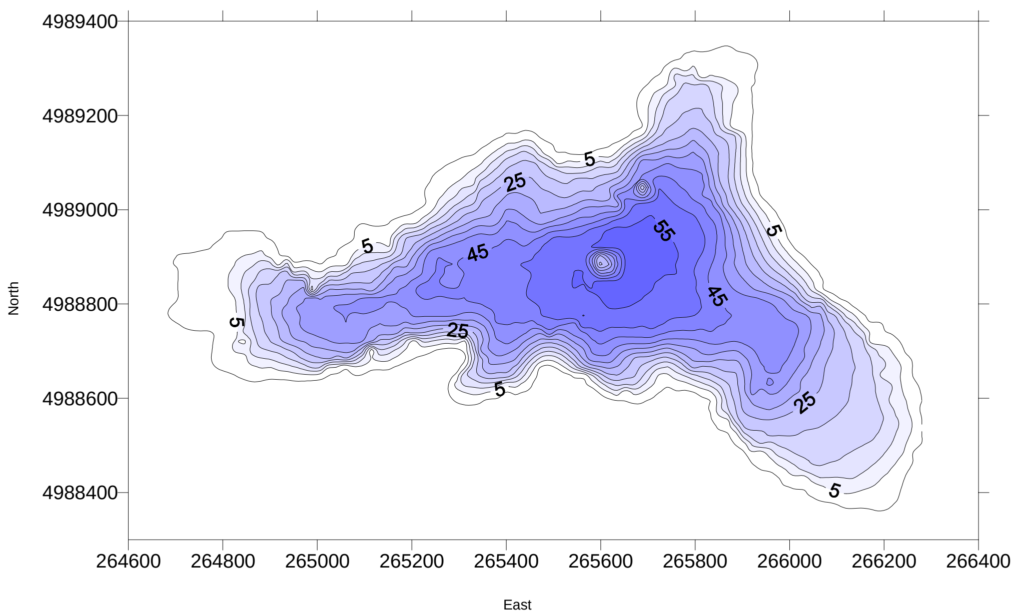
FISHERY RESEARCH

JOB PERFORMANCE REPORT

Grant F-73-R-22



Project 5—Hydroacoustic Studies

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September 2000

Job Performance Report

July 1, 1999 to June 30, 2000

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By

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Table of Contents

List of Figures

JOB PERFORMANCE REPORT
SUBPROJECT #1: HYDROACOUSTIC STUDIES

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ABSTRACT

In 1999, a new statewide hydroacoustics project was initiated. Accomplishments during the first year included the completion of a written proposal, pricing and purchasing a scientific grade sonar system, and completing a sonar survey on Williams Lake. The first section of this report summarizes the written proposal. The second section describes preliminary results from the Williams Lake survey.

Initial project goals for the hydroacoustics project include: 1) providing a method for rapid assessment of trout populations; 2) developing stocking guidelines for trophy trout waters, estimating over-winter survival of hatchery rainbow trout; 3) improving population monitoring for kokanee, perch, bass, etc.; 4) estimating densities of non-game species that may compete with trout; 5) estimating entrainment loss of trout during reservoir drawdown or spring spill; and 6) providing depth contour and lake volume estimates.

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PROJECT PROPOSAL

This proposal contains three sections. The first section reviews common applications of sonar in fisheries science. The second section is a list of proposed research projects. The last section describes equipment characteristics and estimated costs.

Applications of Sonar in Fisheries Management

Sonar applications in fisheries science are diverse. Estimating the abundance of salmon is one of the most common uses (Beauchamp et al. 1997; Burczynski and Johnson 1986; Thorne 1979; Thorne and Dawson 1974; Thorne 1971). Other applications include describing the initial survival and spatial distribution of introduced species (Teuscher 1997), locating lake trout spawning beds (Edsall et al. 1992), estimating forage fish abundance (Burczynski et al. 1987), monitoring adult fish movement in rivers (Banneheka et al. 1995), and estimating entrainment loss at hydroelectric facilities (Maiolie and Elam 1996).

In addition to estimating fish abundance, scientific sonar can be used to monitor fish behavior. Examples include describing fish distribution and schooling behavior under varying moon phases (Luecke and Wurtsbaugh 1993), observing avoidance behavior of kokanee to strobe lights (Maiolie and Elam, in progress), and monitoring fish response to hypolimnetic oxygenation (Aku et al. 1997). Less frequently cited but useful applications include mapping benthic habitat (Edsall et al. 1992), estimating lake volume, and generating bathymetric or depth contour maps.

The application with the greatest potential to benefit fisheries management in Idaho is the recent development of horizontal or sidelooking sonar. Sidelooking methods were developed to monitor fish in shallow waters. To date, sidelooking sonar has been used to monitor brown trout (Kubecka et al. 1994; Kubecka et al. 1992), cutthroat trout (McClain and Thorne 1991), and rainbow trout (Yule 1999; Johnston 1981). Johnston (1981) used sidelooking sonar to estimate rainbow trout abundance in five shallow lakes in Washington. The effort was unique in that the lakes were rotenoned and stocked with rainbow trout prior to completing the survey. In three of the five lakes, survey estimates were within 7% of the stocked number. In Wyoming, sidelooking sonar was compared to purse seine estimate of fish abundance. Yule (2000) reported a significant correlation (r^2=0.89, df=11, $P<0.001$, slope=0.987) between seine and hydroacoustics abundance of rainbow trout in 11 Wyoming waters. Additionally, hydroacoustic estimates of fish size were within 50 mm of the mean sizes of fish caught in purse seines (Yule 2000). The above techniques could be used to substantially increase the amount of information collected on lentic populations of rainbow and cutthroat trout in Idaho.

The proposed sonar systems will have fast multiplexing capabilities. Fast multiplexing allows simultaneous data collection for deep and shallow fish. In lakes like Anderson Ranch and Palisades, kokanee and surface oriented species can be obtained with one survey.

In addition to the fisheries data, lake volume estimates can be made. That application can be used to determine the amount of chemicals required for rotenone projects on small impoundments. The proposed sonar system includes a GPS system that makes accurate mapping possible. Some of the newer models can also quantify bottom substrate while completing standard fish surveys (i.e., BioSonics Bottom Classification Software). These data could replace traditional dredge or visual methods of substrate classification. Similar to fish surveys, the amount of substrate data collected by sonar is generally an order of magnitude greater than traditional sampling techniques.

Limitations

There are several limitations of hydroacoustic sampling. A major limitation of current sonar technology is species identification. Sampling with gillnets, seines, or trawls is often necessary to partition fish targets. Netting requirements depend on the complexity of the fish community and the questions being asked. In complex fisheries, several nights of vertical and horizontal gillnets may be needed. Conversely, many of Idaho's trophy trout waters have relatively few species and could be surveyed with little or no species partitioning (i.e., Williams Lake). Other limitations include high initial investment and poor sampling capability near the bottom. In general, one meter from the substrate can not be sampled efficiently with sonar and is excluded from analysis. The complexity of sonar gear and processing software can also be considered a disadvantage. Familiarity is growing but there are still relatively few biologists trained in hydroacoustic techniques.

Proposed 5 Year Research Projects

Hydroacoustics can be used as a lake and reservoir monitoring tool and to help answer statewide fisheries questions. Examples of both types of work are identified below. The following list was generated to provide more detail on the type of projects that can be addressed. Items on the list, however, may or may not be pursued depending on management priorities. Some of the projects were briefly discussed during a 1999 research prioritization meeting for DJ-funded projects.

Hatchery Trout Evaluations

Since 1992, major objectives of hatchery trout research included comparing the relative return of fingerling and catchable-size rainbow trout in flatwater fisheries and identifying limnological parameters that explain variation in performance. Creel surveys were used to address those questions. While very useful data were collected, varying water conditions and small sample sizes limited the conclusions. Evaluating the performance of catchable and fingerling rainbow trout could be addressed with less effort using hydroacoustics, and the sampling power would be increased by an order of magnitude (Thorne 1983).

The project goals would be to maximize the effectiveness of trout stocking programs in Idaho's lake and reservoir fisheries. One of the major objectives of the project would be to describe general characteristics of successful fingerling rainbow trout stocking programs. Most of the methods of this project are described in Dillon and Alexander (1995 and 1996). However, hydroacoustic estimates of fish survival would replace creel surveys, and less emphasis would be placed on comparing catchable to fingerling plants. The sonar work would focus on relating successful stocking events to physical and chemical parameters (e.g., flushing rate, zooplankton, stocking densities, abundance of large predators, etc). The sample size for a given year would increase from two or three creel surveys to a minimum of 10 sonar surveys.

Entrainment Loss

Entrainment loss of rainbow trout was discussed at the 1999 research prioritization meeting. Similar to work being done for kokanee, entrainment loss can be indirectly evaluated by collecting population data pre- and post-high water periods. Sonar technology is ideally suited for the fish abundance data required. In addition to entrainment of rainbow trout, impacts to other game species could be assessed.

Trophy Trout Management

The project goal would be to identify factors that are most important for establishing a successful trophy trout fishery. The major objective of this work would be to describe the general characteristics of a successful trophy trout fishery and provide examples of densities and biomass estimates for comparison among waters.

In 1995, hatchery trout research began trophy trout evaluations on Daniels Reservoir. The goal of the project was to estimate carryover survival of fingerling plants. To estimate survival, population estimates were made using a purse seine. Unfortunately, small sample size precluded survival estimates for most of the fingerling plants. The other disadvantage of the work was the amount of time (two weeks) required collecting the mark-recapture data. With sonar, total trout abundance partitioned by cohorts could be generated in about four hours of survey time.

General methods would include collecting population and survival data on 10 to 12 trophy trout waters. Survival and growth estimates would be compared to forage abundance, stocking densities, the proportion or biomass made up of nongame species, water residence time, and possibly substrate parameters.

Evaluating Competition Between Nongame Fish and Trout

Competition with nongame fish can be one of the factors that limit growth and survival of hatchery rainbow trout. Despite that common assertion, very little is known regarding the density or biomass of nongame fish that negatively impact trout populations. Side-scanning sonar can be used to estimate densities of nongame species and correlate them with forage abundance, trout growth, and trout survival. The objective of this research would be to better describe the relationships between nongame fish abundance and the performance of trout fisheries.

General Monitoring Projects

General monitoring projects include: 1) estimating year class strength for perch, bass, walleye, etc., 2) monitoring kokanee populations, 3) estimating the abundance of forage fish, 4) making bathymetric maps, 5) estimating lake volume, 6) and possibly quantifying bottom substrate.

<u>Equipment Costs and Description</u>

Three vendors sell the kind of sonar system that could be most applicable for use in Idaho. BioSonics and Hydroacoustics Technology Inc. submitted bids. Purchase costs were estimated at about $47,000. That is a significant amount of money, but when compared to the volume of data collected, acoustic surveys are cost effective. For example, creel surveys are commonly used to evaluate stocking programs (Dillon and Alexander 1996 and 1995; Yule 1999 in press). Estimated cost for creel surveys vary. The estimated cost for a creel survey of Lake DeSmet in Wyoming was $14,000 (Yule 1999 in press). Lake DeSmet is relatively large and may overestimate the cost of an average impoundment in Idaho. For comparison purposes, a conservative value for the cost of a six-month creel survey would be $7,000. In its first year, approximately 15 sonar surveys could be completed. With personnel and the purchase price of $47,000 included, a sonar survey would cost roughly $4,500. Moreover, if the purchase price was spread over a five-year period, the cost of a sonar survey would drop to about $2,000. Purchasing a portable split beam sonar system would significantly increase our knowledge of fish communities and could prove to be one of the most valuable tools available to fish managers in Idaho.

Hydroacoustics equipment is rapidly becoming a standard management tool. A few of the regional agencies using hydroacoustics for evaluating fisheries include: Alaska Department of Fish and Game, Utah Department of Natural Resources, Washington Department of Fish and Wildlife, Montana Fish Wildlife and Parks, Colorado Division of Wildlife, Shoshone-Bannock Tribes, Wyoming Department of Game and Fish, US Army Corps of Engineers, and the US Fish and Wildlife Services.

SONAR SURVEYS OF WILLIAMS LAKE

Methods

In March 2000, a Model 241-2 split-beam digital echo sounder was purchased from Hydroacoustic Technology, Inc. The 200 kHz sounder was equipped with fast multiplexing capability. Fast multiplexing was used to estimate fish densities near the surface (sidelooking transducer) and at depth (downlooking transducer). A 15° transducer was used for downlooking, and a 6° transducer surveyed fish between 8 m and the surface. Both transducers were suspended from the side of a boat using a retractable pole mount. Boat speed during data collection ranged from 1 to 1.5 m/s.

Sounder settings and analysis methods are described in Yule (2000). A transmit pulse width of 0.2 ms was used for both transducers. Sampling rate was 6.7 pings per second. The sampling rate was divided equally between the two transducers (3.35 pings per second for each transducer). Fish tracking criteria were set using a minimum of three returning echoes that were closely (0.2m) associated in three-dimensional space.

Tracked fish were converted to fish densities using a range weighting technique. Yule (2000) describes the method in detail. The method weights each tracked fish back to a 1 m swath at the surface. The method accounts for expanding sample volume with increasing range using the following equation:

$$F_w = 1/(2 \times R \times \tan(7.5^\circ \text{ or } 3^\circ))$$

where F_w equals weighted fish, R equals range, and 7.5° or 3° equals ½ the nominal transducer beam width. A fish tracked at a range of 9.5 m with the 6° transducer equals one weighted fish. At a range of 20 m, the weighted fish value drops to 0.48. To obtain estimates of fish/m^2, weighted fish values were summed for each transect and divided by transect length. Double counting was avoided by removing fish from the downlooking transducer file that were in the top 8 m of the water column.

To determine the best time of day to survey trout densities in Williams Lake, day and night surveys were completed. Each survey consisted of 11 transects (Figure 1). The night survey was completed between 2200 and 2400 hr on June 20, 2000. The day survey was completed on June 21, 2000 between 1000 and 1300 hr. To build a bathymetric map of Williams Lake, depth and associated GPS coordinates were saved to a computer file at one-second intervals. *Surfer* version #7 software was used to plot depth contours. Target strength data (dB) were converted to fish lengths using Love (1977) for dorsal-aspect and Kubecka and Dunken (1998) for side-aspect.

Results

Total fish population estimates were markedly different between day and night surveys (Figure 2). During the day, fish densities ranged from 0.00 to 0.03 fish/m^2. The total day population estimate was 6,845 (94 fish/ha). At night, fish densities ranged from 0.00 to 0.01 fish/m^2. The night population estimate was 1,197 (16 fish/ha).

Fish were concentrated in the top 10 m of the water column. At night, 74% of all tracked fish were above 10 m. During the day, the selection was even stronger with 98% of the fish occurring at depths shallower than 10 m. Mean size of fish tracked was 406 mm (16 in) during the day and 234 mm (9.2 in) at night. The reduction in mean size at night was attributed to a sharp decline (87%) in the number of large (>200 mm) fish tracked near the surface and a corresponding increase (77%) in the number of small deep targets. Figure 3 show depth contours in Williams Lake.

RECOMMENDATION

1. The preliminary tests of the hydroacoustic equipment were successful and we recommend that the project continue for the remainder of the five-year research prioritization period. The prioritization period ends in 2004.

ACKNOWLEDGEMENTS

The Bureau of Reclamation provided funds for purchase of the sonar equipment.

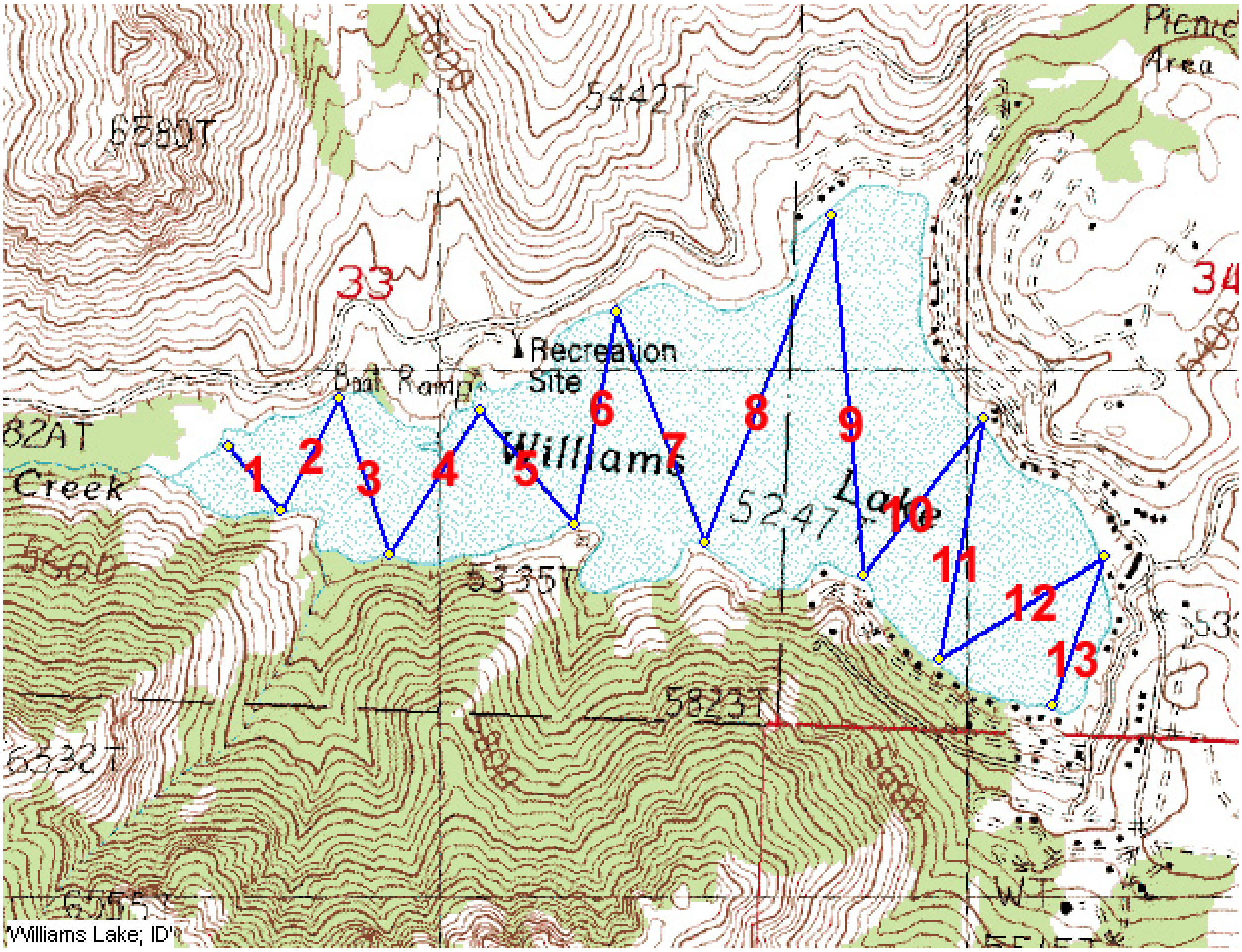

Figure 1. Map of Williams Lake showing hydroacoustic transects. Due to very shallow water (<1 m), transects 1 and 13 were not sampled.

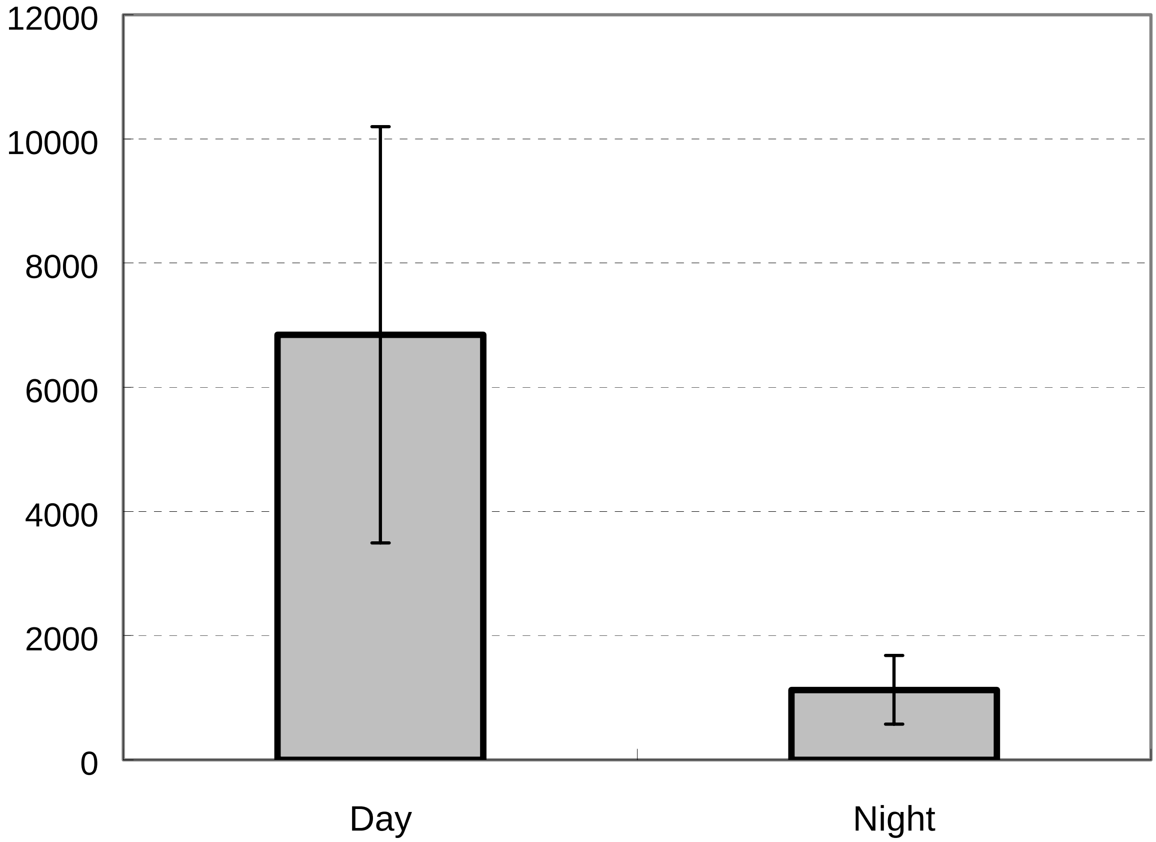

Figure 2. Total fish population estimates for Williams Lake.

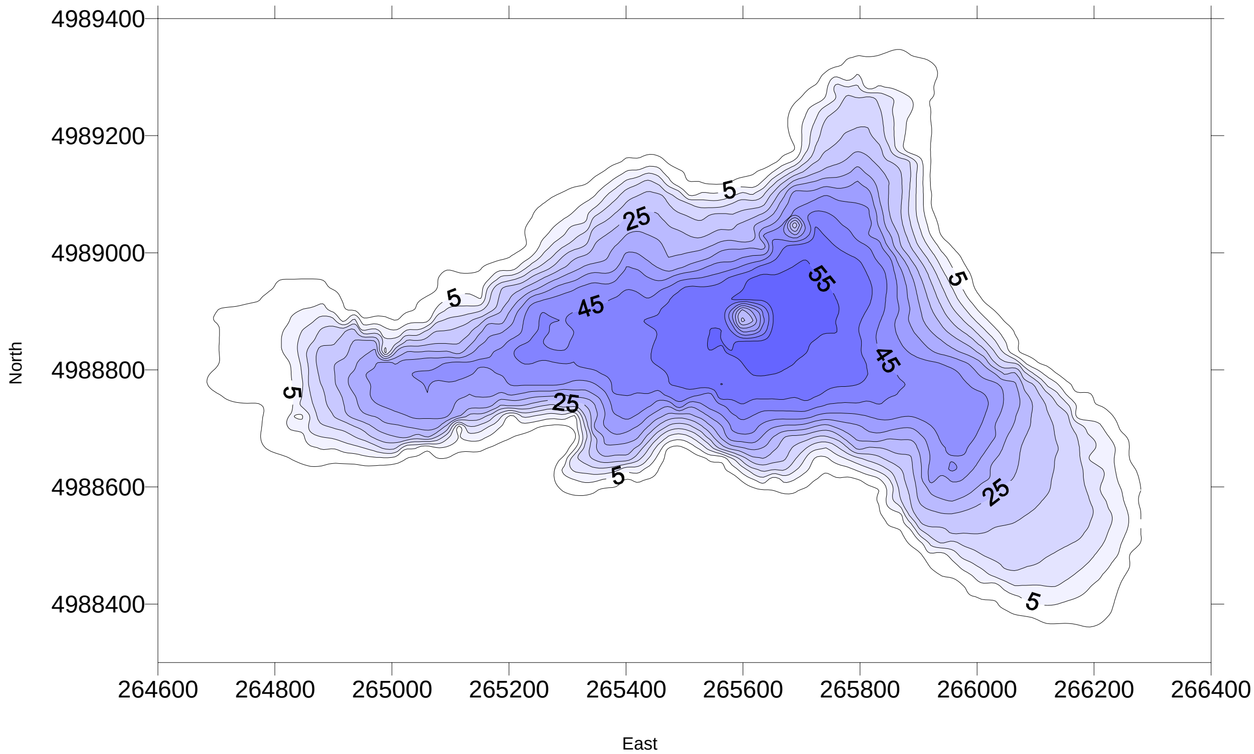

Figure 3. Bathymetric map of Williams Lake. Y and X axis values are UTM coordinates from zone 12.

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