WILLISTON LAKE

DEBRIS STUDY, 1977

ENGINEERING DIVISION

B. C. FOREST SERVICE

DATE: March, 1978

FILE: 0255533

BY: E. Kvarv

NOTED: K. W. Rieche

ACKNOWLEDGEMENT

The sampling method employed for this study was worked out and defined in detail in co-operation with the following individuals who acted in the role of consultants:

Mr. M. Kovats, Research Division,
B.C. Forest Service.

Dr. G. Bailey, Valuation Division,
B. C. Forest Service.

Dr. J. Lee, Canadian Forestry Service,
Pacific Forest Research Centre.

Mr. Kovats also provided most of the expertise with the final statistical treatment of the data.

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INTRODUCTION

On March 4, 1977, the Construction Section of the Engineering Division requested an update of information regarding debris volume on Williston Lake. The request resulted from the need to plan both short-range and long-range cleanup operations on the lake which, for the purposes of this study, include the Parsnip and the Finlay Reach but not the Peace Reach.

Due to the complexities of the project, technical information and participation of the Canadian Forestry Service, the Air Survey Division and the Inventory Division, were requested with emphasis on orbital satellites, high-level flying and low-level flying, respectively.

The request that acted as the basis for this study required only volume information. The breakdown of this figure into salvageable and non-salvageable components was avoided because of the impermanency of these components. Due to the local chip market economy, the need for salvage material depends totally upon uncontrollable factors such as domestic and foreign chip markets. If these markets turn more favorable in the future, then a quick "on the spot" inventory of salvageable material can readily be made to form the basis for the next few years' plans for utilizing salvageable material on the lake.

SUMMARY

The field work of the Williston Lake Debris Study, 1977, was carried out between July 16th and July 20th (1977). At which time the lake was filled to near capacity, ~~and the debris was sampled through the use of photo sampling,~~ with the help of a "Jet Ranger" helicopter with high skid gear, a boom for fixed-base stereo photography and two Hasselblad cameras.

The debris was divided into three strata, each of which was sampled separately. The shoreline debris, comprising 5,198,886 m^3 over 4,356 ha, with an average volume per ha of 1,193.5 m^3, six concentrated "plugs" of lake debris totalling 2,354,831 m^3, which covered 2,140 ha with an average volume per ha of 1,100.4 m^3, and three loosely defined strips of debris in the middle of the lake containing 85,488 m^3, spread over 474 ha. The last two strata were located in the northern part of Williston Lake, from Ospika Arm northward.

~~The sampling method used for~~ In this study ~~was~~ a systematic sampling method with a randomly selected starting point and an assumed random location of the debris within the strata.

Summary Cont.

The shoreline was flown lengthwise with a sample taken every 37 seconds. The plugs were crisscrossed with a sampling interval of 10-15 seconds, whereas the lake strips were covered lengthwise using the same time intervals. A combination of large scale stereo photography and line intercept sampling technique was used for estimation of debris volume. The stereophotos obtained from all three strata were enlarged and transect lines were laid out on the middle portion of a random selection of the frames. The volume per lineal unit figure that was used was obtained by modifying the 1973 study figure by the 60,000 cu. of debris that was salvaged in 1973 and 1974. The 1977 figure for volume per lineal unit used was .0665 m^3/m.

Volume per ha figures was obtained using the metric transect line formula:

$$V = \frac{10{,}000\ n\ a}{lc\quad B}$$

where: n = number of logs crossed by the transect line
a = volume per lineal unit
lc = log orientation factor
B = length of transect line-in meters
V = volume in m^3 per ha.

The total volume figure for buckskinned debris obtained from this study with within the estimated confidence limits is: 95%

$$7{,}639{,}205 \pm 1{,}382{,}766\ m^3$$

i.e. ± 18.1%

1.0 STUDY OBJECTIVE

The objective of this study was threefold:

(1) To determine the total volume of the remaining floating and floatable debris (e.g. total volume of buckskinned logs) as accurately as possible within realistic limits.

(2) To develop a sampling method that had to be tailored to this lake and this debris pattern in particular, but from which can be drawn useful inferances for sampling debris in other pondages.

(3) It was decided to try to correlate information obtained from low-level flying with helicopter, high-level flying with fixed-wing aircraft and one of the regular passes of our orbital satellites, LANDSAT I or II. The aim was to investigate the possibility of obtaining final volume figures of floating debris directly from satellite images, on a regular basis. (LANDSAT I and II are earth resources satellites launched by NASA in 1972 and 1975, respectively.)

2.0 DEVELOPMENTS

When the basic study outline and the proposed budget for the study had been accepted, a field trip was made to Williston Lake. It revealed that at the time, three distinctly different patterns of debris accumulation existed on the pondage:

(a) Shoreline debris was covering most of the shoreline around the lake.

(b) Large accumulations of logs, e.g. plugs, has formed in bays and arms. They were restricted to the northern part of the lake from Ospika Arm northward.

(c) Loosely defined formations of low debris density were floating in the middle of the lake.

All of these debris formations (but in particular the latter two) were known to change drastically, given the right amount of water in the lake and the right wind direction and strength. This had to be kept clearly in mind because then it became imperative to concentrate the photo sampling over as short a time period as possible. should this be quicker?

It was learned on the field trip, that the lake would be flooded to its full capacity of 2,205' ASL. This is 12 feet above the expected high water level and led to changes in the study outline. Firstly all the debris would be afloat and hence the photo sampling plan should be carried out accordingly, since there would not be debris piled up several layers deep on the lakeshore. Secondly, no ground survey would be possible for a volume per lineal unit determination.

3.0 STUDY PROPOSALS

Upon completion of the field trip, four alternate proposals were made, the first of which was accepted. These proposals were as follows:

(1) The photosampling of the debris should be carried out when the lake is filled to capacity. All the debris will be water-borne and wind action would loosen up and spread out the heavily packed "plugs", so that all the floating logs would come to the surface and be visible from the air.

(2) The whole study should be postponed until the fall of the same year when the water level would be down to agreeable levels for ground survey. This would deter the photosampling both from the point of view of weather and availability of air crews and ground crews.

3.0 (3) The whole study should be postponed until next spring before the water level would start to rise. This would necessitate renegotiations with both the Air Survey Division and the Canadian Forestry Service. The cooperation from both of these groups was vital to the completion of all facets of the study.

(4) The idea that we had to go to an all-out sampling of the total debris volume in order to get a reliable volume figure, should be abandoned. A debris volume figure was obtained during a 1973 study and we could utilize these debris volume figures together with figures for debris disposed of and salvaged between 1973 and the present to arrive at a satisfactory result for debris volume - 1977. If the methods used to obtain the figures for disposed debris were not considered satisfactory, time and effort could be devoted to improvement upon these methods.

4.0 PLANNING OF STUDY

It was decided to follow the first alternative and preparation was made for rental of a "Jet Ranger" helicopter with high skid gear to carry a 7 m long boom for fixed-base 70 mm photography, provided by the Inventory Division.

Photosampling of floating debris, without ground access, does not yield a volume per lineal unit figure, unless we have the opportunity to have the film diapositives from the photosampling set up in a Wild A-40 autograph to obtain log size measurements. This stereo photogrammetric equipment, however, is owned and operated by the section of Photogrammetry, Ministry of the Environment, and no personnel were available to operate the equipment for this study.

It was therefore decided to use the volume per lineal unit figure obtained in the course of the previous debris study on the lake in 1973, when a ground survey was undertaken with a debris pattern and water level quite different from that which existed during this study. 2.7% of the debris had been salvaged in the intervening years, or approximately 60,000 cunits. This volume had been extracted from debris that measured 12" and higher in diameter. Using the volume versus diameter graph from the report of the 1973 study, a ratio was established between the sum of the squares of the midpoint of the diameter classes weighted by the respective volumes per diameter classes, 1973 volume and 1973 volume minus 60,000 cunits. This ratio is equal to the ratio between the new and the old volume per lineal unit, and equals .96 which would give a 1977 volume per lineal unit of .0665 m^3/m.

4.0 Cont.

The last salvage operation took place in 1974. Since then land and water-based debris disposal operations have removed debris of all sizes, leaving the volume per lineal unit intact. The dates for the sampling were dependant upon the pass time of the satellites and will be commented upon in the discussion of the sampling methods.

5.0 STUDY ORGANIZATION

In order to achieve our objectives, a three-step approach was contemplated:

(1) A low-level photosampling with helicopter employing fixed-base photography for determining the debris volume.

(2) In conjunction with Step #1, high-level flying was required to determine the acreage of the large "plugs" of debris in the northern part of Williston Lake.

(3) Step #1 and #2 had to be correlated with the concurrent passing of LANDSAT I or II, in order to obtain a satellite image of the area. The passing time must be on a relatively clear day.

Step #1 was organized and carried out according to plan. Because of a fairly unpredictable period of weather up until the scheduled flights, it was decided to go ahead with the low-level sampling on the pre-determined days, i.e. July 17-18, although it was fairly apparent that it was too overcast to be able to expect a good satellite image those days. A later check with Integrated Satellite Information Services Ltd. (ISIS) in Prince Albert, Saskatchewan, confirmed that the cloud cover on the days of low-level sampling was 100%. It was decided, nevertheless, to go ahead with the low-level flying step of the project and thereby rule out the possibility of finding a correlation between this facet and the other two facets of the study, for this time anyway. The reasons were as follows:

(a) At the planning stage the interest was concentrated on the operational part of the inventory and a strong concern was that with the unpredicatable weather pattern in the area, later dates of LANDSAT passes may prove totally unflyable, and that not even the volume sampling would be made possible.

(b) The helicopter boom was for our disposal for less than three weeks only, and the next LANDSAT pass would be on August 4th.

(c) The helicopter with high skid gear that we had booked ahead had come from Hinton, Alberta, for this particular job and would be going back once our project was completed. There was an unstated obligation on our part to use it at that pre-determined date.

5.0 Cont.

After having missed the "rendezvous" with both the satallite and the high-level flying, we were now concerned that we should be able to correlate the high-level flying for area determination with a LANDSAT pass when the weather was acceptable. It was regretable that the Air Survey Division was not able to coordinate their efforts to accomplish this and therefore no opportunity was provided this year for an examination of the potential use of satellite information for pondage investigations.

6.0 DEBRIS CHARACTERISTICS

The debris accumulations along the shoreline as well as that contained in the previously described "plugs" were of two varieties. The overall majority of the volume was made up by the buckskinned variety, which had its name derived from the fact that water and wind action had rendered the logs virtually limbless and barkless. This variety also covered, by far, most of the areas of debris concentration.

It was this type of debris that had experienced volume and locational changes since the last study was undertaken in 1973. A change in the total volume figures would be affected by the combined effects of salvage, sinkage and debris disposal, as well as the addition of new debris from river, shoreline slumps, etc.

The other variety of debris along the shoreline is the downed and drowned variety which still retains most of its limbs and bark.

As this debris is located between the buckskinned logs and the standing forest, in very shallow water, neither debris disposal crews operating on the lake nor wind or water action have created any significant change in its status and therefore its volume and location remain practically the same.

Due to the limited volume of the second variety as well as its static condition, it was decided that this debris study should concentrate on the buckskinned variety of debris.

7.0 SAMPLING METHOD

Debris had accumulated all along the shoreline of the lake. Although the concentration of debris as well as the width of the debris strip varied, a nearly continuous strip has formed which it was our task to sample.

Some interruptions of this continuous strip were identified and excluded from the total length of the shoreline. Sheltered bays were found to contain downed and drowned debris to some extent, but very little of the buckskinned variety had found its way into these well protected areas.

The industrial section of the District of Mackenzie is located along the lakeshore on the east side of the lake. A minimal amount of debris locates along this section of the shoreline. It is associated with industrial log booms and, due to potential sampling difficulties, this section was excluded from the study.

At the time of the study, the debris had formed large "plugs" in six locations around the northern half of the lake. These accumulations along the shoreline had exceeded what could be defined as shoreline debris and had to be mapped and sampled using a method that was a modified version of the shoreline debris sampling method. The length of the shoreline covered by these extensive accumulations was excluded from the total length of shoreline for the purpose of the shoreline photosampling.

Also, at this time, some of these "plugs" had loosened up and, in part, had started to drift into the middle of the lake, forming more or less continuous patterns of debris there. Three such patterns were identified and sampled during the course of the study.

7.1 Shoreline Sampling

The basic method used in this photosampling was a systematic sampling procedure, where we assumed random location of the debris and ~~where we~~ used a random starting point for the sampling.

Previous studies of a similar nature, together with a reconnaissance flight, indicated that no more than 450 photosamples, and probably considerably less, would be sufficient for the whole lake in order to stay within the error of volume estimate that had been considered reasonable for this type of study, namely 10%.

7.1 Cont.

Therefore, with the helicopter carrying the boom at an average ground speed of 128 km/h, the automatic timer was calibrated for an exposure interval of 37 seconds.

Flying height was 300 m above lake level. The decision to choose this height was based on the resolution of photos obtained previously at the same scale with 70 mm film. Also, at the scale provided at this height, there would be adequate free space on either side of the debris strip on the photo to allow for the sideways motion in the regular flight of the helicopter as well as the frequent banking that was necessary to follow the shoreline indentations.

7.2 Plugs and Lake Strips

The same kind of systematic sampling procedure was employed on the other two types of debris. The large plugs were cross-flown at the same altitude, only using a different interval of exposures, from 10 - 15 seconds. This shorter interval was chosen to assure that at least three samples were obtained of the same plug.

The outline of each plug (of which there were six) was mapped from the helicopter on a 1" = 40 chain map after taking the helicopter up to an altitude of 2,000 ft. above the lake level for proper surveillance and shoreline orientation.

The three separate debris formations sampled in the middle of the lake were flown lengthwise with an exposure interval of 15 seconds. Their length and direction was mapped from a high-level helicopter. The width was determined in the same way as was the width of the shoreline debris. (See Photo Analysis-General)

8.0 FILM

The film used - Tri-X, aerographic, black and white - with ASA number 400. The use of color film was contemplated, but we had planned to utilize the processing facilities of the Photo Laboratory of the Information Division for the sake of convenience and speed, and this laboratory processes only black and white film.

9.0 PHOTO ANALYSIS-GENERAL

The 70 mm diapositives were blown up 6.7 times, from an original scale that varied between 1:4000 and 1:7000. The reason for the variation in scale was the difference in altitude of the helicopter. This was caused primarily by differences in atmospheric conditions from day to day and even between different times of the day. Irregular calibration of helicopter altimeter as well as uneven flying due to local air disturbances were other minor causes on subsequent photo samples.

The centre portion of each 13.5" x 13.5" blow up was printed on 8" x 10" Ektamatic paper. A grid of parallel transect lines was laid out on each print. These transect lines totalled 44 cm with half of them, 22 cm, laid out at right angles to the other half, both directions originating at the same point on the photo, on all photos. The logs that were crossed by these transect lines were counted. The minimum diameter at the point of intersection that could be counted was 4".

The information ~~tabulated on the computer cards~~ recorded for electronic data processing was as follows: (See Appendix for a sample of the computer cards used.)

Roll Number	-Film roll number
Photo Number	-Annotated photo number on each roll
Scale	-Scale of diapositive
Debris Type	-Shoreline or lake debris. The latter contains debris mats and strips
Sample Number	-A continuous numbering system
Width of Debris Strip	-Strip was measured three places on each selected diapositive, at the beginning, middle and end of the frame
Length of Line	-Total length of transect line on each photo sample
Number of Logs	-Number of logs crossed by total length of transect line on each photosample.

9.1 Acreages

Shoreline debris acreage was determined first by measuring the width of debris on each randomly selected diapositive on three locations, e.g. the beginning, the middle and the end of the frame, then by measuring the length of the sampled shoreline on a 1" = 40 chain map.

The acreage of the debris mats was measured planimetrically from the high-level mapping made of the accumulations, as mentioned earlier.

The acreage for the lake strips was determined from the length of the strips obtained from the on the spot mapping and the width as measured on the selected diapositives, in a way similar to that used for the shoreline debris.

9.2 ~~Randomized Sampling~~ of Photo Samples

From the systematic sampling done from the helicopter, a total of 492 shoreline samples were obtained. An initial number of 25 were randomly selected to determine the variations in concentration of debris. A coefficient of variance of 25.06% was obtained, indicating a very small variation between samples. It was obtained by using the formula:

$$CV = \frac{S.D.}{\bar{X}} \times 100$$

where: CV = coefficient of variance

SD = standard deviation

$\bar{X}$ = the mean volume per hectare

The final number of samples that were needed to arrive at the maximum error of estimate was determined by the formula:

$$N = \frac{t^2 \, CV^2}{E^2}$$

by progressive approximation: N = final number of samples

t = "student t" value, ~~expressing acceptable confidence limit~~

E = acceptable error of estimate

CV = coefficient of variance

9.2 Cont.

Due to the unexpected low coefficient of variation, the final number of photosamples to be randomly selected was set at 40.

A similar preliminary random sampling was carried out on the width of the shoreline debris strip, and here: CV = 95.51% was obtained. A final "N" yielded 118 photosamples, upon which to measure three different debris widths.

In determining the size of the two groups of randomized samples for volume and width, the following criteria was used:

E = acceptable error of estimate = 10%

t = 2.0 probability level, at 95% confidence limit

10.0 VOLUME CALCULATIONS

Shoreline debris: $S.V. = L \times \bar{W} \times \bar{V} * .0001$

$\bar{V}$ was obtained using the transect line formula for volume:

$$\bar{V} = \frac{10{,}000\ n \alpha}{lc\ B}$$

where: S.V. = shoreline volume, in m^3

$\bar{V}$ = average volume per ha (m^3)

n = number of logs

lc = a constant assurring unbiased orientation of logs

B = length of transect line (m)

α = volume per lineal unit, .0693 x .96 = .0665 m^3/m

$\bar{W}$ = average width of photo samples (m)

L = total length of sampled shoreline (m)

Lake debris:

$$T.V. = A_1 \bar{V}_1 + A_2 \bar{V}_2 + \ldots\ldots + A_9 \bar{V}_9,$$

where: T.V. = Total volume (m^3)

A_1, A_2 etc. = area for different plugs and lake strips (ha)

$\bar{V}_1$, $\bar{V}_2$ etc. = average volume per ha. for A_1, A_2 etc. (m^3)

10.0 Cont.

Variance of shoreline volume:

$$S^2_{S.V.} = (SV)^2 \left(\frac{SE_{\bar{w}}^2}{\bar{w}^2} + \frac{SE_{\bar{v}}^2}{\bar{v}^2} \right)$$

where: $SE_{\bar{w}}$ = standard error of the mean width of debris strip

$SE_{\bar{v}}$ = standard error of the mean volume per ha

Variance for total volume:- shoreline, plugs and lake strips:

$$S^2_{T.V.} = A_1^2 SE_1^2 + A_2^2 SE_2^2 + \ldots\ldots + A_9^2 SE_9^2 + (SV)^2 \left(\frac{SE_{\bar{w}}^2}{\bar{w}^2} + \frac{SE_{\bar{v}}^2}{\bar{v}^2} \right)$$

Standard error for total volume: $SE_{T.V.} = \sqrt{S^2_{T.V.}}$

95% Confidence limit of total volume: $C.L._{T.V.} = T.V. \pm 2\, SE_{T.V.}$

11.0 RESULTS

11.1 Shoreline Debris

Length of sampled shoreline	736.083 km
Average width of shoreline debris strip	59.18 m
Standard error of the mean, debris strip width	7.29 m
Area of shoreline debris	4,356 ha
Volume per ha	1,193.5 m^3
Standard error of the mean, vol/ha	62.65 m^3
Total Shoreline Volume	5,198,886 m^3

11.2 Debris Plugs

Area of plugs (N. Finlay plug 1,145 ha)	2,140 ha
Average volume per ha	1,100.4 m^3
Total Volume (N. Finlay plug - 1,247,648 m^3)	2,354,831 m^3

Standard error of mean, vol/ha ?

11.3 Lake Strips

Area of strips	474 ha
Average volume per ha	180.5 m^3
Total Volume	85,488 m^3

Standard error of mean vol/ha ?

11.4 Grand Total Volume of Buckskin Debris

7,638,205 m^3
(=2,697,762 cu)

Variance of Total Volume: $S^2_{T.V.} = 4{,}780.0986 \times 10^8$

Standard Error: $SE_{T.V.} = \sqrt{S^2_{T.V.}} = 691{,}383\ m^3$

Confidence Limits: 7,639,205 ± 1,382,766 m^3, i.e. ± 18.1%

Note: if there were only 3 strata, the calculations should have been done using these 3, i.e. samples in debris plugs should have been summarized as one stratum, similarly lake strips.

12.0 DISCUSSION

The results of the study indicate that there is a total volume of 7,639,205 ± 1,382,766 m^3 of buckskinned debris on Williston Lake. It means that 19 times out of 20, a sampling of the same debris would yield a volume figure within the expressed confidence limits.

The confidence limits of ± 18.1% give the upper and lower limit for this sampling:

Upper Limit - 8,535,928 m^3

Lower Limit - 5,770,396 m^3

The above result compares with the total volume from the 1973 study of 6,314,646 m3.

Given the upper and lower limit of the 1977 study the means of both total volume figures fall within the confidence limit of the 1977 study figures. Because of the nature of this study, the confidence limits have to be as wide as they are expressed in the results, i.e. ± 18.1%. This limit is remarkably low and during the time when the study was undertaken, it was speculated that the final figure might reach 30% or even higher. In any case, the result would have had to be accepted.

The confidence range of ± 18.1% means a total volume of 2 x 1,382,766 m^3 = 2,765,532 m^3, between the upper and lower limits. This figure is much larger than the combined salvage and estimated volume of disposed debris between 1973 and 1977. Therefore, no precise measure of the disposed and salvaged volume of debris can be obtained, from comparing the 1977 study figures with the 1973 study figures.

The 1973 study does not express its confidence limits. Any estimate based on its total volume figure is, therefore, laden with uncertainty.

The sampling method employed in 1977 has been described in detail earlier in this report. It was made possible to sample the debris when the water level of the lake was raised to its new maximum. This meant that all the wood was floating in a formation that was as close to one layer as possible and, because the debris was spread out in this fashion, the water-saturated logs that floated right below the surface could also be detected. This fact made it possible to make a very careful and accurate log count along the transect lines.

The photo sampling was carried out using a helicopter with "boom" for stereoscopic fixed-base photography. This facility provided a very accurate measure of scale for each separate 70 mm photo and boosted the accuracy of the individual photo and the overall sampling method.

12.0 Cont.

The sampling method of the 1973 study entailed the use of the "layer" factor. The number of layers of logs was estimated for each ground sampling plot. Then an average layer figure was calculated for the whole lakeshore and applied to the overall volume per area figure.

It can be readily appreciated that the number of layers of logs in a log pile can never be clearly defined, particularly when this number is the estimated average number for the length of the transect line. If the log pile is thick then this source of error may become quite substantial and the reliability of the whole sampling method will become questionable despite the potential of high accuracy resting in the other aspects of the whole procedure.

13.0 CONCLUSIONS AND OBSERVATIONS

There were three original objectives in the 1977 Williston Lake Debris Study. Briefly, they were concerned with the following:

(1) Volume determination

(2) Sampling method

(3) LANDSAT images

Due to the difficulty in correlating the three different data-gathering levels, e.g. from low-level flying, high-level flying and orbital satellites, the last objective was not fulfilled. It was therefore not possible to draw any conclusion as to the potential of using information contained in LANDSAT images to obtain results about pondage cleanup operations.

The first two objectives, e.g. determining the volume of the buck-skinned debris and developing an appropriate sampling method, were successfully achieved.

The two objectives above are closely tied together, with a reliable volume figure being dependant upon an adequate sampling method.

It is with confidence in the sampling method that the final grand total of debris volume from this study can be regarded as reliable within the noted confidence limits.

APPENDICES

APPENDICES

WILLISTON LAKE

Scale: 1"=7.5mi Date: Dec. 1970

Drawn by: Pat L. Clark

DEBRIS PATTERN OF JULY 17-19, 1977.

- Plugs
- Lake sfc. not covered by logs
- Lake strips
- Shoreline debris
- # Key to sampling data

N

Ingenika River

Mesilinka River

Osilinka River

Omineca River

FINLAY REACH

Ospika River

PEACE REACH

HUDSON HOPE

W.A.C. BENNETT DAM

FINLAY FORKS

Mile 69

PARSNIP REACH

PARSNIP FOREST ROAD

Manson River

Nation River

CHETWYND

JOHN HART HIGHWAY

TO DAWSON CREEK

MACKENZIE

MCLEOD LAKE

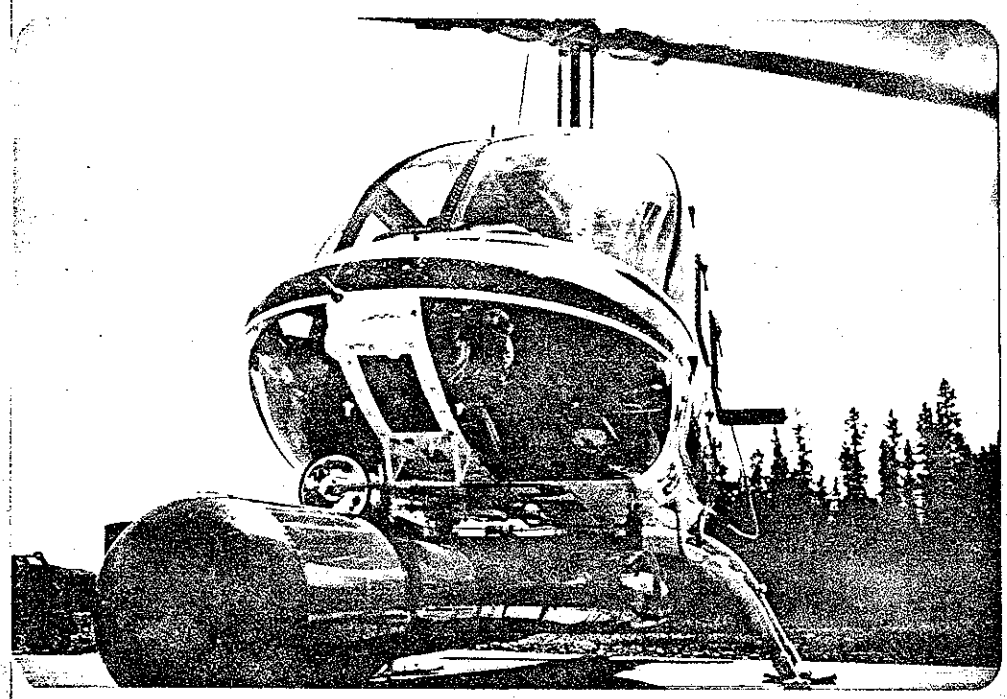
TO PRINCE GEORGE 90 MILES

KEY MAP

Scale: 1" = 150mi

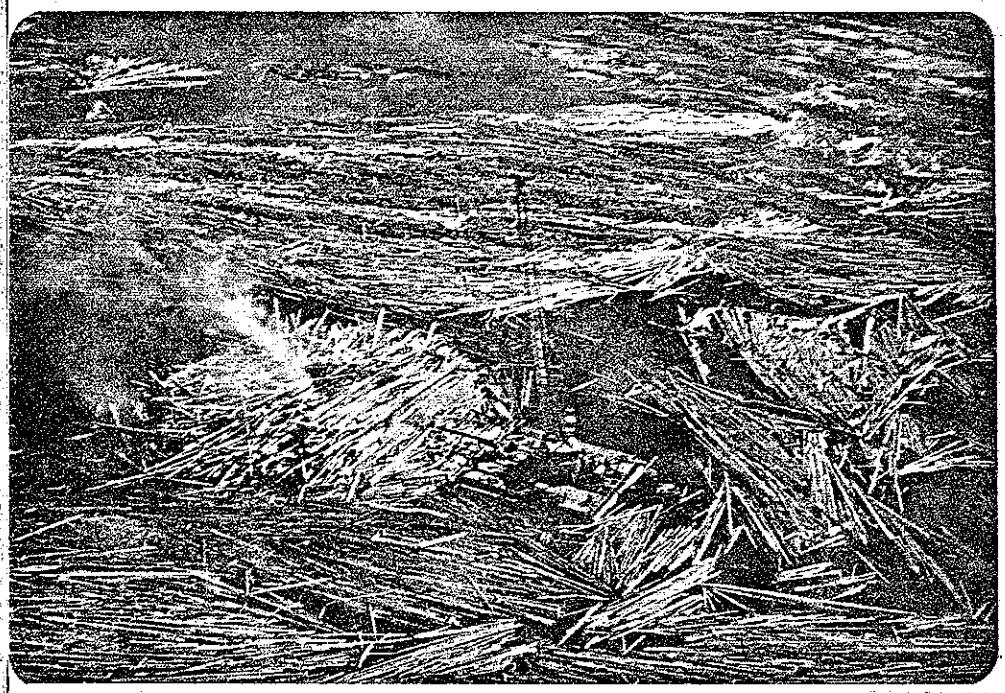
WILLISTON LAKE

BRITISH COLUMBIA



#1

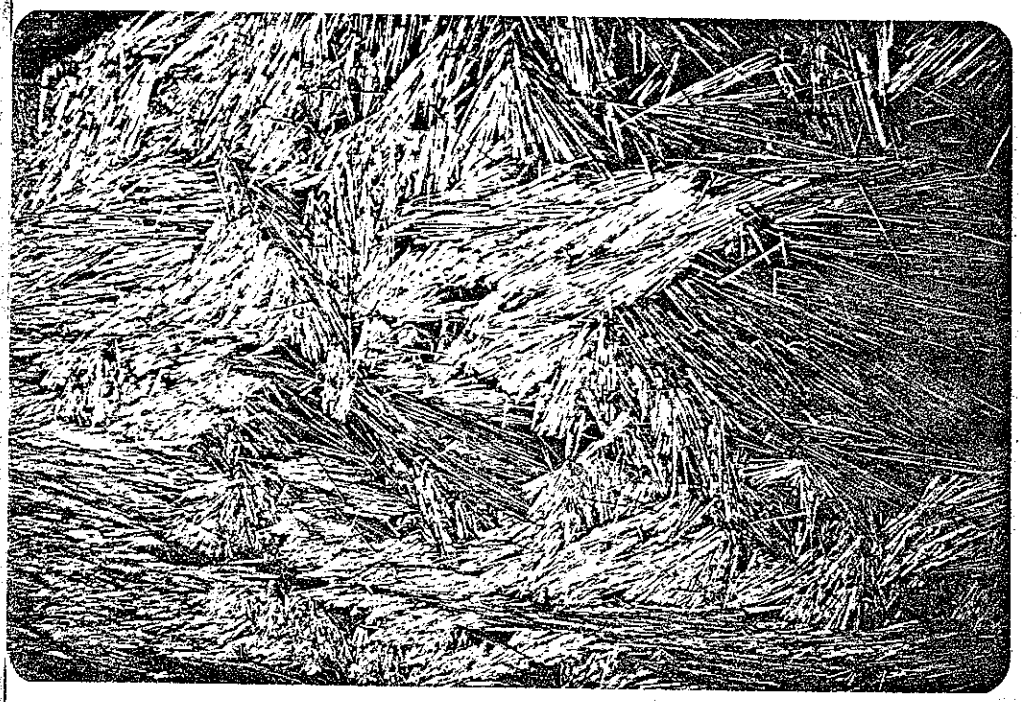
Jet Ranger Helicopter
with high skid gear and boom



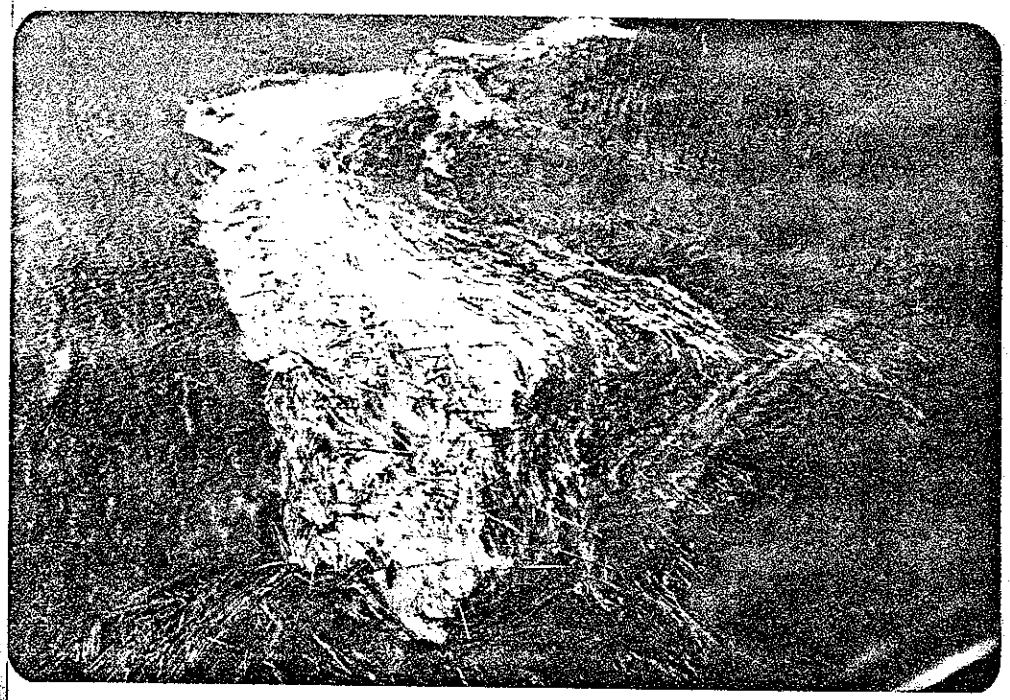
#2

Debris Disposal Barge
and crance

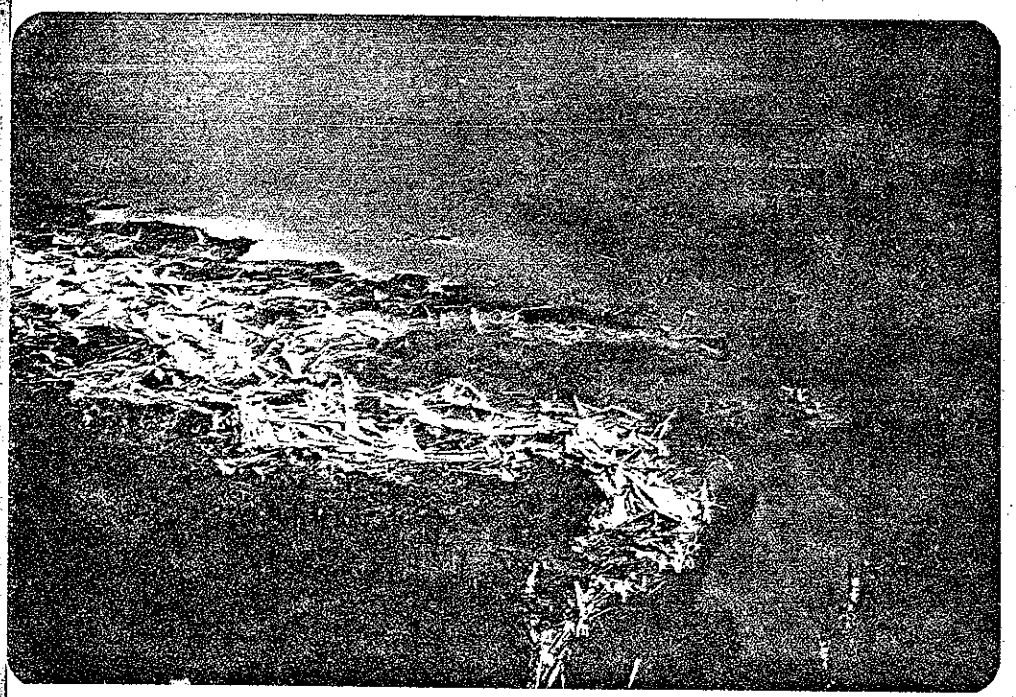
#3
Low level view of North Findlay Arm plug



#4
High level view of North Findlay Arm plug



#5
Shoreline debris, south of Omineca Arm



#6
Shoreline debris, south of Omineca Arm

ROLL NO.	PHOTO NO.	SCALE	DEBRIS TYPE	DEBRIS DENSITY	SAMPLE NO.	WIDTH OF DEBRIS STRIP ON 70MM PHOTO (MM) TOP	MID	BOTTOM	LENGTH OF LINE (CM)	# OF LOGS.
1 2	3 4 5 6 7		8	9	10 11 12	13 14 15	16 17 18	19 20 21	22 23 24 25	26 27 28