LAKE DIEFENBAKER, SASKATCHEWAN:

A CASE STUDY OF RESERVOIR SEDIMENTATION

by

TED R. YUZYK

SEDIMENT SURVEY SECTION
WATER SURVEY OF CANADA DIVISION
WATER RESOURCES BRANCH
INLAND WATERS DIRECTORATE
ENVIRONMENT CANADA
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Executive Summary

In 1965 a field survey program was implemented to monitor general sedimentation patterns, delta formation and bank erosion in what was to become Lake Diefenbaker. The program consisted of establishing 38 range lines (cross sections), spaced so that they would be representative of changes and surveying them on a regular basis. A sampling program was included to collect information on suspended sediment, bed material and water temperatures. The field programs were conducted jointly by the Sediment Survey Section (Ottawa), Water Survey of Canada (Regina) of Environment Canada and the Hydrology Division, Saskatchewan Environment.

After fifteen years of data collection it was agreed that this program should be reviewed. The review focussed on two principal areas:

1. To compile, analyze and interpret all the data collected from Lake Diefenbaker and document the sedimentation patterns;

2. To evaluate the existing data collection program and identify changes required to ensure an effective and efficient program.

Sedimentation has not significantly affected the reservoir operation, since only 1.4% of the total reservoir capacity has been lost between 1966-1980. The area where sedimentation is significant is in the drawdown reach, which lost 19% of its volume, or a 1% loss in live storage. Bank erosion and slumping are active and estimated to have accounted for the other 0.5% of the total 1.5% loss in live storage. The dead storage was computed to have been reduced by 1.3% over this period.

Delta formation was determined to be affected by a low original bed slope, large water level drawdown and reduced sediment loadings in the latter years. The bed slopes indicate that the delta structure has yet to reach equilibrium.

Bed material sampling showed that deposited densities were considerably lower than empirically derived values, which greatly affected the deposited load estimates. Based on the sampling findings, a good agreement between station derived loads and the calculated deposited loads was obtained.

The following recommendations are made based on the findings of this report:

1. This joint program should continue, for it is providing a worthwhile contribution to understanding delta formation and

reservoir sedimentation in the prairies. The information is proving to be not only of site specific importance, but transferable to other reservoir studies. It also provides the opportunity to train and to build upon the expertise already acquired in undertaking sedimentation studies.

2. Due to the low sedimentation rate, the survey interval should be extended from three years to at least five years, the five year interval will insure continuity between surveys. Since most of the deposition is occurring upstream of the Saskatchewan Landing Bridge, and should likely be the case for quite some time, only those upstream ranges should be resurveyed in the future. Special area studies (Elbow, Swift Current Creek Delta) do not have to be resurveyed as they show negligible sedimentation.

3. Certain data collection methodologies (HYDAC-200 data, cross section vs. area method of surveying) need to be further evaluated and more comprehensive guidelines established for sampling (bed material, suspended sediment) in reservoirs.

4. Since the existing range data were not the most suitable data for evaluating the bank contribution; and since bank erosion and slumping are active, an alternative study using either terrestrial photogrammetry or concentrated cross-sectional work should be considered.

5. Numerical modelling of sediment deposition (such as HEC-6, MOBED) was not in the scope of this report, but it should be considered the next logical step. If undertaken prior to the next survey it may help further streamline the program.

Acknowledgements

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1. Introduction

1.1 Design and Construction of Lake Diefenbaker

A Royal Commission (1952) was established by the Government of Canada and presented a report in 1952 on the possibilities of impounding the South Saskatchewan River. By 1958, an agreement had been reached between the governments of Canada and Saskatchewan which outlined the basis on which the South Saskatchewan River Project would be planned, constructed and financed.

The design of the project was undertaken by the federal agency, Prairie Farm Rehabilitation Administration (PFRA). Numerous sites were then examined to determine the most suitable location to construct the dam. These early investigations raised concern over the weakness of the geologically young Bearpaw shale, which was the major underlying formation. However, soil tests and an analysis of the geology (Pollock, 1961) of the area provided the information needed in helping to choose the best site location. A hydrologic investigation was then undertaken to provide the basic information needed to design the outlet works (Berry et al., 1961). Based on the information from these preliminary studies two dams needed to be designed (MacKenzie, 1960). The large earth-filled Gardiner Dam impounded the South Saskatchewan River, while the Qu'Appelle River Dam prevented overflow into the Qu'Appelle River system. A complete detailed description of the design and construction of these dams is available in a PFRA (1980) publication.

The construction work which began in 1959 was completed in 1967 and the South Saskatchewan River Project became officially known as Lake Diefenbaker. The total project cost had amounted to approximately 120 million dollars as Lake Diefenbaker became the largest man-made lake in Canada and the Gardiner Dam was recognized as one of the largest earth-filled dams in the world.

Lake Diefenbaker, which is located in the semi-arid grasslands of southern Saskatchewan (Figure 1), is fed primarily by two tributaries. The major one being the South Saskatchewan River and the other being the smaller Swift Current Creek.

Filling of the reservoir was initiated in 1964, but full supply level (FSL), 556.87 metres above mean sea level, was not reached until 1968. The water level can be drawn down over 11.0 metres to the 545.59 metre elevation. The 225 km-long Lake Diefenbaker has an estimated 9.4 million cubic decametre (dam^3) storage, of which 4.0 million dam^3 is useable or live storage.

The reservoir effectively impounds the South Saskatchewan River while serving a number of purposes: municipal and industrial use, power generation, irrigation, recreation and flood control.

1.2 Pre-reservoir Sedimentation Studies

In 1947, PFRA was concerned that sedimentation of the proposed reservoir could be a problem so a hydrometric station was established at

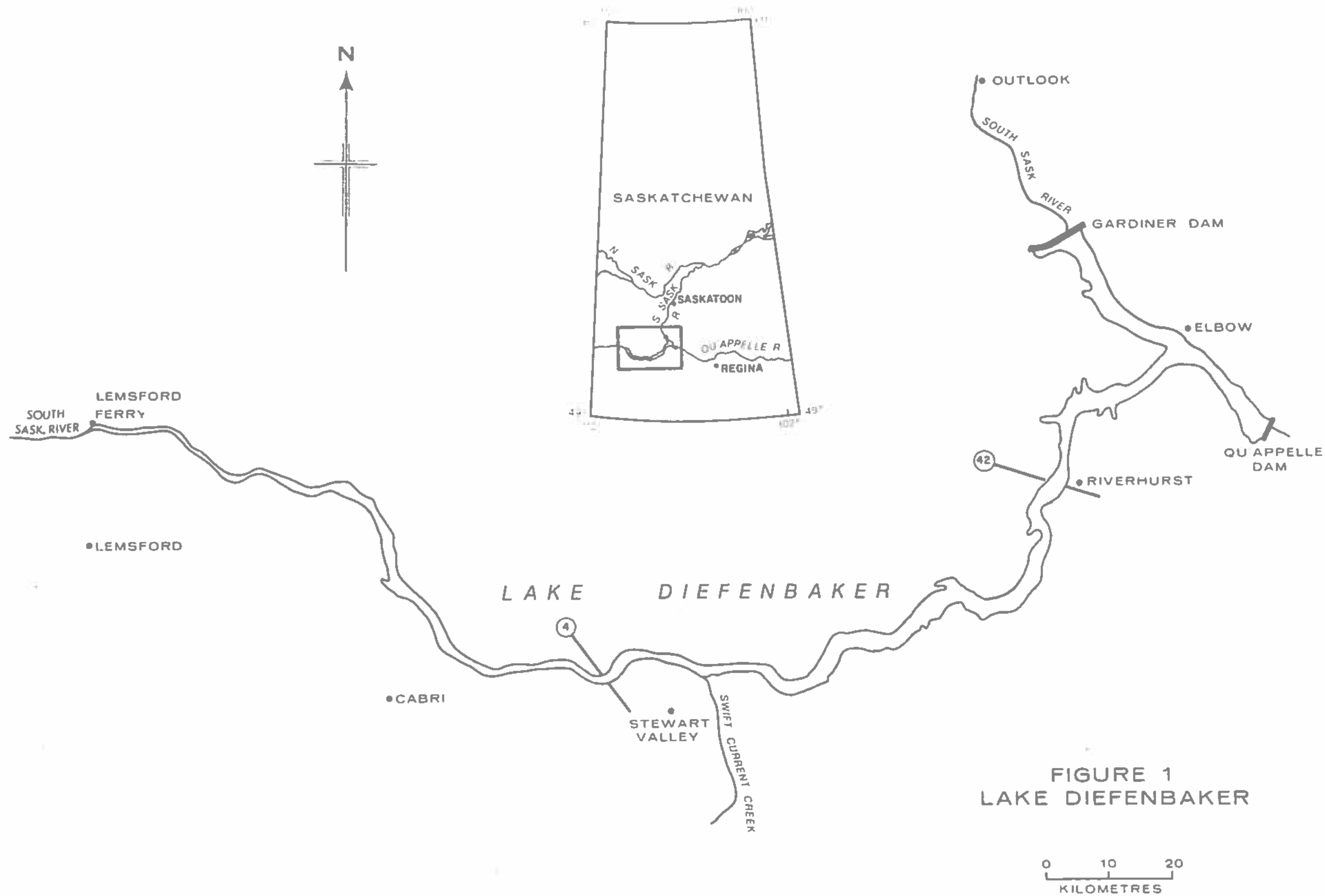

FIGURE 1
LAKE DIEFENBAKER

Outlook, to collect data on sediment transported by the South Saskatchewan River. In 1952, computations revealed that the average annual sediment load would only reduce the proposed total capacity by less than 0.1% per year (PFRA, 1952). Since the value was so low no further work was devoted to sedimentation studies.

In 1959, another consultant was hired to formulate a master plan for the recreational development and utilization of the reservoir. His report identified three sources for concern, which could greatly affect recreational development and for which limited or no data were available. The areas of concern were: deposition of material from eroding banks; sediment transported into the reservoir by Swift Current Creek; and the extent of deposition in the reservoir from the South Saskatchewan River sediment loads (Baker, 1960). This study helped point out the complexities involved in the prediction of sedimentation in a proposed reservoir, and provided the impetus for further studies.

To assess the extent of bank erosion, a specialist in airphoto interpretation and geology was consulted. The basic finding of his study was that the reservoir banks, which were comprised of glacial till and sand, would be highly susceptible to erosion (Mollard, 1961). The report included a topographic map that depicted areas along the proposed shoreline that would be prone to slumping and erosion. However, no quantitative estimates were made because there were insufficient data from which to make such an evaluation. The report stated that to assess the problem properly a study would have to be conducted after the reservoir had been in operation for a few years.

Kuiper (1962) evaluated the processes of sedimentation and forecasted delta formation in the proposed reservoir. Based on suspended sediment data collected at the Outlook station, Kuiper estimated the average annual sediment load to be in the order of 7 400 dam^3. This provided for a sedimentation rate of only 0.1% yearly, based on the total storage capacity. The report projected the longitudinal profiles of the reservoir after 10, 50 and 100 years, based on the incoming sediment load. This study also had limited data with which to work and necessitated the use of data from existing reservoirs. From this study it became apparent that to effectively monitor and forecast future sedimentation in the reservoir, an ongoing hydrographic data collection program should be implemented.

1.3 Objectives of Reservoir Survey Program

These early studies made it apparent that, while the magnitude of sediment inflows to the reservoir was not a problem, the distribution of the sediment load could pose problems. Even with limited data these studies did provide some valuable insight into sedimentation in what was to be Lake Diefenbaker. However, these studies did make it evident that the processes affecting sedimentation were very complex and that a data collection program would help provide more information on how these processes would interact over time.

So in 1963, the Saskatchewan government implemented a standard reservoir program consisting of profiling established cross sections. This program was established to monitor the progress and configuration of the developing delta, and determine the sedimentation rate in the lake. Due to the fact that the project provided a unique opportunity to study sedimentation in a newly formed reservoir of such magnitude, and the significance of the reservoir itself, the federal government established the program as an International Hydrological Decade Project in 1964. The project was entitled, "Delta Formation and Sedimentation in Lake Diefenbaker" and from that point on a joint program of sediment and hydrographic data collection was undertaken.

The specific objectives of the reservoir program were defined in the "IHD Project Saskatchewan-2 Progress Report 1964-67" as:

"1. to provide information that will aid in planning future improvement and developments at Lake Diefenbaker;

2. to provide information relative to the effect of aggradation on structures as the Saskatchewan Landing Bridge, ferry approaches, water supply intake works, and recreational and other developments;

3. to provide information for operational purposes, such as the effect of sediment accumulation on the reservoir capacity relationship and evaporation losses;

4. to provide factual data for possible litigation;

5. to provide information that will aid in future planning of other projects."

1.4 Data Collection Programs Involved in the Project

The program involved the permanent establishment of 38 cross sections, more commonly referred to as ranges, spaced in an ascending numerical order from Gardiner Dam to Lemsford Ferry (Figure 2). The location of the ranges were chosen based on the following criteria: that they were representative of the geometry of the reservoir in a particular reach, that they were easily accessible, and that they would reflect anticipated deposition or erosion. Each range was then to be surveyed for cross-sectional area changes at a predetermined interval, so as to monitor the rates of deposition and/or erosion in the reservoir.

Suspended sediment samples were collected at each range to provide information on the sediment transported by incoming flows. This portion of the program was also initiated to help determine if density currents existed as a mode of transport within the reservoir. Temperature data were obtained to determine if stratification of the water existed in the lake and how it might affect sediment transport and deposition of suspended sediment. Bed material sampling provided information on the densities of deposited sediment as well as depositional patterns.

Hydrometric stations where then established by Water Survey of Canada to provide information on the two major tributaries. Data collection at these stations included sediment data, as well as hydrometric data. On the South Saskatchewan River a station was established just upstream of the

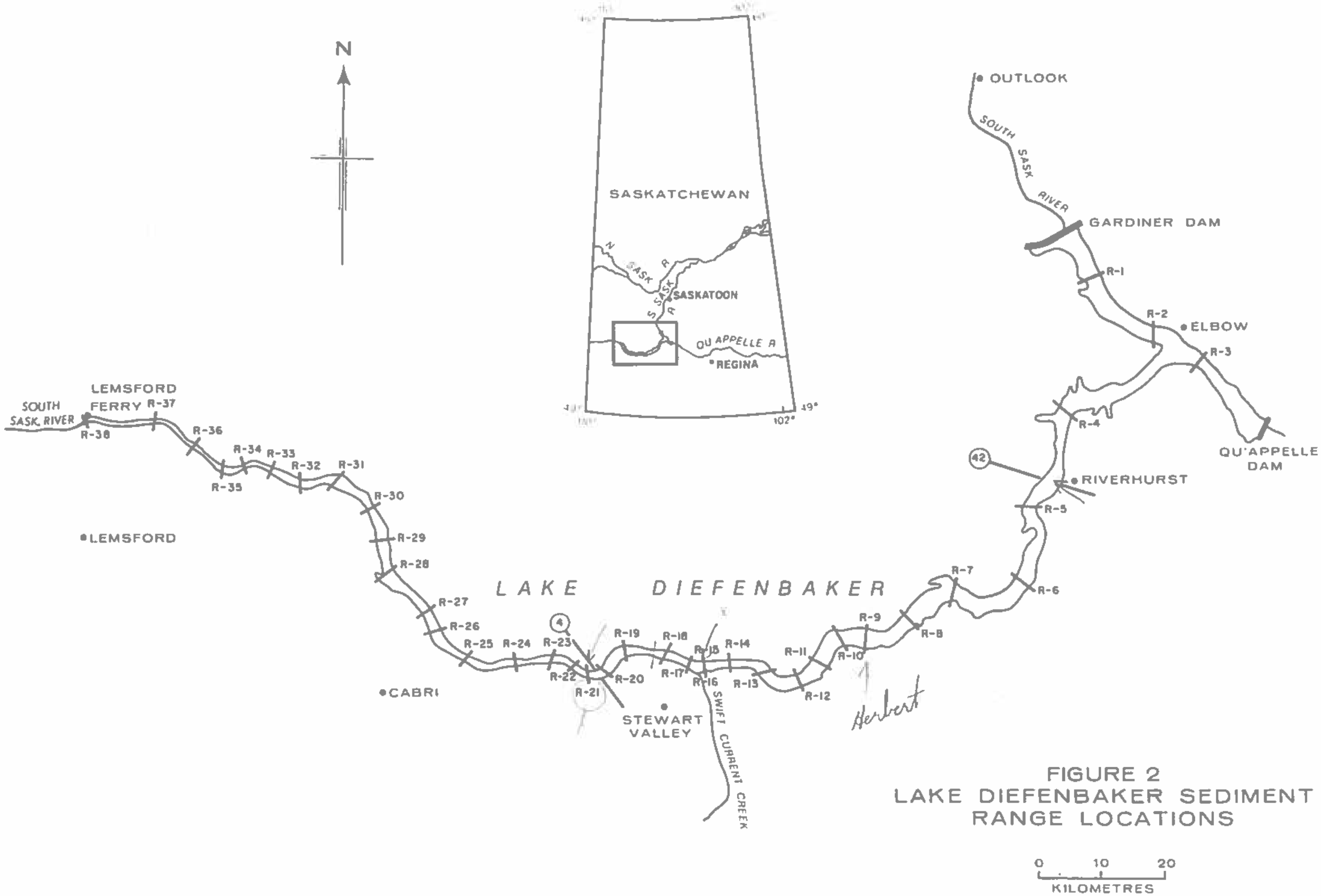

FIGURE 2
LAKE DIEFENBAKER SEDIMENT RANGE LOCATIONS

reservoir near Lemsford in 1958. In 1965, a station was installed on Swift Current Creek where it drains into Lake Diefenbaker.

The other major source of sediment was determined to originate from the banks of the reservoir, so a program to determine the contribution of this source was implemented. Low level aerial photography was determined to be the best approach to identifying areas undergoing significant bank erosion. At a later date three representative sites were chosen for terrestrial photogrammetry application in an attempt to calculate the volume of bank material being eroded.

1.5 Sedimentation Studies Conducted on Lake Diefenbaker

There have only been a few additional sedimentation studies that have been conducted on Lake Diefenbaker since it was established. The first such study was concerned with the effect of bank erosion on the different storage capacities. Van Everdingen (1968) taking into account the water level drawdown, applied soil and slope stability theories, calculated the extent to which the banks could be eroded. Based on range data from Ranges 4, 5 and 6, it was calculated that the live storage could be increased by as much as 7.4% due to bank erosion. This bank material would then be transported down into the dead storage zone, which would decrease its capacity by 4.0%. These changes were expected to occur within the first ten years of the life of the reservoir. It should be noted that the fact that this area was considered to be indicative of the whole shoreline can be considered questionable assumption. The reach for this study has particularly steep banks which would produce a high, overestimated, rate of bank erosion if applied to the whole reservoir.

In 1969, further research in bank erosion and nearshore sedimentation was undertaken in the vicinity of Elbow. Coakley and Hamblin (1969) after a brief field trip provided some general statements concerning the processes involved. Their findings were that most of the erosion was due to gravity slumping of structurally weakened banks and that most of the material was being transported towards the central portion of the reservoir. Measured nearshore currents were found to be too weak to transport sediment along the reservoir and instead sediment was transported from the banks, laterally, down the steep bank gradients. This also explained why no shoreline depositional features were observed and the general lack of beach formation. No estimates concerning the extent of bank erosion or the rate of sedimentation were made from the study.

An analysis of the hydrographic data collected between 1965 and 1972 on Lake Diefenbaker was conducted by Wiebe and Drennan (1973). The analysis dealt primarily with changes to the longitudinal profile of the reservoir with time. Based on changes in the mean bed elevation, deposition was calculated to have occurred from Range 30 to Range 4. Analysis of the suspended sediment data revealed that 85% of suspended load was deposited by Range 21. The sand portion of the suspended sediment load was found to have settled out of suspension by Range 30. Density of deposited material varied from a high of 1 490 kg/m^3 at Range 33, to a low of 240 kg/m^3 by Range 9. Sand was found to be deposited within the old river channel, while silt and clay were deposited relatively uniformly throughout the cross sections in the upper ranges.

Rasid's (1979) study dealt primarily with the effects that the reservoir would have on the downstream regime, but did discuss sedimentation in the reservoir. An analysis of pre-dam to post-dam sediment loads at Lemsford and Saskatoon revealed that about 97% of the sediment load carried by the South Saskatchewan River was being trapped in Lake Diefenbaker. However considering the length of Lake Diefenbaker, it is highly unlikely that any of the sediment load carried by the South Saskatchewan River passes through the reservoir. The load differences measured in this case can probably be attributed to sediment eroded from the banks and bed between Gardiner Dam and Saskatoon.

2. Reservoir Data Collection: Methodology, Techniques and Equipment

2.1 Cross Section (Range Line) Surveys

Through an open control system of surveying, permanent bench marks were located for each of the 38 ranges. A total of four bench marks were installed at each range, two on each bank. The upper bench marks, one located on each side of the reservoir, were to be located so that they would not be affected by unstable ground conditions brought about by the newly established reservoir. The lower bench marks on both sides were located closer to the reservoir shoreline, to minimize the land surveying involved each time the cross sections were surveyed. All the bench marks were then tied into geodetic datum by first order level circuits. The distance across the reservoir, between lower bench marks, was measured by a Tellurometer, an electronic distance measuring device, and a station was assigned to the bench marks. The convention used was that all lower left bench marks were assigned a horizontal station of zero, while the station of the lower right bench marks corresponded to the distance between the two lower bench marks. Bench marks were checked and maintained on an annual basis by personnel from the Hydrology Branch, Saskatchewan Environment.

Profiling of each range first involved the surveying of the land portion of the cross section by means of a surveyor's chain and level. A point was chosen whenever there was a break in slope or the end of the tape was reached. Proceeding from the bench mark to the water's edge the station and elevation of each point were recorded. This procedure was conducted on both banks at each range. The water level elevations obtained from each side were then checked to make sure they compared to the nearest tenth of a foot. In some cases a discrepancy could be explained, such as effects from wind build up, but if there were no logical reasons, then the levelling work was redone.

Once the water level elevation had been obtained, the hydrographic data were collected using an echo sounder mounted in a boat. A continuous profile was obtained along the range line. The water depths were extracted whenever there was a break in profile and converted to bed elevations by substracting them from the known water level elevation.

To keep the boat on line, two methods or aids were employed. The first involved the installation of two highly visible range markers on each bank, this provided the visual assistance for the operator to keep the boat on line. The second was to set up a transit on the bench mark and sighting it on the bench mark across the reservoir, if the boat drifted off the line then the instrument man would give directions to the boat operator by means of a two-way radio.

The horizontal distance the boat travelled was determined by triangulation. A measured baseline was laid out perpendicular to the range line, with a transit situated at the end of the baseline. As the boat moved across the reservoir, a signal was given periodically from the boat, an angle was read and recorded, while simultaneously in the boat the echo sounding chart was marked. Another method used occasionally in the early surveys involved the use of a rangefinder. The rangefinder was set up on the range line and sightings made on the boat as the echo sounder chart was marked. However,the rangefinder was only calibrated for sighting distances greater than 300 m, which restricted its application at many ranges.

In the upper ranges, where river conditions prevail, different techniques and equipment had to be applied. In these cases a tag line was stretched across the channel and a sounding rod used from a boat or by wading to measure depths at fixed intervals.

In 1970, some testing was undertaken to determine the reproducibility of profiles (IHD Annual Project Report, 1970). Based on different triangulation arrangements, the maximum distance measurement discrepancy was calculated to be 20 m. Boat drifting, and to a lesser extent, instrument readings were found to affect the results. The depth data were found to be precise, as long as the echo sounder had been properly calibrated for temperature and salinity. However, it was determined that if the recorder was not adjusted when there was a change in these conditions, then erroneous readings would be obtained. In fact, most of the 1970 hydrographic data collected from the reservoir was determined to be inaccurate because the echo sounder had not been properly calibrated.

In 1971, a distance positioning system was adopted which consisted of a master and slave Tellurometer, a printer and a synchronizing component was used to measure distances. The slave, which was set up at known position on the range line, would transmit to the master unit in the boat. At a push of a button the distance and depth were recorded simultaneously. The

Tellurometer, which was accurate to ±1.5 m proved to be more reliable than the triangulation method for obtaining horizontal distances.

Table 1 indicates the profiles that have been obtained since the beginning of the project. In 1974, the sector method of surveying was incorporated into the program and areas were surveyed instead of cross sections from Range 1 to Range 27. The ranges upstream of Range 27 continued to be surveyed as range lines because they were not easily accessible by the larger boat.

2.2 Area (Sector) Surveys

In 1972, an automated hydrographic system, HYDAC-100, was developed and tested in the reach where Swift Current Creek drains into Lake Diefenbaker. The test results were favorable so the system was adopted for use on Lake Diefenbaker surveys. Instead of collecting a single line of data at each range, as was done before, a collection of lines transecting an area were collected. The area or sector method of surveying at each range was then incorporated into the program in 1974. A detailed description of this system and the survey practices used are available in a technical bulletin by Durette and Zrymiak (1978). In 1978 the system was updated because of technological advances and became known as the HYDAC-200. Since many changes have been made to the prototype, a brief description of the system has been provided in this report.

TABLE 1

CROSS SECTION (RANGE LINE) DATA AVAILABLE

RANGE NO.	YEAR															
	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	X		X	X			X			X						X
2	X				X		X							X		
3	X						X									X
4	X		X	X			X			X				X		X
5	X						X									X
6	X		X	X				X			X					
7		X					X							X		
8		X			X		X						X			
9			X					X			X					X
10			X				X									
11		X	X					X			X					
12		X					X									X
13		X					X						X			X
14		X						X			X					
15		X					X						X			
16		X					X						X			
17		X	X								X			X		
18		X					X			X			X			X
19		X					X						X			X
20		X						X			X			X		
21		X	X					X			X			X		
22		X					X									X
23		X		X				X			X			X		
24		X						X			X					
25		X					X						X			
26		X		X				X			X			X		
27		X			X			X			X			X		
28		X		X			X						X			X
29		X	X		X									X		
30		X	X			X		X			X			X		
31		X	X		X		X									X
32		X	X			X		X			X			X		X
33		X		X				X			X			X		X
34		X					X						X			X
35		X			X			X			X			X		X
36		X						X			X			X		X
37		X				X		X			X			X		X
38		X						X			X			X		X

NOTE: X - CROSS-SECTIONAL DATA

The data collection system shown in the block diagram (Figure 3) can be divided into four sub-systems: positioning, depth sounding, data processing with survey control and data logging. The working relationship of the individual components has also been outlined in the diagram.

The dynamic positioning of the 10 metre-long vessel is accomplished by means of two Tellurometers positioned on shore. The remote Tellurometer locations are fixed by tying them into the network of established survey bench marks. The master Tellurometer on the boat measures the distance to the remote unit under dynamic conditions to a single range accuracy of $\pm$1.0 m. This positioning system was modified in 1978 with the installation of the most currently developed MRD 1 Tellurometers. The original MRB 201 Tellurometers were less reliable and had an accuracy of only $\pm$1.5 m.

The depth sounding sub-system is considered to be accurate to within 50 mm, up to a depth of 100 m. There are two transducers. The 210 kHz frequency detects low density deposits, while the 33 kHz distinguishes material of higher densities. This particular sub-system has not undergone any component changes since it was originally installed.

The sub-system concerned with data processing and survey control monitors the measuring instruments. The quality of data collection can be controlled through the choice of data acquisition rates and coverage density. This is all accomplished by a software package, consisting of four main programs: a driver; a preplot; an on-line and a data dumping program.

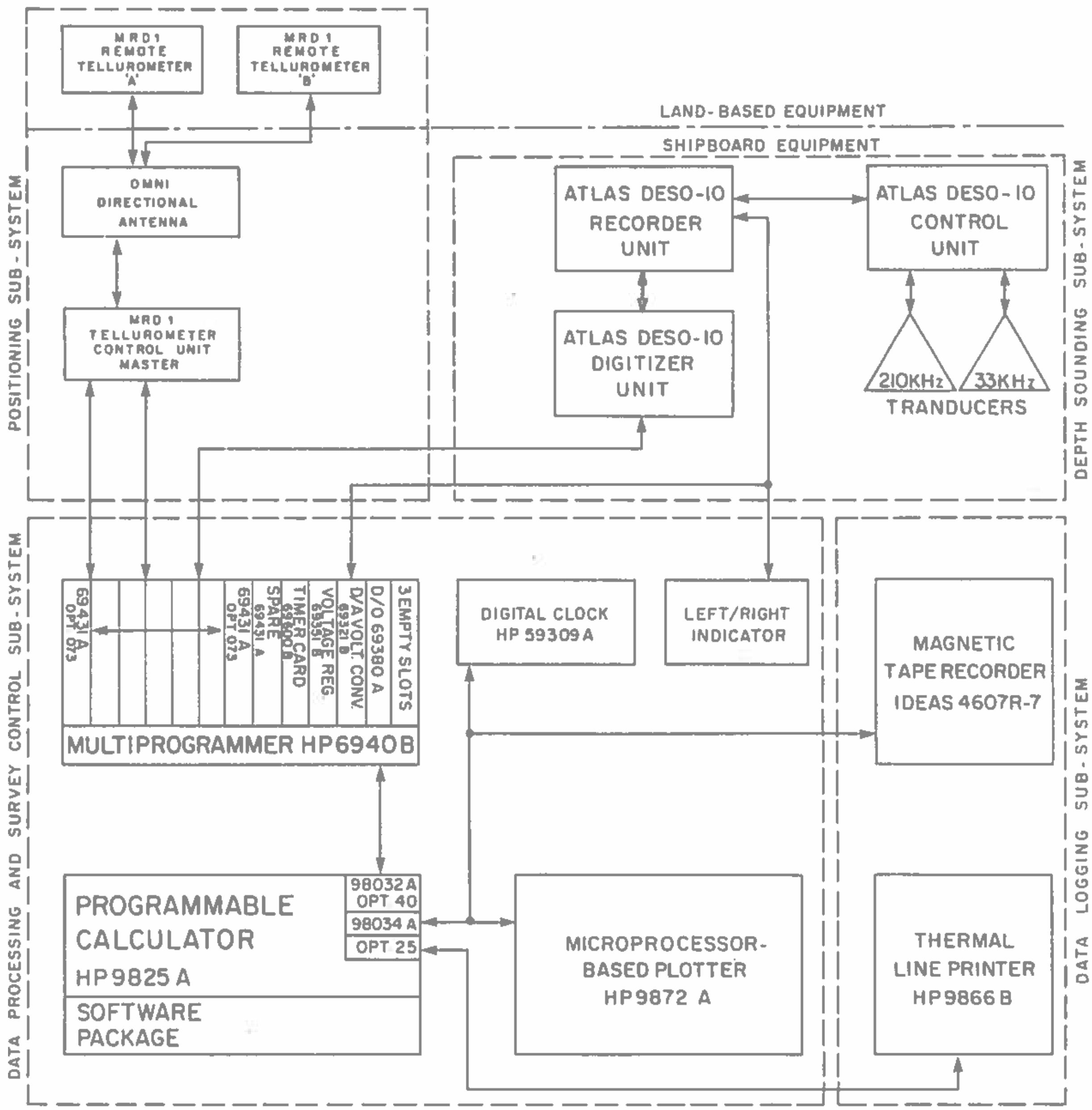

FIGURE 3
HYDAC – 200
A HYDROGRAPHIC DATA ACQUISITION SYSTEM

A point, which is made up of two distances, depth and time, is capable of being collected by the system every two seconds. The addition of an onboard plotter to the system in 1977 greatly improved the coverage, which up until then was not monitored.

The last stage of the data collection system is the storing of the data. The data are stored on two outputs: a seven track magnetic tape and a hardcopy printout. The hardcopy is the backup to the field tape.

The first step in collecting sector data involved land surveying. Profiling was done from the bench mark to the water's edge and the water elevation recorded. The next step was to locate the Tellurometers where they had a good line of sight and reference them to the bench mark network. In most cases a Tellurometer was located on each bank, usually on the range line. This Tellurometer configuration which was used to collect sector data has been found to produce innaccurate range data because of the poor trigonometric arrangement. After the 1978 field season special care was given in locating the Tellurometers to provide accurate range data. The distance between Tellurometers was then measured with an electronic distance measuring device (CA 1000). This distance, which is known as the baseline length, was then fed into the HP 9825A programmable calculator along with a suitable scale. A bearing was then given along with the line interval spacing, and a preplot was produced. On Lake Diefenbaker the line spacing was a standard 50 m apart and approximately 600 m of reservoir length were surveyed for each sector. As a check, the boat transected the baseline and the Tellurometer distances were summed to ensure that the value matched that of the baseline. At this point the driver began surveying by first collecting data along the old range line, then proceeded into a perimeter run, and the last step was to follow the line spacing to complete the coverage.

The sectors which have been collected since 1974 are shown in Table 2. Cross-sectional data were extracted from most of the sectors as a means of comparing the two survey methods.

In addition to the sector surveys there were also three sites within the reservoir which are significant for studying sedimentation and were incorporated into the program as area surveys. The first included the whole reach from Range 27 to Range 25 as one continuous survey. This reach was considered to be the most indicative in terms of monitoring delta formation in the reservoir. This area was surveyed in 1975 and then again in 1980. The area where Swift Current Creek enters Lake Diefenbaker was surveyed in 1972 and was resurveyed in 1978 for comparison. The purpose for this was to monitor deposition from Swift Current Creek sediment loads. The other area surveyed was at the junction of the two arms, the Gordon Mckenzie and Thompson, near Elbow, and was done in 1974 and has yet to be repeated. This was considered to be an area prone to bank slumping and which could also experience sedimentation that might affect the water intake for the town of Elbow.

To process these data, the Sediment Survey Section developed an automated data reduction and analysis system - HYDRA. This system which

TABLE 2
AREA (SECTORS) DATA AVAILABLE

RANGE NO.	YEAR															
	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1										S				S		S
2										S				S		S
3										S				S		S
4										S				S		S
5										S				S		S
6											S			S		
7										S				S		
8										S			S			
9											S					S
10													S			
11											S					S
12										S			S			S
13										S			S			S
14											S			S		
15										S			S			S
16										S						S
17											S			S		
18										S			S			S
19										S			S			S
20											S			S		
21											S			S		
22										S			S			S
23											S			S		
24											S					
25										S			S			
26											S			S		
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37																
38																

NOTE: S - SECTORS
South Saskatchewan Delta Area (Range 27 - Range 25) - 1975, 1980
Swift Current Creek Delta Area - 1972, 1978
Elbow Area - 1974

TABLE 3

HYDRA SYSTEM PROCEDURES

PROC. NO.	PFN	MEANING	PURPOSE
1.	HD	HYDAC DUMP	To dump and convert the Field Tape Data from ASCII to BCD
2.	TP	TRANS PROCESS	To re-format the DUMPFN Data Records to card images
3.	CS	CONVER SECTOR	To convert the PCATDPFN Data of selected sectors to XYZ Coord.
4.	EP	EDIT POINTPLOT	To produce a TAPE30 Point Plot of the CNTLEDPFN
5.	PP	POINT PLOT	To produce a TAPE30 Point Plot of the CNTLPFN
6.	DR	DUPLICATE REMOVAL	To remove any consecutive duplicate XY Coord. in CNTLPFN
7.	PX	PROFILE	To plot X-section from CNTLPFN
8.	NO	NEWORIGIN	To reset a new origin.
9.	MC	MODULE CREATION	To sort CNTLPFN into modules and select BND for Plotting
10.	MS	MODULE SCREEN	To screen MODPFN so as to reduce linear overkill
11.	CP	CONTOUR PLOT	To produce a contour plot of a MODDECK in the MODPFN
12.	BP	BOUNDARY PLOT	To plot the BND Coord. with ten X-section flags
13.	PC	PROFILE CONTOUR	To plot X-sections from the contour plot
14.	AD	ARRAY DIFFERENCE	To prepare an array of the difference of the overlap of two arrays
15.	AC	ARRAYDIF CONTOUR	To plot a contour map of the array of differences
16.	BC	BINARY CONTOUR	To plot a contour map using the binary array of contours
17.	NC	NEWBND CONTOUR	To plot a contour map using new BND (Common) Coord. stored on SURIPF
18.	AP	CONTOUR APPLICON	To plot a color contour map using the Applicon Plotter
19.	D3	3 DIMENSION	To plot a three dimension block with BND cut off option
20.	CC	CAPACITY CURVE	To calculate and plot a capacity curve

PFN = Permanent File Name
CNTLPFN = Converted Data (XYZ)
CNTLEDPFN = Data File used to produce a plot to edit PCATDPFN

MODPFN = CNTL Data split into modules
MODDECK = Module Deck Name on MODPFN
SURIPF = Survey Indirect Permanent File
PCATDPFN = Pre Edited Data from Trans (TP)
DUMPPFN = Output Data from Hydac Dump (HD)

is comprised of twenty computer routines written in Fortran is outlined in Table 3. The software package used to generate contours is the General Purpose Contour Program (GPCP) which is available at the Computer Science Centre, Department of Energy, Mines and Resources.

Figure 4 illustrates the five basic steps in processing the field data. The first step is to prepare the data into standard formats and to input the necessary information. Each data point is then processed based on the input information and converted to X and Y coordinates and an elevation. The points are then plotted, visually examined and any erroneous data are edited. Once there are no more corrections and the boundary conditions have been set, the data are gridded and run through GPCP to generate contours. For Lake Diefenbaker, the contours were based on a 30 by 30 m array. The capacities were computed by dividing the module into horizontal slices with the thickness of the slice being selectable. Figure 5 illustrates this approach, the mathematical formulation for obtaining the volume of a slice (Equation 1), and subsequently the total capacity (Equation 2).

2.3 Suspended Sediment Sampling

After the hydrographic data were collected at each range, suspended sediment samples were collected. Three verticals in each cross section were sampled. They were located at one-sixth, one-half and five-sixths of the distance between the banks. Three samples were obtained from each of the three verticals for a total of nine. In each vertical, a sample was collected near the water surface, one at mid-depth and one near the bed,

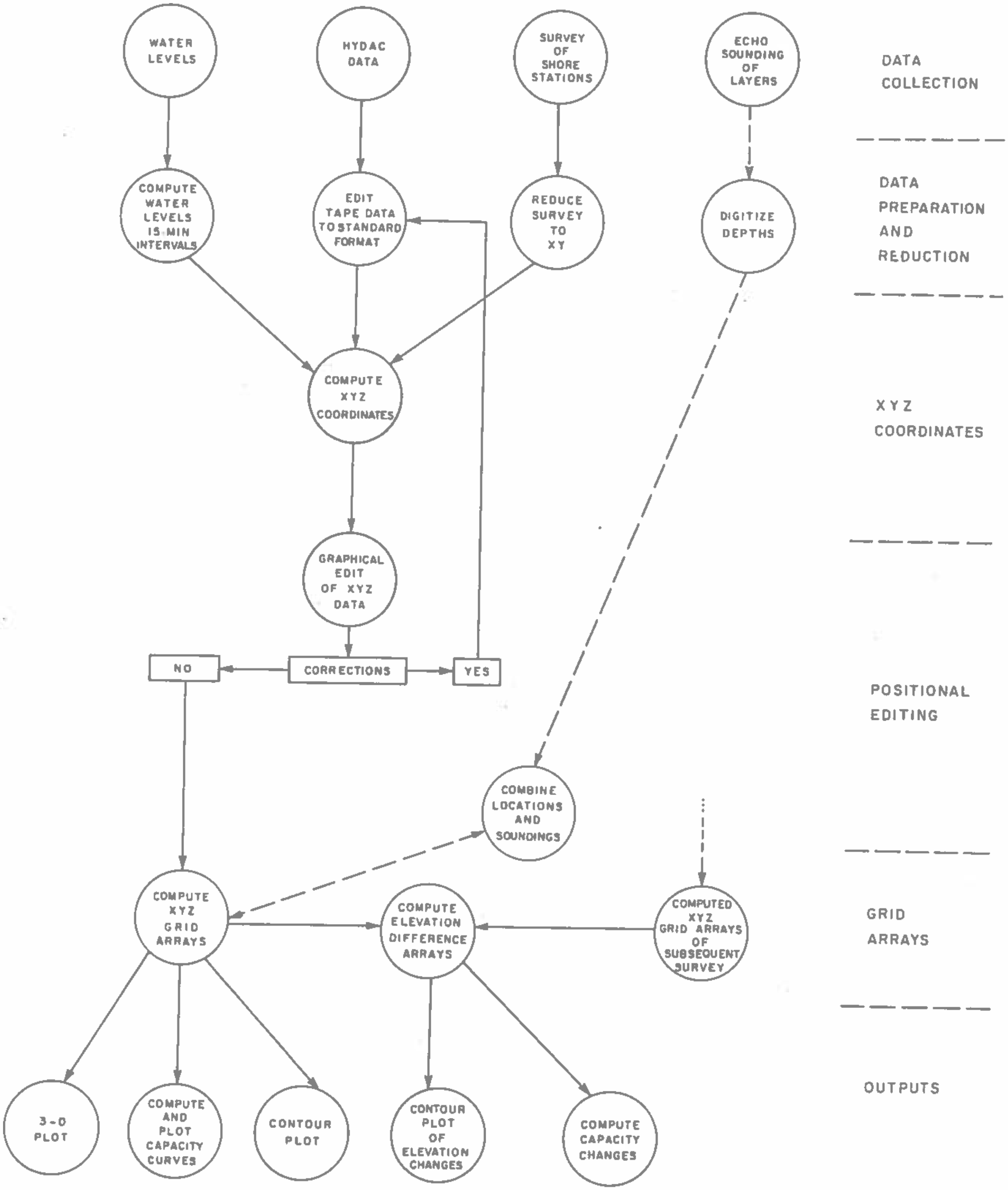


FIGURE 4

HYDRA SYSTEM FLOWCHART

HYDROGRAPHIC DATA REDUCTION AND ANALYSIS

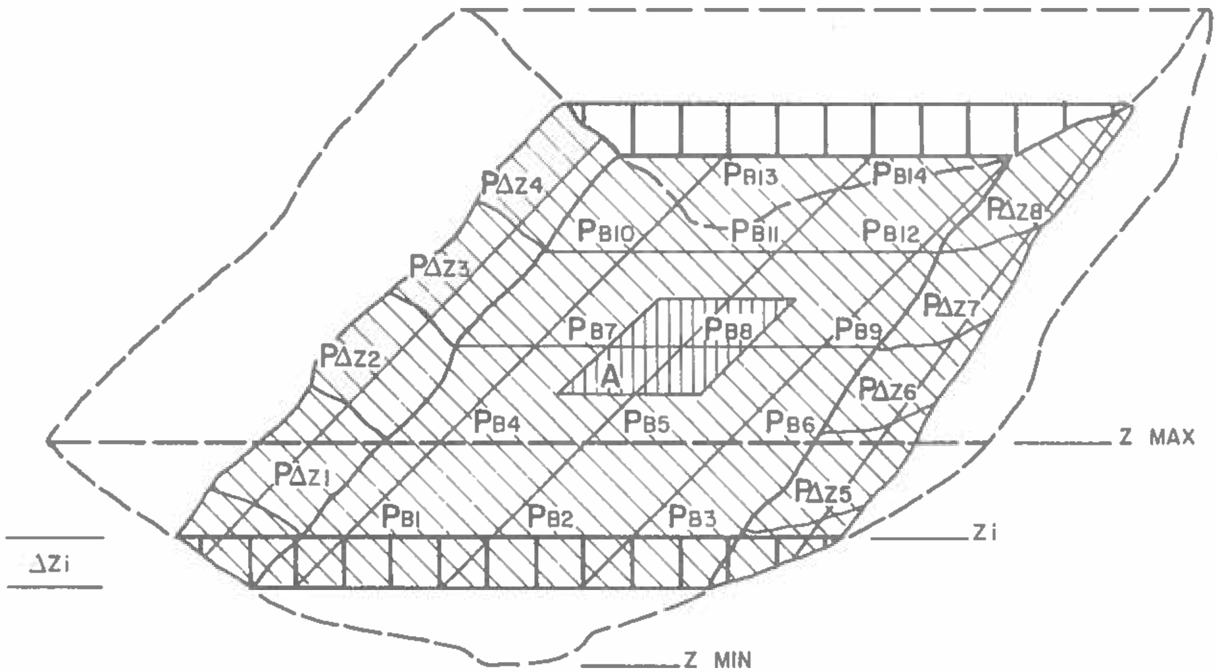


FIGURE 5

ELEVATION-CAPACITY COMPUTATION

$$V_{\Delta z_i} = \frac{1}{2}\,\Delta z_i \left(\sum_{z_i-\Delta z_i}^{z_i} A\, P_{\Delta z_i} \right) + \Delta z_i \left(\sum_{Z_{MIN}}^{z_i-\Delta z_i} A\, P_B \right) \qquad (1)$$

and $$V_{TOT} = \sum_{Z_{MIN}}^{Z_{MAX}} V_{\Delta z_i} \qquad (2)$$

where $V_{\Delta z_i}$ — the volume of the horizontal slice under consideration.

Δz_i — elevation increment defined by the user.

A — Area assigned to each elevation point.

$P_{\Delta z_i}$ — elevation point residing within the elevation increment under consideration.

P_B — elevation points below the elevation $z_i-\Delta z$

V_{TOT} — total volume of water beneath the surveyed area considered.

using an Instantaneous Horizontal suspended sampler. In the upper ranges where there are many channels, a sample was collected from each of them.

These data provided information on the distribution of suspended sediment within a cross section as well as longitudinally in the reservoir. The sediment samples were then analyzed in the laboratory using the evaporation and filtration methods of analysis to determine concentrations; and the bottom withdrawal method to determine particle-size distributions (Guy, 1969).

These sampling procedures, which were implemented in the beginning of the program, have not changed. To collect hydrographic data the most optimum time is when the reservoir is at FSL, therefore ensuring maximum area coverage. However by this time most of the suspended sediment has either settled out of suspension or mixing of the reservoir water has occurred. Since the sediment sampling was undertaken at the same time as the hydrographic surveys it is understandable why this portion of the program has not been very effective. The suspended sediment sampling program was finally discontinued in 1978.

In 1972 sampling was conducted while the reservoir was being filled, and this was the only time suspended sediment samples were of sufficient concentrations to determine particle-size distributions. To obtain particle-size information, concentrations should be in the order of 300 mg/L or have a dry weight of at least 0.5 g.

TABLE 4
SUSPENDED SEDIMENT DATA AVAILABLE

RANGE NO.	YEAR															
	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	C	C	C				C			C				C		
2	C	C		C	C		C			C				C		
3		C				C				C				C		
4		C	C							C				C		
5		C				C				C				C		
6		C	C								C			C		
7										C				C		
8					C					C			C			
9								C			C			C		
10			C				C			C			C			
11		C									C			C		
12					C					C			C			
13				C						C			C			
14								C			C			C		
15							C			C			C			
16										C						
17			C					C						C		
18							C				C		C			
19				C									C			
20					C									C		
21								C			C			C		
22										C			C			
23				C							C			C		
24			C				C				C			C		
25										C			C			
26				C				CP			C			C		
27					C						C			C		
28										C						
29				C	C			CP								
30			C				C	CP								
31					C					C						
32							C									
33								CP								
34										C						
35					C											
36								CP								
37							C									
38																

NOTE: C - CONCENTRATION DATA
P - PARTICLE SIZE DATA

The concentration and particle size data which have been collected over the years are summarized in Table 4.

2.4 Bed Material Sampling

A bed material sample was collected at each of the three verticals used to obtain the suspended sediment samples. In the upper ranges where there are multiple channels, samples were collected in each channel. In most cases samples were collected using a US BM 54 bed material sampler and occasionally the Canadian Drag Bucket (Lane) bed material sampler. As sedimentation occurred, the bed material composition became comprised mostly of loosely deposited silts and clays, making this sampling equipment no longer effective. In 1971, the Phleger 840-A Bottom Corer sampler was introduced into the program for sampling these very low density deposits.

Particle-size distributions were measured by means of sieve analysis for particles larger than 62 mm, and hydrometer analysis for particles less than 62 mm (Guy, 1969). The use of the Phleger Corer made it possible to determine densities. This was done measuring the core length and deriving the volume of the sample. The dry weight of the whole sample when divided by the volume provided the in situ density of the deposited material.

The bed material samples that have been collected are catalogued in Table 5, along with type of information supplied.

TABLE 5
BED MATERIAL DATA AVAILABLE

RANGE NO.	YEAR															
	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1		P	P				P			PD				P		PD
2		P		P	P		P			PD				P		PD
3		P				P								P		PD
4		P	P							P				P		
5		P				P				P				PD		PD
6		P	P								P			PD		
7							P			P			PD	PD		
8		P			P					P						
9			P			P		PD			P			PD		
10			P							P			PD			
11		P	P								P					PD
12					P					P			PD			PD
13				P			P			P			PD			PD
14								PD			P			PD		
15										P			PD			PD
16							P			P						PD
17			P					PD			P			PD		
18						P				P			P			PD
19				P			P			P			PD			PD
20					P						P			PD		
21			P					P			P			PD		
22							P			P			PD			PD
23				P							P			PD		
24						P					P			PD		
25							P			P			PD			
26			P	P				PD			P			PD		
27					P						P			PD		
28			P				P			P			P			P
29				P	P			P						P		P
30						P		P			P			P		P
31					P		P			P			P			
32			P			P					P			P		P
33				P							P			P		P
34							P			P			P			P
35					P			P			P			P		P
36			P								P			P		P
37						P					P					P
38											P					P

NOTE: P - PARTICLE SIZE DATA
D - DENSITY DATA
South Saskatchewan Delta Area (Range 27 - Range 25) - 1975 27 Samples (PD)
- 1980 27 Samples (PD)
Swift Current Creek Delta Area - 1972 37 Samples (PD)
- 1978 13 Samples (PD)
Elbow Area - 1974 31 Samples (PD)

2.5 Water Temperature Data Collection

Originally, water temperature data were collected only at the same nine points as the suspended sediment samples. In 1968, temperature readings were obtained at 1.5 m intervals from the surface to a depth of approximately 18 m, below that depth was every 3.0 m. An electronic thermometer, tied to a 60 m cable, was used for data collection. In 1974 the thermometer malfunctioned part way through the field season and temperature data ceased to be collected. Table 6 depicts when and where temperature data had been collected on Lake Diefenbaker.

Data on surface water temperatures and evaporation rates have been part of an ongoing program with the Atmospheric Environment Service, Environment Canada since 1972 (Environment Canada, 1977). Four sites on the reservoir have been involved in this data collection program.

TABLE 6
TEMPERATURE DATA AVAILABLE

RANGE NO.	YEAR															
	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1		T	T				T									
2		T		T	T		T									
3		T				T										
4		T	T													
5		T				T										
6		T	T													
7							T									
8					T											
9								T								
10			T			T										
11		T														
12					T											
13				T			T	T								
14																
15						T				T						
16										T						
17			T					T								
18						T				T						
19				T			T			T						
20					T											
21								T								
22							T			T						
23				T												
24			T			T										
25							T									
26				T				T								
27					T											
28							T									
29				T	T											
30			T			T										
31					T											
32						T										
33				T			T									
34							T									
35																
36					T											
37						T										
38																

NOTE: T - TEMPERATURE DATA

3. South Saskatchewan River and Swift Current Creek

3.1 Hydrometric Stations

As mentioned earlier there are two tributaries that drain into Lake Diefenbaker, the major one being the South Saskatchewan River, and the other one being Swift Current Creek. Flow and sediment data are available from hydrometric stations that have been established on each of the streams (Table 7).

A hydrometric station was established on the South Saskatchewan River at Lemsford Ferry (STN. NO. 05HB001) in 1958, to collect discharge data, and by 1961 sediment data were being collected at the station as well (Figure 6). However, the station was discontinued in 1970 due to maintenance problems and also because there was concern about the accuracy of data due to backwater effects. A station located further upstream near Hwy 41 (STN. No. 05AK001) and one on the Red Deer near Bindloss (STN. No. 05CK004) provided continuing data after the Lemsford station was closed (Figure 6).

In 1965, a station was set up near the mouth of Swift Current Creek (STN. NO. 05HD037). This station after eight years of operation was moved, due to ice associated problems, to a more ideal location further upstream near Leinan (STN. No. 05HD039) in 1973 (Figure 6), ensuring an unbroken record of data.

TABLE 7

Hydrometric and Sediment Station Data Available

Station	Hydrometric Data Years of Record	Sediment Data Years of Record
South Saskatchewan River at Hwy. 41 (STN. No. 05AK001)	1966-*	1966-*
South Saskatchewan River near Lemsford (STN. No. 05HB001)	1959-1970, 1975	1961-1970, 1975
South Saskatchewan River near Outlook (STN. No. 05HF001)	1947-1966	1948-1961
South Saskatchewan River at Saskatoon (STN. No. 05HG001)	1911-*	1961-1971
Red Deer River near Bindloss (STN. No. 05CK004)	1960-*	1966-*
Swift Current Creek near the Mouth (STN. No. 05HD037)	1965-1972	1965-1972
Swift Current Creek at Leinan (STN. No. 05HD039)	1973-1981	1973-1981
Lake Diefenbaker at Gardiner Dam (STN. No. 05HF003)	1966-*W	
Lake Diefenbaker at Saskatchewan Landing (STN. No. 05HC004)	1968-*W	

* - Still Operating
W - Water Levels Only

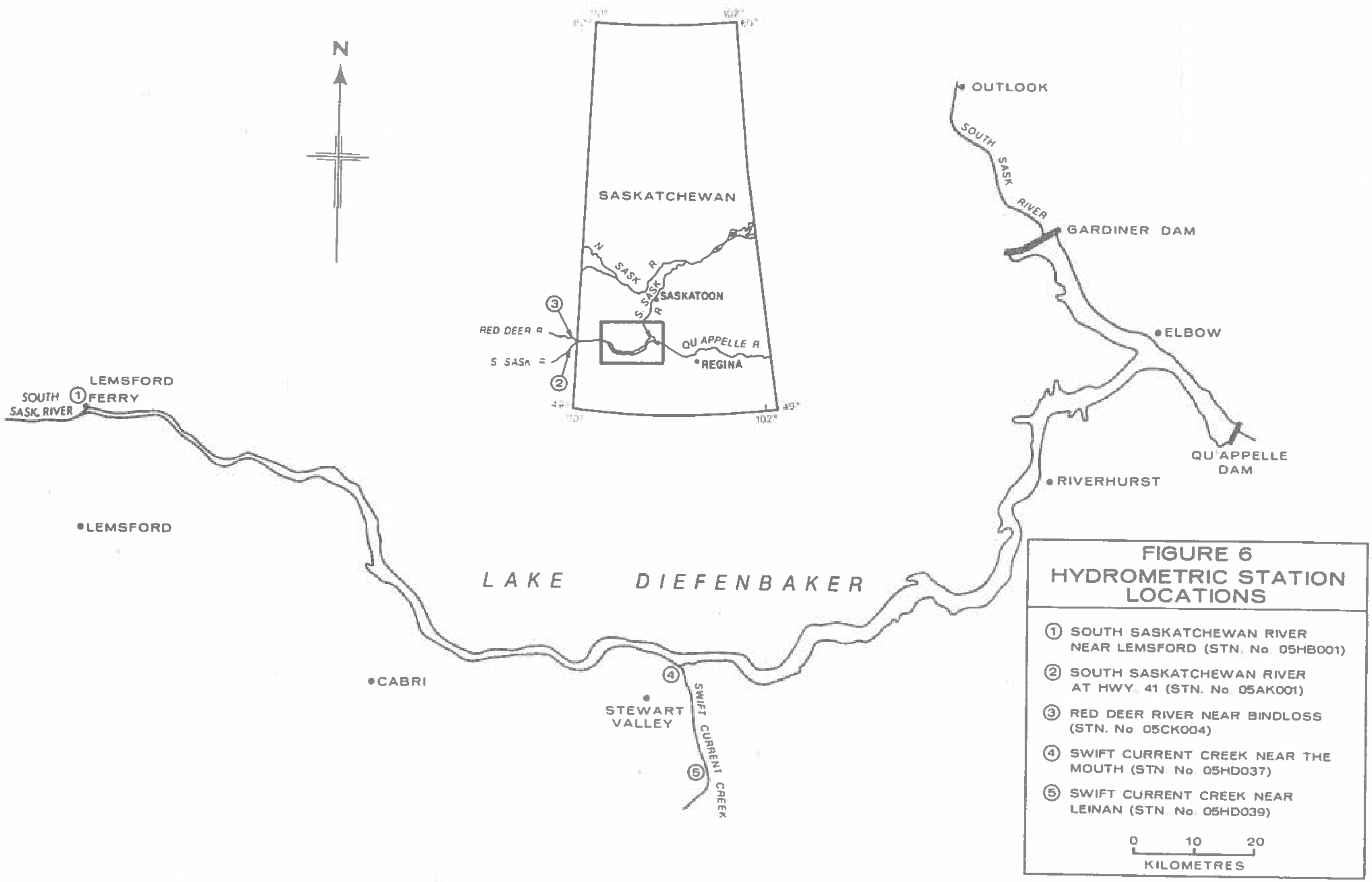


FIGURE 6
HYDROMETRIC STATION LOCATIONS

1. SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD (STN. No. 05HB001)
2. SOUTH SASKATCHEWAN RIVER AT HWY. 41 (STN. No. 05AK001)
3. RED DEER RIVER NEAR BINDLOSS (STN. No. 05CK004)
4. SWIFT CURRENT CREEK NEAR THE MOUTH (STN. No. 05HD037)
5. SWIFT CURRENT CREEK NEAR LEINAN (STN. No. 05HD039)

0 10 20
KILOMETRES

3.2 South Saskatchewan River Hydrology

The South Saskatchewan River drains an area of approximately 120 000 km^2 as it enters Lake Diefenbaker. In terms of the contribution to the flow, this huge drainage basin can be divided into three distinct parts (Berry et al., 1961). The first part of the basin comprises the eastern slopes of the Rockies, while the second part is made up of the foothills east of the mountains. These two parts combined, contribute 92% of the total flow carried by the South Saskatchewan River. The last part of the drainage basin is made up of the prairies, which is the largest in area, but contributes little to the flow. Some reasons why the prairie contribution is so low are: high moisture deficiency, poorly developed drainage and the fact that much of the snowmelt runoff goes into depressional storage (Stichling and Blackwell, 1957).

Flow duration is important in defining the river flow regime and understanding its capacity to transport sediment. With this in mind a flow duration table (Appendix A) was constructed from all the Lemsford data. The maximum daily discharge at Lemsford was 2 890 m^3/s, while the minimum was 23.2 m^3/s. As Figure 7 reveals, the median flow was 146 m^3/s, discharges greater than 579 m^3/s were exceeded 10% of the time, and discharges over 1 490 m^3/s 1% of the time.

Monthly discharges for the period of record show June as the month contributing the greatest amount of flow, with the monthly flow accounting

SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD

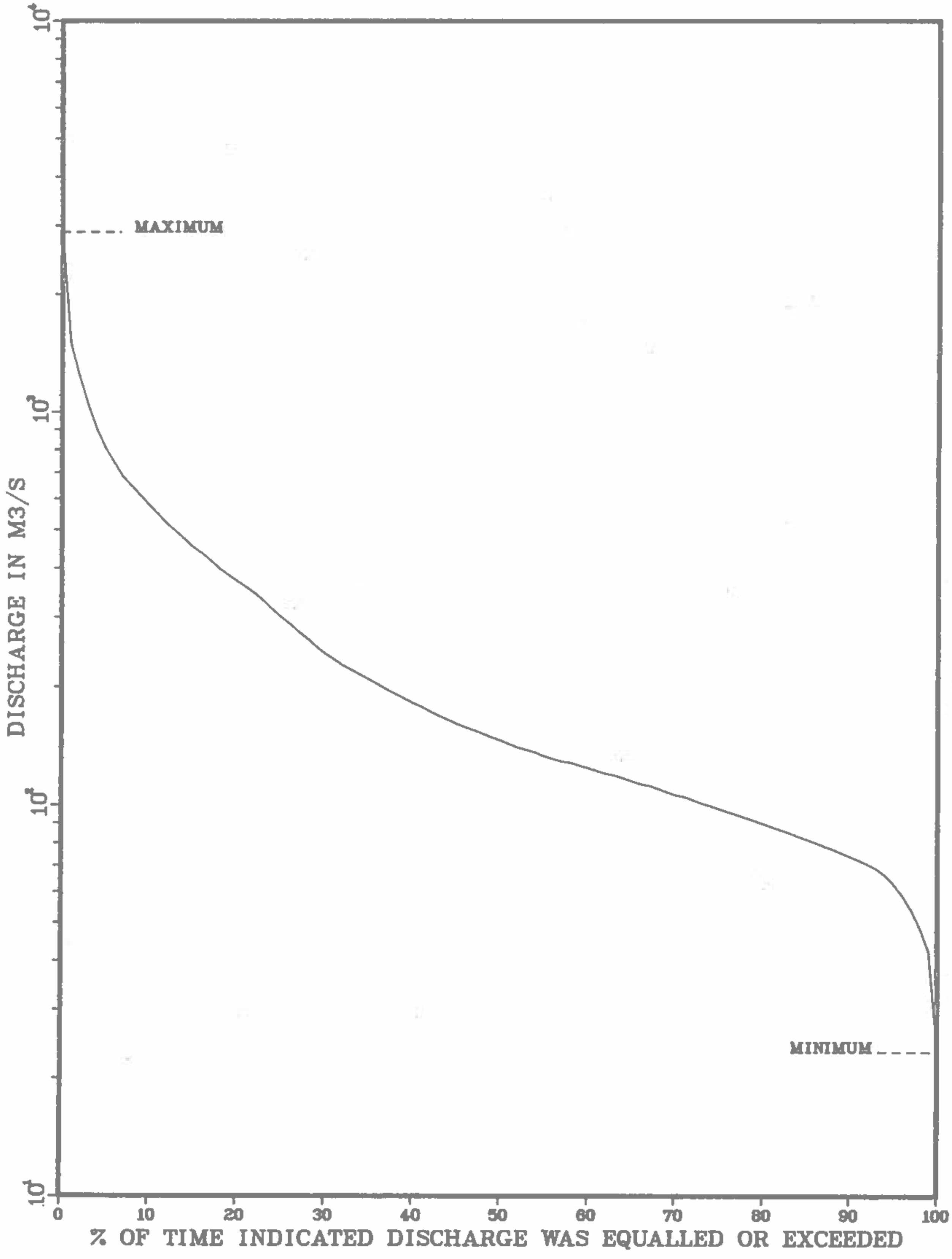


Figure 7
DURATION CURVE OF DAILY DISCHARGES AT LEMSFORD BASED ON AVAILABLE DISCHARGE DATA

for 25% of the total annual flow (Figure 8). It is also the month in which there is the greatest variation in discharges. In most years, the mountain runoff reachs the Lemsford site in June, but occasionally the peak discharge occurrs in early July.

Through correlation analysis it was possible to construct the flows at the Lemsford site based on data from the hydrometric stations located further upstream. Correlation analysis (Figure 9) of the total monthly discharges at Lemsford, and the combined flows for the Bindloss and HWY. 41 stations, available in Appendix B, revealed a high correlation. This correlation equation was then used to reconstruct total monthly discharges at Lemsford, to fill in the missing period from 1971-1980 (Appendix C).

Therefore, using the correlation equation for computation of the total annual flows it was possible to extend the record to 1980. During this 22-year period (Table 8), the South Saskatchewan River had a mean annual flow of 7 679 029 dam^3. The highest year was 1965, with a discharge of 12 007 872 dam^3, while the lowest year was 1977, with only 3 289 421 dam^3 of flow. Based on the average inflow, the reservoir has a total capacity-inflow ratio of 1.22 and can be considered as a hold-over storage reservoir (Brune, 1953).

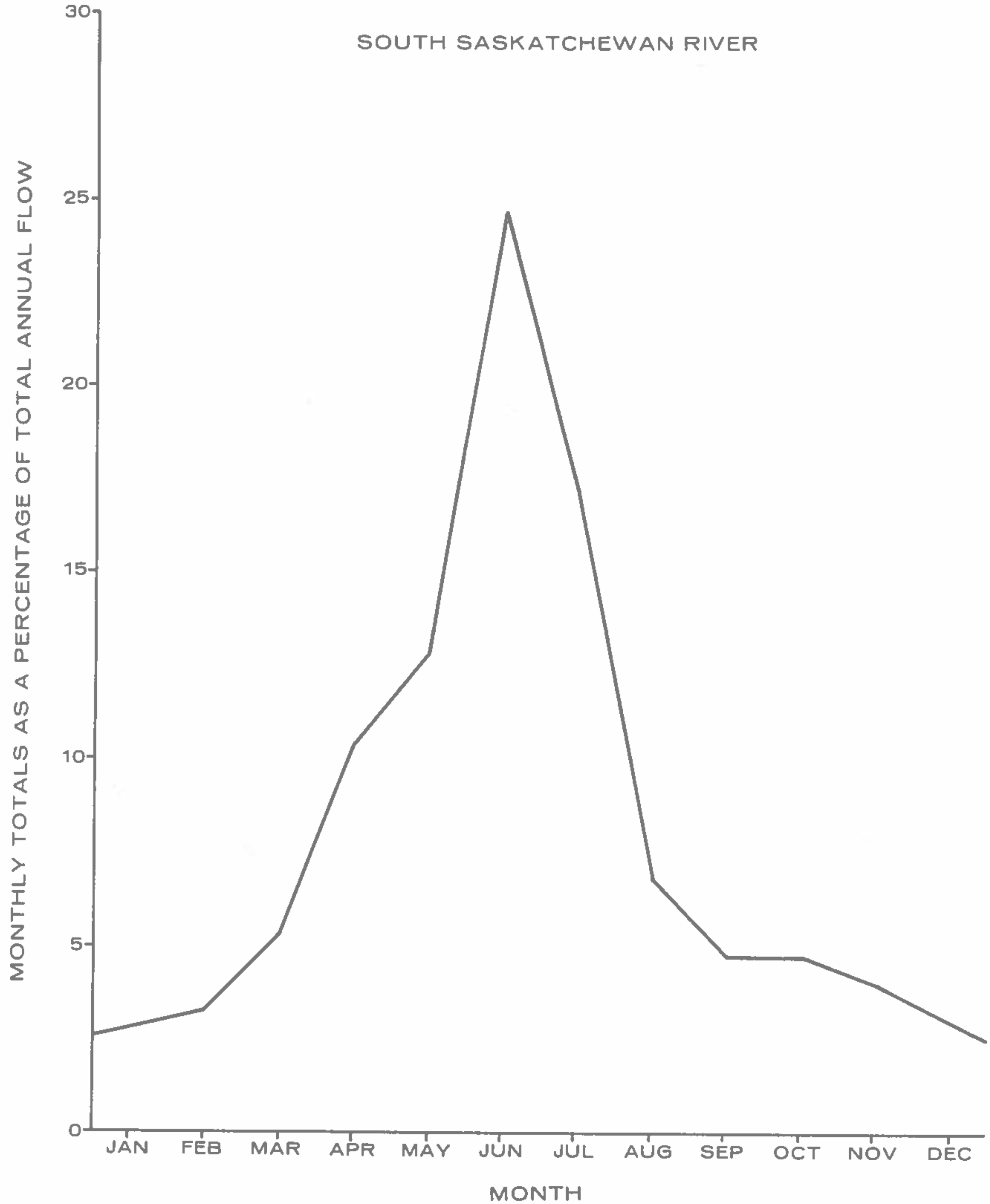


FIGURE 8
MONTHLY CONTRIBUTIONS TO TOTAL ANNUAL FLOW
BASED ON THE LEMSFORD STATION DATA

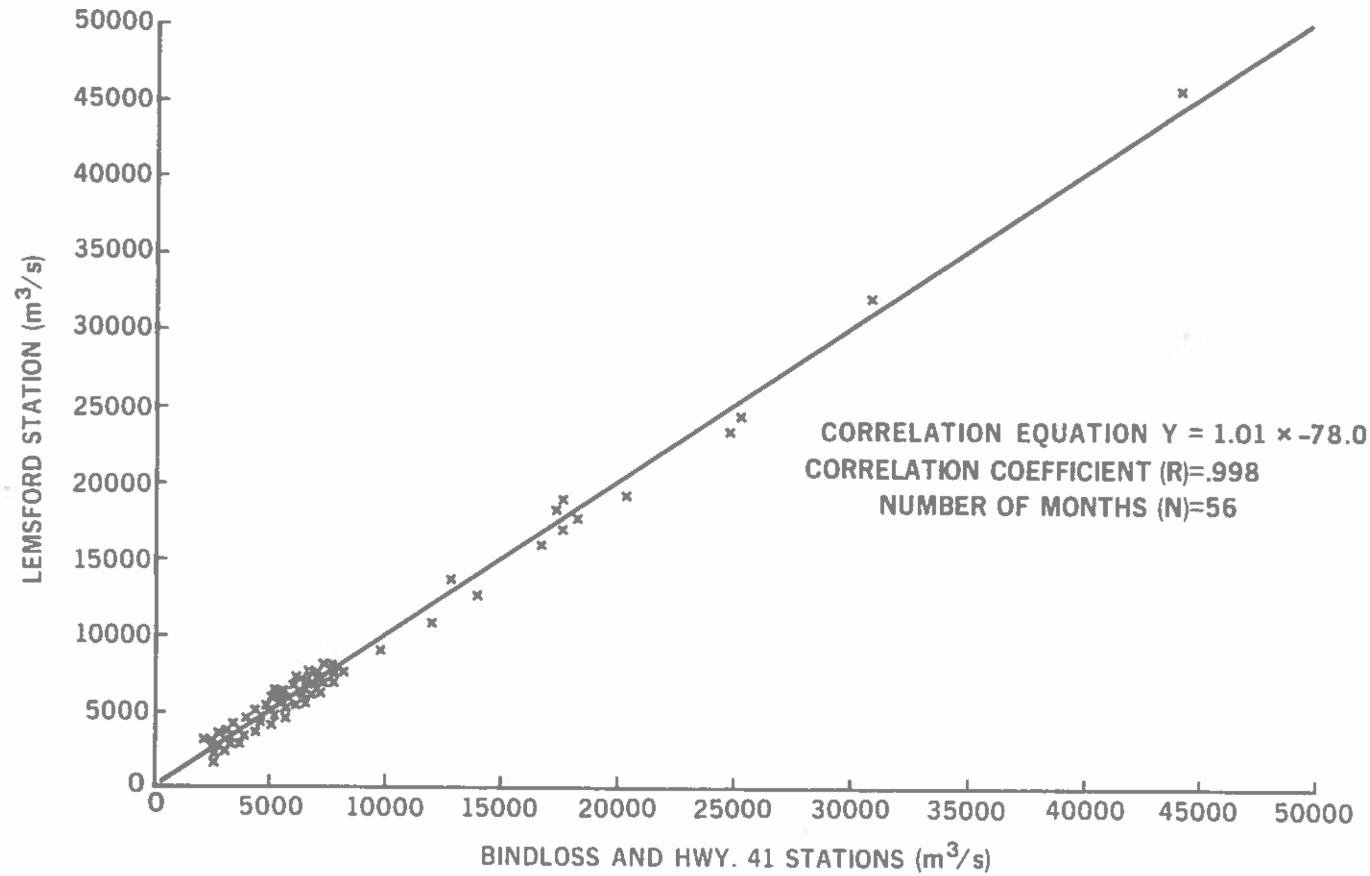


Figure 9
CORRELATION ANALYSIS OF TOTAL MONTHLY DISCHARGES AT LEMSFORD VERSUS BINDLOSS AND HWY 41 COMBINED DISCHARGES

Table 8

Total Annual Flows (dam^3) for the Lemsford Station

Year	Total Annual Flow	Year	Total Annual Flow
1959	8 153 435	1970	6 943 363
1960	6 710 240	1971	8 075 635
1961	5 723 440	1972	10 229 069
1962	5 723 440	1973	6 328 973
1963	6 615 996	1974	9 713 347
1964	7 889 789	1975	8 501 760
1965	12 007 872	1976	6 754 666
1966	8 979 466	1977	3 289 421
1967	11 346 394	1978	8 014 896
1968	6 541 776	1979	4 919 962
1969	10 235 462	1980	6 240 240

MEAN (22 YEARS) 7 679 029

Source: Environment Canada, Surface Water Data Publications

It was determined that total annual flow would be a better parameter than the peak flood for the frequency study, because the South Saskatchewan River is highly regulated. Regulation of discharges tend to affect the peak flood more so than it does the total annual flow values. Frequency analysis is dependent on the number of years of data, and the more years of data, the more representative the distribution will be. Therefore, to increase the number of years of record, flows at Saskatoon (STN. NO. 05HG001) were analyzed. Total annual flows at Saskatoon for the period prior to filling Lake Diefenbaker, which began in late 1964, were correlated with those at Lemsford (Table 9). There existed basically a one to one relationship which meant that the Saskatoon data, which extends back to 1912 could be used in frequency analysis of the South Saskatchewan River near Lemsford.

Table 9

Total Annual Flows (dam^3) at Saskatoon and Lemsford

	Saskatoon	Lemsford
Year	Total Annual Flow	Total Annual Flow
1959	8 153 435	8 293 968
1960	6 710 240	6 906 384
1961	5 723 440	5 644 944
1962	5 734 440	5 865 696
1963	6 615 994	6 622 560
1964	7 889 789	7 694 784

Correlation equation y = 1.0 x -13 336

Correlation coefficient (R) = .979

Number of years (N) = 6

Source: Environment Canada, Surface Water Data Publications

Of the five more commonly used frequency distributions (Condie et al. 1981), the one that produced the best fit, based on coefficients of skewness, kurtosis and the standard error, was the three parameter log-normal distribution (Appendix C). Figure 10, depicts just how well the distribution fits the data. Since filling of the reservoir began in 1964, the greatest return period was 6.364 years, for the 1965 flow. The mean annual flow which corresponds to a return period of 2.333 years, was 8 262 432 dam^3. For a 100-year return period the flow would be in the order of 18 900 000 dam^3, while a 500-year return period would have to produce 23 300 000 dam^3 of flow.

3.3 Characteristics of the Sediment Loads Transported by the South Saskatchewan River

Suspended sediment sampling records for Lemsford showed that the minimum daily concentration was recorded to be 1 mg/L, while the maximum reached a high of 7 200 mg/L. The median concentration was less than 100 mg/L.

A mean annual hydrograph and sediment curve, based on nine years of data, temporally depicts the sediment transport regime (Figure 11). In any one year there are three periods when sediment transport is significant. The first time is in early spring, when snowmelt generates local runoff. The second time, and the most significant period, is when the mountain runoff reaches the site. The third, which is in September, appears not to be

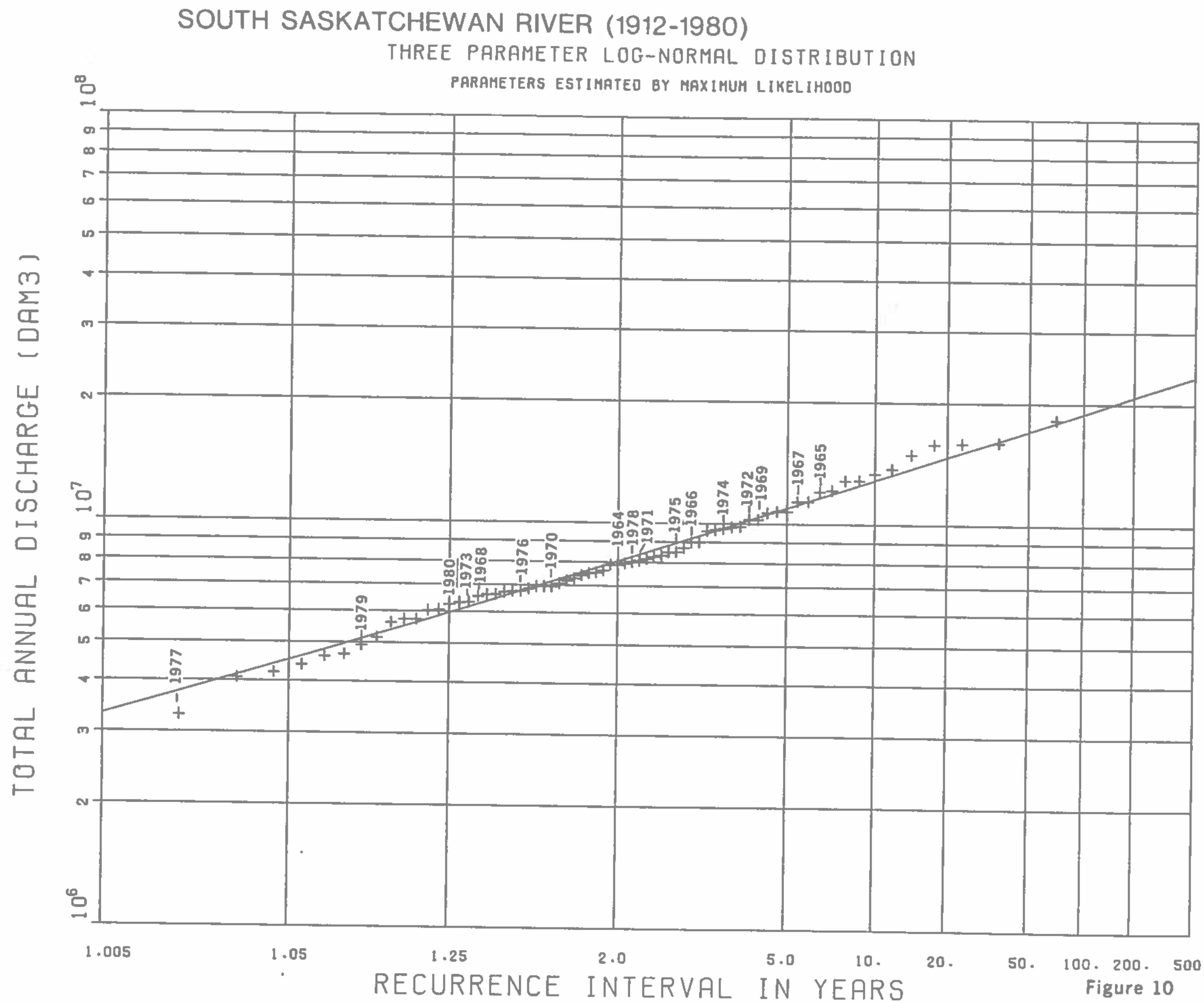


Figure 10
TOTAL ANNUAL DISCHARGE FREQUENCY ANALYSIS FOR THE SOUTH SASKATCHEWAN RIVER

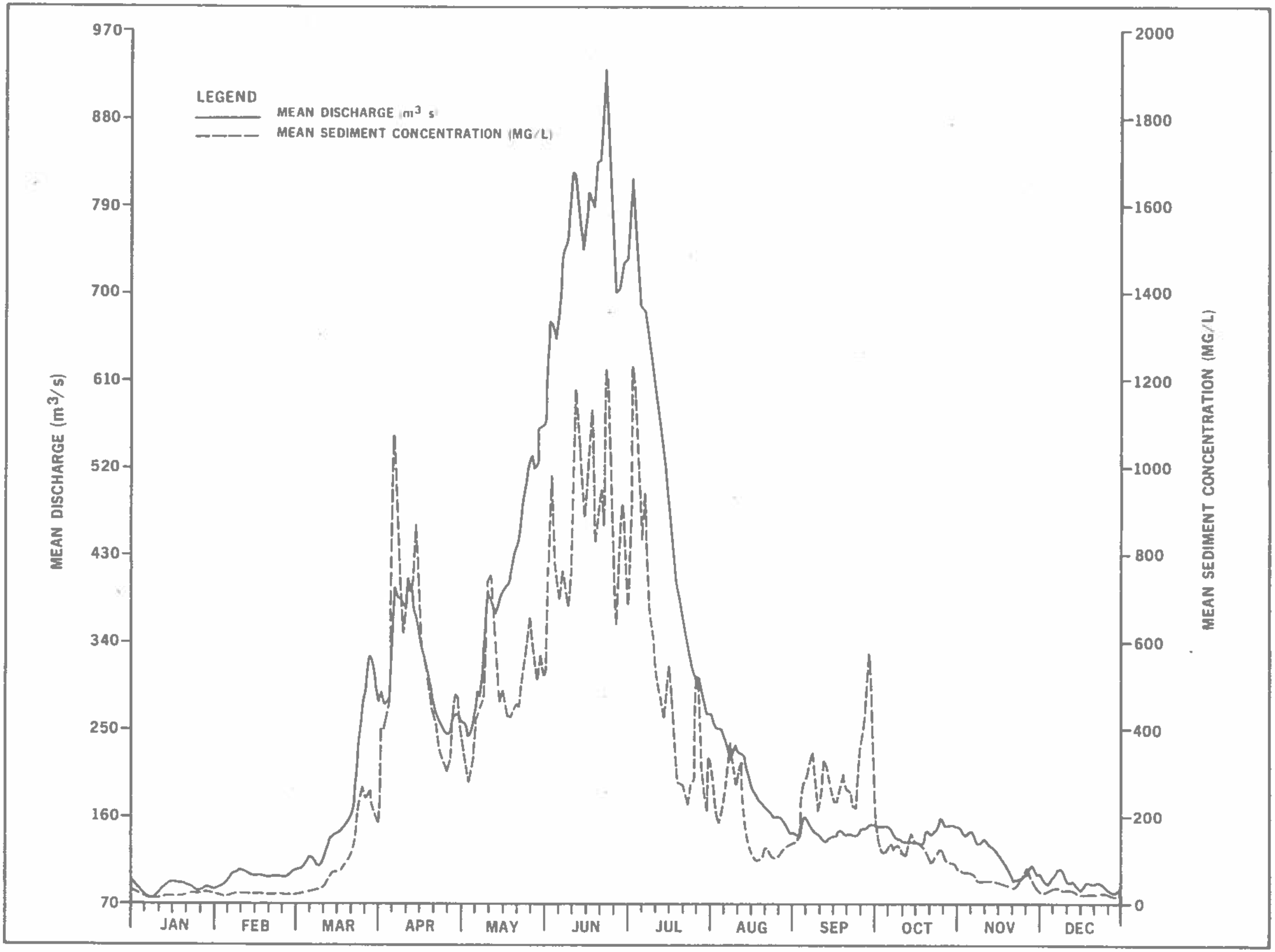


Figure 11
MEAN ANNUAL HYDROGRAPH AND
SEDIMENT CURVE FOR THE LEMSFORD STATION
BASED ON 1962 - 1970 DATA

associated with increased discharge. This increase in concentration is believed to be caused by high concentrations in the water being drained from the irrigation ditches.

Particle-size distributions are not only important in understanding the composition of the suspended sediment loads but more so how it will relate to hydraulics. An examination of the particle-size distribution from the 195 depth integrated samples (Appendix D), revealed that on average, clay made up 38%, silt 41% and sand 28% of the suspended sediment load.

To illustrate the relationship between discharge and suspended sediment, the concentrations from the depth integrating samples were plotted against discharge (Figure 12). The total concentrations showed considerable scatter - in most cases, up to an order of one magnitude. The sand component appears to be well defined, especially when discharges were greater than 400 m^3/s. Most of the samples were collected from the upper median of flow (Q_{50}) because of sample size requirements. This in turn provided good definition of the upper limits of sediment transport for the South Saskatchewan River.

Wash load is commonly defined as that part of the transported sediment load which is comprised of particles not found in significant quantities in the bed (Vanoni, 1975; Tywoniuk, 1972). An analysis of the results of the 49 bed material samples collected from the Lemsford site (Appendix F), indicated that on average silt and clay comprised less than 5%

SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD

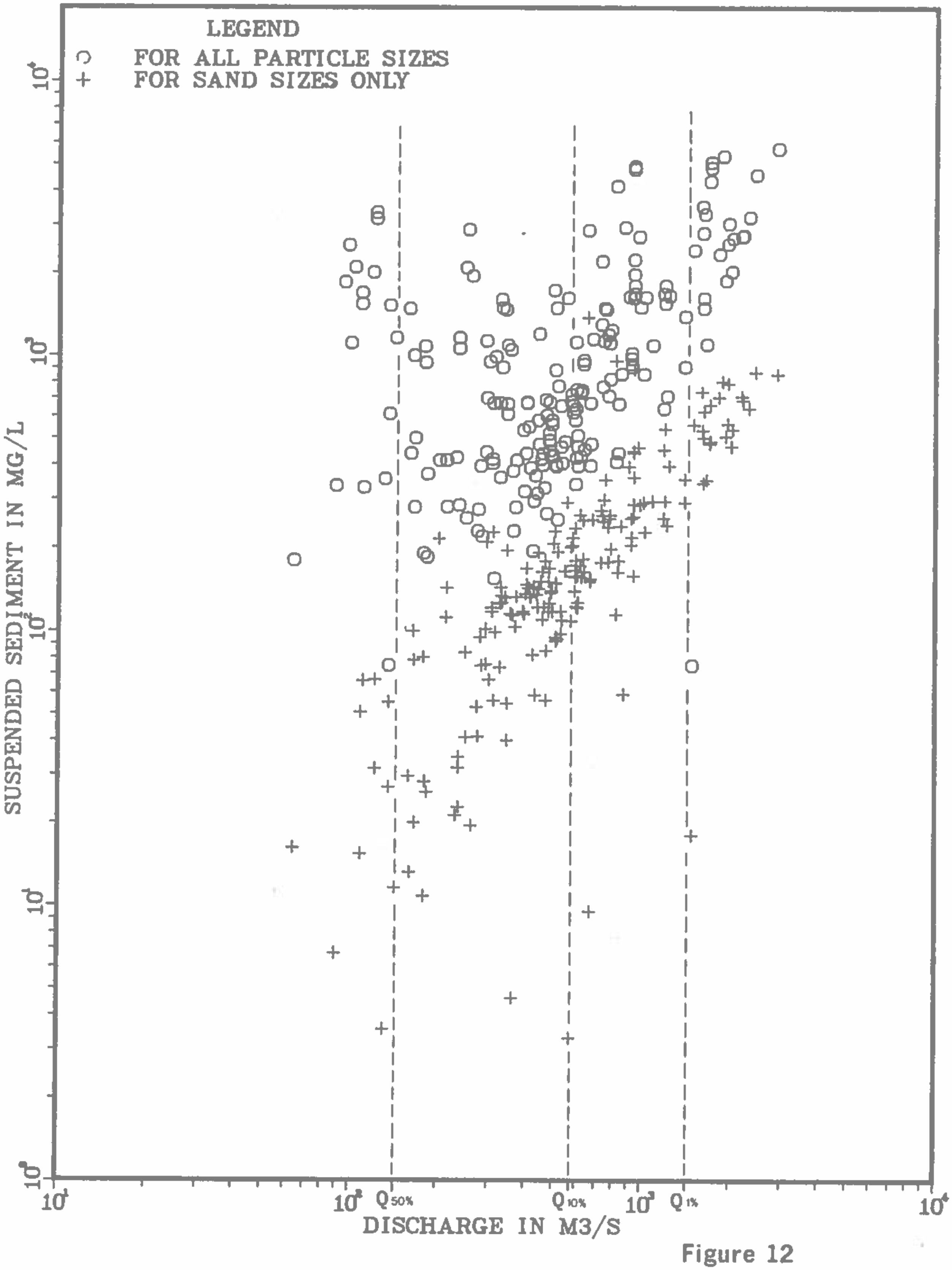


Figure 12
CONCENTRATION RELATIONSHIPS
TO DISCHARGE

of the bed. Therefore, based on this definition, silt and clay can be considered to be the wash load component. Wash load has been found to be controlled by basin supply rather than hydraulics (Kellerhals et al., 1974), therefore explaining the poor relationship to discharge (Figure 12).

Wash load was found to make up a greater portion of the load as concentration increased (Figure 13) suggesting there is an adequate supply of sediment from the basin. However, as discharges increased, there was marked declines in the wash load contribution (Figure 14). This is probably because the stream's energy is being expended on bed material transport, which in the case of the South Saskatchewan River is primarily sand. Therefore, in proportion the wash load contribution would be reduced.

To illustrate the sorting characteristics of the South Saskatchewan River, samples' gradings were plotted against discharge (Figure 15). From this it appears the suspended load is widely graded, as would be expected from a river with a high wash load component. Furthermore, gradings appeared to be consistent even at higher discharges. The mean particle size shows the variability attributed to the wash load component (Figure 16). As expected there is no trend over the range of discharges. The D_{50s}', were all in the coarse clay to very fine sand range.

Further analysis of the sand component of suspended sediment load indicated that it was narrowly graded, with no apparent change with discharge (Figure 17). The mean particle size appears to be somewhat constant over the range of discharges, with most of the D_{50s} being in the very fine to fine sand range (Figure 18).

SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD

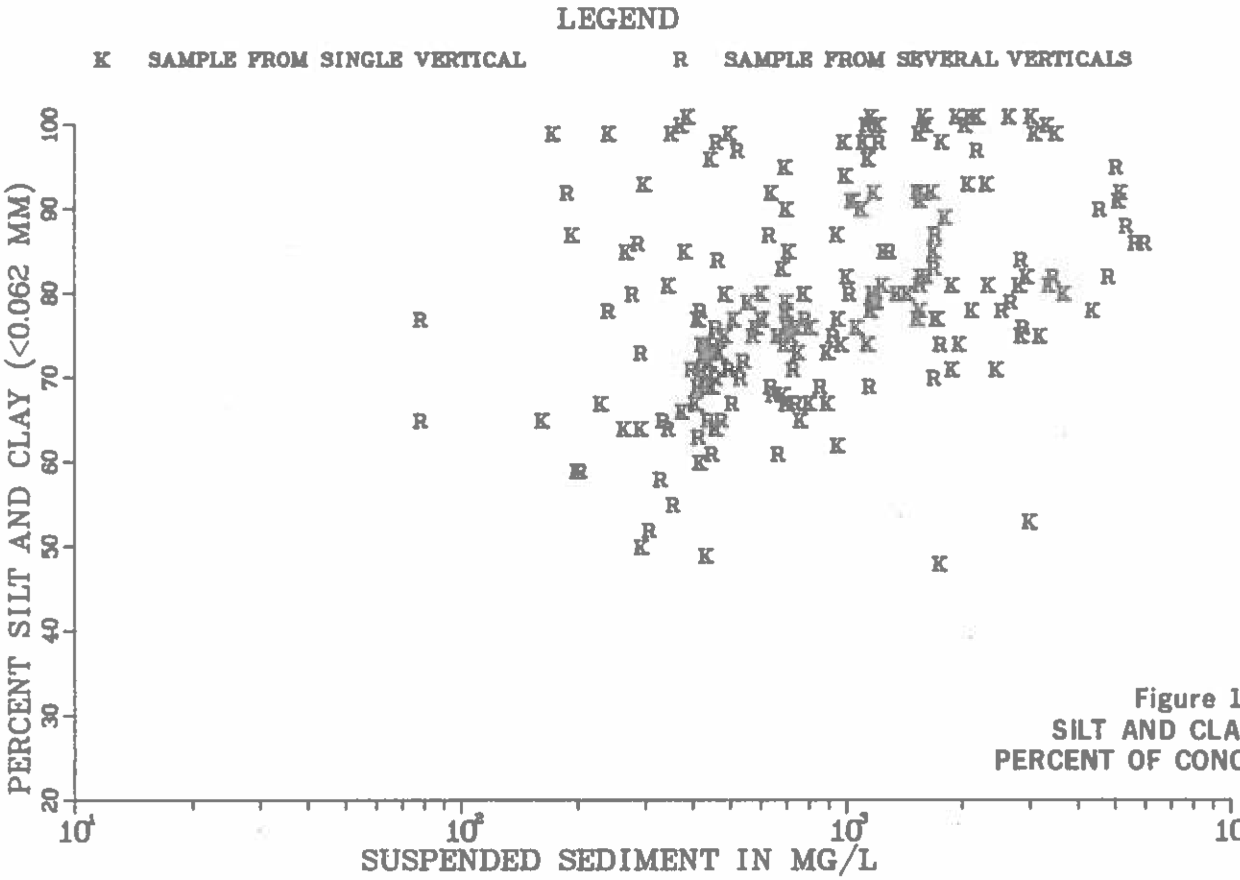


Figure 13
SILT AND CLAY AS A
PERCENT OF CONCENTRATION

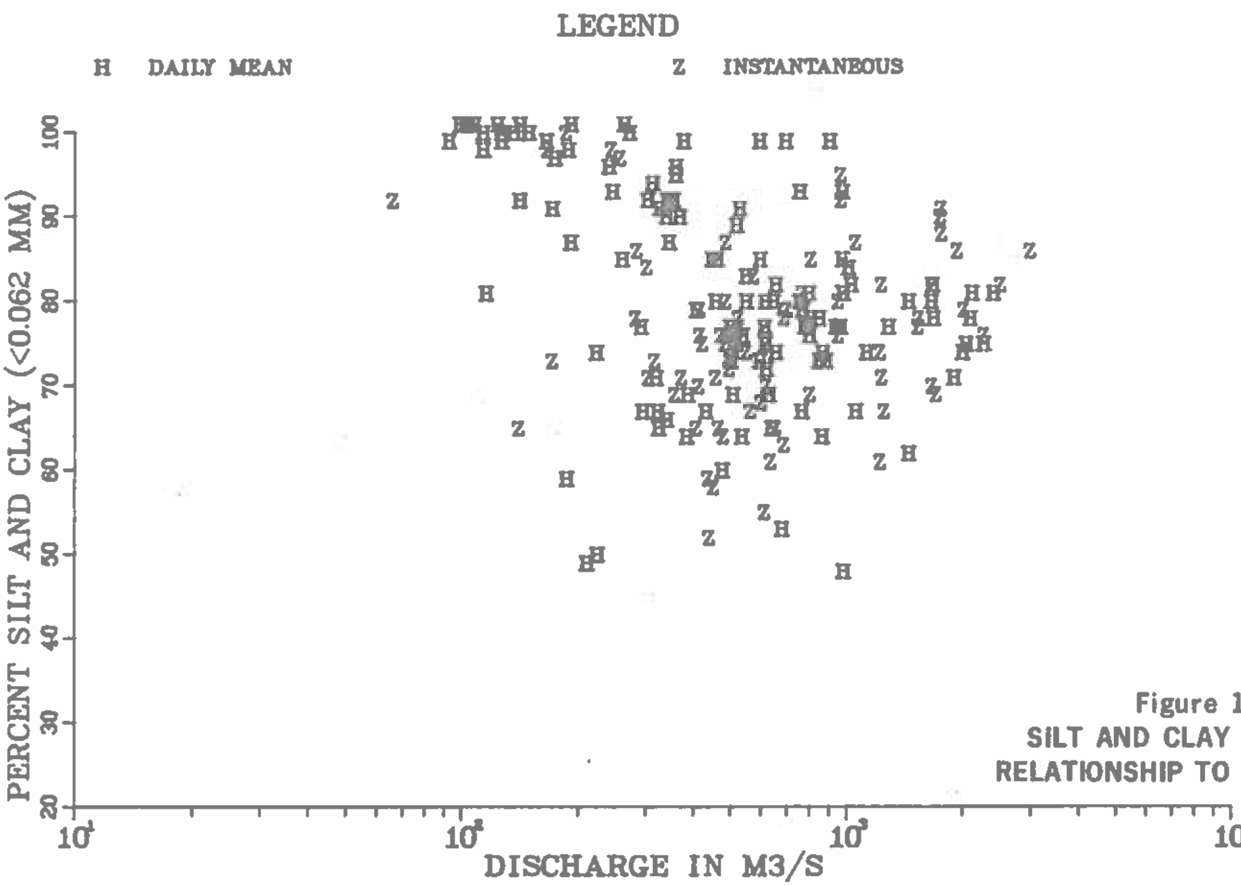


Figure 14
SILT AND CLAY PERCENT
RELATIONSHIP TO DISCHARGE

SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD

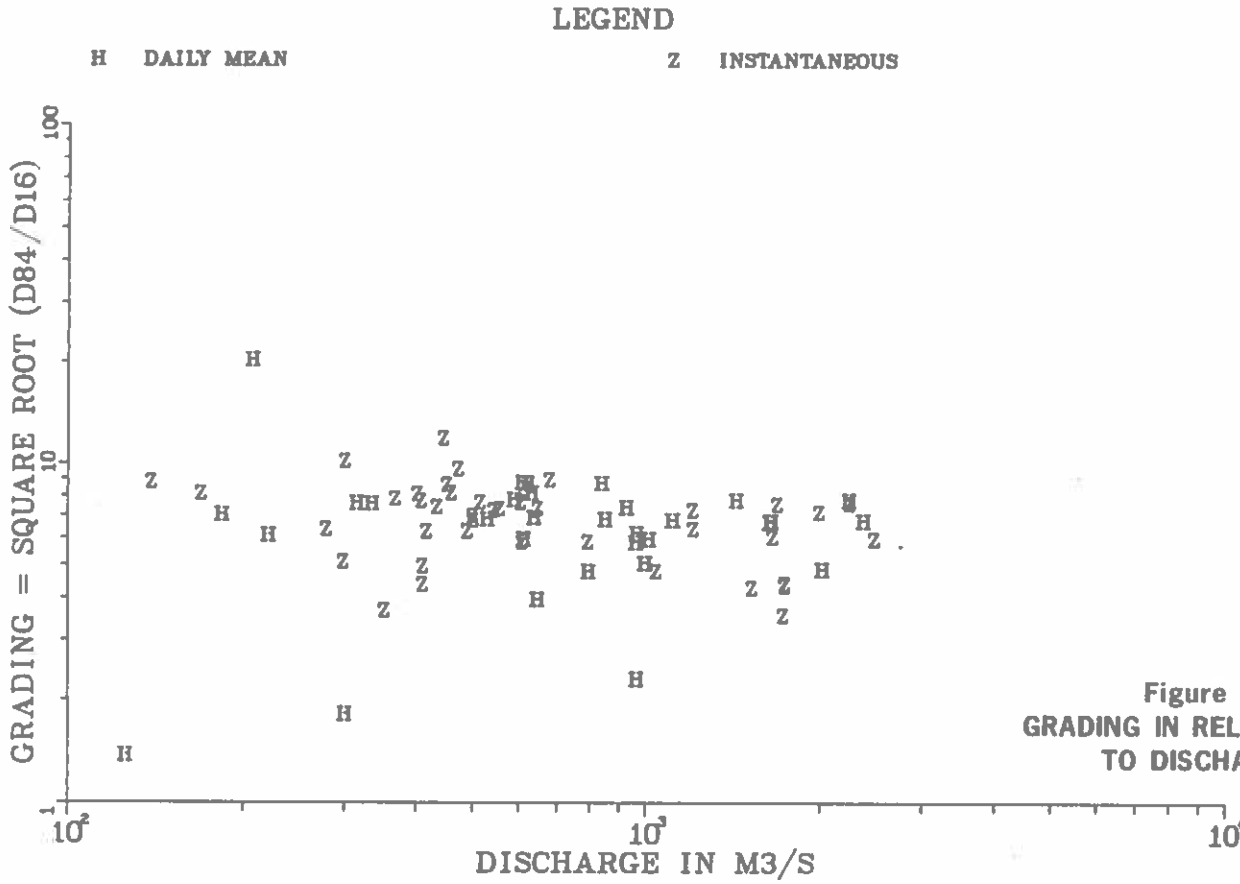


Figure 15
GRADING IN RELATIONSHIP TO DISCHARGE

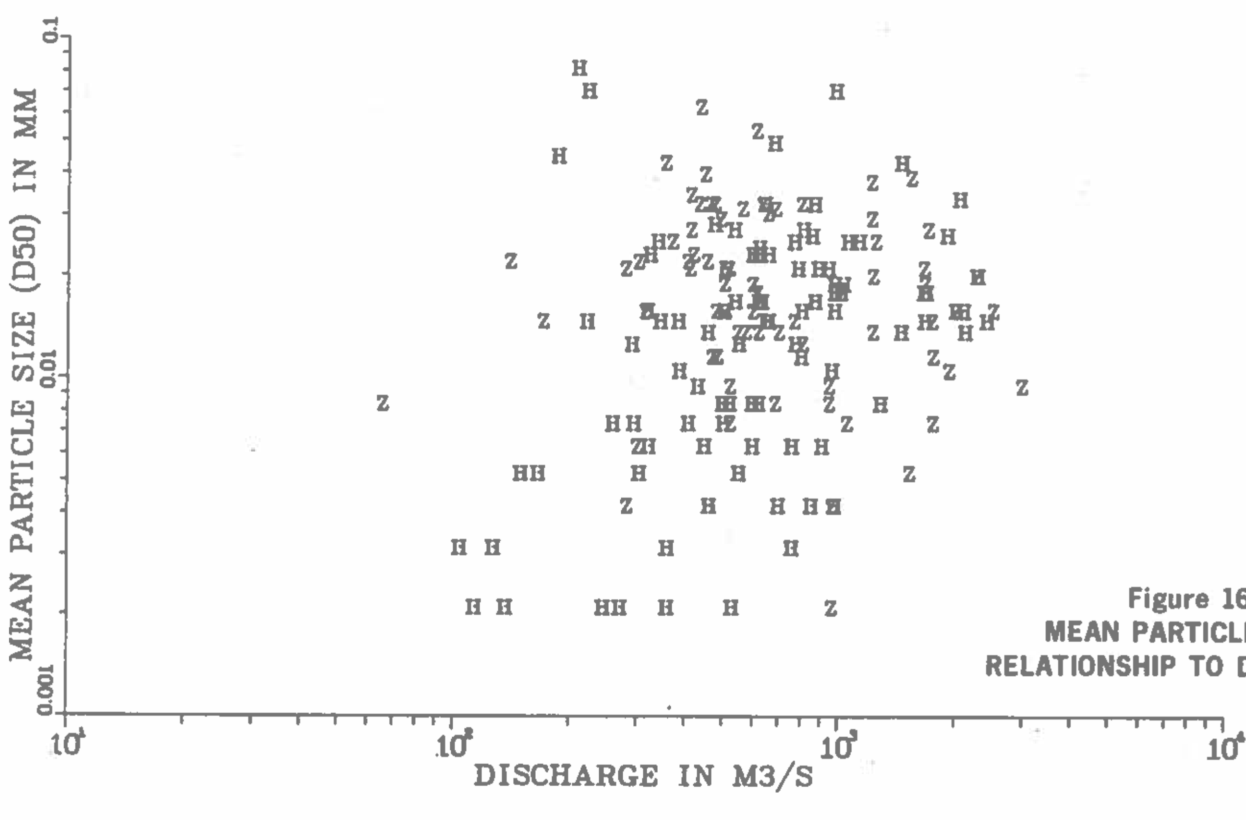


Figure 16
MEAN PARTICLE SIZE RELATIONSHIP TO DISCHARGE

SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD

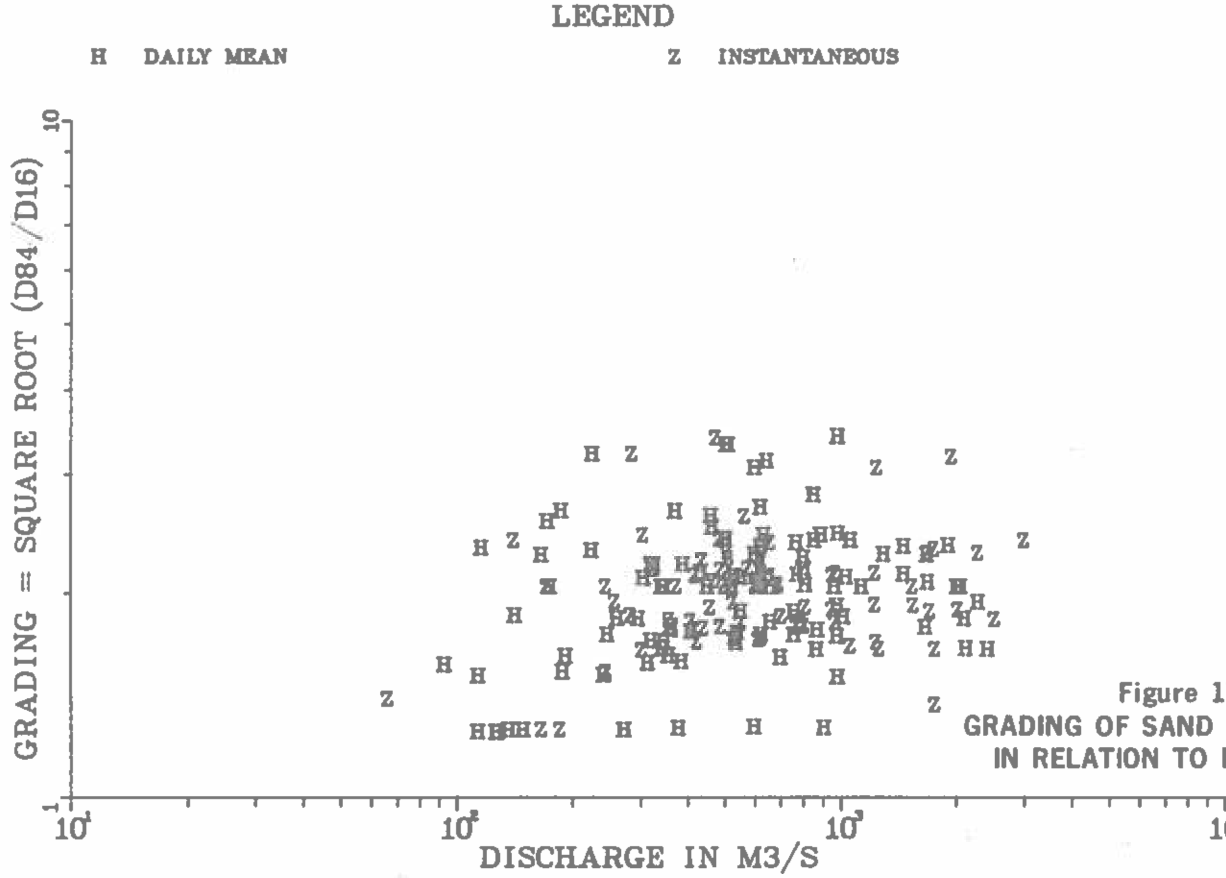


Figure 17
GRADING OF SAND COMPONENT
IN RELATION TO DISCHARGE

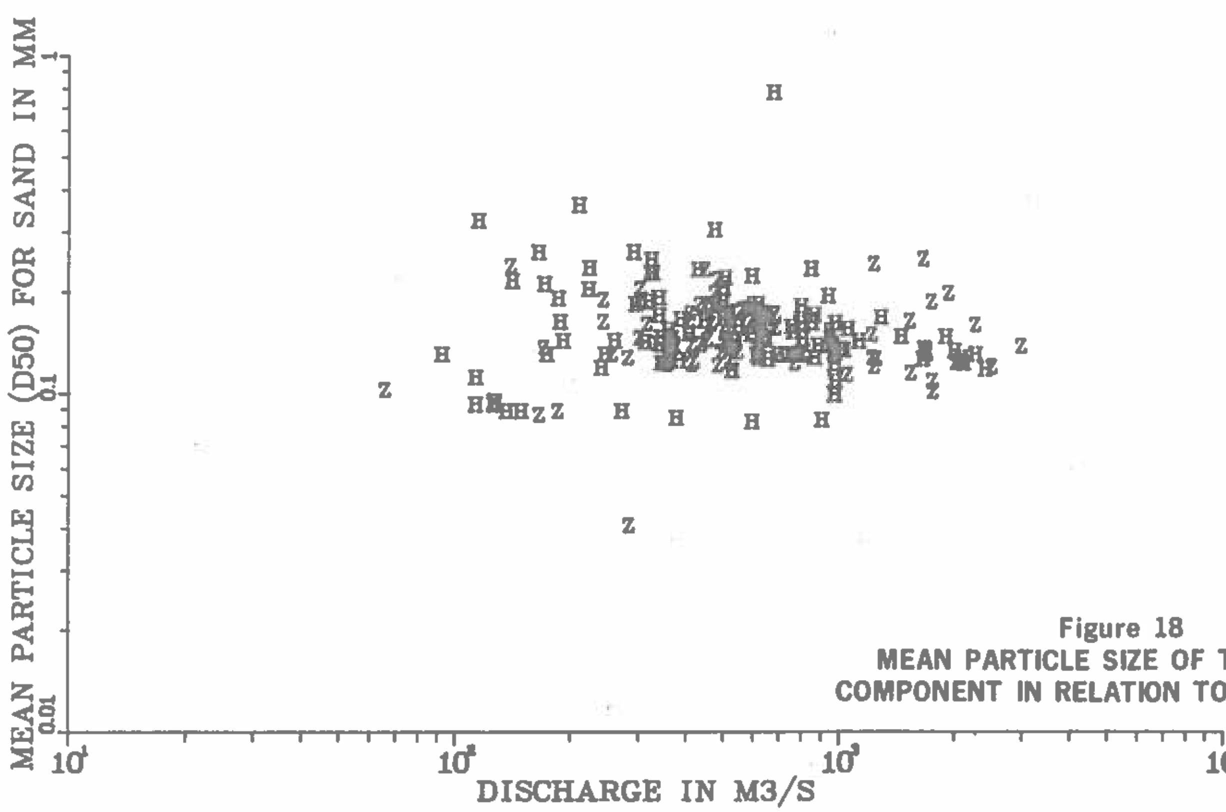


Figure 18
MEAN PARTICLE SIZE OF THE SAND
COMPONENT IN RELATION TO DISCHARGE

Bed material sampling results (Appendix E) revealed that on average silt and clay comprised 5% of the sample, sand 87% and gravel the remaining 8%. The mean particle size of the bed material in most cases was found to be within the fine to medium sand range. The gradings show that the bed has remained fairly homogeneous over the years of sampling.

There has never been any bed load sampling conducted on the South Saskatchewan River. To date the only successful bed load sampling has been restricted to streams with beds of coarse sand and gravel (Nordin, 1981). The South Saskatchewan River bed is made up of fine sands; below what is considered optimum for sampling. Bed load in most cases has been found to make up between 5-20% of the total sediment load (Tywoniuk, 1972). Kuiper (1962), estimated using the Einstein method, that bed load only made up 5% of the total load transported by the South Saskatchewan River. Since, in this study, the suspended sediment loads have only been extrapolated, adding an arbitary bed load contribution would not significantly affect the results.

A comparison of the monthly suspended sediment loads at Lemsford to the combined loads of Bindloss and Hwy. 41 (Appendix F) provided a strong correlation (Figure 19). This correlation equation was then used to reconstruct the monthly loads at Lemsford and continue the period of record to 1980.

During these 19 years, the South Saskatchewan River transported an average suspended sediment load of 5 403 249 tonnes. The maximum annual sediment load transported was 11 438 266 tonnes in 1967, the minimum load was computed to have been 633 963 tonnes in 1977 (Table 10).

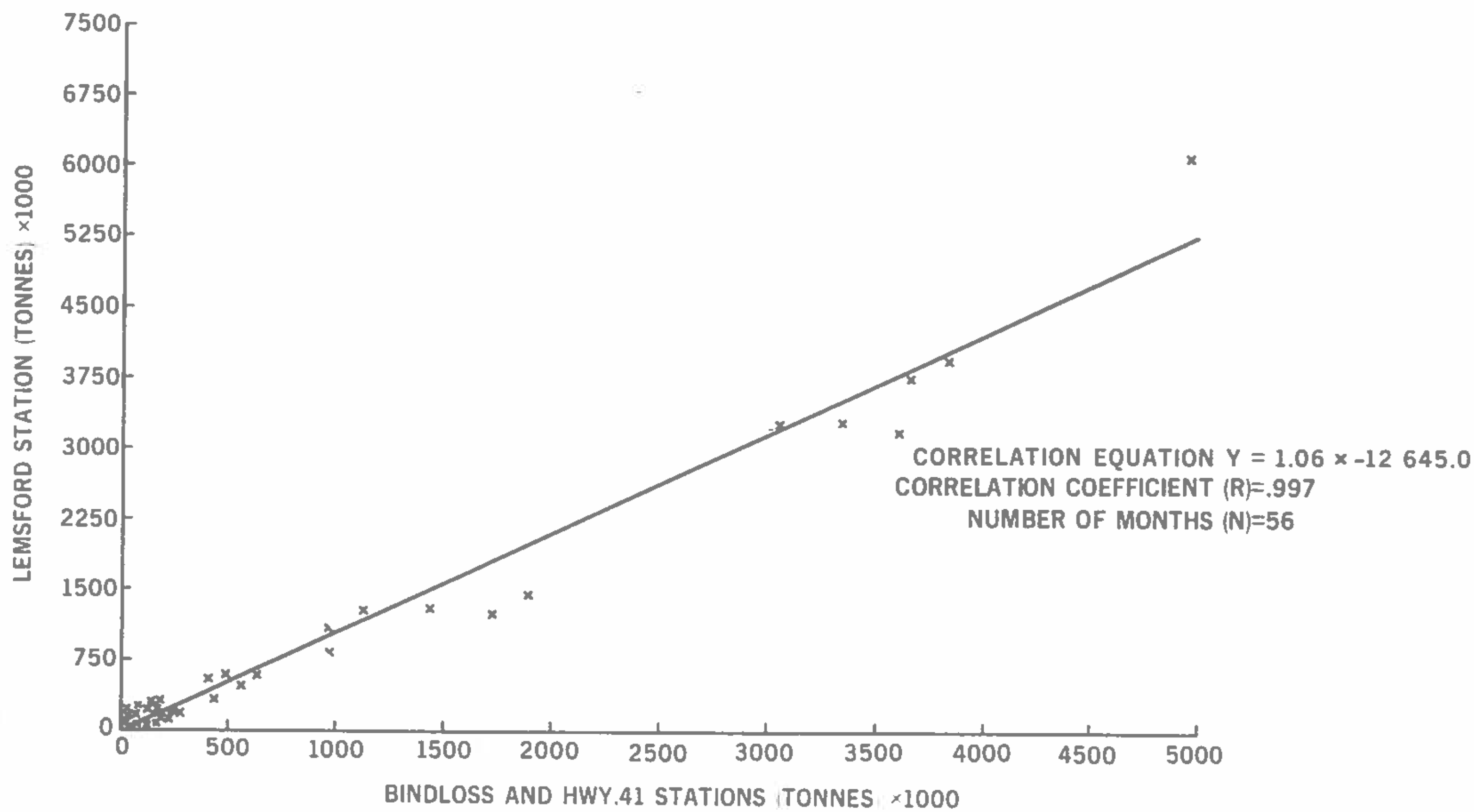


Figure 19

CORRELATION ANALYSIS OF TOTAL MONTHLY SEDIMENT LOADS AT THE LEMSFORD STATION VERSUS THE COMBINED LOADS OF THE BINDLOSS AND HWY 41 STATIONS

Table 10

Total Annual Suspended Sediment Loads (Tonnes) for the Lemsford Station

Year	Annual Suspended Sediment Load	Year	Annual Suspended Sediment Load
1962	1 643 330	1972	6 560 327
1963	4 433 330	1973	2 312 512
1964	6 989 409	1974	9 793 671
1965	8 818 661	1975	8 974 955
1966	4 738 083	1976	2 188 859
1967	11 438 266	1977	633 963
1968	2 410 830	1978	4 204 436
1969	9 576 518	1979	1 443 823
1970	5 111 928	1980	4 155 063
1971	7 233 764	MEAN (19 YEARS)	5 403 249

Source: Environment Canada, Sediment Data Publications

3.4 Swift Current Creek Hydrology

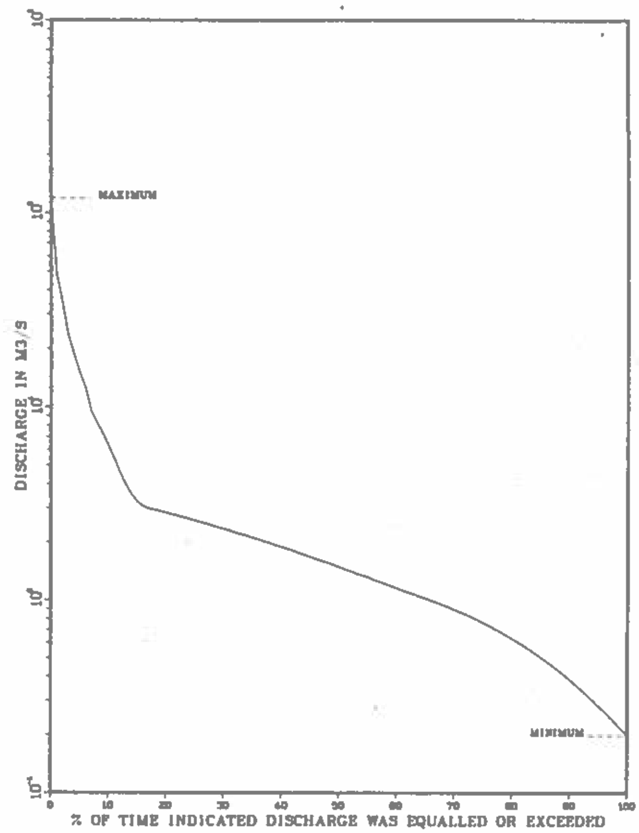
Swift Current Creek drains an area of 3 910 km^2 as it discharges into Lake Diefenbaker. The creek has been regulated since 1942, with the establishment of Reid Lake. The station, Swift Current Creek near the Mouth (STN. NO. 05HD037) operated from 1965 to 1972, but was moved eight kilometres upstream to Leinan (STN. NO. 05HD039) in 1973, reducing the gross drainage area to 3 720 km^2. Initially, the station was operated on a eight-month basis - March to October, but since 1973, discharge data have been collected year round. The sediment data collection program has always been operated only during the open-water period.

The winter months do not account for much of the total annual flow. In fact, based on Leinan data, less than 12% of the total flow was contributed from this four-month period. Since the eight-month period was common to both sites, only that period has been used for comparative purposes.

During the period from 1966 to 1978, a maximum daily discharge of 119 m^3/s and a minimum of .027 m^3/s were recorded for Swift Current Creek. As Figure 20 shows, discharges were significantly less during the period from 1973 to 1978. Flow duration tabulations for the two sites (Appendix G), revealed that the flow regime has changed significantly. A comparison of the median flows from the two periods revealed a reduction of almost 60% in the discharge. This reduction in flow is not considered to be man-induced but just a drier period of record for the prairies. The period from 1973 to 1978 is important for this study, since the hydrographic survey of the mouth region was conducted in 1972 and again in 1978.

Table 11 lists the total annual flows for the 13-year period, of which the maximum annual flow was 121 046 dam^3 in 1967, and the minimum was 10 195 dam^3 in 1973. The mean annual flow was calculated to have been 58 606 dam^3.

SWIFT CURRENT CREEK NEAR THE MOUTH



SWIFT CURRENT CREEK NEAR LEINAN

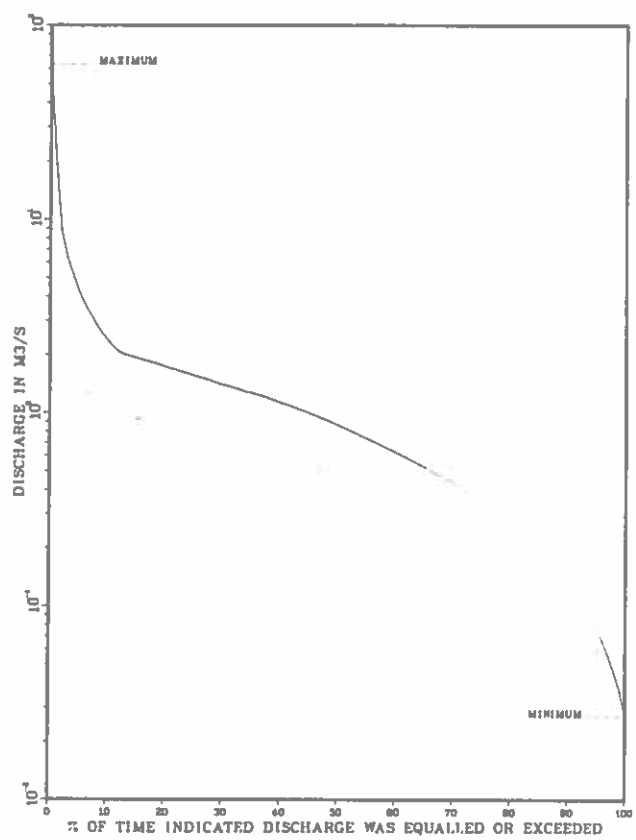


Figure 20
DURATION CURVES OF DAILY DISCHARGES FOR THE TWO STATIONS

Table 11

Total Annual Flows (dam^3) for Swift Current Creek

Year	Total Annual Flow	Year	Total Annual Flow
1966	77 501	1973	10 195
1967	121 046	1974	44 323
1968	37 843	1975	44 852
1969	80 265	1976	66 701
1970	119 318	1977	13 910
1971	99 446	1978	21 859
1972	24 883	MEAN (13 YEARS)	58 606

Source: Environment Canada, Surface Water Data Publications

3.5 Characteristics of the Sediment Loads Transported by Swift Current Creek

Based on findings from the suspended sediment sampling program on Swift Current Creek the minimum daily concentration was 1 mg/L, while the maximum was 4 340 mg/L. For Leinan, the median concentration was determined to be 18 mg/L.

During the period from 1965-1972, there was a distinct freshet flow accounting for most of the sediment transport (Figure 21). More than 90% of the total suspended load carried by the creek was during the month of April.

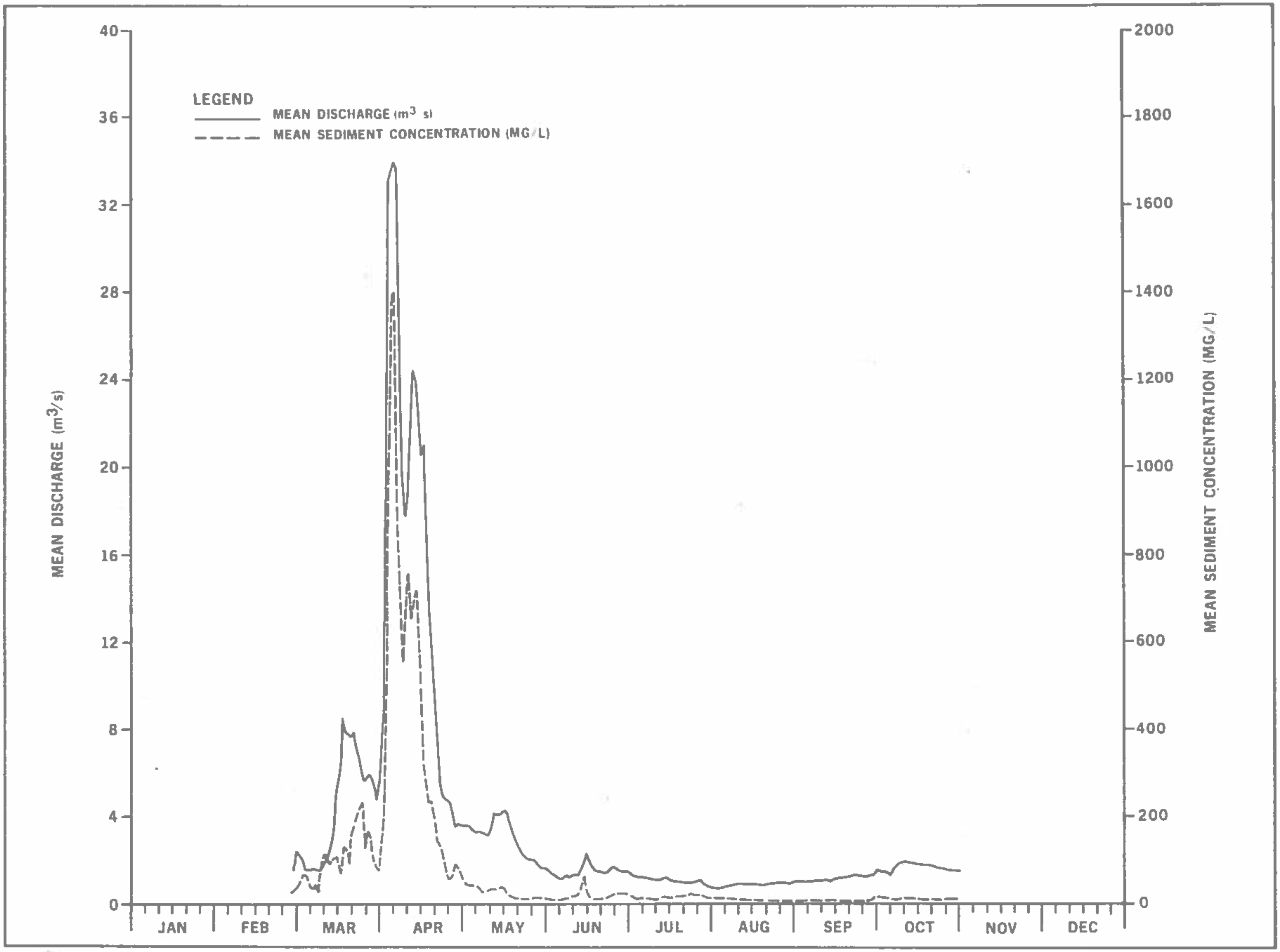


Figure 21
MEAN ANNUAL HYDROGRAPH AND SEDIMENT CURVE FOR THE SWIFT CURRENT NEAR THE MOUTH STATION
DATA COLLECTED FROM 1965 - 1972

However, from 1973-1978 the sediment loads were significantly less, due to the dramatic decrease in the magnitude of the freshet flows (Figure 22). The mean peak concentration was reduced to 25% of what it had been for the prior eight years.

There were 77 depth integrating samples analyzed for particle size (Appendix H) for the station near the mouth. The results show that on average a sample would be made up of 19% clay, 53% silt and 28% sand. Unfortunately, only one sample was collected and analyzed for its particle-size distribution at the Leinan site. Almost all the samples were collected in the upper 10% of the flow range. Total concentration varied an order of magnitude, while the sand component showed even greater variation (Figure 23). This is considered common for flashy streams such as Swift Current Creek. The silt and clay fraction showed a marked decline with increasing discharge, which suggests that availability of sediment from the basin is limited (Figure 24). There was a distinct decline in the silt/clay to discharge relationship with increasing discharge (Figure 25). This was similar to what occurred on the South Saskatchewan River.

The gradings show (Figure 26) the trend is towards the suspended sediment becoming more widely graded with increasing discharge. The mean particle size was found to increase significantly from fine silt to the very fine sand class (Figure 27). The sand component was found to be relatively homogeneous over the flow range (Figure 28). The mean particle size of the

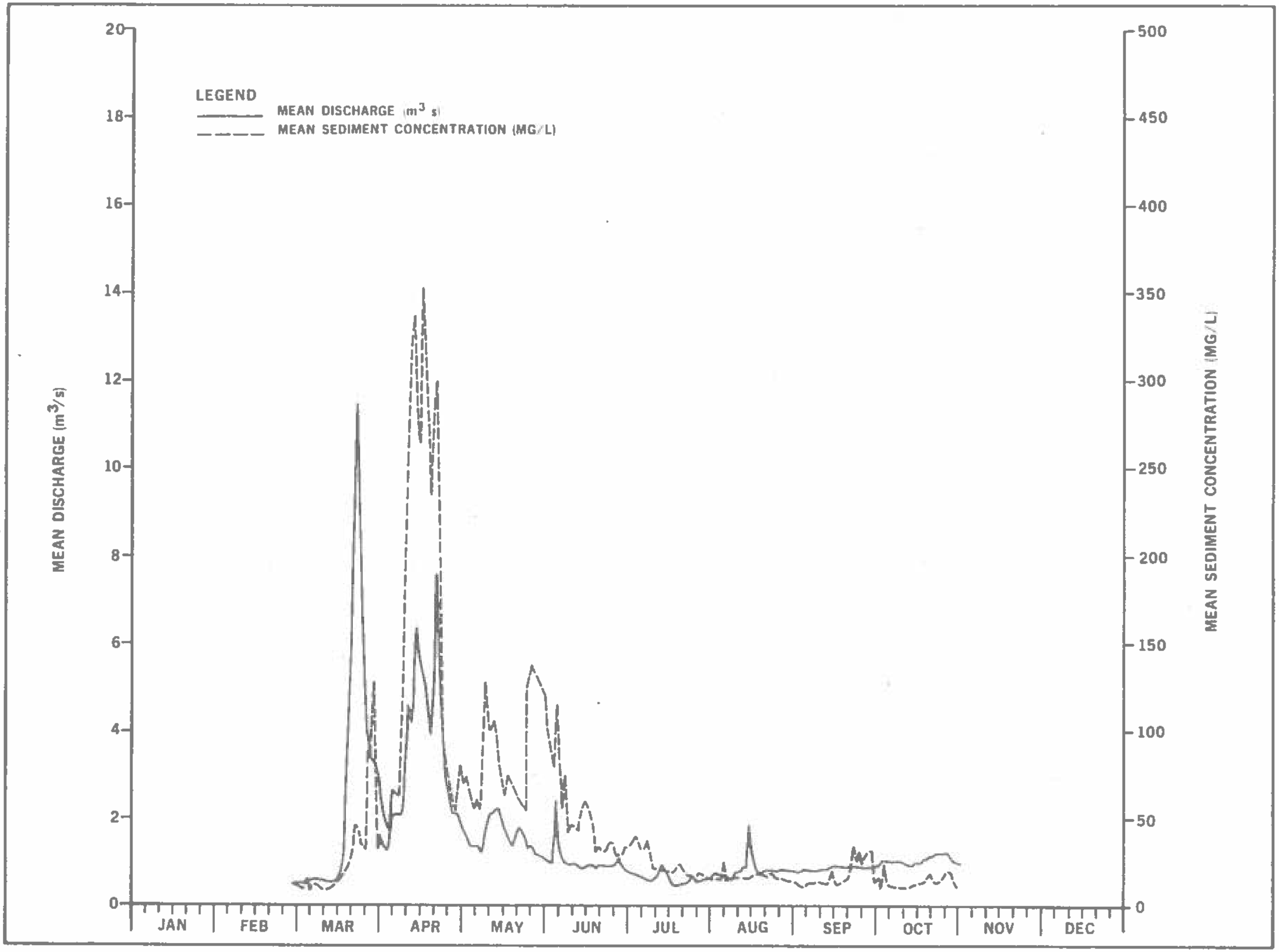


Figure 22
MEAN ANNUAL HYDROGRAPH AND
SEDIMENT CURVE FOR THE LEINAN STATION
DATA COLLECTED FROM 1973 - 1978

SWIFT CURRENT CREEK NEAR THE MOUTH

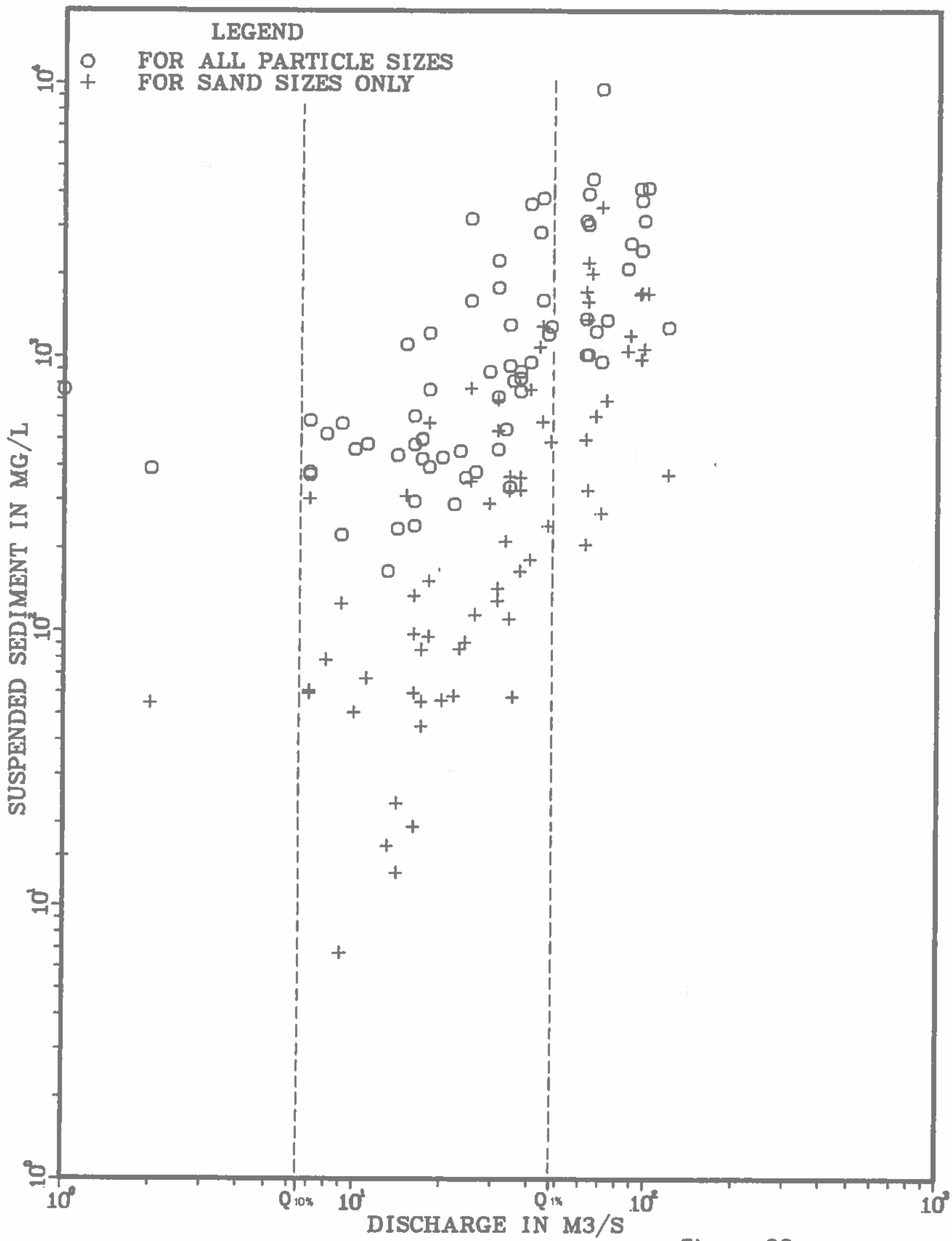


Figure 23
CONCENTRATION RELATIONSHIPS
TO DISCHARGE

SWIFT CURRENT CREEK NEAR THE MOUTH

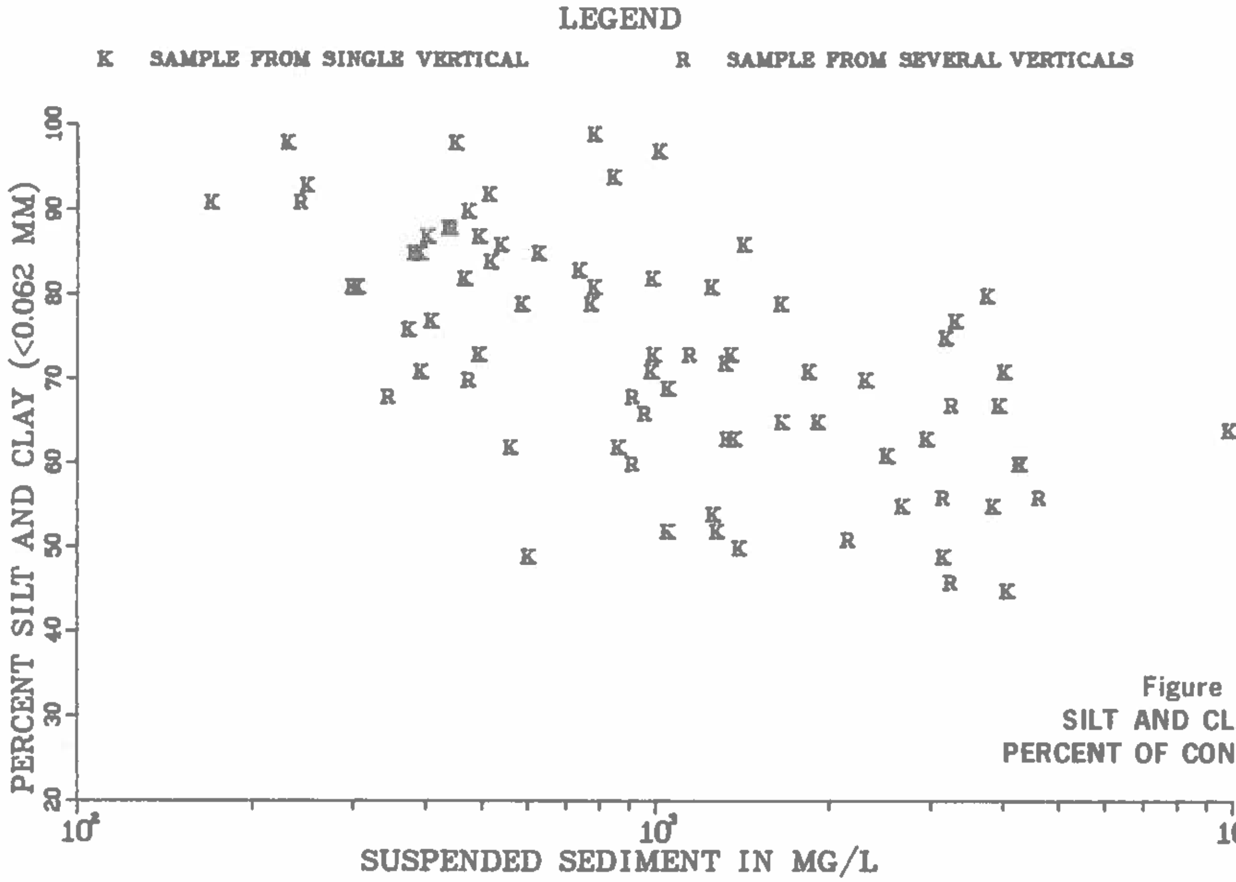


Figure 24
SILT AND CLAY AS A
PERCENT OF CONCENTRATION

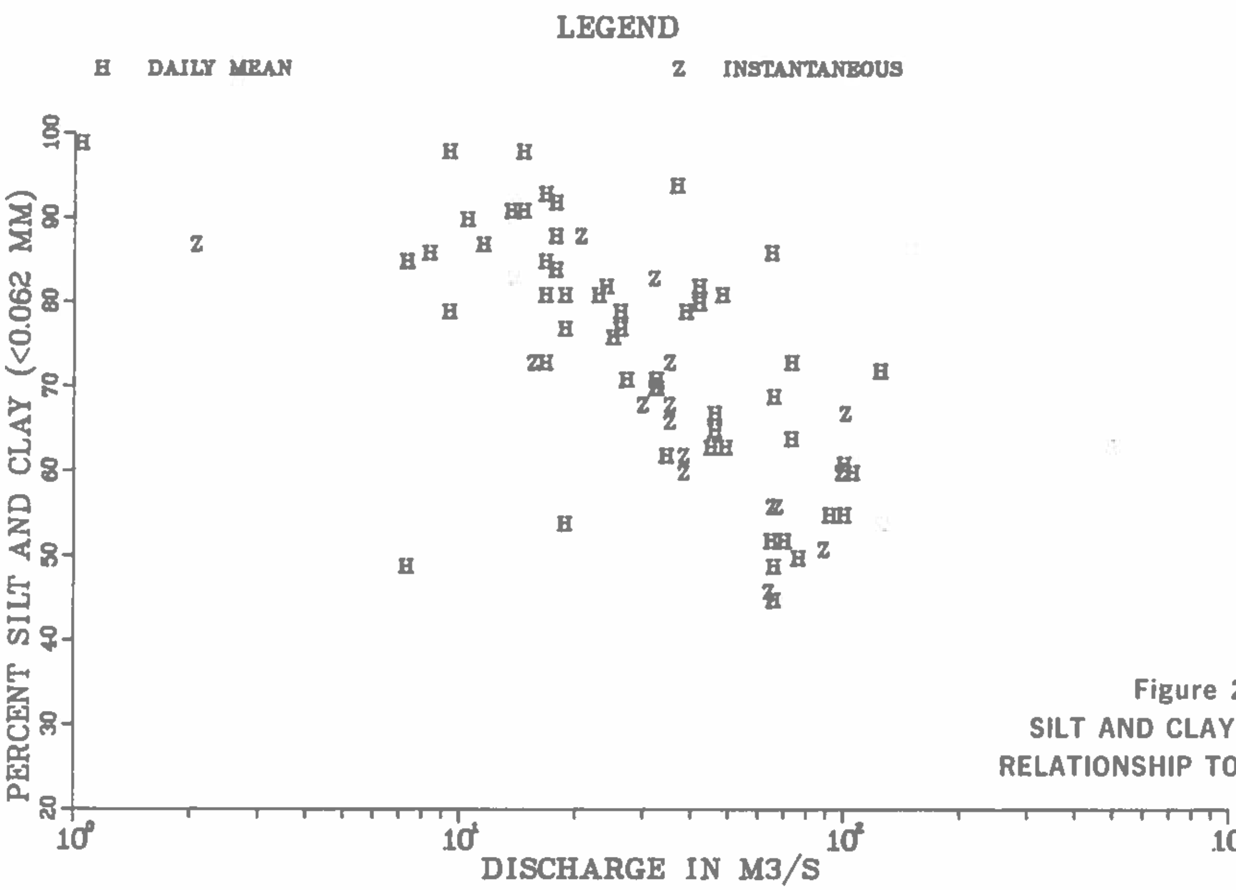


Figure 25
SILT AND CLAY PERCENT
RELATIONSHIP TO DISCHARGE

SWIFT CURRENT CREEK NEAR THE MOUTH

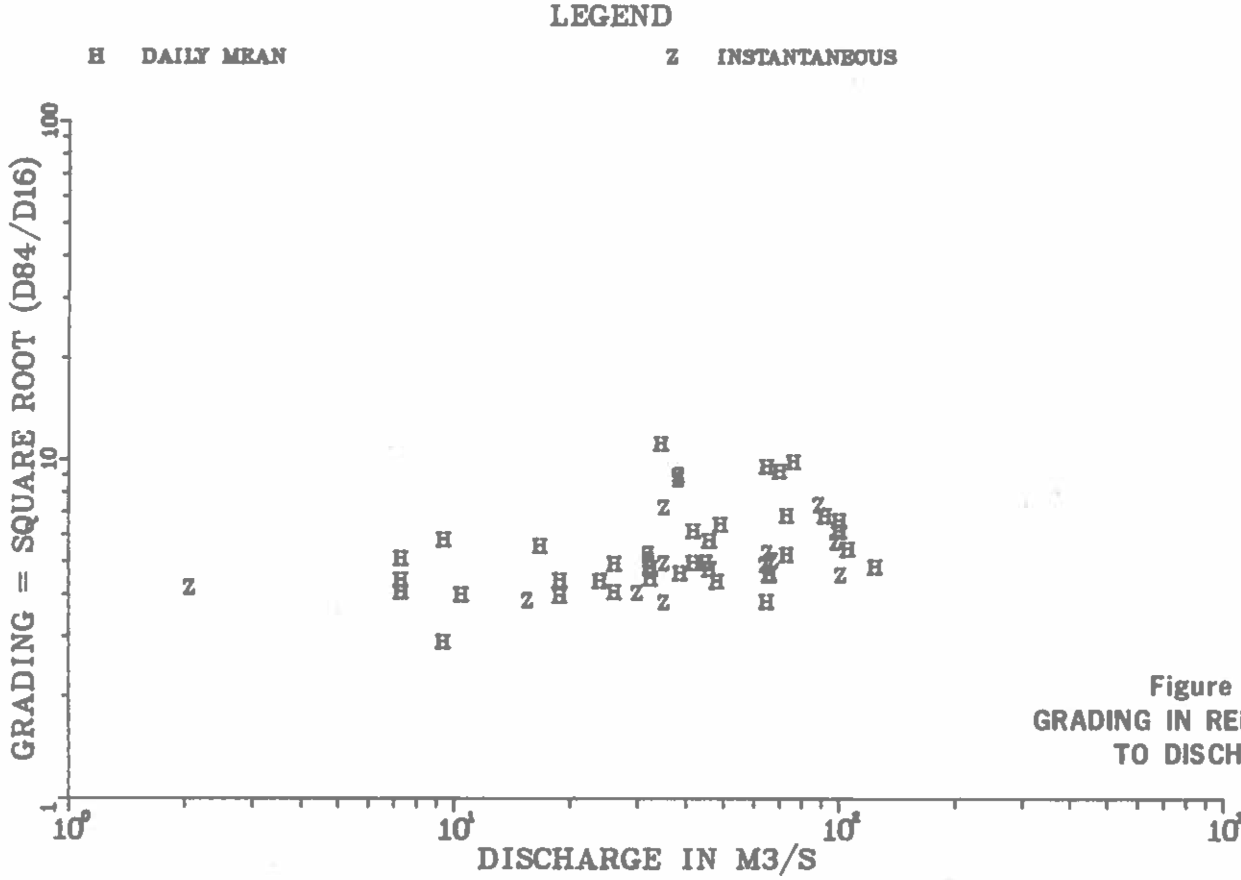


Figure 26
GRADING IN RELATIONSHIP
TO DISCHARGE

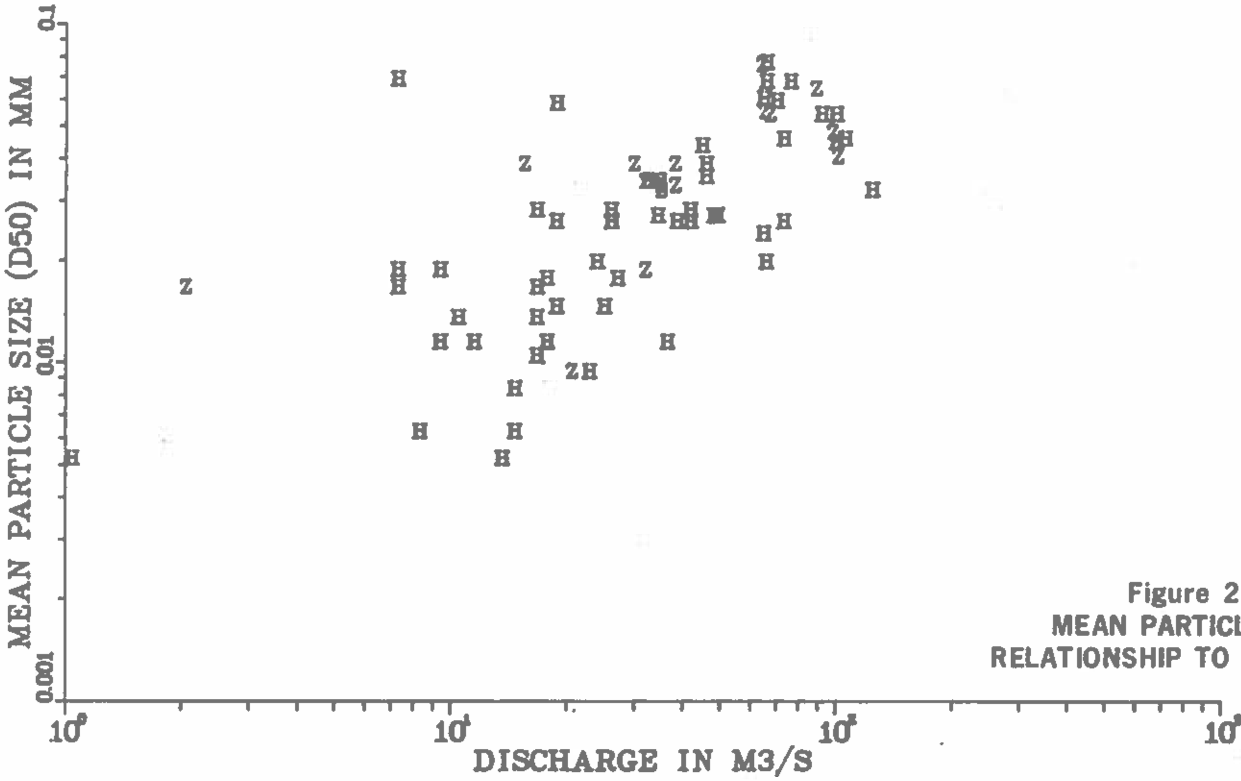


Figure 27
MEAN PARTICLE SIZE
RELATIONSHIP TO DISCHARGE

SWIFT CURRENT CREEK NEAR THE MOUTH

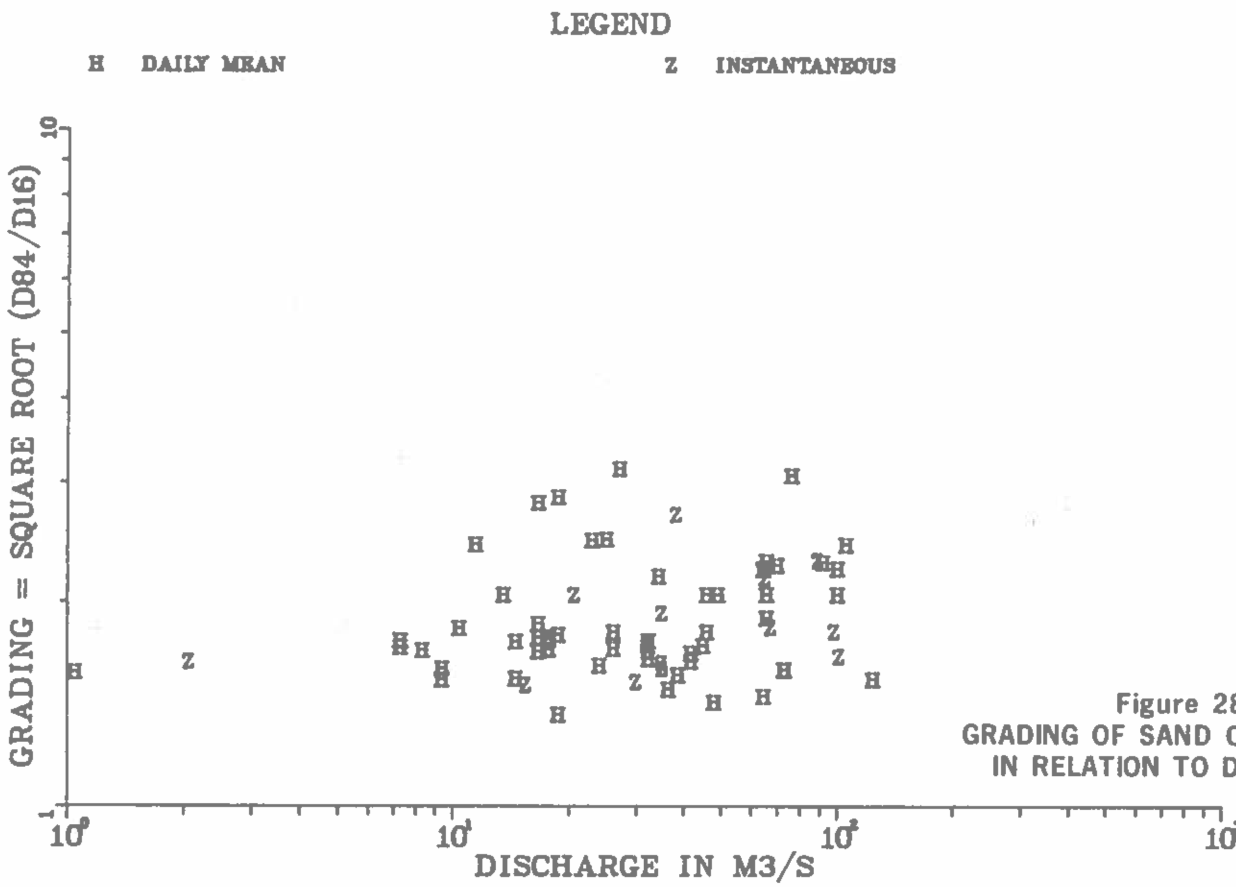


Figure 28
GRADING OF SAND COMPONENT
IN RELATION TO DISCHARGE

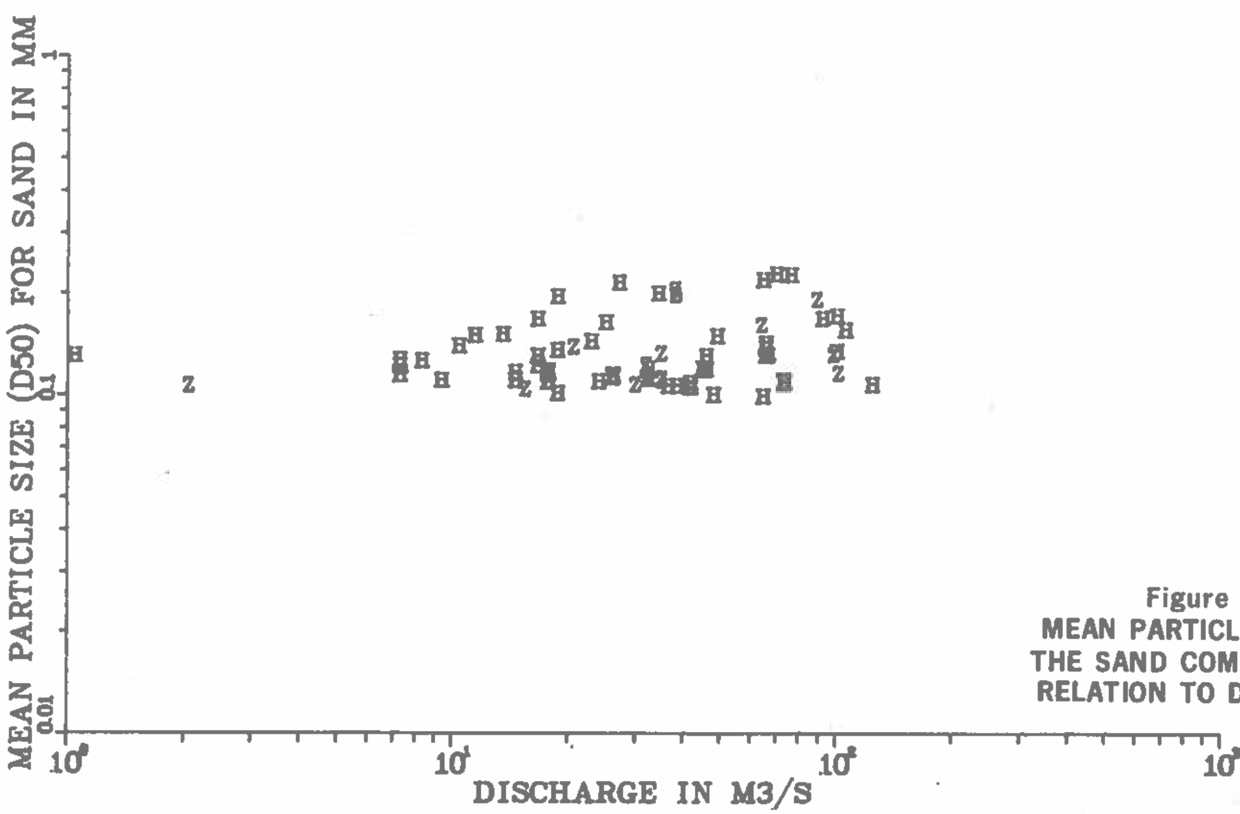


Figure 29
MEAN PARTICLE SIZE OF
THE SAND COMPONENT IN
RELATION TO DISCHARGE

sand fraction did not vary much with discharge and all samples were within the very fine to fine sand range (Figure 29).

Bed material was sampled only once on Swift Current Creek and that was at the mouth. This one sample showed the bed to be comprised totally of sands in the very fine to medium range.

Table 12 indicates the annual suspended sediment load transported by Swift Current Creek during the open-water period. The greatest load was 152 728 tonnes in 1967, and the smallest was 243 tonnes in 1973. On average, the creek transported 40 969 tonnes a year. In comparison to the South Saskatchewan River's contribution, it is insignificant, but it is important as a local input.

Table 12

Total Annual Suspended Sediment Load (Tonnes) for Swift Current Creek

Year	Annual Suspended Sediment Load	Year	Annual Suspended Sediment Load
1966	27 685	1973	243
1967	152 728	1974	19 058
1968	2 119	1975	13 594
1969	84 790	1976	28 713
1970	104 209	1977	1 277
1971	96 011	1978	735
1972	1 433	MEAN (13 YEARS)	40 969

Source: Environment Canada, Sediment Data Publications

4. Data Analyses and Results

4.1 Introduction

4.1.1 Definition of Reaches

In this analysis the 38 ranges have been divided into three distinct reaches. These reaches have been defined on the basis of the original minimum bed elevations and reservoir water level operations.

The first reach, referred to as the upstream reach, extends from Range 38 downstream to Range 32. Range 32 marks the location where the bed elevation approximates the FSL elevation of 556.87 m. Some ranges upstream of Range 32 have minimum bed elevations that are below the FSL elevation, however, this only represents a very small portion of the cross-sectional area of the range. Range 32 marks the point where this becomes a more significant portion of the cross-sectional area. In this reach, the South Saskatchewan River still behaves as a river but is influenced by the backwater effects from the reservoir.

The next reach spans from Range 32 to Range 26 and has been termed the drawdown reach. It is in this reach that conditions change from river to reservoir depending on the reservoir water level. Reservoir studies (US Bureau of Reclamation, 1977) have shown that this is where the major portion of the sediment load transported by the river is deposited. In this reach, the bed elevations are less than that of the FSL elevation, but greater than the minimum operating water level elevation of 545.59 m. The capacity in this reach is live storage capacity and therefore significant in that any changes will directly affect reservoir operations.

Range 26 marks the approximate location where reservoir conditions exist year round and therefore all the ranges downstream are considered as in the reservoir section. This point also marks the beginning of dead storage capacity, which is usually not considered important in terms of the reservoir operation. However, once the dead storage capacity has been depleted, live storage becomes affected, reducing the useful life of the reservoir.

4.1.2 Data Restrictions

As a massive quantity of hydrographic data has been used in this study it is not feasible to make it all available in standard formats. For instance, for every time a range was surveyed the data have been depicted in three formats: a cross-sectional profile, profile sheet and an elevation - area table. Proper representation of the sector data requires a contour plot for each year, elevation-capacity tables and a contour-difference plot between the different years. Since these data are available on request, only the data summaries are contained within this report.

As mentioned earlier both cross-sectional as well as sector (area) data were collected at the ranges downstream of Range 27. This was done primarily to evaluate and compare these two different data collection strategies. However, with the data that have been collected to date, it was not possible to properly compare these two approaches. Some reasons for this are the quality of the early sector surveys were poor, and much of the sector data have been collected where there has been neglible changes, which in turn has significantly reduced the number of ranges for comparison purposes. Therefore, further data will be required to properly evaluate and compare these two different data collection strategies.

Since cross-sectional data have been collected from the beginning of the program and throughout the reservoir over the years, this form of data served as the primary data source used to assess sedimentation. However, it should be noted that at the wider ranges, those below Range 9, the cross section findings were found to be questionable. This can be attributed to the fact that at these wider ranges it was increasingly difficult to stay on the baseline. Therefore, this analysis was restricted to data only as far downstream as Range 9. As this analysis will show this did not affect the purpose of this study, since negligible sedimentation was noted for quite a distance upstream of Range 9.

Background information which is important for the analysis of the reservoir as a whole, as well as for particular reaches, is provided in Table 13. The table contains thalweg distance between ranges, reference elevations used in the measurement of the baseline for each range, and the representative live, dead and total storage volumes for each range. These volume figures were derived by averaging the cross-sectional area of two

TABLE 13

Distance and Volume Information for Ranges

Location	Thalweg Distance (km)	Range No.	Reference Elevation (m)	Baseline Length (m)	Live Storage (dam^3)	Dead Storage (dam^3)	Total Storage (dam^3)
38-37	12.0	38	563.0	121.9	-	-	
37-36	7.6	37	561.0	156.3	-	-	
36-35	6.0	36	560.0	323.8	-	-	
35-34	3.1	35	558.5	210.0	-	-	
34-33	5.1	34	558.0	375.0	-	-	
33-32	5.1	33	557.0	234.0	-	-	
32-31	6.4	32	556.5	453.1	3 520		3 520
31-30	7.1	31	556.5	718.8	14 353	-	14 353
30-29	5.8	30	556.5	1 725.0	27 694	-	27 694
29-28	4.9	29	556.5	1 593.8	36 158	-	36 158
28-27	8.9	28	556.5	1 675.0	51 465	-	51 465
27-26	3.5	27	566.5	589.1	44 186	-	44 186
26-25	6.9	26	556.5	871.3	40 140	835	40 975
25-24	8.0	25	566.5	770.0	53 078	3 832	56 910
24-23	6.0	24	566.5	496.9	40 491	6 513	47 004
23-22	3.6	23	556.5	715.0	27 373	6 093	33 466
22-21	2.9	22	556.5	840.0	21 976	5 156	27 133
21-20	2.4	21	556.5	946.9	91 940	5 419	25 358
20-19	5.5	20	556.5	1 012.5	40 177	10 847	51 025
19-18	6.2	19	556.5	1 162.5	64 281	21 516	85 797
18-17	4.4	18	556.5	822.5	56 405	24 898	81 303
17-15	2.2	17	556.5	1 040.6	35 135	17 809	52 944
15-14	4.7	15	556.5	975.0	46 966	29 787	76 753
14-13	5.8	14	556.5	1 556.3	82 770	57 312	140 089
13-12	6.2	13	556.5	1 375.0	107 056	77 327	184 383
12-11	4.4	12	556.5	2 156.3	111 855	85 905	197 560
11-10	4.9	11	556.5	2 406.3	120 322	101 066	221 388
10-9	5.1	10	556.5	2 400.0	131 055	125 644	256 670
9-8	7.8	9	556.5	1 828.1	151 833	170 345	322 183
8-7	9.7	8	556.5	1 893.8	205 829	240 939	446 768
7-6	13.8	7	556.5	2 080.0	287 593	356 777	644 370
6-5	13.0	6	556.5	2 137.5	323 477	453 430	776 908
5-4	16.6	5	556.5	2 000.0	331 272	580 908	911 370
4-2	24.6	4	556.5	1 625.0	ESTIMATED REMAINING VOLUME		
2-1	13.9	2	556.5	1 968.8	1 533 812	2 970 124	4 503 936
1-DAM	8.3	1	556.5	3 075.0			
Total	262.4				4 010 000	5 350 000	9 360 000

consecutive ranges and multiplying it by the distance between the two ranges. These values then were summed to provide a total, and each individually ratioed to the total. The ratios were applied to the original established capacity values, obtained through mapping, to derive the volumes between each set of ranges. The representative volumes were obtained by taking half the volume to the immediate upper range and half the volume to the next lower range. The baseline length for all the ranges downstream and including Range 32 were measured at the reference elevation of 556.5 m, which approximated the FSL elevation. For the ranges upstream of Range 32, the reference elevation was based on the minimum water level elevation obtained from all the surveys of a particular range, ensuring the cross-sectional changes are comparable for all years.

The hydrograhic surveys since 1972 have been on a three-year cycle, so this interval was used for this analysis. Therefore changes from pre-reservoir to 1972 were studied, 1972 to 1975, 1975 to 1978 and from 1978 to 1980, which was the last survey conducted.

4.2 Upstream Reach

The original bed slope was derived by straight line interpolation between the minimum bed elevation at Range 38 and that of Range 32. The bed changes were derived from differences in the mean depth (cross-sectional area divided by the baseline length).

The upstream reach is normally an aggrading reach as river velocities are reduced due to backwater effects (Vanoni, 1975). However, as the 1972 survey results revealed, the 39 km-long reach had been severely scoured (Figure 30). In this reach, the South Saskatchewan River meanders and there are many islands and migrating sandbars that provide anchorage for ice jams. Two major ice jams have been recorded to have occurred prior to 1972; the first happened on April 7, 1969 and the second April 10, 1971 (Water Survey of Canada Files). The 1969 ice jam was the most significant and was responsible for destroying the Lemsford hydrometric station, located immediately upstream of Range 38. To put a perspective on the magnitude of the ice jam, the highest stage recorded at this site was 6.03 m for the 1975 flood, whereas the stage recorded from the ice jam was 9.36 m. Therefore, it is likely that upon breaking, the water and ice backed up behind the jam were responsible for the scouring noted along the reach.

As can be seen from Table 14, Range 37 had been scoured the most, with 1.3 m of sediment being removed from the channel. All ranges were found to have experienced some degradation and an estimated 4 500 dam^3 of sediment were estimated to have been eroded from this reach by 1972.

By 1975, infilling had taken place along most of the reach. Range 38 findings indicated that further minor degradation had occurred as the river adjusted for the severe change in slope along that section. Cross-sectional changes for Range 33 showed further scour, contrary to the findings from the other ranges in this section. However, Range 33 is a very narrow cross section and probably was affected by local scour.

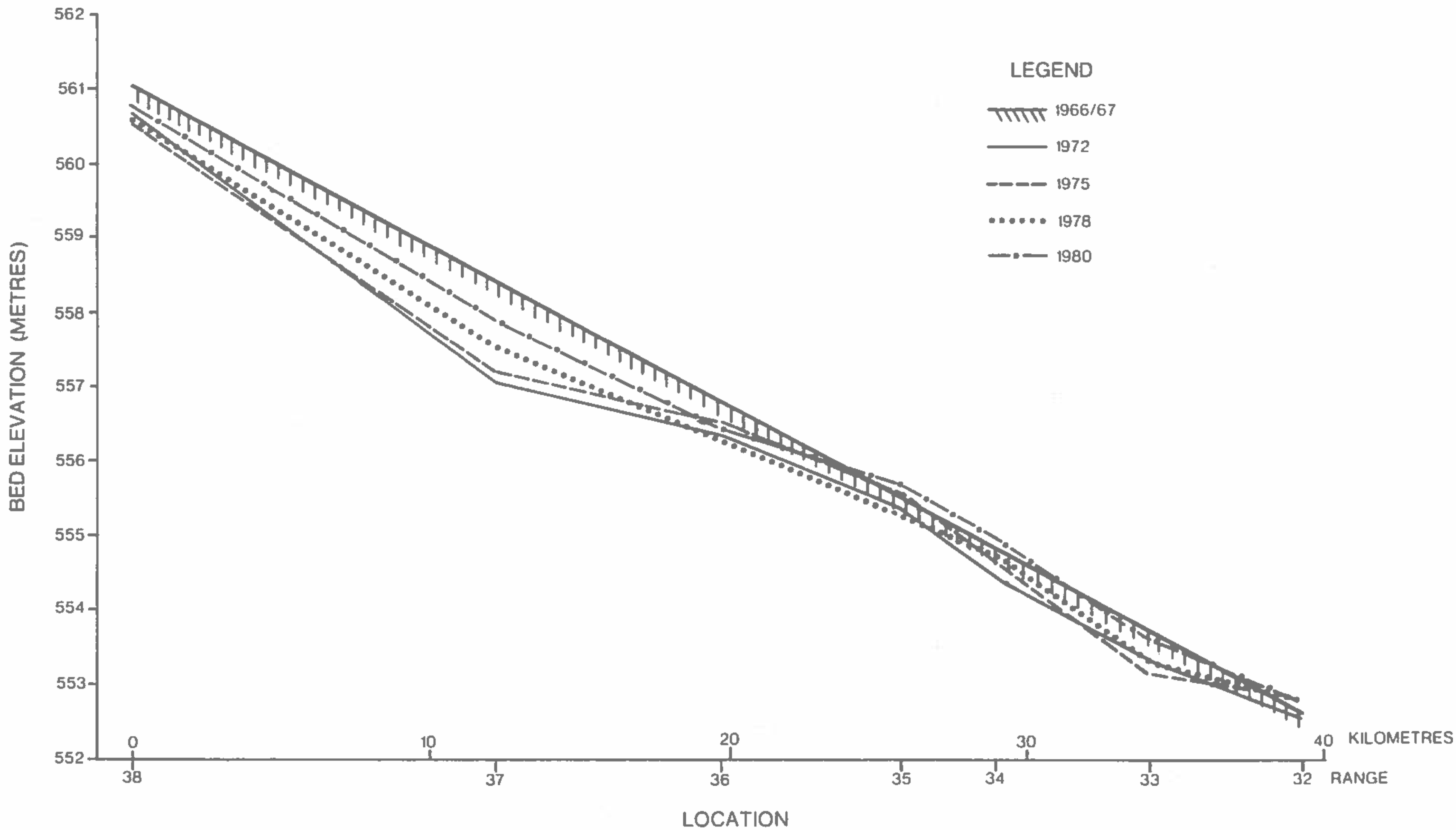


FIGURE 30
BED ELEVATION CHANGES
IN UPSTREAM REACH

TABLE 14

Mean Bed Changes (Metres) and Elevations (Metres) for Upstream Ranges

Year	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
38 Mean Bed Change							-0.40			-0.49			-0.53		-0.30
Elevation	561.05						560.65			560.56			560.52		560.75
37 Mean Bed Change					-1.19		-1.32			-1.09			-0.87		-0.56
Elevation	558.47				557.28		557.15			557.38			557.60		557.91
36 Mean Bed Change							-0.40			-0.26			-0.44		-0.33
Elevation	556.82						556.42			556.56			556.38		556.49
35 Mean Bed Change				-			-0.09			+0.04			-0.17		+0.13
Elevation	555.52			555.52			555.43			555.56			555.35		555.65
34 Mean Bed Change						-0.42						-0.04			+0.15
Elevation	554.86					554.44						554.82			555.01
33 Mean Bed Change			-0.26				-0.35			-0.54			-0.37		-0.15
Elevation	553.76		553.50				553.41			553.22			553.39		553.61
32 Mean Bed Change					-0.03		-0.06			+0.11		+0.12			+0.12
Elevation		552.66			552.63		552.60			552.77		552.78			552.78

The 1978 survey results show further infilling along most of the reach with Range 38 still continuing to show degradation. Also, Range 36 and Range 35 were degrading as the river continued to make adjustments to the ice scour effects.

By 1980 deposition had been recorded at all the ranges, and conditions began to represent those that were there prior to the ice jams.

The original average slope for the reach based on the earliest surveys was 0.00022, and by 1972 it had been reduced to 0.00021. The slope recorded from the 1975, 1978 and 1980 data was slightly lower at 0.00020. Based on these findings it appears that the long term trend should be one of further reduction in bed slope as sediment continues to be deposited in the lower ranges.

4.3 Drawdown Reach

This reach (Range 32-Range 26) extends for 37 km and has an estimated volume of 218 300 dam^3, representing about 5.4% of the total live storage volume. In this reach the river flows into the reservoir and velocities are reduced greatly causing the major portion of the sediment load to be deposited.

The reservoir water level at the time of the freshet is a good indicator as to where the sediment loads will begin to be deposited out of suspension (Table 15). As the reservoir water levels indicate, sedimentation during most years would begin to occur in the upper portion of this reach and

TABLE 15

Reservoir Water Level Elevations at Peak Discharge Time

Date	Peak Discharge (m^3/s)	Return Period (Yr)	Elevation (m)
June 23, 1965	1 951	4.25	525.2
June 8, 1966	1 184	1.70	526.1
June 4, 1967	2 432	8.50	541.0
June 16, 1968	897	1.31	550.1
July 3, 1969	2 178	5.67	555.7
June 21, 1970	1 824	3.40	553.8
June 11, 1971	1 388	2.13	553.5
June 7, 1972	1 472	2.43	552.9
June 3, 1973	779	1.33	552.9
June 23, 1974	1 501	2.83	554.5
June 24, 1975	2 890	17.00	555.1
August 14, 1976	906	1.42	551.4
June 15, 1977	268	1.06	551.3
June 15, 1978	1 076	1.55	553.8
June 2, 1979	825	1.21	553.9
June 1, 1980	1 260	1.89	552.3

Source: Saskatchewan Environment Records most of the reach would be exposed to deposition. Prior to 1968 most of the sediment loads were transported and deposited at the lower ranges in the reservoir. Therefore, the period from 1968 to 1978 basically marks the first ten years the reservoir has been fully operational.

As shown in Figure 31, this reach had been continually aggrading over the years. By 1972, significant accumulation had been recorded for the ranges downstream of Range 30, whereas upstream changes were negligible (Table 16). Range 26 was shown to have the greatest change with 0.87 m of deposition. Both Range 27 and 28 also had significant accumulation with 0.62 and 0.61 m respectively.

The 1975 survey data revealed the same trend with sedimentation occurring throughout the whole reach and the most significant accumulation rates being recorded at the lower ranges. The data shows that the most deposition had occurred at Range 27 with 1.45 m being infilled.

After ten years of reservoir operation significant changes were measured. Range 27 still showed that it was the point of most accumulation within this reach followed closely by Range 26.

The 1980 data, although somewhat limited, does indicate further deposition throughout the reach. Therefore, now that reservoir operations are more stable from year to year, this general pattern of deposition can be expected to continue.

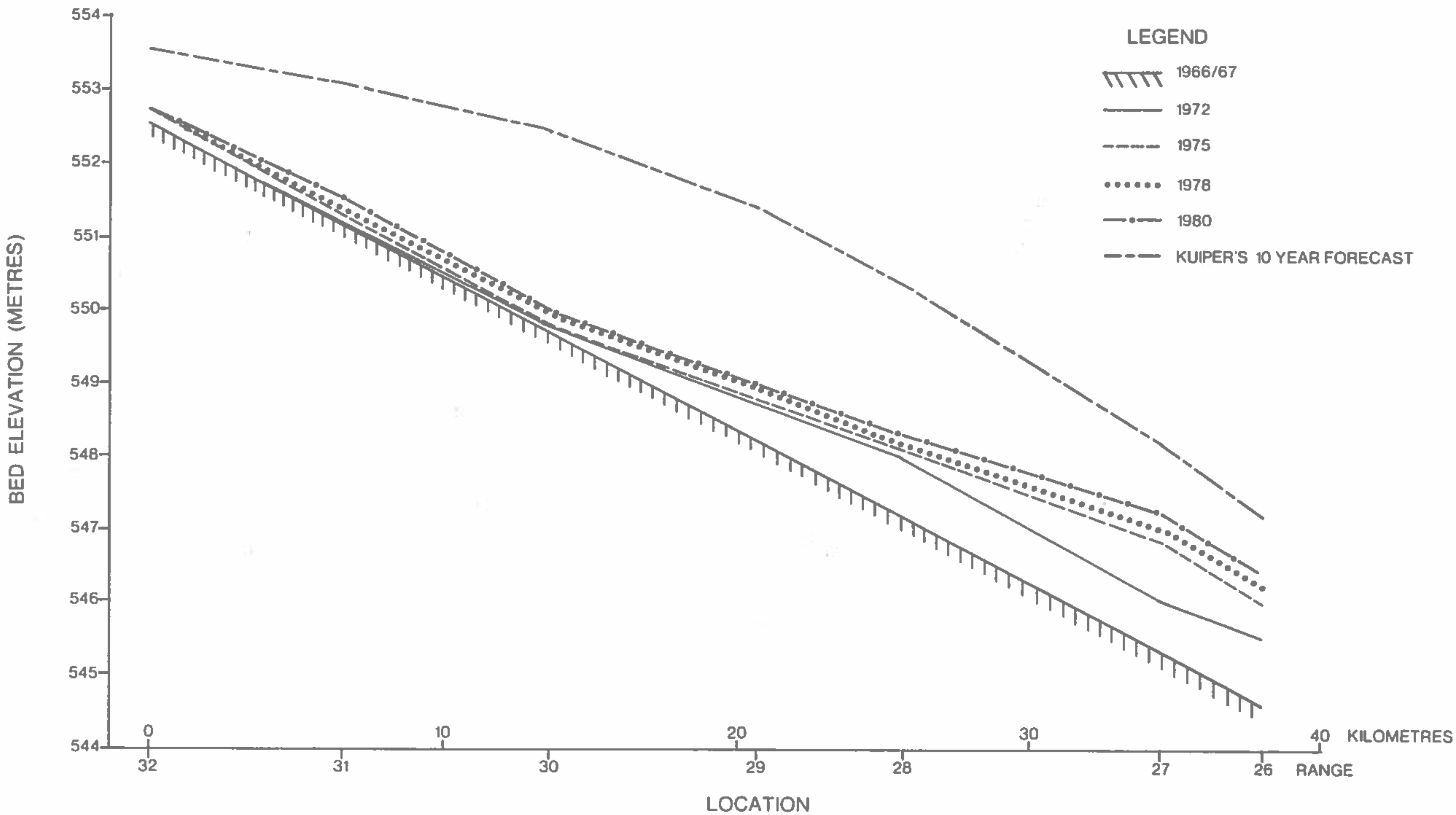


FIGURE 31
BED ELEVATION CHANGES
IN DRAWDOWN REACH

TABLE 16

Mean Bed Changes (Metres) and Elevations (Metres) for Drawdown Ranges

Year	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Kuiper's Forecast
Range																
32 Mean Bed Change					-0.03		-0.06			+0.11			+0.12		+0.12	+0.93
Elevation		552.66			552.63		552.60			552.77			552.78		552.78	553.59
31 Mean Bed Change				+0.03		-0.02									+0.24	+1.88
Elevation		551.27		551.30		551.25									551.51	553.15
30 Mean Bed Change					+0.01		+0.02			+0.06			+0.24			+2.81
Elevation		549.71			549.72		549.73			549.77			549.95			552.52
29 Mean Bed Change				+0.28									+0.56			+3.05
Elevation		548.43		548.71									548.99			551.48
28 Mean Bed Change			+0.31			+0.61						+0.85			+0.99	+3.05
Elevation	547.36		547.67			547.97						548.21			548.35	550.41
27 Mean Bed Change				+0.61			+0.62			+1.45			+1.68			+2.81
Elevation	545.41			546.02			546.03			546.86			547.09			548.22
26 Mean Bed Change			+0.28				+0.87			+1.41			+1.60			+2.59
Elevation	544.65		544.93				545.52			546.06			546.25			547.24

A comparison with Kuiper's (1962) forecast shows that Kuiper overestimated deposition in this reach. There are two reasons why the estimates were so high: the first, was that they were based on sediment loads that were significantly larger; and second, it was assumed the water level would always be at FSL at the time of the freshet. The differences help illustrate some weaknesses in forecasting sedimentation with limited data.

To determine volumetric changes in this reach the percentage change in the cross-sectional area of each range was applied to the representative volume (Table 17). From 1966 to 1972 an estimated 15 400 dam^3 of storage had been lost due to sedimentaton. That is a loss of 7.1% to this particular reach, while in terms of the total live storage of the reservoir it amounts to only 0.4%. Between 1972 and 1975 a further 12 500 dam^3 of sediment had accumulated amounting to a further 5.7% loss to reach and 0.3% to the total live storage. The next three years reduced the storage by 7 600 dam^3, or a 3.5% loss to the reach and 0.2% over all. From 1978 to 1980 an estimated 5 000 dam^3 had been further lost, or 2.6% to the reach and 0.1% to the total live storage. By 1980 there had been a total loss of 18.9% in storage to the drawdown reach, which is about 1.0% of the total live storage and just less than 0.5% of the total reservoir capacity.

The original slope for this reach was 0.00022, and by 1972 it had been reduced to 0.00019. As sedimentation continued, the slope was further reduced to 0.00018 in 1975, and has remained the same to 1980. This gradual reduction in the slope with time should continue as the major portion of sediment load is deposited in the lower portion of the reach.

TABLE 17

Percentage and Volumetric Changes for Drawdown Ranges

Range	Original Volume (dam^3)	Years	Percentage Change	Volume Change (dam^3)	Years	Percentage Change	Volume Change (dam^3)
32	3 520	1967-1972	+4.5	+158	1972-1975	-13.8	-486
31	14 353	1967-1972	+1.1	+158	1972-1975	-7.6	-1 091
30	27 694	1967-1972	-0.9	-249	1972-1975	-2.1	-582
29	36 158	1967-1972	-9.2	-3 327	1972-1975	-3.8	-1 374
28	51 465	1966-1972	-9.0	-4 632	1972-1975	-3.5	-1 801
27	44 186	1966-1972	-7.6	-3 358	1972-1975	-10.0	-4 419
26	40 975	1966-1972	-10.2	-4 192	1972-1975	-6.7	-2, 745
Total	218 300			-15 400			-12 500
32	3 520	1975-1978	-1.3	-46	1978-1980	+0.4	+14
31	14 353	1975-1978	-3.8	-545	1978-1980	-2.5	-359
30	27 694	1975-1978	-7.4	-2 049	1978-1980	-6.1	-1 689
29	36 158	1975-1978	-4.1	-1 482	1978-1980	-3.6	-1 302
28	51 465	1975-1978	-2.5	-1 287	1978-1980	-1.8	-926
27	44 186	1975-1978	-3.0	-1 326	1978-1980	-2.0	-884
26	40 975	1975-1978	-2.2	-901	1978-1980	-1.3	-533
Total	218 300			-7 600			-5 700

4.4 Reservoir

4.4.1 Total Storage Changes

As the longitudinal profile (Figure 32) shows, by 1972 there had been deposition along the whole reservoir reach. These deposition rates show a general decline with increased distance from the source, however there are some areas that do not follow this trend (Table 18). Prior to 1968 the reservoir was being filled and therefore the depositional patterns are somewhat distorted. Also structures such as the Saskatchewan Landing Bridge affected the sedimentation pattern as noted by the changes at Range 20. While channel morphology at the individual ranges have also affected the measured sedimentation rates. An example is Range 18 which is a very narrow cross section with steep banks susceptible to slumping. This high bank material contribution is what is responsible for this high sedimentation rate. Range 15 is an example of a range which is affected by the local input of Swift Current Creek.

Changes between 1972 and 1975 indicate the sedimentation pattern due to a more regular schedule of reservoir operations. The hydrographic survey results show that during this period significant changes were only measured at the ranges upstream of Range 20.

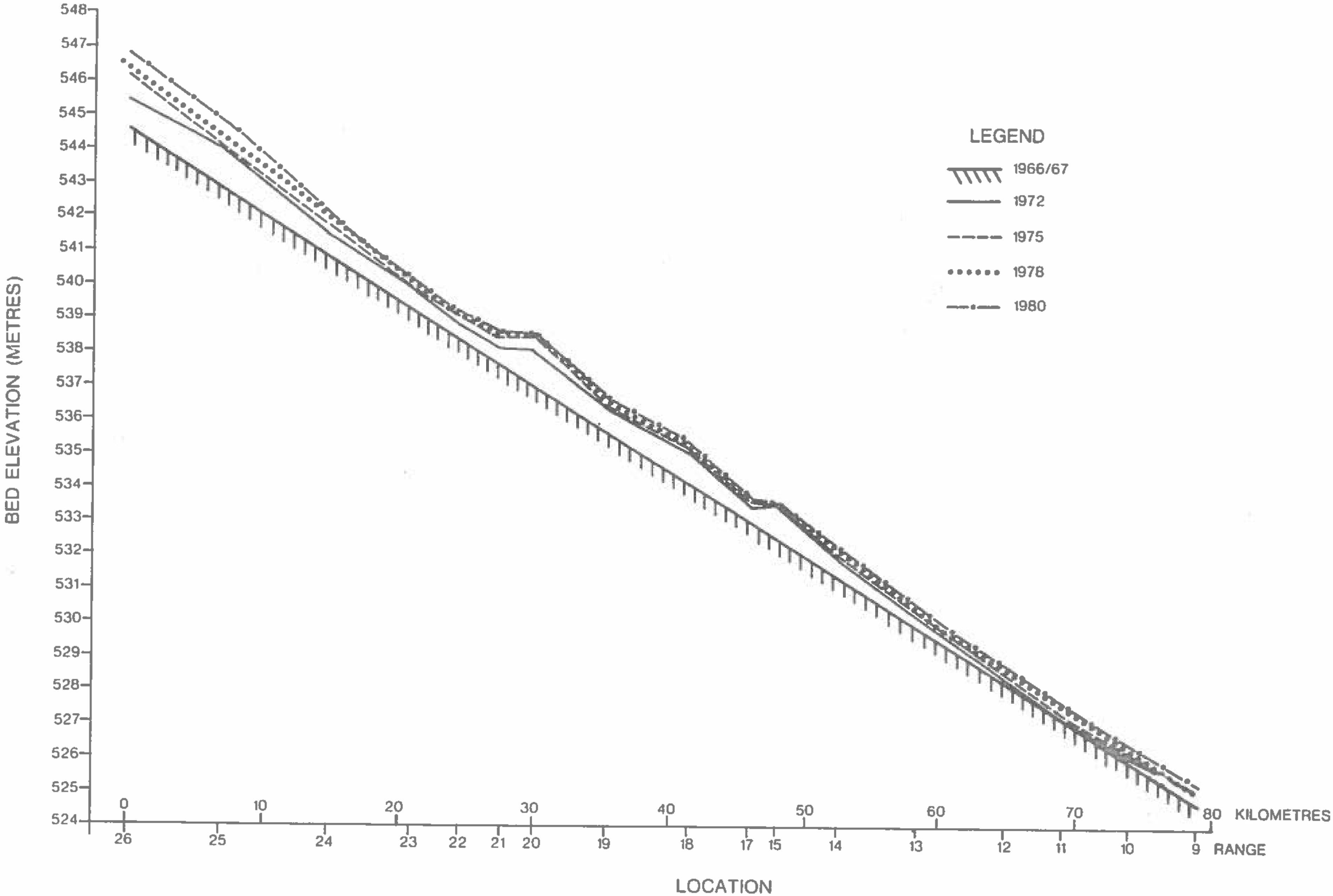


FIGURE 32
BED ELEVATION CHANGES
IN THE RESERVOIR

TABLE 18

Mean Changes (Metres) and Elevations (Metres) for Reservoir Ranges

Range	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Kuiper's Forecast
26 Mean Change			+0.28				+0.87			+1.41			+1.60			+2.58
Elevation	544.65		544.93				545.52			546.06			546.25			547.23
25 Mean Bed Change						+1.07						+1.76				+2.34
Elevation	542.89					543.96						544.65				545.23
24 Mean Bed Change							+0.70			+0.94						+2.11
Elevation	540.86						541.56			541.80						542.97
23 Mean Bed Change			+0.14				+0.42			+0.50			+0.63			+1.41
Elevation	539.34		539.48				539.76			539.84			539.97			540.75
22 Mean Bed Change						+0.39									+0.61	+0.94
Elevation	538.41					538.80									539.02	539.35
21 Mean Bed Change		+0.20					+0.36			+0.68			+0.63			+0.94
Elevation	537.67	537.87					538.03			538.35			538.30			538.61
20 Mean Bed Change							+0.46			+0.81			+0.88			+0.71
Elevation	537.07						538.16			538.51			538.58			537.78
19 Mean Bed Change						+0.69						+0.92			+0.93	+0.71
Elevation	535.69					536.38						536.61			536.62	536.40

TABLE 18 (cont'd)

Mean Changes (Metres) and Elevations (Metres) for Reservoir Ranges

Range	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Kuiper's Forecast
18 Mean Bed Change						+0.98			+1.02						+1.12	+0.71
Elevation	534.11					535.09			535.13						535.23	534.82
17 Mean Bed Change		+0.43					+0.26			+0.46			+0.53			+0.70
Elevation	533.00	533.43					533.26			533.46			533.53			533.70
15 Mean Bed Change						+1.08						+0.94				+0.70
Elevation	532.44					533.52						533.38				533.14
14 Mean Bed Change							+0.75			+0.84						+0.70
Elevation	531.24						531.99			532.08						531.94
13 Mean Bed Change						+0.52									+0.86	+0.47
Elevation	529.76					530.28									530.62	530.23
12 Mean Bed Change															+0.72	+0.47
Elevation	528.18														528.90	528.65
11 Mean Bed Change							+0.07			+0.18						+0.47
Elevation		527.07					527.14			527.25						527.54
10 Mean Bed Change						+0.26						+0.30				+0.47
Elevation		525.83				526.09						526.13				526.30
9 Mean Bed Change							+0.63			+0.54					+0.81	+0.47
Elevation		524.53					525.16			525.07					525.34	525.00

By 1978 it had become apparent that most of the sediment load transported by the South Saskatchewan River settled out of suspension before it reached the Saskatchewan Landing Bridge. Range 25 appears to be the pivotal point for sedimentation with the overall maximum sediment deposition of any of the ranges upstream of the bridge.

The 1980 survey confirms that most of the loads are being deposited in the upper portion with minimal changes to the lower ranges, except where bank slumping provides material.

According to Kuiper (1962) the effects from the South Saskatchewan loadings would be negligible by Range 20. Measured changes confirm this, but show higher than anticipated sedimentation rates below Range 20 due to the bank material contribution.

Table 19 contains the volume losses due to sedimentation in the reservoir section. By 1972 there was 57 300 dam^3 of volume lost, which is approximately 0.6% of the total reservoir capacity. The 1975 results showed that a further 14 400 dam^3 were lost or 0.2% in total volume. The period 1975-1978 revealed that 13 700 dam^3 were infilled or a further 0.2% of total capacity. Limited data for 1980 made it impossible to properly estimate changes, but it is unlikely that the changes would be very significant. Therefore, from 1966 to 1980 about 1% of the total reservoir storage was determined to have been depleted.

TABLE 19

Percentage and Volumetric Changes for Reservoir Ranges

Range	Original Volume (dam^3)	Years	Percentage Change	Volume Change (dam^3)	Years	Percentage Change	Volume Change (dam^3)	Years	Percentage Change	Volume Change (dam^3)
25	56 910	1966-1972	-12.0	-6 829	1972-1975	-4.0	-2 276	1975-1978	-3.0	-1 707
24	47 004	1966-1972	-4.4	-2 068	1972-1975	-5.6	-2 632	1975-1978	-2.4	-1 128
23	33 466	1966-1972	-4.8	-1 606	1972-1975	-0.9	-301	1975-1978	-1.5	-502
22	27 133	1966-1972	-4.5	-1 221	1972-1975	-1.7	-461	1975-1978	-1.2	-326
21	25 358	1966-1972	-4.5	-1 141	1972-1975	-2.5	-634	1975-1978	-0.8	-203
20	51 025	1966-1972	-4.4	-2 245	1972-1975	-3.1	-1 582	1975-1978	-0.9	-459
19	85 797	1966-1972	-6.0	-5 148	1972-1975	-1.4	-1 201	1975-1978	-1.2	-1 030
18	81 303	1966-1972	-6.4	-5 203	1972-1975	-0.9	-732	1975-1978	-1.4	-1 138
17	52 955	1966-1972	-3.3	-1 747	1972-1975	-0.1	-53	1975-1978	-0.5	-265
15	76 753	1966-1972	-3.6	-2 763	1972-1975	-0.5	-384	1975-1978	-1.6	-1 228
14	140 089	1966-1972	-4.4	-6 164	1972-1975	-0.7	-981	1975-1978	-0.1	-140
13	184 383	1966-1972	-3.8	-7 007	1972-1975	-0.4	-738	1975-1978	-0.6	-1 106
12	197 560	1966-1972	-3.1	-6 124	1972-1975	-0.3	-593	1975-1978	-0.4	-790
11	221 388	1967-1972	-0.4	-886	1972-1975	-0.7	-1 550	1975-1978	-0.6	-1 328
10	256 670	1967-1972	-1.4	-3 593	1972-1975	-0.1	-257	1975-1978	-0.3	-770
9	322 183	1967-1972	-1.1	-3 544	1972-1975	-	-	1975-1978	-0.5	-1 611
TOTAL				-57 300			-14 400			-13 700

This 79 km of reservoir bed had an original slope of 0.00025 but because of higher sedimentation rates in the upper ranges the overall slope has increased over time. In 1972 and 1975 the slope had increased to 0.00026 and in 1978 and 1980 it was calculated to have been 0.00027.

4.4.2 Dead Storage Changes

Dead storage losses are not considered important to reservoir operations until that capacity is lost and live storage is directly affected. Figure 33 illustrates the progressive loss of dead storage downstream with time. By 1972, significant losses are noticeable in some areas, especially the first couple of ranges where all the dead storage was lost at Range 26 and 95% of it at Range 25. By 1975, all of the dead storage for Range 25 had been lost and Range 24 had undergone significant change. Below these first few ranges the losses are not as significant as expected and at the wider ranges the changes are minimal. Range 14 marks the point where changes in the dead storage have been negligible since 1972, as limited sediment is transported that far downstream. Between 1975 and 1978 only Range 24 showed significant losses. This lessening of dead storage loss in the latter years is related to the decrease in sediment loadings for the South Saskatchewan River.

From Table 20 the dead storage calculated to have been lost by 1972 was 50 800 dam^3, or 1.0% of the total dead storage capacity of the reservoir. Between 1972 and 1975 only 10 000 dam^3 were determined to

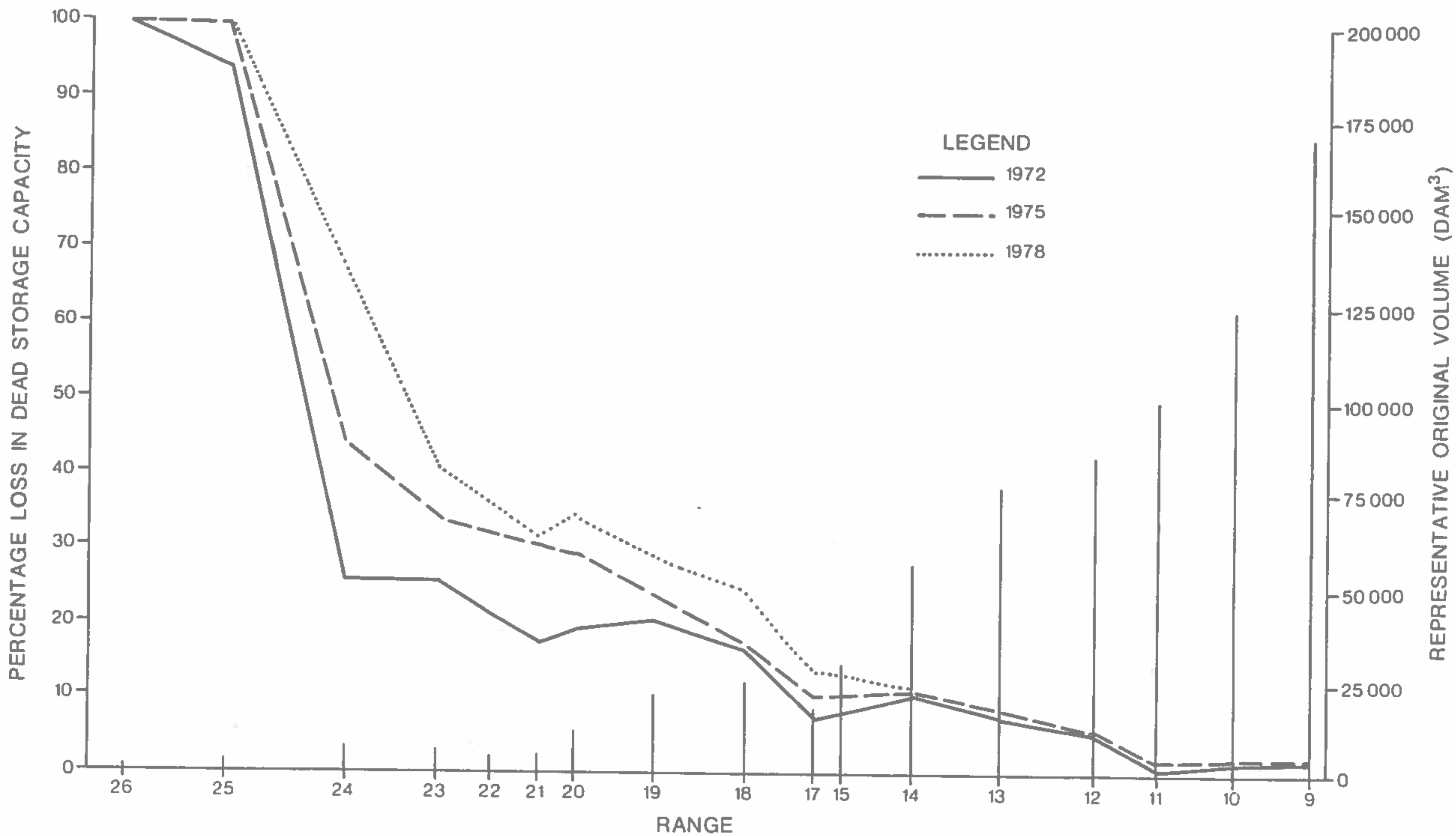


FIGURE 33
PERCENTAGE LOSS IN
DEAD STORAGE CAPACITY

TABLE 20

Percentage and Volumetric Changes in Dead Storage for Reservoir Ranges

Range	Original Volume (dam^3)	Years	Percentage Change	Volume Change (dam^3)	Years	Percentage Change	Volume Change (dam^3)	Years	Percentage Change	Volume Change (dam^3)
26	835	1966-1972	-100	-835	1972-1975	-	-	1975-1978	-	-
25	3 832	1966-1972	-95	-3 640	1972-1975	-5	-192	1975-1978	-	-
24	6 513	1966-1972	-25	-1 628	1972-1975	-20	-1 303	1975-1978	-22	-1 433
23	6 093	1966-1972	-26	-1 584	1972-1975	-8	-487	1975-1978	-8	-487
22	5 157	1966-1972	-22	-1 134	1972-1975	-11	-567	1975-1979	-2	-103
21	5 149	1966-1972	-18	-927	1972-1975	-14	-721	1975-1978	-1	-51
20	10 848	1966-1972	-20	2 170	1972-1975	-9	-976	1975-1978	-6	-651
19	21 516	1966-1972	-20	-4 303	1972-1975	-4	-861	1975-1978	-4	-861
18	24 898	1966-1972	-17	-4 344	1972-1975	-1	-249	1975-1978	-6	-1 494
17	17 810	1966-1972	-8	-1 425	1972-1975	-3	-534	1975-1978	-4	-712
15	29 787	1966-1972	-9	-2 681	1972-1975	-3	-894	1975-1978	-3	-897
14	57 312	1966-1972	-11	-6 304	1972-1975	-1	-573	1975-1978	-1	-573
13	77 327	1966-1972	-8	-6 186	1972-1975	-1	-773	1975-1978	-	-
12	85 905	1966-1972	-6	-5 154	1972-1975	-1	-859	1975-1978	-	-
11	101 066	1967-1972	-1	-1 011	1972-1975	-1	-1 011	1975-1978	-	-
10	125 645	1967-1972	-2	-2 513	1972-1975	-	-	1975-1978	-	-
9	170 350	1967-1972	-3	-5 110	1972-1975	-	-	1975-1978	-	-
TOTAL				-50 800			-10 000			-7 300

have been infilled or 0.2% of the total dead storage. During the period 1975 to 1978 the dead storage loss was estimated at 7 300 dam^3 or 0.1%. The period from 1978 to 1980, due again to the limited hydrograhic data and its quality, could not be properly evaluated. Most of the cross sections however suggest minimal change. Therefore, dead storage loss due to sedimentation between 1966 and 1980 was approximately 1.3%. These results show that very little sediment is transported far into the reservoir and that changes will be significant only in the upper portion for many years to come.

4.4.3 Live Storage Changes

According to Van Everdingen's (1968) calculations the live storage would increase due to bank erosion, by as much as 7.4% within the first ten years of the reservoir life. The hydrographic data findings do not support this forecast, however, these data do not reflect changes in the lowest section of the reservoir. Bank erosion and slumping are noticeable along the length of the reservoir. However, because of the steep banks a considerable amount of bank material is dumped into the live storage resulting in a loss of live storage at most of the ranges. The terrestrial photogrammetry approach would have provided the best estimates, but unfortunately this portion of the program was not pursued.

By 1972, it was estimated that 7 300 dam^3 of bank derived sediment had reduced the total live storage capacity by 0.2% (Table 21). Between 1972 and 1975 there were considerably more ranges that showed erosion, however, the net change for the reservoir was a 4 400 dam^3 further loss in storage capacity, amounting to 0.1%. During the period between 1975 and 1978 deposition at some the larger ranges was significant. A total loss of 6 500 dam^3 was determined to have reduced the live capacity by a further 0.2%. The few cross sections extracted from 1980 data revealed minimal change Therefore, it was calculated that about 0.5% of the total live storage was lost due the bank slumping, since the reservoir was established.

TABLE 21

Volumetric Changes in Live Storage for Reservoir Ranges

Range	Years	Volume Change (dam^3)	Years	Volume Change (dam^3)	Years	Volume Change (dam^3)
25	1966-1972	-3 189	1972-1975	-2 084	1975-1978	-1 707
24	1966-1972	-440	1972-1975	-1 329	1975-1978	+305
23	1966-1972	-22	1972-1975	+186	1975-1978	-15
22	1966-1972	-87	1972-1975	+106	1975-1978	-223
21	1966-1972	-214	1972-1975	+87	1975-1978	-152
20	1966-1972	-75	1972-1975	-606	1975-1978	+192
19	1966-1972	-845	1972-1975	-340	1975-1978	-169
18	1966-1972	-970	1972-1975	-483	1975-1978	+356
17	1966-1972	-322	1972-1975	+481	1975-1978	+447
15	1966-1972	-82	1972-1975	+510	1975-1978	-331
14	1966-1972	+140	1972-1975	-408	1975-1978	+433
13	1966-1972	-821	1972-1975	+35	1975-1978	-1 106
12	1966-1972	-970	1972-1975	+266	1975-1978	-790
11	1967-1972	+125	1972-1975	-539	1975-1978	-1 328
10	1967-1972	-1 080	1972-1975	-257	1975-1978	-770
9	1967-1972	+1 566	1972-1975	-	1975-1978	-1 611
TOTAL		-7 300		-4 400		-6 500

4.5 Sediment Sampling Analyses

4.5.1 Suspended Sediment Sampling

The suspended sediment sampling program provided only limited information because it had been improperly conducted. This was because sampling was undertaken at the same time as the hydrographic surveys, which was after the reservoir had reached FSL. By this time, most of the sediment had settled out of suspension and the concentrations obtained were very low. Only in 1972 was the suspended sediment sampling program conducted at the optimum time - when the reservoir was being filled by the peak discharge. Concentrations at this time are normally sufficiently large enough to perform particle size analyses and provide information on settling characteristics of the incoming sediment loads. The 1972 data revealed that almost 85% of the suspended sediment load had settled out of suspension by Range 21 (Table 22). Furthermore, almost all of the sand component of suspended sediment had been deposited by Range 30. By Range 26 most of the suspended sediment was comprised of clay. The 1972 peak discharge had a return period of 2.43 years, which is just more than the mean annual flood and indicative of the transport capacity of a that magnitude of flood. If this sampling program had been conducted properly over the years, it could have provided this kind of information for the range of peak discharges - valuable supportive information to the hydrographic surveys.

TABLE 22

Concentration and Particle Size Data for 1972 Suspended Sediment Samples

Range	Suspended Sediment Concentration (mg/L)	Percentage Sand	Percentage Silt	Percentage Clay
36	705	49	34	17
33	490	23	45	32
30	326	1	50	49
29	266	1	40	59
26	260	1	26	73
21	111*			
17	24*			
14	51*			
9	22*			

Source: Wiebe and Drennan, 1973
* Insufficient concentration for particle size analysis

4.5.2 Bed material sampling

In most reservoir studies bed material data have seldom been collected, but rather estimated from empirically derived relationships. The most commonly used method of obtaining a density value for the deposited sediment is the Lane and Koelzer (1953) method, where the density is determined by taking into account only the particle size of incoming sediment, the method of operation of the reservoir, and time. The equation used is:

$$W = W_1 + B \log t$$

where: W = density of deposited material after t years

W_1 = initial density

B = constant

t = time (years)

The initial density of the sediment is obtained by applying the percentage of each sediment fraction to a mean density value and then summing the three fractions. The required information is available in Table 23.

TABLE 23

Lane and Koelzer's Deposited Sediment Density Values (kg/m^3)

Reservoir Operation	Sand		Silt		Clay	
	W_1	B	W_1	B	W_1	B
Sediment always submerged or nearly submerged	1 490	0	1 041	91.3	481	256.3
Normally a moderate reservoir drawdown	1 490	0	1 185	43.2	737	171.4
Normally considerable reservoir drawdown	1 490	0	1 265	16.0	961	96.1
Reservoir normally empty	1 490	0	1 313	0	1 249	0

Source: Lane and Koelzer, 1953

In most cases only particle size data were available for the bed samples, so therefore it was important to evaluate this computation method against actual measured values. Up to and including 1978 the sampling procedure had not changed, but in 1980 the collection technique and analysis procedures were modified. The result was that a significantly different set of data was obtained compared to previous years. Until the sampling program can be properly evaluated it was determined that these data be omitted. There have been 144 in situ densities collected from Lake Diefenbaker, which provides a good basis for comparison (Appendix J). Based on particle sizes, densities were computed using values for sediment that would always be submerged. As illustrated in Figure 34, the computed values were

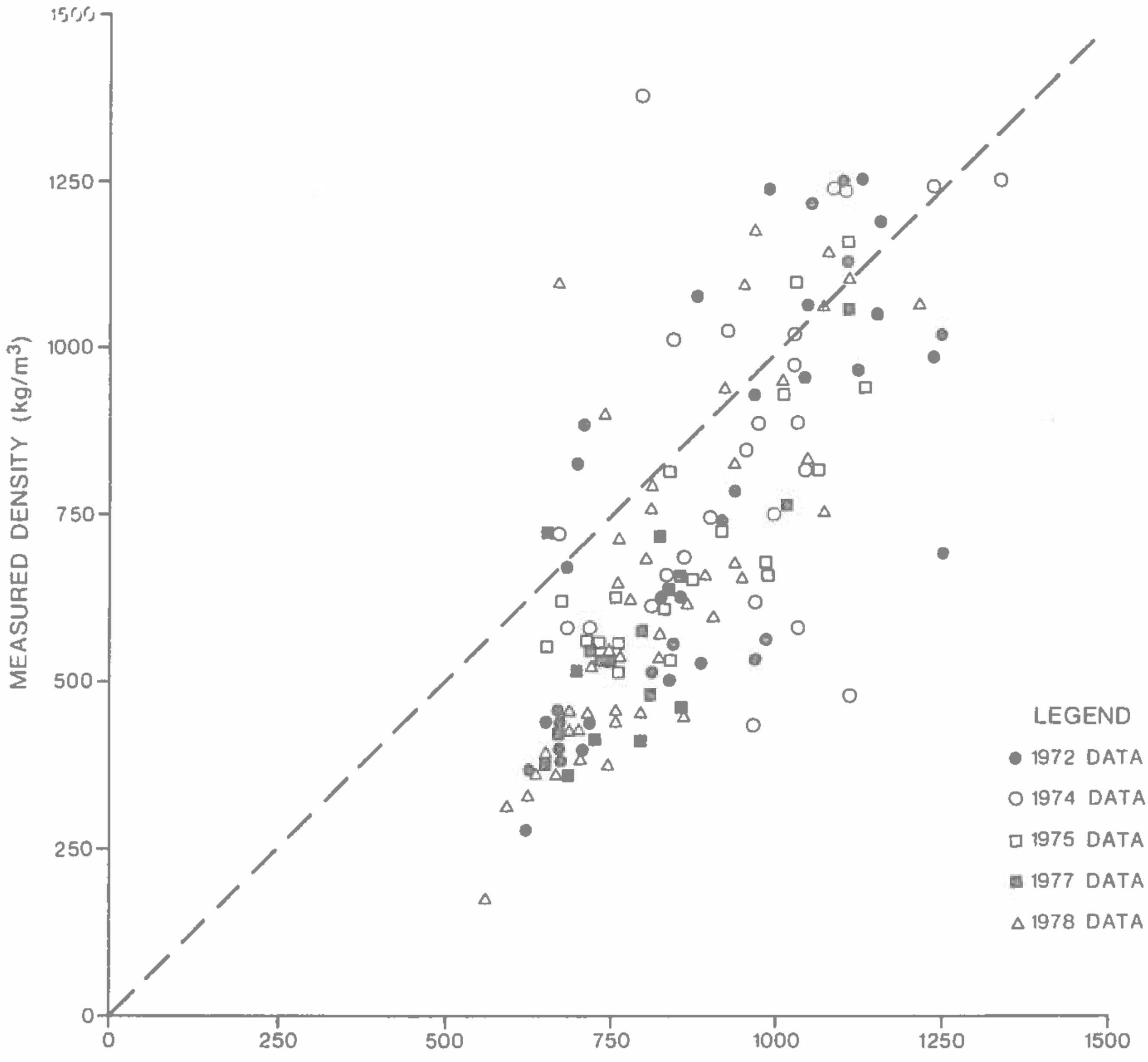


FIGURE 34
MEASURED DENSITIES OBTAINED FROM A PHLEGER CORER VERSUS COMPUTED DENSITIES BASED ON PARTICLE SIZES

significantly higher than those that were actually measured, suggesting that the Lane and Koelzer technique tends to overestimate. This weakness has been acknowledged in other studies (Lara and Pemberton, 1963; Vanoni, 1975).

To derive the most suitable density values, multiple regression correlation analysis was applied to the 144 bed material sample data. The equation derived was:

$$Y = 12\,553\ kg/m^3 - 123.5\ kg/m^3\ (X_1) - 116.3\ kg/m^3\ (X_2) - 110.8\ kg/m^3\ (X_3)$$

R = .75

where: y = density (kg/m^3)

X_1 = Percentage clay

X_2 = Percentage silt

X_3 = Percentage sand

When the average density of each fraction is compared to Lane and Koelzer's (1953) values there is a marked difference for the clay fraction (Table 24).

TABLE 24
Deposited Sediment Densities (kg/m^3) Comparison

Fraction	Multiple Regression Equation	Lane and Koelzer
Pure Clay	203	481
Pure Silt	923	1 041
Pure Sand	1 474	1 490

The clay density value obtained from this study and others show that the Lane and Koelzer value is too high and may be due to some bias in their data. For the other two fractions there appears to be good agreement, especially so for the sand fraction.

This multiple regression equation was then used to determine densities where only particle size data were available. The densities or particle size data used were from samples that were collected in the thalweg, which best represent densities of the loads transported by the South Saskatchewan River. As Table 25 shows, by 1972 the sand component of the load was being deposited upstream of Range 26 and the wash load transported a considerable distance into the reservoir. The 1975 data revealed that sand had been transported as far downstream as Range 26 but past Range 21 mostly clays were being transported and deposited. The reason that the sand component had been transported as far into the reservoir was because the 1975 discharge was an extremely high discharge. In 1978 the sand portion of the load was found to be deposited in the upper ranges with a major portion of the bed being comprised of clays. This is attributed to the considerably lower discharges recorded between 1975 and 1978 which were only capable of transporting finer material. The 1980 data revealed that the sand portion had been deposited within the first couple of ranges which appears to be the prevalent pattern.

TABLE 25

Density (kg/m^3) and Particle Sizes of the Bed

Range	1967 % Sand	1967 % Silt	1967 % Clay	1972 % Sand	1972 % Silt	1972 % Clay	1972 Density*	1975 % Sand	1975 % Silt	1975 % Clay	1975 Density*
32	98	2	-	100	-	-	1 474 C	100	-	-	1 474 C
31											
30											
29											
28	36	34	40	89	7	4	1 384 C				
27								30	42	28	886 C
26	87	5	8	2	56	42	737 M	22	42	36	785 C
25								4	58	38	671 C
24											
23											
22											
21	31	49	20					1	33	66	453 C
20											
19								2	22	76	387 C
18											
17	60	19	8	4	29	67	705 M	1	28	71	417 C
15											
14				2	37	61	721 M				
13											
12											
11	69	17	10					1	25	74	396 C
10	87	11	2								
9	65	10	25	4	48	48	240 M				

* M - Measured with Phleger Corer
C - Calculated using multiple regression equation

TABLE 25 (cont'd)

Density (kg/m^3) and Particle Sizes of the Bed

Range	1978 % Sand	% Silt	% Clay	Density	1980 % Sand	% Silt	% Clay	Density
32	100	-	-	1 474 C	100	-	-	1 474 C
31								
30	80	12	8	1 305 C	66	18	16	1 171 C
29	79	9	12	1 271 C	5	40	55	555 C
28								
27	3	51	46	641 M				
26	2	41	57	432 M				
25					4	50	46	614 C
24	4	59	37	561 M				
23	2	38	60	400 M				
22					3	44	53	558 C
21	9	35	56	544 M				
20	3	33	64	464 M				
19								
18					3	23	74	407 C
17	1	26	73	352 M				
15					-	24	76	376 C
14								
13	2	28	70	368 M	1	31	68	439 C
12					2	22	76	387 C
11								
10								
9	2	14	84	329 M				

* M - Measured with Phleger Corer
C - Calculated using multiple regression equation

Figure 35 illustrates the relationships between density and distance over time. The best data fit was determined to be a quadratic relationship. The 1972 developed relationship was slightly different because filling of the reservoir had distorted the density pattern. The 1975 and 1978 relationships revealed similar sedimentation patterns. By about Range 20 the relationships are asymptotic, as only the finest materials are carried beyond this point. In 1980 the densities were lower in the upper portion than in previous years due to more fines being deposited.

4.6 Delta Formation

The sedimentary structure of deltas has been well documented (Walker, 1979; Reineck and Singh, 1980). The delta is comprised of three types of deposits: topset, foreset, and bottomset (Figure 36). However, because Lake Diefenbaker has such a large drawdown range, causing sediment to be deposited over 37 km of reservoir during filling each year, the beds are not readily identifiable by the bed material composition alone. Therefore, the beds have been identified based on the measured deposition rates at each of the ranges and related to a classical reservoir delta structure.

From the hydrograhic data, Range 25 was determined to mark the pivot point or in other terms the maximum extent of the topset beds into the reservoir. Since Range 32 marks the beginning of reservoir conditions, the topset beds can be said to extend from Range 32 to Range 25. The original

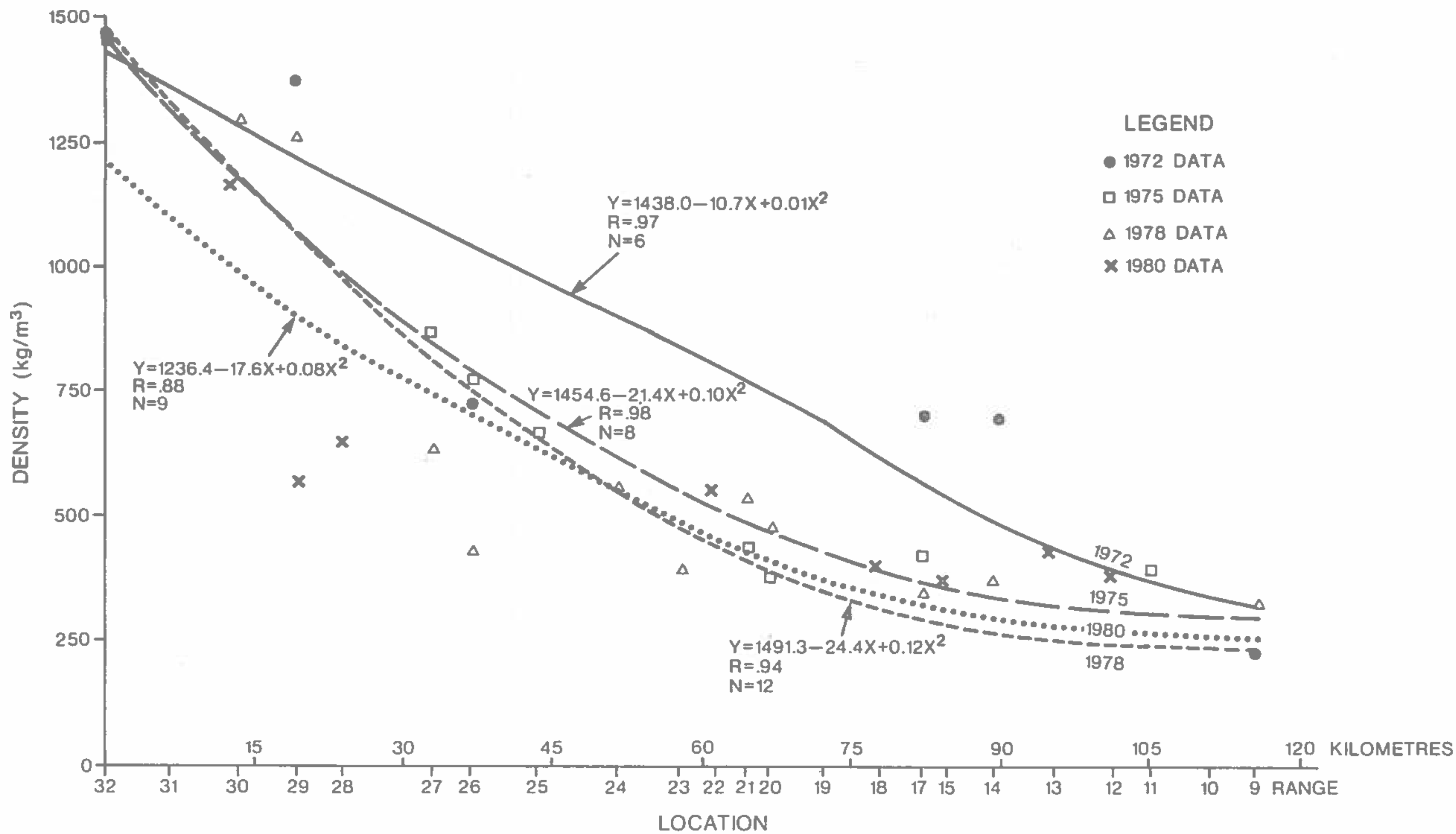


FIGURE 35

BED MATERIAL DENSITY RELATIONSHIPS

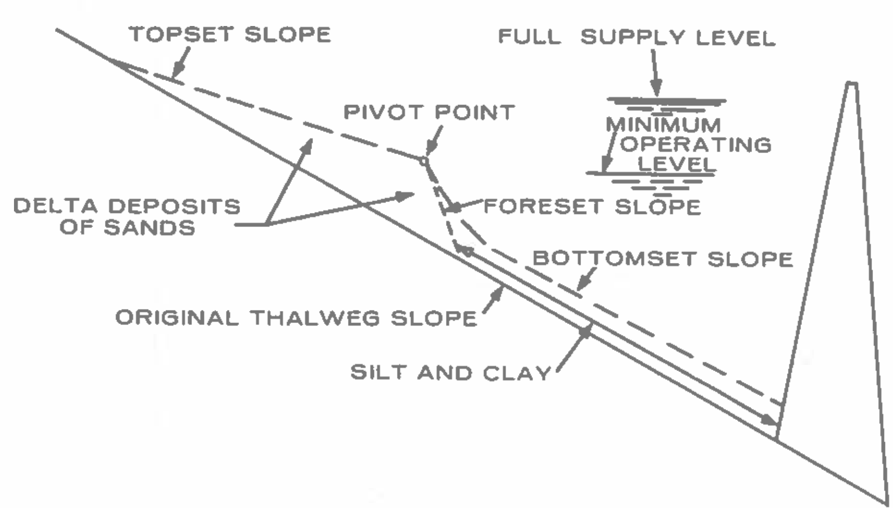


FIGURE 36

A CLASSICAL DELTA PROFILE

slope for this reach was 0.00022 and by 1980 it had been reduced to 0.00018. Reservoir studies in the United States have shown that topset beds in reservoirs normally stabilize once the slope has been reduced to half of the original slope (Shen, 1971; U.S. Bureau of Reclamation, 1977). Therefore, in the case of Lake Diefenbaker, the slope should become stabilized at about 0.00011.

Another approach used to estimate the topset slope is that of determining the theoretical slope at which no bed load will be transported (Vanoni, 1975). Using the Scholitsch formula for zero bed load transport this theoretical slope was calculated. The data used were from the Lemsford station. The equation is:

$$S = \left(\frac{.00021\ DB}{Q}\right)^{3/4}$$

where: S = slope

D = mean bed material particle size (mm) 0.359

B = bankfull width (ft) 830

Q = mean annual flood (ft^3/s) 51 000

Note: data are in both metric and imperial units.

A slope of 0.00004 was determined to be the minimum slope that would ensure no bed load transport. This theoretical value is considerably lower than the empirical findings and probably indicates the lowest limit that the slope might reach.

As noted from both the suspended and bed material data, Range 21 is the beginning of the bottomset deposits and marks the point beyond which only clays are transported. Therefore, the foreset bed slope can be considered to extend from Range 25 to Range 21. Originally the slope for this reach was 0.00025 but has increased to 0.00031 due to deposition. Foreset slopes are normally steep, some 6.5 times greater than topset slopes (U.S. Bureau of Reclamation, 1977). In Lake Diefenbaker, the foreset slope was less than twice that of the topset which shows the effects from factors such as: the large water level drawdown, small sediment loads and an original low slope.

The bottomset slopes are normally very gentle and do not show much change which is the case for Lake Diefenbaker. The original slope for the reach from Range 21 to Range 9 was 0.00025 and by 1980 it had only changed to 0.00026.

4.7 Temperature Data Analysis

Temperature data are useful in determining the circulation pattern of inflows into the reservoir, which in turn affects the sedimentation patterns. Because Lake Diefenbaker is long, narrow, and relatively shallow for a great distance, the inflows from the South Saskatchewan River become well mixed with the existing reservoir water and the suspended sediment becomes relatively evenly dispersed. It is not until the ranges downstream of Swift Current Creek that water stratification is identifiable. The thermal structure of the lake water, as expected in a relatively deep lake, was found to be relatively stable from year to year at the deeper ranges. However, since sedimentation is only significant upstream, the temperature gradient noted in these lower ranges do not affect the sedimentation pattern.

4.8 Hydrometric Station Loads Compared to the Measured Deposited Load Estimates

A comparison of the hydrometric station loads to the measured deposited loads obtained from the surveys showed good agreement, considering the many factors/errors involved in obtaining deposited load estimates. For the period 1966 to 1972, a total load of approximately 47 000 000 t was transported into Lake Diefenbaker by the South Saskatchewan River and Swift Current Creek. For that period the deposited load was calculated to have been in the order of 52 000 000 t - a difference of only +11% (Table 26). From 1972 to 1975, some 20 000 000 t were transported into the reservoir, while the measured trapped load was calculated to have been 19 000 000 t, or only -5% difference. The period for which the results did not agree well was from 1975 to 1978. The sediment loading was considered to be about 6 000 000 t, but the trapped load was estimated to be some 13 000 000 t.

TABLE 26

Measured Deposited Loads

Year Range	1972 Volume (dam^3)	1972 Density (kg/m^3)1	1972 Load (Tonnes)	1975 Volume (dam^3)	1975 Density (kg/m^3)2	1975 Load (Tonnes)
32	+158	1 438	+227 215	-486	1 454	-706 678
31	+158	1 370	+216 471	-1 091	1 322	-1 442 372
30	-249	1 296	-322 720	-582	1 184	-689 122
29	-3 327	1 236	-4 112 372	-1 374	1 078	-1 481 244
28	-4 632	1 185	-5 489 187	-1 801	995	-1 792 082
27	-3 358	1 095	-3 677 189	-4 419	855	-3 778 429
26	-4 192	1 061	-4 447 928	-2 745	805	-2 209 832
25	-6 829	1 992	-6 774 697	-2 276	713	-1 622 867
24	-2 068	915	-1 892 312	-2 632	617	-1 624 023
23	-1 606	857	-1 376 409	-301	554	-166 762
22	-1 221	822	-1 003 711	-461	519	-239 271
21	-1 141	795	-907 139	-634	494	-313 211
20	-2 245	773	-1 735 469	-1 582	474	-749 904
19	-5 148	722	-3 717 037	-1 201	432	-518 857
18	-5 203	665	-3 460 163	-732	393	-287 690
17	-1 747	625	-1 091 928	-53	369	-19 558
15	-2 763	606	-1 674 459	-384	359	-137 863
14	-6 164	563	-3 470 501	-981	340	-333 556
13	-7 007	512	-3 587 758	-738	323	-238 386
12	-6 124	458	-2 804 928	-593	312	-185 025
11	-886	420	-372 138	-1 550	309	-478 973
10	-3 593	378	-1 358 220	-257	305	78 389
9	-3 544	335	-1 187 298	-	303	-
TOTAL			-52 000 000			-19 000 000

NOTE: 1 $Y = 1438.0 + 10.7 X + 0.01 X^2$
2 $Y = 1454.6 - 21.4 X + 0.10 X^2$

TABLE 26 (cont'd)

Measured Deposited Loads

Range	Year	1978			1980	
	Volume (dam^3)	Density (kg/m^3)3	Load (Tonnes)	Volume (dam^3)	Density (kg/m^3)4	Load (Tonnes)
32	-46	1 491	-68 589	+14	1 236	+17 305
31	-545	1 340	-730 336	-359	1 128	-404 972
30	-2 049	1 184	-2 426 134	-1 689	1 014	-1 712 729
29	-1 482	1 064	-1 576 925	-1 302	927	-1 207 213
28	-1 287	970	-1 248 451	-926	857	-793 621
27	-1 326	814	-1 079 416	-884	741	-655 076
26	-901	758	-682 991	-533	700	-373 118
25	-1 707	655	-1 118 139			
24	-1 128	551	-621 551			
23	-502	483	-242 478			
22	-326	446	-145 403			
21	-203	418	-84 858			
20	-459	398	-182 691			
19	-1 030	355	-365 668			
18	-1 138	315	-358 487			
17	-265	293	-77 649			
15	-1 228	283	-347 541			
14	-140	266	-37 242			
13	-1 106	253	-279 832			
12	-790	248	-195 930			
11	-1 328	243	-322 720			
10	-770	239	-184 639			
9	-1 611	236	-380 214			
TOTAL			-13 000 000			-5 000 000

NOTE: 3 $Y = 1491.3 - 24.4 X + 0.12 X^2$
4 $Y = 1236.4 - 17.6 X + 0.08 X^2$

This shows that a 100% difference is possible when comparing these two methods. Because there are so many factors/errors involved it is extremely difficult to assess where the weaknesses may lie. From 1978 to 1980, a further 6 000 000 t had entered the reservoir and estimates show that by Range 26, 5 000 000 t had been deposited.

Therefore, in total, from 1966-1980 the South Saskatchewan River transported 79 000 000 t and based on the hydrographic surveys 89 000 000 t were calculated to be deposited. This is only a +13% difference. These results show that it is possible to achieve fair agreement between station derived loads and measured deposited loads if a comprehensive reservoir program such as the one for Lake Diefenbaker is implemented.

4.9 Swift Current Creek

The hydrographic surveys conducted in 1972 and 1978 were to assess the Swift Current Creek source of sediment. As noted in Chapter III, the sediment loads transported by Swift Current Creek in latter years were significantly smaller. In fact, between 1972 and 1978, only 65 000 t of sediment had been transported into the reservoir by this source. Compared to the long term mean of 41 000 t per annum, this period studied was not characteristic of normal loadings and the results should be taken in this context.

The 1972 contour map (Figure 37) which covers an area of 2.4 km^2 reveals the submerged topography of this area. The arrow points to where Swift Current Creek flows into the reservoir. The side where Swift Current

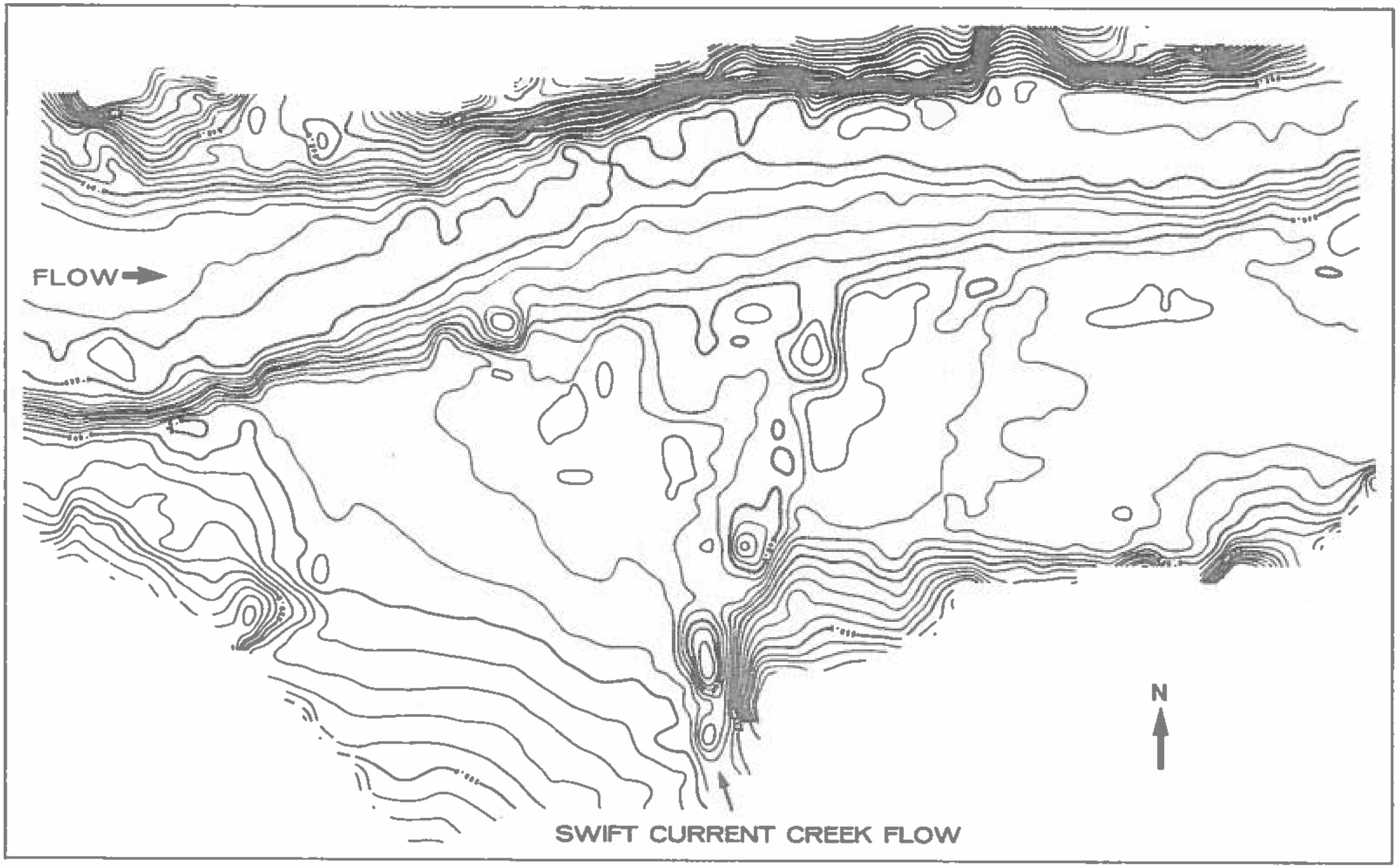


FIGURE 37
SWIFT CURRENT CREEK AREA
1972 CONTOURS
CONTOUR INTERVAL = 1.0 METRE

0 300 600
METRES

Creek drains into the reservoir is marked by a large flood plain, and the channel used by pre-reservoir flows can be identified, as well as the old South Saskatchewan River channel. The north side of the area has steeper slopes. By 1978, (Figure 38) many morphological changes were noticeable. The most significant change was where a bank had slumped across the creek's channel causing the flows to cut a wider channel. Bank slumping was noticeable along the length of the shoreline and is best depicted in Figure 39 of contour differences between 1972 and 1978.

An examination of the bed material samples collected from this reach (sample identifer SCC in Appendix K) reflect the changes that have been occurring. In 1972, the average bed material sample was 71.5% silt and clay, but by 1978 silt and clay made up 90.9% on average. This increase in fines can be attributed to the finer material that was transported by Swift Current Creek, as well as fines derived from bank erosion and slumping. The mean density of the deposited material in 1978 was determined to be only 565 kg/m^3, a very low density.

The capacity table (Appendix L) revealed that 1 200 dam^3 of sediment had been deposited in this area - 180 dam^3 in live storage and the remaining in the dead storage zone. Based on the average density, this volume was converted to a load of approximately 672 500 t. The 65 000 t estimated from Swift Current Creek during this period is to only 10% of the total value. This study points out that the bank material contribution was the most significant source of sediment in this particular area of the reservoir.

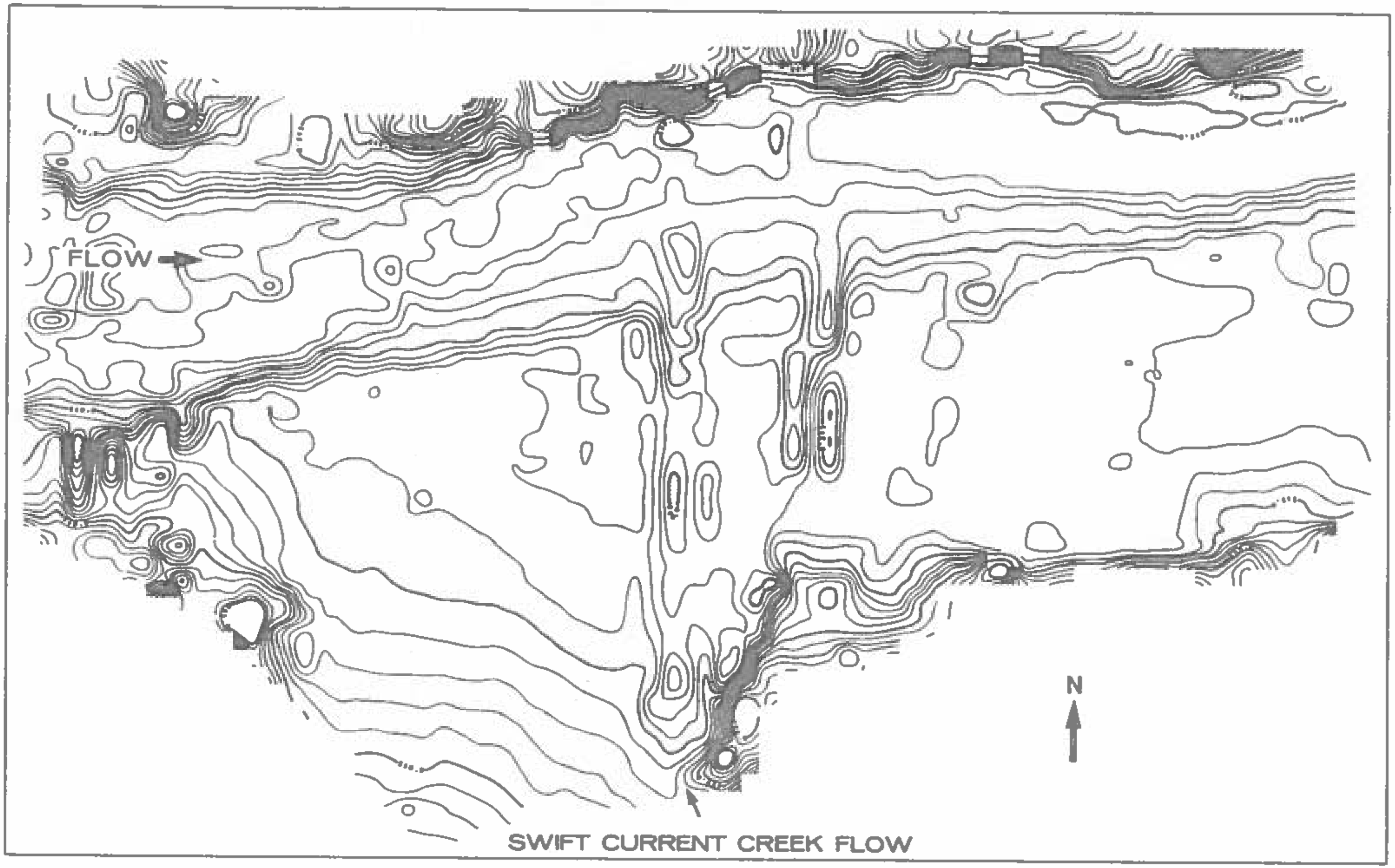


FIGURE 38
SWIFT CURRENT CREEK AREA
1978 CONTOURS
CONTOUR INTERVAL = 1.0 METRE

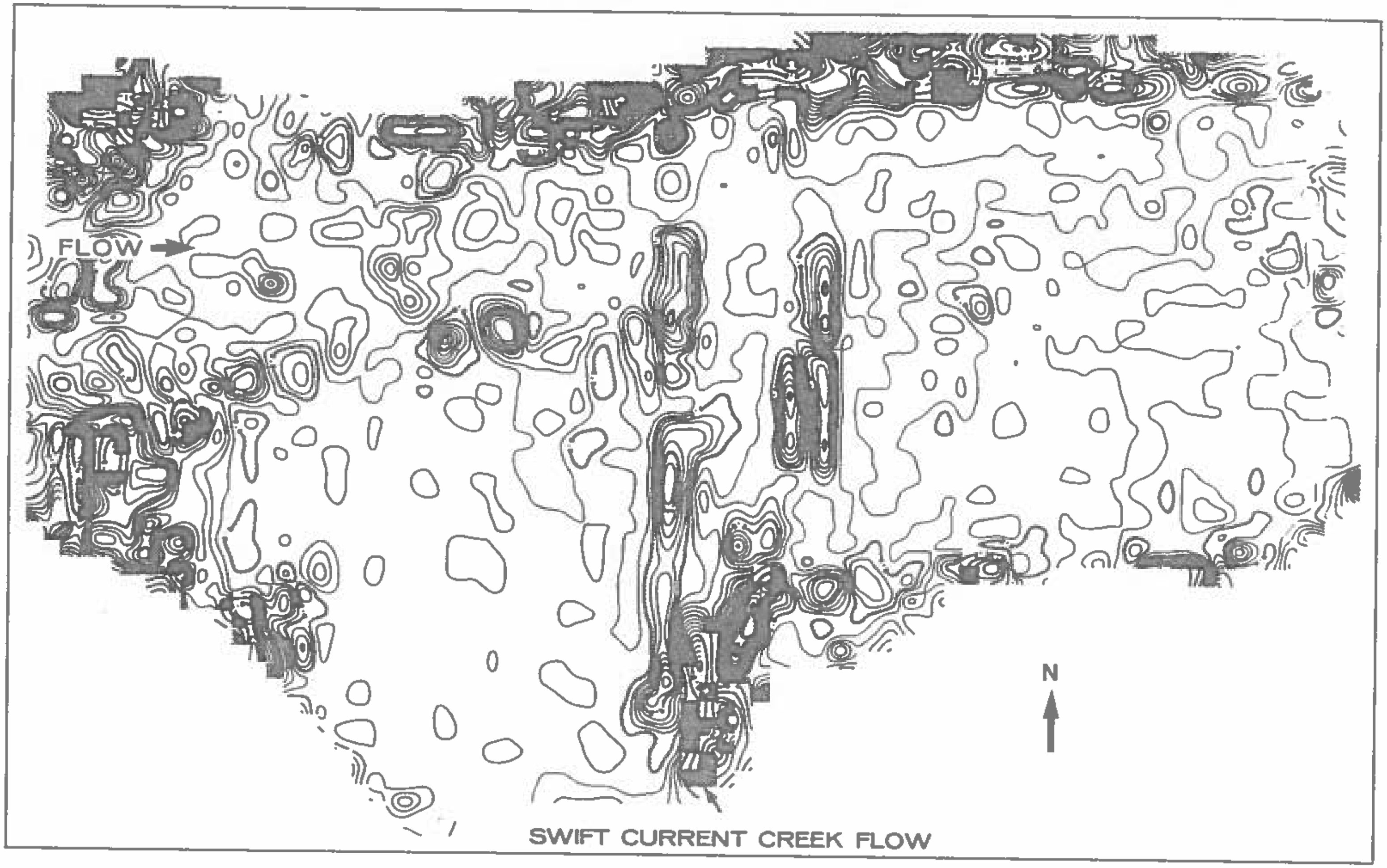


FIGURE 39
SWIFT CURRENT CREEK AREA
1972-1978 CONTOUR DIFFERENCES
CONTOUR INTERVAL = 0.5 METRE

0 300 600
METRES

5. Summary and Recommendations

Based on Lemsford station data the median daily discharge of the South Saskatchewan River is 146 m^3/s. June accounts for 25% of the total annual flow, most of it originating from mountain runoff. Hydrometric stations located further upstream were used to reconstruct the flows after 1970 for the discontinued Lemsford station, thereby, ensuring a complete period for analysis. Based on 69 years of record the South Saskatchewan River, mean annual flow is 8.3 million dam^3. Since filling of the reservoir began in 1964, total annual flows were representative of the long term range of flows.

The estimated average annual suspended sediment load based on data from 1962 to 1980 was 5.4 million t, most of which was transported by the mountain flow freshet. Depth integrating samples collected at Lemsford indicated that on average, sand made up 21% of the load, silt 41% and clay 38%. Bed material samples were found to be comprised mainly of sand (87%). The sediment transport relationships were characteristic of large rivers with a high wash load contribution.

Swift Current Creek's mean annual flow was calculated to be 59 000 dam^3, but for the period under study (1972-1978), flows were significantly less than the long term mean. This in turn severely reduced the sediment loadings. The sediment data showed considerable variability, which is considered common for streams of such a flashy nature.

The upstream ranges (Range 38 - Range 32) had been scoured based on the 1972 hydrographic survey results. This scouring was attributed to at least two major ice jams which had developed in this reach. It was estimated that 4 500 dam^3 of material were eroded from the main channel between 1966 and 1972 due to these ice jams. The maximum depth of scour measured was 1.3 at Range 37. Further bed degradation was observed for 1975 at most of the ranges. The 1978 and 1980 data indicated that infilling was occurring and that slope conditions were beginning to approximate those that had been there prior to the ice jams.

The drawdown reach (Range 32 - Range 26) has been continuously aggrading over the years with the maximum deposition being recorded as 1.9 m at Range 27 in 1980. The rate of deposition was found to be considerably less than had been previously forecasted by Kuiper (1962). By 1980, 19% of the total storage volume of this 37 km-long reach had been lost due to sedimentation. This in turn represents a loss of just less than 1% of the total live storage or 0.4% of the total reservoir volume. The slope of the bed in this reach was significantly reduced due the sediment loads deposited in the lower portion of the reach.

The remaining ranges are located within the reservoir. This analysis however has been limited to ranges upstream of Range 9, because by Range 9 the changes were negligible and there was concern over the quality of the data at these larger ranges. The data that were used show that approximately 1% of the total reservoir capacity had been lost by 1980. Dead storage changes were only significant in the upper part of the reservoir, with 1.3% of the total dead storage capacity being filled in. Bank slumping was estimated to have reduced the total live storage by about 0.5% over the period studied.

An analysis of the Lane and Koelzer method of deriving densities from particle size and reservoir operation was conducted because for some years only particle size data were available. This method of computing densities from particle sizes however was found to overestimate, especially for the clay fraction, based on multiple regression analysis of 144 in situ bed material samples collected from Lake Diefenbaker. The bed material samples also revealed that the sand portion of the load was being deposited in the upper ranges of the drawdown reach and by Range 21 mostly clays were being deposited. The density to distance relationship was determined to be a quadratic and basically asymptotic beyond Range 21, where only fines were being deposited.

The delta beds were distinguished based on the bed composition and sedimentation rates measured at the ranges. It was determined that the topset beds extended from Range 32 to Range 25 and had a slope of 0.00018 based on the latest hydrographic data. The topset slope should stabilize at about 0.00011 based on empirical findings from other reservoir studies. The foreset slope extended from Range 25 to Range 21 and had a slope of 0.00031, which is not very steep in comparison to other reservoir studies. The large water level drawdown, relatively small sediment loads and an originally low bed slope were determined to be responsible for affecting the development of the delta. The bottomset beds extended beyond Range 21, with a slope of 0.00026.

The temperature data revealed that the temperature gradients would not directly affect the sedimentation pattern in the reservoir, as water stratification only existed in the lower portion of the reservoir, where there was minimal sedimentation.

Comparison of the hydrometric station measured sediment loads to the loads estimated from the hydrographic surveys revealed good agreement especially from 1966-1972 (11%) and 1972-1975 (-5%), but for 1975-1978 and 1978-1980 the agreement was not as good. Due to the many weaknesses/errors involved in estimating deposited loads, large discrepancies for small loadings using this method are not uncommon. However, for the total period (1966-1980) the difference between these two methods was good (13%).

Swift Current Creek's contribution of sediment was negligible between 1972 and 1978. Almost all the change to the area where Swift Current Creek drains into Lake Diefenbaker was determined to be from bank slumping. In fact, only 10% of the change that was measured was attributed to the creek's sediment contribution.

Finally, it should be pointed out that besides providing scientific information this project has been very important for the development and testing of new techniques and equipment. The experience and knowledge obtained from this project has been transferred to other projects, therefore providing a valuable contribution to this field.

Recommendations:

1. There are some advantages to continuing this project even though the sedimentation rate has not significantly affected reservoir operations. These advantages are:

    a) The project is providing scientific information on the processes affecting delta development, sedimentation patterns, bank erosion, etc., which is transferable to other sedimentation studies;

    b) Since development around the reservoir has escalated in latter years, the site specific data have become increasing important for other projects (park development, locating marinas, pipeline proposals, etc.);

    c) This project also provides an opportunity for the organizations involved to train personnel and expand their knowledge in conducting sedimentation studies.

2. Certain changes should be made to the existing program to make it more cost effective and efficient. These changes are:

    a) Increasing the survey interval from a three to a five-year return. Five years is considered the maximum extension so as to ensure continuity between surveys and for planning purposes.

    b) Restricting the survey to those range lines upstream of the Saskatchewan Landing Bridge (Range 20), as almost all the load transported by the South Saskatchewan River is deposited by that point.

    c) Special area studies (Elbow, Swift Current Creek Delta) do not have to be resurveyed as they show negligible sedimentation.

3. During the completion of the report it became apparent that certain data collection methodologies and techniques need to be reviewed and evaluated. Such as:

    a) The Hydac/Hydra Systems need to be properly evaluated and the system errors quantified;

    b) To compare and evaluate the cross-section vs. area methods of hydrographic surveying more data will need to be acquired;

c) more comprehensive guidelines are needed for bed material sampling;

d) The guidelines regarding suspended sediment sampling in reservoirs need to be reexamined.

4. To properly quantify bank erosion, which is significant, a study using state-of-the-art techniques (terrestrial photogrammetry, concentrated cross-sectional work) should be considered.

5. A numerical model, such as Hec-6 or Mobed should be run using the existing data base, prior to a resurvey, to ensure the cross section network is adequate.

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Appendix A

<u>Flow Duration of Daily Discharges for the South Saskatchewan River near Lemsford</u>

SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD

% OF TIME INDICATED DISCHARGE WAS EQUALLED OR EXCEEDED

DISCHARGE IN M3/S	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL TIME
23.2	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
42.1	96.90	98.26	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.25	94.39	99.00
48.2	93.08	97.55	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.63	97.54	89.97	98.00
53.6	89.30	96.80	100.00	100.00	100.00	100.00	100.00	100.00	99.36	98.38	95.73	85.52	97.00
58.3	85.09	95.88	100.00	100.00	100.00	100.00	100.00	100.00	97.77	96.99	93.84	81.52	96.00
62.4	82.23	94.74	99.76	100.00	100.00	100.00	100.00	100.00	96.04	95.55	92.04	77.73	95.00
65.8	79.26	93.48	99.52	100.00	100.00	100.00	100.00	100.00	94.35	94.20	90.40	74.44	94.00
68.4	76.82	92.29	99.32	100.00	100.00	100.00	100.00	100.00	92.91	93.06	89.06	71.85	93.00
70.3	74.97	91.27	98.96	100.00	100.00	100.00	100.00	100.00	91.76	92.16	88.04	69.91	92.00
72.0	73.14	90.05	97.56	100.00	100.00	100.00	100.00	100.00	90.64	91.33	87.10	68.11	91.00
73.6	71.21	88.56	95.15	100.00	100.00	100.00	100.00	100.00	89.52	90.52	86.21	66.34	90.00
75.2	69.12	86.76	94.67	100.00	100.00	100.00	100.00	100.00	88.33	89.69	85.29	64.50	89.00
76.8	66.87	84.69	93.13	100.00	99.90	100.00	100.00	100.00	87.08	88.84	84.36	62.61	88.00
78.3	64.65	82.54	91.64	100.00	99.77	100.00	100.00	100.00	85.87	88.01	83.47	60.80	87.00
79.9	62.18	80.04	90.00	100.00	99.63	100.00	100.00	100.00	84.55	87.11	82.51	58.83	86.00
81.5	59.63	77.37	88.34	100.00	99.48	100.00	100.00	100.00	83.19	86.18	81.52	56.84	85.00
83.1	57.01	74.57	86.65	100.00	99.33	100.00	100.00	100.00	81.82	85.22	80.51	54.84	84.00
84.7	54.34	71.65	84.95	100.00	99.18	100.00	100.00	99.92	80.44	84.25	79.47	52.83	83.00
86.3	51.06	68.67	83.25	100.00	99.02	100.00	100.00	99.71	79.05	83.25	78.42	50.82	82.00
87.8	49.14	65.63	81.66	100.00	98.87	100.00	100.00	99.49	77.77	82.29	77.40	48.95	81.00
89.4	46.48	62.79	79.99	100.00	98.71	100.00	100.00	99.23	76.42	81.24	76.29	46.98	80.00
91.1	43.69	59.59	78.25	100.00	98.53	100.00	100.00	98.93	75.01	80.10	75.09	44.93	79.00
92.7	41.14	56.64	76.65	99.92	98.36	100.00	100.00	98.60	73.72	79.00	73.92	43.04	78.00
94.3	38.67	53.78	75.10	99.90	98.19	100.00	100.00	98.24	72.49	77.88	72.73	41.20	77.00
96.0	36.17	50.88	73.52	99.89	98.01	100.00	100.00	97.80	71.24	76.67	71.42	39.32	76.00
97.7	33.82	48.16	72.03	99.87	97.83	100.00	100.00	97.30	70.06	75.42	70.08	37.52	75.00
99.4	31.64	45.60	70.63	99.58	97.65	100.00	100.00	96.72	68.97	74.15	68.70	35.81	74.00
101	29.74	43.50	69.39	99.20	97.47	100.00	100.00	96.13	68.03	72.92	67.37	34.29	73.00
103	27.44	40.82	67.85	98.70	97.26	100.00	100.00	95.36	66.93	71.30	65.63	32.46	72.00
105	25.22	38.16	66.31	98.19	97.03	100.00	100.00	94.58	65.90	69.60	63.84	30.70	71.00
106	24.14	35.83	65.54	97.92	96.92	100.00	100.00	94.19	65.41	68.72	62.93	29.84	70.00
108	22.03	34.21	64.00	97.39	96.69	100.00	100.00	93.39	64.47	66.91	61.06	28.19	69.00
110	20.00	31.61	62.48	96.83	96.46	100.00	100.00	92.57	63.56	65.05	59.15	26.50	68.00
112	19.05	29.04	60.96	96.25	96.22	100.00	100.00	91.76	62.69	63.16	57.22	25.39	67.00
113	17.11	27.78	60.20	95.96	96.09	100.00	100.00	91.34	62.26	62.20	55.25	24.36	66.00
115	15.28	25.28	58.70	95.35	95.84	100.00	99.75	90.52	61.41	60.28	54.23	22.96	65.00
117	13.53	22.83	57.22	94.72	95.57	100.00	99.27	89.69	60.55	58.37	52.32	21.63	64.00
119	11.87	20.44	55.75	94.07	95.30	100.00	98.80	88.86	59.69	56.46	50.35	20.38	63.00
120	11.07	19.27	55.03	93.73	95.16	100.00	98.58	88.44	59.25	55.52	49.37	19.78	62.00
122	9.54	15.97	53.59	93.04	94.86	100.00	98.15	87.52	58.34	53.67	47.43	18.54	61.00
124	8.09	14.75	52.10	92.32	94.50	100.00	97.75	86.80	57.39	51.86	45.51	17.59	60.00
126	6.74	12.60	50.80	91.58	94.24	100.00	97.40	85.99	56.39	50.12	43.63	16.51	59.00
128	5.47	10.53	49.44	90.80	93.90	100.00	97.09	85.19	55.32	48.46	41.79	15.71	58.00
129	4.87	7.53	48.78	90.41	93.73	100.00	96.95	84.80	54.75	47.67	40.89	15.29	57.00
131	3.76	7.02	47.47	89.59	93.36	100.00	96.71	84.03	53.56	46.14	39.12	14.50	56.00
133	2.76	5.95	46.17	88.77	92.97	100.00	96.45	83.31	52.30	44.66	37.34	13.73	55.00
136	2.53	1.59	44.25	87.52	92.34	100.00	96.14	82.33	50.29	42.48	34.65	12.62	54.00
138	2.45	2.60	43.00	85.69	91.38	100.00	95.92	81.72	48.90	41.08	32.87	11.90	53.00
140	2.33	1.91	41.70	85.05	91.40	100.00	95.71	81.13	47.47	39.71	31.11	11.20	52.00
143	2.15	.72	37.74	84.59	90.65	100.00	95.43	80.25	45.29	37.72	28.54	10.21	51.00
146	1.65	.74	35.18	83.33	89.37	100.00	95.13	79.34	43.08	35.83	26.09	9.30	50.00

WATER SURVEY OF CANADA
23/08/82 , PAGE 3 SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD
SEDIMENT SURVEY SECTION

DISCHARGE IN M3/S	% OF TIME INDICATED DISCHARGE WAS EQUALLED OR EXCEEDED JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL TIME
149	1.16	.56	36.47	82.07	89.06	100.00	94.82	78.35	40.90	34.05	23.80	8.48	49.00
152	.66	.37	34.66	80.82	88.24	100.00	94.55	77.25	38.77	32.38	21.71	7.77	48.00
155	.17	0.00	33.31	79.56	87.41	100.00	94.30	75.98	36.72	30.83	19.86	7.16	47.00
158	0.00	0.00	31.84	78.32	86.57	100.00	94.06	74.51	34.80	29.41	18.30	6.69	46.00
161	0.00	0.00	30.46	77.09	85.74	100.00	93.84	72.79	33.04	28.12	17.06	6.35	45.00
165	0.00	0.00	28.74	75.43	84.54	100.00	93.55	70.36	30.82	26.51	15.86	5.95	44.00
169	0.00	0.00	27.12	73.75	83.24	100.00	93.27	67.84	28.72	25.00	15.04	5.55	43.00
173	0.00	0.00	25.63	72.09	81.90	100.00	92.99	65.25	26.76	23.59	14.48	5.17	42.00
176	0.00	0.00	23.94	70.05	80.23	100.00	92.64	61.96	24.49	21.98	13.95	4.68	41.00
182	0.00	0.00	22.73	68.47	78.97	100.00	92.36	59.30	22.84	20.82	13.51	4.29	40.00
187	0.00	0.00	21.40	66.60	77.53	100.00	92.01	56.00	20.99	19.53	12.74	3.79	39.00
192	0.00	0.00	20.26	64.91	76.47	100.00	91.66	52.73	19.37	18.43	11.50	3.26	38.00
197	0.00	0.00	19.19	63.56	75.53	100.00	91.30	49.46	17.88	17.37	9.98	2.72	37.00
203	0.00	0.00	17.96	62.28	74.57	100.00	90.86	45.53	16.25	16.15	8.00	2.06	36.00
209	0.00	0.00	16.65	61.18	73.72	100.00	90.39	41.59	14.90	15.03	6.06	1.40	35.00
215	0.00	0.00	15.82	60.03	72.94	100.00	89.88	37.56	13.87	14.06	4.38	.76	34.00
221	0.00	0.00	14.91	58.63	72.19	100.00	89.31	33.76	13.26	13.28	3.17	.16	33.00
227	0.00	0.00	14.05	57.10	71.52	100.00	88.10	30.37	12.85	12.60	2.29	0.00	32.00
235	0.00	0.00	12.75	55.03	70.71	100.00	85.57	25.77	12.37	11.74	1.38	0.00	31.00
243	0.00	0.00	11.98	52.95	69.83	100.00	82.82	22.41	11.88	10.97	.71	0.00	30.00
253	0.00	0.00	11.04	50.31	68.31	100.00	80.35	19.62	11.16	10.22	.09	0.00	29.00
265	0.00	0.00	10.16	46.93	66.16	100.00	78.07	17.71	10.21	9.41	0.00	0.00	28.00
276	0.00	0.00	9.58	43.84	64.15	99.67	75.95	16.12	9.26	8.69	0.00	0.00	27.00
289	0.00	0.00	9.15	40.65	61.88	99.08	73.23	14.48	7.70	7.89	0.00	0.00	26.00
301	0.00	0.00	8.92	38.44	59.83	98.70	70.67	13.34	5.67	7.19	0.00	0.00	25.00
315	0.00	0.00	8.32	36.67	57.64	98.17	67.75	11.37	3.96	6.55	0.00	0.00	24.00
331	0.00	0.00	7.24	35.10	56.24	97.38	64.56	8.44	2.72	6.53	0.00	0.00	23.00
345	0.00	0.00	6.49	33.60	54.20	95.78	62.16	6.21	1.99	6.02	0.00	0.00	22.00
358	0.00	0.00	5.92	32.07	51.57	93.79	60.20	4.26	1.45	4.54	0.00	0.00	21.00
371	0.00	0.00	5.33	30.42	49.01	91.69	58.32	2.88	1.09	3.13	0.00	0.00	20.00
384	0.00	0.00	4.62	27.77	46.71	89.56	56.52	2.24	.98	1.97	0.00	0.00	19.00
399	0.00	0.00	3.61	24.83	44.24	87.12	54.38	1.90	.85	.81	0.00	0.00	18.00
418	0.00	0.00	3.04	23.05	42.58	84.56	51.14	1.56	.32	.06	0.00	0.00	17.00
437	0.00	0.00	2.52	21.22	39.75	81.60	47.61	1.22	0.00	0.00	0.00	0.00	16.00
453	0.00	0.00	2.22	19.54	36.59	78.23	44.39	.93	0.00	0.00	0.00	0.00	15.00
475	0.00	0.00	2.06	17.99	32.26	74.48	41.75	.64	0.00	0.00	0.00	0.00	14.00
498	0.00	0.00	1.96	16.64	27.74	70.56	39.62	.60	0.00	0.00	0.00	0.00	13.00
519	0.00	0.00	1.88	15.07	24. 6	66.75	36.61	.55	0.00	0.00	0.00	0.00	12.00
548	0.00	0.00	1.82	13.43	21.95	61.76	34.02	.29	0.00	0.00	0.00	0.00	11.00
579	0.00	0.00	1.79	12.28	19.18	56.42	31.55	0.00	0.00	0.00	0.00	0.00	10.00
612	0.00	0.00	1.76	10.44	16.16	51.36	29.24	0.00	0.00	0.00	0.00	0.00	9.00
647	0.00	0.00	1.69	8.56	11.76	47.39	27.14	0.00	0.00	0.00	0.00	0.00	8.00
684	0.00	0.00	1.49	5.83	8.13	44.01	23.57	0.00	0.00	0.00	0.00	0.00	7.00
741	0.00	0.00	1.18	4.90	6.51	39.74	20.12	0.00	0.00	0.00	0.00	0.00	6.00
805	0.00	0.00	.95	3.88	4.44	34.10	16.70	0.00	0.00	0.00	0.00	0.00	5.00
900	0.00	0.00	.66	2.57	3.58	27.12	14.21	0.00	0.00	0.00	0.00	0.00	4.00
1 040	0.00	0.00	.15	2.13	2.00	21.13	10.40	0.00	0.00	0.00	0.00	0.00	3.00
1 230	0.00	0.00	0.00	.87	.62	15.17	7.84	0.00	0.00	0.00	0.00	0.00	2.00
1 490	0.00	0.00	0.00	.17	0.00	9.04	3.04	0.00	0.00	0.00	0.00	0.00	1.00
2 891	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

MINIMUM DISCHARGE = 23.200 MAXIMUM DISCHARGE = 2890.000

Appendix B

Total Monthly Discharges at Lemsford, Bindloss and Hwy 41, and Reconstructed Monthly Discharges for Lemsford

SOUTH SASKATCHEAN RIVER NEAR LEMSFORD
(STN. NO. 05HG001)

TOTAL MONTHLY DISCHARGE
(M^3/S)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1966	-	-	-	-	12 727	23 523	17 234	7 459	5 059	4 283	3 151	3 316
1967	2 736	2 992	5 117	13 791	24 181	45 700	18 015	5 986	3 511	3 056	3 353	2 886
1968	2 865	2 884	4 718	4 030	5 623	17 841	9 283	6 399	6 746	8 045	5 117	2 165
1969	3 109	2 676	4 874	18 403	16 091	19 216	32 081	8 109	4 196	3 803	3 415	2 492
1970	2 032	2 400	3 226	8 032	10 925	24 291	12 914	4 4770	2 660	3 441	3 384	2 319

Source: Environment Canada, Surface Water Publications

SOUTH SASKATCHEWAN RIVER AT HIGHWAY NO. 41
(STN. NO. 05AK001)
AND
RED DEER RIVER NEAR BINDLOSS
(STN. NO. 05CK004)

TOTAL MONTHLY DISCHARGE
(M^3/S)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1966	-	-	-	-	13 823	24 623	17 495	7 586	5 239	4 559	3 747	3 154
1967	2 872	2 902	4 861	12 735	25 109	44 082	17 248	5 734	3 523	3 159	3 390	2 119
1968	2 934	2 626	5 578	3 773	5 961	18 064	9 665	6 470	6 720	7 832	5 210	2 613
1969	3 145	2 663	4 607	17 452	16 524	20 228	30 707	7 264	3 961	3 901	3 062	2 278
1970	2 151	2 224	3 243	8 041	11 858	25 107	12 676	4 808	2 638	3 515	3 405	2 489

Source: Environment Canada, Surface Water Publications

TOTAL MONTHLY DISCHARGES
(M^3/S)

YEAR		JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1971	(A)	2 353	3 231	3 368	17 543	15 669	25 367	9 486	5 686	2 840	3 048	3 331	1 825
	(B)	2 291	3 176	3 314	17 588	15 701	25 467	9 474	5 648	2 782	2 991	3 276	1 760
1972	(A)	1 892	1 832	8 743	9 434	17 857	31 182	18 333	10 611	6 471	5 647	4 305	2 193
	(B)	1 827	1 767	8 726	9 422	17 904	31 322	13 383	10 607	6 438	5 609	4 257	2 130
1973	(A)	2 803	2 828	5 256	8 384	10 823	17 190	10 097	4 561	3 576	2 803	2 355	2 995
	(B)	2 745	2 770	5 215	8 365	10 821	17 232	10 090	4 515	3 523	2 745	2 293	2 938
1974	(A)	2 416	2 767	3 560	15 391	22 484	29 940	15 129	7 416	4 748	3 514	2 845	2 360
	(B)	2 355	2 708	3 507	15 421	22 563	30 072	15 157	7 390	4 703	3 461	2 787	2 299
1975	(A)	2 374	1 869	2 946	6 937	17 692	29 355	16 540	5 486	4 619	4 582	3 027	3 238
	(B)	2 313	1 804	2 889	6 908	17 718	29 482	16 578	5 446	4 573	4 536	2 970	3 183
1976	(A)	3 852	3 733	5 069	6 742	12 035	9 654	8 965	13 695	6 240	3 908	2 550	2 122
	(B)	3 801	3 681	5 026	6 711	12 041	9 644	8 950	13 713	6 206	3 857	2 490	2 059
1977	(A)	2 369	2 822	3 293	3 455	4 090	5 664	2 877	3 892	3 409	3 144	1 914	1 807
	(B)	2 308	2 764	3 238	3 401	4 041	5 626	2 819	3 841	3 355	3 088	1 849	1 742
1978	(A)	1 666	2 014	5 269	8 486	13 176	20 873	12 149	7 131	8 792	6 737	3 321	3 426
	(B)	1 600	1 950	5 228	8 467	13 190	20 941	12 156	7 103	8 776	6 706	3 266	3 382
1979	(A)	2 017	2 041	6 126	6 325	13 422	12 029	4 733	3 022	2 192	2 038	1 983	1 381
	(B)	1 959	1 983	6 109	6 310	13 478	12 071	4 702	2 974	2 136	1 980	1 925	1 317
1980	(A)	1 430	1 804	2 650	8 267	10 920	21 868	6 280	4 260	3 295	4 712	4 247	2 704
	(B)	1 366	1 744	2 599	8 272	10 951	22 009	6 265	4 225	3 249	4 681	4 211	2 653

(A) Total monthly combined discharge from Bindloss and Highway 41
(B) Total monthly discharge near Lemsford (Y = 1.01x - 78.0)

Appendix C

Frequency Analysis of the
South Saskatchewan River Flows

SOUTH SASKATCHEWAN RIVER

YEAR	DATA	ORDERED	YEAR	RANK	PROB.	RET. PERIOD
1912	11352960.	18290880.	1916	1	.014	70.000
1913	9807696.	16051824.	1927	2	.029	35.000
1914	8703936.	15957216.	1951	3	.043	23.333
1915	15862608.	15862608.	1915	4	.057	17.500
1916	18290880.	14948064.	1948	5	.071	14.000
1917	12835152.	13749696.	1928	6	.086	11.667
1918	7505568.	13339728.	1954	7	.100	10.000
1919	5613408.	12835152.	1917	8	.114	8.750
1920	10722240.	12803616.	1953	9	.129	7.778
1921	6843312.	12109824.	1952	10	.143	7.000
1922	6937920.	12007872.	1965	11	.157	6.364
1923	10627632.	11352960.	1912	12	.171	5.833
1924	7190208.	11346394.	1967	13	.186	5.385
1925	9586944.	10722245.	1947	14	.200	5.000
1926	8325504.	10722240.	1920	15	.214	4.667
1927	16051824.	10627632.	1923	16	.229	4.375
1928	13749696.	10235462.	1969	17	.243	4.118
1929	7284816.	10229069.	1972	18	.257	3.889
1930	7064064.	9839232.	1955	19	.271	3.684
1931	4068144.	9807696.	1913	20	.286	3.500
1932	8483184.	9713347.	1974	21	.300	3.333
1933	7884000.	9650016.	1942	22	.314	3.182
1934	6937925.	9586944.	1925	23	.329	3.043
1935	6307200.	8987760.	1956	24	.343	2.917
1936	5140368.	8979466.	1966	25	.357	2.800
1937	4667328.	8703936.	1914	26	.371	2.692
1938	7947072.	8501760.	1975	27	.386	2.593
1939	6054912.	8483184.	1932	28	.400	2.500
1940	6023376.	8325504.	1926	29	.414	2.414
1941	4194288.	8262432.	1943	30	.429	2.333
1942	9650016.	8153435.	1959	31	.443	2.258
1943	8262432.	8075635.	1971	32	.457	2.188
1944	4604256.	8014896.	1978	33	.471	2.121
1945	6748704.	7947072.	1938	34	.486	2.059
1946	7410960.	7889789.	1964	35	.500	2.000
1947	10722245.	7884000.	1933	36	.514	1.944
1948	14948064.	7631712.	1950	37	.529	1.892
1949	4383504.	7537104.	1958	38	.543	1.842
1950	7631712.	7505568.	1918	39	.557	1.795
1951	15957216.	7410960.	1946	40	.571	1.750
1952	12109824.	7284816.	1929	41	.586	1.707
1953	12803616.	7190208.	1924	42	.600	1.667
1954	13339728.	7064064.	1930	43	.614	1.628
1955	9839232.	6943363.	1970	44	.629	1.591
1956	8987760.	6937925.	1934	45	.643	1.556

SOUTH SASKATCHEWAN RIVER

YEAR	DATA	ORDERED	YEAR	RANK	PROB.	RET. PERIOD
1957	6622560.	6937920.	1922	46	.657	1.522
1958	7537104.	6843312.	1921	47	.671	1.489
1959	8153435.	6754666.	1976	48	.686	1.458
1960	6710240.	6748704.	1945	49	.700	1.429
1961	5723440.	6710240.	1960	50	.714	1.400
1962	5723440.	6622560.	1957	51	.729	1.373
1963	6615994.	6615994.	1963	52	.743	1.346
1964	7889789.	6541776.	1968	53	.757	1.321
1965	12007872.	6328973.	1973	54	.771	1.296
1966	8979466.	6307200.	1935	55	.786	1.273
1967	11346394.	6240240.	1980	56	.800	1.250
1968	6541776.	6054912.	1939	57	.814	1.228
1969	10235462.	6023376.	1940	58	.829	1.207
1970	6943363.	5723440.	1961	59	.843	1.186
1971	8075635.	5723440.	1962	60	.857	1.167
1972	10229069.	5613408.	1919	61	.871	1.148
1973	6328973.	5140368.	1936	62	.886	1.129
1974	9713347.	4919962.	1979	63	.900	1.111
1975	8501760.	4667328.	1937	64	.914	1.094
1976	6754666.	4604256.	1944	65	.929	1.077
1977	3289421.	4383504.	1949	66	.943	1.061
1978	8014896.	4194288.	1941	67	.957	1.045
1979	4919962.	4068144.	1931	68	.971	1.029
1980	6240240.	3289421.	1977	69	.986	1.014

SOUTH SASKATCHEWAN RIVER

SAMPLE STATISTICS

MEAN = 8587851. S.D. = 3185038.8 C.S. = .9868 C.K. = 3.8894

SAMPLE STATISTICS (LOGS)

MEAN = 15.9020 S.D. = .3590 C.S. = .0644 C.K. = 3.0498

SAMPLE MIN = 3289421. SAMPLE MAX = 18290880. N = 69

PARAMETERS FOR GUMBEL I A = .000000 U = 7161866.

PARAMETERS FOR LOGNORMAL M = 15.9020 S = .3590

PARAMETERS FOR THREE PARAMETER LOGNORMAL A = 510487. M = 15.8318 S = .3849

STATISTICS OF LOG(X-A)

MEAN = 15.8318 S.D. = .3849 C.S. = -.0104 C.K. = 3.0988

PARAMETERS FOR LOG PEARSON III BY MOMENTS A = .0116 B = .9641E+03 LOG(M) = 4.7565 M = .1163E+03

PARAMETERS FOR LOG PEARSON III BY MAXIMUM LIKELIHOOD A = .0126 B = .7980E+03 LOG(M) = 5.8351 M = .3421E+03

DISTRIBUTION STATISTICS MEAN = 15.9020 S.D. = .3564 C.S. = .0708

	GUMBEL I		LOGNORMAL		THREE PARAMETER LOGNORMAL		LOG PEARSON III MAX. LIKELIHOOD		LOG PEARSON III MOMENTS	
RETURN PERIOD	DATA ESTIMATE	ST. ERROR PERCENT	DATA ESTIMATE	ST.ERROR PERCENT	DATA ESTIMATE	ST. ERROR PERCENT	DATA ESTIMATE	ST. ERROR PERCENT	DATA ESTIMATE	ST. ERROR PERCENT
1.005	3120000.		3200000.		3300000.		3290000.		3270000.	
1.050	4460000.		4460000.		4500000.		4520000.		4490000.	
1.250	6010000.		5960000.		5940000.		5960000.		5950000.	
2.000	8050000.		8060000.		8020000.		8020000.		8030000.	
5.000	10800000.	4.87	10900000.	5.03	10900000.	5.14	10900000.	5.11	10900000.	5.14
10.000	12600000.	5.35	12800000.	5.83	12800000.	6.17	12800000.	6.09	12800000.	6.11
20.000	14400000.	5.75	14500000.	6.63	14700000.	7.49	14600000.	7.51	14600000.	7.55
50.000	16600000.	6.18	16800000.	7.62	17100000.	9.41	17000000.	9.85	17100000.	9.90
100.000	18300000.	6.44	18600000.	8.32	18900000.	10.90	18800000.	11.80	18900000.	11.90
200.000	20000000.	6.67	20300000.	8.98	20800000.	12.40	20700000.	13.90	20800000.	14.00
500.000	22200000.	6.92	22700000.	9.80	23300000.	14.40	23200000.	16.80	23300000.	16.90

Appendix D

Depth Integrating Particle Size Analysis of Suspended Sediment Collected at the Lemsford Station

WATER SURVEY OF CANADA
23/08/82 , PAGE 1
SEDIMENT SURVEY SECTION

SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD

STATION NO. 05HB001

DEPTH INTEGRATING PARTICLE SIZE ANALYSIS OF SUSPENDED SEDIMENT

SAMPLE IDENTIFIER DATE	TIME	DISCHARGE (M3/S)	CONC. (MG/L)	PERCENT FINER THAN INDICATED SIZE, IN MICROMETRES 2	4	8	16	31	62	125	250	500	1000	2000	TOTAL D50	TOTAL GDG	SAND D50	SAND GDG	PERCENT CLAY	PERCENT SILT	PERCENT SAND
AUG 2 1961	110C	167 H	500 R	52	72	84	90	93	96	98	99	100			*	*	0.125	2.0	72	24	4
APR 17 1962		306 H	405 K	11	19	36	51	61	70	78	94	98	100		0.015	7.3	0.180	1.8	19	51	30
APR 18 1962	1330	306	420 R		29	39	52	64	72	83	92	97	100		0.015	*	0.167	2.2	29	43	28
MAY 27 1962	1330	442 H	1 200 K	37	50	61	71	78	84	89	95	97	99		0.004	*	0.188	2.5	50	34	16
MAY 28 1962	2000	467	690 R	22	30	41	52	62	74	83	91	96	98		0.015	*	0.188	2.3	30	44	26
JUN 7 1962	1600	436	315 R	14	20	32	40	48	57	68	81	89	93		0.038	11.4	0.226	*	20	37	43
JUN 13 1962	1145	311 H	155 K	18	25	35	46	56	64	72	83	94	96		0.022	*	0.239	2.3	25	39	36
JUN 20 1962	1530	462	330 R	14	19	28	39	50	63	76	85	90	93		0.031	9.2	0.201	*	19	44	37
JUN 21 1962	1115	487 H	430 K	18	22	33	47	58	68	78	86	91	95		0.020	*	0.219	3.2	22	46	32
JUN 22 1962	1000	479 H	490 K	30	39	50	63	70	76	84	92	96	97		0.008	*	0.188	2.5	39	37	24
JUN 23 1962	1115	456 H	400 K	22	26	33	44	52	59	69	78	84	89		0.027	*	0.313	*	26	33	41
JUN 24 1962	1645	481 H	675 K	27	34	53	64	70	75	83	90	94	96		0.007	*	0.205	3.3	34	41	25
JUN 25 1962	1400	456	440 R	18	29	45	57	69	75	84	91	94	96		0.011	*	0.188	3.3	29	46	25
JUN 27 1962	0920	413 H	390 K	27	36	49	57	61	66	72	86	94	96		0.009	*	0.223	2.3	36	30	34
JUL 10 1962	1800	275	275 R	43	50	64	71	79	85	90	95	96	98		0.004	*	0.188	3.1	50	35	15
JUL 17 1962	2200	253 H	2 880 K		80	92	97	99	100						*	*	**	**	80	20	0
JUL 18 1962	0800	261 H	1 950 K	45	72	92	96	98	99	100					0.002	*	0.094	1.3	72	27	1
AUG 9 1962	1530	180	1 080 R	53	65	94	97	98	99	100					*	*	0.094	1.3	65	34	1
SEP 4 1962	2000	131 H	355 K	42	82	92	96	98	99	100					0.002	*	0.094	1.3	82	17	1
SEP 12 1962	1230	184 H	370 K	83	94	96	98	99	100						*	*	**	**	94	6	0
SEP 13 1962	1530	161	440 R	59	66	85	92	93	97	100					*	*	0.094	1.3	66	31	3
SEP 15 1962	2030	159 H	1 480 K	17	27	94	97	98	98	98	99	100			0.005	*	0.250	2.0	27	71	2
SEP 20 1962	1500	143 H	1 160 K	34	44	87	97	98	99	100					0.005	*	0.094	1.3	44	55	1
MAR 29 1963	1600	294	700 R	16	24	34	46	58	70	80	88	95	97		0.021	9.7	0.203	2.4	24	46	30
JUN 11 1963	1700	399	440 R	12	19	32	47	58	69	81	89	93	95		0.020	7.4	0.180	*	19	50	31
JUN 18 1963	1730	595	750 R	12	18	32	49	65	76	88	94	98	99		0.017	5.6	0.125	2.2	18	58	24
JUN 26 1963	1900	782	1 240 R	19	28	42	58	73	84	92	97	99	100		0.012	*	0.125	1.9	28	56	16
JUL 4 1963	2100	1 690	4 340 R	07	14	33	54	75	89	93	96	99	100		0.014	3.4	0.188	2.2	14	75	11
JUL 31 1963	1600	273	230 R	14	20	40	45	65	77	89	96	98	99		0.020	6.1	0.122	1.9	20	57	23
APR 11 1964	1800	166	280 R	16	24	40	53	60	72	85	94	98	99		0.014	7.8	0.139	2.0	24	48	28
APR 18 1964	1930	202 H	415 K	16	22	30	38	42	48	56	69	80	88		0.078	19.4	0.364	*	22	26	52
MAY 15 1964	1500	677	1 150 R	19	28	42	56	68	78	89	96	99	100		0.013	*	0.125	1.9	28	50	22
MAY 25 1964	1930	773 H	1 110 K	08	13	24	36	57	77	87	95	98	99		0.026	4.6	0.148	2.1	13	64	23
JUN 9 1964	1400	544	485 R	10	16	25	36	51	66	79	88	94	96		0.030	7.0	0.181	2.7	16	50	34
JUN 13 1964	1600	1 870	5 360 R	23	32	47	63	76	85	90	94	96	98		0.010	*	0.203	3.1	32	53	15
JUL 3 1964	1430	634	455 R	09	18	28	40	52	64	80	90	95	98		0.029	7.0	0.150	2.3	18	46	36
JUL 22 1964	1100	422	195 R	20	26	34	43	50	58	71	88	94	98		0.031	*	0.184	2.2	26	32	42
SEP 7 1964	0900	99.7 H	1 110 K	34	94	98	100								0.003	*	**	**	94	6	0
SEP 8 1964	1930	94.9 H	1 850 K	85	93	97	98	99	100						*	*	**	**	93	7	0
SEP 25 1964	1400	63.7	180 R	28	36	50	66	79	91	98	100				0.008	*	0.103	1.5	36	55	9

DISCHARGE FOOTNOTE SYMBOLS
BLANK - INSTANTANEOUS
H - DAILY MEAN

CONCENTRATION FOOTNOTE SYMBOLS
R - SAMPLES COLLECTED IN SEVERAL VERTICALS
K - SAMPLE(S) COLLECTED IN A SINGLE VERTICAL

GDG (GRADING) = SQUARE ROOT (D84/D16)
* - UNABLE TO COMPUTE DUE TO INSUFFICIENT DATA
** - NO SANDS (>0.062 MM)

WATER SURVEY OF CANADA
23/08/82 , PAGE 2
SEDIMENT SURVEY SECTION

SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD

STATION NO. 05HB001

DEPTH INTEGRATING PARTICLE SIZE ANALYSIS OF SUSPENDED SEDIMENT

SAMPLE IDENTIFIER DATE	TIME	DISCHARGE (M3/S)	CONC. (MG/L)	PERCENT FINER THAN INDICATED SIZE, IN MICROMETRES 2	4	8	16	31	62	125	250	500	1000	2000	TOTAL D50	TOTAL GDG	SAND D50	SAND GDG	PERCENT CLAY	PERCENT SILT	PERCENT SAND
SEP 28 1964	1100	88.6 H	335 K	63	75	92	96	97	98	99	100				*	*	0.125	1.6	75	23	2
SEP 30 1964	0900	103 H	2 100 K	75	83	93	97	99	100						*	*	**	**	83	17	0
OCT 4 1964	1615	109 H	1 690 K	42	86	91	93	94	97	99	100				0.002	*	0.109	1.6	86	11	3
OCT 22 1964	1835	136	75 R	09	18	33	47	56	64	72	84	93	96		0.021	8.4	0.229	2.6	18	46	36
APR 20 1965	1125	742	1 490 R	20	27	38	53	68	80	91	97	99	100		0.014	*	0.119	1.7	27	53	20
APR 28 1965	1545	442	475 R	16	24	34	46	57	70	83	94	98	100		0.021	8.3	0.148	2.0	24	46	30
MAY 2 1965	1700	572 H	720 K	15	23	32	45	58	72	84	92	97	99		0.022	7.5	0.156	2.2	23	49	28
MAY 4 1965	1330	614 H	730 K	11	18	28	38	50	64	78	87	92	95		0.031	7.8	0.181	3.2	18	46	36
MAY 20 1965	1225	360	380 R	14	23	32	44	55	70	83	93	98	99		0.024	7.5	0.150	2.1	23	47	30
JUN 2 1965	1645	479	520 R	12	18	29	40	53	71	85	94	98	100		0.028	6.0	0.132	2.0	18	53	29
JUN 7 1965	0930	750 H	1 470 K	19	26	34	46	60	76	88	96	99	100		0.020	*	0.125	1.8	26	50	24
JUN 9 1965	1400	739 H	1 130 K	26	34	44	55	66	78	89	95	98	99		0.012	*	0.125	2.1	34	44	22
JUN 11 1965	0900	733 H	770 K	17	24	33	44	55	66	80	91	95	98		0.024	*	0.159	2.3	24	42	34
JUN 17 1965	1505	776	820 R	11	16	24	35	50	68	84	95	99	100		0.031	5.6	0.125	1.7	16	52	32
JUN 21 1965	1520	1 490	2 430 R	04	12	22	34	43	77	91	96	99	100		0.037	4.1	0.114	1.9	12	65	23
JUN 23 1965	1540	1 950	2 560 R	16	26	38	52	64	78	90	96	99	100		0.015	6.8	0.120	1.9	26	52	22
JUN 29 1965	1150	1 020	1 630 R	08	31	59	66	75	86	95	99	100			0.007	4.6	0.111	1.6	31	55	14
JUL 1 1965	1300	1 230 H	1 650 K	31	41	50	59	67	76	85	93	97	98		0.008	*	0.172	2.2	41	35	24
JUL 8 1965	1350	1 210	710 R	18	24	34	44	55	66	84	97	99	100		0.024	*	0.122	1.7	24	42	34
AUG 8 1965	1730	326 H	670 K	54	63	75	82	86	89	92	97	99	100		*	*	0.188	2.0	63	26	11
AUG 13 1965	1415	450	420 R	14	18	26	39	50	64	78	91	97	98		0.031	7.8	0.163	2.1	18	46	36
SEP 5 1965	1655	309 H	670 K	37	45	54	59	62	66	71	87	93	97		0.006	*	0.219	2.3	45	21	34
SEP 7 1965	1205	292 H	1 130 K	11	30	90	90	90	91	94	97	99	99		0.005	1.7	0.188	2.2	30	61	9
SEP 8 1965	1355	292	445 R	07	25	72	77	79	83	90	98	99	100		0.006	4.9	0.148	1.7	25	58	17
SEP 9 1965	1915	314 H	990 K	62	75	80	85	87	90	92	96	97	98		*	*	0.219	*	75	15	10
SEP 11 1965	1400	331 H	905 K	22	31	41	54	71	86	92	97	99	100		0.014	*	0.150	2.0	31	55	14
SEP 17 1965	1715	283 H	220 K	38	46	52	58	62	66	76	92	98	99		0.007	*	0.180	1.9	46	20	34
OCT 3 1965	1200	368 H	280 K	36	39	46	51	56	63	83	98	100			0.014	*	0.120	1.6	39	24	37
OCT 7 1965	1140	425	295 R	13	16	21	28	38	51	73	91	98			0.060	7.1	0.142	1.9	16	35	49
MAR 25 1966	1430	362 H	230 K	65	73	81	88	94	98	100					*	*	0.094	1.3	73	25	2
APR 3 1966	1330	867 H	2 940 K	32	44	58	78	93	98	100					0.006	*	0.094	1.3	44	54	2
APR 12 1966	1500	408	550 R	13	19	29	44	58	74	88	98	100			0.022	6.0	0.121	1.7	19	55	26
APR 16 1966	1420	326 H	360 K	13	17	31	45	55	65	77	92	97	99		0.024	7.2	0.171	2.0	17	48	35
MAY 11 1966	1130	402	675 R	10	15	22	32	48	75	89	97	99	100		0.033	4.7	0.118	1.7	15	60	25
MAY 11 1966	1135	402	670 K	10	13	20	34	59	78	88	95	98	99		0.026	4.2	0.143	2.1	13	65	22
MAY 16 1966	2000	629 H	960 K	08	11	23	40	65	81	91	97	99	100		0.022	3.8	0.122	1.8	11	70	19
MAY 25 1966	1200	394	320 R	14	18	32	47	56	64	77	93	97	99		0.021	7.7	0.164	1.9	18	46	36
JUN 3 1966	1030	620 H	745 K	15	24	37	54	69	79	88	95	98	99		0.014	6.6	0.152	2.1	24	55	21
JUN 8 1966	1530	1 180	1 680 R	14	18	26	37	53	73	87	95	98	99		0.028	6.1	0.123	1.9	18	55	27
JUN 15 1966	1445	1 010 H	855 K	17	25	34	44	55	66	80	90	95	98		0.024	*	0.163	2.4	25	41	34

DISCHARGE FOOTNOTE SYMBOLS
BLANK - INSTANTANEOUS
H - DAILY MEAN

CONCENTRATION FOOTNOTE SYMBOLS
R - SAMPLES COLLECTED IN SEVERAL VERTICALS
K - SAMPLE(S) COLLECTED IN A SINGLE VERTICAL

GDG (GRADING) = SQUARE ROOT (D84/D16)
* - UNABLE TO COMPUTE DUE TO INSUFFICIENT DATA
** - NO SANDS (>0.062 MM)

WATER SURVEY OF CANADA
23/08/82 , PAGE 3
SEDIMENT SURVEY SECTION

SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD

STATION NO. 05HB001

DEPTH INTEGRATING PARTICLE SIZE ANALYSIS OF SUSPENDED SEDIMENT

SAMPLE IDENTIFIER DATE	TIME	DISCHARGE (M3/S)	CONC. (MG/L)	PERCENT FINER THAN INDICATED SIZE, IN MICROMETRES 2	4	8	16	31	62	125	250	500	1000	2000	TOTAL D50	TOTAL GDG	SAND D50	SAND GDG	PERCENT CLAY	PERCENT SILT	PERCENT SAND
JUN 16 1966	1200	917	975 R	23	43	51	59	69	79	88	95	98	99		0.008	*	0.152	2.1	43	36	21
JUN 16 1966	1205	917	1 020 K	32	40	49	58	66	75	85	95	98	99		0.009	*	0.156	2.0	40	35	25
JUN 16 1966	2000	920 H	910 K	27	36	47	59	68	76	87	95	98	99		0.010	*	0.141	2.0	36	40	24
JUN 22 1966	1300	572 H	165 K	31	42	57	74	87	98	100					0.006	*	0.094	1.3	42	56	2
JUN 23 1966	1400	592	340 R	13	17	26	33	43	54	75	93	98	99		0.051	7.3	0.139	1.7	17	37	46
JUN 28 1966	1100	507	400 R	31	39	49	59	67	77	85	96	99	100		0.009	*	0.165	1.7	39	38	23
JUN 28 1966	1105	507	395 K	33	41	52	64	71	76	87	95	98	99		0.007	*	0.141	2.0	41	35	24
JUL 6 1966	0930	527 H	465 K	40	49	55	62	69	79	87	96	98	99		0.005	*	0.160	1.9	49	30	21
JUL 6 1966	2000	527 H	655 K	28	35	43	56	71	82	89	96	98	99		0.012	*	0.161	2.1	35	47	18
JUL 7 1966	1000	725 H	1 300 K	36	45	55	62	69	79	87	96	98	99		0.006	*	0.160	1.9	45	34	21
JUL 7 1966	1630	725 H	2 210 K	40	55	74	81	88	92	96	99	100			0.003	*	0.125	1.7	55	37	8
JUL 8 1966	1340	934	4 910 K	49	58	68	80	87	91	95	98	99	100		0.002	*	0.146	2.1	58	33	9
JUL 8 1966	1345	934	4 790 R	28	50	74	84	90	94	97	99	100			0.004	*	0.125	1.8	50	44	6
JUL 18 1966	1730	665	670 K	31	41	51	62	70	77	85	94	98	99		0.008	*	0.174	2.1	41	36	23
JUL 20 1966	1420	532	405 R	14	24	39	56	66	73	86	95	99	100		0.013	6.9	0.132	1.9	24	49	27
JUL 27 1966	1400	430 H	365 K	33	44	57	69	79	84	90	96	99	100		0.006	*	0.167	2.0	44	40	16
JUL 29 1966	1300	345 H	1 090 K	50	60	76	90	93	95	97	99	100			0.002	*	0.156	1.9	60	35	5
JUL 29 1966	2100	345 H	665 K	45	55	72	87	92	94	97	99	100			0.003	*	0.125	1.8	55	39	6
AUG 8 1966	2000	231 H	425 K	58	69	82	89	93	95	98	100				*	*	0.115	1.6	69	26	5
AUG 9 1966	1435	236	1 160 R	70	80	88	93	96	97	98	100				*	*	0.156	1.5	80	17	3
AUG 9 1966	1440	236	1 060 K	67	77	89	95	96	97	98	99	100			*	*	0.188	2.0	77	20	3
AUG 10 1966	1930	236 H	285 K	49	57	70	83	88	92	96	99	1CC			0.002	*	0.125	1.7	57	35	8
AUG 12 1966	1300	300 H	950 K	55	64	73	83	89	93	96	100				*	*	0.141	1.6	64	29	7
AUG 24 1966	1945	184 H	185 K	51	59	69	77	83	86	92	99	100			*	*	0.143	1.6	59	27	14
SEP 4 1966	1700	214 H	415 K	35	39	45	52	61	73	81	90	96	99		0.014	*	0.201	2.3	39	34	27
OCT 6 1966	1030	1 480	75 R	38	48	57	65	70	76	85	94	98	99		0.005	*	0.167	2.1	48	28	24
APR 21 1967	130C	592 H	1 120 K	29	39	50	63	72	79	87	94	97	99		0.008	*	0.170	2.3	39	40	21
APR 26 1967	1630	391 H	535 K	33	42	52	65	73	78	87	96	99	10C		0.007	*	0.153	1.8	42	36	22
APR 30 1967	1730	498 H	1 730 K	26	36	49	66	80	88	92	97	99	100		0.008	*	0.175	2.0	36	52	12
MAY 2 1967	1300	555	1 620 R	20	30	42	56	73	82	88	95	98	99		0.013	*	0.179	2.2	30	52	18
MAY 7 1967	1415	439 H	580 K	21	30	41	55	69	79	86	93	96	98		0.013	*	0.188	2.7	30	49	21
MAY 12 1967	1245	968 H	2 720 R	12	20	33	49	68	83	91	97	99	10C		0.017	4.8	0.135	1.8	20	63	17
MAY 16 1967	1700	629 H	930 K	19	27	40	54	65	73	83	93	98	100		0.014	*	0.169	2.1	27	46	27
MAY 20 1967	133C	765 H	1 190 K	21	30	44	58	70	80	88	94	98	99		0.011	*	0.167	2.2	30	50	20
MAY 21 1967	1520	900 H	1 640 K	14	22	32	46	62	76	84	91	94	96		0.020	7.1	0.196	*	22	54	24
MAY 22 1967	1730	937 H	1 800 K	13	22	34	49	66	80	88	94	97	98		0.017	5.9	0.167	2.4	22	58	20
MAY 23 1967	2130	934 H	1 620 K	16	25	37	53	70	84	92	97	99	10C		0.015	5.6	0.125	1.9	25	59	16
MAY 24 1967	1600	983 H	1 500 K	14	21	33	48	65	81	90	96	98	99		0.018	5.7	0.135	2.1	21	60	19
JUN 1 1967	203C	1 080 H	1 090 K	13	20	29	43	57	73	85	94	98	99		0.024	6.5	0.146	2.0	20	53	27
JUN 3 1967	1610	1 960 H	3 040 K	10	14	22	33	49	74	88	95	99	100		0.032	4.6	0.121	1.9	14	60	26

DISCHARGE FOOTNOTE SYMBOLS
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SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD

STATION NO. 05HB001

DEPTH INTEGRATING PARTICLE SIZE ANALYSIS OF SUSPENDED SEDIMENT

SAMPLE IDENTIFIER DATE	TIME	DISCHARGE (M3/S)	CONC. (MG/L)	PERCENT FINER THAN INDICATED SIZE, IN MICROMETRES 2	4	8	16	31	62	125	250	500	1000	2000	TOTAL D50	GDG	SAND D50	GDG	PERCENT CLAY	SILT	SAND
JUN 4 1967	1615	2 430	4 580 R	14	23	37	52	67	81	92	97	99	100		0.015	5.7	0.116	1.8	23	58	19
JUN 5 1967	1315	2 310 H	3 210 K	16	26	39	53	66	80	92	99	100			0.014	6.4	0.115	1.6	26	54	20
JUN 6 1967	1400	2 030 H	2 690 K	21	28	40	56	68	80	91	99	100			0.013	*	0.119	1.6	28	52	20
JUN 7 1967	1000	2 010 H	2 030 K	18	26	39	52	65	77	89	96	99	100		0.015	*	0.122	1.8	26	51	23
JUN 8 1967	0750	1 920 H	1 880 K	18	25	36	51	61	73	86	94	98	99		0.015	*	0.133	2.1	25	48	27
JUN 14 1967	1145	1 650	1 100 R	15	20	30	42	54	68	84	94	98	99		0.026	7.2	0.125	1.9	20	48	32
JUN 21 1967	1335	1 390 H	910 K	13	17	24	34	45	61	78	89	95	98		0.041	7.4	0.153	2.3	17	44	39
JUN 28 1967	1300	1 180	640 R	12	16	25	36	48	60	77	90	96	98		0.036	6.9	0.154	2.2	16	44	40
JUL 7 1967	1030	816 H	410 K	16	20	28	42	56	72	83	92	96	98		0.025	8.3	0.167	2.3	20	52	28
MAY 23 1968	1630	179 H	191 K	12	13	22	33	45	58	72	85	92	95		0.043	6.7	0.192	2.8	13	45	42
MAY 26 1968	2000	215 H	281 K	04	05	11	21	34	49	63	77	88	92		0.067	5.8	0.228	3.2	5	44	51
MAY 27 1968	1405	345	611 R	07	08	14	24	42	68	86	95	98	99		0.041	3.5	0.118	1.8	8	60	32
MAY 30 1968	1600	504	885 R	16	19	32	46	60	74	88	95	98	99		0.020	7.3	0.121	2.0	19	55	26
JUN 3 1968	1430	507 H	1 490 K	49	59	70	78	82	90	96	98	99	100		0.002	*	0.115	2.1	59	31	10
JUN 6 1968	1630	493	435 R	19	28	39	51	61	73	85	93	97	99		0.015	*	0.148	2.2	28	45	27
JUN 6 1968	1635	481 H	450 K	18	28	40	51	61	72	83	91	96	98		0.015	*	0.172	2.3	28	44	28
JUN 8 1968	2000	589 H	581 K	18	22	32	44	58	76	88	95	98	99		0.022	*	0.125	2.1	22	54	24
JUN 16 1968	1500	847 H	856 K	19	25	34	47	59	72	85	92	96	98		0.020	*	0.143	2.4	25	47	28
JUN 25 1968	1530	470	605 R	21	28	44	62	76	86	94	98	99	100		0.011	*	0.117	1.7	28	58	14
JUL 31 1968	1330	280 H	396 K	25	30	43	57	68	76	86	88	92	95		0.012	*	0.250	*	30	46	24
AUG 1 1968	1545	470	266 R	23	32	43	60	72	79	84	92	97	99		0.011	*	0.211	2.1	32	47	21
AUG 1 1968	1550	250 H	256 K	32	40	54	69	78	84	91	97	99	100		0.007	*	0.146	1.9	40	44	16
AUG 13 1968	0930	181 H	942 K	64	76	88	94	96	97	98	100				*	*	0.156	1.5	76	21	3
SEP 25 1968	1150	249	2 090 R	77	86	92	94	95	96	98	99	100			*	*	0.125	2.0	86	10	4
SEP 27 1968	0940	331 H	1 490 K	65	73	78	84	88	91	96	99	100			*	*	0.119	1.7	73	18	9
SEP 28 1968	1520	328 H	1 600 K	76	82	84	87	89	91	95	99	100			*	*	0.141	1.7	82	9	9
SEP 29 1968	1515	340 H	1 470 K	66	75	84	87	90	91	96	99	100			*	*	0.119	1.7	75	16	9
SEP 30 1968	1900	354 H	1 050 K	60	69	78	84	86	89	94	97	98	99		*	*	0.146	2.7	69	20	11
OCT 4 1968	1115	371 H	416 K	31	35	48	58	63	68	80	91	96	98		0.010	*	0.170	2.2	35	33	32
APR 16 1969	1600	668 H	476 K	38	49	65	82	94	98	99	100				0.004	*	0.125	1.6	49	49	2
JUN 3 1969	1315	603 H	396 K	15	20	31	50	58	68	81	90	95	98		0.016	8.3	0.167	2.4	20	48	32
JUN 3 1969	1330	614	430 R	17	21	29	39	50	60	76	90	96	98		0.031	*	0.161	2.1	21	39	40
JUN 17 1969	1640	665	397 R	14	21	31	41	51	62	77	91	97	99		0.030	8.5	0.161	2.1	21	41	38
JUN 30 1969	1525	1 620	3 290 R	14	22	33	48	65	81	90	95	98	99		0.018	5.8	0.138	2.2	22	59	19
JUN 30 1969	1530	1 590 H	3 510 K	15	24	35	49	64	79	90	97	99	100		0.017	6.4	0.122	1.7	24	55	21
JUL 1 1969	0930	1 600 H	2 810 K	16	26	39	54	69	81	90	95	98	99		0.014	6.4	0.138	2.2	26	55	19
JUL 3 1969	1520	2 180 H	2 730 K	16	24	35	47	60	74	87	95	98	100		0.019	7.4	0.125	2.0	24	50	26
JUL 3 1969	1530	2 200	2 750 R	15	23	33	47	62	75	85	93	97	98		0.019	7.3	0.164	2.2	23	52	25
JUL 7 1969	1145	1 390 H	1 390 K	23	30	42	55	67	79	88	95	98	99		0.013	*	0.152	2.1	30	49	21
JUL 10 1969	1255	1 610	1 620 R	20	27	37	47	58	69	78	85	90	94		0.020	*	0.241	*	27	42	31

DISCHARGE FOOTNOTE SYMBOLS
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GDG (GRADING) = SQUARE ROOT (D84/D16)
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WATER SURVEY OF CANADA
23/08/82 , PAGE 5
SEDIMENT SURVEY SECTION

SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD

STATION NO. 05HB001

DEPTH INTEGRATING PARTICLE SIZE ANALYSIS OF SUSPENDED SEDIMENT

SAMPLE IDENTIFIER DATE	TIME	DISCHARGE (M3/S)	CONC. (MG/L)	PERCENT FINER THAN INDICATED SIZE, IN MICROMETRES 2	4	8	16	31	62	125	250	500	1000	2000	TOTAL D50	TOTAL GDG	SAND D50	SAND GDG	PERCENT CLAY	PERCENT SILT	PERCENT SAND
JUL 10 1969	1300	1 610 H	1 490 K	22	28	37	49	63	77	88	95	98	100		0.017	*	0.134	2.1	28	49	23
JUL 17 1969	1100	827 H	441 K	10	15	27	38	50	63	75	94	99	100		0.031	6.5	0.168	1.7	15	48	37
JUL 23 1969	1345	513 H	253 K	18	25	34	44	53	63	79	95	99	100		0.026	*	0.145	1.7	25	38	37
SEP 11 1969	0715	136 H	612 K	74	80	87	90	91	91	93	97	100			*	*	0.203	2.0	80	11	9
SEP 13 1969	1320	119 H	2 010 K	84	92	98	100								*	*	**	**	92	8	0
SEP 14 1969	1545	165 H	1 000 K	51	71	80	85	88	90	93	96	98	99		*	*	0.208	2.7	71	19	10
SEP 27 1969	0830	109 H	1 540 K	77	88	96	98	98	99	100					*	*	0.094	1.3	88	11	1
SEP 28 1969	1700	98.3 H	2 530 K	82	90	96	99	99	100						*	*	**	**	90	10	0
SEP 29 1969	1000	122 H	3 330 K	08	94	96	96	96	98	100					0.003	1.3	0.094	1.3	94	4	2
SEP 29 1969	1005	122 H	3 160 K	62	96	97	98	98	99	100					*	*	0.094	1.3	96	3	1
SEP 30 1969	1400	136 H	1 520 K	87	91	95	98	99	100						*	*	**	**	91	9	0
OCT 3 1969	1830	937 H	1 680 K	02	03	05	09	20	47	85	99	100			0.067	2.2	0.106	1.6	3	44	53
OCT 19 1969	1700	111 H	330 K	58	64	73	77	78	80	83	88	95	98		*	*	0.321	2.5	64	16	20
MAY 24 1970		515 H	774 K	14	20	34	50	64	75	86	96	99	100		0.016	6.5	0.144	1.7	20	55	25
MAY 26 1970	1430	490	580 R	14	21	33	48	64	76	87	94	98	99		0.018	6.5	0.143	2.1	21	55	24
MAY 26 1970	1435	490	560 K	14	20	32	48	62	75	85	93	97	99		0.018	6.7	0.164	2.2	20	55	25
JUN 1 1970	0845	592 H	639 K	16	22	34	50	64	74	83	91	95	97		0.016	8.4	0.188	2.8	22	52	26
JUN 11 1970	2000	595 H	424 K	12	17	30	42	60	71	86	96	99	100		0.023	5.7	0.123	1.7	17	54	29
JUN 15 1970	1640	600	511 R	23	29	39	50	60	69	82	95	99	100		0.016	*	0.149	1.7	29	40	31
JUN 15 1970	1645	600	466 K	23	30	42	55	65	74	84	93	97	99		0.013	*	0.167	2.2	30	44	26
JUN 17 1970	0815	934 H	1 980 K	40	50	62	74	84	92	98	99	100			0.004	*	0.104	1.7	50	42	8
JUN 17 1970	1600	934 H	2 240 K	22	28	37	48	63	80	91	94	96	97		0.018	*	0.119	3.3	28	52	20
JUN 19 1970	1430	1 700	5 090 R	08	23	43	65	75	87	96	99	100			0.011	4.2	0.108	1.6	23	64	13
JUN 19 1970	1435	1 700	4 860 K	06	30	54	65	76	90	98	100				0.007	4.1	0.101	1.4	30	60	10
JUN 21 1970	0830	1 820 H	2 350 K	18	23	32	42	56	70	83	92	96	98		0.025	*	0.153	2.3	23	47	30
JUN 23 1970	1420	1 190	1 550 R	22	28	41	57	69	81	92	98	99	100		0.013	*	0.116	1.7	28	53	19
JUN 23 1970	1425	1 190	1 800 K	20	26	36	48	60	70	78	86	92	96		0.019	*	0.234	3.0	26	44	30
JUN 26 1970	1040	830 H	665 K	17	25	37	50	61	73	87	96	99	100		0.016	*	0.123	1.7	25	48	27
JUL 3 1970	1655	580	659 K	26	33	40	51	56	67	77	91	97	99		0.015	*	0.183	2.1	33	34	33
JUL 3 1970	1700	580	619 R	24	31	40	49	58	67	79	92	97	99		0.018	*	0.168	2.1	31	36	33
JUL 4 1970	1415	651 H	2 870 K	31	38	42	47	48	52	55	60	65	90		0.047	*	0.720	*	38	14	48
JUL 5 1970	1645	813 H	4 160 K	41	50	58	67	72	77	82	90	94	97		0.004	*	0.227	2.9	50	27	23
JUL 7 1970	2030	767 H	712 K	19	25	37	51	66	75	83	93	97	99		0.015	*	0.181	2.2	25	50	25
JUL 9 1970	1045	572 H	679 K	32	41	51	67	76	84	88	93	94	98		0.008	*	0.225	3.0	41	43	16
JUN 24 1975	1715	2 890	5 700 R	18	27	48	63	76	85	92	96	98	99		0.009	*	0.141	2.3	27	58	15

DISCHARGE FOOTNOTE SYMBOLS
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K - SAMPLE(S) COLLECTED IN A SINGLE VERTICAL

GDG (GRADING) = SQUARE ROOT (D84/D16)
* - UNABLE TO COMPUTE DUE TO INSUFFICIENT DATA
** - NO SANDS (>0.062 MM)

Appendix E

Bed Material Particle Size Analysis
of Data Collected at the Lemsford Station

SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD

STATION NO. 05HB001

PARTICLE SIZE ANALYSIS OF BED MATERIAL

SAMPLE IDENTIFIER DATE	TIME	# OF SAMPLE POINTS	PERCENT FINER THAN INDICATED SIZE, IN MILLIMETRES 0.016	0.031	0.062	0.125	0.25	0.50	1.00	2.00	4.00	8.00	16.0	32.0	64.0	TOTAL D50	GDG	TYPE OF SAMPLER
OCT 11 1961		3			01	02	44	77	92	96	99	100				0.295	2.1	
MAY 11 1962		7			04	09	33	75	79	81	82	84	89			0.351	7.0	
JUN 20 1962		3			24	34	48	68	75	77	79	90	95			0.275	*	
JUL 24 1962		9			24	30	46	80	84	85	86	90	95			0.279	*	
AUG 29 1962		5			22	32	68	89	92	92	93	97	100			0.188	*	
JAN 3 1963		7	01	02	04	07	50	74	76	77	78	81	96			0.250	8.1	
MAR 29 1963		7		03	11	16	41	86	89	90	91	93	96			0.300	2.0	
APR 24 1963		5	04	05	11	17	34	83	91	92	93	94	97			0.332	2.2	
JUN 1 1963		5			00	01	17	83	97	99	100					0.375	1.5	
JUN 15 1963		5	13	17	23	31	67	94	98	98	99	99	100			0.191	3.9	
JUN 25 1963		3			04	07	46	99	100							0.292	1.7	
JUL 4 1963		3			01	02	15	64	68	69	70	73	84			0.429	7.9	
JUL 30 1963		5		01	01	04	46	91	97	98	99	100				0.272	1.7	
OCT 28 1963		5				01	32	92	96	98	99	100				0.325	1.6	LANE
DEC 10 1963		4				02	42	87	94	96	98	100				0.294	1.7	LANE
JAN 22 1964		5				01	22	79	89	92	96	99	100			0.373	1.9	LANE
FEB 28 1964		4				02	27	89	97	100						0.343	1.6	LANE
APR 22 1964		4				01	18	82	94	97	98	100				0.375	1.6	LANE
MAY 9 1964		3			01	04	69	98	100							0.213	1.6	LANE
JUN 13 1964		6	15	22	29	36	54	95	99	100						0.222	5.2	BM-54
JUL 3 1964		3			01	03	47	74	76	77	79	82	100			0.278	7.4	LANE
AUG 14 1964		5				02	35	79	81	83	86	89	96			0.335	3.9	BM-54
OCT 22 1964		5			01	02	46	98	100							0.269	1.6	BM-54
MAR 31 1965		3			01	02	47	96	99	99	100					0.265	1.6	LANE
APR 28 1965		5	04	05	13	23	35	66	76	78	79	82	88			0.371	11.5	LANE
JUN 17 1965		7	07	11	17	27	51	87	89	91	93	96	100			0.245	2.9	BM-54
JUN 23 1965		4				02	08	50	66	73	77	82	93			0.500	5.6	BM-54
AUG 13 1965		3			01	03	38	77	78	79	82	86	89			0.327	5.9	BM-54
NOV 2 1965		2				00	12	84	94	97	98	99	100			0.382	1.4	LANE
APR 12 1966		5			00	01	20	83	96	99	100					0.369	1.6	BM-54
JUN 8 1966		1		00	02	22	82	93	98	100						0.183	1.7	BM-54
JUL 8 1966		5			00	05	32	44	48	50	52	55	79			2.000	*	BM-54
AUG 31 1966		3			00	01	43	87	94	98	99	100				0.290	1.7	LANE
APR 22 1967		3				00	15	94	99	100						0.361	1.4	BM-54
MAY 26 1967		1				01	14	97	99	100						0.358	1.3	BM-54
MAR 13 1968	1320	5				00	06	50	79	91	97	100				0.500	2.1	LANE
MAY 31 1968	1010	5			06	03	57	90	96	98	99					0.234	1.7	BM-54
JUN 12 1968	1200	5				01	32	98	100							0.318	1.6	BM-54
OCT 21 1968	1400	5				00	19	75	86	93	93	100				0.388	2.0	BM-54
MAR 11 1969	1410	3				02	13	71	94	99	100					0.409	1.7	BM-54

GDG (GRADING) = SQUARE ROOT (D84/D16)
* - UNABLE TO COMPUTE DUE TO INSUFFICIENT DATA

WATER SURVEY OF CANADA
26/08/82 , PAGE 2
SEDIMENT SURVEY SECTION

SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD

STATION NO. 05HG001

PARTICLE SIZE ANALYSIS OF BED MATERIAL

SAMPLE IDENTIFIER DATE	TIME	# OF SAMPLE POINTS	PERCENT FINER THAN INDICATED SIZE, IN MILLIMETRES 0.016	0.031	0.062	0.125	0.25	0.50	1.00	2.00	4.00	8.00	16.0	32.0	64.0	TOTAL D50	GDG	TYPE OF SAMPLER
JUN 3 1969	1415	4				02	19	65	74	75	75					0.418	*	BM-54
JUN 30 1969	1550	3			14	34	44	80	84	85	86					0.292	3.8	BM-54
JUL 3 1969	1510	3			16	26	40	76	95	98	99					0.319	3.4	BM-54
MAR 19 1970	1745	1				01	36	92	98	100						0.313	1.6	LANE
APR 23 1970	1305	1					22	95	99	99	100					0.346	*	LANE
JUN 15 1970	1745	3				01	33	55	92	95	97					0.332	1.6	BM-54
JUN 19 1970	1540	2			04	48	73	100								0.135	2.1	BM-54
JUL 3 1970	1615	3				01	26	85	99	100						0.352	1.6	BM-54
AUG 25 1970	1300	3			04	17	62	87	94	97	98					0.217	2.0	LANE

GDG (GRADING) = SQUARE ROOT (D84/D16)
* - UNABLE TO COMPUTE DUE TO INSUFFICIENT DATA

Appendix F

Monthly Suspended Sediment Loads at Lemsford, Bindloss and Hwy 41, and Reconstructed Monthly Loads for Lemsford

SOUTH SASKATCHEWAN RIVER NEAR LEMSFORD
(STN. NO. 05HB001)

TOTAL MONTHLY SUSPENDED SEDIMENT LOADS
(TONNES)

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1966	-	-	-	-	531 380	1 453 000	1 250 120	230 290	75 343	38 491	10 101	6 199
1967	4 957	5 077	104 076	1 244 400	3 300 000	6 137 600	517 630	45 456	39 652	9 363	15 025	14 989
1968	20 589	10 386	65 110	33 864	198 500	1 040 870	398 870	101 600	313 546	184 880	38 451	4 164
1969	2 563	1 620	99 058	3 282 740	620 990	1 296 970	3 825 390	92 118	222 068	91 765	32 323	9 941
1970	2 822	3 346	7 800	501 154	362 454	3 219 160	854 620	68 681	17 306	62 800	9 119	2 665

Source: Environment Canada, Sediment Data Publications

SOUTH SASKATHCEWAN RIVER AT HIGHWAY NO. 41
(STN. NO. 05AK001)
AND
RED DEER RIVER NEAR BINDLOSS
(STN. NO. 05CK004)

TOTAL MONTHLY SUSPENDED SEDIMENT LOADS
(TONNES)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1966	-	-	-	-	465 485	1 870 910	1 716 430	136 152	45 462	26 051	6 802	4 609
1967	3 435	3 791	43 756	1 114 156	3 321 660	4 937 250	393 399	35 508	7 894	8 323	12 376	4 259
1968	3 019	3 858	19 874	19 005	204 350	960 550	384 696	107 251	169 216	123 381	18 662	3 089
1969	3 367	3 167	145 874	3 038 370	608 340	1 420 770	3 641 090	82 620	265 553	45 612	7 776	3 332
1970	3 444	2 663	9 156	549 419	427 867	3 587 081	954 505	34 854	12 066	28 525	8 775	5 014

Source: Environment Canada, Sediment Data Publications

TOTAL MONTHLY SUSPENDED SEDIMENT LOADS (TONNES)

YEAR		JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1971	(A)	3 122	14 742	7 903	4 018 543	680 781	1 991 590	152 781	57 013	13 595	10 629	7 803	2 107
	(B)	-	2 937	-	4 234 955	706 941	2 092 466	148 852	47 618	-	-	-	-
1972	(A)	2 065	2 233	631 533	384 704	1 332 177	3 136 169	604 780	143 947	56 986	12 137	6 167	3 304
	(B)	-	-	654 885	393 987	1 395 466	3 302 286	626 607	139 507	47 589	-	-	-
1973	(A)	3 096	3 716	29 841	498 602	282 203	1 143 210	204 802	75 765	37 125	7 365	2 448	2 601
	(B)	-	-	18 897	514 377	285 644	1 195 728	203 831	67 439	26 596	-	-	-
1974	(A)	3 136	6 152	9 593	3 816 723	2 409 250	2 645 230	353 873	73 136	37 835	14 230	3 678	2 108
	(B)	-	-	-	4 021 631	2 533 932	2 783 363	60 342	64 660	27 347	2 396	-	-
1975	(A)	2 052	2 597	4 315	834 824	1 368 190	5 605 907	681 993	51 092	20 742	10 105	6 706	5 469
	(B)	-	-	-	869 764	1 433 532	5 912 799	708 222	41 359	9 279	-	-	-
1976	(A)	11 001	8 471	57 064	182 979	560 566	211 903	196 200	920 235	26 618	7 898	2 289	1 316
	(B)	-	-	47 672	180 764	579 873	211 336	194 738	960 043	14 433	-	-	-
1977	(A)	2 491	3 630	6 755	65 189	199 750	161 090	17 202	38 047	164 390	37 949	6 527	2 210
	(B)	-	-	-	56 620	198 491	157 627	5 538	27 571	161 115	27 361	-	-
1978	(A)	2 323	5 122	234 431	643 167	789 710	1 537 810	205 315	178 628	452 384	31 966	-	-
	(B)	-	-	235 149	677 183	822 078	1 612 820	204 373	176 165	465 525	21 143	-	-
1979	(A)	192	152	14 347	116 351	739 565	441 611	71 482	59 750	11 388	6 213	-	-
	(B)	-	-	2 563	110 687	771 294	445 463	63 126	50 690	-	-	-	-
1980	(A)	-	-	3 260	653 539	1 161 839	1 613 890	332 859	188 977	28 727	23 545	-	-
	(B)	-	-	-	680 106	1 218 904	1 698 078	340 186	187 670	17 806	12 313	-	-

(A) Total monthly combined suspended sediment load from Bindloss and Highway 41
(B) Total monthly suspended sediment load near Lemsford (Y = 1.06x - 12 645.0)

Appendix G

Flow Duration of Daily Discharges
for Swift Current Creek near
the Mouth and the Leinan Stations

WATER SURVEY OF CANADA
23/08/82 , PAGE 2
SEDIMENT SURVEY SECTION

SWIFT CURRENT CREEK NEAR THE MOUTH

DISCHARGE IN M3/S	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL TIME
	% OF TIME INDICATED DISCHARGE WAS EQUALLED OR EXCEEDED												
0.198			100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00			100.00
0.213			98.75	100.00	100.00	100.00	100.00	98.72	100.00	100.00			99.00
0.229			97.42	100.00	100.00	100.00	100.00	97.36	100.00	100.00			98.00
0.246			96.02	100.00	100.00	100.00	100.00	95.94	100.00	100.00			97.00
0.264			94.54	100.00	100.00	100.00	100.00	94.44	99.18	100.00			96.00
0.282			93.07	100.00	100.00	100.00	100.00	92.95	97.57	100.00			95.00
0.301			91.53	100.00	100.00	100.00	100.00	91.40	95.87	100.00			94.00
0.322			89.84	100.00	100.00	100.00	100.00	89.70	94.02	100.00			93.00
0.342			88.25	100.00	100.00	100.00	98.26	88.10	92.27	99.95			92.00
0.364			86.52	100.00	100.00	100.00	95.89	86.36	90.38	99.41			91.00
0.386			84.81	100.00	100.00	100.00	93.54	84.64	88.50	98.86			90.00
0.408			83.13	100.00	100.00	100.00	91.22	82.94	86.65	98.31			89.00
0.431			81.39	100.00	100.00	100.00	88.83	81.19	84.75	97.71			88.00
0.455			79.61	100.00	100.00	100.00	86.37	79.36	82.79	97.08			87.00
0.479			77.86	100.00	100.00	98.24	83.94	77.60	80.86	96.44			86.00
0.503			76.15	100.00	100.00	95.79	81.56	75.84	78.97	95.80			85.00
0.528			74.41	100.00	100.00	93.28	79.13	74.03	77.04	95.11			84.00
0.553			72.70	100.00	100.00	90.81	76.74	72.25	75.14	94.42			83.00
0.579			70.98	100.00	100.00	88.29	74.32	70.43	73.21	93.69			82.00
0.604			69.38	100.00	100.00	85.92	72.05	68.70	71.39	92.98			81.00
0.630			67.76	100.00	100.00	83.52	69.75	66.93	69.54	92.23			80.00
0.656			66.20	100.00	100.00	81.18	67.53	65.19	67.74	91.47			79.00
0.682			64.69	100.00	100.00	78.91	65.37	63.48	65.99	90.71			78.00
0.708			63.25	100.00	100.00	76.72	63.28	61.79	64.28	89.94			77.00
0.735			61.82	100.00	99.75	74.52	61.20	60.07	62.56	89.14			76.00
0.761			60.51	100.00	99.46	72.48	59.28	58.44	60.96	88.36			75.00
0.787			59.28	100.00	99.13	70.54	57.44	56.84	59.40	87.57			74.00
0.813			58.11	100.00	98.76	68.68	55.69	55.27	57.90	86.78			73.00
0.840			56.98	100.00	98.34	66.85	53.97	53.66	56.40	85.96			72.00
0.865			56.00	100.00	97.91	65.25	52.46	52.21	55.06	85.20			71.00
0.891			55.07	100.00	97.44	63.66	50.99	50.71	53.72	84.40			70.00
0.917			54.22	100.00	96.94	62.22	49.63	49.25	52.44	83.60			69.00
0.942			53.48	100.00	96.43	60.93	48.41	47.87	51.27	82.83			68.00
0.967			52.82	99.89	95.90	59.74	47.29	46.51	50.14	82.06			67.00
0.991			52.26	99.66	95.37	58.70	46.31	45.23	49.12	81.33			66.00
1.02			51.67	99.31	94.70	57.54	45.22	43.71	47.94	80.43			65.00
1.04			51.27	99.06	94.22	56.76	44.48	42.56	47.13	79.79			64.00
1.07			50.67	98.66	93.47	55.59	43.38	41.09	45.92	78.82			63.00
1.09			50.28	98.39	92.95	54.82	42.65	40.04	45.11	78.16			62.00
1.12			49.69	97.96	92.14	53.67	41.57	38.48	43.92	77.15			61.00
1.15			49.11	97.52	91.30	52.52	40.50	36.92	42.73	76.11			60.00
1.18			48.54	97.06	90.43	51.39	39.43	35.37	41.55	75.05			59.00
1.21			47.97	96.59	89.52	50.27	38.38	33.83	40.37	73.97			58.00
1.24			47.41	96.10	88.59	49.16	37.34	32.30	39.21	72.86			57.00
1.27			46.85	95.60	87.64	48.06	36.31	30.79	38.06	71.74			56.00
1.31			46.12	94.92	86.32	46.61	34.95	28.79	36.53	70.21			55.00
1.34			45.50	94.39	85.30	45.54	33.94	27.31	35.40	69.05			54.00
1.37			45.05	93.84	84.26	44.43	32.95	25.86	34.26	67.87			53.00
1.41			44.35	93.10	82.84	43.03	31.64	23.95	32.81	66.26			52.00
1.44			43.83	92.54	81.75	42.04	30.68	22.54	31.71	65.05			51.00
1.48			43.15	91.77	80.27	40.63	29.41	20.71	30.28	63.40			50.00

WATER SURVEY OF CANADA
23/08/82 , PAGE 3
SEDIMENT SURVEY SECTION

SWIFT CURRENT CREEK NEAR THE MOUTH

DISCHARGE IN M3/S	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL TIME
	% OF TIME INDICATED DISCHARGE WAS EQUALLED OR EXCEEDED												
1.52			42.48	90.98	78.78	39.34	28.16	18.93	28.86	61.73			49.00
1.56			41.83	90.18	77.22	38.02	26.94	17.20	27.48	60.05			48.00
1.59			41.35	89.58	76.05	37.05	26.03	15.94	26.44	58.77			47.00
1.63			40.71	88.78	74.47	35.77	24.85	14.31	25.08	57.06			46.00
1.67			40.09	87.93	72.87	34.52	23.69	12.75	23.76	55.33			45.00
1.71			39.48	87.09	71.26	33.29	22.55	11.26	22.46	53.59			44.00
1.75			38.89	86.25	69.63	32.09	21.44	9.84	21.19	51.84			43.00
1.80			38.17	85.19	67.58	30.61	20.08	8.18	19.63	49.65			42.00
1.84			37.60	84.34	65.94	29.47	19.02	6.94	18.43	47.89			41.00
1.88			37.05	83.49	64.29	28.34	17.99	5.79	17.25	46.13			40.00
1.92			36.51	82.64	62.64	27.25	16.99	4.73	16.10	44.37			39.00
1.97			35.86	81.58	60.59	25.91	15.77	3.54	14.71	42.17			38.00
2.01			35.35	80.73	58.95	24.88	14.82	2.70	13.64	40.43			37.00
2.06			34.74	79.68	56.92	23.62	13.68	1.80	12.34	38.25			36.00
2.10			34.26	78.85	55.32	22.65	12.80	1.21	11.34	36.53			35.00
2.15			33.69	77.83	53.33	21.47	11.73	.62	10.15	34.39			34.00
2.19			33.25	77.02	51.76	20.56	10.92	0.00	9.23	32.70			33.00
2.24			32.72	76.03	49.84	19.47	9.93	0.00	8.14	30.61			32.00
2.29			32.21	75.06	47.96	18.42	9.00	0.00	7.11	28.55			31.00
2.34			31.72	74.11	46.13	17.43	8.11	0.00	6.14	26.54			30.00
2.38			31.35	73.38	44.71	16.66	7.43	0.00	5.41	24.96			29.00
2.43			30.91	72.49	42.98	15.75	6.63	0.00	4.56	23.02			28.00
2.48			30.49	71.63	41.32	14.90	5.88	0.00	3.78	21.13			27.00
2.53			30.10	70.81	39.73	14.07	5.13	0.00	3.06	19.31			26.00
2.58			29.73	70.03	38.22	13.33	4.53	0.00	2.42	17.54			25.00
2.63			29.39	69.30	36.79	12.63	3.94	0.00	1.84	15.83			24.00
2.68			29.07	68.61	35.46	11.98	3.39	0.00	1.34	14.19			23.00
2.73			28.78	67.97	34.22	11.39	2.90	0.00	.92	12.63			22.00
2.78			28.51	67.38	33.06	10.85	2.45	0.00	.58	11.15			21.00
2.83			28.27	66.84	32.05	10.37	2.08	0.00	.31	9.74			20.00
2.88			28.05	66.37	31.13	9.95	1.76	0.00	0.00	8.43			19.00
2.93			27.87	65.96	30.34	9.58	1.49	0.00	0.00	7.20			18.00
2.98			27.71	65.61	29.67	9.27	1.28	0.00	0.00	6.07			17.00
3.06			27.49	65.14	28.78	8.86	.77	0.00	0.03	3.94			16.00
3.23			27.01	64.19	27.05	7.99	.63	0.00	0.03	3.22			15.00
3.53			26.16	62.59	24.35	6.44	0.00	0.00	0.00	1.95			14.00
3.98			24.89	60.34	21.11	4.30	0.00	0.00	0.00	0.00			13.00
4.61			23.32	57.44	17.91	2.16	0.00	0.00	0.00	0.00			12.00
5.42			21.90	53.93	15.26	1.58	0.00	0.00	0.00	0.00			11.00
6.34			20.42	49.95	12.51	1.44	0.00	0.00	0.00	0.00			10.00
7.28			18.89	46.35	9.55	1.13	0.00	0.00	0.00	0.00			9.00
8.25			17.24	43.29	6.05	.70	0.00	0.00	0.00	0.00			8.00
9.38			15.69	40.09	3.52	.31	0.00	0.00	0.00	0.00			7.00
12.4			13.00	34.74	2.95	0.00	0.00	0.00	0.00	0.00			6.00
15.0			9.22	30.97	2.42	0.00	0.00	0.00	0.00	0.00			5.00
18.6			5.19	27.71	1.02	0.00	0.00	0.00	0.00	0.00			4.00
23.4			4.52	21.06	0.00	0.00	0.00	0.00	0.00	0.00			3.00
34.6			1.99	14.96	0.00	0.00	0.00	0.00	0.00	0.00			2.00
47.9			0.00	8.45	0.00	0.00	0.00	0.00	0.00	0.00			1.00
120			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00

MINIMUM DISCHARGE = .198 MAXIMUM DISCHARGE = 119.000

WATER SURVEY OF CANADA
23/08/82 , PAGE 2
SEDIMENT SURVEY SECTION

SWIFT CURRENT CREEK NEAR LEINAN

% OF TIME INDICATED DISCHARGE WAS EQUALLED OR EXCEEDED

DISCHARGE IN M3/S	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL TIME
0.027			100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00			100.00
0.037			98.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00			99.00
0.046			97.85	100.00	100.00	100.00	100.00	100.00	100.00	100.00			98.00
0.056			96.74	100.00	100.00	100.00	100.00	100.00	100.00	100.00			97.00
0.067			95.51	100.00	100.00	100.00	100.00	100.00	100.00	100.00			96.00
0.077			94.41	99.30	100.00	100.00	98.73	100.00	100.00	100.00			95.00
0.088			93.20	98.45	100.00	100.00	97.18	100.00	100.00	100.00			94.00
0.099			92.01	97.61	100.00	100.00	95.65	100.00	100.00	100.00			93.00
0.111			90.71	96.69	100.00	100.00	93.98	100.00	100.00	100.00			92.00
0.122			89.54	95.85	100.00	100.00	92.46	100.00	100.00	100.00			91.00
0.134			88.26	94.94	100.00	100.00	90.82	100.00	100.00	100.00			90.00
0.146			87.00	94.04	100.00	100.00	89.18	100.00	100.00	100.00			89.00
0.159			85.65	93.06	99.82	99.26	87.43	99.53	98.99	100.00			88.00
0.172			84.31	92.10	99.56	97.72	85.69	97.48	97.53	99.22			87.00
0.185			82.98	91.14	99.28	96.17	83.97	95.44	96.07	98.45			86.00
0.198			81.66	90.20	98.99	94.64	82.27	93.41	94.62	97.68			85.00
0.211			80.36	89.26	98.69	93.11	80.58	91.40	93.18	96.92			84.00
0.225			78.98	88.27	98.35	91.48	78.79	89.24	91.63	96.10			83.00
0.239			77.61	87.29	98.00	89.87	77.02	87.10	90.09	95.28			82.00
0.253			76.25	86.32	97.64	88.28	75.27	84.98	88.56	94.48			81.00
0.268			74.82	85.31	97.23	86.59	73.43	82.75	86.94	93.61			80.00
0.283			73.41	84.31	96.82	84.93	71.61	80.54	85.34	92.76			79.00
0.298			72.02	83.33	96.39	83.29	69.83	78.38	83.75	91.91			78.00
0.314			70.55	82.32	95.91	81.57	67.96	76.11	82.09	91.01			77.00
0.330			69.11	81.33	95.42	79.88	66.14	73.90	80.46	90.11			76.00
0.346			67.69	80.37	94.91	78.23	64.35	71.74	78.86	89.23			75.00
0.362			66.30	79.43	94.39	76.62	62.60	69.65	77.29	88.34			74.00
0.379			64.84	78.48	93.82	74.95	60.80	67.50	75.67	87.41			73.00
0.396			63.41	77.56	93.23	73.32	59.04	65.43	74.10	86.48			72.00
0.413			62.00	76.67	92.63	71.74	57.33	63.44	72.57	85.56			71.00
0.430			60.63	75.83	92.01	70.22	55.68	61.55	71.09	84.65			70.00
0.448			59.20	74.98	91.33	68.66	53.99	59.65	69.59	83.69			69.00
0.466			57.80	74.19	90.64	67.17	52.36	57.87	68.16	82.73			68.00
0.485			56.35	73.40	89.89	65.66	50.72	56.12	66.73	81.73			67.00
0.503			55.02	72.71	89.16	64.31	49.23	54.60	65.44	80.79			66.00
0.523			53.58	72.01	88.33	62.89	47.66	53.07	64.11	79.75			65.00
0.542			52.24	71.41	87.52	61.63	46.25	51.78	62.94	78.77			64.00
0.562			50.87	70.85	86.65	60.39	44.86	50.61	61.82	77.74			63.00
0.582			49.55	70.37	85.76	59.26	43.56	49.63	60.81	76.72			62.00
0.602			48.26	69.90	84.85	58.24	42.36	48.86	59.92	75.71			61.00
0.623			46.94	69.58	83.85	57.21	41.15	48.14	59.03	74.65			60.00
0.644			45.62	69.22	82.78	56.20	39.97	47.45	58.15	73.62			59.00
0.666			44.26	68.85	81.60	55.15	38.75	46.73	57.22	72.55			58.00
0.689			42.86	68.48	80.29	54.07	37.53	46.30	56.26	71.46			57.00
0.712			41.47	68.13	78.93	53.01	36.28	45.28	55.29	70.38			56.00
0.735			40.11	67.78	77.51	51.95	35.03	44.57	54.32	69.32			55.00
0.759			38.72	67.44	75.77	50.89	33.86	43.84	53.31	68.22			54.00
0.784			37.29	67.09	74.33	49.79	32.62	43.10	52.26	67.10			53.00
0.808			35.95	66.77	72.70	48.74	31.45	42.39	51.25	66.03			52.00
0.834			34.54	66.43	70.91	47.64	30.22	41.64	50.16	64.89			51.00
0.859			33.22	66.11	69.16	46.59	29.05	40.72	49.11	63.80			50.00

SWIFT CURRENT CREEK NEAR LEINAN

DISCHARGE IN M3/S	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL TIME
			% OF TIME INDICATED DISCHARGE WAS EQUALLED OR EXCEEDED										
0.885			31.89	65.79	67.31	45.52	27.90	40.18	48.01	62.68			49.00
0.911			30.60	65.47	65.45	44.47	26.76	39.45	46.92	61.57			48.00
0.937			29.35	65.15	63.59	43.44	25.65	38.72	45.82	60.46			47.00
0.964			28.12	64.82	61.66	42.39	24.54	37.96	44.69	59.32			46.00
0.990			26.98	64.51	59.82	41.40	23.49	37.23	43.60	58.22			45.00
1.02			25.73	64.14	57.71	40.28	22.33	36.39	42.33	56.95			44.00
1.04			24.94	63.89	56.34	39.55	21.58	35.83	41.49	56.10			43.00
1.07			23.82	63.50	54.31	38.48	20.48	34.98	40.23	54.83			42.00
1.10			22.79	63.11	52.36	37.43	19.43	34.11	38.97	53.55			41.00
1.12			22.15	62.84	51.09	36.75	18.75	33.53	38.13	52.69			40.00
1.15			21.26	62.42	49.27	35.74	17.75	32.65	36.87	51.39			39.00
1.18			20.46	61.99	47.55	34.76	16.82	31.76	35.60	50.08			38.00
1.21			19.76	61.53	45.94	33.81	15.91	30.84	34.34	48.75			37.00
1.23			19.35	61.21	44.94	33.19	15.33	30.22	33.50	47.85			36.00
1.26			18.82	60.71	43.55	32.28	14.50	29.27	32.24	46.48			35.00
1.28			18.53	60.36	42.71	31.69	13.96	28.62	31.40	45.56			34.00
1.31			18.17	59.81	41.57	30.82	13.19	27.62	30.13	44.15			33.00
1.34			17.84	59.25	40.49	29.96	12.44	26.58	28.87	42.66			32.00
1.37			17.52	58.67	39.43	29.09	11.70	25.50	27.61	41.09			31.00
1.39			17.31	58.28	38.74	28.50	11.20	24.75	26.77	40.01			30.00
1.42			17.00	57.69	37.74	27.63	10.47	23.61	25.51	38.33			29.00
1.46			16.61	56.89	36.44	26.45	9.50	22.05	23.83	35.99			28.00
1.49			16.32	56.28	35.49	25.59	8.78	20.85	22.56	34.18			27.00
1.52			16.04	55.67	34.58	24.72	8.07	19.65	21.30	32.32			26.00
1.55			15.77	55.06	33.69	23.86	7.38	18.44	20.04	30.44			25.00
1.59			15.43	54.24	32.55	22.72	6.48	16.82	18.36	27.88			24.00
1.62			15.19	53.63	31.73	21.88	5.83	15.62	17.10	25.94			23.00
1.66			14.89	52.82	30.68	20.77	4.99	14.04	15.41	23.35			22.00
1.69			14.68	52.21	29.92	19.96	4.39	12.88	14.15	21.40			21.00
1.73			14.42	51.42	28.95	18.90	3.62	11.38	12.47	18.82			20.00
1.77			14.19	50.64	28.03	17.87	2.90	9.95	10.79	16.28			19.00
1.81			13.98	49.89	27.16	16.88	2.24	8.61	9.13	13.78			18.00
1.84			13.85	49.33	26.53	16.16	1.77	7.66	7.84	11.96			17.00
1.88			13.70	48.62	25.74	15.24	1.21	6.49	6.16	9.61			16.00
1.92			13.58	47.93	25.00	14.37	0.00	5.44	4.48	7.35			15.00
1.96			13.49	47.28	24.30	13.55	0.00	4.52	2.79	5.22			14.00
2.00			13.44	46.67	23.66	12.78	0.00	3.76	1.11	3.23			13.00
2.07			13.39	45.64	22.56	11.51	0.00	2.73	.79	.66			12.00
2.20			13.30	43.78	20.52	9.32	0.00	2.55	0.00	0.00			11.00
2.38			13.18	41.32	17.84	6.73	0.00	2.30	0.00	0.00			10.00
2.59			13.02	38.80	15.12	4.57	0.00	1.50	0.00	0.00			9.00
2.37			12.71	35.13	12.43	3.14	0.00	1.30	0.00	0.00			8.00
3.24			12.30	30.72	9.46	1.92	0.00	.83	0.00	0.00			7.00
3.65			11.83	26.05	7.61	1.43	0.00	.66	0.00	0.00			6.00
4.26			11.08	21.46	6.30	1.06	0.00	.51	0.00	0.00			5.00
5.22			8.86	16.89	4.83	.77	0.00	.34	0.00	0.00			4.00
6.38			7.25	12.21	3.63	.53	0.00	.13	0.00	0.00			3.00
8.76			5.93	9.23	0.00	.21	0.00	0.00	0.00	0.00			2.00
20.4			3.44	4.30	0.00	0.00	0.00	0.00	0.00	0.00			1.00
63.2			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00

MINIMUM DISCHARGE = .027 MAXIMUM DISCHARGE = 63.100

Appendix H

Depth Integrating Particle Size Analysis
of Suspended Sediment Collected from
Swift Current Creek near the Mouth Station

WATER SURVEY OF CANADA
13/08/82 , PAGE 1
SEDIMENT SURVEY SECTION

SWIFT CURRENT CREEK NEAR THE MOUTH

STATION NO. 05HD037

DEPTH INTEGRATING PARTICLE SIZE ANALYSIS OF SUSPENDED SEDIMENT

SAMPLE IDENTIFIER DATE	TIME	DISCHARGE (M3/S)	CONC. (MG/L)	PERCENT FINER THAN INDICATED SIZE, IN MICROMETRES 2	4	8	16	31	62	125	250	500	1000	2000	TOTAL D50	TOTAL GDG	SAND D50	SAND GDG	PERCENT CLAY	PERCENT SILT	PERCENT SAND
APR 9 1965	1530		985 K	14	22	33	52	77	96	99	100				0.015	4.0	0.099	1.4	22	74	4
APR 10 1965	1630		955 K	09	12	19	31	48	70	88	98	100			0.033	4.1	0.113	1.6	12	58	30
APR 11 1965	1000		1 330 K	08	13	20	29	44	62	80	95	99	100		0.039	5.2	0.129	1.7	13	49	38
APR 11 1965	1600		3 080 K	09	14	22	32	50	74	91	98	100			0.031	4.4	0.107	1.6	14	60	26
APR 12 1965	1600		3 890 K	08	14	22	31	47	70	89	98	99	100		0.034	4.7	0.110	1.6	14	56	30
APR 18 1965	1530		1 860 K	08	12	20	32	47	64	80	92	98	100		0.034	5.0	0.137	2.0	12	52	36
MAR 12 1966	1530	8.50 H	570 K	12	22	34	46	64	78	93	99	100			0.018	5.5	0.106	1.6	22	56	22
MAR 15 1966	1350	18.3 H	760 K	09	16	24	37	58	80	96	100				0.025	4.2	0.097	1.3	16	64	20
MAR 16 1966	1115	30.6	460 R	10	15	22	33	48	69	89	97	99	100		0.033	4.8	0.109	1.7	15	54	31
MAR 16 1966	1730	30.6	715 K	12	21	31	46	65	82	92	98	99	100		0.018	5.0	0.118	1.7	21	61	18
MAR 18 1966	1100	33.7	335 R	09	14	24	34	48	67	89	98	100			0.033	4.7	0.107	1.6	14	53	33
MAR 18 1966	1730	33.7	1 310 K	07	11	17	28	48	72	91	98	99	100		0.032	3.6	0.106	1.6	11	61	28
MAR 21 1966	1600	37.4 H	750 K	09	16	24	38	56	78	94	99	100			0.025	4.4	0.102	1.5	16	62	22
MAR 24 1966	1500	28.9	885 R	07	10	18	28	44	67	91	99	100			0.037	3.9	0.103	1.5	10	57	33
MAR 27 1966	1400	18.3 H	1 220 K	03	07	11	20	33	53	75	92	99	100		0.056	3.8	0.130	1.7	7	46	47
MAR 29 1966	0245	14.5	1 110 R	07	11	18	28	44	72	93	99	100			0.037	3.7	0.100	1.5	11	61	28
MAR 31 1966	1000	11.2 H	480 K	17	23	41	60	78	86	92	96	98	99		0.011	*	0.144	2.4	23	63	14
JUL 25 1966	1800	0.685 H	760 K	20	32	82	96	97	98	99	100				0.005	*	0.125	1.5	32	66	2
APR 10 1967	1100	24.9 H	1 600 K	09	14	20	34	54	78	92	97	99	100		0.027	3.9	0.108	1.8	14	64	22
APR 10 1967	1830	24.9 H	3 200 K	13	16	26	39	55	76	91	98	100			0.025	4.7	0.110	1.7	16	60	24
APR 11 1967	1100	31.4 H	1 790 K	08	13	20	31	48	70	90	98	100			0.033	4.3	0.107	1.6	13	57	30
APR 11 1967	1700	31.4 H	2 250 K	09	14	20	32	48	69	87	96	98	100		0.033	4.6	0.115	1.7	14	55	31
APR 12 1967	1100	43.9 H	1 610 K	11	15	22	32	47	64	82	92	99	100		0.034	5.5	0.125	2.0	15	49	36
APR 12 1967	1900	43.9 H	3 810 K	08	13	20	31	45	66	86	95	99	100		0.037	4.5	0.114	1.8	13	53	34
APR 13 1967	1450	64.8	4 480 R	07	11	17	25	37	55	77	92	97	99		0.052	4.8	0.126	1.8	11	44	45
APR 14 1967	1330	101 H	4 150 K	07	11	17	27	41	59	76	88	94	97		0.044	5.2	0.149	2.4	11	48	41
APR 15 1967	1300	87.5 H	2 600 K	10	14	20	28	39	54	71	87	94	97		0.052	6.5	0.161	2.2	14	40	46
APR 16 1967	1245	86.4	2 100 R	10	14	20	28	36	50	66	83	93	97		0.062	7.0	0.183	2.2	14	36	50
APR 17 1967	1330	72.5 H	1 360 K	11	15	22	30	39	49	63	78	87	93		0.065	9.4	0.216	3.0	15	34	51
APR 18 1967	1400	66.5 H	1 240 K	13	16	23	32	41	51	62	80	91	97		0.057	8.8	0.217	2.2	16	35	49
APR 19 1967	1000	62.0 H	1 020 K	13	17	24	32	41	51	63	81	92	96		0.058	9.1	0.209	2.2	17	34	49
APR 21 1967	1655	34.3	930 R	12	19	26	37	50	65	82	93	98	99		0.031	6.9	0.127	1.9	19	46	35
APR 26 1967	1900	13.4 H	165 K	29	41	59	72	82	90	94	98	99	100		0.005	*	0.145	2.0	41	49	10
MAY 12 1967	1830	9.88 H	460 K	15	18	34	59	79	89	94	98	100			0.013	3.8	0.134	1.8	18	71	11
MAY 24 1967	2000	6.71 H	585 K	05	08	14	22	33	48	75	93	97	99		0.066	4.2	0.122	1.7	8	40	52
MAR 5 1968	1530	7.19 H	371 K	11	16	28	46	67	84	94	98	99	100		0.018	3.9	0.110	1.7	16	68	16
MAR 6 1968	1530	7.19 H	380 K	13	22	34	50	69	84	93	98	99	100		0.016	4.9	0.117	1.7	22	62	16
APR 3 1969	1630	9.43 H	224 K	14	17	37	65	88	97	99	100				0.011	2.8	0.106	1.5	17	80	3
APR 4 1969	1630	46.2 H	1 210 K	13	16	25	38	55	80	96	99	100			0.026	4.2	0.096	1.4	16	64	20
APR 5 1969	1800	119 H	1 280 K	11	15	22	32	49	71	92	99	100			0.031	4.6	0.103	1.5	15	56	29

DISCHARGE FOOTNOTE SYMBOLS
BLANK - INSTANTANEOUS
H - DAILY MEAN

CONCENTRATION FOOTNOTE SYMBOLS
R - SAMPLES COLLECTED IN SEVERAL VERTICALS
K - SAMPLE(S) COLLECTED IN A SINGLE VERTICAL

GDG (GRADING) = SQUARE ROOT (D84/D16)
* - UNABLE TO COMPUTE DUE TO INSUFFICIENT DATA

WATER SURVEY OF CANADA
13/08/82 , PAGE 2
SEDIMENT SURVEY SECTION

SWIFT CURRENT CREEK NEAR THE MOUTH

STATION NO. 05HD037

DEPTH INTEGRATING PARTICLE SIZE ANALYSIS OF SUSPENDED SEDIMENT

SAMPLE IDENTIFIER DATE	TIME	DISCHARGE (M3/S)	CONC. (MG/L)	PERCENT FINER THAN INDICATED SIZE, IN MICROMETRES 2	4	8	16	31	62	125	250	500	1000	2000	TOTAL D50	TOTAL GDG	SAND D50	SAND GDG	PERCENT CLAY	PERCENT SILT	PERCENT SAND
APR 6 1969	1415	98.0	3 150 R	09	13	19	29	43	66	87	98	100			0.039	4.4	0.111	1.6	13	53	34
APR 8 1969	1430	63.1	3 050 R	09	12	17	25	36	55	77	89	96	99		0.053	5.1	0.126	2.1	12	43	45
APR 9 1969	1000	47.0 H	1 290 K	11	15	23	35	57	62	78	91	97	99		0.026	6.1	0.143	2.0	15	47	38
APR 11 1969	1000	19.7	430 R	20	30	45	61	77	87	93	97	99	99		0.009	*	0.133	2.0	30	57	13
APR 14 1969	1700	14.3 H	236 R	18	29	47	66	79	90	96	99	100			0.008	*	0.112	1.7	29	61	10
MAR 22 1970	1845	14.2 H	438 K	31	41	56	70	83	97	99	100				0.006	*	0.106	1.5	41	56	3
MAR 23 1970	1800	15.6 H	608 K	19	28	40	53	70	84	93	99	100			0.013	*	0.117	1.6	28	56	16
MAR 25 1970	1450	16.9 H	502 K	22	26	33	47	66	83	93	98	100			0.017	*	0.113	1.7	26	57	17
MAR 25 1970	1505	16.9 H	425 K	22	29	41	58	74	87	95	99	100			0.011	*	0.111	1.7	29	58	13
MAR 25 1970	1940	16.9 H	499 K	21	29	42	60	78	91	97	99	100			0.011	*	0.105	1.7	29	62	9
MAR 26 1970	1300	15.5 H	479 K	13	16	25	38	53	72	86	95	99	100		0.027	5.3	0.125	1.8	16	56	28
MAR 26 1970	1430	15.5 H	297 K	19	24	32	50	66	80	88	93	96	98		0.016	*	0.161	2.7	24	56	20
MAR 26 1970	1450	15.5 H	242 K	23	28	43	64	83	92	96	99	100			0.010	*	0.125	1.7	28	64	8
APR 4 1970	1900	35.4 H	821 K	20	27	41	59	78	93	98	100				0.011	*	0.102	1.4	27	66	7
APR 5 1970	1530	62.3 H	1 380 K	11	15	24	39	60	85	97	99	100			0.023	3.6	0.095	1.4	15	70	15
APR 6 1970	0800	69.7 H	962 K	15	21	30	41	54	72	91	99	100			0.025	6.5	0.106	1.5	21	51	28
APR 6 1970	1745	69.7 H	9 550 K	10	15	21	26	39	63	89	98	100			0.044	5.0	0.104	1.5	15	48	37
APR 7 1970	0745	96.3 H	2 450 K	11	15	21	30	42	60	79	92	97	99		0.043	5.9	0.129	2.0	15	45	40
APR 7 1970	1730	96.3 H	3 730 K	09	12	20	27	39	54	71	86	95	98		0.052	6.3	0.164	2.2	12	42	46
APR 8 1970	0745	63.1 H	1 020 K	18	23	35	46	58	68	84	92	96	98		0.019	*	0.125	2.2	23	45	32
APR 8 1970	1120	61.7	3 150 R	06	09	13	20	29	45	67	84	94	97		0.073	4.7	0.154	2.2	9	36	55
APR 8 1970	1150	63.1 H	3 060 K	08	10	14	20	30	48	72	90	96	98		0.065	4.4	0.132	1.8	10	38	52
APR 8 1970	1740	63.1 H	3 950 K	07	09	13	19	27	44	69	87	96	99		0.074	4.4	0.136	2.0	9	35	56
APR 12 1970	1125	37.4	886 R	11	17	26	36	47	59	73	83	89	93		0.037	8.6	0.196	*	17	42	41
APR 12 1970	1210	37.4	838 K	11	18	27	37	49	61	74	85	92	96		0.032	8.4	0.189	2.6	18	43	39
APR 14 1970	1805	33.4 H	544 K	16	21	31	43	52	61	73	86	96	99		0.026	10.7	0.191	2.1	21	40	39
APR 16 1970	1900	25.5 H	381 K	18	27	37	48	60	70	80	87	92	96		0.017	*	0.205	3.1	27	43	30
APR 20 1970	1300	17.6 H	397 K	22	28	38	52	65	76	84	91	95	97		0.014	*	0.187	2.8	28	48	24
JUN 15 1970	2130	8.21 H	523 K	28	38	57	74	81	85	93	98	99	100		0.006	*	0.121	1.7	38	47	15
APR 3 1971	1530	23.1 H	453 K	10	16	26	44	66	81	94	99	100			0.019	4.2	0.105	1.6	16	65	19
APR 5 1971	1330	39.6 H	958 K	09	19	22	34	55	81	94	99	100			0.027	5.9	0.104	1.6	19	62	19
APR 5 1971	1710	39.6 H	3 630 K	12	18	28	40	56	79	94	98	100			0.025	4.7	0.101	1.6	18	61	21
APR 6 1971	1500	42.5 H	2 860 K	09	13	20	27	41	62	84	96	99	100		0.042	4.7	0.115	1.7	13	49	38
APR 8 1971	1435	95.4	4 130 R	10	14	20	28	40	59	79	93	98	100		0.046	5.5	0.126	1.8	14	45	41
APR 12 1971	1030	24.3 H	363 K	19	25	38	52	65	75	85	92	96	98		0.014	*	0.157	2.4	25	50	25
APR 13 1971	1710	21.6 H	290 K	27	34	47	62	72	80	89	94	97	99		0.009	*	0.138	2.4	34	46	20
APR 6 1972	1530	1.78	391 K	13	17	28	48	69	86	96	99	100			0.016	4.0	0.102	1.6	17	69	14

DISCHARGE FOOTNOTE SYMBOLS
BLANK - INSTANTANEOUS
H - DAILY MEAN

CONCENTRATION FOOTNOTE SYMBOLS
R - SAMPLES COLLECTED IN SEVERAL VERTICALS
K - SAMPLE(S) COLLECTED IN A SINGLE VERTICAL

GDG (GRADING) = SQUARE ROOT (D84/D16)
* - UNABLE TO COMPUTE DUE TO INSUFFICIENT DATA

Appendix I

Measured Bed Material Density and
Particle Size for Samples Collected
from Lake Diefenbaker

No.	Year	Sample Identifier	% Sand	% Silt	% Clay	Measured Density (Kg/m^3)	Calculated Density (Kg/m^3)
1	1972	R26	11	56	33	905	737
2	1972	R17	4	29	67	684	705
3	1972	R14	7	54	39	854	721
4	1972	SCC 1	15	48	37	1 110	902
5	1972	SCC 3	48	34	18	988	1 155
6	1972	SCC 4	46	34	20	1 148	1 136
7	1972	SCC 5	39	36	25	980	1 076
8	1972	SCC 6	30	37	33	950	992
9	1972	SCC 7	54	28	18	1 209	1 182
10	1972	SCC 10	49	31	20	1 275	1 150
11	1972	SCC 11	10	26	64	412	727
12	1972	SCC 12	49	37	14	1 073	1 184
13	1972	SCC 13	5	29	66	416	695
14	1972	SCC 14	5	28	67	405	689
15	1972	SCC 15	16	40	44	527	867
16	1972	SCC 16	3	23	74	290	641
17	1972	SCC 17	3	31	66	444	686
18	1972	SCC 18	12	50	38	649	883
19	1972	SCC 19	67	19	14	1 017	1 264
20	1972	SCC 20	9	56	35	697	1 278
21	1972	SCC 21	8	55	37	559	870
22	1972	SCC 22	2	45	53	548	756
23	1972	SCC 28	1	26	73	372	636
24	1972	SCC 29	1	33	66	450	676
25	1972	SCC 30	8	49	43	524	836
26	1972	SCC 31	5	28	67	453	689
27	1972	SCC 32	20	59	21	580	1 014
28	1972	SCC 33	22	36	42	545	905
29	1972	SCC 34	20	54	26	549	985
30	1972	SCC 35	17	35	48	638	849
31	1972	SCC 36	7	33	60	447	737
32	1972	SCC 37	8	59	33	756	892
33	1972	SCC 38	52	24	22	1 280	1 131
34	1972	SCC 39	36	40	24	1 042	1 068
35	1972	SCC 40	28	35	37	801	959
36	1972	SCC 41	69	17	14	1 646	1 273
37	1972	SCC 42	38	37	25	1 252	1 072
38	1974	60-2	9	43	48	1 408	812
39	1974	60-3	24	60	16	905	1 059
40	1974	60-4	15	68	17	1 046	1 062
41	1974	60-5	13	70	17	1 267	1 004
42	1974	60-6	34	31	35	633	998
43	1974	60-8	15	65	20	905	996
44	1974	60-9	31	47	22	529	1 057
45	1974	61-4	39	41	20	487	1 104
46	1974	61-8	18	59	23	452	993
47	1974	61-10	19	33	48	1 056	857
48	1974	62-2	7	24	69	745	686
49	1974	62-3	64	24	12	1 267	1 261

No.	Year	Sample Identifier	% Sand	% Silt	% Clay	Measured Density (Kg/m^3)	Calculated Density (Kg/m^3)
50	1974	62-5	27	58	15	844	1 078
51	1974	62-6	35	50	15	1 267	1 175
52	1974	62-8	41	39	20	1 267	1 381
53	1974	62-10	40	40	20	1 267	1 108
54	1974	63-2	13	56	31	793	926
55	1974	63-3	28	53	19	1 456	1 060
56	1975	D1	17	58	25	860	977
57	1975	D2	22	42	36	1 057	939
58	1975	D3	1	39	60	593	710
59	1975	D4	2	43	55	593	743
60	1975	D5	8	47	45	625	825
61	1975	D6	2	61	37	673	844
62	1975	D7	30	42	28	766	1 020
63	1975	D8	10	52	38	626	873
64	1975	D9	4	58	38	636	846
65	1975	D10	23	52	25	665	1 004
66	1975	D11	37	34	29	939	1 044
67	1975	D12	29	51	20	1 115	1 060
68	1975	D13	21	30	44	548	860
69	1975	D14	39	25	36	687	1 016
70	1975	D15	0	35	65	562	678
71	1975	D16	28	32	40	745	942
72	1975	D17	46	22	32	835	1 068
73	1975	D18	3	39	58	572	730
74	1975	D19	4	46	50	562	778
75	1975	D20	3	42	55	529	778
76	1975	D21	6	44	50	581	746
77	1975	D22	12	47	41	633	788
78	1975	D23	24	51	25	844	867
79	1975	D24	24	31	45	671	897
80	1975	D25	53	28	19	950	1 173
81	1975	D26	1	36	63	628	692
82	1975	D27	46	34	20	1 190	1 136
83	1977	10R	4	32	64	375	700
84	1977	10C	24	56	20	785	1 036
85	1977	12R	14	46	40	678	881
86	1977	12C	12	30	68	388	670
87	1977	12L	10	44	46	497	828
88	1977	13R	48	32	20	1 067	1 144
89	1977	13C	13	36	51	408	814
90	1977	13L	9	28	63	421	729
91	1977	19R	4	31	65	444	695
92	1977	19C	7	38	55	540	764
93	1977	19L	25	26	49	461	879
94	1977	22R	4	28	68	730	678
95	1977	22C	2	40	58	524	726
96	1977	22L	15	41	44	658	863

No.	Year	Sample Identifier	% Sand	% Silt	% Clay	Measured Density (Kg/m^3)	Calculated Density (Kg/m^3)
97	1977	25R	5	35	60	554	729
98	1977	25C	5	51	44	589	819
99	1978	25L	11	45	44	729	844
100	1978	SCC 1	4	44	52	381	767
101	1978	SCC 2	19	52	29	687	964
102	1978	SCC 3	1	35	64	360	687
103	1978	SCC 4	2	55	43	798	809
104	1978	SCC 6	1	43	56	453	732
105	1978	SCC 7	10	45	45	820	835
106	1978	SCC 8	13	47	40	621	875
107	1978	SCC 9	7	42	51	452	786
108	1978	SCC 10	40	38	22	1 081	1 097
109	1978	SCC 11	2	30	68	399	670
110	1978	SCC 12	3	48	49	559	780
111	1978	SCC 13	1	77	22	312	613
112	1978	27L	3	51	46	641	798
113	1978	27C	2	45	53	921	754
114	1978	26L	34	51	15	761	1 110
115	1978	26C	2	41	57	432	698
116	1978	26R	2	42	56	543	737
117	1978	24L	12	45	43	599	855
118	1978	24C	4	59	37	557	852
119	1978	23L	32	26	42	961	950
120	1978	23C	14	45	41	471	875
121	1978	23R	2	38	60	407	714
122	1978	21L	9	35	56	543	769
123	1978	21C	24	45	31	1 124	975
124	1978	21R	38	44	18	1 161	1 110
125	1978	20L	3	33	64	463	697
126	1978	20C	11	34	55	734	782
127	1978	20R	49	29	22	1 134	1 139
128	1978	17L	16	52	32	605	934
129	1978	17C	1	26	73	346	636
130	1978	17R	26	52	22	971	1 035
131	1978	14L	2	28	70	364	658
132	1978	14C	5	45	50	466	785
133	1978	14R	22	52	26	1 198	995
134	1978	9C	2	14	84	184	580
135	1978	9R	3	36	61	429	713
136	1978	7L	15	59	26	849	964
137	1978	7C	11	42	47	463	820
138	1978	7R	14	41	45	1 118	689
139	1978	6L	31	33	36	681	979
140	1978	6C	6	43	51	655	783
141	1978	6R	6	51	43	770	828
142	1978	5L	10	59	31	671	913
143	1978	5C	34	43	23	831	1 065
144	1978	5R	64	23	13	1 076	1 256

Appendix J

1972 and 1978 Swift Current Creek Area Elevation - Capacity Tables

SEDIMENT SURVEY SECTION LOSC72 SC57M1
OTTAWA, ONT.
JUL 1981

ELEVATION - CAPACITY TABLE

ELEVATION (M.)	ACC. VOLUME (1000 CU. M.)	ELEVATION (M.)	ACC. VOLUME (1000 CU. M.)	ELEVATION (M.)	ACC. VOLUME (1000 CU. M.)	ELEVATION (M.)	ACC. VOLUME (1000 CU. M.)
533.50	3.2	546.00	11511.0				
534.00	16.4	546.50	12502.6				
534.50	55.0	547.00	13520.5				
535.00	145.4	547.50	14561.4				
535.50	288.4	548.00	15622.9				
536.00	464.6	548.50	16705.5				
536.50	673.3	549.00	17804.9				
537.00	913.7	549.50	18919.1				
537.50	1179.7	550.00	20047.1				
538.00	1471.3	550.50	21184.3				
538.50	1786.8	551.00	22330.2				
539.00	2121.5	551.50	23484.7				
539.50	2473.7	552.00	24646.6				
540.00	2847.3	552.50	25815.5				
540.50	3246.7	553.00	26990.3				
541.00	3677.7	553.50	28169.8				
541.50	4166.3	554.00	29353.4				
542.00	4749.5	554.50	30539.5				
542.50	5427.5	555.00	31727.1				
543.00	6170.6	555.50	32916.1				
543.50	6966.9						
544.00	7812.8						
544.50	8695.6						
545.00	9606.5						
545.50	10545.1						

SEDIMENT SURVEY SECTION LDSC78 SC57M1
OTTAWA, ONT.
JUL 1981

ELEVATION - CAPACITY TABLE

ELEVATION (M.)	ACC. VOLUME (1000 CU. M.)	ELEVATION (M.)	ACC. VOLUME (1000 CU. M.)	ELEVATION (M.)	ACC. VOLUME (1000 CU. M.)	ELEVATION (M.)	ACC. VOLUME (1000 CU. M.)
535.00	4.0	547.50	13507.7				
535.50	34.3	548.00	14554.0				
536.00	123.1	548.50	15617.0				
536.50	270.2	549.00	16697.2				
537.00	457.6	549.50	17795.0				
537.50	681.2	550.00	18907.5				
538.00	940.7	550.50	20032.1				
538.50	1231.8	551.00	21167.3				
539.00	1550.4	551.50	22313.6				
539.50	1895.1	552.00	23470.0				
540.00	2260.6	552.50	24634.7				
540.50	2644.3	553.00	25806.5				
541.00	3049.5	553.50	26983.3				
541.50	3490.2	554.00	28164.5				
542.00	3998.4	554.50	29349.5				
542.50	4585.2	555.00	30536.9				
543.00	5276.3	555.50	31725.9				
543.50	6034.0						
544.00	6845.9						
544.50	7785.6						
545.00	8602.8						
545.50	9530.4						
546.00	10487.6						
546.50	11471.2						
547.00	12479.0						