YEAR 2000 LAKE STUDIES IN THE PHILLIPS EXPLORATION AREA,

NATIONAL PETROLEUM RESERVE - ALASKA

– 2000 –

by

Richard E. Reanier, Ph.D.

for

PHILLIPS ALASKA, INC.

REANIER & ASSOCIATES
Environmental Science Consultants

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November 29, 2000

Note

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Executive Summary

This study of lakes in the Phillips Exploration Area of the National Petroleum Reserve – Alaska has evaluated 32 lakes that might potentially be used for water withdrawals to construct ice roads and ice pads. Field methods included taking measurements from a helicopter on fixed floats that allowed data to be collected rapidly. Lake volume calculations were made using maximum lake depth and lake area according to the cone-method of Moulton and Lobdell. The cone-method was modified to provide an estimate of the free-water volume below the ice, in order to comply with the BLM stipulations for exploration activities. Of the 32 lakes studied, 19 have depths great enough to allow some water withdrawal even if fish are present in the lake. Water quality data indicate that all of the 32 lakes studied have salinities low enough for their water to be used in ice road and ice pad construction.

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I. Introduction

On August 5, 2000 Reanier & Associates was tasked by Phillips Alaska, Inc. to conduct lake studies to include depth and water quality measurements for lakes in the National Petroleum Reserve – Alaska (NPR-A) that had been identified as potential water sources for ice road and ice pad construction. A map was provided by Phillips that indicated the lakes to be studied. These lakes were examined on August 6, 2000. After these lakes were measured, additional lakes were identified for study by Phillips, and the new lakes were examined on August 7, 2000. Preliminary data from the lake study were provided to Phillips on August 6 and August 7, 2000. This report discusses the purpose, methods and results of the lake survey, and provides the final lake survey data.

II. Acknowledgements

The advice of Mike Joyce (Phillips) was greatly appreciated during the fieldwork phase of this study. Lisa Pekich (Phillips) was instrumental in providing logistical planning and support for the project. Rick Overstreet (Phillips) provided field maps and helpful support in the field. I am grateful to A.J. Rookus (Lounsbury & Associates) for helping identify potential lakes in a very tight time frame. Pilot Jim Fitzpatrick (Air Logistics) provided his superb flying skills and helpful advice during the fieldwork. Support personnel at KOC did their usual fine job of helicopter and logistical support. I am especially thankful to George Johnston (Phillips) and Kelli Thibodeau (Phillips) for their assistance at KOC. Larry Moulton (MJM Research) kindly provided details of the cone-method for lake volume calculations. Mark Major (Phillips), Caryn Rea (Phillips), and Sally Rothwell (Phillips) have provided helpful advice during the analysis phase of this project.

III. Purpose of Study

Lake studies are required as a result of Bureau of Land Management (BLM) stipulations for exploration in the NPR-A (Babbitt 1998). The stipulations for ice roads and water use require that:

1. Water withdrawal is prohibited during winter from lakes less than 7 feet (2.1 m) deep if they are interconnected with or subject to seasonal flooding by a fish-bearing stream (Stipulation 20).
2. Water may be withdrawn from isolated lakes that are less than 7 feet (2.1 m) deep that lack connection to or are not subject to seasonal flooding by a fish-bearing stream. (Stipulation 20).
3. After consultation with the appropriate Federal, State, and NSB regulatory and resource agencies, the AO may authorize withdrawals from any lake less than 7 feet (2.1 m) deep, if the proponent demonstrates that no fish exist in the lake (Stipulation 20).
4. Generally, water withdrawal drawdown during winter from lakes 7 feet (2.1 m) deep or deeper shall be limited to 15 percent of the estimated free-water volume (i.e. excluding the ice) (Stipulation 20).

5. After consultation with the appropriate Federal, State, and NSB regulatory and resource agencies, the AO may authorize drawdown exceeding 15 percent from a lake greater than 7 feet (2.1 m) deep, if the proponent of the additional drawdown demonstrates that no fish exist in the lake (Stipulation 20).
6. The AO, in consultation with appropriate Federal, State, and NSB regulatory and resource agencies, may allow water extraction from any lake used by molting geese, if it is determined that the withdrawal is consistent with Stipulation 20 and will not adversely affect identified goose-feeding habitat along lakeshore margins (Stipulation 21).

These stipulations require that lake depths be measured, and that studies of fish be conducted if proponents desire to withdraw water from lakes less than 7 feet in depth, or to withdraw more than 15 percent of the free-water from lakes more than 7 feet deep. Additionally, studies of geese and their habitats are needed if water is to be withdrawn from lakes used by molting geese. The stipulations also require that free-water volumes of lakes be estimated.

Additionally, in order to protect the tundra, water to be used for ice roads cannot be saline. Generally a conductivity limit of 4,000 µmhos/cm is used, and water less saline than this can be used for ice roads.

This study primarily addresses lake depths, volume estimates, and water quality measurements. It does not address the presence or absence of fish in lakes, except indirectly by noting possible indications of fish observed on depth sounders while recording lake depths, and it does not address the question of goose habitat.

IV. Materials and Methods

For this study a rapid method of obtaining lake depth and water quality data was required. The remoteness of the lakes to be studied necessitated the use of a helicopter to reach them. It was decided that depth and water quality measurements could be obtained directly from the helicopter, avoiding the more time consuming use of a separate watercraft for data collection. A Bell 206L Long Ranger on fixed floats was provided by Air Logistics, Inc. of Fairbanks, and was flown to the North Slope. The fixed floats permitted direct landings on lakes. Navigation was facilitated by a Garmin III+ Global Positioning System (GPS) receiver fitted with an external antenna mounted in the helicopter, and a moving high resolution map approximately equivalent in detail to the USGS 1:63,360 scale topographic series maps. This allowed for easy identification of lakes by shape and location, and for precision positioning of the depth measurement locations within a lake. On April 2, 2000, the Air Force disabled the so-called Selective Availability (SA) feature of the GPS satellites, which had degraded the signal used by civilians. Without SA, GPS locations are thought to be within 10 m of actual locations 95% of the time, though experiments by Reanier & Associates on the North Slope indicate substantially greater accuracy than this.

In this study lake depths were recorded with a Garmin 100 depth sounder, which provides a digital readout of depth and can indicate possible images of fish in the water column. Water quality was measured with a Horiba Model U-10 water checker. The water quality measurements recorded were salinity, temperature, and conductivity.

The field methods for this project were straightforward. After locating a lake to be studied, a landing was made in the approximate center of the lake, and a depth measurement was made. Simultaneously, the position was recorded with the GPS receiver. Depending on the size and depth of the lake, additional depth measurements might be made at other points in the lake. If the depth sounder indicated the possible image of fish in the water column, that was also recorded. At one of the points selected for a depth measurement water quality measurements were also made. These procedures were followed for all of the lakes studied in this project. A total of 139 depth readings were made in 32 lakes, requiring a total of 12 hours of field time – an average of 2.6 lakes per hour.

After the fieldwork, data were transferred a spreadsheet so volume estimates could be made. There are many approaches to calculating the volume of lakes. The most detailed method is to gather a large amount of depth data for a given lake, and then create a bathymetric map of the lake from which volumes can be calculated. The older methods of using strip-chart fathometers and reducing data graphically (e.g. Reanier 1991) have given way to digital fathometers and the use of surface modeling software to calculate basin shape (e.g. Wilson et al. 1997). Surface modeling software has the advantage of being able to calculate volumes automatically once the model has been created. This method, however, is very time-consuming, requiring large amounts of field time to acquire enough data. Efforts to create more simple models of basin shape and volume that require less data but still provide reliable estimates have resulted in a number of different models. One model that has been developed for use with North Slope thaw lakes and has become a standard method is the cone-model.

The cone-model was developed by Lawrence L. Moulton (MJM Research) and John E. Lobdell (Lobdell & Associates) for use on the North Slope. The model assumes that the lake has the shape of a shallow cone (Moulton 2000). The maximum depth of the lake is taken to be the height (or in this case, depth) of the cone, and the surface area of the lake is taken to be the area of the base of the cone (Figure 1). The surface area is calculated with a Geographic Information Systems (GIS) program that contains a map of the lake shape. In practice, this model has proven to provide a good first approximation to lake volume when compared to more detailed bathymetric map-derived results.

The BLM stipulations outlined above require calculation of the free-water volume existing below the ice in lakes used for water withdrawal. Unless a lake can be shown to contain no fish, no water can be withdrawn from lakes less than 7 feet deep, and 15 percent of the free-water volume below the ice can be withdrawn from lakes deeper than 7 feet. Since North Slope lakes generally freeze to a depth of about 7 feet, the 7-foot depth approximates the ice thickness on these lakes.

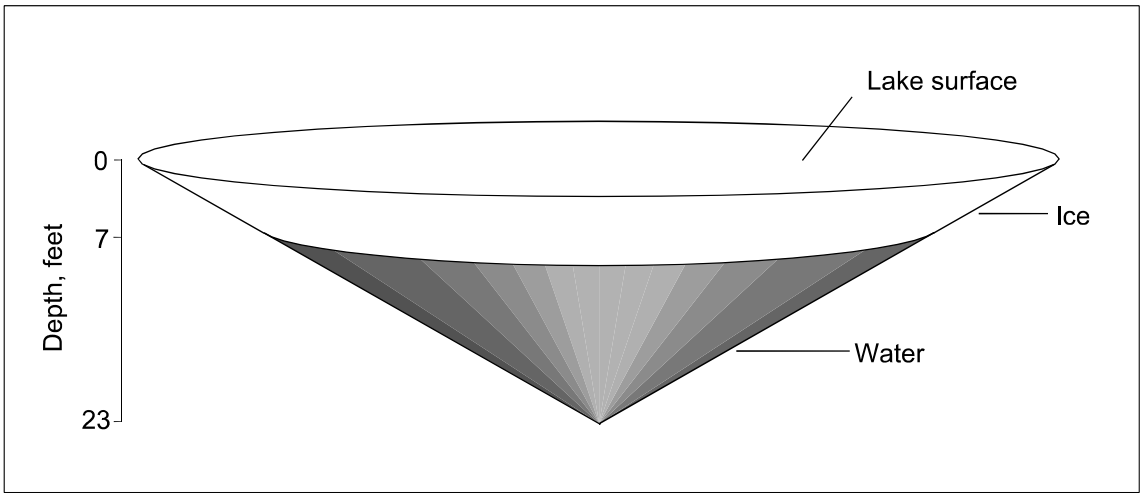

Figure 1. The modified cone-model for NPR-A Lakes. The lake volume is approximated by a cone with height equal to the maximum depth of the lake (here, 23 feet) and with a base area equal to the surface area of the lake. For the NPR-A, the volume of free-water beneath a 7-foot thick layer of ice is estimated by the volume of a new cone (shaded) with a height reduced by 7 feet and a base area equal to the surface of the free water beneath the ice.

For the NPR-A the cone-model must be modified to account for the 7 feet of ice on a lake in order to calculate the free-water volume. The modification requires that the volume of a new cone be calculated, a cone with the height (depth) reduced by 7 feet, and the base area equal to the area of the free-water surface (or equivalently, the area of the bottom surface of the ice) (Figure 1). To calculate the usable water for withdrawal one takes 15 percent of the volume of the free-water calculated by this method. In the example in Figure 1, approximately 2/3 of the lake volume is contained in the ice, and 1/3 remains in the free-water below the ice. Because 15 percent of the free-water can be withdrawn from the lake, only about 5 percent of the total lake volume is available for ice road construction.

V. Results and Discussion

The 32 lakes studied in this project are shown in Figure 2. Lakes in this study are numbered consecutively from R0050 to R0081 to denote the 50th through 81st lake studied by Reanier & Associates in the year 2000. Lakes with other labels are those studied by other investigators. The modified cone-model described above was applied to the depth and surface area data recorded for each lake, and a summary of the results is presented in Table 1. The entire dataset is provided in Appendix 1.

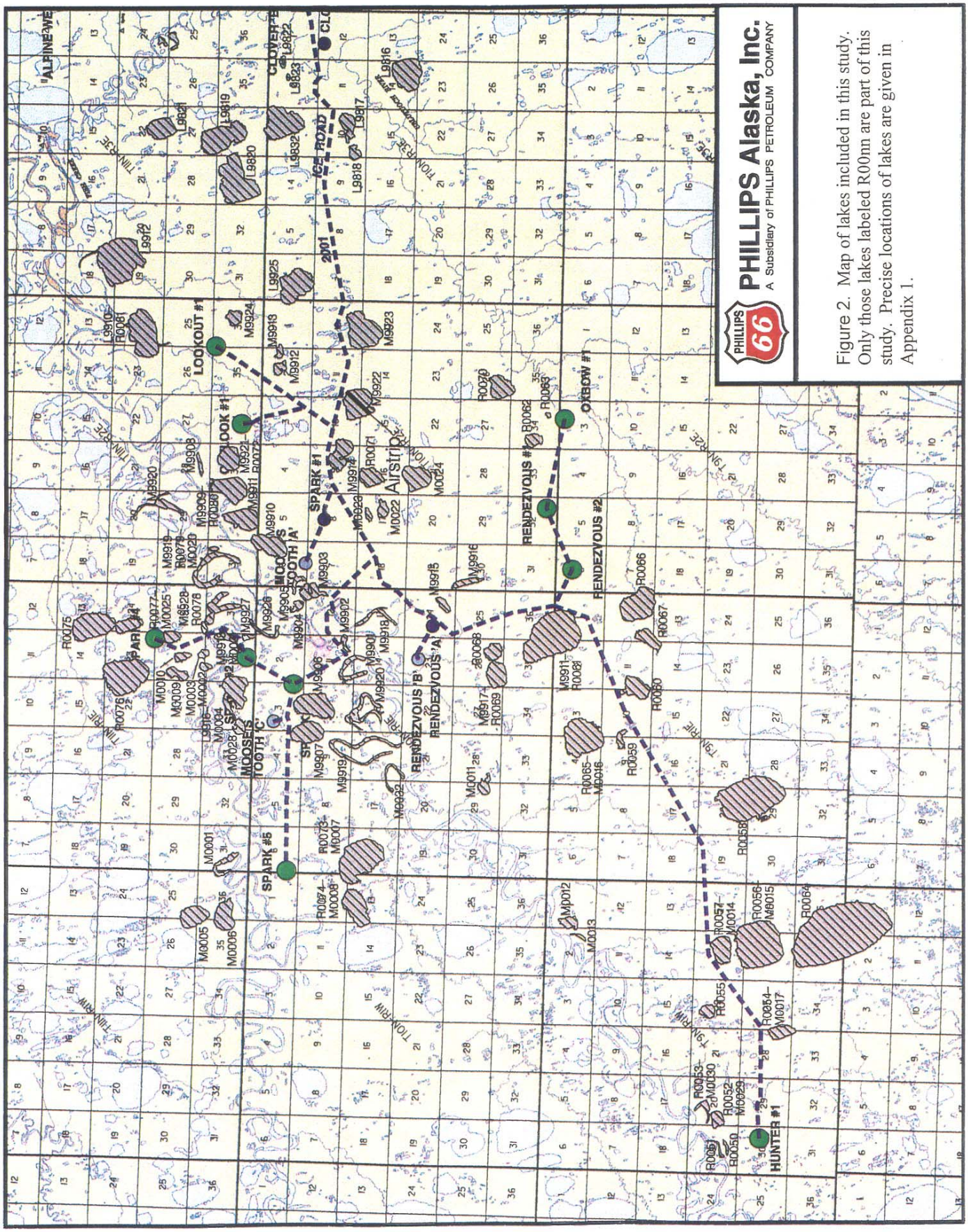

Figure 2. Map of lakes included in this study. Only those lakes labeled R00nn are part of this study. Precise locations of lakes are given in Appendix 1.

Table 1. Summary of results of lake studies in the Phillips exploration area, NPR-A.

Lake	Maximum Depth (feet)	Conductivity (µmhos/cm)	Temperature (°C)	Fish on Depth Sounder?	Surface Area (acres)	Lake Volume (gallons)	Volume Below 7 Feet (gallons)	Usable volume 15% of Volume Below 7 feet (gallons)
R0050	3.5	264	10.5		8.787	3,340,581	0	0
R0051	6.4	215	10.7		8.405	5,842,944	0	0
R0052	10.2	381	11.8	Yes	44.469	49,266,835	1,521,262	228,189
R0053	8.5	161	11.7	Yes	25.995	23,999,701	131,893	19,784
R0054	3.1	240	10.7		70.354	23,689,288	0	0
R0055	6.3	158	11.6		41.808	28,608,661	0	0
R0056	6.6	170	11.4		473.827	339,675,071	0	0
R0057	7.3	166	11.8		114.383	90,695,109	6,295	944
R0058	6.5	245	11.5		570.173	402,550,325	0	0
R0059	8.2	46	11.8		31.244	27,827,456	87,212	13,082
R0060	8.2	116	11.7		113.854	101,405,205	317,806	47,671
R0061	7.9	142	11.6		540.269	463,593,579	685,462	102,819
R0062	3.4	225	11.1		48.822	18,029,855	0	0
R0063	5.8	142	11.3		5.742	3,617,499	0	0
R0064	7.1	207	11.9	Yes	1159.292	894,028,068	2,498	375
R0065	6.5	112	11.4		300.401	212,087,596	0	0
R0066	10.0	94	11.8		232.507	252,543,160	6,818,665	1,022,800
R0067	7.4	162	11.6		78.387	63,005,210	9,951	1,493
R0068	4.0	180	10.7		62.893	27,325,030	0	0
R0069	9.2	169	11.7	Yes	112.413	112,331,916	1,536,058	230,409
R0070	3.6	193	10.6		114.080	44,607,933	0	0
R0071	2.7	89	10.2		90.271	26,473,582	0	0
R0072	4.0	193	10.5		108.336	47,068,543	0	0
R0073	8.6	244	11.3		355.818	332,373,903	2,140,383	321,057
R0074	8.1	105	11.2		172.505	151,769,887	380,109	57,016
R0075	7.2	94	10.8		314.139	245,671,532	5,266	790
R0076	7.2	92	10.8		330.897	258,776,992	5,546	832
R0077	7.9	81	10.8		44.333	38,041,278	56,247	8,437
R0078	16.5	102	11.5	Yes	111.831	200,421,938	38,252,889	5,737,933
R0079	16.2	115	11.4		123.810	217,857,378	39,901,637	5,985,246
R0080	17.2	150	11.8		166.967	311,932,292	65,054,225	9,758,134
R0081	11.3	138	11.5		293.820	360,627,850	19,871,438	2,980,716

A number of observations can me made on the lakes in this study. As expected for North Slope thermokarst or thaw lakes, most are shallow. The deepest lakes (R0079 – R0080) are not thaw lakes, but oxbow lakes formed in abandoned stream channels. The maximum conductivity in this dataset is 381 µmhos/cm, far below the 4,000 µmhos/cm limit for water that can be used for ice roads. In five of the lakes the depth sounder indicated possible fish in the water column. This does not prove that fish are present in these lakes, or for that matter, that fish are absent from lakes where no indication was noted. The fish indications are only useful to help determine which lakes might merit detailed fish studies. The lake surface areas were derived from a NPR-A GIS database maintained by Phillips Alaska, Inc., and these data were provided by Phillips. Lake volume, lake volume below 7 feet, and usable lake volume were calculated according to the modified cone-model described above. Of the 32 lakes studied in this project, 19 have usable volumes that would allow water withdrawals even if fish were present in the

lakes. According to the BLM stipulations, proponents could apply for greater withdrawals if other studies demonstrate that fish are not present in a given lake.

VI. Conclusions

This study of lakes in the NPR-A has evaluated 32 lakes that might potentially be used for water withdrawals to construct ice roads and ice pads. Field methods included taking measurements from a helicopter on fixed floats that allowed data to be collected rapidly. Lake volume calculations were made using maximum lake depth and lake area according to the cone-method of Moulton and Lobdell. The cone method was modified to provide an estimate of the free-water volume below the ice, in order to comply with the BLM stipulations for exploration activities. Of the 32 lakes studied, 19 have depths great enough to allow some water withdrawal even if fish are present in the lake. Water quality data indicate that all of the 32 lakes studied have salinities low enough for their water to be used in ice road and ice pad construction.

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Appendix 1

Complete Data Tables from Lake Studies in the Phillips Exploration Area, National Petroleum Reserve - Alaska

Lake	Depth (feet)	Conductivity (µmhos/cm)	Conductivity (mS/cm)	Temperature (°C)	Salinity (%)	Fish on Depth Sounder	NAD-27 Latitude dd mm ss.ss	NAD-27 Longitude ddd mm ss.ss	Surface Area (acres)	Surface Area (square ft)	Lake volume Volume (cubic ft)	Lake volume Volume (gallons)	Volume Below 7 Feet (cubic ft)	Volume Below 7 Feet (gallons)	Usable volume 15% of Vol Below 7 feet (gallons)
R0050	3.1						70 06 56.13 N	152 14 03.59 W							
R0050	3.5	264	0.264	10.5	0.01		70 06 56.63 N	152 13 51.19 W	8.7873	382,775	446,571	3,340,581	0	0	0
R0051	6.4						70 07 04.43 N	152 13 59.79 W	8.4053	366,135	781,088	5,842,944	0	0	0
R0051	5.6	215	0.215	10.7	0.00		70 07 04.23 N	152 14 05.29 W							
R0052	8.5					Yes	70 07 06.53 N	152 12 24.89 W							
R0052	9.0						70 07 04.73 N	152 12 30.50 W							
R0052	9.0	381	0.381	11.8	0.01		70 07 09.93 N	152 12 41.19 W							
R0052	9.6						70 07 12.03 N	152 12 14.09 W							
R0052	10.2						70 07 05.93 N	152 12 12.70 W	44.469	1,937,064	6,586,018	49,266,835	203,363	1,521,262	228,189
R0053	8.5					Yes	70 07 20.73 N	152 11 38.49 W	25.995	1,132,339	3,208,294	23,999,701	17,632	131,893	19,784
R0053	8.0	161	0.161	11.7	0.00		70 07 18.73 N	152 11 52.69 W							
R0053	7.0						70 07 30.73 N	152 11 56.29 W							
R0053	7.0						70 07 26.63 N	152 11 40.99 W							
R0054	3.1	240	0.240	10.7	0.00		70 06 10.32 N	152 07 55.02 W	70.354	3,064,643	3,166,797	23,689,288	0	0	0
R0054	2.6						70 06 00.52 N	152 07 47.22 W							
R0055	6.3	158	0.158	11.6	0.00		70 07 21.02 N	152 06 50.60 W	41.808	1,821,153	3,824,422	28,608,661	0	0	0
R0056	6.0	170	0.170	11.4	0.00		70 06 34.62 N	152 03 08.92 W							
R0056	5.7						70 06 30.42 N	152 02 23.42 W							
R0056	5.2						70 06 16.22 N	152 03 37.53 W							
R0056	5.8						70 06 45.42 N	152 03 19.92 W							
R0056	6.6						70 06 45.72 N	152 04 03.42 W	473.83	20,639,980	45,407,955	339,675,071	0	0	0
R0056	5.1						70 06 39.82 N	152 04 14.92 W							
R0057	7.3						70 07 06.02 N	152 03 35.21 W	114.38	4,982,537	12,124,173	90,695,109	841	6,295	944
R0057	6.4						70 07 04.52 N	152 03 58.91 W							
R0057	6.6	166	0.166	11.8	0.00		70 07 11.12 N	152 03 58.51 W							
R0057	3.9						70 07 06.62 N	152 03 05.01 W							
R0057	5.8						70 07 14.12 N	152 03 22.11 W							
R0057	7.0						70 07 13.92 N	152 03 41.81 W							
R0058	6.0						70 07 06.20 N	151 55 47.42 W							
R0058	6.5						70 07 06.30 N	151 56 17.32 W							

Lake	Depth (feet)	Conductivity (µmhos/cm)	Conductivity (mS/cm)	Temperature (°C)	Salinity (%)	Fish on Depth Sounder	NAD-27 Latitude dd mm ss.ss	NAD-27 Longitude ddd mm ss.ss	Surface Area (acres)	Surface Area (square ft)	Lake volume Volume (cubic ft)	Lake volume Volume (gallons)	Volume Below 7 Feet (cubic ft)	Volume Below 7 Feet (gallons)	Usable volume 15% of Vol Below 7 feet (gallons)
R0058	4.7						70 06 52.90 N	151 55 04.63 W							
R0058	6.1						70 06 46.20 N	151 55 46.13 W							
R0058	2.0						70 06 44.81 N	151 56 23.23 W							
R0058	1.8						70 06 26.80 N	151 54 49.04 W							
R0058	6.5	245	0.245	11.5	0.00		70 06 23.10 N	151 55 25.64 W	570.17	24,836,841	53,813,155	402,550,325	0	0	0
R0058	5.0						70 06 17.30 N	151 55 35.54 W							
R0059	5.5						70 08 58.29 N	151 52 08.20 W							
R0059	8.2	46	0.046	11.8	0.00		70 09 03.80 N	151 52 23.29 W	31.244	1,360,972	3,719,990	27,827,456	11,659	87,212	13,082
R0059	7.7						70 09 01.10 N	151 52 48.19 W							
R0059	7.7						70 09 01.80 N	151 52 40.09 W							
R0060	7.6	116	0.116	11.7	0.00		70 08 46.89 N	151 49 48.40 W							
R0060	7.4						70 08 54.99 N	151 49 51.50 W							
R0060	8.2						70 08 39.79 N	151 49 45.90 W	113.85	4,959,477	13,555,905	101,405,205	42,485	317,806	47,671
R0060	7.3						70 08 41.59 N	151 50 06.90 W							
R0060	7.9						70 08 51.89 N	151 49 30.60 W							
R0061	6.7						70 10 14.28 N	151 47 16.08 W							
R0061	7.9						70 10 12.79 N	151 47 40.08 W	540.27	23,534,222	61,973,451	463,593,579	91,633	685,462	102,819
R0061	7.0	142	0.142	11.6	0.00		70 10 04.38 N	151 46 35.48 W							
R0061	7.5						70 09 57.99 N	151 47 17.39 W							
R0061	6.5						70 10 27.38 N	151 46 46.98 W							
R0061	7.6						70 10 35.39 N	151 48 00.97 W							
R0062	3.3						70 10 41.87 N	151 36 44.69 W							
R0062	3.3	225	0.225	11.1	0.00		70 10 43.47 N	151 36 50.08 W							
R0062	3.4						70 10 37.47 N	151 36 47.99 W	48.822	2,126,683	2,410,241	18,029,855	0	0	0
R0063	5.8	142	0.142	11.3	0.00		70 10 26.06 N	151 35 30.39 W	5.7422	250,132	483,589	3,617,499	0	0	0
R0063	5.4						70 10 25.56 N	151 35 33.89 W							
R0063	5.5						70 10 26.96 N	151 35 25.59 W							
R0064	5.9						70 04 43.22 N	152 01 12.56 W							
R0064	6.6						70 04 34.72 N	152 01 44.16 W							
R0064	6.1						70 04 27.42 N	152 02 20.66 W							
R0064	5.2						70 05 10.62 N	152 01 26.95 W							
R0064	7.1	207	0.207	11.9	0.00		70 05 01.22 N	152 02 31.25 W	1159.3	50,498,948	119,514,177	894,028,068	334	2,498	375
R0064	5.8						70 04 55.42 N	152 03 13.05 W							

Lake	Depth (feet)	Conductivity (µmhos/cm)	Conductivity (mS/cm)	Temperature (°C)	Salinity (%)	Fish on Depth Sounder	NAD-27 Latitude dd mm ss.ss	NAD-27 Longitude ddd mm ss.ss	Surface Area (acres)	Surface Area (square ft)	Lake volume Volume (cubic ft)	Lake volume Volume (gallons)	Volume Below 7 Feet (cubic ft)	Volume Below 7 Feet (gallons)	Usable volume 15% of Vol Below 7 feet (gallons)
R0064	6.0						70 05 40.32 N	152 02 23.44 W							
R0064	6.5					Yes	70 05 34.62 N	152 03 12.94 W							
R0064	5.8						70 05 32.12 N	152 03 45.84 W							
R0065	5.6						70 09 41.79 N	151 52 21.18 W							
R0065	6.5						70 09 33.59 N	151 52 04.69 W	300.4	13,085,534	28,351,990	212,087,596	0	0	0
R0065	4.6						70 09 28.00 N	151 52 39.39 W							
R0065	5.8						70 09 50.99 N	151 52 03.78 W							
R0065	6.2	112	0.112	11.4	0.00		70 09 46.10 N	151 53 08.18 W							
R0066	8.9						70 08 47.28 N	151 45 36.51 W							
R0066	7.1						70 08 42.58 N	151 44 44.21 W							
R0066	10.0	94	0.094	11.8	0.00		70 08 34.18 N	151 45 10.11 W	232.51	10,128,034	33,760,112	252,543,160	911,523	6,818,665	1,022,800
R0066	9.1						70 08 35.58 N	151 45 38.01 W							
R0066	9.4						70 08 57.18 N	151 45 57.60 W							
R0066	8.0						70 08 42.79 N	151 45 59.61 W							
R0066	7.8						70 08 58.98 N	151 45 22.90 W							
R0066	8.8						70 08 40.98 N	151 45 24.31 W							
R0067	7.4	162	0.162	11.6	0.00		70 08 34.39 N	151 47 10.91 W	78.387	3,414,556	8,422,572	63,005,210	1,330	9,951	1,493
R0067	7.2						70 08 28.89 N	151 47 29.01 W							
R0067	7.2						70 08 39.79 N	151 47 01.21 W							
R0068	4.0	180	0.180	10.7	0.00		70 11 17.18 N	151 48 04.56 W	62.893	2,739,619	3,652,825	27,325,030	0	0	0
R0069	8.8	169	0.169	11.7	0.00	Yes	70 11 11.99 N	151 49 20.66 W							
R0069	6.8						70 11 06.09 N	151 49 41.66 W							
R0069	6.1						70 11 16.59 N	151 49 49.76 W							
R0069	9.2						70 11 19.19 N	151 49 11.56 W	112.41	4,896,715	15,016,594	112,331,916	205,341	1,536,058	230,409
R0069	7.2						70 11 09.29 N	151 48 56.86 W							
R0070	3.6	193	0.193	10.6	0.00		70 11 16.36 N	151 34 06.88 W	114.08	4,969,345	5,963,214	44,607,933	0	0	0
R0071	2.7	89	0.089	10.2	0.00		70 13 30.07 N	151 38 54.14 W	90.271	3,932,226	3,539,003	26,473,582	0	0	0
R0072	4.0	193	0.193	10.5	0.00		70 15 57.66 N	151 37 59.30 W	108.34	4,719,112	6,292,149	47,068,543	0	0	0
R0073	8.6	244	0.244	11.3	0.00		70 13 27.60 N	151 59 11.61 W	355.82	15,499,511	44,431,931	332,373,903	286,128	2,140,383	321,057
R0073	8.3						70 13 23.00 N	151 59 34.91 W							

Lake	Depth (feet)	Conductivity (µmhos/cm)	Conductivity (mS/cm)	Temperature (°C)	Salinity (%)	Fish on Depth Sounder	NAD-27 Latitude dd mm ss.ss	NAD-27 Longitude ddd mm ss.ss	Surface Area (acres)	Surface Area (square ft)	Lake volume Volume (cubic ft)	Lake volume Volume (gallons)	Volume Below 7 Feet (cubic ft)	Volume Below 7 Feet (gallons)	Usable volume 15% of Vol Below 7 feet (gallons)
R0073	2.9						70 13 21.70 N	151 58 31.61 W							
R0073	8.2						70 13 17.20 N	151 58 49.81 W							
R0073	7.6						70 13 12.60 N	151 59 11.71 W							
R0073	8.3						70 13 32.20 N	151 58 54.41 W							
R0073	7.8						70 13 47.10 N	151 59 38.20 W							
R0073	8.6						70 13 44.00 N	151 59 52.90 W							
R0073	2.3						70 13 40.30 N	152 00 20.20 W							
R0074	8.0						70 13 33.50 N	152 01 42.10 W							
R0074	6.6	105	0.105	11.2	0.00		70 13 27.51 N	152 02 19.30 W							
R0074	5.5						70 13 36.70 N	152 01 13.80 W							
R0074	8.1						70 13 41.70 N	152 01 34.10 W	172.5	7,514,327	20,288,684	151,769,887	50,813	380,109	57,016
R0074	6.5						70 13 30.80 N	152 01 17.70 W							
R0075	6.9						70 18 14.67 N	151 47 10.05 W							
R0075	7.2	94	0.094	10.8	0.00		70 18 25.87 N	151 47 27.24 W	314.14	13,683,962	32,841,509	245,671,532	704	5,266	790
R0075	6.2						70 18 00.07 N	151 47 02.45 W							
R0075	5.4						70 18 24.07 N	151 46 57.54 W							
R0075	6.0						70 17 39.87 N	151 47 04.76 W							
R0076	7.2	92	0.092	10.8	0.00		70 17 42.78 N	151 49 45.05 W	330.9	14,413,939	34,593,454	258,776,992	741	5,546	832
R0076	6.5						70 17 55.58 N	151 49 33.85 W							
R0076	3.3						70 17 50.38 N	151 50 23.05 W							
R0076	5.3						70 17 26.88 N	151 49 17.35 W							
R0076	6.8						70 17 23.78 N	151 49 46.05 W							
R0077	7.4	81	0.081	10.8	0.00		70 16 54.17 N	151 47 39.37 W							
R0077	7.9						70 16 49.97 N	151 47 35.67 W	44.333	1,931,157	5,085,379	38,041,278	7,519	56,247	8,437
R0078	15.2						70 16 02.17 N	151 45 21.79 W							
R0078	16.5	102	0.102	11.5	0.00		70 16 10.37 N	151 46 01.58 W	111.83	4,871,367	26,792,518	200,421,938	5,113,668	38,252,889	5,737,933
R0078	13.7					Yes	70 15 52.27 N	151 45 58.19 W							
R0078	13.0						70 16 02.47 N	151 46 05.38 W							
R0078	14.0						70 16 12.77 N	151 46 40.38 W							
R0078	10.6						70 16 19.27 N	151 47 09.68 W							
R0079	12.4						70 15 47.07 N	151 43 29.49 W							
R0079	11.9						70 16 11.07 N	151 44 47.98 W							
R0079	11.4	115	0.115	11.4	0.00		70 16 25.57 N	151 44 52.18 W							

Lake	Depth (feet)	Conductivity (µmhos/cm)	Conductivity (mS/cm)	Temperature (°C)	Salinity (%)	Fish on Depth Sounder	NAD-27 Latitude dd mm ss.ss	NAD-27 Longitude ddd mm ss.ss	Surface Area (acres)	Surface Area (square ft)	Lake volume Volume (cubic ft)	Lake volume Volume (gallons)	Volume Below 7 Feet (cubic ft)	Volume Below 7 Feet (gallons)	Usable volume 15% of Vol Below 7 feet (gallons)
R0079	16.2						70 16 21.77 N	151 43 41.98 W	123.81	5,393,203	29,123,297	217,857,378	5,334,073	39,901,637	5,985,246
R0079	15.2						70 16 08.77 N	151 43 14.19 W							
R0080	17.2						70 16 10.36 N	151 39 27.39 W	166.97	7,273,131	41,699,285	311,932,292	8,696,486	65,054,225	9,758,134
R0080	9.7	150	0.150	11.8	0.00		70 15 47.66 N	151 39 15.80 W							
R0080	10.4						70 15 42.26 N	151 40 01.10 W							
R0080	16.6						70 15 50.46 N	151 40 16.49 W							
R0080	14.0						70 15 59.86 N	151 39 58.69 W							
R0080	15.0						70 15 59.56 N	151 39 16.09 W							
R0081	11.0	138	0.138	11.5	0.00		70 17 29.65 N	151 31 25.98 W							
R0081	8.6						70 17 25.15 N	151 32 11.38 W							
R0081	8.5						70 17 32.54 N	151 30 55.57 W							
R0081	9.5						70 17 37.15 N	151 31 33.67 W							
R0081	11.3						70 17 21.25 N	151 31 21.68 W	293.82	12,798,832	48,208,934	360,627,850	2,656,425	19,871,438	2,980,716