.

3. Applicable Water Quality Standards

The *Iowa Water Quality Standards* (Iowa, 2000) list the designated uses for Arbor Lake as Primary Contact Recreation (Class A) and Aquatic Life (Class B(LW)). Arbor Lake also has general uses of secondary contact recreation, domestic uses, and wildlife watering.

The State of Iowa does not have numeric water quality criteria for siltation or nutrients that apply to Arbor Lake. The 1998 Iowa 305(b) report assessed the Class A uses as "not supporting" and the Class B(LW) uses of Arbor Lake as "fully supported-threatened" due to siltation and nutrients. Excess nutrients are causing algal blooms which are a violation of the narrative water quality standards stating that waters shall be free from aesthetically objectionable conditions and also free from nuisance or undesirable aquatic life (cyanobacteria) (Iowa, 2000). The aesthetically objectionable conditions and nuisance aquatic life present at Arbor Lake are impairing the Class A use (primary contact). In addition, excess siltation and nutrients are threatening the Class B(LW) designated use by potentially 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 are causing impairments to the aquatic habitat necessary for successful spawning and reproduction.

A large carp population is also partly responsible for the decline of the fishery at Arbor Lake. The carp population thrives in the shallow water areas created by the delivery of excess sediment to the lake, and are at least partly responsible for destruction of largemouth bass and bluegill nests, and consequently the survival of these species.

4. Water Quality Conditions

4.1 Water Quality Studies

Water quality surveys have been conducted on Arbor Lake in 1979, 1990, and 2000-01 (Bachmann et al., 1980; Bachmann et al., 1994; Downing and Ramstack, 2002). Monitoring in support of TMDL development was completed by University Hygienic Laboratory under contract with the IDNR from 2001-02.

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 3 in the Appendix.

Arbor Lake was sampled 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 4 and 5 (Appendix).

Arbor Lake and its tributaries were monitored from May 2001 to June 2002 by UHL under contract with the IDNR. The data collected during this study are presented in Tables 6-9 (Appendix).

Arbor Lake was modeled using CNET and EUTROMOD to determine the current phosphorous delivery to the lake. This modeling predicted the current phosphorous loading is 2,490 lbs/year.

4.2 Angling (Paul Sleeper, Fisheries Biologist, IDNR)
The fishery at Arbor Lake is doing fairly well considering the poor condition of the lake. Blue gill average length is 7 inches with some fish over 8 inches. These fish are all in good body condition. It is amazing the blue gill are doing as well as they are in such a poor environment. Largemouth bass are mainly between 10-12 inches with no fish sampled over 15 inches. Body condition is fair. There is a few white and black crappie in the lake, but just a few were sampled. The crappie that were sampled were between 8 - 10 inches and in good body condition. There is a descent channel catfish population. We stock 280 7 inch fish annually. We did not see many catfish in our survey, but the locals commonly catch fish in the 12-18 inch range. There is a growing population of common carp with some individuals over 20 pounds. They are constantly rooting around in the bottom sediments resuspending the silt and nutrients. The past few years surveys have indicated a strong year class of smaller (1-2 pound) carp. Grass carp have been periodically added to try to control the coontail, but has not made much difference.

Siltation has caused the most problems in the lake. The upper north arm by the boat ramp is severely silted in. Much of that end has only one foot or less of water. Coontail, filamentous algae and duck weed are so thick it makes the boat ramp unusable. Coontail covers up to 60-70% of the surface during the summer months. This makes most of the lake unfishable from shore. The water clarity remains pretty good with secchi disc readings commonly between 3-5 feet. Much of the silt and nutrients are being absorbed or filtered out by the dense vegetation in the upper arms before it enters the main lake.

I expect the fishery to continue to get steadily worse unless something is done to improve the conditions of the lake. My recommendation would be to drain the lake and dredge out the shallow sediment. This would allow us to eliminate the fish population and get rid of the common carp. The shorelines could be reshaped and fish habitat could be added to the lake.

5. Desired Target

The listing of Arbor Lake is based on narrative criteria. Arbor Lake has been assessed as "not supported" since 1994. The 1998 Iowa 305(b) report assessed the Class A uses as not supporting and the Class B(LW) uses of Arbor Lake as "fully supported-threatened" due to siltation and nutrients. Excess nutrients are causing algal blooms which are aesthetically objectionable and produce nuisance aquatic life. These are violations of the narrative water quality standards which are applicable to all of Iowa's waterbodies. In addition, excess siltation and nutrients are threatening the Class B(LW) designated use by potentially 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 are causing impairments to the aquatic habitat necessary for successful spawning and reproduction.

There are no numeric criteria for siltation or nutrients applicable to Arbor Lake or its sources in Chapter 61 of the Iowa Water Quality Standards (Iowa, 2000). The targets for Arbor Lake 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 Arbor Lake. 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 water body 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 Arbor Lake to below hypereutrophic. This would be reflected in a TSI of 70 or below. The current TSI based on chlorophyll-a is 68 and for total phosphorous is

80. The nutrient target for Arbor Lake will be measured by a Carlson TSI for total phosphorous of 70 or below. The chlorophyll-a TSI is already below 70, therefore the target for chlorophyll-a will be lowered to a TSI of 65.

The CNET and EUTROMOD modeling completed on Arbor Lake indicate the current phosphorous load to the lake is 2,490 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 1,100 pounds/year (56% 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 Arbor Lake and its watershed predicted a current sediment delivery of 546 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. Because phosphorous is typically bound with soil and sediment delivery, the initial or Phase I target for sediment is to reduce sediment loading by the same percent reduction for phosphorous, a 56% reduction. This sets the Phase I siltation target at 240 tons/year delivered to the lake.

5.3 Aquatic Life

The Phase II aquatic life target for this TMDL will be achieved when the fishery of Arbor Lake 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 Arbor Lake assessment will be compared with the benchmarks being developed. These assessments will include age, growth, size structure, body condition, relative abundance, and species composition.

Arbor Lake will not be considered restored until the Phase II (Aquatic Life) target is achieved. If the aquatic life target is achieved prior to the sediment and nutrient delivery target, then the level of land practices and best management 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 Arbor Lake. Excess siltation and nutrients are causing impairment of the Class A designated use and threatening the Class B(LW) designated use.

The Phase I nutrient target for Arbor Lake is to achieve a Carlson TSI for chlorophyll-a of 65 and for total phosphorous of 70. This initial target will bring the lake below hypereutrophy and result in an initial step towards restoring the aquatic life uses. The Phase I total phosphorous target with a TSI value of 70 results in a loading capacity of 1,100 pounds/year of phosphorous.

The Phase I sediment target for Arbor Lake is based on a reduction of the current modeled sediment delivery. This target results in a loading capacity of 240 tons/year of sediment delivered to the lake.

7. Pollutant Sources

The Arbor Lake watershed is dominated by the urban landscape of Grinnell. Urban landscapes provide more runoff during rainfall events due to the large areas of impermeable surfaces (roofs, pavement, etc.). The tributaries to Arbor Lake are fed by many storm sewer outfalls that direct the stormwater away from the city. This subjects the lake to very high flows during and following rainfall events.

Approximately 25% of the watershed is in rowcrop production. This area contributes sediment and nutrients through sheet and rill erosion, but is considered secondary in comparison to urban runoff. Gully erosion is not perceived to be a problem in the Arbor Lake watershed.

The sanitary sewer system runs along the west side of Arbor Lake. Historically, the sewer system would overflow near the lake, causing untreated sewage to enter the lake. These overflows were a significant source of nutrients to the lake, but were corrected in 1986 and 1992. This historic nutrient load can still cause water quality problems in Arbor Lake by being resuspended into the water column through wind and wave action, rough fish, or waterfowl.

Large populations of waterfowl (mostly Canada geese) are present at both Arbor Lake and Lake Nyanza, which drains to Arbor Lake. A portion of this population is expected to be a resident population, while others are migrants. Both lakes have aerators, which allow some open water through the winter months. Heavy geese populations can be significant contributors of phosphorous and fecal coliform.

The urban watershed provides many opportunities for pollutants to enter Arbor Lake. Lawn chemicals and fertilizers may enter the tributaries through runoff into the storm sewers. Sand, leaves, and other debris may also be washed into the lake through the stormwater system. The banks and bed of the tributaries to Arbor Lake are subjected to short bursts of high flows, subjecting them to scouring and providing a source of sediment and attached nutrient delivery to the lake.

8. Pollutant Allocation

8.1 Point Sources

Although the City of Grinnell does contribute stormwater to Arbor Lake, the city is not required to have a permit or to monitor the stormwater. There are no point source discharges in the Arbor Lake watershed. Therefore, the Wasteload Allocation for siltation and nutrients established under this TMDL is zero.

8.2 Non-Point Sources
The non-point source discharges are originating from sheet and rill erosion and runoff delivered largely through the stormwater system. The majority of the watershed is urban, with approximately 25% of the watershed in rowcrop production. The Load Allocation established under this TMDL is 1100 lbs/year of phosphorous delivered to the lake from internal and external sources. The Load Allocation for sediment established under this TMDL is 240 tons/year.

8.3 Margin of Safety
The margin of safety for this TMDL is implicit. The dual targets for this TMDL assures that the aquatic life uses will be restored regardless of the accuracy of the siltation and nutrient delivery target. 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) used in this TMDL is appropriate.

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

11. Implementation
An implementation plan is not currently a required component of a Total Maximum Daily Load. However, the IDNR, in cooperation with the NRCS field office, and the City of Grinnell are currently developing a watershed plan to implement best management practices and improve the water quality of Arbor Lake.

While improved practices are needed in the watershed and will benefit Arbor Lake, significant improvements in water quality may not be realized without the removal of the nutrient laden sediments from the lake. This would remove a source of nutrients, as well as deepening the lake and allowing it to stratify (reducing nutrient recycling).

12. Public Participation
Public meetings were held in Des Moines and Grinnell regarding the proposed TMDL for siltation and nutrients for Arbor Lake on January 14 and January 28, 2002. A public meeting was also held in Grinnell on November 20, 2002 to present and discuss the draft TMDL. Comments received were reviewed and given consideration and, where appropriate, incorporated into the TMDL.

13. References

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14. Appendix

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

Date Collected	6/27/79		7/31/79			8/30/79			
Depth (meters)	0	1	0	2	4	0	1	3	5
Secchi (meters)	0.4		0.4			0.7			
Suspended Solids (mg/L)	20.2	33.7	30.2	22.6	10.6	13.3	10.3	12.0	16.7
Dissolved Oxygen (mg/L)	8.5	8.4	12.8	0.6	0	19.9	12.0	2.7	0
Ammonia Nitrogen (mg/L)	--	--	--	--	--	--	--	--	--
Nitrate-Nitrite Nitrogen (mg/L)	--	--	--	--	--	0.16	--	--	--
Total Phosphorus (mg/L) po4	0.51	0.52	0.58	0.67	4.99	0.94	0.93	1.55	6.85
Chlorophyll a (ug/L) Corrected	3.0	25.4	131.7	59.1	24	131	44.2	7.5	12.0

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

Date Collected	5/30/1990			7/2/1990			7/30/1990		
Sample Number	1	2	3	1	2	3	1	2	3
Secchi (m)	1.4			0.9			0.7		
Suspended Solids (mg/L)	11.1	12.4	15.1	9.7	12.5	11.3	18.1	18.5	18.1
Total Nitrogen (mg/L)	3.8	3.7	3.7	3.1	3	2.8	2.4	2	2.1
Total Phosphorus (ug/L)	232	232	239	67	66	54	171	184	197
Chlorophyll a (ug/L) Corrected	42.8	51.3	59.8	35.2	36.1	24.6	84.2	76.8	84.9

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	6/26/00	7/24/00	8/15/00
Secchi Depth m	1.3	1.2	1.1
Chlorophyll (ug/L)	62	8	26
NH_3+NH_4^+ -N (ug/L)	411	396	1096
NH_3 –N (un-ionized) (ug/L)	1	38	7
NO_3+NO_2-N (mg/L)	0.19	1.38	0.13
Total Nitrogen (mg/L as N)	1.18	1.13	1.77
Total Phosphorus (ug/l as P)	196	324	441
Silica (mg/L as SiO_2)	30	20	23
pH	6.6	8.3	7.1
Alkalinity (mg/L)	120	140	124
Total Suspended Solids (mg/L)	5.7	9.5	14.0
Inorganic Suspended Solids (mg/L)	2.6	3.6	7.7
Volatile Suspended Solids (mg/L)	3.1	5.9	6.3

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

Parameter	5/30/01	6/25/01	7/30/01
Secchi Depth m	1.6	1.3	--
Chlorophyll (ug/L)	16	67	67
NH_3+NH_4^+ -N (ug/L)	343	895	454
NH_3 –N (un-ionized) (ug/L)	22	25	204
NO_3+NO_2-N (mg/L)	0.96	0.13	0.36
Total Nitrogen (mg/L as N)	2.34	2.78	1.36
Total Phosphorus (ug/l as P)	90	179	207
Silica (mg/L as SiO_2)	6	12	9
pH	8.3	7.9	9.0
Alkalinity (mg/L)	140	136	121
Total Suspended Solids (mg/L)	7.3	11.5	8.9
Inorganic Suspended Solids (mg/L)	2.7	0.5	2.0
Volatile Suspended Solids (mg/L)	4.6	11.1	7.0

Table 6. Surface sample results from Arbor Lake, collected by UHL 5/2001 – 6/2002

Parameter	Min	Max	Median	St Dev
Secchi (m)	0.1	3.7	1.05	0.9
Ammonia Nitrogen as N (mg/L)	0.04	1.8	0.09	0.5
CBOD –20day (mg/L)	6	180	19.5	43.9
Chlorophyll a – corrected (ug/L)	14	147	47	43.1
Dissolved Oxygen (mg/L)	5.7	21	11.7	3.8
pH	7.7	9.3	8.7	0.5
Nitrate + Nitrite Nitrogen as N (mg/L)	0.1	0.8	0.1	0.3
Total Kjeldahl Nitrogen (mg/L)	0.9	15	1.85	3.8
Ortho Phosphate as P (ug/L)	50	370	50	113
Total Phosphate as P (ug/L)	90	1100	210	320
Total Suspended Solids (mg/L)	2	60	8	15.3

Table 7. Mid-water column sample results from Arbor Lake, collected by UHL 5/2001 – 6/2002

Parameter	Min	Max	Median	St Dev
Ammonia Nitrogen as N (mg/L)	0.05	24	0.36	6.3
CBOD –20day (mg/L)	6	95	19.5	22.1
Chlorophyll a – corrected (ug/L)	7	200	79.5	56.02
Dissolved Oxygen (mg/L)	0.2	18.8	8.35	5.0
pH	6.8	9.2	8	0.68
Nitrate + Nitrite Nitrogen as N (mg/L)	0.1	1.2	0.1	0.3
Total Kjeldahl Nitrogen (mg/L)	0.98	24	2.3	6.3
Ortho Phosphate as P (ug/L)	50	830	50	255
Total Phosphate as P (ug/L)	100	9000	240	2300
Total Suspended Solids (mg/L)	3	26	12	6.7

Table 8. Bottom sample results from Arbor Lake, collected by UHL 5/2001 – 6/2002

Parameter	Min	Max	Median	St Dev
Ammonia Nitrogen as N (mg/L)	0.05	18	2.1	4.9
CBOD –20day (mg/L)	9	610	26.5	156
Chlorophyll a – corrected (ug/L)	2	146	78.5	47.7
Dissolved Oxygen (mg/L)	0.2	16.6	5.5	5.2
pH	6.7	9.3	7.3	0.8
Nitrate + Nitrite Nitrogen as N (mg/L)	0.1	0.6	0.1	0.1
Total Kjeldahl Nitrogen (mg/L)	1.3	19	3.3	5.2
Ortho Phosphate as P (ug/L)	50	1500	110	581
Total Phosphate as P (ug/L)	120	7300	800	1900
Total Suspended Solids (mg/L)	5	96	19	24.4

Table 9. Tributary sample results from Arbor Lake watershed, collected by UHL 5/2001 – 6/2002 (all sites combined)

Parameter	Min	Max	Median	St Dev
Ammonia Nitrogen as N (mg/L)	0.02	1.2	0.1	0.24
CBOD –20day (mg/L)	2	80	8	18.2
Dissolved Oxygen (mg/L)	4.8	12.6	9	2.3
pH	7.2	8.2	7.8	0.26
Nitrate + Nitrite Nitrogen as N (mg/L)	0.1	7.6	1.7	1.9
Total Kjeldahl Nitrogen (mg/L)	0.2	5.4	0.8	0.95
Ortho Phosphate as P (ug/L)	50	530	105	136
Total Phosphate as P (ug/L)	20	4600	200	820
Total Suspended Solids (mg/L)	1	420	10	101.4