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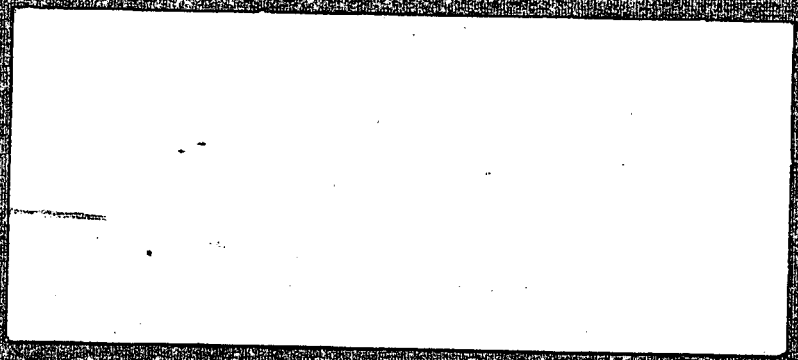

NHRI·INRH

INLAND WATERS DIRECTORATE
OTTAWA, CANADA

DIRECTION GÉNÉRALE DES EAUX INTÉRIEURES
OTTAWA, CANADA

NHRI RESEARCH PROGRAM

Summaries of Activities and Progress
in 1982

CONTENTS

FOREWORD

This report is a compilation of brief summaries of activities and progress for those NHRI studies that were active during 1982. A similar report is issued annually for distribution internally within IWD, primarily for the information and use of the Water Research Advisory Committee.

Summary of Activities and Progress in 1982

Study No. HR 79-8

A Comparative Study of Various Methods of Estimating Potential and Actual Evapotranspiration

B.P. Sangal

Progress on this study has been slow due to other priorities. Some estimates of potential and actual evapotranspiration were carried out for a few selected climatological stations. The results are to be evaluated with respect to recorded data. Work in earnest will resume after the Base Flow Study (SW 81-1) has been completed.

Summary of Activities and Progress in 1982

Study No. SW 81-1

A New Method of Developing Base Flow Recession Curves

B.P. Sangal

Considerable time was devoted to this project. A total of 263 gauging stations in Ontario having records of ten or more years have been analyzed. Recession curves have been drawn for the majority of these stations but difficulty has been encountered for stations with zero flows or where regulation has pronounced effect. The number of streams with zero flows has turned out to be quite large.

Summary of Activities and Progress in 1982

Study No. GW 81-1

Chalk River Hydrogeology Study

K.G. Raven

A shallow ground water flow system in fractured crystalline rock is being studied using borehole characterization techniques to evaluate the usefulness of various investigative tools in defining and predicting ground water flow patterns in fractured media. The study site measuring approximately 200 m x 150 m x 50 m deep is located at the Chalk River Nuclear Laboratories, 200 km northwest of Ottawa. The site was selected using air photo lineament analysis and ground and airborne geophysical techniques in a moderately fractured area bordering on a major structural and hydrogeologic feature.

During FY 1981-82 nine air percussion boreholes were drilled, fracture logged using acoustic televiewer and borehole television logging techniques, injection test profiled and completed with plastic multiple packer standpipe casing. Hydraulic head monitoring and geochemical-isotopic sampling of ground water were conducted in each packer isolated interval. The results of 1981-82 investigations identified the general pattern of ground water movement as well as the existence of three boundary conditions controlling ground water flow in the study site. These boundaries include a flat lying constant head boundary associated with a high permeability fracture zone, a surface infiltration boundary and a vertical impermeable or no flow boundary associated with a diabase dyke.

Activities during 1982-83 have focussed on detailed hydrogeologic characterization of the flow boundaries identified during 1981-82 and determination of interwell fluid flow properties at the test site from multiple well interference tests. During 1982-83 five new boreholes were drilled and one borehole deepened using air percussion drilling techniques. The boreholes were completed in a manner similar to boreholes drilled in 1981-82. In addition, a suite of standard geophysical logs was run in each hole to aid in hydrogeologic interpretation of the test site. With the completion of multiple packer standpipe installations in the new boreholes a total of 75 test intervals are now isolated at the site. Long term hydraulic head monitoring and geochemical-isotopic sampling have continued in the 75 test intervals in 1982-83.

Several long term interference tests have been carried out on the site to evaluate interwell hydraulic properties. Two seven day pump tests and several three day duration pulse tests were completed in 1982-83. Monitoring of vertical and radial response was recorded during these interference tests. The results of these tests indicate wellbore

storage and skin effects at both active and observation well intervals, nonradial flow and stress dependent permeability of the fracture system influence the interpretation of the data. Detailed analysis of the test results is proceeding and initial analysis indicates the existence of four major interconnected fracture zones at the site with equivalent single fracture apertures of 100 to 500 microns and fracture stiffness of 10^8 to 10^{10} Pa/metre. Tracer testing and a large scale stress deformation experiment are planned for 1983-84 to confirm these fracture properties.

A report documenting the first year's activities was completed in June 1982. Work on the second year's progress report is under way.

Summary of Activities and Progress in 1982

Study No. HR 79-3

Chloride-36 Content of Selected Ground Waters

D.J. Bottomley

Several ground water samples were collected from hydrogeochemical borehole CR13 (CRNL) for processing and analysis of their ^{36}Cl contents to determine the magnitude of ^{36}Cl variation in ground waters with relatively young ^{14}C ages (<20,000 years) compared to the ^{36}Cl half life of $\approx 3.0 \times 10^5$ years. These measurements would indicate the sensitivity of ^{36}Cl input into the saturated zone at a given site to radically different environmental conditions during recharge. Unfortunately no ^{36}Cl runs could be scheduled on the University of Rochester accelerator for the latter half of '82 so these samples remain to be analyzed.

However, construction and commissioning of the University of Toronto tandem accelerator and instrumentation ("Ultra-Sensitive Analysis Facility") has recently been completed. Because of Environment Canada's contribution to the funding of the commissioning of this facility a number of samples will be run for the department (and NHRI specifically) at no charge. Initially these samples will be for ^{14}C analyses of CR13 ground water. However when the ^{36}Cl analytical capability is achieved in late 1983 a number of ^{36}Cl analyses of selected ground waters will be performed.

Summary of Activities and Progress in 1982

Study No. GW 82-3

Contaminants in Subsurface Waters

R.E. Jackson/M. Bowron

The NHRI Contaminant Hydrogeology laboratory at the River Road. Environmental Centre has been further brought onto line with the addition of three atomic absorption spectrophotometers, (a Perkin Elmer with graphite furnace for trace metals, a Perkin Elmer automated for major ions and an IL for dedicated analysis of a particular element of interest (e.g. Hg, As). A Spectra Physics high performance liquid chromatograph (HPLC) has been brought to operational status for the determination of organic contaminants in ground water samples and from column experiment in the lab. The Dionex ion chromatograph has been further modified to run anion samples more automatically. The Metrohan automatic titrator is on line and is to be further adapted for closed cell work. The deionized water system has been replumbed and brought up to standards for trace metal analysis by the addition of a Corning automatic still. Chemicals and equipment have been signed over from EPS Ontario Region to NHRI and all equipment is now operational. Repair costs run to ≈$2K but the total replacement cost is approximately ≈$200K.

A computer terminal and printer have been purchased which will be linked to the PDP 11/24 located on the first floor (EPS Inorganic Chemistry Lab). Initially this equipment will be used to run solute transport and geochemical analysis programs.

An interlaboratory check on automated analysis by Dionex ion chromatography has been completed and improvements incorporated into our analytical method. The laboratory has analyzed about 500 samples with an average of ten elements reported for each (to December 15, 1982).

Summary of Activities and Progress in 1982

Study No. SI 80-5

Dielectric Properties of Contaminated Ice

G.P. Johari

Measurements of the velocity, reflectivity and attenuation of radio and microwaves in ice containing varying amounts of organic and inorganic impurities were continued over a wider range of temperatures and frequencies. A new apparatus for measurement of the dielectric properties of ice, which operates at elevated gas pressures has been designed and tested. The apparatus uses metal coated glass electrodes and can be used over a range of temperature.

Under high pressures, the molecular structure of ice transforms into a variety of crystalline forms of entirely different physical properties. The electrical properties of these high pressure modifications of ice were computer-modelled using their molecular structure data. The modelling showed a less than proportionate increase in the dielectric permittivity with increasing density. The density of ice thus seemed to have a relatively minor role in determining its physical properties. A brief report of the study was presented at the VI International Symposium on Physics and Chemistry of Ice held in Rolla, U.S.A., August 2-6, 1982.

Measurements and analysis of the data on the amount of light scattered by ice containing deuterium isotope as impurity were carried out. The results were related to the previous data on ordinary ice and its deuterium (isotope) substitute to obtain conclusions on the mechanism of light scattering from ice. A brief report of the study was presented at the VI International Symposium on Physics and Chemistry of Ice, held in Rolla, U.S.A., August 2-6, 1982.

On invitation from Centre de Physique Theorique, Les Houches, France, a series of lectures on Amorphous and Semi-Crystalline Solids were given at their International Spring School in April-May 1982. A detailed text of these lectures was written for publication in a book entitled, "Les Houches Lectures on Plastic Deformation in Solids" (Les Edition du Physique, France).

A number of reports on the properties of ice were reviewed and suggestions were made regarding their suitability for publication and for funding by the various government agencies.

Summary of Activities and Progress in 1982

Study No. HR 79-4

Effects of Land Use Changes on Evapotranspiration

F.I. Morton

Observations of temperature and humidity continued at six stations in the Spring Creek Basin near Valleyview, Alberta and at three stations in the Kernen Farm near Saskatoon. The instrumentation at Spring Creek, which also includes a sunshine recorder, is a cooperative project with Alberta Environment to investigate the effects of future forest clearing, and the instrumentation at Kernen Farm is a cooperative project with the University of Saskatchewan to compare the effects of cropped grass and fallow lands. Evapotranspiration is computed in Ottawa when the required data are supplied by the cooperating organizations.

Humicells and temperature integrators have also been installed at three sites in Southern Alberta in connection with the Milk River Channel Loss Study (see GWO 81-1). This is a cooperative project with the Calgary Office of the Water Resources Branch of Environment Canada. The sites are representative of phreatophytic vegetation (e.g. cottonwoods and willows) on the floor of the Milk River Valley, riparian grass and sage on the floor of the Milk River Valley, and prairie grass and sage on the nearby uplands. Water surface evaporation and area evapotranspiration have been computed for the months of May, June, July and August of 1982 and the results presented in a preliminary report. They indicate: (1) that the evaporation from the water surface during the summer months is sufficient to reduce the river flow between Writing-on-Stone Bridge and the Eastern Crossing by an average of 0.6 to 0.4 cubic metres per second; and (2) that there is no significant difference between the areal evapotranspiration at the phreatophyte site, the riparian site, the prairie site and the Medicine Hat Airport. The latter finding is tentative because of instrumental difficulties and abnormally wet conditions that prevailed during the summer of 1982. However, if true, it means that the vegetation on the valley floor does not abstract water from the river channel.

Summary of Activities and Progress in 1982

Study No. SI 79-8

Gamma Ray Surveys

J.E. Glynn

Since March 1, 1982, all work on this project has been performed while under secondment to GSC.

A software package has been developed for use on airborne gamma ray snow surveys. The set of programs, designed for use on the Data General minicomputer system at the GSC, includes techniques for energy calibration, energy resolution and radar estimation using multichannel data. Snow water equivalents may be computed using a variety of window methods as well as by a multichannel method. A database package has been designed to store all gamma ray snow survey data on disk on the minicomputer system. Modules have been written to update information stored on the database and to retrieve data from the database for use in snow water equivalent calculations. Data from all gamma ray snow surveys back to 1979 are currently stored on the database. All the programs have been tested and are documented.

The Trent-Severn snow survey of 1982 was completed using a one-flight method. The results were transmitted to Mr. B. Kitchen of the Trent-Severn Waterway within 48 hours of completion of the survey. The results of the airborne survey agreed with ground results to within 1.5 standard deviations of the count statistics error. A report of the results is being written with R.G. Grasty. A repeat survey will be performed in February 1983.

The Saskatchewan snow survey of 1982 was successfully flown. Results of the GSC systems agree to within 5 cm with ground results and with those from the U.S. National Weather Service (NWS) system. Attempts to analyze the data using a one-flight system proved unsuccessful. A paper comparing the GSC and the NWS systems is being prepared with T Carroll and B. Goodison for presentation at the 1983 Western Snow Conference. A repeat survey is scheduled for February 1983.

Presnow gamma ray flights and ground soil moisture collection were carried out in July 1982 on the north shore of Lake Superior in preparation for a snow survey in March 1983. Analysis of the presnow data has been completed.

Summary of Activities and Progress in 1982

Study No. HR 74-8

Geophysical Survey - Strait of Canso

H.M. Elliott

A final report has been completed and is nearing the end of internal review and editing. Due to the lack of others expert in geophysics within NHRI the report may also go to an external reviewer.

Summary of Activities and Progress in 1982

Study No. SW 82-3

Historical Flood Review: Fort Simpson, Fort Norman, Fort Good Hope, Fort McPherson, Aklavik, Fort Liard and Nahanni Butte

L.A. Kriwoken

The Canada-Northwest Territories Flood Damage Reduction Program provides for the identification and mapping of flood risk areas in the Northwest Territories. The Historical Flood Review is one component of that program.

Five communities in the Mackenzie Valley have been studied with the objective to determine, in each, the level and extent of past extreme flood events. Information on past flood events was obtained from field investigations and archival research carried out from May through August, 1982. Long-term residents of each community were interviewed and journals kept by the Hudson's Bay Company, Roman Catholic Church, and Royal Canadian Mounted Police were reviewed for information on past flood events. To supplement the historical data, investigations of physical evidence of past flood and ice shove events were made in each community.

In August, similiar "on-site" historical reviews were undertaken in the communities of Fort Liard and Nahanni Butte.

The data on flood events for all seven communities have since been analyzed to establish historical floodlines. Where evidence was available, ice shove limits of each event have been defined. The extreme flood limits for each community will be plotted on 1:2000 scale topographic maps.

A preliminary report, to be submitted to the Technical Committee of the Northwest Territories Flood Damage Reduction Program by December 31, 1982, is near completion. All available information on the date, cause, timing and areal extent has been described for each flood event. The final report, including flood risk maps, will be available after March 31, 1983.

Summary of Activities and Progress in 1982

Study No. GW 81-3

Hydraulic Testing and Radionuclide Transport in Fractured Rock

K.G. Raven and K.S. Novakowski

The physical and chemical controls on radionuclide transport in fractured crystalline rock are being investigated using field techniques in an NQ borehole array at the Chalk River Nuclear Laboratories, 200 km northwest of Ottawa. During 1978, 79, 80 and 81 the physical hydrogeologic characteristics of a fractured quartz monzonite rock mass were investigated using single and multiple well hydraulic interference tests in a six borehole radial array. The boreholes range in length from 120 to 300 metres. The five radial boreholes CR-7, CR-8, CR-10, CR-11 and CR-12 have been completed with multilevel pvc casing strings creating 57 packer isolated test intervals. The central borehole, CR-6, has remained open to accommodate N size double packer assemblies.

The major effort in the borehole array during 1982-83 has been the successful completion of conservative and reactive radial radioactive tracer experiments at 100 metres depth. In support of analysis and interpretation of the tracer test results single well injection and slug tests, multiple well pump and pulse tests and hydraulic head monitoring were also completed in 1982-83.

In June a forced gradient conservative radioactive tracer experiment utilizing ^{131}I was completed. Ground water collected during a long term pump test from CR-6 was injected for 300 hours at 0.5 litres per minute into borehole CR-6 at a depth of 103 to 108 metres. Radioactive ^{131}I was injected at 1.0 mC per hour for 100 hours in the 100 to 200 hour interval. Breakthrough of ^{131}I in the radial observation intervals was identified and monitored with a natural gamma logging unit, eliminating the need for fluid withdrawal. Logging was carried out from the inside of the multiple packer plastic casing.

A total of nine separate tracer breakthrough points were observed in two of the five observation wells, CR-11 and CR-7 at radial distances of 10.3 and 11.7 metres. Assuming steady state radial symmetric flow conditions in a smooth parallel plate model of the fractures between the two wellbores, the interwell tracer transit times correspond to equivalent single fracture apertures of 13 μm to 57 μm. These calculated apertures are in good agreement with independent interference test result determinations.

In September a combined conservative (^{131}I) and reactive (^{85}Sr) tracer experiment was carried out in the same fractures tested in June. Sixty mC of ^{131}I and 70 mC of ^{85}Sr were injected over a 100 hour period following 25 hours of CR-6 ground water injection. Injection of ground water continued after tracer injection for 150 hours.

Breakthrough of both tracers was identified utilizing gamma spectroscopy logging techniques. Based upon first arrival times a retardation factor of 57 was obtained for ^{85}Sr migration through natural fractures at 100 metres depth over radial distances of 10.3 metres.

Several radioactive point dilution tests using ^{82}Br were also completed in CR-6 with a double packer assembly and downhole gamma counter to estimate natural fracture fluxes. The initial results suggest considerable modification of the mixing and injection apparatus is necessary before the point dilution technique may be used to reliably estimate natural fracture fluxes.

Summary of Activities and Progress in 1982

Study No. SI 80-7

Hydroclimatological Studies on Western Canadian Glaciers

S. Fogarasi

Following the 1980 field work, additional albedo measurements were made between April 28 and May 18, 1982. During the 1980 field work, due to lack of fresh snow, only ice surface albedo values could be measured with a simple instrument.

In 1982, fresh snow-surface albedo values were measured with a new, inhouse-made electronic instrument equipped with double sensors. The design and the construction of this instrument was carried out by the Instrument and Technology Services of the NHRI according to own specifications. The manual of this instrument is being written by the Technology Services with our contribution under the heading "Actual Measurements".

Analysis of this additional information made the construction of an all weather albedo change model possible. The results of this work were presented at the Sixteenth Annual Congress of the Canadian Meteorological and Oceanographic Society, University of Ottawa, May 26-28, 1982, under the title "Albedo Survey and Simulation for Andrei Glacier, B.C.".

Summary of Activities and Progress in 1982

Study No. HR 78-13

Hydrogeochemical Assessment of Crystalline Terrain

D.J. Bottomley

This project, which is funded by Atomic Energy of Canada Ltd., has two main research objectives: 1) to develop a methodology which will enable hydrogeochemical characterization of ground waters in fractured Precambrian rocks to depths of about 1000 m, and 2) to determine the age, origin and chemical evolution of ground water based on the chemical and isotopic analyses of representative ground water samples. During 1982 research was conducted in dedicated hydrogeochemical borehole CR13 located at the Chalk River Nuclear Laboratories. This borehole is completed with multilevel ported casing which allows for sampling from 14 packer isolated test zones to a depth of about 600 m.

Sampling conducted with the geochemical probe in 1982 confirmed the existence of a low ionic strength NaCl plume between 217 m and 341 m. The maximum chloride concentration is approximately 315 mg L^{-1} which occurs near the contact between the gneiss and underlying gabbro suggesting the gabbro represents a permeability barrier to the downward movement of ground water at this site. Pressure drawdown measurements conducted in the gabbro support this view. Above and below this plume the chemistry of the ground water is of the $NaHCO_3$ type.

Stable isotope (^{18}O, ^{2}H) and carbon-14 results indicate that the source of the NaCl water may have been the marine incursion of the Champlain Sea onto this area following deglaciation (≈11,500 years BP). Samples collected for sulphur-34 have not yet been analyzed but it is expected that the ^{34}S results may be very useful in identifying a sea water component for the dissolved sulphate (≈ 50 mg L^{-1}) in the plume.

The geochemical probe was successfully tested to a maximum depth of 575 m in 1982. At this depth a continuous pumping/sampling test was conducted for 17 days at a pumping rate of about 50 mL/min which produced a drawdown of ≈ 10 psi. A test conducted at 487 m for about the same period of time and at the sample pumping rate produced a drawdown of ≈ 200 psi. In CR13 higher pumping rates (i.e. > 50 ml min^{-1}) are not possible with the geochemical probe below about 350 m because:

1) the lower test zones are of relatively low permeability and
2) high hydrostatic pressures on the umbilical cable tend to collapse the hoses to the compressed-gas driven pump resulting in lower fluid flow rates to and from the pump.

Although the geochemical probe cannot be used in the field during the winter, some sampling will be conducted over the winter at a depth of 217 m where the hydrochemical characterization is not considered complete. A "squeeze-pump", installed between two straddle packers and supported by a wire line, is being used. This zone is located near the top of the NaCl plume and is dominated lithologically by a major pegmatite intrusion which appears to have a dominating influence on the uranium chemistry and the $^{234}U/^{238}U$ ratio of the ground water.

Summary of Activities and Progress in 1982

Study No. GW 71-1

Hydrogeology, Fraser Valley

E.C. Halstead

This study was completed in 1981, however report compilations were carried over into 1982. All illustrations have been submitted and presently are being drafted in Ottawa. The completed text is undergoing further revision in Vancouver and should be returned to Ottawa in the near future.

Summary of Activities and Progress in 1982

Study No. HRO 75-1

Hydrogeology, Richmond Landfill - Richmond, B.C.

H.M. Liebscher

This project has been inactive for several years because of the principal investigator's involvement with other studies (GWO 81-3, GWO 81-4) and because of his secondment, beginnning in FY 1982-83, to the IWD Pacific and Yukon regional office. Most of the information required for the study has been gathered, however, and the final report has been partially completed. Completion is scheduled for the 1983-84 fiscal year.

Summary of Activities and Progress in 1982

Study No. HR 78-2

Hydrogeology of Bedrock Aquifers

G. Grove

No progress has been made on this study because of the principal investigator's involvement in other studies (GWO 81-2, GWO 82-1) and a subsequent absence on language training.

Summary of Activities and Progress in 1982

Study No. SI 73-13

Hydrologic Studies, Mackenzie Delta Region, NWT

J.C. Anderson

This study is an outgrowth of research basin investigations at Boot Creek and Peter Lake watersheds which were begun by D.K. MacKay in the late 1960's. During construction of the Dempster Highway between Inuvik and Dawson in the 1970's, difficulties such as washouts and severe icings were encountered owing to a lack of hydrologic information for small and medium-sized drainage basins. In an effort to avoid such problems along the route of the proposed Inuvik-Tuktoyaktuk Highway, the Northern Hydrology Section has been collecting and analyzing data at a variety of basins in the region. The primary aim has been to identify potential trouble spots (e.g. icing sites) and acquire data relevant to highway culvert and bridge design.

Field studies continued in the eastern Mackenzie Delta region in 1981 at three basins in the taiga zone south of Inuvik and six basins in the tundra zone between Inuvik and Tuktoyaktuk. Data were collected on one or more of the following variables:

1. culvert ice accumulation thickness,
2. late winter snowpack water equivalent,
3. field season precipitation,
4. air temperature, and
5. discharge.

Water Survey of Canada personnel, who have been collecting discharge data at three of the tundra basins and one taiga basin, became more involved in 1981 by assuming responsibility for the Boot Creek gauge.

A survey of culvert icings was conducted in the taiga zone on May 9, 1982 and accumulations were found to be above normal in intensity. Snow surveys were done in the taiga and tundra on May 9 and May 24, respectively. Prior to commencement of snowmelt runoff, precipitation, air temperature and water level recorders were installed at selected sites in early May. Monitoring of these variables continued until September 4, while Water Survey continued to record water levels at five sites into the freeze-up period.

A report on the 1981 field season is near completion and an analysis of 1982 data will commence thereafter. As data records lengthen, more meaningful statistical analysis (such as flood frequency analysis) can be undertaken.

Summary of Activities and Progress in 1982

Study No. GW 81-4

Hydrological Effects of Rural Land Drainage

A. Vandenberg

The research scientist involved in this project is presently in the Netherlands conducting work and studying various aspects pertaining to soil moisture. Specifically he is looking at the laboratory determination of conductivity characteristics, i.e. permeability as a function of moisture content and the pF curve (log of negative pressure versus moisture content). The first two months of 1983 will be devoted to an analog model of unsaturated flow. The remainder of the time until April 1983 will be used to investigate the amount of runoff generated under various drainage intensities; for this, the analog model and some digital models will be used.

Last summer, the neutron probe was tested out around Ottawa and some moisture profiles were drawn. The instrument is ready to be used for the next field season.

Summary of Activities and Progress in 1982

Study No. SW 82-4

Hydrological Effects of Rural Land Drainage, Evaporation Studies

F.I. Morton

Humicells and temperature integrators were installed at one site in the basin of the Mannes Drain and at one site in the basin of the Domain Drain on May 21, 1982. One further site on each basin was instrumented on August 19, 1982. The instrumentation for the two sites that were instrumented first has been working satisfactorily and the data produce areal evapotranspiration estimates that look quite reasonable. However there has been some trouble with the temperature integrators for the two sites that were instrumented last so the records there are too spotty to be of much use.

Summary of Activities and Progress in 1982

Study No. SW 82-5

Hydrological Effects of Rural Land Drainage, Snowmelt Studies

J.M. Power

The Gloucester toxic dump site was determined to be unsuitable for snowmelt runoff studies because of the poorly defined drainage basin.

Summary of Activities and Progress in 1982

Study No. SI 79-4

Hydrology of the Mountain Snowpack

R.I. Perla

An understanding of snow metamorphism is fundamental to many aspects of snow hydrology.

In 1982 some progress was made in the study of how temperature boundary conditions affect the texture of snow. Samples were collected in the field, transported to the NHRI lab in Canmore and inserted in chambers, which provided a wide range of temperature boundary conditions. Metamorphism was observed using photomicrography of disaggregated specimens, and using the technique of polished sections (innovated by NHRI, 1980-82) to study the interconnected texture. Strong temperature gradients altered drastically the texture and increased the thermal conductivity of the snow.

The polished section technique was further improved. Promising results were obtained preparing parallel sections at 40 m intervals. Improved knowledge of snow texture is crucial to interpretation of remotely sensed data of the snowpack, especially in the microwave bands. NHRI has taken the lead in North America in the interpretation of snow texture.

Wet snow studies emphasized the development of laboratory studies for calibrating larger scale measurements (based on electromagnetic systems -- D.C. through optical frequencies) of free water in the snowpack. Calorimetry, temperature-depression, centrifugal, and an innovative technique based on dye dilution were compared. To date, the dye dilution appears to be the best calibration tool for large scale measurements.

Also in 1982 several avalanche studies were completed and published.

Recent Publications

Perla, R.I., 1982. Preparation of section planes in snow samples. J. Glaciology 28:98, 199-204.

Perla, R.I. (in press) Avalanches. New Canadian Encyclopedia.

Perla, R.I. and T. Beck (in press) Experience with shear frames. J. Glaciology.

Perla, R.I., T. Beck and T. Cheng, 1982. The shear strength index of alpine snow. Cold Regions Science and Technology 6, 11-20.

Perla, R.I. and K. Everts (in press) On the placement and mass of avalanche explosives. Annals of Glaciology.

Summary of Activities and Progress in 1982

Study No. SW 82-1

Hydrometeorology of Water Storage

S. Fogarasi

The objective of this project is to find relationships among absolute humidity and evaporation, moisture storage changes with boundary elevations and evaporation in the lower boundary layer. It is expected that the description of the diurnal profiles for the heat and moisture exchange coefficients will be possible. Knowledge of these coefficients is important in modelling surface energy, and water budget processes. This study will be a contribution to F. Morton's evaporation model which might be used for drought studies over the Canadian Prairies.

During the first year phase of this project of three years duration, literature study has been done. Aided by a summer student, a prepared data set, "The Wanagara Experimental Data" was stored on tape. This set of data will be very useful for testing evaporation and boundary layer formulas within the lower atmosphere. This testing will be done during the second year of this project (1983-84).

Summary of Activities and Progress in 1982

Study No. HR 75-5

Hydrothermal Effects near Arctic Streams

A. Wankiewicz

Four reports have been prepared for publication on observations and modelling of the interaction between streamflow and permafrost at seasonal rivers near Inuvik. The objective is to provide an understanding of natural hydraulic and hydrological regimes for application to Arctic pipeline/highway route selection and stream crossing design. The Rengling and Caribou Rivers drain 1000 km^2 watersheds and cease flowing in winter from mid-January to the end of April, on average. The papers describe winter channel freezing, flow and outflow phenomena (Wankiewicz,, 1982c); the channel processes producing these phenomena (Wankiewicz, 1982a and b); and the related hydrothermal effects occurring in the subchannel (Wankiewicz, 1982b). The existence of perennially unfrozen ground (river taliks) beneath seasonal rivers near Inuvik has been previously described (Wankiewicz, 1976, 1977, 1981).

A comparison of winter overflow observations and discharge measurements shows that seasonal streams near Inuvik experience overflow episodes within thirty days before or after streamflow cessation. Overflows associated with positive streamflow are widespread while those following flow stoppage are localized along the channel. The channel ice structure determined from three years of borehole and temperature probe observations suggests that watershed moisture conditions in fall determine river icing amounts.

Continuous recordings of winter channel and subchannel temperature indicate that discharge flows intermittently through river ice tunnels during the final weeks of streamflow. The streambed isothermal periods appear to be related to relative warm spells (air temperatures F - 20°C) and are frequently accompanied by overflows on the ice cover. Ice temperature-probe cross-sections show that during this time the channel ice is frozen to portions of the bed presumably resulting in a closed conduit flow system along the channel. Model calculations show that discharge can be accounted for with this system within the limits of error. After streamflow ceases, ground temperature recordings show that underflow continues through the river taliks as well as through connected local convection zones at shallow depth beneath the flood plain. Flood plain overflows continued for fifteen days above one of these convection zones.

Subchannel observations indicated the following hydrothermal processes beneath the river channel. After the channels freeze in midwinter, frost develops in the streambed to a depth of 70 to 250 cm.

Spring runoff thaws the frozen bed over a period of several weeks after commencement of flow in the channel. Solar heating in summer is stored in the subchannel, below the freeze thaw layer, primarily by thermal conduction at Caribou Creek. The rates of heat transfer into the subchannel are an order of magnitude larger at Rengling River, however, because of macroscopic dispersion of heat by ground water flowing in the permeable talik. The apparent thermal conductivities were derived by fitting the results of numerical simulations to observed temperature profiles.

The heat stored in the subchannel is released back to the channel during the fall and winter according to ground temperature observations. It is shown from turbulent heat flow theory that the small streambed heat flux in winter is concentrated by nonuniform streamflow at small flow sections. Numerical calculations show that this heat transfer limits river ice thickening at these locations which control low-water flow in channels.

The series of papers described above are based on over 2200 temperature observations and 192 months of thermograph records. Reports in progress include: a comparison of mean annual temperature of subchannel ground at sites near Inuvik and a revision of the field observation report (Wankiewicz, 1981) for publication in the NHRI research paper series. In total, the papers define the composite channel and subchannel hydrothermal flow systems of seasonal Arctic rivers.

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Wankiewicz, A. Hydrothermal processes in Arctic river taliks. Submitted for publication to Water Resources Research.

Wankiewicz, A. Characteristics of river-ice overflows of seasonal Arctic rivers near Inuvik, NWT. Submitted for approval to publish.

Wankiewicz, A. Channel freezing and winter overflow of seasonal Arctic rivers. Submitted for approval to publish.

Summary of Activities and Progress in 1982

Study No. SI 79-3

Ice Core - Climate Change Study

G. Holdsworth

(1) The 103 m Mt. Logan ice core which covers an estimated 500 years is processed to 1900 AD. The oxygen isotope variations at seasonal wavelengths are locked in and long term trends agree with station temperature trends except at certain intervals. This requires further measurements of Deuterium/Hydrogen for clarification.

The total n-activity of the upper 26 m (1951-1980) gives an excellent correlation with the record of air sampling from Whitehorse and Kodiak.

Carbon dioxide and total gas content of deep (96-101 m) core has been measured at the Laboratoire de Glaciologie, CNRS, Grenoble. The air in the bubbles is younger than the age of the ice which is about 410-488 years. The firn/ice transition is at 70 m or 180 years, therefore air as young as 230-308 years may be included.

Chemical analyses carried out at CNRS, Grenoble establish the snow to the purest the laboratory has analyzed so far. The following ions were measured: Na^+, NH^+_4, H^+, NO^-_3, SO_4^{2-}, CL^-.

The temperature profile in the borehole establishes a low value of geothermal gradient, as expected for a high mountain block.

(2) Ice core reconnaissance sites at the Flint Ice Fields (NWT) and Eclipse (near Mt. Logan, Y.T.) established that of the two, Eclipse (3000 m) is superior. The Flint ice fields are tempered ice and there is no seasonal signature in the oxygen isotope profile. At Eclipse there is a seasonal signature in the oxygen isotope profile; the temperature of -6°C and accumulation rate R 1.2 m. water equivalent and depth of 500 m requires the use of a thermal ice corer.

(3) An electrothermal core drill is currently being constructed for use in warm deep ice. The unit is compatible with the entire drill rig used for the electro-mechanical drill which can be used in the upper section of the firn.

Reports

Holdsworth, G. 1982. Glaciological reconnaissance of Mt. Edziza and Tellot Glacier Col, British Columbia. Internal NHRI Report 22 p.

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Summary of Activities and Progress in 1982

Study No. SI 80-2

Ice Regime of Lower Mackenzie River and Mackenzie Delta

A.C.D. Terroux

During the third year of a five year study to examine the ice regime of the lower Mackenzie River and Mackenzie Delta, emphasis was again placed on ice break-up observations. Ice thickness and winter ice levels were recorded in April for several Delta locations. The progress of break-up was studied during May and early June from Norman Wells to the Beaufort Sea using vertical aerial photography and oblique 35 mm photography, using transects established in previous study years. Water level changes were monitored using standard levelling techniques at a number of river and delta sites and water temperatures were measured subsequent to ice clearance. Because of record or near record water levels throughout the delta during break-up, extensive photography of backwater flooding was obtained.

Late season water temperatures were monitored using recording submersible thermographs at Inuvik, Arctic Red River and Fort Macpherson during October until freeze-up occurred.

The absence of warm water from the Liard River during the 1982 spring break-up resulted in broken ice filling the Mackenzie River for distances of over 400 km culminating in the series of densely packed ice jams below Point Separation which produced record or near record levels at Arctic Red River and later at Aklavik and Inuvik. Preliminary estimates suggest that over 95% of the delta experienced ice-related flood conditions.

One report "Ice Regime of the Lower Mackenzie River and Mackenzie Delta" was completed, submitted to the Mackenzie River Basin Committee and subsequently published as Chapter 4 of the Mackenzie River Basin Study Report Supplement 3, Spring Breakup. A further report covering spring break-up studies in 1981 and 1982 is being prepared.

Summary of Activities and Progress in 1982

Study No. GW 82-1

Induced Polarization - Quantitative Application to Chemically Contaminated Ground Water

H.M. Elliott

Induced polarization (IP) data were collected in May, July and August during thirty-four Schlumberger array resistivity soundings performed to acquire bedrock depths for the Gloucester waste disposal site study (GW 81-2). The utilization of the IP data for determining the location and extent of contamination plumes originating at the waste disposal site is under investigation.

Some literature study has been done but more will have to be undertaken before an acceptable interpretation method can be identified and the necessary interpretation aids acquired.

Summary of Activities and Progress in 1982

Study No. HR 76-2

Investigation of Ground Water Flow in the Pine Point Region

K.U. Weyer

The field work has been terminated. The three gauging stations have been retrieved from the field. The gauging stations may be operated in future by an operational group. A decision on the matter is pending.

During 1982 borehole logs of 1501 mineral exploration holes and 64 oilwells have been collected from public files and evaluated for hydrogeologic and geologic parameters by means of a newly developed computer data and retrieval system and a series of programs.

The first draft of a final report was in preparation at the end of the calendar year.

References

Weyer, K.U., 1981. Hydrogeology, In: Open Pit dewatering at Pine Point by K.J. Durston. Mine Drainage, Proceedings of the first International Mine Drainage Symposium (2nd. edition), p. 275-303.

Weyer, K.U., 1983. Salt dissolution, karst geology, glacial events and ground water flow in the Pine Point region, N.W.T. (in preparation).

Weyer, K.U. and Horwood-Brown, W.C., 1982. Data report for microbiological study at Pine Point, N.W.T. 26 pages.

Summary of Activities and Progress in 1982

Study No. SI 80-6

Investigation of Utility of X and L Band Synthetic Aperture Radar (SAR) for Mapping Snow Conditions

E.J. Langham

This study has been terminated due to the resignation of the study leader.

Summary of Activities and Progress in 1982

Study No. SI 80-1

Lake Regimes, Mackenzie Delta, NWT

S.C. Bigras

The Lake Regimes Study, Mackenzie Delta, NWT is in its third year of a proposed five year plan. It began initially in 1980 and was designed to develop an understanding of the hydrological regimes of the Mackenzie Delta Lakes. It is hoped that the knowledge gained through this study may aid in determining the hydrological regimes of a variety of lakes in the Mackenzie Delta under current Mackenzie River flow conditions, which in turn will aid in identifying any potentially hazardous environmental impacts as a result of increased flow regulation upon the Mackenzie Delta.

Through the use of 16 mm time lapse photography, NHRI has been monitoring water levels at six sites (Area 8 - 68°43'N:134°15'W and Area 2 - 67°56'N:134°07'W; both areas consist of a channel site, a connected lake site and an unconnected lake site) along the eastern sector of the Mackenzie Delta from April to September.

Using a similar camera system and level set-up, B.C. Hydro has been monitoring water levels at nine sites along the western sector of the Delta. Cooperation between B.C. Hydro and NHRI has been established to exchange water level data in order to obtain as complete an understanding as possible of the Delta's hydrological regime.

Along with the hydrological data, climatological data (precipitation, air/water temperatures, wind direction and velocity) were collected at NHRI's two Delta study areas.

As part of the 1982 field season an investigation of water quality characteristics was initiated at ten Study Areas throughout the Delta. Ice core/water samples of a variety of lakes and channels were taken prior to (April-May) and after break-up (June), and later on at low water levels in September. This information is intended to provide some indication as to whether or not the Delta is a pulse stabilizing system.

This fall another three water level monitoring sites (Area 4 - 68°19'N:134°33'W; consisting of a channel site, a connected lake site and an unconnected lake site) were established just southwest of Inuvik. This brings the total number of NHRI water level monitoring sites operating in the Mackenzie Delta to nine for the Spring of 1983.

Abstraction and analysis of the 1982 data are progressing, and a report of the 1981 results is to be prepared by March, 1983.

Summary of Activities and Progress in 1982

Study No. GW 80-5

LRTAP Related Ground Water Studies - Turkey Lakes

D. Craig, H.M. Elliott

The objective of the 1982-83 season was to carry out a sampling program to determine the role of ground water in modifying the effects of acid precipitation. To this end several projects were undertaken including geophysical surveys, piezometer installation, seepage meter installation, sampling and analysis of ground water from piezometers, seeps and seepage meters, analysis of soil samples, and the estimation of the ground water component of streamflow using stable isotope techniques.

Geophysical field work was conducted by H. Elliott for two weeks from May 8-18 during which time thirty resistivity and induced polarization soundings utilizing the Schlumberger array were executed. All the soundings have been interpreted and six profiles assembled and rough drafted. The profiles showed overburden thicknesses ranging from non-existent to more than sixty metres. The deepest profile also showed induced polarization values for the bedrock that were anomalously high, as much as four times the background level. A report describing results of geophysical field work prior to 1982 is complete and results of the 1982 survey are pending.

The collection of ground water samples continued from wells installed prior to March 1982. Temperature, pH, redox potential (mV), specific conductance and dissolved oxygen were measured in the field. Laboratory analyses of the major ions (Ca, Mg, K, Na, SO_4, Cl, total alkalinity, silica, pH, conductivity) are complete, and results for trace metals (Fe, Al, Zn, Cu, Mg, Cd, Pb, Mn, Co, Sr) are pending. Data available indicate trends of increasing pH, HCO_3, Ca^{2+} and Mg^{2+} with depth. Ground water chemistries appear to vary significantly with location in the watershed, probably reflecting spatial variation in overburden.

Sediment samples collected during the March 1982 drilling program were analyzed for grain size and carbonate content. The tills display large variations in mean grain size, frequency distribution and degree of dispersion and asymmetry. Carbonate content varies between approximately 0.3% to 1.5% and appears to increase with depth in the overburden.

Further drilling, sediment sampling and piezometer installation was completed in November 1982. There is now a total of 48 separate wells with 60 sampling points installed in 8 areas of the watershed. Seepage meters were installed in Big Turkey and Batchawana Lake during summer 1982. This work concludes the major field installations.

Stable isotope (O^{18}, H^{2}) samples were collected during spring melt at three points to enable fractionation of the Norburg creek hydrograph. A similar set of samples was collected during and after a precipitation event (fall 1982). Results of these sample sets are pending, but results of previous spring runoff samples (1981) indicate approximately 70% of stream flow was generated by ground water discharge.

Summary of Activities and Progress in 1982

Study No. SI 79-2

Mechanical Properties of Ice and Permafrost

S.J. Jones

Work has continued throughout the year on three projects and a fourth project started.

1. The effect of grain size on the compressive strength of polycrystalline ice. Testing was completed and a paper presented at the Applied Glaciology Symposium in Hanover, N.H. in August 1982.

2. Mechanical behaviour of frozen sand and permafrost. This work has continued in cooperation with the Division of Building Research of the National Research Council of Canada. The testing program is almost complete and a paper will be presented at the 4th International Conference on Permafrost, Fairbanks, Alaska, July 1983.

3. A study of the long term strength, or creep, of polycrystalline ice (under triaxial conditions) continued. A preliminary report was presented at the Physics and Chemistry of Ice Symposium in Rolla, Mo., in July 1982. Further experiments are planned at different temperatures.

4. The new project was a field trip to McMurdo Sound, Antarctica, carried out at the invitation of the Institute of Ocean Sciences, Victoria, B.C. Sea ice cores were obtained from 12 places in the Sound and one core was studied in the field by taking thin sections along its length. A marked change in the type of ice growth was found at a depth of 1.4 m, from columnar ice above, to platelet ice below the transition. Further work will be carried out when cores are returned to Ottawa.

Summary of Activities and Progress in 1982

Study No. GWO 81-2

Milk River Channel Losses

G. Grove

The ground water related work on this study during the past year has basically been the compilation and analysis of data collected during the 1981-82 fiscal year. A field program was planned for the summer of 1982 but was postponed when budgeting problems could not be resolved before it was too late to conduct the field work. However, during the summer, water level recorders were installed on the wells and water level measurements were taken in the piezometers installed the previous year.

A preliminary analysis of the data from the site at the Highway 880 crossing of the Milk River would seem to indicate that the bedrock surface slopes from the river into the buried bedrock valley which is indicated approximately 2.4 - 3.2 km (1.5 - 2 mi) North of this site on the bedrock topography map (Westgate, 1968). Gravel and coarse sand layers from 8.4 - 10.7 m (27.5 - 35.1 ft) and from 12.7 - 17.4 m (41.7 - 57.1 ft) were intersected in hole C3 near the base of the bluff. Because the sand and gravel layers in borehole C6, 16.8 m (55.2 ft) south of C3 were not as well developed and because the response in borehole C6 during a pump test of borehole C3 was poor it is probable that the sand and gravel layers in C3 have been truncated immediately to the south of well C3 by post glacial erosion in the Milk River valley at this site. A piezometer in borehole C5 which was set from 8.43 - 9.95 m (27.7 - 32.6 ft) in the shallower sand and gravel layer was pumped dry after approximately 4 hours of pumping. This would indicate that there is a good hydraulic connection between the upper and lower sand and gravel layers at this site. A good response was also obtained in a piezometer in borehole C4 across the road approximately 31 m (102 ft) from the pumped well. An analytical interpretation of the pump test data remains to be done.

The testholes at site B approximately 3 km (2 mi) downstream from the end of Pakowki Coulee and site C near the end of Pakowki Coulee indicated that Recent fine-grained sediments in excess of 45 m (147.6 ft) thick exist within the channels at these sites.

Considerable work remains to be done on the interpretation of the geologic conditions at the three sites along the Milk River. No attempt has yet been made to correlate the geologic logs at each of the sites, to interpret the geologic conditions at the sites or to relate these conditions to the regional geologic setting. From a quick examination of the geologic logs it would appear that development of a detailed geologic interpretation of the sites will be difficult. A problem during drilling was to determine where the contact occurred between the unconsolidated fine-grained sands, silts and clays and the

Cretaceous siltstones and shales. The Cretaceous sediments in this area are almost indistinguishable from the Quaternary and Recent sediments particularly when the bedrock has been weathered or has been reworked by glacial ice. On some of the logs it seems that intervals of shale are underlain by unconsolidated sediments. Either reinterpretation of the logs is necessary or it is possible that slumping of large blocks of bedrock materials from the nearby uplands onto the floodplains may have occurred. Furthermore, although the water levels collected this summer from the wells and piezometers are not yet available, the plotting and analysis of these data should provide the most direct evidence on the ground water conditions at the three sites.

Westgate, J.A., 1968. Surficial geology of the Foremost-Cypress Hills area, Alberta; Alberta Research Council Bull. 22.

Summary of Activities and Progress in 1982

Study No. SW 82-6

New Approaches to Ice Thickness Measurement

H. Gross

1) A new form of time domain reflectometry (TDR) probe will be installed this winter in the Ottawa River to measure ice thickness and formation, over a range of 8 cm to 1 metre.

2) In conjunction with the ice TDR probe, a resistivity electrode will be used to give an alternate means of ice thickness measurement at the same location. Both systems are mounted on the same body.

3) The probes are constructed of inexpensive readily available materials, allowing for large arrays with no requirement for recovery or ice breakup.

4) Other TDR probes are on site for ground frost and snow measurement over the winter.

5) Techniques for in situ studies of ice formation will be investigated to see if any practical sensor can be built.

Summary of Activities and Progress in 1982

Study No. SI 80-8

Nimbus-7 Scanning Multichannel Microwave Radiometer Snow Experiment

E.J. Langham

Although this experiment was carried out over the Souris River basin in March 1982, the resignation of the study leader has resulted in its termination as an NHRI study. Data analysis is continuing under AES supervision.

Summary of Activities and Progress in 1982

Study No. HR 74-2

Northern Ground Water and Engineering Problems

R.O. van Everdingen

The "filling-time" counter installed at the Takhini Hot Spring, Yukon, in November 1981, is performing according to expectations.

Field measurements were carried out and water samples were collected for chemical and isotope (^{2}H, ^{3}H, ^{18}O and ^{34}S) analyses, in a number of ground water discharge areas along the Dempster Highway between Klondike Crossing and Fort McPherson. Points of interest were selected for the Yukon - Mackenzie field trip of the Fourth International Conference on Permafrost, and descriptions prepared for the field trip guidebook.

Recent reconstruction of the Alaska Highway crossing of Burlap Creek (km 1817.5) may affect icing activity and ground movement at this site. For this reason, three time-lapse cameras, ice-level gauges and shallow piezometers were installed in the Burlap Creek icing area. A section across the icing area was surveyed to enable monitoring of ground movements during the 1982/83 winter.

Publications

Krouse, H.R., M.A. Shakur, R.O. van Everdingen, and M.P. Cecile, 1982. $\delta^{34}S$ and $\delta^{18}O$ variations in terrestrial sulfates (Abstract). Fifth International Conference on Geochronology, Cosmochronology, Isotope Geology, Nikko National Park, Japan, p. 193-194.

Michel, F.A., R.O. van Everdingen, and W.H. Pollard. Isotope geochemistry of frost-blister ice from a spring site near North Fork Pass, Yukon. Submitted to: Canadian Journal of Earth Sciences.

van Everdingen, R.O. 1982. Frost blisters of the Bear Rock spring area near Fort Norman, N.W.T. Arctic, vol. 35(2), p. 243-265.

van Everdingen, R.O. 1982. Management of groundwater discharge for the solution of icing problems in the Yukon. In: The Roger J.E. Brosh Memorial Volume (H.M. French, Ed.), Proceedings, Fourth Canadian Permafrost Conference, National Research Council of Canada, Ottawa, p. 212-226.

van Everdingen, R.O., and H.D. Allen. Ground movements and dendrogeomorphology in a small icing area on the Alaska Highway. Submitted for presentation at Fourth International Conference on Permafrost, Fairbanks, Alaska, 1983.

van Everdingen, R.O., M.A. Shakur, and H.R. Krouse, 1982. $\delta^{34}S$ and $\delta^{18}O$ abundances differentiate Upper Cambrian and Lower Devonian gypsum-bearing units, District of Mackenzie, N.W.T. - An update. Canadian Journal of Earth Sciences, vol. 19(6), p. 1246-1254.

van Everdingen, R.O., M.A. Shakur, and H.R. Krouse, 1982. Isotope geochemistry of dissolved, precipitated, airborne and fallout sulfur species associated with springs near Paige Mountain, Norman Range, N.W.T. Canadian Journal of Earth Sciences, vol. 19(7), p. 1395-1407.

Summary of Activities and Progress in 1982

Study No. GWO 82-1

Operational Ground Water

G. Grove

Since the beginning of fiscal year 1982-83, the Operational Ground Water Section (OGWS) has been involved with assessing the technical soundness of the investigations and conclusions pertaining to ground water in documents submitted by proponents for mining, oil and gas and other civil engineering developments and by proponents seeking funding for unsolicited proposals.

OGWS provides operational ground water advice and assistance to the IWD Regions and also provides a coordinated review of the ground water related components of environmental assessments for projects such as uranium mining developments, uranium and metal tailings disposal, hazardous waste dumps on behalf of the IWD Regions and EPS. The work pertains to interprovincial, international and territorial waters and to other developments which are of direct concern to the federal government.

A tabulation of the work is as follows:

Reviews:	Mine related	8
	Land fill/waste disposal	7
	Other hydrogeology	6
Investigations:	Mine related	1
Technical assistance:	Computerization	2
N.B. 3 are ongoing of Total		24

Major input was made into the following projects:

Canada Tungsten Mine tailings disposal - Tungsten, NWT (for EPS)
Winter River Basin Water Supply project - PEI (for IWD)
Waste disposal sites affecting Canadian waters near Niagara Falls, NY, (for EPS)
Esso Minerals Midwest Lake uranium project (for IWD)
In situ oil sands, heavy crude oil and enhanced recovery waste disposal (for EPS)

Summary of Activities and Progress in 1982

Study No. GWO 81-4

Pesticide Contamination in Ground Water, Okanagan Valley, B.C.

H.M. Liebscher

The west bank of Osoyoos Lake has been extensively used for agriculture following the development of an irrigation system in the 1920's. This side of the lake is unique in that ground water recharge occurs primarily during summer months whereas the nonirrigated undeveloped east bank experiences recharge during winter months.

Pesticides and fertilizers have been extensively used on the agricultural land and concern has been expressed for ground water nutrient and pesticide discharge into surface water bodies and for potential deterioration of local ground water supplies.

Ground water-surface water interflow measurements have been made at various locations on the Canadian side of the lake using mini piezometers and seepage meters developed by Lee (1977). Ground water flow is highly variable due to local geology, local irrigation practices, season, lake bottom sediments and other variables. Insufficient data are available to calculate ground water discharge into the lake. Additional measurements will be taken during different seasons in an attempt to quantify ground water flow.

Ground water samples have been collected using minipiezometers below the shoreline to determine nutrient and pesticide content. Nutrient samples were collected from slotted polyethylene tubing, using a peristaltic pump and generator. The table shows results of the October 1982 nutrient sampling program.

One pesticide sample was collected on the western shoreline using a screened teflon piezometer, resin, teflon-stainless steel resin cannister, peristaltic pump and generator. Fourteen litres of ground water were pumped through the resin in less than 15 hours. Concern is expressed that some lake water entered the resin due to overpumping. Pumping was restricted or terminated when ground water pH and temperature started to shift towards lake water pH and temperature. Additional safeguards will be used in future sampling. Results of ground water pesticide analysis show traces (ppt) of Botran (dichloran), 2,4-D, and pentachlorophenol. Pesticides which have been extensively used in the area but were undetected in the analysis include DDT, other organochlorides and a number of organophosphorous compounds. Additional pesticide analyses will be made on the resin in the near future by the Water Quality Branch laboratories, IWD, Pacific and Yukon Region.

Work to date includes geological correlations of well records, surficial mapping along shorelines, reviewing land use, pesticide and fertilizer use.

Additional work plans include seasonal flow and chemical monitoring along the shoreline.

In part this study enjoys joint cooperation with other agencies including NWRI (nutrient discharge, flow rates and geological setting); and Water Quality Branch (ground water pesticide chemistry, nutrients and flow rates). Other agencies showing interest in the project include Agriculture Canada, Water Planning and Management Branch, IWD and B.C. Ministry of Environment.

TABLE 1

Osoyoos Lake - Nutrient Sampling - October 1982

Sample number	Distance from shoreline m	Water Depth cm	Piezometer depth in sediments cm	Geology of Sediments	Ground Water Temp. oC	Lake Water Temp. oC	Ground Water pH	Lake Water pH	Soluble Reactive Phosphorous ppm	Total Dissolved Phosphorous ppm	Nitrate and Nitrite (N) ppm	Nitrite (N) ppm	Ammonium (N) ppm	Total Dissolved Nitrogen ppm	Specific Conductance $\mu S/cm$	Land Use
OS-1	4.4	45	76.5	2 cm mud sands & gravels	14	12	6.65	7.10	0.025	0.022	9.35	0.005	<0.002	10.2	656	orchard urban
OS-2	3.7	26	67.6	3 cm mud med. sand	12	11	8.25	8.75	0.060	0.058	0.011	<0.002	0.45	0.652	502	orchards urban
OS-3	3.0	32	58.7	med. sand	12	10.5	7.45	7.90	0.065	0.062	0.005	<0.002	0.463	0.610	816	primar. orchards urban
OS-4	3.7	30	52.6	4 cm mud fine sand interbedded with clays	13	11	6.85	7.40	0.002	0.265	0.015	<0.002	18	21.5	1097	
OS-5	3.7	26	76.0	fine sand	13	11	7.15	7.55	0.003	0.101	0.007	<0.002	1.41	1.77	542	campsite orchards
OS-6	3.18	25.3	46.1	dirty fine to med. sand	12.5	11.5	7.15	7.85	0.018	0.022	0.004	<0.002	0.021	0.145	586	orchards campsite
OS-7	3.2	23.5	32.8	fine sand & gravel	11	10	*7.65	7.35	0.200	0.150	0.004	<0.002	0.384	0.695	376	orchards grassland marshy
OS-8	3.2	23.5	22.8	fine sand & gravel	11	10	*6.85	7.35	0.009	0.019	<0.002	<0.002	0.938	1.18	407	same hole as OS-7
OS-9	3.2	23.5	40.6	fine sand & gravel	11.5	10	*6.80	7.35	0.146	0.149	0.008	0.002	0.161	0.745	575	1 m south OS-7&OS-8
OS-10	lake water					10		7.35	0.002	0.006	0.015	<0.002	0.004	0.200	267	lake water

*H_2S odor in ground water samples OS-7, OS-8, and OS-9

Summary of Activities and Progress in 1982

Study No. SI 67-4

Peyto/Yoho Glacier Hydrology

J.M. Power

During the summer of 1982 three Ottawa University undergraduate students were employed on contract to collect mass balance data at Peyto Glacier, Alberta and streamflow, meteorological and hydrochemical data at Peyto Glacier and in the adjacent Kicking Horse River basin in British Columbia.

As part of the mass balance program, ice ablation and snow and firn accumulation and abalation were measured at various stake locations, snow pits were dug and snow density profiles taken, and locations of the stakes were surveyed. Streamflow was recorded at a point below the glacier tongue and at three locations within the upper Kicking Horse River basin. A paper given at the High Mountain Symposium at Exeter in July 1982 (IAHS Publ. No. 138) derives the proportions of total runoff from glacier ice and firn, seasonal snow-packs and summer precipitaion based on the 1967 to 1974 records. The movement of the transient snowline up glacier is seen to be a prime factor influencing basin response time and the proportion of ice and firn melt to total flow.

Standard meteorological variables were measured at Peyto base camp on a moraine near the tongue of the glacier. In addition, rainfall was measured in the upper Kicking Horse River basin to help determine timing of precipitation events in the basin. A paper published in Water Resources Research describes a net shortwave radiation model which can be used to map radiation distribution, under clear and cloudy skies, over the basin. A minimum of observational inputs is required, including: topographic map data, monitoring of the snowline and routine weather observations. A paper published in the Journal of Climatology demonstrated the degree of control exercised by synoptic-scale meteorological conditions on the development and characteristics of a katabatic layer above a melting glacier. Under anticyclonic conditions a well developed katabatic layer was often observed with a wind velocity maximum below 5 m.

A hydrochemical program was undertaken by Dr. D.N. Collins of Manchester Unviversity with the aim of separating out components of flow in rivers which arise fom differing sources at varying elevations during the hydrological year. Along with discharge, electrical conductivity and pH were recorded at Amiskwi River, the Kicking Horse River at Cathedral Mountain, Twin Falls Creek and Peyto Creek. The structure, behaviour and functioning of the internal drianage system of Peyto Glacier was examined indirectly using an additional site for conductivity monitoring, suspended sediment concentration in meltwaters at the snout, fluorimetric

dye-tracer tests and by collecting samples of water for chemical determinations. A paper published in Beilraege Zur Geologie der Schwerz-Hydrologie based on dye-tracer shows that transit times for tracer flow-through decreased markedly with increasing discharge. Average flow-through velocity ranged from 0.13 - 0.35 m s^{-1} showing a strong dependence on discharge. A paper published in Nordic Hydrology showed that snow- and ice-melt have contrasting roles in determining distinctive patterns of diurnal and seasonal temperal variations of discharge and hydrochemistry in mountain basins.

^{1} showing a strong dependence on discharge

Summary of Activities and Progress in 1982

Study No. SI 79-1

Photogrammetric Applications to Glacier Research and Water Supply from Glacierized Basins

Keith C. Arnold

A report on the application of photogrammetric techniques to the determination of mass balance for an Arctic glacier was published jointly with McGill University. Plans to do further experiments on temperate, alpine glaciers have been cancelled and this project terminated.

Arnold, K.C., 1982. Ice ablation measured by stakes and terrestrial photogrammetry - a comparison on the lower part of the White Glacier, Axel Heiberg Island, Canadian Arctic Archipelago.

Axel Heiberg Island Research Reports, Glaciology No. 2, McGill University, Montreal, Quebec, and NHRI Paper No. 19, National Hydrology Research Institute, Environment Canada, Ottawa, Ontario, 98 pp. + maps.

Summary of Activities and Progress in 1982

Study No. GW 68-8

Potential Evaporation - Significance and Measurement

F.I. Morton

The two papers that will complete this study have been accepted for publication and should appear in the Journal of Hydrology during the first part of 1983.

Summary of Activities and Progress in 1982

Study No. HR 79-7

Relationship Between Mean Daily and Peak Flow

B.P. Sangal

This study has officially ended. The results have been reported in an IWD Technical Bulletin.

Reference

Sangal, B.P. 1981. A Practical Method of Estimating Peak from Mean Daily Flows with Application to Streams in Ontario. NHRI Paper No. 16, IWD Technical Bulletin No. 122, p. 242.

Summary of Activities and Progress in 1982

Study No. HR 78-8

River Basin Moisture Measurement

A. Wankiewicz

This project consists of a sensitivity analysis of natural microwave emission from snow cover. The MIT random scattering model for natural microwave emission had been combined with an NHRI model relating snowpack electromagnetic properties in terms of hydrologic variables. Simulations were performed for an assumed 0.3 metre deep snow cover (density 0.3 gm/cc and grain size 1 mm) over an unfrozen loam soil at field capacity moisture content. Each hydrological variable was then varied individually to determine the sensitivity of passive microwaves emitted by the snowpack to changes in that variable. The preliminary results in the table are for snow cover microwave emission at 37 GHz frequency, vertical polarization and emission angle at 50° from zenith (except where otherwise indicated). For example, when the variable 'dry snow depth' was varied from 0 to 10 metres in value, the simulated microwave brightness temperature was found to decrease from 255 to 35°K, a range of 22°K. Thus passive microwave measurement has a very large sensitivity to dry snow depth. By using several frequencies and polarizations, it should be possible to develop algorithms for measuring the more sensitive variables.

A report on this project is in progress.

Summary of Activities and Progress in 1982

Study No. SW 82-2

River Ice Jams, Mackenzie River Basin, NWT

J.C. Anderson and T.D. Prowse

Observations of breakup on the Liard and Mackenzie Rivers near Fort Simpson, NWT were made during May 1982. The timing and characteristics of break-up were recorded using 35 mm oblique aerial photography; ice thickness was obtained from pans stranded along the shore, surface water temperatures were monitored, and water levels were observed. A report detailing the results of this work has been prepared and submitted to the Water Resources Division, Department of Indian Affairs and Northern Development.

Anderson, J.C., 1982. Liard and Mackenzie River Ice Break-up, Fort Simpson Region, NWT, 1982. NHRI report. 37 pp., 23 Illus.

In June 1982, Terry D. Prowse joined the Northern Hydrology Secton of NHRI and assumed responsibility for this project. Progression of the 1982 freeze-up was monitored from light aircraft along portions of the Liard River and on the Mackenzie River from Fort Providence to the Mackenzie Delta. Field reconnaissance was also made of potential jam sites, especially in the region near Fort Simpson, N.W.T.

A number of techniques for measuring ice jam characteristics and processes are being devised and appropriate equipment assembled for the 1983 spring field study. In particular, a 35 mm aerial camera system, which will allow inexpensive, repetitive photography of ice jam sites, is currently under construction. A 'false parallax' technique of photo interpretation is also being refined in order to measure river velocities during break-up.

Other techniques and equipment under review focus on the measurement of ice jam water levels, ice thickness and the energy balance leading to the deterioration of river ice prior to break-up.

Summary of Activities and Progress in 1982

Study No. SI 80-9

Runoff Estimation - Sentinel Glacier, B.C.

S. Fogarasi

In cooperation with the Computing and Applied Statistics Directorate, ARIMA Model was tried to show some of the relationships existing between runoff and melting degree days.

In the present phase of this study the feasibility of the ARIMA Model was evaluated. So far it has been found that the melting degree day variable is sufficient as a predictor during stable weather conditions. Under variable weather spells, however, the energy budget is expected to be a better predictor than melting degree days alone.

These results were presented at the Canadian Association of Geographers Annual Congress, University of Ottawa, June 2, 1982. A co-authorship was my own contribution beside P. Cohen and O. Mokievsky-Zubok. The full title of the paper was "Assessment of the ARIMA Model in Forecasting Runoff from Sentinel Glacier, B.C.".

Summary of Activities and Progress in 1982

Study No. SI 79-5

Simulation of Alpine Runoff

J.M. Power

In preparation for modelling of the Kicking Horse River basin, data from two local climate stations were acquired and tranformed into a format compatible with the UBC Watershed Model. Water level charts for the Amiskwi, Kicking Horse at Cathedral and Twins Falls Creek sites for the period 1977-1982 were digitized, stage-discharge curves produced, and streamflow data transferred onto computer files. An updated version of the UBC Watershed Model requiring considerably less computer stage was acquired and converted for use on the CDC computer system.

Summary of Activities and Progress in 1982

Study No. SI 67-15

Snow and Ice Information and Data Systems

C. Simon L. Ommanney and John W. Clarkson

With support made available through the Federal Government's Summer Canada programme, the glacier inventory of the Stikine River basin was undertaken in 1982. At year's end, some 6,500 glaciers had been inventoried and the data obtained from the maps and aerial photographs keypunched; this included data compiled in 1981 for the Iskut River basin. The data set is the standard Canada glacier inventory one with the addition of the area of ice cover within 100 m elevation bands for each glacier. Work continues on the five remaining basins in the Iskut River basin and four in the Stikine for which resource materials still have to be obtained. The basin designations are based on those of the Water Survey of Canada. The number of glaciers within each basin are listed below.

CAA	72	CBC	26	CCD	54	CEF	195	CFF	40	CFM	173	CGG	399
CAB	-	CBD	82	CDA	6	CEG	177	CFG	165	CGA	-	CGH	418
CAC	144	CBE	2	CEA	88	CFA	-	CFH	177	CGB	-	CGI	509
CAD	483	CBF	74	CEB	15	CFB	-	CFI	215	CGC	-	CGJ	337
CAE	9	CCA	83	CEC	28	CFC	27	CFJ	49	CGD	115	CGK	293
CBA	151	CCB	300	CED	17	CFD	68	CFK	87	CGE	68	CGL	-
CBB	-	CCC	800	CEE	174	CFE	34	CFL	60	CGF	350	CGM	-

The Computer and Applied Statistics Directorate continued to grapple with the problem of providing area elevation data from previously digitized data. Apart from the technical difficulties of interpolation there are added complications due to spiking and poor quality in the original "blind digitized" data.

Bibliographies on Ellesmere Island glaciers and ice shelves and on ice islands in the Arctic Ocean were published as were three issues of ICE. Changing priorities during the year meant that bibliograhies of Canadian glaciology for 1976 and 1977 could not be completed.

A major effort was made to provide the various provincial and federal agencies with information on, and delineations of, their named glaciological features. This work has led to a number of internal reports and is expected to be completed in 1983.

PUBLICATIONS

Canada, Environment Canada, 1982. The Canadian glacier inventory project.

Internal report, National Hydrology Research Institute, Environment Canada, Ottawa, Ontario, September, 45 pp.

Ommanney, C.S.L., 1982. Bibliograhie de la glaciologie canadienne, 1982 - Bibliograhie No. 2/Glaciers et plates-formes de glace de l'ile Ellesmere.

Note No. 9 de l'inventaire des glaciere, Rapports No. 20 de l'INRH, Etude No. 58, série des rapport généraux de la DGEI, Institut national de recherche en hydrologie, Direction général des eaux intérieures, Environnement Canada, Ottawa, Ontario 53 pp.

Ommanney, C.S.L., 1982. Bibliographie de la glaciologie canadienne, 1982 - Bibliographie No. 3/Iles de glace de l'océan Arctique.

Note No. 11 de l'inventaire des glaciers, Rapport No. 21 de l'INRH, Etude No. 73, série des rapport généraux de la DGEI, Institut national de recherche en hydrologie, Direction général des eaux intérieures, Environnement Canada, Ottawa, Ontario, 40 pp.

Ommanney, C.S.L., 1982. Bibliography of Canadian Glaciology, 1982 - Bibliography No. 2/Ellesmere Island glaciers and ice shelves.

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ICE, News Bulletin of the International Glaciological Society, No. 68, 1st Issue, 32 pp.

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Internal report, Glacier Inventory Project, Snow and Ice Division, National Hydrology Research Institute, Ottawa, Ontario, K1A OE7, November, 182 pp.

Ommanney, C.S.L., 1982. Toponymic recognition for glaciologist Fritz Muller.

Canoma, Vol. 8, No. 1, July/juillet, 43-43.

Ommanney, C.S.L., 1982. Generics in use in Canada. Volume I: A-F. Supplement.

Internal report, Advisory Committee on Glaciological and Alpine Nomenclature, Canadian Permanent Committee on Geogrpahical Names, Ottawa, Ontario, October, 58 pp.

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Internal report, Glacier Inventory Project, Snow and Ice Division, National Hydrology Research Institute, Ottawa, Ontario, K1A OE7, December, 326 pp.

Ommanney, C.S.L., 1982. Named glaciers in Canada: map sheets 26I/2, 26I/3, 26I/4, 26I/5, 26I/6, 26I/7, 26I/8, 26I/9 and 26I/10. Report to the Department of Indian and Northern Affairs, Parks Canada, the Geographical Names Secretariat and the Advisory Committee on Glaciological and Alpine Nomenclature.

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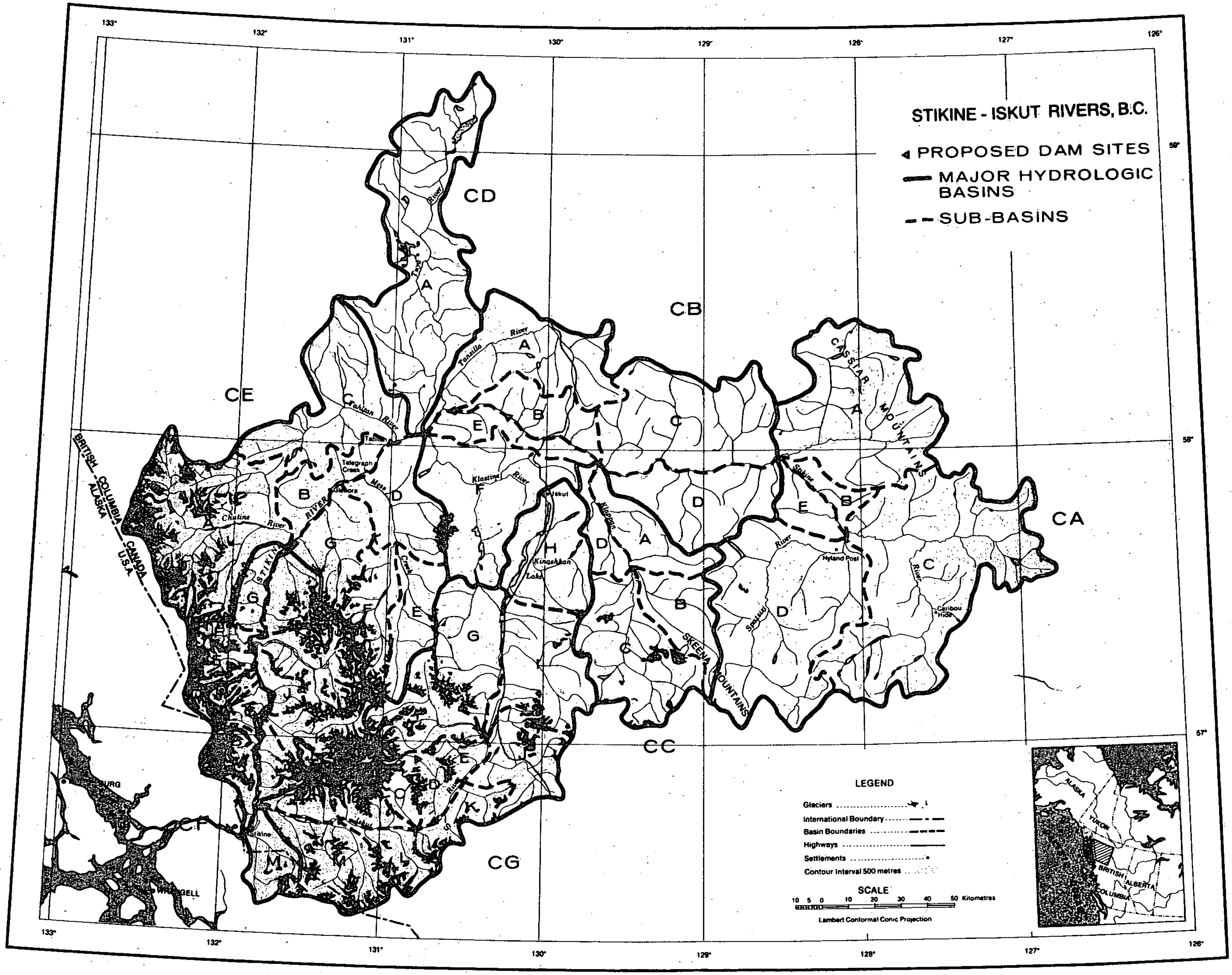
STIKINE - ISKUT RIVERS, B.C.
PROPOSED DAM SITES
MAJOR HYDROLOGIC BASINS
SUB-BASINS
CA
CB
CC
CD
CE
CF
CG
CASSIAR MOUNTAINS
SKEENA MOUNTAINS
STIKINE RIVER
Tahltan River
Tanzilla River
Klastine River
Klappan River
Chutine River
Spatsizi
Stikine
Tahltan
Telegraph Creek
Iskut
Kinaskan Lake
Hyland Post
Caribou Hide
BRITISH COLUMBIA
ALASKA
CANADA
U.S.A.
WRANGELL
LEGEND
Glaciers
International Boundary
Basin Boundaries
Highways
Settlements
Contour Interval 500 metres
SCALE
10 5 0 10 20 30 40 50 Kilometres
Lambert Conformal Conic Projection
YUKON
BRITISH COLUMBIA
ALBERTA
133°
132°
131°
130°
129°
128°
127°
126°
59°
58°
57°

Summary of Activities and Progress in 1982

Study No. HR 77-4

Snowmelt Infiltration and Runoff

A. Wankiewicz

This study is based on a set of winter ground temperature profiles and isotherm maps measured at a Perch Lake forest site near Chalk River, Ontario. The data show the microclimatic effects on winter soil temperature and hence on infiltration of snowmelt due to microtopography and vegetation at the forest floor and in a stream discharge area.

Because of the effort required to complete the analysis and prepare publications for the higher priority permafrost streamflow interaction study (HR 75-5), no progress was made on HR 77-4 in 1982-83. The results of the project are on file and will be published when time permits.

Summary of Activities and Progress in 1982

Study No. SW 81-4

Snow Moisture Measurement, Alternative Methods

H. Gross

Investigation of a number of proposed alternative techniques indicated that none would be suitable from a practical viewpoint. No construction of prototypes will be undertaken. This study has been terminated.

Summary of Activities and Progress in 1982

Study No. SW 81-5

Snow Pack Structure, Alternative Methods

H. Gross

Investigation of a number of proposed alternative techniques indicated that none would be suitable from a practical viewpoint. No construction of prototypes will be undertaken. This study has been terminated.

Summary of Activities and Progress in 1982

Study No. HR 77-3

Stochastic Rainfall-Runoff Relations

V. Klemes

Implicit in many stochastic rainfall-runoff models is the assumption that the time-averaging of the variables over progressively longer intervals reduces the degree of nonlinearity in their relationship thus justifying the use of linear theory (correlation techniques) in the analysis. To verify the above assumption, extensive simulation experiments have been carried out involving a lognormal uncorrelated input routed through a physical system represented by a single nonlinear reservoir as well as a series of nonlinear reservoirs. The sample size of the input series was n=8000 and the averaging of all the three variables involved (input, instantaneous storage, and output) was done for i = 5, 10, 20, 40 and 80 time units thus providing subsamples of sizes m = 1600, 800, 400, 200 and 100, respectively.

Contrary to the above mentioned assumption, the increase of the averaging interval did not reduce or otherwise change the original system nonlinearity expressed by the underlying relationship $y_j = as_j^b$ (where y is system output, s is system storage, a and b are positive constants, and j = 1, 2, ..., 8000).

For a series of k equals nonlinear reservoirs of the type indicated above, the relationship between average output over an interval of length i, $\bar{y}_i = \frac{1}{j} \sum_{j=1}^{i} y_j$ and total average storage $\bar{s}_i = \frac{1}{j} \sum_{j=1}^{i} \sum_{h=1}^{k} s_{jh}$ seemed to converge to $y_i = (s_i/k)^b$. This was a rather unexpected result which, if confirmed, would mean that for every conceptual distributed system composed of nonlinear storage elements there is a time interval i for which the system can be lumped and modelled by one storage element equal to a simple sum of storages of the underlying time distributed system. This tentative result will be further investigated.

Whether or not the latter result is confirmed, the fact that a nonlinear system does not converge to a linear one by the time-averaging of the process casts a serious doubt on the usefulness of stochastic linear techniques for system structure identification and the goodness-of-fit testing.

Summary of Activities and Progress in 1982

Study No. HR 78-5

Streamflow Forecasts Based on Basin Storage

F.I. Morton

The data management and data processing problems involved in producing residual mass curves of six-day net basin input (i.e. precipitation less evapotranspiration) and six-day basin output (i.e. runoff) have been solved so that studies on detecting the differing effects of tension and gravity storage on future runoff events for eight rivers in Ontario and Quebec can now begin.

Summary of Activities and Progress in 1982

Study No. SI 78-4

Thermal Infrared Remote Sensing of the Columbia Icefield

A.C.D. Terroux

No significant progress has been achieved on this study during the reporting period.

Summary of Activities and Progress in 1982

Study No. GWO 81-5

Thermal Springs in Rocky Mountain National Parks

R.O. van Everdingen

In early July 1982 the waters of the Miette Hot Springs, Jasper National Park, became heavily contaminated with sediments which forced closure of the swimming facilities. Results of temperature, conductivity and pH measurements suggested that heavy rainfall could be responsible for the problem. Samples of spring water and sediments were collected for chemical, isotope (^{18}O, ^{2}H, ^{3}H, ^{34}S), mineral and grain-size analyses, to aid in identification of both the source of the sediment and the cause of the problem.

Also in early July, air-sampling equipment was set up in the Cave, Banff National Park, to collect samples of airborne sulfur species (H_2S, SO_2, H_2SO_4) and water vapor, as part of an investigation of cave development. Isotope analyses were made on the sulfur species (for ^{18}O and ^{34}S) and on the water vapor (for ^{18}O and ^{2}H).

Reports

Mazor, E., R.O. van Everdingen, and H.R. Krouse. Noble-gas evidence for geothermal activity in karstic terrain - Rocky Mountains, Canada. Submitted to: Geochimica et Cosmochimica Acta.

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van Everdingen, R.O., M.A. Shakur, and H.R. Krouse. Cave development in travertine deposits through corrosion by natural H_2SO_4 fallout - Evidence from sulfur and oxygen isotopes. Submitted for presentation at Fourth International Symposium on Water-Rock Interaction, Misasa, Japan, 1983.

Summary of Activities and Progress in 1982

Study No. SI 79-6

Time Domain Reflectometry Study of Ground Frost and Ground Moisture

H. Gross

Five probes were constructed by R.H. Brancher. Two are installed over the winter at a local site in Ottawa, and one is on loan to the Geography Department at Carleton University.

The mathematical model for data interpretation developed here at NHRI has been extended to include resistivity effects, with some extension to multiple reflections.

An interface device for the field logging unit being built here had been withdrawn from the market by Hewlett-Packard in July of 1982, but is now available and construction of the logger is proceeding and will be available for field use.

Joint testing and model development is being done with D. Patterson of Carleton University and a paper on the lab work will be published.

Summary of Activities and Progress in 1982

Study No. GW 81-2

Toxic Contaminants, Gloucester Landfill

R.E. Jackson, B.W. Graham

The first phase of the study as outlined in the original 1980 proposal has been completed with respect to the hydrogeology (hydrostratigraphy, hydraulic properties and ground water flow direction) and hydrogeochemistry (inorganic and organic ground water quality) of the aquifer underlying the Gloucester landfill.

Due to the provision of additional funds by EPS-WMB and ECS-NHRI, the project was able to continue even without the requested 82/83 funding from TOXFUND (TCMP). The proposed field and lab remedial technology experiments were only superficially investigated because of the reduced funding.

Hydrogeology

The field program is now complete and included:

(1) a geophysical survey by H. Elliott (NHRI) to identify contaminated zones of the aquifer and the bedrock topography;

(2) hydraulic conductivity and ground water velocity testing by D. Belanger of the University of Waterloo;

(3) measurement of water levels in the piezometer network to determine the ground water flow pattern in the water-table and confined aquifers, and therefore to allow an improved prediction of the migration of contaminants at the site.

(4) three holes drilled to bedrock, two on private land at the leading edge of the domestic and special waste plumes.

Geophysical field work undertaken in May, July and August consisted of thirty-four resistivity and induced polarization soundings using the Schlumberger array and one reversed seismic refraction sounding. All of the resistivity soundings have been interpreted and the interpretations have been verified using a master-curve data generating computer program. A program to plot the computer generated data was written, tested and proved to be very worthwhile in handling large numbers of soundings.

Results of the geophysical survey and reinterpretation of sediment cores have been used to develop a three-dimensional hydrostratigraphic map (fence diagram) of the site. This will allow the development of a numerical model of ground water flow and contaminant transport which is being undertaken as a cooperative project with the Department of Applied Earth Sciences, Stanford University.

A series of short-(1 hour) and medium-(12 hour) term pump tests were conducted at the site during August and were complemented by slug tests of piezometers and permeameter tests of split-spoon samples. The pump tests conducted in the lower aquifer which is contaminated by the special-waste leachate suggest aquifer parameters with the following values:--

Transmissivity	= 10^{-2} m^2/s
Storativity	= 1.3 x 10^{-3}
Hydraulic Conductivity*	= 3.1 x 10^{-4} m/s
Ground-Water Velocity≈	= 20 cm/day

* saturated thickness of aquifer = 25 m.
≈ hydraulic gradient = 0.002, porosity = 0.3.

Using this revised ground water velocity it may be computed that organic contaminants will appear in the first well on Delzotto Avenue within four years.

A tracer-dilution device for measuring in situ the velocity of ground water was developed by D. Belanger. It employs a small circulating pump to mix the tracer (a halide salt), a halide-sensing electrode and a packer system to isolate the mixing cell within the borehole. While the system has been proven to work in the laboratory, problems were encountered during the field measurements which suggest that its detection limit is of the order of 10 cm/day. It is planned to continue development of the system next summer.

The expanded piezometer network has permitted improved delineation of the ground water flow pattern of the aquifer system. Significantly it indicates that a linear excavation 10 metres fom the south end of the Special Waste Site has created a window in the low-permeability sediments and allowed the migration of contaminants into the lower aquifer.

Ground Water Quality

A survey of volatile organic contaminants was conducted during the summer by J. Barbash of the University of Waterloo and J. Lockwood of Farrington, Lockwood Co. Ltd. Approximately 50 samples were taken from 20 multilevel sampler installations. The leachate plume in the shallow aquifer originating in the former Gloucester Township Landfill contains ppb quantities of benzene (1-200 µg/L) and toluene (2-17 µg/L). The special-waste plume contains ppb quantities of trichloroethane (570 µg/L) and toluene (3-49 µg/L) at its leading edge (at the CPR tracks near Delzotto Avenue) in the lower aquifer. Furthermore there is evidence of ppm amounts of chloroform, benzene, methylene chloride and dichloroethane beneath the special-waste compound.

Sedimentary organic carbon analyses have been conducted by J. Young of Chalk River Nuclear Labs on samples of aquifer sediment from both the special waste and landfill-leachate plumes. The values vary from 0.13 to 0.45% organic carbon.

An inorganic hydrochemical survey was undertaken at the site to complement the study of organic-contaminant migration. Particular attention was paid to the measurement of redox-active species (i.e. O_2, S^{2-}) which will facilitate understanding of biodegradation reactions. The leading edges of the landfill-leachate and special-waste plumes have pH values in the range of 7.7-8.0 and Eh values in the range 0-50 mV. Dissolved oxygen is absent from these samples, however dissolved sulfide is present at about 10^{-7} M (J. Gulens, AECL, Chalk River pers. comm.).

D. Chaput of l'Universite de Sherbrooke and B. Graham (NHRI) developed a rapid method for preconcentration of heavy metals in the field using cation-exchange resins. Chaput and Jackson (NHRI) investigated the shape of the isotherm describing Cu(II) adsorption on Gloucester aquifer sediments; the isotherm appears linear in the observed range of copper in the ground waters at Gloucester (< 50 µg/L).

Remedial Measures

A Gloucester Working Group has been formed, consisting of EPS and ECS personnel under the chairmanship of D. Cameron, to develop a remedial-measures program for the site. A summary report has been sent to EPS HQ requesting funds for FY 83-84 ($250K) to undertake decontamination of the lower aquifer contaminated by the special-waste plume.

Summary of Activities and Progress in 1982

Study No. SW 81-3

Unification of Storage Models

V. Klemes

The study was completed in 1982 and results published in a paper.

V. Klemes, 1982. The essence of mathematical models of reservoir storage, Canadian Journal of Civil Engineering, 9(4), 624-635, 1982.

Summary of Activities and Progress in 1982

Study No. GWO 81-3

Vancouver Office, Interagency Assistance

H.M. Liebscher

H.M. Liebscher was seconded to Pacific and Yukon Region, IWD office for a one-year period effective April 1, 1982 with the possibility for a 1-year renewal.

Ground water impact assessment reviews carried out during the secondment include assistance to individual requests, reviews for task force committees and assistance to outside agencies. Work has been done for IWD in the region, for other federal agencies and for provincial and local government agencies as well, in cooperation with NHRI's Vancouver Ground Water Section. In addition, assistance is being provided to the Operational Ground Water Division, NHRI in their review of possible hydrogeological research at coal mines in Western Canada.

A. IWD (Pacific & Yukon Region)

1. Review of hydrogeological assessment of proposed Sage Creek Coal site.
2. Review of 5 million gpd sewage effluent spray and drip irrigation system proposal for Southeast Kelowna Irrigation District.
3. Review of subsurface sewage effluent disposal at Westbank, B.C.
4. Review of sewage effluent irrigation proposal near Cranbrook, B.C.
5. Assessment of cause of high copper values (ppm per litre total) in local ground water supply, Langley, B.C.
6. Proposal for a number of ground water investigations which could be carried out in the Liard drainage basin.
7. Review of hydrogeological data at proposed Murphy Creek-Keenleyside Hydro Project.
8. Review of subsurface sewage effluent disposal and ground water development near Vernon, B.C.
9. Review of ground water impact of proposed open pit molybdenum and gold mine near Rossland B.C. (for Water Planning & Management Branch).

Reports have been submitted for all of the above projects, except the Rossland, B.C. study, which is still in progress.

B. Other Federal Agencies

1. EPS request to review hydrogeological reports and assess contaminant ground water plumes at Western Mines, Vancouver Island. Work also included proposing remedial measures to recover contaminant plume and the review of expansion plans which might cause further deterioration of local ground waters. H. Liebscher represented EPS at federal-provincial hearings and is currently reviewing the effectiveness of remedial action. This work continues.

2. EPS request to speculate on subsurface impact of 530,000 IGPD sewage effluent disposal infiltration at I.R. 1, Kelowna, B.C.

3. Fisheries and Oceans request to review potential ground water contamination at proposed fire fighting school in Maple Ridge B.C. Concern was expressed for toxic fire retardants, fuels and retardant residues causing deterioration of ground and surface waters beside salmon enhancement facilities. Reports have been prepared and submitted on the above projects.

4. EPS, F&O and B.C. Ministry of Environment request to review ground water contamination at a former wood preserving plant lying adjacent to the Fraser River. Concern is expressed for subsurface contaminant plumes of creosote, pentachloraphenols and CCA (copper, chromium and arsenic) which are presently discharging into the river.

5. EPS and DINA requests to review ground water development and subsurface sewage effluent disposal at I.R. 1. Penticton B.C.

C. Provincial and Local Government Agencies

1. Assisted provincial agencies and municipal offices requesting help with contaminant ground water investigations.

2. Designed a drilling program to monitor subsurface PCP contamination at a local saw mill. (for B.C. Pollution Control Branch)

3. Attended meetings with local Medical Health Officers (MHO's) and Health Inspectors discussing:

   a) Large contaminant ground water nitrate plume complex in Lower Fraser Valley.
   b) Leachate discharge from Langley Landfill.
   c) Leachate egress and ground water development around Richmond Landfill.

No reports were prepared for these projects. Two letters of public health concern were forwarded to local MHOs.

D. Field Trips

1. Provided class room discussion and hydrogeological field trips with

   a) BCIT environmental health students
   b) UBC Dept. of Civil Eng. graduate environmental engineering students.

2. Provided a half day hydrogeological segment to International Association of Sedimentologists 6-day field trip in southwestern B.C.

Summary of Activities and Progress in 1982

Study No. SI 73-12

Water Management of Glacierized Basins

O. Mokievsky-Zubok

Mass balance studies were continued on three representative glaciers (106 km^2) in the Iskut River basin. The vertical height loss of ic eon the Yuri and Alexander glaciers was 2.1 m and 3.1 m respectively. On Andrei Glacier it was 4.1 m and the glacier retreated 19.5 m. All three glaciers had negative mass balances.

Observations were also continued on the glacier-dammed Flood and Natavas lakes in the Stikine and Iskut river watersheds. Flood lake was filled to capacity (approx. 200 x $10^6 m^{-3}$) and discharged partially twice during August.

Studies to determine the mass blance and glacier melt contriution of the Tiedemann and Bench glaciers to flow regimes downstream entered their second year. Their potential influence on proposed dam sites in the Mt. Waddington area will be assessed. Vertical ice losses were 7.2 m and 4.4. m respectively at the snouts and both had negative balances.

Investigations continued on the Bridge River glaciers in order to determine the effect of the glaciers on basin runoff and to evaluate seasonal and operational forecast models in conjunction with J.R. Gordon of BC Hydro. A data collection platform (DCP) provided hydro-met data.

Measurements of winter and summer balances, meteorological variables and meltwater flow continued on Sentinel and Place glaciers with mass balance only being measured on Helm Glacier. Sentinel Glacier had to have a positive balance whilst the other two have negative balances. Since 1979 Sentinel Glacier has retreated 24 m.

Reports and conclusions based on the results obtained from field work are being prepared and will be submitted to the interested parties: B.C. Hydro's various offices in Burnaby and Vancouver, IWD, Pacific and Yukon Regional office, Water Survey of Canada. A paper on forecasting runoff from a glacier was presented at the poster session at the Annual Meeting of CAG. Albedo studies, as a separate project, continued on Andrei Glavier and were started on Tiedemann Glacier.

References:

Mokievsky-Zubok, O., 1982. Glaciological studies in Homathko River basin: progress report for 1981.

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Cohen, P., Mokievsky-Zubok, O. and Fogarasi, S., 1982. Assessment of the ARIMA model in forecasting runoff from Sentinel Glacier, B.C.

Poster Session No. 4, presented at Annual Meeting of the Canadian Association of Geographers, 9-12 June 1982, Ottawa University, Ottawa, Ontario, 18 pp.

Summary of Activities and Progress in 1982

Study No. SW 82-8

Yukon River Break-up at Dawson City

S.C. Bigras and T.D. Prowse

The time lapse photography of this years break-up at Dawson City has provided an excellent record of ice conditions during the break-up period. This was basically a pilot project intended to test the effectiveness of the time lapse camera system for recording break-up events at remote locations.

Two camera systems facing up and downstream were placed at a considerable distance from the river on a ridge northwest of the Midnight Dome, approximately 400 m above river level. The systems were set to take photos every 45 minutes over a three-week period (April 18 - May 21).

The resolution of the photography allows the viewer to accurately determine the pattern and sequence of break-up along the selected reaches of the Yukon River.

If sufficient funds are available for the 1983 spring break-up, plans to expand the study will include an ice survey of the region, climatic data collection and a final report.

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