Water Quality Improvement Plan
for

George Wyth Lake

Black Hawk County, Iowa

Total Maximum Daily Load
for Pathogens (*E. coli*)

Iowa Department of Natural Resources
Watershed Improvement Section
2008

Prepared by RESPEC for the Iowa DNR

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General Report Summary

The Federal Clean Water Act requires the Iowa Department of Natural Resources (IDNR) to develop a total maximum daily load (TMDL) for waters identified on the state's 303(d) list as impaired by a pollutant. George Wyth Lake is identified as impaired by pathogens. The purpose of this TMDL for George Wyth Lake is to calculate the maximum allowable pathogen load for the lake associated with *Escherichia coli (E. coli)* levels that will meet water-quality standards and/or beneficial uses.

This document consists of a dual-TMDL target for pathogens designed to provide George Wyth Lake water quality that fully supports its designated uses. Because the available data were collected only in the "beach section" of the lake and the immersion recreation primarily occurs in the waters adjacent to the beach, this TMDL will focus on the pathogen impairment of *E. coli* delivered to the near shore beach volume (NSBV). Using the NSBV is appropriate because it targets critical conditions, even though the water-quality standards for the designated uses apply throughout the whole lake.

This TMDL has been prepared in compliance with the current regulations for TMDL development promulgated in 1992 as 40 CFR Part 130.7. These regulations and consequent TMDL development are summarized below and in Table GRS-1.

Table GRS-1. George Wyth Lake summary.

Waterbody name	George Wyth Lake
County	Black Hawk
Water-quality standards designated uses	1. Primary contact recreation (Class A1) 2. Aquatic life support (Class B(LW))
Major river basin	Cedar River
Pollutant	Pathogens (*E. coli*)
Pollutant sources	Goose population on beach
Watershed area	484 acres
Lake surface area	75 acres
Lake volume	788 acre-feet
NSBV[(a)]	0.90 acre-foot
Receiving waterbody	None
Targets	One-time daily maximum: 235 *E. coli* colony forming units per 100 milliliters (cfu/100 ml) Geometric mean: 126 *E. coli* cfu/100 ml
Target total *E. coli* load	Daily maximum 1.50E+11 *E. coli* cfu/day[(b)] Geometric mean 8.03E+10 *E. coli* cfu/day[(c)]
Existing potential total *E. coli* load[(d)]	Up to 4.51E+12 *E. coli* cfu/day
Margin of safety	Implicit
Wasteload allocation	0 *E. coli* cfu/day
Load allocation	Daily maximum 1.50E+11 *E. coli* cfu/day[(b)] Geometric mean 8.03E+10 *E. coli* cfu/day[(c)]

(a) Because of the recreational use by small children—thought to be more susceptible to elevated bacteria levels—a distance of 10 feet into the lake from the beach was chosen, and the representative volume of water was estimated to be 0.90 acre-foot.
(b) Based on 235 cfu/100 ml target compliance in near shore beach value (NSBV).
(c) Based on 126 cfu/100 ml target compliance in NSBV.
(d) Based on the number of resident geese and per capita *E. coli* load.

1. Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established.

George Wyth Lake, Section 6 T89N R13W, within the Waterloo-Cedar Falls metropolitan area, Black Hawk County.

2. Identification of the pollutant and applicable water-quality standards are the cause of the water-quality impairments (pathogens associated with excessive loading of fecal material).

Designated uses for George Wyth Lake are Primary Contact Recreation (Class A1) and Aquatic Life Support (B (LW)). Excess pathogen loading has caused an exceedence of *E. coli* concentrations resulting in impairment of the primary contact recreation beneficial use as described in the Iowa Administrative Code [Iowa Administration Code, 2006].

3. Quantification of the pollutant load that may be present in the waterbody and still allow attainment and maintenance of water-quality standards.

For this TMDL, a daily maximum load and geometric mean load were identified. This effectively sets a bounding range of loads that will result in compliance of the water-quality standards. These load criteria apply during the recreational season from March 15 to November 15 of each year. Based on model results, the geometric mean load and daily maximum load that may be present in the NSBV, and still attain water-quality standards, are 8.03E+10 *E. coli* cfu/day and 1.50E+11 *E. coli* cfu/day, respectively.

4. Quantification of the amount or degree by which the current pollutant load in the waterbody, not accounting for direct deposition in the lake, deviates from the pollutant load needed to attain and maintain water-quality standards.

The existing potential instantaneous *E. coli* load to the beach section of the lake is up to 4.51E+12 cfu/day, given the approximate population of 100 resident geese on the beach. This load is significantly greater than the allowable load for the NSBV.

5. Identification of pollution source categories.

The large goose population residing on the beach near the water's edge was identified as the primary nonpoint source of pathogen load. Other typical point and nonpoint sources were investigated and determined to be insignificant.

6. Wasteload allocations for pollutants from point sources.

No point sources were identified. Therefore, the wasteload allocation (WLA) was set to zero.

7. Load allocations for pollutants from nonpoint sources.

After pairing precipitation (from Waterloo Airport) and concentration data, no significant correlation could be made to designate a nonpoint source influence from the watershed. Though a significant correlation between precipitation and *E. coli* concentration is not apparent, it is not dismissed as nonexistent. However, from land use investigations, it is known that no significant sources of *E. coli* loads exist within the watershed from other than the geese on the beach. Furthermore, sampling from a watershed runoff inlet to the lake did not yield significant results for pathogens. Though a deer population exists in the park, the watershed boundary follows the southern border of George Wyth Lake and deer are not reported to populate the beach at any time. Because of this, the natural background levels are considered negligible. The only nonpoint source load at the beach section comes from the goose population residing on the beach. Therefore, the total pathogen load allocation (LA) was restricted to the goose loading from the beach at 1.50E+11 *E. coli* cfu/day for a daily maximum load and 8.03E+10 *E. coli* cfu/day for a geometric mean load.

8. A margin of safety.

An implicit margin of safety (MOS) was used in the development of this TMDL. Using a near shore beach volume (NSBV) instead of the entire lake volume, assigning conservative model parameters, and using a Monte Carlo simulation to explore uncertainties in model predictions are all conservative assumptions built into the mass balance model approach of this TMDL.

9. Consideration of seasonal variation.

This TMDL was developed based on the pathogen loading that will result in attainment of water-quality targets for the recreational season (March 15 through November 15) in the NSBV.

10. Allowance for reasonably foreseeable increases in pollutant loads.

An allowance for increased pathogen loading was not included in this TMDL. Significant changes in the George Wyth Lake Watershed land use are unlikely. Likewise, the deer population is unlikely to change because the park allows a hunting season to keep numbers down. The goose population has been declining in recent years because of managerial efforts by George Wyth State Park staff.

11. Implementation plan.

Suggestions for continual and new management practices are discussed in the body of this report.

1. George Wyth Lake, Description and History

1.1. The Lake

George Wyth Memorial State Park (GWMSP) is located adjacent to the Cedar River within the Waterloo-Cedar Falls metropolitan area. The large woodland area is abundant with many varieties of wildlife. White-tailed deer and more than 200 different species of birds can be seen year-round. The park has been designated as a National Urban Wildlife Sanctuary [Iowa Department of Natural Resources (IDNR), 2007a].

The park was dedicated in 1940 as “Josh Higgins Parkway,” named after a popular radio character. In 1956, it was renamed George Wyth Memorial State Park after a well-known Cedar Falls businessman and conservationist [IDNR, 2007b].

Public use for the park and lake is estimated at approximately 800,000 visitors per year [Dusenberry, 2007]. Users of the lake and of GWMSP enjoy fishing, swimming, picnicking, hiking, bicycling, bird watching and boating. Table 1-1 presents summary information on George Wyth Lake.

Table 1-1. George Wyth Lake features.

Waterbody Name	George Wyth Lake
Hydrologic unit code	HUC10 0708020504
IDNR waterbody ID	IA 02-CED-00485-L_0
Location	Section 6 T89N R13W
Latitude	42° 32’ 09” N
Longitude	92° 24’ 11” W
Water-quality standards designated uses	1. Primary contact recreation (A1) 2. Aquatic life support (B(LW))
Tributaries	None (borrow lake)
Receiving waterbody	None
Lake surface area	75 acres
Maximum depth	17 feet
Mean depth	8 feet
Volume	788 acre-feet
Near shore beach volume (NSBV)	0.9 acre-foot
Watershed area	484 acres
Watershed/lake area ratio	6.5:1

1.2. Morphometry

George Wyth Lake has a mean depth of 8 feet, a surface area of 75 acres, and a storage volume of approximately 788 acre-feet. The shallower western section of the lake has a maximum depth of about 5½ feet and a deeper central and eastern section with a maximum depth of 17 feet (Figure 1-1). The beach is located on the south shore of the western section. Stratification has been shown to occur in George Wyth Lake [IDNR, 2006]. However, because the lake is fairly shallow and windswept, stratification, if any, occurs for only brief periods each year.

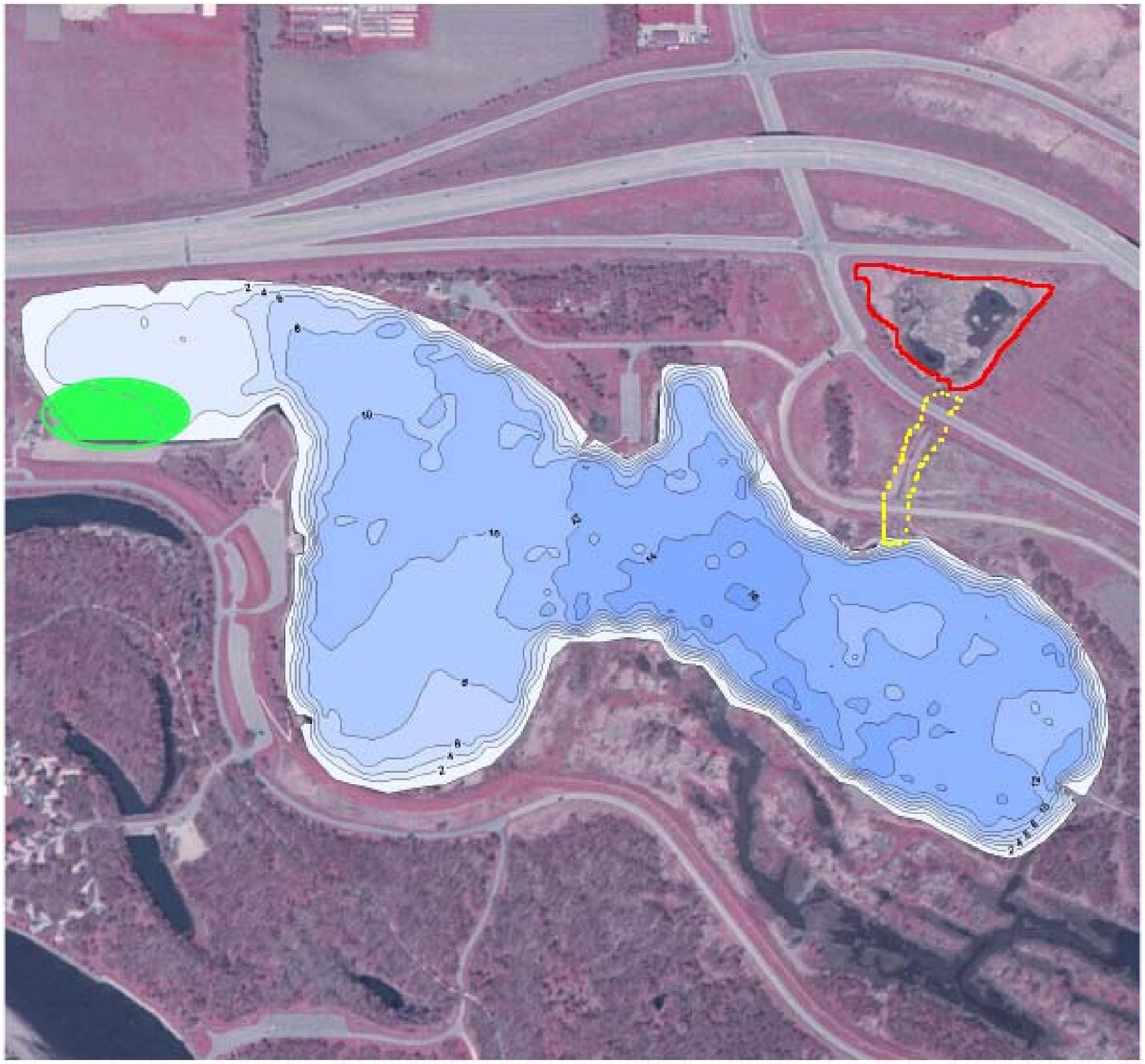

Figure 1-1. Overview of George Wyth Lake. The red outline shows the detention structure/wetland, yellow-dotted line indicates the culvert draining the wetland to the lake on the northeast shore, green ellipse represents the beach area. The Cedar River can be seen in the lower left corner.

1.3. Hydrology

George Wyth Lake is a borrow lake and is in subsurface hydraulic connection with the Cedar River that flows approximately ¼ mile away. A rise in lake water level can be seen about 14 days after a rise in the Cedar River [Dusenberry, 2007]. Average precipitation in the area is 35 inches per year, with 75 percent of the precipitation falling between April and September.

1.4. The Watershed

The George Wyth Lake Watershed (Figure 1-2) has an area of approximately 484 acres (see Figure 1-2). With a lake area of 75 acres, the watershed-to-lake ratio is 6.5:1. This is a moderate ratio, meaning that a fairly small concentration of bacteria per acre in runoff can accumulate to a large overall load. However, the land use surrounding George Wyth Lake does not support significant pathogen loadings. The watershed is connected to the lake via a detention structure/wetland and culvert (Figure 1-1). Anecdotal evidence claims that runoff into the lake from the detention structure/wetland is rare. The watershed is relatively flat (0 – 2 percent slope), clay loam soil and urban land complex. The major soil type within the watershed is Marshan Clay Loam. A large amount of the remainder of the watershed falls into Orthents, Wiota and Finchford urban land complex.

1.5. Landuse

The watershed landuse is predominately industrial and commercial. George Wyth Lake is in close proximity to Highway 218 that runs along the north and wraps around the east side of the lake. Watershed landuse information is shown in Table 1-2 [IDNR, 2002]. There are no livestock located within the watershed [Dusenberry, 2007].

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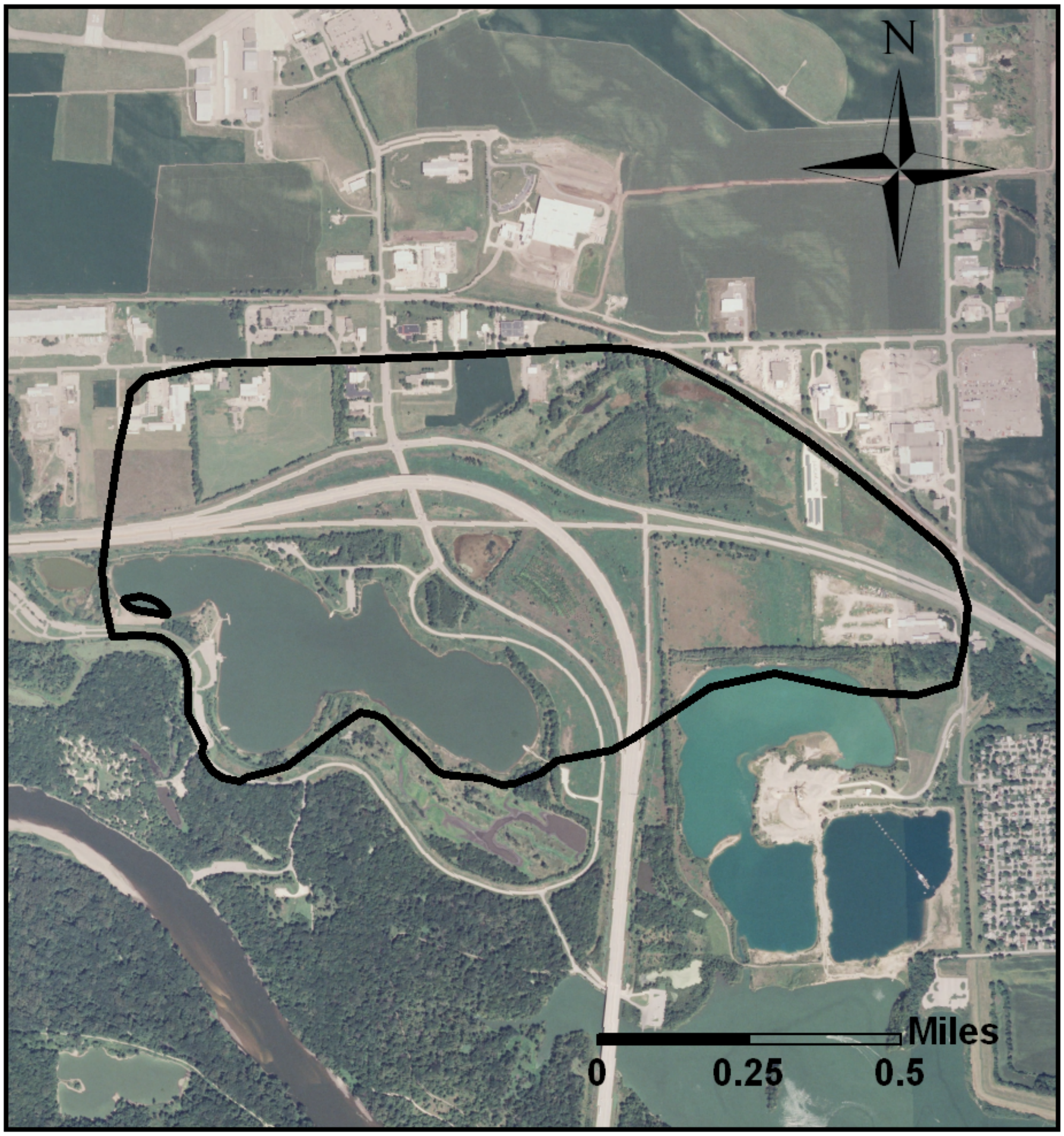

Figure 1-2. George Wyth Lake Watershed and Beach Section (Inset Black Outline).

Table 1-2. 2002 landuse in the George Wyth Lake watershed.

Land use	Area (acres)	Percent of total area
Commercial/Industrial	152	31
Row crops	109	23
Grassland	97	20
Water/Wetland	50	10
CRP/Alfalfa	43	9
Forest	17	4
Residential	15	3
Total	**484**	**100**

2. Total Maximum Daily Load for Pathogens

2.1. Problem Identification

In 2004, George Wyth Lake was included on the impaired water list as recommended by the IDNR Fisheries Bureau and Beach Monitoring Program because of elevated levels of indicator bacteria (fecal coliform and *E. coli*) that exceeded the water-quality standard. This assessment was based on IDNR beach monitoring data.

This document consists of a dual Total Maximum Daily Load (TMDL) target for pathogens designed to provide George Wyth Lake water quality that fully supports its designated uses. Because the available data were collected only in the “beach section” of the lake and the immersion recreation primarily occurs in the waters adjacent to the beach, this TMDL will focus on the pathogen impairment of *E. coli* delivered to the near shore beach volume (NSBV). Using the NSBV is appropriate because it targets critical conditions, even though the water-quality standards for the designated uses apply throughout the whole lake.

2.2. Impaired Beneficial Uses and Applicable Water-Quality Standards

The Surface Water Classification document [IDNR, 2004] lists the designated use for George Wyth Lake as Class A1 and Class B(LW). The Iowa water-quality Standards [Iowa Administrative Code, 2006] describe these use classifications as follows:

Primary contact recreational use (Class A1). Waters in which recreational or other uses may result in prolonged and direct contact with the water, involving considerable risk of ingesting water in quantities sufficient to pose a health hazard. Such activities would include, but not be limited to, swimming, diving, waterskiing and water contact recreational canoeing. Recreational use applies between March 15 and November 15 of each year.

Lakes and wetlands (Class B(LW)). These are artificial and natural impoundments with hydraulic retention times and other physical and chemical characteristics suitable to maintain a balanced community normally associated with lake-like conditions.

George Wyth Lake was added to the impaired waters list for violating the state of Iowa water-quality standard for bacteria, which was based on fecal coliform criteria. The standard stated that levels shall not exceed a geometric mean of 200 colony forming units per 100 milliliters (cfu/100 ml) or a one-time sample maximum of 400 cfu/100 ml. In 2002, the Iowa water-quality standard for fecal coliform was replaced by a water-quality standard for *E. coli*. The new *E. coli* standard states that levels shall not exceed a geometric mean of 126 cfu/100 ml or a one-time daily maximum of 235 cfu/100 ml. Because the goal of this TMDL is to meet current water-quality standards, loads and allocations are presented based on the *E. coli* standard.

2.3. Data Sources

Water-quality data for this TMDL was compiled from the IDNR Beach Water Monitoring Program. Two separate datasets were used:

- Data for *E. coli* were collected from June 1999 through October 2006 at George Wyth Lake beach. Before 2002, one sample was taken at a knee-deep location in the center of the NSBV. On a weekly basis since 2002, a total of nine grab samples were taken from three transects across the beach and at three depth locations (ankle, knee and chest). The samples were then field-composited into one representative sample for the NSBV.
- Intensive data for *E. coli* were collected on July 11, July 31 and August 13, 2007, at the beach at George Wyth Lake. The nine total samples were collected in the same manner as previous sampling, except no field-compositing was done and concentration data were recorded for each sample.

2.4. Interpreting George Wyth Lake Water-Quality Data

High concentrations of *E. coli* were detected as early as June of both 1999 and 2000 (Figure 2-1). During the monitoring period, June 1999 – October 2006, 10.8 percent of the samples exceeded the one-time daily maximum standard of 235 *E. coli* cfu/100 ml during the recreational season. The summer months of July and August have the highest rate of exceedence at 17.9 percent and 17.1 percent, respectively. Table 2-1 summarizes the data collected during the monitoring period.

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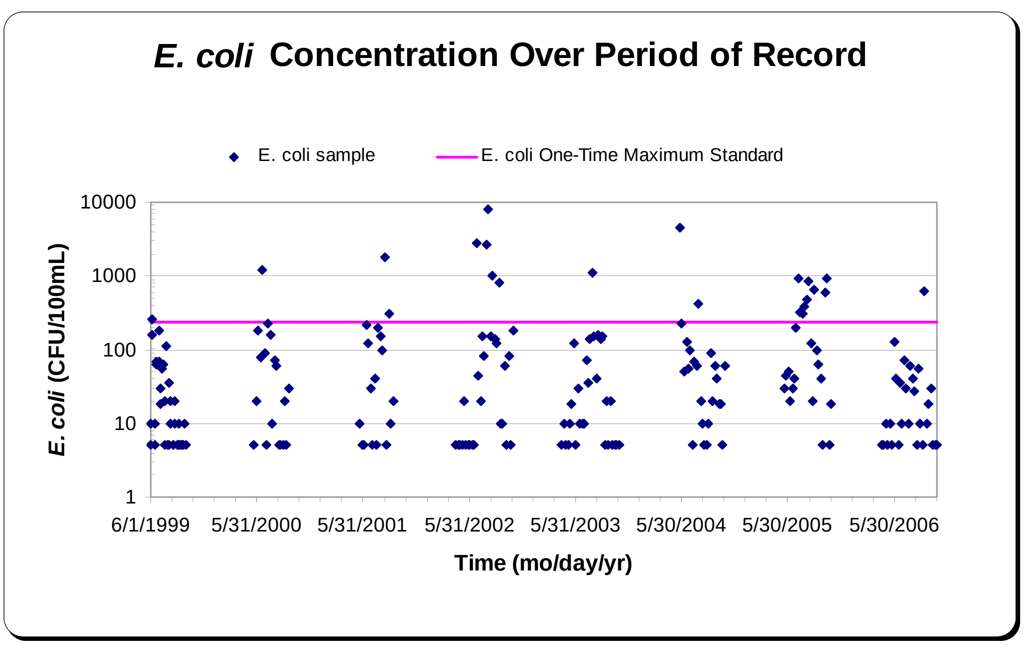

Figure 2-1. *E. coli* Concentration Data Collected for the Period of Record, June 1999 to October 2006.

Table 2-1. *E. coli* concentration exceedances for the period of record, June 1999 to October 2006.

Input/Summary				
Exceedance criteria		235 cfu/100 ml		
No. of samples		204		
No. of times exceeded		22		
Month	**Monthly$_{avg}$ precipitation (in)**	**No. samples**	**No. exceeding**	**% Exceedance**
April	2.9	8	0	0.0
May	6.4	22	1	4.5
June	4.8	39	3	7.7
July	5.9	39	7	17.9
August	3.0	41	7	17.1
September	1.9	35	2	5.7
October	1.5	20	2	10.0
Total		**204**	**22**	**10.8**
Year	**Yearly precipitation (in)**	**No. samples**	**No. exceeding**	**% Exceedance**
1999	24.2	36	1	2.8
2000	32.0	18	1	5.6
2001	32.2	17	2	11.8
2002	30.9	29	5	17.2
2003	28.2	29	1	3.4
2004	34.8	23	2	8.7
2005	28.1	24	9	37.5
2006[(a)]	—	28	1	3.6
Total		**204**	**22**	**10.8**

(a) Readily-available data ended in 2005.

The *E. coli* concentration data were paired with precipitation data obtained from the Waterloo Airport and analyzed on a yearly basis to determine if a correlation between precipitation and bacteria concentration could be made. The plots obtained (Figures C-1 through C-7 in Appendix C) showed no significant correlation between precipitation and *E. coli* concentrations. In 2003 (Figure C-5), there appeared to be a slight correlation in the form of a dilution effect (i.e., for increased precipitation, there are lower concentration values). However, a definitive relationship cannot be made for any year. Though a significant correlation between precipitation and *E. coli* concentration is not apparent, it is not dismissed as nonexistent. However, from land use investigations, it is known that no significant sources of *E. coli* loads exist within the watershed from other than the geese on the beach. Therefore, the high concentrations recorded in the NSBV do not appear to be linked to a nonpoint source influence from the upper watershed.

The *E. coli* data used in analyses were from samples collected in the NSBV of George Wyth Lake. Figure 2-2 is an image from Iowa's Ambient Monitoring Program showing the sample locations in the NSBV and concentrations recorded from the intensive sampling data collected August 28, 2002 [IDNR, 2005]. The figure shows a concentration that decreases as a function of distance from the beach.

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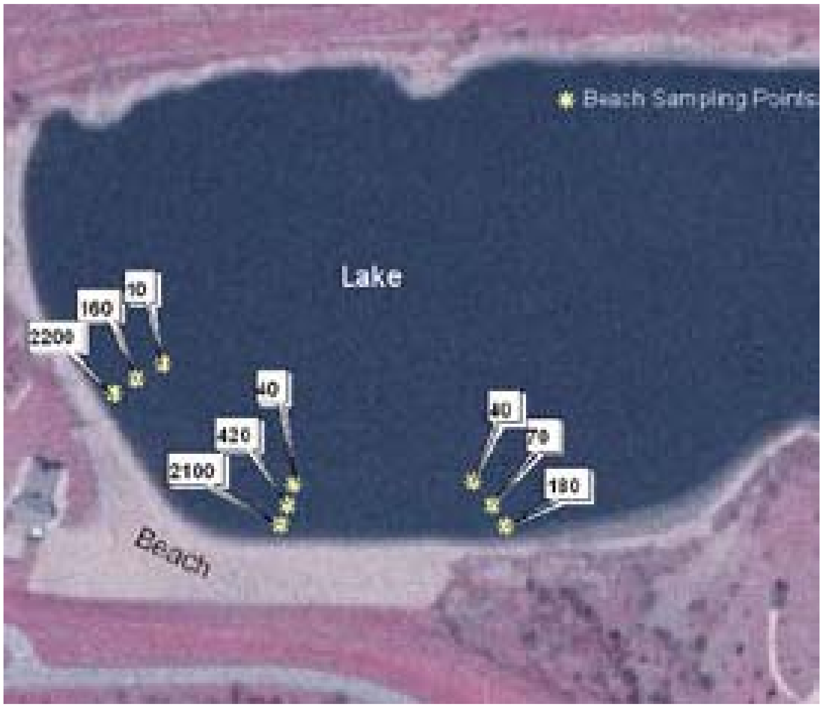

Figure 2-2. Concentrations at Ankle-, Knee- and Chest-Deep Locations in the Near Shore Beach Volume From the Intensive Sampling Data Collected August 28, 2002 [IDNR, 2005].

The only inflow to the lake is from a culvert at the northeast shore (Figure 1-1). The culvert carries storm runoff from a small detention pond/wetland. Lake water samples were taken where the culvert opens to the lake both prior to and after rainfall events [Eberhard, 2007]. Mr. Gary Dusenberry, a GWMSP ranger and lake resident (located on the northern shore), stated that sampling has also been performed on his own initiative off of the dock at his lake residence. *E. coli* concentrations of samples taken at the culvert location and from Mr. Dusenberry's dock were nondetectable [Dusenberry, 2007].

The combination of the inconclusive nonpoint watershed source correlation, the alternate sampling locations yielding insignificant results, and Figure 2-2 indicate that the primary cause of the pathogen impairment in the NSBV is from the beach and likely the geese.

2.5. Total Maximum Daily Load Target

Criteria for Assessing Water-Quality Standards Attainment. Water-quality standards in the state of Iowa [Iowa Administrative Code, 2006] have dual criteria for bacteria.

Geometric Mean. *E. coli* levels shall not exceed a geometric mean of 126 cfu/100 ml of water.

Daily Maximum. *E. coli* levels shall not exceed a sample maximum of 235 cfu/100 ml of water.

Selection of Environmental Conditions. The critical condition for this pathogen TMDL is limited seasonally. Recreational uses of Iowa lakes that involve bodily contact with the water occur primarily in the spring, summer and fall. For this reason, the *E. coli* standard for Class A Primary Contact Recreational Use only applies between March 15 and November 15.

The primary contact recreation use period coincides with the seasonal migratory patterns of geese in this area. The largest population of geese on the beach at George Wyth Lake occurs during the spring, summer and fall seasons. The bacteria loads generated by geese can significantly impact water quality. Therefore, this TMDL focuses on controlling the bacteria load from the goose population in the beach section at George Wyth Lake.

Waterbody Pollutant Loading Capacity. The load capacity for this TMDL is based on achieving an *E. coli* concentration less than the daily maximum of 235 cfu/100 ml and the geometric mean of 126 cfu/100 ml in the NSBV at George Wyth Lake. The dual-target concentrations were determined to be achievable by controlling the population of geese in the NSBV and/or the transport efficiency of loads generated by geese on the shore to the waterbody.

2.6. Pollution Source Assessment

Direct Sources. There are no permitted point sources in the George Wyth Lake Watershed. There is one restroom facility located near the beach that is connected with city water and sewer [Eberhard, 2007]. The lines have been pressure tested and show no leaks.

Indirect Sources. The nonpoint sources of pathogens in the George Wyth Lake watershed include deer and pet wastes. Approximately 80 deer populate GWMSP throughout the year. There are no cattle or other livestock within the watershed. Approximately 100 geese are known to roost on the beach at George Wyth Lake [Dusenberry, 2007]. Because the watershed is so small, it was assumed that no other goose population resides within the watershed creating nonpoint loading. Less than five people per day enter GWMSP with pets. The pets are allowed on hiking trails but not on the beach [Dusenberry, 2007]. Because of the low numbers of pets and their restriction from the beach, the bacteria contributions of pets were considered negligible.

Area highway maps were obtained from the Waterloo Engineering Department. The only source of watershed runoff (influent to the lake) is from a culvert at the northeast side of the lake.

Natural Background Conditions. Natural background levels are evaluated as entities naturally occurring in the environment like wildlife. The George Wyth Lake Watershed slope along the southern boundary is steep down to the edge of the lake. For this reason, and because deer do not spend a significant amount of time near or in the water at the beach, the natural background levels of the deer population were considered minimal. To control animal numbers, GWMSP has allowed a deer hunting season within the park the past few years. After the hunting season, the population within the park is thought to dip to around 40 deer [Dusenberry, 2007].

Existing Load. The only significant *E. coli* load source identified in the beach section at George Wyth Lake is the goose population roosting on the beach. This goose population poses a considerable threat to the health and safety of people immersing in the NSBV.

Managers at George Wyth State Park estimate that 100 geese reside in the park throughout the recreational season. When the lake freezes in the winter, the geese move to the Cedar River nearby [Dusenberry, 2007]. Behavioral patterns of geese can provide insight into characterizing the loads they produce. South Dakota Waterfowl Biologist Mr. Paul Mammenga has worked extensively with geese and said that geese spend most of their time in the “corridor” between the food source and water’s edge. He also said that geese will deposit droppings while on the water [Mammenga, 2007].

Bacterial loads from geese are approximately 4.9E+10 fecal coliform organisms per goose per day [United States Environmental Protection Agency (U.S. EPA), 2001]. *E. coli* is a subset of fecal coliform bacteria, so fecal coliform data were converted to *E. coli* using the following equation developed by IDNR which represents the ratio of *E. coli* to fecal coliform that has been detected in water bodies in Iowa:

$$E.\,coli = FC \times 0.92 \tag{2-1}$$

Using the equation above, the bacteria load generated from geese is about 4.51E+10 *E. coli* organisms/day-goose. Based on the assumption that 100 resident geese spend the majority of their time in or near the lake when it is not frozen, the possible total loading to the beach section is 4.51E+12 *E. coli* cfu/day during the recreational season. This conservative estimate assumes all the geese are present and 100 percent of the generated load is received by the lake, both of which are unlikely.

2.7. Linkage of Sources to Target

Two approaches were taken to illustrate the potential impact of bacteria loads from geese. The approaches used Equations 2-2 and 2-3 which represent steady-state concentrations due to a load, *W*, without and with diffusion, respectively (Equations 3.17 and 16.31 from Chapra [1997].

$$C = \frac{W}{\left(Q + kV + vA_s\right)} \tag{2-2}$$

$$C = \frac{W}{\pi HE} K_0 \sqrt{\frac{kr^2}{E}} \tag{2-3}$$

where:

$$
\begin{aligned}
V &= \text{volume of water } \left(\text{length}^3\right) \\
W &= \text{mass loading rate percentage (mass/time)} \\
Q &= \text{flow rate } \left(\frac{\text{length}^3}{\text{time}}\right) \\
H &= \text{depth, corresponding with radius (length)} \\
E &= \text{diffusion } \left(\frac{\text{length}^2}{\text{time}}\right) \\
k &= \text{decay rate } \left(\text{/time}\right) \\
r &= \text{radius/distance from beach (length)} \\
c &= \text{concentration} \left(\text{mass/length}^3\right) \\
K_0 &= \text{first-order modified bessel function of the second kind: } f\left(k, r, E\right) \text{(-)} \\
A_s &= \text{area of bottom surface} \left(\text{length}^2\right).
\end{aligned}
$$

Model 1 – No Diffusion (Equation 2-2). The inflow and outflow of water to the lake is relatively negligible and removal of mass through settling can be encapsulated through the decay rate. Because of the recreational use by small children – thought to be more susceptible to elevated bacteria levels – a distance of 10 feet into the lake from the beach was chosen, and the representative volume of water was estimated to be 0.90 acre-foot. Thus, Equation 2-2 can be reduced to the following and assumes that the load *W* is completely mixed in the volume *V*.

$$W = kVc \tag{2-4}$$

where:

$$
\begin{aligned}
k &= 1.6 \text{ per day} \\
V &= 0.9 \text{ acre-foot} \\
c &= \frac{235 \text{ cfu}}{100 \text{ ml}} \text{ or } 2.90\text{E+09 cfu/acre-foot.}
\end{aligned}
$$

An average decay rate (*k*) of 1.6 per day was taken from Bowie et al. [1985]. The allowable bacteria load was calculated as 4.17E+9 *E. coli* cfu/day. This load equates to the daily load generated by approximately 0.1 goose (and represents the daily allowable steady-state load). These results show that as few as ten geese could cause water-quality violations in the NSBV with minimal transport of one percent of the generated load.

Model 2 – Diffusion (Equation 2-3). This model was created to characterize the allowable load when diffusion of organisms within the water column was considered within the NSBV. Table 2-2 gives the parameter values used for this model. Ranges and uniform distributions were assigned for parameters with higher uncertainty.

Table 2-2. Values and distributions assigned to parameters in Model 2.

Parameter	Value/range	Units
W	4.51E+10	*E. coli* per day per goose
H	3	ft
E	930 to 9.3E+08	Feet squared per day (ft^2/day)
k	1 to 2	per day
r	10	ft
c	2.90E+09	cfu/ acre-feet

A Monte Carlo simulation using Equation 2-3 was then performed. The simulation involved exercising Equation 2-3 1,000 times with parameters being assigned using Latin Hypercube Sampling (LHS) for each iteration. For a volume of 0.90 acre-foot, the allowable daily maximum bacteria load from geese was estimated as 1.50E+11 *E. coli* cfu/day. Likewise, the allowable geometric mean bacteria load from geese was estimated as 8.03E+10 *E. coli* cfu/day. These loads represent the median loads of the 1,000 results and equate to the daily loads generated by approximately three geese (daily maximum) and two geese (geometric mean).

A comparative model was created to understand which equation (model) could best represent conditions found in the field. Radius values were chosen so that a gradient of expected concentrations could be seen. Note that changing the radius values resulted in a change in volume, and, hence, concentration. The results of this comparative model, shown in Figure 2-3, are two boxplots of estimated E. coli concentrations that are governed by the two Equations, 2-2 and 2-3, on the top and bottom, respectively. The box has lines at the lower quartile, median, and upper quartile values. Whiskers extend from each end of the box to the most extreme values within 1.5 times the interquartile range from the ends of the box. Outliers are values beyond the ends of the whiskers and are displayed with a red + sign. The effect of introducing diffusion can be seen from the figure. The boxplot for Equation 2-3 (bottom) seemed to represent the findings from the field. It can be seen that concentration spikes as high as 8,100 cfu/ 100 ml within 20 feet are, at least, probable. A concentration of 8,100 cfu/100 ml was used as an upper limit because it was the maximum concentration from the field data. This comparative model used a varying transport efficiency factor that incorporated uncertainty in natural conditions. The transport efficiency factor was used for both equations, and is, essentially, a factor that bridges the gap between uncertain field conditions and trying to model results obtained from the field. The transport efficiency factor represents the fraction of generated load which is received by the waterbody after transport and fate processes. Transport efficiency was characterized as a percentage of the total possible generated bacteria load that can be available for contamination of the NSBV. This factor also provided insight into implementation and management practices.

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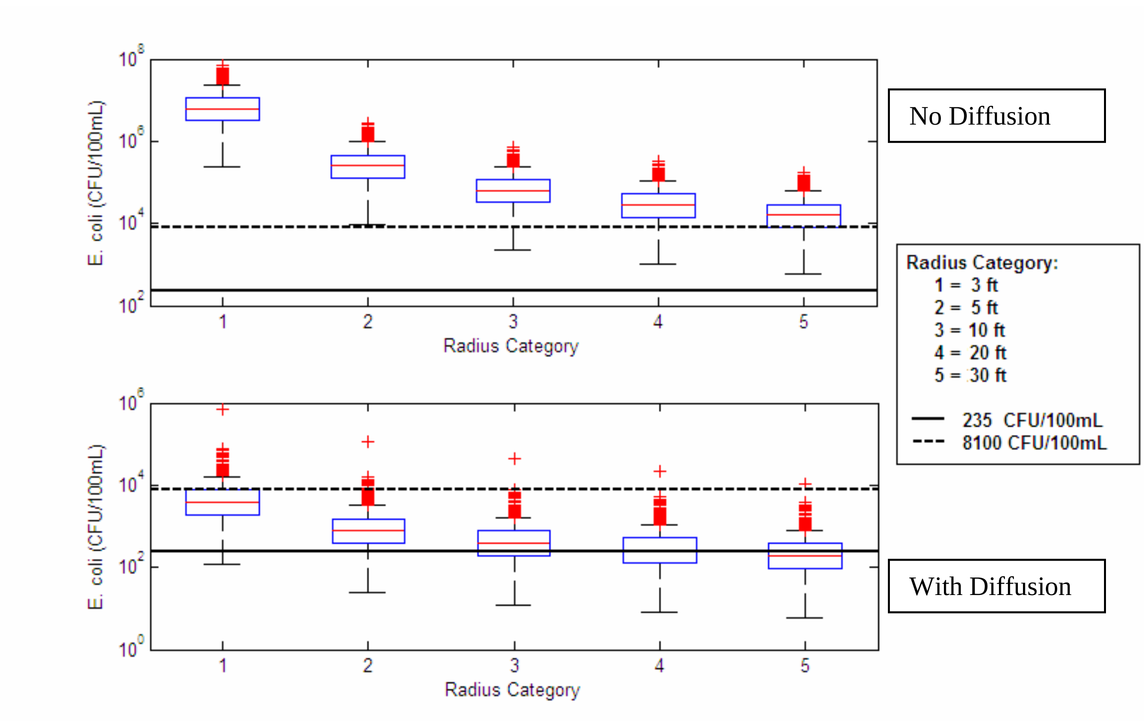

Figure 2-3. Boxplots of Estimated *E. coli* Concentrations Governed by Different Equations.

2.8. Pollutant Allocation

TMDLs are composed of the sum of individual wasteload allocations for permitted point sources, load allocations for both nonpoint sources and natural background levels for a given waterbody, and a margin of safety (MOS), either implicit or explicit [U.S. EPA, 2001]:

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS}. \qquad (2\text{-}5)$$

Wasteload Allocation. There are no permitted point sources in the George Wyth Lake watershed. As a result, the wasteload allocation (WLA) is 0 cfu/day.

Load Allocation. After studying the relationship between concentration data and precipitation, no significant correlation between the two could be established. Sampling near the culvert inlet and Mr. Dusenberry's dock yielded nondetectable levels of bacteria. Additionally, the culvert inlet is on the opposite side of the lake from NSBV where this TMDL focuses and the primary immersion recreation occurs. Thus the allowable load calculated by Models 1 and 2 represents the load allocation (LA) and the primary source is the geese local to the beach.

The LA from Model 1 was calculated as 4.17E+9 *E. coli* cfu/day for the NSBV. Model 2 employed diffusion and a direct load representation and yielded a higher acceptable load, as expected. LAs of 1.50E+11 *E. coli* cfu/day for the daily maximum target and 8.03E+10 *E. coli* cfu/day for the geometric mean target for the NSBV were calculated using Model 2.

The load allocation from Model 1 was the most conservative value for the NSBV because it employs an equation without diffusion and represents an instantaneous daily load. Because Model 1 was likely overly conservative and Equation 2-3 better represents field data, the prediction from Model 2 was used for the LA.

Margin of Safety. An implicit margin of safety (MOS) was used in the development of this TMDL. Using a NSBV instead of the entire lake volume, assigning conservative model parameters and using a Monte Carlo simulation to explore uncertainties in model predictions are all conservative assumptions built into the mass balance model approach of this TMDL.

3. Implementation Plan

The greatest potential bacteria load comes from geese residing in the beach corridor at George Wyth Lake. Samples from the culvert inlet at the northeast end of the lake and from Mr. Dusenberry's dock did not yield significant *E. coli* concentrations i.e., all samples were less than the detection limit. The watershed will likely remain predominately an urban land complex. Because of this, only quarterly monitoring of the culvert inlet to the lake is suggested. However, the bacteria load in the beach corridor must be significantly reduced.

There are many factors that impact bacteria concentrations in the near shore beach volume (NSBV) at George Wyth Lake. These factors, like storm events, ultraviolet (UV) light and temperature exposure, goose dropping surface area, proliferation in sediment/soil, goose behavioral patterns, the number of geese and diffusion and decay in water can vary on a daily basis. Since data are available for only a few of these factors, expressing the existing load in a very dynamic scenario can be extremely difficult.

A model using Equation 2-3 was created to better understand the relationship between the factors, the number of geese, and resulting load in the NSBV. To simplify the model analysis (and because of a lack of data to support accounting for separate factors), the number of geese, diffusion and decay in water were left as separate factors while UV exposure, temperature, fecal matter surface area, and behavioral patterns were combined into one composite factor called "transport efficiency." The transport efficiency factor represents the fraction of generated load which is received by the waterbody after transport and fate processes. Transport efficiency was characterized as a percentage of the total possible generated bacteria load that can be available for contamination of the NSBV. The model was used to calculate potential daily delivered loads, converted to number of geese, for transport efficiencies from 1 to 100 percent.

Reducing the bacteria load in the beach corridor can be accomplished in ways such as controlling the number of geese at the beach and/or manipulating factors that affect the transport efficiency of bacteria to the water. Figure 3-1 shows the number of geese (i.e., loading) allowable for an effective load transport efficiency which results in attainment of the water-quality standards, i.e., 235 cfu/100 ml and 126 cfu/100 ml. Table 3-1 summarizes the number of geese (or load) that could be present under various load transport efficiencies and meet water-quality standards.

Controlling numbers of geese can be performed effectively in two ways: translocation and removal of the food source. Black Hawk County Biologist Mr. Doug Chafa has said that for the past few years, about 30 – 50 geese per summer have been translocated. GWMSP managers have noted fewer numbers of geese in recent years [Chafa, 2007]. Removing the food source will force geese out of the beach corridor in search of a stable food supply. Public participation in this effort is critical because some public feeding does occur [Chafa, 2007]. If other food sources near the beach exist, GWMSP managers will need to consider removing it.

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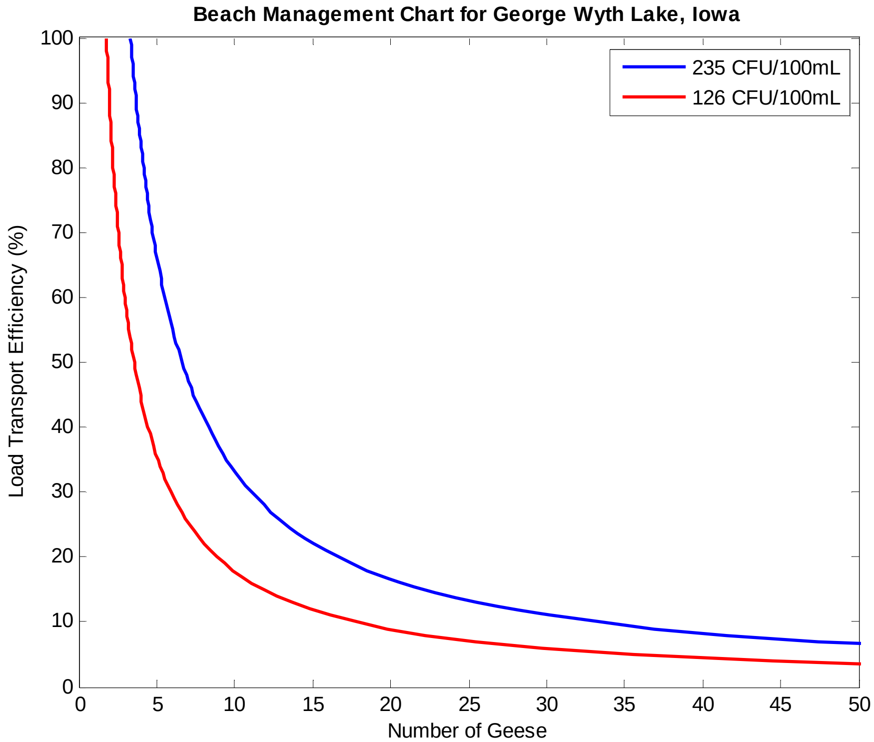

Figure 3-1. Beach Management Chart Showing the Number of Geese Allowable for Load Transport Efficiencies.

Table 3-1. Tabular values showing load transport efficiencies and the corresponding number of geese allowed.

Beach Management Table		
Load Transport Efficiency (%)	**Number of Geese Allowed (Attainment of One-Time Max)**	**Number of Geese Allowed (Attainment of Geometric Mean)**
5	68	36
10	34	18
15	23	12
20	17	9
50	7	4
75	5	2
100	3	2

Manipulating the factors that affect the transport efficiency of bacteria to the water is a more difficult strategy to assess. *E. coli* bacteria will decompose at faster rates if exposed to greater UV light and higher temperatures. These two factors are nearly impossible to control directly. However, the surface area over which UV light and temperature act can be controlled. Disking the beach sand is a measure that breaks up (increases surface area) the fecal matter. Disking the beach has been done on a weekly basis for an unknown period of time [Eberhard, 2007].

The most effective approach to reducing the pathogen load at the beach at George Wyth Lake will be using groomers to remove feces from the beach, translocating geese and their goslings and removing the food source from the beach corridor.

4. Monitoring

Continued weekly monitoring will be conducted by the IDNR under the Beach Monitoring Program. This monitoring will continue each year from approximately the last week of May until October 31. During weekly monitoring, documentation of the number of geese on the beach and in the NSBV is recommended. Microbial source tracking (MST) is a technology used to specifically determine the sources of fecal bacteria. The Beach Monitoring Program is considering MST for George Wyth Lake and other lakes as well.

5. Public Participation

A public comment period was open for the draft of the George Wyth Lake TMDL beginning on July 17 and closing on August 19, 2008. No public comments were received by the Iowa Department of Natural Resources (IDNR) during the public comment period.

IDNR also facilitated a public meeting regarding the TMDL at the Hartman Reserve Nature Center in Cedar Falls, Iowa. The meeting was held from 7:00 to 9:00 pm on July 29, 2008. IDNR was represented by TMDL staff, state park officials, wildlife biologists, and the state's beach monitoring program coordinator. Local stakeholders present included the manager of the Hartman Reserve Nature Center, several citizens of Cedar Falls, and several members of area fishing clubs and organizations.

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7. Appendices

Appendix A — Glossary of Terms and Acronyms

303(d) list: Refers to section 303(d) of the Federal Clean Water Act, which requires a listing of all public surface water bodies (creeks, rivers, wetlands, and lakes) that do not support their general and/or designated uses. Also called the state's "Impaired Waters List."

305(b) assessment: Refers to section 305(b) of the Federal Clean Water Act, it is a comprehensive assessment of the state's public water bodies ability to support their general and designated uses. Those bodies of water which are found to be not supporting or just partially supporting their uses are placed on the 303(d) list.

319: Refers to Section 319 of the Federal Clean Water Act, the Nonpoint Source Management Program. Under this amendment, States receive grant money from EPA to provide technical & financial assistance, education, & monitoring to implement local nonpoint source water-quality projects.

AFO: Animal Feeding Operation. A livestock operation, either open or confined, where animals are kept in small areas (unlike pastures) allowing manure and feed become concentrated.

Base flow: The fraction of discharge (flow) in a river which comes from ground water.

BMIBI: Benthic Macroinvertebrate Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of bottom-dwelling invertebrates.

BMP: Best Management Practice. A general term for any structural or upland soil or water conservation practice. For example terraces, grass waterways, sediment retention ponds, reduced tillage systems, etc.

CAFO: Confinement Animal Feeding Operation. An animal feeding operation in which livestock are confined and totally covered by a roof, and not allowed to discharge manure to a water of the state.

Credible data law: Refers to 455B.193 of the Iowa Administrative Code, which ensures that water-quality data used for all purposes of the Federal Clean Water Act are sufficiently up-to-date and accurate.

Cyanobacteria (blue-green algae):	Members of the phytoplankton community that are not true algae but can photosynthesize. Some species can be toxic to humans and pets.
Designated use(s):	Refer to the type of economic, social, or ecologic activities that a specific water body is intended to support. See Appendix B for a description of all general and designated uses.
DNR (or IDNR):	Iowa Department of Natural Resources.
Ecoregion:	A system used to classify geographic areas based on similar physical characteristics such as soils and geologic material, terrain, and drainage features.
EPA (or USEPA):	United States Environmental Protection Agency.
FIBI:	Fish Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of fish species.
FSA:	Farm Service Agency (United States Department of Agriculture). Federal agency responsible for implementing farm policy, commodity, and conservation programs.
General use(s):	Refer to narrative water-quality criteria that all public water bodies must meet to satisfy public needs and expectations. See Appendix B for a description of all general and designated uses.
GIS:	Geographic Information System(s). A collection of map-based data and tools for creating, managing, and analyzing spatial information.
Gully erosion:	Soil movement (loss) that occurs in defined upland channels and ravines that are typically too wide and deep to fill in with traditional tillage methods.
HEL:	Highly Erodible Land. Defined by the USDA Natural Resources Conservation Service (NRCS), it is land which has the potential for long term annual soil losses to exceed the tolerable amount by eight times for a given agricultural field.

Integrated report:	Refers to a comprehensive document which combines the 305(b) assessment with the 303(d) list, as well as narratives and discussion of overall water-quality trends in the state's public water bodies. The Iowa Department of Natural Resources submits an integrated report to the EPA biennially in even numbered years.
LA:	Load Allocation. The fraction of the total pollutant load of a water body which is assigned to all combined *nonpoint sources* in a watershed. (The total pollutant load is the sum of the waste load and load allocations.)
Load:	The total amount (mass) of a particular pollutant in a waterbody.
MOS:	Margin of Safety. In a total maximum daily load (TMDL) report, it is a set-aside amount of a pollutant load to allow for any uncertainties in the data or modeling.
MS4 Permit:	Municipal Separate Storm Sewer System Permit. An NPDES license required for some cities and universities which obligates them to ensure adequate water-quality and monitoring of runoff from urban storm water and construction sites, as well as public participation and outreach.
Nonpoint source pollution:	A collective term for contaminants which originate from a diffuse source.
NPDES:	National Pollution Discharge Elimination System, which allows a facility (e.g. an industry, or a wastewater treatment plant) to discharge to a water of the United States under regulated conditions.
NSVB:	Near Shore Beach Volume
NRCS:	Natural Resources Conservation Service (United States Department of Agriculture). Federal agency which provides technical assistance for the conservation and enhancement of natural resources.
Periphyton:	Algae that are attached to substrates (rocks, sediment, wood, and other living organisms).
Phytoplankton:	Collective term for all self-feeding (photosynthetic) organisms which provide the basis for the aquatic food chain. Includes many types of algae and cyanobacteria.

Point source pollution:	A collective term for contaminants which originate from a specific point, such as an outfall pipe. Point sources are generally regulated by an NPDES permit.
PPB:	Parts per Billion. A measure of concentration which is the same as micrograms per liter (µg/l).
PPM:	Parts per Million. A measure of concentration which is the same as milligrams per liter (mg/l).
Riparian:	Refers to site conditions that occur near water, including specific physical, chemical, and biological characteristics that differ from upland (dry) sites.
RUSLE:	Revised Universal Soil Loss Equation. An empirical model for estimating long term, average annual soil losses due to sheet and rill erosion.
Secchi disk:	A device used to measure transparency in water bodies. The greater the secchi depth (measured in meters), the more transparent the water.
Sediment delivery ratio:	A value, expressed as a percent, which is used to describe the fraction of gross soil erosion which actually reaches a water body of concern.
Seston:	All particulate matter (organic and inorganic) in the water column.
Sheet & rill erosion	Soil loss which occurs diffusely over large, generally flat areas of land.
SI:	Stressor Identification. A process by which the specific cause(s) of a biological impairment to a water body can be determined from cause-and-effect relationships.
Storm flow (or stormwater):	The fraction of discharge (flow) in a river which arrived as surface runoff directly caused by a precipitation event. *Storm water* generally refers to runoff which is routed through some artificial channel or structure, often in urban areas.
STP:	Sewage Treatment Plant. General term for a facility that processes municipal sewage into effluent suitable for release to public waters.

SWCD:	Soil and Water Conservation District. Agency which provides local assistance for soil conservation and water-quality project implementation, with support from the Iowa Department of Agriculture and Land Stewardship.
TMDL:	Total Maximum Daily Load. As required by the Federal Clean Water Act, a comprehensive analysis and quantification of the maximum amount of a particular pollutant that a water body can tolerate while still meeting its general and designated uses.
TSI (or Carlson's TSI):	Trophic State Index. A standardized scoring system (scale of 0-100) used to characterize the amount of algal biomass in a lake or wetland.
TSS:	Total Suspended Solids. The quantitative measure of seston, all materials, organic and inorganic, which are held in the water column.
Turbidity:	The degree of cloudiness or murkiness of water caused by suspended particles.
UAA:	Use Attainability Analysis. A protocol used to determine which (if any) designated uses apply to a particular water body. (See Appendix B for a description of all general and designated uses.)
UHL:	University Hygienic Laboratory (University of Iowa). Provides physical, biological, and chemical sampling for water-quality purposes in support of beach monitoring and impaired water assessments.
USGS:	United States Geologic Survey (United States Department of the Interior). Federal agency responsible for implementation and maintenance of discharge (flow) gauging stations on the nation's water bodies.
Watershed:	The land (measured in units of surface area) which drains water to a particular body of water or outlet.
WLA:	Waste Load Allocation. The fraction of waterbody loading capacity assigned to point sources in a watershed. Alternatively, the allowable pollutant load that an NPDES permitted facility may discharge without exceeding water-quality standards.

WQS: Water-quality Standards. Defined in Chapter 61 of Environmental Protection Commission [567] of the Iowa Administrative Code, they are the specific criteria by which water-quality is gauged in Iowa.

WWTP: Waste Water Treatment Plant. General term for a facility which processes municipal, industrial, or agricultural waste into effluent suitable for release to public waters or land application.

Zooplankton: Collective term for all animal plankton which serve as secondary producers in the aquatic food chain and the primary food source for larger aquatic organisms.

Appendix B — General and Designated Uses of Iowa's Waters

Introduction

Iowa's water-quality standards (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code) provide the narrative and numerical criteria by which water bodies are judged when determining the health and quality of our aquatic ecosystems. These standards vary depending on the type of water body (lakes versus rivers) and the assigned uses (general use versus designated uses) of the water body that is being dealt with. This appendix is intended to provide information about how Iowa's water bodies are classified and what the use designations mean, hopefully providing a better general understanding for the reader.

All public surface waters in the state are protected for certain beneficial uses, such as livestock and wildlife watering, aquatic life, noncontact recreation, crop irrigation, and other incidental uses (e.g., withdrawal for industry and agriculture). However, certain rivers and lakes warrant a greater degree of protection because they provide enhanced recreational, economical, or ecological opportunities. Thus, all public bodies of surface water in Iowa are divided into two main categories: *general* use segments and *designated* use segments. This is an important classification because it means that not all of the criteria in the state's water-quality standards apply to all water ways; rather, the criteria which apply depend on the use designation & classification of the water body.

General Use Segments

A general use segment water body is one which does not maintain perennial (year-round) flow of water or pools of water in most years (i.e. ephemeral or intermittent waterways). In other words, stream channels or basins which consistently dry up year after year would be classified as general use segments. Exceptions are made for years of extreme drought or floods. For the full definition of a general use water body, consult section 61.3(1) in the state's published water-quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

General use waters are protected for the beneficial uses listed above, which are: livestock and wildlife watering, aquatic life, noncontact recreation, crop irrigation, and industrial, agricultural, domestic and other incidental water withdrawal uses. The criteria used to ensure protection of these uses are described in section 61.3(2) in the state's published water-quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

Designated Use Segments

Designated use segments are water bodies which maintain flow throughout the year, or at least hold pools of water which are sufficient to support a viable aquatic community (i.e. perennial waterways). In addition to being protected for the same beneficial uses as the general use segments, these perennial waters are protected for more specific activities such as primary contact recreation, drinking water sources, or cold-water fisheries. There are a total of thirteen different designated use classes (Table B-1) which may apply, and a water body may have more than one designated use. For definitions of the use classes and more detailed descriptions, consult section 61.3(1) in the state's published water-quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

Table B-1. Designated use classes for Iowa water bodies.

Class prefix	Class	Designated use	Brief comments
A	A1	Primary contact recreation	Supports swimming, water skiing, etc.
	A2	Secondary contact recreation	Limited/incidental contact occurs, such as boating
	A3	Children's contact recreation	Urban/residential waters that are attractive to children
B	B(CW1)	Cold water aquatic life – Type 1	Able to support coldwater fish (e.g. trout) populations
	B(CW2)	Cold water aquatic life – Type 2	Typically unable to support consistent trout populations
	B(WW-1)	Warm water aquatic life – Type 1	Suitable for game and nongame fish populations
	B(WW-2)	Warm water aquatic life – Type 2	Smaller streams where game fish populations are limited by physical conditions & flow
	B(WW-3)	Warm water aquatic life – Type 3	Streams that only hold small perennial pools which extremely limit aquatic life
	B(LW)	Warm water aquatic life – Lakes and Wetlands	Artificial and natural impoundments with "lake-like" conditions
C	C	Drinking water supply	Used for raw potable water
Other	HQ	High quality water	Waters with exceptional water-quality
	HQR	High quality resource	Waters with unique or outstanding features
	HH	Human health	Fish are routinely harvested for human consumption

Appendix C — Water-Quality Data

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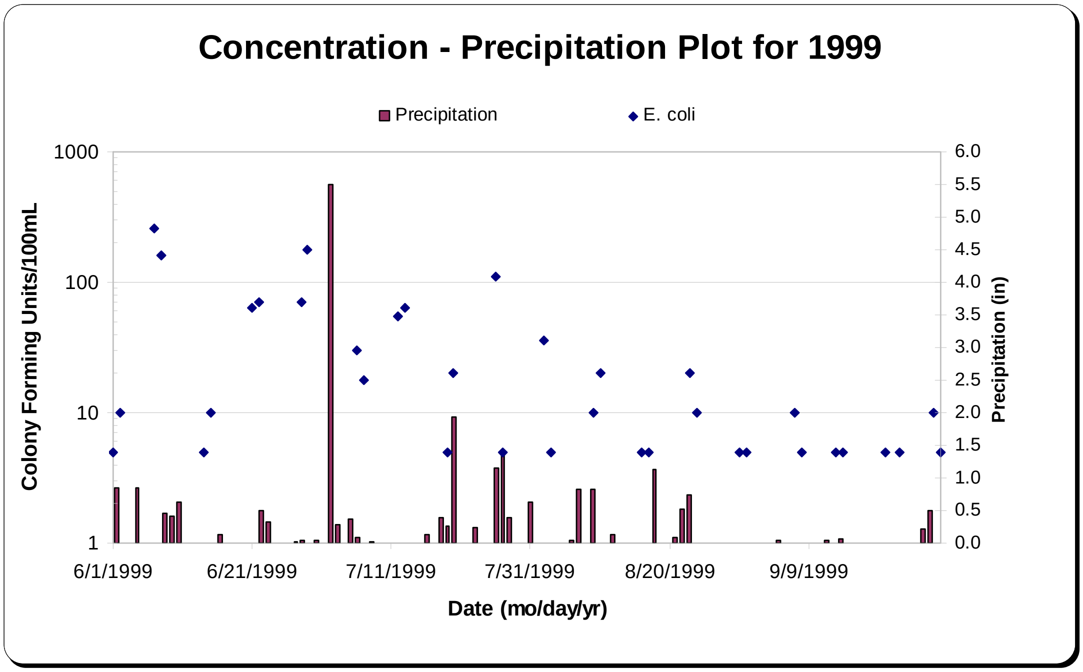

Figure C-1. Concentration and Precipitation Data Plotted Together for 1999.

RSI-1748-08-089

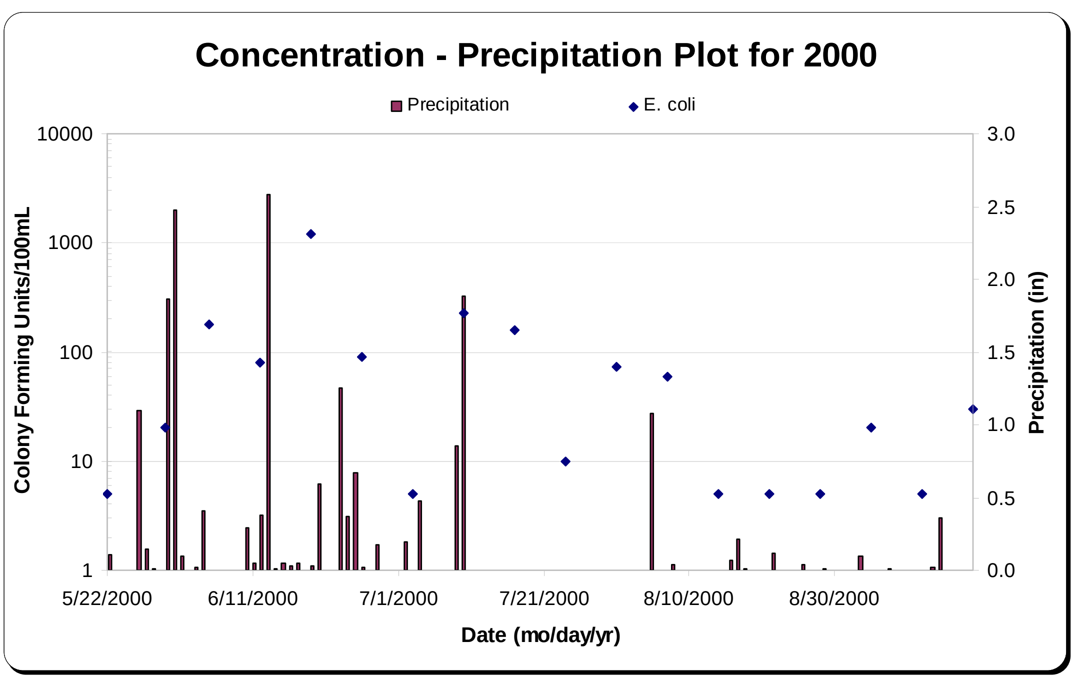

Figure C-2. Concentration and Precipitation Data Plotted Together for 2000.

RSI-1748-08-090

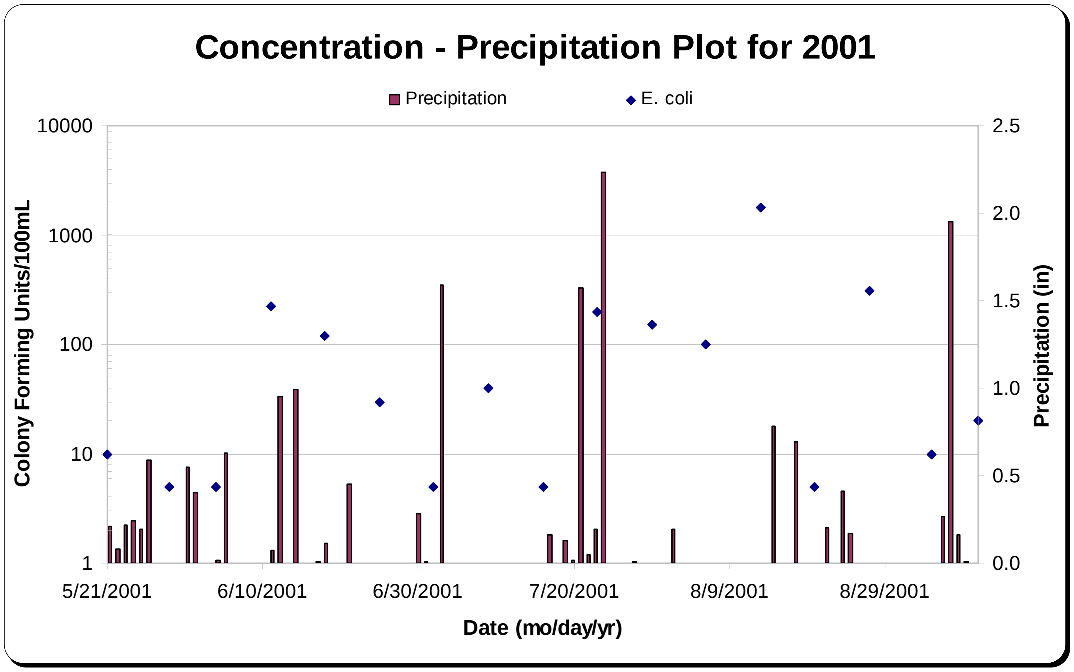

Figure C-3. Concentration and Precipitation Data Plotted Together for 2001.

RSI-1748-08-091

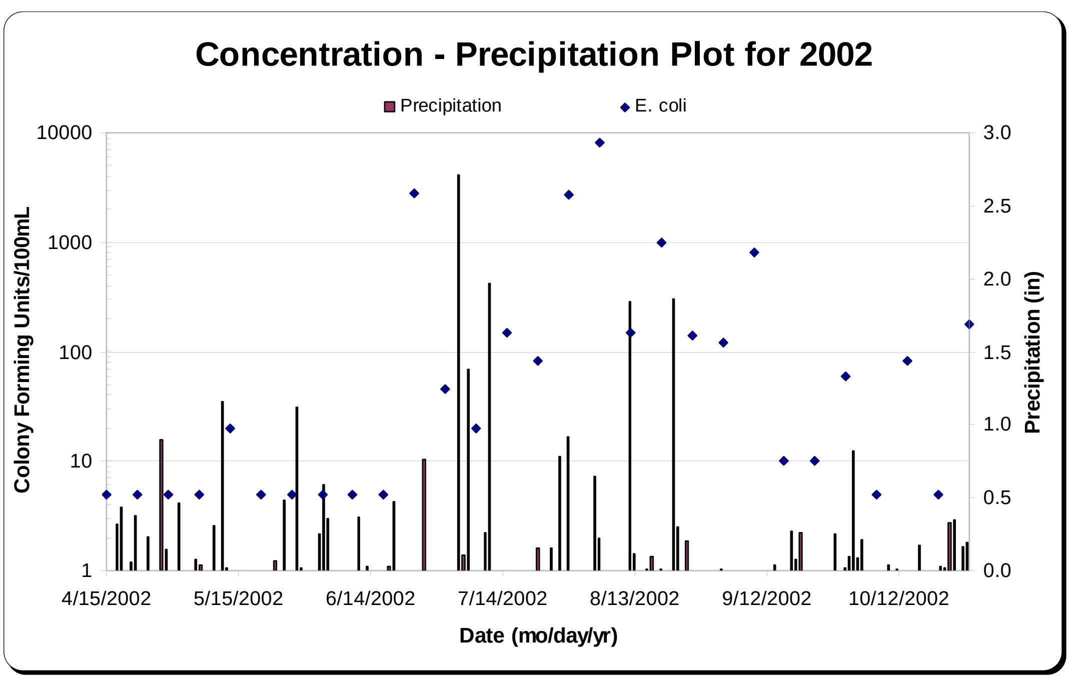

Figure C-4. Concentration and Precipitation Data Plotted Together for 2002.

RSI-1748-08-092

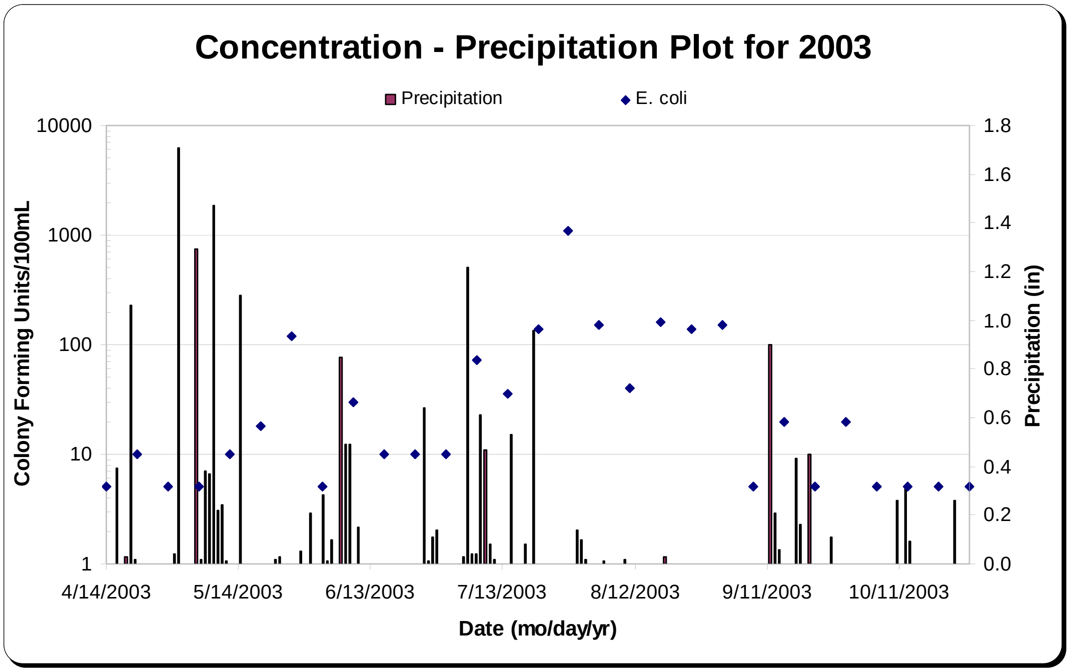

Figure C-5. Concentration and Precipitation Data Plotted Together for 2003.

RSI-1748-08-093

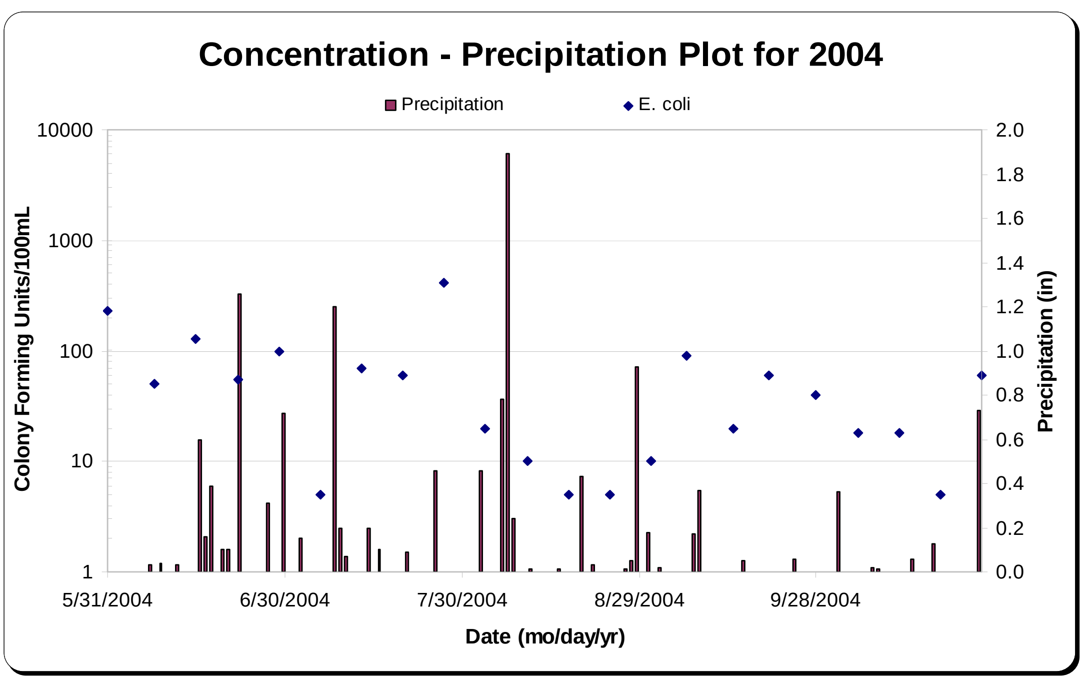

Figure C-6. Concentration and Precipitation Data Plotted Together for 2004.

RSI-1748-08-094

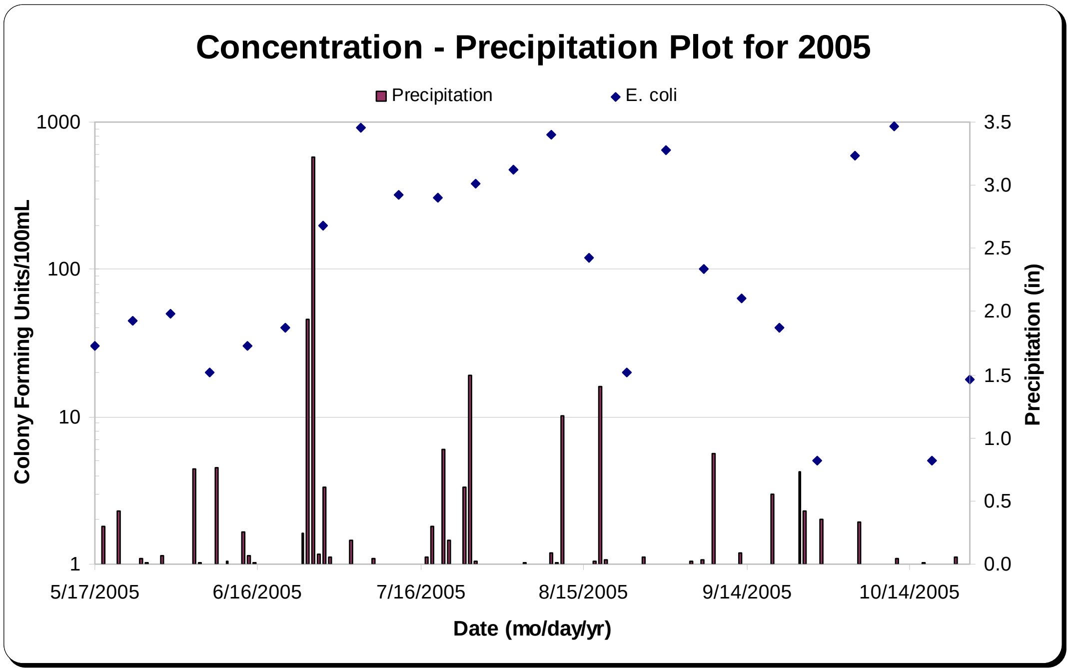

Figure C-7. Concentration and Precipitation Data Plotted Together for 2005.

Appendix D — Public Comments

A public comment period was open for the draft of the George Wyth Lake TMDL beginning on July 17 and closing on August 19, 2008. No public comments were received by the Iowa Department of Natural Resources (IDNR) during the public comment period.