JEWEL LAKE FECAL COLIFORM ASSESSMENT

2009-2010 Final Report

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Kristine Dunker, Fisheries Biologist at the Alaska Department of Fish and Game (ADF&G), although busy with her own research, took the time to share her knowledge of fish issues in Jewel Lake. Deanna Crump, microbiologist as SGS, analyzed all our samples in a timely manner, and discussions with her and her colleague Forest Taylor were very helpful in analyzing some of the bacterial results. The busy folks at Anchorage Water and Wastewater Utility (AWWU) and the Municipality's OnSite Water and Wastewater Section graciously assisted us in locating the information on septic systems surrounding Jewel Lake. Jeffrey A. Garness, President of Garness Engineering Group, Ltd. freely imparted his knowledge, expertise, and years of experience with Anchorage's fickle septic systems.

Last, but not least, we would like to thank the Board Members of the Anchorage Waterways Council for their support, encouragement, and enthusiasm about this project.

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1. Overview

This final report, prepared under Grant Number ACWA 09-17, Jewel Lake Fecal Coliform Assessment, is a grant agreement between the Alaska Department of Environmental Conservation (ADEC) Division of Water (grantor), and the Anchorage Waterways Council (AWC)(grantee).

Jewel Lake (Figures 1 & 2) is located in the Municipality of Anchorage (MOA), the urban center of the Anchorage Bowl in Southcentral Alaska. The state of Alaska included this lake as a Category 4a water (impaired with a completed Total Maximum Daily Load (TMDL)) in the 2004 Integrated Water Quality Monitoring and Assessment Report (ADEC, 2006a). The TMDL established in 1997 stated that the primary source of fecal coliform in Jewel Lake was runoff from a public beach on the northeast side of the lake where people, dogs, and Canada Geese (*Branta Canadensis)* congregate in June and July.

Applicable water quality standards for fecal coliform in Jewel Lake include criteria for the protection of designated uses for water supply, water recreation, and growth and propagation of fish, shellfish, other aquatic life, and wildlife. The TMDL was developed for the most stringent of these—the fecal coliform criteria for drinking, culinary, and food processing water supply and states that in a 30-day period, the geometric mean may not exceed 20 FC/100 ml, and not more than 10% of the samples may exceed 40 FC/100 ml. (18 AAC 70.020(b)(2)(A)(i)) (ADEC, 2009).

The ADEC initiated this project to collect updated data on Jewel Lake, to determine the current water quality status, and to reassess the Category 4a status of this waterbody. In 2008, the AWC, under the direction of Monitoring Director Kate Malloy, began a two-year (2008-2009 and 2009-2010) project for the ADEC to update data on Jewel Lake to determine the current water quality status, and to reassess the Category 4a status of the waterbody. Ms. Malloy completed all the monitoring for 2008 and 2009, and then left AWC to work for the Alaska Department of Fish and Game (ADF&G). Drs. Cherie Northon and Thom Eley completed the 2010 monitoring and final report preparation.

Figure 1. Jewel Lake looking northeast, June 2010 (Photo by Cherie Northon).

Figure 2. Jewel Lake looking south, June 2010 (Photo by Cherie Northon).

2.1 Geography

Jewel Lake is a small urban lake located in the Anchorage Bowl in the MOA (Figure 3). Anchorage, with an estimated 290,972 residents, has the largest population of any city in Alaska and about 42% of the population of Alaska (Alaska Dept. Labor, 2010). Jewel Lake is a local name reported in 1942 by the Army Map Service[1], and is located in the Campbell Creek watershed to the northwest of Campbell Lake and to the south of Sand and Sundi Lakes (Figure 4). Information on the size, depth and elevation are shown in Table 1 and the bathymetry is shown in Figure 5.

[1] Orth, D. 1968. *Dictionary of Alaska Place Names.* Washington, DC: U.S. Government Printing Office.

Figure 3. Map of the Anchorage bowl and the location of Jewel Lake.

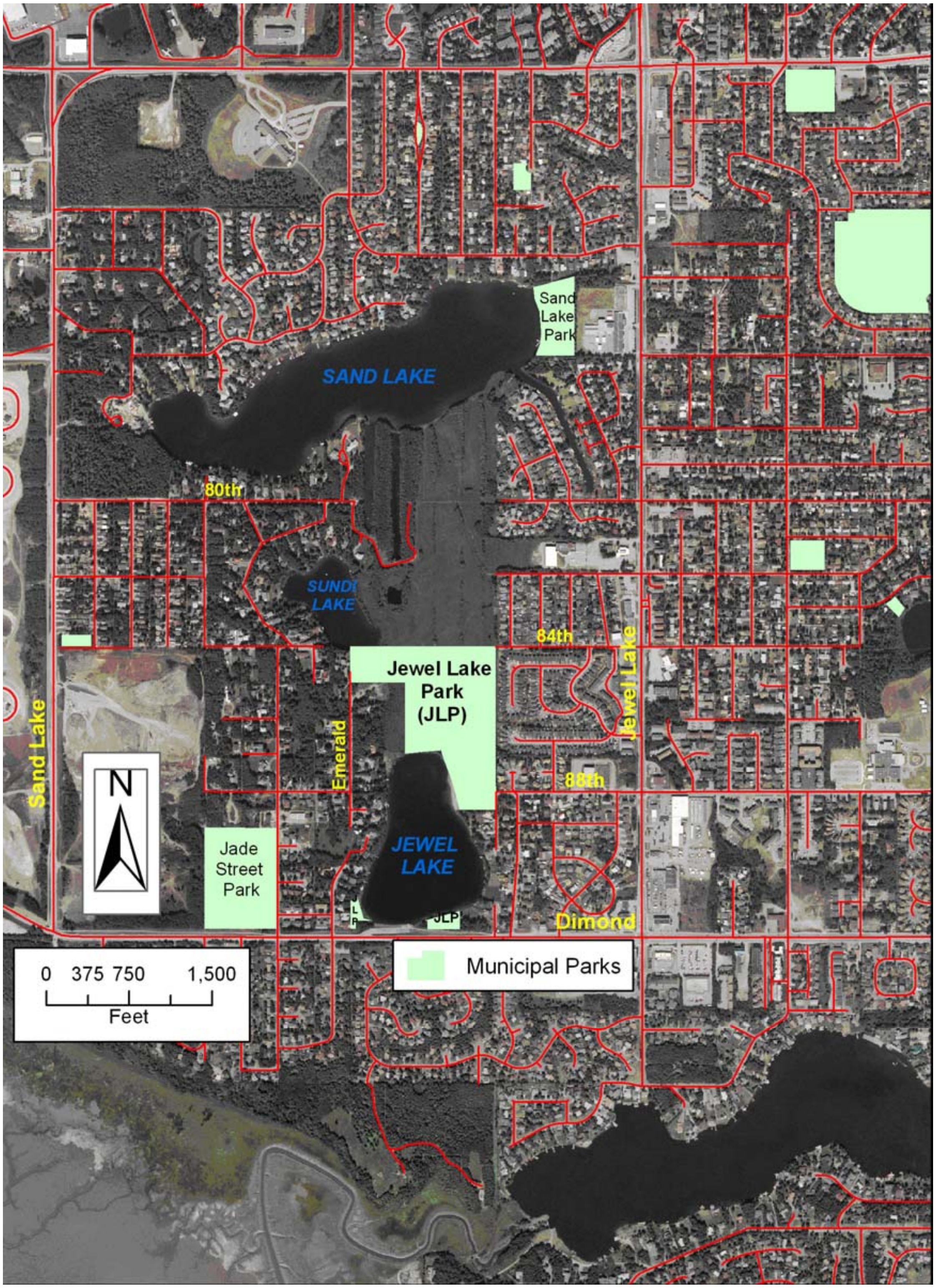

Figure 4. Jewel Lake study area and immediate surroundings in Anchorage, Alaska (Cartography by Dr. Thom Eley).

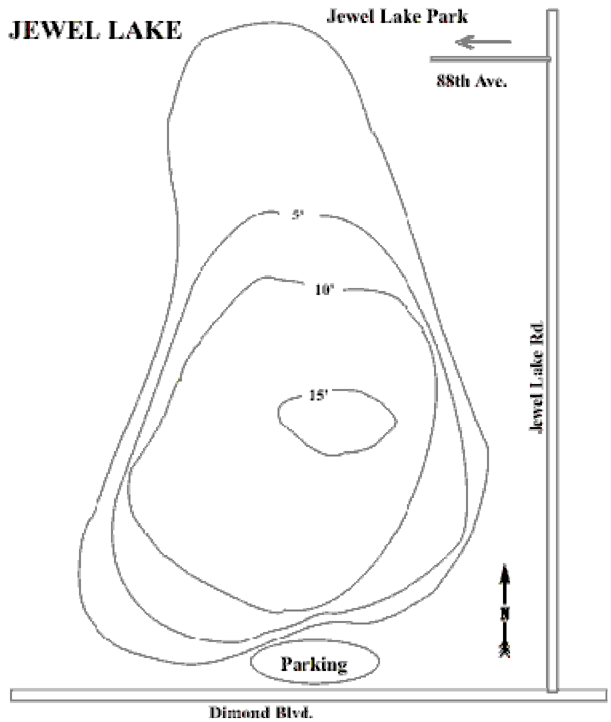

Figure 5. Bathymetry of Jewel Lake (ADF&G).

Table 1. Physical characteristics of Jewel Lake (ADF&G, 2008)

Surface Area	26.2 Acres (10.6 hectares)
Volume	170.2 Acre Ft. (209,938 m^3)
Elevation	100 Feet (30.98 m)
Mean Depth	6.5 Feet (1.9 m)
Maximum Depth	15 Feet (4.6 m)
Shoreline Length	0.9 Miles (1,448.4 m)

2.2 Land Use

The dominant land use in the Jewel Lake area is residential and park land. Jewel Lake Park borders the northeast corner of the lake and is a popular recreation spot with covered picnic tables, portable toilets, a playground, and several ball fields; the lake itself is one of the most popular lakes for summer swimming in Anchorage.

A parking area is located at the southern end of the lake and provides access for fishing. The lake is a popular fishing area in both summer and winter, and between 1998 and 2010 the ADF&G stocked the lake with 433,245 fish, predominantly rainbow trout (*Oncorhynchus mykiss*). Arctic char (*Salvelinus alpinus*) and Chinook salmon (*Oncorhynchus tschawytscha*) are also stocked. The mean length of stocked fish was 23 cm (9 in) (ADF&G, 2010). Kristine Dunker, an ADF&G fisheries biologist, (pers. comm.) reported ADF&G has not confirmed Northern pike (*Esox lucius*) in Jewel Lake, however, she does have a pretty credible report of one being caught there last September. ADF&G will attempt to confirm that report this summer. The lake is also an important nesting and resting area for a number of bird species (Figure 6). Table 2 lists the bird species recorded during 2010 surveys. Jewel

Lake is protected by ADF&G as a de facto “loon refuge” for Common Loons (*Gavia immer*), and no harassing or disturbing of the loons is permitted (Figure 7).

Figure 6. Lesser Yellowlegs (*Tringa flavipes*) in Jewel Lake, June 2010 (Photo by Cherie Northon).

Figure 7. Pair of Common Loons on Jewel Lake, June 2010 (Photo by Cherie Northon).

Table 2. Birds and mammals observed at Jewel Lake, May-June 2010.

Common Name	Scientific Name
Common Loon	*Gavia immer*
Red-necked Grebe	*Podicepts grisegenq*
Canada Goose	*Branta Canadensis*
Mallard	*Anas platyrhynchos*
American Wigeon	*Mareca Americana*
Common Merganser	*Mergus merganser*
Bald Eagle	*Haliaeetus leucocephalus*
Lesser Yellowlegs	*Tringa flavipes*
Spotted Sandpiper	*Actitis macularia*
Bonaparte's Gull	*Larus Philadelphia*
Mew Gull	*Larus canus*
Herring Gull	*Larus argentatus*
Arctic Tern	*Sterna paradisaea*
Rock Dove	*Columbia livia*
Belted Kingfisher	*Megaceryle alcyon*
Violet-green Swallow	*Tachycineta thalassina*
Black-billed Magpie	*Pica pica*
Common Raven	*Corvus corax*
American Robin	*Turdus migratorius*
Starling	*Sturnus vulgaris*

2.3 Climate

Anchorage is located in a transitional climate zone in Alaska, between maritime and continental zones. The climate is warmer and wetter than the continental, interior climate zone and cooler and drier than the maritime, coastal climate zone (Dilley and Dilley, 2000). Transitional zone temperatures normally range from 0°F (-17.7°C) to 65°F (18.3°C). Temperatures are moderated by the surrounding Chugach Mountains and Cook Inlet. In Anchorage, the average high temperature is 42.9°F (6.1°C) and the average low is 28.9°F (-1.7°C) based on data from Anchorage International Airport between April 1952 and December 2000; monthly averages are provided in Figure 8.

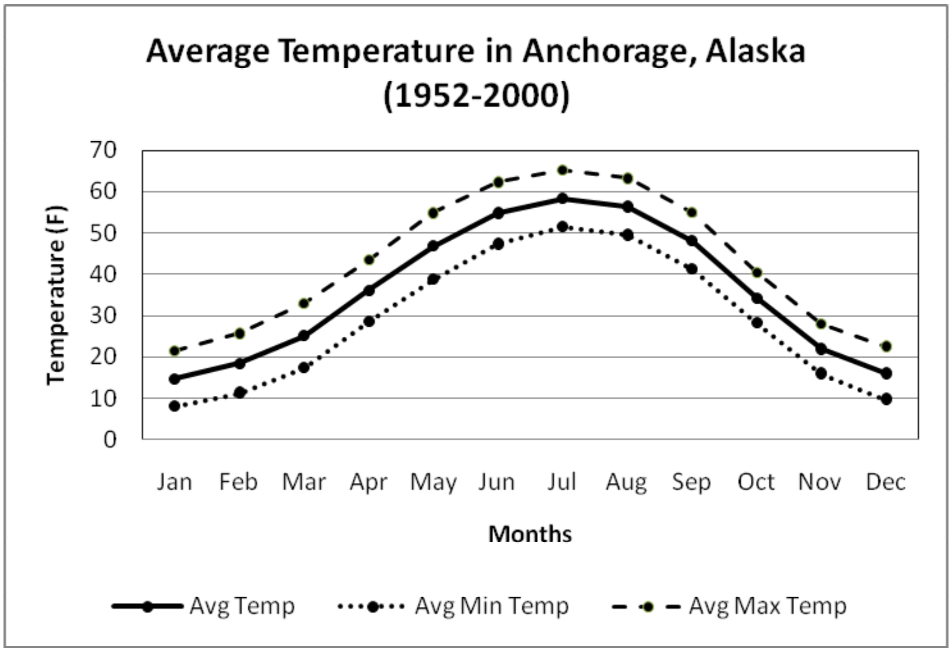

Figure 8. Average temperature in Anchorage, Alaska, by month, based on climate data collected at Anchorage International Airport from 1952-2000.

The Chugach Mountains serve as a barrier for the warm, moist air from the Gulf of Alaska and the result is often precipitation. Average annual precipitation (rain and snowmelt) is less than 20 inches (Dilley and Dilley, 2000). Average annual snowfall ranges from approximately 70 inches on the west side of Anchorage to 90 inches on the east side; total snow increases as elevation increases in the Chugach Mountains. Average monthly snowfall data from Anchorage's official measuring station at Anchorage International Airport are shown in Figure 9.

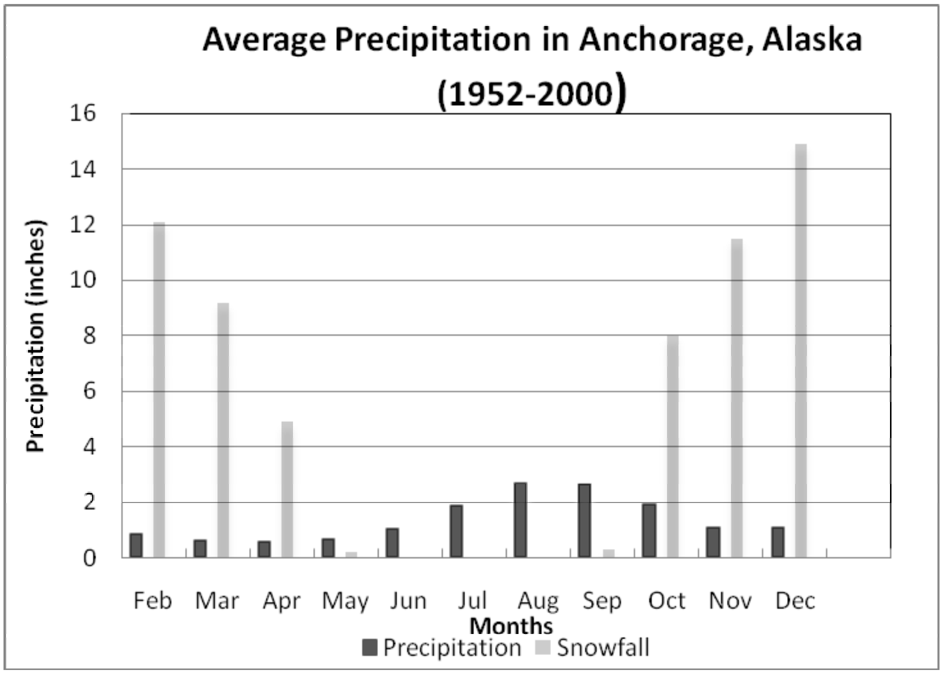

Figure 9. Average precipitation and snowfall in Anchorage, Alaska, by month, based on climate data collected at Anchorage International Airport from 1952-2000.

Climate, particularly precipitation, seems an integral component in the study of fecal coliform bacteria in the aquatic environment. Climatic data were not initially incorporated into this study of Jewel Lake. The general climatic data used to describe the study area during the 2008-2009 sampling period and in the 2009 portion of the 2009-2010 sampling period were averages from 1952 to 2000. Given the concern with climate change and our intent to incorporate some climate data in the analyses, monthly maximum, mean, and minimum temperatures and total precipitation were obtain from the U. S. Weather Service. These data will be used later in this report.

Table 3. The actual monthly maximum, mean, and minimum and total precipitation for the 2009-2010 study period (U.S. Weather Service, Anchorage, Alaska).

Month	Mean Max Temp	Mean Temp	Mean Min Temp	Precipitation
2009	(°F)	(°F)	(°F)	(in)
July	71	63	56	1.50
August	66	59	52	2.56
Sept	58	51	46	1.26
October	47	42	38	2.08
November	27	23	17	0.51
Dec	25	21	16	0.47
2010				
Jan	24	19	14	0.42
Feb	31	26	21	1.09
Mar	36	28	21	0.44
Apr	45	38	33	0.94
May	60	51	43	0.07
Jun	63	57	51	1.28

Precipitation may play a significant part in fecal coliform levels as surface runoff washes fecal coliform bacteria from numerous sources into the lake. Further, runoff can stir up bacteria that have settled out of the water column into the bottom sediments. The highest precipitation, which falls as rain, is in the summer and fall months thus potentially having the largest impact of fecal coliform bacteria. The winter precipitation, falling as snow, probably has minimal impact because the lake is frozen.

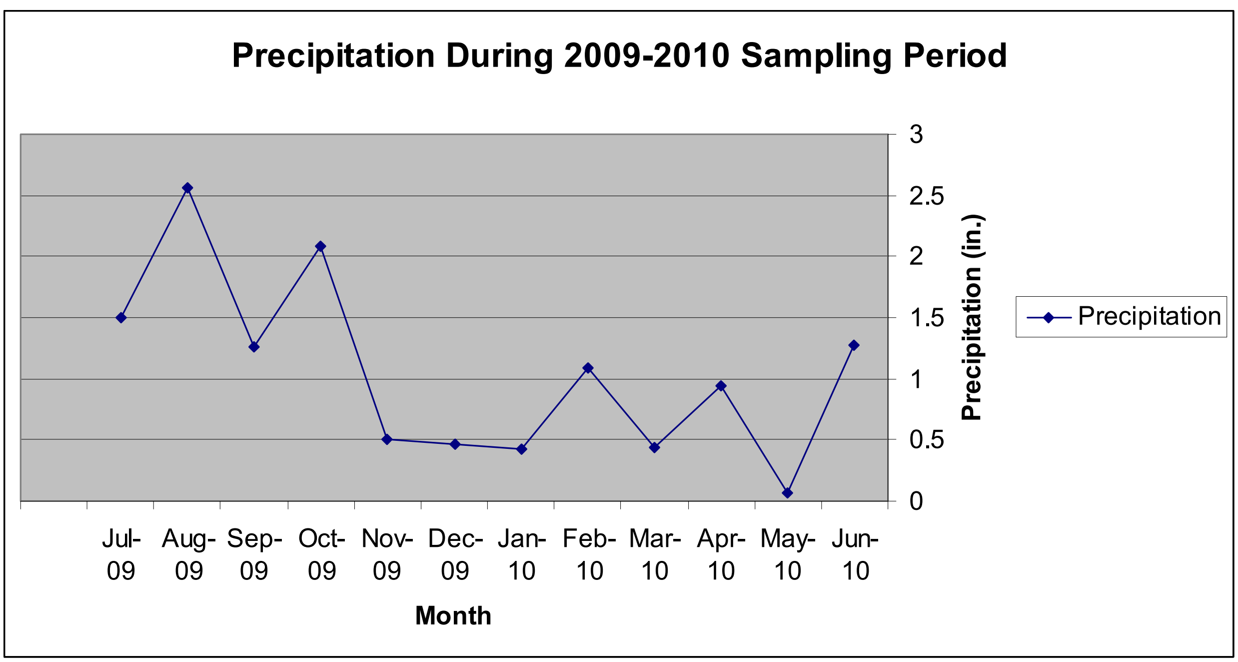

Figure 10. The actual total precipitation for the 2009-2010 study period (U.S. Weather Service, Anchorage, Alaska).

3. Summary of Pre-existing Water Quality Status

Title 18, Chapter 70 of the Alaska Administrative Code (ACC) establishes water quality standards for the State of Alaska. The ACC also includes designated "uses" that are to be protected and the water quality criteria necessary to ensure protection of those uses. The following uses have been designated and apply to Jewel Lake. 1) water supply, 2) water recreation, and 3) growth and propagation of fish, shellfish, and other aquatic life. Past data indicate that Jewel Lake did not meet the applicable water quality standards for fecal coliform during the summer months.

3.1 Non-attainment of Fecal Coliform Bacteria Standard

In 1996 the State of Alaska included Jewel Lake in the EPA's Section 303(d) impaired waters list for non-attainment of the fecal coliform bacteria standard (ADEC, 2006a). A Total Maximum Daily Load (TMDL) for fecal coliform was developed and approved by the EPA in 1997, attributing summer spikes in fecal coliform exceedances to the presence and usage of the lake by Canada Geese (EPA, 1997). Jewel Lake was removed from the Section 303(d) list after the TMDL's were developed and is currently listed as a Category 4a water in Alaska's 2006 Integrated Water Quality Monitoring and Assessment Report, for non-attainment of the fecal coliform bacteria standard due to urban runoff (ADEC, 2006a). Class 4a waters are designated as impaired, but not needing a TMDL because one has already been completed. The Alaska Water Quality Standards for fecal coliform are in Table 4.

Table 4. Alaska water quality standards for fecal coliform bacteria 2010 (ADEC, 2009).

Water Use	Fecal Coliform Bacteria Standard
(A) Water Supply (i) drinking, culinary and food processing	In a 30-day period, the geometric mean may not exceed 20 FC/100 ml, and not more than 10% of the samples may exceed 40 FC/100ml. For groundwater, the FC concentration must be less than 1 FC/100 ml, using the fecal coliform Membrane Filter Technique, or less 3 than FC/100 ml, using the fecal coliform most probable number (MPN) technique.
(A) Water Supply (ii) agriculture, including irrigation and stock watering	The geometric mean of samples taken in a 30-day period may not exceed 200 FC/100ml, and not more than 10% of the samples may exceed 400 FC/ml. For products not normally cooked and for dairy sanitation of unpasteurized products, the criteria for drinking water supply, (2)(A)(i), apply.
(A) Water Supply (iii) aquaculture	For products normally cooked, the geometric mean of samples taken in a 30-day period may not exceed 200 FC/100ml, and not more than 10% of the samples may exceed 400 FC/100ml. For products not normally cooked, the criteria for drinking water supply (2)(A)(i), apply.
(A) Water Supply (iv) industrial	Where worker contact is present, the geometric mean of samples taken in a 30-day period may not exceed 200 FC/100 ml, and not more than 10% of the samples may exceed 400 FC/100 ml.
(B) Water Recreation (i) contact recreation	In a 30-day period, the geometric mean of samples many not exceed 100 FC/100 ml, and not more than one sample, or more than 10% of the samples if there are more than 10 samples, may exceed 200 FC/100 ml.
(B) Water Recreation (ii) secondary recreation	In a 30-day period, the geometric mean of samples may not exceed 200 FC/100 ml, and not more than 10% of the total samples may exceed 400 FC/100ml.
(C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife	Not applicable.

3.1.1 Non-point Sources

During TMDL development, both non-point source and point source fecal coliform pollution was considered. In the past, the primary non-point source of fecal coliform was assumed to be runoff from the Jewel Lake Park and beach area. Waterfowl, primarily, but not only geese, have been observed in the area in the summer months of June and July. While geese may be a common water bird found on the lake, many other species of birds (Table 2) and mammals, such as moose, and many of these could be a source of fecal coliform pollution.

Humans were observed urinating into and near the lake, and evidence was found of humans defecating on land close to the lake shore. During a high rainfall event, the feces were in the direct path of a storm drain that enters the south end of Jewel Lake adjacent to the fishing area. These activities could provide human sources of fecal coliform.

Dog feces are common on the Jewel Lake Park beach at the northeast corner of the lake. People were observed driving into the park's parking lot and turning their dogs loose to go defecate either in the grassy or wooded portion of the park. No one cleaned up after these dogs even though a "Scoop-the-Poop" station is located (and stocked with bags) and readily observable at the park. Additionally, dogs swim in the lake, and dogs are known to defecate when they swim. Dog feces were observed in abundance on the lake ice adjacent to the park in the 2010 winter and spring. This is a common ice fishing area, and many people bring their dogs with them. We also observed people stopping at the park and allowing their dogs to run on the lake ice and defecate.

Runoff from other residential areas around the lake were also initially considered as potential non-point sources of fecal coliform due to runoff from cat, dog, moose and other wildlife excrement. If runoff were a significant source of fecal coliform to the lake, counts should peak around the time of spring break up, April and May, as well as in June, July, August and September, which are the rainiest months of the year. No sample data were available for April because the lake was still frozen, however data collected in May suggest that levels were well below the fecal coliform water supply standard (EPA, 1997). Although runoff from residential property was not considered a significant source of fecal coliform for the lake in the 2008-2009 report on this project, no data were presented to support this claim. Our Best Management Practices (BMP) surveys indicate that several residents' property could be sources of fecal coliform due to high run off and the dumping of yard debris, including chicken and dog feces, into the lake. We would suggest that sampling after major precipitation events be conducted to accurately assess the role of runoff from residential and public property.

Migratory geese arrive in Anchorage in late April and early May, and goslings hatch in late May and June. During July the geese molt and brood and remain in their immediate area until August. This is the time of year geese are observed on lawns and near the public swimming beach on the northeastern portion of the lake. Waterfowl counts and fecal coliform data collected from 1993-1997 indicate that fecal coliform counts are highest in July which is also when the greatest number of geese are observed on the lake (EPA, 1997). However, July is also a high use time by humans and their dogs. Geese near Jewel Lake congregate in the grassy area of the park and near the gravel/swimming beach and on the large manicured lawns adjacent to the lake—particularly those without a 25 foot buffer of natural vegetation between the lake and the yard. Runoff from rain events would transport fecal matter into the lake from these grassy areas. In addition, geese directly defecate into the lake as do many other animals including humans.

3.1.2 Point Sources

There are two storm water outfalls that drain runoff from a section of Dimond Blvd. and the parking lot at the south end of Jewel Lake and a residential area south of Dimond Blvd. into the south portion of Jewel Lake. When the 1997 EPA report was written, only one storm drain was discussed—apparently the one that drains the section of Dimond Blvd. and the parking lot. The report states, "EPA and ADEC personnel conducted a site visit of Jewel Lake to evaluate the potential fecal coliform contributions from the outfall. EPA and ADEC staff believe that runoff entering the drain is unlikely to contain significant fecal coliform loadings because the runoff drains a short section of paved road. Further, the drain discharges only episodically into the lake…(EPA 1997:7-8). What was not considered by Malloy (2009), who reported the foregoing conclusion, is that there are two storm drains at the south end of the lake. The second storm drain, shown in Figure 11, has been in place for several years, but perhaps not as far back as 1997. It was depicted on maps by the MOA's Street Maintenance (2008), and by looking at the houses in the neighborhood catchment area south of Dimond Blvd., it has been emptying their stormwater runoff into the lake for several years.

Figure 11. Major stormwater outfall (originates on south side of Dimond Blvd.) after a rain event, June 2010 (Photo by Cherie Northon).

Because Malloy (2009) did not provide any data on the precipitation during her study period or attempt to assess storm drain discharge, we (Dr. Cherie Northon and Dr. Thom Eley) contend that these stormwater outfalls may be an important source of fecal coliform bacteria, and we sampled these drains for data related to this contention. Unfortunately, we were not able to ascertain discharge rates. Our findings will be discussed in greater deal under another section.

4. Sampling Methods

The purpose of the 2009-2010 work described in the remainder of this report was to continue the monitoring of fecal coliform levels during the ice-free seasons (July-October and mid-May to 30 June). Weekly surveys have been conducted using a canoe to access the sample locations. Turbidity and Secchi depth measurements were collected (Figure 12), but these subjects were adequately investigated during 2008-2009. During the 2009-2010 season, a YSI Pro Plus was acquired to measure temperature, pH, and dissolved oxygen (DO) (Figure 13), and we focused our efforts on examining the impact of these parameters on fecal coliform levels. The non-attainment status of Jewel Lake with respect to the fecal coliform standards, the identification of possible sources, and determination of temporal and spatial fluctuations were continued.

Figure 12. Dr. Cherie Northon records the Secchi depth on Jewel Lake, June 2010 (Photo by Thom Eley).

Figure 13. Dr. Thom Eley recording water temperature, pH, and dissolved oxygen with a YSI Professional Plus Instrument on Jewel Lake, June 2010 (Photo by Cherie Northon).

4.1 Sampling Locations

During the first year of the grant, all sample sites were randomly selected using ArcGIS and supplemental ArcGIS tools created by Hawthorn Beyer (www.spatialecology.com/htools/). The supplemental ArcGIS tools are detailed on the Geographic Information Network of Alaska (http://gina.uas.alaska.edu/). It was assumed that sample sites that were less than 2 ft deep could not be effectively sampled without disturbing the bottom sediment. In the absence of bathymetric data for the lake at the 2 ft depth, if a randomly selected site was too shallow, it was skipped and the next randomly selected site was sampled. To avoid points on the shore, a buffer of 20 feet was established around the perimeter of the lake. In selecting the random points, a list of 250 points, with a minimum distance of 50 feet between points, was generated in July, 2009. Points were generated so they did not fall within the 20 ft shoreline buffer. 250 points were generated to provide back-up points should any of the 250 sample locations be in water that is too shallow to sample (<2 ft) or otherwise inaccessible. The coordinates for each sample point can be found in the Microsoft Excel database that was turned into ADEC at the project's completion. The map below (Figure 14) shows the overall distribution of the 250 points.

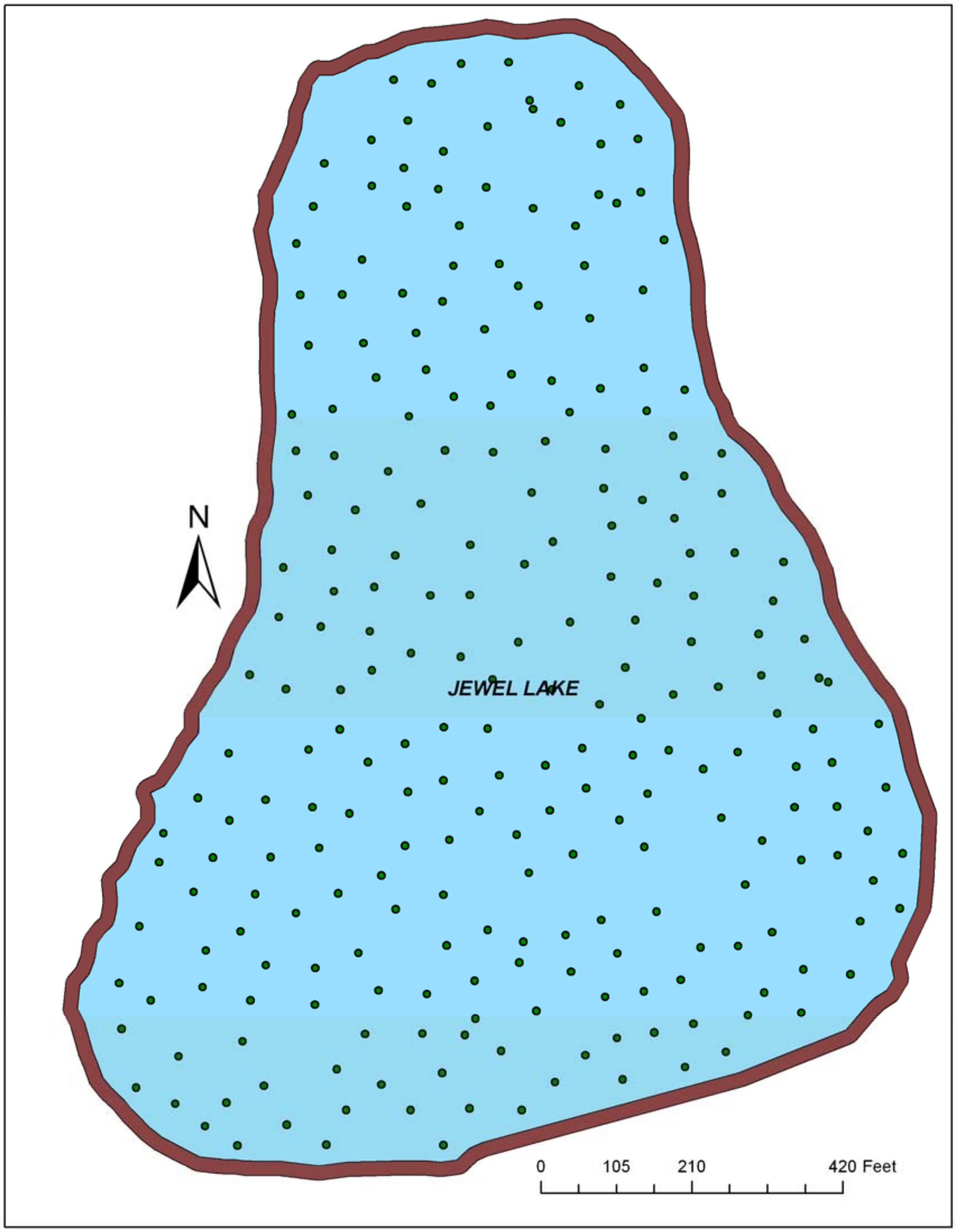

Figure 14. Distribution of 250 randomly generated sample points within Jewel Lake with the 20 foot shoreline buffer shown.

4.2 Sample Collection

Nine samples and 1 duplicate sample were collected, one day per week. Weekly samples were collected between 9 July – 22 October 2009 and again 13 May – 30 June 2010 for a combined total of 22 weeks and 220 samples (other discrete samples were taken but were not entered into the analysis of the impaired water analysis). Sample days were varied throughout the week, although sample collection times were in the morning and early afternoon to ensure samples were delivered to the lab and processed within the 6 hour time limit.

Fecal coliform bacteria samples, turbidity measurements, and Secchi depth were collected once a week from nine randomly selected locations in Jewel Lake. The lake was generally ice free from May through early October in any given year. A duplicate sample was collected for fecal coliform analysis each week.

All samples were collected in accordance with AWC's ADEC approved Quality Assurance Project Plan (QAPP). At each site, water samples for fecal coliform were collected first, followed by turbidity measurements and then Secchi depth. This order was selected to prevent contamination by collecting the bacteria sample first. Turbidity was measured before Secchi depth because lowering the Secchi disk to the bottom stirred up sediment and could have artificially increased the turbidity readings.

A 100 ml water sample for fecal coliform analysis was collected at each site using the sterile sample bottles provided by SGS Environmental Services, Inc (SGS). Water samples were collected where water is > 2 ft deep to avoid sampling in the "swash zone" (the area of low wave/nearshore water) (Nevers and Whitman, 2001). When the sample site was located by GPS, the sample container was carefully opened with effort made not to touch the interior of the container. The container was then swept down through the water in a U-shaped motion to elbow depth and then turned upright to fill. The container was then immediately closed and placed in a cooler on ice. After completion of sampling for the day, samples were delivered to SGS and analyzed for fecal coliform under Standard Method 9222D. The 6 hour hold time was observed.

Turbidity samples were collected in the instrument container designed for the LaMotte Model 2020e Portable Turbidity Meter . The hand-held dip sampling procedure for non-isokinetic sampling of surface waters method described in the USGS National Field Manual for the Collection of Water-Quality Data (USGS, 2006) was used whenever possible.

A 20 cm Secchi disk with 20 meters of calibrated line was used, in addition to turbidity measurements, to assess water clarity in Jewel Lake. The Secchi disk was lowered into the water, on the shaded side of the boat, at each sample site. The depth at which the disk was no longer visible was recorded (however in 2010 it was rare for the Secchi disk to not be seen). The Secchi disk was pulled up and the depth at which the disk became visible again was recorded. The two depths were then averaged. To maintain consistency in reading the Secchi disk, every effort was made to have the same staff member determine Secchi depth for all samples.

The YSI Pro Plus probe was lowered into the lake, and when the readings stabilized, temperature, pH, and DO data were collected at each sample site. The YSI Pro Plus was calibrated for pH and DO before each sampling sections. The temperature reading of the YSI Pro Plus was compared several times to a National Institute of Standards thermometer (NIST) with no discrepancies.

Additionally, field notes were recorded about weather, presence of wildlife, and human and pet activities on the sample date. All data were recorded in a bound field notebook which will be turned into ADEC at the project's completion.

5. Jewel Lake Data Analysis

5.1.a Fecal Coliform Findings: 2009-2010

During the sampling period (July-October 2009 and May-June 2010), 219 samples of Jewel lake water were collected with 189 from randomly selected points[2] and 20 duplicate samples. Fecal coliform concentrations in Jewel Lake for the sampling period ranged from ND (None Detected)[3] to 23 FC/l00 ml. The range for all samples was ND to 23, while the geometric mean was 2.40, the median 2, and the mode was 1.

Fecal coliform concentrations were highest in July 2009 and lowest in September 2009 during the 2009-2010 sampling period (Table 5). In the 2008-2009 sampling period fecal coliform concentrations were highest in September 2008, and lowest in July 2008 (Table 6).

Table 5. Monthly fecal coliform statistics for Jewel Lake during the 2009-2010 sampling period.

Month	No. of samples	Fecal Coliform (FC/100ml)				
		Min	Median	Geometric Mean	Mode	Max
July 2009	39	ND	4	4.12	3	14
August 2009	50	ND	2	2.44	1	23
September 2009	30	ND	2	1.46	1	12
October 2009	20	ND	3	2.58	1	9
May 2010	30	ND	1	1.68	1	6
June 2010	50	ND	2	1.78	1	7
TOTALS of ALL SAMPLES	**219**	**ND**	**2**	**2.40**	**1**	**23**

[2] During the July-October 2009 collection period, Jewel Lake location #30 was inadvertently missed. Both Ms. Malloy's field notes and SGS fecal coliform reports were checked, and the site was definitely not sampled—the reason is unknown.

[3] Malloy (2009) treated a ND or None Detected rating for the analysis of a water sample for fecal coliform as a "0." A "None Detected" does not mean there weren't fecal coliform present in the sample, but only that none were detected. Therefore we used ND instead of 0 for the 2009-2010 computations.

Table 6. Monthly fecal coliform statistics for Jewel Lake during the 2008-2009 sampling period.

Month	No. of samples	Fecal Coliform (FC/100ml)			
		Min	Median	Geometric Mean	Max
July 2008	18	0	0	0.5	2
August 2008	45	0	1	0.91	6
September 2008	45	0	2	3.71	27
October 2008	18	0	0	0.89	5
May 2009	27	0	0	0.96	10
June 2009	45	0	0	0.6	8

During the 2009-2010 sampling period, fecal coliform concentrations showed a relatively homogenous spatial pattern throughout the lake (Figure 15) as was found in the 2008-2009 sampling. A map of the comprehensive coliform distribution for Jewel Lake during the 2008-2009 sampling period is provided for comparison (Figure 16). The 2009-2010 fecal coliform data are also mapped by month (Figures 17-22) No particular “hot spots” are noted.

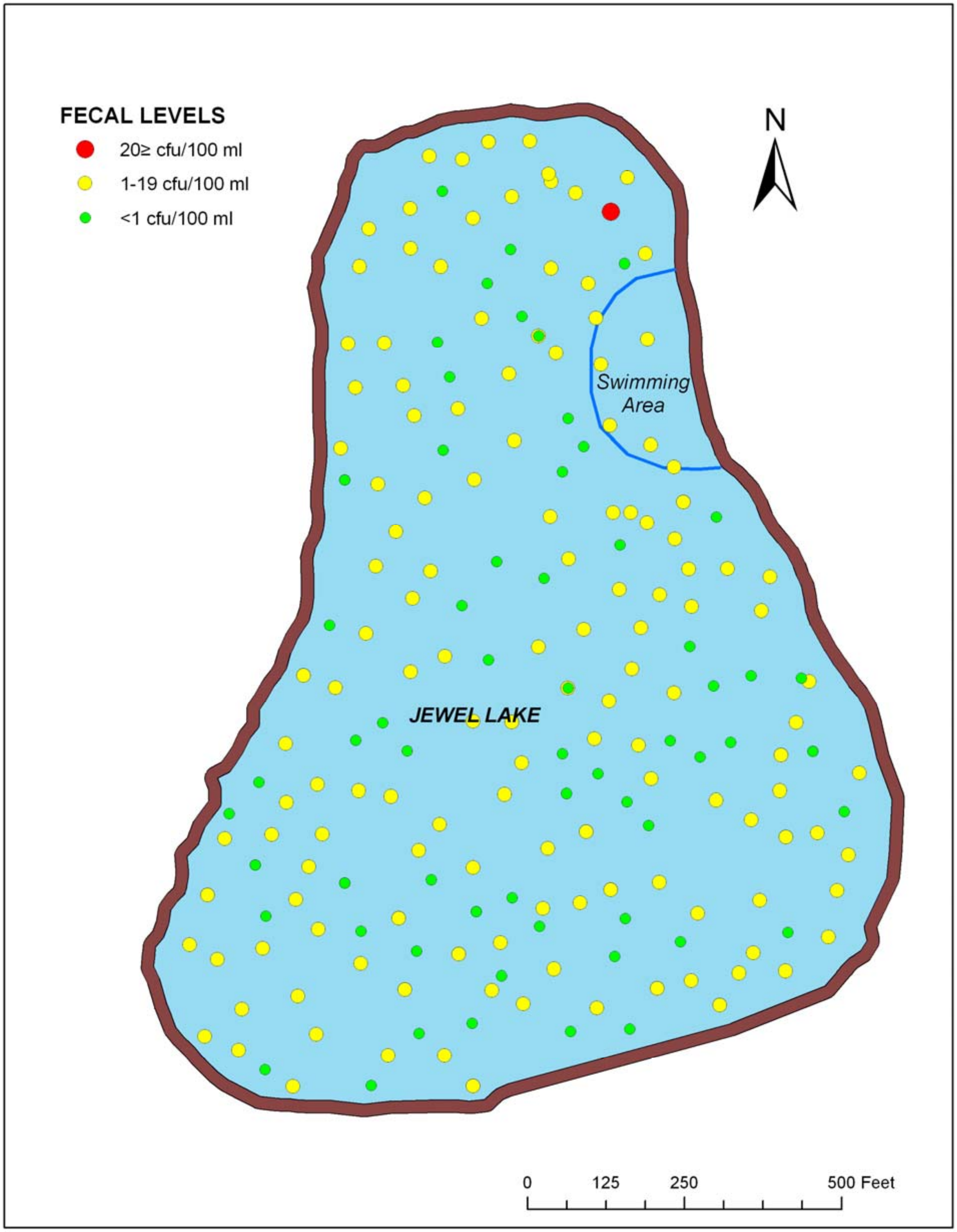

Figure 15. Fecal coliform bacteria data collected from Jewel Lake for the July 2009-June 2010 sampling period (Cartography by Dr. Thom Eley).

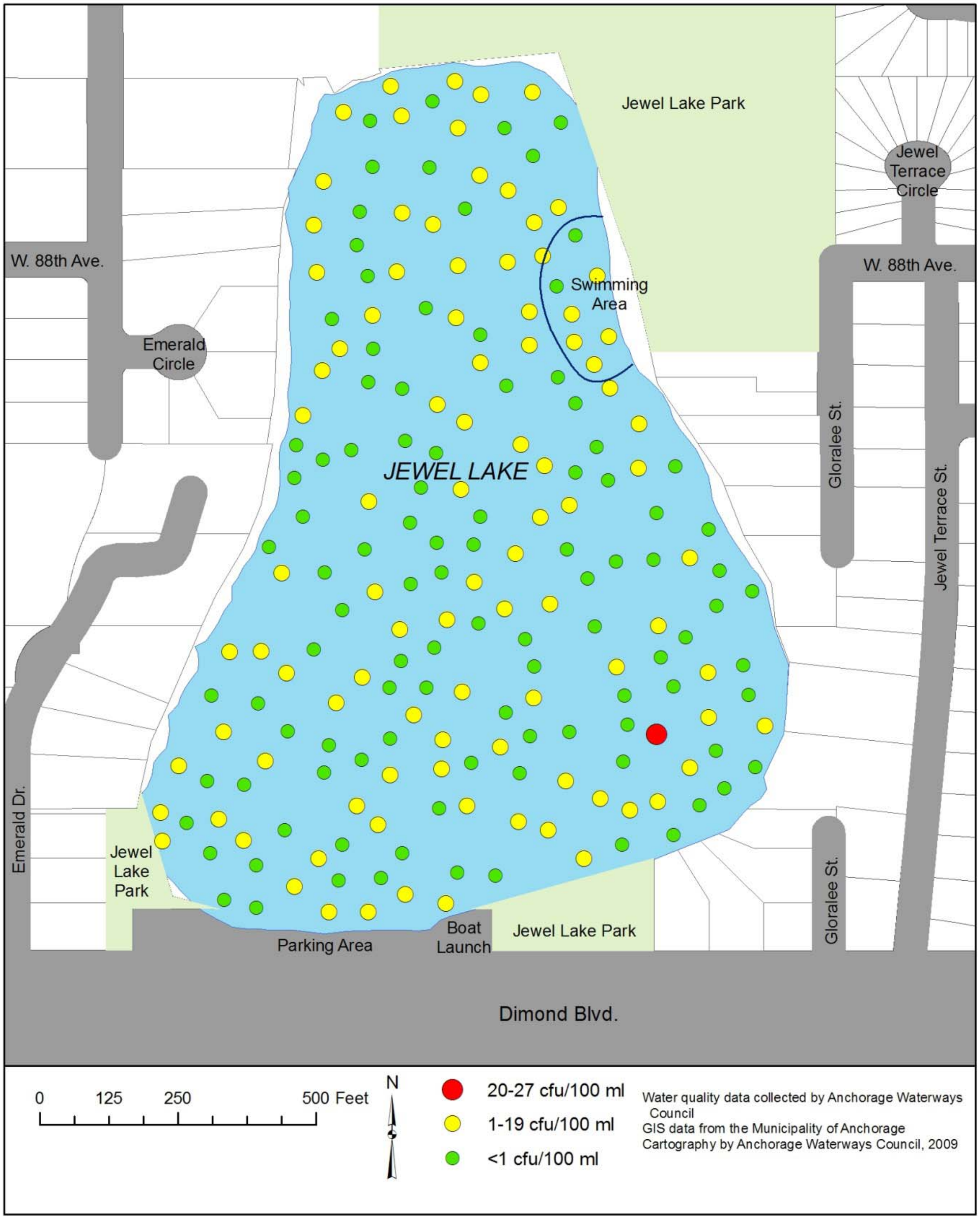

Figure 16. Fecal coliform bacteria data collected from Jewel Lake for the July 2008-June 2009 sampling period (Cartography by Dr. Cherie Northon).

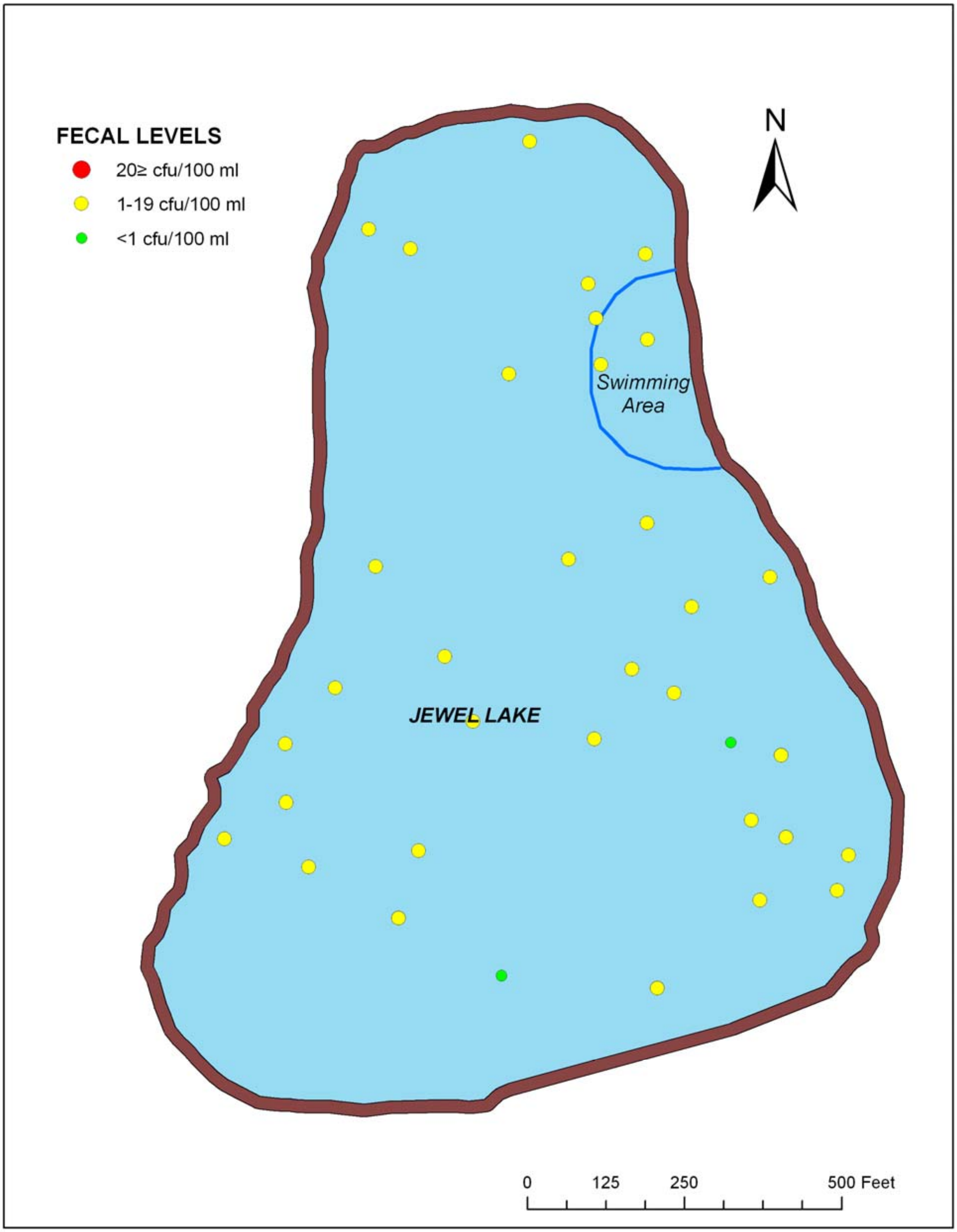

Figure 17. Fecal coliform bacteria data collected from Jewel Lake, July 2009 (Cartography by Dr. Thom Eley).

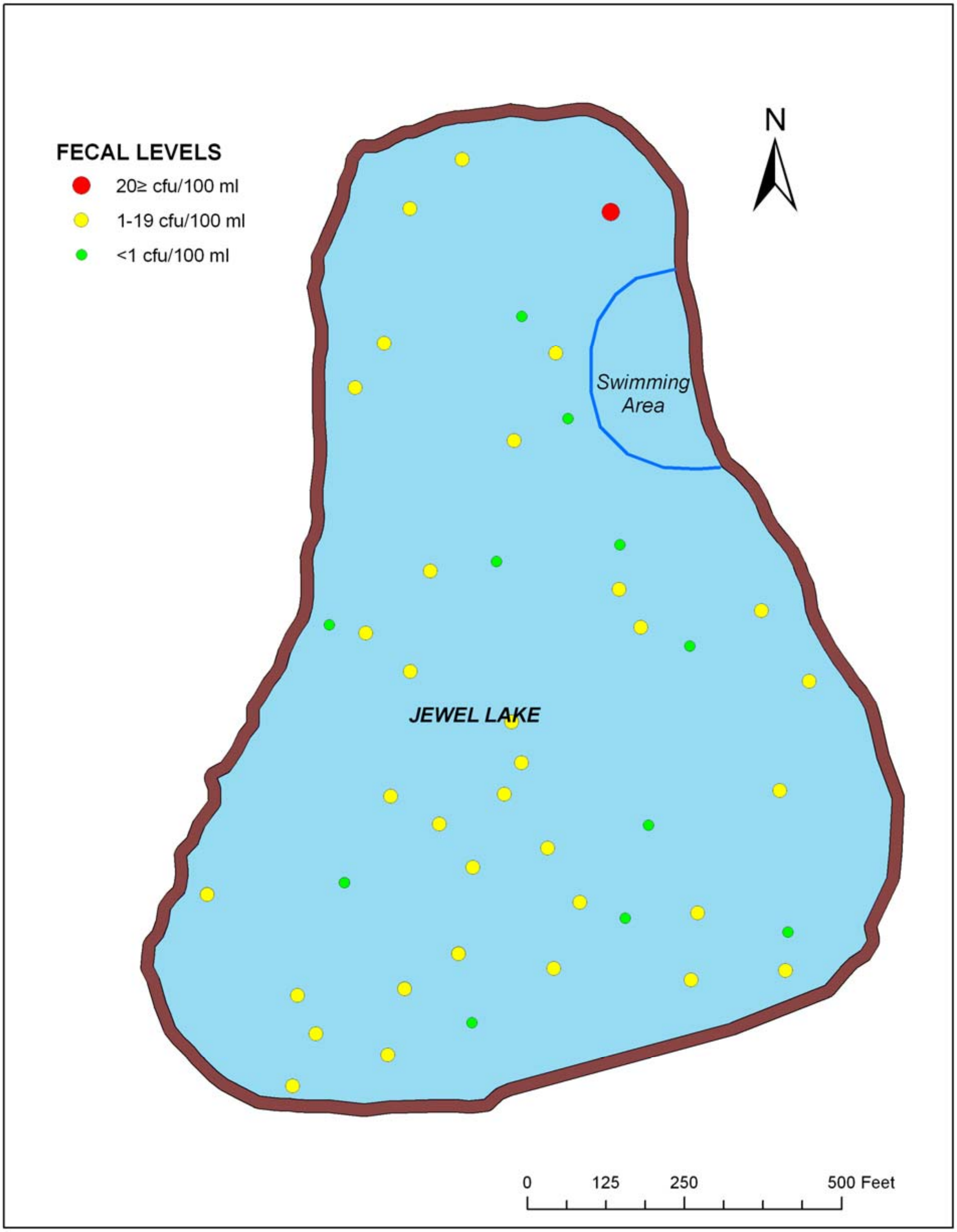

Figure 18. Fecal coliform bacteria data collected from Jewel Lake, August 2009 (Cartography by Dr. Thom Eley).

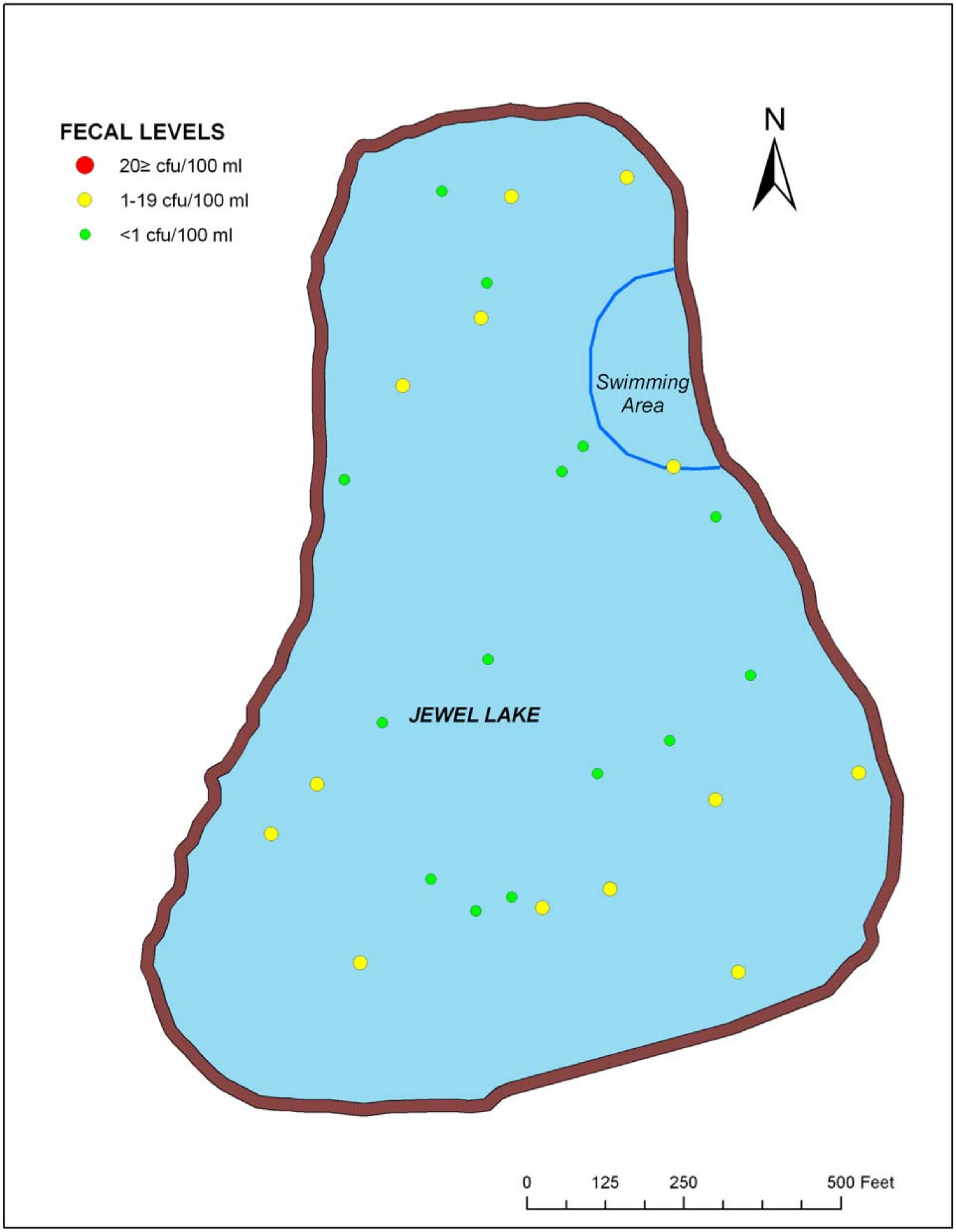

Figure 19. Fecal coliform bacteria data collected from Jewel Lake, September 2009 (Cartography by Dr. Thom Eley).

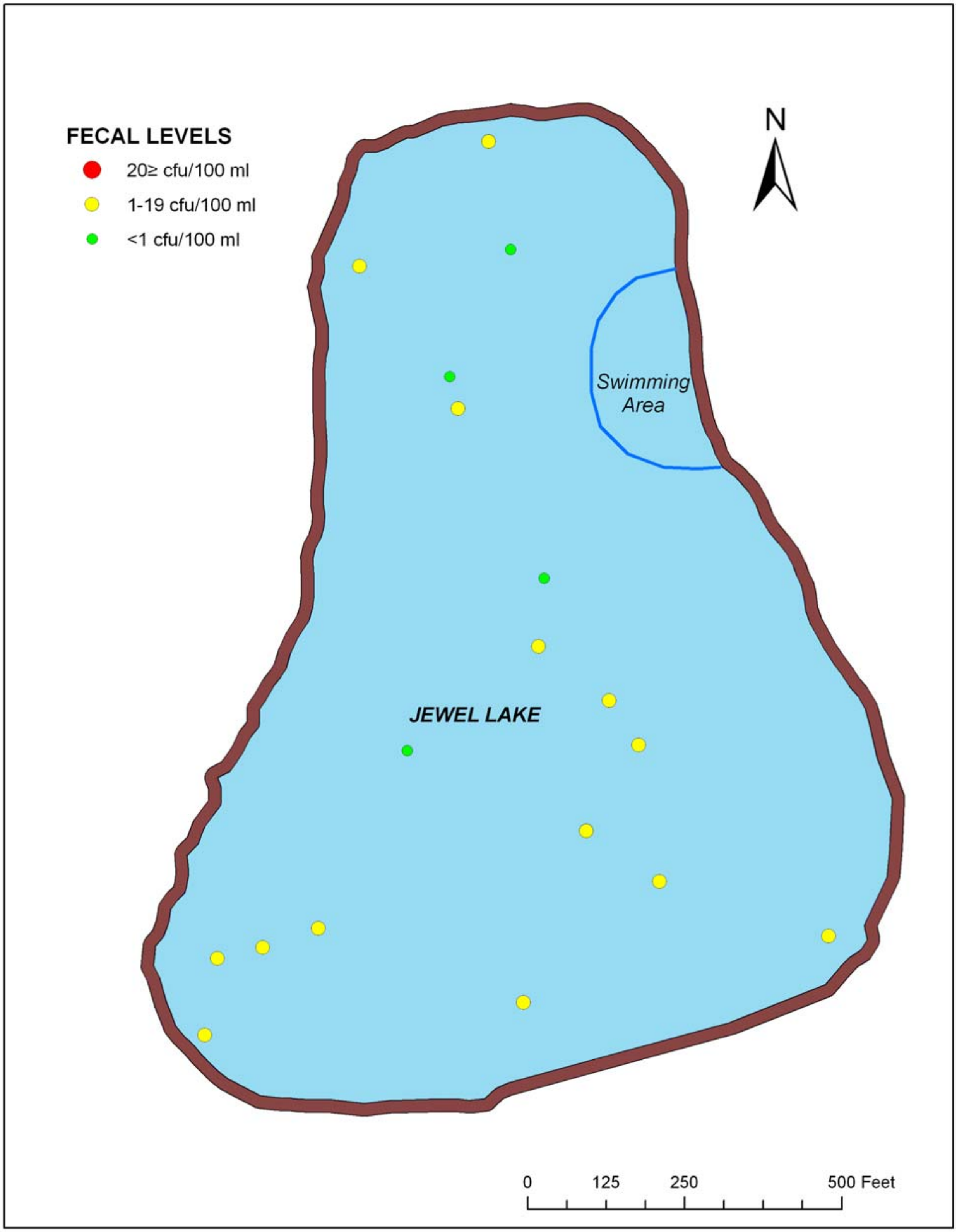

Figure 20. Fecal coliform bacteria data collected from Jewel Lake, October 2009 (Cartography by Dr. Thom Eley).

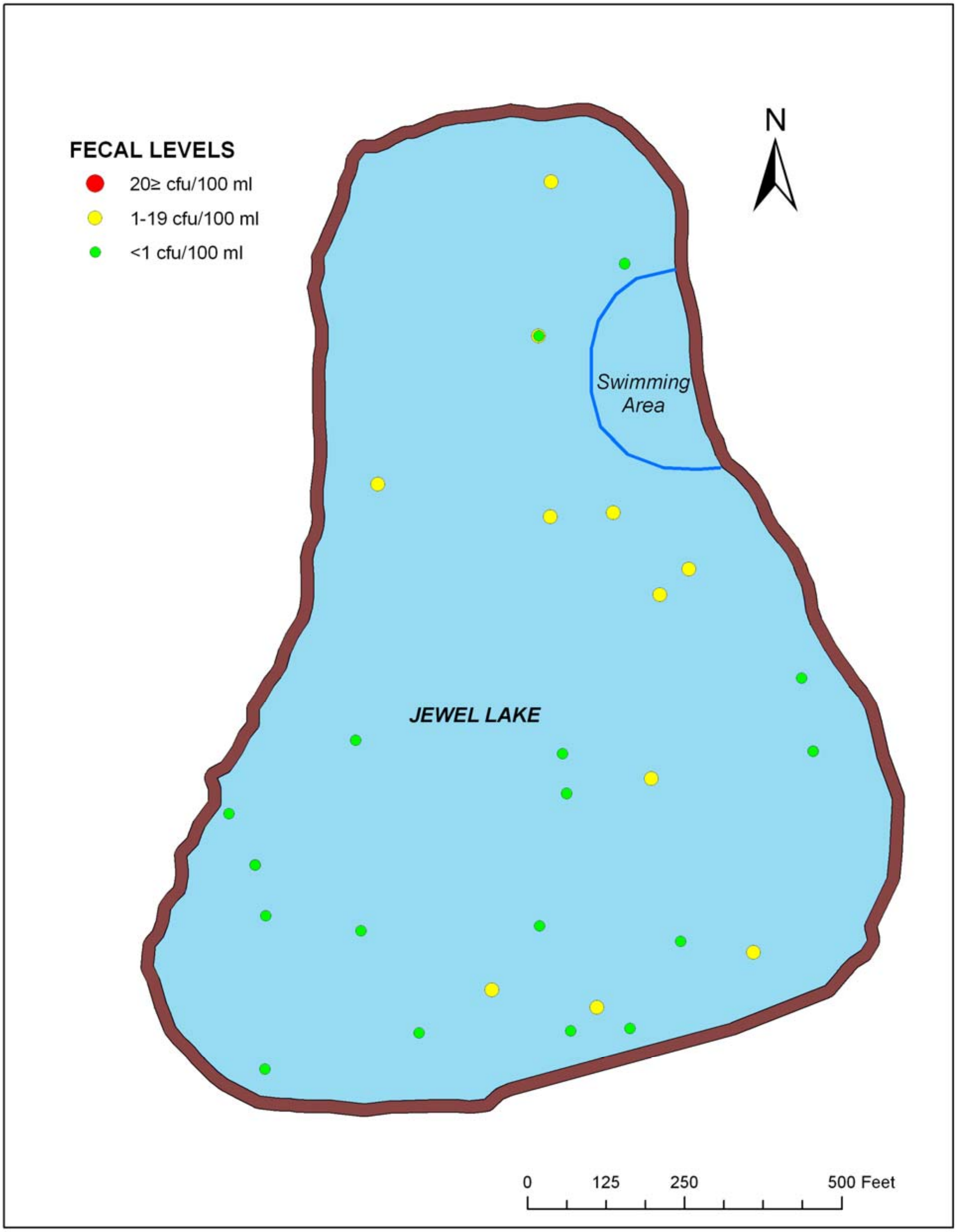

Figure 21. Fecal coliform bacteria data collected from Jewel Lake, May 2010 (Cartography by Dr. Thom Eley).

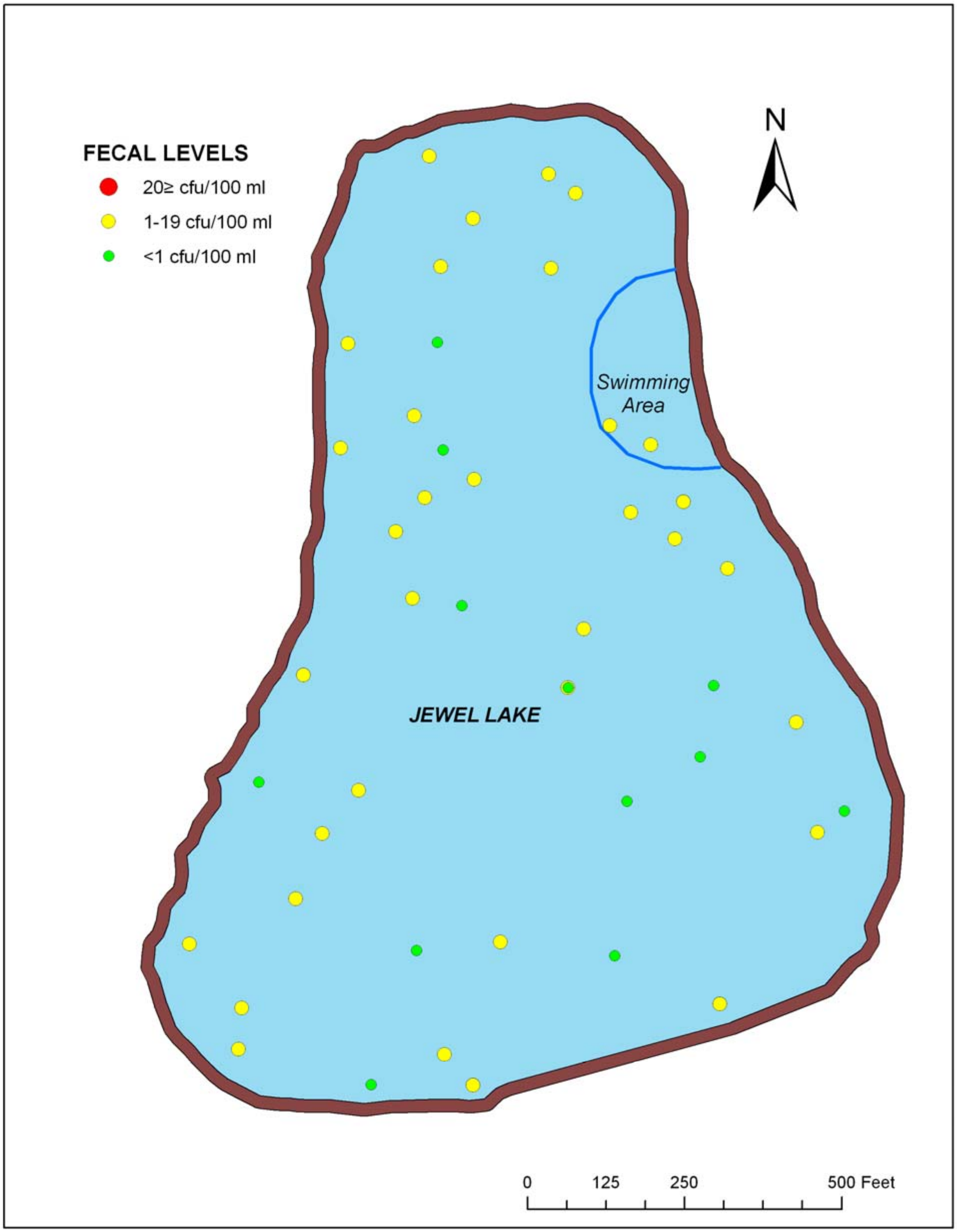

Figure 22. Fecal coliform bacteria data collected from Jewel Lake, June 2010 (Cartography by Dr. Thom Eley).

5.1.b Lake-wide Fecal Coliform Exceedances

The Alaska State Water Quality Standard for fecal coliform was described in detail in Section 3. The relevant criteria for Jewel Lake are the water supply standard for drinking, culinary and food processing. The State of Alaska Water Quality Standards for the drinking water quality state: “In a 30-day period, the geometric mean may not exceed 20 FC/100 ml, and not more than 10% of the sample may exceed 40 FC/100 ml” (ADEC 2009). There is an argument to be discussed later that Jewel Lake should be reclassified from the drinking water standard to the less stringent “contact recreation” standard, which raises the geometric mean limit for a 30-day period to 100 FC/100 ml.

During the 2009-2010 sampling period the geometric mean ranged from 1.46 to 4.12 (Table 5) while the geometric means ranged from 0.5 to 3.71 in the 2008-2009 period (Table 6). The highest fecal coliform concentration recorded in 2009-2010 was a one-time value of 23 FC/100 ml, which was collected in the northeast part of the lake near the swimming beach. During the 2008-2009 sampling period, a 27 FC/100 ml sample was collected in the southeast part of the lake. During both of the sampling periods no geometric mean for a 30-day period exceeded the 20 FC/100 ml standard. AWC ascertained that Jewel Lake met the water quality standards.

5.1.c Replicate Samples

Twenty-two replicate samples were taken during this year’s sampling process and consisted of the 10th sample each week. The differences in replicates ranged from 0 to 7 FC/100 ml with 17 (77.3%) being two or less FC/100 ml differences (Table 7). We could not determine a reason for these differences in replicates, however, the bulk of them were in the southern portion of the lake (Figure 23).

Table 7. Differences between replicate pairs of fecal coliform samples in Jewel Lake, 2009-2010.

Differences between the replicates (FC/100 ml)	Number	Percent
0	10	45.5
1-2	7	31.8
3-4	3	13.6
5-6	1	4.5
7	1	4.5

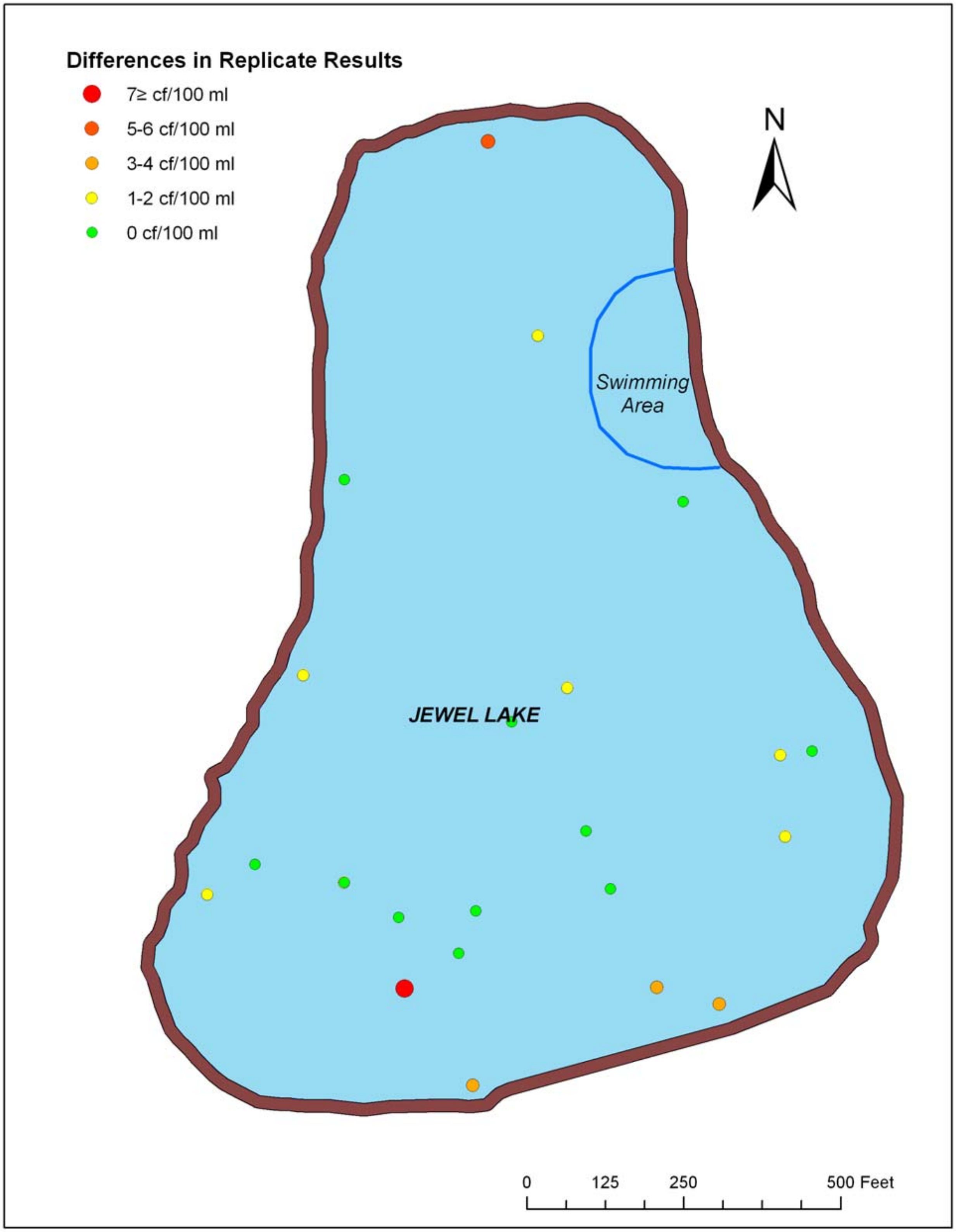

Figure 23. Spatial distribution of the differences in replicates, Jewel Lake, 2009-2010 (Cartography by Dr. Thomas Eley).

5.2 Secchi Disk Depth

Secchi depth in Jewel Lake for the 2009-2010 sampling period ranged from 0.5 – 4.8 m, with a median of 2.5 and a mean of 2.6. Although the Secchi disk is used to measure water clarity and while we found the water amazing clear, we do not think it was very effective. In about 94% of our samples, the Secchi disk was on the lake bottom for the readings. Effectively what the Secchi data gives us is basically a bathymetric survey of the lake (Figure 24). However the monthly descriptive statistics are presented in Table 8, and the spatial distribution of Secchi measurements are mapped in Figures 25-31 .

Table 8. Summary of Jewel Lake Secchi depth by month, 2009-2010.

Month	No. of sampling events	No. of samples	Secchi Depth (m)			
			Min	Median	Mean	Max
July 2009	4	35	0.75	2.4	2.3	4.5
August 2009	5	45	0.75	2.8	2.5	3.5
September 2009	3	27	0.50	3.25	2.7	4.5
October 2009	2	18	0.75	3.25	2.6	4.5
May 2010	3	27	1.25	3.0	2.9	4.8
June 2010	5	45	0.75	2.5	2.7	4.5
TOTAL	**22**	**197**	**0.50**	**2.5**	**2.6**	**4.8**

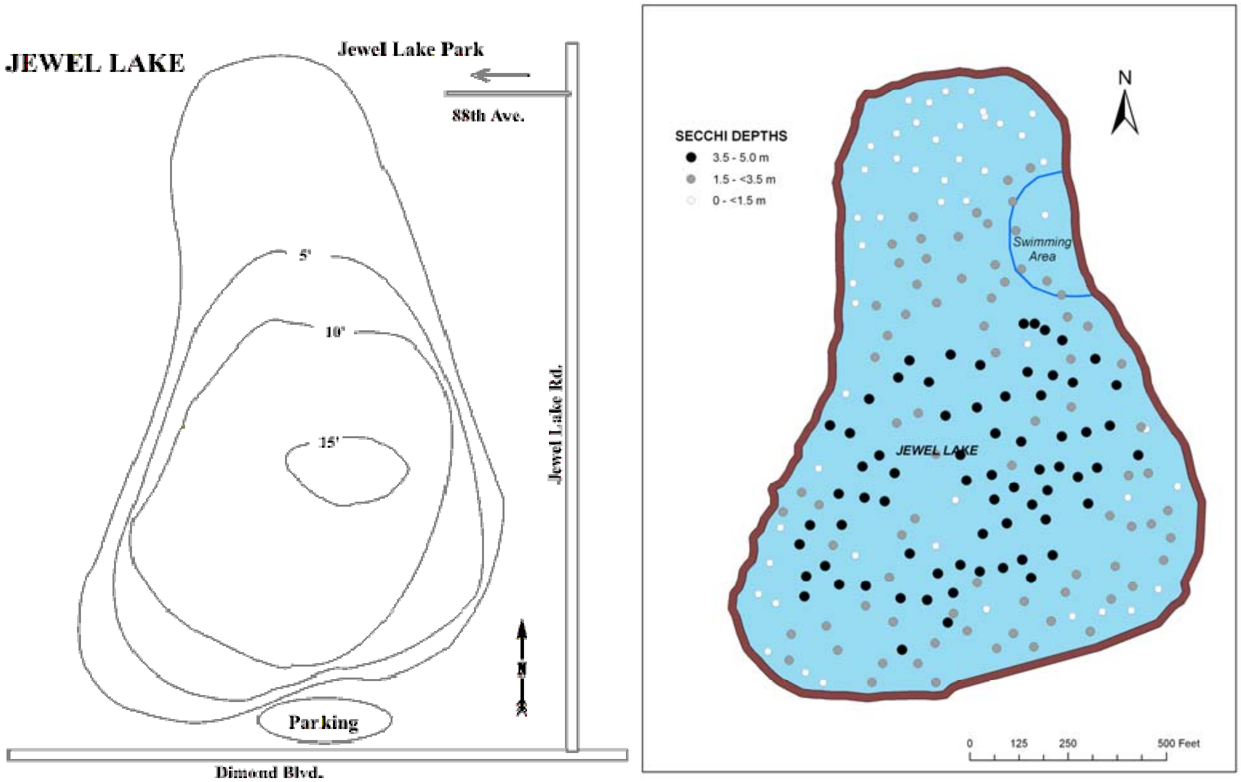

Figure 24. Comparison of bathymetric and Secchi maps of Jewel Lake, 2009-2010.

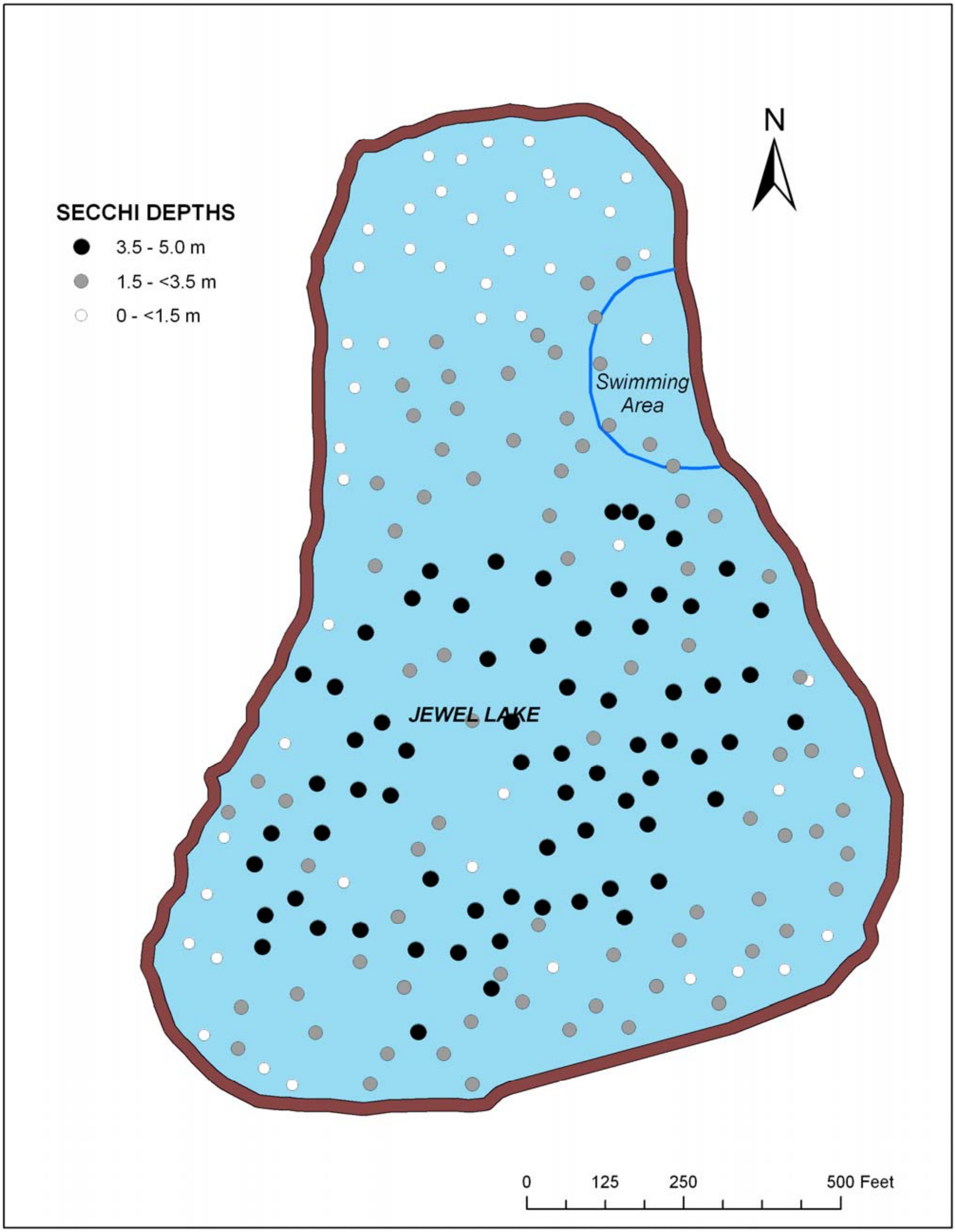

Figure 25. All Secchi depth data collected in Jewel Lake from 1 July 2009 to 30 June 2010 (Cartography by Dr. Thom Eley).

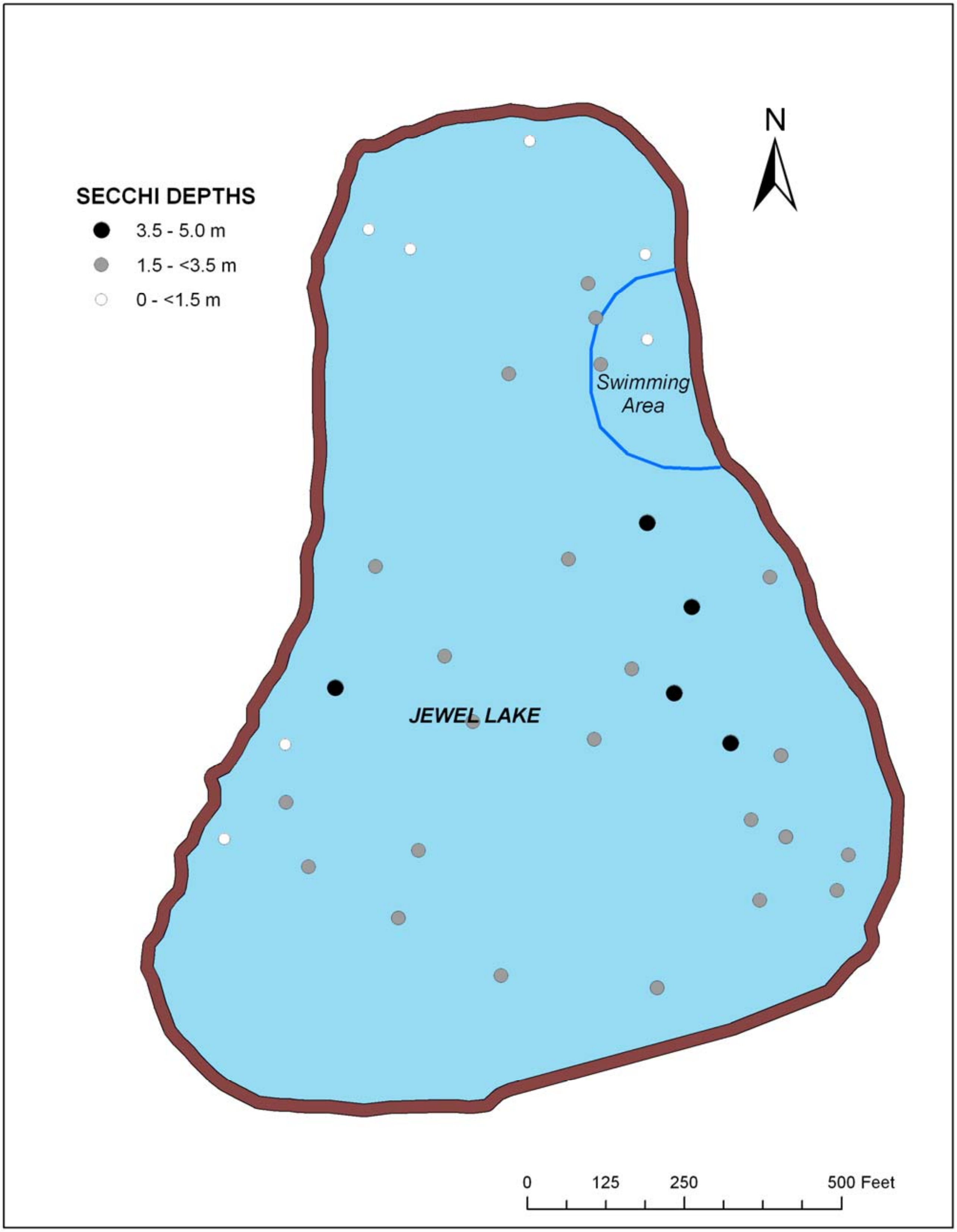

Figure 26. All Secchi depth data collected in Jewel Lake during July 2009 (Cartography by Dr. Thom Eley).

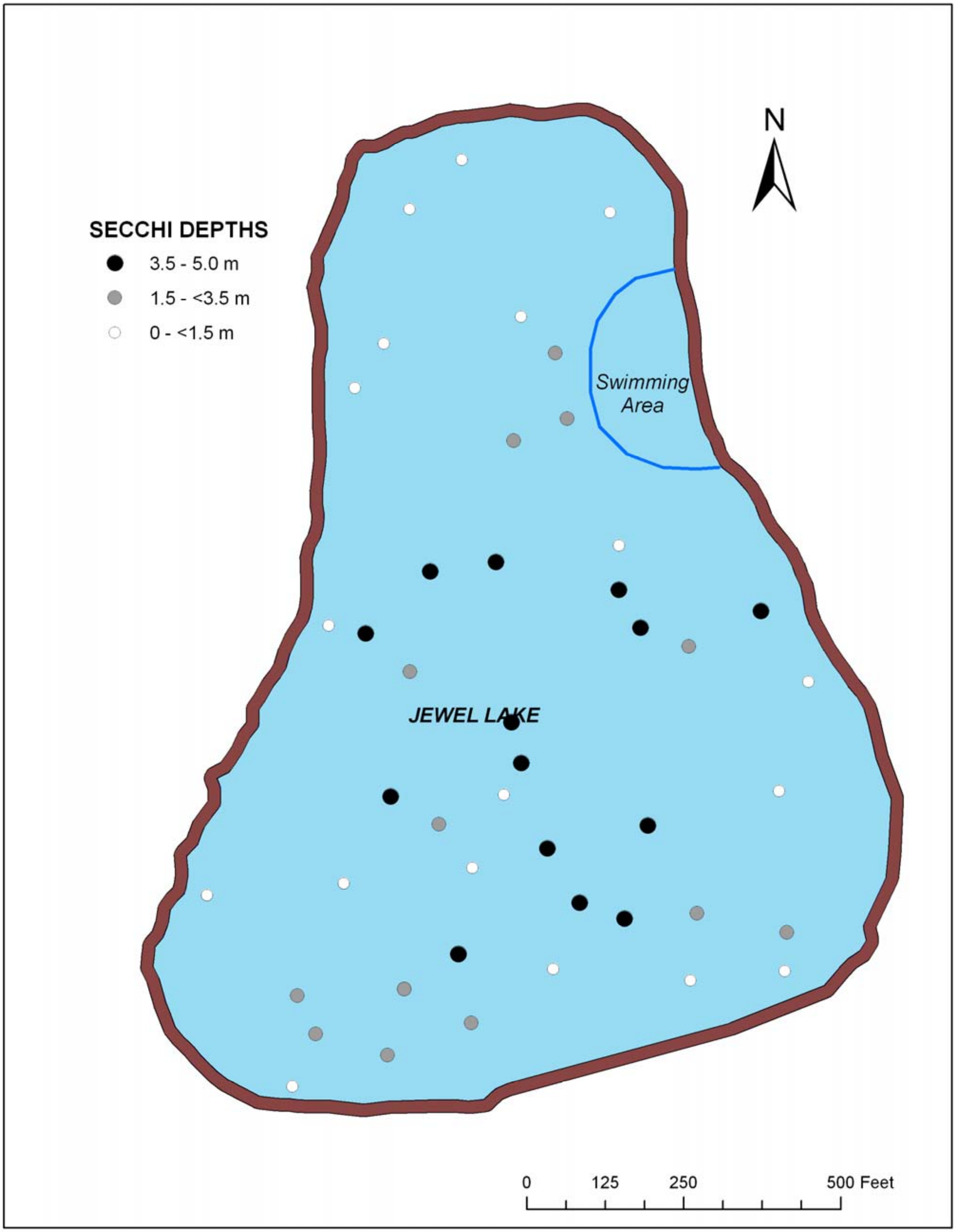

Figure 27. All Secchi depth data collected in Jewel Lake during August 2009 (Cartography by Dr. Thom Eley).

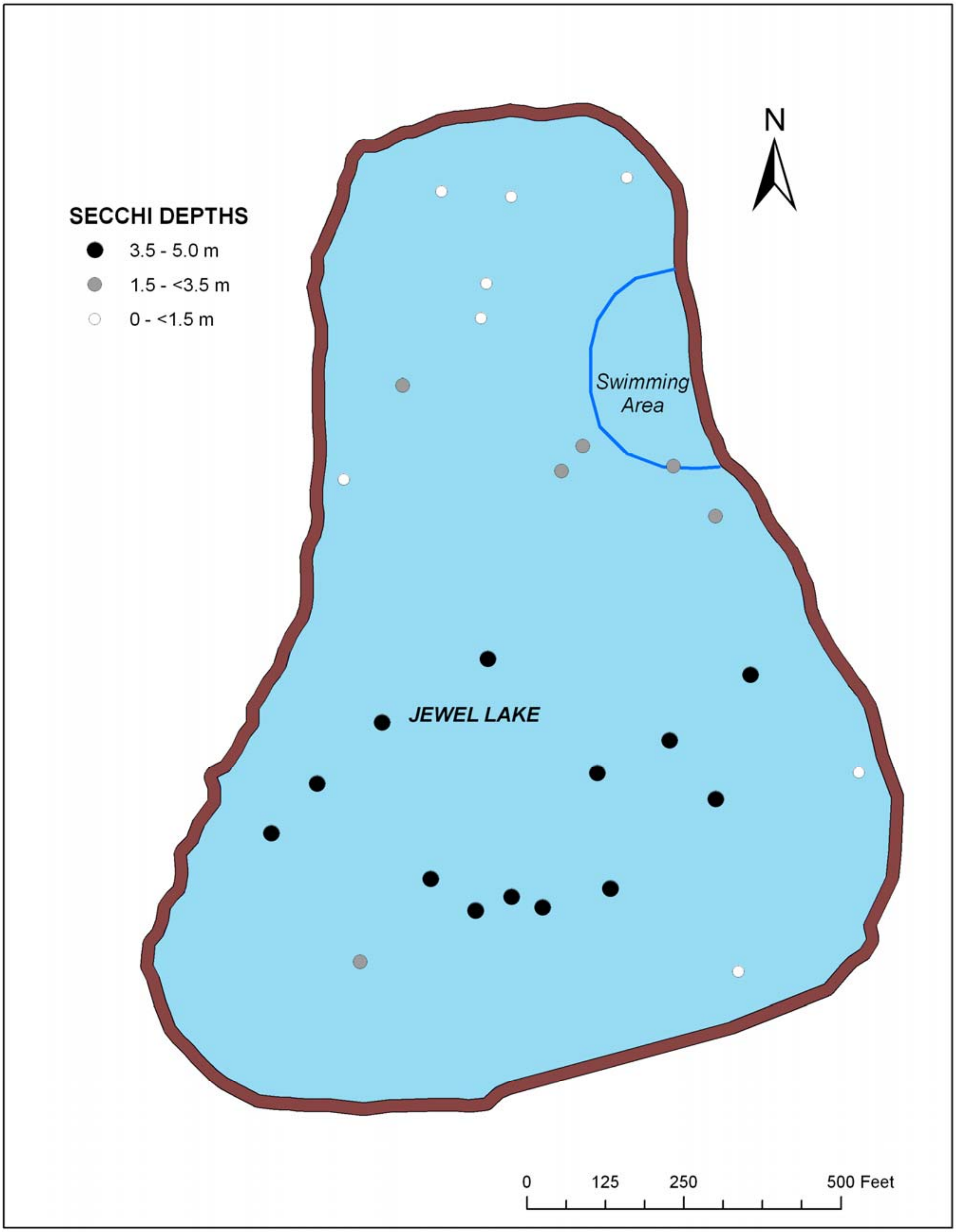

Figure 28. All Secchi depth data collected in Jewel Lake during September 2009 (Cartography by Dr. Thom Eley).

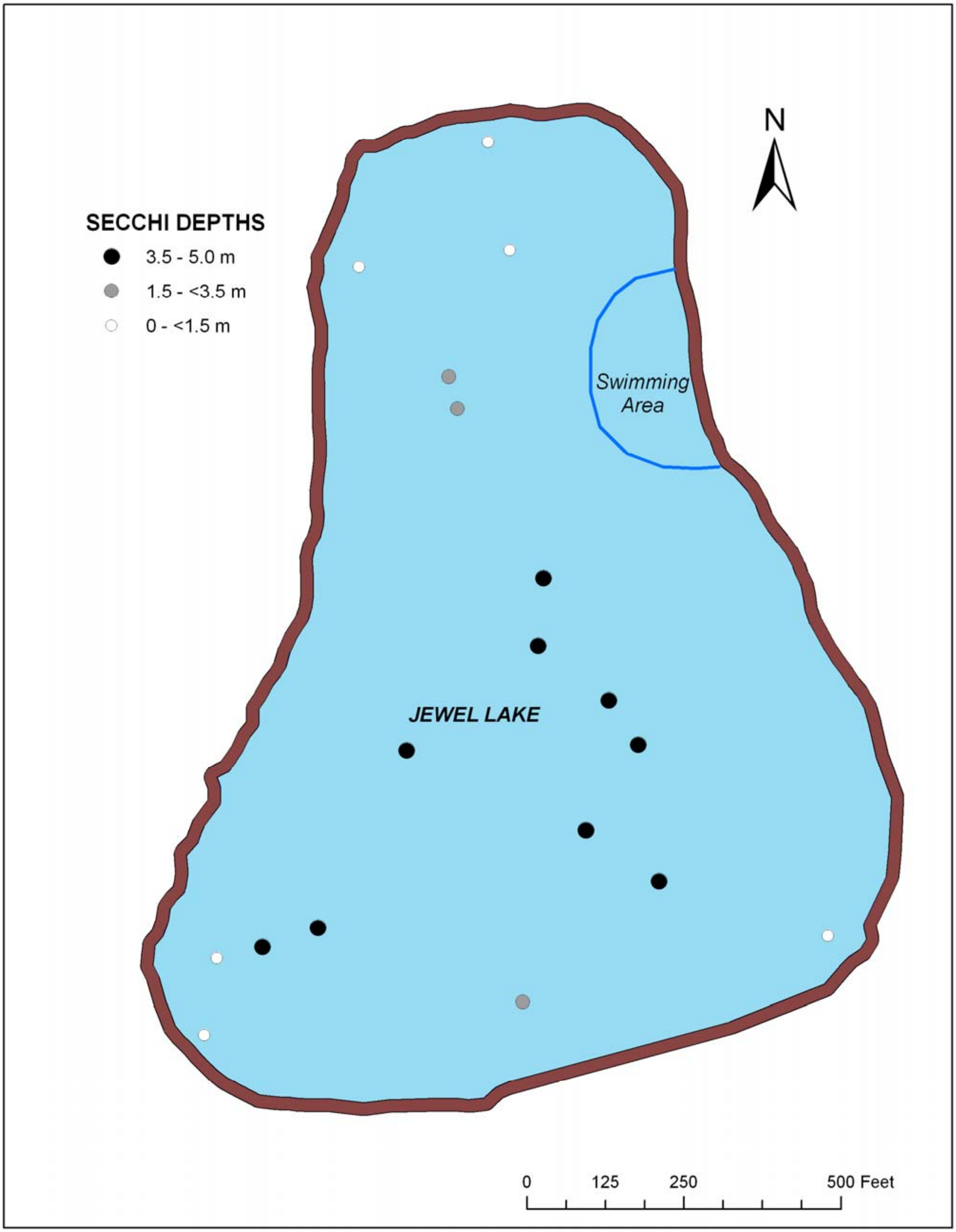

Figure 29. All Secchi depth data collected in Jewel Lake during October 2009 (Cartography by Dr. Thom Eley).

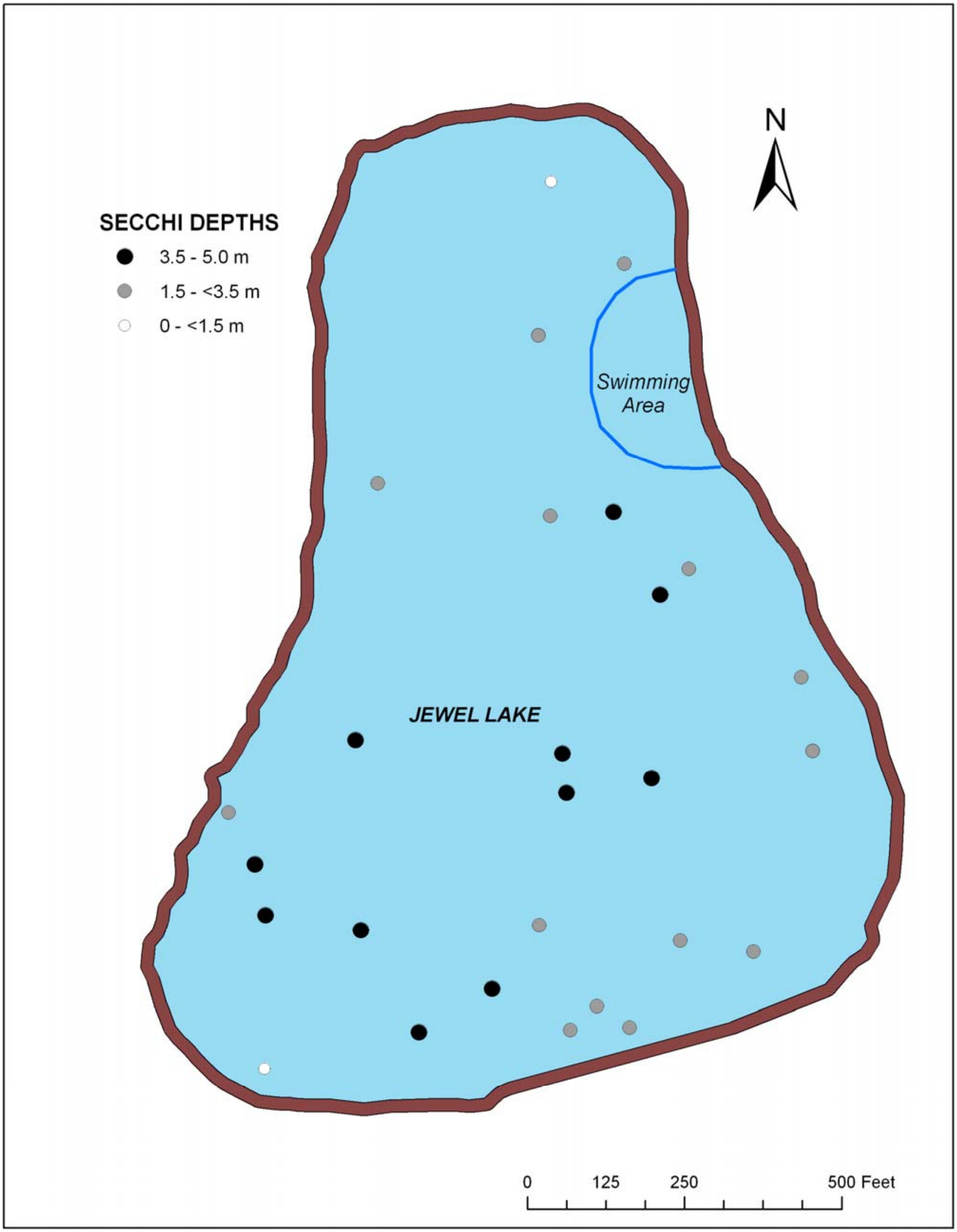

Figure 30. All Secchi depth data collected in Jewel Lake during May 2010 (Cartography by Dr. Thom Eley).

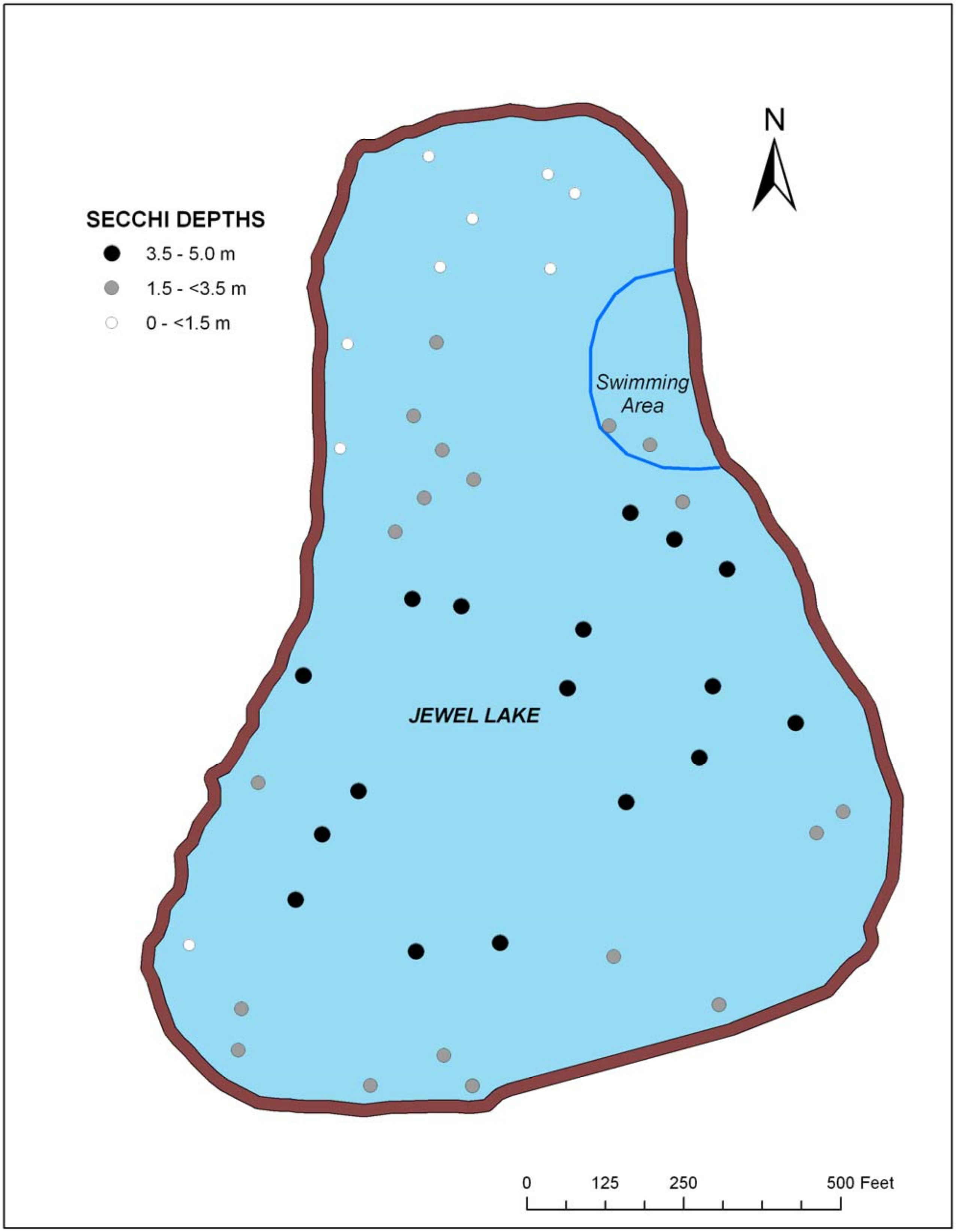

Figure 31. All Secchi depth data collected in Jewel Lake during June 2010 (Cartography by Dr. Thom Eley).

5.3 Lake Water Turbidity

Turbidity in Jewel Lake during the sampling period ranged from 0.02 to 2.71 Nephelometric Turbidity Units (NTU's), with a median of 0.71 and an average of 0.88 NTU's. Turbidity was highest in July 2009 (highest mean 1.25 NTU's) and June 2010 (maximum 2.71 NTU's). The lowest mean was in May 2010 (mean 0.39 NTU's), however, the lowest reading of 0.02 NTU's was on July 28, 2009, when two 0.02 readings were made. We question whether these are valid readings. They are incredibly low, and out of line with other readings for that day. We had trouble with both of the AWC's turbidity meters, and we did not put figures that seemed unreasonable into the database. Recent conversations with other researchers have found difficulties in getting consistent accurate readings. One group has their turbidity meter professionally calibrated before each use as they had problems with the calibration procedure. Monthly descriptive statistics are included for turbidity in Jewel Lake in Table 9.
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Turbidity for the 2009-2010 sampling period is mapped in Figure 32. The highest values (i.e., red dots) occurred in the southern portion of the lake. Depths are also greater in the southern portion of the lake. Monthly turbidity values were also mapped in Figures 33-38.

Table 9. Summary of Jewel Lake turbidity by month, 2009-2010.

Month	No. of sampling events	No. of samples	Turbidity (NTU)			
			Min	Median	Mean	Max
July 2009	4	29	0.02	1.39	1.25	2.02
August 2009	5	40	0.21	0.90	0.88	1.86
September 2009	3	30	0.08	0.68	0.83	2.21
October 2009	2	3	0.33	0.42	0.57	0.95
May 2010	3	22	0.25	0.35	0.39	0.70
June 2010	5	8	0.34	0.63	1.22	2.71
TOTAL SAMPLE	**22**	**132**	**0.02**	**0.71**	**0.88**	**2.71**

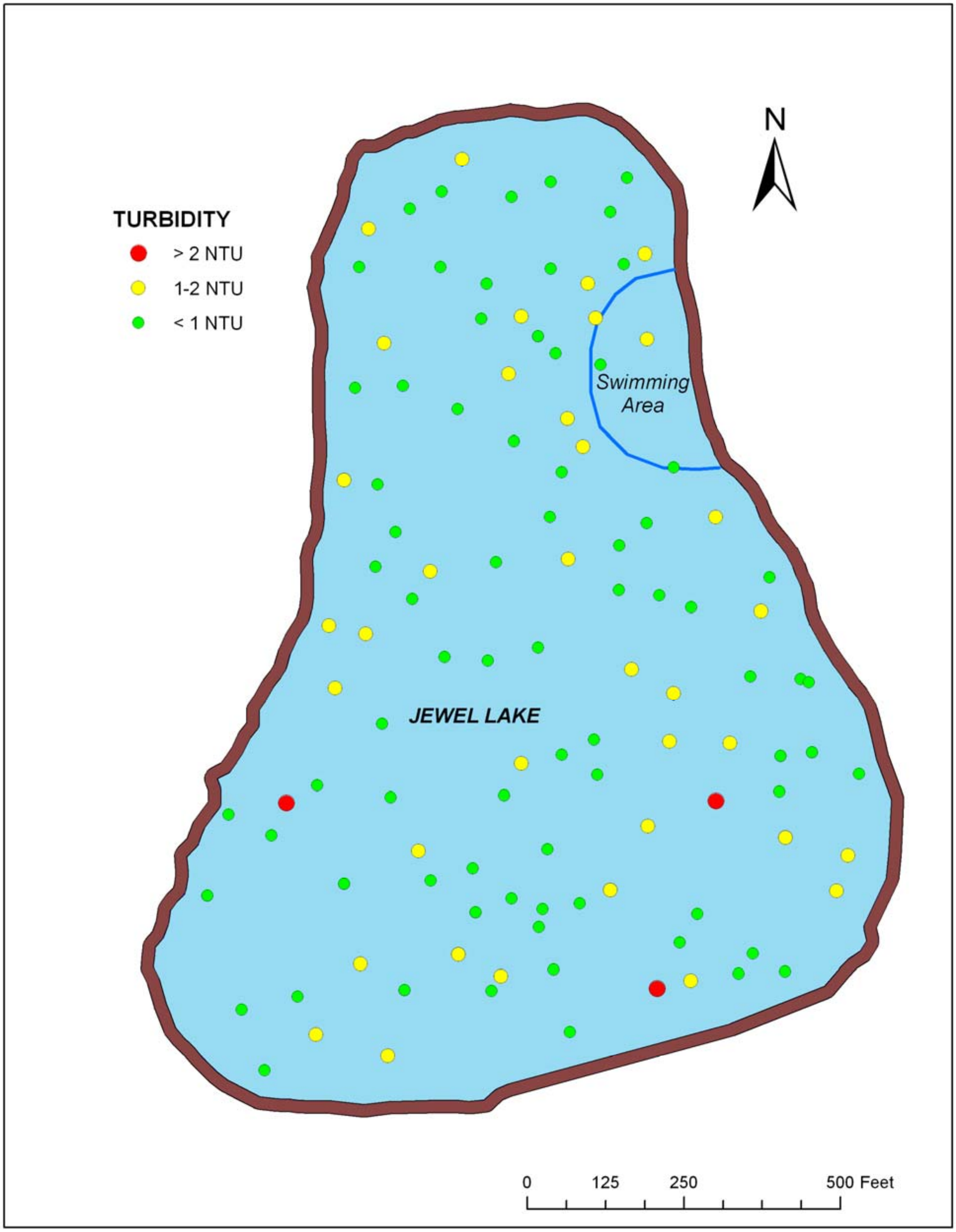


Figure 32. Summary of all turbidity measurements (NTU's) in Jewel Lake for the 2009-2010 sampling period (Cartography by Dr. Thom Eley).

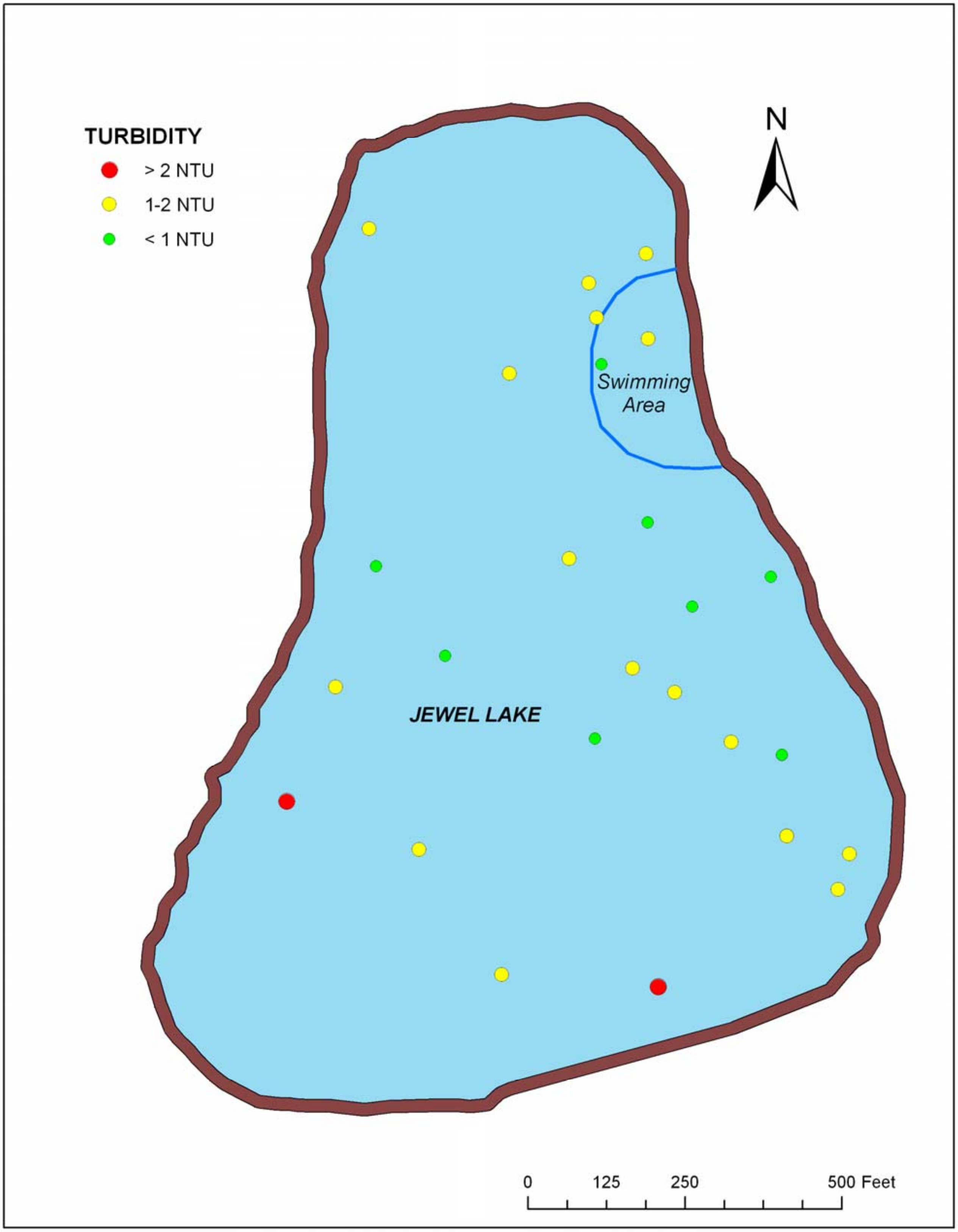


Figure 33. Summary of all turbidity measurements (NTU's) in Jewel Lake for July 2009 (Cartography by Dr. Thom Eley).

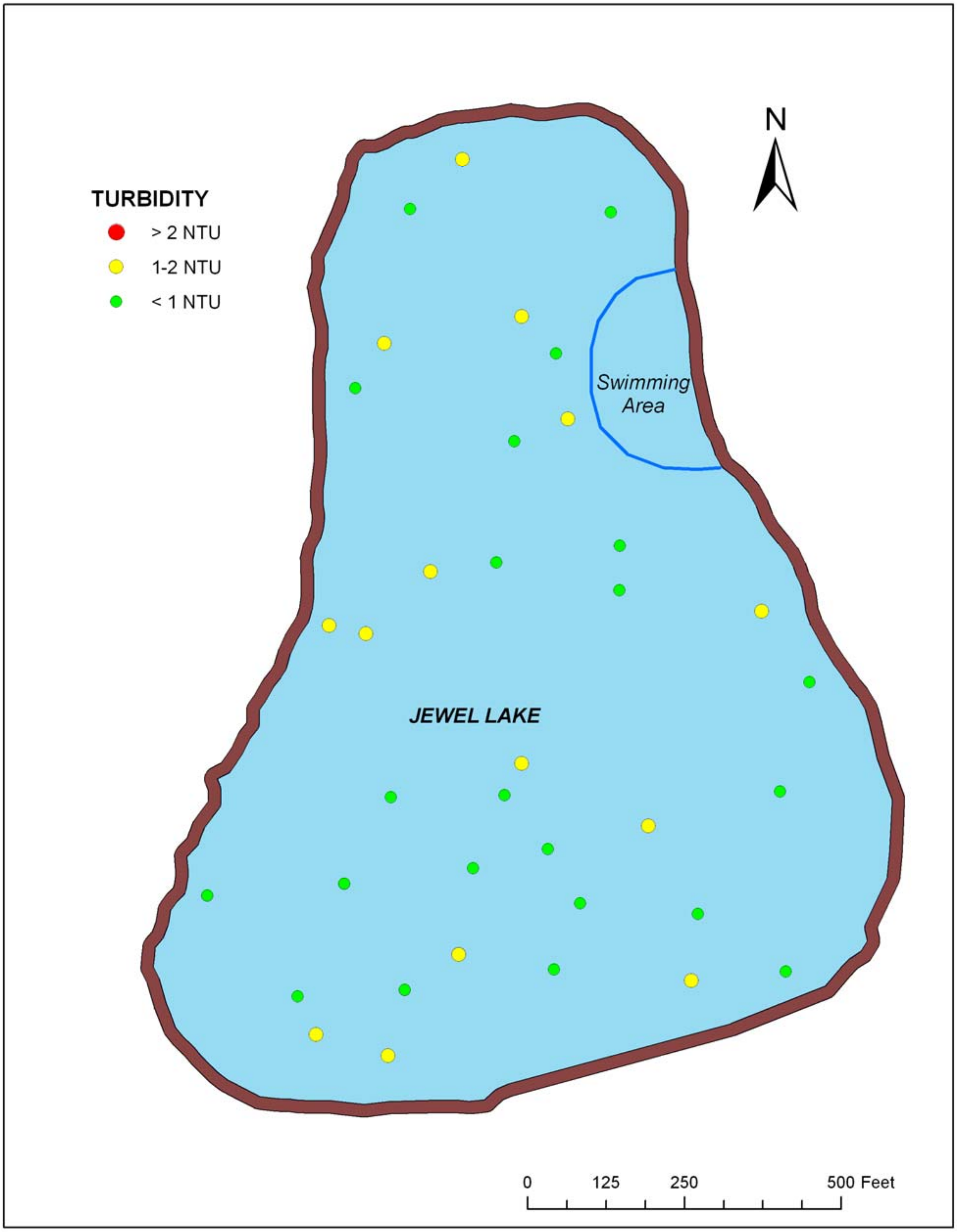


Figure 34. Summary of all turbidity measurements (NTU's) in Jewel Lake for August 2009 (Cartography by Dr. Thom Eley).

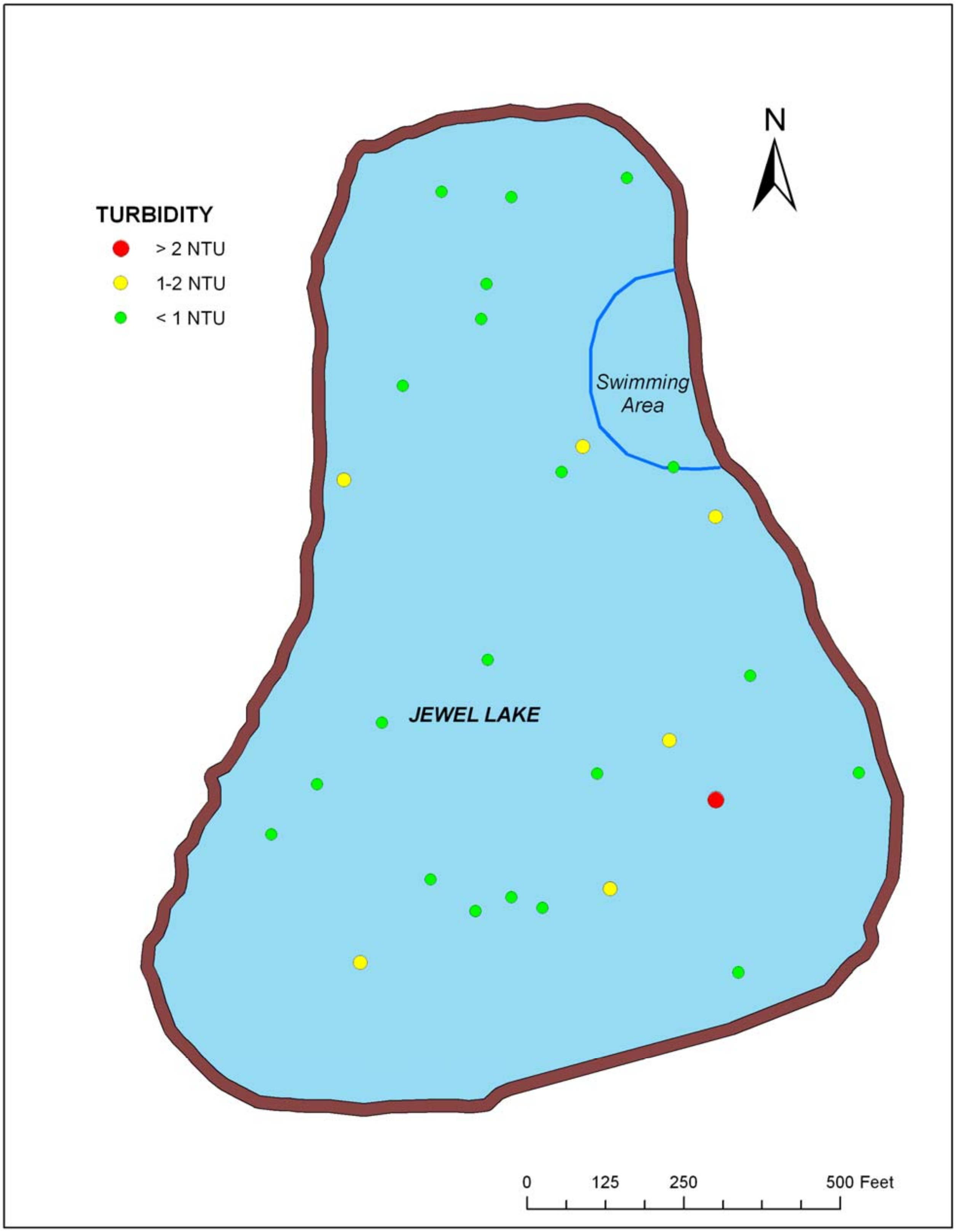


Figure 35. Summary of all turbidity measurements (NTU's) in Jewel Lake for September 2009 (Cartography by Dr. Thom Eley).

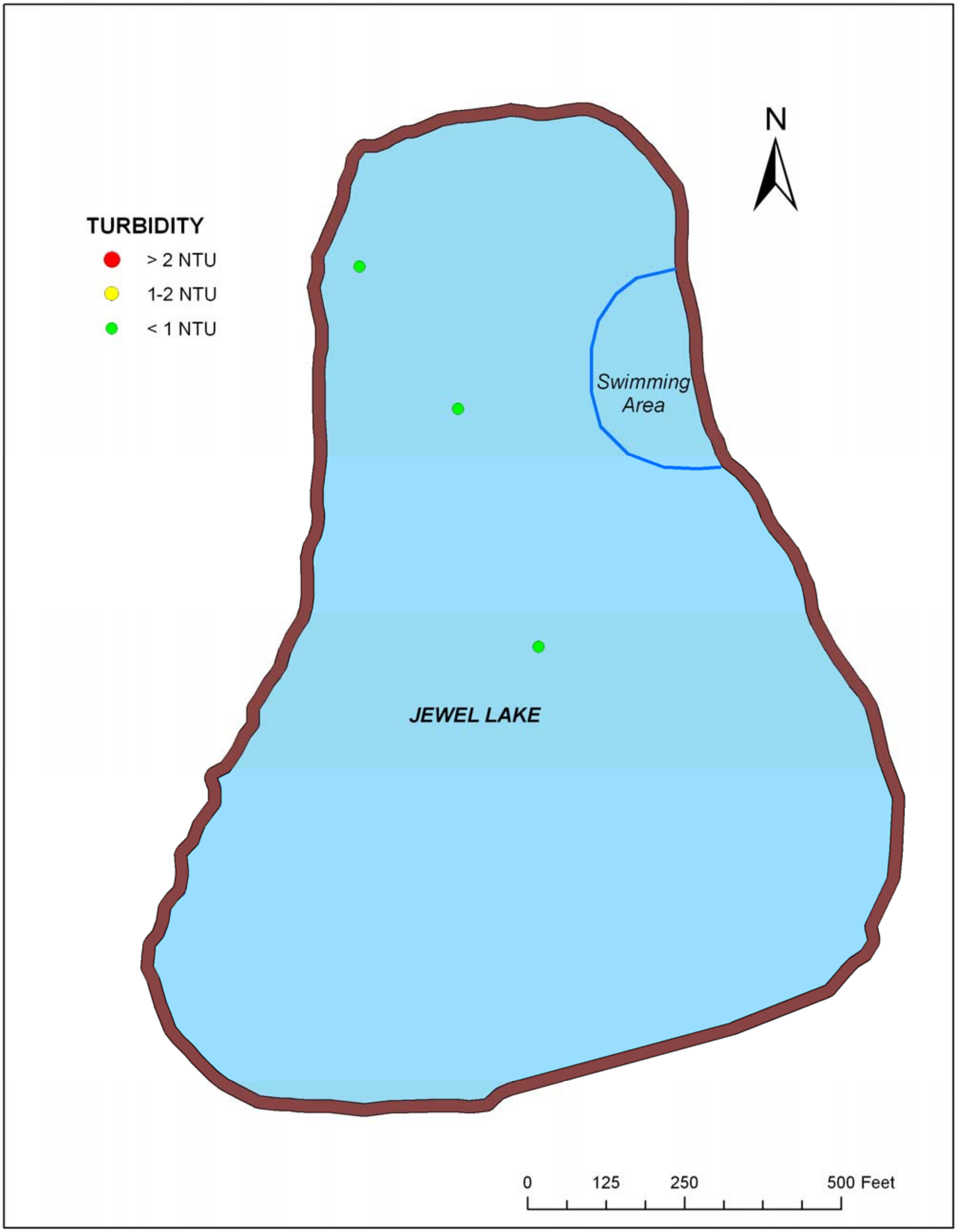


Figure 36. Summary of all turbidity measurements (NTU's) in Jewel Lake for October 2009 (Cartography by Dr. Thom Eley).

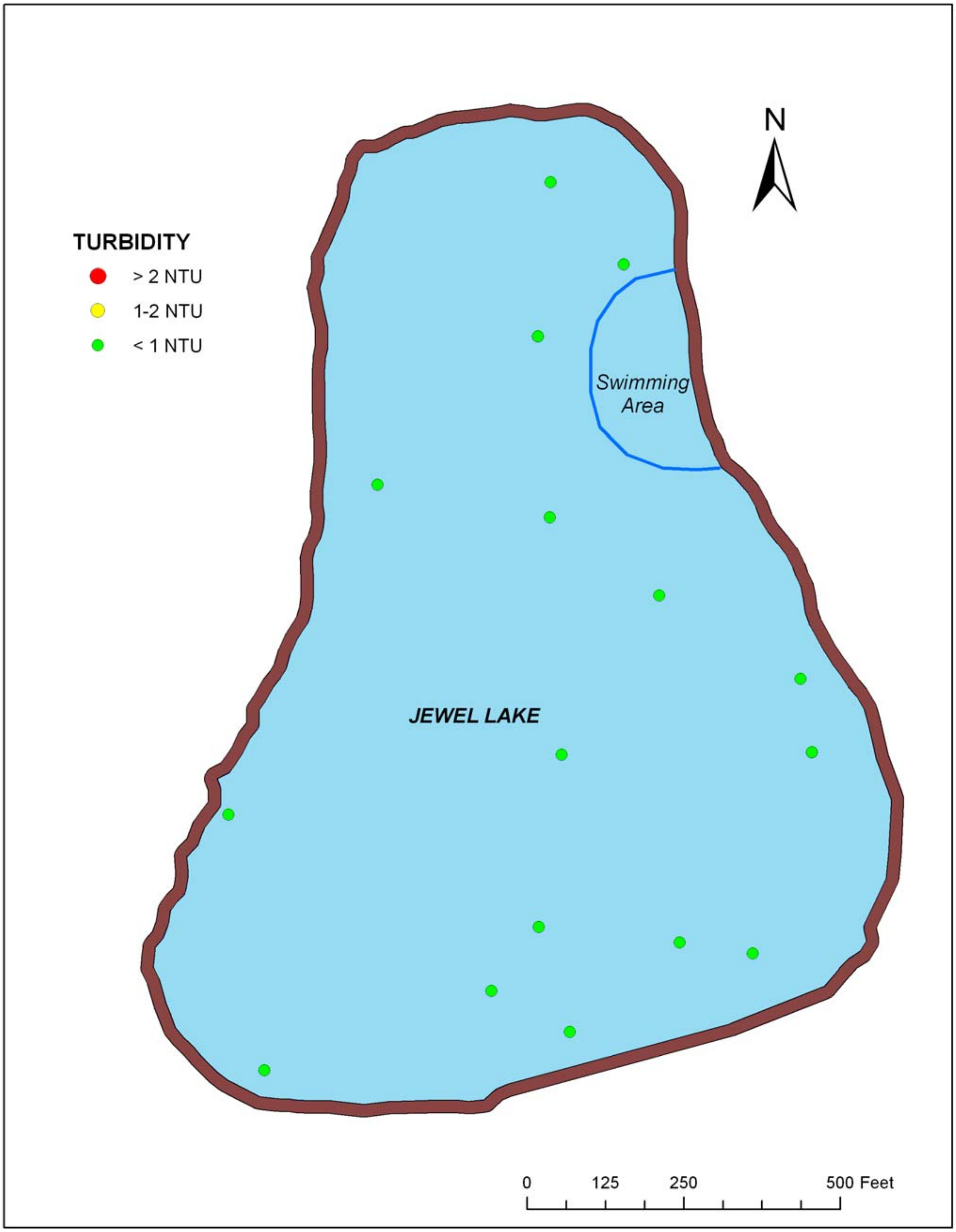


Figure 37. Summary of all turbidity measurements (NTU's) in Jewel Lake for May 2010 (Cartography by Dr. Thom Eley).

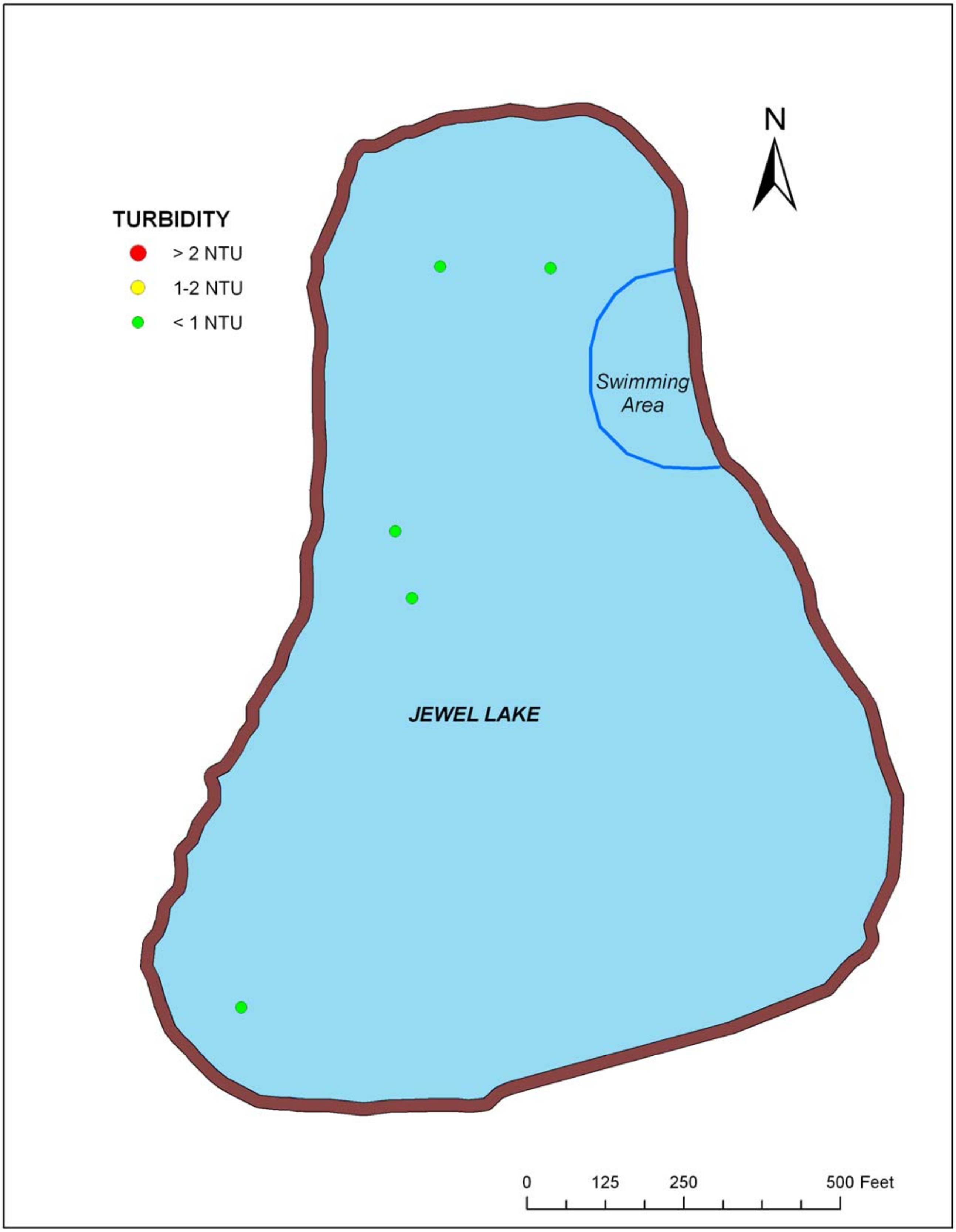


Figure 38. Summary of all turbidity measurements (NTU's) in Jewel Lake for June 2010 (Cartography by Dr. Thom Eley).

5.4 Lake Water Temperatures

A YSI Professional Plus was obtained early in the 2009-2010 sampling year, and lake water temperature was recorded at each sample site. The monthly ranges, medians and mean were calculated, and these are presented in Table 10 and Figure 39. The weekly means and ranges of temperature are shown in Table 11. The highest mean temperature of 17.0 ^{o}C was registered on June 23, 2010 while the lowest mean temperature of 5.3 ^{o}C was recorded on October 22, 2009. The lake temperatures follow the seasonal warming and cooling in Anchorage, and it reaches its highest temperatures from late June through early August. No temperatures were recorded between October 22, 2009 and May 13, 2010. Additionally, No temperature sampling was done in July 2009 due to the non-availability of equipment.

Table 10. Summary of Jewel Lake water temperature by month, 2009-2010

Month	No. of sampling events	No. of samples	Water Temperature (^{o}C)			
			Min	Median	Mean	Max
July 2009	4	0	-	-	-	-
August 2009	5	30	15.9	16.4	16.4	16.8
September 2009	3	30	8.5	13.5	12.5	15.3
October 2009	2	20	5.2	6.7	6.7	8.0
May 2010	3	30	8.3	10.5	11.1	14.3
June 2010	5	50	15.2	16.6	16.5	2.71
TOTAL	**22**	**160**	**5.2**	**15.3**	**13.5**	**17.1**

Table 11. Weekly means and ranges of Jewel Lake temperatures (^{o}C).

Date	Mean Lake Temp	Min. Temp	Max Lake Temp
8/20/2009	16.7	16.4	16.8
8/26/2009	16.4	16.3	16.5
8/31/2009	16.2	15.9	16.3
9/8/2009	15.2	14.8	15.3
9/17/2009	13.5	13.0	13.6
9/28/2009	8.9	8.5	9.0
10/15/2009	8.0	7.9	8.0
10/22/2009	5.3	5.0	5.5
5/13/2010	8.8	8.7	8.9
5/20/2010	10.5	10.5	10.6
5/25/2010	14.1	14.0	14.3
6/2/2010	16.5	16.2	16.6
6/8/2010	15.3	15.2	15.4
6/14/2010	16.6	16.5	16.7
6/23/2010	17.0	16.8	17.1
6/29/2010	16.9	16.8	17.0

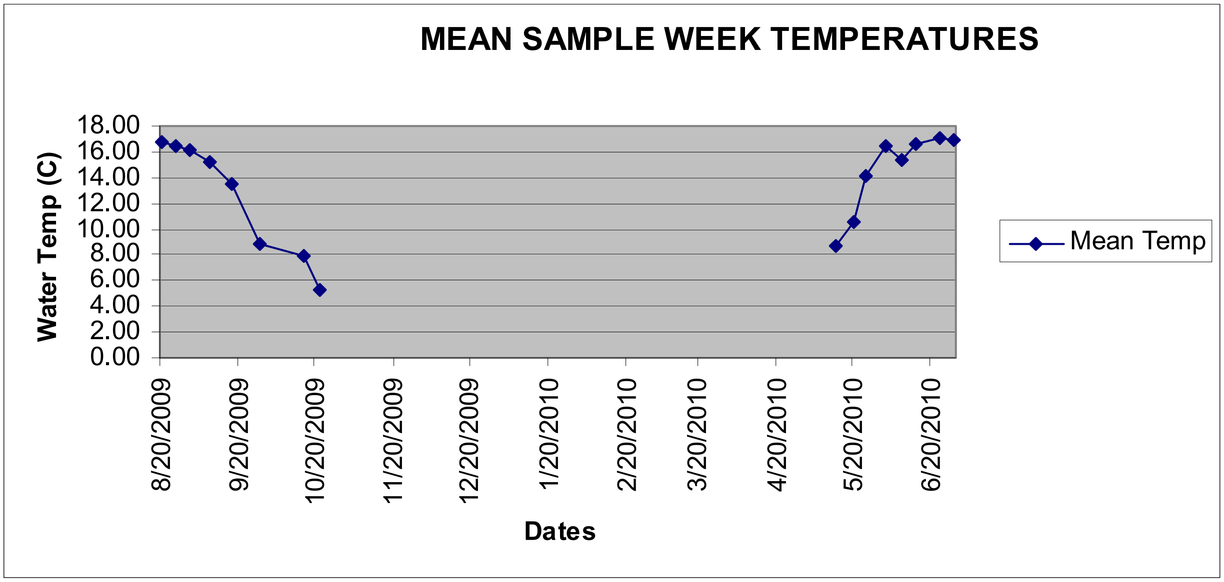


Figure 39. Mean sample week lake temperatures, July 2009 to June 2010.

5.5 Lake Water pH

A YSI Professional Plus was obtained early in the 2009-2010 sampling season, and lake water pH was recorded at each sample site. During the sampling period (August-October 2009 and May-June 2010), 144 pH readings were taken in Jewel Lake. The readings ranged from a low of 6.91 to a high of 8.26. The lowest pH was found in May, but the lowest mean pH was in September and October (Table 12). The highest pH was recorded in October with the highest mean pH found in June. No pH sampling was done in July 2009 due to the non-availability of equipment.

Table 12. Summary of Jewel Lake pH by month, 2009-2010.

Month	No. of sampling events	No. of samples	pH			
			Min	Median	Mean	Max
July 2009	4	0	-	-	-	-
August 2009	5	27	7.38	7.51	7.53	8.18
September 2009	3	27	7.32	7.43	7.49	8.09
October 2009	2	18	7.30	7.40	7.49	8.26
May 2010	3	27	6.91	7.60	7.56	7.74
June 2010	5	45	7.36	7.68	7.70	8.00
TOTAL SAMPLE	**22**	**144**	**6.91**	**7.56**	**7.58**	**8.26**

All pH's for the 2009-2010 sampling reported are mapped on Figure 40 and the individual months are mapped in Figures 41-4 None of the samples exceeded the State of Alaska water quality standards for pH Water Supply—Drinking, Culinary, and Food Processing, which "May not be less than 6.0 or greater than 8.5". Six sites [4 at the north end and 2 at the southwest end of Jewel Lake] exceeded 8.0, and we recommend that these sites be watched as the highest pH 8.29 is approaching the 8.5 limit. These sites with pH's greater than 8 occurred during every month except May. The reason for these higher pH numbers could not be ascertained.

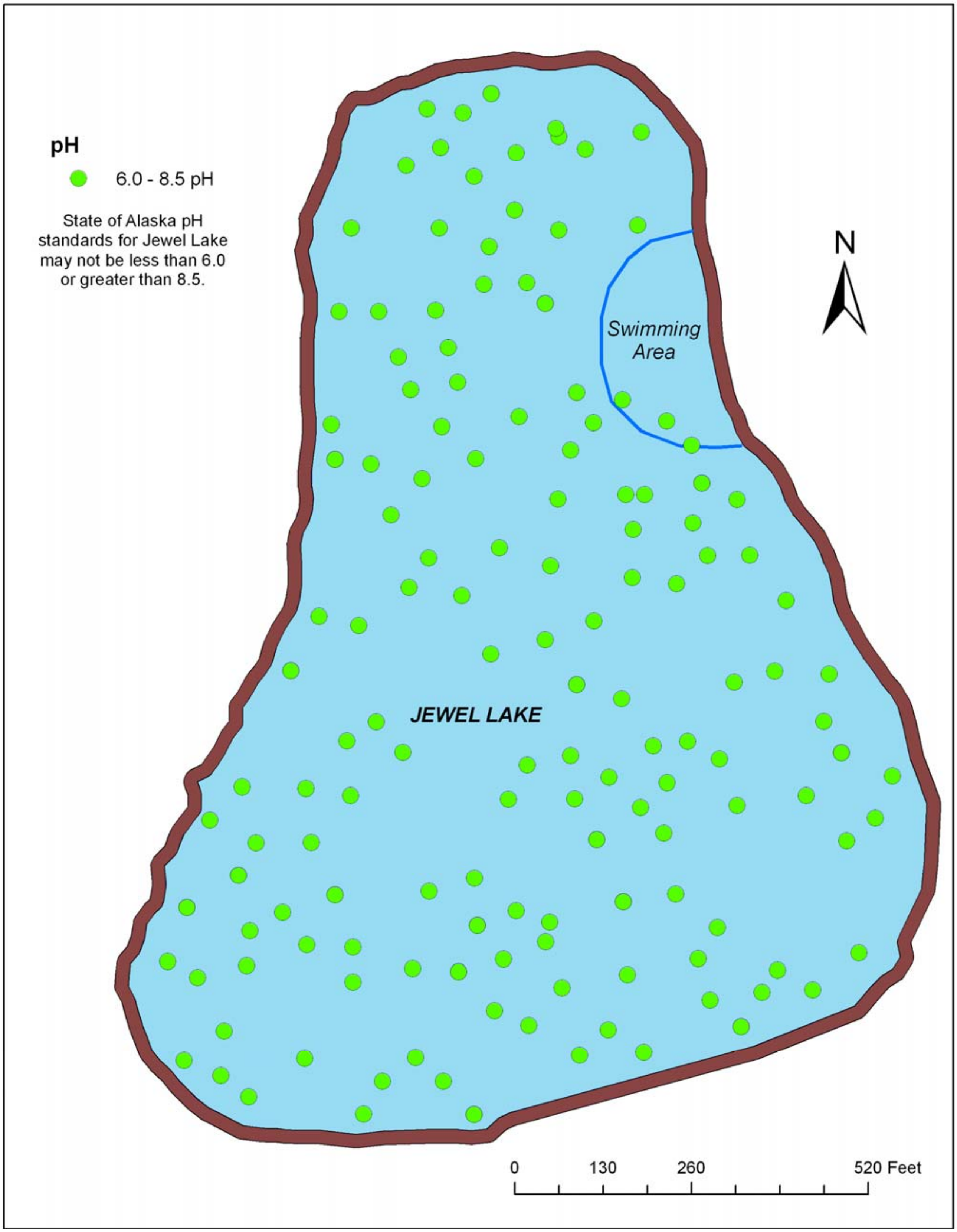


Figure 40. pH readings for all sample sites for Jewel Lake, 2009-2010 (Cartography by Dr. Thom Eley).

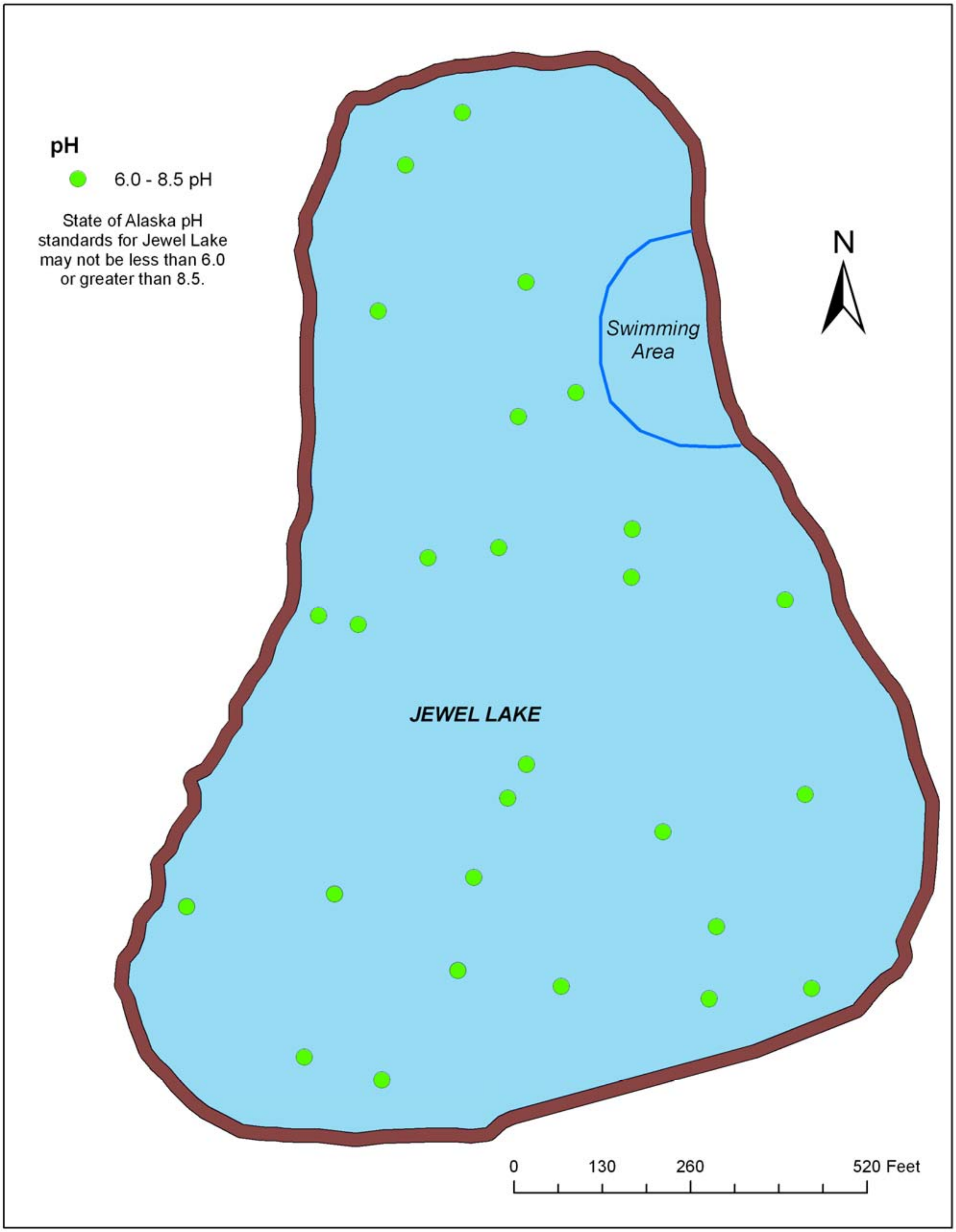


Figure 41. pH readings for sample sites for Jewel Lake, August 2009 (Cartography by Dr. Thom Eley).

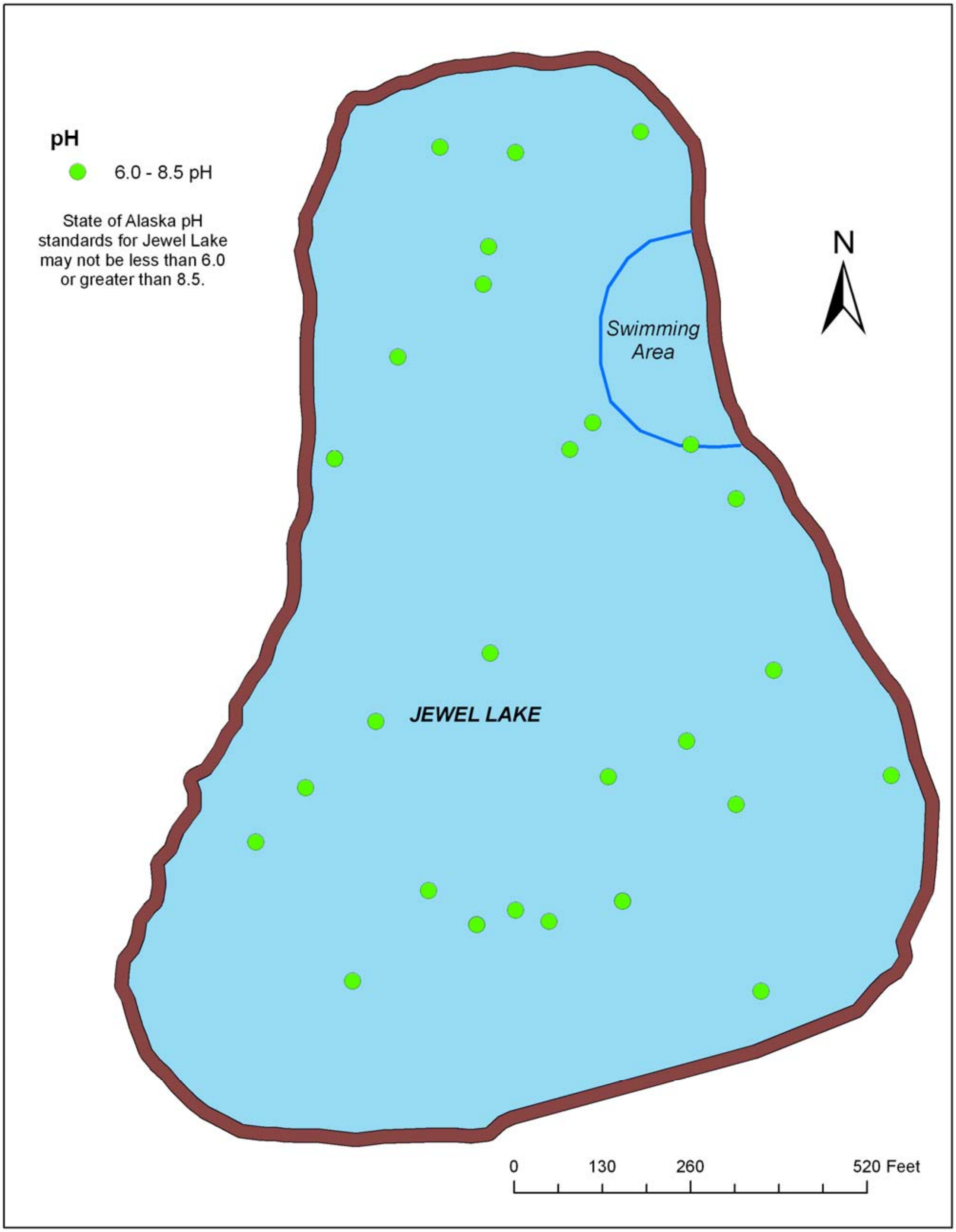


Figure 42. pH readings for sample sites for Jewel Lake, September 2009 (Cartography by Dr. Thom Eley).

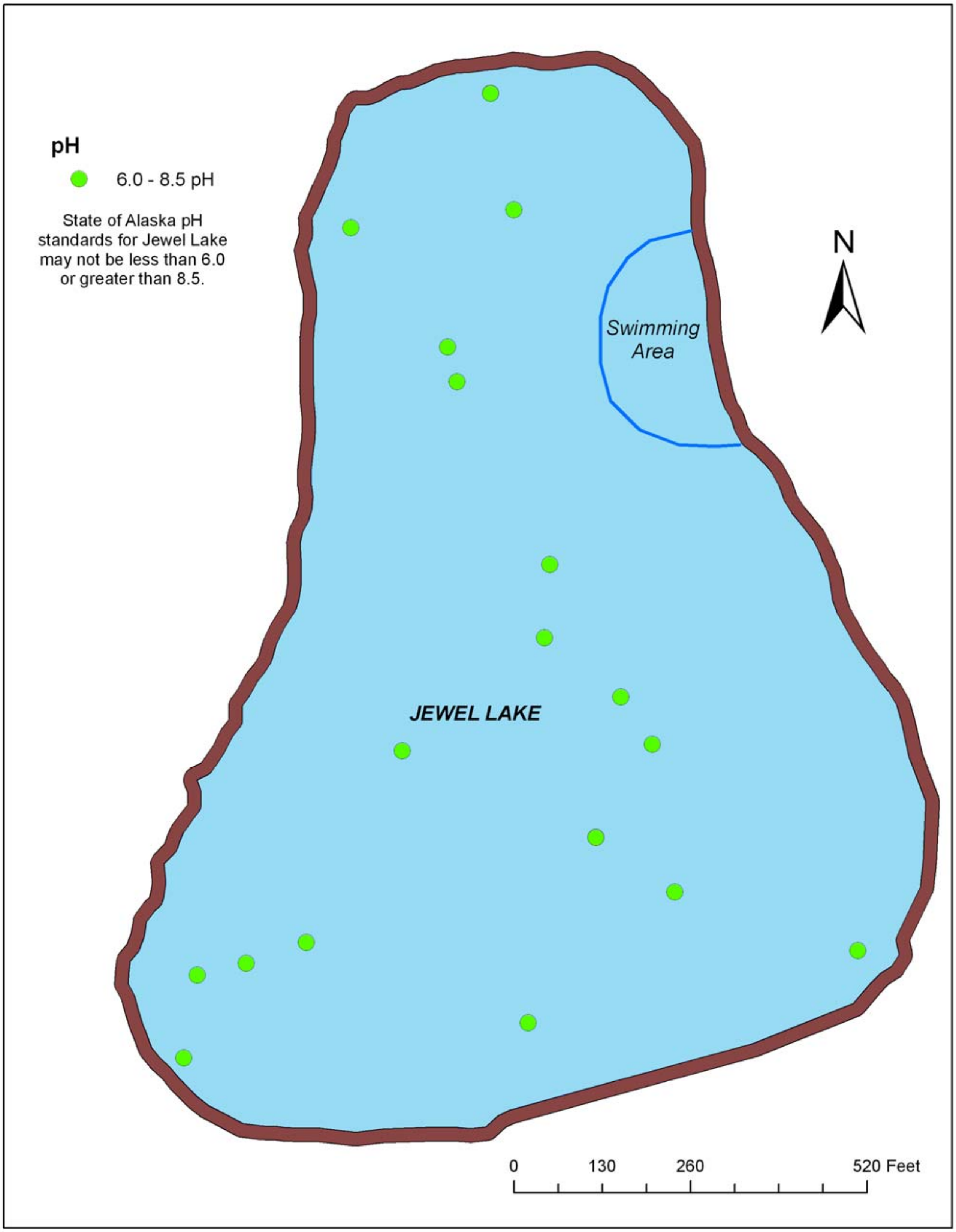


Figure 43. pH readings for sample sites for Jewel Lake, October 2009 (Cartography by Dr. Thom Eley).

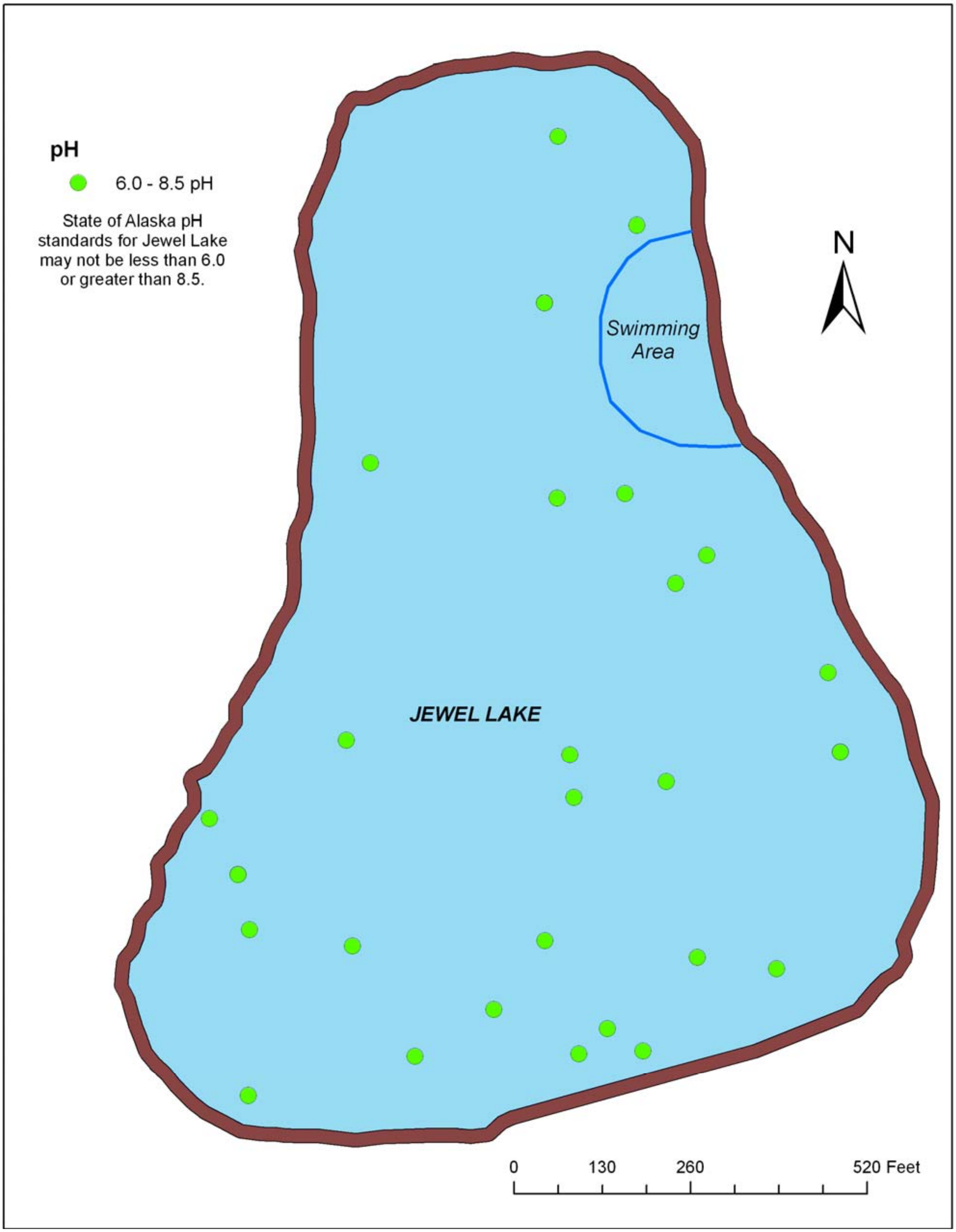


Figure 44. pH readings for sample sites for Jewel Lake, May 2010 (Cartography by Dr. Thom Eley).

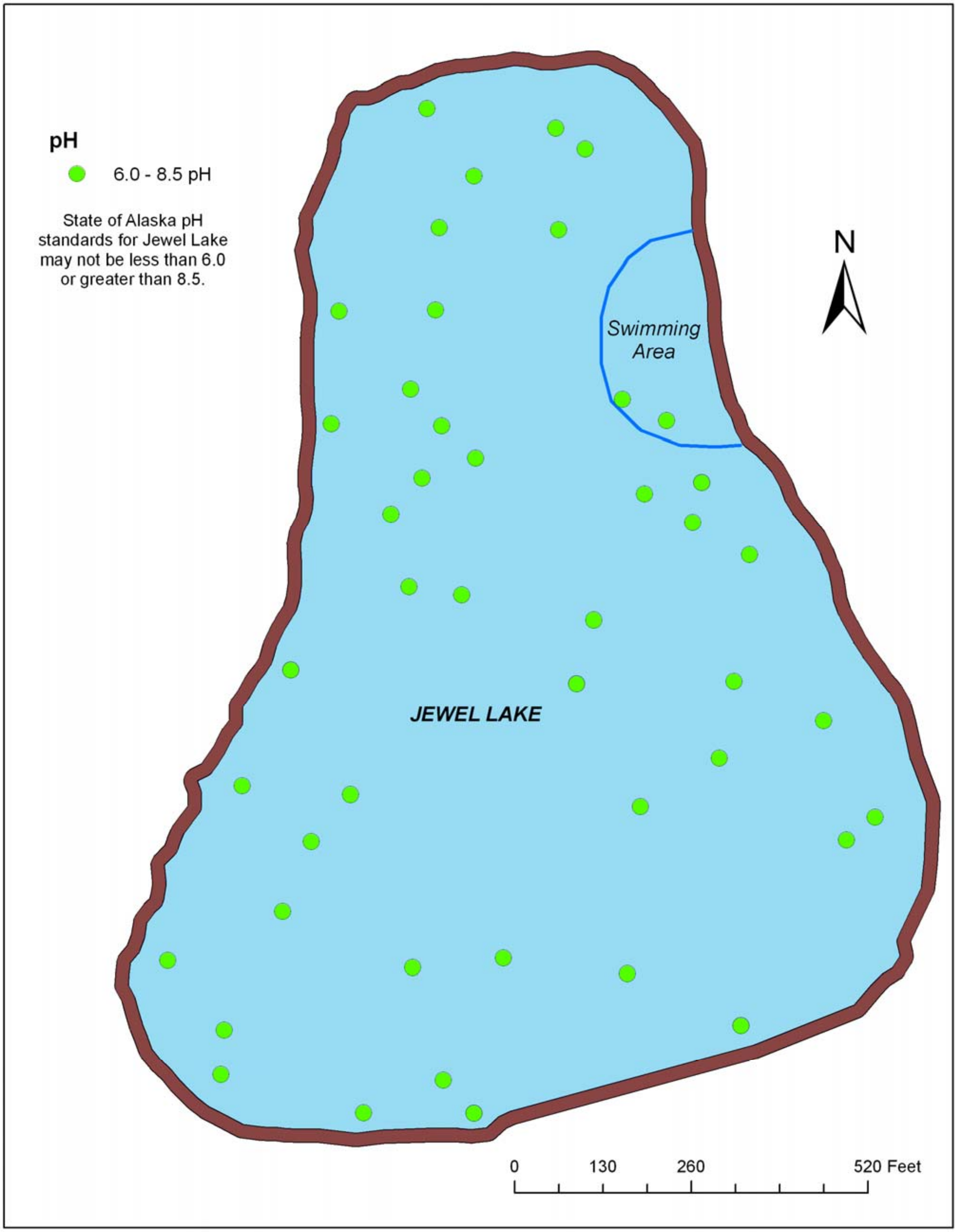


Figure 45. pH readings for sample sites for Jewel Lake, June 2010 (Cartography by Dr. Thom Eley).

5.6 Lake Water Dissolved Oxygen (DO)

Dissolved oxygen is a critical water quality parameter as it characterizes the health of an aquatic system. DO testing measures the oxygen dissolved in water and what is then available for fish and other aquatic life. The DO level results from the respiratory and photosynthetic activities of plants and animals in the aquatic system as well as the input of oxygen from the atmosphere through the action of wind and currents. The optimal level for salmon is 9 mg/l. Any reading below the level of 7 mg/l is considered to be less than optimal.

From August 2009 through June 2010, 144 sites were sampled for DO. The samples ranged from a low of 8.25 mg/l to a high of 11.97 mg/l. The samples' mean was 9.74 mg/l, and the median was 9.80 mg/l. Monthly ranges, means and medians are presented in Table 13. No DO sampling was done in July 2009 due to the non-availability of equipment.

Table 13. Summary of Jewel Lake dissolved oxygen (DO) by month, 2009-2010.

Month	No. of sampling events	No. of samples	DO (mg/l)			
			Min	Median	Mean	Max
July 2009	4	0	-	-	-	-
August 2009	5	27	8.28	8.62	8.62	9.05
September 2009	3	27	8.25	8.94	9.08	9.84
October 2009	2	18	10.02	10.56	10.53	10.91
May 2010	3	27	9.92	10.69	10.93	11.97
June 2010	5	45	9.52	9.80	9.80	10.04
TOTAL SAMPLE	**22**	**144**	**8.25**	**9.80**	**9.74**	**11.97**

During the 2009-2010 sampling period DO concentrations showed a relatively homogenous spatial pattern throughout the lake (Figure 46). Maps of monthly DO concentrations are shown in Figures 47-51.

The State of Alaska standards are a minimum DO of 4.0 for drinking water and contact recreation and a DO greater than 7.0 for aquaculture and waters used by anadromous or resident fish or wildlife. In no case can DO exceed 17.0 mg/l. All the Jewel Lake standards were found to meet the state standards for DO.

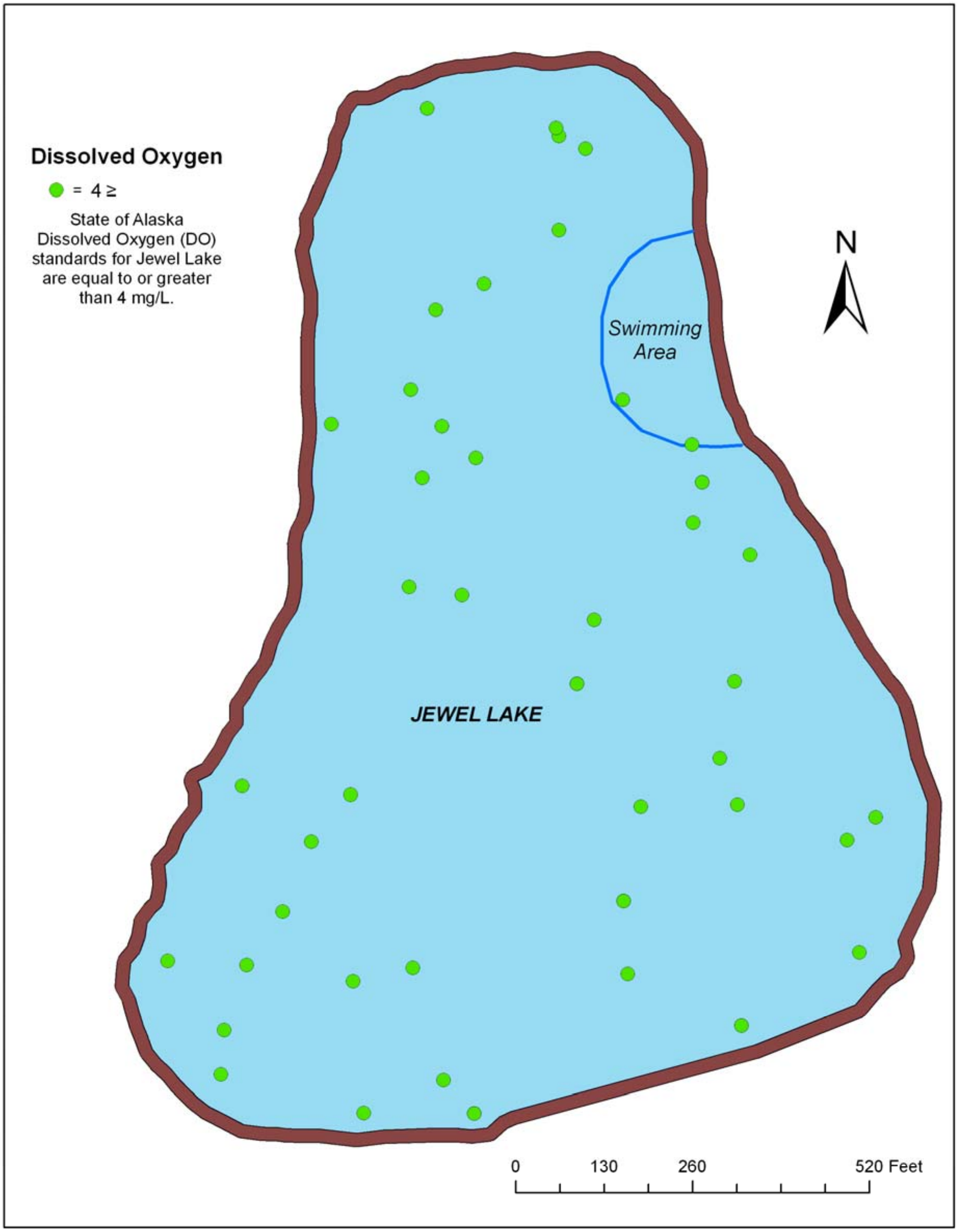


Figure 46. Dissolved oxygen (DO) readings for all DO sample sites for Jewel Lake, 2009-2010 (Cartography by Dr. Thom Eley).

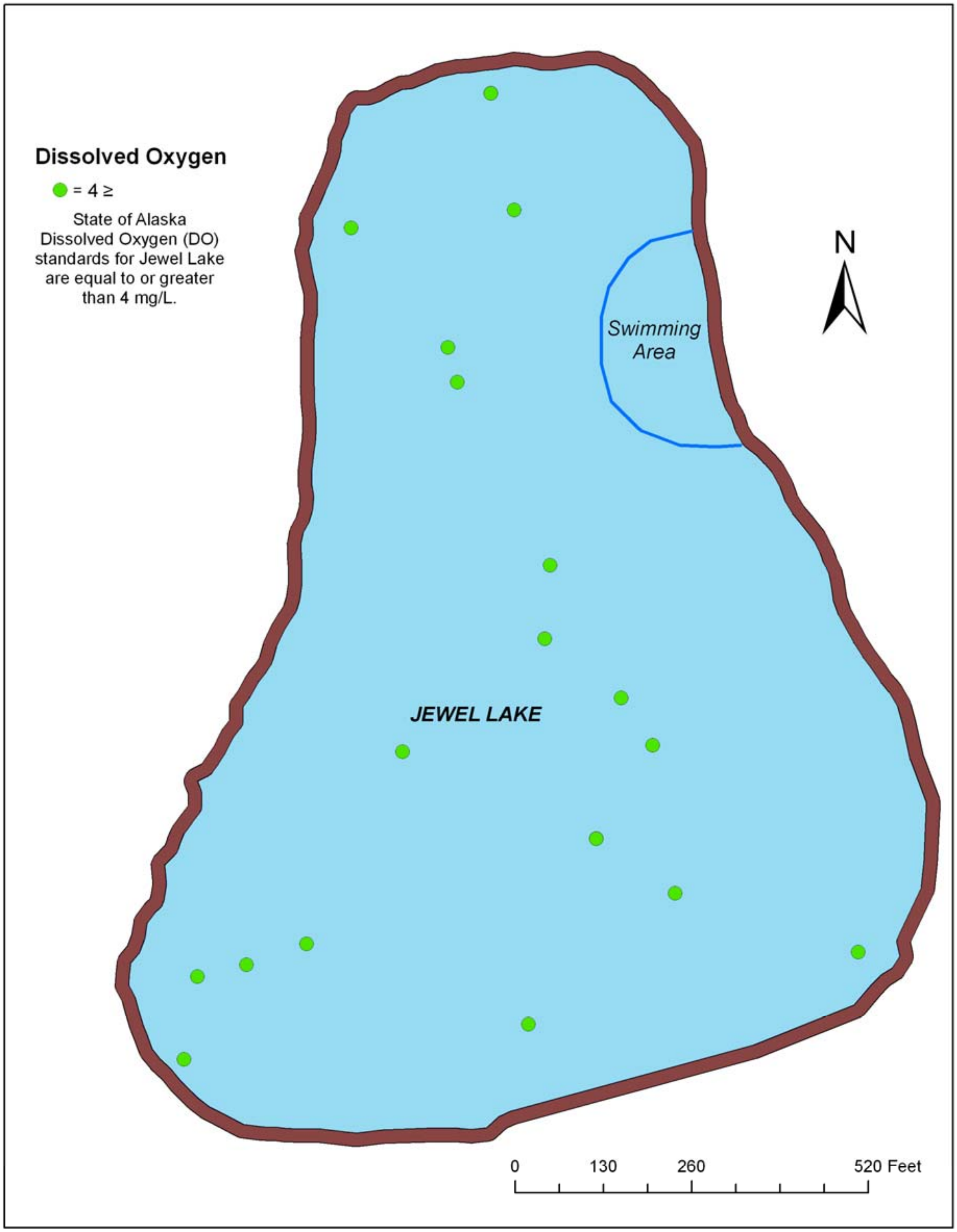


Figure 47. DO readings for 09 sample sites for Jewel Lake, August 2009 (Cartography by Dr. Thom Eley).

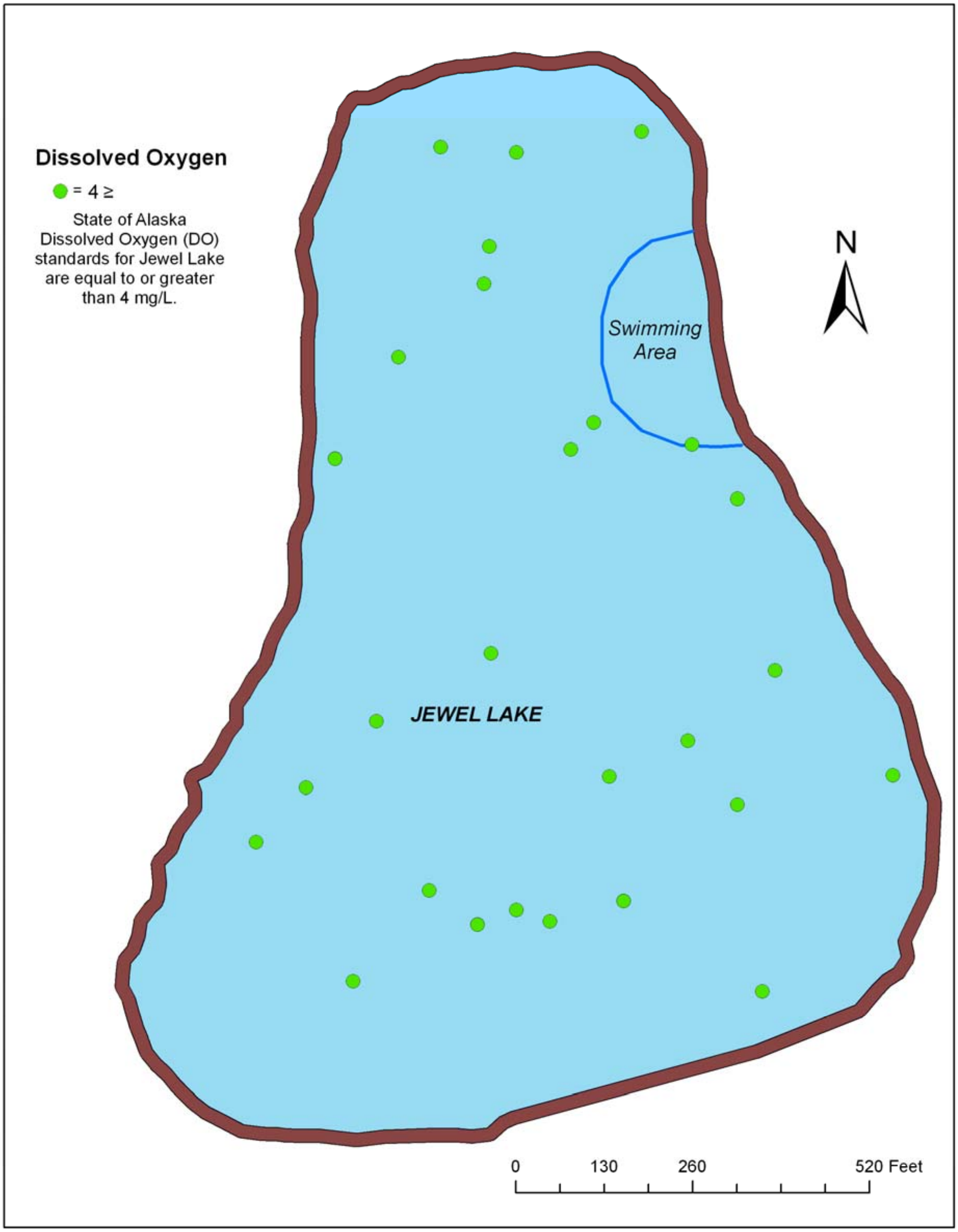


Figure 48. DO readings for sample sites for Jewel Lake, September 2009 (Cartography by Dr. Thom Eley).

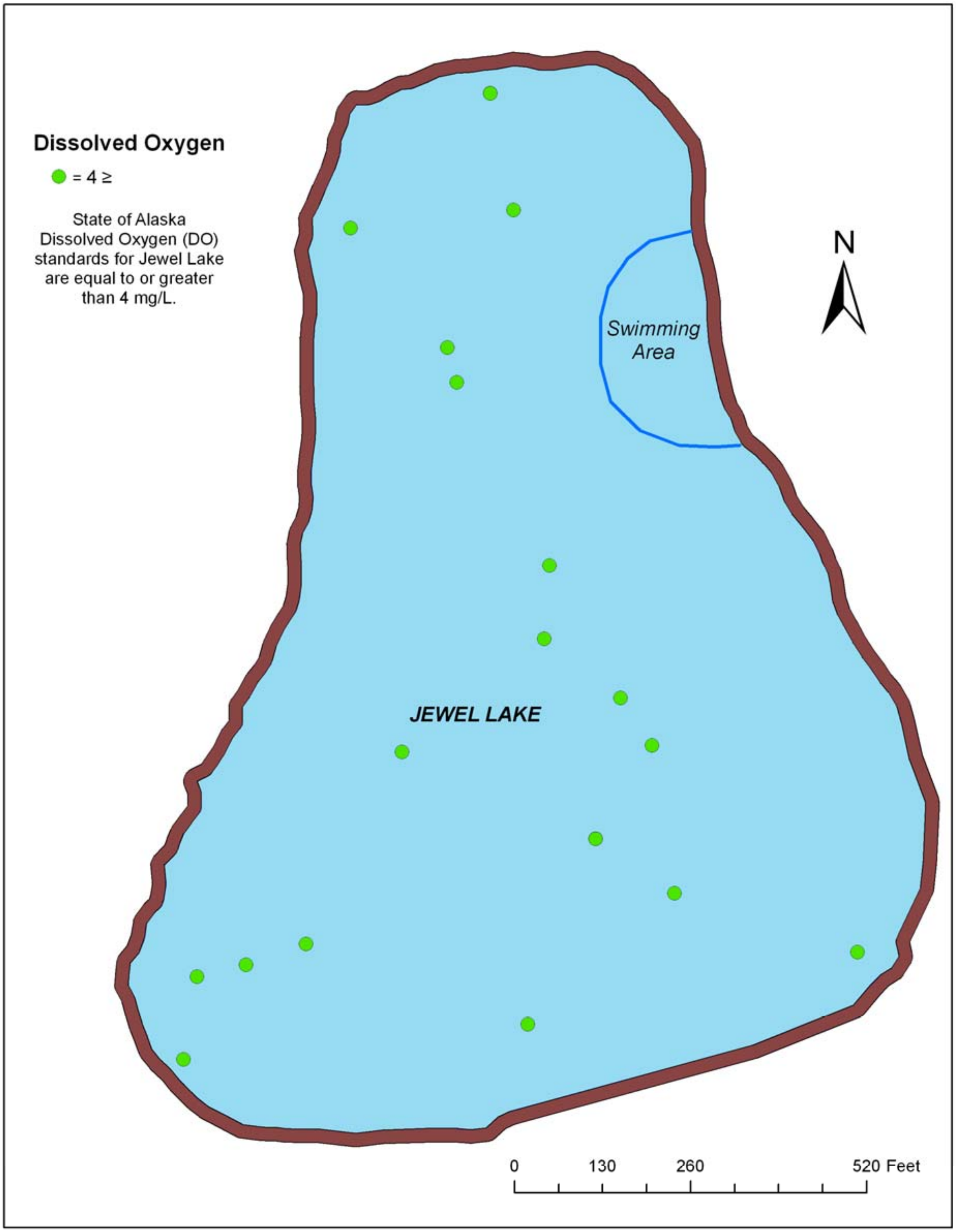


Figure 49. DO readings for sample sites for Jewel Lake, October 2009 (Cartography by Dr. Thom Eley).

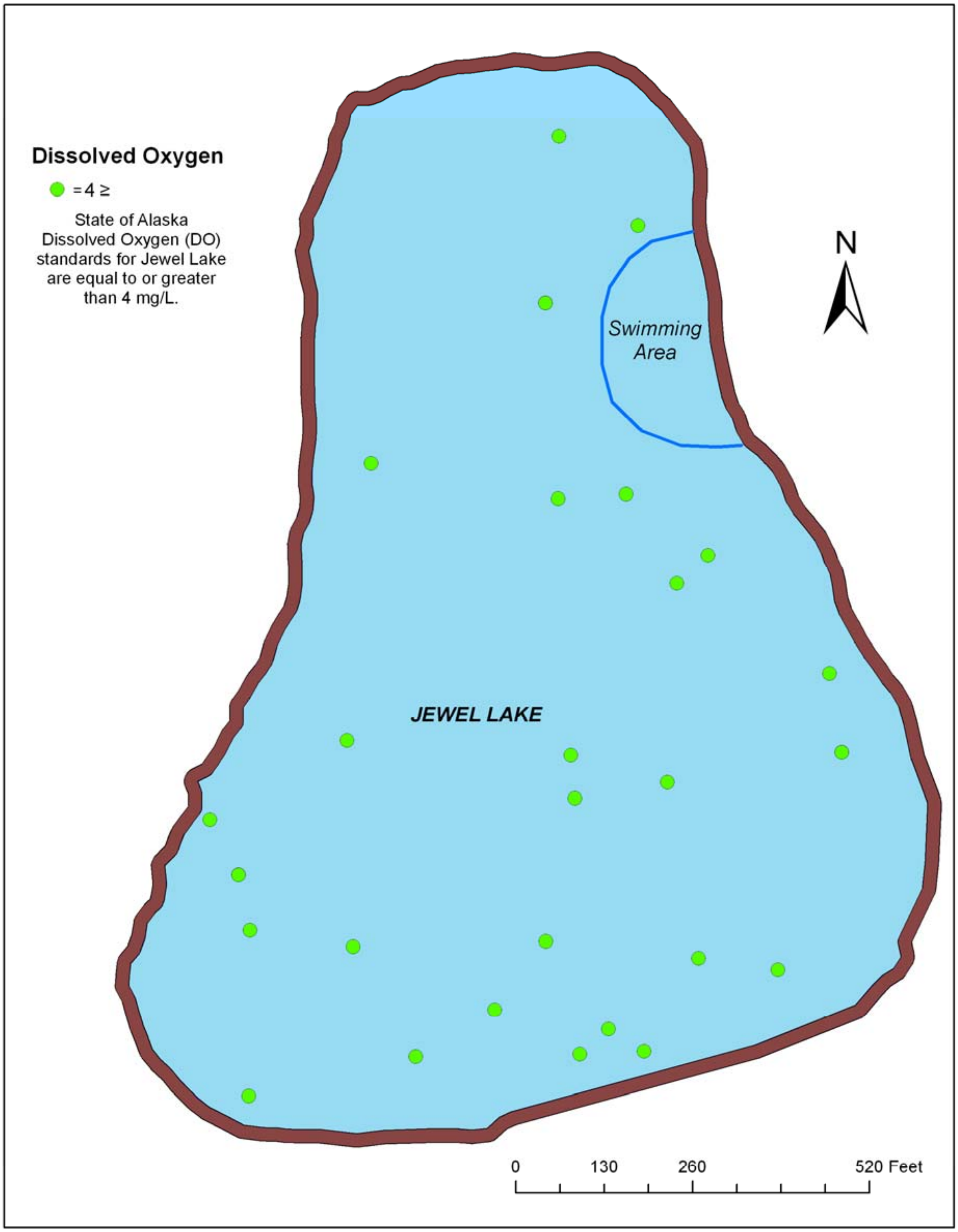


Figure 50. DO readings for sample sites for Jewel Lake, May 2010 (Cartography by Dr. Thom Eley).

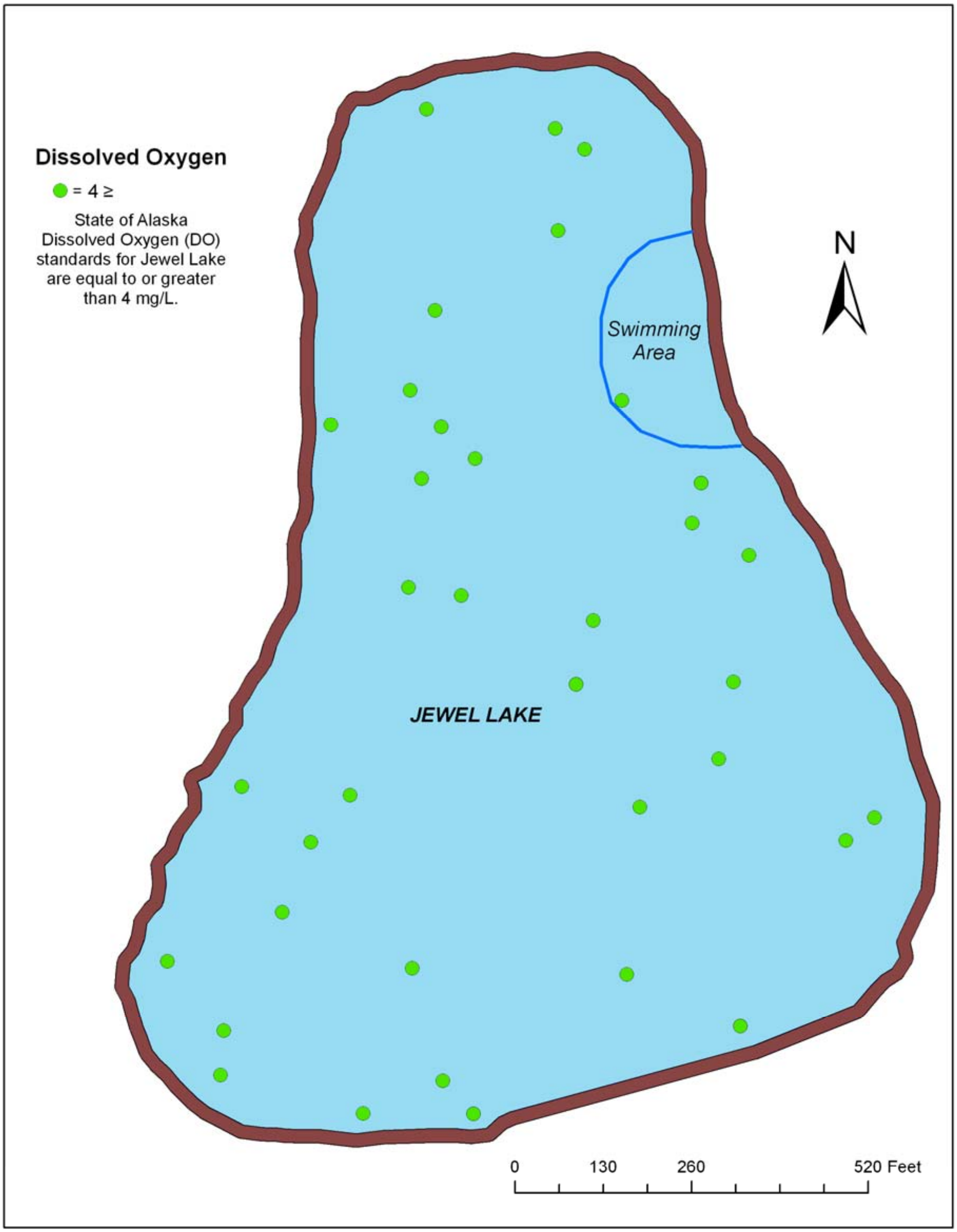


Figure 51. DO readings for sample sites for Jewel Lake, June 2010 (Cartography by Dr. Thom Eley).

6.0 Correlations

Although correlations do not establish causality among variables, they can help identify potential relationships. It has been suggested that fecal coliform has an affinity for sediment particles, therefore fecal coliform concentrations may increase with higher turbidity levels. Secchi depth is a measurement of water clarity and it follows that fecal coliform concentrations could potentially be higher with reduced Secchi visibility. However, Secchi depth results are influenced by the overall depth of the lake at the sample spot.

Although Secchi depths and turbidity data were collected and are presented in this report, we feel that the 2008-2009 Jewel Lake report adequately discussed these two parameters. We concur with Ms. Malloy's findings, and we do not think that our data would alter her findings. Further, we have elected to focus on lake temperature, pH, and DO as they were not examined during 2008-2009 sampling as well as look at a couple of other parameters that probably should receive more attention.

6.1 Lake Water Temperatures and Fecal Coliform Bacteria

From August through freeze up in October, fecal counts were inversely related to water temperature (Figure 52), whereas in May and June coliform counts are certainly correlated with water temperature. In the fall, it may be that the seasonal change in temperature results in an expected decline in lake temperature. However, the higher precipitation that is characteristic of Anchorage would result in more fecal coliform being washed from the shoreline and stormwater outfalls into the lake thus increasing the fecal counts.

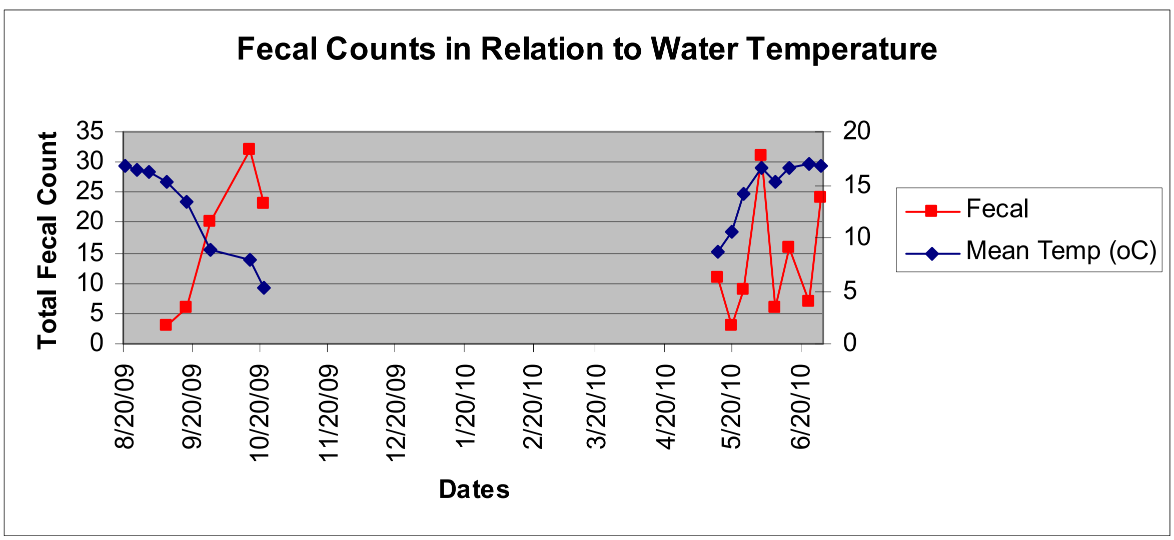


Figure 52. Fecal counts (FC/100 ml) in relation to temperature (°C) in Jewel Lake, 2009-2010

6.2 pH and Fecal Coliform Bacteria

Total fecal coliform counts for each pH level were determined and these counts were then plotted with pH levels (not in chronological order but by a rise in pH). No correlation between pH and fecal coliform counts was apparent.

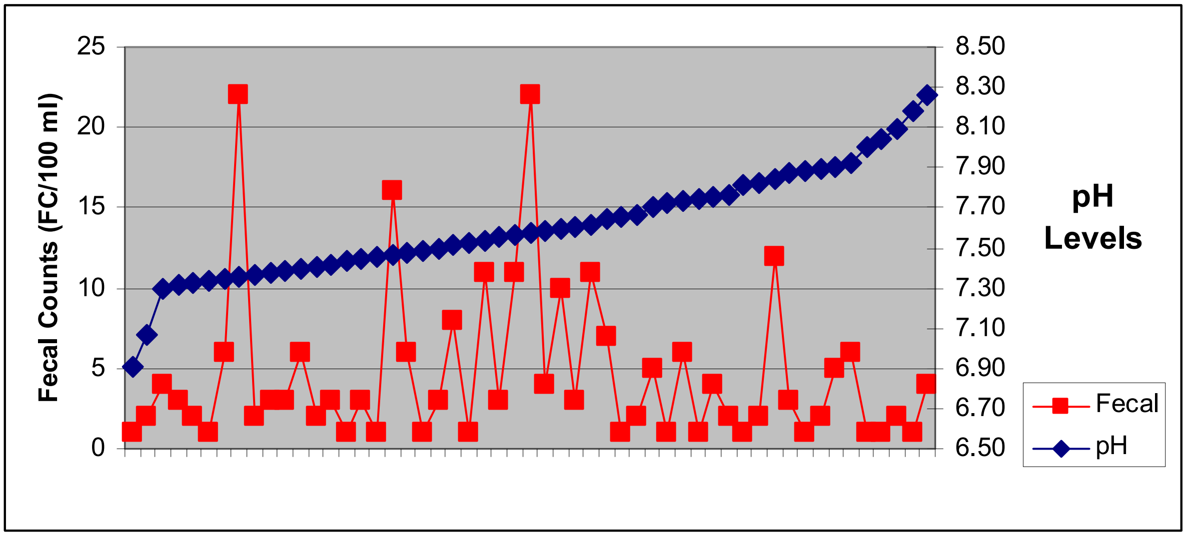


Figure 53. The relationship between pH level and fecal coliform bacteria counts, during the 2009-2010 sampling period.

6.3 Dissolved Oxygen (DO) and Fecal Coliform Bacteria

No correlation was noted in fecal coliform counts and dissolved oxygen levels.

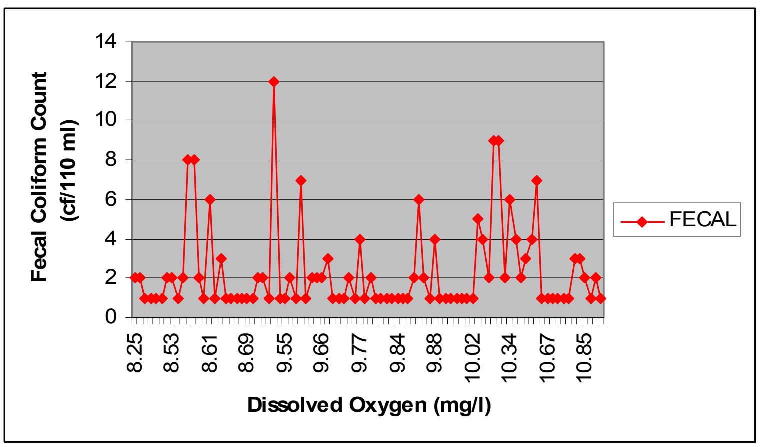


Figure 54. Fecal coliform numbers in relation to DO levels, 2009-2010.

7.0 Potential Sources of Fecal Coliform Bacteria

The identification of sources of fecal coliform pollution is an important step in improving water quality conditions in waterbodies that are not meeting state water quality standards. The Alaska 303d list identifies urban runoff and land development as the source of fecal coliform pollution in Jewel Lake (ADEC, 2006). Bacteria is deposited by domestic animals (e.g., cats and dogs), and wildlife (e.g., moose, bear, birds, etc.) and accumulates on the land surface or is directly deposited in the streams. Rainfall and snowmelt transport bacteria deposited on land into the creeks. Estimating the amount of fecal coliform and locations where it is deposited is typically difficult due to the mobility and large range of animals throughout the

MOA. However, Canada Geese inhabit Jewel Lake for a specific amount of time and loading calculations were done in the 1997 Jewel Lake TMDL report (EPA, 1997:10).

Figure 55. Photos showing some potential sources of fecal contamination observed at Jewel Lake, 2010 (Photos by Dr. Cherie Northon or Dr. Thom Eley).


Human waste near the lake (in a tussock surrounded by lake water) and adjacent wetlands. Humans can produce 1,950 x 10^6 CFU/AU[4] (Yagow et al. 2001).


People observed allowing their dogs to poop in the park woodlands and not cleaning it up — *"Scooping the Poop!"* Dogs can produce 500 x 10^6 CFU/AU (Yagow et al. 2001).

[4] CFU/AU. CFU is equivalent to FC/100 ml. AU stands for 1,000 lbs. of animal weight.


People allow their dogs to poop on the pavement and lake ice in winter (April 2010). Some of these folks are ice fishers, and others are transient folks that drive in and let their dogs out to do their business. Ironically, these were close to the Scoop the Poop Station which was stocked with plastic bags.

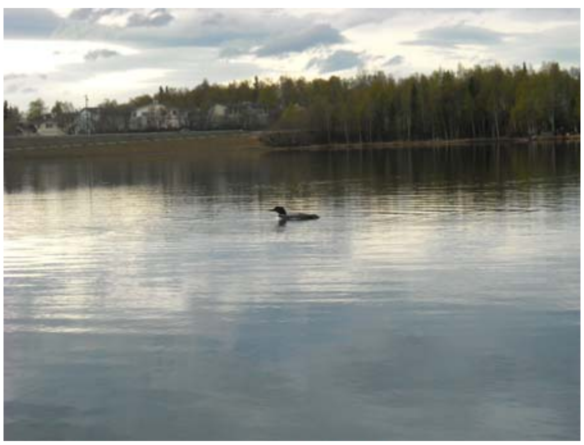

People and their dogs using Jewel Lake for recreation.

A yard with dogs and chickens on the east side. We could not determine if animal waste was being thrown into the lake, but there was a gate opening onto the edge of the lake.

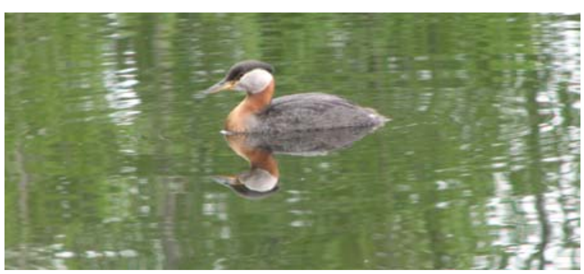
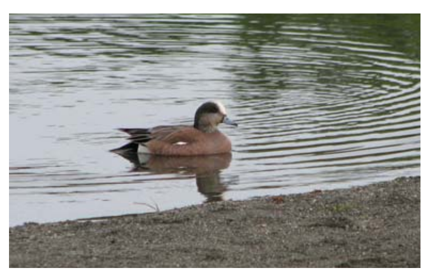
Jewel Lake is one of the more popular fishing lakes in Anchorage. The fisherman on the right urinated and defecated into at the Jewel Lake shore.

Wildlife on Jewel Lake


Moose enjoying aquatic plants, while gulls—notorious defecators over water—Watch over the beach. A 200 lb deer can produce about 350 x 10^6 CFU/AU daily (Yagow et al. 2001). The moose (*Alces alces*) is the largest member of the deer family and can exceed 1,600 lbs.




A pair of Common Loons made Jewel Lake their summer 2010 home.

Red-necked Grebes and American Wigeon inhabit and breed on Jewel Lake. A wild duck can produce from about 2430 to 4853 x 10^6 CFU/AU (Yagow et al. 2001).

THE INFAMOUS CANADA GEESE

Canada Geese and their goslings at Jewel Lake Park.

More Canada Geese.

Canada Goose feces on beach.

Manicured lawns of residents around Jewel Lake are attracting Canada Geese, and this residence appears to be a main breeding area for Canada Geese around. A wild goose can produce 130 to 800 x 10^{6} CFU/AU (Yagow et al. 2001).

7.1 Precipitation and Fecal Coliform Bacteria

We believe that the lack of inclusion of weather data as a variable in the sampling plan was one of the short-comings of this research project. Since surface and sub-surface runoff may be an important source of fecal coliform bacteria, weather data, particularly precipitation, should have been included at all phases of the study as a parameter. Further, stormwater runoff can mix and stir up the sediments causing fecal coliform bacteria, which have settled into to the bottom sediment, to move back into the water column.

A simple look at precipitation measurements for Anchorage International Airport and monthly fecal coliform counts for the 2008-2009 and 2009-2010 sampling periods certainly shows a positive correlation (Figure 56). Monitoring precipitation and fecal coliform over a longer period is needed to refine the relationship between the two in Anchorage waterbodies. The role of precipitation in increasing fecal coliform counts has been reported by many researchers (EPA 2000, GEI Consultants, Inc. 2008).

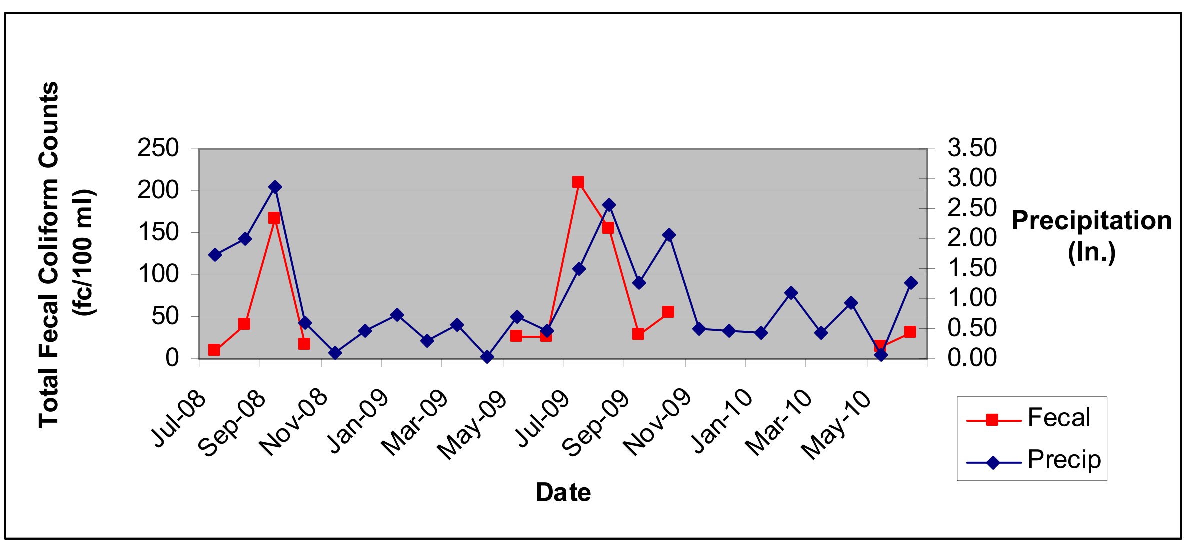


Figure 56. Total monthly fecal coliform counts plotted with precipitation by month.

7.2 Stormwater Outfalls

It is our belief that stormwater outfalls and drains are a major, yet neglected, source of consideration for fecal coliform in the Jewel Lake area. Two stormwater outfalls drain runoff into the south portion of Jewel Lake from a section of Dimond Blvd. and the fishing area parking lot as well as approximately 15 acres of a residential neighborhood on the south side of Dimond Blvd. The following maps (Figures 57 and 58) illustrate the approximate catchment area of the subdivision to the south of Jewel Lake that drains directly into Jewel Lake. In the 1997 EPA report, only one outfall was mentioned, and by its description it was not draining the residential area across Dimond Blvd. As shown on subsequent maps, there is a small outfall that drains the parking area that was discussed in the 1997 EPA report.

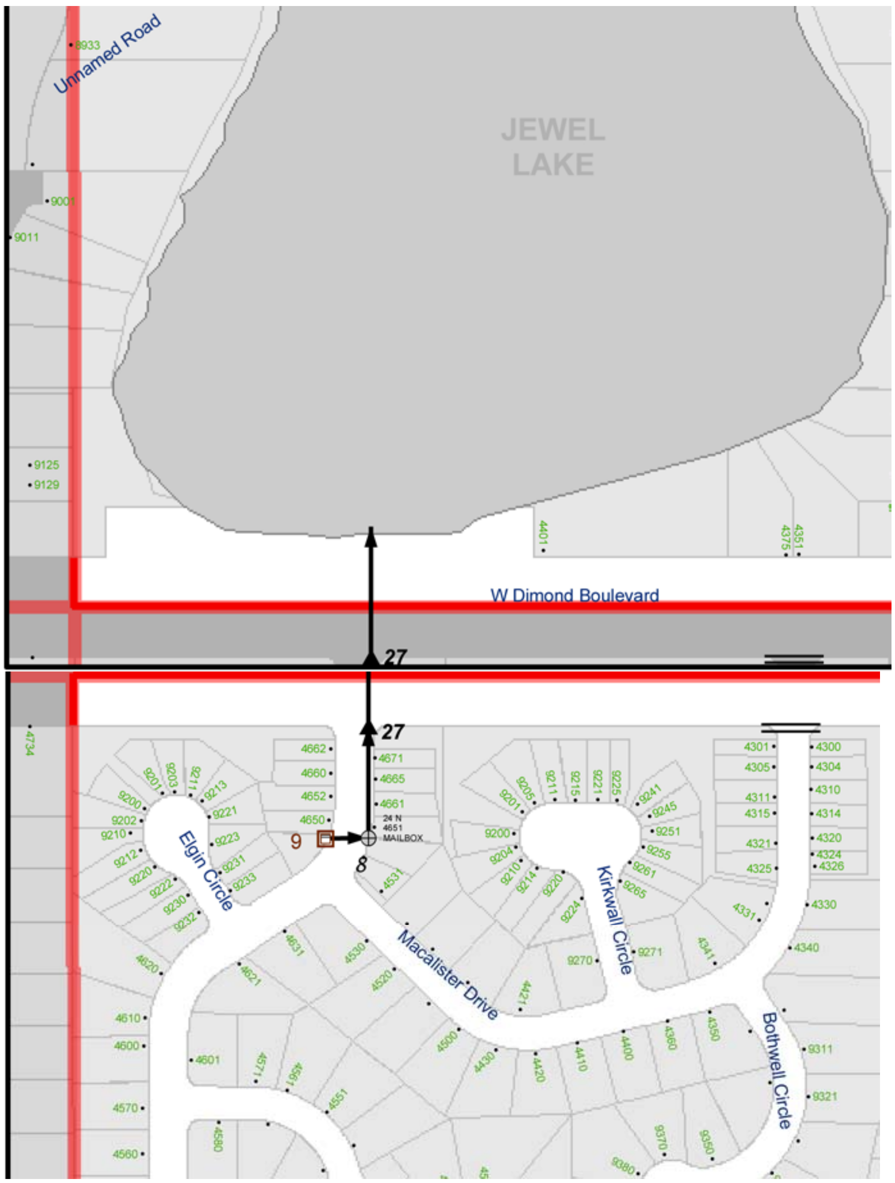


Fig. 57 MOA Street Maintenance maps showing catchment area for stormwater drain (9) and outfall (27) into Jewel Lake (MOA Street Maintenance 2008 Storm Drain Maps-ANSW2325 and ANSW2425.)

Figure 58. Area drained by Municipal storm drains that empty directly into Jewel Lake via Stormwater Outfall 1 (Cartography by Dr. Cherie Northon).

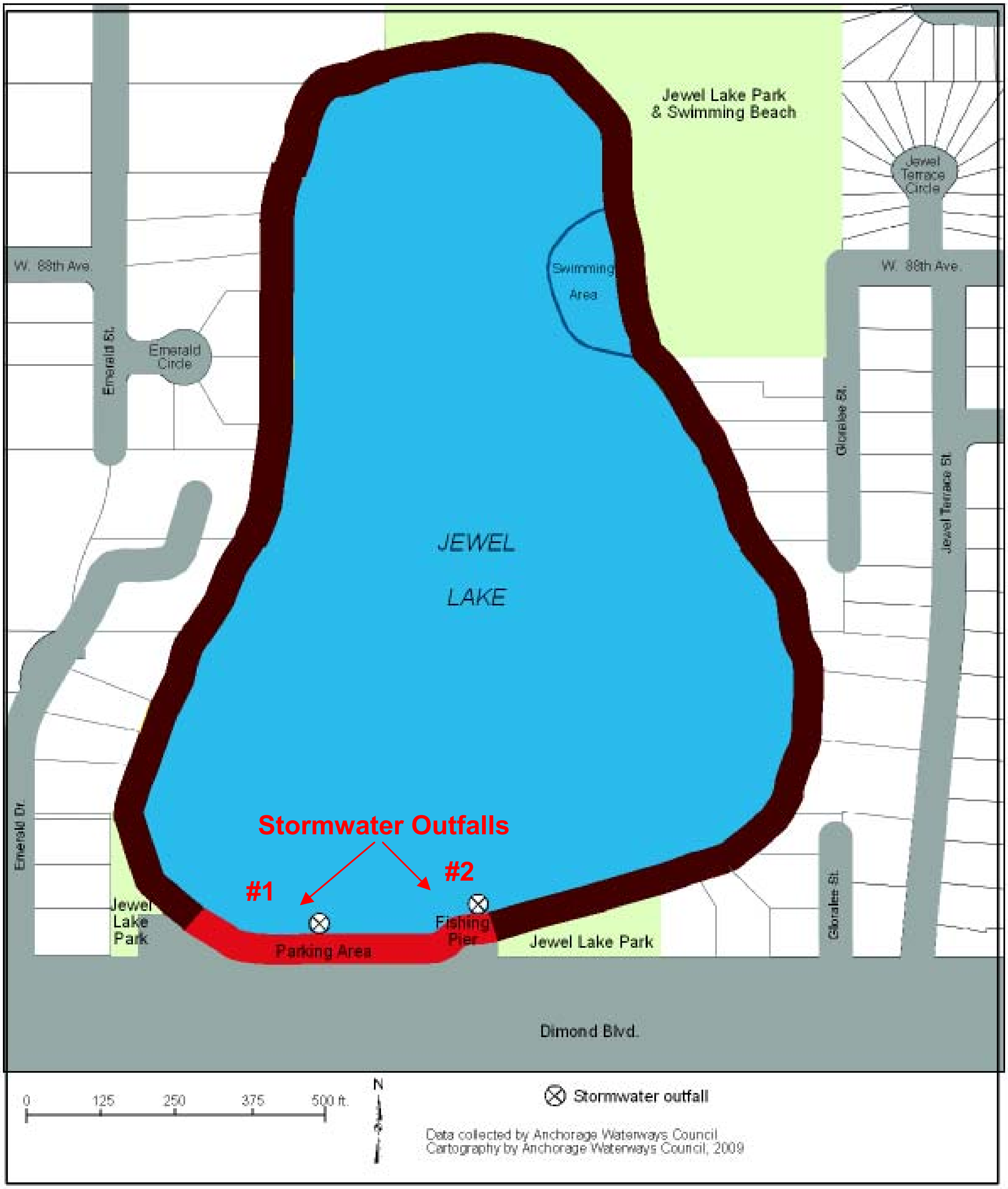


Figure 59. Map showing the location of the two current stormwater outfalls at the south end of Jewel Lake, 2009-2010 (Cartography by Dr. Thom Eley)

Stormwater Outfall #1 **Stormwater Outfall #2**

Figure 60. Stormwater Outfalls—the western-most stormwater outfall on the left [Outfall #1] and the eastern-most stormwater outfall on the right [Outfall #2], Jewel Lake, June 26, 2010 (Photos by Dr. Thom Eley and Dr. Cherie Northon).

During the TMDL development (EPA, 1997), only one of these drains was discussed. This would suggest that only one was in existence or there was some confusion regarding whether the shorter, black PVC pipe (Outfall #2), was considered to be a stormwater outfall. Regardless the report states,

> *A small storm water outfall drains road runoff from a short section of a road (Diamond [sic] Boulevard) along the south side of Jewel Lake, emptying into the southern end of Jewel Lake. There is no sampling data for the storm drain discharge. EPA and ADEC personnel conducted a site visit of Jewel Lake to evaluate the potential fecal coliform contributions from the outfall. EPA and ADEC staff believe that runoff entering the drain is unlikely to contain significant fecal coliform loadings because the runoff drains a short section of paved road. Further, the drain discharges only episodically into the lake, and the discharge location is located approximately 1,500 feet form [sic] the sampling location (at the park beach) where exceedances have been measured. (EPA, 1997:7-8)*

Malloy (2009) did not provide any information in her report other than part of the above quote, and it is unclear why both storm drains were not discussed. She also did not provide data on the precipitation during her study. Due to the contradiction and the potential for high fecal levels in stormwater outfalls, we made the decision to do some sampling of the outfalls after precipitation.

On June 14 and 23, 2010, we sampled the drip from the stormwater outfalls or the water in front of the outfalls if there was no drip. The samples were collected in the same type of containers and with the same care as was used in the normal lake sampling. SGS analyzed the samples. From June 24 to June 28, Anchorage International Airport reported 0.6 inches of rainfall. The stormwater outfalls were visited again on June 28, and water was running from both of these outfalls, and running water was collected and analyzed (Table 14). Of the six water samples analyzed from the stormwater outfalls, five (83%) had fecal coliform counts ranging from 1 to 1464 FC/100 ml, and for one sample no fecal coliform were detected (ND).

Table 14. Fecal coliform count from the water from two stormwater outfalls at the south end of Jewel Lake, June 2010.

Date	Location	Precipitation	Sample Source	Fecal Coliform Count (FC/100 ml)
14 June 2010	Stormwater Outfall #1	No recent precipitation	Culvert drip	6
14 June 2010	Stormwater Outfall #2	No recent precipitation	Culvert drip	6
23 June 2010	Stormwater Outfall #1	No recent precipitation	Culvert drip	1
23 June 2010	Stormwater Outfall #2	No recent precipitation	Lake water directly in front of culvert—no drip	ND
28 June 2010	Stormwater Outfall #1	~0.6 inches of rainfall over the last four days	Water running from culvert	1464
28 June 2010	Stormwater Outfall #2)	~0.6 inches of rainfall over the last four days	Water running from culvert	200
28 June 2010	Lake water directly in front of the Stormwater Outfalls #1 and #2	~0.6 inches of rainfall over the last four days	Lake water about ½ way between culverts @ ~12 in. (30.5 cm)	96

An investigation of the stormwater sources coming from the outfalls proved interesting. Outfall #2 runs under the sidewalk from the borrow ditch between Dimond Blvd. (Figure 61) and drains the parking lot from the west and the sidewalk from the east. We followed the stormwater flow path from Outfall #2, and approximately 2 meters from the landward side of the outfall in the stormwater flow bed were three piles of relatively fresh human feces, which we determined were most likely there for the June 28 precipitation event. Even though this stormwater outfall is not viewed as significant because it is not connected to a large catchment area, human and animal actions in the adjacent bushes obviously can provide a very strong dose of fecal coliform to Jewel Lake.

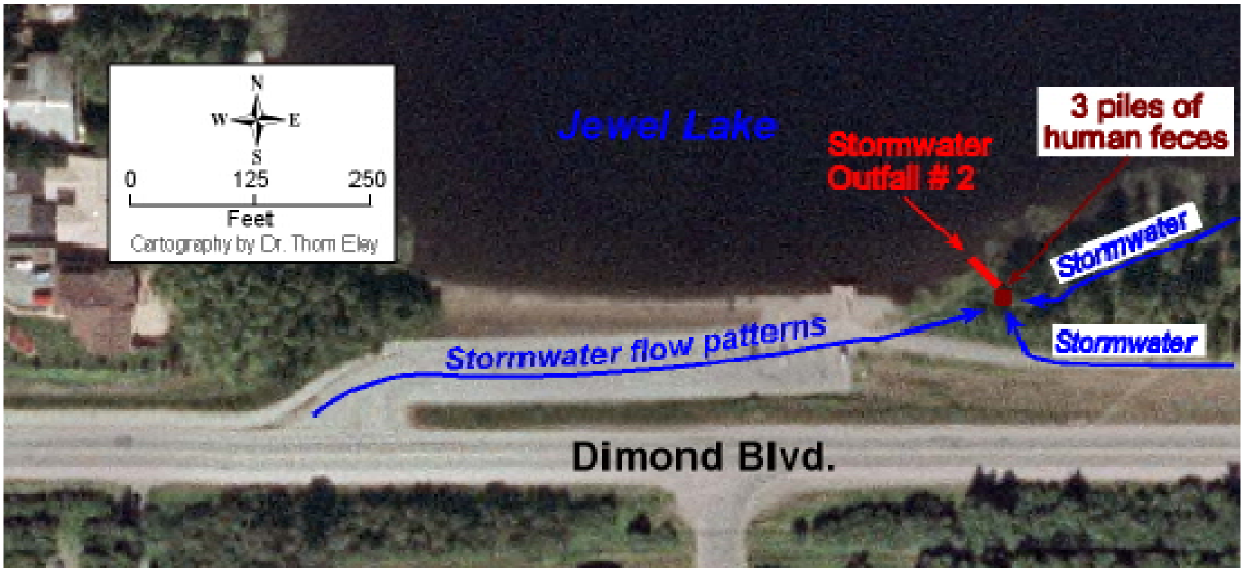


Figure 61. Stormwater flow pattern into Stormwater Outfall #2 and showing the location of the 3 piles of human feces found on June 29, 2010 (Cartography by Dr. Thom Eley).

Stormwater Outfall 1 receives water from a 15 acre area covered with about 75 duplex and single-family homes (Figures 57 and 58). The whole area is basically an impervious surface so the bulk of the rainfall will become runoff into Jewel Lake. This is the area that produced the stormwater outflow with a fecal coliform level of 1464 on June 28, 2010.

7.3.a Twenty-Foot Buffer Studies

A twenty-foot buffer was established around Jewel Lake as a "No Survey Zone." There was concern that due to the shallowness, sampling activities might stir up the sediments and invalidate the turbidity and Secchi data. However, with the use of the YSI and careful water collection methods, this 20-foot zone could be sampled. It was this 20-foot zone that we observed people using most often, and would be a natural collection area for run-off transported bacteria. Further there was concern that the 20-foot zone would be "stirred up" by wind and wave action, again invalidating some measurement. The 20-foot zone was not observed to be overly impacted by waves during our sampling sessions.

This 20-foot zone is where fecal coliform washed into the lake by overland transport and stormwater outfall will first settle into the water column and bottom sediment. It is the area most likely to be disturbed by human and wildlife activities. We collected four water samples within the 20-foot buffer, and these samples were analyzed by SGS. Fecal coliform counts ranged from 4 to 930,000 FC/100 ml (Table 15).

Table 15. Fecal coliform counts from within the 20-foot buffer.

Date	Location	Water Depth	Comments	Coliform Count FC/100 ml
28 June 2010	Jewel Lake Park @ South end of Lake	6-12 inches (15.25-30.5 cm)	Fisherman observed defecating into the lake. Water in the area was sample after he departed area.	930,000
28 June 2010	Jewel Lake Beach	6-12 inches (15.25-30.5 cm)	Common swimming and use area	96
29 June 2010	Jewel Lake Beach	12 inches (30.5 cm)	Common swimming and use area	41
29 June 2010	Jewel Lake Beach about 25 meters from above sample	12 inches (30.5 cm)	Common swimming and use area	4

7.4.a Septic Systems

Malloy (2009) paraphrased part of the 1997 EPA TMDL study and reported that,

> *several residences on the western side of the lake were not connected to the city sewer system and the septic tanks were considered as a potential non-point source. However, after an assessment of the location and slope of the septic tanks relative to the lake, combined with the fact that fecal coliform counts in the lake were not as high as those typically associated with failing septic systems, the EPA determined the* ***three*** *[emphasis is ours] homes were not a source of fecal coliform (EPA, 1997).*

Because of the contradiction between “several” and an absolute number of “three”, we reviewed files from the Anchorage Water and Wastewater Utility (AWWU) and the Municipality’s Division of Development Service’s, Building Safety, OnSite Water and Wastewater Section concerning septic systems around Jewel Lake. It was determined that there are actually nine parcels (not three parcels) on the west shore of Jewel Lake that have private septic systems and wells instead of being connected to AWWU (Figure 62). These septic systems are potentially non-point sources of fecal coliform bacteria.

These nine septic systems range in age from over 42 years old (prior to 1968) to 24 years old, and at least one has had a failure within 10 years of installation. One septic tank may be wood crib instead of steel as is now required by Municipal Code. Many of the septic tanks are not shown on the “as builts.” Some of the tanks have been pumped regularly, but the pumping frequency is not known for most. The conventional wisdom of the Alaska “septic tank construction community” is that the life of a septic system is about 20-25 years, however there is considerable variation. Wood crib septic tanks would have a shorter life span.

Many of the septic systems next to Jewel Lake are between the houses and the streets, but the leach fields extend to within 130 feet of the lake. There is a 100 foot setback zone around the lake for septic and well systems. Given the age of these septic systems, it might be worthwhile to occasionally collect water samples just off shore of these septic system properties and have the sample analyzed for fecal coliform bacteria. Jeffrey A. Garness, President of Garness Engineering Group, Ltd. and who has installed hundreds of septic systems, wrote***:***

> *It is my understanding that over 15 years ago, the MOA onsite well /septic department did a review of their records and concluded that the average life of a drainfield in the Anchorage Bowl was about 10 years. Based upon my experience testing thousands of septic systems in the Anchorage area, the average life is probably pretty close to 10 years; however, some systems can last 40 years and others only 5 years* (Garness, pers. comm. 2010).

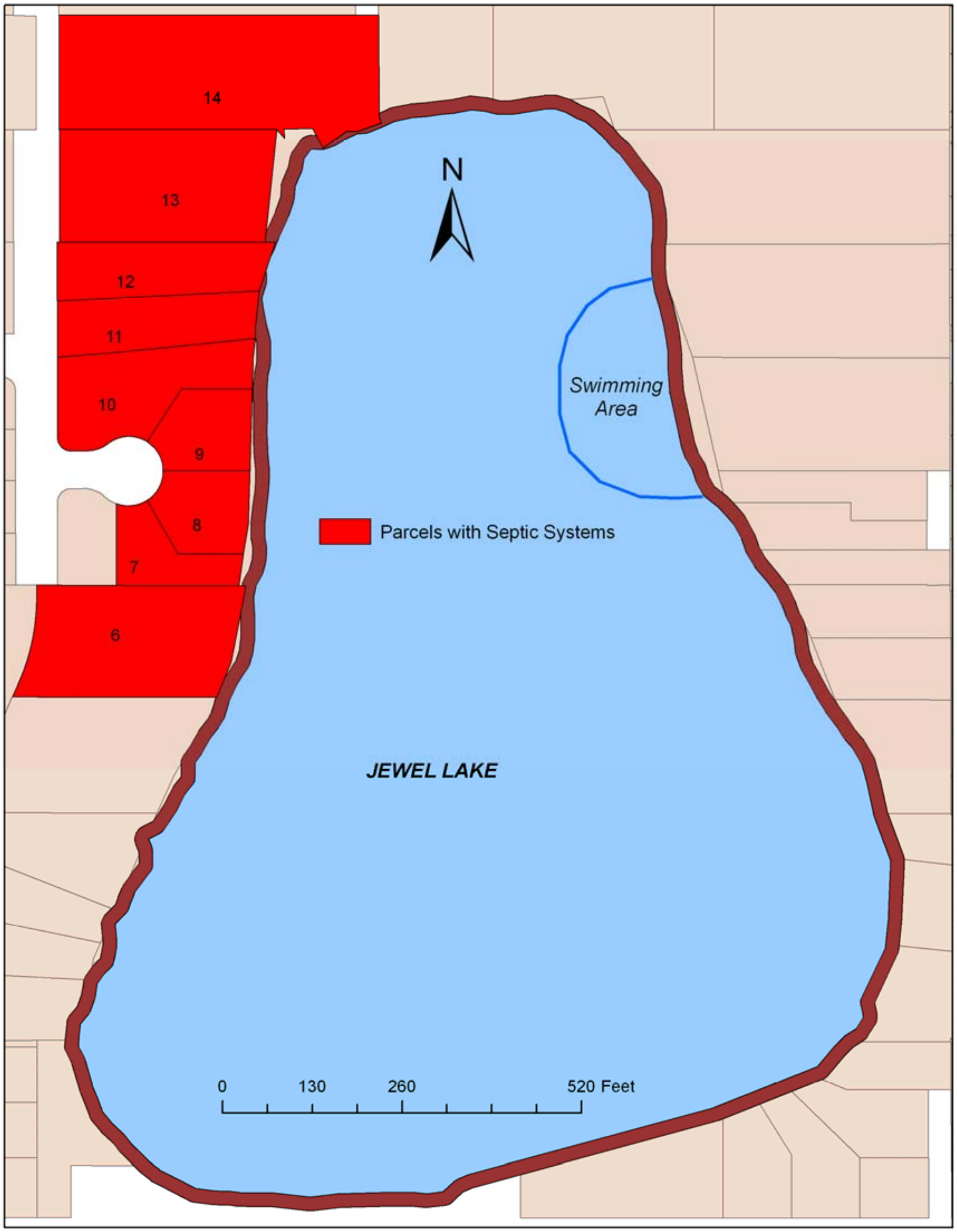


Figure 62. Map showing the nine properties adjacent to Jewel Lake that have private septic systems and are not on AWWU, (Cartography by Dr. Thom Eley).

8.0 Best Management Practices (BMPs):
"Best Management Practices (BMPs) are effective and practical, structural or nonstructural methods which prevent or reduce the movement of sediment, nutrients, fecal coliform bacteria, pesticides and other pollutants from the land to surface or ground water. BMPs may consist of constructed and non-constructed technologies—including the changing of human behavior—which protect water quality. These practices are developed to achieve a balance between water quality protection and human use of surrounding land areas. The State of Hawaii, Dept. of Land and Natural Resources aptly wrote:

> *A thorough understanding of BMPs and the flexibility in their application are of vital importance in selecting BMPS which offer site specific control of potential nonpoint source pollution. With each situation encountered at various sites, there may be more than one correct BMP for reducing or controlling potential nonpoint source pollution. Care must also be taken to select BMPs that are practical and economical while maintaining both water quality and the productivity of forest land. BMPs have been developed to guide…landowners, other land managers and [municipalities} toward voluntary compliance [federal, state, and local laws to maintain] water quality to provide "fishable" and "swimmable" waters. The Environmental Protection Agency (EPA) recognizes the use of BMPs as an acceptable method of reducing nonpoint source pollution (*State of Hawaii, Watershed Protection and Management Program. 2001).

Nonpoint source is diffuse pollution that comes from many different origins. It occurs naturally in some areas, and has increased due to the activities of humans. Although the amount of pollutants such as fecal coliform bacteria from a particular site can be small, when combined with a number of sources from over and around the landscape, water quality problems can result, and they can create problems. It is unrealistic to expect that all nonpoint source pollution can be eliminated, but BMPs can be used to minimize the impact of land use practices on water quality. These BMPs must be reasonable, achievable and cost effective, and they must provide a mechanism for attaining and maintaining water quality.

Task 5 of the work plan was the development of a BMP assessment. The intent of this BMP guide was to ascertain sources and reduce fecal coliform bacteria sources to the lake, however, the BMP assessment turned into a tool or guide to promote better stewardship of Jewel Lake. In many cases, common sense is most often a good guide, but some additional ideas for property owners, including the MOA, can be helpful. Compliance with any watershed protection practices could be on a voluntary basis backed up with a public water quality education and awareness program, or it could become codified in state and local laws and ordinances.

8.1 Checklist for BMP Assessment for Jewel Lake:
A check list was developed by Kate Malloy in 2008-2009 for assessment of BMPs. The criteria are listed below, but we have reworded several of the criteria so that they were more in a "checklist form." Several of these criteria were difficult to assess from a canoe even with the use of powerful binoculars. We did not have access to private property to assess things, such as pet or animal wastes in yards.

Criteria:

1. Turf/landscaped areas should end 25 ft from shoreline and shoreline buffer of native plants and shrubs should be in place;
2. All pollutants like gas, paint, fertilizer, etc. are stored properly in containers and at least 50 feet from water's edge;
3. There is preservation of the natural structure of the shoreline and emergent vegetation is allowed to grow and colonize on some portion of waterfront area;
4. Impervious surfaces (walkways, manicured lawns, etc.) should be reduced on all properties;
5. Vegetation should be well established and minimal bare soil exposure;
6. No visible pet or animal waste left in yard or in adjacent areas of the lake;
7. No evidence of discarded lawn clippings/yard waste or debris being dumped in lake.

To create a useful measure, a scale of 100 was used to assess each property. Each item on the BMP checklist was worth 14.29 points. The point value was translated to a color coded grading scale for easy interpretation. However, a grading scale based on 14.29 points proved a bit awkward.

The following scoring system was used:

- A/Good =91-100 points (green area)
- B/Fair=85-90 points (yellow area)
- C/Poor=<85 points (red area)

8.2 The Assessment of BMPs:

A visual assessment of lake shore properties was conducted from the land and from canoe to see if property owners have implemented BMPs to prevent polluted runoff from entering the lake and provide quality riparian lake shore habitat. The assessment was conducted on five separate dates--June 2, 7, 14, 23, and 29, 2010, with a follow up on June 30, 2010. Each of the properties was rated by one of the investigators utilizing the criteria listed above, and then the scoring was verified or clarified by both investigators.

A map was prepared showing the BMP assessments for 2010 (Figure 63). The BMP assessment map for 2009 is also included (Figure 64) for comparison. The results of the two years' surveys are very similar. Seven properties improved their BMPs, particularly by encouraging native terrestrial and emergent aquatic vegetation to colonize along shore lines and re-vegetating steep areas. Five properties had a decline in the BMP score, and several reasons for this were noted. Many of the problems may not have been there during the 2009 survey, such as fresh grass and yard debris, which could include dog and chicken feces. Further, a shed that contained gasoline, pesticides, and other chemicals within 50 feet of the shoreline was open so that we could see inside. If the shed's door was closed last year, the person conducting the survey would never know the contents.

The sorts of issues we found during our survey in 2010 include:

- Yard and grass clippings dumped into the lake—possible source of fecal coliform contamination.
- Dog and chicken feces part of yard debris on lake edge—possible source of fecal coliform contamination.
- Other debris such as pallets, pipes, and lumber thrown into the lake.
- Long manicured lawns that extend into the 25-foot protected zone around the lake, and in some cases the lawns went right to the water's edge. These lawns can act as impervious surfaces increasing runoff into the lake—possible source of fecal coliform contamination.
- Long manicured lawns tended to attract geese, and several broods of Canada Geese were raised around these lawns—possible source of fecal contamination.
- Bare soil on steep terrain on the west side of the lake, which could result in increased sediment run off into the lake—possible source of fecal coliform contamination. This bare soil appears to have resulted from trips up and down the hill to docks in the lakes. One property owner has constructed a switch back system down to the lake, and has gone to great lengths to successfully re-vegetate damaged areas. Another property owner has terraced their property to create small level areas to catch precipitation instead of having runoff.
- Many people who are transient park users allow their dogs to swim in the lake. Some dog owners have their dogs defecate in the wooded park areas and then don't clean it up—possible source of fecal coliform contamination.
- People defecating in the wetlands and the lake. One fisherman was observed defecating in the lake in the park woods near the fishing dock on the south end of the lake—certainly a source of fecal coliform contamination.
- Debris, particularly hundreds of golf balls and beer cans in the lake. The golf balls appear to be coming from both sides of the lake (both from residences and park areas).
- Fishing debris (hundreds of feet of filament line, bait containers, and hook holders) and dead fish left on the shoreline or in the lake.
- The beach and picnic area at the northeast end of the lake appears to be a party spot on the weekend and during the week. All types of residue were found near or in the lake, including clothes, diapers, beer and soda boxes, tampons and sanitary napkins, and charcoal to name a few—many of these are potential sources of fecal coliform contamination.
- Several property owners were pumping water from the lake to water their yards.
- Inflow from stormwater outfalls could be a significant source of fecal coliform contamination.
- It appeared that most property owners, other than the Municipality, were taking some measures to maintain their property in harmony with the lake. Results of a door-to-door survey of lakeside residents will be presented later in this report. The use of a BMP checklist on a handout for lake shore property owners, and a discussion of "Living with a Lake," would be a helpful tool. The AWC could perhaps facilitate this with complimentary BMP surveys for land owners or a mailed survey to those owners who have specific problems. There would be no threat of legal or other action, but a

more positive approach of trying to help the resident. This could reduce the amount of fecal coliform contamination as well as help residents be better lake stewards.

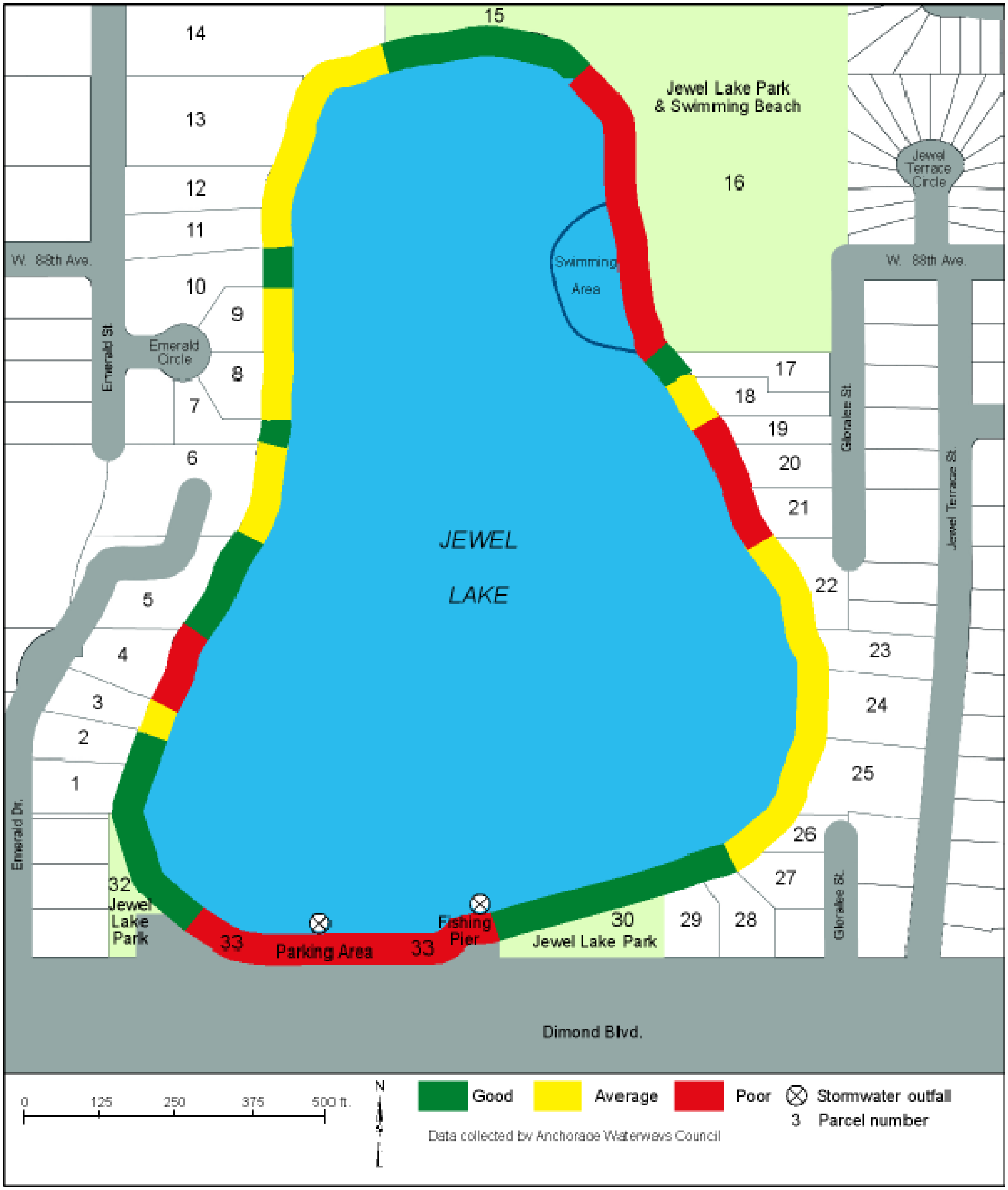
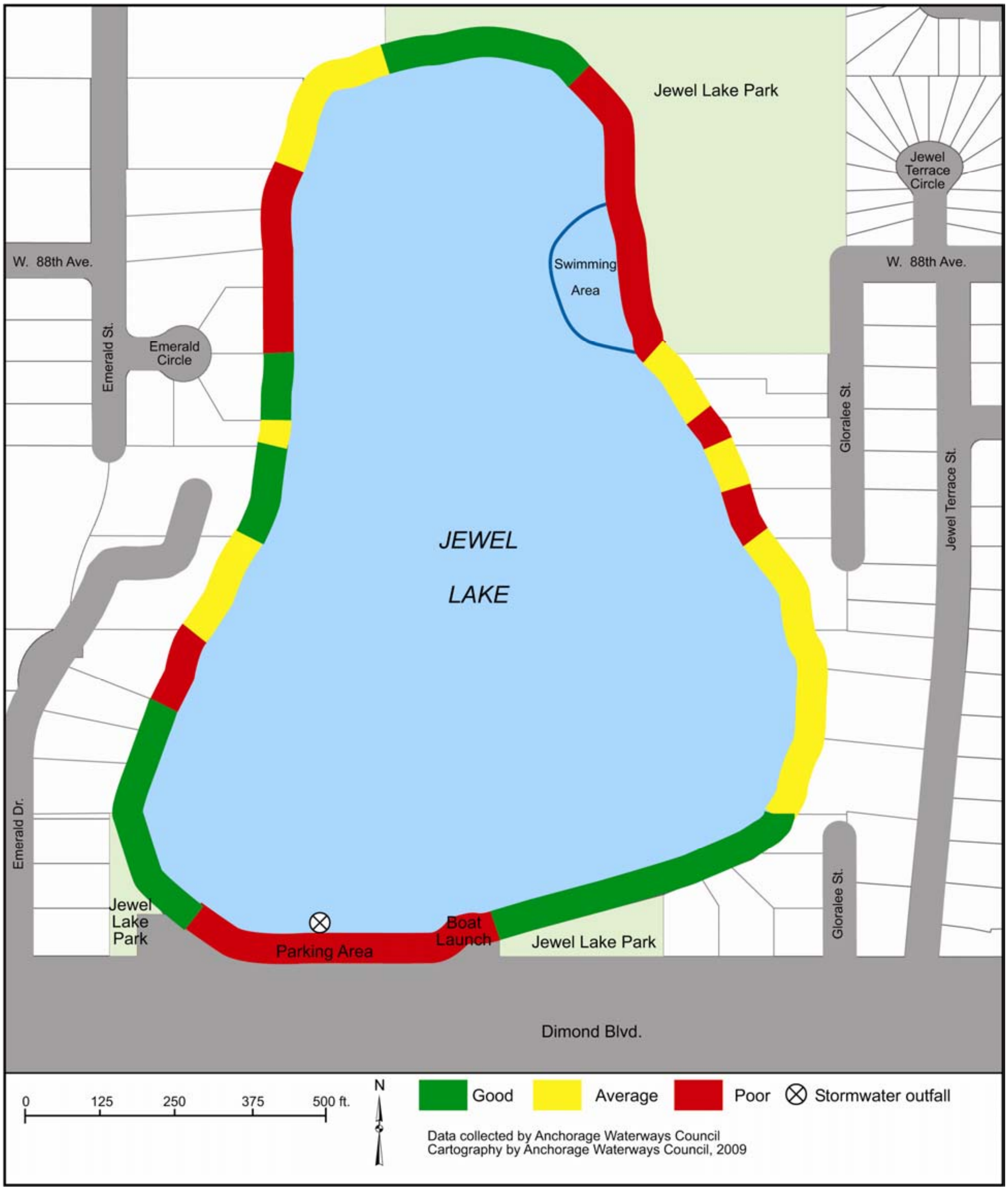


Figure 63. BMP ratings for properties surrounding Jewel Lake, 2010 (Cartography by Dr. Thom Eley).



64. BMP ratings for properties surrounding Jewel Lake, 2009.

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8.3 Revised Checklist for BMP Assessment for Jewel Lake
After conducting the BMP survey, it became apparent that the initial one used for both the 2009 and 2010 surveys was lacking a few issues. Actually a BMP survey form should be an evolving document with items added as appropriate. The next section is our revised BMP criteria checklist. All properties were assessed with these criteria, and they produced essentially the same results as the original criteria. These new criteria have the advantage of being a bit more comprehensive, and a ten-point per criteria scale is used instead of the awkward 14.29 point scale.

Criteria:

1. Landscaped areas should stop at least 25 ft from shoreline.
2. A shoreline buffer of native plants and shrubs should be in place;
3. All potential pollutants like gas, paint, fertilizer, etc. are stored properly in containers and at least 50 feet from water's edge;
4. There is preservation of the natural structure of the shoreline and emergent vegetation is allowed to grow and colonize on significant portions of waterfront area;
5. Impervious surfaces (walkways, manicured lawns, etc.) should be reduced on all properties;
6. Vegetation should be well established with minimal bare soil exposure;
7. Properties with steep slopes to the lake should have a mitigating process to prevent vegetation deterioration and erosion as a result of people and pets going up and down the slope.
8. No visible pet, animal waste, yard clippings, and general debris left in yard near the lake edge or in adjacent areas of the lake;
9. Houses with septic systems—time since the installation of the current system (<5 years = 10 points; 10-19 years = 5 points; and 20+ years = 0 points.).
10. No pumping of water from the lake.

Photos of each property were taken and are included in electronic Appendix A that accompanies this report. However, representative photos of good (Figures 65-66), fair (Figures 67-68) and poor (Figures 69-70) quality shoreline habitat are provided in this document.

Figure 65. Area of park land (adjacent to fishing area) bordering Jewel Lake that received a Good (A) habitat quality rating based on the BMP assessment. The extreme left side of the photo shows the parking area at the south end of the lake which has a poor rating. (Photo by Dr. Cherie Northon).

Figure 66. Example of lakeshore residential property on Jewel Lake that received a Good (A) habitat quality rating based on the BMP assessment. (Photo by Dr. Cherie Northon).

Figure 67. Residential property on northwest portion of lake that received a Fair (B) habitat quality rating based on the BMP assessment. (Photo by Dr. Cherie Northon).

Figure 68. Another residential property on the west side of Jewel Lake that received a Fair (B) habitat quality rating. (Photo by Dr. Cherie Northon).

Figure 69. Residential property on the west side of Jewel Lake that received a Poor (C) habitat quality rating, due mainly to the lack of buffer present, bare areas and erosion on a steep slope, and debris (pallets) in the water. (Photo by Dr. Cherie Northon).

Figure 70. Parking and fishing area at the south end of the lake showing bare slope, trails where people have walked up and down the slope, stormwater outfall, and all matter of debris on the beach. This area received a Poor (C) rating. (Photo by Dr. Cherie Northon).

8.4 "Scoop the Poop" Outreach to Residents Around Jewel Lake

During June 2010, Jadelle Riski, a high school student at Polaris K-12, visited approximately 100 homes in the Jewel Lake area to talk with residents about good pet practices and leave information regarding the problems of animal feces (see Appendix 3 for brochure example). Almost every resident that borders the lake was home when she visited, but as she moved into the side streets where there are more multiple-family homes, the number of those at home dropped. She also took advantage of people working in the area (AKDOT road crews, yard and house repair people, and general pedestrians) to provide information to. The primary streets covered in the survey include: Emerald Ct., Glorilee St., Jewel Terrace and W. 88th.

Ms. Riski reports that all the people she talked to who lived on the lake were very receptive—even if they didn't own dogs. It appears that very few people who live on the lake are dog owners, but they do get "visiting" dogs in their yards on occasion. The lake is heavily used by dog owners, and every time we were there monitoring or checking the lake, at least one dog (often two or three) was there with his/her owner. Retrieving sticks from the lake is a common activity for some dogs, and for others it might be fetching a ball or Frisbee. Frequently we saw dogs disappear into the woods and return, so we can only make assumptions as to what happened.

Residents bordering the lake who don't own dogs but have dogs enter their yards stated that they would clean up dog feces because they want the area clean because children often play in their yards. In our review of the yards from the perspective of the canoe, those yards that were well groomed and landscaped, were very clean and free of debris for the most part, although from the distance that we had to keep it was impossible to ascertain whether or not any dog waste was actually on the ground. The yards that were more "natural", appeared clean, but it was not possible to know what might be in the bushes, shrubbery, or trees.

On our initial visit this spring when there was still ice on the lake and ground (April), there was an enormous amount of dog waste in the recreation area (beach) on the east side of the lake.

Figure 71. Dog waste by parking lot barrier and dog waste on asphalt walkway to beach, Jewel Lake, April 4, 2010 (Photos by Dr. Cherie Northon).

Since this slopes down toward the beach and lake, it is likely that much of it ended up in the lake after breakup. There is some irony here, because within 50’ of this recreation area is a Scoop-the-Poop Station (always supplied with bags) and a sign asking residents to clean up after their pets.

Figure 72. Scoop the Poop station and Scoop the Poop sign, Jewel Lake, April 4, 2010 (Photo by Dr. Cherie Northon)

Even on the last sampling visit to Jewel Lake on June 29, 2010, two large piles of dog feces were found on the grassy area next to a bench and a garbage can by the beach, and within 75’ of the Scoop-the-Poop Station.

Figure 73. One of two dog feces piles observed June 29, 2010, Jewel Lake (Photo by Dr. Cherie Northon).

Some of the other comments from the Jewel Lake neighborhood that Ms. Riski noted include:

- Would anyone do a “deep” clean to take out trash and debris similar to the one done on Cheney Lake earlier this month (and shown in the *Anchorage Daily News* on 6/8/10)?
- Several people commented that the lake needs to be cleaned and monitored—their idea being that the locals pitch in. Sounds like they need some organization and they’d do it.
- One woman wondered if the lake water was hazardous to health.

9.0 Summary of Current Water Quality Status and Recommendations

9.1 Water Quality and State Standards

Jewel Lake met the state water quality standard for fecal coliform during the duration of this study. Fecal coliform bacteria concentrations in Jewel Lake were very low compared with past data that exceeded the state water quality standards. The highest fecal coliform concentration recorded was a one-time value of 27 FC/100ml recorded in 2008-2009, while the highest count for 2009-2010 was a one-time value of 23 FC/100 ml. However the state standard is based on a geometric mean of 20 FC/100 ml or less, not a singularly occurring value.

Fecal coliform concentrations were mapped to allow analysis by location in an effort to isolate potential sources and hot spots of fecal coliform loading in Jewel Lake. However, the range of values was rather homogenously distributed throughout the lake and the highest value of 23 FC/100ml was found relatively near the swimming beach, where geese, children and dogs congregate. High fecal coliform numbers were also found in the stormwater outfall after a rainfall event, and in nearshore water areas, but these were not part of the original workplan. Regardless, these areas merit future investigation.

Turbidity data in Jewel Lake was not positively correlated with fecal coliform concentrations as anticipated. Because fecal coliform bacteria have been described as having an affinity to sediment particles, it was expected that the highest bacteria concentrations would be observed during periods of high turbidity. However, a slight inverse relationship was found between bacteria concentrations and turbidity. No relationship was observed between fecal coliform concentrations and Secchi disk depth. Further, no correlation between fecal coliform bacteria levels and pH and dissolved oxygen was detected. Temperature, dissolved oxygen, and pH were all within acceptable State of Alaska water quality standards.

Water temperature provided some conflicting correlations, whereas in the fall water temperature was negatively correlated to fecal levels yet in the spring and early summer, fecal levels were positively correlated. We have speculated that this conflict is due to seasonal warming and cooling and increased precipitation. Precipitation did show a positive correlation to fecal coliform levels. The relationship between fecal coliform levels, water and air temperatures, and precipitation merits further study.

9.2 Recommendations for Future Efforts

Based on the data and results obtained during this study, several recommendations can be made for future sampling in Jewel and other lakes.

1) **Continuity in Available Data:** It would be helpful to collect more data in Jewel Lake in order to get a comprehensive look at Jewel Lake's water quality.
    a. Further studies should be conducted assessing fecal coliform levels, water and air temperatures, and precipitation. These studies should include several lakes within the Anchorage Bowl and perhaps creeks as well.
    b. Data should be collected within the 20-foot buffer as these high-use areas could have higher fecal coliform levels than the state standards.
    c. Collect fecal coliform data after rainfall events to assess the impact of runoff and stormwater outfall as a source of fecal coliform bacteria.
    d. In relation to the above recommendation, stormwater entering lakes in Anchorage should be assessed for fecal coliform, and an analysis of the sources of lake stormwater outfall—where does the water come from?—should be done.
    e. Some winter fecal coliform monitoring in the ice fishing area—you could use the hole the ice fishers have made—to see what is going on in the winter. We all think we know what is happening, but we have no data to substantiate it.
    f. Regular fecal coliform monitoring just offshore (within 20-feet) of the houses with septic systems should be done due to the age of the septic systems in these houses.

2) **Other Recommendations:**
    a. ADF&G and the MOA's Department of Parks and Recreation need to team up to work with ice and summer fishers about littering the fishing area with monofilament line and other fishing debris, the wanton waste of caught fish, and cleaning up after their pets.
    b. Install a Rent-a-Can at the south end parking lot so that people don't have to defecate and urinate in or near the lake.
    c. The Anchorage Police Department should make an effort to target Jewel Lake Park at the northeast end of the lake to discourage some of the party and littering activities going on there in the evenings and weekends.

d. Develop a "Living with a Lake" brochure for residents around Anchorage's lakes that discuss BMPs that property owners could implement.

3) **Jewel Lake Advisory Group:** A citizens' advisory group made up of residents around Jewel Lake, users of Jewel Lake, and agency personnel interested in water quality such as ADF&G, ADEC, and the MOA. This advisory group could take on some of the issues plaguing Jewel Lake, such as the "party site" issue, litter around and in the lake (golf balls and beer cans were truly abundant), dog poop not cleaned up including poop on the lake ice in winter, wanton waste of fish, and the littering of fishing debris (monofilament line, hooks, gear packaging, bait containers, etc.). Additionally, they would be in a good spot for dealing with the issues involving the residents around the lake, particularly depositing yard, pet and animal, and general debris in the lake; storage of hazardous materials near the lake; and pumping of water from the lake to water their yards as a permit is required for this activity.

4) **Consideration of the Designated Water Use :** Currently, Jewel Lake is required to meet the Alaska State Water Quality Standards for the most stringent standard which is for water supply- drinking, culinary and food processing [30-day geometric mean 20 FC/100 ml or less and only 10% of the sample may exceed 40 FC/100 ml]. Consideration could be given as to whether to change the standard level to Water Recreation--Contact Recreation [30-day geometric mean less than 100 FC/100 ml and only 10% of the samples may exceed 200 FC/100 ml]. This would base Jewel Lake's standard on actual use of the lake. We didn't see anyone using the water supply for drinking, culinary or food processing.

9.3 Conclusion

Jewel Lake should be removed from the State's list of impaired waters.

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APPENDICES

Appendix 1: Photos of all properties surrounding Jewel Lake: Provided digitally.

Appendix 2: SGS Laboratory Reports and Chain-of-Custody: Provided digitally.

Appendix 3: Scoop the Poop Brochure and letter for residents. Provided digitally.